
# User's Manual
# v2.13.02

Micriμm®

For the Way Engineers Work

Micriμm
1290 Weston Road, Suite 306
Weston, FL 33326
USA

www.Micrium.com



600-uC-TCP-IP-010

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# Table of Contents

Chapter

# 1

# Introduction to µC/TCP-IP

µC/TCP-IP is a compact, reliable, high-performance TCP/IP protocol stack. Built from the ground up with Micrium's unique combination of quality, scalability and reliability, µC/TCP-IP, the result of many man-years of development, enables the rapid configuration of required network options to minimize time to market.

The source code for µC/TCP-IP contains over 100,000 lines of the cleanest, most consistent ANSI C source code available in a TCP/IP stack implementation. C was chosen since C is the predominant language in the embedded industry. Over 50% of the code consists of comments and most global variables and all functions are described. References to RFC (Request For Comments) are included in the code where applicable.

## 1-1 PORTABLE

µC/TCP-IP is ideal for resource-constrained embedded applications. The code was designed for use with nearly any CPU, RTOS, and network device. Although µC/TCP-IP can work on some 8 and 16-bit processors, µC/TCP-IP is optimized for use with 32 or 64-bit CPUs.

## 1-2 SCALABLE

The memory footprint of µC/TCP-IP can be adjusted at compile time depending on the features required, and the desired level of run-time argument checking appropriate for the design at hand. SinceµC/TCP-IP is rich in its ability to provide statistics computation, unnecessary statistics computation can be disabled to further reduce the footprint.

## 1-3 CODING STANDARDS

Coding standards were established early in the design of µC/TCP-IP. They include:

- C coding style
- Naming convention for #define constants, macros, variables and functions
- Commenting
- Directory structure

These conventions make µC/TCP-IP the preferred TCP/IP stack implementation in the industry, and result in the ability to attain third party certification more easily as outlined in the next section.

## 1-4 MISRA C

The source code for µC/TCP-IP follows Motor Industry Software Reliability Association (MISRA) C Coding Standards. These standards were created by MISRA to improve the reliability and predictability of C programs in safety-critical automotive systems. Members of the MISRA consortium include such companies as Delco Electronics, Ford Motor Company, Jaguar Cars Ltd., Lotus Engineering, Lucas Electronics, Rolls-Royce, Rover Group Ltd., and universities dedicated to improving safety and reliability in automotive electronics. Full details of this standard can be obtained directly from the MISRA web site at: www.misra.org.uk.

## 1-5 SAFETY CRITICAL CERTIFICATION

µC/TCP-IP was designed from the ground up to be certifiable for use in avionics, medical devices, and other safety-critical products. Validated Software's Validation Suite™ for µC/TCP-IP will provide all of the documentation required to deliver µC/TCP-IP as a pre-certifiable software component for avionics RTCA DO-178B and EUROCAE ED-12B, medical FDA 510(k), IEC 61508 industrial control systems, and EN-50128 rail transportation and nuclear systems. The Validation Suite, available through Validated Software, will be

immediately certifiable for DO-178B Level A, Class III medical devices, and SIL3/SIL4 IEC-certified systems. For more information, check out the µC/TCP-IP page on the Validated Software web site at: www.ValidatedSoftware.com.

If your product is not safety critical, however, the presence of certification should be viewed as proof that µC/TCP-IP is very robust and highly reliable.

## 1-6 RTOS

µC/TCP-IP assumes the presence of an RTOS, yet there are no assumptions as to which RTOS to use with µC/TCP-IP. The only requirements are that it must:

- Be able to support multiple tasks
- Provide binary and counting semaphore management services
- Provide message queue services

µC/TCP-IP contains an encapsulation layer that allows for the use of almost any commercial or open source RTOS. Details regarding the RTOS are hidden from µC/TCP-IP. µC/TCP-IP includes the encapsulation layer for µC/OS-II and µC/OS-III real-time kernels.

## 1-7 NETWORK DEVICES

µC/TCP-IP may be configured with multiple-network devices and network (IP) addresses. Any device may be used as long as a driver with appropriate API and BSP software is provided. The API for a specific device (i.e., chip) is encapsulated in a couple of files and it is quite easy to adapt devices to µC/TCP-IP (see Chapter 12, “Statistics and Error Counters” on page 298).

Although Ethernet devices are supported today, Micrium is currently working on adding Point-to-Point Protocol (PPP) support to µC/TCP-IP.

## 1-8 µC/TCP-IP PROTOCOLS

µC/TCP-IP consists of the following protocols:

- Device drivers
- Network interfaces (e.g., Ethernet, PPP (TBA), etc.)
- Address Resolution Protocol (ARP)
- Internet Protocol (IP)
- Internet Control Message Protocol (ICMP)
- Internet Group Management Protocol (IGMP)
- User Datagram Protocol (UDP)
- Transport Control Protocol (TCP)
- Sockets (Micrium and BSD v4)

## 1-9 APPLICATION PROTOCOLS

Micrium offers application layer protocols as add-ons to µC/TCP-IP. A list of these network services and applications includes:

- µC/DCHPc, DHCP Client
- µC/DNSc, DNS Client
- µC/HTTPs, HTTP Server (web server)
- µC/TFTPc, TFTP Client
- µC/TFTPs, TFTP Server

- µC/FTPc, FTP Client
- µC/FTPs, FTP Server
- µC/SMTPc, SMTP Client
- µC/POP3, POP3 Client
- µC/SNTPc, Network Time Protocol Client

Any well known application layer protocols following the BSD socket API standard can be used with µC/TCP-IP.

Chapter

# 2

# µC/TCP-IP Architecture

µC/TCP-IP was written to be modular and easy to adapt to a variety of Central Processing Units (CPUs), Real-Time Operating Systems (RTOSs), network devices, and compilers. Figure 2-1 shows a simplified block diagram of µC/TCP-IP modules and their relationships.

Notice that all µC/TCP-IP files start with '`net_`'. This convention allows us to quickly identify which files belong to µC/TCP-IP. Also note that all functions and global variables start with '`Net`', and all macros and `#defines` start with '`net_`'.

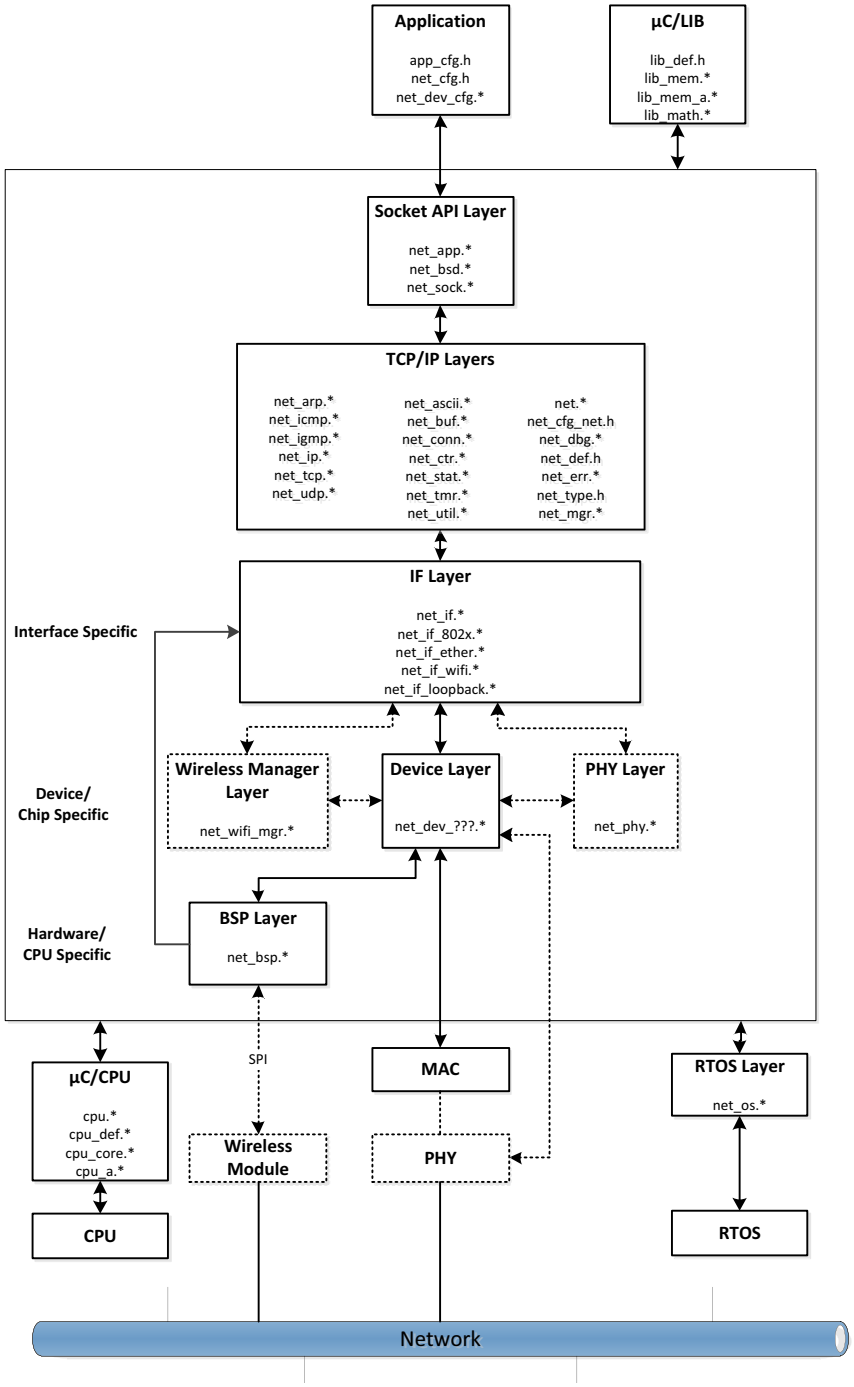



Figure 2-1 **Module Relationships**

# 2-1 µC/TCP-IP MODULE RELATIONSHIPS

## 2-1-1 APPLICATION

An application provides configuration information to µC/TCP-IP in the form of four C files: `app_cfg.h`, `net_cfg.h`, `net_dev_cfg.c` and `net_dev_cfg.h`.

`app_cfg.h` is an application-specific configuration file that *must* be present in the application. `app_cfg.h` contains `#defines` to specify the task priorities of each of the tasks within the application (including those of µC/TCP-IP), and the stack size for those tasks. Task priorities are placed in a file to make it easier to "see" task priorities for the entire application in one place.

Configuration data in `net_cfg.h` consists of specifying the number of timers to allocate to the stack, whether or not statistic counters will be maintained, the number of ARP cache entries, how UDP checksums are computed, and more. One of the most important configurations necessary is the size of the TCP Receive Window. In all, there are approximately 50 `#define` to set. However, most of the `#define` constants can be set to their recommended default value.

Finally, `net_dev_cfg.c` consists of device-specific configuration requirements such as the number of buffers allocated to a device, the MAC address for that device, and necessary physical layer device configuration including physical layer device bus address and link characteristics. Each µC/TCP-IP-compatible device requires that its configuration be specified within `net_dev_cfg.c`.

## 2-1-2 µC/LIB LIBRARIES

Given that µC/TCP-IP is designed for use in safety critical applications, all "standard" library functions such as `strcpy()`, `memset()`, *etc.* have been rewritten to conform to the same quality as the rest as the protocol stack.

## 2-1-3 BSD SOCKET API LAYER

The application interfaces to µC/TCP-IP uses the BSD socket Application Programming Interface (API). The software developer can either write their own TCP/IP applications using the BSD socket API or, purchase a number of off-the-shelf TCP/IP components (Telnet, Web server, FTP server, etc.),for use with the BSD socket interface. Note that the BSD socket layer is shown as a separate module but is actually part of µC/TCP-IP.

Alternatively, the software developer can use µC/TCP-IP's own socket interface functions (`net_sock.*`). `net_bsd.*` is a layer of software that converts BSD socket calls to µC/TCP-IP socket calls. Of course, a slight performance gain is achieved by interfacing directly to `net_sock.*` functions. Micrium network products use µC/TCP-IP socket interface functions.

## 2-1-4 TCP/IP LAYER

The TCP/IP layer contains most of the CPU, RTOS and compiler-independent code for µC/TCP-IP. There are three categories of files in this section:

1 TCP/IP protocol specific files include:

ARP (`net_arp.*`),

ICMP (`net_icmp.*`),

IGMP (`net_igmp.*`),

IP (`net_ip.*`),

TCP (`net_tcp.*`),

UDP (`net_udp.*`)

2 Support files are:

ASCII conversions (`net_ascii.*`),

Buffer management (`net_buf.*`),

TCP/UDP connection management (net_conn.*),

Counter management (net_ctr.*),

Statistics (net_stat.*),

Timer Management (net_tmr.*),

Other utilities (net_util.*).

3 Miscellaneous header files include:

Master µC/TCP-IP header file (net.h)

File containing error codes (net_err.h)

Miscellaneous µC/TCP-IP data types (net_type.h)

Miscellaneous definitions (net_def.h)

Debug (net_dbg.h)

Configuration definitions (net_cfg_net.h)

## 2-1-5 NETWORK INTERFACE (IF) LAYER

The IF Layer involves several types of network interfaces (Ethernet, Token Ring, etc.). However, the current version of µC/TCP-IP only supports Ethernet interfaces, wired and wireless. The IF layer is split into two sub-layers.

net_if.* is the interface between higher Network Protocol Suite layers and the link layer protocols. This layer also provides network device management routines to the application.

net_if_*.* contains the link layer protocol specifics independent of the actual device (i.e., hardware). In the case of Ethernet, net_if_ether.* understands Ethernet frames, MAC addresses, frame de-multiplexing, and so on, but assumes nothing regarding actual Ethernet hardware.

## 2-1-6 NETWORK DEVICE DRIVER LAYER

As previously stated, µC/TCP-IP works with just nearly any network device. This layer handles the specifics of the hardware, e.g., how to initialize the device, how to enable and disable interrupts from the device, how to find the size of a received packet, how to read a packet out of the frame buffer, and how to write a packet to the device, etc.

In order for device drivers to have independent configuration for clock gating, interrupt controller, and general purpose I/O, an additional file, `net_bsp.c`, encapsulates such details.

`net_bsp.c` contains code for the configuration of clock gating to the device, an internal or external interrupt controller, necessary IO pins, as well as time delays, getting a time stamp from the environment, and so on. This file is assumed to reside in the user application.

## 2-1-7 NETWORK PHYSICAL (PHY) LAYER

Often, devices interface to external physical layer devices, which may need to be initialized and controlled. This layer is shown in Figure 2-1 asa "dotted" area indicating that it is not present with all devices. In fact, some devices have PHY control built-in. Micrium provides a generic PHY driver which controls most external (R)MII compliant Ethernet physical layer devices.

## 2-1-8 NETWORK WIRELESS MANAGER

Often, wireless device may need to initialize a command and wait to receive the result (i.e. Scan). This layer manages specific wireless management commands. Micrium provides a generic Wireless Manager which should be able to controls most wireless module.

## 2-1-9 CPU LAYER

µC/TCP-IP can work with either an 8, 16, 32 or even 64-bit CPU, but it must have information about the CPU used. The CPU layer defines such information as the C data type corresponding to 16-bit and 32-bit variables, whether the CPU is little or big endian, and how interrupts are disabled and enabled on the CPU.

CPU-specific files are found in the `...\uC-CPU` directory and are used to adapt µC/TCP-IP to a different CPU, modify either the `cpu*.*` files or, create new ones based on the ones supplied in the uC-CPU directory. In general, it is much easier to modify existing files.

## 2-1-10 REAL-TIME OPERATING SYSTEM (RTOS) LAYER

µC/TCP-IP assumes the presence of an RTOS, but the RTOS layer allows µC/TCP-IP to be independent of a specific RTOS. µC/TCP-IP consists of three tasks. One task is responsible for handling packet reception, another task for asynchronous transmit buffer de-allocation, and the last task for managing timers. Depending on the configuration, a fourth task may be present to handle loopback operation.

As a minimum, the RTOS:

1 Must be able to create at least three tasks (a Receive task, a Transmit De-allocation task, and a Timer task)

2 Provide semaphore management (or the equivalent) and the µC/TCP-IP needs to be able to create at least two semaphores for each socket and an additional four semaphores for internal use.

3 Provides timer management services

4 Port must also include support for pending on multiple OS objects if BSD socket `select()` is required.

µC/TCP-IP is provided with a µC/OS-II and µC/OS-III interface. If a different RTOS is used, the `net_os.*` for µC/OS-II or µC/OS-III can be used as templates to interface to the RTOS chosen.

## 2-2 TASK MODEL

The user application interfaces to µC/TCP-IP via a well known API called BSD sockets (or µC/TCP-IP's internal socket interface). The application can send and receive data to/from other hosts on the network via this interface.

The BSD socket API interfaces to internal structures and variables (i.e., data) that are maintained by µC/TCP-IP. A binary semaphore (the global lock in Figure 2-2) is used to guard access to this data to ensure exclusive access. In order to read or write to this data, a task needs to acquire the binary semaphore before it can access the data and release it when finished. Of course, the application tasks do not have to know anything about this semaphore nor the data since its use is encapsulated by functions within µC/TCP-IP.

Figure 2-2 shows a simplified task model of µC/TCP-IP along with application tasks.

### 2-2-1 µC/TCP-IP TASKS AND PRIORITIES

µC/TCP-IP defines three internal tasks: a Receive task, a Transmit De-allocation task, and a Timer task. The Receive task is responsible for processing received packets from all devices. The Transmit De-allocation task frees transmit buffer resources when they are no longer required. The Timer task is responsible for handling all timeouts related to TCP/IP protocols and network interface management.

When setting up task priorities, we generally recommend that tasks that use µC/TCP-IP's services be configured with higher priorities than µC/TCP-IP's internal tasks. However, application tasks that use µC/TCP-IP should voluntarily relinquish the CPU on a regular basis. For example, they can delay or suspend the tasks or wait on µC/TCP-IP services. This is to reduce starvation issues when an application task sends a substantial amount of data.

We recommend that you configure the network interface Transmit De-allocation task with a higher priority than all application tasks that use µC/TCP-IP network services; but configure the Timer task and network interface Receive task with lower priorities than almost other application tasks.

See also section D-20-1 "Operating System Configuration" on page 770.

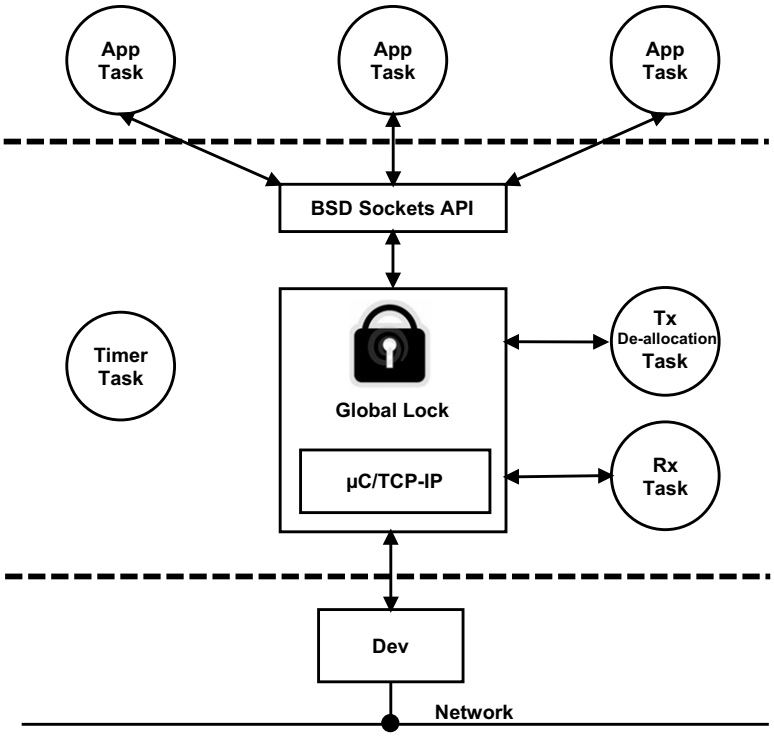



Figure 2-2 **µC/TCP-IP Task model**

## 2-2-2 RECEIVING A PACKET

Figure 2-3 shows a simplified task model of µC/TCP-IP when packets are received from the device.

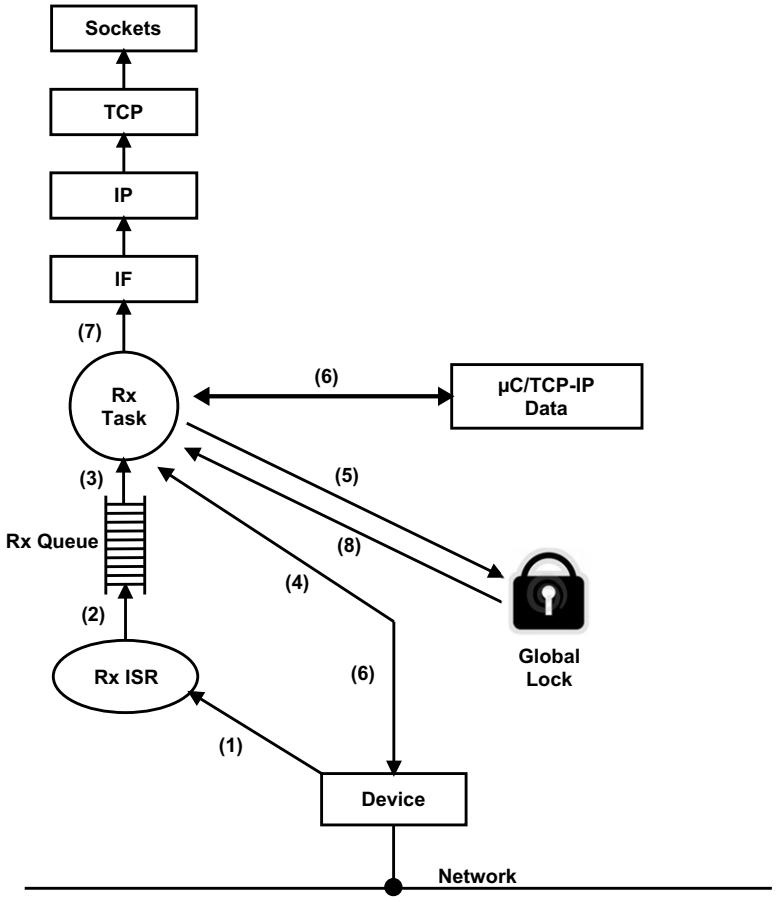



Figure 2-3 **µC/TCP-IP Receiving a Packet**

F2-3(1) A packet is sent on the network and the device recognizes its address as the destination for the packet. The device then generates an interrupt and the BSP global ISR handler is called for non-vectored interrupt controllers. Either the global ISR handler or the vectored interrupt controller calls the Net BSP device specific

ISR handler, which in turn indirectly calls the device ISR handler using a predefined Net IF function call. The device ISR handler determines that the interrupt comes from a packet reception (as opposed to the completion of a transmission).

F2-3(2) Instead of processing the received packet directly from the ISR, it was decided to pass the responsibility to a task. The Rx ISR therefore simply "signals" the Receive task by posting the interface number to the Receive task queue. Note that further Rx interrupts are generally disabled while processing the interrupt within the device ISR handler.

F2-3(3) The Receive task does nothing until a signal is received from the *Rx ISR*.

F2-3(4) When a signal is received from an Ethernet device, the Receive task wakes up and extracts the packet from the hardware and places it in a receive buffer. For DMA based devices, the receive descriptor buffer pointer is updated to point to a new data area and the pointer to the receive packet is passed to higher layers for processing.

µC/TCP-IP maintains three types of device buffers: small transmit, large transmit, and large receive. For a common Ethernet configuration, a small transmit buffer typically holds up to 256 bytes of data, a large transmit buffer up to 1500 bytes of data, and a large receive buffer 1500 bytes of data. Note that the large transmit buffer size is generally specified within the device configuration as 1594 or 1614 bytes (see Chapter 9, "Buffer Management" on page 277 for a precise definition). The additional space is used to hold additional protocol header data. These sizes as well as the quantity of these buffers are configurable for each interface during either compile time or run time.

F2-3(5) Buffers are shared resources and any access to those or any other µC/TCP-IP data structures is guarded by the binary semaphore that guards the data. This means that the Receive task will need to acquire the semaphore before it can receive a buffer from the pool.

F2-3(6) The Receive task gets a buffer from the buffer pool. The packet is removed from the device and placed in the buffer for further processing. For DMA, the acquired buffer pointer replaces the descriptor buffer pointer that received the current frame. The pointer to the received frame is passed to higher layers for further processing.

F2-3(7) The Receive task examines received data via the appropriate link layer protocol and determines whether the packet is destined for the ARP or IP layer, and passes the buffer to the appropriate layer for further processing. Note that the Receive task brings the data all the way up to the application layer and therefore the appropriate µC/TCP-IP functions operate within the context of the Receive task.

F2-3(8) When the packet is processed, the lock is released and the Receive task waits for the next packet to be received.

## 2-2-3 TRANSMITTING A PACKET

Figure 2-4 shows a simplified task model of µC/TCP-IP when packets are transmitted through the device.

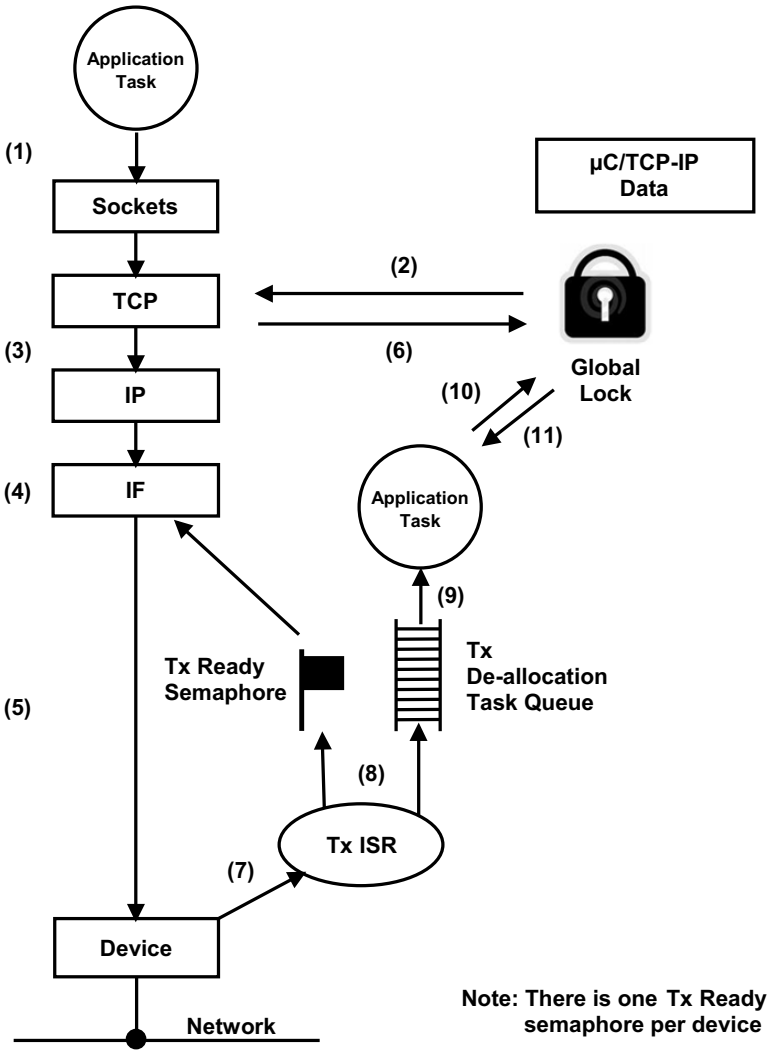



Figure 2-4 **µC/TCP-IP Sending a Packet**

F2-4(1) A task (assuming an application task) that wants to send data interfaces to µC/TCP-IP through the BSD socket API.

F2-4(2) A function within µC/TCP-IP acquires the binary semaphore (i.e., the global lock) in order to place the data to send into µC/TCP-IP's data structures.

F2-4(3) The appropriate µC/TCP-IP layer processes the data, preparing it for transmission.

F2-4(4) The task (via the IF layer) then waits on a counting semaphore, which is used to indicate that the transmitter in the device is available to send a packet. If the device is not able to send the packet, the task blocks until the semaphore is signaled by the device. Note that during device initialization, the semaphore is initialized with a value corresponding to the number of packets that can be sent at one time through the device. If the device has sufficient buffer space to be able to queue up four packets, then the counting semaphore is initialized with a count of 4. For DMA-based devices, the value of the semaphore is initialized to the number of available transmit descriptors.

F2-4(5) When the device is ready, the driver either copies the data to the device internal memory space or configures the DMA transmit descriptor. When the device is fully configured, the device driver issues a transmit command.

F2-4(6) After placing the packet into the device, the task releases the global data lock and continues execution.

F2-4(7) When the device finishes sending the data, the device generates an interrupt.

F2-4(8) The Tx ISR signals the Tx Available semaphore indicating that the device is able to send another packet. Additionally, the Tx ISR handler passes the address of the buffer that completed transmission to the Transmit De-allocation task via a queue which is encapsulated by an OS port function call.

F2-4(9) The Transmit De-allocation task wakes up when a device driver posts a transmit buffer address to its queue.

F2-4(10) The global data lock is acquired. If the global data lock is held by another task, the Transmit De-allocation task must wait to acquire the global data lock. Since it is recommended that the Transmit De-allocation task be configured as the highest priority µC/TCP-IP task, it will run following the release of the global data lock, assuming the queue has at least one entry present.

F2-4(11) The lock is released when transmit buffer de-allocation is finished. Further transmission and reception of additional data by application and µC/TCP-IP tasks may resume.

Chapter

# 3

# Directories and Files

This chapter will discuss the modules available for µC/TCP-IP, and how they all fit together. A Windows®-based development platform is assumed. The directories and files make references to typical Windows-type directory structures. However, since µC/TCP-IP is available in source form, it can also be used with any ANSI-C compatible compiler/linker and any Operating System.

The names of the files are shown in upper case to make them stand out. However, file names are actually lower case.

## 3-1 BLOCK DIAGRAM

Figure 3-1 is a block diagram of the modules found in µC/TCP-IP and their relationship. Also included are the names of the files that are related to µC/TCP-IP.

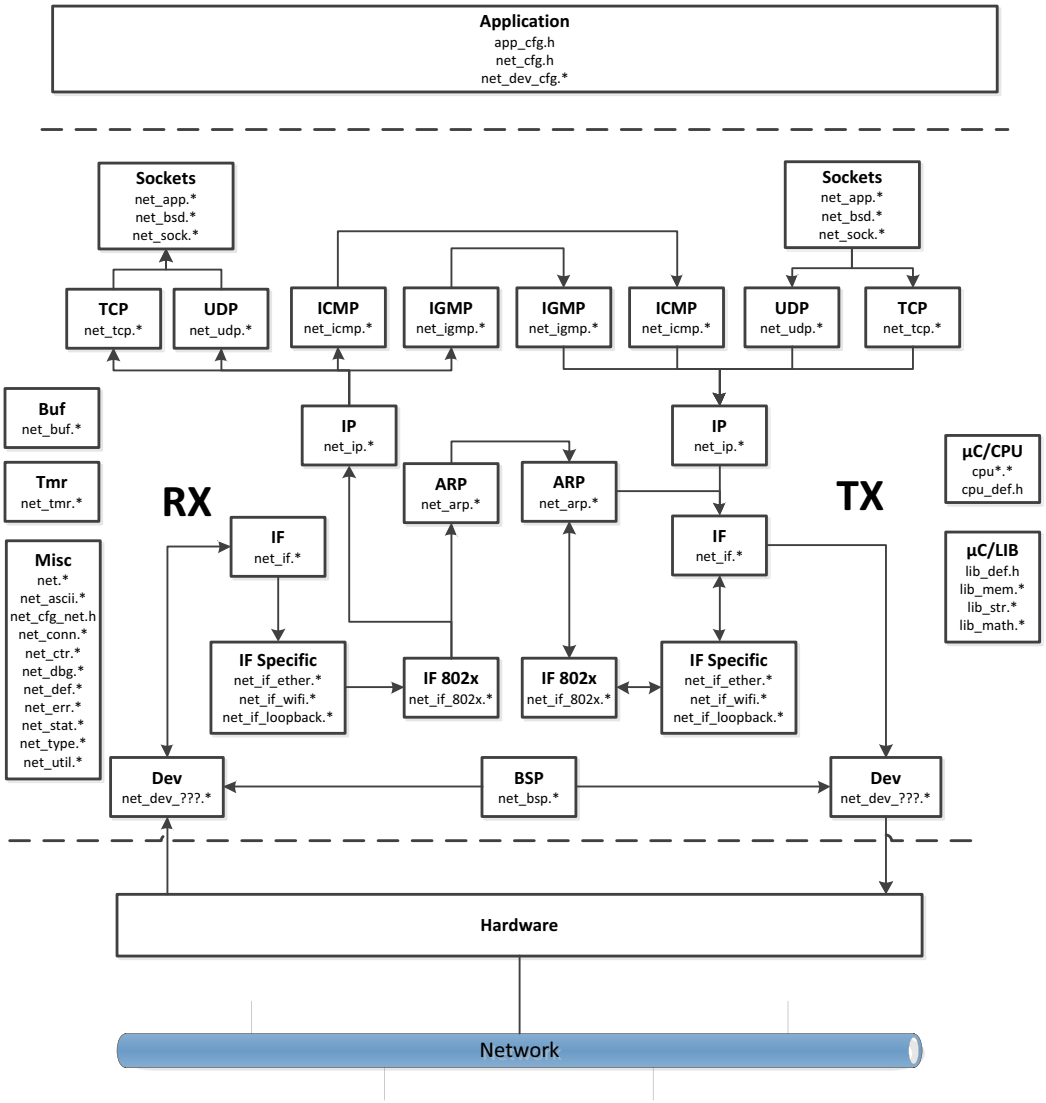



Figure 3-1 **µC/TCP-IP Block Diagram**

## 3-2 APPLICATION CODE

When Micrium provides example projects, they are placed in a directory structure shown below. Of course, a directory structure that suits a particular project/product can be used.

```
\Micrium
   \Software
      \EvalBoards
         \<manufacturer>
            \<board_name>
               \<compiler>
                  \<project name>
                     \*.*
```

**\Micrium**
This is where we place all software components and projects provided by Micrium. This directory generally starts from the root directory of the computer.

**\Software**
This sub-directory contains all software components and projects.

**\EvalBoards**
This sub-directory contains all projects related to evaluation boards supported by Micrium.

**\<manufacturer>**
This is the name of the manufacturer of the evaluation board. The '<' and '>' are not part of the actual name.

**\<board name>**
This is the name of the evaluation board. A board from Micrium will typically be called `uC-Eval-xxxx` where `xxxx` represents the CPU or MCU used on the board. The '<' and '>' are not part of the actual name.

**\<compiler>**
This is the name of the compiler or compiler manufacturer used to build the code for the evaluation board. The '<' and '>' are not part of the actual name.

**\<project name>**

The name of the project that will be demonstrated. For example a simple µC/TCP-IP project might have a project name of '`OS-Ex1`'. The '`-Ex1`' represents a project containing only µC/OS-III. A project name of `OS-Probe-Ex1` contains µC/TCP-IP and µC/Probe. The '`<`' and '`>`' are not part of the actual name.

***.***

These are the source files for the project. Main files can optionally be called `APP*.*`. This directory also contains configuration files `app_cfg.h`, `net_cfg.h`, `net_decv_cfg.h`, `net_dev_cfg.c`,`os_cfg.h`, `os_cfg_app.h` and other project-required source files.

**`includes.h`** is the application-specific master include header file. Almost all Micrium products require this file.

**`net_cfg.h`** is a configuration file used to configure such µC/TCP-IP parameters as the number of network timers, sockets, and connections created; default timeout values, and more. `net_cfg.h` *must* be included in the application as µC/TCP-IP requires this file. See Chapter 16, "Network Interface Layer" on page 361 for more information.

**`net_dev_cfg.c`** and **`net_dev_cfg.h`** are configuration files used to configure µC/TCP-IP interface parameters such as the number of transmit and receive buffers. See Chapter 5, "Network Interface Configuration" on page 77 for more details.

**`os_cfg.h`** is a configuration file used to configure µC/OS-III parameters such as the maximum number of tasks, events, and objects; which µOS-III services are enabled (semaphores, mailboxes, queues); *etc*. `os_cfg.h`is a required file for any µC/OS-III application. See µC/OS-III documentation and books for further information.

**`app.c`** contains the application code for the Processor example project. As with most C programs, code execution starts at `main()` which is shown in Listing 4-1 on page 69. The application code starts µC/TCP-IP.

## 3-3 CPU

The directory shown below contains semiconductor manufacturer peripheral interface source files. Any directory structure that suits the project/product may be used.

```
\Micrium
   \Software
      \CPU
         \<manufacturer>
            \<architecture>
               \*.*
```

**\Micrium**
The location of all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\CPU**
This sub-directory is always called CPU.

**\<manufacturer>**
Is the name of the semiconductor manufacturer providing the peripheral library. The **<** and **>** are not part of the actual name.

**\<architecture>**
The name of the specific library, generally associated with a CPU name or an architecture.

***.***
Indicates library source files. The semiconductor manufacturer names the files.

## 3-4 BOARD SUPPORT PACKAGE (BSP)

The Board Support Package (BSP) is generally found with the evaluation or target board, and it is specific to that board. In fact, when well written, the BSP should be used for multiple projects.

```
\Micrium
   \Software
      \EvalBoards
         \<manufacturer>
            \<board name>
               \<compiler>
                  \BSP
                     \*.*
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\EvalBoards**
This sub-directory contains all projects related to evaluation boards.

**\<manufacturer>**
The name of the manufacturer of the evaluation board. The **<** and **>** are not part of the actual name.

**\<board name>**
The name of the evaluation board. A board from Micrium will typically be called `uC-Eval-xxxx` where `xxxx` is the name of the CPU or MCU used on the evaluation board. The **<** and **>** are not part of the actual name.

**\<compiler>**
The name of the compiler or compiler manufacturer used to build code for the evaluation board. The **<** and **>** are not part of the actual name.

**\BSP**
This directory is always called BSP.

***.***
The source files of the BSP. Typically all of the file names start with BSP. It is therefore normal to find `bsp.c` and `bsp.h` in this directory. BSP code should contain such functions as LED control functions, initialization of timers, interface to Ethernet controllers, and more.

BSP stands for Board Support Package and the 'services' the board provides are placed in such a file. In this case, `bsp.c` contains I/O, timer initialization code, LED control code, and more. The I/Os used on the board are initialized when `BSP_Init()` is called.

The concept of a BSP is to hide the hardware details from the application code. It is important that functions in a BSP reflect the function and do not make references to any CPU specifics. For example, the code to turn on an LED is called `LED_On()` and not `MCU_led()`. If `LED_On()` is used in the code, it can be easily ported to another processor (or board) by simply rewriting `LED_On()` to control the LEDs on a different board. The same is true for other services. Also notice that BSP functions are prefixed with the function's group. LED services start with `LED_`, timer services start with `Tmr_`, etc. In other words, BSP functions do not need to be prefixed by `BSP_`.

## 3-5 NETWORK BOARD SUPPORT PACKAGE (NET_BSP)

In addition to the general (BSP) there are specific network initialization and configuration requirements. This additional file is generally found with the evaluation or target board as it is specific to that board.

```
\Micrium
   \Software
      \EvalBoards
         \<manufacturer>
            \<board name>
               \<compiler>
                  \BSP
                     \TCPIP-V2
                        \*.*
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\EvalBoards**
This sub-directory contains all projects related to evaluation boards.

**\<manufacturer>**
The name of the manufacturer of the evaluation board. The '<' and '>' are not part of the actual name.

**\<board name>**
The name of the evaluation board. A board from Micrium will typically be called `uC-Eval-xxxx` where `xxxx` is the name of the CPU or MCU used on the evaluation board. The '<' and '>' are not part of the actual name.

**\<compiler>**
The name of the compiler or compiler manufacturer used to build code for the evaluation board. The '<' and '>' are not part of the actual name.

**\BSP**
This directory is always called BSP.

**\TCPIP-V2**
This directory is always called TCPIP-V2 as it is the directory for the network related BSP files.

***.***
The `net_bsp.*` files contain hardware-dependent code specific to the network device(s) and other µC/TCP-IP functions. Specifically, these files may contain code to read data from and write data to network devices, handle hardware-level device interrupts, provide delay functions, and get time stamps, etc.

## 3-6 µC/OS-III, CPU INDEPENDENT SOURCE CODE

The files in these directories are available to µC/OS-III licensees (see Appendix X, "Licensing Policy").

```
\Micrium
   \Software
      \uCOS-III
         \Cfg\Template
         \Source
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uCOS-III**
This is the main µC/OS-III directory.

**\Cfg\Template**
This directory contains examples of configuration files to copy to the project directory. These files can be modified to suit the needs of the application.

**\Source**
The directory contains the CPU-independent source code for µC/OS-III. All files in this directory should be included in the build (assuming the presence of the source code). Features that are not required will be compiled out based on the value of #define constants in `os_cfg.h` and `os_cfg_app.h`.

## 3-7 µC/OS-III, CPU SPECIFIC SOURCE CODE

The µC/OS-III port developer provides these files. See Chapter 17 in the µC/OS-III book.

```
\Micrium
   \Software
      \uCOS-III
         \Ports
            \<architecture>
               \<compiler>
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uCOS-III**
The main µC/OS-III directory.

**\Ports**
The location of port files for the CPU architecture(s) to be used.

**\<architecture>**
This is the name of the CPU architecture that µC/OS-III was ported to. The '<' and '>' are not part of the actual name.

**\<compiler>**
The name of the compiler or compiler manufacturer used to build code for the port. The **<** and **>** are not part of the actual name.

The files in this directory contain the µC/OS-III port, see Chapter 17 "Porting µC/OS-III" in the µC/OS-III book for details on the contents of these files.

## 3-8 µC/CPU, CPU SPECIFIC SOURCE CODE

µC/CPU consists of files that encapsulate common CPU-specific functionality and CPU and compiler-specific data types.

```
\Micrium
    \Software
        \uC-CPU
            \cpu_core.c
            \cpu_core.h
            \cpu_def.h
            \Cfg\Template
                \cpu_cfg.h
            \<architecture>
                \<compiler>
                    \cpu.h
                    \cpu_a.asm
                    \cpu_c.c
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uC-CPU**
This is the main µC/CPU directory.

**cpu_core.c** contains C code that is common to all CPU architectures. Specifically, this file contains functions to measure the interrupt disable time of the `CPU_CRITICAL_ENTER()` and `CPU_CRITICAL_EXIT()` macros, a function that emulates a count leading zeros instruction and a few other functions.

**cpu_core.h** contains function prototypes for the functions provided in `cpu_core.c` and allocation of the variables used by the module to measure interrupt disable time.

**cpu_def.h** contains miscellaneous #define constants used by the µC/CPU module.

### \Cfg\Template

This directory contains a configuration template file (cpu_cfg.h) that is required to be copied to the application directory to configure the µC/CPU module based on application requirements.

**cpu_cfg.h** determines whether to enable measurement of the interrupt disable time, whether the CPU implements a count leading zeros instruction in assembly language, or whether it will be emulated in C, and more.

### \<architecture>

The name of the CPU architecture that µC/CPU was ported to. The '<' and '>' are not part of the actual name.

### \<compiler>

The name of the compiler or compiler manufacturer used to build code for the µC/CPU port. The '<' and '>' are not part of the actual name.

The files in this directory contain the µC/CPU port, see Chapter 17 of the µC/OS-III book, "Porting µC/OS-III" for details on the contents of these files.

**cpu.h** contains type definitions to make µC/OS-III and other modules independent of the CPU and compiler word sizes. Specifically, one will find the declaration of the CPU_INT16U, CPU_INT32U, CPU_FP32 and many other data types. This file also specifies whether the CPU is a big or little endian machine, defines the CPU_STK data type used by µC/OS-III, defines the macros OS_CRITICAL_ENTER() and OS_CRITICAL_EXIT(), and contains function prototypes for functions specific to the CPU architecture, etc.

**cpu_a.asm** contains the assembly language functions to implement code to disable and enable CPU interrupts, count leading zeros (if the CPU supports that instruction), and other CPU specific functions that can only be written in assembly language. This file may also contain code to enable caches, and setup MPUs and MMU. The functions provided in this file are accessible from C.

**cpu_c.c** contains the C code of functions that are based on a specific CPU architecture but written in C for portability. As a general rule, if a function can be written in C then it should be, unless there is significant performance benefits available by writing it in assembly language.

## 3-9 µC/LIB, PORTABLE LIBRARY FUNCTIONS

µC/LIB consists of library functions meant to be highly portable and not tied to any specific compiler. This facilitates third-party certification of Micrium products. µC/OS-III does not use any µC/LIB functions, however the µC/CPU assumes the presence of `lib_def.h` for such definitions as: `DEF_YES`, `DEF_NO`, `DEF_TRUE`, `DEF_FALSE`, *etc*.

```
\Micrium
    \Software
        \uC-LIB
            \lib_ascii.c
            \lib_ascii.h
            \lib_def.h
            \lib_math.c
            \lib_math.h
            \lib_mem.c
            \lib_mem.h
            \lib_str.c
            \lib_str.h
            \Cfg\Template
                \lib_cfg.h
            \Ports
                \<architecture>
                    \<compiler>
                        \lib_mem_a.asm
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uC-LIB**
This is the main µC/LIB directory.

**\Cfg\Template**
This directory contains a configuration template file (`lib_cfg.h`) that is required to be copied to the application directory to configure the µC/LIB module based on application requirements.

**`lib_cfg.h`** determines whether to enable assembly language optimization (assuming there is an assembly language file for the processor, i.e., `lib_mem_a.asm`) and a few other `#defines`.

## 3-10 µC/TCP-IP NETWORK DEVICES

The files in these directories are

```
\Micrium
   \Software
      \uC-TCPIP-V2
         \Dev
            \Ether
               \PHY
                  \Generic
               \<Controller>
            \WiFi
               \Manager
                  \Generic
               \<Controller>
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uC-TCPIP-V2**
This is the main directory for the µC/TCP-IP code. The name of the directory contains a version number to differentiate it from previous versions of the stack.

**\Dev**
This directory contains device drivers for different interfaces. Currently, µC/TCP-IP only supports one type of interface, Ethernet. µC/TCP-IP is tested with many types of Ethernet devices.

**\Ether**
Ethernet controller drivers are placed under the Ether sub-directory. Note that device drivers must also be called `net_dev_<controller>.*`.

**\WiFi**
Wireless controller drivers are placed under the WiFi sub-directory. Note that device drivers must also be called net_dev_<controller>.*.

**\PHY**
This is the main directory for Ethernet Physical layer drivers.

**\Generic**
This is the directory for the Micrium provided generic PHY driver. Micrium's generic Ethernet PHY driver provides sufficient support for most (R)MII compliant Ethernet physical layer devices. A specific PHY driver may be developed in order to provide extended functionality such as link state interrupt support.

**net_phy.h** is the network physical layer header file.

**net_phy.c** provides the (R)MII interface port that is assumed to be part of the host Ethernet MAC. Therefore, (R)MII reads/writes *must* be performed through the network device API interface via calls to function pointers `Phy_RegRd()` and `Phy_RegWr()`.

**\Manager**
This is the main directory for Wireless Manager layer.

**\Generic**
This is the directory for the Micriµm provided generic Wireless Manager layer. Micriµm's generic Wireless Manager layer provides sufficient support for most wireless devices that embed a wireless supplicant. A specific Wireless Manager may be developed in order to provide extended functionality.

**net_wifi_mgr.h** is the network Wireless Manager layer header file.

**net_wifi_mgr.c** provides functionality to access the device for management command that could required asynchronous response such as scan for available network.

**\<controller>**
The name of the Ethernet or wireless controller or chip manufacturer used in the project. The '<' and '>' are not part of the actual name. This directory contains the network device driver for the Network Controller specified.

**net_dev_<controller>.h** is the header file for the network device driver.

**net_dev_<controller>.c** contains C code for the network device driver API.

## 3-11 µC/TCP-IP NETWORK INTERFACE

This directory contains interface-specific files. Currently, µC/TCP-IP only supports three type of interfaces, Ethernet, wireless and loopback. The Ethernet and wireless interface-specific files are found in the following directories:

```
\Micrium
   \Software
      \uC-TCPIP-V2
         \IF
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uC-TCPIP-V2**
This is the main µC/TCP-IP directory.

**\IF**
This is the main directory for network interfaces.

**net_if.*** presents a programming interface between higher µC/TCP-IP layers and the link layer protocols. These files also provide interface management routines to the application.

**net_if_802x.*** contains common code to receive and transmit 802.3 and Ethernet packets. This file should not need to be modified.

**net_if_ether.*** contains the Ethernet interface specifics. This file should not need to be modified.

**net_if_wifi.*** contains the wireless interface specifics. This file should not need to be modified.

**net_if_loopback.*** contains loopback interface specifics. This file should not need to be modified.

## 3-12 µC/TCP-IP NETWORK FILE SYSTEM ABSTRACTION LAYER

This directory contains the file system abstraction layer which allows the TCP-IP application such as µC/HTTPs, µC/FTPc, µC/FTPs, etc. with nearly any commercial or in-house file system. The abstraction layer for the selected file system is placed in a sub-directory under FS as follows:

```
\Micrium
   \Software
      \uC-TCPIP-V2
         \FS
            \<file_system_name>
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uC-TCPIP-V2**
This is the main µC/TCP-IP directory.

**\FS**
This is the main FS directory that contain generic file system port header file. This file must be included if one or more application that required a file system such as µC/HTTPs, µC/FTPc, µC/FTPs, etc. are present in the project.

**\<file_system_name>**
This is the directory that contains the files to perform file system abstraction.

µC/TCP-IP has been tested with µC/FS-V4 and the file system layer files for this file system are found in the following directories:

```
\Micrium\Software\uC-TCPIP-V2\FS\uC-FS-V4\net_fs_v4.*
```

## 3-13 µC/TCP-IP NETWORK OS ABSTRACTION LAYER

This directory contains the RTOS abstraction layer which allows the use of µC/TCP-IP with nearly any commercial or in-house RTOS. The abstraction layer for the selected RTOS is placed in a sub-directory under OS as follows:

```
\Micrium
   \Software
      \uC-TCPIP-V2
         \OS
            \<rtos_name>
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uC-TCPIP-V2**
This is the main µC/TCP-IP directory.

**\OS**
This is the main OS directory.

**\<rtos_name>**
This is the directory that contains the files to perform RTOS abstraction. Note that files for the selected RTOS abstraction layer must always be named net_os.*.

µC/TCP-IP has been tested with µC/OS-II, µC/OS-III and the RTOS layer files for these RTOS are found in the following directories:

\Micrium\Software\uC-TCPIP-V2\OS\uCOS-II\net_os.*

\Micrium\Software\uC-TCPIP-V2\OS\uCOS-III\net_os.*

## 3-14 µC/TCP-IP NETWORK CPU SPECIFIC CODE

Some functions can be optimized in assembly to improve the performance of the network protocol stack. An easy candidate is the checksum function. It is used at multiple levels in the stack, and a checksum is generally coded as a long loop.

```
\Micrium
   \Software
      \uC-TCPIP-V2
         \Ports
            \<architecture>
               \<compiler>
                  \net_util_a.asm
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uC-TCPIP-V2**
This is the main µC/TCP-IP directory.

**\Ports**
This is the main directory for processor specific code.

**\<architecture>**
The name of the CPU architecture that was ported to. The '<' and '>' are not part of the actual name.

**\<compiler>**
The name of the compiler or compiler manufacturer used to build code for the optimized function(s). The '<' and '>' are not part of the actual name.

`net_util_a.asm` contains assembly code for the specific CPU architecture. All functions that can be optimized for the CPU architecture are located here.

## 3-15 µC/TCP-IP NETWORK CPU INDEPENDENT SOURCE CODE

This directory contains all the CPU and RTOS independent files for µC/TCP-IP. Nothing should be changed in this directory in order to use µC/TCP-IP.

```
\Micrium
   \Software
      \uC-TCPIP-V2
         \Source
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uC-TCPIP-V2**
This is the main µC/TCP-IP directory.

**\Source**
This is the directory that contains all the CPU and RTOS independent source code files.

## 3-16 µC/TCP-IP NETWORK SECURITY MANAGER CPU INDEPENDENT SOURCE CODE

This directory contains all the CPU independent files for µC/TCP-IP Network Security Manager. Nothing should be changed in this directory in order to use µC/TCP-IP.

```
\Micrium
   \Software
      \uC-TCPIP-V2
         \Secure
            \<security_suite_name>
```

**\Micrium**
Contains all software components and projects provided by Micrium.

**\Software**
This sub-directory contains all software components and projects.

**\uC-TCPIP-V2**
This is the main µC/TCP-IP directory.

**\Secure**
This is the main Secure directory that contains the generic secure port header file. This file should be included in the project only if a security suite is available and is to be used by the application.

**\Secure\<security_suite_name>**
This is the directory that contains the files to perform security suite abstraction. These files should only be included in the project if a security suite (i.e Mocana - NanoSSL) is available and is to be used by the application.

## 3-17 SUMMARY

Below is a summary of all directories and files involved in a µC/TCP-IP-based project. The '<-Cfg' on the far right indicates that these files are typically copied into the application (i.e., project) directory and edited based on project requirements.

```
\Micrium
    \Software
        \EvalBoards
            \<manufacturer>
                \<board name>
                    \<compiler>
                        \<project name>
                            \app.c
                            \app.h
                            \other
                        \BSP
                            \bsp.c
                            \bsp.h
                            \others
                            \TCPIP-V2
                                \net_bsp.c
                                \net_bsp.h
        \CPU
            \<manufacturer>
                \<architecture>
                    \*.*
        \uCOS-III
            \Cfg\Template
                \os_app_hooks.c
                \os_cfg.h                          <-Cfg
                \os_cfg_app.h                      <-Cfg
            \Source
                \os_cfg_app.c
                \os_core.c
                \os_dbg.c
                \os_flag.c
                \os_int.c
```

```
        \os_mem.c
        \os_msg.c
        \os_mutex.c
        \os_pend_multi.c
        \os_prio.c
        \os_q.c
        \os_sem.c
        \os_stat.c
        \os_task.c
        \os_tick.c
        \os_time.c
        \os_tmr.c
        \os_var.c
        \os.h
        \os_type.h                          <-Cfg
    \Ports
        \<architecture>
            \<compiler>
                \os_cpu.h
                \os_cpu_a.asm
                \os_cpu_c.c
\uC-CPU
    \cpu_core.c
    \cpu_core.h
    \cpu_def.h
    \Cfg\Template
        \cpu_cfg.h                          <-Cfg
    \<architecture>
        \<compiler>
            \cpu.h
            \cpu_a.asm
            \cpu_c.c
\uC-LIB
    \lib_ascii.c
    \lib_ascii.h
    \lib_def.h
    \lib_math.c
    \lib_math.h
```

```
    \lib_mem.c
    \lib_mem.h
    \lib_str.c
    \lib_str.h
    \Cfg\Template
        \lib_cfg.h                          <-Cfg
    \Ports
        \<architecture>
            \<compiler>
                \lib_mem_a.asm
\uC-TCPIP-V2
    \BSP
        Template
            \net_bsp.c                      <-Cfg
            \net_bsp.h                      <-Cfg
            OS
                \<rtos_name>
                    \net_bsp.c              <-Cfg
    \CFG
        \Template
            \net_cfg.h                      <-Cfg
            \net_dev_cfg.c                  <-Cfg
            \net_dev_cfg.h                  <-Cfg
    \Dev
        \Ether
            \<controller>
                \net_dev_<controller>.c
                \net_dev_<controller>.h
            \PHY
                \controller>
                    \net_phy_<controller>.c
                    \net_phy_<controller>.h
                \Generic
                    \net_phy.c
                    \net_phy.h
        \WiFi
            \<controller>
                \net_dev_<controller>.c
```

```
            \net_dev_<controller>.h
        \Manager
            \Generic
                \net_wifi_mgr.c
                \net_wifi_mgr.h
\IF
    \net_if.c
    \net_if.h
    \net_if_802x.c
    \net_if_802x.h
    \net_if_ether.c
    \net_if_ether.h
    \net_if_wifi.c
    \net_if_wifi.h
    \net_if_loopback.c
    \net_if_loopback.h
\OS
    \<template>
        \net_os.c                       <-Cfg
        \net_os.h                       <-Cfg
    \<rtos_name>
        \net_os.c
        \net_os.h
\Ports
    \<architecture>
        \<compiler>
            \net_util_a.asm
\Secure
    net_secure.h
    \<security_suite_name>
        \net_secure_<suite_name>.c
        \net_secure_<suite_name>.h
\Source
    \net.c
    \net.h
    \net_app.c
    \net_app.h
    \net_arp.c
```

**\net_arp.h**
**\net_ascii.c**
**\net_ascii.h**
**\net.bsd.c**
**\net.bsd.h**
**\net.buf.c**
**\net.buf.h**
**\net.cfg_net.h**
**\net.conn.c**
**\net.conn.h**
**\net.ctr.c**
**\net.ctr.h**
**\net.dbg.c**
**\net.dbg.h**
**\net.def.h**
**\net.err.c**
**\net.err.h**
**\net.icmp.c**
**\net.icmp.h**
**\net.igmp.c**
**\net.igmp.h**
**\net.ip.c**
**\net.ip.h**
**\net.mgr.c**
**\net.mgr.h**
**\net.sock.c**
**\net.sock.h**
**\net.stat.c**
**\net.stat.h**
**\net.tcp.c**
**\net.tcp.h**
**\net.tmr.c**
**\net.tmr.h**
**\net.type.h**
**\net.udp.c**
**\net.udp.h**
**\net.util.c**
**\net.util.h**

Chapter

# 4

# Getting Started with µC/TCP-IP

As previously stated, the Directories and Files structure used herein assumes you have access to the µC/TCP-IP source code. The samples and examples in Part II of this book, however, use µC/TCP-IP as a library. The project structure is therefore different.

µC/TCP-IP requires an RTOS and, for the purposes of this book, µC/OS-III has been chosen. First, because it is the latest kernel from Micrium, and second, because all the examples in this book were developed with the evaluation board that is available with the µC/OS-III book. This way there is no need for an additional evaluation board.

## 4-1 INSTALLING µC/TCP-IP

Distribution of µC/TCP-IP is performed through release files. The release archive files contain all of the source code and documentation for µC/TCP-IP. Additional support files such as those located within the CPU directory may or may not be required depending on the target hardware and development tools. Example startup code, if available, may be delivered upon request. Example code is located in the Evalboards directory when applicable.

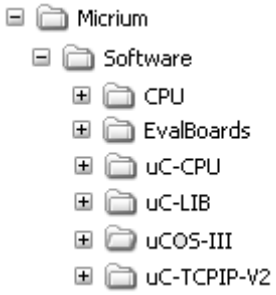



Figure 4-1 **Directory tree for µC/TCP-IP**

## 4-2 µC/TCP-IP EXAMPLE PROJECT

The following example project is used to show the basic architecture of µC/TCP-IP and to build an empty application. The application also uses µC/OS-III as the RTOS. Figure 4-1 shows the project test setup. A Windows-based PC and the target system were connected to a 100 Mbps Ethernet switch or via an Ethernet cross-over cable. The PC's IP address is set to 10.10.10.111 and one of the target's addresses is configured to 10.10.10.64.

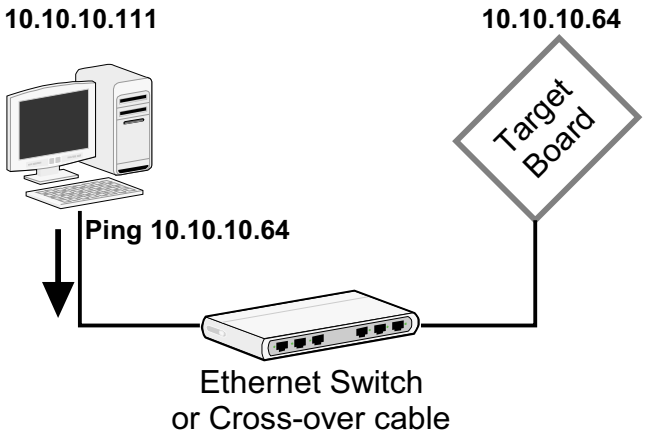



Figure 4-2 **Test setup**

This example contains enough code to be able to ping the board.The IP address of the board is forced to be 10.10.10.64. With a similar setup, the following command from a command-prompt is issued:

```
ping 10.10.10.64
```

Ping (on the PC) should reply back with the ping time to the target. µC/TCP-IP target projects connected to the test PC on the same Ethernet switch or Ethernet cross-over cable achieve ping times of less than 2 milliseconds.

The next sections show the directory tree of different components required to build a µC/TCP-IP example project.

## 4-3 APPLICATION CODE

File `app.c` contains the application code for the Processor example project. As with most C programs, code execution starts at `main()` which is shown in Listing 4-1. The application code starts µC/TCP-IP.

```
void  main (void)
{
    OS_ERR  err_os;

    BSP_IntDisAll();                                                          (1)

    OSInit(&err_os);                                                          (2)
    APP_TEST_FAULT(err_os, OS_ERR_NONE);

    OSTaskCreate((OS_TCB     *)&AppTaskStartTCB,                              (3)
                 (CPU_CHAR   *)"App Task Start",                              (4)
                 (OS_TASK_PTR ) AppTaskStart,                                 (5)
                 (void       *) 0,                                            (6)
                 (OS_PRIO     ) APP_OS_CFG_START_TASK_PRIO,                   (7)
                 (CPU_STK    *)&AppTaskStartStk[0],                           (8)
                 (CPU_STK_SIZE) APP_OS_CFG_START_TASK_STK_SIZE / 10u,         (9)
                 (CPU_STK_SIZE) APP_OS_CFG_START_TASK_STK_SIZE,              (10)
                 (OS_MSG_QTY  ) 0u,
                 (OS_TICK     ) 0u,
                 (void       *) 0,
                 (OS_OPT      ) (OS_OPT_TASK_STK_CHK | OS_OPT_TASK_STK_CLR), (11)
                 (OS_ERR     *)&err_os);                                      (12)
    APP_TEST_FAULT(err_os, OS_ERR_NONE);

    OSStart(&err_os);                                                         (13)
    APP_TEST_FAULT(err_os, OS_ERR_NONE);
}
```

Listing 4-1 **Code execution starts at main()**

L4-1(1) Start `main()` by calling a BSP function that disables all interrupts. On most processors, interrupts are disabled at startup until explicitly enabled by application code. However, it is safer to turn off all peripheral interrupts during startup.

L4-1(2) Call `OSInit()`, which is responsible for initializing µC/OS-III internal variables and data structures, and also creates two (2) to five (5) internal tasks. At minimum, µC/OS-III creates the idle task (`OS_IdleTask()`), which executes when no other task is ready to run. µC/OS-III also creates the tick task, responsible for keeping track of time.

Depending on the value of `#define` constants, µC/OS-III will create the statistic task (`OS_StatTask()`), the timer task (`OS_TmrTask()`), and interrupt handler queue management task (`OS_IntQTask()`).

Most µC/OS-III's functions return an error code via a pointer to an `OS_ERR` variable, err in this case. If `OSInit()` was successful, `err` will be set to `OS_ERR_NONE`. If `OSInit()` encounters a problem during initialization, it will return immediately upon detecting the problem and set err accordingly. If this occurs, look up the error code value in `os.h`. All error codes start with `OS_ERR_`.

Note that `OSInit()` must be called before any other µC/OS-III function.

L4-1(3) Create a task by calling `OSTaskCreate()`. `OSTaskCreate()` requires 13 arguments. The first argument is the address of the `OS_TCB` that is declared for this task.

L4-1(4) `OSTaskCreate()` allows a name to be assigned to each of the tasks. µC/OS-III stores a pointer to the task name inside the `OS_TCB` of the task. There is no limit on the number of ASCII characters used for the name.

L4-1(5) The third argument is the address of the task code. A typical µC/OS-III task is implemented as an infinite loop as shown:

```
void  MyTask (void *p_arg)
{
    /* Do something with 'p_arg'.
    while (1) {
        /* Task body */
    }
}
```

The task receives an argument when at inception. The task resembles any C function that can be called by code. However, the code *must not* call `MyTask()`.

L4-1(6) The fourth argument of `OSTaskCreate()` is the argument that the task receives when it first begins. In other words, the `p_arg` of `MyTask()`. In the example a NULL pointer is passed, and thus `p_arg` for `AppTaskStart()` will be a NULL pointer.

The argument passed to the task can actually be any pointer. For example, you may pass a pointer to a data structure containing parameters for the task.

L4-1(7) The next argument to `OSTaskCreate()` is the priority of the task. The priority establishes the relative importance of this task with respect to other tasks in the application. A low-priority number indicates a high priority (or more important task). Set the priority of the task to any value between 1 and `OS_CFG_PRIO_MAX-2`, inclusively. Avoid using priority #0, and priority `OS_CFG_PRIO_MAX-1`, because these are reserved for µC/OS-III. `OS_CFG_PRIO_MAX` is a compile time configuration constant, which is declared in `os_cfg.h`.

L4-1(8) The sixth argument to `OSTaskCreate()` is the base address of the stack assigned to this task. The base address is always the lowest memory location of the stack.

L4-1(9) The next argument specifies the location of a "watermark" in the task's stack that can be used to determine the allowable stack growth of the task. In the code above, the value represents the amount of stack space (in `CPU_STK` elements) before the stack is empty. In other words, in the example, the limit is reached when 10% of the stack is left.

L4-1(10) The eighth argument to `OSTaskCreate()` specifies the size of the task's stack in number of `CPU_STK` elements (not bytes). For example, if allocating 1 Kbytes of stack space for a task and the `CPU_STK` is a 32-bit word, pass 256.

L4-1(11) The next three arguments are skipped as they are not relevant to the current discussion. The next argument to `OSTaskCreate()` specifies options. In this example, it is specified that the stack will be checked at run time (assuming the statistic task was enabled in `os_cfg.h`), and that the contents of the stack will be cleared when the task is created.

L4-1(12) The last argument of `OSTaskCreate()` is a pointer to a variable that will receive an error code. If `OSTaskCreate()` is successful, the error code will be `OS_ERR_NONE` otherwise, the value of the error code can be looked up in `os.h` (see `OS_ERR_xxxx`) to determine the problem with the call.

L4-1(13) The final step in `main()` is to call `OSStart()`, which starts the multitasking process. Specifically, µC/OS-III will select the highest-priority task that was created before calling `OSStart()`. The highest-priority task is always `OS_IntQTask()` if that task is enabled in `os_cfg.h` (through the `OS_CFG_ISR_POST_DEFERRED_EN` constant). If this is the case, `OS_IntQTask()` will perform some initialization of its own and then µC/OS-III will switch to the next most important task that was created.

A few important points are worth noting. You can create as many tasks as you want before calling `OSStart()`. However, it is recommended to only create one task as shown in the example. Notice that interrupts are not enabled. µC/OS-III and µC/OS-II always start a task with interrupts enabled. As soon as the first task executes, the interrupts are enabled. The first task is `AppTaskStart()` and its contents is examined in can Listing 4-2.

```
static  void  AppTaskStart (void *p_arg)                        (1)
{
    CPU_INT32U  cpu_clk_freq;
    CPU_INT32U  cnts;
    OS_ERR      err_os;

    (void)&p_arg;

    BSP_Init();                                                 (2)
    CPU_Init();                                                 (3)
    cpu_clk_freq = BSP_CPU_ClkFreq();                           (4)
    cnts = cpu_clk_freq / (CPU_INT32U)OSCfg_TickRate_Hz;
    OS_CPU_SysTickInit(cnts);
```

```
    Mem_Init();                                                 (5)
    AppInit_TCPIP(&net_err);                                    (6)
                                                                (7)
    BSP_LED_Off(0u);                                            (8)
    while (1) {                                                 (9)
        BSP_LED_Toggle(0u);                                    (10)
        OSTimeDlyHMSM((CPU_INT16U) 0u,                         (11)
                      (CPU_INT16U) 0u,
                      (CPU_INT16U) 0u,
                      (CPU_INT16U) 100u,
                      (OS_OPT    ) OS_OPT_TIME_HMSM_STRICT,
                      (OS_ERR   *)&err_os);
    }
}
```

Listing 4-2 **AppTaskStart**

L4-2(1) As previously mentioned, a task looks like any other C function. The argument `p_arg` is passed to `AppTaskStart()` by `OSTaskCreate()`.

L4-2(2) `BSP_Init()` is a BSP function responsible for initializing the hardware on an evaluation or target board. The evaluation board might have General Purpose Input Output (GPIO) lines that need to be configured, relays, and sensors, etc. This function is found in a file called `bsp.c`.

L4-2(3) `Cuprite()` initializes µC/CPU services. µC/CPU provides services to measure interrupt latency, receive time stamps, and provide emulation of the count leading zeros instruction if the processor used does not have that instruction.

L4-2(4) `BSP_CPU_ClkFreq()` determines the system tick reference frequency of this board. The number of system ticks per OS tick is calculated using `OSCfg_TickRate_Hz`, which is defined in `os_cfg_app.h.` Finally, `OS_CPU_SysTickInit()` sets up the µC/OS-III tick interrupt. For this, the function needs to initialize one of the hardware timers to interrupt the CPU at the `OSCfg_TickRate_Hz` rate calculated previously.

L4-2(5) `Mem_Init()` initializes the memory management module. µC/TCP-IP object creation uses this module. This function is part of µC/LIB. The memory module *must* be initialized by calling `Mem_Init()` *prior* to calling `Net_Init()`. It is recommended to initialize the memory module before calling `OSStart()`, or

near the top of the startup task. The application developer must enable and configure the size of the µC/LIB memory heap available to the system. `LIB_MEM_CFG_HEAP_SIZE` should be defined from within `app_cfg.h` and set to match the application requirements.

L4-2(6) `AppInit_TCPIP()` initializes the TCP/IP stack and the initial parameters to configure it. See section F-1-6 "µC/TCP-IP Initialization" on page 788 for a description of `AppInit_TCPIP()`.

L4-2(7) If other IP applications are required this is where they are initialized

L4-2(8) `BSP_LED_Off()` is a function that will turn off all LEDs because the function is written so that a zero argument refers to all LEDs.

L4-2(9) Most µC/OS-III tasks will need to be written as an infinite loop.

L4-2(10) This BSP function toggles the state of the specified LED. Again, a zero indicates that all the LEDs should be toggled on the evaluation board. Simply change the zero to 1 causing LED #1 to toggle. Exactly which LED is LED #1? That depends on the BSP developer. Encapsulate access to LEDs through such functions as `BSP_LED_On()`, `BSP_LED_Off()` and `BSP_LED_Toggle()`. Also, LEDs are assigned logical values (1, 2, 3, etc.) instead of specifying a port and specific bit on each port.

L4-2(11) Finally, each task in the application must call one of the µC/OS-III functions that will cause the task to "wait for an event." The task can wait for time to expire (by calling `OSTimeDly()`, or `OSTimeDlyHMSM()`), or wait for a signal or a message from an ISR or another task.

`AppTaskStart()` calls the `AppInit_TCPIP()` to initialize and start the TCP/IP stack. This function is shown in:

```
static  void  AppInit_TCPIP (NET_ERR *perr)
{
    NET_IF_NBR   if_nbr;
    NET_IP_ADDR  ip;
    NET_IP_ADDR  msk;
    NET_IP_ADDR  gateway;
    NET_ERR      err_net;


    err_net = Net_Init();                                                (1)
    APP_TEST_FAULT(err_net, NET_ERR_NONE);

    if_nbr  = NetIF_Add((void    *)&NetIF_API_Ether,                     (2)
                        (void    *)&NetDev_API_<controller>,             (3)
                        (void    *)&NetDev_BSP_<controller>,             (4)
                        (void    *)&NetDev_Cfg_<controller>,             (5)
                        (void    *)&NetPhy_API_Generic,                  (6)
                        (void    *)&NetPhy_Cfg_<controller>,             (7)
                        (NET_ERR *)&err_net);                            (8)
    APP_TEST_FAULT(err_net, NET_ERR_NONE);

    NetIF_Start(if_nbr, perr);                                           (9)
    APP_TEST_FAULT(err_net, NET_IF_ERR_NONE);

    ip      = NetASCII_Str_to_IP((CPU_CHAR *)"10.10.1.65",              (10)
                                 (NET_ERR *)&err_net);
    msk     = NetASCII_Str_to_IP((CPU_CHAR *)"255.255.255.0",           (11)
                                 (NET_ERR *)&err_net);
    gateway = NetASCII_Str_to_IP((CPU_CHAR *)"10.10.1.1",               (12)
                                 (NET_ERR *)&err_net);

    NetIP_CfgAddrAdd(if_nbr, ip, msk, gateway, &err_net);                (13)
    APP_TEST_FAULT(err_net, NET_IP_ERR_NONE);

}
```

Listing 4-3 **AppInit_TCPIP()**

L4-3(1) `Net_Init()` is the Network Protocol stack initialization function.

L4-3(2) `NetIF_Add()` is a network interface function responsible for initializing a Network Device driver. The first parameter is the `address of` the Ethernet API function. `if_nbr` is the interface index number. The first interface is index number 1. If the loopback interface is configured it has interface index number 0.

L4-3(3) The second parameter is the address of the device API function.

L4-3(4) The third parameter is the address of the device BSP data structure.

L4-3(5) The third parameter is the address of the device configuration data structure.

L4-3(6) The fourth parameter is the address of the PHY API function

L4-3(7) The fifth and last parameter is the address of the PHY configuration data structure.

L4-3(8) The error code is used to validate the result of the function execution.

L4-3(9) `NetIF_Start()` makes the network interface ready to receive and transmit.

L4-3(10) Definition of the IP address to be used by the network interface. The `NetASCII_Str_to_IP()` converts the human readable address into a format required by the protocol stack. In this example the `10.10.1.65` address out of the 10.10.1.0 network with a subnet mask of `255.255.255.0` is used. To match different network, this address, the subnet mask and the default gateway IP address have to be customized.

L4-3(11) Definition of the subnet mask to be used by the network interface. The `NetASCII_Str_to_IP()` converts the human readable subnet mask into the format required by the protocol stack.

L4-3(12) Definition of the default gateway address to be used by the network interface. The `NetASCII_Str_to_IP()` converts the human readable default gateway address into the format required by the protocol stack.

L4-3(13) `NetIP_CfgAddrAdd()` configures the network parameters (IP address, subnet mask and default gateway IP address) required for the interface. More than one set of network parameters can be configured per interface. Lines from (10) to (13) can be repeated for as many network parameter sets as need to be configured for an interface.

Once the source code is built and loaded into the target, the target will respond to ICMP Echo (ping) requests.

Chapter

# 5

# Network Interface Configuration

This chapter describes how to configure a network interface for µC/TCP-IP.

## 5-1 BUFFER MANAGEMENT

This section describe how µC/TCP-IP uses buffers to receive and transmit application data and network protocol control information. You should understand how network buffers are used by µC/TCP-IP to correctly configure your interface(s).

### 5-1-1 NETWORK BUFFERS

µC/TCP-IP stores transmitted and received data in data structures known as Network Buffers. Each Network Buffer consists of two parts: the Network Buffer header and the Network Buffer Data Area pointer. Network Buffer headers contain information about the data pointed to via the data area pointer. Data to be received or transmitted is stored in the Network Buffer Data Area.

µC/TCP-IP is designed with the inherent constraints of an embedded system in mind, the most important being the restricted RAM space. µC/TCP-IP defines network buffers for the Maximum Transmission Unit (MTU) of the Data Link technology used, which is most of the time Ethernet. Default Ethernet's maximum transmit unit (MTU) size is 1500 bytes.

### 5-1-2 RECEIVE BUFFERS

Network Buffers used for reception for a Data Link technology are buffers that can hold one maximum frame size. Because it is impossible to predict how much data will be received, only large buffers can be configured. Even if the packet does not contain any payload, a large buffer must be used, as worst case must always be assumed.

## 5-1-3 TRANSMIT BUFFERS

On transmission, the number of bytes to transmit is always known, so it is possible to use a Network Buffer size smaller than the maximum frame size. µC/TCP-IP allows you to reduce the RAM usage of the system by defining small buffers. When the application does not require a full size frame to transmit, it is possible to use smaller Network Buffers. Depending on the configuration, up to eight pools of Network Buffer related objects may be created per network interface. Only four pools are shown below and the remaining pools are used for maintaining Network Buffer usage statistics for each of the pools shown.

In transmission, the situation is different. The TCP/IP stack knows how much data is being transmitted. In addition to RAM being limited in embedded systems, another feature is the small amount of data that needs to be transmitted. For example, in the case of sensor data to be transmitted periodically, a few hundred bytes every second can be transferred. In this case, a small buffer can be used and save RAM instead of waste a large transmit buffer. Another example is the transmission of TCP acknowledgment packets, especially when they are not carrying any data back to the transmitter. These packets are also small and do not require a large transmit buffer. RAM is also saved.

## 5-1-4 NETWORK BUFFER ARCHITECTURE

µC/TCP-IP uses both small and large network buffers:

- Network buffers
- Small transmit buffers
- Large transmit buffers
- Large receive buffers

A single network buffer is allocated for each small transmit, large transmit and large receive buffer. Network buffers contain the control information for the network packet data in the network buffer data area. Currently, network buffers consume approximately 200 bytes each. The network buffers' data areas are used to buffer the actual transmit and receive packet data. Each network buffer is connected to the data area via a pointer to the network

buffer data area, and both move through the network protocol stack layers as a single entity. When the data area is no longer required, both the network buffer and the data area are freed. Figure 5-1 depicts the network buffer and data area objects.

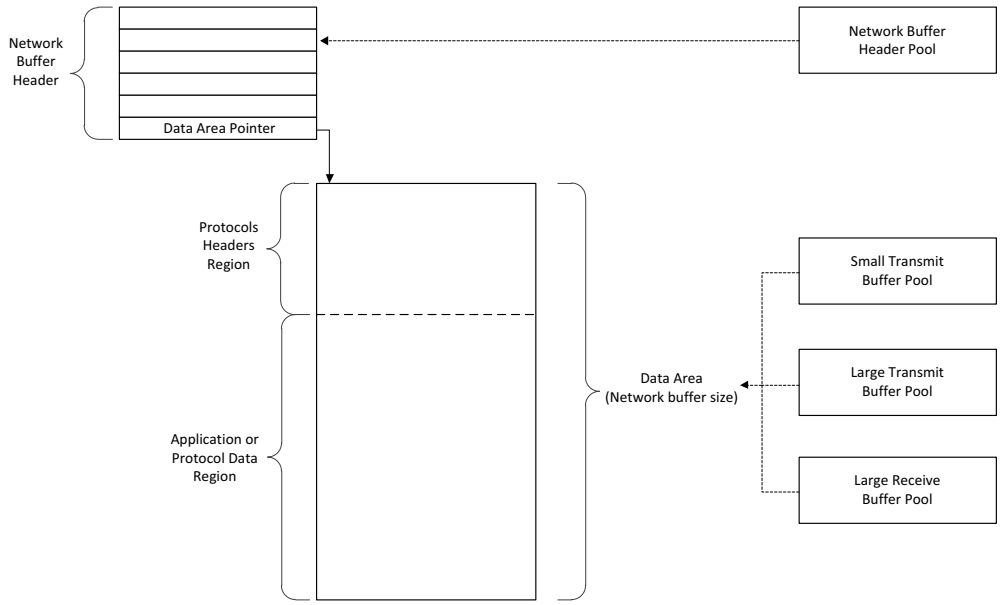



Figure 5-1 **Network Buffer Architecture**

All transmit data areas contain a small region of reserved space located at the top of the data area address space. The reserved space is used for network protocol header data and is currently fixed to 134 bytes in length. In general, not all of this space is required. However, the network protocol header region has been sized according to the maximum network protocol header usage for TCP/IP Ethernet packets.

First, µC/TCP-IP copies application-specified data from the application buffer into the application data region before writing network protocol header data to the protocol header region. After that, depending on the type of the packet being sent, each required layers will add its own protocol headers in the Protocols Headers Region of the Data Area. Starting from the highest layer to the lowest layer, all required headers are stacked on top of each other.

## 5-1-5 NETWORK BUFFER SIZES

µC/TCP-IP requires that network buffer sizes configured in `net_dev_cfg.c` satisfy the minimum and maximum packet frame sizes of network interfaces/devices.

Assuming an Ethernet interface (with non-jumbo or VLAN-tagged frames), the minimum frame packet size is 64 bytes (including its 4-byte CRC). If an Ethernet frame is created such that the frame length is less than 60 bytes (before its 4-byte CRC is appended), frame padding must be appended by the network driver or the Ethernet network interface layer to the application data area to meet Ethernet's minimum packet size. For example, the ARP protocol typically creates packets of 42 bytes and therefore 18 bytes of padding must be added. The additional padding must fit within the network buffer's data area.

Ethernet's maximum transmit unit (MTU) size is 1500 bytes. When TCP is used as the transport protocol, TCP and IP protocol header sizes are subtracted from Ethernet's 1500-byte MTU. A maximum of 1460 bytes of TCP application data may be sent in a full-sized Ethernet frame.

In addition, the variable size of network packet protocol headers must also be considered when configuring buffer sizes. The following computations demonstrate how to configure network buffer sizes to transmit and receive maximum sized network packets.

For transmit buffer size configuration, each layer's maximum header sizes must be assumed/included to achieve the maximum payload for each layer. The maximum header sizes for each layer are:

```
Max Ethernet header :  14 bytes  (this is a fixed size w/o CRC)
Max ARP header      :  28 bytes  (this is a fixed size for Ethernet/IPv4)
Max IP  header      :  60 bytes  (with maximum length IP  options)
Max TCP header      :  60 bytes  (with maximum length TCP options)
Max UDP header      :   8 bytes  (this is a fixed size)
```

Assuming both TCP and UDP are available as transport layer protocols, TCP's maximum header size is the value used as the maximum transport layer header size since it is greater than UDP's header size. Thus, the total maximum header size can then be computed as:

```
Max Hdr Size = Interface Max Header     (Ethernet hdr is 14 bytes)
             + Network   Max Header     (IP   max hdr is 60 bytes)
             + Transport Max Header     (TCP  max hdr is 60 bytes)
             = 14 + 60 + 60 = 134 bytes
```

µC/TCP-IP configures `NET_BUF_DATA_PROTOCOL_HDR_SIZE_MAX` with this value in `net_cfg_net.h` to use as the starting data area index for transmit buffers' application data.

The next step is to define transmit buffers' total data area size. The issue is that we used the maximum header size for the transport and network layers. However, most of the time, the network and transport layer headers typically do not have any options:

```
Typical IP  header :  20 bytes  (without IP  options)
Typical TCP header :  20 bytes  (without TCP options)
```

These header values are used to determine the maximum payload a Data Link frame can carry. Since a TCP header is larger than UDP headers, the following compares the TCP maximum payload, also known as TCP's Maximum Segment Size (MSS), over an Ethernet data link:

```
TCP payload (max) = Interface Max         (Ethernet 1514 bytes w/o CRC)
                  - Interface Header      (Ethernet   14 bytes w/o CRC)
                  - Min IP  Header        (IP  min hdr is 20 bytes)
                  - Min TCP Header        (TCP min hdr is 20 bytes)
                  = 1514 - 14 - 20 - 20 = 1460 bytes
```

When TCP is used in a system, it is recommended to configure the large buffer size to at least this size in order to transmit maximum size TCP MSS:

```
TCP Max Buf Size = Max TCP payload         (1460 bytes)
                 + Max Hdr sizes            (134 bytes)
                 = 1460 + 134 = 1594 bytes
```

If any IP or TCP options are used, it is possible that the payload must be reduced, but unfortunately, that cannot be known by the application when transmitting. It is possible that, when the packet is at the network layer and because the TCP or IP headers are larger than usual because an option is enabled, a packet is too large and needs to be fragmented

to be transmitted. However, µC/TCP-IP does not yet support fragmentation; but since options are seldom used and the standard header sizes for TCP and IP are the ones supported, this is generally not a problem.

For UDP, the UDP header has no options and the size does not change – it is always 8 bytes. Thus, UDP's maximum payload is calculated as follows:

```
UDP payload (max) = Interface Max        (Ethernet 1514 bytes w/o CRC)
                  - Interface Header     (Ethernet   14 bytes w/o CRC)
                  - Min IP  Header       (IP  min hdr is 20 bytes)
                  - Min UDP Header       (UDP     hdr is  8 bytes)
                  = 1514 - 14 - 20 - 8 = 1472 bytes
```

So to transmit maximum-sized UDP packets, configure large buffer sizes to at least:

```
Max UDP Buf Size = Max UDP payload         (1472 bytes)
                 + Max Hdr sizes            (134 bytes)
                 = 1472 + 134 = 1606 bytes
```

ICMP packets which are encapsulated within IP datagrams also have variable-length header sizes from 8 to 20 bytes. However, for certain design reasons, ICMP headers are included in an IP datagram's data area and are not included in the maximum header size calculation. (IGMP packets have a fixed header size of 8 bytes but are also included in an IP datagram's data area.) Thus, ICMP's maximum payload is calculated as follows:

```
ICMP payload (max) = Interface Max        (Ethernet 1514 bytes w/o CRC)
                   - Interface Header     (Ethernet   14 bytes w/o CRC)
                   - Min IP Header        (IP min hdr is 20 bytes)
                   = 1514 - 14 - 20 = 1480 bytes
```

And to transmit maximum-sized ICMP packets, configure large buffer sizes to at least:

```
Max ICMP Buf Size = Max ICMP payload        (1480 bytes)
                  + Max Hdr  sizes           (134 bytes)
                  = 1480 + 134 = 1614 bytes
```

Small transmit buffer sizes must also be appropriately configured to at least the minimum packet frame size for the network interface/device. This means configuring a buffer size that supports sending a minimum sized packet for each layer's minimum header sizes. The minimum header sizes for each layer are:

```
Min Ethernet header :  14 bytes  (this is a fixed size w/o CRC)
Min ARP header      :  28 bytes  (this is a fixed size for Ethernet/IPv4)
Min IP  header      :  20 bytes  (with minimum length IP  options)
Min TCP header      :  20 bytes  (with minimum length TCP options)
Min UDP header      :   8 bytes  (this is a fixed size)
```

For Ethernet frames, the following computation shows that both ARP packets and UDP/IP packets share the smallest minimum header sizes of 42 bytes:

```
ARP packet (min) = Interface Min Header     (Ethernet 14 bytes w/o CRC)
                 + ARP Min Header           (ARP  min hdr is 28 bytes)
                 = 14 + 28 = 42 bytes

UDP packet (min) = Interface Min Header     (Ethernet 14 bytes w/o CRC)
                 + IP  Min Header           (IP   min hdr is 20 bytes)
                 + UDP Min Header           (UDP  min hdr is  8 bytes)
                 = 14 + 20 + 8 = 42 bytes
```

And since Ethernet packets must be at least 60 bytes in length (not including 4-byte CRC), small transmit buffers must be minimally configured to at least 152 bytes to receive the smallest payload for each layer:

```
Min Tx Pkt Size = Interface Min Size        (Ethernet 60 bytes w/o CRC)
                + Max Hdr Sizes             (134 bytes)
                - Min Pkt Size               (42 bytes)
                = 60 + 134 - 42 = 152 bytes
```

Figure 5-2 shows transmit buffers with reserved space of 134 bytes/octets for the maximum protocol header sizes, application data sizes from 0 to 1472 bytes/octets, and the valid range of configured buffer data area sizes for Ethernet of 152 to 1614 bytes/octets.

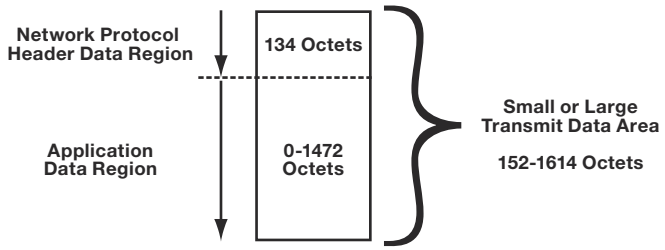



Figure 5-2 **Transmit Buffer Data Areas**

Note that the application data size range plus the maximum header sizes of 134 bytes do not exactly add up to the small or large transmit data area configuration total. This is due to certain protocols (e.g., ICMP) whose protocol headers are not included in the typical network protocol header region but start at index 134.

Also note that if no small transmit buffer data areas are available, a data area from the large transmit data area pool is allocated if both small and large transmit data areas are configured.

µC/TCP-IP does *not* require receive buffer data areas to reserve space for maximum header sizes but *does* require that each receive buffer data area be configured to the maximum expected packet frame size for the network interface/device. For Ethernet interfaces, receive buffers must be configured to at least 1514 bytes, assuming the interface's Ethernet device is configured to discard and not buffer the packet's 4-byte CRC, or 1518 bytes, if the device does buffer the CRC. Although network buffers may require additional bytes to properly align each buffer, µC/TCP-IP creates the buffers with the appropriate alignment specified in `net_dev_cfg.c` so no additional bytes need be added to the receive buffer size.

The following table shown how each network buffer should be configured to handle most of the worst cases.

| **Type of network buffer** | **Size** |
|---|---|
| Receive Large Buffer | 1518 + Alignment |
| Transmit Large Buffer | 1618 + Alignment |
| Transmit Small Buffer | 156 + Alignment |

## 5-2 µC/TCP-IP NETWORK INTERFACE CONFIGURATION

All µC/TCP-IP device drivers require a configuration structure for each device that must be compiled into your driver. You must place all device configuration structures and declarations within a pair of files named `net_dev_cfg.c` and `net_dev_cfg.h`.

Micrium provides sample configuration code free of charge; however, most sample code will likely require modification depending on the combination of compiler, processor, evaluation board, and device hardware used.

### 5-2-1 MEMORY CONFIGURATION

The first step in creating a device driver configuration for µC/TCP-IP begins with the memory configuration structure. This section describes the memory configuration settings for most device drivers, and should provide you an in-depth understanding of memory configuration. You will also discover which settings to modify in order to enhance the performances of the driver.

Listing 5-1 shows a sample memory configuration structure.

```
const  NET_DEV_CFG  NetDev_Cfg_Dev1 = {
                            /* Structure member:                                    */
    NET_IF_MEM_TYPE_MAIN,   /*     .RxBufPoolType                                   */ (1)
    1518u,                  /*     .RxBufLargeSize                                  */ (2)
       9u,                  /*     .RxBufLargeNbr                                   */ (3)
      16u,                  /*     .RxBufAlignOctets                                */ (4)
       0u,                  /*     .RxBufIxOffset                                   */ (5)

    NET_IF_MEM_TYPE_MAIN,   /*     .TxBufPoolType                                   */ (6)
    1606u,                  /*     .TxBufLargeSize                                  */ (7)
       4u,                  /*     .TxBufLargeNbr                                   */ (8)
     256u,                  /*     .TxBufSmallSize                                  */ (9)
       2u,                  /*     .TxBufSmallNbr                                  */ (10)
      16u,                  /*     .TxBufAlignOctets                               */ (11)
       0u,                  /*     .TxBufIxOffset                                  */ (12)

    0x00000000u,            /*     .MemAddr                                        */ (13)
            0u,             /*     .MemSize                                        */ (14)

    NET_DEV_CFG_FLAG_NONE, /*     .Flag                                            */ (15)
};
```

Listing 5-1 **Sample memory configuration**

L5-1(1) `.RxBufPoolType` specifies the memory location for the receive data buffers. Buffers may located either in main memory or in a dedicated memory region. This setting is used by the IF layer to initialize the Rx memory pool. This field must be set to one of two macros: `NET_IF_MEM_TYPE_MAIN` or `NET_IF_MEM_TYPE_DEDICATED`. You may want to set this field when DMA with dedicated memory is used. It is possible that you might have to store descriptors within the dedicated memory if your device requires it.

L5-1(2) `.RxBufLargeSize` specifies the size of all receive buffers. Specifying a value is required. The buffer length is set to 1518 bytes which corresponds to the Maximum Transmission Unit (MTU) of an Ethernet network. For DMA-based Ethernet controllers, you must set the receive data buffer size to be greater or equal to the size of the largest receivable frame. If the size of the total buffer allocation is greater than the amount of available memory in the chosen memory region, a run-time error will be generated when the device is initialized.

L5-1(3) `.RxBufLargeNbr` specifies the number of receive buffers that will be allocated to the device. There should be at least one receive buffer allocated, and it is recommended to have at least ten receive buffers. The optimal number of receive buffers depends on your application.

L5-1(4) `.RxBufAlignOctets` specifies the required alignment of the receive buffers, in bytes. Some devices require that the receive buffers be aligned to a specific byte boundary. Additionally, some processor architectures do not allow multi-byte reads and writes across word boundaries and therefore may require buffer alignment. In general, it is probably a best practice to align buffers to the data bus width of the processor, which may improve performance. For example, a 32-bit processor may benefit from having buffers aligned on a four-byte boundary.

L5-1(5) `.RxBufIxOffset` specifies the receive buffer offset in bytes. Most devices receive packets starting at base index zero in the network buffer data areas. However, some devices may buffer additional bytes prior to the actual received Ethernet packet. This setting configures an offset to ignore these additional bytes. If a device does not buffer any additional bytes ahead of the received Ethernet packet, then an offset of 0 must be specified. However, if a device

does buffer additional bytes ahead of the received Ethernet packet, then you should configure this offset with the number of additional bytes. Also, the receive buffer size must also be adjusted by the number of additional bytes.

L5-1(6) `.TxBufPoolType` specifies the memory placement of the transmit data buffers. Buffers may be placed either in main memory or in a dedicated memory region. This field is used by the IF layer, and it should be set to one of two macros: `NET_IF_MEM_TYPE_MAIN` or `NET_IF_MEM_TYPE_DEDICATED`. When DMA descriptors are used, they may be stored into the dedicated memory.

L5-1(7) `.TxBufLargeSize` specifies the size of the large transmit buffers in bytes. This field has no effect if the number of large transmit buffers is configured to zero. Setting the size of the large transmit buffers below 1594 bytes may hinder the µC/TCP-IP module's ability to transmit full sized IP datagrams since IP transmit fragmentation is not yet supported. We recommend setting this field between 1594 and 1614 bytes in order to accommodate the maximum transmit packet sizes all µC/TCP-IP's protocols.

You can optimize the transmit buffer if you know in advance what will be the maximum size of the packets the user will want to transmit through the device.

L5-1(8) `.TxBufLargeNbr` specifies the number of large transmit buffers allocated to the device. You may set this field to zero to make room for additional small transmit buffers, however, the size of the maximum transmittable packet will then depend on the size of the small transmit buffers.

L5-1(9) `.TxBufSmallSize` specifies the small transmit buffer size. For devices with a minimal amount of RAM, it is possible to allocate small transmit buffers as well as large transmit buffers. In general, we recommend a 152 byte small transmit buffer size, however, you may adjust this value according to the application requirements. This field has no effect if the number of small transmit buffers is configured to zero.

L5-1(10) `.TxBufSmallNbr` specifies the numbers of small transmit buffers. This field controls the number of small transmit buffers allocated to the device. You may set this field to zero to make room for additional large transmit buffers if required.

L5-1(11) `.TxBufAlignOctets` specifies the transmit buffer alignment in bytes. Some devices require that the transmit buffers be aligned to a specific byte boundary. Additionally, some processor architectures do not allow multi-byte reads and writes across word boundaries and therefore may require buffer alignment. In general, it probably a best practice to align buffers to the data bus width of the processor which may improve performance. For example, a 32-bit processor may benefit from having buffers aligned on a four-byte boundary.

L5-1(12) `.TxBufIxOffset` specifies the transmit buffer offset in bytes. Most devices only need to transmit the actual Ethernet packets as prepared by the higher network layers. However, some devices may need to transmit additional bytes prior to the actual Ethernet packet. This setting configures an offset to prepare space for these additional bytes. If a device does not transmit any additional bytes ahead of the Ethernet packet, the default offset of zero should be configured. However, if a device does transmit additional bytes ahead of the Ethernet packet then configure this offset with the number of additional bytes. Also, the transmit buffer size must be adjusted by the number of additional bytes.

L5-1(13) `.MemAddr` specifies the starting address of the dedicated memory region for devices with such memory. For devices with non-dedicated memory, you can initialize this field to zero. You may use this setting to put DMA descriptors into the dedicated memory.

L5-1(14) `.MemSize` specifies the size of the dedicated memory region in bytes for devices with such memory. For devices with non-dedicated memory, you can initialize this field to zero. You may use this setting to put DMA descriptors into the dedicated memory.

L5-1(15) `.Flags` specify the optional configuration flags. Configure (optional) device features by logically OR'ing bit-field flags:

| | |
|---|---|
| `NET_DEV_CFG_FLAG_NONE` | No device configuration flags selected. |
| `NET_DEV_CFG_FLAG_SWAP_OCTETS` | Swap data bytes (i.e., swap data words' high-order bytes with data words' low-order bytes, and vice-versa) if required by device-to-CPU data bus wiring and/or CPU endian word order. |

## 5-2-2 µC/TCP-IP MEMORY MANAGEMENT

Memory is allocated to µC/TCP-IP device drivers through the µC/LIB memory module. You must enable and configure the size of the µC/LIB memory heap available to the system. The following configuration constants should be defined from within app_cfg.h and set to match the application requirements.

```
#define LIB_MEM_CFG_ALLOC_EN      DEF_ENABLED
#define LIB_MEM_CFG_HEAP_SIZE           58000
```

The heap size is specified in bytes. If the heap size is not configured large enough, an error will be returned during the Network Protocol Stack initialization, or during interface addition.

Since the needed heap size is related to the stack configuration (net_cfg.h) and is specific to each device driver, it's not possible to provide an exact formula to calculate it. Thus to optimize the heap size, you should try different heap size until no error is returned for all interfaces added.

Note: The memory module *must* be initialized by the application by calling Mem_Init() *prior* to calling Net_Init(). We recommend initializing the memory module before calling OSStart(), or near the top of the startup task.

# 5-3 ETHERNET INTERFACE CONFIGURATION

## 5-3-1 ETHERNET DEVICE CONFIGURATION

Listing 5-2 shows a sample Ethernet configuration structure for Ethernet devices.

```
const  NET_DEV_CFG_ETHER  NetDev_Cfg_Dev1_0 = {
                           /* Structure member:                                    */
    NET_IF_MEM_TYPE_MAIN,  /*     .RxBufPoolType                                   */ (1)
    1518u,                 /*     .RxBufLargeSize                                  */
       9u,                 /*     .RxBufLargeNbr                                   */
      16u,                 /*     .RxBufAlignOctets                                */
       0u,                 /*     .RxBufIxOffset                                   */

    NET_IF_MEM_TYPE_MAIN,  /*     .TxBufPoolType                                   */
    1606u,                 /*     .TxBufLargeSize                                  */
       4u,                 /*     .TxBufLargeNbr                                   */
     256u,                 /*     .TxBufSmallSize                                  */
       2u,                 /*     .TxBufSmallNbr                                   */
      16u,                 /*     .TxBufAlignOctets                                */
       0u,                 /*     .TxBufIxOffset                                   */

    0x00000000u,           /*     .MemAddr                                         */
            0u,            /*     .MemSize                                         */

    NET_DEV_CFG_FLAG_NONE, /*     .Flag                                            */

            4u,           /*     .RxDescNbr                                       */ (2)
            4u,           /*     .TxDescNbr                                       */ (3)
    0x40028000u,          /*     .BaseAddr                                        */ (4)
            0u,           /*     .DataBusSizeNbrBits                              */ (5)
   "00:50:C2:25:61:00",    /*     .HW_AddrStr                                      */ (6)
};
```

Listing 5-2 **Memory configuration for Ethernet device**

L5-2(1) Memory configuration of the Ethernet Device. See “Memory Configuration” on page 85. for further information about how to configure the memory of your Ethernet interface.

L5-2(2) `.RxDescNbr` specifies the number of receive descriptors. For DMA-based devices, this value is used by the device driver during initialization in order to allocate a fixed-size pool of receive descriptors to be used by the device. The number of descriptors must be less than the number of configured receive

buffers. We recommend setting this value to something within 40% and 70% of the number of receive buffers. Non-DMA based devices may configure this value to zero. You must use this setting with DMA based devices and he must set at least two descriptors. The Device driver could

L5-2(3) `.TxDescNbr` specifies the number of transmit descriptors. For DMA based devices, this value is used by the device driver during initialization to allocate a fixed size pool of transmit descriptors to be used by the device. For best performance, the number of transmit descriptors it's recommended to set equal to the number of small, plus the number of large transmit buffers configured for the device. Non-DMA based devices may configure this value to zero. You must use this setting with DAM based devices and must set at least two descriptors.

L5-2(4) `.BaseAddr` specifies the base address of device's hard ware/registers.

L5-2(5) `.DataBusSizeNbrBits` specifies the size of device's data bus (in bits), if available.

L5-2(6) `.HW_AddrStr` specifies the desired device hardware address; may be NULL address or string if the device hardware address is configured or set at run-time.Depending of the driver, if this value is kept NULL or invalid, most of device driver will automatically try to load and use the hardware address located in the memory of the device.

## 5-3-2 ETHERNET PHY CONFIGURATION

Listing 5-3 shows a typical Ethernet PHY configuration structure.

```
NET_PHY_CFG_ETHER NetPhy_Cfg_FEC_0= {
  NET_PHY_ADDR_AUTO,                    (1)
  NET_PHY_BUS_MODE_MII,                 (2)
  NET_PHY_TYPE_EXT                      (3)
  NET_PHY_SPD_AUTO,                     (4)
  NET_PHY_DUPLEX_AUTO,                  (5)
};
```

Listing 5-3 **Sample Ethernet PHY Configuration**

L5-3(1) PHY Address. This field represents the address of the PHY on the (R)MII bus. The value configured depends on the PHY and the state of the PHY pins during power-up. Developers may need to consult the schematics for their board to determine the configured PHY address. Alternatively, the PHY address may be detected automatically by specifying `NET_PHY_ADDR_AUTO`; however, this will increase the initialization latency of µC/TCP-IP and possibly the rest of the application depending on where the application places the call to `NetIF_Start()`.

L5-3(2) PHY bus mode. This value should be set to one of the following values depending on the hardware capabilities and schematics of the development board. The network device BSP should configure the Phy-level hardware based on this configuration value.

`NET_PHY_BUS_MODE_MII`
`NET_PHY_BUS_MODE_RMII`
`NET_PHY_BUS_MODE_SMII`

L5-3(3) PHY bus type. This field represents the type of electrical attachment of the PHY to the Ethernet controller. In some cases, the PHY may be internal to the network controller, while in other cases, it may be attached via an external MII or RMII bus. It is desirable to specify which attachment method is in use so that

a device driver can initialize additional hardware resources if an external PHY is attached to a device that also has an internal PHY. Available settings for this field are:

```
NET_PHY_TYPE_INT
NET_PHY_TYPE_EXT
```

L5-3(4) Initial PHY link speed. This configuration setting will force the PHY to link to the specified link speed. Optionally, auto-negotiation may be enabled. This field must be set to one of the following values:

```
NET_PHY_SPD_AUTO
NET_PHY_SPD_10
NET_PHY_SPD_100
NET_PHY_SPD_1000
```

L5-3(5) Initial PHY link duplex. This configuration setting will force the PHY to link using the specified duplex. This setting must be set to one of the following values:

```
NET_PHY_DUPLEX_AUTO
NET_PHY_DUPLEX_HALF
NET_PHY_DUPLEX_FULL
```

## 5-3-3 ADDING AN ETHERNET INTERFACE

Once µC/TCP-IP is initialized, each network interface must be added to the stack via `NetIF_Add()` function. `NetIF_Add()` validates the network interface arguments, initializes the interface, and adds it to the interface list of the TCP/IP stack. µC/TCP-IP uses a structure that contains pointers to API functions which are used to access the interface layer, and configuration structures are used to initialize resources needed by the network interface. You must pass the following arguments to the `NetIF_Add()` function:

```
NET_IF_NBR  NetIF_Add (void     *if_api,                            (1)
                       void     *dev_api,                           (2)
                       void     *dev_bsp,                           (3)
                       void     *dev_cfg,                           (4)
                       void     *ext_api,                           (5)
                       void     *ext_cfg,                           (6)
                       NET_ERR  *perr)                              (7)
```

Listing 5-4 **NetIF_Add() arguments**

L5-4(1) The first argument specifies the link layer API pointers structure that will receive data from the hardware device. For an Ethernet interface, this value will always be defined as `NetIF_API_Ether`. This symbol is defined by µC/TCP-IP and it can be used to add as many Ethernet network interface's as necessary. This API should always be provided with the TCP-IP stack which can be find under the interface folder (`/IF/net_if_ether.*`).

L5-4(2) The second argument represents the hardware device driver API pointers structure which is defined as a fixed structure of function pointers of the type specified by Micrium for use with µC/TCP-IP. If Micrium supplies the device driver, the symbol name of the device API will be defined within the device driver at the top of the device driver source code file. You can find the device driver under the device folder (`/Dev/Ether/<controller>`). Otherwise, the driver developer is responsible for creating the device driver and the API structure should start from the device driver template which can be find under the device folder (`/Dev/Ether/Template`).

L5-4(3) The third argument specifies the specific device's board-specific (BSP) interface functions which is defined as a fixed structure of function pointers. The application developer must define both the BSP interface structure of

function pointers and the actual BSP functions referenced by the BSP interface structure and should start from the BSP template provided with the stack which you can find under the BSP folder (`/BSP/Template`). Micrium may be able to supply example BSP interface structures and functions for certain evaluation boards. For more information about declaring BSP interface structures and BSP functions device, see Chapter 6, "Network Board Support Package" on page 121 for further information about the BSP API.

L5-4(4) The fourth argument specifies the device driver configuration structure that will be used to configure the device hardware for the interface being added. The device configuration structure format has been specified by Micrium and must be provided by the application developer since it is specific to the selection of device hardware and design of the evaluation board. Micrium may be able to supply example device configuration structures for certain evaluation boards. For more information about declaring a device configuration structure, See "Ethernet Device Configuration" on page 90..

L5-4(5) The fifth argument represents the physical layer hardware device API. In most cases, when Ethernet is the link layer API specified in the first argument, the physical layer API may be defined as `NetPHY_API_Generic`. This symbol has been defined by the generic Ethernet physical layer device driver which can be supplied by Micrium. If a custom physical layer device driver is required, then the developer would be responsible for creating the API structure. Often Ethernet devices have built-in physical layer devices which are *not* (R)MII compliant. In this circumstance, the physical layer device driver API field may be left NULL and the Ethernet device driver may implement routines for the built-in PHY.

L5-4(6) The sixth argument represents the physical layer hardware device configuration structure. This structure is specified by the application developer and contains such information as the physical device connection type, address, and desired link state upon initialization. For devices with built in non (R)MII compliant physical layer devices, this field may be left `NULL`. However, it may be convenient to declare a physical layer device configuration structure and use some of the members for physical layer device initialization from within the Ethernet device driver. For more information about declaring a physical layer hardware configuration structure, see Chapter 5, "Ethernet PHY Configuration" on page 92.

L5-4(7) The last argument is a pointer to a `NET_ERR` variable that contains the return error code for `NetIF_Add()`. This variable should be checked by the application to ensure that no errors have occurred during network interface addition. Upon success, the return error code will be `NET_IF_ERR_NONE`.

Note: If an error occurs during the call to `NetIF_Add()`, the application *may* attempt to call `NetIF_Add()` a second time for the same interface but unless a temporary hardware fault occured, the application developer should observe the error code, determine and resolve the cause of the error, rebuild the application and try again. If a hardware failure occurred, the application may attempt to add an interface as many times as necessary, but a common problem to watch for is a µC/LIB Memory Manager heap out-of-memory condition. This may occur when adding network interfaces if there is insufficient memory to complete the operation. If this error occurs, the configured size of the µC/LIB heap within `app_cfg.h` must be increased.

Once an interface is added successfully, the next step is to configure the interface with one or more network layer protocol addresses.

For a thorough description of the µC/TCP-IP files and directory structure, see Chapter 3, "Directories and Files" on page 41.

When the network interface is added without error, it must be started via `NetIF_Start()` function to be available and be used by the µC/TCP-IP. The following code example shows how to initialize µC/TCP-IP, add an interface, configure the IP address and start it:

```
#include  <net.h>
#include  <net_dev_dev1.h>
#include  <net_bsp.h>
#include  <net_phy.h>

void  App_InitTCPIP (void)
{
    NET_IF_NBR   if_nbr;
    NET_IP_ADDR  ip;
    NET_IP_ADDR  msk;
    NET_IP_ADDR  gateway;
    CPU_BOOLEAN  cfg_success;
    NET_ERR      err;

    err = Net_Init();
    if (err != NET_ERR_NONE) {
        return;
    }

    if_nbr  = NetIF_Add((void    *)&NetIF_API_Ether
                        (void    *)&NetDev_API_Etherxxx,
                        (void    *)&NetDev_BSP_API,
                        (void    *)&NetDev_Cfg_Ether_0,
                        (void    *)&NetPhy_API_Generic,
                        (void    *)&NetPhy_Cfg_0,
                        (NET_ERR *)&err);
    if (err != NET_IF_ERR_NONE) {
        return;
    }

    ip      = NetASCII_Str_to_IP((CPU_CHAR *)"192.168.1.65",  perr);
    msk     = NetASCII_Str_to_IP((CPU_CHAR *)"255.255.255.0", perr);
    gateway = NetASCII_Str_to_IP((CPU_CHAR *)"192.168.1.1",   perr);

    cfg_success = NetIP_CfgAddrAdd(if_nbr, ip, msk, gateway,  perr);
   (void)&cfg_success;

    NetIF_Start(if_nbr, &err);
    if (err != NET_IF_ERR_NONE) {
        return;
    }
}
```

Listing 5-5 **Ethernet interface initialization example**

## 5-4 WIRELESS INTERFACE CONFIGURATION

### 5-4-1 WIRELESS DEVICE CONFIGURATION

Listing 5-6 shows a sample wireless configuration structure for wireless devices.

```
const  NET_DEV_CFG_WIFI  NetDev_Cfg_WiFi_0 = {
                                        /* Structure member:                          */
    NET_IF_MEM_TYPE_MAIN,               /*     .RxBufPoolType                         */ (1)
    1518u,                              /*     .RxBufLargeSize                        */
       9u,                              /*     .RxBufLargeNbr                         */
      16u,                              /*     .RxBufAlignOctets                      */
       0u,                              /*     .RxBufIxOffset                         */

    NET_IF_MEM_TYPE_MAIN,               /*     .TxBufPoolType                         */
    1606u,                              /*     .TxBufLargeSize                        */
       4u,                              /*     .TxBufLargeNbr                         */
     256u,                              /*     .TxBufSmallSize                        */
       2u,                              /*     .TxBufSmallNbr                         */
      16u,                              /*     .TxBufAlignOctets                      */
       0u,                              /*     .TxBufIxOffset                         */

    0x00000000u,                        /*     .MemAddr                               */
             0u,                        /*     .MemSize                               */

    NET_DEV_CFG_FLAG_NONE,              /*     .Flag                                  */

    NET_DEV_BAND_DUAL,                 /*     .Band                                  */ (2)

      25000000L,                       /*     .SPI_ClkFreq                           */ (3)
    NET_DEV_SPI_CLK_POL_INACTIVE_HIGH,  /*     .SPI_ClkPol                            */ (4)
    NET_DEV_SPI_CLK_PHASE_FALLING_EDGE, /*     .SPI_ClkPhase                          */ (5)
    NET_DEV_SPI_XFER_UNIT_LEN_8_BITS,   /*     .SPI_XferUnitLen                       */ (6)
    NET_DEV_SPI_XFER_SHIFT_DIR_FIRST_MSB, /*   .SPI_XferShiftDir                      */ (7)

   "00:50:C2:25:60:02",                 /*     .HW_AddrStr                            */ (8)
};
```

Listing 5-6 **Wireless device memory configuration**

L5-6(1) Memory configuration of the wireless device. See “Memory Configuration” on page 85. for further information about how to configure the memory of your wireless interface.

L5-6(2) `.Band` specifies the desired wireless band enabled and used by the wireless device. This value should be set to one of the following values depending on the hardware capabilities and the application requirements.

`NET_DEV_BAND_2_4_GHZ`

`NET_DEV_BAND_5_0_GHZ`

`NET_DEV_BAND_DUAL`

L5-6(3) `.SPI_ClkFreq` specifies the SPI controller's clock frequency (in Hertz) configuration for writing and reading on the wireless device.

L5-6(4) `.SPI_ClkPol` specifies the SPI controller's clock polarity configuration for writing and reading on the wireless device. The network device BSP should configure the SPI controller's clock polarity based on this configuration value.

`NET_DEV_SPI_CLK_POL_INACTIVE_LOW`

`NET_DEV_SPI_CLK_POL_INACTIVE_HIGH`

L5-6(5) `.SPI_ClkPhase` specifies the SPI controller's clock phase configuration for writing and reading on the wireless device. The network device BSP should configure the SPI controller's clock phase based on this configuration value.

`NET_DEV_SPI_CLK_PHASE_FALLING_EDGE`

`NET_DEV_SPI_CLK_PHASE_RAISING_EDGE`

L5-6(6) `.SPI_XferUnitLen` specifies the SPI controller's transfer unit length configuration for writing and reading on the wireless device. The network device BSP should configure the SPI controller's transfer unit length based on this configuration value.

`NET_DEV_SPI_XFER_UNIT_LEN_8_BITS`

`NET_DEV_SPI_XFER_UNIT_LEN_16_BITS`

NET_DEV_SPI_XFER_UNIT_LEN_32_BITS

NET_DEV_SPI_XFER_UNIT_LEN_64_BITS

L5-6(7) `.SPI_XferShiftDir` specifies the SPI controller's shift direction configuration for writing and reading on the wireless device. The network device BSP should configure the SPI controller's transfer unit length based on this configuration value.

NET_DEV_SPI_XFER_SHIFT_DIR_FIRST_MSB

NET_DEV_SPI_XFER_SHIFT_DIR_FIRST_LSB

L5-6(8) `.HW_AddrStr` specifies the desired device hardware address; may be NULL address or string if the device hardware address is configured or set at run-time. Depending of the driver, if this value is kept NULL or invalid, most of device driver will automatically try to load and use the hardware address located in the memory of the device.

## 5-4-2 ADDING A WIRELESS INTERFACE

Once µC/TCP-IP is initialized each network interface must be added to the stack via `NetIF_Add()` function which validates the network interface arguments, initializes the interface and adds it to the interface list. µC/TCP-IP uses a structure that contains pointers to API functions which are used to access the interface layer and configuration structures are used to initialize resources needed by the network interface. You must pass the following arguments to the `NetIF_Add()` function:

```
NET_IF_NBR  NetIF_Add (void     *if_api,                        (1)
                       void     *dev_api,                       (2)
                       void     *dev_bsp,                       (3)
                       void     *dev_cfg,                       (4)
                       void     *ext_api,                       (5)
                       void     *ext_cfg,                       (6)
                       NET_ERR  *perr)                          (7)
```

Listing 5-7 **NetIF_Add() arguments**

L5-7(1) The first argument specifies the link layer API pointers structure that will receive data from the hardware device. For an wireless interface, this value will always be defined as `NetIF_API_WiFi`. This symbol is defined by µC/TCP-IP and it can be used to add as many wireless network interfaces as necessary. This API should always be provided with the TCP-IP stack which can be find under the interface folder (`/IF/net_if_wifi.*`).

L5-7(2) The second argument represents the hardware device driver API which is defined as a fixed structure of function pointers of the type specified by Micrium for use with µC/TCP-IP. If Micrium supplies the device driver, the symbol name of the device API will be defined within the device driver at the top of the device driver source code file. You can find the device driver under the device folder (`/Dev/WiFi/<device>`). Otherwise, the driver developer is responsible for creating the device driver and the API structure should start from the device driver template which can be find under the device folder (`/Dev/WiFi/Template`).

L5-7(3) The third argument specifies the specific device's board-specific (BSP) interface functions which is defined as a fixed structure of function pointers. The application developer must define both the BSP interface structure of function pointers and the actual BSP functions referenced by the BSP interface structure and should start from the BSP template provided with the stack which you can find under the BSP folder (`/BSP/Template`). Micrium may be able to supply example BSP interface structures and functions for certain evaluation boards. For more information about declaring BSP interface structures and BSP functions device, see Chapter 6, "Network Board Support Package" on page 121 for further information about the BSP API.

L5-7(4) The fourth argument specifies the device driver configuration structure that will be used to configure the device hardware for the interface being added. The device configuration structure format has been specified by Micrium and must be provided by the application developer since it is specific to the selection of device hardware and design of the evaluation board. Micrium may be able to supply example device configuration structures for certain evaluation boards. For more information about declaring a device configuration structure, See "Wireless Device Configuration" on page 98.

L5-7(5) The fifth argument represents the extension layer device API. In most cases, when wireless is the Wireless Manager layer API specified in the first argument, the Wireless Manager layer API may be defined as `NetWiFiMgr_API_Generic`. This symbol has been defined by the generic Wireless Manager layer which can be supplied by Micrium. If a custom Wireless Manager layer is required, then the developer would be responsible for creating the API structure.

L5-7(6) The sixth argument represents the extension layer configuration structure. This structure is specified by the application developer. For devices which uses the generic Wireless Manager this field should be left `NULL`. However, it may be convenient to declare a Wireless Manager layer device configuration structure and use some of the members for Wireless Manager layer initialization from within the wireless device driver or a custom Wireless Manager.

L5-7(7) The last argument is a pointer to a `NET_ERR` variable that contains the return error code for `NetIF_Add()`. This variable *should* be checked by the application to ensure that no errors have occurred during network interface addition. Upon success, the return error code will be `NET_IF_ERR_NONE`.

Note: If an error occurs during the call to `NetIF_Add()`, the application *may* attempt to call `NetIF_Add()` a second time for the same interface but unless a temporary hardware fault occured, the application developer should observe the error code, determine and resolve the cause of the error, rebuild the application and try again. If a hardware failure occurred, the application may attempt to add an interface as many times as necessary, but a common problem to watch for is a µC/LIB Memory Manager heap out-of-memory condition. This may occur when adding network interfaces if there is insufficient memory to complete the operation. If this error occurs, the configured size of the µC/LIB heap within `app_cfg.h` must be increased.

Once an interface is added successfully, the next step is to configure the interface with one or more network layer protocol addresses.

For a thorough description of the µC/TCP-IP files and directory structure, see Chapter 3, “Directories and Files” on page 41.

Once a network interface is added without error, it must be started via `NetIF_Start()` function to be see as available and to be use by the µC/TCP-IP. The following code example shows how to initialize µC/TCP-IP, add an interface, add an IP address and start the interface:

```
#include  <net.h>
#include  <net_dev_rs9110n2x.h>
#include  <net_bsp.h>
#include  <net_phy.h>

void  App_InitTCPIP (void)
{
    NET_IF_NBR   if_nbr;
    NET_IP_ADDR  ip;
    NET_IP_ADDR  msk;
    NET_IP_ADDR  gateway;
    CPU_BOOLEAN  cfg_success;
    NET_ERR      err;

    err = Net_Init();
    if (err != NET_ERR_NONE) {
        return;
    }

    if_nbr  = NetIF_Add((void    *)&NetIF_API_WiFi
                        (void    *)&NetDev_API_RS9110N2x,
                        (void    *)&NetDev_BSP_SPI_API,
                        (void    *)&NetDev_Cfg_WiFi_0,
                        (void    *)&NetWiFiMgr_API_Generic,
                        (void    *) 0,
                        (NET_ERR *)&err);
    if (err != NET_IF_ERR_NONE) {
        return;
    }

    ip      = NetASCII_Str_to_IP((CPU_CHAR *)"192.168.1.65",  perr);
    msk     = NetASCII_Str_to_IP((CPU_CHAR *)"255.255.255.0", perr);
    gateway = NetASCII_Str_to_IP((CPU_CHAR *)"192.168.1.1",   perr);

    cfg_success = NetIP_CfgAddrAdd(if_nbr, ip, msk, gateway,  perr);
   (void)&cfg_success;

    NetIF_Start(if_nbr, &err);
    if (err != NET_IF_ERR_NONE) {
        return;
    }
}
```

Listing 5-8 **Wireless interface initialization example**

# 5-5 LOOPBACK INTERFACE CONFIGURATION

## 5-5-1 LOOPBACK CONFIGURATION

Configuring the loopback interface requires only a memory configuration, as described in section 5-2-1 on page 85.

Listing 5-9 shows a sample configuration structure for the loopback interface.

```
const  NET_IF_CFG_LOOPBACK  NetIF_Cfg_Loopback = {

    NET_IF_MEM_TYPE_MAIN,                          (1)
    1518,                                          (2)
      10,                                          (3)
       4,                                          (4)
       0,                                          (5)

    NET_IF_MEM_TYPE_MAIN,                          (6)
    1594,                                          (7)
       5,                                          (8)
     134,                                          (9)
       5,                                         (10)
       4,                                         (11)
       0,                                         (12)

    0x00000000,                                    (13)
             0,                                    (14)

    NET_DEV_CFG_FLAG_NONE                          (15)
};
```

Listing 5-9 **Sample loopback interface configuration**

L5-9(1) Receive buffer pool type. This configuration setting controls the memory placement of the receive data buffers. Buffers may either be placed in main memory or in a dedicated, possibly higher speed, memory region (see L5-9(13)). This field should be set to one of the two macros:

```
NET_IF_MEM_TYPE_MAIN
NET_IF_MEM_TYPE_DEDICATED
```

L5-9(2) Receive buffer size. This field sets the size of the largest receivable packet, and can be set to match the application's requirements.

Note: If packets are sent from a socket bound to a non local-host address, to the local host address (127.0.0.1), then the receive buffer size must be configured to match the maximum transmit buffer size, or maximum expected data size, that could be generated from a socket bound to any other interface.

L5-9(3) Number of receive buffers. This setting controls the number of receive buffers that will be allocated to the loopback interface. This value *must* be set greater than or equal to one buffer if loopback is receiving *only* UDP. If TCP data is expected to be transferred across the loopback interface, then there *must* be a minimum of four receive buffers.

L5-9(4) Receive buffer alignment. This setting controls the alignment of the receive buffers in bytes. Some processor architectures do not allow multi-byte reads and writes across word boundaries and therefore may require buffer alignment. In general, it is probably best practice to align buffers to the data bus width of the processor which may improve performance. For example, a 32-bit processor may benefit from having buffers aligned on a 4-byte boundary.

L5-9(5) Receive buffer offset. The loopback interface receives packets starting at base index 0 in the network buffer data areas. This setting configures an offset from the base index of 0 to receive loopback packets. The default offset of 0 *should* be configured. However, if loopback receive packets are configured with an offset, the receive buffer size *must* also be adjusted by the additional number of offset bytes.

L5-9(6) Transmit buffer pool type. This configuration setting controls the memory placement of the transmit data buffers for the loopback interface. Buffers may either be placed in main memory or in a dedicated, possibly higher speed, memory region (see L5-9(13)). This field should be set to one of two macros:

```
NET_IF_MEM_TYPE_MAIN
NET_IF_MEM_TYPE_DEDICATED
```

L5-9(7) Large transmit buffer size. At the time of this writing, transmit fragmentation is *not* supported; therefore this field sets the size of the largest transmittable buffer for the loopback interface when the application sends from a socket that is bound to the local-host address.

L5-9(8) Number of large transmit buffers. This field controls the number of large transmit buffers allocated to the loopback interface. The developer may set this field to zero to make room for additional large transmit buffers, however, the number of large plus the number of small transmit buffers *must* be greater than or equal to one for UDP traffic and three for TCP traffic.

L5-9(9) Small transmit buffer size. For devices with a minimal amount of RAM, it is possible to allocate small transmit buffers as well as large transmit buffers. In general, we recommend 152 byte small transmit buffers, however, the developer may adjust this value according to the application requirements. This field has no effect if the number of small transmit buffers is configured to zero.

L5-9(10) Number of small transmit buffers. This field controls the number of small transmit buffers allocated to the device. The developer may set this field to zero to make room for additional large transmit buffers, however, the number of large plus the number of small transmit buffers *must* be greater than or equal to one for UDP traffic and three for TCP traffic.

L5-9(11) Transmit buffer alignment. This setting controls the alignment of the receive buffers in bytes. Some processor architectures do not allow multi-byte reads and writes across word boundaries and therefore may require buffer alignment. In general, it is probably best practice to align buffers to the data bus width of the processor which may improve performance. For example, a 32-bit processor may benefit from having buffers aligned on a 4-byte boundary.

L5-9(12) Transmit buffer offset. This setting configures an offset from the base transmit index to prepare loopback packets. The default offset of 0 *should* be configured. However, if loopback transmit packets are configured with an offset, the transmit buffer size *must* also be adjusted by the additional number of offset bytes.

L5-9(13) Memory address. By default, this field is configured to 0x00000000. A value of 0 tells µC/TCP-IP to allocate buffers for the loopback interface from the µC/LIB Memory Manager default heap. If a faster, more specialized memory is available, the loopback interface buffers may be allocated into an alternate region if desired.

L5-9(14) Memory size. By default, this field is configured to 0. A value of 0 tells µC/TCP-IP to allocate as much memory as required from the µC/LIB Memory Manager default heap. If an alternate memory region is specified in the 'Memory Address' field above, then the maximum size of the specified memory segment must be specified.

L5-9(15) Optional configuration flags. Configure (optional) loopback features by logically **OR**'ing bit-field flags:

`NET_DEV_CFG_FLAG_NONE` No loopback configuration flags selected

## 5-5-2 ADDING A LOOPBACK INTERFACE

Basically to enable and add the loopback interface you only have to enable the loopback interface within the network configuration (`net_cfg.h`) as follow:

```
#define  NET_IF_CFG_LOOPBACK_EN                    DEF_ENABLED
```

# 5-6 NETWORK INTERFACE API

## 5-6-1 CONFIGURING AN IP ADDRESS

Each network interface must be configured with at least one IP address. This may be performed using µC/DHCPc or manually during run-time. If run-time configuration is chosen, the following functions may be utilized to set the IP, network mask, and gateway addresses for a specific interface. More than one set of addresses may be configured for a specific network interface by calling the functions below. Note that on the default interface, the first IP address added will be the default address used for all default communication.

`NetASCII_Str_to_IP()`
`NetIP_CfgAddrAdd()`

The first function aids the developer by converting a string format IP address such as "192.168.1.2" to its hexadecimal equivalent. The second function is used to configure an interface with the specified IP, network mask and gateway addresses. An example of each function call is shown below.

```
ip      = NetASCII_Str_to_IP((CPU_CHAR*)"192.168.1.2",   &err);       (1)
msk     = NetASCII_Str_to_IP((CPU_CHAR*)"255.255.255.0", &err);
gateway = NetASCII_Str_to_IP((CPU_CHAR*)"192.168.1.1",   &err);
```

Listing 5-10 **Calling NetASCII_Str_to_IP()**

L5-10(1) `NetASCII_Str_to_IP()` requires two arguments. The first function argument is a string representing a valid IP address, and the second argument is a pointer to a `NET_ERR` to contain the return error code. Upon successful conversion, the return error will contain the value `NET_ASCII_ERR_NONE` and the function will return a variable of type `NET_IP_ADDR` containing the hexadecimal equivalent of the specified address.

```
cfg_success = NetIP_CfgAddrAdd(if_nbr,       (1)
                               ip,           (2)
                               msk,          (3)
                               gateway,      (4)
                              &err);         (5)
```

Listing 5-11 **Calling NetIP_CfgAddrAdd()**

L5-11(1) The first argument is the number representing the network interface that is to be configured. This value is obtained as the result of a successful call to `NetIF_Add()`.

L5-11(2) The second argument is the `NET_IP_ADDR` value representing the IP address to be configured.

L5-11(3) The third argument is the `NET_IP_ADDR` value representing the subnet mask address that is to be configured.

L5-11(4) The fourth argument is the `NET_IP_ADDR` value representing the default gateway IP address that is to be configured.

L5-11(5) The fifth argument is a pointer to a `NET_ERR` variable containing the return error code for the function. If the interface address information is configured successfully, then the return error code will contain the value `NET_IP_ERR_NONE`. Additionally, function returns a Boolean value of `DEF_OK` or `DEF_FAIL` depending on the result. Either the return value or the `NET_ERR` variable may be checked for return status; however, the `NET_ERR` contains more detailed information and should therefore be the preferred check.

Note: The application may configure a network interface with more than one set of IP addresses. This may be desirable when a network interface and its paired device are connected to a switch or HUB with more than one network present. Additionally, an application may choose to *not* configure any interface addresses, and thus may *only* receive packets and should not attempt to transmit.

Additionally, addresses may be removed from an interface by calling NetIP_CfgAddrRemove() (see section C-12-5 "NetIP_CfgAddrRemove()" on page 549 and section C-12-6 "NetIP_CfgAddrRemoveAll()" on page 551).

Once a network interface has been successfully configured with IP address information, the next step is to start the interface.

## 5-6-2 STARTING NETWORK INTERFACES

When a network interface is started, it becomes an active interface that is capable of transmitting and receiving data assuming an operational link to the network medium. A network interface may be started any time after the network interface has been successfully "added" to the system. A successful call to NetIF_Start() marks the end of the initialization sequence of µC/TCP-IP for a specific network interface. Recall that the first interface added and started will be the default interface.

The application developer may start a network interface by calling the NetIF_Start() API function with the necessary parameters. A call to NetIF_Start() is shown below.

```
NetIF_Start(if_nbr, &err);   (1)
```

Listing 5-12 **Calling NetIF_Start()**

L5-12(1) NetIF_Start() requires two arguments. The first function argument is the interface number that the application wants to start, and the second argument is a pointer to a NET_ERR to contain the return error code. The interface number is acquired upon successful addition of the interface and upon the successful start of the interface; the return error variable will contain the value NET_IF_ERR_NONE.

There are very few things that could cause a network interface to not start properly. The application developer should always inspect the return error code and take the appropriate action if an error occurs. Once the error is resolved, the application may again attempt to call NetIF_Start().

## 5-6-3 STOPPING NETWORK INTERFACES

Under some circumstances, it may be desirable to stop a network interface. A network interface may be stopped any time after it has been successfully "added" to the system. Stopping an interface may be performed by calling `NetIF_Stop()` with the appropriate arguments shown below.

```
NetIF_Stop(if_nbr, &err);   (1)
```

Listing 5-13 **Calling NetIF_Stop()**

L5-13(1) `NetIF_Stop()` requires two arguments. The first function argument is the interface number that the application wants to stop, and the second argument is a pointer to a `NET_ERR` to contain the return error code. The interface number is acquired upon the successful addition of the interface and upon the successful stop of the interface; the return error variable will contain the value `NET_IF_ERR_NONE`.

There are very few things that may cause a network interface to not stop properly. The application developer should always inspect the return error code and take the appropriate action if an error occurs. Once the error is resolved, the application may attempt to call `NetIF_Stop()` again.

## 5-6-4 GETTING NETWORK INTERFACE MTU

On occasion, it may be desirable to have the application aware of an interface's Maximum Transmission Unit. The MTU for a particular interface may be acquired by calling NetIF_MTU_Get() with the appropriate arguments.

```
mtu = NetIF_MTU_Get(if_nbr, &err);   (1)
```

Listing 5-14 **Calling NetIF_MTU_Get()**

L5-14(1) NetIF_MTU_Get() requires two arguments. The first function argument is the interface number to get the current configured MTU, and the second argument is a pointer to a NET_ERR to contain the return error code. The interface number is acquired upon the successful addition of the interface, and upon the successful return of the function, the return error variable will contain the value NET_IF_ERR_NONE. The result is returned into a local variable of type NET_MTU.

## 5-6-5 SETTING NETWORK INTERFACE MTU

Some networks prefer to operate with a non-standard MTU. If this is the case, the application may specify the MTU for a particular interface by calling NetIF_MTU_Set() with the appropriate arguments.

```
NetIF_MTU_Set(if_nbr, mtu, &err);   (1)
```

Listing 5-15 **Calling NetIF_MTU_Set()**

L5-15(1) NetIF_MTU_Set() requires three arguments. The first function argument is the interface number of the interface to set the specified MTU. The second argument is the desired MTU to set, and the third argument is a pointer to a NET_ERR variable that will contain the return error code. The interface number is acquired upon the successful addition of the interface, and upon the successful return of the function, the return error variable will contain the value NET_IF_ERR_NONE and the specified MTU will be set.

Note: The configured MTU cannot be greater than the largest configured transmit buffer size associated with the specified interfaces' device minus overhead. Transmit buffer sizes are specified in the device configuration structure for the specified interface. For more information about configuring device buffer sizes, refer to section 9-3 "Network Buffer Sizes" on page 279.

## 5-6-6 GETTING NETWORK INTERFACE HARDWARE ADDRESSES

Many types of network interface hardware require the use of a link layer protocol address. In the case of Ethernet, this address is sometimes known as the hardware address or MAC address. In some applications, it may be desirable to get the current configured hardware address for a specific interface. This may be performed by calling `NetIF_AddrHW_Get()` with the appropriate arguments.

```
NetIF_AddrHW_Get((NET_IF_NBR  ) if_nbr,                 (1)
                 (CPU_INT08U *)&addr_hw_sender[0],      (2)
                 (CPU_INT08U *)&addr_hw_len,            (3)
                 (NET_ERR    *) perr);                  (4)
```

Listing 5-16 **Calling NetIF_AddrHW_Get()**

L5-16(1) The first argument specifies the interface number from which to get the hardware address. The interface number is acquired upon the successful addition of the interface.

L5-16(2) The second argument is a pointer to a `CPU_INT08U` array used to provide storage for the returned hardware address. This array *must* be sized large enough to hold the returned number of bytes for the given interface's hardware address. The lowest index number in the hardware address array represents the most significant byte of the hardware address.

L5-16(3) The third function is a pointer to a `CPU_INT08U` variable that the function returns the length of the specified interface's hardware address.

L5-16(4) The fourth argument is a pointer to a `NET_ERR` variable containing the return error code for the function. If the hardware address is successfully obtained, then the return error code will contain the value `NET_IF_ERR_NONE`.

## 5-6-7 SETTING NETWORK INTERFACE HARDWARE ADDRESS

Some applications prefer to configure the hardware device's hardware address via software during run-time as opposed to a run-time auto-loading EEPROM as is common for many Ethernet devices. If the application is to set or change the hardware address during run-time, this may be performed by calling `NetIF_AddrHW_Set()` with the appropriate arguments. Alternatively, the hardware address may be statically configured via the device configuration structure and later changed during run-time.

```
NetIF_AddrHW_Set((NET_IF_NBR  ) if_nbr,           (1)
                 (CPU_INT08U *)&addr_hw[0],       (2)
                 (CPU_INT08U *)&addr_hw_len,      (3)
                 (NET_ERR    *) perr);            (4)
```

Listing 5-17 **Calling NetIF_AddrHW_Set()**

L5-17(1) The first argument specifies the interface number to set the hardware address. The interface number is acquired upon the successful addition of the interface.

L5-17(2) The second argument is a pointer to a `CPU_INT08U` array which contains the desired hardware address to set. The lowest index number in the hardware address array represents the most significant byte of the hardware address.

L5-17(3) The third function is a pointer to a `CPU_INT08U` variable that specifies the length of the hardware address being set. In most cases, this can be specified as `sizeof(addr_hw)` assuming `addr_hw` is declared as an array of `CPU_INT08U`.

L5-17(4) The fourth argument is a pointer to a `NET_ERR` variable containing the return error code for the function. If the hardware address is successfully obtained, then the return error code will contain the value `NET_IF_ERR_NONE`.

Note: In order to set the hardware address for a particular interface, it *must* first be stopped. The hardware address may then be set, and the interface re-started.

## 5-6-8 GETTING LINK STATE

Some applications may wish to get the physical link state for a specific interface. Link state information may be obtained by calling `NetIF_IO_Ctrl()` or `NetIF_LinkStateGet()` with the appropriate arguments.

Calling `NetIF_IO_Ctrl()` will poll the hardware for the current link state. Alternatively, `NetIF_LinkStateGet()` gets the approximate link state by reading the interface link state flag. Polling the Ethernet hardware for link state takes significantly longer due to the speed and latency of the MII bus. Consequently, it may not be desirable to poll the hardware in a tight loop. Reading the interface flag is fast, but the flag is only periodically updated by the Net IF every 250mS (default) when using the generic Ethernet PHY driver. PHY drivers that implement link state change interrupts may change the value of the interface flag immediately upon link state change detection. In this scenario, calling `NetIF_LinkStateGet()` is ideal for these interfaces.

```
NetIF_IO_Ctrl((NET_IF_NBR) if_nbr,                                  (1)
              (CPU_INT08U) NET_IF_IO_CTRL_LINK_STATE_GET_INFO,      (2)
              (void     *)&link_state,                              (3)
              (NET_ERR  *)&err);                                    (4)
```

Listing 5-18 **Calling NetIF_IO_Ctrl()**

L5-18(1) The first argument specifies the interface number from which to get the physical link state.

L5-18(2) The second argument specifies the desired function that `NetIF_IO_Ctrl()` will perform. In order to get the current interfaces' link state, the application should specify this argument as either:

`NET_IF_IO_CTRL_LINK_STATE_GET`

`NET_IF_IO_CTRL_LINK_STATE_GET_INFO`

L5-18(3) The third argument is a pointer to a link state variable that must be declared by the application and passed to `NetIF_IO_Ctrl()`.

## 5-6-9 SCANNING FOR A WIRELESS ACCESS POINT

When a wireless network interface is started, it becomes an active interface that is not yet capable of transmitting and receiving data since no operational link to a network medium is configured. The first step to join a network to have an operational link is the scan operation which consists to find the wireless network available in the range of the wireless module.

A wireless network interface should be able to scan any time after the network interface has been successfully started. A successful call to `NetIF_WiFi_Scan()` return the wireless network available to join which can be joined by the wireless network interface. See section C-10-1 “NetIF_WiFi_Scan()” on page 530 for more information.

You can scan for a wireless network by calling the `NetIF_WiFi_Scan()` API function with the necessary parameters. A call to `NetIF_WiFi_Scan()` is shown below.

```
NET_IF_WIFI_AP  ap_buf[NB_AP_MAX]
CPU_INT16U      ap_ctn;
NET_ERR         err;

ap_ctn = NetIF_WiFi_Scan(if_nbr,            (1)
                         ap_buf,            (2)
                         NB_AP_MAX,         (3)
                         0,                 (4)
                         NET_IF_WIFI_CH_ALL, (5)
                        &err);              (6)
```

Listing 5-19 **Calling NetIF_Start()**

L5-19(1) `NetIF_WiFi_Scan()` requires six arguments. The first function argument is the interface number that the application wants to scan with. The interface number is acquired upon successful addition of the interface and upon the successful start of the interface.

L5-19(2) The second argument is a pointer to a wireless access point buffer to contain the wireless network found in the range of the interface.

L5-19(3) The third argument is the number of wireless access point that can be contained in the wireless access point buffer.

L5-19(4) The fourth argument is a pointer to a string that can contains the SSID of an hidden wireless access point to find.

L5-19(5) The fifth argument is the wireless channel to scan.

L5-19(6) The last argument is a pointer to a `NET_ERR` to contain the return error code. The return error variable will contain the value `NET_IF_WIFI_ERR_NONE` if the scan process has been completed successfully.

There are very few things that could cause a network interface to not scan properly. The application developer should always inspect the return error code and take the appropriate action if an error occurs. Once the error is resolved, the application may again attempt to call `NetIF_WiFi_Scan()`.

## 5-6-10 JOINING WIRELESS ACCESS POINT

When a wireless network interface is started, it becomes an active interface that is not yet capable of transmitting and receiving data, since no operational link to a network medium is configured. Once once the interface has found a wireless network, it must be joined to get an operational link. A wireless network interface should be able to join any time after the network interface has been successfully started and before a wireless access point has been joined. See section C-10-2 “NetIF_WiFi_Join()” on page 532 for more information.

The application developer may join a wireless network by calling the `NetIF_WiFi_Join()` API function with the necessary parameters. A call to `NetIF_WiFi_Join()` is shown below.

```
NET_ERR         err;

ap_ctn = NetIF_WiFi_Join(if_nbr,                              (1)
                         NET_IF_WIFI_NET_TYPE_INFRASTRUCTURE, (2)
                         NET_IF_WIFI_DATA_RATE_AUTO,          (3)
                         NET_IF_WIFI_SECURITY_WPA2,           (4)
                         NET_IF_WIFI_PWR_LEVEL_HI,            (5)
                        “network_ssid”,                       (6)
                        “network_password”,                   (7)
                        &err);                                (8)
```

Listing 5-20 **Calling NetIF_Start()**

L5-20(1) `NetIF_WiFi_Join()` requires height arguments. The first function argument is the interface number that the application wants to join with. The interface number is acquired upon successful addition of the interface and upon the successful start of the interface.

L5-20(2) The second argument is wireless network type.

L5-20(3) The third argument is data rate use to communicate on the wireless network.

L5-20(4) The fourth argument is the wireless security configured for the wireless network to join.

L5-20(5) The fifth argument is the wireless radio power level use to communicate on the wireless network.

L5-20(6) The sixth argument is a pointer to a string that contains the SSID of the wireless access point to join.

L5-20(7) The seventh argument is a pointer to a string that contains the pre shared key of the wireless access point to join.

L5-20(8) The last argument is a pointer to a `NET_ERR` to contain the return error code. The return error variable will contain the value `NET_IF_WIFI_ERR_NONE` if the join process has been completed successfully.

There are very few things that could cause a network interface to not join properly. The application developer should always inspect the return error code and take the appropriate action if an error occurs. Once the error is resolved, the application may again attempt to call `NetIF_WiFi_Join()`.

## 5-6-11 CREATING WIRELESS AD HOC ACCESS POINT

Some applications may need to create an wireless ad hoc access point that can be accessed by other devices. Wireless ad hoc access points can be created by calling the NetIF_WiFi_CreateAdhoc() API function with the necessary parameters. See section C-10-3 "NetIF_WiFi_CreateAdhoc()" on page 535 for more information.

A call to NetIF_WiFi_CreateAdhoc() is shown below:

```
NET_ERR         err;

ap_ctn = NetIF_WiFi_CreateAdhoc(if_nbr,                              (1)
                                NET_IF_WIFI_DATA_RATE_AUTO,          (2)
                                NET_IF_WIFI_SECURITY_WEP,            (3)
                                NET_IF_WIFI_PWR_LEVEL_HI,            (4)
                                NET_IF_WIFI_CH_1                     (5)
                               "adhoc_ssid",                         (6)
                               "adhoc_password",                     (7)
                               &err);                                (8)
```

Listing 5-21 **Call to NetIF_WiFi_CreateAdhoc()**

L5-21(1) NetIF_WiFi_CreateAdhoc() requires height arguments. The first argument is the interface number, which is acquired upon successful addition and successful start of the interface.

L5-21(2) The second argument is the data rate used on the wireless network.

L5-21(3) The third argument is the wireless security type of wireless network.

L5-21(4) The fourth argument is the radio power level use to communicate on the wireless network.

L5-21(5) The fifth argument is the wireless channel for the ad hoc network.

L5-21(6) The sixth argument is a pointer to a string that contains the SSID of the wireless access point.

L5-21(7) The seventh argument is a pointer to a string that contains the pre-shared key of the wireless access point.

L5-21(8) The last argument is a pointer to a NET_ERR to contain the return error code. The return error variable will contain the value NET_IF_WIFI_ERR_NONE if the create process has been completed successfully.

If an error occurs, you should always inspect the return error code and take the appropriate action. There are very few things that could cause a failure to create an ad hoc network properly. Once the error is resolved, the application may again attempt to call NetIF_WiFi_CreateAdhoc().

## 5-6-12 LEAVING WIRELESS ACCESS POINT

When an application needs to leave a wireless access point, it can do so by calling the NetIF_WiFi_Leave() API function with the necessary parameters.

A call to NetIF_WiFi_Leave() is shown below.

```
NET_ERR         err;

ap_ctn = NetIF_WiFi_Leave(if_nbr, (1)
                          &err);   (2)
```

Listing 5-22 **Call to NetIF_WiFi_Leave()**

L5-22(1) NetIF_WiFi_Leave() requires two arguments. The first function argument is the interface number. The interface number is acquired upon successful addition of the interface and upon the successful start of the interface.

L5-22(2) The last argument is a pointer to a NET_ERR to contain the return error code. The return error variable will contain the value NET_IF_WIFI_ERR_NONE if the leave process has been completed successfully.

There are very few things that could cause a network interface to leave improperly. You should always inspect the return error code and take the appropriate action if an error occurs. Once the error is resolved, the application may again attempt to call NetIF_WiFi_Leave().

Chapter

# 6

# Network Board Support Package

This chapter describes all board-specific functions that you may need to implement.

In order for a device driver to be platform independent, it is necessary to provide a layer of code that abstracts details such as configuring clocks, interrupt controllers, general-purpose input/ouput (GPIO) pins, direct-memory access (DMA) modules, and other such hardware modules. The board support package (BSP) code layer enables you to implement certain high-level functionality in µC/TCP-IP that is independent of any specific hardware. It also allows you to reuse device drivers from various architectures and bus configurations without having to customize µC/TCP-IP or the device driver source code for each architecture or hardware platform.

To understand the concepts discussed in this guide, you should be familiar with networking principles, the TCP/IP stack, real-time operating systems, microcontrollers and processors.

Micrium provides sample BSP code free of charge; however, most sample code will likely require modification depending on the combination of compiler, processor, board, and device hardware used.

# 6-1 ETHERNET BSP LAYER

## 6-1-1 DESCRIPTION OF THE ETHERNET BSP API

This section describes the BSP API functions that you should implement during the integration of an Ethernet interface for µC/TCP-IP.

For each Ethernet interface/device, an application must implement in `net_bsp.c`, a unique device-specific implementation of each of the following BSP functions:

```
void         NetDev_CfgClk    (NET_IF   *p_if,
                               NET_ERR  *p_err);
void         NetDev_CfgIntCtrl(NET_IF   *p_if,
                               NET_ERR  *p_err);
void         NetDev_CfgGPIO   (NET_IF   *p_if,
                               NET_ERR  *p_err);
CPU_INT32U   NetDev_ClkFreqGet(NET_IF   *p_if,
                               NET_ERR  *p_err);
```

Since each of these functions is called from a unique instantiation of its corresponding device driver, a pointer to the corresponding network interface (`p_if`) is passed in order to access the specific interface's device configuration or data.

Network device driver BSP functions may be arbitrarily named but since development boards with multiple devices require unique BSP functions for each device, it is recommended that each device's BSP functions be named using the following convention:

`NetDev_[Device]<Function>[Number]()`

`[Device]` Network device name or type. For example, MACB. (Optional if the development board does not support multiple devices.)

`<Function>` Network device BSP function. For example, `CfgClk.`

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the NetDev_CfgClk() function for the #2 MACB Ethernet controller on an Atmel AT91SAM9263-EK should be named NetDev_MACB_CfgClk2(), or NetDev_MACB_CfgClk_2() with additional underscore optional.

Similarly, network devices' BSP-level interrupt service routine (ISR) handlers should be named using the following convention:

NetDev_[Device]ISR_Handler[Type][Number]()

[Device] Network device name or type. For example, MACB. (Optional if the development board does not support multiple devices.)

[Type] Network device interrupt type. For example, receive interrupt. (Optional if interrupt type is generic or unknown.)

[Number] Network device number for each specific instance of device (optional if the development board does not support multiple instances of a specific device).

For example, the receive ISR handler for the #2 MACB Ethernet controller on an Atmel AT91SAM9263-EK should be named NetDev_MACB_ISR_HandlerRx2(), or NetDev_MACB_ISR_HandlerRx_2(), with additional underscore optional.

Next, the BSP functions for each device/interface must be organized into an interface structure. This structure is used by the device driver to call specific devices' BSP functions via function pointer instead of by name. It allows applications to add, initialize, and configure any number of instances of various devices and drivers by creating similar but unique BSP functions and interface structures for each network device/interface. (See Appendix C, "NetIF_Add()" on page 498 for details on how applications add interfaces to µC/TCP-IP.)

The BSP for each device or interface must be declared in the BSP source file (net_bsp.c) for each application or development board. The BSP must also be externally declared in the network BSP header file (net_bsp.h) with exactly the same name and type as declared in net_bsp.c. These BSP interface structures and their corresponding functions must have unique names, and should clearly identify the development board, device name, function name, and possibly the specific device number (assuming the development board supports multiple instances of any given device). BSP interface structures may be given arbitrary names, but it is recommended that they be named using the following convention:

NetDev_BSP_<Board><Device>[Number]{}

<Board> Development board name. For example, Atmel AT91SAM9263-EK).

<Device> Network device name or type. For example, MACB.

[Number] Network device number for each specific instance of the device (optional if the development board does not support multiple instances of the device).

For example, a BSP interface structure for the #2 MACB Ethernet controller on an Atmel AT91SAM9263-EK board should be named NetDev_BSP_AT91SAM9263-EK_MACB_2{} and declared in the AT91SAM9263-EK board's net_bsp.c:

```
                        /* AT91SAM9263-EK MACB #2's BSP fnct ptrs :  */
const  NET_DEV_BSP_ETHER  NetDev_BSP_AT91SAM9263-EK_MACB_2 = {
    NetDev_MACB_CfgClk_2,      /*   Cfg MACB #2's clk(s)            */
    NetDev_MACB_CfgIntCtrl_2,  /*   Cfg MACB #2's int ctrl(s)       */
    NetDev_MACB_CfgGPIO_2,     /*   Cfg MACB #2's GPIO              */
    NetDev_MACB_ClkFreqGet_2   /*   Get MACB #2's clk freq          */
};
```

In order for the application to configure an interface with this BSP interface structure, the structure must also be externally declared in the AT91SAM9263-EK board's net_bsp.h :

```
extern  const  NET_DEV_BSP_ETHER  NetDev_BSP_AT91SAM9263-EK_MACB_2;
```

Lastly, the AT91SAM9263-EK board's MACB #2 BSP functions must also be declared in net_bsp.c:

```
static  void        NetDev_MACB_CfgClk_2    (NET_IF   *pif,
                                             NET_ERR  *perr);
static  void        NetDev_MACB_CfgIntCtrl_2(NET_IF   *pif,
                                             NET_ERR  *perr);
static  void        NetDev_MACB_CfgGPIO_2   (NET_IF   *pif,
                                             NET_ERR  *perr);
static  CPU_INT32U  NetDev_MACB_ClkFreqGet_2(NET_IF   *pif,
                                             NET_ERR  *perr);
```

Note that since all network device BSP functions are accessed only by function pointer via their corresponding BSP interface structure, they don't need to be globally available and should therefore be declared as `static`.

Also note that although certain device drivers may not need to implement or call all of the above network device BSP function, we recommend that each device's BSP interface structure define all device BSP functions, and not assign any of its function pointers to `NULL`. Instead, for any device's unused BSP functions, create empty functions that return `NET_DEV_ERR_NONE`. This way, if the device driver is ever modified to start using a previously-unused BSP function, there will at least be an empty function for the BSP function pointer to execute.

Details for these functions may be found in their respective sections in Appendix A, "Device Driver BSP Functions" on page 336 and templates for network device BSP functions and BSP interface structures are available in the `\Micrium\Software\uC-TCPIP-V2\BSP\Template\` directories.

## 6-1-2 CONFIGURING CLOCKS FOR AN ETHERNET DEVICE

`NetDev_CfgClk()` sets a specific network device's clocks to a specific interface.

Each network device's `NetDev_CfgClk()` should configure and enable all required clocks for the specified network device. For example, on some devices it may be necessary to enable clock gating for an embedded Ethernet MAC, as well as various GPIO modules in order to configure Ethernet PHY pins for (R)MII mode and interrupts. See section A-3-1 "NetDev_CfgClk()" on page 336 for more information.

## 6-1-3 CONFIGURING GENERAL I/O FOR AN ETHERNET DEVICE

`NetDev_CfgGPIO()` configures a specific network device's general-purpose input/output (GPIO) on a specific interface. This function is called by a device driver's `NetDev_Init()`.

Each network device's `NetDev_CfgGPIO()` should configure all required GPIO pins for the network device. For Ethernet devices, this function is necessary to configure the (R)MII bus pins, depending on whether the user has configured an Ethernet interface to operate in the RMII or MII mode, and optionally the Ethernet PHY interrupt pin.

See section A-3-2 "NetDev_CfgGPIO()" on page 338 for more information.

## 6-1-4 CONFIGURING THE INTERRUPT CONTROLLER FOR AN ETHERNET DEVICE

`NetDev_CfgIntCtrl()` is called by a device driver's `NetDev_Init()` to configure a specific network device's interrupts and/or interrupt controller on a specific interface.

Each network device's `NetDev_CfgIntCtrl()` function must configure and enable all required interrupt sources for the network device. This means it must configure the interrupt vector address of each corresponding network device BSP interrupt service routine (ISR) handler and enable its corresponding interrupt source.

For `NetDev_CfgIntCtrl()`, the following actions should be performed:

1 Configure/store each device's network interface number to be available for all necessary `NetDev_ISR_Handler()` functions (see section 6-3 on page 137 for more information). Even though devices are added dynamically, the device's interface number must be saved in order for each device's ISR handlers to call `NetIF_ISR_Handler()` with the device's network interface number.

2 Configure each of the device's interrupts on an interrupt controller (either an external or CPU-integrated interrupt comptroller). However, vectored interrupt controllers may not require higher-level interrupt controller sources to be explicitly configured and enabled. In this case, you may need to configure the system's interrupt vector table with the name of the ISR handler functions declared in `net_bsp.c`.

   `NetDev_CfgIntCtrl()` should enable only each devices' interrupt sources, but not the local device-level interrupts themselves, which are enabled by the device driver only after the device has been fully configured and started.

See section A-3-3 "NetDev_CfgIntCtrl()" on page 340 for more information.

### 6-1-5 GETTING A DEVICE CLOCK FREQUENCY

`NetDev_ClkFreqGet()` return a specific network device's clock frequency for a specific interface. This function is called by a device driver's `NetDev_Init()`.

Each network device's `NetDev_ClkFreqGet()` should return the device's clock frequency (in Hz). For Ethernet devices, this is the clock frequency of the device's (R)MII bus. The device driver's `NetDev_Init()` uses the returned clock frequency to configure an appropriate bus divider to ensure that the (R)MII bus logic operates within an allowable range. In general, the device driver should not configure the divider such that the (R)MII bus operates faster than 2.5MHz.

See section A-3-4 "NetDev_ClkGetFreq()" on page 344 for more information.

## 6-2 WIRELESS BSP LAYER

### 6-2-1 DESCRIPTION OF THE WIRELESS BSP API

This section describes the BSP API functions that you should implement during the integration of a wireless interface for µC/TCP-IP.

For each wireless interface/device, an application must implement (in `net_bsp.c`) a unique device-specific implementation of each of the following BSP functions:

```
void  NetDev_WiFi_Start         (NET_IF      *p_if,
                                 NET_ERR     *p_err);

void  NetDev_WiFi_Stop          (NET_IF      *p_if,
                                 NET_ERR     *p_err);

void  NetDev_WiFi_CfgGPIO       (NET_IF      *p_if,
                                 NET_ERR     *p_err);

void  NetDev_WiFi_CfgIntCtrl    (NET_IF      *p_if,
                                 NET_ERR     *p_err);
```

```
void  NetDev_WiFi_IntCtrl       (NET_IF      *p_if,
                                 CPU_BOOLEAN  en,
                                 NET_ERR     *p_err);
void  NetDev_WiFi_SPI_Init      (NET_IF      *p_if,
                                 NET_ERR     *p_err);

void  NetDev_WiFi_SPI_Lock      (NET_IF      *p_if,
                                 NET_ERR     *p_err);

void  NetDev_WiFi_SPI_Unlock    (NET_IF      *p_if);
void  NetDev_WiFi_SPI_WrRd      (NET_IF      *p_if,
                                 CPU_INT08U  *p_buf_wr,
                                 CPU_INT08U  *p_buf_rd,
                                 CPU_INT16U   len,
                                 NET_ERR     *p_err);

void  NetDev_WiFi_SPI_ChipSelEn (NET_IF      *p_if,
                                 NET_ERR     *p_err);

void  NetDev_WiFi_SPI_ChipSelDis(NET_IF      *p_if);

void  NetDev_WiFi_SPI_Cfg(NET_IF                          *p_if,
                          NET_DEV_CFG_SPI_CLK_FREQ         freq,
                          NET_DEV_CFG_SPI_CLK_POL          pol,
                          NET_DEV_CFG_SPI_CLK_PHASE        phase,
                          NET_DEV_CFG_SPI_XFER_UNIT_LEN    xfer_unit_len,
                          NET_DEV_CFG_SPI_XFER_SHIFT_DIR   xfer_shift_dir,
                          NET_ERR                         *p_err);
```

Since each of these functions is called from a unique instantiation of its corresponding device driver, a pointer to the corresponding network interface (`p_if`) is passed in order to access the specific interface's device configuration or data.

Network device driver BSP functions may be arbitrarily named but since development boards with multiple devices require unique BSP functions for each device, it is recommended that each device's BSP functions be named using the following convention:

NetDev_[Device]<Function>[Number]()

[Device] Network device name or type. For example, MACB (optional if the development board does not support multiple devices).

<Function> Network device BSP function. For example, CfgClk

[Number] Network device number for each specific instance of device (optional if the development board does not support multiple instances of a specific device)

For example, the NetDev_CfgGPIO() function for the #2 RS9110-N-21 wireless module on an Atmel AT91SAM9263-EK should be named NetDev_RS9110N21_CfgGPIO2(), or NetDev_RS9110N21_CfgGPIO_2() with additional underscore optional.

Similarly, network devices' BSP-level interrupt service routine (ISR) handlers should be named using the following convention:

NetDev_[Device]ISR_Handler[Type][Number]()

[Device] Network device name or type. For example, MACB. (Optional if the development board does not support multiple devices.)

[Type] Network device interrupt type. For example, receive interrupt. (Optional if interrupt type is generic or unknown.)

[Number] Network device number for each specific instance of device (optional if the development board does not support multiple instances of a specific device).

For example, the receive ISR handler for the #2 RS9110-N-21 wireless module on an Atmel AT91SAM9263-EK should be named NetDev_RS9110N21_ISR_HandlerRx2(), or NetDev_RS9110N21_ISR_HandlerRx_2() with additional underscore optional.

Next, each device's/interface's BSP functions must be organized into an interface structure used by the device driver to call specific devices' BSP functions via function pointer instead of by name. This allows applications to add, initialize, and configure any number of instances of various devices and drivers by creating similar but unique BSP functions and interface structures for each network device/interface. (See Appendix C, "NetIF_Add()" on page 498 for details on how applications add interfaces to µC/TCP-IP.)

Each device's/interface's BSP interface structure must be declared in the application's/development board's network BSP source file, net_bsp.c, as well as externally declared in network BSP header file, net_bsp.h, with the exact same name and type as declared in net_bsp.c. These BSP interface structures and their corresponding functions must be uniquely named and should clearly identify the development board, device name, function name, and possibly the specific device number (assuming the development board supports multiple instances of any given device). BSP interface structures may be arbitrarily named but it is recommended that they be named using the following convention:

NetDev_BSP_<Board><Device>[Number]{}

<Board> Development board name. For example, Atmel AT91SAM9263-EK.

<Device> Network device name (or type). For example, RS9110-N-21.

[Number] Network device number for each specific instance of the device (optional if the development board does not support multiple instances of the device).

For example, a BSP interface structure for the #2 RS9110-N21 wireless module on an Atmel AT91SAM9263-EK board should be named NetDev_BSP_AT91SAM9263-EK_RS9110N21_2{} and declared in the AT91SAM9263-EK board's net_bsp.c:

```
                        /* AT91SAM9263-EK RS9110-N21 #2's BSP fnct ptrs :  */
const  NET_DEV_BSP_WIFI_SPI NetDev_BSP_AT91SAM9263-EK_RS9110N21_2 = {
    NetDev_RS9110N21_Start_2
    NetDev_RS9110N21_Stop_2,
    NetDev_RS9110N21_CfgGPIO_2,
    NetDev_RS9110N21_CfgExtIntCtrl_2
    NetDev_RS9110N21_ExtIntCtrl_2,
    NetDev_RS9110N21_SPI_Cfg_2,
    NetDev_RS9110N21_SPI_Lock_2,
    NetDev_RS9110N21_SPI_Unlock_2,
    NetDev_RS9110N21_SPI_WrRd_2,
    NetDev_RS9110N21_SPI_ChipSelEn_2,
    NetDev_RS9110N21_SPI_ChipSelDis_2,
    NetDev_RS9110N21_SetCfg_2
};
```

And in order for the application to configure an interface with this BSP interface structure, the structure must be externally declared in the AT91SAM9263-EK board's `net_bsp.h`:

```
extern  const  NET_DEV_BSP_WIFI_SPI  NetDev_BSP_AT91SAM9263-EK_RS9110N21_2;
```

Lastly, the board's RS9110-N-21 #2 BSP functions must also be declared in `net_bsp.c`:

```
static  void  NetDev_RS9110N21_Start_2         (NET_IF      *p_if,
                                                NET_ERR     *p_err);

static  void  NetDev_RS9110N21_Stop_2          (NET_IF      *p_if,
                                                NET_ERR     *p_err);

static  void  NetDev_RS9110N21_CfgGPIO_2       (NET_IF      *p_if,
                                                NET_ERR     *p_err);

static  void  NetDev_RS9110N21_CfgIntCtrl_2    (NET_IF      *p_if,
                                                NET_ERR     *p_err);

static  void  NetDev_RS9110N21_IntCtrl_2       (NET_IF      *p_if,
                                                CPU_BOOLEAN  en,
                                                NET_ERR     *p_err);

static  void  NetDev_RS9110N21_SPI_Init_2      (NET_IF      *p_if,
                                                NET_ERR     *p_err);

static  void  NetDev_RS9110N21_SPI_Lock_2      (NET_IF      *p_if,
                                                NET_ERR     *p_err);

static  void  NetDev_RS9110N21_SPI_Unlock_2    (NET_IF      *p_if);

static  void  NetDev_RS9110N21_SPI_WrRd_2      (NET_IF      *p_if,
                                                CPU_INT08U  *p_buf_wr,
                                                CPU_INT08U  *p_buf_rd,
                                                CPU_INT16U   len,
                                                NET_ERR     *p_err);
```

```
static  void  NetDev_RS9110N21_SPI_ChipSelEn_2 (NET_IF      *p_if,
                                                NET_ERR     *p_err);

static  void  NetDev_RS9110N21_SPI_ChipSelDis_2(NET_IF      *p_if);

static  void  NetDev_RS9110N21_SPI_Cfg_2(
                        NET_IF                              *p_if,
                        NET_DEV_CFG_SPI_CLK_FREQ             freq,
                        NET_DEV_CFG_SPI_CLK_POL              pol,
                        NET_DEV_CFG_SPI_CLK_PHASE            phase,
                        NET_DEV_CFG_SPI_XFER_UNIT_LEN        xfer_unit_len,
                          NET_DEV_CFG_SPI_XFER_SHIFT_DIR     xfer_shift_dir,
                          NET_ERR                           *p_err);
```

Note that since all network device BSP functions are accessed only by function pointer via their corresponding BSP interface structure, they don't need to be globally available and should therefore be declared as `static`.

Also note that although certain device drivers may not need to implement or call all of the above network device BSP function, we recommend that each device's BSP interface structure define all device BSP functions and not assign any of its function pointers to `NULL`. Instead, for any device's unused BSP functions, create empty functions that return `NET_DEV_ERR_NONE`. This way, if the device driver is ever modified to start using a previously-unused BSP function, there will at least be an empty function for the BSP function pointer to execute.

Details for these functions may be found in their respective sections in section A-3 "Device Driver BSP Functions" on page 336. Templates for network device BSP functions and BSP interface structures can be found in the directory `\Micrium\Software\uC-TCPIP-V2\BSP\Template\`.

## 6-2-2 CONFIGURING GENERAL-PURPOSE I/O FOR A WIRELESS DEVICE

`NetDev_WiFi_CfgGPIO()` configures a specific network device's general-purpose input/ouput (GPIO) on a specific interface. This function is called by a device driver's `NetDev_Init()`.

Each network device's `NetDev_WiFi_CfgGPIO()` should configure all required GPIO pins for the network device. For wireless devices, this function is necessary to configure the power, reset and interrupt pins.

See section B-3-3 “NetDev_WiFi_CfgGPIO()” on page 391 for more information.

## 6-2-3 STARTING A WIRELESS DEVICE

`NetDev_WiFi_Start()` is used to power up the wireless chip. This function is called by a device driver's `NetDev_WiFi_Start()` each time the interface is started.

Each network device's `NetDev_WiFi_Start()` must set GPIO pins to power up and reset the wireless device. For wireless devices, this function is necessary to configure the power pin and other required pins to power up the wireless chip. Note that some wireless device could require a toggle on the Reset pin to be started or restarted correctly.

See section B-3-1 “NetDev_WiFi_Start()” on page 387 for more information.

## 6-2-4 STOPPING A WIRELESS DEVICE

`NetDev_WiFi_Stop()` is used to power down a wireless chip. This function is called by a device driver's `NetDev_WiFi_Stop()` each time the interface is stopped.

Each network device's `NetDev_WiFi_Start()` must set GPIO pins to power down the wireless chip to reduce the power consumption. For wireless devices, this function is necessary to configure the power pin and other required pins to power down the wireless chip.

See section B-3-2 “NetDev_WiFi_Stop()” on page 389 for more information.

## 6-2-5 CONFIGURING THE INTERRUPT CONTROLLER FOR A WIRELESS DEVICE

`NetDev_WiFi_CfgIntCtrl()` is called by a device driver's `NetDev_WiFi_Init()` to configure a specific wireless device's external interrupts a specific wireless interface.

Each network device's `NetDev_WiFi_CfgIntCtrl()` function must configure without enabling all required interrupt sources for the network device. This means it must configure the interrupt vector address of each corresponding network device BSP interrupt service routine (ISR) handler and disable its corresponding interrupt source. For `NetDev_WiFi_CfgIntCtrl()`, the following actions should be performed:

1 Configure/store each device's network interface number to be available for all necessary `NetDev_WiFi_ISR_Handler()` functions (see section 6-3 on page 137 for more information). Even though devices are added dynamically, the device's interface number must be saved in order for each device's ISR handlers to call `NetIF_WiFi_ISR_Handler()` with the device's network interface number.

2 Configure each of the device's interrupts on an interrupt controller (either an external or CPU-integrated interrupt comptroller). However, vectored interrupt controllers may not require higher-level interrupt controller sources to be explicitly configured and enabled. In this case, you may need to configure the system's interrupt vector table with the name of the ISR handler functions declared in `net_bsp.c`.

`NetDev_WiFi_CfgIntCtrl()` should disable only each devices' interrupt sources. See section B-3-4 "NetDev_WiFi_CfgIntCtrl()" on page 393 for more information.

## 6-2-6 ENABLING AND DISABLING WIRELESS INTERRUPT

Each network device's `NetDev_WiFi_IntCtrl()` function must enable or disable all external required interrupt sources for the wireless device. This means enable or disable its corresponding interrupt source following the enable argument received.

See section B-3-5 "NetDev_WiFi_IntCtrl()" on page 397 for more information.

## 6-2-7 CONFIGURING THE SPI INTERFACE

`NetDev_WiFi_SPI_Init()` initializes a specific network device's SPI controller. This function will be called by a device driver's `NetDev_WiFi_SPI_Init()` when the interface is added.

Each network device's `NetDev_WiFi_SPI_Init()` should configure all required SPI controllers register for the network device. Since more than one device may share the same SPI bus, this function could be empty if the SPI controller is already configured.

If the SPI bus is not shared with other devices, it is recommended that `NetDev_WiFi_SPI_Init()` configures the SPI controller following the SPI device's communication settings and keep `NetDev_WiFi_SPI_Cfg()` empty.

See section B-3-12 "NetDev_WiFi_SPI_Cfg()" on page 411 for more information.

## 6-2-8 SETTING SPI CONTROLLER FOR A WIRELESS DEVICE

`NetDev_WiFi_SPI_Cfg()` configure a specific network device's SPI communication setting. This function is called by a device driver after the SPI's bus lock has been acquired and before starting to write and read to the SPI bus.

Each network device's `NetDev_WiFi_SPI_Cfg()` should configure all required SPI controllers register for the SPI's communication setting of the network wireless device. Several aspects of SPI communication may need to be configured, including:

- Clock frequency
- Clock polarity
- Clock phase
- Transfer unit length
- Shift direction

Since more than one device with different SPI's communication setting may share the same SPI bus, this function must reconfigure the SPI controller following the device's SPI communication setting each time the device driver must access the SPI bus. If the SPI bus is

not shared with other devices, it's recommended that NetDev_SPI_Cfg() configures SPI controller following the SPI's communication setting of the wireless device and to keep this function empty.

See section B-3-12 "NetDev_WiFi_SPI_Cfg()" on page 411 for more information.

## 6-2-9 LOCKING AND UNLOCKING SPI BUS

NetDev_WiFi_SPI_Lock() acquires a specific network device's SPI bus access. This function will be called before the device driver begins to access the SPI. The application should not use the same bus to access another device until the matching call to NetDev_WiFI_SPI_Unlock() has been made. If no other SPI device shares the same SPI bus, it's recommended to keep this function empty.

See section B-3-7 "NetDev_WiFi_SPI_Lock()" on page 401 for more information.

## 6-2-10 ENABLING AND DISABLING SPI CHIP SELECT

NetDev_WiFi_SPI_ChipSelEn() enables the chip select pin of the wireless device. This function is called before the device driver begins to access the SPI. The chip select pin should stay enabled until the matching call to NetDev_WiFi_SPI_ChipSelDis() has been made. The chip select pin is typically "active low." To enable the device, the chip select pin should be cleared; to disable the device, the chip select pin should be set.

See section B-3-10 "NetDev_WiFi_SPI_ChipSelEn()" on page 407 for more information.

## 6-2-11 WRITING AND READING TO THE SPI BUS

NetDev_WiFi_SPI_WrRd() writes and reads data to and from the SPI bus. This function is called each time the device driver accesses the SPI bus. NetDev_WiFi_SPI_WrRd() must not return until the write/read operation is complete. Writing and reading to the SPI bus by using DMA is possible, but the BSP layer must implement a notification mechanism to return from this function only when the write and read operations are entirely completed. See section B-3-9 "NetDev_WiFi_SPI_WrRd()" on page 405 for more information.

## 6-3 SPECIFYING THE INTERFACE NUMBER OF THE DEVICE ISR

`NetDev_ISR_Handler()` handles a network device's interrupts on a specific interface.

Each network device's interrupt, or set of device interrupts, must be handled by a unique BSP-level interrupt service routine (ISR) handler, `NetDev_ISR_Handler()`, which maps each specific device interrupt to its corresponding network interface ISR handler, `NetIF_ISR_Handler()`. For some CPUs, this may be a first- or second-level interrupt handler. The application must configure the interrupt controller to call every network device's unique `NetDev_ISR_Handler()` when the device's interrupt occurs (see section A-3-3 "NetDev_CfgIntCtrl()" on page 340). Every unique `NetDev_ISR_Handler()` must then perform the following actions:

1 Call `NetIF_ISR_Handler()` with the device's unique network interface number and appropriate interrupt type. The network interface number should be available in the device's `NetDev_CfgIntCtrl()` function after configuration (see section A-3-3 on page 340). `NetIF_ISR_Handler()` in turn calls the appropriate device driver's interrupt handler.

   In most cases, each device requires only a single `NetDev_ISR_Handler()`. This is possible when the device's driver is able determine the device's interrupt type via internal device registers or the interrupt controller. In this case, `NetDev_ISR_Handler()` calls `NetIF_ISR_Handler()` with interrupt type code `NET_DEV_ISR_TYPE_UNKNOWN`.

   However, some devices cannot determine the interrupt type when an interrupt occurs and may therefore require multiple, unique `NetDev_ISR_Handler()`'s, each of which calls `NetIF_ISR_Handler()` with the appropriate interrupt type code.

   Ethernet physical layer (PHY) interrupts should call `NetIF_ISR_Handler()` with interrupt type code `NET_DEV_ISR_TYPE_PHY`.

2 Clear the device's interrupt source, possibly via an external or CPU-integrated interrupt controller source.

See section B-3-13 "NetDev_WiFi_ISR_Handler()" on page 414 for more information.

## 6-4 MISCELLANEOUS NETWORK BSP

µC/TCP-IP also implements hardware abstraction code other than the device driver BSP. The following functions *must* be declared and implemented in `net_bsp.c`:

```
NET_TS    NetUtil_TS_Get     (void);
NET_TS_MS NetUtil_TS_Get_ms  (void);
void      NetTCP_InitTxSeqNbr(void);
```

The first two functions provide internal timestamp µC/TCP-IP functionality (although `NetUtil_TS_Get()` is not absolutely required), while the latter function is only necessary if µC/TCP-IP is configured to include the TCP module. Details for these functions can be found in their respective sections in Appendix C, "µC/TCP-IP API Reference" on page 417, and templates for these BSP functions are available in the `\Micrium\Software\uC-TCPIP-V2\BSP\Template\` directories.

Chapter

# 7

# Device Driver Implementation

This chapter describes the hardware (device) driver architecture for µC/TCP-IP. In order to understand the concepts discussed in this guide, you should be familiar with networking principles, the TCP/IP stack, real-time operating systems, and microcontrollers and processors.

µC/TCP-IP operates with a variety of network devices. Currently, µC/TCP-IP supports Ethernet type interface controllers wired and wireless, and will support serial, PPP, USB, and other popular interfaces in future releases.

There are many Ethernet controllers available on the market and each requires a driver to work with µC/TCP-IP. The amount of code needed to port a specific device to µC/TCP-IP greatly depends on device complexity.

If a driver for your hardware is not already available, you can develop a driver as described in this book. The best approach is to modify an already device driver with your device's specific code, following the Micrium coding convention for consistency. It is also possible to adapt drivers written for other TCP/IP stacks, especially if the driver code is short and it is a matter of simply copying data to and from the device.

## 7-1 CONCEPTS

Several aspects of the µC/TCP-IP driver architecture that are discussed in this chapter include:

### NETWORK INTERFACE

The network interface is the physical and logical implementation. Currently only network interface which use the IEEE 802.3 and/or Ethernet standards are supported.

### DEVICE DRIVER

A device driver is an interface between the common API of the µC/TCP-IP stack and the device specific architecture and available resources (RAM, DMA, IO, Peripheral Registers, etc…).

### ETHERNET DEVICE LAYER

The device layer of the Ethernet device driver implements functions to control the Media Access Controller (MAC). µC/TCP-IP supports internal and external wired Ethernet controller and connected to an Ethernet PHY. This layer implements functionality required by other network interface layers which are specific to the device and not to the board such as initializing, receiving and transmitting. This layer may implement functionally by setting and using controller register, DMA, or memory copy.

### ETHERNET PHY LAYER

PHY is the physical layer of the TCP/IP stack model between the Media Access Controller (MAC) and physical medium of the network (copper, optical fiber or RF). The PHY accomplishes two tasks: the first is to encode the transmitted data and decode received data; the second is to drive and read the medium with respect to bit timing, signal level and modulation.

### WIRELESS DEVICE LAYER

The device layer of the wireless device driver implements functions to control the Media Access Controller (MAC) a wireless module. µC/TCP-IP supports only wireless modules that include an integrated wireless supplicant (which is responsible for making login requests) and which communicate via SPI. Also the packet format used by the module must be 802.3 or Ethernet. This layer implements functionality required by other network interface layers

which are specific to the device and not to the board such as initializing, receiving and transmitting. This layer may implement functionally by writing and reading in the wireless device register through SPI.

### WIRELESS MANAGER

The Wireless Manager is a set of internal mechanisms to perform management operations on the wireless module such as scan, join, leave, and so on.

### DIRECT MEMORY ACCESS (DMA)

Direct Memory Access controller is a common hardware feature of processors and microcontrollers. DMA allows copying memory blocks from peripherals and internal memory while offloading the processor. An interrupt is generated when the transfer is completed to notify the CPU when a data transfer is completed.

### MEMORY COPY

In the case where the processor doesn't have DMA controllers, all memory transfers have to be executed by the processor. This method is called Memory Copy. It is less efficient than DMA transfers because the CPU has to move each element of the data, whereas it could do other tasks if a DMA was available to perform the data transfer.

### SPI

SPI (Serial Peripheral Interface) is a synchronous serial data link used by peripherals commonly built-in to CPUs. Since the communication can easily be accomplished by software control of GPIO pins ("software SPI" also known as "bit-banging"), SPI devices can be connected to almost any platform. Any SPI device uses four signals, which are used to communicate with the host (CS, DataIn, CLK and DataOut).

The four signals connecting the host and device (also known as master and slave) are named variously in different manuals and documents. The MOSI pin (Master Out Slave In) may be called DI on device pinouts; similarly, MISO pin (Master In Slave Out) may be called DO on device pinouts. The CS and CLK pins (also known as SSEL and SCK) are the chip select and clock pins. The host selects the slave by asserting CS, potentially allowing it to choose a single peripheral among several that are sharing the bus (i.e., by sharing the CLK, MOSI and MISO signals).

## 7-2 OVERVIEW OF THE µC/TCP-IP INTERFACE LAYERS

This section describe several aspects which are common to all Network interface type, wired or wireless.

### 7-2-1 CONFIGURATION STRUCTURES AND APIs INTERACTIONS

Once µC/TCP-IP is initialized each type of network interface, wired or wireless, must be added to the stack via `NetIF_Add()` the same function as shown previously in section 5-3-3 "Adding an Ethernet Interface" on page 94 and section 5-4-2 "Adding a Wireless Interface" on page 100.

µC/TCP-IP uses API functions to access the interface layer and configuration structures are used to initialize resources needed by the network interface. When writing a device drive you may have to create device driver and extension APIs and uses configurations structures in your implementation. Thus you must understand what is the interaction between each layer and API.

This is the `NetIF_Add()` prototype with the argument that you must pass:

```
NET_IF_NBR  NetIF_Add (void     *if_api,                    (1)
                       void     *dev_api,                   (2)
                       void     *dev_bsp,                   (3)
                       void     *dev_cfg,                   (4)
                       void     *ext_api,                   (5)
                       void     *ext_cfg,                   (6)
                       NET_ERR  *perr)                      (7)
```

Listing 7-1 **NetIF_Add() arguments**

L7-1(1) Pointer to specific network interface API. This API should always be provided with the TCP-IP stack, you must only pass the API of your interface type. You can find the API under the interface folder (`/IF`).

L7-1(2) Pointer to specific network device driver API. If you want to develop your own driver you must implement this API and you should start from the device driver template which can be find under the device folder (`/Dev/Template`). APIs for Ethernet and wireless have some differences; see section 7-5 "Ethernet Device

Driver Implementation" on page 158 and section 7-10 "Wireless Device Driver Implementation" on page 216 for further information about each type of Interface's API.

L7-1(3) Pointer to specific network device board-specific API. This API is used by the device driver initialization to configure several device aspect which are specific to the board and the application. Thus you must implements the API needed by your network interface. You should start from the BSP template provided with the stack which you can find under the BSP folder (`/BSP/Template`). For further information about the BSP layer to implement, section 6-1 "Ethernet BSP Layer" on page 122 and section 6-2 "Wireless BSP Layer" on page 127.

L7-1(4) Pointer to specific network device hardware configuration. This configuration structure is used by the interface and the device driver initialize resources needed by the interface. Each interface type has their own configuration structure which always starts with the standard memory configuration. You should start from the interface configuration template which you can find under the configuration template (`CFG/Template/net_dev_cfg.*`). See section 5-3 "Ethernet Interface Configuration" on page 90 and section 5-4 "Wireless Interface Configuration" on page 98 for further information about configurations structures. The device driver should validate the configuration structure before initializing registers and peripherals.

L7-1(5) Pointer to specific network extension layer API. This API is used by the interface to accomplish some operation specific to the physical type. For an Ethernet interface the extension layer is the PHY API. Micrium provides a generic Ethernet PHY which are compatible with the (R)MII standard, if your PHY is not compatible, you may have to implement an API for it. For further information about the Ethernet PHY API, see section 7-4 "Ethernet PHY API Implementation" on page 155.

For a wireless interface, the extension layer is the Wireless Manager API which can be found under (`Dev/WiFi/Manager`). If you write your own driver you may have to implement the extension API if the provided Wireless Manager doesn't provide the functionality needed by your device driver.

L7-1(6) Pointer to specific network extension layer configuration. This configuration structure is used by the extension layer to initialize by the interface. For an Ethernet interface you should pass the PHY configuration. This configuration structure might be null for a Wireless Manager.

L7-1(7) Pointer to variable that will receive the return error code from this function.

For a thorough description of the µC/TCP-IP files and directory structure, see Chapter 3, "Directories and Files" on page 41.

Figure 7-1 shows where these API are used by µC/TCP-IP and also the interaction between each interface layers and API passed to `NetIF_Add()`:

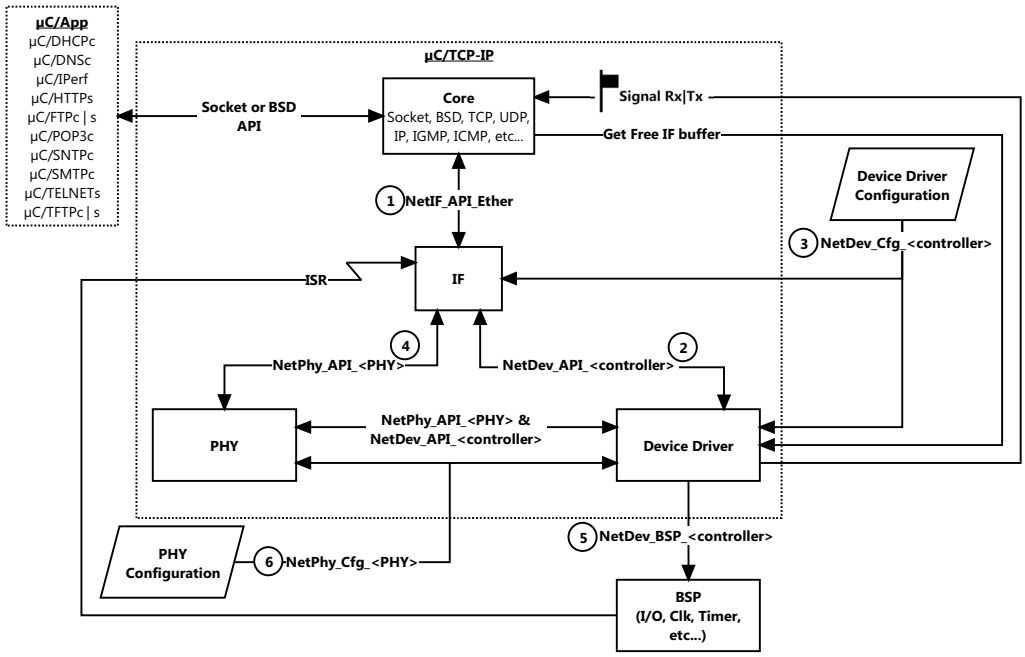



Figure 7-1 **Overview of µC/TCP-IP**

F7-1(1) `NetIF_API_Ether` and `NetIF_API_WiFi` specify the address of the link layer API structure used by the µC/TCPIP module to transmit and receive data from the hardware device. For an Ethernet interface, this value is always defined as

NetIF_API_Ether. For an wireless interface, this value is always defined as NetIF_API_WiFi. So, all you need to do is to add to your project the files contained in the IF folder.

F7-1(2) NetDev_API_<controller> is the address of the API structure used by the IF layer to initialize the controller and control transmissions/reception, multicast, controller speed, and so on.

F7-1(3) NetDev_Cfg_<controller> is a configuration structure used by the IF and driver layers to configure memory, reserve buffers, reserve descriptor area, and so on. You have to update this structure following your application requirements. Refer to section 5-3 "Ethernet Interface Configuration" on page 90 and section 5-4 "Wireless Interface Configuration" on page 98 for more information about how to configure an interface.

F7-1(4) For an Ethernet interface, a PHY API should be used. NetPhy_API_<phy> is the address of the API structure used by the IF and controller layers to control the PHY speed and to get the link state. If a generic (R)MII PHY provides the features you need, you do not have to implement this layer yourself; you can use the generic PHY. However, if the PHY does not support the MII or RMII standard, or necessary features are not provided by the generic (R)MII PHY, you will have to implement a new PHY.

For an wireless interface a Wireless Manager API should be used. NetWiFiMgr_API_Generic is the address of the API structure used by the IF and controller layers to control the wireless connection state.

F7-1(5) NetDev_BSP_<controller> is the address of the API structure used by the device driver to initialize interfaces specific to the board and the processor.

F7-1(6) For an Ethernet interface, a PHY configuration must be passed. NetPhy_Cfg_<phy> is the address of the API structure where the initial PHY configuration settings (such as link speed and link dupex) are defined. More details are provided on that structure in section 5-3 "Ethernet Interface Configuration" on page 90

For an wireless interface no configuration structure is needed.

## 7-2-2 µC/TCP-IP MEMORY MANAGEMENT

One of the most important aspect when writing a device driver is the memory management since each type of device driver should at least validate the interface memory configuration as shown in section 5-2-1 “Memory Configuration” on page 85. The device driver developer could use the memory configuration of the interface during the initialization to allocate memory uses uniquely within the device driver.

See section 5-2 “µC/TCP-IP Network Interface configuration” on page 85 for further information about the memory management and it’s configuration.

For non-DMA based devices, additional memory allocation from within the device driver may not be necessary. However, DMA based devices should allocate memory from the µC/LIB memory module for descriptors. By using the µC/LIB memory module instead of declaring arrays, the driver developer can easily align descriptors to any required boundary and benefit from the run-time flexibility of the device configuration structure.

If you have access to the source code, see the µC/LIB documentation for additional information and usage notes.

`Net_dev_cfg_<controller>.c/.h` is used to specify how much memory should be reserved by the µC/TCP-IP module for the device buffer and where to map it. As Figure 7-4 shows, the memory regions are managed by the core (`NetBuf` layer) which uses the µC/LIB memory module. The IF layer creates the memory pools for all configured buffers as per the information in `Net_dev_cfg_<controller>.c`.

When the driver requires additional memory, it is the responsibility of the developer to create the additional memory pools. For example, when your device supports DMA access, you have to reserve memory for the Receive/Transmit descriptors. As all memory pools are managed using µC/LIB, when you increase some device configuration value, the heap size of µC/LIB must follow the value modification. If not done properly, the µC/TCP-IP module will run out of memory during the initialization or too much memory will be reserved by µC/LIB.

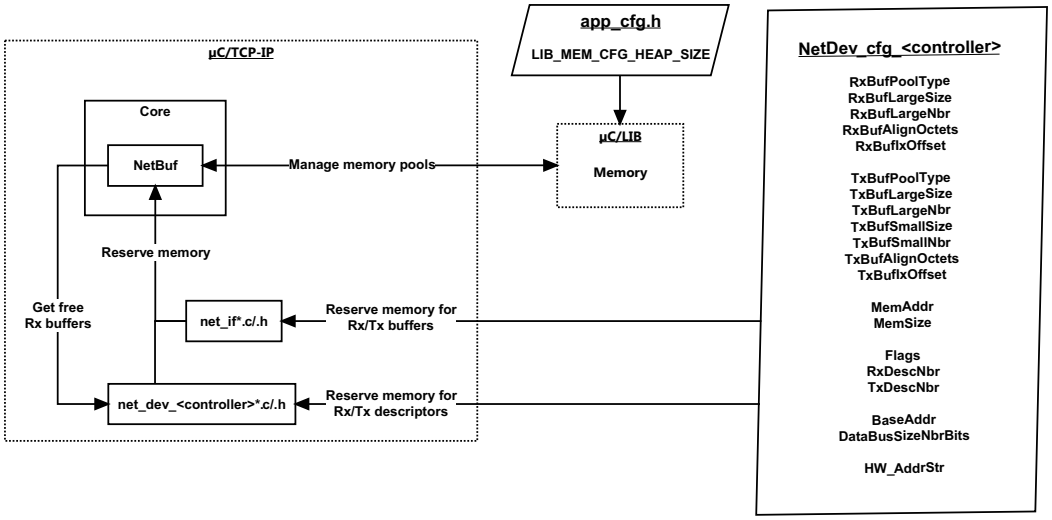
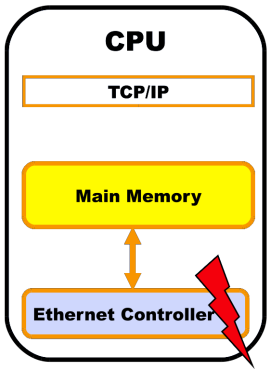



Figure 7-2 **Memory management**

µC/TCP-IP has been designed to operate with several device driver memory configurations. There are four possible memory configuration arrangements which are shown below:

## CPU WITH AN INTERNAL MEDIA ACCESS CONTROLLER (MAC)

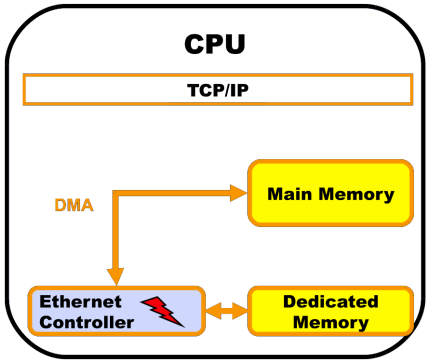
When a packet is received by the MAC, a DMA transfer from the MAC's internal buffer into main memory is initiated by the MAC. This method generally provides for shortened development time and excellent performance.



### CPU WITH AN INTERNAL MAC BUT WITH DEDICATED MEMORY

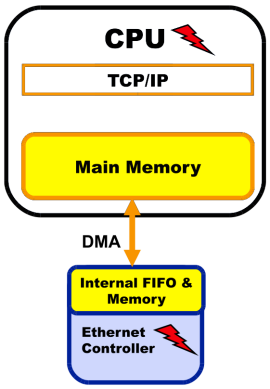
When a packet is received, the MAC initiates a DMA transfer into dedicated memory. Generally, most configurations of this type allow for transmission from main memory while reserving dedicated memory for either receive or transmit operations. Both the MAC and the CPU can read and write from dedicated memory and so the stack can process packets directly from dedicated memory.

Porting to this architecture is generally not difficult and provides for excellent performance. However, performance may be limited by the size of the dedicated memory; especially in cases where transmit and receive operations share the dedicated memory space.



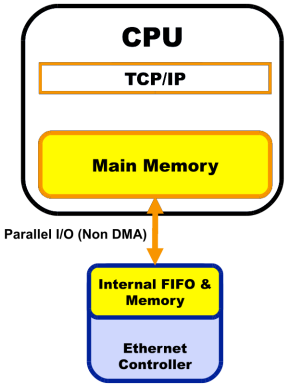

### COOPERATIVE DMA SOLUTION WHERE BOTH THE CPU AND MAC TAKE PART IN THE DMA OPERATION

This configuration is generally found on external devices that are either connected directly to the processor bus or connected via the ISA or PCI standard. This method requires that the CPU contain a DMA peripheral that can be configured to work within the architectural limitations of the external device. This method is more difficult to port to, but generally offers excellent performance.



### EXTERNAL DEVICE ATTACHED VIA THE CPU'S EXTERNAL BUS

Data is moved between main memory and the external device's internal memory via bus read and write cycles. The amount of data transferred in a given bus operation depends on the width of the data bus. This method requires additional CPU intervention in order to copy all of the data to and from the device when necessary. This method is generally easy to port and offers average performance.




These settings are likely to be influenced by the size of the available memory on the device. You will have to find these specific configuration values for the device driver and provides them to the stack user. An example of a typical device and buffer configuration is available in section F-2-2 "Network and Device Buffer Configuration" on page 792. The size and number of receive and transmit buffers depends on many factors, including, but not limited to:

- The desired level of performances
- The bandwidth required for the application
- CPU utilization

## 7-2-3 INTERRUPT HANDLING

This section provides an overview of interrupt handling, which is necessary to understand the reception and transmission of network packets. After reading this section, you should be ready to understand the description and explanations of the follow section of this chapter

Interrupt handling is accomplished using the following multi-level scheme.

1 Processor level interrupt handler

2 µC/TCP-IP BSP interrupt handler (Network BSP)

3 Device driver interrupt handler

During initialization, the device driver registers all necessary interrupt sources with the BSP interrupt management code. This may also be accomplished by plugging an interrupt vector table during compile time. Once the global interrupt vector sources are configured and an interrupt occurs, the system will call the first-level interrupt handler. The first-level handler then calls the network device's BSP handler which in turn calls `NetIF_ISR_Handler()` with the interface number and ISR type. The ISR type may be known if a dedicated interrupt vector is assigned to the source, or it may be de-multiplexed from the device driver by reading a register. If the interrupt type is unknown, then the BSP interrupt handler should call `NetIF_ISR_Handler()` with the appropriate interface number and `NET_IF_ISR_TYPE_UNKNOWN`.

The following ISR types have been defined from within µC/TCP-IP, however, additional type codes may be defined within each device's `net_dev.h`:

```
NET_DEV_ISR_TYPE_UNKNOWN
NET_DEV_ISR_TYPE_RX
NET_DEV_ISR_TYPE_RX_RUNT
NET_DEV_ISR_TYPE_RX_OVERRUN
NET_DEV_ISR_TYPE_TX_RDY
NET_DEV_ISR_TYPE_TX_COMPLETE
NET_DEV_ISR_TYPE_TX_COLLISION_LATE
NET_DEV_ISR_TYPE_TX_COLLISION_EXCESS
NET_DEV_ISR_TYPE_JABBER
NET_DEV_ISR_TYPE_BABBLE
NET_DEV_ISR_TYPE_TX_DONE
NET_DEV_ISR_TYPE_PHY
```

Depending on the architecture, there may be a network device BSP interrupt handler for each implemented device interrupt type (see also Chapter 6, "Network Board Support Package" on page 121 and section A-3-5 "NetDev_ISR_Handler()" on page 346). PHY interrupts should call `NetIF_ISR_Handler()` with a type code equal to `NET_DEV_ISR_TYPE_PHY`.

F7-2(1) The device driver must call the network device BSP during initialization in order to configure any module clocks, GPIO, or external interrupt controllers that require configuration. Note: Network device BSP is processor- and device-specific and must be supplied by the application developer. See Chapter 6, "Network Board Support Package" on page 121 for more details.

## 7-2-4 NETWORK PACKET RECEPTION OVERVIEW

This section is a quick overview of the mechanism put in place to handle the reception of network packets within the device driver, the µC/TCP-IP module and the OS.

A device's receive interrupt signals the µC/TCP-IP module for each packet received so that each receive is queued and later handled by µC/TCP-IP's network interface Receive task. Processing devices' received packets is deferred to the network interface Receive task to keep device ISRs as short as possible and make the driver easier to write.

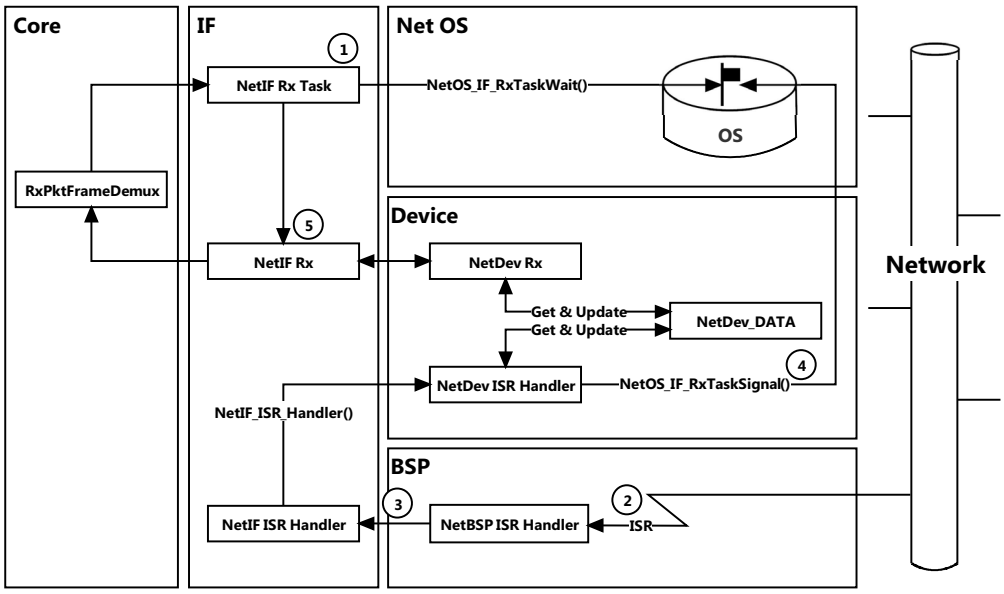



Figure 7-3 **Device Receive interrupt and network receive signaling**

F7-3(1) The µC/TCP-IP's network interface Receive task calls `NetOS_IF_RxTaskWait()` to wait for device receive packets to arrive by waiting (ideally without timeout) for the Device Rx Signal to be signaled.

F7-3(2) When a device packet is received, the device generates a receive interrupt which calls the device's BSP-level ISR handler.

F7-3(3) The device's BSP-level ISR handler determines which network interface number the specific device's interrupt is signaling and then calls `NetIF_ISR_Handler()` to handle the device's receive interrupt.

F7-3(4) `NetIF_Ether_ISR_Handler()` and `NetDev_ISR_Handler()`) (the network interface and device ISR handlers) call `NetOS_IF_RxTaskSignal()` to signal the Device Rx Signal for each received packet.

F7-3(5) µC/TCP-IP's network interface Receive task's call to `NetOS_IF_RxTaskWait()` is made ready for each received packet that signals the Device Rx Signal. The network interface Receive task then calls the specific network interface and device receive handler functions to retrieve the packet from the device. If the packet was not already received directly into a network buffer (e.g., via DMA), it is copied into a network buffer data. The network buffer is then de-multiplexed to higher-layer protocol(s) for further processing.

## 7-2-5 NETWORK PACKET TRANSMISSION OVERVIEW

A device's transmit complete interrupt signals µC/TCP-IP that another transmit packet is available to be transmitted or be queued for transmit by the device.

Figure 7-3 shows the relationship between a device's transmit complete interrupt, its transmit complete ISR handling and µC/TCP-IP's network interface transmit.

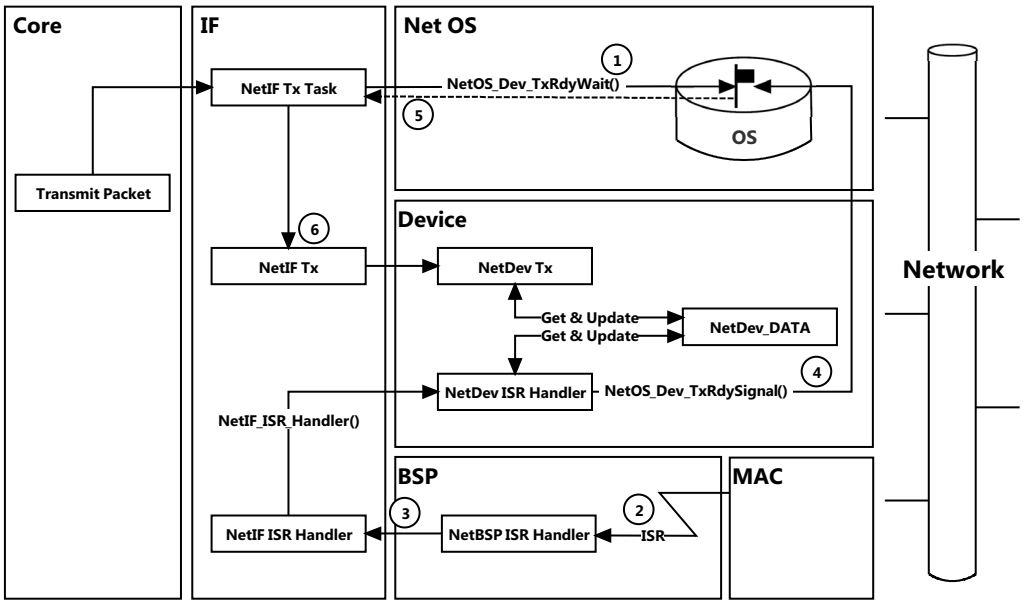



Figure 7-4 **Device transmit complete interrupt and transmit ready signal**

F7-4(1) The µC/TCP-IP's Network Interface Transmit calls `NetOS_Dev_TxRdyWait()` to wait for a specific network interface device semaphore to become ready and/or available to transmit a packet by waiting (with or without timeout) for the specific network interface's Device Tx Ready Signal to be signaled.

F7-4(2) When a device is ready and/or available to transmit a packet, the device generates an interrupt which calls the device's BSP-level ISR handler.

F7-4(3) The device's BSP-level ISR handler determines which network interface number the specific device's interrupt is signaling and then calls `NetIF_ISR_Handler()` to handle the transmit complete interrupt.

F7-4(4) The specific device ISR handlers `NetDev_ISR_Handler()` calls `NetOS_Dev_TxRdySignal()` to signal the Device Tx Ready Signal for each packet or descriptor that is now available to transmit by the device.

F7-4(5) µC/TCP-IP's Network Interface Transmit's call to `NetOS_Dev_TxRdyWait()` returns since the semaphore is made ready by each available device transmit complete that signals the Device Tx Ready Signal.

F7-4(6) The Network Interface Transmit then calls the specific network interface and device transmit handler functions to prepare the packet for transmission by the device.

## 7-3 ETHERNET LAYERS INTERACTIONS

This sections that follow describe the interactions between the IF layer, the Ethernet device driver API functions, the BSP API functions and the Ethernet PHY API functions. Since the device driver is made of not only logic but also from interactions with the parts on the board, you'll need to understand the calls made to the these layers of the µC/TCP-IP module and to the CPU and board-dependent layers.

Figure 7-5 shows the logical path between the physical layer and the device driver through the function calls and interruptions.

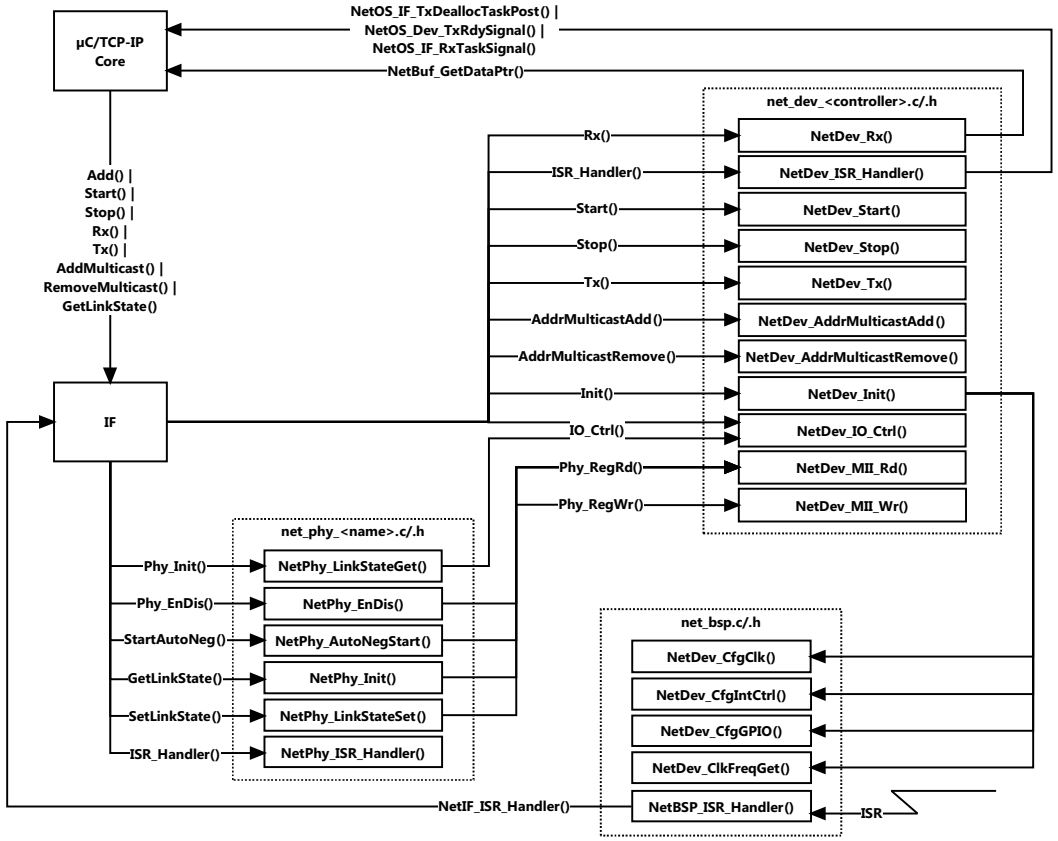



Figure 7-5 **PHY, device driver & BSP interactions**

# 7-4 ETHERNET PHY API IMPLEMENTATION

## 7-4-1 DESCRIPTION OF THE ETHERNET PHY API

Many Ethernet devices use external (R)MII compliant physical layers (PHYs) to attach themselves to the Ethernet wire. However, some MACs use embedded PHYs and do not have a MII-compliant communication interface. In this case, it may acceptable to merge the PHY functionality with the MAC device driver, in which case a separate PHY API and configuration structure may not be required. But in the event that an external (R)MII-compliant device is attached to the MAC, the PHY driver must implement the PHY API as follows:

```
const NET_PHY_API_ETHER NetPHY_API_DeviceName = { NetPhy_Init,                          (1)
                                                  NetPhy_EnDis,                        (2)
                                                  NetPhy_LinkStateGet,                 (3)
                                                  NetPhy_LinkStateSet,                 (4)
                                                  0                                    (5)
};
```

Listing 7-2 **PHY interface API**

L7-2(1) PHY initialization function pointer

L7-2(2) PHY enable/disable function pointer

L7-2(3) PHY link get status function pointer

L7-2(4) PHY link set status function pointer

L7-2(5) PHY interrupt service routine (ISR) handler function pointer

µC/TCP-IP provides code that is compatible with most (R)MII compliant PHYs. However, extended functionality, such as link state interrupts, must be implemented on a per-PHY basis. If additional functionality is required, it may be necessary to create an application specific PHY driver.

Note: It is the PHY driver developers' responsibility to ensure that all of the functions listed within the API are properly implemented and that the order of the functions within the API structure is correct. The `NetPhy_ISR_Handler` field is optional and may be populated as `(void *)0` if interrupt functionality is not required.

### 7-4-2 HOW TO INITIALIZE THE PHY

`NetPhy_Init()` initializes the PHY driver. It is called by the Ethernet network interface layer after the MAC device driver, if the latter initialized without error.

The PHY initialization function is responsible of the following actions:

1 Reset the PHY and wait with timeout for reset to complete. If a timeout occurs, return `perr` set to `NET_PHY_ERR_RESET_TIMEOUT`.

2 Start the auto-negotiation process. This should configure the PHY registers such that the desired link speed and duplex specified within the PHY configuration are respected. It is not required to wait until the auto-negotiation process has completed, as this can take upwards of many seconds. This action is performed by calling the PHY's `NetPhy_AutoNegStart()` function.

3 If no errors occur, return `perr` set to `NET_PHY_ERR_NONE`.

### 7-4-3 HOW ENABLE OR DISABLE THE PHY

`NetPhy_EnDis()` is called by the Ethernet network interface layer when an interface is started or stopped.

Disabling the PHY will causes the PHY to power down which will causes the link state to be disconnected.

### 7-4-4 HOW TO GET THE NETWORK LINK STATE

The `NetPhy_LinkStateGet()` function returns the current Ethernet link state. Results are passed back to the caller in a `NET_DEV_LINK_ETHER` structure which contains fields for link speed and duplex. This function is called periodically by the µC/TCP-IP module.

The generic PHY driver does not return a link state. Instead, in order to avoid access to extended registers which are PHY specific, the driver attempts to determine link state by analyzing the PHY and PHY partner capabilities. The best combination of auto-negotiated link state is selected as the current link state.

### 7-4-5 HOW TO SET THE LINK SPEED AND DUPLEX

NetPhy_LinkStateSet() function sets the current Ethernet link state. Results are passed back to the caller within a NET_DEV_LINK_ETHER structure which contains fields for link speed and duplex. This function is called by NetIF_Start().

### 7-4-6 HOW TO SPECIFY THE ADDRESS OF THE PHY ISR

NetPhy_ISR_Handler() handles PHY's interrupts. See section 7-4-7 on page 157 for more details on how to handle PHY interrupts. µC/TCP-IP does not require PHY drivers to enable or handle PHY interrupts. The generic PHY drivers does not even define a PHY interrupt handler function but instead handles all events by either periodic or event-triggered calls to other PHY API functions.

### 7-4-7 NETPHY_ISR_HANDLER()

NetPhy_ISR_Handler() is the physical layer interrupt handier. The PHY ISR handler is called though the network device BSP in a similar manner to that of the device ISR handler. The network device BSP is used to initialize the host interrupt controller, clocks, and any necessary I/O pins that are required for configuring and recognizing PHY interrupt sources. When an interrupt occurs, the first level interrupt handler calls the network device BSP interrupt handler which in turn calls NetIF_ISR_Handler() with the interface number and interrupt type set to NET_IF_ISR_TYPE_PHY. The PHY ISR handler should execute the necessary instructions, clear the PHY interrupt flag and exit.

Note: Link state interrupts must call both the Ethernet device driver and Net IF in order to inform both layers of the current link status. This is performed by calling pdev_api->IO_Ctrl() with the option NET_IF_IO_CTRL_LINK_STATE_UPDATE as well as a pointer to a NET_DEV_LINK_ETHER structure containing the current link state speed and duplex. Additionally, the PHY device driver must call NetIF_LinkStateSet() with a pointer to the interface and a Boolean value set to either NET_IF_LINK_DOWN or NET_IF_LINK_UP.

Note: The Generic PHY driver provided with µC/TCP-IP does not support interrupts. PHY interrupt support requires use of the extended PHY registers which are PHY-specific. However, link state is polled periodically by µC/TCP-IP and you can configure the period during compile time.

## 7-5 ETHERNET DEVICE DRIVER IMPLEMENTATION

### 7-5-1 DESCRIPTION OF THE ETHERNET DEVICE DRIVER API

All device drivers must declare an instance of the appropriate device driver API structure as a global variable within the source code. The API structure is an ordered list of function pointers utilized by µC/TCP-IP when device hardware services are required.

A sample Ethernet interface API structure is shown below.

```
const  NET_DEV_API_ETHER  NetDev_API_<controler> = { NetDev_Init,                          (1)
                                                     NetDev_Start,                         (2)
                                                     NetDev_Stop,                          (3)
                                                     NetDev_Rx,                            (4)
                                                     NetDev_Tx,                            (5)
                                                     NetDev_AddrMulticastAdd,              (6)
                                                     NetDev_AddrMulticastRemove,           (7)
                                                     NetDev_ISR_Handler,                   (8)
                                                     NetDev_IO_Ctrl,                       (9)
                                                     NetDev_MII_Rd,                       (10)
                                                     NetDev_MII_Wr                        (11)
                                                   };
```

Listing 7-3 **Ethernet interface API**

Note: It is the device driver developers' responsibility to ensure that all of the functions listed within the API are properly implemented and that the order of the functions within the API structure is correct.

L7-3(1) Device initialization/add function pointer

L7-3(2) Device start function pointer

L7-3(3) Device stop function pointer

L7-3(4) Device Receive function pointer

L7-3(5) Device transmit function pointer

L7-3(6) Device multicast address add function pointer

L7-3(7) Device multicast address remove function pointer

L7-3(8) Device interrupt service routine (ISR) handler function pointer

L7-3(9) Device I/O control function pointer

L7-3(10) Physical layer (PHY) register read function pointer

L7-3(11) Physical layer (PHY) register write function pointer

Note: µC/TCP-IP device driver API function names may not be unique. Name clashes between device drivers are avoided by never globally prototyping device driver functions and ensuring that all references to functions within the driver are obtained by pointers within the API structure. The developer may arbitrarily name the functions within the source file so long as the API structure is properly declared. The user application should never need to call API functions by name. Unless special care is taken, calling device driver functions by name may lead to unpredictable results due to reentrancy.

The following figure describes the call path from the application layer through the Core, Interface and Controller layers.

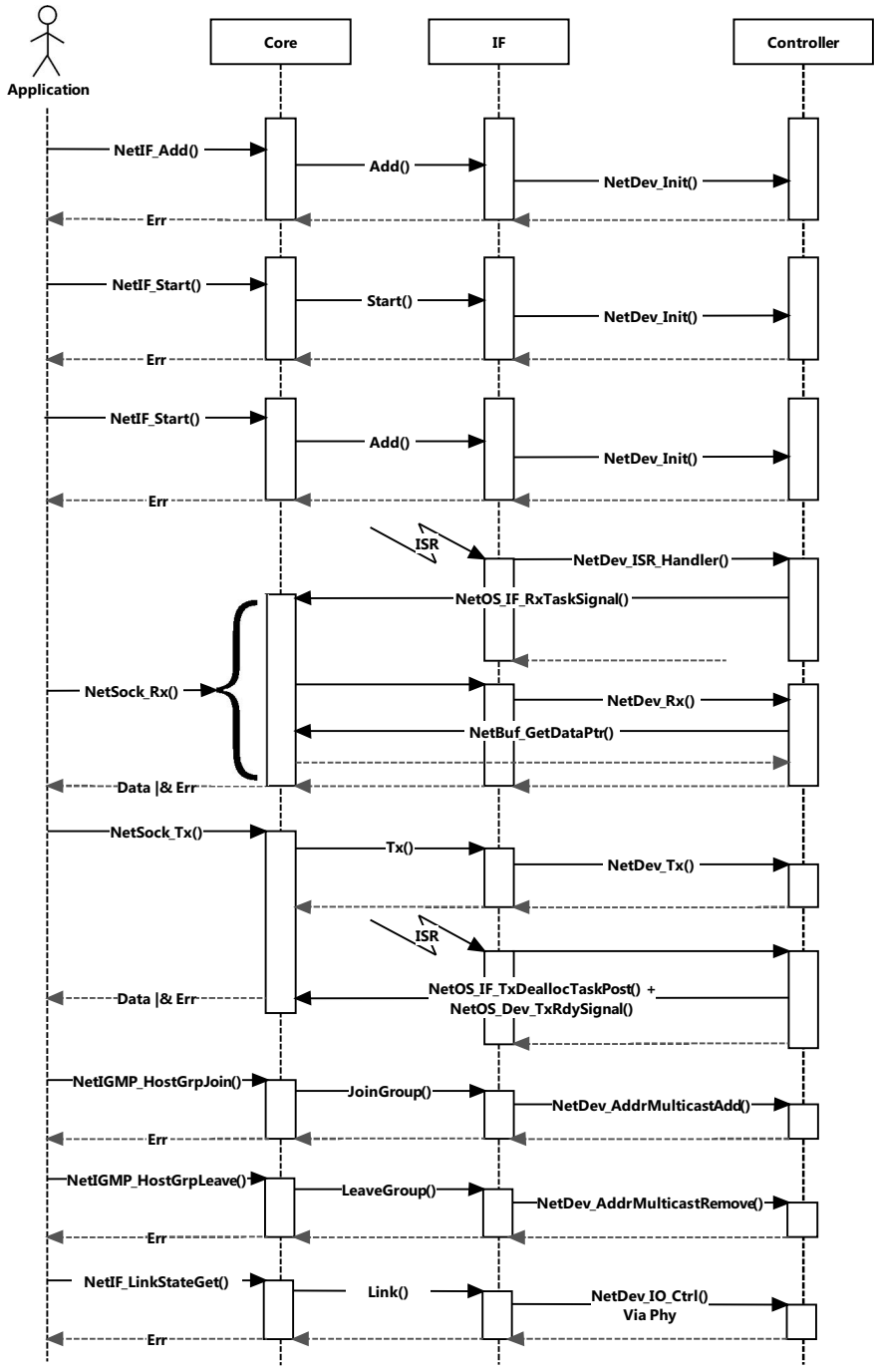



Figure 7-6 **Call path of controller functions**

## 7-5-2 INITIALIZING A NETWORK DEVICE

`NetDev_Init()` is called by `NetIF_Add()` exactly once for each specific network device added by the application. If multiple instances of the same network device are present on the board, then this function is called for each instance of the device. However, applications should not try to add the same specific device more than once. If a network device fails to initialize, we recommend debugging to find and correct the cause of the failure.

`NetDev_Init()` performs the following operations. However, depending on the device being initialized, functionality may need to be added or removed:

1 Configure clock gating to the MAC device, if applicable. This is performed via the network device's BSP function pointer, `NetDev_CfgClk()`, implemented in `net_bsp.c` (see section A-3-1 "NetDev_CfgClk()" on page 336).

2 Configure all necessary I/O pins for both an internal or external MAC and PHY, if present. This is performed via the network device's BSP function pointer, `NetDev_CfgGPIO()`, implemented in `net_bsp.c`.

Configure the host interrupt controller for receive and transmit complete interrupts. Additional interrupt services may be initialized depending on the device and driver requirements. This is performed via the network device's BSP function pointer, `NetDev_CfgIntCtrl()`, implemented in `net_bsp.c`.

3 For DMA devices: Allocate memory for all necessary descriptors. This is performed via calls to µC/LIB's memory module.

4 For DMA devices: Initialize all descriptors to their ready states. This may be performed via calls to locally-declared, static functions.

5 Initialize the (R)MII bus interface, if applicable. This entails configuring the (R)MII bus frequency which is dependent on the system clock. Static values for clock frequencies should never be used when determining clock dividers. Instead, the driver should reference the associated clock function(s) for getting the system clock or peripheral bus frequencies, and use these values to compute the correct (R)MII bus clock divider(s). This is performed via the network device's BSP function pointer, `NetDev_ClkFreqGet()`, implemented in `net_bsp.c`.

6 Disable the transmitter and receiver (should already be disabled).

7 Disable and clear pending interrupts (should already be cleared).

8 Set `perr` to `NET_DEV_ERR_NONE` if initialization proceeded as expected. Otherwise, set `perr` to an appropriate network device error code.

### 7-5-3 STARTING A NETWORK DEVICE

`NetDev_Start()` is called once each time an interface is started. It performs the following actions:

1 Call the `NetOS_Dev_CfgTxRdySignal()` function to configure the transmit ready semaphore count. This function call is optional and is performed if the hardware device supports queuing multiple transmit frames. By default, the semaphore count is initialized to one. However, DMA devices should set the semaphore count equal to the number of configured transmit descriptors for optimal performance. Non-DMA devices that support queuing more than one transmit frame may also benefit from a non-default value.

2 Initialize the device MAC address, if applicable. For Ethernet devices, this step is mandatory. The MAC address data may come from one of three sources and should be set using the following priority scheme:

- Configure the MAC address using the string found within the device configuration structure. This is a form of static MAC address configuration and may be performed by calling `NetASCII_Str_to_MAC()` and `NetIF_AddrHW_SetHandler()`. If the device configuration string has been left empty, or is specified as all 0's, an error will be returned and the next method should be attempted.

- Check if the application developer has called `NetIF_AddrHW_Set()` by making a call to `NetIF_AddrHW_GetHandler()` and `NetIF_AddrHW_IsValidHandler()` in order to check if the specified MAC address is valid. This method may be used as a static method for configuring the MAC address during run-time, or a dynamic method should a pre-programmed external memory device exist. If the acquired MAC address does not pass the check function, then:

- Call `NetIF_AddrHW_SetHandler()` using the data found within the individual MAC address registers. If an auto-loading EEPROM is attached to the MAC, the registers will contain valid data. If not, then a configuration error has occurred. This method is often used with a production process where the MAC supports automatically loading individual address registers from a serial EEPROM. When using this method, you should specify an empty string for the MAC address within the device configuration, and refrain from calling `NetIF_AddrHW_Set()` from within the application.

3 Initialize additional MAC registers required by the MAC for proper operation.

4 Clear all interrupt flags.

5 Locally enable interrupts on the hardware device. The host interrupt controller should have already been configured within the device driver `NetDev_Init()` function.

6 Enable the receiver and transmitter.

7 Set perr equal to `NET_DEV_ERR_NONE` if no errors have occurred. Otherwise, set perr to an appropriate network device error code

### 7-5-4 STOPPING A NETWORK DEVICE

`NetDev_Stop()` is called once each time an interface is stopped.

`NetDev_Stop()` must perform the following operations:

1 Disable the receiver and transmitter.

2 Disable all local MAC interrupt sources.

3 Clear all local MAC interrupt status flags.

4 For DMA devices, re-initialize all receive descriptors.

5 For DMA devices, free all transmit descriptors by calling `NetOS_IF_DeallocTaskPost()` with the address of the transmit descriptor data areas.

6 For DMA devices, re-initialize all transmit descriptors.

7 Set `perr` to `NET_DEV_ERR_NONE` if no error occurs. Otherwise, set `perr` to an appropriate network device error code.

### 7-5-5 NETDEV_ISR_HANDLER()

`NetDev_ISR_Handler()` is the device interrupt handler. In general, the device interrupt handler must perform the following functions:

1 Determine which type of interrupt event occurred by switching on the ISR type argument, or reading an interrupt status register if the event type is unknown.

2 If a receive event has occurred, the driver must post the interface number to the µC/TCP-IP Receive task by calling `NetOS_IF_RxTaskSignal()` for each new frame received.

3 If a transmit complete event has occurred, the driver must perform the following items for each transmitted packet.

   aPost the address of the data area that has completed transmission to the transmit buffer de-allocation task by calling `NetOS_IF_TxDeallocTaskPost()` with the pointer to the data area that has completed transmission.

   bCall `NetOS_Dev_TxRdySignal()` with the interface number that has just completed transmission.

4 Clear local interrupt flags.

External or CPU's integrated interrupt controllers should be cleared from within the network device's BSP-level ISR after `NetDev_ISR_Handler()` returns. Additionally, it is highly recommended that device driver ISR handlers be kept as short as possible to reduce the amount of interrupt latency in the system.

Each device's `NetDev_ISR_Handler()` should check all applicable interrupt sources to see if they are active. This additional checking is necessary because multiple interrupt sources may be set within the interrupt response time and will reduce the number and overhead of handling interrupts. `NetDev_ISR_Handler()` should never return early.

## 7-5-6 RECEIVING PACKETS ON A NETWORK DEVICE

`NetDev_Rx()` is called by µC/TCP-IP's Receive task after the Interrupt Service Routine handler has signaled to the Receive task that a receive event has occurred. `NetDev_Rx()` requires that the device driver return a pointer to the data area containing the received data and return the size of the received frame via pointer.

`NetDev_Rx()` should perform the following actions:

1 Check for receive errors, if applicable. If an error should occur during reception, the driver should set `*size` to 0 and `*p_data` to `(CPU_INT08U *)0` and return. Additional steps may be necessary depending on the device being serviced.

2 For Ethernet devices, get the size of the received frame and subtract four bytes for the CRC. It's recommended to first check the frame size to ensure that it is larger than four bytes before performing the subtraction, to ensure that an underflow does not occur. Set `*size` to the adjusted frame size.

3 Get a new data buffer area by calling `NetBuf_GetDataPtr()`. If memory is not available, an error will be returned and the device driver should set `*size` to 0 and `*p_data` to `(CPU_INT08U *)0`.

4 If an error does not occur while getting a new data area, `*p_data` must be set to the address of the data area.

5 Set `perr` to `NET_DEV_ERR_NONE` and return from the receive function. Otherwise, set `perr` to an appropriate network device error code.

## 7-5-7 TRANSMITTING PACKETS ON A NETWORK DEVICE

`NetDev_Tx()` is used to notify the Ethernet device that a new packet is available to be transmitted. It performs the following actions:

1 For DMA-based hardware, the driver should select the next available transmit descriptor and set the pointer to the data area equal to the address pointer to by `p_data`.

2 For non-DMA hardware, the driver should call `Mem_Copy()` to copy the data stored in the buffer to the device's internal memory. The address of the buffer is specified by `p_data`.

3 Once completed, the driver must configure the device with the number of bytes to transmit. This value contained in the `size` argument. DMA-based devices have a size field within the transmit descriptor. Non-DMA devices have a transmit size register that must be configured.

4 The driver then takes all necessary steps to initiate transmission of the data.

5 `NetDev_Tx()` sets `perr` to `NET_DEV_ERR_NONE` and return from the transmit function.

## 7-5-8 ADDING AN ADDRESS TO THE MULTICAST ADDRESS FILTER OF A NETWORK DEVICE

`NetDev_AddrMulticastAdd()` is used to configure a device with an (IP-to-Ethernet) multicast hardware address.

Since many network controllers' documentation fails to properly indicate how to add/configure an Ethernet MAC device with a multicast address, the following method is recommended for determining and testing the correct multicast hash bit algorithm.

1 Configure a packet capture program or multicast application to broadcast a multicast packet with Ethernet destination address of 01:00:5E:00:00:01 (which is an IPv4 Ethernet multicast address). This MAC address corresponds to the multicast group IP address of 224.0.0.1 which will be converted to a MAC address by higher layers and passed to this function.

2 Set a break point in the receive ISR handler, and transmit one Send packet to the target. The break point should not be reached as the result of the transmitted packet. Use caution to ensure that other network traffic is not the source of the interrupt when the button is pressed. Sometimes asynchronous network events happen very close in time and the end result can be deceiving. Ideally, these tests should be performed on an isolated network, but if that is not an option, disconnect as many other hosts from the network as possible.

3 Use the debugger to stop the application and program the MAC multicast hash register low bits to 0xFFFFFFFF. Go to step 2. Repeat for the hash bit high register if necessary. The goal is to bracket off which bit in either the high or low hash bit register causes the device to be interrupted when the broadcast frame is received by the target. Once the correct bit is known, the hash algorithm can be easily written and tested.

4 Update the device driver's `NetDev_AddrMulticastAdd()` function to calculate and configure the correct CRC. The sample code in Listing 7-4 can be adjusted as per the network controller's documentation in order to get the hash from the correct subset of CRC bits. Most of the code is similar between various devices and is thus reusable. The hash algorithm is the exclusive OR of every 6th bit of the destination address:

```
hash[5] = da[5] ^ da[11] ^ da[17] ^ da[23] ^ da[29] ^ da[35] ^ da[41] ^ da[47]
hash[4] = da[4] ^ da[10] ^ da[16] ^ da[22] ^ da[28] ^ da[34] ^ da[40] ^ da[46]
hash[3] = da[3] ^ da[09] ^ da[15] ^ da[21] ^ da[27] ^ da[33] ^ da[39] ^ da[45]
hash[2] = da[2] ^ da[08] ^ da[14] ^ da[20] ^ da[26] ^ da[32] ^ da[38] ^ da[44]
hash[1] = da[1] ^ da[07] ^ da[13] ^ da[19] ^ da[25] ^ da[31] ^ da[37] ^ da[43]
hash[0] = da[0] ^ da[06] ^ da[12] ^ da[18] ^ da[24] ^ da[30] ^ da[36] ^ da[42]
```

Where da[0] represents the least significant bit of the first byte of the Ethernet destination address (da) received and where da[47] represents the most significant bit of the last byte of the Ethernet destination address received.

5 Test the device driver's `NetDev_AddrMulticastAdd()` function by ensuring that the group address 224.0.0.1, when joined from the application correctly configures the device to receive multicast packets destined to the 224.0.0.1 address. Then broadcast to 224.0.0.1 to test if the device receives the multicast packet.

```
                                                /* ---------- CALCULATE HASH CODE ---------- */
hash = 0;
for (i = 0; i < 6; i++) {                       /* For each row in the bit hash table:       */
    bit_val = 0;                                /* Clear initial xor value for each row.     */
    for (j = 0; j < 8; j++) {                   /* For each bit in each octet:               */
        bit_nbr    = (j * 6) + i;               /* Determine which bit in stream, 0-47.      */
        octet_nbr  =  bit_nbr / 8;              /* Determine which octet bit belongs to.     */
        octet      =  paddr_hw[octet_nbr];      /* Get octet value.                          */
                                                /* Check if octet's bit is set.              */
        bit        =  octet & (1 << (bit_nbr % 8));
        bit_val   ^= (bit > 0) ? 1 : 0;         /* Calculate table row's XOR hash value.     */
    }
     hash |= (bit_val << i);                    /* Add row's XOR hash value to final hash.   */
}
                                                /* ---- ADD MULTICAST ADDRESS TO DEVICE ---- */
reg_sel = (hash >> 5) & 0x01;                   /* Determine hash register     to configure. */
reg_bit = (hash >> 0) & 0x1F;                   /* Determine hash register bit to configure. */
                                                /* (Substitute '0x01'/'0x1F' with device's ..*/
                                                /* .. actual hash register bit masks/shifts.)*/
  paddr_hash_ctrs = &pdev_data->MulticastAddrHashBitCtr[hash];
(*paddr_hash_ctrs)++;                           /* Increment hash bit reference counter.     */
if (reg_sel == 0) {                             /* Set multicast hash register bit.          */
    pdev->MCAST_REG_LO |= (1 << reg_bit);       /* (Substitute 'MCAST_REG_LO/HI' with ..     */
} else {                                        /* .. device's actual multicast registers.)  */
    pdev->MCAST_REG_HI |= (1 << reg_bit);
}
```

Listing 7-4 **Explicit multicast hash code**

## ALTERNATE HASH CODE

Alternatively, Figure 7-7 shows how the CRC hash can be computed with a call to `NetUtil_32BitCRC_CalcCpl()` followed by an optional call to `NetUtil_32BitReflect()`, with four possible combinations:

- CRC without complement, without reflection
- CRC without complement, with reflection
- CRC with complement, without reflection
- CRC with complement, with reflection

```
                                                    /* ---------- CALCULATE HASH CODE ---------- */
                                                    /* Calculate CRC.                             */
crc = NetUtil_32BitCRC_Calc((CPU_INT08U *)paddr_hw,
                            (CPU_INT32U  ) addr_hw_len,
                            (NET_ERR    *)perr);
if (*perr != NET_UTIL_ERR_NONE) {
     return;
}
                                                    /* ---- ADD MULTICAST ADDRESS TO DEVICE ---- */
crc     =  NetUtil_32BitReflect(crc);               /* Optionally, complement CRC.              */
hash    = (crc >> 23u) & 0x3F;                      /* Determine hash register     to configure. */
reg_bit = (hash % 32u);                             /* Determine hash register bit to configure. */
                                                    /* (Substitute '23u'/'0x3F' with device's .. */
                                                    /* .. actual hash register bit masks/shifts.)*/
  paddr_hash_ctrs = &pdev_data->MulticastAddrHashBitCtr[hash];
(*paddr_hash_ctrs)++;                               /* Increment hash bit reference counter.     */
if (hash <= 31u) {                                  /* Set multicast hash register bit.          */
    pdev->MCAST_REG_LO |= (1 << reg_bit);           /* (Substitute 'MCAST_REG_LO/HI' with ..     */
} else {                                            /* .. device's actual multicast registers.)  */
    pdev->MCAST_REG_HI |= (1 << reg_bit);
}
```

Listing 7-5 **CRC Multicast Hash Code**

Unfortunately, the network controller's documentation will likely not tell you which combination of complement and reflection is needed to properly compute the hash value. The documentation will likely state 'Standard Ethernet CRC', which when compared to other documents, means any of the four combinations above; different than the actual frame CRC.

Fortunately, if the code is written to perform both the complement and reflection, then you can use the debugger to repeat the code block over and over, skipping either the line that performs the complement or the function call to the reflection, until the output hash bit is computed correctly.

## 7-5-9 REMOVING AN ADDRESS FROM THE MULTICAST ADDRESS FILTER OF A NETWORK DEVICE

`NetDev_AddrMulticastRemove()` is used to remove an (IP-to-Ethernet) multicast hardware address from a device.

You can use exactly the same code as in `NetDev_AddrMulticastAdd()` to calculate the device's CRC hash, but instead remove a multicast address by decrementing the device's hash bit reference counters and clearing the appropriate bits in the device's multicast registers. See Figure 7-8 below.

```
                                                /* ---------- CALCULATE HASH CODE ---------- */
/* Use NetDev_AddrMulticastAdd()'s algorithm to calculate CRC hash.                          */
                                                /* - REMOVE MULTICAST ADDRESS FROM DEVICE -- */
paddr_hash_ctrs = &pdev_data->MulticastAddrHashBitCtr[hash];
if (*paddr_hash_ctrs > 1u) {                    /* If multiple multicast addresses hashed, ..*/
   (*paddr_hash_ctrs)--;                        /* .. decrement hash bit reference counter ..*/
    *perr = NET_DEV_ERR_NONE;                   /* .. but do NOT unconfigure hash register.  */
     return;
}
*paddr_hash_ctrs = 0u;                          /* Clear hash bit reference counter.         */
if (hash <= 31u) {                              /* Clear multicast hash register bit.        */
    pdev->MCAST_REG_LO &= ~(1u << reg_bit);     /* (Substitute 'MCAST_REG_LO/HI' with ..     */
} else {                                        /* .. device's actual multicast registers.)  */
    pdev->MCAST_REG_HI &= ~(1u << reg_bit);
}
```

Listing 7-6 **Removing Multicast Address**

## 7-5-10 SETTING THE MAC LINK, DUPLEX AND SPEED SETTINGS

NetDev_IO_Ctrl() is used to implement miscellaneous functionality such as setting and getting the PHY link state, as well as updating the MAC link state registers when the PHY link state has changed. An optional void pointer to a data variable is passed into the function and may be used to get device parameters from the caller, or to return device parameters to the caller. µC/TCP-IP defines the following default options: NET_DEV_LINK_STATE_GET_INFO and NET_DEV_LINK_STATE_UPDATE.

The NET_DEV_LINK_STATE_GET_INFO option expects p_data to point to a variable of type NET_DEV_LINK_ETHER for the case of an Ethernet driver. This variable has two fields, Speed and Duplex, which are filled in by the PHY device driver via a call through the PHY API. µC/TCP-IP internally uses this option code in order to periodically poll the PHYs for link state. The NET_DEV_LINK_STATE_UPDATE option is used by the PHY driver to communicate with the MAC when either µC/TCP-IP polls the PHY for link status, or when a PHY interrupt occurs. Not all MAC's require PHY link state synchronization. Should this be the case, then the device driver may not need to implement this option.

## 7-5-11 READING PHY REGISTERS

NetDev_MII_Rd() is implemented within the Ethernet device driver file, since (R)MII bus reads are associated with the MAC device. In the case that the PHY communication mechanism is separate from the MAC, then a handler function may be provided within the net_bsp.c file and called from the device driver file instead. Note: This function must be implemented with a timeout and should not block indefinitely should the PHY fail to respond.

## 7-5-12 WRITING TO PHY REGISTERS

NetDev_MII_Wr() is implemented within the Ethernet device driver file since (R)MII bus writes are associated with the MAC device. In the case that the PHY communication mechanism is separate from the MAC, a handler function may be provided within the net_bsp.c file and called from the device driver file instead.

Note: This function must be implemented with a timeout and not block indefinitely should the PHY fail to respond.

## 7-6 ETHERNET - TRANSMITTING & RECEIVING USING DMA

A DMA controller is a device that moves data through a system independently of the CPU/MCU. It connects internal and peripheral memories via a set of dedicated buses. A DMA controller can also be considered a peripheral itself in the sense that the processor programs it to perform data transfers.

In general, a DMA controller includes an address bus, a data bus, and control registers. An efficient DMA controller possesses the ability to request access to any resource it needs, without involving the CPU. It must have the capability to generate interrupts and to calculate addresses.

A processor might contain multiple DMA controllers, multiple DMA channels, and multiple buses that link the memory banks and peripherals directly. Processors with an integrated Ethernet controller typically have a DMA controller for their Ethernet hardware.

Generally, the processor should need to respond to DMA interrupts only after the data transfers are completed. The DMA controller is programmed by the processor to move data in parallel while the processor is doing its regular processing tasks.

Since the DMA controller has the capability to interface with memory, it can get its own instruction from memory. Picture a DMA controller as a simple processor with a simple instruction set. DMA channels have a finite number of registers that need to be filled with values, each of which gives a description of how to transfer the data.

There are two main classes of DMA transfer: Register Mode and Descriptor Mode. In Register mode, the DMA controller is programmed by the CPU by writing the required parameters in the DMA registers. In Descriptor mode, the DMA can use its read memory circuitry to fetch the register values itself rather than burdening the CPU to write the values. The blocks of memory containing the required register parameters are called *descriptors.* When the DMA runs in Register Mode, the DMA controller simply uses the values contained in the registers.

Descriptor Mode provides the best results, and is mostly found in microprocessor/ microcontroller DMA controllers with integrated Ethernet controller. This is the mode described in detail below.

## DESCRIPTOR MODE

In Descriptor Mode, the formatting of the descriptor information is provided by the DMA controller. The descriptor contains all of the same parameters that the CPU (operating in Register Mode) would program into the DMA control registers.

Descriptor Mode allows multiple DMA sequences to be chained together so the controller be programmed to automatically set up and start another DMA transfer after the current sequence completes. The descriptor-based model provides the most flexible configuration to manage a system's memory.

The DMA controller provides a main descriptor model method; normally called a *Descriptor List*. Depending on the DMA controller, the descriptor list may reside in consecutive memory locations, but this is not mandatory. µC/TCP-IP reserves consecutive memory blocks for descriptors and both models can be used.

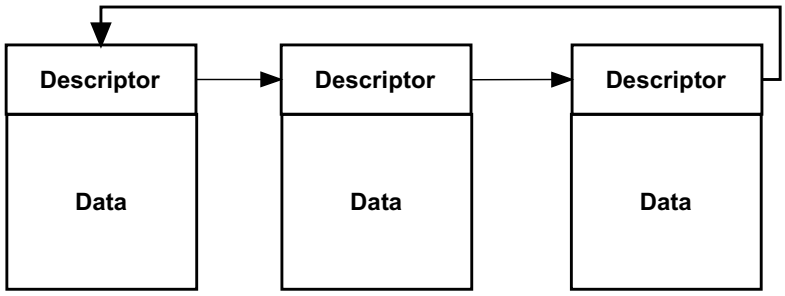



Figure 7-7 **Descriptor link list**

In the µC/TCP-IP device driver, a linked list of descriptors is created, as shown in Figure 7-7. The term *linked* implies that one descriptor points to the next descriptor, which is loaded automatically. To complete the chain, the last descriptor points back to the first descriptor, and the process repeats. This mechanism is used for Ethernet frame reception.

The vast majority of processors that include Ethernet support come with a Direct Memory Access Controller (DMAC). This has the advantage reducing the load on the CPU, as the DMAC handles data transfers from the CPU internal memory to the Ethernet controller memory area or vice versa. If a DMAC is present on your device, we encourage you to take advantage of it.

## 7-6-1 DRIVER DATA & CONTROL USING DMA

Each driver should have their own data structure NET_DEV_DATA, which contains status information about data reception, transmission and statistics. The driver's state structure is stored by the core and can be retrieving within any driver API functions. Figure 7-8 illustrates the structure to track and control Receive & Transmit descriptors.

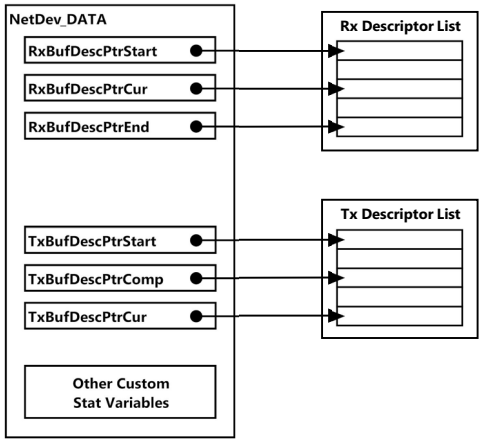



Figure 7-8 **NET_DEV_DATA data structure**

## 7-6-2 RECEPTION USING DMA

### INITIALIZATION

When µC/TCP-IP is initialized, the Network Device Driver allocates a memory block for all Receive descriptors; this is performed via calls to µC/LIB.

Then, the network device driver must allocate a list of descriptors and configure each address field to point to the start address of a Receive buffer. At the same time, the network device driver initializes three pointers: one to track the current descriptor, which is expected to contain the next received frame; a second to remember the descriptor list boundaries; and a third for the descriptor list starting address.

The DMA controller is initialized and the hardware is informed of the address of descriptor list.

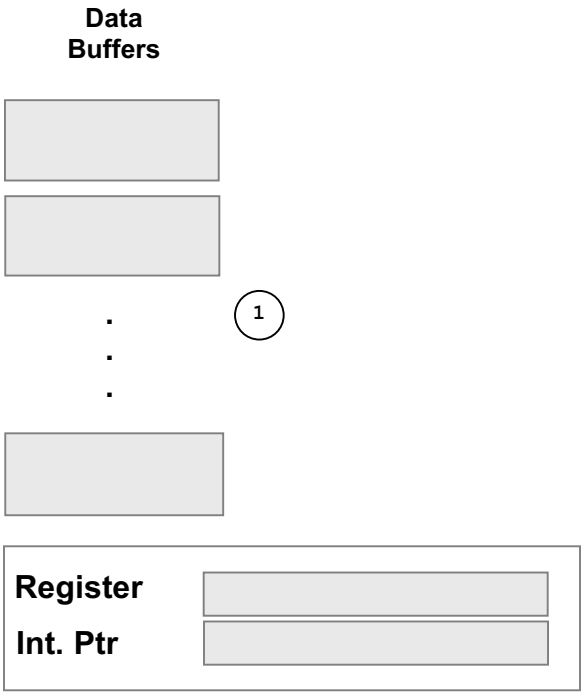



Figure 7-9 **Allocation of buffers**

F7-9(1) The result of `Mem_Init()` and the first step in the intialization of the Network Device Driver is the allocation of buffers.

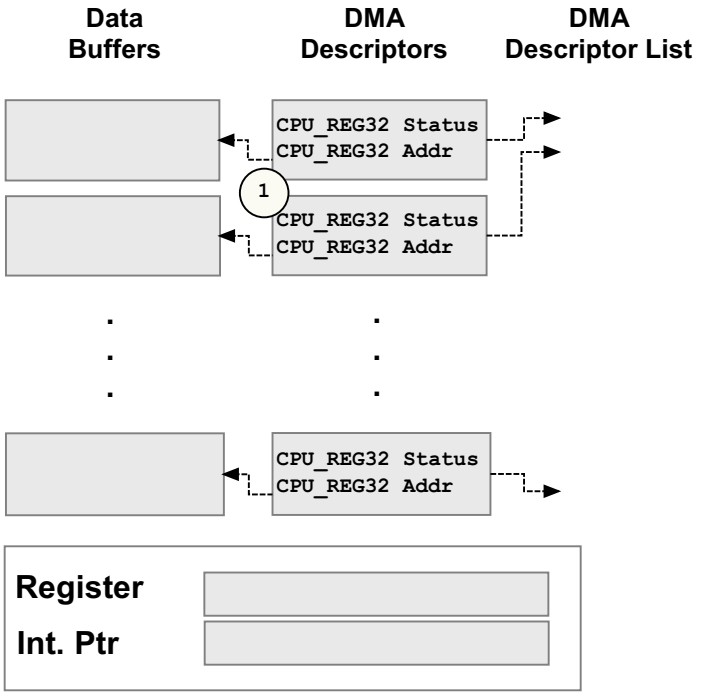



Figure 7-10 **Descriptor allocation**

F7-10(1) µC/TCP-IP allocates a list of descriptors based on the network device driver configuration and sets each address field to point to the start address of a receive buffer.

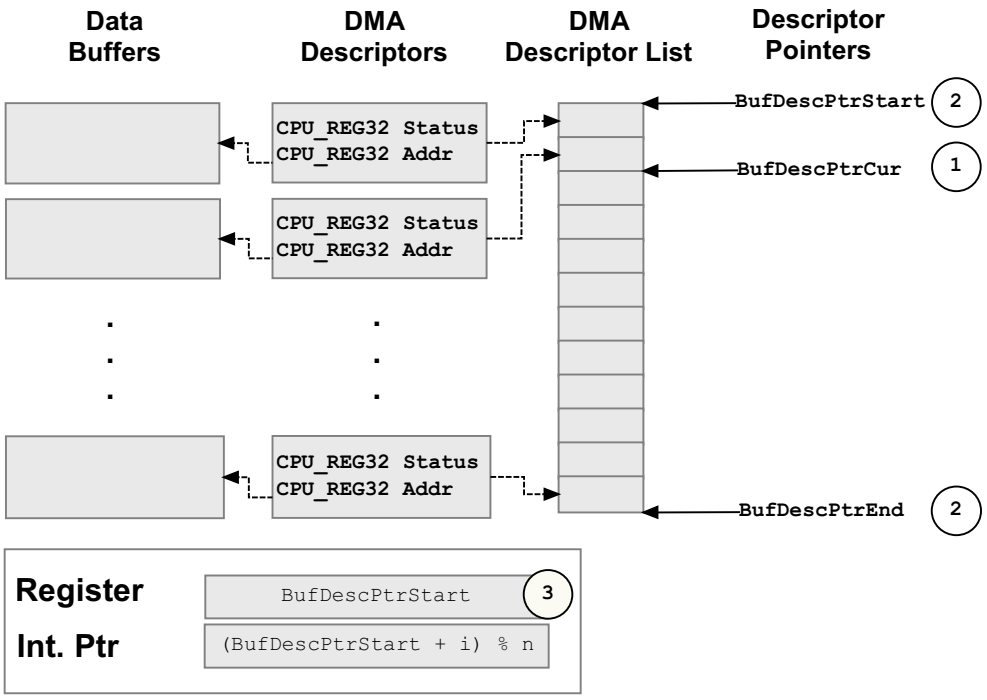



Figure 7-11 **Reception descriptor pointers initialization**

F7-11(1) The network device driver initializes three pointers. One to track the current descriptor which is expected to contain the next received frame

F7-11(2) A second pointer to remember the descriptor list boundaries.

F7-11(3) Finally, the DMA controller is initialized and hardware is informed of the descriptor list starting address.

## RECEPTION

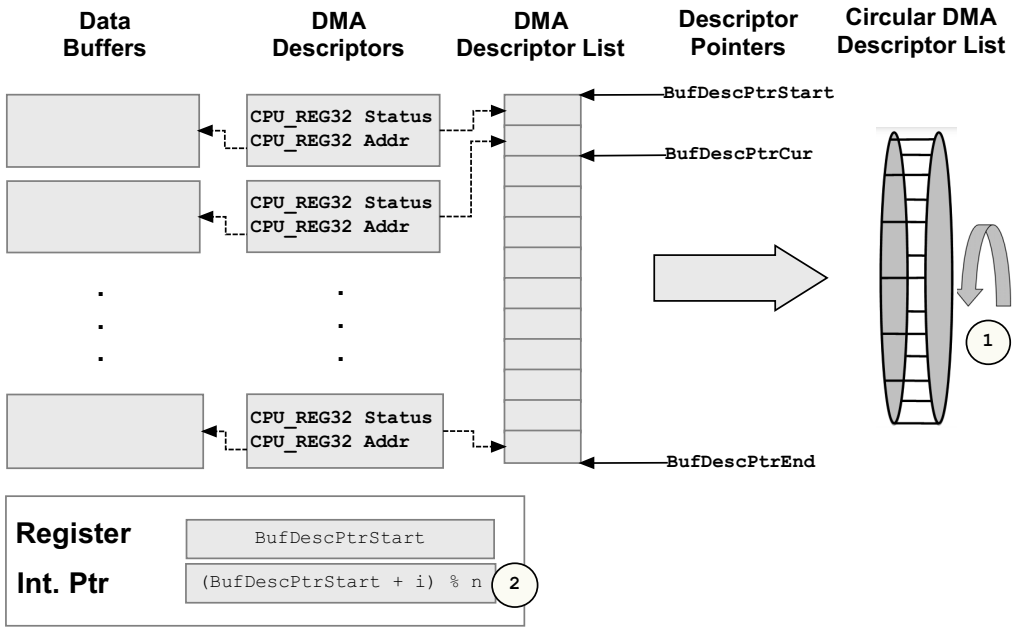



Figure 7-12 **Receiving an Ethernet frame with DMA**

F7-12(1) With each new received frame, the network device driver increments `BufDescPtrCur` by 1 and wraps around the descriptor list as necessary

F7-12(2) The hardware applies the same logic to an internal descriptor pointer.

When a received frame is processed, the driver gets a pointer to a new data buffer and updates the current descriptor address field. The previous buffer address is passed to the protocol stack for processing. If a buffer pointer cannot be obtained, the existing pointer remains in place and the frame is dropped.

### ISR HANDLER

When a frame is received, the DMA controller will generate an interrupt. The ISR handler must signal the network interface. The network interface will automatically call the receive function.

DMA are using a control data structure that indicates the transfer configuration. These data structure are called descriptors and to be able to receive multiple packets at the same time, we need multiple descriptors that we arrange in a list.

We use three pointers to manage and keep track of the Rx descriptors:

| | |
|---|---|
| `RxBufDescPtrStart` | This pointer doesn't move, it always points to the first descriptor. |
| `RxBufDescPtrCur` | This pointer must track the current descriptor which data is ready to be processed. |
| `RxBufDescPtrEnd` | This pointer doesn't move, it always points to the last descriptor. |

### INITIALIZING DEVICE RECEPTION DESCRIPTORS

`NetDev_Start()` starts the network interface hardware by initializing the receive and transmit descriptors, enabling the transmitter and receiver and starting and enabling the DMA. Initialization the Rx DMA descriptors list can done in a sub-function `NetDev_RxDescInit()`. The memory needed by the descriptors must be reserved by the function `NetDev_Init()`. Initialization of the Rx descriptor list consist of setting the descriptors pointers of the `NET_DEV_DATA` and fill all Receive descriptors with a Receive buffer.

The descriptors should be organized in a ring configuration. This means that each descriptor contains a pointer to the next descriptor and the last descriptor's next pointer refers to the first descriptor of the list.

You also have to initialize each descriptor. You must initialize descriptor field according to the controller documentation. Note that the descriptor must be configured to be owned by the DMA and *not* the software. Here is the pseudo code of the descriptor ring initialization:

```
pdesc                       = (DEV_DESC *)pdev_data->RxBufDescPtrStart;                (1)
pdev_data->RxBufDescPtrCur  = (DEV_DESC *)pdesc;                                       (2)
pdev_data->RxBufDescPtrEnd  = (DEV_DESC *)pdesc + (pdev_cfg->RxDescNbr - 1);           (3)
for (i = 0; i < pdev_cfg->RxDescNbr; i++) {                                            (4)
    pdesc->Field   = value;                                                            (5)
    pdesc->Status  = ETH_DMA_RX_DESC_OWN;                                              (6)
    pdesc->Buf     = NetBuf_GetDataPtr((NET_IF        *)pif,                           (7)
                                       (NET_TRANSACTION)NET_TRANSACTION_RX,
                                       (NET_BUF_SIZE   )NET_IF_ETHER_FRAME_MAX_SIZE,
                                       (NET_BUF_SIZE   )NET_IF_IX_RX,
                                       (NET_BUF_SIZE  *)0,
                                       (NET_BUF_SIZE  *)0,
                                       (NET_TYPE      *)0,
                                       (NET_ERR       *)perr);
    if (*perr != NET_BUF_ERR_NONE) {                                                   (8)
         return;
    }
    pdesc->Next = (DEV_DESC *)(pdesc + 1);                                             (9)
    pdesc++;                                                                           (10)
}
```

Listing 7-7 **Descriptor Ring Initialization**

L7-7(1) Initialize the descriptor pointer to the first Rx buffer descriptor of `pdev_data`.

L7-7(2) Initialize current descriptor pointer of `pdev_data` to the first Rx buffer descriptor of `pdev_data`.

L7-7(3) Initialize last descriptor pointer of `pdev_data` to the last descriptor declared using pointer arithmetic and the Rx descriptor number defined by `RxDescNbr` in `NET_DEV_CFG_ETHER`.

L7-7(4) Repeat for each descriptor defined in `.RxDescNbr` in `NET_DEV_CFG_ETHER`.

L7-7(5) Initialize the description fields to their initial value as defined by the DMA Descriptor's documentation in the device data sheet. There might be more than a single field to define depending of the specifications of the DMA used (a field describing the size of associated data buffer might be present and require to be initialized to the length of the requested buffer area below.)

L7-7(6) Initialize the status bit of the descriptor to specify that it is owned by the DMA engine (not by the software).

L7-7(7) Call `NetBuf_GetDataPtr()` to get a buffer area and initialize the descriptor's buffer start address to the address of the buffer area.

L7-7(8) If an error occurred during the allocation of a buffer area, return as it might mean that there is an issue with the values declared in `NET_DEV_CFG_ETHER` and the available device memory or heap size.

L7-7(9) Initialize the next descriptor location of the current descriptor to the next descriptor using pointer arithmetic.

L7-7(10) Increment the descriptor using pointer arithmetics.

Once the Rx descriptor ring is ready, you have to configure controller register to enable the controller reception. Controller's interrupt generation should be enabled for the following events: reception of a packet with and without errors and completed transmission of a packet with and without errors.

### WHAT NEEDS TO BE DONE IN THE ISR FOR RECEPTION

`NetDev_ISR_Handler()` is the function called by the IF layer when a Ethernet related ISR is generated and handled by the BSP layer. When Rx ISR occur, only `NetOS_IF_RxTaskSignal()` has to be called. Nothing has to be done on `RxBufDescPtrCur`. The complete receive process is delayed in order to have the fastest ISR handler as possible. If an error occurred on RX, you can increment driver statistic into the ISR handler or into `NetDev_Rx()`, it's up to you to determine which of the cases is best. You must always signal the core that a packet is received using `NetOS_IF_RxTaskSignal()`. If you fail to notify the core for each packet, a buffer leak will occur and performance will degrade. `NetDev_Rx()` will discard the packet and it will say to the µC/TCP-IP module that the packet is received with an error.

### MOVING BUFFERS FROM THE DEVICE TO THE TCP-IP STACK USING DMA

`NetDev_Rx()` is called by core once a `NetOS_IF_RxTaskSignal()` call has been made to recover the received packet. If data received is valid, this function must replace the buffer of the current descriptor with a free buffer. Also, the current descriptor must be restarted (owned by the DMA) to be able to receive again. `RxBufDescPtrCur` must be moved to point on the next descriptor. The sub-function `NetDev_RxDescPtrCurInc()` is called to restart the current descriptor and to move the pointer to the next descriptor. If an error has occurred, you have to set data and length pointers to 0 and return an error. If there is no

free Rx buffer available, the packet must be discarded by leaving the current data buffer assigned to the DMA, increment the current descriptor and return an error to the µC/TCP-IP module. Here is a pseudo code of `NetDev_Rx()`:

```
static  void  NetDev_Rx (NET_IF       *pif,
                         CPU_INT08U  **p_data,
                         CPU_INT16U   *size,
                         NET_ERR      *perr)
{
    pdesc = (DEV_DESC *)pdev_data->RxBufDescPtrStart;                        (1)

    if (pdesc owned by DMA) {                                                (2)
       *perr   =  NET_DEV_ERR_RX;
       *size   =  0;
       *p_data = (CPU_INT08U *)0;
        return;
    }

    if (is Rx error) {                                                       (3)
        if needed, restart DMA;
        if needed, NetDev_RxDescPtrCurInc();
       *perr   =  NET_DEV_ERR_RX;
       *size   =  0;
       *p_data = (CPU_INT08U *)0;
        return;
    }

    if (is Data length valid) {                                              (4)
        if needed, NetDev_RxDescPtrCurInc();
       *perr   =  NET_DEV_ERR_INVALID_SIZE;
       *size   =  0;
       *p_data = (CPU_INT08U *)0;
        return;
    }
```

```
    pbuf_new = NetBuf_GetDataPtr(…, perr);                              (5)
    if (*perr != NET_BUF_ERR_NONE) {
        NetDev_RxDescPtrCurInc();
       *size   =  0;
       *p_data = (CPU_INT08U *)0;
        return;
    }


   *size   =  pdesc->Length;                                            (6)
   *p_data = (CPU_INT08U *)pdesc->Buf;                                  (7)
    pdesc->Buf = pbuf_new;                                              (8)
    NetDev_RxDescPtrCurInc();                                           (9)
   *perr   = NET_DEV_ERR_NONE;                                          (10)
}
```

Listing 7-8 **Packet Reception**

L7-8(1) Obtain pointer to the next ready descriptor.

L7-8(2) If this descriptor is owned by the DMA (e.g., the DMA is currently receiving data or hasn't started receiving data yet). The descriptor has to be owned by the software to be processed. If owned by the DMA, set `*perr` to `NET_DEV_ERR_RX` signaling that the interrupt that there was an error within the reception. Set `*size` to 0, `*p_data` to `(CPU_INT08U*)0` and return.

L7-8(3) If a reception error is reported in the descriptor set `*perr` to `NET_DEV_ERR_RX` notifying that an error occured within the reception. Set `*size` to 0, `*p_data` to `(CPU_INT08U*)0` and return.

L7-8(4) If the frame length is either runt or overrun set `*perr` to `NET_DEV_ERR_INVALID_SIZE` signaling that the size of the received frame is invalid. Set `*size` to 0, `*p_data` to `(CPU_INT08U*)0` and return.

L7-8(5) Once every error has been handled, acquire a new data buffer to replace the one we're about to take from the descriptor. If no buffers are available set `*size` to 0, `*p_data` to `(CPU_INT08U*)0`, increment `pdev_data` current descriptor and return.

L7-8(6) Set `*size` to the value of the Length field of the current descriptor. This field should specify how many bytes of data were received by the descriptor.

L7-8(7) Set `*p_data` to the value of the data buffer of the descriptor.

L7-8(8) Set the value of the descriptor's data buffer to the newly allocated data area.

L7-8(9) Increment the current descriptor to the next descriptor.

L7-8(10) Set `*perr` to `NET_DEV_ERR_NONE` to notify that no errors were found.

The following is the pseudo code for `NetDev_RxDescPtrCurInc()`:

```
    pdesc                      = pdev_data->RxBufDescPtrCur;                (1)
    pdev_data->RxBufDescPtrCur = pdesc->Next;                               (2)
```

Listing 7-9 **Descriptor Increment**

L7-9(1) Get current `pdev_data` current descriptor.

L7-9(2) Set `pdev_data` current descriptor to the next descriptor in the current one.

## STOPPING THE RECEPTION OF PACKETS

`NetDev_Stop()` is called to shutdown a network interface hardware by disabling the receiver and transmitter, disabling receive and transmit interrupts, free all receive descriptors and deallocate all transmit buffers. When the interface is stopped, you must deallocate the DMA descriptor ring. To do that, a sub-function is called `NetDev_RxDescFreeAll()` where each descriptor's buffer is freed and the DMA controller control is disabled:

```
pdesc  = pdev_data->RxBufDescPtrStart;                                      (1)
for (i = 0; i < pdev_cfg->RxDescNbr; i++) {                                 (2)
    pdesc_data = (CPU_INT08U *)(pdesc->Addr);                               (3)
    NetBuf_FreeBufDataAreaRx(pif->Nbr, pdesc_data);                         (4)
    pdesc->Status = Not owned by the controller                             (5)
    pdesc++;                                                                (6)
}
```

Listing 7-10 **Deallocation of Descriptor Ring**

L7-10(1) Get `pdev_data`'s first descriptor.

L7-10(2) For each descriptor defined in `.RxDescNbr` in `NET_DEV_CFG_ETHER`:

L7-10(3) Get the address of the descriptor's buffer.

L7-10(4) Deallocate the buffer area.

L7-10(5) Set the status of the descriptor to be owned by the software (to disable reception on that descriptor).

L7-10(6) Increment the current descriptor using pointer arithmetic.

## 7-6-3 RECEPTION USING DMA WITH LISTS

Micrium provides an alternate method for executing DMA transfers: DMA with Lists. The goal of this implementation is to reduce the number of controller errors (overrun, underrun, etc.), and increase driver performance. The typical implementation of the DMA descriptor initialization still applies here.

In order to keep the interrupt time short as possible, you cannot call the µC/TCP-IP module to get a free buffer from within the ISR. In order manage buffers, you must maintain a list of buffers within the device driver.

To implement the list method, create three lists: the Buffer List, the Ready List and the Free List. The three lists contain nodes which are moved from one list to another. A node is a memory space where you store pointers to the buffer address and the location of the next node.

The device driver data `NET_DEV_DATA` must contain three pointers which point to the first node of each list. The following is a description of the three lists:

Buffers List This list contains empty nodes. Once a node is filled with the location of a free buffer, you must add this node to the Free List. If a node cannot be filled with the location of a free buffer, or a buffer ready to be processed, you must move the node back into the Buffers List.

Ready List — This list contains buffers which are ready to be processed (i.e., used by the application). When no resources are available to fill a node because they are occupied by the µC/TCP-IP module or by a DMA descriptor, the node must be moved into Buffer List.

Free List — This list contains nodes that point to free buffers. When a buffer is no longer in use by the stack, a node from the Buffer List is moved to the Free List and the pointer in that node set to the free buffer. When a pointer in a node in the Free List is used to replace a pointer to a descriptor buffer, you must move the node from the Free List to the Ready List.

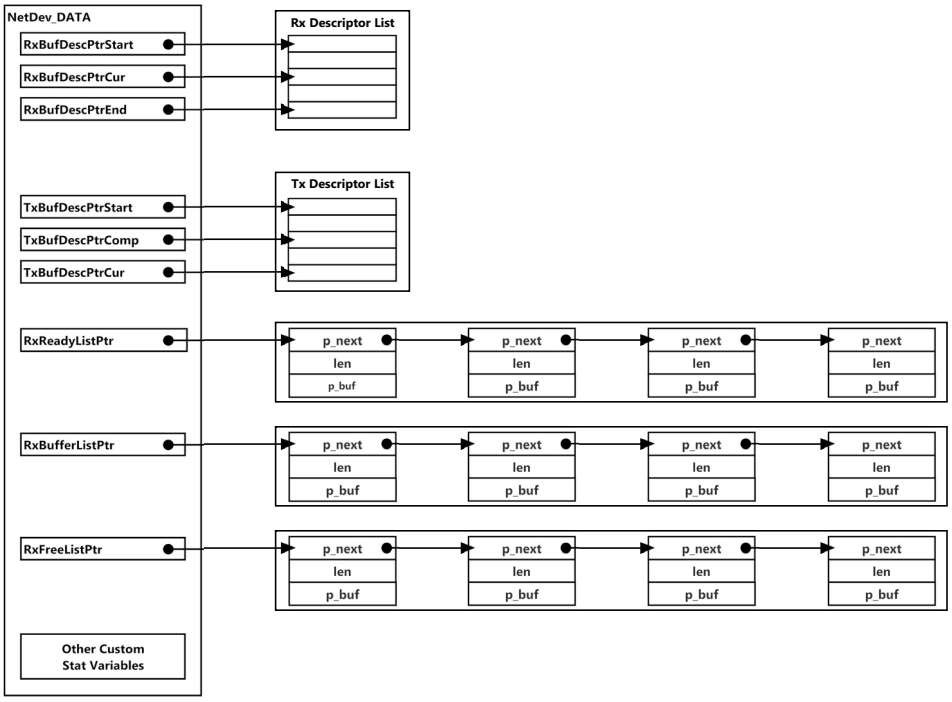



Figure 7-13 **Buffers in lists**

## ALLOCATION OF BUFFER LIST NODES

`NetDev_Init()` is called to allocate memory for the device DMA's descriptors, among other things. You must reserve some memory for each node within the device driver initialization. Since the device is not yet started after the initialization, and no resources are available for the driver, all created nodes must be assigned to the Free List.

Listing Figure 7-13 shows the pseudo code for memory allocation for nodes, and list initialization. These steps should be performed during the device initialization.

```
pdev_data->RxReadyListPtr  = (LIST_ITEM *)0;                                    (1)
pdev_data->RxBufferListPtr = (LIST_ITEM *)0;
pdev_data->RxFreeListPtr   = (LIST_ITEM *)0;
cnt = pdev_cfg->RxBufLargeNbr - pdev_cfg->RxDescNbr;                            (2)
for (ix = 0; ix < cnt; ix++) {
    plist = (LIST_ITEM *)Mem_HeapAlloc((CPU_SIZE_T  ) sizeof(LIST_ITEM),        (3)
                                       (CPU_SIZE_T  ) 4,
                                       (CPU_SIZE_T *)&reqd_octets,
                                       (LIB_ERR    *)&lib_err);
    if (plist == (LIST_ITEM *)0) {                                              (4)
       *perr = NET_DEV_ERR_MEM_ALLOC;
        return;
    }
    plist->Buffer = (void *)0;                                                  (5)
    plist->Len    =  0;
    plist->Next   =  pdev_data->RxFreeListPtr;                                  (6)
    pdev_data->RxFreeListPtr = plist;                                           (7)
}
```

Listing 7-11 **Descriptor List Initialization**

L7-11(1) Initialize `RxReadyListPtr`, `RxBufferListPtr` and `RxFreeListPtr` of `pdev_data` to `(LIST_ITEM *)0`.

L7-11(2) The initial number of `LIST_ITEM`s in `RxFreeListPtr` is calcuated as the number of `.RxBufLargeNbr` minus `.RxDescNbr`. From the pool of Receive buffers, only that number of buffers needs to be placed in the `RxFreeListPtr` since the rest of the buffers are initially assigned to a descriptor.

L7-11(3) Allocate a `LIST_ITEM` object from the heap.

L7-11(4) If an error occurred during the allocation of a `LIST_ITEM` set `*perr` to `NET_DEV_ERR_MEM_ALLOC` to notify that there was an error during memory allocation and then return.

L7-11(5) Set the `.Buffer` field to `(void *)0` and the `.Len` field to 0 since no buffer is associated with the list nodes yet.

L7-11(6) Set the `.Next` field of the list node to the current node of `RxFreeListPtr`

L7-11(7) Insert the newly allocated node to the single ended list of `RxFreeListPtr`.

Thus after the device initialization, all nodes are added into the Free List. The buffers and the ready lists pointers are null.

### INITIALIZATION OF BUFFER LIST NODES

`NetDev_Start()` is used to initialize the reception buffer list. Nodes in the Free List are used to assign a buffer to each of the Receive descriptors, and then removed from the Free List. Any nodes remaining in the Free List should be moved to the Buffer List. Nodes in the Buffer List will be used to replace a descriptor buffer when the ISR handler signals that a new packet has been received. Listing 7-12 shows pseudocode for the Buffer list initialization:

```
cnt = pdev_cfg->RxBufLargeNbr - pdev_cfg->RxDescNbr;                  (1)
for (i = 0; i < cnt; i++) {
    plist                    = pdev_data->RxFreeListPtr;              (2)
    pdev_data->RxFreeListPtr = plist->Next;
    plist->Buffer = NetBuf_GetDataPtr(perr);
    if (*perr != NET_BUF_ERR_NONE) {
         plist->Next             = pdev_data->RxFreeListPtr;          (3)
         pdev_data->RxFreeListPtr = plist;
         break;
    }
    plist->Next               = pdev_data->RxBufferListPtr;           (4)
    pdev_data->RxBufferListPtr = plist;
}
```

Listing 7-12 **Buffer List initialization**

L7-12(1) Get the number of available Receive buffers to put into the `.RxBufferListPtr`. Of the `RxBufLargeNbr` buffers, `RxDescNbr` will be assigned to Receive descriptors; the rest will be put into the `.RxBufferListPtr`.

L7-12(2) Get the list element pointer from free list.

L7-12(3) Return the list element pointer to free list in case of error.

L7-12(4) Store the list element pointer on Buffer list.

Thus after the device start, all nodes should be added into the Buffer List. So the Free and the Ready Lists should be null.

### DEALLOCATION OF BUFFER LIST NODES

As with typical DMA implementation, you must remove the DMA descriptor ring and free the buffers. Also, you must move all nodes into the Free List. Listing 7-12 shows pseudocode for the node deallocation:

```
plist = pdev_data->RxBufferListPtr;
while (plist != (LIST_ITEM *)0) {                                          (1)
    plist_next = plist->Next;
    pdesc_data = plist->Buffer;
    NetBuf_FreeBufDataAreaRx(pif->Nbr, pdesc_data);                        (2)
    plist->Buffer = (void *)0;
    plist->Len    =  0;
    plist->Next              = pdev_data->RxFreeListPtr;                   (3)
    pdev_data->RxFreeListPtr = plist;
    plist = plist_next;
}
```

```
pdev_data->RxBufferListPtr = (LIST_ITEM *)0;                                    (4)
plist = pdev_data->RxReadyListPtr;
while (plist != (LIST_ITEM *)0) {                                               (5)
    plist_next = plist->Next;
    pdesc_data = plist->Buffer;
    NetBuf_FreeBufDataAreaRx(pif->Nbr, pdesc_data);                             (6)
    plist->Buffer = (void *)0;
    plist->Len    =  0;
    plist->Next              = pdev_data->RxFreeListPtr;                        (7)
    pdev_data->RxFreeListPtr = plist;
    plist = plist_next;
}
pdev_data->RxReadyListPtr = (LIST_ITEM *)0;                                     (8)
```

Listing 7-13 **Descriptor and Buffer List deallocation**

L7-13(1) Repeat deallocation process for the nodes in `RxBufferListPtr` the until the `.Next` field of the node is null.

L7-13(2) Return data area to Receive data area pool.

L7-13(3) Remove the node from `RxBufferListPtr`.

L7-13(4) Set .`RxBufferListPtr` of `pdev_data` to null.

L7-13(5) Repeat deallocation process for the nodes in `RxFreeListPtr` until the `.Next` field of the node is null.

L7-13(6) Return data area to Rx data area pool.

L7-13(7) Remove the node from `RxFreeListPtr`.

L7-13(8) Set `.RxFreeListPtr` of `pdev_data` to null.

## BUFFER NODE PROCESSING DURING ISR

In order to process received packets, you must call the function `NetDev_ISR_Handler()`.

If there are errors associated with the received packet, the packet must be discarded by returning the control of the descriptor back to the Direct Memory Access Controller. If the Buffer List is empty (meaning that there is no available buffer to exchange with a received DMA buffer) the packet must also be discarded.

On the other hand, if a buffer is available in the Buffer List, you must replace the buffer assigned to the DMAC with the available buffer. You must then move the received buffer from the DMAC to the Ready List in order to be processed by the Receive task. We suggest you to put the ISR Receive task in a separate sub-function. Note that you must call your sub-function for each individual Receive descriptor that is owned by the software, since you might receive only a single interrupt signal for a multiple DMA Receive completions.

Pseudo code of what should be put into the `NetDev_ISR_Handler()` is described below:

```
if ((interrupt source == Receive) ||                                    (1)
    (interrupt source == Receive error)) {
    valid = DEF_TRUE;
    while (valid == DEF_TRUE) {
        pdesc = (DEV_DESC *)pdev_data->RxBufDescCurPtr;                 (2)

        if (pdesc->status indicates desc' is owned by soft.) {          (3)
            valid = NetDev_ISR_Rx(pif, pdesc);                          (4)

            pdev_data->RxBufDescCurPtr = pdesc->next;                   (5)
        } else {
            valid = DEF_FALSE;
        }
    }
}
```

Listing 7-14 **ISR Handling**

L7-14(1) If the interrupt register indicates a completed reception, or a reception error, proceed with handling of the interrupt.

L7-14(2) Obtain the pointer to the next ready descriptor.

L7-14(3) The descriptor is ready to be processed (reception is complete and descriptor is owned by the software).

L7-14(4) Call `NetDev_ISR_Rx()` to execute the buffer, and list element manipulation required to exchange the buffer of the descriptor with an available buffer.

L7-14(5) Move to the next descriptor in order to repeat the process with that descriptor, if it is owned by the software.

Your sub-function (`NetDev_ISR_Rx()`) must replace the current descriptor buffer with a buffer from a node into the Buffer List, and then signal the µC/TCP-IP module to process received packets and refill the Buffer list. You must also make sure that the Buffer List is not null (i.e., there is a buffer available). If no buffers are available, you must discard the packet.

The pseudo code for the Receive ISR sub-function is described below:

```
static  CPU_BOOLEAN  NetDev_ISR_Rx (NET_IF    *pif,
                                    DEV_DESC  *pdesc)
{
    NET_DEV_DATA  *pdev_data;
    LIST_ITEM     *plist_buf;
    LIST_ITEM     *plist_ready;
    void          *p_buf;
    CPU_BOOLEAN    valid;
    CPU_BOOLEAN    signal;
    NET_ERR        err;
    pdev_data = (NET_DEV_DATA *)pif->Dev_Data;                              (1)
    valid     =  DEF_TRUE;
    signal    =  DEF_FALSE;

    if (Frame error) {                                                      (2)
        valid = DEF_FALSE;
    }
    if (Frame data spans over multiple buffers) {                           (3)
        valid = DEF_FALSE;
    }

    if (pdev_data->RxBufferListPtr == (LIST_ITEM *)0) {                     (4)
        valid  = DEF_FALSE;
        signal = DEF_TRUE;
    }
```

```
    Clear Interrupt source;
    if (valid == DEF_TRUE) {
        plist_buf                 = pdev_data->RxBufferListPtr;              (5)
        pdev_data->RxBufferListPtr = plist_buf->Next;
        p_buf                     = plist_buf->Buffer;
        plist_buf->Buffer         = pdesc->p_buf;
        plist_buf->Len            = pdesc->size;
        plist_buf->Next           = (LIST_ITEM *)0;
        if (pdev_data->RxReadyListPtr == (LIST_ITEM *)0) {                   (6)
            pdev_data->RxReadyListPtr  = plist_buf;
        } else {
            plist_ready = pdev_data->RxReadyListPtr;
            while (plist_ready != (LIST_ITEM *)0) {                          (7)
                if (plist_ready->Next == (LIST_ITEM *)0) {
                    break;
                }
                plist_ready = plist_ready->Next;
            }
            plist_ready->Next = plist_buf;
        }
        pdesc->p_buf = p_buf;                                                (8)
        pdesc->size  = 0;
    }


    if ((valid  == DEF_TRUE) ||
        (signal == DEF_TRUE)) {
        NetOS_IF_RxTaskSignal(pif->Nbr, &err);                               (9)
    }
    Reset Descriptor;
    return (valid);
}
```

Listing 7-15 **Rx ISR Handling**

L7-15(1) Obtain pointer to `NET_DEV_DATA` object.

L7-15(2) If there is an error with the received frame, discard it.

L7-15(3) If the frame doesn't hold in a single buffer, discard it.

L7-15(4) If there is no node in `RxBufferListPtr` it means that there is no buffer to exchange with the descriptor's buffer and the received frame must be discarded.

L7-15(5) Remove a node from the `RxBufferListPtr`. Exchange the buffer of that node with the buffer of the descriptor.

L7-15(6) If the `RxReadyListPtr` is empty, move the node removed from `RxBufferListPtr` to the `RxReadyListPtr`.

L7-15(7) If the `RxReadyListPtr` is not empty, move the node removed from `RxBufferListPtr` to the end of `RxReadyListPtr`.

L7-15(8) Assign the buffer removed from `RxBufferListPtr` to the descriptor.

L7-15(9) Signal the Receive task that there is a new frame available.

### MOVING THE NODE'S BUFFER TO THE TCP-IP STACK

`NetDev_Rx()` is called by the Receive task of the µC/TCP-IP module to return a buffer to the application if there is one that is available. This function must return the oldest packet received which should be added into the Ready list by the ISR handler. If the list is empty, you must return an error. If the list is not empty, you must set the `p_data` pointer argument to the current node buffer, set the node buffer to null and move the node to the Free list. Then you have to try to move Free list node to the Buffer list. To do so, you must to get a free buffer from the µC/TCP-IP module, fill a node buffer from the Free List and move the node to the Buffer List.

The following is the pseudo code describing this process:

```
if ((interrupt source == Receive) ||
static  void  NetDev_Rx (NET_IF       *pif,
                         CPU_INT08U  **p_data,
                         CPU_INT16U   *size,
                         NET_ERR      *perr)
{
    NET_DEV_DATA       *pdev_data;
    NET_DEV_CFG_ETHER  *pdev_cfg;
    LIST_ITEM          *plist;
    CPU_INT08U         *pbuf;
    CPU_BOOLEAN         valid;
    NET_ERR             net_err;
    CPU_SR_ALLOC();
    pdev_cfg  = (NET_DEV_CFG_ETHER *)pif->Dev_Cfg;
    pdev_data = (NET_DEV_DATA *)pif->Dev_Data;
```

```
    CPU_CRITICAL_ENTER();                                                (1)
    plist = pdev_data->RxReadyListPtr;                                   (2)
    if (plist != (LIST_ITEM *)0) {
        pdev_data->RxReadyListPtr = plist->Next;
       *size   = plist->Len;                                             (3)
       *p_data = (CPU_INT08U *)plist->Buffer;                            (4)
        plist->Len    =  0;
        plist->Buffer = (void *)0;
                                                                         (5)
        plist->Next              = pdev_data->RxFreeListPtr;
        pdev_data->RxFreeListPtr = plist;
        CPU_CRITICAL_EXIT();                                             (6)

       *perr = NET_DEV_ERR_NONE;
    } else {
        CPU_CRITICAL_EXIT();                                             (7)

       *size   = (CPU_INT16U  )0;
       *p_data = (CPU_INT08U *)0;

       *perr = NET_DEV_ERR_RX;
    }
    valid = DEF_TRUE;
    while (valid == DEF_TRUE) {
        pbuf = NetBuf_GetDataPtr((NET_IF        *)pif,
                                 (NET_TRANSACTION)NET_TRANSACTION_RX,
                                 (NET_ERR       *)&net_err);
        if (net_err != NET_BUF_ERR_NONE) {
            valid = DEF_FALSE;
        } else {
            CPU_CRITICAL_ENTER();                                        (1)
            plist = pdev_data->RxFreeListPtr;
            if (plist != (LIST_ITEM *)0) {
                pdev_data->RxFreeListPtr   = plist->Next;
                plist->Buffer              = pbuf;
                plist->Next                = pdev_data->RxBufferListPtr;
                pdev_data->RxBufferListPtr = plist;
                CPU_CRITICAL_EXIT();
            } else {
                CPU_CRITICAL_EXIT();
                valid = DEF_FALSE;

                NetBuf_FreeBufDataAreaRx(pif->Nbr, pbuf);                (8)
            }
        }
    }
}
```

Listing 7-16 **Packet Reception**

L7-16(1) Disable interrupts to alter shared data.

L7-16(2) Get the next ready buffer.

L7-16(3) Return the size of the received frame.

L7-16(4) Return a pointer to the received data area.

L7-16(5) Move the list header into free list.

L7-16(6) Restore interrupts.

L7-16(7) Restore interrupts and mark the received frame as invalid.

L7-16(8) Return data to received data area pool.

## 7-6-4 TRANSMISSION USING DMA

When µC/TCP-IP has a packet to transmit, it updates an available descriptor in memory and then writes to a DMA register to start the stalled DMA channel. On transmissions, it is simpler to setup the descriptors. The number and length of the packets to transmit is well defined. This information determines the number of transmit descriptors required and the number of bytes to transmit on each descriptor. The transmit descriptor list is often used in a non-circular fashion. The initial descriptors in the descriptor list are setup for transmission, when the transmission is completed they are cleared, and the process starts over in the next transmission.

### INITIALIZATION

Similarly to the receive descriptors, the Network Device Driver should allocate a memory block for all transmit buffers and descriptors shown in Figure 7-9.

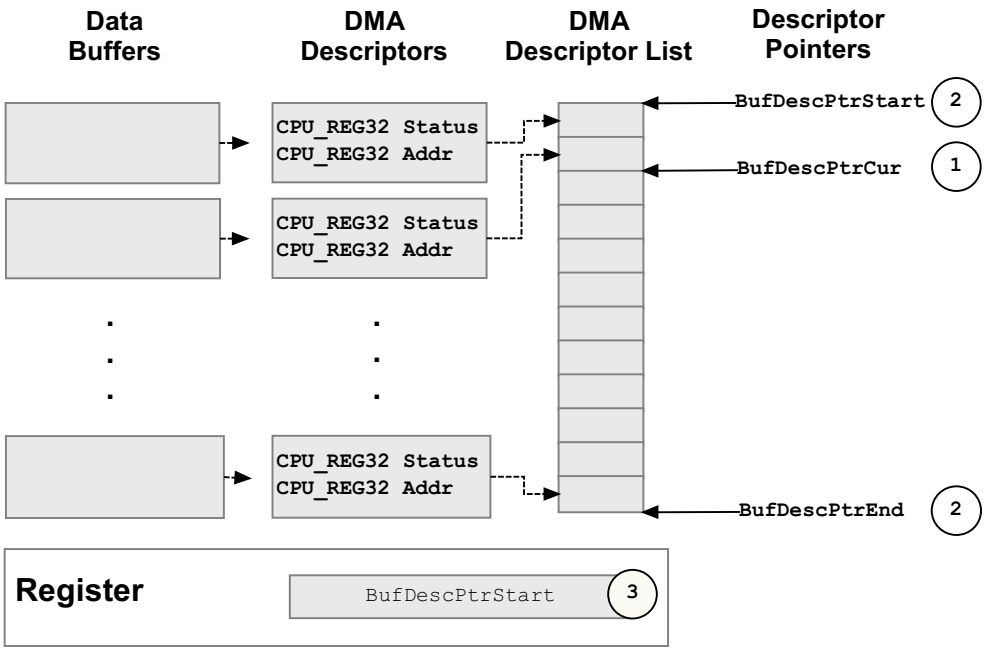



Figure 7-14 **Transmission descriptor pointers initialization**

F7-14(1) The Network Device Driver must allocate a list of descriptors and configure each address field to point to a null location.

F7-14(2) The Network Device Driver can initialize three pointers. One to track the current descriptor which is expected to contain the next buffer to transmit. A second points to the beginning of the descriptor list. The last pointer may point to the last descriptor in the list or depending on the implementation, it can also point to the last descriptor to transmit. Another method, depending on the DMA controller used, is to configure a parameter containing the number of descriptors to transmit in one of the DMA controller registers.

Finally, the DMA controller is initialized and hardware is informed of the descriptor list starting address.

## TRANSMISSION

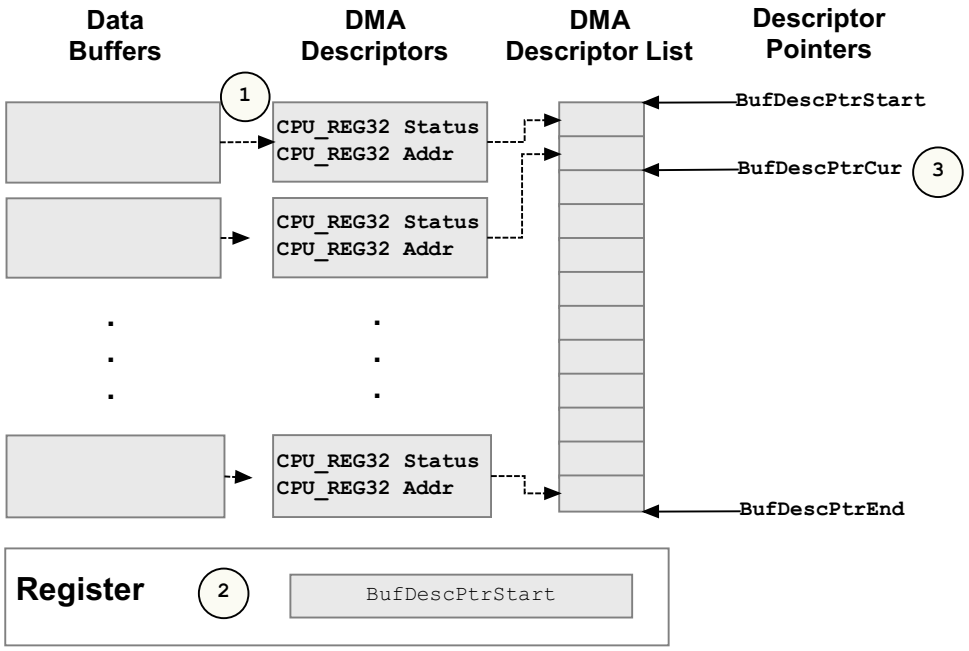



Figure 7-15 **Moving a buffer to the Ethernet controller with DMA**

F7-15(1) With each new transmit buffer, the current descriptor address is set to the buffer address.

F7-15(2) DMA transfer is enabled.

F7-15(3) The current descriptor pointer is set to the next descriptor for the next transmission.

If no descriptor is free an error should be returned to the Network Protocol stack.

### ISR HANDLER

When the ISR handler receives a DMA interrupt after the transmission completion, a list of descriptors for the completed transmit buffers is determined. Each completed transmit buffer address is passed to the Network Transmit De-allocation task, where the correspondent buffer gets released if it is not referenced by any other part of the Network stack. The Network interface is also signaled for each one of the completed transmit buffers to allow the Network stack to continue transmission of subsequent packets. To complete the operation, the transmit descriptors are cleared to make room for subsequent transmissions.

Transmission of packets can also benefit from a DMA implementation. Similar to the reception of packets, the DMA can be used to move the packet data from the application memory space to the memory location of the Ethernet controller. By using the DMA, the CPU can work on other tasks and driver performances can be increased.

### DESCRIPTION OF THE TRANSMISSION POINTERS

We use three pointers to manage the transmission of buffers:

`TxBufDescPtrStart` This pointer points to the first descriptor and should not take any other value.

`TxBufDescPtrComp` This pointer tracks the current descriptor which completed its transmission.

`TxBufDescPtrCur` This pointer tracks the current descriptor available for transmission.

### INITIALIZATION OF THE TRANSMISSION DESCRIPTORS

The function `NetDev_Start()` initializes the Transmit buffer descriptor pointers and the DMA Transmit descriptors. The sub-function `NetDev_TxDescInit()` initializes the Transmit descriptors ring. The descriptors must not filled with buffers and they must be owned by the software. Your code should activate the current Transmit descriptor only when `NetDev_Tx()` is called.

The following is the pseudo code for this initialization:

```
pdesc                       = (DEV_DESC *)pdev_data->TxBufDescPtrStart;       (1)
pdev_data->TxBufDescPtrComp = (DEV_DESC *)pdev_data->TxBufDescPtrStart;
pdev_data->TxBufDescPtrCur  = (DEV_DESC *)pdev_data->TxBufDescPtrStart;
for (i = 0; i < pdev_cfg->TxDescNbr; i++) {                                   (2)
    pdesc->Addr   =  0;
    pdesc->Len    =  0;
    pdesc->Status =  (not started) & (owned by software)
    pdesc->Next   = (DEV_DESC *)(pdesc + 1);
    pdesc++;                                                                  (3)
}
pdesc--;                                                                      (4)
pdesc->Next    = (DEV_DESC *)pdev_data->TxBufDescPtrStart;                    (5)
```

Listing 7-17 **Descriptor Initialization**

L7-17(1) Initialize descriptor, `.TxBufDescPtrComp` and `.TxBufDescPtrCur` to `.TxBufDescPtrStart` of `pdev_data`

L7-17(2) For every `.TxDescNbr` in `pdev_cfg`: Set the Transmit Buffer address to null, set the `Len` field to 0, and set the status to "not started" and "owned by the software". Then set the current descriptor's next descriptor to the location of the next descriptor (using pointer arithmetic).

L7-17(3) Increment descriptor using pointer arithmetic.

L7-17(4) Decrement descriptor to compensate for over-incrementation in the while loop.

L7-17(5) Set the `.Next` field of the descriptor to `.TxBufDescPtrStart`.

## MOVING PACKETS FROM THE TCP-IP STACK TO THE NETWORK DEVICE

The function `NetDev_Tx()` is called by the µC/TCP-IP module when a packet must be transmitted over the network. This function resets and activates a DMA Transmit descriptor for the packet to transmit. It must first make sure that a Transmit descriptor is available to initialize a transmission. Once the buffer has been assigned to the current Transmit descriptor, an interrupt will be generated to signal that the packet has been transmitted.

The following is the pseudo code for the `NetDev_Tx()` function.

```
static  void  NetDev_Tx (NET_IF      *pif,
                         CPU_INT08U  *p_data,
                         CPU_INT16U   size,
                         NET_ERR     *perr)
{
    NET_DEV_CFG_ETHER  *pdev_cfg;
    NET_DEV_DATA       *pdev_data;
    NET_DEV            *pdev;
    DEV_DESC           *pdesc;
    pdev_cfg  = (NET_DEV_CFG_ETHER *)pif->Dev_Cfg;
    pdev_data = (NET_DEV_DATA      *)pif->Dev_Data;
    pdev      = (NET_DEV           *)pdev_cfg->BaseAddr;
    pdesc     = (DEV_DESC          *)pdev_data->TxBufDescPtrCur;
    if ((pdesc->Status & Hardware) != 0) {                                          (1)
       *perr = NET_DEV_ERR_TX_BUSY;
        return;
    }
    pdesc->Addr                =  p_data;                                           (2)
    pdesc->Len                 =  size;                                             (3)

    pdesc->Status              =  Hardware;                                         (4)
    pdev->REGISTER             =  Inform harware that a Tx desc has been made avail;
    pdev_data->TxBufDescPtrCur =  pdesc->Next;                                      (5)

   *perr = NET_DEV_ERR_NONE;
}
```

Listing 7-18 **Packet Transmission**

L7-18(1) If current Transmit Descriptor is still owned by the DMA engine, set `*perr` to `NET_DEV_ERR_TX_BUSY` indicating that the DMA engine is still occupied at transmitting that frame.

L7-18(2) Configure the descriptor with the transmit data area address.

L7-18(3) Configure the descriptor frame length.

L7-18(4) Give the descriptor ownership to hardware.

L7-18(5) Move the pointer of the current transmit descriptor to the next one.

## DEALLOCATING PACKETS AFTER TRANSMISSION

`NetDev_ISR_Handler()` is called when the transmission is completed. Within the ISR handler, you must signal the µC/TCP-IP module for each packet transmitted successfully.

It is possible that some packets may be transmitted or received during the ISR handler. As a result, sometimes only one ISR is generated for multiple packets transmitted. You must make sure that all descriptors not owned by the hardware and completed have been signaled the µC/TCP-IP module.

```
int_status = pdev->REGISTER;                                          (1)

clear active int;
if ((int_status & TX_INTERRUPT) > 0) {                                (2)

    while(p_desc         != TxBufDescPtrCur ||
        pdev->REGISTER == Owned by software) {                        (3)
        pdesc = pdev_data->TxBufDescPtrComp;
        pdev_data->TxBufDescPtrComp = pdesc->Next;
        NetOS_IF_TxDeallocTaskPost(pdesc->Addr, &err);
        NetOS_Dev_TxRdySignal(pif->Nbr);                              (4)
    }
     pdesc = pdev_data->TxBufDescPtrComp;
     pdev_data->TxBufDescPtrComp = pdesc->Next;                       (5)
}
```

Figure 7-16 **ISR handling**

L7-18(6) Record the current state of the interrupt register.

L7-18(7) Verify if there is a transmission interrupt triggered.

L7-18(8) Cycle through the Transmit descriptor while the working descriptor is not pointing on `.TxBufFescPtrCur` and that the working descriptor pointer is owned by the software (transmission done).

L7-18(9) Deallocate the transmission buffer used by the descriptor.

L7-18(10) Signal `NetIF` that the Transmit resources are now available.

L7-18(11) Move the `.TxBufDescPtrComp` descriptor pointer to the `.Next` one of that descriptor.

### DEALLOCATING THE TRANSMIT BUFFERS

`NetDev_Stop()` is called to free the receive descriptors ring and to deallocate all transmit buffers. To do that, a sub-function is called `NetDev_TxDescFreeAll()` where each descriptor's buffer is freed:

```
pdesc = pdev_data->TxBufDescPtrStart;                                    (1)
for (i = 0; i < pdev_cfg->TxDescNbr; i++) {
    NetOS_IF_TxDeallocTaskPost((CPU_INT08U *)pdesc->Addr, &err);         (2)
    (void)&err;                                                          (3)
    pdesc++;
}
```

Listing 7-19 **Transmit descriptor deallocation**

L7-19(1) Set the current pointer descriptor to `.TxBufDescPtrStart` of `NET_DEV_DATA`.

L7-19(2) For each descriptor defined in the configuration, deallocate the network buffer associated with the descriptor.

L7-19(3) Any error returned by `NetOS_IF_TxDeallocTaskPost()` should be ignored since we are doing a best effort to deallocate the buffer and carry on with the rest of the device stopping procedure.

# 7-7 ETHERNET - TRANSMITTING AND RECEIVING USING MEMORY COPY

## 7-7-1 RECEPTION USING MEMORY COPY

On some devices, the MAC is not part of processor peripherals, and is connected through a serial or a parallel communication scheme. You will have to create specific data transfer functions for writing and reading the data structures of the MAC.

### PROCESSING RECEPTION BUFFERS IN THE ISR

The following a list of the actions that must be performed in `NetDev_ISR_Handler()` to receive packets using Memory Copy.

- Read MAC Status Register
- Handle Receive ISR:
  - Signal Net IF Receive task
  - Clear Interrupt
- Handle any other reported interrupts by MAC controller.

Listing 7-20 shows a template for the `NetDev_ISR_Handle()` function:

```
static  void  NetDev_ISR_Handler (NET_IF           *pif,
                                  NET_DEV_ISR_TYPE   type)
{
    NET_DEV_CFG_ETHER  *pdev_cfg;
    NET_DEV_DATA       *pdev_data;
    NET_DEV            *pdev;
    CPU_DATA            reg_val;
    CPU_INT08U         *p_data;
    NET_ERR             err;
   (void)&type;                                                          (1)
    pdev_cfg  = (NET_DEV_CFG_ETHER *)pif->Dev_Cfg;                       (2)
    pdev_data = (NET_DEV_DATA      *)pif->Dev_Data;                      (3)
    pdev      = (NET_DEV           *)pdev_cfg->BaseAddr;                 (4)
    reg_val = pdev->ISR;                                                 (5)
    if ((reg_val & RX_ISR_EVENT_MSK) > 0) {                              (6)
         NetOS_IF_RxTaskSignal(pif->Nbr, &err);                          (7)
          switch (err) {
              case NET_IF_ERR_NONE:
                  No error during signalling.
                  break;
              case NET_IF_ERR_RX_Q_FULL:
              case NET_IF_ERR_RX_Q_SIGNAL_FAULT:
              default:
                  An error occurred during signalling.
                  break;
         }
         pdev->ISR |= RX_ISR_EVENT_MSK;                                  (8)
    }
                                                                         (9)
    if ((reg_val & TX_ISR_EVENT_MSK) > 0) {
                                                                         (10)
         p_data = (CPU_INT08U *)pdev_data->TxBufCompPtr;
         NetOS_IF_TxDeallocTaskPost(p_data, &err);
         NetOS_Dev_TxRdySignal(pif->Nbr);                                (11)
         pdev->ISR |= TX_ISR_EVENT_MSK;                                  (12)
    }
    pdev->ISR |= UNHANDLED_ISR_EVENT_MASK;                               (13)
}
```

Listing 7-20 **ISR Handler function template**

L7-20(1) Prevent “variable unused” compiler warning.

L7-20(2) Obtain pointer to the device configuration structure.

L7-20(3) Obtain pointer to device data area.

L7-20(4) Overlay device register structure on top of device base address.

L7-20(5) Determine interrupt type.

L7-20(6) Handle reception interrupts.

L7-20(7) Signal `NetIF` reception queue task for each new ready descriptor.

L7-20(8) Clear device's reception interrupt event flag.

L7-20(9) Handle transmission interrupts.

L7-20(10) Increment transmission packet counter.

L7-20(11) Signal `NetIF` that transmission resources are now available.

L7-20(12) Clear device's transmission interrupt event flag.

L7-20(13) Clear unhandled interrupt event flag.

## MOVING BUFFERS FROM THE DEVICE TO THE TCP-IP STACK USING MEMORY COPY

The following a list of the actions that must be performed in `NetDev_Rx()` to receive packets using Memory Copy.

- Disable interrupts
- Read the length of the received frame
- Obtain pointer to new data area
- Copy frame to new data area
- Set return values. Pointer to received data area and size
- Re-Enable interrupts
- Check for additional ready frames, and signal Net IF receive task

Listing 7-21 shows a template for the `NetDev_Rx()` function:

```
static  void  NetDev_Rx (NET_IF       *pif,
                         CPU_INT08U  **p_data,
                         CPU_INT16U   *size,
                         NET_ERR      *perr)
{
    NET_DEV_CFG_ETHER  *pdev_cfg;
    NET_DEV_DATA       *pdev_data;
    NET_DEV            *pdev;
    CPU_INT08U         *pbuf_new;
    CPU_INT16S          length;
    CPU_INT16U          cnt;
    CPU_INT16U          i;
    pdev_cfg  = (NET_DEV_CFG_ETHER *)pif->Dev_Cfg;                                  (1)
    pdev_data = (NET_DEV_DATA      *)pif->Dev_Data;                                 (2)
    pdev      = (NET_DEV           *)pdev_cfg->BaseAddr;                            (3)

    if ((pdev->RSTAT & RX_STATUS_ERR_MSK) > 0) {                                    (4)
        *size   = (CPU_INT16U  )0;
        *p_data = (CPU_INT08U *)0;
        *perr   = (NET_ERR     )NET_DEV_ERR_RX;
         return;
    }

    length = (pdev->STATUS & RX_STATUS_SIZE_MSK) - NET_IF_ETHER_FRAME_CRC_SIZE;     (5)
    if (length < NET_IF_ETHER_FRAME_MIN_SIZE) {
       *size   = (CPU_INT16U  )0;
       *p_data = (CPU_INT08U *)0;
       *perr   = (NET_ERR     )NET_DEV_ERR_INVALID_SIZE;
        return;
    }

    pbuf_new = NetBuf_GetDataPtr((NET_IF        *)pif,                              (6)
                                 (NET_TRANSACTION)NET_TRANSACTION_RX,
#if (NET_VERSION >= 21000u)
                                 (NET_BUF_SIZE   )NET_IF_ETHER_FRAME_MAX_SIZE,
                                 (NET_BUF_SIZE   )NET_IF_IX_RX,
                                 (NET_BUF_SIZE  *)0,
#else
                                 (NET_BUF_SIZE   )pdev_cfg->RxBufLargeSize,
                                 (NET_BUF_SIZE   )0u,
#endif
                                 (NET_BUF_SIZE  *)0,
                                 (NET_TYPE      *)0,
                                 (NET_ERR       *)perr);
```

```
    if (*perr != NET_BUF_ERR_NONE) {                                        (7)
        *size   = (CPU_INT16U  )0;
        *p_data = (CPU_INT08U *)0;
         return;
    }

   *size   =  length;                                                       (8)
    cnt    =  length / pdev_cfg->DataBusSizeNbrBits;                        (9)

    for (i = 0; i < cnt; i++) {
        Read data from device using Memcopy.                                (10)
    }

   *p_data = pbuf_new;                                                      (11)
   *perr = NET_DEV_ERR_NONE;
}
```

Listing 7-21 **NetDev_Rx() function template**

F7-16(1) Obtain pointer to the device configuration structure.

F7-16(2) Obtain pointer to device data area.

F7-16(3) Overlay device register structure on top of device base address.

F7-16(4) If the frame contains reception errors, discard the frame by setting `*size` to 0, `*p_data` to null. Set `*perr` to `NET_DEV_ERR_RX` to indicate a reception error.

F7-16(5) If frame is a runt, discard the frame.

F7-16(6) Request an empty buffer.

F7-16(7) If unable to get a buffer, discard the frame.

F7-16(8) Return the size of the received frame.

F7-16(9) Determine the number of device memory or FIFO reads that are required to complete the memory copy.

F7-16(10) Read data from device.

F7-16(11) Return a pointer to the received data.

## 7-7-2 TRANSMISSION USING MEMORY COPY

The following a list of the actions that must be done in `NetDev_Tx()` in order to implement transmission using Memory Copy:

- Disable interrupts.
- Prepare device to receive the transmit frame in memory.
- Copy frame to transmit to MAC buffer.
- If no frames are queued for transmission, issue a transmission request to the MAC.
- Update the device's list of transmit pointers
- Re-enable interrupts

Listing 7-22 shows a template for the `NetDev_Tx()` function:

```
static  void  NetDev_Tx (NET_IF      *pif,
                         CPU_INT08U  *p_data,
                         CPU_INT16U   size,
                         NET_ERR     *perr)
{
    NET_DEV_CFG_ETHER  *pdev_cfg;
    NET_DEV_DATA       *pdev_data;
    NET_DEV            *pdev;
    CPU_INT16U          cnt;
    CPU_INT16U          i;
    pdev_cfg  = (NET_DEV_CFG_ETHER *)pif->Dev_Cfg;                              (1)
    pdev_data = (NET_DEV_DATA      *)pif->Dev_Data;                             (2)
    pdev      = (NET_DEV           *)pdev_cfg->BaseAddr;                        (3)
    if ((pdev->STATUS & TX_STATUS_BUSY) > 0) {                                  (4)
      *perr = NET_DEV_ERR_TX_BUSY;
       return;
    }
    cnt = size / pdev_cfg->DataBusSizeNbrBits;                                  (5)
    for (i = 0; i < cnt; i++) {
        Copy data to device using Memcopy                                       (6)
    }
    pdev->CTRL = 1;                                                             (7)
    pdev_data->TxBufCompPtr = p_data;
}
```

Listing 7-22 **NetDev_Tx() function template**

L7-22(1) Obtain pointer to the device configuration structure.

L7-22(2) Obtain pointer to device data area.

L7-22(3) Overlay device register structure on top of the device base address.

L7-22(4) Check if the device is ready to transmit.

L7-22(5) Determine the number of device memory or FIFO writes that are required to complete the transfer.

L7-22(6) Copy data to device using memory copy.

L7-22(7) Initiate transmission of the packet.

### PROCESSING TRANSMISSION BUFFER IN THE ISR

The following is a list of actions that must be performed in `NetDev_ISR_Handler()` to transmit packets using Memory Copy.

- Setup next frame to transmit if any
- Signal already transmitted frame for deallocation
- Signal that Transmit resources have become available
- Clear interrupt

For the template of `NetDev_ISR_Handler()` refer to the template in Listing 7-20 on page 205.

## 7-8 WIRELESS LAYERS INTERACTION

This sections that follow describe the interactions between the IF layer, the wireless device driver API functions, the BSP API functions and the Wireless Manager API functions. Since the device driver is made of not only logic but also from interactions with the parts on the board, you'll need to understand the calls made to the these layers of the µC/TCP-IP module and to the CPU and board-dependent layers.

Figure 7-17 shows the logical path between the Wireless Manager layer, BSP APIs functions and the device driver through the function calls and interruptions.

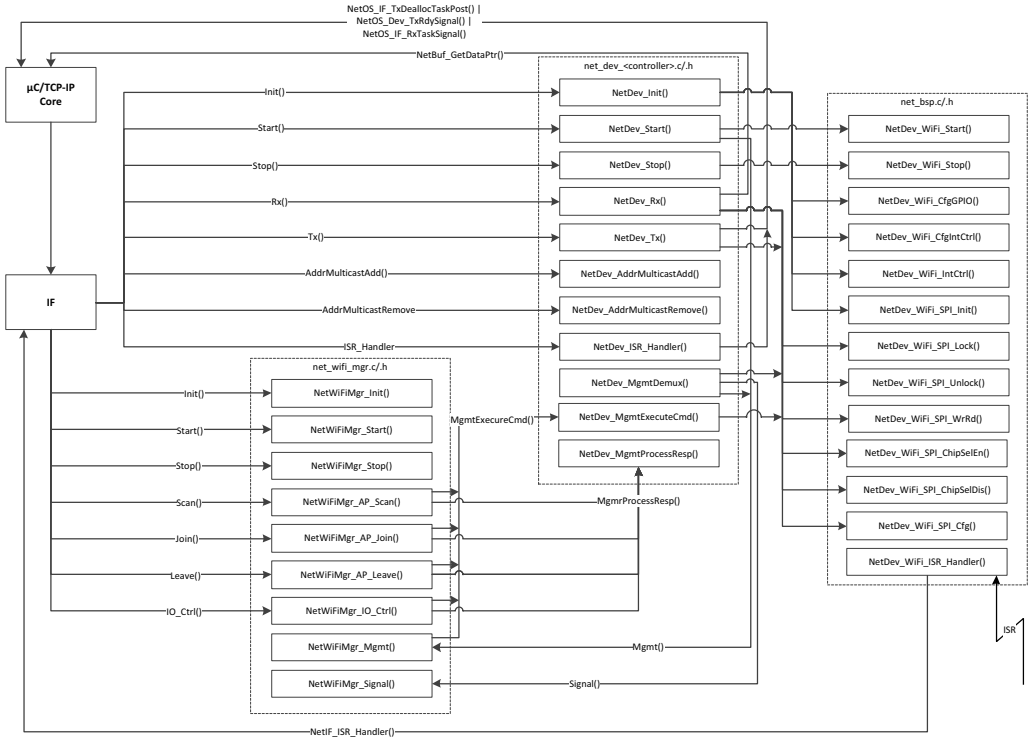



Figure 7-17 **Wireless Manager, device driver & BSP interactions**

## 7-9 WIRELESS MANAGER API IMPLEMENTATION

µC/TCP-IP supports only wireless devices which include an integrated wireless supplicant (i.e., the client-side software that performs scan and login requests). This kind of hardware requires to send management command to device to accomplish some operation such as scan, join, set MAC address, etc. Some of these management command may take a while to be completed. For those command most of wireless device return the command result via a management frame which must be received like a packet. So, the Wireless Manager must provide mechanisms to send management commands, and then return once the management command is completed.

The Wireless Manager API should be implemented as follows:

```
const  NET_WIFI_MGR_API  NetWiFiMgr_API_Generic = {
                                                    &NetWiFiMgr_Init,           (1)
                                                    &NetWiFiMgr_Start,          (2)
                                                    &NetWiFiMgr_Stop,           (3)
                                                    &NetWiFiMgr_AP_Scan,        (4)
                                                    &NetWiFiMgr_AP_Join,        (5)
                                                    &NetWiFiMgr_AP_Leave,       (6)
                                                    &NetWiFiMgr_IO_Ctrl,        (7)
                                                    &NetWiFiMgr_Mgmt,           (8)
                                                    &NetWiFiMgr_Signal          (9)
                                                   };
```

Listing 7-23 **Wireless Manager**

L7-23(1) Wireless Manager initialization function pointer

L7-23(2) Wireless Manager start function pointer

L7-23(3) Wireless Manager stop function pointer

L7-23(4) Wireless Manager access point scan pointer

L7-23(5) Wireless Manager access point join pointer

L7-23(6) Wireless Manager access point leave pointer

L7-23(7) Wireless Manager IO control pointer

L7-23(8) Wireless Manager device driver management pointer

L7-23(9) Wireless Manager signal response signal pointer

µC/TCP-IP provides code that is compatible with most wireless device that embed the wireless supplicant. However, extended functionality must be implemented on a per wireless device basis. If additional functionality is required, it may be necessary to create an application specific Wireless Manager.

Note: It is the Wireless Manager developers' responsibility to ensure that all of the functions listed within the API are properly implemented and that the order of the functions within the API structure is correct.

This sections that follow describe the interactions between the device driver and the Wireless Manager layer provided with µC/TCP-IP.

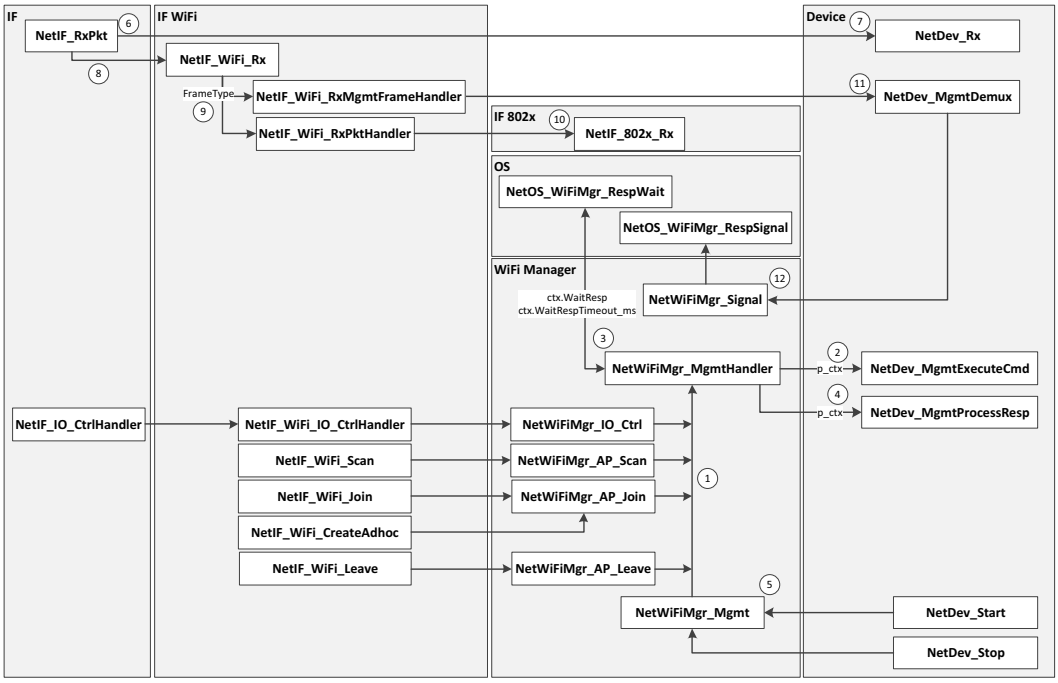



Figure 7-18 **Interactions between the device driver and the Wireless Manager layer**

F7-18(1) All management functionality present in the Wireless Manager API uses a simple state machine that uses a state machine context set and updated by the device driver. The state machine context contains some fields use by the state machine to know what it should be done after the call. Basically, the state machine is implemented in `NetWiFiMgr_MgmtHadler()` that calls `NetDev_MgmtExecuteCmd()` to start and execute the management command, following the state machine context, the state machine can wait to receive the response and then calls `NetDev_MgmtProcessResp()` to analyze the response data and rearrange the data.

F7-18(2) `NetDev_MgmtExecuteCmd()` can executes a management command directly if it doesn't require to received a response or just initialize the management command when a response is needed to complete the command. The function let know to the state machine of what should be done after by setting the state machine context that is passed as pointer argument to the function.

F7-18(3) If no response is needed to complete the command then the `NetWiFiMgr_MgmtHanlder()` returns immediately. If the management command requires a response to complete the command then it returns only if the timeout has expired (i.e. the response not received) or if the Wireless Manager has been signalled and the response is analyzed and translated.

F7-18(4) When the response of the management command is received `NetDev_MgmtProcessResp()` is called to analyze and to translate the data for upper layers. Also this function must update the state machine context to let know if the management command is completed or if more data must be send to complete the current management command.

F7-18(5) The device driver can also uses the Wireless Manager to send management command defined within the driver during start and stop of the interface especially when a response is needed to complete the management command such as updating the wireless device firmware. Note that it's not possible to use the Wireless Manager during the initialization since it's not possible to receive packet and management frame before the initialization is completed.

F7-18(6) When data ready ISR occurs and the interface is signalled, the function `NetIF_RxPkt()` calls the driver to read the data from the wireless device no matter if its management frame or data packet.

F7-18(7) `NetDev_Rx()` must determine if the data received is a management frame or a packet and must set at least the frame type within the offset of the network buffer. See "Receiving Packets and Management Frames" on page 222. If the data read is a management frame that it's not a response, the processing must be done in `NetDev_DemuxMgmt()` to let the stack increment his statistics.

F7-18(8) Once the data is read and the frame type set by the device driver then the buffer is passing to the wireless interface layer to be processed.

F7-18(9) `NetIF_WiFi_Rx()` uses the frame type within the buffer offset and set previously by the device driver to know which layer to call and pass the network buffer.

F7-18(10) If the data received is a packet then the 802x layer is called to process the packet as it's should done for an Ethernet packet.

F7-18(11) If the data received is a management frame then `8` is called to determine what to do with the data. If it's a response for a management command initialized previously then the Wireless Manager must be signalled. If it's information about the wireless device state, then some operation on the stack could be done such as updating the link state of the interface. Note that the buffer offset section could be used by the device driver to help to determine what kind of data is contained in the data section of the buffer.

F7-18(12) When the data is a management response previously initialized then the Wireless Manager must be signalled by using the Wireless Manager API.

# 7-10 WIRELESS DEVICE DRIVER IMPLEMENTATION

## 7-10-1 DESCRIPTION OF THE WIRELESS DEVICE DRIVER API

All device drivers must declare an instance of the appropriate device driver API structure as a global variable within the source code. The API structure is an ordered list of function pointers utilized by µC/TCP-IP when device hardware services are required.

A sample Ethernet interface API structure is shown below.

```
const  NET_DEV_API_WIFI  NetDev_API_<controler> = { NetDev_Init,                          (1)
                                                    NetDev_Start,                         (2)
                                                    NetDev_Stop,                          (3)
                                                    NetDev_Rx,                            (4)
                                                    NetDev_Tx,                            (5)
                                                    NetDev_AddrMulticastAdd,              (6)
                                                    NetDev_AddrMulticastRemove,           (7)
                                                    NetDev_ISR_Handler,                   (8)
                                                    NetDev_MgmtDemux,                     (9)
                                                    NetDev_MgmtExcuteCmd,                (10)
                                                    NetDev_mgmtProcessResp               (11)
                                                  };
```

Listing 7-24 **Ethernet interface API**

Note: It is the device driver developers' responsibility to ensure that all of the functions listed within the API are properly implemented and that the order of the functions within the API structure is correct.

L7-24(1) Device initialization/add function pointer

L7-24(2) Device start function pointer

L7-24(3) Device stop function pointer

L7-24(4) Device Receive function pointer

L7-24(5) Device transmit function pointer

L7-24(6) Device multicast address add function pointer

L7-24(7) Device multicast address remove function pointer

L7-24(8) Device interrupt service routine (ISR) handler function pointer

L7-24(9) Device demultiplex management frame function pointer.

L7-24(10) Device execute management command function pointer.

L7-24(11) Device process management response function pointer.

Note: µC/TCP-IP device driver API function names may not be unique. Name clashes between device drivers are avoided by never globally prototyping device driver functions and ensuring that all references to functions within the driver are obtained by pointers within the API structure. The developer may arbitrarily name the functions within the source file so long as the API structure is properly declared. The user application should never need to call API functions by name. Unless special care is taken, calling device driver functions by name may lead to unpredictable results due to reentrancy.

## 7-10-2 HOW TO ACCESS THE SPI BUS

µC/TCP-IP currently supports only wireless devices that communicate with the host via SPI. Also, many other devices/hardware can share the same SPI bus, so each time the device driver need to access the SPI bus it must acquire the access and set the SPI controller following the wireless device's SPI requirement. This procedure must be followed each time the device driver needs to access the SPI:

1 Acquire the SPI lock by calling network device's BSP function pointer, `NetDev_WiFi_SPI_Lock()`.

2 Enable chip select of the wireless device via network device's BSP function pointer, `NetDev_WiFi_SPI_ChipSelEn()`.

3 Configure the SPI controller by calling network device's BSP function pointer, `NetDev_WiFi_SPI_SetCfg()`.

4 Write data and read data from the SPI with appropriate buffer pointer to write buffer and read buffer to the network device's BSP function pointer, `Net_Dev_SPI_WrRd()`.

5 Disable the device's chip select via network device's BSP function pointer, NetDev_WiFi_SPI_ChipSelDis().

6 Release the SPI lock by calling network device's BSP function pointer, NetDev_WiFi_SPI_Unlock().

## 7-10-3 INITIALIZING A NETWORK DEVICE

NetDev_Init() is called by NetIF_Add() exactly once for each specific network device added by the application. If multiple instances of the same network device are present on the board, then this function is called for each instance of the device. However, applications should not try to add the same specific device more than once. If a network device fails to initialize, we recommend debugging to find and correct the cause of the failure.

NetDev_Init() performs the following operations. However, depending on the device being initialized, functionality may need to be added or removed:

1 Perform device configuration validation. Since some devices require special configuration, the configuration structure received should be examined at the initialization of the device and set *p_err if and unacceptable value have been specified to NET_DEV_ERR_INVALID_CFG must be returned.

2 Configure all necessary I/O pins for SPI, external interrupt, power pin, reset pin. This is performed via the network device's BSP function pointer, NetDev_WiFi_CfgGPIO(), implemented in net_bsp.c.

   Configure the host interrupt controller for receive and transmit complete interrupts. Additional interrupt services may be initialized depending on the device and driver requirements. This is performed via the network device's BSP function pointer, NetDev_WiFi_CfgIntCtrl(), implemented in net_bsp.c. However, receive interrupt should not be enabled before starting the interface.

3 Allocate memory for all necessary local buffers. This is performed via calls to µC/LIB's memory module.

4 Initialize the SPI controller. This is performed via the network device's BSP function pointer, `NetDev_WiFi_SPI_Init()`. The communication between the host and the wireless module should not be initialized, the wireless device should be powered down during and after the initialization.

5 Set `p_err` to `NET_DEV_ERR_NONE` if initialization proceeded as expected. Otherwise, set `p_err` to an appropriate network device error code.

`NetDev_Init()` can access the SPI bus for command that doesn't requires to receive the command result via a response. Since it's not possible to receive Network packet and management frame before the interface has been started.

## 7-10-4 STARTING A NETWORK DEVICE

`NetDev_Start()` is called each time an interface is started. It performs the following actions:

1 Call the `NetOS_Dev_CfgTxRdySignal()` function to configure the transmit ready semaphore count. This function call is optional and is performed if the hardware device supports queuing multiple transmit frames. By default, the semaphore count is initialized to one. However, wireless devices should set the semaphore count equal to the number of configured transmit queues size for optimal performance.

2 Power up the wireless module, this is performed via the network device's BSP function pointer, `NetDev_WiFi_Start()`.

3 The wireless device driver must initializes and start the communication between the host and the wireless module.

4 The device driver should validate the current firmware loaded in the wireless device and upgrade the device firmware if required.

Note: After a firmware upgrade, most of the time the wireless device requires to be reset, reinitialized and restarted.

5 Initialize the device MAC address, if applicable. For wireless devices, this step is mandatory. The MAC address data may come from one of three sources and should be set using the following priority scheme:

- Configure the MAC address using the string found within the device configuration structure. This is a form of static MAC address configuration and may be performed by calling `NetASCII_Str_to_MAC()` and `NetIF_AddrHW_SetHandler()`. If the device configuration string has been left empty, or is specified as all 0's, an error will be returned and the next method should be attempted.

- Check if the application developer has called `NetIF_AddrHW_Set()` by making a call to `NetIF_AddrHW_GetHandler()` and `NetIF_AddrHW_IsValidHandler()` in order to check if the specified MAC address is valid. This method may be used as a static method for configuring the MAC address during run-time, or a dynamic method should a pre-programmed external memory device exist. If the acquired MAC address does not pass the check function, then:

- Call `NetIF_AddrHW_SetHandler()` using the data found within the individual MAC address registers. If an auto-loading EEPROM is attached to the MAC, the registers will contain valid data. If not, then a configuration error has occurred. This method is often used with a production process where the MAC supports automatically loading individual address registers from a serial EEPROM. When using this method, you should specify an empty string for the MAC address within the device configuration, and refrain from calling `NetIF_AddrHW_Set()` from within the application.

6 Initialize additional MAC registers required by the MAC for proper operation.

7 Clear all interrupt flags.

8 Locally enable interrupts on the hardware device. This is performed via the network device's BSP function pointer, `NetDev_WiFi_IntCtrl()`. The host interrupt controller should have already been configured within the device driver `NetDev_Init()` function.

9 Enable the receiver and transmitter.

10 Set `perr` equal to `NET_DEV_ERR_NONE` if no errors have occurred. Otherwise, set `perr` to an appropriate network device error code

Some wireless module return result of commands via a response. The device's Wireless Manager function pointer, `NetWiFiMgr_Mgmt()` should be used to perform these type of command since it will return only when the response is received and processed.

## 7-10-5 STOPPING A NETWORK DEVICE

`NetDev_Stop()` is called once each time an interface is stopped.

`NetDev_Stop()` must perform the following operations:

1 Disable the receiver and transmitter.

2 Disable all local MAC interrupt sources.

3 Clear all local MAC interrupt status flags.

4 Power down the wireless device via network device's BSP function pointer, `NetDev_WiFi_Stop()`.

5 For wireless devices which can queued up packet to transmit, free all transmit buffer not yet transmitted by calling `NetOS_IF_DeallocTaskPost()` with the address of the transmit buffer data areas.

6 Set perr to `NET_DEV_ERR_NONE` if no error occurs. Otherwise, set `perr` to an appropriate network device error code.

Some wireless module return result of commands via a response. The device's Wireless Manager function pointer, `NetWiFiMgr_Mgmt()` should be used to perform these type of command since it will return only when the response is received and processed.

## 7-10-6 HANDLING A WIRELESS DEVICE ISR

`NetDev_ISR_Handler()` is the device interrupt handler. In general, the device interrupt handler must perform the following functions:

1 Determine which type of interrupt event occurred by switching on the ISR type argument. The ISR handler should not access the SPI bus for reading an interrupt status register.

2 If a receive event has occurred, the driver must post the interface number to the µC/TCP-IP Receive task by calling `NetOS_IF_RxTaskSignal()` for each new frame received (management or packet).

3 If a transmit complete event has occurred and it is specified in the ISR type argument, the driver must perform the following items for each transmitted packet.

   aPost the address of the data area that has completed transmission to the transmit buffer de-allocation task by calling `NetOS_IF_TxDeallocTaskPost()` with the pointer to the data area that has completed transmission.

   bCall `NetOS_Dev_TxRdySignal()` with the interface number that has just completed transmission.

4 Interrupt flags on the wireless device should not be cleared. CPU's integrated interrupt controllers should be cleared from within the network device's BSP-level ISR after `NetDev_WiFi_ISR_Handler()` returns.

Additionally, it is highly recommended that device driver ISR handlers be kept as short as possible to reduce the amount of interrupt latency in the system.

If the wireless module support transmit complete event, but reading an interrupt status register is required to know it, the receive task must be signaled and in `NetDev_Rx()` should return a management frame which will be passed to `NetDev_MgmtDemux()` and then you can perform the transmit complete operations.

## 7-10-7 RECEIVING PACKETS AND MANAGEMENT FRAMES

`NetDev_Rx()` is called by µC/TCP-IP's Receive task after the Interrupt Service Routine handler has signaled to the Receive task that a receive event has occurred. `NetDev_Rx()` requires that the device driver return a pointer to the data area containing the received data and return the size of the received frame via pointer.

### RECEIVE BUFFER STRUCTURE

Since `NetDev_Rx()` can be called to receive management frames and data packets, all wireless receive buffers must contain an offset before the data area to specify the frame type. So to understand data reception, you first need to understand the structure of receive buffers.

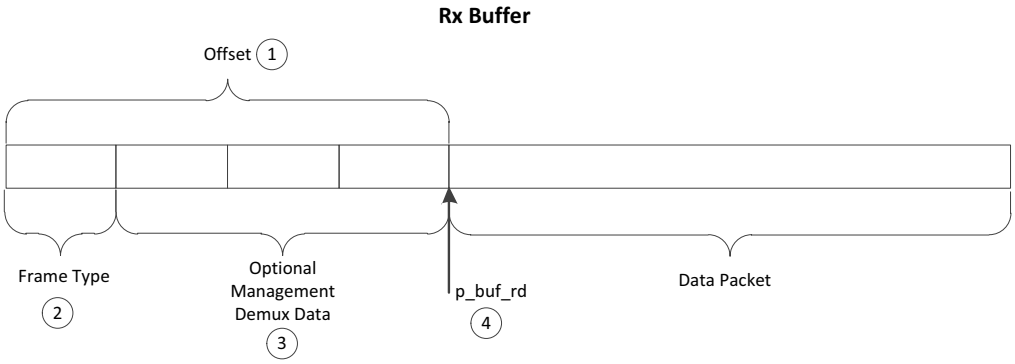



Figure 7-19 **Wireless receive buffer structure**

F7-19(1) The buffer offset is specified within the device's Memory configuration. The offset must be at least equal to one octet to handle the Frame type. The offset can include option control data for demultiplex and or to respect the buffer alignment.

F7-19(2) The frame type space is always the first octet of the buffer. If receiving data packet, set the frame type equal to `NET_IF_WIFI_DATA_PKT` and the packet will be processed by the stack. For a management frame the byte must be set equal to `NET_IF_WIFI_MGMT_FRAME`, in this case `NetDev_MgmtDemux()` will be called after return to analyses the management frame and signal the Wireless Manager or update the driver data's state.

F7-19(3) The receive buffer can include extra space to help to demultiplex a management frame or to respect buffer alignment required by the device's BSP function.

F7-19(4) The pointer passed to the network device's BSP function pointer, `NetDev_WiFi_SPI_WrRd()`, must point to the frame data area.

## RECEIVING FRAMES

`NetDev_Rx()` should perform the following actions:

1 Read the interrupt register which should be done by writing and reading on the SPI bus. This is performed by following the procedure to access the SPI bus. Also, the frame to receive must be know (Management frame or data packet). You should use small local buffer to write and read to complete that step.

2 Check for errors, if applicable. If an error occurs during reception, the driver should set `*size` to 0 and `*p_data` to `(CPU_INT08U *)0` and return. Additional steps may be necessary depending on the device being serviced.

3 Get the size of the received frame and get a new data buffer area by calling `NetBuf_GetDataPtr()`. If memory is not available, an error will be returned and the device driver should set `*size` to 0 and `*p_data` to `(CPU_INT08U *)0`.

4 If an error does not occur while getting a new data area, `*p_data` must be set to the address of the data area.

5 Set the frame type within the receive buffer equal to `NET_IF_WIFI_DATA_PKT` for a packet which must be processed by the stack and equal to `NET_IF_WIFI_MGMT_FRAME` for any management frame which will be passed to `NetDev_MgmtDemux()` to demultiplex the management frame.

6 Read from the device to the receive buffer data area by calling the network device's BSP function pointer, `NetDev_WiFi_SPI_WrRd()`, with an appropriate pointer to the data area of the receive buffer.

7 Set `p_err` to `NET_DEV_ERR_NONE` and return from the receive function. Otherwise, set `p_err` to an appropriate network device error code.

#### TRANSMIT COMPLETED NOTIFICATION

Since the SPI cannot be accessed within the ISR handler most of time all interrupts type are read in `NetDev_Rx()`. Also, when the ISR type is for a transmit completed notification, it is not recommended to notify the stack by the function and return an error since the reception statistics and errors counter will be affected. Instead it is recommended to return a management frame that contains the address of the data area successfully transmitted. Since all management frame are processed by `NetDev_MgmtDemux()`, the step to notify the stack should be done into it.

## 7-10-8 TRANSMITTING PACKETS

`NetDev_Tx()` is used to notify the wireless device that a new packet is available to be transmitted. It performs the following actions:

1 The driver follow the procedure to access the SPI bus, and it takes all necessary steps to initiate transmission of the data by writing to the wireless device's register using appropriate device's BSP functions. The driver must configure the device with the number of bytes to transmit. This value contained in the `size` argument.

2 The driver must write the data stored in the network buffer to the device's memory. The address of the buffer is specified by `p_data` which can be passed directly to 'Write Read' device's BSP function pointer.

3 For wireless devices that do not support transmit completed notifications, the packet is assumed to be transmitted successfully, and the driver must perform the following actions.

   aPost the address of the just-used network buffer to the transmit buffer de-allocation task by calling `NetOS_IF_TxDeallocTaskPost()` with the pointer `p_data`.

   bCall `NetOS_Dev_TxRdySignal()` with the number of the interface that had just completed transmission.

4 For wireless devices that do support transmit completed notifications, the previous transmit complete steps should be performed by `NetDev_MgmtDemux()`.

5 `NetDev_Tx()` sets `p_err` to `NET_DEV_ERR_NONE` and return from the transmit function.

## 7-10-9 ADDING AN ADDRESS TO THE MULTICAST ADDRESS FILTER OF A NETWORK DEVICE

`NetDev_AddrMulticastAdd()` is used to configure a device with an (IP-to-Ethernet) multicast hardware address.

You should follow the same steps described in section 7-5-8 "Adding an Address to the Multicast Address Filter of a Network Device" on page 166, except that the device's registers must be accessed through SPI.

If the wireless device return the result through a response, `NetDev_AddrMulticastAdd()` should calls the device's Wireless Manager function pointer, `NetWiFiMgr_Mgmt()`, to complete the operation.

## 7-10-10 REMOVING AN ADDRESS FROM THE MULTICAST ADDRESS FILTER OF A NETWORK DEVICE

`NetDev_AddrMulticastRemove()` is used to remove an (IP-to-Ethernet) multicast hardware address from a device.

You should follow the same steps described in section 7-5-9 "Removing an Address from the Multicast Address Filter of a Network Device" on page 170 should be followed, except that the device's registers must be accessed through SPI.

If the wireless device return the result through a response, `NetDev_AddrMulticastAdd()` should calls the device's Wireless Manager function pointer, `NetWiFiMgr_Mgmt()`, to complete the operation.

## 7-10-11 HOW TO DEMULTIPLEX MANAGEMENT FRAMES

`NetDev_MgmtDemux()` is called by µC/TCP-IP's Receive task after the device's receive function has returned a management frame. `NetDev_MgmtDemux()` requires that the device driver analyses management frames received and it must performs all necessary operations. It performs the following actions:

1 Determine if the management frame is a response of a previous management command sent or if it is a management frame which require the driver to update driver's state.

2 If the management frame is a response, the device's Wireless Manager must be signaled using the function pointer `NetWiFiMgr_Signal()`. No other steps are required in that case.

3 If the management frame is a state update, the driver should update device's data or interface's link state or perform transmit complete operations.

4 `NetDev_MgmtDemux()` sets `p_err` to `NET_DEV_ERR_NONE` and return from the demultiplex function.

If the management frame is only used within `NetDev_MgmtDemux()` (i.e., device's Wireless Manager not signaled), the network buffer must be freed by calling `NetBuf_Free()`.

## 7-10-12 HOW TO EXECUTE MANAGEMENT COMMAND

`NetDev_MgmtExcuteCmd()` is used to notify the wireless device that a new management command must be executed. It performs the following actions:

1 The driver follow the procedure to access the SPI bus and it takes all necessary steps to initiate the management command by writing to the wireless device's register using appropriate device's BSP functions. The driver must use the command data argument to send the data needed by the wireless device to perform the management command.

2 Update the pointer to the device's Wireless Manager context state argument following how the command result must be handled by the Wireless Manager.

a) If the management command requires multiple calls to `NetDev_MgmtExecuteCmd()` before completion, `MgmtCompleted` should be set to false. By doing this, `NetDev_MgmtExecuteCmd` is called in loop until `MgmtCompleted` comes equal to true or an error is returned.

b) If the management command requires to wait a response before completing the management command process, `WaitResp` must be set equal to true. In this case, once the response is received `NetDev_MgmtProcessResp` will be called. Also, `WaitRespTimeout_ms` should be set to let the Wireless Manager return an error when the response is not received.

3 If the result is not sent via a response, NetDev_MgmtProcessCmd() must fill the return buffer with appropriate data following the stack format.

4 NetDev_MgmtExecuteCmd() sets p_err to NET_DEV_ERR_NONE and returns from the execute management command function.

## 7-10-13 HOW TO PROCESS MANAGEMENT RESPONSE

NetDev_MgmtProcessResp() is called when the response of the current management command is received which means that NetDev_Demux() has signaled the device's Wireless Manager and the response must be analyzed and translated. NetDev_MgmtProcessResp() performs the following actions:

1 The function must translate the response and it must fills the return buffer with appropriate data following the stack format.

2 Update the device's Wireless Manager context state argument pointer following how the command result must be handled by the Wireless Manager.

a) If the management command is completed, MgmtCompleted must be set to true.

b) If the management command is not completed and more calls to NetDev_MgmtExecuteCmd() are required before completing the current management command, MgmtCompleted should be set to false. NetDev_MgmtExecuteCmd will be called and the management command will not return until MgmtCompleted comes equal to true.

3 NetDev_MgmtProcessResp() sets p_err to NET_DEV_ERR_NONE and return from the Process management response function.

Chapter

# 8

# Device Driver Validation

To help in the development of the Ethernet driver, Micrium provides a Windows-based tool called the Network Driver Integrated Tester (NDIT). The NDIT encapsulates many of the performance tests that you perform on your driver during development. It handles synchronisation between the test station and the target device, and parses and displays test results, all in one interface.

Tools that may help you during the design or tuning phase are presented in this chapter. These tools test and exercise different parts of the Ethernet device driver and can help uncovering flaws in the implementation of the driver. A set of test procedures is also provided in order to validate the proper behavior of the driver.

## 8-1 CHECKLIST

It is strongly suggested that you use the following checklist when writing a new device driver or when an existing driver is modified. You can fill it out as you develop your device driver and perform the tests described in the document.

| Element of Validation | Directly connected | Networked |
|---|---|---|
| Hardware Address configuration | q | q |
| Answer to all received ping | q | q |
| Answer to all received ping via fping | q | q |
| Transmit UDP Test 1 (transmit UDP packet of 1472 bytes) | q | q |
| Receive UDP Test 1 (Receive UDP packet of 1472 bytes) | q | q |
| Receive UDP Test 2 (Receive UDP packet with different length) | q | q |
| Transmit TCP Test 1 | q | q |
| Receive TCP Test 1 (Receive with default RX windows size) | q | q |
| Receive TCP Test 2 (Receive with optimized RX windows size) | q | q |
| No buffers leak | q | q |
| Configuration & Performance results are logged | q | q |
| Multicast | q | q |
| IF Start/Stop | q | q |

## 8-2 TEST MANAGEMENT INTERFACE

NDIT requires a connection with the target to configure the tests. There are two connection protocols available: RS-232 or TCP/IP (Ethernet). The use of TCP/IP requires a functional Ethernet driver and TCP/IP stack. It is common to start with RS-232, when a UART is available.

Upon starting NDIT, the following dialog box appears:

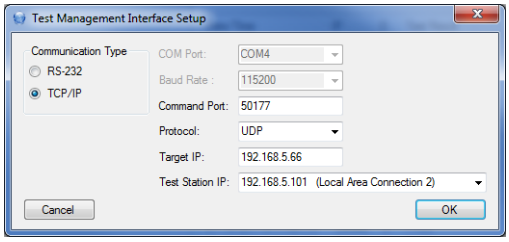



Figure 8-1 **Test management interface setup dialog**

The connection setup options are as followed:

**Connection type**

**RS-232**
COM port (ex: COM1).
Baud rate (8 bits, no parity, 1 stop bit and no flow control)

**TCP/IP**
Command port (UDP or TCP port)
The test station and target exchange commands and return results on this port. It must match the port number defined in `app_cfg.h` (`#define NDIT_PORT`).

**Transport protocol**

TCP or UDP. Either one of the protocol can be chosen as long as the target's TCP/IP implementation supports it.

**Target IP**

The target IP address must be the one used by `App_TCPIP_Init()` in `app.c` in order for the test station to reach the target board. This parameter is also used when the NDIT is setup for RS-232 communication.

**Network**

The network interface used to communicate with the target. By default, the first IPv4 network interface found is used. In order for the tests to work, the target has to be reachable via the selected network interface.

Once you click 'OK' the NDIT main window (see next section) appears, and your chosen connection settings are stored and will be reloaded at the next startup of NDIT.

## 8-2-1 NDIT MAIN WINDOW

The features of the main window are described in the following section. Below is a screen shot of the main window:

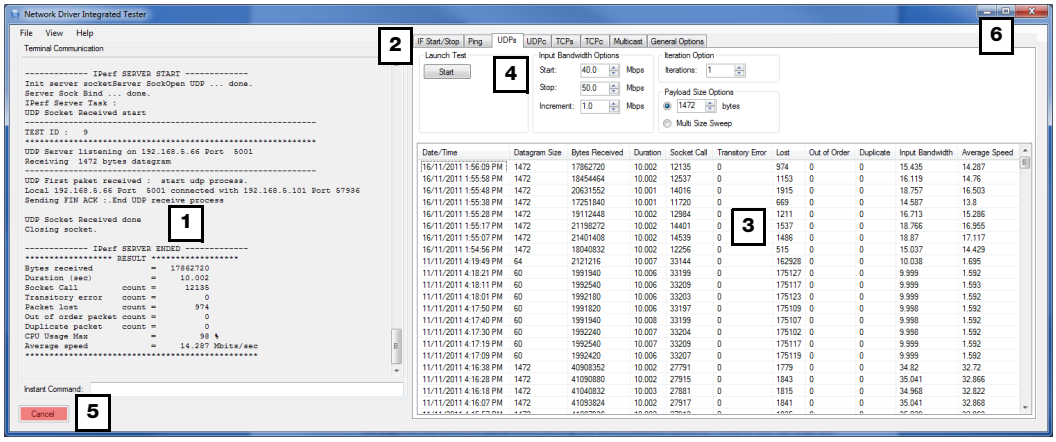



Figure 8-2 **NDIT Main Window**

F8-2(1) The target's communication log: The target received data is displayed in this scrollable text box.

F8-2(2) Test tabs: Each tab contains tests and test options:

1 IF Start/Stop: The network interface of the device is turned off and on again after a specified delay.

2 Ping: The target receives an ICMP echo request.

3 UDPs (UDP server): The target receives UDP frames from the test station at a specified bandwidth.

4 UDPc (UDP client): The target transmits UDP frames to the test station computer at the highest possible bandwidth achievable by the target.

5 TCPs (TCP server): The target receives TCP frames from the test station computer.

6 TCPc (TCP client): The target transmits TCP frames to the test station computer.

7 Multicast: The test station computer sends multicast packets to the target.

8 General Options: Common parameters for all the tests.

F8-2(3) Test results table: Each tab has its own test results table that displays the input information and the output results for each test ,along with the date and time at which that test was executed. When the NDIT is launched, it loads the test results logs from previous tests and displays them in the test results table.

F8-2(4) Tests and test options: This section contains the different tests and test options that can be performed from the selected tab.

In addition to the options specified in the current test tab, there is another set of options located in the General Option tab. These options, like test duration and target IP address, are common to more than one test.

F8-2(5) Cancel button: When an iterative or a parameter sweep test is launched, it can be cancelled by clicking the Cancel button. The current test will finish and the results will be displayed in the test result table.

F8-2(6) Exit button: Upon clicking the Exit button, the test results will be saved, and connections, if any, will be closed with the target.

## 8-2-2 GENERAL OPTIONS TAB

The General Options tab contains common test properties that are used throughout the test cases.

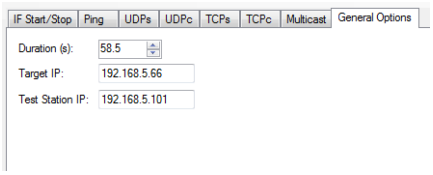



Figure 8-3 **General Options tab**

This tab contains three options:

- Duration (s): Used for IPerf testing. Specifies the duration of the data transfer between the test station and the target.
- Target IP: The target IP address as specified in `app.c`.
- Test Station IP: The test station IP address to which the target will reply when using IPerf.

## 8-3 VALIDATING A DEVICE DRIVER

This section describes how a driver should be validated. These tests must be performed for each new driver and any modifications to an existing driver. The tests provided have been chosen to highlight potential flaws that may be present in the device driver.

### 8-3-1 FILES NEEDED

The required source files needed to validate a device driver are as follows:

```
$/Micrium/Software/uC-IPerf/Source/iperf.c
$/Micrium/Software/uC-IPerf/Source/iperf.h
$/Micrium/Software/uC-IPerf/Source/iperf-c.c
$/Micrium/Software/uC-IPerf/Source/iperf-s.c
$/Micrium/Software/uC-IPerf/Reporter/Terminal/iperf_rep.c
$/Micrium/Software/uC-IPerf/Reporter/Terminal/iperf_rep.h
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/Source/ndit.c
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/Source/ndit.h
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/Source/ndit_ifss.c
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/Source/ndit_ifss.h
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/Source/ndit_mcast.c
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/Source/ndit_mcast.h
```

When using µC/OS-II:

```
$/Micrium/Software/uC-IPerf/Source/uCOS-II.c
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/OS/uCOS-II/ndit_os.c
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/OS/uCOS-II/ndit_mcast_os.c
```

Or when using µC/OS-III:

```
$/Micrium/Software/uC-IPerf/Source/uCOS-III.c
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/OS/uCOS-III/ndit_os.c
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/OS/uCOS-III/ndit_mcast_os.c
```

Copy the contents of

```
$/Micrium/Software/uC-IPerf/Cfg/Template/iperf_cfg.h
```

and

```
$/Micrium/Software/uC-TCPIP-V2/App/NDIT/Cfg/Template/ndit_cfg.h
```

into your `app_cfg.h`.

## 8-3-2 PROJECT EXAMPLE

Figure 8-4 shows the workspace with groups expanded for a development board with NDIT and IPerf modules included.

The **APP group** is where the actual code for the example is located.

The **BSP group** contains the 'Board Support Package' code to use for several of the Input/Output (I/O) devices on the development board.

The **NDIT group** contains the necessary files to interact with the NDIT software on the test station host. In hold the executive code for the test procedures describes in Section 10 of this document.

The **µC/CPU group** contains source and header files for the µC/CPU module. Header files contain definitions and declaration that are required by some of the application code.

The **µC/IPerf group** contains the source and header for the µC/IPerf module. It also contains the IPerf Reporter module which formats and displays IPerf's test results.

The **µC/LIB group** contains the source and header for the µC/LIB module. Again, the header files are needed as some of the application code requires definitions and declarations found in these files.

The **µC/OS-III group** contains the source and header files for the µC/OS-III module.

The **µC/TCP-IP group** contains the source and header files for the µC/TCP-IP module.

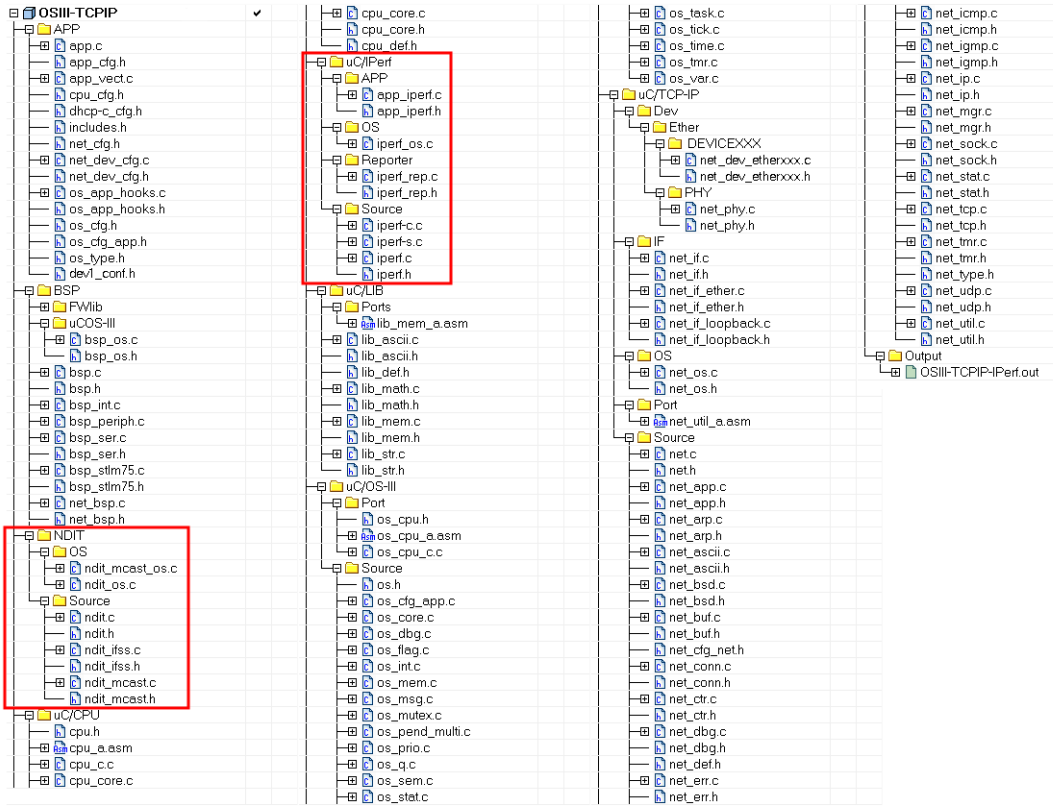



Figure 8-4 **Project Workspace with NDIT and IPerf modules highlighted**

## 8-3-3 HARDWARE ADDRESS CONFIGURATION

It is important to validate the configuration of the Ethernet interface's hardware address. The physical hardware address should be configured from within `NetDev_Start()` to allow for the proper use of `NetIF_Ether_HW_AddrSet()`, hard coded hardware addresses from the device configuration structure, or auto-loading EEPROM's. Changes to the physical address only take effect when the device transitions from the `NET_IF_LINK_DOWN` to `NET_IF_LINK_UP` state. These states are defined in `net_if.h`, and the current state of the controller can be found by calling `NetIF_LinkStateGet()` from your application.

The device hardware address is set from one of the data sources below, listed in the order of precedence.

1 From the device configuration structure (NET_DEV_CFG_ETHER) defined in net_dev_cfg.c. Configure a valid hardware address (i.e., not null) for .HW_AddrStr[] in NetDev_Cfg_<device>_<Nbr> in net_dev_cfg.c at compilation time.

2 From a call to NetIF_Ether_HW_AddrSet():

The value of .HW_AddrStr[] must be set to "00:00:00:00:00:00", or an empty string. NetIF_Ether_HW_AddrSet() must be called with the desired hardware address before calling NetIF_Start().

3 From Auto-Loading via EEPROM

If .HW_AddrStr[] is set to "00:00:00:00:00:00", and NetIF_Ether_HW_AddrSet() is not called, then NetDev_Start() will attempt to configure the hardware address with the network hardware address registers. These registers are the low and high hardware address register from the MAC device registers.

Note that this test is not available in NDIT since automatic source code compilation and binary download to the target are not supported by NDIT.

### TESTING

In order to verify that the three hardware address configuration methods work, there are a few steps that you will have to perform:

1 Set the value of .HW_AddrStr[] in NetDev_Cfg_<device>_<Nbr> in net_dev_cfg.c to a valid unicast MAC address. Then set up Wireshark to capture the ARP and ICMP traffic on the network interface used by your target. Send an ICMP echo request to the IP address of the target and verify that the device responds with the hardware address specified by .HW_AddrStr[] in the Wireshark trace.

2 Set the value of .HW_AddrStr[] in NetDev_Cfg_<device>_<Nbr> in net_dev_cfg.c to "00:00:00:00:00:00", before calling NetIF_Start() in your application code call NetIF_AddrHW_Set() with a valid unicast MAC address (i.e., not null) Then set up Wireshark to capture the ARP and ICMP traffic on the network interfece on which your

target is connected. Send an ICMP echo request to the IP address of the target and verify that the device responds with the hardware address specified with `NetIF_AddrHW_Set()` in the Wireshark trace.

3 The third method can be tested if the MAC on your device stores the MAC address registers in an EEPROM. If the EEPROM is accessible from the program loader, you can configure the high and low address registers with a valid HW address. Then setup Wireshark to capture the ARP and ICMP traffic on the network interface on which your target is connected. Send an ICMP echo request to the IP address of the target and verify, in the Wireshark trace, that the device responds with the hardware address specified.

## 8-3-4 IF START / STOP

The purpose of the Interface Start / Stop test is to validate that the driver can successfully stop a network interface and restart it again. Testing the driver's ability to stop the network interface is often skipped, but it is an essential function. Stopping and starting the network interface of your device is one of the ways to detect buffer leaks since stopping the device will deallocate all the network buffers and descriptors. If restarting the network interface fails, it might indicate that you have a buffer leak situation.

### IF START / STOP TEST USING NDIT

To validate the start/stop function, the NDIT verifies tthat the network device should:

- Respond to an echo request (ping) before stopping the network interface.
- Ignore an echo request after the network interface has been stopped.
- Respond again to an echo request after restarting the network interface.

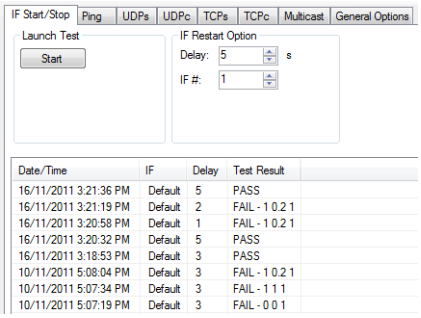



Figure 8-5 **Interface Start / Stop test tab**

There is a single option for the Interface Start / Stop test:

Delay The time between the Interface Stops and the Interface Starts (in seconds).

IF # The Interface number to Start / Stop.

## ANALYZING THE RESULTS

If the Test Result column does not indicate a PASS, it will show a FAIL followed by three echo request results. The first result should be 1 and represents a 100% echo reply success rate before the interface is stopped. The second result should be 0 and represents a 0% echo reply success rate while the interface is stopped. The final result should be 1 and represents a 100% echo reply success rate after the interface is restarted.

In the example shown in Figure 8-5, the test result that shows "FAIL – 1 1 1" indicates that the Interface continued replying to the test station host after it has sent the `ifss` stop command. Since all commands sent by the NDIT are acknowledged by the target, it is unlikely that the command wasn't received and processed by the target. Furthermore, the 100% success rate for the ICMP echo shows that the target is responsive. Therefore the error should be in the implementation of the `NetDev_Stop()` function.

## 8-3-5 ICMP ECHO REQUEST (PING) TESTS

The ping can be used as a starting point to validate the driver. But keep in mind that if your target answers to a ping request, it doesn't mean that your work is done. Since a ping request sends only a small payload to the target, and the device sends back an equally small payload to the test station, it is not a test for reliability or performance. The goal of this test is only to quickly determine whether or not the basic mechanism for receiving and transmitting a packet are implemented in your device driver.

```
ping <target.ip.address>
```

The µC/TCP-IP module needs a heavier load to see if the device driver is robust and stable. Your device driver must be able to answer (for a of minimum 15 seconds) this command:

```
ping <target.ip.address> -n 15 -l 1472
```

Once your driver is able to handle the previous ping command, you can increase the load by using fping.

A Windows version of fping can be found under the folder '\Micrium\Software\uC-TCPIP-V2\App\NDIT\Tool\Release'. Additional download sites are available for Linux and other operating systems. Note that NDIT is a Windows-only tool.

Your driver must be able to handle these fping commands:

```
fping <target.ip.address> -t 1 –c –i
```

`-t 1` Sets the interval between two subsequent ICMP echo request to 1 ms

`-c` Send the request indefinitely

`-i` Disables an annoying fping warning

A good result would be if your device can sustain that rate of request without ever stalling. Otherwise, you might have a buffer leak issue or a device configuration issue you should fix first before continuing with the subsequent tests.

```
fping <target.ip.address> -t 1 -S 1/1464
```

## 8-3-6 TARGET BOARD CONFIGURATION

The following sections require interactions between the NDIT on the test station and the code in your target. To be able to communicate with the test station, both the target and the test station must share the same configuration.

The first thing to configure is the communication protocol. The NDIT supports either serial port RS-232 communication or network TCP-IP communication. The communication protocol is configured in app_cfg.h.

### FOR RS-232 COMMUNICATION

```
#define  NDIT_COM                                    NDIT_SERIAL_COM
```

The data rate of the serial communication has to be defined to one of the available bit rates supported by the NDIT: 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600 or 115200 bits/sec. If your device has a serial port, the bit rate parameter should be defined in the BSP layer of the software architecture of the device. Your device must also implement a framing of 8 data bits, no parity and 1 stop bit. Also, flow control should not be used with NDIT.

### FOR TCP/IP CONNECTION

```
#define  NDIT_COM                                    NDIT_NETWORK_COM
```

The command port can be changed in app_cfg.h to any available port number:

```
#define  NDIT_PORT                                   50177u
```

## 8-4 USING IPERF

Perf is a tool designed to perform performance tests and to measure various variables of a network. IPerf is a benchmaring tool for measuring performance between two systems. It can be used as a server or a client for both the TCP and UDP protocols. Many IPerf applications are available for different operating systems. IPerf applications for the PC are easily found on the web. However, we suggest to use the IPerf function integrated in the Network Driver Integrated Tester for version compatibility purposes with the target software.

It is strongly recommended that you use IPerf to validate your driver and find the best target configuration. Perform four tests (Receive and Transmit are from the target point of view):

- TCP Server (Receive)
- TCP Client (Transmit)
- UDP Server (Receive)
- UDP Client (Transmit)

You have to test your driver with different TCP/IP stack configuration (`net_cfg.h`). Tests must be performed with the target directly connected to the test station and on a network and you it is recommended to log all performances results and configurations into a device drivers test result document.

You can find more information on IPerf at `http://sourceforge.net/projects/iperf/`.

## 8-4-1 GETTING STARTED WITH IPERF

Mircium's implementation of IPerf is called µC/IPerf. It can be used in many ways, the most practical being to launch a test on the target using the NDIT test management interface via a string command. µC/IPerf doesn't generate output by itself. Rather, statistics are compiled by IPerf for your test. To get the results, you must query IPerf using your own application or an existing tool. µC/IPerf comes with two built-in applications to query test status and output test results.

IPerf is available within the NDIT. It allows you to test the performance of your driver quickly, since the NDIT tests are using predefined IPerf commands. The results are logged and displayed in a table which makes it easier to track the driver's performances.

## 8-4-2 IPERF TOOLS

### TERMINAL REPORTER ON THE TARGET

If your target board has a serial interface, you should use the Terminal Reporter. You must create a function which will transmit a string buffer via the serial interface. The NDIT module must be able to use this function to send back the menu or any command errors. Listing 8-1 shows an example.

```
/*
*********************************************************************************************
*                                          NDIT_OutputFnct()
*
* Description : Output a string on the display.
*
* Argument(s) : p_buf       Pointer to buffer to output.
*
*               p_param     Pointer to IPerf output parameters. (unused)
*
* Return(s)   : none.
*
* Caller(s)   : various.
*
* Note(s)     : (1) The string pointed to by p_buf has to be NUL ('\0') terminated.
*********************************************************************************************
*/
#if (NDIT_COM == NDIT_SERIAL_COM)
void  NDIT_OutputFnct (CPU_CHAR         *p_buf,
                       IPERF_OUT_PARAM  *p_param)
{
   (void)&p_param;                                                              (1)

    if (p_buf == (CPU_CHAR *)0) {                                               (2)
        return;
    }
    APP_TRACE_INFO((p_buf));                                                    (3)
}
#endif
```

Listing 8-1 **Terminal reporter output function**

L8-1(1) Prevent “variable unused” compiler warning.

L8-1(2) Validate that the pointer to the string is not null.

L8-1(3) Display the string on the serial port of the board. `BSP_Ser_WrStr()` is a BSP-specific function that outputs each character of the string passed in the parameter until it reaches the NULL character ("\0"). It terminates the string with the Carriage Return symbol ("\r") followed by the Line Feed symbol ("\n"). The null is not transmitted.

You will also need to implement the task `NDIT_TaskTerminal()` which performs Terminal I/O. It must be able to:

1 Receive a string from the serial interface.

2 Launch IPerf or other NDIT commands with the string received on the serial interface.

Listing 8-2 shows a Terminal I/O task example.

```
/*
*********************************************************************************************
*                                          NDIT_TaskTerminal()
*
* Description : Task that reads the serial port input, processes the commands and verifies
*               that the cmd has been correctly executed.
*
* Argument(s) : p_arg           Pointer to task input parameter (unused).
*
* Return(s)   : none.
*
* Caller(s)   : AppTaskCreateTerminal().
*
* Note(s)     : none.
*********************************************************************************************
*/
#if (NDIT_COM == NDIT_SERIAL_COM)
void  NDIT_TaskTerminal (void  *p_arg)
{
    CPU_CHAR       cmd_str[TASK_TERMINAL_CMD_STR_MAX_LEN];
    CPU_SIZE_T     cmd_len;
    NDIT_ERR       err;

#if (IPERF_REPORTER == DEF_ENABLED)
    APP_TRACE_INFO(("\r\nTerminal I/O\r\n\r\n"));
    while (DEF_ON) {
        APP_TRACE(("\r\n>  "));
        BSP_Ser_RdStr((CPU_CHAR *)&cmd_str[0],                                          (1)
                      (CPU_INT16U) TASK_TERMINAL_CMD_STR_MAX_LEN);
```

```
        cmd_len = Str_Len(&cmd_str[0]);

        NDIT_ProcessCommand((CPU_CHAR     *)&cmd_str[0],                                    (2)
                            (CPU_INT16U    ) cmd_len,
                            (NDIT_OUT_FNCT )&NDIT_Output,
                            (IPERF_OUT_FNCT)&NDIT_OutputFnct,
                            (NDIT_ERR     *)&err);

        switch(err) {                                                                      (3)
            case NDIT_NO_ERR:
            case NDIT_ERR_NO_CMD:
                break;
            case NDIT_ERR_IPERF:                                                           (4)
                NDIT_Output(("Error in IPerf Test\r\n\r\n"));
                break;
            case NDIT_ERR_MCAST:                                                           (5)
                NDIT_Output(("Error in Mcast Test\r\n\r\n"));
                break;
            case NDIT_ERR_IFSS:                                                            (6)
                NDIT_Output(("Error in IFSS Test\r\n\r\n"));
                break;
            case NDIT_ERR_NO_MATCH:                                                        (7)
                NDIT_Output(("Command not recognized\r\n\r\n"));
                break;
        }
    }
#endif
}
#endif
```

Listing 8-2 **Terminal I/O task**

L8-2(1) Read string command from serial port.

L8-2(2) The command read from the serial port is processed and executed by the `NDIT_ProcessCommand()` function.

L8-2(3) Verify test executed correctly based on the return error from the `NDIT_ProcessCommand()` function.

L8-2(4) An error occurred during an IPerf test.

L8-2(5) An error occurred during a Multicast test.

L8-2(6) An error occurred during an Interface Start/Stop test.

L8-2(7) The provided command was neither recognized by the IPerf, Multicast or Interface Start/Stop test modules.

Note that you must initialize µC/IPerf before using the "Terminal Reporter."

### SERVER REPORTER ON THE TARGET

You can also use the network interface of your device to send commands to the NDIT. This way, if you don't have a Serial Port on your device, you can still send commands and receive results through the `NDIT_TaskServer()` task and `NDIT_NetOutputFnct()` display function.

The source of `NDIT_NetOutputFnct()` is displayed in Listing 8-3:

```
/*
*********************************************************************************************
*                                        NDIT_NetOutputFnct()
*
* Description : Outputs a string to the test host application.
*
* Argument(s) : p_buf       Pointer to buffer to output.
*
*               p_param     Pointer to IPERF_OUT_PARAM object.
*
* Return(s)   : none.
*
* Caller(s)   : various.
*
* Note(s)     : (1) The string pointed to by p_buf has to be NUL ('\0') terminated.
*********************************************************************************************
*/
#if (NDIT_COM == NDIT_NETWORK_COM)
void  NDIT_NetOutputFnct (CPU_CHAR         *p_buf,
                          IPERF_OUT_PARAM  *p_param)
{
    CPU_INT16U  tx_len;
    NET_ERR     net_err;

   (void)&p_param;                                                              (1)
```

```
    if (p_buf == (CPU_CHAR *)0) {                                                (2)
        return;
    }

    if (NDIT_TS_SockInfo.NetSockID != NET_SOCK_BSD_ERR_OPEN) {

        tx_len = (CPU_INT16U)Str_Len(p_buf);                                     (3)

        (void)NetApp_SockTx ((NET_SOCK_ID      ) NDIT_TS_SockInfo.NetSockID,     (4)
                             (void            *) p_buf,
                             (CPU_INT16U       ) tx_len,
                             (CPU_INT16S       ) NET_SOCK_FLAG_NONE,
                             (NET_SOCK_ADDR   *)&NDIT_TS_SockInfo.NetSockAddr,
                             (NET_SOCK_ADDR_LEN) NDIT_TS_SockInfo.NetSockAddrLen,
                             (CPU_INT16U       ) NDIT_SERVER_RETRY_MAX,
                             (CPU_INT32U       ) NDIT_SERVER_DELAY_MS,
                             (CPU_INT32U       ) NDIT_SERVER_DELAY_MS,
                             (NET_ERR         *)&net_err);    }
    }
}
#endif
```

Listing 8-3 **NDIT_NetOutputFnct display function**

L8-3(1) Prevent “variable unused” compiler warning.

L8-3(2) Verify that the pointer is not null.

L8-3(3) Calculate buffer length.

L8-3(4) Send the buffer to the test station host using the test station host information found in the DIS_TS_SockInfo global variable.

Listing 8-4 shows the `NDIT_TaskServer()` function, which reads the commands from the test station host, processes them, and gives back the results to the test station host.

```
typedef  struct  host_sock_info {                                                                (1)
    NET_SOCK_ID        NetSockID;
    NET_SOCK_ADDR      NetSockAddr;
    NET_SOCK_ADDR_LEN  NetSockAddrLen;
} HOST_SOCK_INFO;
static  HOST_SOCK_INFO    NDIT_TS_SockInfo;                                                      (2)
/*
*********************************************************************************************
*                                          NDIT_TaskServer()
*
* Description:  This function creates a input/output ethernet communication link to use iPerf.
*
* Argument(s) : p_arg       Pointer to arg. (unused)
*
* Return(s)   : none.
*
* Caller(s)   : NDIT_TaskCreateServer().
*
* Note(s)     : (1) NDIT_COM must be defined to NDIT_NETWORK_COM in app_cfg.h for this function
to be used.
*
*********************************************************************************************
*/
#if (NDIT_COM == NDIT_NETWORK_COM)
void  NDIT_TaskServer (void  *p_arg)
{
    NET_SOCK_ID        net_sock_id;
    NET_SOCK_ADDR_IP   server_addr_port;
    NET_SOCK_ADDR      client_addr_port;
    NET_SOCK_ADDR_LEN  client_addr_port_len;
    CPU_CHAR           buf[TASK_TERMINAL_CMD_STR_MAX_LEN];
    CPU_INT16S         rx_len;
    CPU_BOOLEAN        socket_connected;
    NET_ERR            net_err;
    NDIT_ERR           test_err;

    (void)&p_arg;                                                                               (3)

    Mem_Clr((void     *)&server_addr_port,                                                      (4)
            (CPU_SIZE_T) sizeof(server_addr_port));

    server_addr_port.AddrFamily = NET_SOCK_ADDR_FAMILY_IP_V4;
    server_addr_port.Port       = NET_UTIL_HOST_TO_NET_16(NDIT_PORT);
    server_addr_port.Addr       = NET_SOCK_ADDR_IP_WILDCARD;
```

```
while (DEF_TRUE){
    socket_connected = DEF_YES;

    net_sock_id = NetApp_SockOpen((NET_SOCK_PROTOCOL_FAMILY) NET_SOCK_FAMILY_IP_V4,     (5)
                                  (NET_SOCK_TYPE           ) NET_SOCK_TYPE_DATAGRAM,
                                  (NET_SOCK_PROTOCOL       ) NET_SOCK_PROTOCOL_UDP,
                                  (CPU_INT16U              ) NDIT_SERVER_RETRY_MAX,
                                  (CPU_INT32U              ) NDIT_SERVER_DELAY_MS,
                                  (NET_ERR                *)&net_err);

    if (net_err != NET_APP_ERR_NONE) {
        APP_TRACE_INFO(("\r\nFail to open socket.\r\n\r\n"));                           (6)
        socket_connected = DEF_NO;
    } else {

        (void)NetApp_SockBind((NET_SOCK_ID      ) net_sock_id,                          (7)
                              (NET_SOCK_ADDR   *)&server_addr_port,
                              (NET_SOCK_ADDR_LEN) NET_SOCK_ADDR_SIZE,
                              (CPU_INT16U       ) NDIT_SERVER_RETRY_MAX,
                              (CPU_INT32U       ) NDIT_SERVER_DELAY_MS,
                              (NET_ERR         *)&net_err);

        if (net_err != NET_APP_ERR_NONE) {

            (void)NetApp_SockClose((NET_SOCK_ID) net_sock_id,                         (8)
                                   (CPU_INT32U ) 0u,
                                   (NET_ERR   *)&net_err);

             socket_connected = DEF_NO;
        }
    }

    while(socket_connected == DEF_YES) {                                               (9)

        rx_len = NetApp_SockRx ((NET_SOCK_ID        ) net_sock_id,                   (10)
                                (void              *)&buf[0],
                                (CPU_INT16U         ) TASK_TERMINAL_CMD_STR_MAX_LEN,
                                (CPU_INT16U         ) 0,
                                (CPU_INT16S         ) NET_SOCK_FLAG_NONE,
                                (NET_SOCK_ADDR     *)&client_addr_port,
                                (NET_SOCK_ADDR_LEN *)&client_addr_port_len,
                                (CPU_INT16U         ) 1,
                                (CPU_INT32U         ) 0,
                                (CPU_INT32U         ) 0,
                                (NET_ERR           *)&net_err);
```

```
            switch (net_err) {
                case NET_APP_ERR_CONN_CLOSED:                                           (11)
                    socket_connected = DEF_NO;
                    break;
                case NET_APP_ERR_NONE:
                default:
                    break;
            }

            NDIT_TS_SockInfo.NetSockID      = net_sock_id;                              (12)
            NDIT_TS_SockInfo.NetSockAddr    = client_addr_port;
            NDIT_TS_SockInfo.NetSockAddrLen = client_addr_port_len;

            buf[rx_len] = '\0';
            NDIT_NetOutput(&buf[0]);                                                    (13)
            NDIT_NetOutput(NEW_LINE);

            NDIT_ProcessCommand((CPU_CHAR     *)&buf[0],                                (14)
                                (CPU_INT16U    ) rx_len,
                                (NDIT_OUT_FNCT  )&NDIT_NetOutput,
                                (IPERF_OUT_FNCT)&NDIT_NetOutputFnct,
                                (NDIT_ERR      *)&test_err);
            switch(test_err) {                                                          (15)
                case NDIT_NO_ERR:
                case NDIT_ERR_NO_CMD:
                    break;
                case NDIT_ERR_IPERF:
                    NDIT_NetOutput("\r\nError in IPerf Test\r\n\r\n");                   (16)
                    break;
                case NDIT_ERR_MCAST:
                    NDIT_NetOutput("\r\nError in Mcast Test\r\n\r\n");                   (17)
                    break;
                case NDIT_ERR_IFSS:
                    NDIT_NetOutput("\r\nError in IFSS Test\r\n\r\n");                    (18)
                    break;
                case NDIT_ERR_NO_MATCH:
                default:
                    NDIT_NetOutput("\r\nCommand not recognized\r\n\r\n");               (19)
                    break;
            }

            NDIT_Delay (0, 0, 0, 100);
        }
    }
}
#endif
```

Listing 8-4 **NDIT_TaskServer() task**

L8-4(1) Structure that contains the test station host socket id, socket address and socket address length.

L8-4(2) The global variable that hold the necessary information for the NDIT display function to return the test results and information messages to the test station host.

L8-4(3) Prevent the "variable unused" warning from the compiler.

L8-4(4) Initialize NDIT Server Address and Port.

L8-4(5) Open socket for receiving host commands and publish results.

L8-4(6) An error has occurred during the opening of the socket.

L8-4(7) Bind the socket to a local port.

L8-4(8) If binding fails, close the socket.

L8-4(9) Server reading and command processing loop.

L8-4(10) Read the incoming command from the test station host.

L8-4(11) If socket is closed, then exit the while loop and restart connection process.

L8-4(12) Update remote host socket information for displaying test results and messages to the test station host.

L8-4(13) Reply to test station for acknowledgement.

L8-4(14) The command read from the serial port is processed and executed by the `NDIT_ProcessCommand()` function.

L8-4(15) Verify test executed correctly based on the return error from the `NDIT_ProcessCommand()` function.

L8-4(16) An error occurred during an IPerf test.

L8-4(17) An error occurred during a Multicast test.

L8-4(18) An error occurred during an Interface Start/Stop test.

L8-4(19) The provided command was neither recognized by the IPerf, Multicast or Interface Start/Stop test modules.

## 8-5 IPERF TEST CASE

Once the target answers to ping requests on a switched network, you should perform additional IPerf tests with the target connected directly to the test station, and on a network. It is best to perform standard tests, and log the results into a device driver test result document.

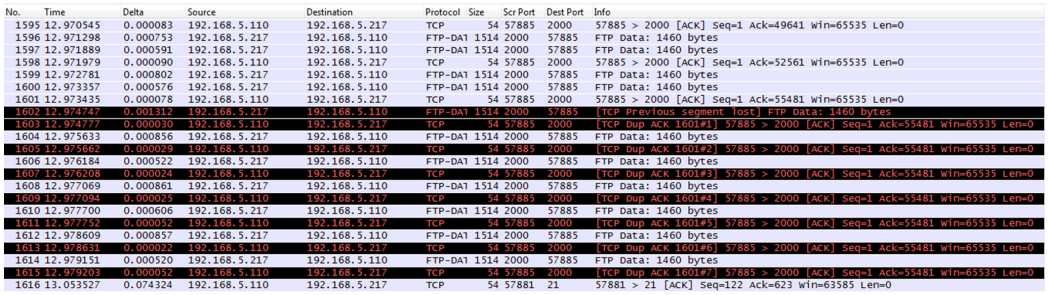
### BUFFER LEAKS

For each IPerf test, make sure that your driver does not have any buffer leaks. If the driver performance decrease over time, or if the driver suddenly stops, you might have a buffer leak.

Buffer leaks can happen in many cases. The root cause of a buffer leak is when the program loses track of memory allocation pointers. Assigning a newly allocated buffer to a pointer without deallocating the previous memory block that the pointer associated with will also cause a buffer leak. If no other pointer refers to that memory location, then there is no way it can be deallocated in the future, and that memory block will remain unusable unless the system is reset.

Transmit buffer leaks can be detected by having the target transmit a large buffer to the test station using TCP. A good example would be an FTP test. If a given buffer is not transmitted because it has leaked, the test station will request its retransmission by the target. This operation should fail since the leaked buffer is lost.

In Figure 8-6, the test station (192.168.5.110) requests the retransmission of a lost segment and the target (192.168.5.217) fails to retransmit it:



| No. | Time | Delta | Source | Destination | Protocol | Size | Scr Port | Dest Port | Info |
|---|---|---|---|---|---|---|---|---|---|
| 1595 | 12.970545 | 0.000083 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57885 | 2000 | 57885 > 2000 [ACK] Seq=1 Ack=49641 Win=65535 Len=0 |
| 1596 | 12.971298 | 0.000753 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | FTP Data: 1460 bytes |
| 1597 | 12.971889 | 0.000591 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | FTP Data: 1460 bytes |
| 1598 | 12.971979 | 0.000090 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57885 | 2000 | 57885 > 2000 [ACK] Seq=1 Ack=52561 Win=65535 Len=0 |
| 1599 | 12.972781 | 0.000802 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | FTP Data: 1460 bytes |
| 1600 | 12.973357 | 0.000576 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | FTP Data: 1460 bytes |
| 1601 | 12.973435 | 0.000078 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57885 | 2000 | 57885 > 2000 [ACK] Seq=1 Ack=55481 Win=65535 Len=0 |
| 1602 | 12.974747 | 0.001312 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | [TCP Previous segment lost] FTP Data: 1460 bytes |
| 1603 | 12.974777 | 0.000030 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57885 | 2000 | [TCP Dup ACK 1601#1] 57885 > 2000 [ACK] Seq=1 Ack=55481 Win=65535 Len=0 |
| 1604 | 12.975633 | 0.000856 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | FTP Data: 1460 bytes |
| 1605 | 12.975662 | 0.000029 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57885 | 2000 | [TCP Dup ACK 1601#2] 57885 > 2000 [ACK] Seq=1 Ack=55481 Win=65535 Len=0 |
| 1606 | 12.976184 | 0.000522 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | FTP Data: 1460 bytes |
| 1607 | 12.976208 | 0.000024 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57885 | 2000 | [TCP Dup ACK 1601#3] 57885 > 2000 [ACK] Seq=1 Ack=55481 Win=65535 Len=0 |
| 1608 | 12.977069 | 0.000861 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | FTP Data: 1460 bytes |
| 1609 | 12.977094 | 0.000025 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57885 | 2000 | [TCP Dup ACK 1601#4] 57885 > 2000 [ACK] Seq=1 Ack=55481 Win=65535 Len=0 |
| 1610 | 12.977700 | 0.000606 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | FTP Data: 1460 bytes |
| 1611 | 12.977752 | 0.000052 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57885 | 2000 | [TCP Dup ACK 1601#5] 57885 > 2000 [ACK] Seq=1 Ack=55481 Win=65535 Len=0 |
| 1612 | 12.978609 | 0.000857 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | FTP Data: 1460 bytes |
| 1613 | 12.978631 | 0.000022 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57885 | 2000 | [TCP Dup ACK 1601#6] 57885 > 2000 [ACK] Seq=1 Ack=55481 Win=65535 Len=0 |
| 1614 | 12.979151 | 0.000520 | 192.168.5.217 | 192.168.5.110 | FTP-DAT | 1514 | 2000 | 57885 | FTP Data: 1460 bytes |
| 1615 | 12.979203 | 0.000052 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57885 | 2000 | [TCP Dup ACK 1601#7] 57885 > 2000 [ACK] Seq=1 Ack=55481 Win=65535 Len=0 |
| 1616 | 13.053527 | 0.074324 | 192.168.5.110 | 192.168.5.217 | TCP | 54 | 57881 | 21 | 57881 > 21 [ACK] Seq=122 Ack=623 Win=63585 Len=0 |

Figure 8-6 **Transmission Buffer Leak Example**

### NO RETRANSMISSION

Retransmissions should never happen unless they are requested by the communication protocol. Erroneous retransmissions can happen if a transmitted buffer remains assigned to a descriptor, and the buffer is not deallocated.

While performing performance tests on the target, you should use Wireshark or another packet capture tool to monitoring the trafic. Unrequested packets retransmission can be detected by searching for frames marked with “[This frame is a (suspected) retransmission]” in Wireshark.

### ADVERTISED WINDOW SIZE

The total memory available for the reception buffer should always be equal to or greater than the window size advertised by the target. If it is not the case, the test station might send too many packets before waiting for an acknowledge message, and the target might lose packets. Loosing those packets will trigger a retransmission of the lost packets, and thus slow down the data transfer.

### PERFORMANCE RESULTS

You should log your driver performance in the driver document. This document is used as a reference for support requests, so it’s very important to log performance when you write or update a driver. The performance data that you should log is described in the following sections.

Certain TCP/IP features reduce performance, so you should disable these features before logging the results. The µC/TCP-IP configuration switches for these features are shown in Listing 8-5, and can be found in `net_cfg.h`.

```
Net Configuration:
#define  NET_DBG_CFG_INFO_EN                    DEF_DISABLED
#define  NET_DBG_CFG_STATUS_EN                  DEF_DISABLED
#define  NET_DBG_CFG_MEM_CLR_EN                 DEF_DISABLED
#define  NET_DBG_CFG_TEST_EN                    DEF_DISABLED
#define  NET_ERR_CFG_ARG_CHK_EXT_EN             DEF_DISABLED
#define  NET_ERR_CFG_ARG_CHK_DBG_EN             DEF_DISABLED
#define  NET_CTR_CFG_STAT_EN                    DEF_DISABLED
#define  NET_CTR_CFG_ERR_EN                     DEF_DISABLED
#define  NET_IF_CFG_LOOPBACK_EN                 DEF_DISABLED
#define  NET_ICMP_CFG_TX_SRC_QUENCH_EN          DEF_DISABLED
```

Listing 8-5 **Net Configuration for optimal performances**

## TASK PRIORITIES

In order to obtain the best possible performance for your tests, you should use appropriate task priorities.

When setting up task priorities, we recommend that tasks that use µC/TCP-IP's services be given higher priorities than µC/TCP-IP's internal tasks. However, application tasks that use µC/TCP-IP should voluntarily relinquish the CPU on a regular basis. For example, they can delay or suspend the tasks, or wait on µC/TCP-IP services. The purpose is to reduce starvation issues when an application task sends a substantial amount of data.

We recommend that you configure the network interface Transmit De-allocation task with a higher priority than all application tasks that use µC/TCP-IP network services; but configure the Timer task and network interface Receive task with lower priorities than almost other application tasks.

Listing 8-6 shows an example of task priorities and stack sizes for a typical device performance measurement application.

```
*
*********************************************************************************************************
*                                             TASK PRIORITIES
*********************************************************************************************************
*/
#define  IPERF_OS_CFG_TASK_PRIO                          11u
#define  APP_TASK_START_PRIO                             13u
#define  NDIT_TASK_TERMINAL_PRIO                         15u
#define  NDIT_TASK_MULTICAST_PRIO                        12u
#define  NDIT_TASK_SERVER_PRIO                           16u
#define  NET_OS_CFG_IF_TX_DEALLOC_TASK_PRIO               2u
#define  NET_OS_CFG_TMR_TASK_PRIO                        15u
#define  NET_OS_CFG_IF_RX_TASK_PRIO                      18u
#define  NDIT_MCAST_TASK_PRIO                            20u
/*
*********************************************************************************************************
*                                             TASK STACK SIZES
*                             Size of the task stacks (# of OS_STK entries)
*********************************************************************************************************
*/
#define  APP_TASK_START_STK_SIZE                        128u
#define  NDIT_TASK_TERMINAL_STK_SIZE                    512u
#define  IPERF_OS_CFG_TASK_STK_SIZE                     512u
#define  NDIT_TASK_SERVER_STK_SIZE                      512u
#define  NDIT_MCAST_TASK_STK_SIZE                       512u
#define  NET_OS_CFG_TMR_TASK_STK_SIZE                   512u
#define  NET_OS_CFG_IF_TX_DEALLOC_TASK_STK_SIZE         128u
#define  NET_OS_CFG_IF_RX_TASK_STK_SIZE                 512u
```

Listing 8-6 **Example of task priorities and stack sizes**

## 8-5-1 TESTING UDP TRANSMISSION

The first IPerf test you should perform is UDP transmission. Your target must be able to transmit UDP packets reliably and with acceptable throughput. Also, your target must be able to transmit packets that have the maximum UDP packet length, which is 1472 bytes (make sure to have the correct Transmit buffer size).

### TEST: TRANSMIT UDP PACKET (1472 BYTES) USING NDIT

Selecting the UDPc test tab in the main NDIT window. The UDPc test tab appears:

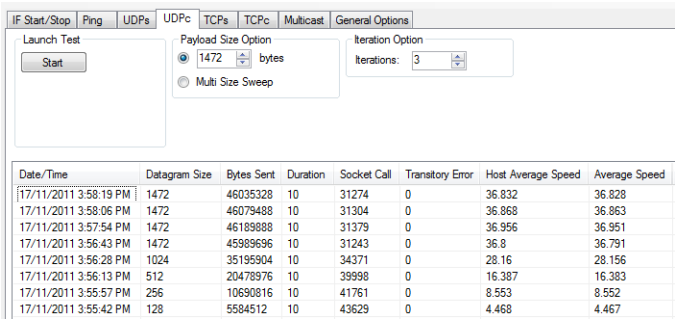



Figure 8-7 **UDPc test tab**

There are three options for this test. The first is the size of the datagram (either a single 1472 or a sweep of multiple packets that are 64, 128, 256, 512, 1024 and 1472 bytes in size). The second option is the number of times the test is repeated. The third is the test duration (in seconds), which is located in the General Options tab.

### EXPECTED RESULTS

- Highest throughput possible.

  Although it is difficult to estimate the achievable throughput with a particular device, it is possible to compare with other drivers sharing roughly the same quantity of network buffers or processor speed.

  Table 8-1 shows an example of performance results for different devices and configurations:

| **Development Board** | Device 1 | Device 2 |
|---|---|---|
| **CPU Speed** | 72 MHz | 70 MHz |
| **CPU Architecture** | ARM® Cortex-M3™ | ARM® Cortex-M4™ |
| **Tx Buffers** | 4 | 3 |
| **Tx Descr.** | 4 | 3 |
| **64 byte Datagram** | | |
| **Socket Call** | 44253 | 29994 |
| **Throughput (Mbps)** | 2.265 | 1.535 |
| **1472 byte Datagram** | | |
| **Socket Call** | 31245 | 29991 |
| **Throughput (Mbps)** | 36.794 | 35.317 |

Table 8-1 **UDPc Performance Example**

Tweaking the task priorities might help increasing the throughput out the network driver.

- Few transitory errors.

  Transitory errors are errors that temporarily prevent the transmission of packets. Transitory errors are often recoverable. These errors include:

  - Trying to receive on a socket where the host has disconnected prematurely.
  - Trying to receive on a socket before the network initialization is completed.
  - Trying to receive on a socket that is in use by another process.

  To solve these issues, make sure that you use valid parameters for your tests. Make sure that the resources you use are still valid, and not already used by another task.

- Ability to send packets with a size equal to the MTU.

  To find out the MTU size for your network type, enter the following command in the command shell in Windows:

  ```
  netsh interface ipv4 show subinterfaces
  ```

  The results you should get is something like this:

  ```
  Microsoft Windows [Version 6.1.7601]
  Copyright (c) 2009 Microsoft Corporation.  All rights reserved.
  C:\Users\user01>netsh interface ipv4 show subinterfaces
         MTU  MediaSenseState   Bytes In  Bytes Out  Interface
  ----------  ---------------  ---------  ---------  -------------
        1500                5          0          0  Wireless Network Connection
        1500                5          0          0  Local Area Connection
        1500                1  693970658   90284509  Local Area Connection 2
  ```

  In the above example, the MTU size is set to 1500 for all the network interfaces. For this reason, we use 1472 bytes as the length for the payload in our UDP test. Since the MAC-IP-UDP headers account for 28 bytes that leaves 1472 bytes left for the payload.

  In subsequent TCP tests, we use a value of 1460 or multiple of that value to set buffer sizes, window sizes, and so on. Since the size of the TCP header is slightly larger than the UDP header, this yields a smaller payload.

- Comparable results for the target directly connected, or on a network.

- No buffer leaks.

  See section "Buffer leaks" on page 253 for more details.

- Logging performance results (with the target directly connected, and networked).

## 8-5-2 TESTING UDP RECEPTION

Your target must be able to receive UDP packets reliably and with acceptable throughput. It must also be able to receive UDP packets with a size equal to the MTU.

### TEST 1: MAXIMUM BANDWIDTH RECEIVE UDP TEST USING NDIT

Select the UDPs test tab in the NDIT main window. The UDP test tab appears

The first test we suggest you to run is a 100 Mbps, 1472-byte payload test. It is the most demanding test in terms of data reception, as UDP is a light transport protocol and the CPU will be strained with a flood of UDP datagrams.

Figure 8-8 shows the UDPs test tab.

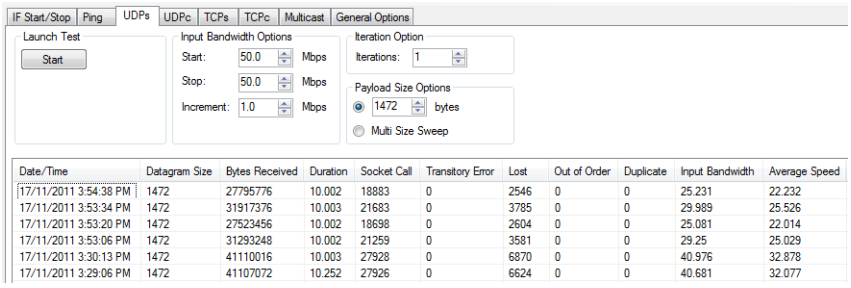



Figure 8-8 **UDPs test tab**

There are four options for the UDP receive test:

**Input Bandwidth** — To test at a single bandwidth, set the Start and Stop values to the same bandwidth value. Values are in megabits per seconds.

If the Start and Stop values are different, a UDP receive test will be launch with the Start bandwidth. The bandwidth of the subsequent tests will increase by the value of Increment until the Stop bandwidth is reached.

**Iterations** — NDIT will repeat the UDP receive test and its conditions for the specified number of times.

**Payload Size** 1472 bytes is maximum value for the payload size, and will maximize throughput.

Multi Size Sweep will repeat the test with payloads of 64, 128, 256, 512, 1024 and 1472 bytes.

**Test Duration** This option can be found in the General Options tab.

## EXPECTED RESULTS

- Highest throughput possible

Although it is difficult to estimate the achievable throughput with a particular device, it is possible to compare with other drivers sharing roughly the same quantity of network buffers or processor speed.

| **Development Board** | Device 1 | Device 2 |
|---|---|---|
| **CPU Speed** | 72 MHz | 70 MHz |
| **CPU Architecture** | ARM® Cortex-M3™ | ARM® Cortex-M4™ |
| **Rx Buffers** | 4 | 3 |
| **Rx Descr.** | 4 | 3 |
| **64 byte Datagram** | | |
| **Socket Call** | 33144 | 58652 |
| **Throughput (Mbps)** | 1.695 | 3.002 |
| **1472 byte Datagram** | | |
| **Socket Call** | 27915 | 31788.91 |
| **Throughput (Mbps)** | 32.866 | 37.433 |

Listing 8-7 **UDPs Performance Example**

There is also a practical limit at which the network driver can operate. At one point, as you increase the input data rate, the network driver will be overwhelmed and will start dropping the excess of packets it cannot handle.

As shown in Figure 8-9, there is a point where the rate of increase in throughput will slow down, and the error rate will increase until the throughput reaches its limit. Depending on the driver's architecture, increasing the input data rate will decrease the performances of the driver. This is due to an increase in the number of receive interrupts that have to be handled.

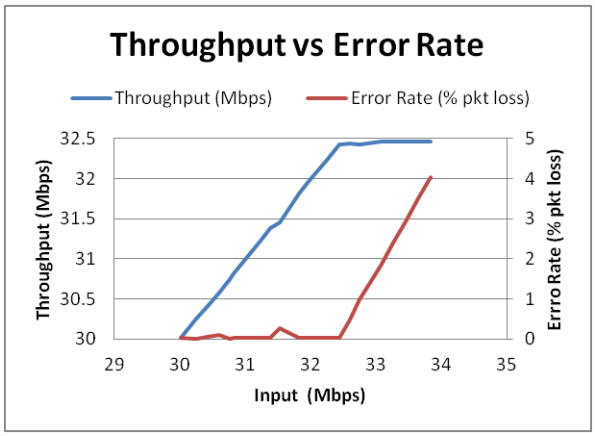



Figure 8-9 **Throughput and Error Rate**

- Few transitory errors.

  See the section on transitory errors on page 258 for more information.

- Low packet loss.

  Packet loss should begin to happen only near or after the driver reached maximum throughput (close to 32 Mbps as in the example in Figure 8-9). If there is a constant packet loss throughout the input data rate range, than something is wrong.

- Ability to receive packets with a size equal to the MTU.

  See the section on sending packets on page 259 for more information.

- Similar results with target directly connected and on a network.

  Unless there is a heavy broadcasting of packets on the real network, the results should be fairly similar.

- No buffer leaks.

  See section "Buffer leaks" on page 253 for more details.

- Logging performance results (with the target directly connected, and networked).

### TEST 2: PAYLOAD SIZE SWEEP RECEIVE UDP TEST USING NDIT

This test is similar to the previous one, except that we are modifying the size of the payload received by the target. We will set the payload size to 64, 128, 256, 512 and 1024 bytes. By reducing the size of the packet, we can increase the number of packets processed by the target in the same amount of time. By using a payload size of 64 bytes (the smallest payload for a Ethernet frame) you can get the maximum packet rate that you driver can handle.

### EXPECTED RESULTS

- Highest throughput possible

  Once again predicting the achievable throughput might be difficult. As the length of the payload decreases, the packet rate increases to sustain the required data rate. This decrease is likely due to the fact that it is more time consuming to execute the µC/TCP-IP module operation than the transfer the packet from the network device to the processor memory.

- Few transitory errors

  See the section on transitory errors on page 258 for more information.

- Ability to send packets with a size equal to the MTU.

  See the section on sending packets on page 259 for more information.

- Similar results with the target directly connected and on a network.

- No buffer leaks

  See section "Buffer leaks" on page 253 for more details.

- Logging performance results (with the target directly connected, and networked).

## 8-5-3 TESTING TCP TRANSMISSION

Your target must be able to transmit TCP packets reliably, and with acceptable throughput. You should also validate the driver with various TCP window sizes.

### TRANSMIT TCP TEST USING NDIT

This test measures the capacity of the target to send packets to a server located on the test station. To optimize performance, the value of `NET_TCP_CFG_TX_WIN_SIZE_OCTET` in `net_cfg.h` should be set to the number of transmit descriptors multiplied by 1460 bytes. The TCP Transmit Window Size should be set to the target's number of transmit buffers multiplied by 1460 bytes.

Select the TCPc test tab in the NDIT main window. The TCP transmit test panel appears.

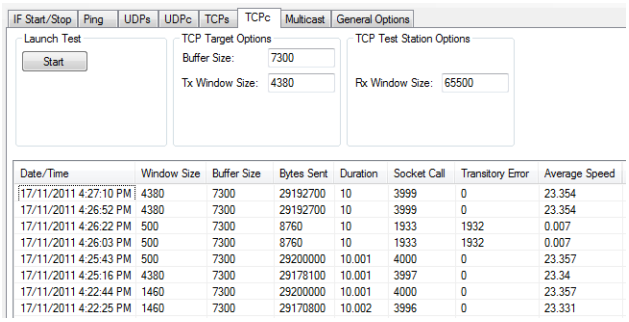



Figure 8-10 **TCPc test tab**

There are four options for the TCP transmit test:

**Buffer Size** The length of the buffer to transmit.

**Tx Window Size** The size of the transmit socket window on the target host.

**Rx Window Size** The size of the receive socket window on the test station.

**Test Duration** Located in the General Options tab.

#### EXPECTED RESULTS

- Highest throughput possible

  Although it is difficult to estimate the achievable throughput with a particular device, it is possible to compare with other drivers sharing roughly the same quantity of network buffers or processor speed. Tweaking the task priorities might help increasing the throughput out the network driver.

- Few transitory errors. See the section on transitory errors on page 258 for more information.

- No retransmission. See the section on retransmission on page 254 for more details.

- No buffer leaks. See section "Buffer leaks" on page 253 for more details.

- Logging performance results (with the target directly connected, and networked).

## 8-5-4 TESTING TCP RECEPTION

Along with the reception of UDP traffic, you should test your device driver for TCP traffic. The following are two tests that measure the driver performance under different conditions.

#### TEST 1: RECEIVE TCP TEST WITH USING NDIT

To achieve the best possible throughput, you might have to increase the number of receive descriptors and receive buffers. On the other hand, it is also possible to reserve too many buffers for reception. To find out the ideal number of descriptors and buffers, there are two things you need to measure.

First, you must determine the rate at which the target can receive data. This value, in bits per second, will be referred to as the bandwidth. You can obtain this value by running the receive UDP test.

Second, you must determine the round trip time (RTT) of a message between the test station and the target. This is achieved by sending an ICMP echo request to the target and measuring the RTT of the reply. You can use ping (or preferably fping) to acquire this value.

Then take these two value and multiply them to determine the *Bandwidth-Delay Product*.

`BDP (bytes) = total_available_bandwidth (KBytes/sec) • round_trip_time (ms)`

The BDP is approximately equal to the Receive TCP Window Size. It is recommended to round up the calculated value to a multiple of the Maximum Segment Size (MSS), typically 1460 bytes.

For example, the bandwidth of a test station-target link is 32.461 Mbps as found by the Receive UDP test. The measured RTT is 0.9 millisecond. It gives us a BDP of 28315 bits (32.461 Mbps x 0.9 ms) or 3539 bytes. Rounding up this result to a multiple of the MSS value gives us 4380 bytes. If the combined size of the receive buffers cannot hold the BDP, the receive buffers must be increased in order to have optimal performances. It is important to increase the number of receive descriptors (`RxDescNbr`) accordingly.

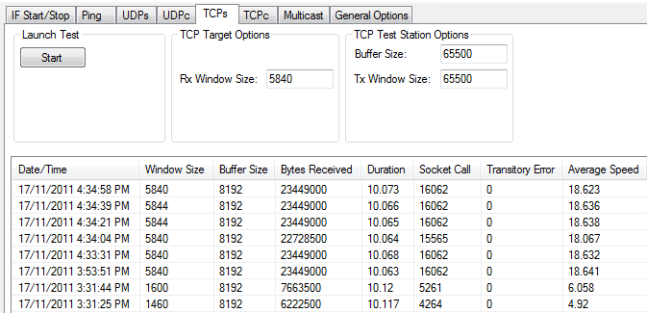



Figure 8-11 **TCPs test tab**

There are four options for the TCP receive test:

**Rx Window Size** The size of the receive socket window on the target host.

**Buffer Size** The length of the buffer to transmit to the target.

**Tx Window Size** The size of the transmit socket window on the test station.

**Test Duration** Located in the General Options tab.

The TCPs test parameters must be adjusted to the following: both Buffer Size and Tx Window Size should be set to 65500. These settings will minimize the overhead of socket creation on the test station, and make full use of the available processing power of the target. The Receive Window Size must be set to the value of the BDP, rounded up to a multiple of the MSS.

You should set the TCP Receive Window size in `net_cfg.h` as follows:

```
#define  NET_TCP_CFG_RX_WIN_SIZE_OCTET       (RxDescNbr * 1460)u
```

## EXPECTED RESULTS

- Driver throughput should be optimized.
- Few transitory errors.

  See the section on transitory errors on page 258 for more information.

- No retransmission.

  See the section on retransmission on page 254 for more details.

- The messages “Window update”, “Zero window” and “Window probe” are acceptable.

  These messages are part of a flow control mechanism that prevents the receiver from getting more packets that it can actually handle, or for the transmitter to wait indefinitely for acknowledgement to resume the transmission.

- No buffer leaks.

  See section “Buffer leaks” on page 253 for more details.

- Logging performance results (with the target directly connected, and networked).

## 8-6 MULTICAST

Multicast is a routing scheme that enables data delivery to a group of hosts. Multicast allows the source to transmit the data once, while routers in the network take care of duplicating the data and transmitting it to the registered hosts. Multicast requires UDP support. TCP is not designed to work with Multicast, but there are some reliable Multicast protocols that can replace TCP such as Pragmatic General Multicast (PGM).

### 8-6-1 MULTICAST TEST SETUP

In order for multicast to work, the source and the destination must be linked by multicast-enabled routers. Multicast cannot operate when the target is directly connected to the test station. Moreover, the router(s) between the target and the test station must support the IGMP protocol.

The goal of this test is to validate that the driver properly configures the MAC filter to allow the multicast packets to be passed by the µC/TCP-IP module when the target is registered to a multicast group. Also, the test ensures that, when the target is unregistered from the multicast group, multicast packets are dropped by the MAC filter.

The following steps are performed by NDIT to validate the behavior of the driver:

- Register the target to an IP multicast group.
- Have the test station send a packet to the IP multicast group.
- Upon reception of the multicast packet, the target replies to the test station to acknowledge the reception of the multicast packet.
- Unregister the target from the IP multicast group.
- Have the test station to send a packet to the IP multicast group.
- Verify that, after a certain timeout, no reply was received by the test station.

## 8-6-2 MULTICAST TEST USING NDIT

This section describes how to run a multicast test using NDIT. Select the Multicast test tab in the NDIT main window. The Multicast test panel appears.

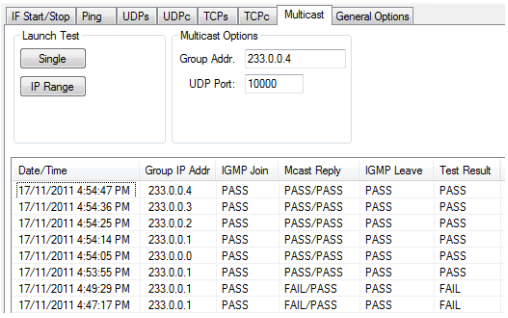



Figure 8-12 **Multicast test tab**

There are two options for the multicast test:

**Group Address** The Group IP multicast address at which the test station will send the packets.

**UDP Port** The UDP port at which the packets will be delivered.

To run a multicast test, click either the Single or IP Range button in the Launch Text box.

Clicking the Single button will send a command to the target to create an IGMP Join request for the specified Group Address, and create a UDP socket that listens for incoming traffic on the specified UDP port. Upon receiving a packet on the specified UDP port, the target will reply to the packet source with the received payload. In return, NDIT will listen to the target reply, and determine if the multicast test was successful.

Clicking the IP Range button will do the exact same test as the Single button, but will do the test for the IP address range from xxx.xxx.xxx.0 to xxx.xxx.xxx.255

## 8-6-3 ANALYZING THE RESULTS

The Mcast Reply column contains two results. The first one refers to the success of the reception of a multicast message while it is registered to the specified IP multicast group. The second one refers to the success of the multicast message being not received while the target is unregistered from the specified IP multicast group.

### ROUND-TRIP TIME

| Payload size | Average Round-Trip Time (ms) |
|---|---|
| 32 | |
| 64 | |
| 128 | |
| 256 | |
| 512 | |
| 1024 | |
| 1464 | |

### PING RESULTS

| ICMP Payload Size | Round Trip Time (ms) |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |

### UDP SERVER

| Payload size | Socket Calls | Packets Lost | Throughput (Mbps) |
|---|---|---|---|
| 64 | | | |
| 128 | | | |
| 256 | | | |
| 512 | | | |
| 1024 | | | |
| 1472 | | | |

### UDP CLIENT

| Payload size | Socket Calls | Throughput (Mbps) |
|---|---|---|
| 64 | | |
| 128 | | |
| 256 | | |
| 512 | | |
| 1024 | | |
| 1472 | | |

### TCP SERVER

| Buffer size | Socket Calls | Throughput (Mbps) |
|---|---|---|
| 1460 | | |
| 2920 | | |
| 4380 | | |
| 5840 | | |
| 7300 | | |
| 8192 | | |

## TCP CLIENT

| Buffer size | Socket Calls | Throughput (Mbps) |
|---|---|---|
| 1460 | | |
| 2920 | | |
| 4380 | | |
| 5840 | | |
| 7300 | | |
| 8192 | | |

Chapter

# 9

# Socket Programming

The two network socket interfaces supported by µC/TCP-IP were previously introduced. Now, in this chapter, we will discuss socket programming, data structures, and API functions calls.

## 9-1 NETWORK SOCKET DATA STRUCTURES

Communication using sockets requires configuring or reading network addresses from network socket address structures. The BSD socket API defines a generic socket address structure as a blank template with no address-specific configuration…

```
struct  sockaddr {                          /* Generic BSD   socket address structure    */
    CPU_INT16U  sa_family;                  /*  Socket address family                    */
    CPU_CHAR    sa_data[14];                /*  Protocol-specific address informatio     */
};


typedef  struct  net_sock_addr {            /* Generic µC/TCP-IP socket address structure */
    NET_SOCK_ADDR_FAMILY   AddrFamily;
    CPU_INT08U             Addr[NET_SOCK_BSD_ADDR_LEN_MAX = 14];
} NET_SOCK_ADDR;
```

Listing 9-1 **Generic (non-address-specific) address structures**

…as well as specific socket address structures to configure each specific protocol address family's network address configuration (e.g., IPv4 socket addresses):

```
struct  in_addr {
    NET_IP_ADDR  s_addr;                        /* IPv4 address (32 bits)                */
};


struct  sockaddr_in {                           /* BSD    IPv4 socket address structure    */
    CPU_INT16U       sin_family;                /*  Internet address family (e.g. AF_INET) */
    CPU_INT16U       sin_port;                  /*  Socket  address port number (16 bits)  */
    struct in_addr   sin_addr;                  /*  IPv4   address       (32 bits)         */
    CPU_CHAR         sin_zero[8];               /*  Not used (all zeroes)                  */
};


typedef  struct  net_sock_addr_ip {             /* µC/TCP-IP socket address structure     */
    NET_SOCK_ADDR_FAMILY   AddrFamily;
    NET_PORT_NBR           Port;
    NET_IP_ADDR            Addr;
    CPU_INT08U             Unused[NET_SOCK_ADDR_IP_NBR_OCTETS_UNUSED = 8];
} NET_SOCK_ADDR_IP;
```

Listing 9-2 **Internet (IPv4) address structures**

A socket address structure's `AddrFamily/sa_family/sin_family` value *must* be read/written in host CPU byte order, while all `Addr/sa_data` values *must* be read/written in network byte order (big endian).

Even though socket functions – both µC/TCP-IP and BSD – pass pointers to the generic socket address structure, applications *must* declare and pass an instance of the specific protocol's socket address structure (e.g., an IPv4 address structure). For microprocessors that require data access to be aligned to appropriate word boundaries, this forces compilers to declare an appropriately-aligned socket address structure so that all socket address members are correctly aligned to their appropriate word boundaries.

Caution: Applications should avoid, or be cautious when, declaring and configuring a generic byte array as a socket address structure, since the compiler may not correctly align the array to or the socket address structure's members to appropriate word boundaries.

Figure 9-1 shows an example IPv4 instance of the µC/TCP-IP `NET_SOCK_ADDR_IP (sockaddr_in)` structure overlaid on top of `NET_SOCK_ADDR (sockaddr) the` structure.

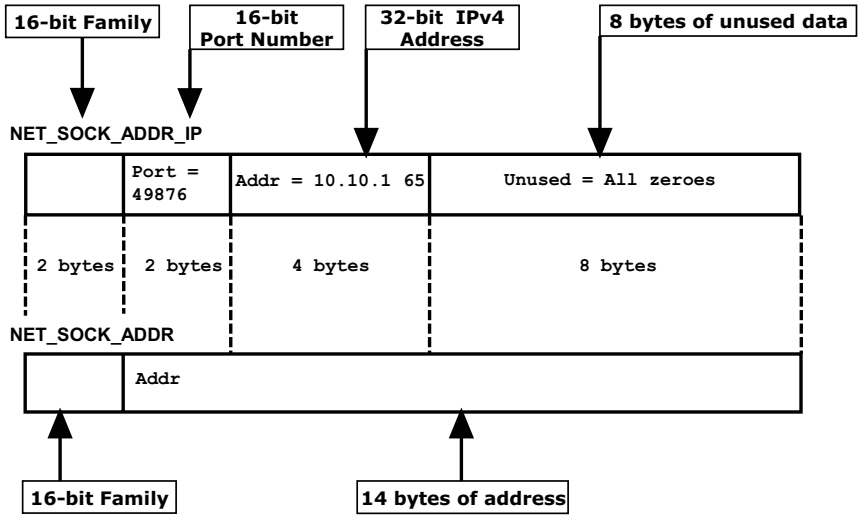



Figure 9-1 **NET_SOCK_ADDR_IP is the IPv4 specific instance of the generic NET_SOCK_ADDR data structure**

A socket could configure the example socket address structure in Figure 9-1 to bind on IP address 10.10.1.65 and port number 49876 with the following code:

```
NET_SOCK_ADDR_IP   addr_local;
NET_IP_ADDR        addr_ip;
NET_PORT_NBR       addr_port;
NET_SOCK_RTN_CODE  rtn_code;
NET_ERR            err;


addr_ip   = NetASCII_Str_to_IP(“10.10.1.65”, &err);
addr_port = 49876;
Mem_Clr((void   *)&addr_local,
        (CPU_SIZE_T) sizeof(addr_local));
addr_local.AddrFamily = NET_SOCK_ADDR_FAMILY_IP_V4;                /* = AF_INET†† Figure 9-1 */
addr_local.Addr       = NET_UTIL_HOST_TO_NET_32(addr_ip);
addr_local.Port       = NET_UTIL_HOST_TO_NET_16(addr_port);
rtn_code              = NetSock_Bind((NET_SOCK_ID      ) sock_id,
                                     (NET_SOCK_ADDR   *)&addr_local,  /* Cast to generic addr† */
                                     (NET_SOCK_ADDR_LEN) sizeof(addr_local),
                                     (NET_ERR         *)&err);
```

Listing 9-3 **Bind on 10.10.1.65**

† The address of the specific IPv4 socket address structure is cast to a pointer to the generic socket address structure.

## 9-2 COMPLETE SEND() OPERATION

`send()` returns the number of bytes actually sent out. This might be less than the number that are available to send. The function will send as much of the data as it can. The developer must make sure that the rest of the packet is sent later.

```
{
    int  total     = 0;        /* how many bytes we've sent      */
    int  bytesleft = *len;     /* how many we have left to send  */
    int  n;


    while (total < *len) {
        n = send(s, buf + total, bytesleft, 0);                                    (1)
        if (n == -1) {
            break;
        }
        total += n;                                                                (2)
        bytesleft -= n;                                                            (3)
    }
}
```

Listing 9-4 **Completing a send()**

L9-4(1) Send as many bytes as there are transmit network buffers available.

L9-4(2) Increase the number of bytes sent.

L9-4(3) Calculate how many bytes are left to send.

This is another example that, for a TCP/IP stack to operate smoothly, sufficient memory to define enough buffers for transmission and reception is a design decision that requires attention if optimum performance for the given hardware is desired.

## 9-3 SOCKET APPLICATIONS

Two socket types are identified: Datagram sockets and Stream sockets. The following sections provide sample code describing how these sockets work.

In addition to the BSD 4.x sockets application interface (API), the µC/TCP-IP stack gives the developer the opportunity to use Micrium's own socket functions with which to interact.

Although there is a great deal of similarity between the two APIs, the parameters of the two sets of functions differ slightly. The purpose of the following sections is o give developers a first look at Micrium's functions by providing concrete examples of how to use the API.

For those interested in BSD socket programming, there are plenty of books, online references, and articles dedicated to this subject.

The examples have been designed to be as simple as possible. Hence, only basic error checking is performed. When it comes to building real applications, those checks should be extended to deliver a product that is as robust as possible.

## 9-3-1 DATAGRAM SOCKET (UDP SOCKET)

Figure 9-2 reproduces a diagram that introduces sample code using the typical socket functions for a UDP client-server application. The example uses the Micrium proprietary socket API function calls. A similar example could be written using the BSD socket API.

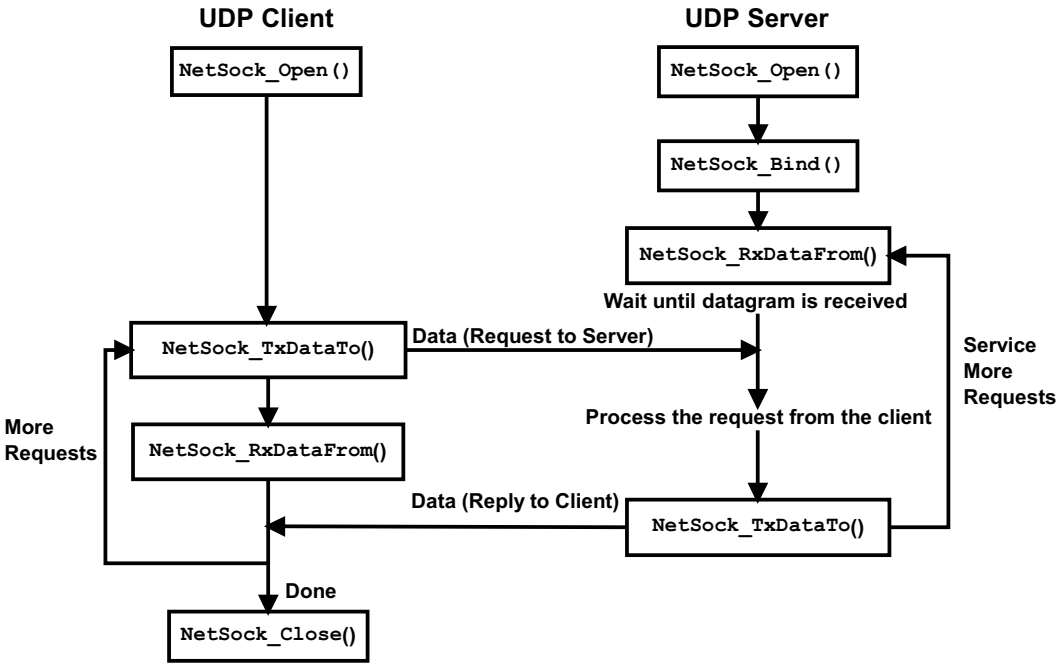



Figure 9-2 **µC/TCP-IP Socket calls used in a typical UDP client-server application**

The code in Listing 9-5 implements a UDP server. It opens a socket and binds an IP address, listens and waits for a packet to arrive at the specified port. See Appendix C, "µC/TCP-IP API Reference" on page 417 for a list of all µC/TCP-IP socket API functions.

## DATAGRAM SERVER (UDP SERVER)

```
#define  UDP_SERVER_PORT  10001
#define  RX_BUF_SIZE         15
CPU_BOOLEAN  TestUDPServer (void)
{
    NET_SOCK_ID        sock;
    NET_SOCK_ADDR_IP   server_sock_addr_ip;
    NET_SOCK_ADDR_LEN  server_sock_addr_ip_size;
    NET_SOCK_ADDR_IP   client_sock_addr_ip;
    NET_SOCK_ADDR_LEN  client_sock_addr_ip_size;
    NET_SOCK_RTN_CODE  rx_size;
    CPU_CHAR           rx_buf[RX_BUF_SIZE];
    CPU_BOOLEAN        attempt_rx;
    NET_ERR            err;

    sock = NetSock_Open( NET_SOCK_ADDR_FAMILY_IP_V4,                                    (1)
                         NET_SOCK_TYPE_DATAGRAM,
                         NET_SOCK_PROTOCOL_UDP,
                        &err);
    if (err != NET_SOCK_ERR_NONE) {
        return (DEF_FALSE);
    }

    server_sock_addr_ip_size = sizeof(server_sock_addr_ip);                             (2)
    Mem_Clr((void     *)&server_sock_addr_ip,
            (CPU_SIZE_T) server_sock_addr_ip_size);
    server_sock_addr_ip.AddrFamily = NET_SOCK_ADDR_FAMILY_IP_V4;
    server_sock_addr_ip.Addr       = NET_UTIL_HOST_TO_NET_32(NET_SOCK_ADDR_IP_WILD_CARD);
    server_sock_addr_ip.Port       = NET_UTIL_HOST_TO_NET_16(UDP_SERVER_PORT);

    NetSock_Bind((NET_SOCK_ID      ) sock,                                              (3)
                 (NET_SOCK_ADDR   *)&server_sock_addr_ip,
                 (NET_SOCK_ADDR_LEN) NET_SOCK_ADDR_SIZE,
                 (NET_ERR         *)&err);
    if (err != NET_SOCK_ERR_NONE) {
        NetSock_Close(sock, &err);
        return (DEF_FALSE);
    }
```

```
    do {
        client_sock_addr_ip_size = sizeof(client_sock_addr_ip);

        rx_size = NetSock_RxDataFrom((NET_SOCK_ID ) sock,                                    (4)
                                     (void *) rx_buf,
                                     (CPU_INT16S ) RX_BUF_SIZE,
                                     (CPU_INT16S ) NET_SOCK_FLAG_NONE,
                                     (NET_SOCK_ADDR *)&client_sock_addr_ip,
                                     (NET_SOCK_ADDR_LEN *)&client_sock_addr_ip_size,
                                     (void *) 0,
                                     (CPU_INT08U ) 0,
                                     (CPU_INT08U *) 0,
                                     (NET_ERR *)&err);
        switch (err) {
            case NET_SOCK_ERR_NONE:
                attempt_rx = DEF_NO;
                break;
            case NET_SOCK_ERR_RX_Q_EMPTY:
            case NET_OS_ERR_LOCK:
                attempt_rx = DEF_YES;
                break;
            default:
                attempt_rx = DEF_NO;
                break;
        }
    } while (attempt_rx == DEF_YES);

    NetSock_Close(sock, &err);                                                       (5)

    if (err != NET_SOCK_ERR_NONE) {
        return (DEF_FALSE);
    }

    return (DEF_TRUE);
}
```

Listing 9-5 **Datagram Server**

L9-5(1) Open a datagram socket (UDP protocol).

L9-5(2) Populate the `NET_SOCK_ADDR_IP` structure for the server address and port, and convert it to network order.

L9-5(3) Bind the newly created socket to the address and port specified by `server_sock_addr_ip`.

L9-5(4) Receive data from any host on port DATAGRAM_SERVER_PORT.

L9-5(5) Close the socket.

### DATAGRAM CLIENT (UDP CLIENT)

The code in Listing 9-6 implements a UDP client. It sends a 'Hello World!' message to a server that listens on the UDP_SERVER_PORT.

```
#define  UDP_SERVER_IP_ADDR   "192.168.1.100"
#define  UDP_SERVER_PORT               10001
#define  UDP_SERVER_TX_STR     "Hello World!"


CPU_BOOLEAN  TestUDPClient (void)
{
    NET_SOCK_ID         sock;
    NET_IP_ADDR         server_ip_addr;
    NET_SOCK_ADDR_IP    server_sock_addr_ip;
    NET_SOCK_ADDR_LEN   server_sock_addr_ip_size;
    CPU_CHAR           *pbuf;
    CPU_INT16S          buf_len;
    NET_SOCK_RTN_CODE   tx_size;
    NET_ERR             err;
    pbuf    = UDP_SERVER_TX_STR;
    buf_len = Str_Len(UDP_SERVER_TX_STR);

    sock = NetSock_Open( NET_SOCK_ADDR_FAMILY_IP_V4,                                    (1)
                         NET_SOCK_TYPE_DATAGRAM,
                         NET_SOCK_PROTOCOL_UDP,
                        &err);
    if (err != NET_SOCK_ERR_NONE) {
        return (DEF_FALSE);
    }

    server_ip_addr = NetASCII_Str_to_IP(UDP_SERVER_IP_ADDR, &err);                      (2)
    if (err != NET_ASCII_ERR_NONE) {
        NetSock_Close(sock, &err);
        return (DEF_FALSE);
    }
```

```
    server_sock_addr_ip_size = sizeof(server_sock_addr_ip);                                    (3)
    Mem_Clr((void     *)&server_sock_addr_ip,
            (CPU_SIZE_T) server_sock_addr_ip_size);
    server_sock_addr_ip.AddrFamily = NET_SOCK_ADDR_FAMILY_IP_V4;
    server_sock_addr_ip.Addr       = NET_UTIL_HOST_TO_NET_32(server_ip_addr);
    server_sock_addr_ip.Port       = NET_UTIL_HOST_TO_NET_16(UDP_SERVER_PORT);

    tx_size = NetSock_TxDataTo((NET_SOCK_ID ) sock,
(4)
                               (void *) pbuf,
                               (CPU_INT16S ) buf_len,
                               (CPU_INT16S ) NET_SOCK_FLAG_NONE,
                               (NET_SOCK_ADDR *)&server_sock_addr_ip,
                               (NET_SOCK_ADDR_LEN) sizeof(server_sock_addr_ip),
                               (NET_ERR *)&err);

    NetSock_Close(sock, &err);                                                                 (5)
    if (err != NET_SOCK_ERR_NONE) {
        return (DEF_FALSE);
    }
    return (DEF_TRUE);
}
```

Listing 9-6 **Datagram Client**

L9-6(1) Open a datagram socket (UDP protocol).

L9-6(2) Convert an IPv4 address from ASCII dotted-decimal notation to a network protocol IPv4 address in host-order.

L9-6(3) Populate the NET_SOCK_ADDR_IP structure for the server address and port, and convert it to network order.

L9-6(4) Transmit data to host DATAGRAM_SERVER_IP_ADDR on port DATAGRAM_SERVER_PORT.

L9-6(5) Close the socket.

## 9-3-2 STREAM SOCKET (TCP SOCKET)

Figure 9-3 reproduces Figure 8-8, which introduced sample code using typical socket functions for a TCP client-server application. The example uses the Micrium proprietary socket API function calls. A similar example could be written using the BSD socket API.

Typically, after a TCP server starts, TCP clients can connect and send requests to the server. A TCP server waits until client connections arrive and then creates a dedicated TCP socket connection to process the client's requests and reply back to the client (if necessary). This continues until either the client or the server closes the dedicated client-server connection. Also while handling multiple, simultaneous client-server connections, the TCP server can wait for new client-server connections

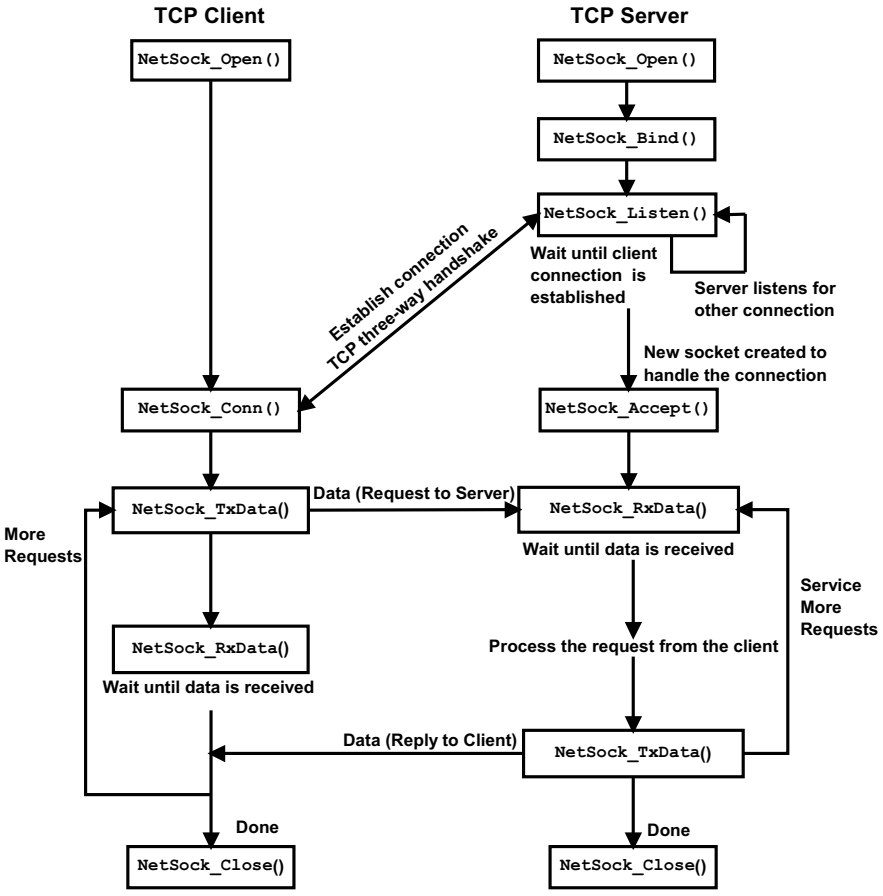



Figure 9-3 **µC/TCP-IP Socket calls used in a typical TCP client-server application**

### STREAM SERVER (TCP SERVER)

This example presents a very basic client-server application over a TCP connection. The server presented is simply waits for a connection and send the string `'Hello World!'`. See section "µC/TCP-IP API Reference" on page 417 for a list of all µC/TCP-IP socket API functions.

```
#define  TCP_SERVER_PORT                  10000
#define  TCP_SERVER_CONN_Q_SIZE               1
#define  TCP_SERVER_TX_STR         "Hello World!"

CPU_BOOLEAN  TestTCPServer (void)
{
    NET_SOCK_ID         sock_listen;
    NET_SOCK_ID         sock_req;
    NET_SOCK_ADDR_IP    server_sock_addr_ip;
    NET_SOCK_ADDR_LEN   server_sock_addr_ip_size;
    NET_SOCK_ADDR_IP    client_sock_addr_ip;
    NET_SOCK_ADDR_LEN   client_sock_addr_ip_size;
    CPU_BOOLEAN         attempt_conn;
    CPU_CHAR           *pbuf;
    CPU_INT16S          buf_len;
    NET_SOCK_RTN_CODE   tx_size;
    NET_ERR             err;
    pbuf    = TCP_SERVER_TX_STR;
    buf_len = Str_Len(TCP_SERVER_TX_STR);


    sock_listen = NetSock_Open( NET_SOCK_ADDR_FAMILY_IP_V4,                              (1)
                                NET_SOCK_TYPE_STREAM,
                                NET_SOCK_PROTOCOL_TCP,
                               &err);
    if (err != NET_SOCK_ERR_NONE) {
        return (DEF_FALSE);
    }


    server_sock_addr_ip_size = sizeof(server_sock_addr_ip);                              (2)
    Mem_Clr((void     *)&server_sock_addr_ip,
            (CPU_SIZE_T) server_sock_addr_ip_size);
    server_sock_addr_ip.AddrFamily = NET_SOCK_ADDR_FAMILY_IP_V4;
    server_sock_addr_ip.Addr       = NET_UTIL_HOST_TO_NET_32(NET_SOCK_ADDR_IP_WILD_CARD);
    server_sock_addr_ip.Port       = NET_UTIL_HOST_TO_NET_16(TCP_SERVER_PORT);
```

```
    NetSock_Bind((NET_SOCK_ID ) sock_listen,                                        (3)
                 (NET_SOCK_ADDR *)&server_sock_addr_ip,
                 (NET_SOCK_ADDR_LEN) NET_SOCK_ADDR_SIZE,
                 (NET_ERR *)&err);
    if (err != NET_SOCK_ERR_NONE) {
        NetSock_Close(sock_listen, &err);
        return (DEF_FALSE);
}

    NetSock_Listen( sock_listen,                                                    (4)
                    TCP_SERVER_CONN_Q_SIZE,
                   &err);
    if (err != NET_SOCK_ERR_NONE) {
        NetSock_Close(sock_listen, &err);
        return (DEF_FALSE);
    }

    do {
        client_sock_addr_ip_size = sizeof(client_sock_addr_ip);

         sock_req = NetSock_Accept((NET_SOCK_ID ) sock_listen,                      (5)
                                   (NET_SOCK_ADDR *)&client_sock_addr_ip,
                                   (NET_SOCK_ADDR_LEN *)&client_sock_addr_ip_size,
                                   (NET_ERR *)&err);
        switch (err) {
            case NET_SOCK_ERR_NONE:
                attempt_conn = DEF_NO;
                break;
            case NET_ERR_INIT_INCOMPLETE:
            case NET_SOCK_ERR_NULL_PTR:
            case NET_SOCK_ERR_NONE_AVAIL:
            case NET_SOCK_ERR_CONN_ACCEPT_Q_NONE_AVAIL:
            case NET_SOCK_ERR_CONN_SIGNAL_TIMEOUT:
            case NET_OS_ERR_LOCK:
                attempt_conn = DEF_YES;
                break;

            default:
                attempt_conn = DEF_NO;
                break;
        }
    } while (attempt_conn == DEF_YES);

    if (err != NET_SOCK_ERR_NONE) {
        NetSock_Close(sock_req, &err);
        return (DEF_FALSE);
    }
```

```
    tx_size = NetSock_TxData( sock_req,                                          (6)
                              pbuf,
                              buf_len,
                              NET_SOCK_FLAG_NONE,
                             &err);

    NetSock_Close(sock_req, &err);                                               (7)
    NetSock_Close(sock_listen, &err);

    return (DEF_TRUE);
}
```

Listing 9-7 **Stream Server**

L9-7(1) Open a stream socket (TCP protocol).

L9-7(2) Populate the `NET_SOCK_ADDR_IP` structure for the server address and port, and convert it to network order.

L9-7(3) Bind the newly created socket to the address and port specified by `server_sock_addr_ip`.

L9-7(4) Set the socket to listen for a connection request coming on the specified port.

L9-7(5) Accept the incoming connection request, and return a new socket for this particular connection. Note that this function call is being called from inside a loop because it might timeout (no client attempts to connect to the server).

L9-7(6) One the connection has been established between the server and a client, transmit the message. Note that the return value of this function is not used here, but a real application should make sure all the message has been sent by comparing that value with the length of the message.

L9-7(7) Close both listen and request sockets. When the server need to stay active, the listen socket stays open so that I can accept additional connection requests. Usually, the server will wait for a connection, `accept()` it, and `OSTaskCreate()` a task to handle it.

## STREAM CLIENT (TCP CLIENT)

The client of Listing 9-8 connects to the specified server and receives the string the server sends.

```
#define  TCP_SERVER_IP_ADDR  "192.168.1.101"
#define  TCP_SERVER_PORT              10000
#define  RX_BUF_SIZE                     15

CPU_BOOLEAN  TestTCPClient (void)
{
    NET_SOCK_ID        sock;
    NET_IP_ADDR        server_ip_addr;
    NET_SOCK_ADDR_IP   server_sock_addr_ip;
    NET_SOCK_ADDR_LEN  server_sock_addr_ip_size;
    NET_SOCK_RTN_CODE  conn_rtn_code;
    NET_SOCK_RTN_CODE  rx_size;
    CPU_CHAR           rx_buf[RX_BUF_SIZE];
    NET_ERR            err;


    sock = NetSock_Open( NET_SOCK_ADDR_FAMILY_IP_V4,                                (1)
                         NET_SOCK_TYPE_STREAM,
                         NET_SOCK_PROTOCOL_TCP,
                        &err);
    if (err != NET_SOCK_ERR_NONE) {
        return (DEF_FALSE);
    }

    server_ip_addr = NetASCII_Str_to_IP(TCP_SERVER_IP_ADDR, &err);                  (2)
    if (err != NET_ASCII_ERR_NONE) {
        NetSock_Close(sock, &err);
        return (DEF_FALSE);
    }

    server_sock_addr_ip_size = sizeof(server_sock_addr_ip);                         (3)
    Mem_Clr((void     *)&server_sock_addr_ip,
            (CPU_SIZE_T) server_sock_addr_ip_size);
    server_sock_addr_ip.AddrFamily = NET_SOCK_ADDR_FAMILY_IP_V4;
    server_sock_addr_ip.Addr       = NET_UTIL_HOST_TO_NET_32(server_ip_addr);
    server_sock_addr_ip.Port       = NET_UTIL_HOST_TO_NET_16(TCP_SERVER_PORT);
```

```
    conn_rtn_code = NetSock_Conn((NET_SOCK_ID ) sock,                                   (4)
                                 (NET_SOCK_ADDR *)&server_sock_addr_ip,
                                 (NET_SOCK_ADDR_LEN) sizeof(server_sock_addr_ip),
                                 (NET_ERR *)&err);
    if (err != NET_SOCK_ERR_NONE) {
        NetSock_Close(sock, &err);
        return (DEF_FALSE);
    }

    rx_size = NetSock_RxData( sock,                                                     (5)
                              rx_buf,
                              RX_BUF_SIZE,
                              NET_SOCK_FLAG_NONE,
                             &err);
    if (err != NET_SOCK_ERR_NONE) {
        NetSock_Close(sock, &err);
        return (DEF_FALSE);
    }

    NetSock_Close(sock, &err);                                                          (6)
    return (DEF_TRUE);
}
```

Listing 9-8 **Stream Client**

L9-8(1) Open a stream socket (TCP protocol).

L9-8(2) Convert an IPv4 address from ASCII dotted-decimal notation to a network protocol IPv4 address in host-order.

L9-8(3) Populate the `NET_SOCK_ADDR_IP` structure for the server address and port, and convert it to network order.

L9-8(4) Connect the socket to a remote host.

L9-8(5) Receive data from the connected socket. Note that the return value for this function is not used here.However, a real application should make sure everything has been received.

L9-8(6) Close the socket.

### TCP CONNECTION CONFIGURATION

µC/TCP-IP provides a set of APIs to configure TCP connections on an individual basis. These APIs are listed below and detailed in section C-14 "TCP Functions" on page 671:

- NetTCP_ConnCfgIdleTimeout()
- NetTCP_ConnCfgMaxSegSizeLocal()
- NetTCP_ConnCfgReTxMaxTh()
- NetTCP_ConnCfgReTxMaxTimeout()
- NetTCP_ConnCfgRxWinSize()
- NetTCP_ConnCfgTxWinSize()
- NetTCP_ConnCfgTxAckImmedRxdPushEn()
- NetTCP_ConnCfgTxNagleEn()
- NetTCP_ConnCfgTxKeepAliveEn()
- NetTCP_ConnCfgTxKeepAliveTh()
- NetTCP_ConnCfgTxAckDlyTimeout()

## 9-4 SOCKET CONFIGURATION

µC/TCP-IP provides a set of APIs to configure sockets on an individual basis. These APIs are listed below and detailed in section C-13 "Network Socket Functions" on page 572:

- NetSock_CfgBlock() (TCP/UDP)
- NetSock_CfgSecure() (TCP)
- NetSock_CfgRxQ_Size() (TCP/UDP)
- NetSock_CfgTxQ_Size() (TCP/UDP)
- NetSock_CfgTxIP_TOS() (TCP/UDP)
- NetSock_CfgTxIP_TTL() (TCP/UDP)
- NetSock_CfgTxIP_TTL_Multicast() (TCP/UDP)

- NetSock_CfgTimeoutConnAcceptDflt() (TCP)
- NetSock_CfgTimeoutConnAcceptGet_ms() (TCP)
- NetSock_CfgTimeoutConnAcceptSet() (TCP)
- NetSock_CfgTimeoutConnCloseDflt() (TCP)
- NetSock_CfgTimeoutConnCloseGet_ms() (TCP)
- NetSock_CfgTimeoutConnCloseSet() (TCP)
- NetSock_CfgTimeoutConnReqDflt() (TCP)
- NetSock_CfgTimeoutConnReqGet_ms() (TCP)
- NetSock_CfgTimeoutConnReqSet() (TCP)
- NetSock_CfgTimeoutRxQ_Dflt() (TCP/UDP)
- NetSock_CfgTimeoutRxQ_Get_ms() (TCP/UDP)
- NetSock_CfgTimeoutRxQ_Set() (TCP/UDP)
- NetSock_CfgTimeoutTxQ_Dflt() (TCP)
- NetSock_CfgTimeoutTxQ_Get_ms() (TCP)
- NetSock_CfgTimeoutTxQ_Set() (TCP)

### 9-4-1 SOCKET OPTIONS

µC/TCP-IP provides two APIs to read and configure socket option values. These APIs are listed below and detailed in section C-13 “Network Socket Functions” on page 572:

- NetSock_OptGet()
- NetSock_OptSet()

Their BSD equivalent are listed below. See also section C-18 “BSD Functions” on page 715.

- getsockopt() (TCP/UDP)
- setsockopt() (TCP/UDP)

## 9-5 SECURE SOCKETS

If a network security module (such as Mocana - NanoSSL) is available, µC/TCP-IP socket security option APIs can be used to secure sockets. Basically, it provides APIs to install the required keying material and to set the secure flag on a specific socket. These APIs are listed below and detailed in section F-6 “Using Network Security Manager” on page 810:

- `NetSock_CfgSecureServerCertKeyInstall()`
- `NetSock_CfgSecureClientCommonName()`
- `NetSock_CfgSecureClientTrustCallBack()`

## 9-6 2MSL

Maximum Segment Lifetime (MSL) is the time a TCP segment can exist in the network, and is defined as two minutes. 2MSL is twice this lifetime. It is the maximum lifetime of a TCP segment on the network because it supposes segment transmission and acknowledgment.

Currently, Micrium does not support multiple sockets with identical connection information. This prevents new sockets from binding to the same local addresses as other sockets. Thus, for TCP sockets, each `close()` incurs the TCP 2MSL timeout and prevents the next `bind()` from the same client from occurring until after the timeout expires. This is why the 2MSL value is used. This can lead to a long delay before the socket resource is released and reused. µC/TCP-IP configures the TCP connection's default maximum segment lifetime (MSL) timeout value, specified in integer seconds. A starting value of 3 seconds is recommended.

If TCP connections are established and closed rapidly, it is possible that this timeout may further delay new TCP connections from becoming available. Thus, an even lower timeout value may be desirable to free TCP connections and make them available for new connections as rapidly as possible. However, a 0 second timeout prevents µC/TCP-IP from performing the complete TCP connection close sequence and will instead send TCP reset (RST) segments.

For UDP sockets, the sockets `close()` without delay. Thus, the next `bind()` is not blocked.

## 9-7 µC/TCP-IP SOCKET ERROR CODES

When socket functions return error codes, the error codes should be inspected to determine if the error is a temporary, non-fault condition (such as no data to receive) or fatal (such as the socket has been closed).

### 9-7-1 FATAL SOCKET ERROR CODES

Whenever any of the following fatal error codes are returned by any µC/TCP-IP socket function, that socket *must* be immediately `closed()`'d without further access by any other socket functions:

```
NET_SOCK_ERR_INVALID_FAMILY
NET_SOCK_ERR_INVALID_PROTOCOL
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_FAULT
```

Whenever any of the following fatal error codes are returned by any µC/TCP-IP socket function, that socket *must not* be accessed by any other socket functions but must also *not* be `closed()`'d:

```
NET_SOCK_ERR_NOT_USED
```

### 9-7-2 SOCKET ERROR CODE LIST

See section E-7 "IP Error Codes" on page 778 for a brief explanation of all µC/TCP-IP socket error codes.

Chapter

# 10

# Timer Management

µC/TCP-IP manages software timers used to keep track of various network-related timeouts. Timer management functions are found in `net_tmr.*`. Timers are required for:

- Network interface/device driver link-layer monitor 1 total
- Network interface performance statistics 1 total
- ARP cache management 1 per ARP cache entry
- IP fragment reassembly 1 per fragment chain
- Various TCP connection timeouts up to 7 per TCP connection
- Debug monitor task 1 total
- Performance monitor task 1 total

Of the three mandatory µC/TCP-IP tasks, one of them, the timer task, is used to manage and update timers. The timer task updates timers periodically. `NET_TMR_CFG_TASK_FREQ` determines how often (in Hz) network timers are to be updated. This value *must not* be configured as a floating-point number. This value is typically set to **10 Hz**.

See section D-5-1 on page 746 for more information on timer usage and configuration.

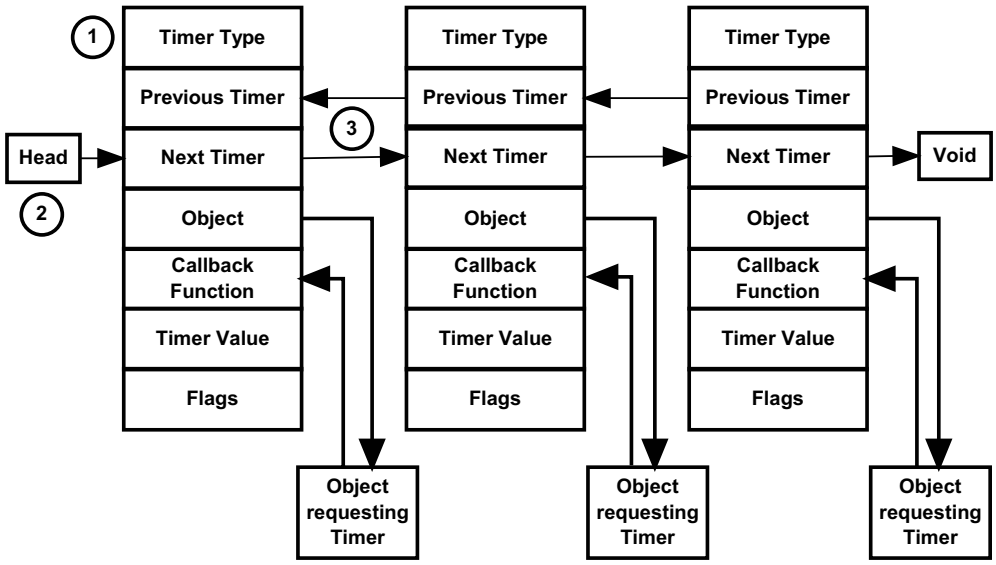



Figure 10-1 **Timer List**

L10-0(1) Timer types are either `NONE` or `TMR`, meaning unused or used. This field is defined as ASCII representations of network timer types. Memory displays of network timers will display the timer TYPEs with their chosen ASCII name.

L10-0(2) To manage the timers, the head of the timer list is identified by `NetTmr_TaskListHead`, a pointer to the head of the Timer List.

L10-0(3) `PrevPtr` and `NextPtr` doubly link each timer to form the Timer List.

The flags field is currently unused.

Network timers are managed by the Timer task in a doubly-linked Timer List. The function that executes these operation is the `NetTmr_TaskHandler()` function. This function is an operating system (OS) function and *should* be called only by appropriate network-operating system port function(s). `NetTmr_TaskHandler()` is blocked until network initialization completes.

`NetTmr_TaskHandler()` handles the network timers in the Timer List by acquiring the global network lock first. This function blocks all other network protocol tasks by pending on and acquiring the global network lock. Then it handles every network timer in Timer List

by decrementing the network timer(s) and for any timer that expires, execute the timer's callback function and free the timer from Timer List. When a network timer expires, the timer is be freed *prior* to executing the timer callback function. This ensures that at least one timer is available if the timer callback function requires a timer. Finally, `NetTmr_TaskHandler()` releases the global network lock.

New timers are added at the head of the Timer List. As timers are added into the list, older timers migrate to the tail of the Timer List. Once a timer expires or is discarded, it is removed.

`NetTmr_TaskHandler()` handles of all the valid timers in the Timer List, up to the first corrupted timer. If a corrupted timer is detected, the timer is discarded/unlinked from the List. Consequently, any remaining valid timers are unlinked from Timer List and are not handled. Finally, the Timer task is aborted.

Since `NetTmr_TaskHandler()` is asynchronous to ANY timer Get/Set, one additional tick is added to each timer's count-down so that the requested timeout is *always* satisfied. This additional tick is added by NOT checking for zero ticks after decrementing; any timer that expires is recognized at the next tick.

A timer value of 0 ticks/seconds is allowed. The next tick will expire the timer.

The `NetTmr_***()` functions are internal functions and should not be called by application functions. This is the reason they are not described here or in Appendix C, "µC/TCP-IP API Reference" on page 417. For more details on these functions, please refer to the `net_tmr.*` files.

Chapter

# 11

# Debug Management

µC/TCP-IP contains debug constants and functions that may be used by applications to determine network RAM usage, check run-time network resource usage, and check network error or fault conditions. These constants and functions are found in `net_dbg.*`. Most of these debug features must be enabled by appropriate configuration constants (see Appendix D, "µC/TCP-IP Configuration and Optimization" on page 735).

## 11-1 NETWORK DEBUG INFORMATION CONSTANTS

Network debug information constants provide the developer with run-time statistics on µC/TCP-IP configuration, data type and structure sizes, and data RAM usage. The list of debug information constants can be found in `net_dbg.c`, sections `GLOBAL NETWORK MODULE DEBUG INFORMATION CONSTANTS & GLOBAL NETWORK MODULE DATA SIZE CONSTANTS`. These debug constants are enabled by configuring `NET_DBG_CFG_DBG_INFO_EN` to `DEF_ENABLED`.

For example, these constants can be used as follows:

```
CPU_INT16U    net_version;
CPU_INT32U    net_data_size;
CPU_INT32U    net_data_nbr_if;


net_version     = Net_Version;
net_data_size   = Net_DataSize;
net_data_nbr_if = NetIF_CfgMaxNbrIF;
printf("µC/TCP-IP Version         : %05d\n", net_version);
printf("Total Network RAM Used    : %05d\n", net_data_size);
printf("Number Network Interfaces : %05d\n", net_data_nbr_if);
```

## 11-2 NETWORK DEBUG MONITOR TASK

The Network Debug Monitor task periodically checks the current run-time status of certain µC/TCP-IP conditions and saves that status to global variables which may be queried by other network modules.

Currently, the Network Debug Monitor task is only enabled when ICMP Transmit Source Quenches are enabled (see section D-10-1 on page 753) because this is the only network functionality that requires a periodic update of certain network status conditions. Applications do not need Debug Monitor task functionality since applications have access to the same debug status functions that the Monitor task calls and may call them asynchronously.

Chapter

# 12

# Statistics and Error Counters

µC/TCP-IP maintains counters and statistics for a variety of expected or unexpected error conditions. Some of these statistics are optional since they require additional code and memory and are enabled only if `NET_CTR_CFG_STAT_EN` or `NET_CTR_CFG_ERR_EN` is enabled (see section D-4 "Network Counter Configuration" on page 745).

## 12-1 STATISTICS

µC/TCP-IP maintains run-time statistics on interfaces and most µC/TCP-IP object pools. If desired, an application can thus query µC/TCP-IP to find out how many frames have been processed on a particular interface, transmit and receive performance metrics, buffer utilization and more. An application can also reset the statistic pools back to their initialization values (see `net_stat.h`).

Applications may choose to monitor statistics for various reasons. For example, examining buffer statistics allows you to better manage the memory usage. Typically, more buffers can be allocated than necessary and, by examining buffer usage statistics, adjustments can be made to reduce their number.

Network protocol and interface statistics are kept in an instance of a data structure named `Net_StatCtrs`. This variable may be viewed within a debugger or referenced externally by the application for run-time analysis.

Unlike network protocol statistics, object pool statistics have functions to get a copy of the specified statistic pool and functions for resetting the pools to their default values. These statistics are kept in a data structure called `NET_STAT_POOL` which can be declared by the application and used as a return variable from the statistics API functions.

The data structure is shown below:

```
typedef struct net_stat_pool {
    NET_TYPE           Type;
    NET_STAT_POOL_QTY  EntriesInit;
    NET_STAT_POOL_QTY  EntriesTotal;
    NET_STAT_POOL_QTY  EntriesAvail;
    NET_STAT_POOL_QTY  EntriesUsed;
    NET_STAT_POOL_QTY  EntriesUsedMax;
    NET_STAT_POOL_QTY  EntriesLostCur;
    NET_STAT_POOL_QTY  EntriesLostTotal;
    CPU_INT32U         EntriesAllocatedCtr;
    CPU_INT32U         EntriesDeallocatedCtr;
} NET_STAT_POOL;
```

NET_STAT_POOL_QTY is a data type currently set to CPU_INT16U and thus contains a maximum count of 65535.

Access to buffer statistics is obtained via interface functions that the application can call (described in the next sections). Most likely, only the following variables in NET_STAT_POOL need to be examined, because the **.Type** member is configured at initialization time as NET_STAT_TYPE_POOL :

**.EntriesAvail**
This variable indicates how many buffers are available in the pool.

**.EntriesUsed**
This variable indicates how many buffers are currently used by the TCP/IP stack.

**.EntriesUsedMax**
This variable indicates the maximum number of buffers used since it was last reset.

**.EntriesAllocatedCtr**
This variable indicates the total number of times buffers were allocated (i.e., used by the TCP/IP stack).

**.EntriesDeallocatedCtr**
This variable indicates the total number of times buffers were returned back to the buffer pool.

In order to enable run-time statistics, the macro NET_CTR_CFG_STAT_EN located within net_cfg.h must be defined to DEF_ENABLED.

## 12-2 ERROR COUNTERS

µC/TCP-IP maintains run-time counters for tracking error conditions within the Network Protocol Stack. If desired, the application may view the error counters in order to debug run-time problems such as low memory conditions, slow performance, packet loss, *etc*.

Network protocol error counters are kept in an instance of a data structure named `Net_ErrCtrs`. This variable may be viewed within a debugger or referenced externally by the application for run-time analysis (see `net_stat.h`).

In order to enable run-time error counters, the macro `NET_CTR_CFG_ERR_EN` located within `net_cfg.h` must be defined to `DEF_ENABLED`.

Appendix

# A

# µC/TCP-IP Ethernet Device Driver APIs

This appendix provides a reference to the µC/TCP-IP Device Driver API. Each user-accessible service is presented in alphabetical order. The following information is provided for each of the services:

- A brief description
- The function prototype
- The filename of the source code
- A description of the arguments passed to the function
- A description of the returned value(s)
- Specific notes and warnings on the use of the service

# A-1 DEVICE DRIVER FUNCTIONS FOR MAC

## A-1-1 NetDev_Init()

The first function within the Ethernet API is the device driver initialization/`Init()` function. This function is called by `NetIF_Add()` exactly once for each specific network device added by the application. If multiple instances of the same network device are present on the development board, then this function is called for each instance of the device. However, applications should not try to add the same specific device more than once. If a network device fails to initialize, we recommend debugging to find and correct the cause of failure.

Note: This function relies heavily on the implementation of several network device board support package (BSP) functions. See Chapter 6, "Network Board Support Package" on page 121 and Appendix A, "Device Driver BSP Functions" on page 336 for more information on network device BSP functions.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_Init (NET_IF  *pif,
                         NET_ERR *perr);
```

Note that since every device driver's `Init()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to initialize a network device.

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The `Init()` function generally performs the following operations, however, depending on the device being initialized, functionality may need to be added or removed:

1 Configure clock gating to the MAC device, if applicable. This is generally performed via the network device's BSP function pointer, `CfgClk()`, implemented in `net_bsp.c` (see section A-3-1 on page 336).

2 Configure all necessary I/O pins for both an internal or external MAC and PHY, if present. This is generally performed via the network device's BSP function pointer, `CfgGPIO()`, implemented in `net_bsp.c` (see section A-3-2 on page 338).

   Configure the host interrupt controller for receive and transmit complete interrupts. Additional interrupt services may be initialized depending on the device and driver requirements. This is generally performed via the network device's BSP function pointer, `CfgIntCtrl()`, implemented in `net_bsp.c` (see section A-3-3 on page 340).

3 For DMA devices: Allocate memory for all necessary descriptors. This is performed via calls to µC/LIB's memory module.

4 For DMA devices: Initialize all descriptors to their ready states. This may be performed via calls to locally-declared, '`static`' functions.

5 Initialize the (R)MII bus interface, if applicable. This generally entails configuring the (R)MII bus frequency which is dependent on the system clock. Static values for clock frequencies should never be used when determining clock dividers. Instead, the driver should reference the associated clock function(s) for getting the system clock or peripheral bus frequencies, and use these values to compute the correct (R)MII bus clock divider(s). This is generally performed via the network device's BSP function pointer, `ClkFreqGet()`, implemented in `net_bsp.c` (see section A-3-4 on page 344).

6 Disable the transmitted and receiver (should already be disabled).

7 Disable and clear pending interrupts (should already be cleared).

8 Set `perr` to `NET_DEV_ERR_NONE` if initialization proceeded as expected. Otherwise, set `perr` to an appropriate network device error code.

## A-1-2 NetDev_Start()

The second function is the device driver `Start()` function. This function is called once each time an interface is started.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_Start (NET_IF  *pif,
                          NET_ERR *perr);
```

Note that since every device driver's `Start()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to start a network device.

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The `Start()` function performs the following items:

1 Configure the transmit ready semaphore count via a call to `NetOS_Dev_CfgTxRdySignal()`. This function call is optional and is generally performed when the hardware device supports the queuing of multiple transmit frames. By default, the count is initialized to one. However, DMA devices should set the semaphore count equal to the number of configured transmit descriptors for optimal performance. Non-DMA devices that support the queuing of more than one transmit frame may also benefit from a non-default value.

2 Initialize the device MAC address if applicable. For Ethernet devices, this step is mandatory. The MAC address data may come from one of three sources and should be set using the following priority scheme:

a. Configure the MAC address using the string found within the device configuration structure. This is a form of static MAC address configuration and may be performed by calling `NetASCII_Str_to_MAC()` and `NetIF_AddrHW_SetHandler()`. If the device configuration string has been left empty, or is specified as all 0's, an error will be returned and the next method should be attempted.

b. Check if the application developer has called `NetIF_AddrHW_Set()` by making a call to `NetIF_AddrHW_GetHandler()` and `NetIF_AddrHW_IsValidHandler()` in order to check if the specified MAC address is valid. This method may be used as a static method for configuring the MAC address during run-time, or a dynamic method should a pre-programmed external memory device exist. If the acquired MAC address does not pass the check function, then:

c. Call `NetIF_AddrHW_SetHandler()` using the data found within the MAC individual address registers. If an auto-loading EEPROM is attached to the MAC, the registers will contain valid data. If not, then a configuration error has occurred. This method is often used with a production process where the MAC supports the automatic loading of individual address registers from a serial EEPROM. When using this method, the developer should specify an empty string for the MAC address within the device configuration and refrain from calling `NetIF_AddrHW_Set()` from within the application.

3 Initialize additional MAC registers required by the MAC for proper operation.

4 Clear all interrupt flags.

5 Locally enable interrupts on the hardware device. The host interrupt controller should have already been configured within the device driver `Init()` function.

6 Enable the receiver and transmitter.

7 Set `perr` equal to `NET_DEV_ERR_NONE` if no errors have occurred. Otherwise, set `perr` to an appropriate network device error code.

## A-1-3 NetDev_Stop()

The next function within the device API structure is the device `Stop()` function. This function is called once each time an interface is stopped.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_Stop (NET_IF  *pif,
                         NET_ERR *perr);
```

Note that since every device driver's `Stop()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to start a network device.

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The `Stop()` function must perform the following operations:

1 Disable the receiver and transmitter.

2 Disable all local MAC interrupt sources.

3 Clear all local MAC interrupt status flags.

4 For DMA devices, re-initialize all receive descriptors.

5 For DMA devices, free all transmit descriptors by calling `NetOS_IF_DeallocTaskPost()` with the address of the transmit descriptor data areas.

6 For DMA devices, re-initialize all transmit descriptors.

7 Set `perr` to `NET_DEV_ERR_NONE` if no error occurs. Otherwise, set `perr` to an appropriate network device error code.

## A-1-4 NetDev_Rx()

The receive/`Rx()` function is called by µC/TCP-IP's Receive task after the Interrupt Service Routine handler has signaled to the Receive task that a receive event has occurred. The Receive function requires that the device driver return a pointer to the data area containing the received data and return the size of the received frame via pointer.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_Rx (NET_IF      *pif,
                       CPU_INT08U **p_data,
                       CPU_INT16U  *size,
                       NET_ERR     *perr);
```

Note that since every device driver's `Rx()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to receive data from a network device.

`p_data` Pointer to return the address of the received data.

`size` Pointer to return the size of the received data.

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The receive function should perform the following actions:

1 Check for receive errors if applicable. If an error should occur during reception, the driver should set `*size` to 0 and `*p_data` to `(CPU_INT08U *)0` and return. Additional steps may be necessary depending on the device being serviced.

2 For Ethernet devices, get the size of the received frame and subtract 4 bytes for the CRC. It it always recommended that the frame size is checked to ensure that it is greater than 4 bytes before performing the subtraction to ensure that an underflow does not occur. Set `*size` equal to the adjusted frame size.

3 Get a new data buffer area by calling `NetBuf_GetDataPtr()`. If memory is not available, an error will be returned and the device driver should set `*size` to 0 and `*p_data` to (`CPU_INT08U *)0`. For DMA devices, the current receive descriptor should be marked as available or owned by hardware. The device driver should then return from the receive function.

4 If an error does not occur while getting a new data area, DMA devices should perform the following operations:

   a. Set `*p_data` equal to the address of the data area within the descriptor being serviced.

   b. Set the data area pointer within the receive descriptor to the address of the data area obtained by calling `NetBuf_GetDataPtr()`.

   c. Update any descriptor ring pointers if applicable.

5 Non DMA devices should `Mem_Copy()` the data stored within the device to the address of the buffer obtained by calling `NetBuf_GetDataPtr()` and set `*p_data` equal to the address of the obtained data area.

6 Set `perr` to `NET_DEV_ERR_NONE` and return from the receive function. Otherwise, set `perr` to an appropriate network device error code.

## A-1-5 NetDev_Tx()

The next function in the device API structure is the transmit/`Tx()` function.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_Tx (NET_IF     *pif,
                       CPU_INT08U *p_data,
                       CPU_INT16U  size,
                       NET_ERR    *perr);
```

Note that since every device driver's `Tx()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to start a network device.

`p_data` Pointer to address of the data to transmit.

`size` Size of the data to transmit.

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The transmit function should perform the following actions:

1 For DMA-based hardware, the driver should select the next available transmit descriptor and set the pointer to the data area equal to the address pointer to by `p_data`.

2 Non-DMA hardware should `Mem_Copy()` the data stored within the buffer pointed to by `p_data` to the device's internal memory.

3 Once completed, the driver must configure the device with the number of bytes to transmit. This is passed directly by value within the size argument. DMA-based devices generally have a size field within the transmit descriptor. Non-DMA devices generally have a transmit size register that needs to be configured.

4 The driver should then take all necessary steps to initiate transmission of the data.

5 Set `perr` to `NET_DEV_ERR_NONE` and return from the transmit function.

## A-1-6 NetDev_AddrMulticastAdd()

The next API function is the `AddrMulticastAdd()` function used to configure a device with an (IP-to-Ethernet) multicast hardware address.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_AddrMulticastAdd (NET_IF     *pif,
                                     CPU_INT08U *paddr_hw,
                                     CPU_INT08U  addr_hw_len,
                                     NET_ERR    *perr);
```

Note that since every device driver's `AddrMulticastAdd()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to add/configure a multicast address.

`paddr_hw` Pointer to multicast hardware address to add.

`addr_hw_len` Length of multicast hardware address.

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Necessary only if `NET_IP_CFG_MULTICAST_SEL` is configured for transmit and receive multicasting (see section D-9-2 on page 752).

## NOTES / WARNINGS

Since many network controllers' documentation fail to properly indicate how to add/configure an Ethernet MAC device with a multicast address, the following methodology is recommended for determining and testing the correct multicast hash bit algorithm.

1 Configure a packet capture program or multicast application to broadcast a multicast packet with Ethernet destination address of 01:00:5E:00:00:01. This MAC address corresponds to the multicast group IP address of 224.0.0.1 which will be converted to a MAC address by higher layers and passed to this function.

2 Set a break point in the receive ISR handler and transmit one send packet to the target. The break point should *not* be reached as the result of the transmitted packet. Use caution to ensure that other network traffic is not the source of the interrupt when the button is pressed. Sometimes asynchronous network events happen very close in time and the end result can be deceiving. Ideally, these tests should be performed on an isolated network but disconnect as many other hosts from the network as possible.

3 Use the debugger to stop the application and program the MAC multicast hash register low bits to 0xFFFFFFFF. Go to step 2. Repeat for the hash bit high register if necessary. The goal is to bracket off which bit in either the high or low hash bit register causes the device to be interrupted when the broadcast frame is received by the target. Once the correct bit is known, the hash algorithm can be easily written and tested.

4 The following hash bit algorithm code below could be adjusted per the network controller's documentation in order to get the hash from the correct subset of CRC bits. Most of the code is similar between various devices and is thus reusable. The hash algorithm is the exlusive **OR** of every 6th bit of the destination address:

```
hash[5] = da[5] ^ da[11] ^ da[17] ^ da[23] ^ da[29] ^ da[35] ^ da[41] ^ da[47]
hash[4] = da[4] ^ da[10] ^ da[16] ^ da[22] ^ da[28] ^ da[34] ^ da[40] ^ da[46]
hash[3] = da[3] ^ da[09] ^ da[15] ^ da[21] ^ da[27] ^ da[33] ^ da[39] ^ da[45]
hash[2] = da[2] ^ da[08] ^ da[14] ^ da[20] ^ da[26] ^ da[32] ^ da[38] ^ da[44]
hash[1] = da[1] ^ da[07] ^ da[13] ^ da[19] ^ da[25] ^ da[31] ^ da[37] ^ da[43]
hash[0] = da[0] ^ da[06] ^ da[12] ^ da[18] ^ da[24] ^ da[30] ^ da[36] ^ da[42]
```

Where `da0` represents the least significant bit of the first byte of the destination address received and where `da47` represents the most significant bit of the last byte of the destination address received.

```
                                                /* ---------- CALCULATE HASH CODE ---------- */
hash = 0;
for (i = 0; i < 6; i++) {                       /* For each row in the bit hash table:       */
    bit_val = 0;                                /* Clear initial xor value for each row.     */
    for (j = 0; j < 8; j++) {                   /* For each bit in each octet:               */
        bit_nbr    = (j * 6) + i;               /* Determine which bit in stream, 0-47.      */
        octet_nbr  =  bit_nbr / 8;              /* Determine which octet bit belongs to.     */
        octet      =  paddr_hw[octet_nbr];      /* Get octet value.                          */
        bit        =  octet & (1 << (bit_nbr % 8));  /* Check if octet's bit is set.        */
        bit_val   ^= (bit > 0) ? 1 : 0;         /* Calculate table row's XOR hash value.     */
    }
     hash |= (bit_val << i);                    /* Add row's XOR hash value to final hash.   */
}
                                                /* ---- ADD MULTICAST ADDRESS TO DEVICE ---- */
reg_sel = (hash >> 5) & 0x01;                   /* Determine hash register     to configure. */
reg_bit = (hash >> 0) & 0x1F;                   /* Determine hash register bit to configure. */
                                                /* (Substitute '0x01'/'0x1F' with device's ..*/
                                                /* .. actual hash register bit masks/shifts.)*/

  paddr_hash_ctrs = &pdev_data->MulticastAddrHashBitCtr[hash];
(*paddr_hash_ctrs)++;                           /* Increment hash bit reference counter.     */

if (reg_sel == 0) {                             /* Set multicast hash register bit.          */
    pdev->MCAST_REG_LO |= (1 << reg_bit);       /* (Substitute 'MCAST_REG_LO/HI' with ..     */
} else {                                        /* .. device's actual multicast registers.)  */
    pdev->MCAST_REG_HI |= (1 << reg_bit);
}
                                                /* ---------- CALCULATE HASH CODE ---------- */
                                                /* Calculate CRC.                            */
crc = NetUtil_32BitCRC_Calc((CPU_INT08U *)paddr_hw,
                            (CPU_INT32U  ) addr_hw_len,
                            (NET_ERR    *)perr);
```

Listing A-1 **Example device multicast address configuration using CRC hash code algorithm**

Alternatively, you may be able to compute the CRC hash with a call to `NetUtil_32BitCRC_CalcCpl()` followed by an optional call to `NetUtil_32BitReflect()`, with four possible combinations:

a. CRC without complement and without reflection

b. CRC without complement and with reflection

c. CRC with complement and without reflection

d. CRC with complement and with reflection

```
if (*perr != NET_UTIL_ERR_NONE) {
     return;
}
                                                /* ---- ADD MULTICAST ADDRESS TO DEVICE ---- */
crc     =  NetUtil_32BitReflect(crc);           /* Optionally, complement CRC.              */
hash    = (crc >> 23u) & 0x3F;                  /* Determine hash register     to configure. */
reg_bit = (hash % 32u);                         /* Determine hash register bit to configure. */
                                                /* (Substitute '23u'/'0x3F' with device's .. */
                                                /* .. actual hash register bit masks/shifts.)*/

  paddr_hash_ctrs = &pdev_data->MulticastAddrHashBitCtr[hash];
(*paddr_hash_ctrs)++;                           /* Increment hash bit reference counter.     */

if (hash <= 31u) {                              /* Set multicast hash register bit.          */
    pdev->MCAST_REG_LO |= (1 << reg_bit);       /* (Substitute 'MCAST_REG_LO/HI' with ..     */
} else {                                        /* .. device's actual multicast registers.)  */
    pdev->MCAST_REG_HI |= (1 << reg_bit);
}
```

Listing A-2 **Example device multicast address configuration using CRC and reflection functions**

Unfortunately, the product documentation will *not* likely tell you which combination of complement and reflection is necessary in order to properly compute the hash value. Most likely, the documentation will simply state 'Standard Ethernet CRC' which when compared to other documents, means any of the four combinations above; different than the actual frame CRC.

Fortunately, if the code is written to perform both the complement and reflection, then the debugger may be used to repeat the code block over and over skipping either the line that performs the complement or the function call to the reflection until the output hash bit is computed correctly.

5 Update the device driver's `AddrMulticastAdd()` function to calculate and configure the correct CRC.

6 Test the device driver's `AddrMulticastAdd()` function by ensuring that the group address 224.0.0.1, when joined from the application (see section C-11-1 on page 539), correctly configures the device to receive multicast packets destined to the 224.0.0.1 address. Then broadcast the 224.0.0.1 (see step 1) to test if the device receives the multicast packet.

## A-1-7 NetDev_AddrMulticastRemove()

The next API function is the `AddrMulticastRemove()` function used to remove an (IP-to-Ethernet) multicast hardware address from a device.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_AddrMulticastRemove (NET_IF     *pif,
                                        CPU_INT08U *paddr_hw,
                                        CPU_INT08U  addr_hw_len,
                                        NET_ERR    *perr);
```

Note that since every device driver's `AddrMulticastRemove()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

| | |
|---|---|
| `pif` | Pointer to the interface to remove a multicast address. |
| `paddr_hw` | Pointer to multicast hardware address to remove. |
| `addr_hw_len` | Length of multicast hardware address. |
| `perr` | Pointer to variable that will receive the return error code from this function. |

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Necessary only if `NET_IP_CFG_MULTICAST_SEL` is configured for transmit and receive multicasting (see section D-9-2 on page 752).

### NOTES / WARNINGS

Use same exact code as in `NetDev_AddrMulticastAdd()` to calculate the device's CRC hash (see section A-1-6 on page 314), but remove a multicast address by decrementing the device's hash bit reference counters and clearing the appropriate bits in the device's multicast registers.

```
                                                /* ---------- CALCULATE HASH CODE ---------- */
/* Use NetDev_AddrMulticastAdd()'s algorithm to calculate CRC hash.                          */
                                                /* - REMOVE MULTICAST ADDRESS FROM DEVICE -- */
paddr_hash_ctrs = &pdev_data->MulticastAddrHashBitCtr[hash];
if (*paddr_hash_ctrs > 1u) {                    /* If multiple multicast addresses hashed, ..*/
   (*paddr_hash_ctrs)--;                        /* .. decrement hash bit reference counter ..*/
    *perr = NET_DEV_ERR_NONE;                   /* .. but do NOT unconfigure hash register.  */
     return;
}
*paddr_hash_ctrs = 0u;                          /* Clear hash bit reference counter.         */

if (hash <= 31u) {                              /* Clear multicast hash register bit.        */
    pdev->MCAST_REG_LO &= ~(1u << reg_bit);     /* (Substitute 'MCAST_REG_LO/HI' with ..     */
} else {                                        /* .. device's actual multicast registers.)  */
    pdev->MCAST_REG_HI &= ~(1u << reg_bit);
}
```

Listing A-3 **Example device multicast address removal**

## A-1-8 NetDev_ISR_Handler()

A device's ISR_Handler() function is used to handle each device's interrupts. See section 7-5-5 on page 164 for more details on how to handle each device's interrupts.

### FILES

Every device driver's net_dev.c

### PROTOTYPE

```
static void NetDev_ISR_Handler (NET_IF           *pif,
                                NET_DEV_ISR_TYPE  type);
```

Note that since every device driver's ISR_Handler() function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

pif Pointer to the interface to handle network device interrupts.

type Device's interrupt type:

NET_DEV_ISR_TYPE_UNKNOWN
NET_DEV_ISR_TYPE_RX
NET_DEV_ISR_TYPE_RX_RUNT
NET_DEV_ISR_TYPE_RX_OVERRUN
NET_DEV_ISR_TYPE_TX_RDY
NET_DEV_ISR_TYPE_TX_COMPLETE
NET_DEV_ISR_TYPE_TX_COLLISION_LATE
NET_DEV_ISR_TYPE_TX_COLLISION_EXCESS
NET_DEV_ISR_TYPE_JABBER
NET_DEV_ISR_TYPE_BABBLE
NET_DEV_ISR_TYPE_PHY

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Each device's `NetDev_ISR_Handler()` should never return early but check all applicable interrupt sources to see if they are active. This additional checking is necessary because multiple interrupt sources may be set within the interrupt response time and will reduce the number and overhead of handling interrupts.

## A-1-9 NetDev_IO_Ctrl()

A device's input/output control/IO_Ctrl() function is used to implement miscellaneous functionality such as setting and getting the PHY link state, as well as updating the MAC link state registers when the PHY link state has changed. An optional void pointer to a data variable is passed into the function and may be used to get device parameters from the caller, or to return device parameters to the caller.

### FILES

Every device driver's net_dev.c

### PROTOTYPE

```
static void NetDev_IO_Ctrl (NET_IF     *pif,
                            CPU_INT08U  opt,
                            void       *p_data,
                            NET_ERR    *perr);
```

Note that since every device driver's IO_Ctrl() function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

pif — Pointer to the interface to handle network device I/O operations.

opt — I/O operation to perform.

p_data — A pointer to a variable containing the data necessary to perform the operation or a pointer to a variable to store data associated with the result of the operation.

perr — Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

µC/TCP-IP defines the following default options:

```
NET_DEV_LINK_STATE_GET_INFO
NET_DEV_LINK_STATE_UPDATE
```

The `NET_DEV_LINK_STATE_GET_INFO` option expects `p_data` to point to a variable of type `NET_DEV_LINK_ETHER` for the case of an Ethernet driver. This variable has two fields, `Spd` and `Duplex`, which are filled in by the PHY device driver via a call through the PHY API. µC/TCP-IP internally uses this option code in order to periodically poll the PHYs for link state.

The `NET_DEV_LINK_STATE_UPDATE` option is used by the PHY driver to communicate with the MAC when either µC/TCP-IP polls the PHY for link status, or when a PHY interrupt occurs. Not all MAC's require PHY link state synchronization. Should this be the case, then the device driver may not need to implement this option.

## A-1-10 NetDev_MII_Rd()

The next function to implement is the (R)MII read/Phy_RegRd() function. This function is generally implemented within the Ethernet device driver file, since (R)MII bus reads are generally associated with the MAC device. In the case that the PHY communication mechanism is separate from the MAC, then a handler function may be provided within the net_bsp.c file and called from the device driver file instead.

Note: This function must be implemented with a timeout and should *not* block indefinitely should the PHY fail to respond.

### FILES

Every device driver's net_dev.c

### PROTOTYPE

```
static void NetDev_MII_Rd (NET_IF     *pif,
                           CPU_INT08U  phy_addr,
                           CPU_INT08U  reg_addr,
                           CPU_INT16U *p_data,
                           NET_ERR    *perr);
```

Note that since every device driver's Phy_RegRd()/MII_Rd() function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to read a (R)MII PHY register.

`phy_addr` The bus address of the PHY.

`reg_addr` The MII register number to read.

`p_data` Pointer to a address to store the content of the PHY register being read.

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

None.

## A-1-11 NetDev_MII_Wr()

Next is the (R)MII write/Phy_RegWr() function. This function is generally implemented within the Ethernet device driver file since (R)MII bus writes are generally associated with the MAC device. In the case that the PHY communication mechanism is separate from the MAC, a handler function may be provided within the net_bsp.c file and called from the device driver file instead.

Note: This function must be implemented with a timeout and not block indefinitely should the PHY fail to respond.

### FILES

Every device driver's net_dev.c

### PROTOTYPE

```
static void NetDev_MII_Wr (NET_IF     *pif,
                           CPU_INT08U  phy_addr,
                           CPU_INT08U  reg_addr,
                           CPU_INT16U  data,
                           NET_ERR    *perr);
```

Note that since every device driver's Phy_RegWr()/MII_Wr() function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

pif Pointer to the interface to read a (R)MII PHY register.

phy_addr The bus address of the PHY.

reg_addr The MII register number to write to.

p_data Pointer to the data to write to the specified PHY register.

perr Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

None.

## A-2 DEVICE DRIVER FUNCTIONS FOR PHY

### A-2-1 NetPhy_Init()

The first function within the Ethernet PHY API is the PHY driver initialization/`Init()` function which is called by the Ethernet network interface layer after the MAC device driver is initialized without error.

#### FILES

Every physical layer driver's `net_phy.c`

#### PROTOTYPE

```
static void NetPhy_Init (NET_IF  *pif,
                         NET_ERR *perr)
```

Note that since every PHY driver's `Init()` function is accessed only by function pointer via the PHY driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

#### ARGUMENTS

`pif` Pointer to the interface to initialize a PHY.

`perr` Pointer to variable that will receive the return error code from this function.

#### RETURNED VALUE

None.

#### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

The PHY initialization function is responsible for the following actions:

1 Reset the PHY and wait with timeout for reset to complete. If a timeout occurs, return `perr` set to `NET_PHY_ERR_RESET_TIMEOUT`.

2 Start the auto-negotiation process. This should configure the PHY registers such that the desired link speed and duplex specified within the PHY configuration are respected. It is not necessary to wait until the auto-negotiation process has completed, as this can take upwards of many seconds. Generally, this action is performed by calling the PHY's `NetPhy_AutoNegStart()` function.

3 If no errors occur, return `perr` set to `NET_PHY_ERR_NONE`.

## A-2-2 NetPhy_EnDis()

The next Ethernet PHY function is the enable-disable/`EnDis()` function. This function is called by the Ethernet network interface layer when an interface is started or stopped.

### FILES

Every physical layer driver's `net_phy.c`

### PROTOTYPE

```
static void NetPhy_EnDis (NET_IF      *pif,
                          CPU_BOOLEAN  en,
                          NET_ERR     *perr);
```

Note that since every PHY driver's `EnDis()` function is accessed only by function pointer via the PHY driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to enable/disable a PHY.

`en` A flag representing the next desired state of the PHY:
`DEF_ENABLED`
`DEF_DISABLED`

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

Disabling the PHY will generally cause the PHY to power down which will cause link state to be disconnected.

## A-2-3 NetPhy_LinkStateGet()

The Ethernet PHY's `LinkStateGet()` function determines the current Ethernet link state. Results are passed back to the caller in a `NET_DEV_LINK_ETHER` structure which contains fields for link speed and duplex. This function is called periodically by µC/TCP-IP.

### FILES

Every physical layer driver's `net_phy.c`

### PROTOTYPE

```
static void NetPhy_LinkStateGet (NET_IF             *pif,
                                 NET_DEV_LINK_ETHER *plink_state,
                                 NET_ERR            *perr);
```

Note that since every PHY driver's `LinkStateGet()` function is accessed only by function pointer via the PHY driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to get a PHY's current link state.

`plink_state` Pointer to a link state structure to return link state information. The `NET_DEV_LINK_ETHER` structure contains two fields for link speed and duplex. Link speed is returned via `plink_state->Spd` :

`NET_PHY_SPD_0`
`NET_PHY_SPD_10`
`NET_PHY_SPD_100`

And link duplex is returned via `plink_state->Duplex` :

`NET_PHY_DUPLEX_UNKNOWN`
`NET_PHY_DUPLEX_HALF`
`NET_PHY_DUPLEX_FULL`

NET_PHY_SPD_0 and NET_PHY_DUPLEX_UNKNOWN represent an unlinked or unknown link state if an error occurs.

perr — Pointer to variable that will receive the return error code from this function.

### RETURNED VALUES

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

The generic PHY driver does not return a link state. Instead, in order to avoid access to extended registers which are PHY specific, the driver attempts to determine link state by analyzing the PHY and PHY partner capabilities. The best combination of auto-negotiated link state is selected as the current link state.

## A-2-4 NetPhy_LinkStateSet()

The Ethernet PHY's `LinkStateSet()` function determines the current Ethernet link state. Results are passed back to the caller within a `NET_DEV_LINK_ETHER` structure which contains fields for link speed and duplex. This function is called periodically by µC/TCP-IP.

### FILES

Every physical layer driver's `net_phy.c`

### PROTOTYPE

```
static void NetPhy_LinkStateSet (NET_IF             *pif,
                                 NET_DEV_LINK_ETHER *plink_state,
                                 NET_ERR            *perr);
```

Note that since every PHY driver's `LinkStateSet()` function is accessed only by function pointer via the PHY driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to set a PHY's current link state.

`plink_state` Pointer to a link state structure with link state information to configure. The `NET_DEV_LINK_ETHER` structure contains two fields for link speed and duplex. Link speed is set via `plink_state->Spd` :

`NET_PHY_SPD_10`
`NET_PHY_SPD_100`

And link duplex is set via `plink_state->Duplex` :

`NET_PHY_DUPLEX_HALF`
`NET_PHY_DUPLEX_FULL`

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

None.

## A-2-5 NetPhy_ISR_Handler()

An Ethernet PHY's `ISR_Handler()` function is used to handle a PHY's interrupts. See section 7-4-7 "NetPhy_ISR_Handler()" on page 157 for more details on how to handle PHY interrupts. µC/TCP-IP does not require PHY drivers to enable or handle PHY interrupts. The generic PHY drivers does not even define a PHY interrupt handler function but instead handles all events by either periodic or event-triggered calls to other PHY API functions.

### FILES

Every physical layer driver's `net_phy.c`

### PROTOTYPE

```
static void NetPhy_ISR_Handler (NET_IF *pif);
```

Note that since every PHY driver's `ISR_Handler()` function is accessed only by function pointer via the PHY driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to the interface to handle PHY interrupts.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

None.

## A-3 DEVICE DRIVER BSP FUNCTIONS

### A-3-1 NetDev_CfgClk()

This function is called by a device driver's `NetDev_Init()` to configure a specific network device's clocks on a specific interface.

#### FILES

`net_bsp.c`

#### PROTOTYPE

```
static void NetDev_CfgClk (NET_IF  *pif,
                           NET_ERR *perr);
```

Note: since `NetDev_CfgClk()` is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

#### ARGUMENTS

`pif` Pointer to specific interface to configure device's clocks.

`perr` Pointer to variable that will receive the return error code from this function:

`NET_DEV_ERR_NONE`
`NET_DEV_ERR_FAULT`

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

#### RETURNED VALUE

None.

#### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Each network device's `NetDev_CfgClk()` should configure and enable all required clocks for the network device. For example, on some devices it may be necessary to enable clock gating for an embedded Ethernet MAC as well as various GPIO modules in order to configure Ethernet Phy pins for (R)MII mode and interrupts.

Since each network device requires a unique `NetDev_CfgClk()`, it is recommended that each device's `NetDev_CfgClk()` function be named using the following convention:

`NetDev_[Device]CfgClk[Number]()`

`[Device]` Network device name or type, e.g. MACB (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_CfgClk()` function for the #2 MACB Ethernet controller on an Atmel AT91SAM9263-EK should be named `NetDev_MACB_CfgClk2()`, or `NetDev_MACB_CfgClk_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## A-3-2 NetDev_CfgGPIO()

This function is called by a device driver's `NetDev_Init()` to configure a specific network device's general-purpose input/ouput (GPIO) on a specific interface.

### FILES

`net_bsp.c`

### PROTOTYPE

```
static void NetDev_CfgGPIO (NET_IF  *pif,
                            NET_ERR *perr);
```

Note that since `NetDev_CfgGPIO()` is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to specific interface to configure device's GPIO.

`perr` Pointer to variable that will receive the return error code from this function:

`NET_DEV_ERR_NONE`
`NET_DEV_ERR_FAULT`

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Each network device's `NetDev_CfgGPIO()` should configure all required GPIO pins for the network device. For Ethernet devices, this function is usually necessary to configure the (R)MII bus pins, depending on whether you have configured an Ethernet interface to operate in the RMII or MII mode, and optionally the Ethernet Phy interrupt pin.

Since each network device requires a unique `NetDev_CfgGPIO()`, it is recommended that each device's `NetDev_CfgGPIO()` function be named using the following convention:

`NetDev_[Device]CfgGPIO[Number]()`

`[Device]` Network device name or type, e.g. MACB (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_CfgGPIO()` function for the #2 MACB Ethernet controller on an Atmel AT91SAM9263-EK should be named `NetDev_MACB_CfgGPIO2()`, or `NetDev_MACB_CfgGPIO_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## A-3-3 NetDev_CfgIntCtrl()

This function is called by a device driver's NetDev_Init() to configure a specific network device's interrupts and/or interrupt controller on a specific interface.

### FILES

net_bsp.c

### PROTOTYPE

```
static void NetDev_CfgIntCtrl (NET_IF  *pif,
                               NET_ERR *perr);
```

Note that since NetDev_CfgIntCtrl() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

pif — Pointer to specific interface to configure device's interrupts.

perr — Pointer to variable that will receive the return error code from this function:

NET_DEV_ERR_NONE
NET_DEV_ERR_FAULT

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Each network device's `NetDev_CfgIntCtrl()` should configure and enable all required interrupt sources for the network device. This usually means configuring the interrupt vector address of each corresponding network device BSP interrupt service routine (ISR) handler and enabling its corresponding interrupt source. Thus, for most `NetDev_CfgIntCtrl()`, the following actions *should* be performed:

1 Configure/store each device's network interface number to be available for all necessary `NetDev_ISR_Handler()` functions (see section A-3-5 on page 346). Even though devices are added dynamically, the device's interface number must be saved in order for each device's ISR handlers to call `NetIF_ISR_Handler()` with the device's network interface number.

Since each network device maps to a unique network interface number, it is recommended that each instance of network devices' interface numbers be named using the following convention:

`<Board><Device>[Number]_IF_Nbr`

`<Board>` Development board name

`<Device>` Network device name (or type)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the network device interface number variable for the #2 MACB Ethernet controller on an Atmel AT91SAM9263-EK should be named `AT91SAM9263-EK_MACB_2_IF_Nbr`.

Network device interface number variables *should* be initialized to `NET_IF_NBR_NONE` at system initialization prior to being configured by their respective devices.

2 Configure each of the device's interrupts on either an external or CPU's integrated interrupt controller. However, vectored interrupt controllers may not require the explicit configuration and enabling of higher-level interrupt controller sources. In this case, the application developer may need to configure the system's interrupt vector table with the name of the ISR handler functions declared in `net_bsp.c`.

`NetDev_CfgIntCtrl()` should only enable each devices' interrupt sources but *not* the local device-level interrupts themselves, which are enabled by the device driver only after the device has been fully configured and started.

Since each network device requires a unique `NetDev_CfgIntCtrl()`, it is recommended that each device's `NetDev_CfgIntCtrl()` function be named using the following convention:

`NetDev_[Device]CfgIntCtrl[Number]()`

`[Device]` Network device name or type, e.g. MACB (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_CfgIntCtrl()` function for the #2 MACB Ethernet controller on an Atmel AT91SAM9263-EK should be named `NetDev_MACB_CfgIntCtrl2()`, or `NetDev_MACB_CfgIntCtrl_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## EXAMPLES

```
static  void  NetDev_MACB_CfgIntCtrl (NET_IF   *pif,
                                      NET_ERR  *perr)
{
                              /* Configure AT91SAM9263-EK MACB #2's specific IF number.       */
    AT91SAM9263-EK_MACB_2_IF_Nbr = pif->Nbr;
                              /* Configure AT91SAM9263-EK MACB #2's interrupts:               */
    BSP_IntVectSet(BSP_INT, &NetDev_MACB_ISR_Handler_2);/* Configure interrupt vector.        */
    BSP_IntEn(BSP_INT);                                 /* Enable    interrupts.              */

   *perr = NET_DEV_ERR_NONE;
}


static  void  NetDev_MACB_CfgIntCtrlRx_2 (NET_IF   *pif,
                                          NET_ERR  *perr)
{
                              /* Configure AT91SAM9263-EK MACB #2's specific IF number.       */
    AT91SAM9263-EK_MACB_2_IF_Nbr = pif->Nbr;
                              /* Configure AT91SAM9263-EK MACB #2's receive interrupt:        */
    BSP_IntVectSet(BSP_INT_RX, &NetDev_MACB_ISR_HandlerRx_2);   /* Configure interrupt vector. */
    BSP_IntEn(BSP_INT_RX);                                      /* Enable    interrupt.        */

   *perr = NET_DEV_ERR_NONE;
}
```

## A-3-4 NetDev_ClkGetFreq()

This function is called by a device driver's `NetDev_Init()` to return a specific network device's clock frequency for a specific interface.

### FILES

`net_bsp.c`

### PROTOTYPE

```
static CPU_INT32U NetDev_ClkGetFreq (NET_IF  *pif,
                                     NET_ERR *perr);
```

Note that since `NetDev_ClkFreqGet()` is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`pif` Pointer to specific interface to return device's clock frequency.

`perr` Pointer to variable that will receive the return error code from this function:

`NET_DEV_ERR_NONE`
`NET_DEV_ERR_FAULT`

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

Network device's clock frequency (in Hz).

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Each network device's `NetDev_ClkFreqGet()` should return the device's clock frequency (in Hz). For Ethernet devices, this is usually the clock frequency of the device's (R)MII bus. The device driver's `NetDev_Init()` uses the returned clock frequency to configure an appropriate bus divider to ensure that the (R)MII bus logic operates within an allowable range. In general, the device driver should not configure the divider such that the (R)MII bus operates faster than 2.5MHz.

Since each network device requires a unique `NetDev_ClkFreqGet()`, it is recommended that each device's `NetDev_ClkFreqGet()` function be named using the following convention:

`NetDev_[Device]ClkGetFreq[Number]()`

`[Device]` Network device name or type, e.g. MACB (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_ClkFreqGet()` function for the #2 MACB Ethernet controller on an Atmel AT91SAM9263-EK should be named `NetDev_MACB_ClkGetFreq2()`, or `NetDev_MACB_ClkGetFreq_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## A-3-5 NetDev_ISR_Handler()

Handle a network device's interrupts on a specific interface.

### FILES

`net_bsp.c`

### PROTOTYPE

```
static void NetDev_ISR_Handler (void);
```

Note that since `NetDev_ISR_Handler()` is accessed only by function pointer usually via an interrupt vector table, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

None.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Each network device's interrupt, or set of device interrupts, must be handled by a unique BSP-level interrupt service routine (ISR) handler, `NetDev_ISR_Handler()`, which maps each specific device interrupt to its corresponding network interface ISR handler, `NetIF_ISR_Handler()`. For some CPUs this may be a first- or second-level interrupt handler. Generally, the application must configure the interrupt controller to call every network device's unique `NetDev_ISR_Handler()` when the device's interrupt occurs (see section A-3-3 on page 340). Every unique `NetDev_ISR_Handler()` *must* then perform the following actions:

1 Call NetIF_ISR_Handler() with the device's unique network interface number and appropriate interrupt type. The device's network interface number should be available after configuration in the device's NetDev_CfgIntCtrl() function (see section A-3-3 "NetDev_CfgIntCtrl()" on page 340). NetIF_ISR_Handler() in turn calls the appropriate device driver's interrupt handler.

   In most cases, each device requires only a single NetDev_ISR_Handler() which calls NetIF_ISR_Handler() with interrupt type code NET_DEV_ISR_TYPE_UNKNOWN. This is possible when the device's driver can determine the device's interrupt type to via internal device registers or the interrupt controller. However, some devices cannot generically determine the interrupt type when an interrupt occurs and may therefore require multiple, unique NetDev_ISR_Handler()'s each of which calls NetIF_ISR_Handler() with the appropriate interrupt type code.

   Ethernet Physical layer (Phy) interrupts should call NetIF_ISR_Handler() with interrupt type code NET_DEV_ISR_TYPE_PHY.

   See also section C-9-12 "NetIF_ISR_Handler()" on page 519.

2 Clear the device's interrupt source, possibly via an external or CPU-integrated interrupt controller source.

Since each network device requires a unique NetDev_ISR_Handler() for each device interrupt, it is recommended that each device's NetDev_ISR_Handler() function be named using the following convention:

NetDev_[Device]ISR_Handler[Type][Number]()

[Device] Network device name or type, e.g., MACB (optional if the development board does not support multiple devices)

[Type] Network device interrupt type, e.g., receive interrupt (optional if interrupt type is generic or unknown)

[Number] Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the receive ISR handler for the #2 MACB Ethernet controller on an Atmel AT91SAM9263-EK should be named `NetDev_MACB_ISR_HandlerRx2()`.

See also Chapter 6, “Network Board Support Package” on page 121.

## EXAMPLES

```
static void NetDev_MACB_ISR_Handler_2 (void)
{
    NET_ERR  err;

    NetIF_ISR_Handler(AT91SAM9263-EK_MACB_2_IF_Nbr, NET_DEV_ISR_TYPE_UNKNOWN, &err);
    /* Clear external or CPU’s integrated interrupt controller. */
}


static void NetDev_MACB_ISR_HandlerRx_2 (void)
{
    NET_ERR  err;

    NetIF_ISR_Handler(AT91SAM9263-EK_MACB_2_IF_Nbr, NET_DEV_ISR_TYPE_RX, &err);
    /* Clear external or CPU’s integrated interrupt controller. */
}
```

Appendix

# B

# µC/TCP-IP Wireless Device Driver APIs

This appendix provides a reference to the µC/TCP-IP Device Driver API. Each user-accessible service is presented in alphabetical order. The following information is provided for each of the services:

- A brief description
- The function prototype
- The filename of the source code
- A description of the arguments passed to the function
- A description of the returned value(s)
- Specific notes and warnings on the use of the service

## B-1 DEVICE DRIVER FUNCTIONS FOR WIRELESS MODULE

### B-1-1 NetDev_Init()

The first function within the wireless API is the device driver initialization/`Init()` function. This function is called by `NetIF_Add()` exactly once for each specific network device added by the application. If multiple instances of the same network device are present on the development board, then this function is called for each instance of the device. However, applications should not try to add the same specific device more than once. If a network device fails to initialize, we recommend debugging to find and correct the cause of failure.

Note: This function relies heavily on the implementation of several network device board support package (BSP) functions. See Chapter 6, "Network Board Support Package" on page 121 and Appendix B, "Device Driver BSP Functions" on page 387 for more information on network device BSP functions.

#### FILES

Every device driver's `net_dev.c`

#### PROTOTYPE

```
static void NetDev_Init (NET_IF  *p_if,
                         NET_ERR *p_err);
```

Note that since every device driver's `Init()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

#### ARGUMENTS

`p_if` Pointer to the interface to initialize a network device.

`p_err` Pointer to variable that will receive the return error code from this function.

#### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The `Init()` function generally performs the following operations, however, depending on the device being initialized, functionality may need to be added or removed:

1 Validate all wireless configuration values.

2 Configure all necessary I/O pins for the wireless device such as power enable or reset pin. This is generally performed via the network device's BSP function pointer, `CfgGPIO()`, implemented in `net_bsp.c` (see section A-3-2 on page 338).

3 Initialize SPI controller for writing and reading from the wireless module.

4 Configure the host interrupt controller for receive and transmit complete interrupts. Additional interrupt services may be initialized depending on the device and driver requirements. This is generally performed via the network device's BSP function pointer, `CfgIntCtrl()`, implemented in `net_bsp.c` (see section B-3-4 on page 393).

5 Allocate memory for all necessary driver buffers that will be reuse only by the driver such as a read buffer to validate the command sent. This is performed via calls to µC/LIB's memory module.

6 Disable the transmitted and receiver (should already be disabled).

7 Set `p_err` to `NET_DEV_ERR_NONE` if initialization proceeded as expected. Otherwise, set `p_err` to an appropriate network device error code.

## B-1-2 NetDev_Start()

The second function is the device driver `Start()` function. This function is called once each time an interface is started.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_Start (NET_IF  *p_if,
                          NET_ERR *p_err);
```

Note that since every device driver's `Start()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to start a network device.

`p_err` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The `Start()` function performs the following items:

1 Configure the transmit ready semaphore count via a call to `NetOS_Dev_CfgTxRdySignal()`. This function call is optional and is generally performed when the hardware device supports the queuing of multiple transmit frames. By default, the count is initialized to one.

2 Send command to start and initialize wireless device. If a specific firmware must be loaded on the device, the firmware should be validated and updated if necessary.

3 Initialize the device MAC address if applicable. For Ethernet devices, this step is mandatory. The MAC address data may come from one of three sources and should be set using the following priority scheme:

a. Configure the MAC address using the string found within the device configuration structure. This is a form of static MAC address configuration and may be performed by calling `NetASCII_Str_to_MAC()` and `NetIF_AddrHW_SetHandler()`. If the device configuration string has been left empty, or is specified as all 0's, an error will be returned and the next method should be attempted.

b. Check if the application developer has called `NetIF_AddrHW_Set()` by making a call to `NetIF_AddrHW_GetHandler()` and `NetIF_AddrHW_IsValidHandler()` in order to check if the specified MAC address is valid. This method may be used as a static method for configuring the MAC address during run-time, or a dynamic method should a pre-programmed external memory device exist. If the acquired MAC address does not pass the check function, then:

c. Call `NetIF_AddrHW_SetHandler()` using the data found within the MAC individual address registers. If an auto-loading EEPROM is attached to the MAC, the registers will contain valid data. If not, then a configuration error has occurred. This method is often used with a production process where the MAC supports the automatic loading of individual address registers from a serial EEPROM. When using this method, the developer should specify an empty string for the MAC address within the device configuration and refrain from calling `NetIF_AddrHW_Set()` from within the application.

4 Initialize additional MAC registers required by the MAC for proper operation.

5 Clear all interrupt flags.

6 Locally enable interrupts on the hardware device. The host interrupt controller should have already been configured within the device driver `Init()` function.

7 Enable the receiver and transmitter.

8 Set `p_err` equal to `NET_DEV_ERR_NONE` if no errors have occurred. Otherwise, set `p_err` to an appropriate network device error code.

## B-1-3 NetDev_Stop()

The next function within the device API structure is the device `Stop()` function. This function is called once each time an interface is stopped.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_Stop (NET_IF  *p_if,
                         NET_ERR *p_err);
```

Note that since every device driver's `Stop()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to start a network device.

`p_err` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The `Stop()` function must perform the following operations:

1 Disable the receiver and transmitter.

2 Disable all local MAC interrupt sources.

3 Clear all local MAC interrupt status flags.

4 Power down the wireless device.

5 Set `p_err` to `NET_DEV_ERR_NONE` if no error occurs. Otherwise, set `p_err` to an appropriate network device error code.

## B-1-4 NetDev_Rx()

The receive/Rx() function is called by µC/TCP-IP's Receive task after the Interrupt Service Routine handler has signaled to the Receive task that a receive event has occurred. The Receive function requires that the device driver return a pointer to the data area containing the received data and return the size of the received frame via pointer.

### FILES

Every device driver's net_dev.c

### PROTOTYPE

```
static void NetDev_Rx (NET_IF      *p_if,
                       CPU_INT08U **p_data,
                       CPU_INT16U  *p_size,
                       NET_ERR     *p_err);
```

Note that since every device driver's Rx() function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to the interface to receive data from a network device.

p_data Pointer to return the address of the received data.

p_size Pointer to return the size of the received data.

p_err Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The receive function should perform the following actions:

1 For SPI wireless device, get the access to the SPI bus by performing the following operation:

   a. Acquire the SPI lock by calling `p_dev_bsp->SPI_Lock().`

   b. Enable the chip select by calling `p_dev_bsp->SPI_ChipSelEn()`.

   c. Configure the SPI controller for the wireless device by calling `p_dev_bsp->SPI_SetCfg()`.

2 Check for receive errors if applicable. If an error should occur during reception, the driver should set `*size` to 0 and `*p_data` to `(CPU_INT08U *)0` and return. Additional steps may be necessary depending on the device being serviced.

3 For wireless devices, get the size of the received frame and subtract 4 bytes for the CRC. It is always recommended that the frame size is checked to ensure that it is greater than 4 bytes before performing the subtraction to ensure that an underflow does not occur. Set `*size` equal to the adjusted frame size.

4 Get a new data buffer area by calling `NetBuf_GetDataPtr()`. If memory is not available, an error will be returned and the device driver should set `*size` to 0 and `*p_data` to `(CPU_INT08U *)0`.

5 If an error does not occur while getting a new data area, the function should perform the following operations:

   a. Set the frame type of the data received (`NET_IF_WIFI_MGMT_FRAME` or `NET_IF_WIFI_DATA_PKT`) at the beginning of the network buffer.

   b. The data stored within the device should be transferred to the address of the data section (after the frame type) of the network buffer by calling `p_dev_bsp->SPI_WrRd()` and by using a global buffer to write data and set `*p_data` equal to the address of the obtained data area.

6 Sidable the device chip select by calling `p_dev_bsp->SPI_ChipSelDis()` and unlock the SPI bus access by calling `p_dev_bsp->SPI_Unlock()`.

7 Set `p_err` to `NET_DEV_ERR_NONE` and return from the receive function. Otherwise, set `p_err` to an appropriate network device error code.

## B-1-5 NetDev_Tx()

The next function in the device API structure is the transmit/`Tx()` function.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_Tx (NET_IF     *p_if,
                       CPU_INT08U *p_data,
                       CPU_INT16U  size,
                       NET_ERR    *p_err);
```

Note that since every device driver's `Tx()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to start a network device.

`p_data` Pointer to address of the data to transmit.

`size` Size of the data to transmit.

`p_err` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The transmit function should perform the following actions:

1 For SPI wireless device, get the access to the SPI bus by performing the following operation:

   a. Acquire the SPI lock by calling `p_dev_bsp->SPI_Lock().`

   b. Enable the chip select by calling `p_dev_bsp->SPI_ChipSelEn()`.

   c. Configure the SPI controller for the wireless device by calling `p_dev_bsp->SPI_SetCfg()`.

2 Write data to the device by calling `p_dev_bsp->SPI_WrRd()` and by using the network buffer passed as argument and by using a global buffer to read data.

3 The driver should then take all necessary steps to initiate transmission of the data.

4 Set `perr` to `NET_DEV_ERR_NONE` and return from the transmit function.

## B-1-6 NetDev_AddrMulticastAdd()

The next API function is the `AddrMulticastAdd()` function used to configure a device with an (IP-to-Ethernet) multicast hardware address.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_AddrMulticastAdd (NET_IF     *p_if,
                                     CPU_INT08U *p_addr_hw,
                                     CPU_INT08U  addr_hw_len,
                                     NET_ERR    *p_err);
```

Note that since every device driver's `AddrMulticastAdd()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to add/configure a multicast address.

`p_addr_hw` Pointer to multicast hardware address to add.

`addr_hw_len` Length of multicast hardware address.

`p_err` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Necessary only if `NET_IP_CFG_MULTICAST_SEL` is configured for transmit and receive multicasting (see section D-9-2 on page 752).

## NOTES / WARNINGS

Since many network controllers' documentation fail to properly indicate how to add/configure an MAC device with a multicast address, the following methodology is recommended for determining and testing the correct multicast hash bit algorithm.

1 Configure a packet capture program or multicast application to broadcast a multicast packet with destination address of 01:00:5E:00:00:01. This MAC address corresponds to the multicast group IP address of 224.0.0.1 which will be converted to a MAC address by higher layers and passed to this function.

2 Set a break point in the receive ISR handler and transmit one send packet to the target. The break point should *not* be reached as the result of the transmitted packet. Use caution to ensure that other network traffic is not the source of the interrupt when the button is pressed. Sometimes asynchronous network events happen very close in time and the end result can be deceiving. Ideally, these tests should be performed on an isolated network but disconnect as many other hosts from the network as possible.

3 Use the debugger to stop the application and program the MAC multicast hash register low bits to 0xFFFFFFFF. Go to step 2. Repeat for the hash bit high register if necessary. The goal is to bracket off which bit in either the high or low hash bit register causes the device to be interrupted when the broadcast frame is received by the target. Once the correct bit is known, the hash algorithm can be easily written and tested.

4 The following hash bit algorithm code below could be adjusted per the network controller's documentation in order to get the hash from the correct subset of CRC bits. Most of the code is similar between various devices and is thus reusable. The hash algorithm is the exlusive **OR** of every 6th bit of the destination address:

```
hash[5] = da[5] ^ da[11] ^ da[17] ^ da[23] ^ da[29] ^ da[35] ^ da[41] ^ da[47]
hash[4] = da[4] ^ da[10] ^ da[16] ^ da[22] ^ da[28] ^ da[34] ^ da[40] ^ da[46]
hash[3] = da[3] ^ da[09] ^ da[15] ^ da[21] ^ da[27] ^ da[33] ^ da[39] ^ da[45]
hash[2] = da[2] ^ da[08] ^ da[14] ^ da[20] ^ da[26] ^ da[32] ^ da[38] ^ da[44]
hash[1] = da[1] ^ da[07] ^ da[13] ^ da[19] ^ da[25] ^ da[31] ^ da[37] ^ da[43]
hash[0] = da[0] ^ da[06] ^ da[12] ^ da[18] ^ da[24] ^ da[30] ^ da[36] ^ da[42]
```

Where `da0` represents the least significant bit of the first byte of the destination address received and where `da47` represents the most significant bit of the last byte of the destination address received.

```
                                                /* ---------- CALCULATE HASH CODE ---------- */
hash = 0;
for (i = 0; i < 6; i++) {                       /* For each row in the bit hash table:       */
    bit_val = 0;                                /* Clear initial xor value for each row.     */
    for (j = 0; j < 8; j++) {                   /* For each bit in each octet:               */
        bit_nbr    = (j * 6) + i;               /* Determine which bit in stream, 0-47.      */
        octet_nbr  =  bit_nbr / 8;              /* Determine which octet bit belongs to.     */
        octet      =  paddr_hw[octet_nbr];      /* Get octet value.                          */
        bit        =  octet & (1 << (bit_nbr % 8));  /* Check if octet's bit is set.        */
        bit_val   ^= (bit > 0) ? 1 : 0;         /* Calculate table row's XOR hash value.     */
    }
     hash |= (bit_val << i);                    /* Add row's XOR hash value to final hash.   */
}
                                                /* ---- ADD MULTICAST ADDRESS TO DEVICE ---- */
reg_sel = (hash >> 5) & 0x01;                   /* Determine hash register     to configure. */
reg_bit = (hash >> 0) & 0x1F;                   /* Determine hash register bit to configure. */
                                                /* (Substitute '0x01'/'0x1F' with device's ..*/
                                                /* .. actual hash register bit masks/shifts.)*/

  paddr_hash_ctrs = &pdev_data->MulticastAddrHashBitCtr[hash];
(*paddr_hash_ctrs)++;                           /* Increment hash bit reference counter.     */

if (reg_sel == 0) {                             /* Set multicast hash register bit.          */
    pdev->MCAST_REG_LO |= (1 << reg_bit);       /* (Substitute 'MCAST_REG_LO/HI' with ..     */
} else {                                        /* .. device's actual multicast registers.)  */
    pdev->MCAST_REG_HI |= (1 << reg_bit);
}
                                                /* ---------- CALCULATE HASH CODE ---------- */
                                                /* Calculate CRC.                            */
crc = NetUtil_32BitCRC_Calc((CPU_INT08U *)paddr_hw,
                            (CPU_INT32U  ) addr_hw_len,
                            (NET_ERR    *)perr);
```

Listing B-1 **Example device multicast address configuration using CRC hash code algorithm**

Alternatively, you may be able to compute the CRC hash with a call to `NetUtil_32BitCRC_CalcCpl()` followed by an optional call to `NetUtil_32BitReflect()`, with four possible combinations:

a. CRC without complement and without reflection

b. CRC without complement and with reflection

c. CRC with complement and without reflection

d. CRC with complement and with reflection

```
if (*perr != NET_UTIL_ERR_NONE) {
     return;
}
                                                /* ---- ADD MULTICAST ADDRESS TO DEVICE ---- */
crc     =  NetUtil_32BitReflect(crc);           /* Optionally, complement CRC.              */
hash    = (crc >> 23u) & 0x3F;                  /* Determine hash register     to configure. */
reg_bit = (hash % 32u);                         /* Determine hash register bit to configure. */
                                                /* (Substitute '23u'/'0x3F' with device's .. */
                                                /* .. actual hash register bit masks/shifts.)*/

  paddr_hash_ctrs = &pdev_data->MulticastAddrHashBitCtr[hash];
(*paddr_hash_ctrs)++;                           /* Increment hash bit reference counter.     */

if (hash <= 31u) {                              /* Set multicast hash register bit.          */
    pdev->MCAST_REG_LO |= (1 << reg_bit);       /* (Substitute 'MCAST_REG_LO/HI' with ..     */
} else {                                        /* .. device's actual multicast registers.)  */
    pdev->MCAST_REG_HI |= (1 << reg_bit);
}
```

Listing B-2 **Example device multicast address configuration using CRC and reflection functions**

Unfortunately, the product documentation will *not* likely tell you which combination of complement and reflection is necessary in order to properly compute the hash value. Most likely, the documentation will simply state 'Standard Ethernet CRC' which when compared to other documents, means any of the four combinations above; different than the actual frame CRC.

Fortunately, if the code is written to perform both the complement and reflection, then the debugger may be used to repeat the code block over and over skipping either the line that performs the complement or the function call to the reflection until the output hash bit is computed correctly.

5 Update the device driver's `AddrMulticastAdd()` function to calculate and configure the correct CRC.

6 Test the device driver's `AddrMulticastAdd()` function by ensuring that the group address 224.0.0.1, when joined from the application (see section C-11-1 on page 539), correctly configures the device to receive multicast packets destined to the 224.0.0.1 address. Then broadcast the 224.0.0.1 (see step 1) to test if the device receives the multicast packet.

## B-1-7 NetDev_AddrMulticastRemove()

The next API function is the `AddrMulticastRemove()` function used to remove an (IP-to-Ethernet) multicast hardware address from a device.

### FILES

Every device driver's `net_dev.c`

### PROTOTYPE

```
static void NetDev_AddrMulticastRemove (NET_IF     *p_if,
                                        CPU_INT08U *p_addr_hw,
                                        CPU_INT08U  addr_hw_len,
                                        NET_ERR    *p_err);
```

Note that since every device driver's `AddrMulticastRemove()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

| | |
|---|---|
| `p_if` | Pointer to the interface to remove a multicast address. |
| `p_addr_hw` | Pointer to multicast hardware address to remove. |
| `addr_hw_len` | Length of multicast hardware address. |
| `p_err` | Pointer to variable that will receive the return error code from this function. |

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Necessary only if `NET_IP_CFG_MULTICAST_SEL` is configured for transmit and receive multicasting (see section D-9-2 on page 752).

### NOTES / WARNINGS

Use same exact code as in `NetDev_AddrMulticastAdd()` to calculate the device's CRC hash (see section B-1-6 on page 362), but remove a multicast address by decrementing the device's hash bit reference counters and clearing the appropriate bits in the device's multicast registers.

```
                                                /* ---------- CALCULATE HASH CODE ---------- */
/* Use NetDev_AddrMulticastAdd()'s algorithm to calculate CRC hash.                          */
                                                /* - REMOVE MULTICAST ADDRESS FROM DEVICE -- */
paddr_hash_ctrs = &pdev_data->MulticastAddrHashBitCtr[hash];
if (*paddr_hash_ctrs > 1u) {                    /* If multiple multicast addresses hashed, ..*/
   (*paddr_hash_ctrs)--;                        /* .. decrement hash bit reference counter ..*/
    *perr = NET_DEV_ERR_NONE;                   /* .. but do NOT unconfigure hash register.  */
     return;
}
*paddr_hash_ctrs = 0u;                          /* Clear hash bit reference counter.         */

if (hash <= 31u) {                              /* Clear multicast hash register bit.        */
    pdev->MCAST_REG_LO &= ~(1u << reg_bit);     /* (Substitute 'MCAST_REG_LO/HI' with ..     */
} else {                                        /* .. device's actual multicast registers.)  */
    pdev->MCAST_REG_HI &= ~(1u << reg_bit);
}
```

Listing B-3 **Example device multicast address removal**

## B-1-8 NetDev_ISR_Handler()

A device's ISR_Handler() function is used to handle each device's interrupts. See section 7-5-5 "NetDev_ISR_Handler()" on page 164 for more details on how to handle each device's interrupts.

### FILES

Every device driver's net_dev.c

### PROTOTYPE

```
static void NetDev_ISR_Handler (NET_IF           *pif,
                                NET_DEV_ISR_TYPE  type);
```

Note that since every device driver's ISR_Handler() function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

pif Pointer to the interface to handle network device interrupts.

type Device's interrupt type:

NET_DEV_ISR_TYPE_UNKNOWN
NET_DEV_ISR_TYPE_RX
NET_DEV_ISR_TYPE_RX_RUNT
NET_DEV_ISR_TYPE_RX_OVERRUN
NET_DEV_ISR_TYPE_TX_RDY
NET_DEV_ISR_TYPE_TX_COMPLETE
NET_DEV_ISR_TYPE_TX_COLLISION_LATE
NET_DEV_ISR_TYPE_TX_COLLISION_EXCESS
NET_DEV_ISR_TYPE_JABBER
NET_DEV_ISR_TYPE_BABBLE
NET_DEV_ISR_TYPE_PHY

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Each device's `NetDev_ISR_Handler()` should never return early but check all applicable interrupt sources to see if they are active. This additional checking is necessary because multiple interrupt sources may be set within the interrupt response time and will reduce the number and overhead of handling interrupts.

## B-1-9 NetDev_MgmtDemux()

A device's management demultiplex function is used to demultiplex a management frame to signal the Wireless Manager the response or to implement miscellaneous functionality such as updating the link state when the wireless network is out of the range and the connection is lost.

### FILES

Every wireless device driver's `net_dev.c`

### PROTOTYPE

```
static  void  NetDev_MgmtDemux (NET_IF  *p_if,
                                NET_BUF *p_buf,
                                NET_ERR *p_err);
```

Note that since every device driver's `MgmtDemux()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to handle network device I/O operations.

`p_buf` Pointer to the network buffer that contains the management frame.

`p_err` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

When a management command has been sent and the Wireless Manager is waiting for the response, the Wireless Manager *must* be signaled by calling `p_mgr_api->Signal()`.

The network buffer *must* be freed by the function if the Wireless Manager is not signaled and no error are returned by calling `NetBuf_Free()`.

## B-1-10 NetDev_MgmtExecuteCmd()

A device's execute management command function is used to implement miscellaneous wireless management functionality such as scanning for available wireless network.

### FILES

Every wireless device driver's `net_dev.c`

### PROTOTYPE

```
static  CPU_INT32U  NetDev_MgmtExecuteCmd   (NET_IF           *p_if,
                                             NET_IF_WIFI_CMD   cmd,
                                             NET_WIFI_MGR_CTX *p_ctx,
                                             void             *p_cmd_data,
                                             CPU_INT16U        cmd_data_len,
                                             CPU_INT08U       *p_buf_rtn,
                                             CPU_INT08U        buf_rtn_len_max,
                                             NET_ERR          *p_err);
```

Note that since every device driver's `MgmtDemux()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to handle network device I/O operations.

`cmd` Management command to execute:

`NET_IF_WIFI_CMD_SCAN`
`NET_IF_WIFI_CMD_JOIN`
`NET_IF_WIFI_CMD_LEAVE`
`NET_IF_IO_CTRL_LINK_STATE_GET`
`NET_IF_IO_CTRL_LINK_STATE_GET_INFO`
`NET_IF_IO_CTRL_LINK_STATE_UPDATE`
Others management commands defined by the driver.

| | |
|---|---|
| p_ctx | Pointer to the Wireless Manager context. |
| p_cmd_data | Pointer to a buffer that contains data to be used by the driver to execute the command. |
| cmd_data_len | Command data length. |
| p_buf_rtn | Pointer to buffer that will receive return data. |
| buf_rtn_len_max | Return maximum data length. |
| p_err | Pointer to variable that will receive the return error code from this function. |

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The state machine context is used by the Wireless Manager to know what it MUST do after the call such as waiting for a management response.

## B-1-11 NetDev_MgmtProcessResp()

A device's process management response function is used to analyse the response, set the state machine context of the Wireless Manager and fill the return buffer.

### FILES

Every wireless device driver's `net_dev.c`

### PROTOTYPE

```
static  CPU_INT32U  NetDev_MgmtProcessResp  (NET_IF           *p_if,
                                             NET_IF_WIFI_CMD   cmd,
                                             NET_WIFI_MGR_CTX *p_ctx,
                                             CPU_INT08U       *p_buf_rxd,
                                             CPU_INT16U        buf_rxd_len,
                                             CPU_INT08U       *p_buf_rtn,
                                             CPU_INT16U        buf_rtn_len_max,
                                             NET_ERR          *p_err);
```

Note that since every device driver's `MgmtDemux()` function is accessed only by function pointer via the device driver's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to handle network device I/O operations.

`cmd` Management command to execute:

`NET_IF_WIFI_CMD_SCAN`
`NET_IF_WIFI_CMD_JOIN`
`NET_IF_WIFI_CMD_LEAVE`
`NET_IF_IO_CTRL_LINK_STATE_GET`
`NET_IF_IO_CTRL_LINK_STATE_GET_INFO`
`NET_IF_IO_CTRL_LINK_STATE_UPDATE`

Others management commands defined by the driver.

| | |
|---|---|
| p_ctx | Pointer to the Wireless Manager context. |
| p_buf_rxd | Pointer to a network buffer that contains the command response |
| cmd_data_len | Length of the data response. |
| p_buf_rtn | Pointer to buffer that will receive return data. |
| buf_rtn_len_max | Return maximum data length. |
| p_err | Pointer to variable that will receive the return error code from this function. |

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## B-2 WIRELESS MANAGER API

### B-2-1 NetWiFiMgr_Init()

The first function within the Wireless Manager API is the manager initialization/`Init()` function which is called by the wireless network interface layer.

#### FILES

Every Wireless Manager layer `net_wifi_mgr.c`

#### PROTOTYPE

```
static void NetWiFiMgr_Init (NET_IF  *p_if,
                             NET_ERR *p_err)
```

Note that since every Wireless Manager's `Init()` function is accessed only by function pointer via the Wireless Manager's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

#### ARGUMENTS

`pif` Pointer to the interface to initialize a Wireless Manager.

`perr` Pointer to variable that will receive the return error code from this function.

#### RETURNED VALUE

None.

#### REQUIRED CONFIGURATION

None.

#### NOTES/WARNINGS

None.

## B-2-2 NetWiFiMgr_Start()

The next Wireless Manager function is the `Start()` function. This function is called by the wireless network interface layer when an interface is started.

### FILES

Every Wireless Manager layer `net_wifi_mgr.c`

### PROTOTYPE

```
static void NetWiFiMgr_Start (NET_IF  *p_if,
                              NET_ERR *p_err);
```

Note that since every Wireless Manager's `Start()` function is accessed only by function pointer via the Wireless Manager's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to start the Wireless Manager.

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

None.

## B-2-3 NetWiFiMgr_Stop()

The Wireless Manager function `Stop()` function is called by the wireless network interface layer when an interface is stopped.

### FILES

Every Wireless Manager layer `net_wifi_mgr.c`

### PROTOTYPE

```
static void NetWiFiMgr_Stop (NET_IF  *p_if,
                             NET_ERR *p_err);
```

Note that since every Wireless Manager's `Stop()` function is accessed only by function pointer via the Wireless Manager's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to stop the Wireless Manager.

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

None.

## B-2-4 NetWiFiMgr_AP_Scan()

The Wireless Manager's AP_Scan() function start the scan process. Results are passed back to the caller in a table of NET_IF_WIFI_AP structure which contains fields for link network SSID, channel, network type, Security type and signal strength.

### FILES

Every Wireless Manager layer net_wifi_mgr.c

### PROTOTYPE

```
static void NetWiFiMgr_AP_Scan       (NET_IF           *p_if,
                                      NET_IF_WIFI_AP   *p_buf_scan,
                                      CPU_INT16U        scna_len_max,
                                const NET_IF_WIFI_SSID *p_ssid,
                                      NET_IF_WIFI_CH    ch,
                                      NET_ERR          *perr);
```

Note that since every Wireless Manager's AP_Scan() function is accessed only by function pointer via the Wireless Manager's API structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to the interface to scan with.

p_buf_scan Pointer to table that will receive the return network found.

scan_len_max Length of the scan buffer (i.e., number of network that can be found).

p_ssid Pointer to variable that contains the SSID to find.

ch The wireless channel to scan:

NET_IF_WIFI_CH_ALL
NET_IF_WIFI_CH_1
NET_IF_WIFI_CH_2
NET_IF_WIFI_CH_3
NET_IF_WIFI_CH_4

NET_IF_WIFI_CH_5
NET_IF_WIFI_CH_6
NET_IF_WIFI_CH_7
NET_IF_WIFI_CH_8
NET_IF_WIFI_CH_9
NET_IF_WIFI_CH_10
NET_IF_WIFI_CH_11
NET_IF_WIFI_CH_12
NET_IF_WIFI_CH_13
NET_IF_WIFI_CH_14

`perr` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUES

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

None.

## B-2-5 NetWiFiMgr_AP_Join()

The Wireless Manager's AP_Join() function completes the join process.

### FILES

Every Wireless Manager layer net_wifi_mgr.c

### PROTOTYPE

```
static void NetWiFiMgr_AP_Join       (NET_IF              *p_if,
                                const  NET_IF_WIFI_AP_JOIN *p_join,
                                       NET_ERR             *p_err);
```

Note that since every Wireless Manager's AP_Join() function is accessed only by function pointer via the Wireless Manager's API structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to the interface to join with.

p_join Pointer to variable that contains the wireless network to join.

p_err Pointer to variable that will receive the return error code from this function.

### RETURNED VALUES

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

None.

## B-2-6 NetWiFiMgr_AP_Leave()

The Wireless Manager's `AP_Leave()` function completes the disconnect.

### FILES

Every Wireless Manager layer `net_wifi_mgr.c`

### PROTOTYPE

```
static void NetWiFiMgr_AP_Leave (NET_IF  *p_if,
                                 NET_ERR *p_err);
```

Note that since every Wireless Manager's `AP_Leace()` function is accessed only by function pointer via the Wireless Manager's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to join with.

`p_join` Pointer to variable that contains the wireless network to join.

`p_err` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUES

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

None.

## B-2-7 NetWiFiMgr_IO_Ctrl()

A device's input/output control/IO_Ctrl() function is used to implement miscellaneous functionality such as setting and getting the link state. An optional void pointer to a data variable is passed into the function and may be used to get device parameters from the caller, or to return device parameters to the caller.

### FILES

Every Wireless Manager layer `net_wifi_mgr.c`

### PROTOTYPE

```
static void NetWiFiMgr_IO_Ctrl (NET_IF     *p_if,
                                CPU_INT08U  opt,
                                void       *p_data,
                                NET_ERR    *p_err);
```

Note that since every Wireless Manager's `IO_Ctrl()` function is accessed only by function pointer via the Wireless Manager's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to handle network device I/O operations.

`opt` I/O operation to perform.

`p_data` A pointer to a variable containing the data necessary to perform the operation or a pointer to a variable to store data associated with the result of the operation.

`p_err` Pointer to variable that will receive the return error code from this function.

### RETURNED VALUES

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

µC/TCP-IP defines the following default options:

- `NET_DEV_LINK_STATE_GET_INFO`
- `NET_DEV_LINK_STATE_UPDATE`

The `NET_DEV_LINK_STATE_GET_INFO` option expects `p_data` to point to a variable of type `NET_DEV_LINK_WIFI` for the case of an Ethernet driver. This variable has one field, link state, which are filled in by the device driver API. µC/TCP-IP internally uses this option code in order to periodically poll the driver for linkstate.

## B-2-8 NetWiFiMgr_Mgmt()

A wireless management/Mgmt() function is used to implement miscellaneous functionality needed by the driver such as command that need response.

### FILES

Every Wireless Manager layer `net_wifi_mgr.c`

### PROTOTYPE

```
static void NetWiFiMgr_Mgmt (NET_IF           p_if,
                             NET_IF_WIFI_CMD  cmd,
                             CPU_INT08U      *p_buf_cmd,
                             CPU_INT16U       buf_cmd_len,
                             CPU_INT08U      *p_buf_rtn,
                             CPU_INT16U       buf_rtn_len_max,
                             NET_ERR         *p_err);
```

Note that since every Wireless Manager's `Mgmt()` function is accessed only by function pointer via the Wireless Manager's API structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to the interface to wireless device to manage.

`cmd` Management command to send.

The driver can define and implement its own management commands which need a response by calling the Wireless Manager api (p_mgr_api->Mgmt()) to send the management command and to receive the response.

Driver management command code '100' series reserved for driver.

`p_buf_cmd` Pointer to variable that contains the data to send.

`buf_cmd_len` Length of the command buffer.

| | |
|---|---|
| p_buf_rtn | Pointer to variable that will receive the return data. |
| buf_rtn_len_max | Length of the return buffer. |
| p_err | Pointer to variable that will receive the return error code from this function. |

### RETURNED VALUES

None.

### REQUIRED CONFIGURATION

None.

### NOTES/WARNINGS

Prior calling this function, the network lock must be acquired.

## B-3 DEVICE DRIVER BSP FUNCTIONS

### B-3-1 NetDev_WiFi_Start()

This function is called by a device driver's `NetDev_Start()` to start and power up the wireless hardware.

#### FILES

`net_bsp.c`

#### PROTOTYPE

```
static void NetDev_WiFi_Start (NET_IF  *p_if,
                               NET_ERR *p_err);
```

Note: since `NetDev_WiFi_Start()` is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

#### ARGUMENTS

`p_if` Pointer to specific interface to start device's hardware.

`p_err` Pointer to variable that will receive the return error code from this function:

`NET_DEV_ERR_NONE`
`NET_DEV_ERR_FAULT`

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

#### RETURNED VALUE

None.

#### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Since each network device requires a unique `NetDev_WiFi_Start()`, it is recommended that each device's `NetDev_WiFi_Start()` function be named using the following convention:

`NetDev_WiFi_[Device]_Start[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_Start()` function for the #2 RS9110 wireless devie should be named `NetDev_WiFi_RS9110_Start2()`, or `NetDev_WiFI_RS9110_Start_2()` with additional underscore optional.

## B-3-2 NetDev_WiFi_Stop()

This function is called by a device driver's NetDev_Stop() to stop &/or power down the wireless hardware.

### FILES

net_bsp.c

### PROTOTYPE

```
static void NetDev_WiFi_Stop (NET_IF  *p_if,
                              NET_ERR *p_err);
```

Note: since NetDev_WiFi_Stop() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to specific interface to stop device's hardware.

p_err Pointer to variable that will receive the return error code from this function:

NET_DEV_ERR_NONE
NET_DEV_ERR_FAULT

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Since each network device requires a unique `NetDev_WiFi_Stop()`, it is recommended that each device's `NetDev_WiFi_Stop()` function be named using the following convention:

`NetDev_WiFi_[Device]_Stop[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_Stop()` function for the #2 RS9110 wireless devie should be named `NetDev_WiFi_RS9110_Stop2()`, or `NetDev_WiFI_RS9110_Stop_2()` with additional underscore optional.

## B-3-3 NetDev_WiFi_CfgGPIO()

This function is called by a device driver's NetDev_Init() to configure a specific network device's general-purpose input/ouput (GPIO) on a specific interface such as SPI, external interrupt, power & reset pins.

### FILES

net_bsp.c

### PROTOTYPE

```
static void NetDev_WiFi_CfgGPIO (NET_IF  *p_if,
                                 NET_ERR *p_err);
```

Note that since NetDev_WiFi_CfgGPIO() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to specific interface to configure device's GPIO.

p_err Pointer to variable that will receive the return error code from this function:

NET_DEV_ERR_NONE
NET_DEV_ERR_FAULT

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Since each network device requires a unique `NetDev_WiFi_CfgGPIO()`, it is recommended that each device's `NetDev_WiFi_CfgGPIO()` function be named using the following convention:

`NetDev_WiFi_[Device]_CfgGPIO[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_CfgGPIO()` function for the #2 RS9110 wireless device should be named `NetDev_WiFi_RS9110_CfgGPIO2()`, or `NetDev_WiFI_RS9110_CfgGPIO_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## B-3-4 NetDev_WiFi_CfgIntCtrl()

This function is called by a device driver's NetDev_Init() to configure a specific network device's interrupts and/or interrupt controller on a specific interface.

### FILES

net_bsp.c

### PROTOTYPE

```
static void NetDev_CfgIntCtrl (NET_IF  *pif,
                               NET_ERR *perr);
```

Note that since NetDev_WiFi_CfgIntCtrl() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to specific interface to configure device's interrupts.

p_err Pointer to variable that will receive the return error code from this function:

NET_DEV_ERR_NONE
NET_DEV_ERR_FAULT

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Each network device's `NetDev_WiFi_CfgIntCtrl()` should configure and enable all required interrupt sources for the network device. This usually means configuring the interrupt vector address of each corresponding network device BSP interrupt service routine (ISR) handler and enabling its corresponding interrupt source. Thus, for most `NetDev_WiFi_CfgIntCtrl()`, the following actions *should* be performed:

1 Configure/store each device's network interface number to be available for all necessary `NetDev_WiFi_ISR_Handler()` functions (see section B-3-13 on page 414). Even though devices are added dynamically, the device's interface number must be saved in order for each device's ISR handlers to call `NetIF_ISR_Handler()` with the device's network interface number.

   Since each network device maps to a unique network interface number, it is recommended that each instance of network devices' interface numbers be named using the following convention:

   `<Board><Device>[Number]_IF_Nbr`

   `<Board>` Development board name

   `<Device>` Network device name (or type)

   `[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

   For example, the network device interface number variable for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named `AT91SAM9263-EK_RS9110_2_IF_Nbr`.

   Network device interface number variables *should* be initialized to `NET_IF_NBR_NONE` at system initialization prior to being configured by their respective devices.

2 Configure each of the device's interrupts on either an external or CPU's integrated interrupt controller. However, vectored interrupt controllers may not require the explicit configuration and enabling of higher-level interrupt controller sources. In this case, the application developer may need to configure the system's interrupt vector table with the name of the ISR handler functions declared in `net_bsp.c`.

`NetDev_WiFi_CfgIntCtrl()` should only enable each devices' interrupt sources but *not* the local device-level interrupts themselves, which are enabled by the device driver only after the device has been fully configured and started.

Since each network device requires a unique `NetDev_WiFi_CfgIntCtrl()`, it is recommended that each device's `NetDev_WiFi_CfgIntCtrl()` function be named using the following convention:

`NetDev_WiFi_[Device]CfgIntCtrl[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_CfgIntCtrl()` function for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named `NetDev_WiFi_RS9110_CfgIntCtrl2()`, or `NetDev_WiFi_RS9110_CfgIntCtrl_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## EXAMPLES

```
static  void  NetDev_WiFi_RS9110_CfgIntCtrl (NET_IF  *p_if,
                                             NET_ERR *p_err)
{
                            /* Configure AT91SAM9263-EK RS9110 #2's specific IF number.       */
    AT91SAM9263-EK__WiFi_RS9110_2_IF_Nbr = pif->Nbr;
                            /* Configure AT91SAM9263-EK RS9110 #2's interrupts:               */
                            /* Configure interrupt vector.                                    */
    BSP_IntVectSet(BSP_INT, &NetDev_WiFi_RS9110_ISR_Handler_2);
    BSP_IntEn(BSP_INT);     /* Enable    interrupts.                                          */

   *perr = NET_DEV_ERR_NONE;
}


static  void  NetDev_WiFi_RS9110_CfgIntCtrlRx_2 (NET_IF  *p_if,
                                                 NET_ERR *p_err)
{
                            /* Configure AT91SAM9263-EK RS9110 #2's specific IF number.       */
    AT91SAM9263-EK_WiFi_RS9110_2_IF_Nbr = pif->Nbr;
                            /* Configure AT91SAM9263-EK RS9110 #2's receive interrupt:        */
                            /* Configure interrupt vector.                                    */
    BSP_IntVectSet(BSP_INT_RX, &NetDev_WiFi_RS9100_ISR_HandlerRx_2);
    BSP_IntEn(BSP_INT_RX);  /* Enable    interrupt.                                           */

   *perr = NET_DEV_ERR_NONE;
}
```

## B-3-5 NetDev_WiFi_IntCtrl()

This function is called by a device driver to enable or disable interface's/device's interrupt.

### FILES

net_bsp.c

### PROTOTYPE

```
static CPU_INT32U NetDev_WiFi_IntCtrl (NET_IF      *p_if,
                                       CPU_BOOLEAN  en,
                                       NET_ERR     *p_err);
```

Note that since NetDev_WiFi_IntCtrl() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if — Pointer to specific interface to enable or disable the interrupt.

en — Enable or disable the interrupt.

p_err — Pointer to variable that will receive the return error code from this function:

NET_DEV_ERR_NONE
NET_DEV_ERR_FAULT

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Since each network device requires a unique `NetDev_WiFi_IntCtrl()`, it is recommended that each device's `NetDev_WiFi_IntCtrl()` function be named using the following convention:

`NetDev_WiFi_[Device]IntCtrl[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_IntCtrl()` function for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named `NetDev_WiFi_RS9110_IntCtrl2()`, or `NetDev_WiFi_RS9110_IntCtrl_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## B-3-6 NetDev_WiFi_SPI_Init()

This function is called by a device driver to initialize interface's/device's SPI bus.

### FILES

net_bsp.c

### PROTOTYPE

```
static CPU_INT32U NetDev_WiFi_SPI_Init (NET_IF  *p_if,
                                        NET_ERR *p_err);
```

Note that since NetDev_WiFi_SPI_Init() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to specific interface to initialize the SPI.

p_err Pointer to variable that will receive the return error code from this function:

NET_DEV_ERR_NONE
NET_DEV_ERR_FAULT

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

1 This function can configure the SPI mode by accessing the device configuration if no other device's hardware sahre the same SPI bus.

2 Since each network device requires a unique `NetDev_WiFi_SPI_Init()`, it is recommended that each device's `NetDev_WiFi_SPI_Init()` function be named using the following convention:

`NetDev_WiFi_[Device]SPI_Init[Number]()`

`[Device]` Network device name or type. For example, RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_SPI_Init()` function for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named `NetDev_WiFi_RS9110_SPI_Init2()`, or `NetDev_WiFi_RS9110_SPI_Init_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## B-3-7 NetDev_WiFi_SPI_Lock()

This function is called by a device driver to acquire the SPI lock and restrict the access to the SPI bus only to the wireless driver.

### FILES

net_bsp.c

### PROTOTYPE

```
static CPU_INT32U NetDev_WiFi_SPI_Lock (NET_IF  *p_if,
                                        NET_ERR *p_err);
```

Note that since NetDev_WiFi_SPI_Lock() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to specific interface to lock.

p_err Pointer to variable that will receive the return error code from this function:

NET_DEV_ERR_NONE
NET_DEV_ERR_FAULT

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

1 `NetDev_WiFi_SPI_Lock must be` implemented if more than one device's hardware share the same SPI bus.

2 Since each network device requires a unique `NetDev_WiFi_SPI_Lock()`, it is recommended that each device's `NetDev_WiFi_SPI_Lock()` function be named using the following convention:

`NetDev_WiFi_[Device]SPI_Lock[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_SPI_Lock()` function for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named `NetDev_WiFi_RS9110_SPI_Lock2()`, or `NetDev_WiFi_RS9110_SPI_Lock_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## B-3-8 NetDev_WiFi_SPI_Unlock()

This function is called by a device driver `to` release the SPI lock and give the access to the SPI bus to other device's hardware.

### FILES

`net_bsp.c`

### PROTOTYPE

```
static CPU_INT32U NetDev_WiFi_SPI_Unlock (NET_IF *p_if);
```

Note that since `NetDev_WiFi_SPI_Unlock()` is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as '`static`'.

### ARGUMENTS

`p_if` Pointer to specific interface to unlock.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

1 `NetDev_WiFi_SPI_Unlock must be` implemented if more than one hardware device share the same SPI bus.

2 Since each network device requires a unique `NetDev_WiFi_SPI_Unlock()`, it is recommended that each device's `NetDev_WiFi_SPI_Unlock()` function be named using the following convention:

`NetDev_WiFi_[Device]SPI_Unlock[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_SPI_Unlock()` function for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named `NetDev_WiFi_RS9110_SPI_Unlock2()`, or `NetDev_WiFi_RS9110_SPI_Unlock_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## B-3-9 NetDev_WiFi_SPI_WrRd()

This function is called by a device driver each time some data must be written &/or read from the wireless device/interface.

### FILES

net_bsp.c

### PROTOTYPE

```
static CPU_INT32U NetDev_WiFi_SPI_WrRd (NET_IF     *p_if,
                                        CPU_INT08U *p_buf_wr,
                                        CPU_INT08U *p_buf_rd,
                                        CPU_INT16U  wr_rd_len,
                                        NET_ERR    *p_err);
```

Note that since NetDev_WiFi_SPI_Unlock() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if — Pointer to specific interface to write and read data to SPI bus.

p_buf_wr — Pointer to a buffer that contains the data to write.

p_buf_rd — Pointer to a buffer that will receive the data read.

wr_rd_len — Number of octet to write and read.

p_err — Pointer to variable that will receive the return error code from this function:

NET_DEV_ERR_NONE
NET_DEV_ERR_FAULT

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

1 `NetDev_WiFi_SPI_ChipSelEn()` should be called only after the SPI lock has been acquired by calling `NetDev_WiFi_SPI_Lock()`.

2 Since each network device requires a unique `NetDev_WiFi_SPI_WrRd()`, it is recommended that each device's `NetDev_WiFi_SPI_WrRd()` function be named using the following convention:

`NetDev_WiFi_[Device]SPI_WrRd[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_SPI_WrRd()` function for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named `NetDev_WiFi_RS9110_SPI_WrRd2()`, or `NetDev_WiFi_RS9110_SPI_WrRd_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## B-3-10 NetDev_WiFi_SPI_ChipSelEn()

This function is called by a device driver to enable the SPI chip select of the wireless device.

### FILES

net_bsp.c

### PROTOTYPE

```
static CPU_INT32U NetDev_WiFi_SPI_ChipSelEn (NET_IF  *p_if,
                                             NET_ERR *p_err);
```

Note that since NetDev_WiFi_SPI_ChipSelEn() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to specific interface to enable the chip select.

p_err Pointer to variable that will receive the return error code from this function:

NET_DEV_ERR_NONE
NET_DEV_ERR_FAULT

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

1 `NetDev_WiFi_SPI_ChipSelEn()` should be called only after the SPI lock has been acquired by calling `NetDev_WiFi_SPI_Lock()`.

2 Since each network device requires a unique `NetDev_WiFi_SPI_ChipSelEn()`, it is recommended that each device's `NetDev_WiFi_SPI_ChipSelEn()` function be named using the following convention:

`NetDev_WiFi_[Device]SPI_ChipSelEn[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_SPI_ChipSelEn()` function for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named `NetDev_WiFi_RS9110_SPI_ChipSelEn2()`, or `NetDev_WiFi_RS9110_SPI_ChipSelEn_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## B-3-11 NetDev_WiFi_SPI_ChipSelDis()

This function is called by a device driver to disable the SPI chip select of the wireless device.

### FILES

net_bsp.c

### PROTOTYPE

```
static CPU_INT32U NetDev_WiFi_SPI_ChipSelDis (NET_IF *p_if);
```

Note that since NetDev_WiFi_SPI_ChipSelDis() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to specific interface to enable the chip select.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

1 `NetDev_WiFi_SPI_ChipSelDis() should be called only after the SPI lock has been acquired by calling NetDev_WiFi_SPI_Lock()`.

2 Since each network device requires a unique `NetDev_WiFi_SPI_ChipSelDis()`, it is recommended that each device's `NetDev_WiFi_SPI_ChipSelDis()` function be named using the following convention:

`NetDev_WiFi_[Device]SPI_ChipSelDis[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_SPI_ChipSelDis()` function for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named `NetDev_WiFi_RS9110_SPI_ChipSelDis2()`, or `NetDev_WiFi_RS9110_SPI_ChipSelDis_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## B-3-12 NetDev_WiFi_SPI_Cfg()

This function is called by a device driver to configure the SPI controller accordingly with device's SPI setting.

### FILES

net_bsp.c

### PROTOTYPE

```
static CPU_INT32U NetDev_WiFi_SPI_Cfg (NET_IF                        *p_if,
                                       NET_DEV_CFG_SPI_CLK_FREQ       freq,
                                       NET_DEV_CFG_SPI_CLK_POL        pol,
                                       NET_DEV_CFG_SPI_CLK_PHASE      phase,
                                       NET_DEV_CFG_SPI_XFER_UNIT_LEN  xfer_unit_len,
                                       NET_DEV_CFG_SPI_XFER_SHIFT_DIR xfer_shift_dir,
                                       NET_ERR                       *p_err);
```

Note that since NetDev_WiFi_SPI_Cfg() is accessed only by function pointer via a BSP interface structure, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

p_if Pointer to specific interface to configure the SPI controller.

freq SPI system clock frequency in hertz.

pol SPI clock polarity:

NET_DEV_SPI_CLK_POL_INACTIVE_LOW
NET_DEV_SPI_CLK_POL_INACTIVE_HIGH

phase SPI clock phase:

NET_DEV_SPI_CLK_PHASE_FALLING_EDGE
NET_DEV_SPI_CLK_PHASE_RASING_EDGE

`xfer_unit_len` SPI Transfer unit length:

`NET_DEV_SPI_XFER_UNIT_LEN_8_BITS`
`NET_DEV_SPI_XFER_UNIT_LEN_16_BITS`
`NET_DEV_SPI_XFER_UNIT_LEN_32_BITS`
`NET_DEV_SPI_XFER_UNIT_LEN_64_BITS`

`xfer_shift_dir` SPI transfer shift direction:

`NET_DEV_SPI_XFER_SHIFT_DIR_FIRST_MSB`
`NET_DEV_SPI_XFER_SHIFT_DIR_FIRST_LSB`

`p_err` Pointer to variable that will receive the return error code from this function:

`NET_DEV_ERR_NONE`
`NET_DEV_ERR_FAULT`

This is *not* an exclusive list of return errors and specific network device's or device BSP functions may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

1 `NetDev_WiFi_SPI_Cfg()` should be called only after the SPI lock has been acquired by calling `NetDev_WiFi_SPI_Lock()`.

2 If no other device's hardware share the same SPI controller, the configuration can be applied only at the initialization when NetDev_WiFi_SPI_Init() is called.

3 Since each network device requires a unique `NetDev_WiFi_SPI_ChipSelEn()`, it is recommended that each device's `NetDev_WiFi_SPI_ChipSelEn()` function be named using the following convention:

`NetDev_WiFi_[Device]SPI_ChipSelEn[Number]()`

`[Device]` Network device name or type, e.g. RS9110 (optional if the development board does not support multiple devices)

`[Number]` Network device number for each specific instance of device (optional if the development board does not support multiple instances of the specific device)

For example, the `NetDev_WiFi_SPI_ChipSelEn()` function for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named `NetDev_WiFi_RS9110_SPI_ChipSelEn2()`, or `NetDev_WiFi_RS9110_SPI_ChipSelEn_2()` with additional underscore optional.

See also Chapter 6, "Network Board Support Package" on page 121.

## B-3-13 NetDev_WiFi_ISR_Handler()

Handle a network device's interrupts on a specific interface.

### FILES

net_bsp.c

### PROTOTYPE

```
static void NetDev_ISR_Handler (void);
```

Note that since NetDev_ISR_Handler() is accessed only by function pointer usually via an interrupt vector table, it doesn't need to be globally available and should therefore be declared as 'static'.

### ARGUMENTS

None.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Each network device's interrupt, or set of device interrupts, must be handled by a unique BSP-level interrupt service routine (ISR) handler, NetDev_WiFi_ISR_Handler(), which maps each specific device interrupt to its corresponding network interface ISR handler, NetIF_ISR_Handler(). For some CPUs this may be a first- or second-level interrupt handler. Generally, the application must configure the interrupt controller to call every network device's unique NetDev_WiFi_ISR_Handler() when the device's interrupt occurs (see section B-3-4 on page 393). Every unique NetDev_WiFi_ISR_Handler() *must* then perform the following actions:

1 Call NetIF_ISR_Handler() with the device's unique network interface number and appropriate interrupt type. The device's network interface number should be available after configuration in the device's NetDev_WiFi_CfgIntCtrl() function (see section B-3-4 "NetDev_WiFi_CfgIntCtrl()" on page 393). NetIF_ISR_Handler() in turn calls the appropriate device driver's interrupt handler.

   In most cases, each device requires only a single NetDev_WiFi_ISR_Handler() which calls NetIF_ISR_Handler() with interrupt type code NET_DEV_ISR_TYPE_UNKNOWN. This is possible when the device's driver can determine the device's interrupt type to via the interrupt controller. However, some devices cannot generically determine the interrupt type when an interrupt occurs and may therefore require multiple, unique NetDev_WiFi_ISR_Handler()'s each of which calls NetIF_ISR_Handler() with the appropriate interrupt type code.

   See also section C-9-12 "NetIF_ISR_Handler()" on page 519.

2 Clear the device's interrupt source, possibly via an external or CPU-integrated interrupt controller source.

Since each network device requires a unique NetDev_WiFi_ISR_Handler() for each device interrupt, it is recommended that each device's NetDev_WiFi_ISR_Handler() function be named using the following convention:

NetDev_WiFi_[Device]ISR_Handler[Type][Number]()

[Device] Network device name or type, e.g., RS9110 (optional if the development board does not support multiple devices)

[Type] Network device interrupt type, e.g., receive interrupt (optional if interrupt type is generic or unknown)

[Number] Network device number for each specific instance of device (optional if the development board does not support multiple instances of a specific device)

For example, the receive ISR handler for the #2 RS9110 wireless device on an Atmel AT91SAM9263-EK should be named NetDev_WiFi_RS9110_ISR_HandlerRx2().

See also Chapter 6, "Network Board Support Package" on page 121.

## EXAMPLES

```
static void NetDev_WiFi_RS9110_ISR_Handler_2 (void)
{
    NET_ERR  err;

    NetIF_ISR_Handler(AT91SAM9263-EK_RS9110_2_IF_Nbr, NET_DEV_ISR_TYPE_UNKNOWN, &err);
    /* Clear external or CPU's integrated interrupt controller. */
}


static void NetDev_WiFi_RS9110_ISR_HandlerRx_2 (void)
{
    NET_ERR  err;

    NetIF_ISR_Handler(AT91SAM9263-EK_RS9110_2_IF_Nbr, NET_DEV_ISR_TYPE_RX, &err);
    /* Clear external or CPU's integrated interrupt controller. */
}
```

Appendix

# C

# µC/TCP-IP API Reference

The application programming interfaces (APIs) to µC/TCP-IP using any of the functions or macros are described in this appendix. The functions/macros in this appendix are organized alphabetically with the exception of alphabetizing all BSD functions/macros in their own section, section C-18 on page 715.

## C-1 GENERAL NETWORK FUNCTIONS

### C-1-1 Net_Init()

Initializes µC/TCP-IP and *must* be called prior to calling any other µC/TCP-IP API functions.

#### FILES

net.h/net.c

#### PROTOTYPE

```
NET_ERR Net_Init(void);
```

#### ARGUMENTS

None.

#### RETURNED VALUE

| | |
|---|---|
| NET_ERR_NONE, | if successful; |
| Specific initialization error code, | otherwise. |

Return value *should* be inspected to determine whether or not µC/TCP-IP successfully initialized. If µC/TCP-IP did *not* successfully initialize, search for the returned error code in net_err.h and source files to locate where the µC/TCP-IP initialization failed.

#### REQUIRED CONFIGURATION

None.

#### NOTES / WARNINGS

µC/LIB memory management function Mem_Init() *must* be called prior to calling Net_Init().

## C-1-2 Net_InitDflt()

Initialize default values for all µC/TCP-IP configurable parameters.

### FILES

net.h/net.c

### PROTOTYPE

```
void Net_InitDflt(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Some default parameters are specified in net_cfg.h (see Appendix D, "µC/TCP-IP Configuration and Optimization" on page 735).

## C-1-3 Net_VersionGet()

Get the µC/TCP-IP software version.

### FILES

net.h/net.c

### PROTOTYPE

```
CPU_INT16U Net_VersionGet(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

µC/TCP-IP software version.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

µC/TCP-IP's software version is denoted as follows:

Vx.yy.zz

where
V denotes Version label
x denotes major software version revision number
yy denotes minor software version revision number
zz denotes sub-minor software version revision number

The software version is returned as follows:

```
ver = x.yyzz * 100 * 100
```

where
`ver` denotes software version number scaled as an integer value
`x.yyzz` denotes software version number, where the unscaled integer portion denotes the major version number and the unscaled fractional portion denotes the (concatenated) minor version numbers

For example, (version) V2.11.01 would be returned as `21101`.

## C-2 NETWORK APPLICATION INTERFACE FUNCTIONS

### C-2-1 NetApp_SockAccept() (TCP)

Return a new application socket accepted from a listen application socket, with error handling. See section C-13-1 on page 572 for more information.

#### FILES

net_app.h/net_app.c

#### PROTOTYPE

```
NET_SOCK_ID  NetApp_SockAccept (NET_SOCK_ID         sock_id,
                                NET_SOCK_ADDR      *paddr_remote,
                                NET_SOCK_ADDR_LEN  *paddr_len,
                                CPU_INT16U          retry_max,
                                CPU_INT32U          timeout_ms,
                                CPU_INT32U          time_dly_ms,
                                NET_ERR            *perr);
```

#### ARGUMENTS

sock_id — This is the socket ID returned by NetApp_SockOpen()/NetSock_Open()/socket() when the socket was created. This socket is assumed to be bound to an address and listening for new connections (see section C-13-40 on page 648).

paddr_remote — Pointer to a socket address structure (see section 9-1 "Network Socket Data Structures" on page 273) to return the remote host address of the new accepted connection.

paddr_len — Pointer to the size of the socket address structure which *must* be passed the size of the socket address structure [e.g., sizeof(NET_SOCK_ADDR_IP)]. Returns size of the accepted connection's socket address structure, if no errors; returns 0, otherwise.

retry_max — Maximum number of consecutive socket accept retries.

`timeout_ms` Socket accept timeout value per attempt/retry.

`time_dly_ms` Socket accept delay value, in milliseconds.

`perr` Pointer to variable that will receive the error code from this function:

`NET_APP_ERR_NONE`
`NET_APP_ERR_NONE_AVAIL`
`NET_APP_ERR_INVALID_ARG`
`NET_APP_ERR_INVALID_OP`
`NET_APP_ERR_FAULT`
`NET_APP_ERR_FAULT_TRANSITORY`

### RETURNED VALUE

Socket descriptor/handle identifier of new accepted socket, if no errors.

`NET_SOCK_BSD_ERR_ACCEPT`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_APP_CFG_API_EN` is enabled (see section D-18-1 on page 768) *and* `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

Some socket arguments and/or operations are validated only if validation code is enabled (see section D-3-1 on page 744).

If a non-zero number of retries is requested (`retry_max`) *and* socket blocking is configured for non-blocking operation (see section D-15-3 on page 761); then a non-zero timeout (`timeout_ms`) and/or a non-zero time delay (`time_dly_ms`) should also be requested. Otherwise, all retries will most likely fail immediately since no time will elapse to wait for and allow socket operations to successfully complete.

## C-2-2 NetApp_SockBind() (TCP/UDP)

Bind an application socket to a local address, with error handling. See section C-13-2 on page 574 for more information.

### FILES

net_app.h/net_app.c

### PROTOTYPE

```
CPU_BOOLEAN  NetApp_SockBind (NET_SOCK_ID         sock_id,
                              NET_SOCK_ADDR      *paddr_local,
                              NET_SOCK_ADDR_LEN   addr_len,
                              CPU_INT16U          retry_max,
                              CPU_INT32U          time_dly_ms,
                              NET_ERR            *perr);
```

### ARGUMENTS

`sock_id` This is the socket ID returned by `NetApp_SockOpen()`/ `NetSock_Open()`/ `socket()` when the socket was created.

`paddr_local` Pointer to a socket address structure (see section 8-2 "Socket Interface" on page 212) which contains the local host address to bind the socket to.

`addr_len` Size of the socket address structure which *must* be passed the size of the socket address structure [for example, `sizeof(NET_SOCK_ADDR_IP)`].

`retry_max` Maximum number of consecutive socket bind retries.

`time_dly_ms` Socket bind delay value, in milliseconds.

`perr` Pointer to variable that will receive the error code from this function:

`NET_APP_ERR_NONE`
`NET_APP_ERR_NONE_AVAIL`
`NET_APP_ERR_INVALID_ARG`
`NET_APP_ERR_INVALID_OP`
`NET_APP_ERR_FAULT`

### RETURNED VALUE

DEF_OK, Application socket successfully bound to a local address.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_APP_CFG_API_EN is enabled (see section D-18-1 on page 768) *and* either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

Some socket arguments and/or operations are validated only if validation code is enabled (see section D-3-1 on page 744).

If a non-zero number of retries is requested (retry_max) then a non-zero time delay (time_dly_ms) should also be requested. Otherwise, all retries will most likely fail immediately since no time will elapse to wait for and allow socket operations to successfully complete.

## C-2-3 NetApp_SockClose() (TCP/UDP)

Close an application socket, with error handling. See section C-13-31 on page 632 for more information.

### FILES

net_app.h/net_app.c

### PROTOTYPE

```
CPU_BOOLEAN  NetApp_SockClose (NET_SOCK_ID   sock_id,
                               CPU_INT32U    timeout_ms,
                               NET_ERR      *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetApp_SockOpen()/ NetSock_Open()/ socket() when the socket was created *or* by NetApp_SockAccept()/ NetSock_Accept()/accept() when a connection was accepted.

timeout_ms — Socket close timeout value per attempt/retry.

perr — Pointer to variable that will receive the error code from this function:

NET_APP_ERR_NONE
NET_APP_ERR_INVALID_ARG
NET_APP_ERR_FAULT
NET_APP_ERR_FAULT_TRANSITORY

### RETURNED VALUE

DEF_OK, — Application socket successfully closed.

DEF_FAIL, — otherwise.

### REQUIRED CONFIGURATION

Available only if NET_APP_CFG_API_EN is enabled (see section D-18-1 on page 768) *and* either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

Some socket arguments and/or operations are validated only if validation code is enabled (see section D-3-1 on page 744).

## C-2-4 NetApp_SockConn() (TCP/UDP)

Connect an application socket to a remote address, with error handling. See section C-13-32 on page 634 for more information.

### FILES

net_app.h/net_app.c

### PROTOTYPE

```
CPU_BOOLEAN  NetApp_SockConn (NET_SOCK_ID         sock_id,
                              NET_SOCK_ADDR      *paddr_remote,
                              NET_SOCK_ADDR_LEN   addr_len,
                              CPU_INT16U          retry_max,
                              CPU_INT32U          timeout_ms,
                              CPU_INT32U          time_dly_ms,
                              NET_ERR            *perr);
```

### ARGUMENTS

| | |
|---|---|
| sock_id | This is the socket ID returned by NetApp_SockOpen()/ NetSock_Open()/socket() when the socket was created. |
| paddr_remote | Pointer to a socket address structure (see section 8-2 "Socket Interface" on page 212) which contains the remote socket address to connect the socket to. |
| addr_len | Size of the socket address structure which *must* be passed the size of the socket address structure [e.g., sizeof(NET_SOCK_ADDR_IP)]. |
| retry_max | Maximum number of consecutive socket connect retries. |
| timeout_ms | Socket connect timeout value per attempt/retry. |
| time_dly_ms | Socket connect delay value, in milliseconds. |

`perr` Pointer to variable that will receive the error code from this function:

`NET_APP_ERR_NONE`
`NET_APP_ERR_NONE_AVAIL`
`NET_APP_ERR_INVALID_ARG`
`NET_APP_ERR_INVALID_OP`
`NET_APP_ERR_FAULT`
`NET_APP_ERR_FAULT_TRANSITORY`

### RETURNED VALUE

`DEF_OK`, Application socket successfully connected to a remote address.

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_APP_CFG_API_EN` is enabled (see section D-18-1 on page 768) *and* either `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755) and/or `NET_UDP_CFG_APP_API_SEL` is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

Some socket arguments and/or operations are validated only if validation code is enabled (see section D-3-1 on page 744).

If a non-zero number of retries is requested (`retry_max`) *and* socket blocking is configured for non-blocking operation (see section D-15-3 on page 761); then a non-zero timeout (`timeout_ms`) and/or a non-zero time delay (`time_dly_ms`) should also be requested. Otherwise, all retries will most likely fail immediately since no time will elapse to wait for and allow socket operations to successfully complete.

## C-2-5 NetApp_SockListen() (TCP)

Set an application socket to listen for connection requests, with error handling. See section C-13-40 on page 648 for more information.

### FILES

net_app.h/net_app.c

### PROTOTYPE

```
CPU_BOOLEAN  NetApp_SockListen (NET_SOCK_ID       sock_id,
                                NET_SOCK_Q_SIZE   sock_q_size,
                                NET_ERR          *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetApp_SockOpen()/ NetSock_Open()/ socket() when the socket was created.

sock_q_size — Maximum number of new connections allowed to be waiting. In other words, this argument specifies the maximum queue length of pending connections while the listening socket is busy servicing the current request.

perr — Pointer to variable that will receive the error code from this function:

NET_APP_ERR_NONE
NET_APP_ERR_INVALID_ARG
NET_APP_ERR_INVALID_OP
NET_APP_ERR_FAULT
NET_APP_ERR_FAULT_TRANSITORY

### RETURNED VALUE

DEF_OK, — Application socket successfully set to listen.

DEF_FAIL, — otherwise.

### REQUIRED CONFIGURATION

Available only if NET_APP_CFG_API_EN is enabled (see section D-18-1 on page 768) *and* NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

Some socket arguments and/or operations are validated only if validation code is enabled (see section D-3-1 on page 744).

## C-2-6 NetApp_SockOpen() (TCP/UDP)

Open an application socket, with error handling. See section C-13-41 on page 650 for more information.

### FILES

net_app.h/net_app.c

### PROTOTYPE

```
NET_SOCK_ID  NetApp_SockOpen (NET_SOCK_PROTOCOL_FAMILY   protocol_family,
                              NET_SOCK_TYPE               sock_type,
                              NET_SOCK_PROTOCOL           protocol,
                              CPU_INT16U                  retry_max,
                              CPU_INT32U                  time_dly_ms,
                              NET_ERR                    *perr);
```

### ARGUMENTS

protocol_family — This field establishes the socket protocol family domain. Always use NET_SOCK_FAMILY_IP_V4/PF_INET for TCP/IP sockets.

sock_type — Socket type:

NET_SOCK_TYPE_DATAGRAM/PF_DGRAM for datagram sockets (i.e., UDP)

NET_SOCK_TYPE_STREAM/PF_STREAM for stream sockets (i.e., TCP)

NET_SOCK_TYPE_DATAGRAM sockets preserve message boundaries. Applications that exchange single request and response messages are examples of datagram communication.

NET_SOCK_TYPE_STREAM sockets provides a reliable byte-stream connection, where bytes are received from the remote application in the same order as they were sent. File transfer and terminal emulation are examples of applications that require this type of protocol.

`protocol` Socket protocol:
`NET_SOCK_PROTOCOL_UDP/IPPROTO_UDP` for UDP
`NET_SOCK_PROTOCOL_TCP/IPPROTO_TCP` for TCP

`0` for default-protocol:
UDP for `NET_SOCK_TYPE_DATAGRAM/PF_DGRAM`
TCP for `NET_SOCK_TYPE_STREAM/PF_STREAM`

`retry_max` Maximum number of consecutive socket open retries.

`time_dly_ms` Socket open delay value, in milliseconds.

`perr` Pointer to variable that will receive the error code from this function:

`NET_APP_ERR_NONE`
`NET_APP_ERR_NONE_AVAIL`
`NET_APP_ERR_INVALID_ARG`
`NET_APP_ERR_FAULT`

### RETURNED VALUE

Socket descriptor/handle identifier of new socket, if no errors.

`NET_SOCK_BSD_ERR_OPEN`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_APP_CFG_API_EN` is enabled (see section D-18-1 on page 768) *and* either `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755) and/or `NET_UDP_CFG_APP_API_SEL` is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

Some socket arguments and/or operations are validated only if validation code is enabled (see section D-3-1 on page 744).

If a non-zero number of retries is requested (`retry_max`) then a non-zero time delay (`time_dly_ms`) should also be requested. Otherwise, all retries will likely fail immediately since no time will elapse to wait for and allow socket operations to successfully complete.

## C-2-7 NetApp_SockRx() (TCP/UDP)

Receive application data via socket, with error handling. See section C-13-46 on page 659 for more information.

### FILES

net_app.h/net_app.c

### PROTOTYPE

```
CPU_INT16U  NetApp_SockRx (NET_SOCK_ID         sock_id,
                           void               *pdata_buf,
                           CPU_INT16U          data_buf_len,
                           CPU_INT16U          data_rx_th,
                           CPU_INT16S          flags,
                           NET_SOCK_ADDR      *paddr_remote,
                           NET_SOCK_ADDR_LEN  *paddr_len,
                           CPU_INT16U          retry_max,
                           CPU_INT32U          timeout_ms,
                           CPU_INT32U          time_dly_ms,
                           NET_ERR            *perr);
```

### ARGUMENTS

sock_id This is the socket ID returned by NetApp_SockOpen()/ NetSock_Open()/ socket() when the socket was created *or* by NetApp_SockAccept()/ NetSock_Accept()/accept() when a connection was accepted.

pdata_buf Pointer to the application memory buffer to receive data.

data_buf_len Size of the destination application memory buffer (in bytes).

data_rx_th Application data receive threshold:

0, no minimum receive threshold; i.e. receive any amount of data. Recommended for datagram sockets;

Minimum amount of application data to receive (in bytes) within maximum number of retries, otherwise.

`flags` Flag to select receive options; bit-field flags logically **OR**'d:

| | |
|---|---|
| `NET_SOCK_FLAG_NONE/0` | No socket flags selected |
| `NET_SOCK_FLAG_RX_DATA_PEEK/ MSG_PEEK` | Receive socket data without consuming it |
| `NET_SOCK_FLAG_RX_NO_BLOCK/ MSG_DONTWAIT` | Receive socket data without blocking |

In most cases, this flag would be set to `NET_SOCK_FLAG_NONE/0`.

`paddr_remote` Pointer to a socket address structure (see section 8-2 "Socket Interface" on page 212) to return the remote host address that sent the received data.

`paddr_len` Pointer to the size of the socket address structure which *must* be passed the size of the socket address structure [e.g., `sizeof(NET_SOCK_ADDR_IP)`]. Returns size of the accepted connection's socket address structure, if no errors; returns `0`, otherwise.

`retry_max` Maximum number of consecutive socket receive retries.

`timeout_ms` Socket receive timeout value per attempt/retry.

`time_dly_ms` Socket receive delay value, in milliseconds.

`perr` Pointer to variable that will receive the error code from this function:

`NET_APP_ERR_NONE`
`NET_APP_ERR_INVALID_ARG`
`NET_APP_ERR_INVALID_OP`
`NET_APP_ERR_FAULT`
`NET_APP_ERR_FAULT_TRANSITORY`
`NET_APP_ERR_CONN_CLOSED`
`NET_APP_ERR_DATA_BUF_OVF`
`NET_ERR_RX`

### RETURNED VALUE

Number of data bytes received, if no errors.

`0`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_APP_CFG_API_EN` is enabled (see section D-18-1 on page 768) *and* either `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755) and/or `NET_UDP_CFG_APP_API_SEL` is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

Some socket arguments and/or operations are validated only if validation code is enabled (see section D-3-1 on page 744).

If a non-zero number of retries is requested (`retry_max`) *and* socket blocking is configured for non-blocking operation (see section D-15-3 on page 761); then a non-zero timeout (`timeout_ms`) and/or a non-zero time delay (`time_dly_ms`) should also be requested. Otherwise, all retries will most likely fail immediately since no time will elapse to wait for and allow socket operations to successfully complete.

## C-2-8 NetApp_SockTx() (TCP/UDP)

Transmit application data via socket, with error handling. See section C-13-48 on page 666 for more information.

### FILES

net_app.h/net_app.c

### PROTOTYPE

```
CPU_INT16U  NetApp_SockTx (NET_SOCK_ID         sock_id,
                           void               *p_data,
                           CPU_INT16U          data_len,
                           CPU_INT16S          flags,
                           NET_SOCK_ADDR      *paddr_remote,
                           NET_SOCK_ADDR_LEN   addr_len,
                           CPU_INT16U          retry_max,
                           CPU_INT32U          timeout_ms,
                           CPU_INT32U          time_dly_ms,
                           NET_ERR            *perr);
```

### ARGUMENTS

sock_id — The socket ID returned by NetApp_SockOpen()/NetSock_Open()/socket() when the socket was created *or* by NetApp_SockAccept()/NetSock_Accept()/accept() when a connection was accepted.

p_data — Pointer to the application data memory buffer to send.

data_len — Size of the application data memory buffer (in bytes).

flags — Flag to select transmit options; bit-field flags logically **OR**'d:

| | |
|---|---|
| NET_SOCK_FLAG_NONE/0 | No socket flags selected |
| NET_SOCK_FLAG_TX_NO_BLOCK/ MSG_DONTWAIT | Send socket data without blocking |

In most cases, this flag would be set to NET_SOCK_FLAG_NONE/0.

`paddr_remote` Pointer to a socket address structure (see section 8-2 "Socket Interface" on page 212) which contains the remote socket address to send data to.

`addr_len` Size of the socket address structure which *must* be passed the size of the socket address structure [e.g., `sizeof(NET_SOCK_ADDR_IP)`].

`retry_max` Maximum number of consecutive socket transmit retries.

`timeout_ms` Socket transmit timeout value per attempt/retry.

`time_dly_ms` Socket transmit delay value, in milliseconds.

`perr` Pointer to variable that will receive the error code from this function:

```
NET_APP_ERR_NONE
NET_APP_ERR_INVALID_ARG
NET_APP_ERR_INVALID_OP
NET_APP_ERR_FAULT
NET_APP_ERR_FAULT_TRANSITORY
NET_APP_ERR_CONN_CLOSED
NET_ERR_TX
```

### RETURNED VALUE

Number of data bytes transmitted, if no errors.

`0`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_APP_CFG_API_EN` is enabled (see section D-18-1 on page 768) *and* either `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755) and/or `NET_UDP_CFG_APP_API_SEL` is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

Some socket arguments and/or operations are validated only if validation code is enabled (see section D-3-1 on page 744).

If a non-zero number of retries is requested (`retry_max`) *and* socket blocking is configured for non-blocking operation (see section D-15-3 on page 761); then a non-zero timeout (`timeout_ms`) and/or a non-zero time delay (`time_dly_ms`) should also be requested. Otherwise, all retries will most likely fail immediately since no time will elapse to wait for and allow socket operations to successfully complete.

## C-2-9 NetApp_TimeDly_ms()

Delay for specified time, in milliseconds.

### FILES

net_app.h/net_app.c

### PROTOTYPE

```
void  NetApp_TimeDly_ms (CPU_INT32U   time_dly_ms,
                         NET_ERR     *perr);
```

### ARGUMENTS

time_dly_ms Time delay value, in milliseconds.

perr Pointer to variable that will receive the error code from this function:

NET_APP_ERR_NONE
NET_APP_ERR_INVALID_ARG
NET_APP_ERR_FAULT

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if NET_APP_CFG_API_EN is enabled (see section D-18-1 on page 768).

### NOTES / WARNINGS

Time delay of 0 milliseconds allowed. Time delay limited to the maximum possible time delay supported by the system/OS.

## C-3 ARP FUNCTIONS

### C-3-1 NetARP_CacheCalcStat()

Calculate ARP cache found percentage statistics.

#### FILES

net_arp.h/net_arp.c

#### PROTOTYPE

```
CPU_INT08U NetARP_CacheCalcStat(void);
```

#### ARGUMENTS

None.

#### RETURNED VALUE

ARP cache found percentage, if no errors.

NULL cache found percentage, otherwise.

#### REQUIRED CONFIGURATION

Available only if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

#### NOTES / WARNINGS

None.

## C-3-2 NetARP_CacheGetAddrHW()

Get the hardware address corresponding to a specific ARP cache's protocol address.

### FILES

net_arp.h/net_arp.c

### PROTOTYPE

```
NET_ARP_ADDR_LEN NetARP_CacheGetAddrHW (CPU_INT08U        *paddr_hw
                                        NET_ARP_ADDR_LEN   addr_hw_len_buf,
                                        CPU_INT08U        *paddr_protocol,
                                        NET_ARP_ADDR_LEN   addr_protocol_len,
                                        NET_ERR           *perr);
```

### ARGUMENTS

paddr_hw — Pointer to a memory buffer that will receive the hardware address:

Hardware address that corresponds to the desired protocol address, if no errors; hardware address cleared to all zeros, otherwise.

addr_hw_len_buf — Size of hardware address memory buffer (in bytes).

paddr_protocol — Pointer to the specific protocol address.

addr_protocol_len — Length of protocol address (in bytes).

perr — Pointer to variable that will receive the error code from this function:

NET_ARP_ERR_NONE
NET_ARP_ERR_NULL_PTR
NET_ARP_ERR_INVALID_HW_ADDR_LEN
NET_ARP_ERR_INVALID_PROTOCOL_ADDR_LEN
NET_ARP_ERR_CACHE_NOT_FOUND
NET_ARP_ERR_CACHE_PEND

### RETURNED VALUE

Length of returned hardware address, if available;

`0`, otherwise.

### REQUIRED CONFIGURATION

Available only if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

### NOTES / WARNINGS

`NetARP_CacheGetAddrHW()` may be used in conjunction with `NetARP_ProbeAddrOnNet()` to determine if a specific protocol address is available on the local network.

## C-3-3 NetARP_CachePoolStatGet()

Get ARP caches' statistics pool.

### FILES

net_arp.h/net_arp.c

### PROTOTYPE

```
NET_STAT_POOL NetARP_CachePoolStatGet(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

ARP caches' statistics pool, if no errors.

NULL statistics pool, otherwise.

### REQUIRED CONFIGURATION

Available only if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

### NOTES / WARNINGS

None.

## C-3-4 NetARP_CachePoolStatResetMaxUsed()

Reset ARP caches' statistics pool's maximum number of entries used.

### FILES

net_arp.h/net_arp.c

### PROTOTYPE

```
void NetARP_CachePoolStatResetMaxUsed(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

### NOTES / WARNINGS

None.

## C-3-5 NetARP_CfgCacheAccessedTh()

Configure ARP cache access promotion threshold.

### FILES

net_arp.h/net_arp.c

### PROTOTYPE

```
CPU_BOOLEAN NetARP_CfgCacheAccessedTh(CPU_INT16U nbr_access);
```

### ARGUMENTS

nbr_access — Desired number of ARP cache accesses before ARP cache entry is promoted.

### RETURNED VALUE

DEF_OK, ARP cache access promotion threshold successfully configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

### NOTES / WARNINGS

None.

## C-3-6 NetARP_CfgCacheTimeout()

Configure ARP cache timeout for ARP Cache List. ARP cache entries will be retired if they are not used within the specified timeout.

### FILES

net_arp.h/net_arp.c

### PROTOTYPE

```
CPU_BOOLEAN NetARP_CfgCacheTimeout(CPU_INT16U timeout_sec);
```

### ARGUMENTS

| | |
|---|---|
| timeout_sec | Desired value for ARP cache timeout (in seconds) |

### RETURNED VALUE

DEF_OK, ARP cache timeout successfully configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

### NOTES / WARNINGS

None.

## C-3-7 NetARP_CfgReqMaxRetries()

Configure maximum number of ARP request retries.

### FILES

net_arp.h/net_arp.c

### PROTOTYPE

```
CPU_BOOLEAN NetARP_CfgReqMaxRetries(CPU_INT08U max_nbr_retries);
```

### ARGUMENTS

max_nbr_retries  Desired maximum number of ARP request retries.

### RETURNED VALUE

DEF_OK, maximum number of ARP request retries configured.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

### NOTES / WARNINGS

None.

## C-3-8 NetARP_CfgReqTimeout()

Configure timeout between ARP request timeouts.

### FILES

net_arp.h/net_arp.c

### PROTOTYPE

```
CPU_BOOLEAN NetARP_CfgReqTimeout(CPU_INT08U timeout_sec);
```

### ARGUMENTS

timeout_sec — Desired value for ARP request pending ARP reply timeout (in seconds).

### RETURNED VALUE

DEF_OK, ARP request timeout successfully configured,

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

### NOTES / WARNINGS

None.

## C-3-9 NetARP_IsAddrProtocolConflict()

Check interface's protocol address conflict status between this interface's ARP host protocol address(es) and any other host(s) on the local network.

### FILES

net_arp.h/net_arp.c

### PROTOTYPE

```
CPU_BOOLEAN NetARP_IsAddrProtocolConflict (NET_IF_NBR  if_nbr,
                                           NET_ERR    *perr);
```

### ARGUMENTS

if_nbr  Interface number to get protocol address conflict status.

perr  Pointer to variable that will receive the return error code from this function:

NET_ARP_ERR_NONE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_YES  if address conflict detected;

DEF_NO  otherwise.

### REQUIRED CONFIGURATION

Available only if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

### NOTES / WARNINGS

None.

## C-3-10 NetARP_ProbeAddrOnNet()

Transmit an ARP request to probe the local network for a specific protocol address.

### FILES

net_arp.h/net_arp.c

### PROTOTYPE

```
void NetARP_ProbeAddrOnNet(NET_PROTOCOL_TYPE  protocol_type,
                           CPU_INT08U        *paddr_protocol_sender,
                           CPU_INT08U        *paddr_protocol_target
                           NET_ARP_ADDR_LEN   addr_protocol_len,
                           NET_ERR           *perr);
```

### ARGUMENTS

protocol_type Address protocol type.

paddr_protocol_sender Pointer to protocol address to send probe from.

paddr_protocol_target Pointer to protocol address to probe local network.

addr_protocol_len Length of protocol address (in bytes).

perr Pointer to variable that will receive the return error code from this function:

NET_ARP_ERR_NONE
NET_ARP_ERR_NULL_PTR
NET_ARP_ERR_INVALID_PROTOCOL_ADDR_LEN
NET_ARP_ERR_CACHE_INVALID_TYPE
NET_ARP_ERR_CACHE_NONE_AVAIL
NET_MGR_ERR_INVALID_PROTOCOL
NET_MGR_ERR_INVALID_PROTOCOL_ADDR
NET_MGR_ERR_INVALID_PROTOCOL_ADDR_LEN
NET_TMR_ERR_NULL_OBJ
NET_TMR_ERR_NULL_FNCT
NET_TMR_ERR_NONE_AVAIL
NET_TMR_ERR_INVALID_TYPE
NET_OS_ERR_LOCK

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

### NOTES / WARNINGS

`NetARP_ProbeAddrOnNet()` may be used in conjunction with `NetARP_CacheGetAddrHW()` to determine if a specific protocol address is available on the local network.

## C-4 NETWORK ASCII FUNCTIONS

### C-4-1 NetASCII_IP_to_Str()

Convert an IPv4 address in host-order into an IPv4 dotted-decimal notation ASCII string.

#### FILES

net_ascii.h/net_ascii.c

#### PROTOTYPE

```
void  NetASCII_IP_to_Str(NET_IP_ADDR   addr_ip,
                         CPU_CHAR     *paddr_ip_ascii,
                         CPU_BOOLEAN   lead_zeros,
                         NET_ERR      *perr);
```

#### ARGUMENTS

addr_ip IPv4 address (in host-order).

paddr_ip_ascii Pointer to a memory buffer of size greater than or equal to NET_ASCII_LEN_MAX_ADDR_IP bytes to receive the IPv4 address string. Note that the first ASCII character in the string is the most significant nibble of the IP address's most significant byte and that the last character in the string is the least significant nibble of the IP address's least significant byte. Example: "10.10.1.65" = 0x0A0A0141

lead_zeros Select formatting the IPv4 address string with leading zeros ('0') prior to the first non-zero digit in each IP address byte. The number of leading zeros added is such that each byte's total number of decimal digits is equal to the maximum number of digits for each byte (i.e., 3).

| | |
|---|---|
| DEF_NO | Do *not* prepend leading zeros to each IP address byte |
| DEF_YES | Prepend leading zeros to each IP address byte |

perr Pointer to variable that will receive the return error code from this function:

NET_ASCII_ERR_NONE
NET_ASCII_ERR_NULL_PTR
NET_ASCII_ERR_INVALID_CHAR_LEN

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

RFC 1983 states that "dotted-decimal notation... refers [to] IP addresses of the form A.B.C.D; where each letter represents, in decimal, one byte of a four-byte IP address." In other words, the dotted-decimal notation separates four decimal byte values by the dot, or period, character ('.'). Each decimal value represents one byte of the IP address starting with the most significant byte in network order.

**IPv4 Address Examples:**

| DOTTED DECIMAL NOTATION | HEXADECIMAL EQUIVALENT |
|---|---|
| 127.0.0.1 | 0x7F000001 |
| 192.168.1.64 | 0xC0A80140 |
| 255.255.255.0 | 0xFFFFFF00 |
| MSB ..... LSB | MSB .... LSB |

MSB Most Significant Byte in Dotted-Decimal IP Address

LSB Least Significant Byte in Dotted-Decimal IP Address

## C-4-2 NetASCII_MAC_to_Str()

Convert a Media Access Control (MAC) address into a hexadecimal address string.

### FILES

net_ascii.h/net_ascii.c

### PROTOTYPE

```
void NetASCII_MAC_to_Str(CPU_INT08U   *paddr_mac,
                         CPU_CHAR     *paddr_mac_ascii,
                         CPU_BOOLEAN   hex_lower_case,
                         CPU_BOOLEAN   hex_colon_sep,
                         NET_ERR      *perr);
```

### ARGUMENTS

paddr_mac — Pointer to a memory buffer of NET_ASCII_NBR_OCTET_ADDR_MAC bytes in size that contains the MAC address.

paddr_mac_ascii — Pointer to a memory buffer of size greater than or equal to NET_ASCII_LEN_MAX_ADDR_MAC bytes to receive the MAC address string. Note that the first ASCII character in the string is the most significant nibble of the MAC address's most significant byte and that the last character in the string is the least significant nibble of the MAC address's least significant address byte.

Example: "00:1A:07:AC:22:09" = 0x001A07AC2209

hex_lower_case — Select formatting the MAC address string with upper- or lower-case ASCII characters:

| | |
|---|---|
| DEF_NO | Format MAC address string with upper-case characters |
| DEF_YES | Format MAC address string with lower-case characters |

| | | |
|---|---|---|
| hex_colon_sep | Select formatting the MAC address string with colon (':') or dash ('-') characters to separate the MAC address hexadecimal bytes: | |
| | DEF_NO | Separate MAC address bytes with hyphen characters |
| | DEF_YES | Separate MAC address bytes with colon characters |
| perr | Pointer to variable that will receive the return error code from this function: | |
| | NET_ASCII_ERR_NONE<br>NET_ASCII_ERR_NULL_PTR | |

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-4-3 NetASCII_Str_to_IP()

Convert a string of an IPv4 address in dotted-decimal notation to an IPv4 address in host-order.

### FILES

net_ascii.h/net_ascii.c

### PROTOTYPE

```
NET_IP_ADDR NetASCII_Str_to_IP(CPU_CHAR  *paddr_ip_ascii,
                               NET_ERR   *perr);
```

### ARGUMENTS

paddr_ip_ascii — Pointer to an ASCII string that contains a dotted-decimal IPv4 address. Each decimal byte of the IPv4 address string must be separated by a dot, or period, character ('.'). Note that the first ASCII character in the string is the most significant nibble of the IP address's most significant byte and that the last character in the string is the least significant nibble of the IP address's least significant byte.

Example: "10.10.1.65" = 0x0A0A0141

perr — Pointer to variable that will receive the return error code from this function:

NET_ASCII_ERR_NONE
NET_ASCII_ERR_NULL_PTR
NET_ASCII_ERR_INVALID_STR_LEN
NET_ASCII_ERR_INVALID_CHAR
NET_ASCII_ERR_INVALID_CHAR_LEN
NET_ASCII_ERR_INVALID_CHAR_VAL
NET_ASCII_ERR_INVALID_CHAR_SEQ

## RETURNED VALUE

Returns the IPv4 address, represented by the IPv3 address string, in host-order, if no errors.

NET_IP_ADDR_NONE, otherwise.

## REQUIRED CONFIGURATION

None.

## NOTES / WARNINGS

RFC 1983 states that "dotted decimal notation… refers [to] IP addresses of the form A.B.C.D; where each letter represents, in decimal, one byte of a four-byte IP address". In other words, the dotted-decimal notation separates four decimal byte values by the dot, or period, character ('.'). Each decimal value represents one byte of the IP address starting with the most significant byte in network order.

### IPv4 Address Examples

| DOTTED DECIMAL NOTATION | HEXADECIMAL EQUIVALENT |
|---|---|
| 127.0.0.1 | 0x7F000001 |
| 192.168.1.64 | 0xC0A80140 |
| 255.255.255.0 | 0xFFFFFF00 |
| MSB ..... LSB | MSB .... LSB |

MSB Most Significant Byte in Dotted-Decimal IP Address

LSB Least Significant Byte in Dotted-Decimal IP Address

The IPv4 dotted-decimal ASCII string *must* include *only* decimal values and the dot, or period, character ('.'); all other characters are trapped as invalid, including any leading or trailing characters. The ASCII string *must* include exactly four decimal values separated by exactly three dot characters. Each decimal value *must not* exceed the maximum byte value (i.e., 255), or exceed the maximum number of digits for each byte (i.e., 3) including any leading zeros.

## C-4-4 NetASCII_Str_to_MAC()

Convert a hexadecimal address string to a Media Access Control (MAC) address.

### FILES

net_ascii.h/net_ascii.c

### PROTOTYPE

```
void NetASCII_Str_to_MAC(CPU_CHAR    *paddr_mac_ascii,
                         CPU_INT08U  *paddr_mac,
                         NET_ERR     *perr);
```

### ARGUMENTS

paddr_mac_ascii — Pointer to an ASCII string that contains hexadecimal bytes separated by colons or dashes that represents the MAC address. Each hexadecimal byte of the MAC address string must be separated by either the colon (':') or dash ('-') characters. Note that the first ASCII character in the string is the most significant nibble of the MAC address's most significant byte and that the last character in the string is the least significant nibble of the MAC address's least significant address byte.

Example: "00:1A:07:AC:22:09" = 0x001A07AC2209

paddr_mac — Pointer to a memory buffer of size greater than or equal to NET_ASCII_NBR_OCTET_ADDR_MAC bytes to receive the MAC address.

perr — Pointer to variable that will receive the return error code from this function:

NET_ASCII_ERR_NONE
NET_ASCII_ERR_NULL_PTR
NET_ASCII_ERR_INVALID_STR_LEN
NET_ASCII_ERR_INVALID_CHAR
NET_ASCII_ERR_INVALID_CHAR_LEN
NET_ASCII_ERR_INVALID_CHAR_SEQ

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-5 NETWORK BUFFER FUNCTIONS

### C-5-1 NetBuf_PoolStatGet()

Get an interface's Network Buffers' statistics pool.

#### FILES

net_buf.h/net_buf.c

#### PROTOTYPE

```
NET_STAT_POOL NetBuf_PoolStatGet(NET_IF_NBR if_nbr);
```

#### ARGUMENTS

if_nbr  Interface number to get Network Buffer statistics.

#### RETURNED VALUE

Network Buffers' statistics pool, if no errors.

NULL statistics pool, otherwise.

#### REQUIRED CONFIGURATION

None.

#### NOTES / WARNINGS

None.

## C-5-2 NetBuf_PoolStatResetMaxUsed()

Reset an interface's Network Buffers' statistics pool's maximum number of entries used.

### FILES

net_buf.h/net_buf.c

### PROTOTYPE

```
void NetBuf_PoolStatResetMaxUsed(NET_IF_NBR if_nbr);
```

### ARGUMENTS

if_nbr  Interface number to reset Network Buffer statistics.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-5-3 NetBuf_RxLargePoolStatGet()

Get an interface's large receive buffers' statistics pool.

### FILES

net_buf.h/net_buf.c

### PROTOTYPE

```
NET_STAT_POOL NetBuf_RxLargePoolStatGet(NET_IF_NBR if_nbr);
```

### ARGUMENTS

if_nbr  Interface number to get Network Buffer statistics.

### RETURNED VALUE

Large receive buffers' statistics pool, if no errors.

NULL statistics pool, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-5-4 NetBuf_RxLargePoolStatResetMaxUsed()

Reset an interface's large receive buffers' statistics pool's maximum number of entries used.

### FILES

net_buf.h/net_buf.c

### PROTOTYPE

```
void NetBuf_RxLargePoolStatResetMaxUsed(NET_IF_NBR if_nbr);
```

### ARGUMENTS

if_nbr  Interface number to reset Network Buffer statistics.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-5-5 NetBuf_TxLargePoolStatGet()

Get an interface's large transmit buffers' statistics pool.

### FILES

net_buf.h/net_buf.c

### PROTOTYPE

```
NET_STAT_POOL NetBuf_TxLargePoolStatGet(NET_IF_NBR if_nbr);
```

### ARGUMENTS

if_nbr  Interface number to get Network Buffer statistics.

### RETURNED VALUE

Large transmit buffers' statistics pool, if no errors.

NULL statistics pool, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-5-6 NetBuf_TxLargePoolStatResetMaxUsed()

Reset an interface's large transmit buffers' statistics pool's maximum number of entries used.

### FILES

net_buf.h/net_buf.c

### PROTOTYPE

```
void NetBuf_TxLargePoolStatResetMaxUsed(NET_IF_NBR if_nbr);
```

### ARGUMENTS

if_nbr  Interface number to reset Network Buffer statistics.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-5-7 NetBuf_TxSmallPoolStatGet()

Get an interface's small transmit buffers' statistics pool.

### FILES

net_buf.h/net_buf.c

### PROTOTYPE

```
NET_STAT_POOL NetBuf_TxSmallPoolStatGet(NET_IF_NBR if_nbr);
```

### ARGUMENTS

if_nbr  Interface number to get Network Buffer statistics.

### RETURNED VALUE

Small transmit buffers' statistics pool, if no errors.

NULL statistics pool, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-5-8 NetBuf_TxSmallPoolStatResetMaxUsed()

Reset an interface's small transmit buffers' statistics pool's maximum number of entries used.

### FILES

net_buf.h/net_buf.c

### PROTOTYPE

```
void NetBuf_TxSmallPoolStatResetMaxUsed(NET_IF_NBR if_nbr);
```

### ARGUMENTS

if_nbr  Interface number to reset Network Buffer statistics.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

# C-6 NETWORK CONNECTION FUNCTIONS

## C-6-1 NetConn_CfgAccessedTh()

Configure network connection access promotion threshold.

### FILES

net_conn.h/net_conn.c

### PROTOTYPE

```
CPU_BOOLEAN NetConn_CfgAccessedTh(CPU_INT16U nbr_access);
```

### ARGUMENTS

nbr_access Desired number of accesses before network connection is promoted.

### RETURNED VALUE

DEF_OK, network connection access promotion threshold configured.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-6-2 NetConn_PoolStatGet()

Get Network Connections' statistics pool.

### FILES

net_conn.h/net_conn.c

### PROTOTYPE

```
NET_STAT_POOL NetConn_PoolStatGet(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

Network Connections' statistics pool, if no errors.

NULL statistics pool, otherwise.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-6-3 NetConn_PoolStatResetMaxUsed()

Reset Network Connections' statistics pool's maximum number of entries used.

### FILES

net_conn.h/net_conn.c

### PROTOTYPE

```
void NetConn_PoolStatResetMaxUsed(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-7 NETWORK DEBUG FUNCTIONS

### C-7-1 NetDbg_CfgMonTaskTime()

Configure Network Debug Monitor time.

#### FILES

net_dbg.h/net_dbg.c

#### PROTOTYPE

```
CPU_BOOLEAN NetDbg_CfgMonTaskTime(CPU_INT16U time_sec);
```

#### ARGUMENTS

time_sec  Desired value for Network Debug Monitor task time (in seconds).

#### RETURNED VALUE

DEF_OK,  Network Debug Monitor task time successfully configured.

DEF_FAIL,  otherwise.

#### REQUIRED CONFIGURATION

Available only if the Network Debug Monitor task is enabled (see section 11-2 “Network Debug Monitor Task” on page 297).

#### NOTES / WARNINGS

None.

## C-7-2 NetDbg_CfgRsrcARP_CacheThLo()

Configure ARP caches' low resource threshold.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
CPU_BOOLEAN NetDbg_CfgRsrcARP_CacheThLo(CPU_INT08U th_pct,
                                        CPU_INT08U hyst_pct);
```

### ARGUMENTS

th_pct  Desired percentage of ARP caches available to trip low resources.

hyst_pct  Desired percentage of ARP caches freed to clear low resources.

### RETURNED VALUE

DEF_OK,  ARP caches' low resource threshold successfully configured.

DEF_FAIL,  otherwise.

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742) and/or if the Network Debug Monitor task is enabled (Se section 11-2 on page 297) *and* if an appropriate network interface layer is present (e.g., Ethernet; see section D-7-3 on page 748).

### NOTES / WARNINGS

None.

## C-7-3 NetDbg_CfgRsrcBufThLo()

Configure an interface's network buffers' low resource threshold.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
CPU_BOOLEAN NetDbg_CfgRsrcBufThLo(NET_IF_NBR if_nbr,
                                  CPU_INT08U th_pct,
                                  CPU_INT08U hyst_pct);
```

### ARGUMENTS

| | |
|---|---|
| if_nbr | Interface number to configure low threshold and hysteresis. |
| th_pct | Desired percentage of network buffers available to trip low resources. |
| hyst_pct | Desired percentage of network buffers freed to clear low resources. |

### RETURNED VALUE

| | |
|---|---|
| DEF_OK, | Network buffers' low resource threshold successfully configured. |
| DEF_FAIL, | otherwise. |

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742) and/or if the Network Debug Monitor task is enabled (see section 11-2 on page 297).

### NOTES / WARNINGS

None.

## C-7-4 NetDbg_CfgRsrcBufRxLargeThLo()

Configure an interface's large receive buffers' low resource threshold.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
CPU_BOOLEAN NetDbg_CfgRsrcBufRxLargeThLo(NET_IF_NBR if_nbr,
                                         CPU_INT08U th_pct,
                                         CPU_INT08U hyst_pct);
```

### ARGUMENTS

`if_nbr` Interface number to configure low threshold & hysteresis.

`th_pct` Desired percentage of large receive buffers available to trip low resources.

`hyst_pct` Desired percentage of large receive buffers freed to clear low resources.

### RETURNED VALUE

`DEF_OK`, Large receive buffers' low resource threshold successfully configured.

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_DBG_CFG_DBG_STATUS_EN` is enabled (see section D-2-2 on page 742) and/or if the Network Debug Monitor task is enabled (see section 11-2 on page 297).

### NOTES / WARNINGS

None.

## C-7-5 NetDbg_CfgRsrcBufTxLargeThLo()

Configure an interface's large transmit buffers' low resource threshold.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
CPU_BOOLEAN NetDbg_CfgRsrcBufTxLargeThLo(NET_IF_NBR if_nbr,
                                         CPU_INT08U th_pct,
                                         CPU_INT08U hyst_pct);
```

### ARGUMENTS

`if_nbr` Interface number to configure low threshold and hysteresis.

`th_pct` Desired percentage of large transmit buffers available to trip low resources.

`hyst_pct` Desired percentage of large transmit buffers freed to clear low resources.

### RETURNED VALUE

`DEF_OK`, Large transmit buffers' low resource threshold successfully configured.

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_DBG_CFG_DBG_STATUS_EN` is enabled (see section D-2-2 on page 742) and/or if the Network Debug Monitor task is enabled (see section 11-2 on page 297).

### NOTES / WARNINGS

None.

## C-7-6 NetDbg_CfgRsrcBufTxSmallThLo()

Configure an interface's small transmit buffers' low resource threshold.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
CPU_BOOLEAN NetDbg_CfgRsrcBufTxSmallThLo(NET_IF_NBR if_nbr,
                                         CPU_INT08U th_pct,
                                         CPU_INT08U hyst_pct);
```

### ARGUMENTS

| | |
|---|---|
| if_nbr | Interface number to configure low threshold & hysteresis. |
| th_pct | Desired percentage of small transmit buffers available to trip low resources. |
| hyst_pct | Desired percentage of small transmit buffers freed to clear low resources. |

### RETURNED VALUE

| | |
|---|---|
| DEF_OK, | Small transmit buffers' low resource threshold successfully configured. |
| DEF_FAIL, | otherwise. |

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742) and/or if the Network Debug Monitor task is enabled (see section 11-2 on page 297).

### NOTES / WARNINGS

None.

## C-7-7 NetDbg_CfgRsrcConnThLo()

Configure network connections' low resource threshold.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
CPU_BOOLEAN NetDbg_CfgRsrcConnThLo(CPU_INT08U th_pct,
                                   CPU_INT08U hyst_pct);
```

### ARGUMENTS

th_pct Desired percentage of network connections available to trip low resources.

hyst_pct Desired percentage of network connections freed to clear low resources.

### RETURNED VALUE

DEF_OK, Network connections' low resource threshold successfully configured.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742) and/or if the Network Debug Monitor task is enabled (see section 11-2 on page 297) *and* if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-7-8 NetDbg_CfgRsrcSockThLo()

Configure network sockets' low resource threshold.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
CPU_BOOLEAN NetDbg_CfgRsrcSockThLo(CPU_INT08U th_pct,
                                   CPU_INT08U hyst_pct);
```

### ARGUMENTS

th_pct Desired percentage of network sockets available to trip low resources.

hyst_pct Desired percentage of network sockets freed to clear low resources.

### RETURNED VALUE

DEF_OK, Network sockets' low resource threshold successfully configured.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742) and/or if the Network Debug Monitor task is enabled (see section 11-2 on page 297) *and* if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-7-9 NetDbg_CfgRsrcTCP_ConnThLo()

Configure TCP connections' low resource threshold.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
CPU_BOOLEAN NetDbg_CfgRsrcTCP_ConnThLo(CPU_INT08U th_pct,
                                       CPU_INT08U hyst_pct);
```

### ARGUMENTS

th_pct Desired percentage of TCP connections available to trip low resources.

hyst_pct Desired percentage of TCP connections freed to clear low resources.

### RETURNED VALUE

DEF_OK, TCP connections' low resource threshold successfully configured.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742) and/or if the Network Debug Monitor task is enabled (see section 11-2 on page 297) *and* if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-7-10 NetDbg_CfgRsrcTmrThLo()

Configure network timers' low resource threshold.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
CPU_BOOLEAN NetDbg_CfgRsrcTmrThLo(CPU_INT08U th_pct,
                                  CPU_INT08U hyst_pct);
```

### ARGUMENTS

th_pct  Desired percentage of network timers available to trip low resources.

hyst_pct  Desired percentage of network timers freed to clear low resources.

### RETURNED VALUE

DEF_OK,  Network timers' low resource threshold successfully configured.

DEF_FAIL,  otherwise.

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742) and/or if the Network Debug Monitor task is enabled (see section 11-2 on page 297).

### NOTES / WARNINGS

None.

## C-7-11 NetDbg_ChkStatus()

Return the current run-time status of certain µC/TCP-IP conditions.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
NET_DBG_STATUS NetDbg_ChkStatus(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

NET_DBG_STATUS_OK, if all network conditions are OK (i.e., no warnings, faults, or errors currently exist);

Otherwise, returns the following status condition codes logically **OR**'d:

| | |
|---|---|
| NET_DBG_STATUS_FAULT | Some network status fault(s) |
| NET_DBG_STATUS_RSRC_LOST | Some network resources lost. |
| NET_DBG_STATUS_RSRC_LO | Some network resources low. |
| NET_DBG_STATUS_FAULT_BUF | Some network buffer management fault(s). |
| NET_DBG_STATUS_FAULT_TMR | Some network timer management fault(s). |
| NET_DBG_STATUS_FAULT_CONN | Some network connection management fault(s). |
| NET_DBG_STATUS_FAULT_TCP | Some TCP layer fault(s). |

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742).

### NOTES / WARNINGS

None.

## C-7-12 NetDbg_ChkStatusBufs()

Return the current run-time status of µC/TCP-IP network buffers.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
NET_DBG_STATUS NetDbg_ChkStatusBufs(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

NET_DBG_STATUS_OK, if all network buffer conditions are OK (i.e., no warnings, faults, or errors currently exist);

Otherwise, returns the following status condition codes logically **OR**'d:

| | |
|---|---|
| NET_DBG_SF_BUF | Some Network Buffer management fault(s). |

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742).

### NOTES / WARNINGS

Debug status information for network buffers has been deprecated in µC/TCP-IP.

## C-7-13 NetDbg_ChkStatusConns()

Return the current run-time status of µC/TCP-IP network connections.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
NET_DBG_STATUS NetDbg_ChkStatusConns(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

NET_DBG_STATUS_OK, if all network connection conditions are OK (i.e., no warnings, faults, or errors currently exist);

Otherwise, returns the following status condition codes logically **OR**'d:

| | |
|---|---|
| NET_DBG_SF_CONN | Some network connection management fault(s). |
| NET_DBG_SF_CONN_TYPE | Network connection invalid type. |
| NET_DBG_SF_CONN_FAMILY | Network connection invalid family. |
| NET_DBG_SF_CONN_PROTOCOL_IX_NBR_MAX | Network connection invalid protocol list index number. |
| NET_DBG_SF_CONN_ID | Network connection invalid ID. |
| NET_DBG_SF_CONN_ID_NONE | Network connection with no connection IDs. |

| | |
|---|---|
| NET_DBG_SF_CONN_ID_UNUSED | Network connection linked to unused connection. |
| NET_DBG_SF_CONN_LINK_TYPE | Network connection invalid link type. |
| NET_DBG_SF_CONN_LINK_UNUSED | Network connection link unused. |
| NET_DBG_SF_CONN_LINK_BACK_TO_CONN | Network connection invalid link back to same connection. |
| NET_DBG_SF_CONN_LINK_NOT_TO_CONN | Network connection invalid link not back to same connection. |
| NET_DBG_SF_CONN_LINK_NOT_IN_LIST | Network connection not in appropriate connection list. |
| NET_DBG_SF_CONN_POOL_TYPE | Network connection invalid pool type. |
| NET_DBG_SF_CONN_POOL_ID | Network connection invalid pool id. |
| NET_DBG_SF_CONN_POOL_DUP | Network connection pool contains duplicate connection(s). |
| NET_DBG_SF_CONN_POOL_NBR_MAX | Network connection pool number of connections greater than maximum number of connections. |
| NET_DBG_SF_CONN_LIST_NBR_NOT_SOLITARY | Network connection lists number of connections not equal to solitary connection. |
| NET_DBG_SF_CONN_USED_IN_POOL | Network connection used but in pool. |
| NET_DBG_SF_CONN_USED_NOT_IN_LIST | Network connection used but not in list. |
| NET_DBG_SF_CONN_UNUSED_IN_LIST | Network connection unused but in list. |

| | |
|---|---|
| NET_DBG_SF_CONN_UNUSED_NOT_IN_POOL | Network connection unused but not in pool. |
| NET_DBG_SF_CONN_IN_LIST_IN_POOL | Network connection in list and in pool. |
| NET_DBG_SF_CONN_NOT_IN_LIST_NOT_IN_POOL | Network connection not in list nor in pool. |

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742) *and* if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-7-14 NetDbg_ChkStatusRsrcLost() / NetDbg_MonTaskStatusGetRsrcLost()

Return whether any µC/TCP-IP resources are currently lost.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPES

```
NET_DBG_STATUS NetDbg_ChkStatusRsrcLost(void);
NET_DBG_STATUS NetDbg_MonTaskStatusGetRsrcLost(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

NET_DBG_STATUS_OK, if no network resources are lost; otherwise, returns the following status condition codes logically **OR**'d:

| | |
|---|---|
| NET_DBG_SF_RSRC_LOST | Some network resources lost. |
| NET_DBG_SF_RSRC_LOST_BUF_SMALL | Some network SMALL buffer resources lost. |
| NET_DBG_SF_RSRC_LOST_BUF_LARGE | Some network LARGE buffer resources lost. |
| NET_DBG_SF_RSRC_LOST_TMR | Some network timer resources lost. |
| NET_DBG_SF_RSRC_LOST_CONN | Some network connection resources lost. |
| NET_DBG_SF_RSRC_LOST_ARP_CACHE | Some network ARP cache resources lost. |
| NET_DBG_SF_RSRC_LOST_TCP_CONN | Some network TCP connection resources lost. |
| NET_DBG_SF_RSRC_LOST_SOCK | Some network socket resources lost. |

### REQUIRED CONFIGURATION

`NetDbg_ChkStatusRsrcLost()` available only if `NET_DBG_CFG_DBG_STATUS_EN` is enabled (see section D-2-2 on page 742). `NetDbg_MonTaskStatusGetRsrcLost()` available only if the Network Debug Monitor task is enabled (see section 11-2 on page 297).

### NOTES / WARNINGS

`NetDbg_ChkStatusRsrcLost()` checks network conditions lost status inline, whereas `NetDbg_MonTaskStatusGetRsrcLost()` checks the Network Debug Monitor task's last known lost status.

## C-7-15 NetDbg_ChkStatusRsrcLo() / NetDbg_MonTaskStatusGetRsrcLo()

Return whether any µC/TCP-IP resources are currently low.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPES

```
NET_DBG_STATUS NetDbg_ChkStatusRsrcLo(void);
NET_DBG_STATUS NetDbg_MonTaskStatusGetRsrcLo(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

NET_DBG_STATUS_OK, if no network resources are low; otherwise, returns the following status condition codes logically **OR**'d:

| | |
|---|---|
| NET_DBG_SF_RSRC_LO | Some network resources low. |
| NET_DBG_SF_RSRC_LO_BUF_SMALL | Network SMALL buffer resources low |
| NET_DBG_SF_RSRC_LO_BUF_LARGE | Network LARGE buffer resources low. |
| NET_DBG_SF_RSRC_LO_TMR | Network timer resources low. |
| NET_DBG_SF_RSRC_LO_CONN | Network connection resources low. |
| NET_DBG_SF_RSRC_LO_ARP_CACHE | Network ARP cache resources low. |
| NET_DBG_SF_RSRC_LO_TCP_CONN | Network TCP connection resources low. |
| NET_DBG_SF_RSRC_LO_SOCK | Network socket resources low. |

### REQUIRED CONFIGURATION

`NetDbg_ChkStatusRsrcLo()` available only if `NET_DBG_CFG_DBG_STATUS_EN` is enabled (see section D-2-2 on page 742). `NetDbg_MonTaskStatusGetRsrcLo()` available only if the Network Debug Monitor task is enabled (see section 11-2 on page 297).

### NOTES / WARNINGS

`NetDbg_ChkStatusRsrcLo()` checks network conditions low status inline, whereas `NetDbg_MonTaskStatusGetRsrcLo()` checks the Network Debug Monitor task's last known low status.

## C-7-16 NetDbg_ChkStatusTCP()

Return the current run-time status of µC/TCP-IP TCP connections.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
NET_DBG_STATUS NetDbg_ChkStatusTCP(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

NET_DBG_STATUS_OK, if all TCP layer conditions are OK (i.e., no warnings, faults, or errors currently exist); otherwise, returns the following status condition codes logically **OR**'d:

| | |
|---|---|
| NET_DBG_SF_TCP | Some TCP layer fault(s). |
| NET_DBG_SF_TCP_CONN_TYPE | TCP connection invalid type. |
| NET_DBG_SF_TCP_CONN_ID | TCP connection invalid id. |
| NET_DBG_SF_TCP_CONN_LINK_TYPE | TCP connection invalid link type. |
| NET_DBG_SF_TCP_CONN_LINK_UNUSED | TCP connection link unused. |
| NET_DBG_SF_TCP_CONN_POOL_TYPE | TCP connection invalid pool type. |
| NET_DBG_SF_TCP_CONN_POOL_ID | TCP connection invalid pool id. |
| NET_DBG_SF_TCP_CONN_POOL_DUP | TCP connection pool contains duplicate connection(s). |

| | |
|---|---|
| NET_DBG_SF_TCP_CONN_POOL_NBR_MAX | TCP connection pool number of connections greater than maximum number of connections. |
| NET_DBG_SF_TCP_CONN_USED_IN_POOL | TCP connection used in pool. |
| NET_DBG_SF_TCP_CONN_UNUSED_NOT_IN_POOL | TCP connection unused *not* in pool. |
| NET_DBG_SF_TCP_CONN_Q | Some TCP connection queue fault(s). |
| NET_DBG_SF_TCP_CONN_Q_BUF_TYPE | TCP connection queue buffer invalid type. |
| NET_DBG_SF_TCP_CONN_Q_BUF_UNUSED | TCP connection queue buffer unused. |
| NET_DBG_SF_TCP_CONN_Q_LINK_TYPE | TCP connection queue buffer invalid link type. |
| NET_DBG_SF_TCP_CONN_Q_LINK_UNUSED | TCP connection queue buffer link unused. |
| NET_DBG_SF_TCP_CONN_Q_BUF_DUP | TCP connection queue contains duplicate buffer(s). |

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742) *and* if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-7-17 NetDbg_ChkStatusTmrs()

Return the current run-time status of µC/TCP-IP network timers.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
NET_DBG_STATUS NetDbg_ChkStatusTmrs(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

NET_DBG_STATUS_OK, if all network timer conditions are OK (i.e., no warnings, faults, or errors currently exist);

Otherwise, returns the following status condition codes logically **OR**'d:

| | |
|---|---|
| NET_DBG_SF_TMR | Some network timer management fault(s). |
| NET_DBG_SF_TMR_TYPE | Network timer invalid type. |
| NET_DBG_SF_TMR_ID | Network timer invalid id. |
| NET_DBG_SF_TMR_LINK_TYPE | Network timer invalid link type. |
| NET_DBG_SF_TMR_LINK_UNUSED | Network timer link unused. |
| NET_DBG_SF_TMR_LINK_BACK_TO_TMR | Network timer invalid link back to same timer. |
| NET_DBG_SF_TMR_LINK_TO_TMR | Network timer invalid link back to timer. |
| NET_DBG_SF_TMR_POOL_TYPE | Network timer invalid pool type. |

| | |
|---|---|
| NET_DBG_SF_TMR_POOL_ID | Network timer invalid pool id. |
| NET_DBG_SF_TMR_POOL_DUP | Network timer pool contains duplicate timer(s). |
| NET_DBG_SF_TMR_POOL_NBR_MAX | Network timer pool number of timers greater than maximum number of timers. |
| NET_DBG_SF_TMR_LIST_TYPE | Network Timer task list invalid type. |
| NET_DBG_SF_TMR_LIST_ID | Network Timer task list invalid id. |
| NET_DBG_SF_TMR_LIST_DUP | Network Timer task list contains duplicate timer(s). |
| NET_DBG_SF_TMR_LIST_NBR_MAX | Network Timer task list number of timers greater than maximum number of timers. |
| NET_DBG_SF_TMR_LIST_NBR_USED | Network Timer task list number of timers *not* equal to number of used timers. |
| NET_DBG_SF_TMR_USED_IN_POOL | Network timer used but in pool. |
| NET_DBG_SF_TMR_UNUSED_NOT_IN_POOL | Network timer unused but *not* in pool. |
| NET_DBG_SF_TMR_UNUSED_IN_LIST | Network timer unused but in Timer task list. |

### REQUIRED CONFIGURATION

Available only if NET_DBG_CFG_DBG_STATUS_EN is enabled (see section D-2-2 on page 742).

### NOTES / WARNINGS

None.

## C-7-18 NetDbg_MonTaskStatusGetRsrcLost()

Return whether any µC/TCP-IP resources are currently lost.

See section C-7-14 on page 488 for more information.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
NET_DBG_STATUS NetDbg_MonTaskStatusGetRsrcLost(void);
```

## C-7-19 NetDbg_MonTaskStatusGetRsrcLo()

Return whether any µC/TCP-IP resources are currently low.

See section C-7-15 on page 490 for more information.

### FILES

net_dbg.h/net_dbg.c

### PROTOTYPE

```
NET_DBG_STATUS NetDbg_MonTaskStatusGetRsrcLo(void);
```

## C-8 ICMP FUNCTIONS

### C-8-1 NetICMP_CfgTxSrcQuenchTh()

Configure ICMP transmit source quench entry's access transmit threshold.

#### FILES

net_icmp.h/net_icmp.c

#### PROTOTYPE

```
CPU_BOOLEAN NetICMP_CfgTxSrcQuenchTh(CPU_INT16U th);
```

#### ARGUMENTS

th — Desired number of received IP packets from a specific IP source host that trips the transmission of an additional ICMP Source Quench Error Message.

#### RETURNED VALUE

DEF_OK, ICMP transmit source quench threshold configured.

DEF_FAIL, otherwise.

#### REQUIRED CONFIGURATION

None.

#### NOTES / WARNINGS

None.

# C-9 NETWORK INTERFACE FUNCTIONS

## C-9-1 NetIF_Add()

Add a network device and hardware as a network interface.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
NET_IF_NBR NetIF_Add(void    *if_api,
                     void    *dev_api,
                     void    *dev_bsp,
                     void    *dev_cfg,
                     void    *phy_api,
                     void    *phy_cfg,
                     NET_ERR *perr);
```

### ARGUMENTS

`if_api` Pointer to the desired link-layer API for this network interface and device hardware. In most cases, the desired link-layer interface will point to the Ethernet API, `NetIF_API_Ether` (see also section L16-1(1) on page 362).

`dev_api` Pointer to the desired device driver API for this network interface (see also section 5-3-3 “Adding an Ethernet Interface” on page 94 and section 5-4-2 “Adding a Wireless Interface” on page 100).

`dev_bsp` Pointer to the specific device's BSP interface for this network interface (see also Chapter 6, “Network Board Support Package” on page 121).

`dev_cfg` Pointer to a configuration structure used to configure the device hardware for the specific network interface (see also Chapter 5, “Network Interface Configuration” on page 77).

phy_api — Pointer to an optional physical layer device driver API for this network interface. In most cases, the generic physical layer device API will be used, NetPhy_API_Generic, but for Ethernet devices that have non-MII or non-RMII compliant physical layer components, another device-specific physical layer device driver API may be necessary. See also section 7-4 “Ethernet PHY API Implementation” on page 155.

phy_cfg — Pointer to a configuration structure used to configure the physical layer hardware for the specific network interface (see also section 5-3-2 “Ethernet PHY Configuration” on page 92).

perr — Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_NULL_PTR
NET_IF_ERR_INVALID_IF
NET_IF_ERR_INVALID_CFG
NET_IF_ERR_NONE_AVAIL
NET_BUF_ERR_POOL_INIT
NET_BUF_ERR_INVALID_POOL_TYPE
NET_BUF_ERR_INVALID_POOL_ADDR
NET_BUF_ERR_INVALID_POOL_SIZE
NET_BUF_ERR_INVALID_POOL_QTY
NET_BUF_ERR_INVALID_SIZE
NET_OS_ERR_INIT_DEV_TX_RDY
NET_OS_ERR_INIT_DEV_TX_RDY_NAME
NET_OS_ERR_LOCK

### RETURNED VALUE

Network interface number, if device and hardware successfully added;

NET_IF_NBR_NONE, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The first network interface added and started is the default interface used for all default communication. See also section C-12-1 on page 542 and section C-12-2 on page 544.

Both physical layer API and configuration parameters *must* ,either be specified or passed `NULL` pointers.

Additional error codes may be returned by the specific interface or device driver.

See section 16-1-1 “Adding Network Interfaces” on page 361 for a detailed example of how to add an interface.

## C-9-2 NetIF_AddrHW_Get()

Get network interface's hardware address.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
void NetIF_AddrHW_Get(NET_IF_NBR  if_nbr,
                      CPU_INT08U *paddr_hw,
                      CPU_INT08U *paddr_len,
                      NET_ERR    *perr);
```

### ARGUMENTS

`if_nbr` Network interface number to get the hardware address.

`paddr_hw` Pointer to variable that will receive the hardware address.

`paddr_len` Pointer to a variable to pass the length of the address buffer pointed to by `paddr_hw` and return the size of the returned hardware address, if no errors.

`perr` Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_NULL_PTR
NET_IF_ERR_NULL_FNCT
NET_IF_ERR_INVALID_IF
NET_IF_ERR_INVALID_CFG
NET_IF_ERR_INVALID_ADDR_LEN
NET_OS_ERR_LOCK

### RETURNED VALUE

None.

## REQUIRED CONFIGURATION

None.

## NOTES / WARNINGS

The hardware address is returned in network-order; i.e., the pointer to the hardware address points to the highest-order byte. Additional error codes may be returned by the specific interface or device driver.

## C-9-3 NetIF_AddrHW_IsValid()

Validate a network interface hardware address.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
CPU_BOOLEAN NetIF_AddrHW_IsValid(NET_IF_NBR  if_nbr,
                                 CPU_INT08U  *paddr_hw,
                                 NET_ERR     *perr);
```

### ARGUMENTS

if_nbr Network interface number to validate the hardware address.

paddr_hw Pointer to a network interface hardware address.

perr Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_NULL_PTR
NET_IF_ERR_NULL_FNCT
NET_IF_ERR_INVALID_IF
NET_IF_ERR_INVALID_CFG
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_YES if hardware address valid;

DEF_NO otherwise.

## REQUIRED CONFIGURATION

None.

## NOTES / WARNINGS

None.

## C-9-4 NetIF_AddrHW_Set()

Set network interface's hardware address.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
void NetIF_AddrHW_Set(NET_IF_NBR  if_nbr,
                      CPU_INT08U *paddr_hw,
                      CPU_INT08U  addr_len,
                      NET_ERR    *perr);
```

### ARGUMENTS

if_nbr Network interface number to set hardware address.

paddr_hw Pointer to a hardware address.

addr_len Length of hardware address.

perr Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_NULL_PTR
NET_IF_ERR_NULL_FNCT
NET_IF_ERR_INVALID_IF
NET_IF_ERR_INVALID_CFG
NET_IF_ERR_INVALID_STATE
NET_IF_ERR_INVALID_ADDR
NET_IF_ERR_INVALID_ADDR_LEN
NET_OS_ERR_LOCK

### RETURNED VALUE

None.

## REQUIRED CONFIGURATION

None.

## NOTES / WARNINGS

The hardware address *must* be in network-order (i.e., the pointer to the hardware address *must* point to the highest-order byte).

The network interface *must* be stopped *before* setting a new hardware address, which does *not* take effect until the interface is re-started.

Additional error codes may be returned by the specific interface or device driver.

## C-9-5 NetIF_CfgPerfMonPeriod()

Configure the network interface Performance Monitor Handler timeout.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
CPU_BOOLEAN NetIF_CfgPerfMonPeriod(CPU_INT16U timeout_ms);
```

### ARGUMENTS

timeout_ms Desired value for network interface Performance Monitor Handler timeout (in milliseconds).

### RETURNED VALUE

DEF_OK, Network interface Performance Monitor Handler timeout configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CTR_CFG_STAT_EN is enabled (see section D-4-1 on page 745).

### NOTES / WARNINGS

None.

## C-9-6 NetIF_CfgPhyLinkPeriod()

Configure network interface Physical Link State Handler timeout.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
CPU_BOOLEAN NetIF_CfgPhyLinkPeriod(CPU_INT16U timeout_ms);
```

### ARGUMENTS

timeout_ms Desired value for network interface Link State Handler timeout (in milliseconds).

### RETURNED VALUE

DEF_OK, Network interface Physical Link State Handler timeout configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-9-7 NetIF_GetRxDataAlignPtr()

Get an aligned pointer into a receive application data buffer.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
void  *NetIF_GetRxDataAlignPtr(NET_IF_NBR   if_nbr,
                               void        *p_data,
                               NET_ERR     *perr);
```

### ARGUMENTS

if_nbr Network interface number to get a receive application buffer's aligned data pointer.

p_data Pointer to receive application data buffer to get an aligned pointer into (see also Note #2).

perr Pointer to variable that will receive the return error code from this function :

NET_IF_ERR_NONE
NET_IF_ERR_NULL_PTR
NET_IF_ERR_INVALID_IF
NET_IF_ERR_ALIGN_NOT_AVAIL
NET_ERR_INIT_INCOMPLETE
NET_ERR_INVALID_TRANSACTION
NET_OS_ERR_LOCK

### RETURNED VALUE

Pointer to aligned receive application data buffer address, if no errors.

Pointer to NULL, otherwise.

### NOTES/WARNINGS #1

1 Optimal alignment between application data buffers and the network interface's network buffer data areas is *not* guaranteed, and is possible if, and only if, all of the following conditions are true:

- Network interface's network buffer data areas *must* be aligned to a multiple of the CPU's data word size.

Otherwise, a single, fixed alignment between application data buffers and network interface's buffer data areas is *not* possible.

2 Even when application data buffers and network buffer data areas are aligned in the best case, optimal alignment is *not* guaranteed for every read/write of data to/from application data buffers and network buffer data areas.

For any single read/write of data to/from application data buffers and network buffer data areas, optimal alignment occurs if, and only if, all of the following conditions are true:

- Data read/written to/from application data buffers to network buffer data areas *must* start on addresses with the same relative offset from CPU word-aligned addresses.

  In other words, the modulus of the specific read/write address in the application data buffer with the CPU's data word size *must* be equal to the modulus of the specific read/write address in the network buffer data area with the CPU's data word size.

  This condition *might not* be satisfied whenever:

  - Data is read/written to/from fragmented packets
  - Data is *not* maximally read/written to/from stream-type packets (e.g., TCP data segments)
  - Packets include variable number of header options (e.g., IP options)

However, even though optimal alignment between application data buffers and network buffer data areas is *not* guaranteed for every read/write; optimal alignment *should* occur more frequently, leading to improved network data throughput.

### NOTES/WARNINGS #2

Since the first aligned address in the application data buffer may be 0 to `(CPU_CFG_DATA_SIZE-1)` bytes after the application data buffer's starting address, the application data buffer *should* allocate and reserve an additional `(CPU_CFG_DATA_SIZE-1)` number of bytes.

However, the application data buffer's effective, useable size is still limited to its original declared size (before reserving additional bytes), and *should not* be increased by the additional, reserved bytes.

## C-9-8 NetIF_GetTxDataAlignPtr()

Get an aligned pointer into a transmit application data buffer.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
void  *NetIF_GetTxDataAlignPtr(NET_IF_NBR   if_nbr,
                               void        *p_data,
                               NET_ERR     *perr);
```

### ARGUMENTS

if_nbr Network interface number to get a transmit application buffer's aligned data pointer.

p_data Pointer to transmit application data buffer to get an aligned pointer into (see also Note #2b).

perr Pointer to variable that will receive the return error code from this function :

NET_IF_ERR_NONE
NET_IF_ERR_NULL_PTR
NET_IF_ERR_INVALID_IF
NET_IF_ERR_ALIGN_NOT_AVAIL
NET_ERR_INIT_INCOMPLETE
NET_ERR_INVALID_TRANSACTION
NET_OS_ERR_LOCK

### RETURNED VALUE

Pointer to aligned transmit application data buffer address, if no errors.

Pointer to NULL, otherwise.

## REQUIRED CONFIGURATION

None.

## NOTES/WARNINGS #1

1 Optimal alignment between application data buffers and the network interface's network buffer data areas is *not* guaranteed, and is possible if, and only if, all of the following conditions are true:

- Network interface's network buffer data areas *must* be aligned to a multiple of the CPU's data word size.

Otherwise, a single, fixed alignment between application data buffers and network interface's buffer data areas is *not* possible.

2 Even when application data buffers and network buffer data areas are aligned in the best case, optimal alignment is *not* guaranteed for every read/write of data to/from application data buffers and network buffer data areas.

For any single read/write of data to/from application data buffers and network buffer data areas, optimal alignment occurs if, and only if, all of the following conditions are true:

- Data read/written to/from application data buffers to network buffer data areas *must* start on addresses with the same relative offset from CPU word-aligned addresses.

  In other words, the modulus of the specific read/write address in the application data buffer with the CPU's data word size *must* be equal to the modulus of the specific read/write address in the network buffer data area with the CPU's data word size.

  This condition *might not* be satisfied whenever:

  - Data is read/written to/from fragmented packets
  - Data is *not* maximally read/written to/from stream-type packets (e.g., TCP data segments)
  - Packets include variable number of header options (e.g., IP options)

However, even though optimal alignment between application data buffers and network buffer data areas is *not* guaranteed for every read/write; optimal alignment *should not* occur more frequently, leading to improved network data throughput.

### NOTES/WARNINGS #2

Since the first aligned address in the application data buffer may be 0 to `(CPU_CFG_DATA_SIZE-1)` bytes after the application data buffer's starting address, the application data buffer *should* allocate and reserve an additional `(CPU_CFG_DATA_SIZE-1)` number of bytes.

However, the application data buffer's effective, useable size is still limited to its original declared size (before reserving additional bytes), and *should not* be increased by the additional, reserved bytes.

## C-9-9 NetIF_IO_Ctrl()

Handle network interface and/or device specific (I/O) control(s).

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
void NetIF_IO_Ctrl(NET_IF_NBR  if_nbr,
                   CPU_INT08U  opt,
                   void       *p_data,
                   NET_ERR    *perr);
```

### ARGUMENTS

if_nbr — Network interface number to handle (I/O) controls.

opt — Desired I/O control option code to perform; additional control options may be defined by the device driver:

NET_IF_IO_CTRL_LINK_STATE_GET
NET_IF_IO_CTRL_LINK_STATE_UPDATE

p_data — Pointer to variable that will receive the I/O control information.

perr — Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_NULL_PTR
NET_IF_ERR_NULL_FNCT
NET_IF_ERR_INVALID_IF
NET_IF_ERR_INVALID_CFG
NET_IF_ERR_INVALID_IO_CTRL_OPTNET_OS_ERR_LOCK

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Additional error codes may be returned by the specific interface or device driver.

## C-9-10 NetIF_IsEn()

Validate network interface as enabled.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
CPU_BOOLEAN NetIF_IsEn(NET_IF_NBR  if_nbr,
                       NET_ERR    *perr);
```

### ARGUMENTS

if_nbr  Network interface number to validate.

perr  Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_YES  network interface valid and enabled;

DEF_NO  network interface invalid or disabled.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-9-11 NetIF_IsEnCfgd()

Validate configured network interface as enabled.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
CPU_BOOLEAN NetIF_IsEnCfgd(NET_IF_NBR  if_nbr,
                           NET_ERR    *perr);
```

### ARGUMENTS

if_nbr Network interface number to validate.

perr Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_YES network interface valid and enabled;

DEF_NO network interface invalid or disabled.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-9-12 NetIF_ISR_Handler()

Handle a network interface's device interrupts.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
void NetIF_ISR_Handler (NET_IF_NBR        if_nbr,
                        NET_DEV_ISR_TYPE  type,
                        NET_ERR          *perr);
```

### ARGUMENTS

if_nbr Network interface number to handler device interrupts.

type Device interrupt type(s) to handle:

| | |
|---|---|
| NET_DEV_ISR_TYPE_UNKNOWN | Handle unknown device interrupts. |
| NET_DEV_ISR_TYPE_RX | Handle device receive interrupts. |
| NET_DEV_ISR_TYPE_RX_OVERRUN | Handle device receive overrun interrupts. |
| NET_DEV_ISR_TYPE_TX_RDY | Handle device transmit ready interrupts. |
| NET_DEV_ISR_TYPE_TX_COMPLETE | Handle device transmit complete interrupts. |

This is *not* an exclusive list of interrupt types and specific network device's may handle other types of interrupts.

perr Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_INVALID_CFG
NET_IF_ERR_NULL_FNCT
NET_IF_ERR_INVALID_STATE
NET_ERR_INIT_INCOMPLETE
NET_IF_ERR_INVALID_IF

This is *not* an exclusive list of return errors and specific network interface's or device's may return any other specific errors as required.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-9-13 NetIF_IsValid()

Validate network interface number.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
CPU_BOOLEAN NetIF_IsValid(NET_IF_NBR  if_nbr,
                          NET_ERR    *perr);
```

### ARGUMENTS

if_nbr  Network interface number to validate.

perr  Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_YES  network interface number valid;

DEF_NO  network interface number invalid/*not* yet configured.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-9-14 NetIF_IsValidCfgd()

Validate configured network interface number.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
CPU_BOOLEAN NetIF_IsValidCfgd(NET_IF_NBR  if_nbr,
                              NET_ERR    *perr);
```

### ARGUMENTS

if_nbr  Network interface number to validate.

perr  Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_YES  network interface number valid;

DEF_NO  network interface number invalid/*not* yet configured or reserved.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-9-15 NetIF_LinkStateGet()

Get network interface's last known physical link state.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
CPU_BOOLEAN NetIF_LinkStateGet(NET_IF_NBR  if_nbr,
                               NET_ERR    *perr);
```

### ARGUMENTS

if_nbr — Network interface number to get last known physical link state.

perr — Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

NET_IF_LINK_UP — if no errors and network interface's last known physical link state was 'UP';

NET_IF_LINK_DOWN — otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Use NetIF_IO_Ctrl() with option NET_IF_IO_CTRL_LINK_STATE_GET to get a network interface's current physical link state.

## C-9-16 NetIF_LinkStateWaitUntilUp()

Wait for a network interface's physical link state to be UP.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
CPU_BOOLEAN NetIF_LinkStateWaitUntilUp(NET_IF_NBR   if_nbr,
                                       CPU_INT16U   retry_max,
                                       CPU_INT32U   time_dly_ms,
                                       NET_ERR     *perr);
```

### ARGUMENTS

if_nbr Network interface number to wait for link state to be UP.

retry_max Maximum number of consecutive socket open retries.

time_dly_ms Transitory socket open delay value, in milliseconds.

perr Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_INVALID_IF
NET_IF_ERR_LINK_DOWN
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

NET_IF_LINK_UP if no errors and network interface's physical link state is UP;

NET_IF_LINK_DOWN otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

If a non-zero number of retries is requested (`retry_max`) then a non-zero time delay (`time_dly_ms`) should also be requested. Otherwise, all retries will most likely fail immediately since no time will elapse to wait for and allow the network interface's link state to successfully be `UP`.

## C-9-17 NetIF_MTU_Get()

Get network interface's MTU.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
NET_MTU NetIF_MTU_Get(NET_IF_NBR  if_nbr,
                      NET_ERR    *perr);
```

### ARGUMENTS

if_nbr  Network interface number to get MTU.

perr  Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

Network interface's MTU, if no errors.

0, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-9-18 NetIF_MTU_Set()

Set network interface's MTU.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
void NetIF_MTU_Set(NET_IF_NBR  if_nbr,
                   NET_MTU     mtu,
                   NET_ERR    *perr);
```

### ARGUMENTS

if_nbr Network interface number to set MTU.

mtu Desired maximum transmission unit size to configure.

perr Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_NULL_FNCT
NET_IF_ERR_INVALID_IF
NET_IF_ERR_INVALID_CFG
NET_IF_ERR_INVALID_MTU
NET_OS_ERR_LOCK

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Additional error codes may be returned by the specific interface or device driver.

## C-9-19 NetIF_Start()

Start a network interface.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
void NetIF_Start(NET_IF_NBR  if_nbr,
                 NET_ERR    *perr);
```

### ARGUMENTS

if_nbr  Network interface number to start.

perr  Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_NULL_FNCT
NET_IF_ERR_INVALID_IF
NET_IF_ERR_INVALID_CFG
NET_IF_ERR_INVALID_STATE
NET_OS_ERR_LOCK

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Additional error codes may be returned by the specific interface or device driver.

## C-9-20 NetIF_Stop()

Stop a network interface.

### FILES

net_if.h/net_if.c

### PROTOTYPE

```
void NetIF_Stop(NET_IF_NBR  if_nbr,
                NET_ERR    *perr);
```

### ARGUMENTS

if_nbr  Network interface number to stop.

perr  Pointer to variable that will receive the return error code from this function:

NET_IF_ERR_NONE
NET_IF_ERR_NULL_FNCT
NET_IF_ERR_INVALID_IF
NET_IF_ERR_INVALID_CFG
NET_IF_ERR_INVALID_STATE
NET_OS_ERR_LOCK

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Additional error codes may be returned by the specific interface or device driver.

## C-10 WIRELESS NETWORK INTERFACE FUNCTION

### C-10-1 NetIF_WiFi_Scan()

Scan available wireless access point.

#### FILES

net_if_wifi.h/net_if_wifi.c

#### PROTOTYPE

```
void NetIF_WiFi_Scan (NET_IF_NBR           if_nbr,
                      NET_IF_WIFI_AP      *p_buf_scan,
                      CPU_INT16U           buf_scan_len_max,
                const NET_IF_WIFI_SSID    *p_ssid,
                      NET_IF_WIFI_CH       ch,
                      NET_ERR             *p_err);
```

#### ARGUMENTS

| | |
|---|---|
| if_nbr | Interface number to scan wireless access point. |
| p_buf_scan | Pointer to a buffer that will receive wireless access point found. |
| buf_scan_len_max | Maximum number of access point that can be stored in the scan buffer. |
| p_ssid | Pointer to a:<br><br>a. string that contains the hidden SSID to scan for<br><br>b. null pointer, if the scan is for all SSID broadcasted. |

ch — Wireless channel number to scan:

NET_IF_WIFI_CH_ALL
NET_IF_WIFI_CH_1
NET_IF_WIFI_CH_2
NET_IF_WIFI_CH_3
NET_IF_WIFI_CH_4
NET_IF_WIFI_CH_5
NET_IF_WIFI_CH_6
NET_IF_WIFI_CH_7
NET_IF_WIFI_CH_8
NET_IF_WIFI_CH_9
NET_IF_WIFI_CH_10
NET_IF_WIFI_CH_11
NET_IF_WIFI_CH_12
NET_IF_WIFI_CH_13
NET_IF_WIFI_CH_14

perr — Pointer to variable that will receive the return error code from this function:

NET_IF_WIFI_ERR_NONE
NET_IF_WIFI_ERR_CH_INVALID
NET_IF_WIFI_ERR_SCAN
NET_IF_ERR_NULL_PTR

### RETURNED VALUE

Number of wireless access point found and set in the scan buffer.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-10-2 NetIF_WiFi_Join()

Join an wireless access point.

### FILES

net_if_wifi.h/net_if_wifi.c

### PROTOTYPE

```
void NetIF_WiFi_Join (NET_IF_NBR                if_nbr,
                      NET_IF_WIFI_NET_TYPE      net_type,
                      NET_IF_WIFI_DATA_RATE     data_rate,
                      NET_IF_WIFI_SECURITY_TYPE security_type,
                      NET_IF_WIFI_PWR_LEVEL     pwr_level,
                      NET_IF_WIFI_SSID          ssid,
                      NET_IF_WIFI_PSK           psk,
                      NET_ERR                  *p_err);
```

### ARGUMENTS

`if_nbr` Interface number to join wireless access point.

`net_type` Wireless network type of the access point:

NET_IF_WIFI_NET_TYPE_INFRASTRUCTURE
NET_IF_WIFI_NET_TYPE_ADHOC

`data_rate` Wireless data rate to configure:

NET_IF_WIFI_DATA_RATE_AUTO
NET_IF_WIFI_DATA_RATE_1_MBPS
NET_IF_WIFI_DATA_RATE_2_MBPS
NET_IF_WIFI_DATA_RATE_5_5_MBPS
NET_IF_WIFI_DATA_RATE_6_MBPS
NET_IF_WIFI_DATA_RATE_9_MBPS
NET_IF_WIFI_DATA_RATE_11_MBPS
NET_IF_WIFI_DATA_RATE_12_MBPS
NET_IF_WIFI_DATA_RATE_18_MBPS
NET_IF_WIFI_DATA_RATE_24_MBPS

NET_IF_WIFI_DATA_RATE_36_MBPS
NET_IF_WIFI_DATA_RATE_48_MBPS
NET_IF_WIFI_DATA_RATE_54_MBPS
NET_IF_WIFI_DATA_RATE_MCS0
NET_IF_WIFI_DATA_RATE_MCS1
NET_IF_WIFI_DATA_RATE_MCS2
NET_IF_WIFI_DATA_RATE_MCS3
NET_IF_WIFI_DATA_RATE_MCS4
NET_IF_WIFI_DATA_RATE_MCS5
NET_IF_WIFI_DATA_RATE_MCS6
NET_IF_WIFI_DATA_RATE_MCS7
NET_IF_WIFI_DATA_RATE_MCS8
NET_IF_WIFI_DATA_RATE_MCS9
NET_IF_WIFI_DATA_RATE_MCS10
NET_IF_WIFI_DATA_RATE_MCS11
NET_IF_WIFI_DATA_RATE_MCS12
NET_IF_WIFI_DATA_RATE_MCS13
NET_IF_WIFI_DATA_RATE_MCS14
NET_IF_WIFI_DATA_RATE_MCS15

`security_type` Wireless security type:

NET_IF_WIFI_SECURITY_OPEN
NET_IF_WIFI_SECURITY_WEP
NET_IF_WIFI_SECURITY_WPA
NET_IF_WIFI_SECURITY_WPA2

`pwr_level` Wireless radio power to configure:

NET_IF_WIFI_PWR_LEVEL_LO
NET_IF_WIFI_PWR_LEVEL_MED
NET_IF_WIFI_PWR_LEVEL_HI

`ssid` SSID of the access point to join.

`psk` Pre shared key of the access point to join.

p_err Pointer to variable that will receive the return error code from this function:

NET_IF_WIFI_ERR_NONE
NET_IF_WIFI_ERR_JOIN
NET_IF_WIFI_ERR_INVALID_NET_TYPE
NET_IF_WIFI_ERR_INVALID_DATA_RATE
NET_IF_WIFI_ERR_INVALID_SECURITY
NET_IF_WIFI_ERR_INVALID_PWR_LEVEL

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Prior joining an access point a scan should be performed to find the access point.

## C-10-3 NetIF_WiFi_CreateAdhoc()

Create an wireless adhoc access point.

### FILES

net_if_wifi.h/net_if_wifi.c

### PROTOTYPE

```
void NetIF_WiFi_CreateAdhoc (NET_IF_NBR                if_nbr,
                             NET_IF_WIFI_DATA_RATE     data_rate,
                             NET_IF_WIFI_SECURITY_TYPE security_type,
                             NET_IF_WIFI_PWR_LEVEL     pwr_level,
                             NET_IF_WIFI_CGH           ch,
                             NET_IF_WIFI_SSID          ssid,
                             NET_IF_WIFI_PSK           psk,
                             NET_ERR                  *p_err);
```

### ARGUMENTS

if_nbr Interface number to join wireless access point.

data_rate Wireless data rate to configure:

NET_IF_WIFI_DATA_RATE_AUTO
NET_IF_WIFI_DATA_RATE_1_MBPS
NET_IF_WIFI_DATA_RATE_2_MBPS
NET_IF_WIFI_DATA_RATE_5_5_MBPS
NET_IF_WIFI_DATA_RATE_6_MBPS
NET_IF_WIFI_DATA_RATE_9_MBPS
NET_IF_WIFI_DATA_RATE_11_MBPS
NET_IF_WIFI_DATA_RATE_12_MBPS
NET_IF_WIFI_DATA_RATE_18_MBPS
NET_IF_WIFI_DATA_RATE_24_MBPS
NET_IF_WIFI_DATA_RATE_36_MBPS
NET_IF_WIFI_DATA_RATE_48_MBPS
NET_IF_WIFI_DATA_RATE_54_MBPS
NET_IF_WIFI_DATA_RATE_MCS0
NET_IF_WIFI_DATA_RATE_MCS1

NET_IF_WIFI_DATA_RATE_MCS2
NET_IF_WIFI_DATA_RATE_MCS3
NET_IF_WIFI_DATA_RATE_MCS4
NET_IF_WIFI_DATA_RATE_MCS5
NET_IF_WIFI_DATA_RATE_MCS6
NET_IF_WIFI_DATA_RATE_MCS7
NET_IF_WIFI_DATA_RATE_MCS8
NET_IF_WIFI_DATA_RATE_MCS9
NET_IF_WIFI_DATA_RATE_MCS10
NET_IF_WIFI_DATA_RATE_MCS11
NET_IF_WIFI_DATA_RATE_MCS12
NET_IF_WIFI_DATA_RATE_MCS13
NET_IF_WIFI_DATA_RATE_MCS14
NET_IF_WIFI_DATA_RATE_MCS15

`security_type` Wireless security type:

NET_IF_WIFI_SECURITY_OPEN
NET_IF_WIFI_SECURITY_WEP
NET_IF_WIFI_SECURITY_WPA
NET_IF_WIFI_SECURITY_WPA2

`pwr_level` Wireless radio power to configure:

NET_IF_WIFI_PWR_LEVEL_LO
NET_IF_WIFI_PWR_LEVEL_MED
NET_IF_WIFI_PWR_LEVEL_HI

`ch` Wireless channel number of the access point:

NET_IF_WIFI_CH_1
NET_IF_WIFI_CH_2
NET_IF_WIFI_CH_3
NET_IF_WIFI_CH_4
NET_IF_WIFI_CH_5
NET_IF_WIFI_CH_6
NET_IF_WIFI_CH_7
NET_IF_WIFI_CH_8

NET_IF_WIFI_CH_9
NET_IF_WIFI_CH_10
NET_IF_WIFI_CH_11
NET_IF_WIFI_CH_12
NET_IF_WIFI_CH_13
NET_IF_WIFI_CH_14

`ssid` SSID of the access point.

`psk` Pre shared key of the access point.

`p_err` Pointer to variable that will receive the return error code from this function:

NET_IF_WIFI_ERR_NONE
NET_IF_WIFI_ERR_CREATE_ADHOC
NET_IF_WIFI_ERR_INVALID_CH
NET_IF_WIFI_ERR_INVALID_NET_TYPE
NET_IF_WIFI_ERR_INVALID_DATA_RATE
NET_IF_WIFI_ERR_INVALID_SECURITY
NET_IF_WIFI_ERR_INVALID_PWR_LEVEL

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-10-4 NetIF_WiFi_Leave()

Leave the access point previously joined.

### FILES

net_if_wifi.h/net_if_wifi.c

### PROTOTYPE

```
void NetIF_WiFi_Leave (NET_IF_NBR   if_nbr,
                       NET_ERR     *p_err);
```

### ARGUMENTS

| | |
|---|---|
| if_nbr | Interface number to join wireless access point. |
| p_err | Pointer to variable that will receive the return error code from this function:<br><br>NET_IF_WIFI_ERR_NONE<br>NET_IF_WIFI_ERR_LEAVE |

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

# C-11 IGMP FUNCTIONS

## C-11-1 NetIGMP_HostGrpJoin()

Join a host group.

### FILES

net_igmp.h/net_igmp.c

### PROTOTYPE

```
void NetIGMP_HostGrpJoin (NET_IF_NBR   if_nbr,
                          NET_IP_ADDR  addr_grp,
                          NET_ERR     *perr);
```

### ARGUMENTS

if_nbr Interface number to join host group.

addr_grp IP address of host group to join.

perr Pointer to variable that will receive the return error code from this function:

NET_IGMP_ERR_NONE
NET_IGMP_ERR_INVALID_ADDR_GRP
NET_IGMP_ERR_HOST_GRP_NONE_AVAIL
NET_IGMP_ERR_HOST_GRP_INVALID_TYPE
NET_IF_ERR_INVALID_IF
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

`DEF_OK`, if host group successfully joined.

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_IP_CFG_MULTICAST_SEL` is configured for transmit and receive multicasting (see section D-9-2 on page 752).

### NOTES / WARNINGS

`addr_grp` *must* be in host-order.

## C-11-2 NetIGMP_HostGrpLeave()

Leave a host group.

### FILES

net_igmp.h/net_igmp.c

### PROTOTYPE

```
void NetIGMP_HostGrpLeave (NET_IF_NBR   if_nbr,
                           NET_IP_ADDR  addr_grp,
                           NET_ERR     *perr);
```

### ARGUMENTS

`if_nbr` Interface number to leave host group.

`addr_grp` IP address of host group to leave.

`err` Pointer to variable that will receive the return error code from this function:

`NET_IGMP_ERR_NONE`
`NET_IGMP_ERR_HOST_GRP_NOT_FOUND`
`NET_ERR_INIT_INCOMPLETE`
`NET_OS_ERR_LOCK`

### RETURNED VALUE

`DEF_OK`, if host group successfully left.

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_IP_CFG_MULTICAST_SEL` is configured for transmit and receive multicasting (see section D-9-2 on page 752).

### NOTES / WARNINGS

`addr_grp` *must* be in host-order.

## C-12 IP FUNCTIONS

### C-12-1 NetIP_CfgAddrAdd()

Add a static IP host address, subnet mask, and default gateway to an interface.

#### FILES

net_ip.h/net_ip.c

#### PROTOTYPE

```
CPU_BOOLEAN NetIP_CfgAddrAdd(NET_IF_NBR   if_nbr,
                             NET_IP_ADDR  addr_host,
                             NET_IP_ADDR  addr_subnet_mask,
                             NET_IP_ADDR  addr_dflt_gateway,
                             NET_ERR     *perr);
```

#### ARGUMENTS

`if_nbr` Interface number to configure.

`addr_host` Desired IP address to add to this interface.

`addr_subnet_mask` Desired IP address subnet mask.

`addr_dflt_gateway` Desired IP default gateway address.

`perr` Pointer to variable that will receive the error code from this function:

NET_IP_ERR_NONE
NET_IP_ERR_INVALID_ADDR_HOST
NET_IP_ERR_INVALID_ADDR_GATEWAY
NET_IP_ERR_ADDR_CFG_STATE
NET_IP_ERR_ADDR_TBL_FULL
NET_IP_ERR_ADDR_CFG_IN_USE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

`DEF_OK`, if valid IP address, subnet mask, and default gateway statically-configured;

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP addresses *must* be configured in host-order.

An interface may be configured with either:

- One or more statically- configured IP addresses (default configuration) *or*
- Exactly one dynamically-configured IP address (see section C-12-2 on page 544).

If an interface's address(es) are dynamically-configured, no statically-configured address(es) may be added until all dynamically-configured address(es) are removed.

The maximum number of IP address(es) configured on any interface is limited to `NET_IP_CFG_IF_MAX_NBR_ADDR` (see section D-9-1 on page 752).

Note that on the default interface, the first IP address added will be the default address used for all default communication. See also section C-9-1 on page 498.

A host *may* be configured without a gateway address to allow communication only with other hosts on its local network. However, any configured gateway address *must* be on the same network as the configured host IP address (i.e., the network portion of the configured IP address and the configured gateway addresses *must* be identical).

## C-12-2 NetIP_CfgAddrAddDynamic()

Add a dynamically-configured IP host address, subnet mask, and default gateway to an interface.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_CfgAddrAddDynamic(NET_IF_NBR   if_nbr,
                                    NET_IP_ADDR  addr_host,
                                    NET_IP_ADDR  addr_subnet_mask,
                                    NET_IP_ADDR  addr_dflt_gateway,
                                    NET_ERR     *perr);
```

### ARGUMENTS

`if_nbr` Interface number to configure.

`addr_host` Desired IP address to add to this interface.

`addr_subnet_mask` Desired IP address subnet mask.

`addr_dflt_gateway` Desired IP default gateway address.

`perr` Pointer to variable that will receive the return error code from this function:

NET_IP_ERR_NONE
NET_IP_ERR_INVALID_ADDR_HOST
NET_IP_ERR_INVALID_ADDR_GATEWAY
NET_IP_ERR_ADDR_CFG_STATE
NET_IP_ERR_ADDR_CFG_IN_USE
NET_IF_ERR_INVALID_IF
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

`DEF_OK`, if valid IP address, subnet mask, and default gateway dynamically configured;

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP addresses *must* be configured in host-order.

An interface may be configured with either:

- One or more statically- configured IP addresses (see section C-12-1 on page 542) *or*
- Exactly one dynamically-configured IP address.

This function should *only* be called by appropriate network application function(s) [e.g., DHCP initialization functions]. However, if the application attempts to dynamically configure IP address(es), it *must* call `NetIP_CfgAddrAddDynamicStart()` before calling `NetIP_CfgAddrAddDynamic()`. Note that on the default interface, the first IP address added will be the default address used for all default communication. See also section C-9-1 on page 498.

A host *may* be configured without a gateway address to allow communication only with other hosts on its local network. However, any configured gateway address *must* be on the same network as the configured host IP address (i.e., the network portion of the configured IP address and the configured gateway addresses *must* be identical).

## C-12-3 NetIP_CfgAddrAddDynamicStart()

Start dynamic IP address configuration for an interface.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_CfgAddrAddDynamicStart(NET_IF_NBR  if_nbr,
                                         NET_ERR    *perr);
```

### ARGUMENTS

if_nbr  Interface number to start dynamic address configuration.

perr  Pointer to variable that will receive the return error code from this function:

NET_IP_ERR_NONE
NET_IP_ERR_ADDR_CFG_STATE
NET_IP_ERR_ADDR_CFG_IN_PROGRESS
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK,  if dynamic IP address configuration successfully started;

DEF_FAIL,  otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

This function should *only* be called by appropriate network application function(s) [e.g., DHCP initialization functions]. However, if the application attempts to dynamically configure IP address(es), it *must* call `NetIP_CfgAddrAddDynamicStart()` before calling `NetIP_CfgAddrAddDynamic()`.

## C-12-4 NetIP_CfgAddrAddDynamicStop()

Stop dynamic IP address configuration for an interface.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_CfgAddrAddDynamicStop(NET_IF_NBR  if_nbr,
                                        NET_ERR    *perr);
```

### ARGUMENTS

if_nbr  Interface number to stop dynamic address configuration.

perr  Pointer to variable that will receive the return error code from this function:

NET_IP_ERR_NONE
NET_IP_ERR_ADDR_CFG_STATE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK,  if dynamic IP address configuration successfully stopped;

DEF_FAIL,  otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

This function should *only* be called by appropriate network application function(s) [e.g., DHCP initialization functions]. However, if the application attempts to dynamically configure IP address(es), it must call NetIP_CfgAddrAddDynamicStop() *only* after calling NetIP_CfgAddrAddDynamicStart() and dynamic IP address configuration has failed.

## C-12-5 NetIP_CfgAddrRemove()

Remove a configured IP host address from an interface.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_CfgAddrRemove(NET_IF_NBR   if_nbr,
                                NET_IP_ADDR  addr_host,
                                NET_ERR     *perr);
```

### ARGUMENTS

if_nbr Interface number to remove configured IP host address.

addr_host IP address to remove.

perr Pointer to variable that will receive the return error code from this function:

NET_IP_ERR_NONE
NET_IP_ERR_INVALID_ADDR_HOST
NET_IP_ERR_ADDR_CFG_STATE
NET_IP_ERR_ADDR_TBL_EMPTY
NET_IP_ERR_ADDR_NOT_FOUND
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, if interface's configured IP host address successfully removed;

DEF_FAIL, otherwise.

## REQUIRED CONFIGURATION

None.

## NOTES / WARNINGS

None.

## C-12-6 NetIP_CfgAddrRemoveAll()

Remove all configured IP host address(es) from an interface.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_CfgAddrRemoveAll(NET_IF_NBR  if_nbr,
                                   NET_ERR    *perr);
```

### ARGUMENTS

if_nbr  Interface number to remove all configured IP host address(es).

perr  Pointer to variable that will receive the return error code from this function:

NET_IP_ERR_NONE
NET_IP_ERR_ADDR_CFG_STATE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK,  if all interface's configured IP host address(es) successfully removed;

DEF_FAIL,  otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-12-7 NetIP_CfgFragReasmTimeout()

Configure IP fragment reassembly timeout.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_CfgFragReasmTimeout(CPU_INT08U timeout_sec);
```

### ARGUMENTS

timeout_sec Desired value for IP fragment reassembly timeout (in seconds).

### RETURNED VALUE

DEF_OK, IP fragment reassembly timeout successfully configured.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Fragment reassembly timeout is the maximum time allowed between received fragments of the same IP datagram.

## C-12-8 NetIP_GetAddrDfltGateway()

Get the default gateway IP address for a host's configured IP address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
NET_IP_ADDR NetIP_GetAddrDfltGateway(NET_IP_ADDR  addr,
                                     NET_ERR     *perr);
```

### ARGUMENTS

addr  Configured IP host address.

perr  Pointer to variable that will receive the return error code from this function:

NET_IP_ERR_NONE
NET_IP_ERR_INVALID_ADDR_HOST
NET_OS_ERR_LOCK

### RETURNED VALUE

Configured IP host address's default gateway (in host-order), if no errors.

NET_IP_ADDR_NONE, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

*All* IP addresses in host-order.

## C-12-9 NetIP_GetAddrHost()

Get an interface's configured IP host address(es).

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_GetAddrHost(NET_IF_NBR        if_nbr,
                              NET_IP_ADDR      *paddr_tbl,
                              NET_IP_ADDRS_QTY *paddr_tbl_qty,
                              NET_ERR          *perr);
```

### ARGUMENTS

`if_nbr` Interface number to get configured IP host address(es).

`paddr_tbl` Pointer to IP address table that will receive the IP host address(es) in host-order for this interface.

`paddr_tbl_qty` Pointer to a variable to:

Pass the size of the address table, in number of IP addresses, pointed to by `paddr_tbl`.

Returns the actual number of IP addresses, if no errors.

Returns `0`, otherwise.

perr Pointer to variable that will receive the error code from this function:

NET_IP_ERR_NONE
NET_IP_ERR_NULL_PTR
NET_IP_ERR_ADDR_NONE_AVAIL
NET_IP_ERR_ADDR_CFG_IN_PROGRESS
NET_IP_ERR_ADDR_TBL_SIZE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, if interface's configured IP host address(es) successfully returned;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP addresses returned in host-order.

## C-12-10 NetIP_GetAddrHostCfgd()

Get corresponding configured IP host address for a remote IP address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
NET_IP_ADDR NetIP_GetAddrHostCfgd(NET_IP_ADDR addr_remote);
```

### ARGUMENTS

| | |
|---|---|
| addr_remote | Remote address to get configured IP host address |

### RETURNED VALUE

| | |
|---|---|
| Configured IP host address, | if available; |
| NET_IP_ADDR_NONE, | otherwise. |

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP addresses returned in host-order.

## C-12-11 NetIP_GetAddrSubnetMask()

Get the IP address subnet mask for a host's configured IP address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
NET_IP_ADDR NetIP_GetAddrSubnetMask(NET_IP_ADDR  addr,
                                    NET_ERR     *perr);
```

### ARGUMENTS

addr  Configured IP host address.

perr  Pointer to variable that will receive the return error code from this function:

NET_IP_ERR_NONE
NET_IP_ERR_INVALID_ADDR_HOST
NET_OS_ERR_LOCK

### RETURNED VALUE

Configured IP host address's subnet mask (in host-order), if no errors.

NET_IP_ADDR_NONE, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP addresses in host-order.

## C-12-12 NetIP_IsAddrBroadcast()

Validate an IP address as the limited broadcast IP address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsAddrBroadcast(NET_IP_ADDR addr);
```

### ARGUMENTS

addr IP address to validate.

### RETURNED VALUE

DEF_YES if IP address is a limited broadcast IP address;

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order.

The broadcast IP address is 255.255.255.255.

## C-12-13 NetIP_IsAddrClassA()

Validate an IP address as a Class-A IP address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsAddrClassA(NET_IP_ADDR addr);
```

### ARGUMENTS

addr IP address to validate.

### RETURNED VALUE

DEF_YES if IP address is a Class-A IP address;

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order.

Class-A IP addresses have their most significant bit be '0'.

## C-12-14 NetIP_IsAddrClassB()

Validate an IP address as a Class-B IP address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsAddrClassB(NET_IP_ADDR addr);
```

### ARGUMENTS

addr IP address to validate.

### RETURNED VALUE

DEF_YES if IP address is a Class-B IP address;

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order.

Class-B IP addresses have their most significant bits be '10'.

## C-12-15 NetIP_IsAddrClassC()

Validate an IP address as a Class-C IP address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsAddrClassC(NET_IP_ADDR addr);
```

### ARGUMENTS

addr IP address to validate.

### RETURNED VALUE

DEF_YES if IP address is a Class-C IP address;

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order.

Class-C IP addresses have their most significant bits be '110'.

## C-12-16 NetIP_IsAddrHost()

Validate an IP address as one the host's IP address(es).

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsAddrHost(NET_IP_ADDR addr);
```

### ARGUMENTS

addr IP address to validate.

### RETURNED VALUE

DEF_YES if IP address is any one of the host's IP address(es);

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order.

## C-12-17 NetIP_IsAddrHostCfgd()

Validate an IP address as one the host's configured IP address(es).

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsAddrHostCfgd(NET_IP_ADDR addr);
```

### ARGUMENTS

addr IP address to validate.

### RETURNED VALUE

DEF_YES if IP address is any one of the host's configured IP address(es);

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order.

## C-12-18 NetIP_IsAddrLocalHost()

Validate an IP address as a Localhost IP address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsAddrLocalHost(NET_IP_ADDR addr);
```

### ARGUMENTS

addr IP address to validate.

### RETURNED VALUE

DEF_YES if IP address is a Localhost IP address;

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order.

Localhost IP addresses are any host address in the '127.<host>' subnet.

## C-12-19 NetIP_IsAddrLocalLink()

Validate an IP address as a link-local IP address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsAddrLocalLink(NET_IP_ADDR addr);
```

### ARGUMENTS

addr IP address to validate.

### RETURNED VALUE

DEF_YES if IP address is a link-local IP address;

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order.

Link-local IP addresses are any host address in the '169.254.<host>' subnet.

## C-12-20 NetIP_IsAddrsCfgdOnIF()

Check if any IP address(es) are configured on an interface.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsAddrsHostCfgdOnIF(NET_IF_NBR  if_nbr,
NET_ERR   *perr);
```

### ARGUMENTS

if_nbr Interface number to check for configured IP host address(es).

perr Pointer to variable that will receive the return error code from this function:

NET_IP_ERR_NONE
NET_IF_ERR_INVALID_IF
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_YES if *any* IP host address(es) are configured on the interface;

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-12-21 NetIP_IsAddrThisHost()

Validate an IP address as the 'This Host' initialization IP address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsAddrThisHost(NET_IP_ADDR addr);
```

### ARGUMENTS

addr IP address to validate.

### RETURNED VALUE

DEF_YES if IP address is a 'This Host' initialization IP address;

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order.

The 'This Host' initialization IP address is 0.0.0.0.

## C-12-22 NetIP_IsValidAddrHost()

Validate an IP address as a valid IP host address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsValidAddrHost(NET_IP_ADDR addr_host);
```

### ARGUMENTS

addr_host IP host address to validate.

### RETURNED VALUE

DEF_YES if valid IP host address;

DEF_NO otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order. A valid IP host address must *not* be one of the following:

- This Host (see section C-12-21 on page 567)
- Specified Host
- Localhost (see section C-12-18 on page 564)
- Limited Broadcast (see section C-12-12 on page 558)
- Directed Broadcast

## C-12-23 NetIP_IsValidAddrHostCfgd()

Validate an IP address as a valid, configurable IP host address.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsValidAddrHostCfgd(NET_IP_ADDR addr_host,
                                      NET_IP_ADDR addr_subnet_mask);
```

### ARGUMENTS

| | |
|---|---|
| addr_host | IP host address to validate. |
| addr_subnet_mask | IP host address subnet mask. |

### RETURNED VALUE

| | |
|---|---|
| DEF_YES | if configurable IP host address; |
| DEF_NO | otherwise. |

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP addresses *must* be in host-order.

A configurable IP host address must *not* be one of the following:

- This host (see section C-12-21 on page 567)
- Specified host
- Localhost (see section C-12-18 on page 564)

- Limited broadcast (see section C-12-12 on page 558)
- Directed broadcast
- Subnet broadcast

## C-12-24 NetIP_IsValidAddrSubnetMask()

Validate an IP address subnet mask.

### FILES

net_ip.h/net_ip.c

### PROTOTYPE

```
CPU_BOOLEAN NetIP_IsValidAddrSubnetMask(NET_IP_ADDR addr_subnet_mask);
```

### ARGUMENTS

addr_subnet_mask  IP host address subnet mask.

### RETURNED VALUE

DEF_YES  if valid IP address subnet mask;

DEF_NO  otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

IP address *must* be in host-order.

# C-13 NETWORK SOCKET FUNCTIONS

## C-13-1 NetSock_Accept() / accept() (TCP)

Wait for new socket connections on a listening server socket (see section C-13-40 on page 648). When a new connection arrives and the TCP handshake has successfully completed, a new socket ID is returned for the new connection with the remote host's address and port number returned in the socket address structure.

### FILES

net_sock.h/net_sock.c
net_bsd.h/net_bsd.c

### PROTOTYPES

```
NET_SOCK_ID NetSock_Accept(NET_SOCK_ID        sock_id,
                           NET_SOCK_ADDR     *paddr_remote,
                           NET_SOCK_ADDR_LEN *paddr_len,
                           NET_ERR           *perr);

int accept(int               sock_id,
           struct sockaddr  *paddr_remote,
           socklen_t        *paddr_len);
```

### ARGUMENTS

`sock_id` This is the socket ID returned by `NetSock_Open()/socket()` when the socket was created. This socket is assumed to be bound to an address and listening for new connections (see section C-13-40 on page 648).

`paddr_remote` Pointer to a socket address structure (see section 9-1 "Network Socket Data Structures" on page 273) to return the remote host address of the new accepted connection.

`paddr_len` Pointer to the size of the socket address structure which *must* be passed the size of the socket address structure [e.g., `sizeof(NET_SOCK_ADDR_IP)`]. Returns size of the accepted connection's socket address structure, if no errors; returns `0`, otherwise.

perr Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NULL_PTR
NET_SOCK_ERR_NONE_AVAIL
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_CLOSED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_FAMILY
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_OP
NET_SOCK_ERR_CONN_ACCEPT_Q_NONE_AVAIL
NET_SOCK_ERR_CONN_SIGNAL_TIMEOUT
NET_SOCK_ERR_CONN_FAIL
NET_SOCK_ERR_FAULT
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

Returns a non-negative socket descriptor ID for the new accepted connection, if successful; NET_SOCK_BSD_ERR_ACCEPT/-1, otherwise.

If the socket is configured for non-blocking, a return value of NET_SOCK_BSD_ERR_ACCEPT/-1 may indicate that the no requests for connection were queued when NetSock_Accept()/accept() was called. In this case, the server can "poll" for a new connection at a later time.

### REQUIRED CONFIGURATION

NetSock_Accept() is available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

In addition, accept() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

See section 8-2 "Socket Interface" on page 212 for socket address structure formats.

## C-13-2 NetSock_Bind() / bind() (TCP/UDP)

Assign network addresses to sockets. Typically, server sockets bind to addresses but client sockets do not. Servers may bind to one of the local host's addresses but usually bind to the wildcard address (NET_SOCK_ADDR_IP_WILDCARD/INADDR_ANY) on a specific, well-known port number. Whereas client sockets usually bind to one of the local host's addresses but with a random port number (by configuring the socket address structure's port number field with a value of 0).

### FILES

net_sock.h/net_sock.c
net_bsd.h/net_bsd.c

### PROTOTYPES

```
NET_SOCK_RTN_CODE NetSock_Bind(NET_SOCK_ID        sock_id,
                               NET_SOCK_ADDR     *paddr_local,
                               NET_SOCK_ADDR_LEN  addr_len,
                               NET_ERR           *perr);

int bind(int               sock_id,
         struct sockaddr  *paddr_local,
         socklen_t         addr_len);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created.

paddr_local — Pointer to a socket address structure (see section 8-2 "Socket Interface" on page 212) which contains the local host address to bind the socket to.

addr_len — Size of the socket address structure which *must* be passed the size of the socket address structure [for example, sizeof(NET_SOCK_ADDR_IP)].

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED

NET_SOCK_ERR_CLOSED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_FAMILY
NET_SOCK_ERR_INVALID_PROTOCOL
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_OP
NET_SOCK_ERR_INVALID_ADDR
NET_SOCK_ERR_ADDR_IN_USE
NET_SOCK_ERR_PORT_NBR_NONE_AVAIL
NET_SOCK_ERR_CONN_FAIL
NET_IF_ERR_INVALID_IF
NET_IP_ERR_ADDR_NONE_AVAIL
NET_IP_ERR_ADDR_CFG_IN_PROGRESS
NET_CONN_ERR_NULL_PTR
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_NONE_AVAIL
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_INVALID_FAMILY
NET_CONN_ERR_INVALID_TYPE
NET_CONN_ERR_INVALID_PROTOCOL_IX
NET_CONN_ERR_INVALID_ADDR_LEN
NET_CONN_ERR_ADDR_NOT_USED
NET_CONN_ERR_ADDR_IN_USE
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

| | |
|---|---|
| NET_SOCK_BSD_ERR_NONE/0 | if successful; |
| NET_SOCK_BSD_ERR_BIND/-1 | otherwise. |

### REQUIRED CONFIGURATION

`NetSock_Bind()` is available only if either `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755) and/or `NET_UDP_CFG_APP_API_SEL` is configured for sockets (see section D-13-1 on page 756).

In addition, `bind()` is available only if `NET_BSD_CFG_API_EN` is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

See section 8-2 "Socket Interface" on page 212 for socket address structure formats.

Sockets may bind to any of the host's configured addresses, any localhost address (127.x.y.z network; e.g., 127.0.0.1), any link-local address (169.254.y.z network; e.g., 169.254.65.111), as well as the wildcard address (`NET_SOCK_ADDR_IP_WILDCARD/INADDR_ANY`, i.e., 0.0.0.0).

Sockets may bind to specific port numbers or request a random, ephemeral port number by configuring the socket address structure's port number field with a value of 0. Sockets may *not* bind to a port number that is within the configured range of random port numbers (see section D-15-2 on page 760 and section D-15-7 on page 762):

```
 NET_SOCK_CFG_PORT_NBR_RANDOM_BASE <= RandomPortNbrs <=
(NET_SOCK_CFG_PORT_NBR_RANDOM_BASE + NET_SOCK_CFG_NBR_SOCK + 10)
```

## C-13-3 NetSock_CfgBlock() (TCP/UDP)

Configure a socket's blocking mode.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgBlock(NET_SOCK_ID  sock_id,
                             CPU_INT08U   block,
                             NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

block — Desired value for socket blocking mode:

| | |
|---|---|
| NET_SOCK_BLOCK_SEL_DFLT | Socket operations will block |
| NET_SOCK_BLOCK_SEL_BLOCK | Socket operations will block |
| NET_SOCK_BLOCK_SEL_NO_BLOCK | Socket operations will not block |

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_ARG
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

`DEF_OK`, Socket blocking mode successfully configured;

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755) and/or `NET_UDP_CFG_APP_API_SEL` is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-13-4 NetSock_CfgIF()

Configure the interface that must be used by the socket.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgIF(NET_SOCK_ID   sock_id,
                          NET_IF_NBR    if_nbr,
                          NET_ERR      *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created.

if_nbr — Interface number that must be used.

perr — Pointer to variable that will receive the return error code from this function:
NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_CONN_ERR_NOT_USED
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, interface number successfully configured.
DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

none.

### NOTES / WARNINGS

None.

## C-13-5 NetSock_CfgConnChildQ_SizeGet() (TCP)

Get socket's connection child queue size value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgConnChildQ_SizeGet(NET_SOCK_ID  sock_id,
                                          NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_PROTOCOL
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_OS_ERR_LOCK

### RETURNED VALUE

Socket's connection child queue size value:

| | |
|---|---|
| `NET_SOCK_Q_SIZE_NONE` | on any error(s). |
| `NET_SOCK_Q_SIZE_UNLIMITED` | if unlimited (i.e., *no* limit) value configured. |

child connection queue size, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Available only for stream-type sockets (e.g., TCP sockets).

## C-13-6 NetSock_CfgConnChildQ_SizeSet() (TCP)

Configure socket's child connection queue size.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgConnChildQ_SizeSet(NET_SOCK_ID       sock_id,
                                          NET_SOCK_Q_SIZE   queues_size
                                          NET_ERR          *perr);
```

### ARGUMENTS

sock_id This is the socket ID returned by NetSock_Open()/socket() when the socket was created.

queue_size Desired child connection queue size.

perr Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_PROTOCOL
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_OS_ERR_LOCK

### RETURNED VALUE

`DEF_OK`, Socket child connection queue size successfully configured;

`DEF_FAIL` otherwise.

### REQUIRED CONFIGURATION

none.

### NOTES / WARNINGS

Available only for stream-type sockets (e.g., TCP sockets).

## C-13-7 NetSock_CfgSecure() (TCP)

Configure a socket's secure mode.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgBlock(NET_SOCK_ID  sock_id,
                             CPU_INT08U   secure,
                             NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created.

block — Desired value for socket secure mode:

| | |
|---|---|
| DEF_ENABLED | Socket operations will be secured. |
| DEF_DISABLED | Socket operations will not be secured. |

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_ARG
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_SECURE_ERR_NOT_AVAIL
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket secure mode successfully configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) *and* if NET_SECURE_CFG_EN is enabled (see section D-15 on page 760).

### NOTES / WARNINGS

Available only for stream-type sockets (e.g., TCP sockets).

## C-13-8 NetSock_CfgServerCertKeyInstall() (TCP)

Install certificate (CERT) and private key (KEY) from a buffer which must be used by a server.

### FILE

net_sock.h/net_sock.c

### CALLED FROM

Application

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgSecureServerCertKeyInstall (      NET_SOCK_ID                  sock_id,
                                                   const void                        *pcert,
                                                         CPU_INT32U                   cert_len,
                                                   const void                        *pkey,
                                                         CPU_INT32U                   key_len,
                                                         NET_SOCK_SECURE_CERT_KEY_FMT  fmt,
                                                         CPU_BOOLEAN                  cert_chain,
                                                         NET_ERR                      *perr)
```

### ARGUMENTS

sock_id — Socket descriptor/handle identifier of server socket to configure secure certificate and key.

pcert — Pointer to buffer that contains the certificate.

cert_len — Certificate length.

pkey — Pointer to buffer that contains the key.

key_len — Key length.

`fmt` Certificate and key format:

`NET_SOCK_SECURE_CERT_KEY_FMT_PEM`
`NET_SOCK_SECURE_CERT_KEY_FMT_DER`

`cert_chain` Certificate point to a chain of certificate.

`DEF_YES` Certificate points to a chain of certificate.
`DEF_NO` Certificate points to a single certificate.

`p_err` Pointer to variable that will receive the return error code from this function:

`NET_SOCK_ERR_NONE`
`NET_SOCK_ERR_NOT_USED`
`NET_SOCK_ERR_INVALID_ARG`
`NET_SOCK_ERR_INVALID_TYPE`
`NET_SOCK_ERR_INVALID_STATE`
`NET_SOCK_ERR_INVALID_OP`
`NET_SOCK_ERR_API_DIS`
`NET_ERR_INIT_INCOMPLETE`
`NET_SOCK_ERR_INVALID_SOCK`
`NET_SECURE_ERR_NOT_AVAIL`
`NET_OS_ERR_LOCK`

### RETURNED VALUE

`DEF_OK`, certificate and key successfully installed;

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_SECURE_CFG_EN` is enabled (see section D-16-1 on page 764) *and* `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The socket's secure mode must be configured before calling this function, see section C-13-7 "NetSock_CfgSecure() (TCP)" on page 584

## C-13-9 NetSock_CfgSecureClientCommonName() (TCP)

Configure client socket's common name.

### FILE

net_sock.h/net_sock.c

### CALLED FROM

Application

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgSecureClientCommonName(NET_SOCK_ID   sock_id,
                                              CPU_CHAR     *pcommon_name,
                                              NET_ERR      *perr);
```

### ARGUMENTS

sock_id Socket descriptor/handle identifier of client socket to configure common name.

pcommon_name Pointer to string that contain the common name.

p_err Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_ARG
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_OP
NET_SOCK_ERR_API_DIS
NET_ERR_INIT_INCOMPLETE
NET_SOCK_ERR_INVALID_SOCK
NET_SECURE_ERR_NOT_AVAIL
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, common name successfully configured.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_SECURE_CFG_EN is enabled (see section D-16-1 on page 764) *and* NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The socket's secure mode must be configured before calling this function, see section C-13-7 "NetSock_CfgSecure() (TCP)" on page 584

## C-13-10 NetSock_CfgSecureClientTrustCallBack() (TCP)

Configure client socket's trust call back function.

### FILE

net_sock.h/net_sock.c

### CALLED FROM

Application

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgSecureClientTrustCallBack(NET_SOCK_ID                 sock_id,
                                                 NET_SOCK_SECURE_TRUST_FNCT  pcall_back_fnct,
                                                 NET_ERR                    *perr);
```

### ARGUMENTS

sock_id Socket descriptor/handle identifier of client socket to configure trust call back function.

pcall_back_fnct Pointer to the trust call back function.

p_err Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_ARG
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_OP
NET_SOCK_ERR_API_DIS
NET_ERR_INIT_INCOMPLETE
NET_SOCK_ERR_INVALID_SOCK
NET_SECURE_ERR_NOT_AVAIL
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, trust call back function successfully configured.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_SECURE_CFG_EN is enabled (see section D-16-1 on page 764) *and* NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The socket's secure mode must be configured before calling this function, see section C-13-7 "NetSock_CfgSecure() (TCP)" on page 584

## C-13-11 NetSock_CfgRxQ_Size() (TCP/UDP)

Configure socket's receive queue size.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgRxQ_Size(NET_SOCK_ID         sock_id,
                                NET_SOCK_DATA_SIZE  size
                                NET_ERR            *perr);
```

### ARGUMENTS

sock_id This is the socket ID of socket to configure receive queue size.

size Desired receive queue size.

perr Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_PROTOCOL
NET_SOCK_ERR_INVALID_DATA_SIZE
NET_ERR_INIT_INCOMPLETE
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_NOT_USED
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_CONN_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_OS_ERR_LOCK

### RETURNED VALUE

`DEF_OK`, Socket receive queue size successfully configured;

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

For datagram sockets, configured size does *not*:

- Limit or remove any received data currently queued but becomes effective for later received data.
- Partially truncate any received data but instead allows data from exactly one received packet buffer to overflow the configured size since each datagram *must* be received atomically (see section C-13-46 “NetSock_RxData() / recv() (TCP) NetSock_RxDataFrom() / recvfrom() (UDP)” on page 659).

For steam sockets, size *may* be required to be configured prior to connecting (see section C-14-5 “NetTCP_ConnCfgRxWinSize()” on page 679).

## C-13-12 NetSock_CfgTxQ_Size() (TCP/UDP)

Configure socket's transmit queue size.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTxQ_Size(NET_SOCK_ID         sock_id,
                                NET_SOCK_DATA_SIZE  size
                                NET_ERR            *perr);
```

### ARGUMENTS

sock_id This is the socket ID of socket to configure transmit queue size.

size Desired transmit queue size.

perr Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_PROTOCOL
NET_SOCK_ERR_INVALID_DATA_SIZE
NET_ERR_INIT_INCOMPLETE
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_NOT_USED
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_CONN_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_OS_ERR_LOCK

### RETURNED VALUE

`DEF_OK`, Socket transmit queue size successfully configured;

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

For datagram sockets, configured size does *not*:

- Partially truncate any transmitted data but instead allows data from exactly one transmitted packet buffer to overflow the configured size since each datagram *must* be transmitted atomically (see section C-13-48 “NetSock_TxData() / send() (TCP) NetSock_TxDataTo() / sendto() (UDP)” on page 666).

For steam sockets, size *may* be required to be configured prior to connecting (see section C-14-6 “NetTCP_ConnCfgTxWinSize()” on page 681).

## C-13-13 NetSock_CfgTxIP_TOS() (TCP/UDP)

Configure socket's transmit IP TOS.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTxIP_TOS(NET_SOCK_ID  sock_id,
                                NET_IP_TOS   ip_tos
                                NET_ERR     *perr);
```

### ARGUMENTS

sock_id This is the socket ID of socket to configure transmit IP TOS.

size Desired transmit IP TOS.

perr Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_OP
NET_ERR_INIT_INCOMPLETE
NET_SOCK_ERR_INVALID_SOCK
NET_CONN_ERR_INVALID_ARG
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket transmit IP TOS successfully configured;

DEF_FAIL, otherwise.

## REQUIRED CONFIGURATION

None.

## NOTES / WARNINGS

None.

## C-13-14 NetSock_CfgTxIP_TTL() (TCP/UDP)

Configure socket's transmit IP TTL.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTxIP_TTL(NET_SOCK_ID  sock_id,
                                NET_IP_TTL   ip_ttl
                                NET_ERR     *perr);
```

### ARGUMENTS

sock_id This is the socket ID of socket to configure transmit IP TTL.

size Desired transmit IP TTL:

| | |
|---|---|
| NET_IP_TTL_MIN | Minimum TTL transmit value (1) |
| NET_IP_TTL_MAX | Maximum TTL transmit value (255) |
| NET_IP_TTL_DFLT | Default TTL transmit value (128) |
| NET_IP_TTL_NONE | Replace with default TTL |

perr Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_OP
NET_ERR_INIT_INCOMPLETE
NET_SOCK_ERR_INVALID_SOCK
NET_CONN_ERR_INVALID_ARG
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket transmit IP TTL successfully configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

## C-13-15 NetSock_CfgTxIP_TTL_Multicast() (TCP/UDP)

Configure socket's transmit IP multicast TTL.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTxIP_TTL_Multicast(NET_SOCK_ID  sock_id,
                                          NET_IP_TTL   ip_ttl
                                          NET_ERR     *perr);
```

### ARGUMENTS

sock_id This is the socket ID of socket to configure transmit IP TTL.

size Desired transmit IP multicast TTL:

| | |
|---|---|
| NET_IP_TTL_MIN | Minimum TTL transmit value (1) |
| NET_IP_TTL_MAX | Maximum TTL transmit value (255) |
| NET_IP_TTL_DFLT | Default TTL transmit value (1) |
| NET_IP_TTL_NONE | Replace with default TTL |

perr Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_OP
NET_SOCK_ERR_API_DIS
NET_ERR_INIT_INCOMPLETE
NET_SOCK_ERR_INVALID_SOCK
NET_CONN_ERR_INVALID_ARG
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_OS_ERR_LOCK

### RETURNED VALUE

`DEF_OK`, Socket transmit IP multicast TTL successfully configured;

`DEF_FAIL`, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_SOCK_CFG_FAMILY` is configured for IPv4 sockets (see section D-15-1 "NET_SOCK_CFG_FAMILY" on page 760).

### NOTES / WARNINGS

None.

## C-13-16 NetSock_CfgTimeoutConnAcceptDflt() (TCP)

Set socket's connection accept timeout to configured-default value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTimeoutConnAcceptDflt(NET_SOCK_ID  sock_id,
                                             NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_INVALID_TIME
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket connection accept configured-default timeout successfully set;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-17 NetSock_CfgTimeoutConnAcceptGet_ms() (TCP)

Get socket's connection accept timeout value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_INT32U NetSock_CfgTimeoutConnAcceptGet_ms(NET_SOCK_ID  sock_id,
                                              NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

0, on any errors;

NET_TMR_TIME_INFINITE, if infinite (i.e., no timeout) value configured.

Timeout in number of milliseconds, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-18 NetSock_CfgTimeoutConnAcceptSet() (TCP)

Set socket's connection accept timeout value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTimeoutConnAcceptSet(NET_SOCK_ID  sock_id,
                                            CPU_INT32U   timeout_ms,
                                            NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

timeout_ms — Desired timeout value:

NET_TMR_TIME_INFINITE, if infinite (i.e., no timeout) value desired.

In number of milliseconds, otherwise.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_INVALID_TIME
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket connection accept timeout successfully set;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-19 NetSock_CfgTimeoutConnCloseDflt() (TCP)

Set socket's connection close timeout to configured-default value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTimeoutConnCloseDflt(NET_SOCK_ID  sock_id,
                                            NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_INVALID_TIME
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket connection close configured-default timeout successfully set;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-20 NetSock_CfgTimeoutConnCloseGet_ms() (TCP)

Get socket's connection close timeout value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_INT32U NetSock_CfgTimeoutConnCloseGet_ms(NET_SOCK_ID  sock_id,
                                             NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

0, on any errors;

NET_TMR_TIME_INFINITE, if infinite (i.e., no timeout) value configured;

Timeout in number of milliseconds, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-21 NetSock_CfgTimeoutConnCloseSet() (TCP)

Set socket's connection close timeout value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTimeoutConnCloseSet(NET_SOCK_ID  sock_id,
                                           CPU_INT32U   timeout_ms,
                                           NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

timeout_ms — Desired timeout value:

NET_TMR_TIME_INFINITE, if infinite (i.e., no timeout) value desired.

In number of milliseconds, otherwise.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_INVALID_TIME
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket connection close timeout successfully set;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-22 NetSock_CfgTimeoutConnReqDflt() (TCP)

Set socket's connection request timeout to configured-default value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTimeoutConnReqDflt(NET_SOCK_ID  sock_id,
                                          NET_ERR   *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_INVALID_TIME
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket connection request configured-default timeout successfully set;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-23 NetSock_CfgTimeoutConnReqGet_ms() (TCP)

Get socket's connection request timeout value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_INT32U NetSock_CfgTimeoutConnReqGet_ms(NET_SOCK_ID  sock_id,
                                           NET_ERR   *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

0, on any errors;

NET_TMR_TIME_INFINITE, if infinite (i.e., no timeout) value configured;

Timeout in number of milliseconds, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-24 NetSock_CfgTimeoutConnReqSet() (TCP)

Set socket's connection request timeout value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTimeoutConnReqSet(NET_SOCK_ID  sock_id,
                                         CPU_INT32U   timeout_ms,
                                         NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

timeout_ms — Desired timeout value:

NET_TMR_TIME_INFINITE, if infinite (i.e., no timeout) value desired.

In number of milliseconds, otherwise.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_INVALID_TIME
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket connection request timeout successfully set;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-25 NetSock_CfgTimeoutRxQ_Dflt() (TCP/UDP)

Set socket's connection receive queue timeout to configured-default value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTimeoutRxQ_Dflt(NET_SOCK_ID  sock_id,
                                       NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_PROTOCOL
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_INVALID_TIME
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket receive queue configured-default timeout successfully set;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-13-26 NetSock_CfgTimeoutRxQ_Get_ms() (TCP/UDP)

Get socket's receive queue timeout value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_INT32U NetSock_CfgTimeoutRxQ_Get_ms(NET_SOCK_ID  sock_id,
                                        NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_PROTOCOL
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

`0`, on any errors;

`NET_TMR_TIME_INFINITE`, if infinite (i.e., no timeout) value configured;

Timeout in number of milliseconds, otherwise.

### REQUIRED CONFIGURATION

Available only if either `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755) and/or `NET_UDP_CFG_APP_API_SEL` is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-13-27 NetSock_CfgTimeoutRxQ_Set() (TCP/UDP)

Set socket's connection receive queue timeout value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTimeoutRxQ_Set(NET_SOCK_ID  sock_id,
                                      CPU_INT32U   timeout_ms,
                                      NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

timeout_ms — Desired timeout value:

NET_TMR_TIME_INFINITE, if infinite (i.e., no timeout) value desired. In number of milliseconds, otherwise.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_PROTOCOL
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_INVALID_TIME
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket receive queue timeout successfully set;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-13-28 NetSock_CfgTimeoutTxQ_Dflt() (TCP)

Set socket's connection transmit queue timeout to configured-default value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTimeoutTxQ_Dflt(NET_SOCK_ID  sock_id,
                                       NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_PROTOCOL
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_INVALID_TIME
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket transmit queue configured-default timeout successfully set;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-29 NetSock_CfgTimeoutTxQ_Get_ms() (TCP)

Get socket's transmit queue timeout value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_INT32U NetSock_CfgTimeoutTxQ_Get_ms(NET_SOCK_ID  sock_id,
                                        NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_PROTOCOL
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

`0`, on any errors;

`NET_TMR_TIME_INFINITE`, if infinite (i.e., no timeout) value configured;

Timeout in number of milliseconds, otherwise.

### REQUIRED CONFIGURATION

Available only if `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-30 NetSock_CfgTimeoutTxQ_Set() (TCP)

Set socket's connection transmit queue timeout value.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_CfgTimeoutTxQ_Set(NET_SOCK_ID  sock_id,
                                      CPU_INT32U   timeout_ms,
                                      NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

timeout_ms — Desired timeout value:

NET_TMR_TIME_INFINITE, if infinite (i.e., no timeout) value desired. In number of milliseconds, otherwise.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_PROTOCOL
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_CONN
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_INVALID_TIME
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, Socket transmit queue timeout successfully set;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-13-31 NetSock_Close() / close() (TCP/UDP)

Terminate communication and free a socket.

### FILES

net_sock.h/net_sock.c
net_bsd.h/net_bsd.c

### PROTOTYPES

```
NET_SOCK_RTN_CODE NetSock_Close(NET_SOCK_ID  sock_id,
                                NET_ERR   *perr);

int close(int sock_id);
```

### ARGUMENTS

sock_id — The socket ID returned by NetSock_Open()/socket() when the socket is created *or* by NetSock_Accept()/accept() when a connection is accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_CLOSED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_FAMILY
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_CLOSE_IN_PROGRESS
NET_SOCK_ERR_CONN_SIGNAL_TIMEOUT
NET_SOCK_ERR_CONN_FAIL
NET_SOCK_ERR_FAULT
NET_CONN_ERR_NULL_PTR
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_INVALID_ADDR_LEN
NET_CONN_ERR_ADDR_IN_USE
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

NET_SOCK_BSD_ERR_NONE/0, if successful;

NET_SOCK_BSD_ERR_CLOSE/-1, otherwise.

### REQUIRED CONFIGURATION

NetSock_Close() is available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

In addition, close() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

After closing a socket, no further operations should be performed with the socket.

## C-13-32 NetSock_Conn() / connect() (TCP/UDP)

Connect a local socket to a remote socket address. If the local socket was not previously bound to a local address and port, the socket is bound to the default interface's default address and a random port number. When successful, a connected socket has access to both local and remote socket addresses.

Although both UDP and TCP sockets may both connect to remote servers or hosts, UDP and TCP connections are inherently different:

For TCP sockets, `NetSock_Conn()/connect()` returns successfully only after completing the three-way TCP handshake with the remote TCP host. Success implies the existence of a dedicated connection to the remote socket similar to a telephone connection. This dedicated connection is maintained for the life of the connection until one or both sides close the connection.

For UDP sockets, `NetSock_Conn()/connect()` merely saves the remote socket's address for the local socket for convenience. All UDP datagrams from the socket will be transmitted to the remote socket. This pseudo-connection is not permanent and may be re-configured at any time.

### FILES

`net_sock.h/net_sock.c`
`net_bsd.h/net_bsd.c`

### PROTOTYPES

```
NET_SOCK_RTN_CODE NetSock_Conn(NET_SOCK_ID        sock_id,
                               NET_SOCK_ADDR     *paddr_remote,
                               NET_SOCK_ADDR_LEN  addr_len,
                               NET_ERR           *perr);

int connect(int               sock_id,
            struct sockaddr  *paddr_remote,
            socklen_t         addr_len);
```

### ARGUMENTS

`sock_id` This is the socket ID returned by `NetSock_Open()/socket()` when the socket was created.

`paddr_remote` Pointer to a socket address structure (see section 8-2 "Socket Interface" on page 212) which contains the remote socket address to connect the socket to.

`addr_len` Size of the socket address structure which *must* be passed the size of the socket address structure [e.g., `sizeof(NET_SOCK_ADDR_IP)`].

`perr` Pointer to variable that will receive the return error code from this function:

`NET_SOCK_ERR_NONE`
`NET_SOCK_ERR_NOT_USED`
`NET_SOCK_ERR_CLOSED`
`NET_SOCK_ERR_INVALID_SOCK`
`NET_SOCK_ERR_INVALID_FAMILY`
`NET_SOCK_ERR_INVALID_PROTOCOL`
`NET_SOCK_ERR_INVALID_TYPE`
`NET_SOCK_ERR_INVALID_STATE`
`NET_SOCK_ERR_INVALID_OP`
`NET_SOCK_ERR_INVALID_ADDR`
`NET_SOCK_ERR_INVALID_ADDR_LEN`
`NET_SOCK_ERR_ADDR_IN_USE`
`NET_SOCK_ERR_PORT_NBR_NONE_AVAIL`
`NET_SOCK_ERR_CONN_SIGNAL_TIMEOUT`
`NET_SOCK_ERR_CONN_IN_USE`
`NET_SOCK_ERR_CONN_FAIL`

NET_SOCK_ERR_FAULT
NET_IF_ERR_INVALID_IF
NET_IP_ERR_ADDR_NONE_AVAIL
NET_IP_ERR_ADDR_CFG_IN_PROGRESS
NET_CONN_ERR_NULL_PTR
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_NONE_AVAIL
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_INVALID_FAMILY
NET_CONN_ERR_INVALID_TYPE
NET_CONN_ERR_INVALID_PROTOCOL_IX
NET_CONN_ERR_INVALID_ADDR_LEN
NET_CONN_ERR_ADDR_NOT_USED
NET_CONN_ERR_ADDR_IN_USE
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

NET_SOCK_BSD_ERR_NONE/0, if successful;

NET_SOCK_BSD_ERR_CONN/-1, otherwise.

### REQUIRED CONFIGURATION

NetSock_Conn() is available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

In addition, connect() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

See section 8-2 “Socket Interface” on page 212 for socket address structure formats.

## C-13-33 NET_SOCK_DESC_CLR() / FD_CLR() (TCP/UDP)

Remove a socket file descriptor ID as a member of a file descriptor set. See also section C-13-47 "NetSock_Sel() / select() (TCP/UDP)" on page 663.

### FILES

net_sock.h

### PROTOTYPE

```
NET_SOCK_DESC_CLR(desc_nbr, pdesc_set);
```

### ARGUMENTS

desc_nbr — This is the socket file descriptor ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

pdesc_set — Pointer to a socket file descriptor set.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756) *and* if NET_SOCK_CFG_SEL_EN is enabled (see section D-15-4 on page 761).

In addition, FD_CLR() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

`NetSock_Sel()/select()` checks or waits for available operations or error conditions on any of the socket file descriptor members of a socket file descriptor set.

No errors are returned even if the socket file descriptor ID or the file descriptor set is invalid, or the socket file descriptor ID is *not* set in the file descriptor set.

## C-13-34 NET_SOCK_DESC_COPY() (TCP/UDP)

Copy a file descriptor set to another file descriptor set. See also section C-13-47 "NetSock_Sel() / select() (TCP/UDP)" on page 663.

### FILES

net_sock.h

### PROTOTYPE

```
NET_SOCK_DESC_COPY(pdesc_set_dest, pdesc_set_src);
```

### ARGUMENTS

| | |
|---|---|
| pdesc_set_dest | Pointer to the destination socket file descriptor set. |
| pdesc_set_src | Pointer to the source socket file descriptor set to copy. |

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756) *and* if NET_SOCK_CFG_SEL_EN is enabled (see section D-15-4 on page 761).

### NOTES / WARNINGS

NetSock_Sel()/select() checks or waits for available operations or error conditions on any of the socket file descriptor members of a socket file descriptor set.

No errors are returned even if either file descriptor set is invalid.

## C-13-35 NET_SOCK_DESC_INIT() / FD_ZERO() (TCP/UDP)

Initialize/zero-clear a file descriptor set. See also section C-13-47 "NetSock_Sel() / select() (TCP/UDP)" on page 663.

### FILES

net_sock.h

### PROTOTYPE

```
NET_SOCK_DESC_INIT(pdesc_set);
```

### ARGUMENTS

pdesc_set  Pointer to a socket file descriptor set.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756) *and* if NET_SOCK_CFG_SEL_EN is enabled (see section D-15-4 on page 761).

In addition, FD_ZERO() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

NetSock_Sel()/select() checks or waits for available operations or error conditions on any of the socket file descriptor members of a socket file descriptor set.

No errors are returned even if the file descriptor set is invalid.

## C-13-36 NET_SOCK_DESC_IS_SET() / FD_IS_SET() (TCP/UDP)

Check if a socket file descriptor ID is a member of a file descriptor set. See also section C-13-47 "NetSock_Sel() / select() (TCP/UDP)" on page 663.

### FILES

net_sock.h

### PROTOTYPE

```
NET_SOCK_DESC_IS_SET(desc_nbr, pdesc_set);
```

### ARGUMENTS

desc_nbr — This is the socket file descriptor ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

pdesc_set — Pointer to a socket file descriptor set.

### RETURNED VALUE

1, if the socket file descriptor ID is a member of the file descriptor set;

0, otherwise.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756) *and* if NET_SOCK_CFG_SEL_EN is enabled (see section D-15-4 on page 761).

In addition, FD_IS_SET() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

`NetSock_Sel()/select()` checks or waits for available operations or error conditions on any of the socket file descriptor members of a socket file descriptor set.

`0` is returned if the socket file descriptor ID or the file descriptor set is invalid.

## C-13-37 NET_SOCK_DESC_SET() / FD_SET() (TCP/UDP)

Add a socket file descriptor ID as a member of a file descriptor set. See also section C-13-47 "NetSock_Sel() / select() (TCP/UDP)" on page 663.

### FILES

net_sock.h

### PROTOTYPE

```
NET_SOCK_DESC_SET(desc_nbr, pdesc_set);
```

### ARGUMENTS

desc_nbr — This is the socket file descriptor ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

pdesc_set — Pointer to a socket file descriptor set.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756) *and* if NET_SOCK_CFG_SEL_EN is enabled (see section D-15-4 on page 761). In addition, FD_SET() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

NetSock_Sel()/select() checks or waits for available operations or error conditions on any of the socket file descriptor members of a socket file descriptor set.

No errors are returned even if the socket file descriptor ID or the file descriptor set is invalid, or the socket file descriptor ID is *not* cleared in the file descriptor set.

## C-13-38 NetSock_GetConnTransportID()

Gets a socket's transport layer connection handle ID (e.g., TCP connection ID) if available.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
NET_CONN_ID NetSock_GetConnTransportID(NET_SOCK_ID  sock_id,
                                       NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_TYPE
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

Socket's transport connection handle ID (e.g., TCP connection ID), if no errors.

`NET_CONN_ID_NONE`, otherwise.

### REQUIRED CONFIGURATION

Available only if either `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755) and/or `NET_UDP_CFG_APP_API_SEL` is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-13-39 NetSock_IsConn() (TCP/UDP)

Check if a socket is connected to a remote socket.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
CPU_BOOLEAN NetSock_IsConn(NET_SOCK_ID  sock_id,
                           NET_ERR     *perr);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_INVALID_SOCK
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_YES — if the socket is valid and connected;

DEF_NO — otherwise.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-13-40 NetSock_Listen() / listen() (TCP)

Set a socket to accept incoming connections. The socket must already be bound to a local address. If successful, incoming TCP connection requests addressed to the socket's local address will be queued until accepted by the socket (see section C-13-1 "NetSock_Accept() / accept() (TCP)" on page 572).

### FILES

net_sock.h/net_sock.c
net_bsd.h/net_bsd.c

### PROTOTYPES

```
NET_SOCK_RTN_CODE NetSock_Listen(NET_SOCK_ID      sock_id,
                                 NET_SOCK_Q_SIZE  sock_q_size,
                                 NET_ERR         *perr);

int listen(int sock_id,
           int sock_q_size);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created.

sock_q_size — Maximum number of new connections allowed to be waiting. In other words, this argument specifies the maximum queue length of pending connections while the listening socket is busy servicing the current request.

perr — Pointer to variable that will receive the return error code from this function:

NET_SOCK_ERR_NONE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_CLOSED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_FAMILY
NET_SOCK_ERR_INVALID_PROTOCOL
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE

NET_SOCK_ERR_INVALID_OP
NET_SOCK_ERR_CONN_FAIL
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

NET_SOCK_BSD_ERR_NONE/0, if successful;

NET_SOCK_BSD_ERR_LISTEN/-1, otherwise.

### REQUIRED CONFIGURATION

NetSock_Listen() is available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

In addition, listen() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

None.

## C-13-41 NetSock_Open() / socket() (TCP/UDP)

Create a datagram (i.e., UDP) or stream (i.e., TCP) type socket.

### FILES

net_sock.h/net_sock.c
net_bsd.h/net_bsd.c

### PROTOTYPES

```
NET_SOCK_ID NetSock_Open(NET_SOCK_PROTOCOL_FAMILY  protocol_family,
                         NET_SOCK_TYPE             sock_type,
                         NET_SOCK_PROTOCOL         protocol,
                         NET_ERR                  *perr);

int socket(int protocol_family,
           int sock_type,
           int protocol);
```

### ARGUMENTS

protocol_family — This field establishes the socket protocol family domain. Always use NET_SOCK_FAMILY_IP_V4/PF_INET for TCP/IP sockets.

sock_type — Socket type:

NET_SOCK_TYPE_DATAGRAM/PF_DGRAM for datagram sockets (i.e., UDP)

NET_SOCK_TYPE_STREAM/PF_STREAM for stream sockets (i.e., TCP)

NET_SOCK_TYPE_DATAGRAM sockets preserve message boundaries. Applications that exchange single request and response messages are examples of datagram communication.

NET_SOCK_TYPE_STREAM sockets provides a reliable byte-stream connection, where bytes are received from the remote application in the same order as they were sent. File transfer and terminal emulation are examples of applications that require this type of protocol.

`protocol` Socket protocol:

`NET_SOCK_PROTOCOL_UDP/IPPROTO_UDP` for UDP

`NET_SOCK_PROTOCOL_TCP/IPPROTO_TCP` for TCP

`0` for default-protocol:

UDP for `NET_SOCK_TYPE_DATAGRAM/PF_DGRAM`

TCP for `NET_SOCK_TYPE_STREAM/PF_STREAM`

`perr` Pointer to variable that will receive the return error code from this function:

`NET_SOCK_ERR_NONE`
`NET_SOCK_ERR_NONE_AVAIL`
`NET_SOCK_ERR_INVALID_FAMILY`
`NET_SOCK_ERR_INVALID_PROTOCOL`
`NET_SOCK_ERR_INVALID_TYPE`
`NET_ERR_INIT_INCOMPLETE`
`NET_OS_ERR_LOCK`

The table below shows you the different ways you can specify the three arguments.

| **TCP/IP Protocol** | **Arguments** | | |
|---|---|---|---|
| | **protocol_family** | **sock_type** | **protocol** |
| **UDP** | NET_SOCK_FAMILY_IP_V4 | NET_SOCK_TYPE_DATAGRAM | NET_SOCK_PROTOCOL_UDP |
| **UDP** | NET_SOCK_FAMILY_IP_V4 | NET_SOCK_TYPE_DATAGRAM | 0 |
| **TCP** | NET_SOCK_FAMILY_IP_V4 | NET_SOCK_TYPE_STREAM | ET_SOCK_PROTOCOL_TCP |
| **TCP** | NET_SOCK_FAMILY_IP_V4 | NET_SOCK_TYPE_STREAM | 0 |

### RETURNED VALUE

Returns a non-negative socket descriptor ID for the new socket connection, if successful;

NET_SOCK_BSD_ERR_OPEN/-1 otherwise.

### REQUIRED CONFIGURATION

NetSock_Open() is available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

In addition, socket() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

The family, type, and protocol of a socket is fixed once a socket is created. In other words, you cannot change a TCP stream socket to a UDP datagram socket (or vice versa) at run-time.

To connect two sockets, both sockets must share the same socket family, type, and protocol.

## C-13-42 NetSock_OptGet()

Get the specified socket option from the `sock_id` socket.

### FILES

`net_sock.h/net_sock.c`

### PROTOTYPE

```
NET_SOCK_RTN_CODE_ID NetSock_OptGet(NET_SOCK_ID        sock_id,
                                    NET_SOCK_PROTOCOL  level,
                                    NET_SOCK_OPT_NAME  opt_name,
                                    void              *popt_val,
                                    NET_SOCK_OPT_LEN  *popt_len,
                                    NET_ERR           *perr);
```

### ARGUMENTS

`sock_id` This is the socket ID returned by `NetSock_Open()/socket()` when the socket was created *or* by `NetSock_Accept()/accept()` when a connection was accepted.

`level` Protocol level from which to retrieve the socket option.

`opt_name` Socket option to get the value.

`popt_val` Pointer to a socket option value buffer.

`popt_len` Pointer to variable a socket option value buffer length.

`perr` Pointer to variable that will receive the return error code from this function:

`NET_SOCK_ERR_NONE`
`NET_SOCK_ERR_INVALID_OPT`
`NET_SOCK_ERR_INVALID_ARG`
`NET_SOCK_ERR_INVALID_OPT_LEN`
`NET_CONN_ERR_INVALID_OPT_GET`
`NET_CONN_ERR_INVALID_OPT_LEVEL`

### RETURNED VALUE

NET_SOCK_BSD_ERR_NONE/0, if successful; NET_SOCK_BSD_ERR_OPT_GET/-1, otherwise.

### REQUIRED CONFIGURATION

NetSock_OptGet() is available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

In addition, getsockopt() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

The supported options are:

- Protocol level NET_SOCK_PROTOCOL_SO:
  - NET_SOCK_OPT_SOCK_TYPE
  - NET_SOCK_OPT_SOCK_KEEP_ALIVE
  - NET_SOCK_OPT_SOCK_ACCEPT_CONN
  - NET_SOCK_OPT_SOCK_TX_BUF_SIZE / NET_SOCK_OPT_SOCK_RX_BUF_SIZE
  - NET_SOCK_OPT_SOCK_TX_TIMEOUT / NET_SOCK_OPT_SOCK_RX_TIMEOUT
- Protocol level NET_SOCK_PROTOCOL_IP:
  - NET_SOCK_OPT_IP_TOS
  - NET_SOCK_OPT_IP_TTL
  - NET_SOCK_OPT_IP_RX_IF
- Protocol level NET_SOCK_PROTOCOL_TCP:
  - NET_SOCK_OPT_TCP_NO_DELAY
  - NET_SOCK_OPT_TCP_KEEP_CNT
  - NET_SOCK_OPT_TCP_KEEP_IDLE
  - NET_SOCK_OPT_TCP_KEEP_INTVL

## C-13-43 NetSock_OptSet()

Set the specified socket option to the `sock_id` socket.

### FILES

`net_sock.h/net_sock.c`

### PROTOTYPE

```
NET_SOCK_RTN_CODE_ID NetSock_OptSet(NET_SOCK_ID        sock_id,
                                    NET_SOCK_PROTOCOL  level,
                                    NET_SOCK_OPT_NAME  opt_name,
                                    void              *popt_val,
                                    NET_SOCK_OPT_LEN   opt_len,
                                    NET_ERR           *perr);
```

### ARGUMENTS

`sock_id` This is the socket ID returned by `NetSock_Open()/socket()` when the socket was created *or* by `NetSock_Accept()/accept()` when a connection was accepted.

`level` Protocol level from which to set the socket option.

`opt_name` Name of the option to set.

`popt_val` Pointer to the value to set the socket option.

`opt_len` Option length.

`perr` Pointer to variable that will receive the return error code from this function:

`NET_SOCK_ERR_NONE`
`NET_SOCK_ERR_INVALID_DATA_SIZE`
`NET_SOCK_ERR_NULL_PTR`
`NET_SOCK_ERR_INVALID_OPT`

### RETURNED VALUE

NET_SOCK_BSD_ERR_NONE/0, if successful;

NET_SOCK_BSD_ERR_OPT_SET/-1, otherwise.

### REQUIRED CONFIGURATION

NetSock_OptSet() is available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

In addition, setsockopt() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

The supported options are:

- Protocol level NET_SOCK_PROTOCOL_SO:
  - NET_SOCK_OPT_SOCK_KEEP_ALIVE
  - NET_SOCK_OPT_SOCK_TX_BUF_SIZE / NET_SOCK_OPT_SOCK_RX_BUF_SIZE
  - NET_SOCK_OPT_SOCK_TX_TIMEOUT / NET_SOCK_OPT_SOCK_RX_TIMEOUT
- Protocol level NET_SOCK_PROTOCOL_IP:
  - NET_SOCK_OPT_IP_TOS
  - NET_SOCK_OPT_IP_TTL
- Protocol level NET_SOCK_PROTOCOL_TCP:
  - NET_SOCK_OPT_TCP_NO_DELAY
  - NET_SOCK_OPT_TCP_KEEP_CNT
  - NET_SOCK_OPT_TCP_KEEP_IDLE
  - NET_SOCK_OPT_TCP_KEEP_INTVL

## C-13-44 NetSock_PoolStatGet()

Get Network Sockets' statistics pool.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
NET_STAT_POOL NetSock_PoolStatGet(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

Network Sockets' statistics pool, if no errors.

NULL statistics pool, otherwise.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-13-45 NetSock_PoolStatResetMaxUsed()

Reset Network Sockets' statistics pool's maximum number of entries used.

### FILES

net_sock.h/net_sock.c

### PROTOTYPE

```
void NetSock_PoolStatResetMaxUsed(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

### NOTES / WARNINGS

None.

## C-13-46 NetSock_RxData() / recv() (TCP) NetSock_RxDataFrom() / recvfrom() (UDP)

Copy up to a specified number of bytes received from a remote socket into an application memory buffer.

### FILES

net_sock.h/net_sock.c
net_bsd.h/net_bsd.c

### PROTOTYPES

```
NET_SOCK_RTN_CODE NetSock_RxData(NET_SOCK_ID      sock_id,
                                 void            *pdata_buf,
                                   CPU_INT16U       data_buf_len,
                                   CPU_INT16S       flags,
                                   NET_ERR         *perr);

NET_SOCK_RTN_CODE NetSock_RxDataFrom(NET_SOCK_ID     sock_id,
                                     void           *pdata_buf,
                                       CPU_INT16U       data_buf_len,
                                       CPU_INT16S       flags,
                                       NET_SOCK_ADDR   *paddr_remote,
                                       NET_SOCK_ADDR_  *paddr_len,
                                     void           *pip_opts_buf,
                                       CPU_INT08U       ip_opts_buf_len,
                                       CPU_INT08U      *pip_opts_len,
                                       NET_ERR         *perr);

ssize_t recv(int      sock_id,
             void    *pdata_buf,
             _size_t  data_buf_len,
             int      flags);

ssize_t recvfrom(int              sock_id,
                 void            *pdata_buf,
                 _size_t          data_buf_len,
                 int              flags,
                 struct sockaddr  *paddr_remote,
                 socklen_t        *paddr_len);
```

### ARGUMENTS

`sock_id` This is the socket ID returned by `NetSock_Open()/socket()` when the socket was created *or* by `NetSock_Accept()/accept()` when a connection was accepted.

`pdata_buf` Pointer to the application memory buffer to receive data.

`data_buf_len` Size of the destination application memory buffer (in bytes).

`flags` Flag to select receive options; bit-field flags logically **OR**'d:

| | |
|---|---|
| `NET_SOCK_FLAG_NONE/0` | No socket flags selected |
| `NET_SOCK_FLAG_RX_DATA_PEEK/ MSG_PEEK` | Receive socket data without consuming it |
| `NET_SOCK_FLAG_RX_NO_BLOCK/ MSG_DONTWAIT` | Receive socket data without blocking |

In most cases, this flag would be set to `NET_SOCK_FLAG_NONE/0`.

`paddr_remote` Pointer to a socket address structure (see section 8-2 "Socket Interface" on page 212) to return the remote host address that sent the received data.

`paddr_len` Pointer to the size of the socket address structure which *must* be passed the size of the socket address structure [e.g., `sizeof(NET_SOCK_ADDR_IP)`]. Returns size of the accepted connection's socket address structure, if no errors; returns `0`, otherwise.

`pip_opts_buf` Pointer to buffer to receive possible IP options.

`pip_opts_len` Pointer to variable that will receive the return size of any received IP options.

`perr` Pointer to variable that will receive the return error code from this function:

```
NET_SOCK_ERR_NONE
NET_SOCK_ERR_NULL_PTR
NET_SOCK_ERR_NULL_SIZE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_CLOSED
```

NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_FAMILY
NET_SOCK_ERR_INVALID_PROTOCOL
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_OP
NET_SOCK_ERR_INVALID_FLAG
NET_SOCK_ERR_INVALID_ADDR_LEN
NET_SOCK_ERR_INVALID_DATA_SIZE
NET_SOCK_ERR_CONN_FAIL
NET_SOCK_ERR_FAULT
NET_SOCK_ERR_RX_Q_EMPTY
NET_SOCK_ERR_RX_Q_CLOSED
NET_ERR_RX
NET_CONN_ERR_NULL_PTR
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_INVALID_ADDR_LEN
NET_CONN_ERR_ADDR_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

Positive number of bytes received, if successful;

NET_SOCK_BSD_RTN_CODE_CONN_CLOSED/0, if the socket is closed;

NET_SOCK_BSD_ERR_RX/-1, otherwise.

### BLOCKING VS NON-BLOCKING

The default setting for µC/TCP-IP is blocking. However, this setting can be changed at compile time by setting the NET_SOCK_CFG_BLOCK_SEL (see section D-15-3 on page 761) to one of the following values:

NET_SOCK_BLOCK_SEL_DFLT sets blocking mode to the default, or blocking, unless modified by run-time options.

NET_SOCK_BLOCK_SEL_BLOCK sets the blocking mode to blocking. This means that a socket receive function will wait forever, until at least one byte of data is available to return or the socket connection is closed, unless a timeout is specified by NetSock_CfgTimeoutRxQ_Set() [See section C-13-27 on page 624].

NET_SOCK_BLOCK_SEL_NO_BLOCK sets the blocking mode to non-blocking. This means that a socket receive function will *not* wait but immediately return either any available data, socket connection closed, or an error indicating no available data or other possible socket faults. Your application will have to "poll" the socket on a regular basis to receive data.

The current version of µC/TCP-IP selects blocking or non-blocking at compile time for all sockets. A future version may allow the selection of blocking or non-blocking at the individual socket level. However, each socket receive call can pass the NET_SOCK_FLAG_RX_NO_BLOCK/MSG_DONTWAIT flag to disable blocking on that call.

### REQUIRED CONFIGURATION

NetSock_RxData()/NetSock_RxDataFrom() is available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

In addition, recv()/recvfrom() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

TCP sockets typically use NetSock_RxData()/recv(), whereas UDP sockets typically use NetSock_RxDataFrom()/recvfrom().

For stream sockets (i.e., TCP), bytes are guaranteed to be received in the same order as they were transmitted, without omissions.

For datagram sockets (i.e., UDP), each receive returns the data from exactly one send but datagram order and delivery is not guaranteed. Also, if the application memory buffer is not big enough to receive an entire datagram, the datagram's data is truncated to the size of the memory buffer and the remaining data is discarded.

Only some receive flag options are implemented. If other flag options are requested, an error is returned so that flag options are *not* silently ignored.

## C-13-47 NetSock_Sel() / select() (TCP/UDP)

Check if any sockets are ready for available read or write operations or error conditions.

### FILES

net_sock.h/net_sock.c
net_bsd.h/net_bsd.c

### PROTOTYPES

```
NET_SOCK_RTN_CODE NetSock_Sel(NET_SOCK_QTY      sock_nbr_max,
                              NET_SOCK_DESC    *psock_desc_rd,
                              NET_SOCK_DESC    *psock_desc_wr,
                              NET_SOCK_DESC    *psock_desc_err,
                              NET_SOCK_TIMEOUT *ptimeout,
                              NET_ERR          *perr);

int select(int             desc_nbr_max,
           struct fd_set  *pdesc_rd,
           struct fd_set  *pdesc_wr,
           struct fd_set  *pdesc_err,
           struct timeval *ptimeout);
```

### ARGUMENTS

sock_nbr_max — Specifies the maximum number of socket file descriptors in the file descriptor sets.

psock_desc_rd — Pointer to a set of socket file descriptors to:

- Check for available read operations.
- Returns the actual socket file descriptors ready for available read operations, if no errors;
  - Returns the initial, non-modified set of socket file descriptors, on any errors;
  - Returns a null-valued (i.e., zero-cleared) descriptor set, if any timeout expires.

`psock_desc_wr` Pointer to a set of socket file descriptors to:

- Check for available read operations.
- Returns the actual socket file descriptors ready for available write operations, if no errors;
  - Returns the initial, non-modified set of socket file descriptors, on any errors;
  - Returns a null-valued (i.e., zero-cleared) descriptor set, if any timeout expires.

`psock_desc_err` Pointer to a set of socket file descriptors to:

- Check for any available socket errors.
- Returns the actual socket file descriptors ready with any pending errors;
  - Returns the initial, non-modified set of socket file descriptors, on any errors;
  - Returns a null-valued (i.e., zero-cleared) descriptor set, if any timeout expires.

`ptimeout` Pointer to a timeout argument.

`perr` Pointer to variable that will receive the error code from this function:

```
NET_SOCK_ERR_NONE
NET_SOCK_ERR_TIMEOUT
NET_ERR_INIT_INCOMPLETE
NET_SOCK_ERR_INVALID_DESC
NET_SOCK_ERR_INVALID_TIMEOUT
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_EVENTS_NBR_MAX
NET_OS_ERR_LOCK
```

### RETURNED VALUE

Returns the number of sockets ready with available operations, if successful;

`NET_SOCK_BSD_RTN_CODE_TIMEOUT/0`, upon timeout;

`NET_SOCK_BSD_ERR_SEL/-1`, otherwise.

### REQUIRED CONFIGURATION

`NetSock_Sel()` is available only if either `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755) and/or `NET_UDP_CFG_APP_API_SEL` is configured for sockets (see section D-13-1 on page 756) *and* if `NET_SOCK_CFG_SEL_EN` is enabled (see section D-15-4 on page 761).

In addition, `select()` is available only if `NET_BSD_CFG_API_EN` is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

Supports socket file descriptors *only* (i.e., socket ID numbers).

The descriptor macro's is used to prepare and decode socket file descriptor sets (see section C-13-33 on page 637 through section C-13-37 on page 643).

See "`net_sock.c NetSock_Sel()` Note #3" for more details.

## C-13-48 NetSock_TxData() / send() (TCP) NetSock_TxDataTo() / sendto() (UDP)

Copy bytes from an application memory buffer into a socket to send to a remote socket.

### FILES

net_sock.h/net_sock.c
net_bsd.h/net_bsd.c

### PROTOTYPES

```
NET_SOCK_RTN_CODE NetSock_TxData(NET_SOCK_ID  sock_id,
                                 void        *p_data,
                                 CPU_INT16U   data_len,
                                 CPU_INT16S   flags,
                                 NET_ERR     *perr);

NET_SOCK_RTN_CODE NetSock_TxDataTo(NET_SOCK_ID        sock_id,
                                   void              *p_data,
                                   CPU_INT16U         data_len,
                                   CPU_INT16S         flags,
                                   NET_SOCK_ADDR     *paddr_remote,
                                   NET_SOCK_ADDR_LEN  addr_len,
                                   NET_ERR           *perr);

ssize_t send (int   sock_id,
              void  *p_data,
             _size_t  data_len,
             int   flags);

ssize_t sendto(int               sock_id,
               void             *p_data,
               _size_t           data_len,
               int               flags,
               struct sockaddr  *paddr_remote,
               socklen_t         addr_len);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

p_data — Pointer to the application data memory buffer to send.

`data_len` Size of the application data memory buffer (in bytes).

`flags` Flag to select transmit options; bit-field flags logically **OR**'d:

| | |
|---|---|
| `NET_SOCK_FLAG_NONE/0` | |
| `NET_SOCK_FLAG_TX_NO_BLOCK/` | No socket flags selected |
| `MSG_DONTWAIT` | Send socket data without blocking |

In most cases, this flag would be set to `NET_SOCK_FLAG_NONE/0`.

`paddr_remote` Pointer to a socket address structure (see section 8-2 "Socket Interface" on page 212) which contains the remote socket address to send data to.

`addr_len` Size of the socket address structure which *must* be passed the size of the socket address structure [e.g., `sizeof(NET_SOCK_ADDR_IP)`].

`perr` Pointer to variable that will receive the return error code from this function:

```
NET_SOCK_ERR_NONE
NET_SOCK_ERR_NULL_PTR
NET_SOCK_ERR_NOT_USED
NET_SOCK_ERR_CLOSED
NET_SOCK_ERR_INVALID_SOCK
NET_SOCK_ERR_INVALID_FAMILY
NET_SOCK_ERR_INVALID_PROTOCOL
NET_SOCK_ERR_INVALID_TYPE
NET_SOCK_ERR_INVALID_STATE
NET_SOCK_ERR_INVALID_OP
NET_SOCK_ERR_INVALID_FLAG
NET_SOCK_ERR_INVALID_DATA_SIZE
NET_SOCK_ERR_INVALID_CONN
NET_SOCK_ERR_INVALID_ADDR
NET_SOCK_ERR_INVALID_ADDR_LEN
NET_SOCK_ERR_INVALID_PORT_NBR
NET_SOCK_ERR_ADDR_IN_USE
NET_SOCK_ERR_PORT_NBR_NONE_AVAIL
NET_SOCK_ERR_CONN_FAIL
NET_SOCK_ERR_FAULT
```

NET_ERR_TX
NET_IF_ERR_INVALID_IF
NET_IP_ERR_ADDR_NONE_AVAIL
NET_IP_ERR_ADDR_CFG_IN_PROGRESS
NET_CONN_ERR_NULL_PTR
NET_CONN_ERR_NOT_USED
NET_CONN_ERR_INVALID_CONN
NET_CONN_ERR_INVALID_FAMILY
NET_CONN_ERR_INVALID_TYPE
NET_CONN_ERR_INVALID_PROTOCOL_IX
NET_CONN_ERR_INVALID_ADDR_LEN
NET_CONN_ERR_ADDR_IN_USE
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

Positive number of bytes (queued to be) sent, if successful;

NET_SOCK_BSD_RTN_CODE_CONN_CLOSED/0, if the socket is closed;

NET_SOCK_BSD_ERR_TX/-1, otherwise.

Note that a positive return value does not mean that the message was successfully delivered to the remote socket, just that it was sent or queued for sending.

### BLOCKING VS NON-BLOCKING

The default setting for µC/TCP-IP is blocking. However, this setting can be changed at compile time by setting the NET_SOCK_CFG_BLOCK_SEL (see section D-15-3 on page 761) to one of the following values:

NET_SOCK_BLOCK_SEL_DFLT sets blocking mode to the default, or blocking, unless modified by run-time options.

NET_SOCK_BLOCK_SEL_BLOCK sets the blocking mode to blocking. This means that a socket transmit function will wait forever, until it can send (or queue to send) at least one byte of data or the socket connection is closed, unless a timeout is specified by NetSock_CfgTimeoutTxQ_Set() [See section C-13-30 on page 630].

NET_SOCK_BLOCK_SEL_NO_BLOCK sets the blocking mode to non-blocking. This means that a socket transmit function will *not* wait but immediately return as much data sent (or queued to be sent), socket connection closed, or an error indicating no available memory to send (or queue) data or other possible socket faults. The application will have to "poll" the socket on a regular basis to transmit data.

The current version of µC/TCP-IP selects blocking or non-blocking at compile time for all sockets. A future version may allow the selection of blocking or non-blocking at the individual socket level. However, each socket transmit call can pass the NET_SOCK_FLAG_TX_NO_BLOCK/MSG_DONTWAIT flag to disable blocking on that call.

Despite these socket-level blocking options, the current version of µC/TCP-IP possibly blocks at the device driver when waiting for the availability of a device's transmitter.

### REQUIRED CONFIGURATION

NetSock_TxData()/NetSock_TxDataTo() is available only if:

- NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755), and/or
- NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756).

In addition, send()/sendto() is available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

TCP sockets typically use NetSock_TxData()/send(), whereas UDP sockets typically use NetSock_TxDataTo()/sendto().

For datagram sockets (i.e., UDP), each receive returns the data from exactly one send but datagram order and delivery is not guaranteed. Also, if the receive memory buffer is not large enough to receive an entire datagram, the datagram's data is truncated to the size of the memory buffer and the remaining data is discarded.

For datagram sockets (i.e., UDP), all data is sent atomically – i.e., each call to send data *must* be sent in a single, complete datagram. Since µC/TCP-IP does *not* currently support IP transmit fragmentation, if a datagram socket attempts to send data greater than a single datagram, then the socket send is aborted and no socket data is sent.

Only some transmit flag options are implemented. If other flag options are requested, an error is returned so that flag options are *not* silently ignored.

## C-14 TCP FUNCTIONS

### C-14-1 NetTCP_ConnCfgIdleTimeout()

Configure TCP connection's idle timeout.

#### FILES

net_tcp.h/net_tcp.c

#### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgIdleTimeout(NET_TCP_CONN_ID      conn_id_tcp,
                                      NET_TCP_TIMEOUT_SEC  timeout_sec,
                                      NET_ERR             *perr);
```

#### ARGUMENTS

conn_id_tcp TCP connection handle ID to configure connection handle timeout.

timeout_sec Desired value for TCP connection idle timeout (in seconds).

perr Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

#### RETURNED VALUE

DEF_OK, TCP connection's idle timeout successfully configured.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

Configured timeout does not reschedule any current idle timeout in progress but becomes effective the next time a TCP connection sets its idle timeout.

The conn_id_tcp argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) {/* If NO errors, ...                                          */
                               /* ... configure TCP connection maximum re-transmit threshold. */
    NetTCP_ConnCfgIdleTimeout(conn_id_tcp, 240u, &err);
}
```

NetTCP_ConnCfgIdleTimeout() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-2 NetTCP_ConnCfgMaxSegSizeLocal()

Configure TCP connection's local maximum segment size.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgMaxSegSizeLocal(NET_TCP_CONN_ID   conn_id_tcp,
                                          NET_TCP_SEG_SIZE  max_seg_size,
                                          NET_ERR          *perr);
```

### ARGUMENTS

conn_id_tcp TCP connection handle ID to configure local maximum segment size.

max_seg_size Desired maximum segment size.

perr Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_CONN_STATE
NET_TCP_ERR_INVALID_CONN_OP
NET_TCP_ERR_INVALID_CONN_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's local maximum segment size successfully configured, if no errors.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle — *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) { /* If NO errors, ...                                      */
                                /* ... configure TCP connection local maximum segment size. */
    NetTCP_ConnCfgMaxSegSizeLocal(conn_id_tcp, 1360u);
}
```

NetTCP_ConnCfgMaxSegSizeLocal() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-3 NetTCP_ConnCfgReTxMaxTh()

Configure TCP connection's maximum number of same segment retransmissions.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgReTxMaxTh(NET_TCP_CONN_ID  conn_id_tcp,
                                    NET_PKT_CTR      nbr_max_re_tx,
                                    NET_ERR         *perr);
```

### ARGUMENTS

conn_id_tcp TCP connection handle ID to configure maximum number of same segment retransmissions.

nbr_max_re_tx Desired maximum number of same segment retransmissions.

perr Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's maximum number of retransmissions successfully configured, if no errors.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) {/* If NO errors, ...                                          */
                               /* ... configure TCP connection maximum re-transmit threshold. */
    NetTCP_ConnCfgReTxMaxTh(conn_id_tcp, 4u, &err);
}
```

NetTCP_ConnCfgReTxMaxTh() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-4 NetTCP_ConnCfgReTxMaxTimeout()

Configure TCP connection's maximum retransmission timeout.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgReTxMaxTimeout(NET_TCP_CONN_ID      conn_id_tcp,
                                         NET_TCP_TIMEOUT_SEC  timeout_sec,
                                         NET_ERR             *perr);
```

### ARGUMENTS

conn_id_tcp TCP connection handle ID to configure maximum retransmission timeout value.

timeout_sec Desired value for TCP connection maximum retransmission timeout (in seconds).

perr Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's maximum retransmission timeout successfully configured, if no errors.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle — *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) { /* If NO errors, ...                                        */
                                /* ... configure TCP connection maximum re-transmit timeout. */
    NetTCP_ConnCfgReTxMaxTimeout(conn_id_tcp, 30u);
}
```

NetTCP_ConnCfgReTxMaxTimeout() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-5 NetTCP_ConnCfgRxWinSize()

Configure TCP connection's receive window size.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgRxWinSize(NET_TCP_CONN_ID   conn_id_tcp,
                                    NET_TCP_WIN_SIZE  win_size,
                                    NET_ERR          *perr);
```

### ARGUMENTS

conn_id_tcp TCP connection handle ID to configure receive window size.

win_size Desired receive window size.

perr Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_CONN_STATE
NET_TCP_ERR_INVALID_CONN_OP
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's receive window size successfully configured, if no errors.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) { /* If NO errors, ...                                 */
                                /* ... configure TCP connection receive window size. */
    NetTCP_ConnCfgRxWinSize(conn_id_tcp, (4u * 1460u));
}
```

NetTCP_ConnCfgRxWindowsSize() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-6 NetTCP_ConnCfgTxWinSize()

Configure TCP connection's transmit window size.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgTxWinSize(NET_TCP_CONN_ID   conn_id_tcp,
                                    NET_TCP_WIN_SIZE  win_size,
                                    NET_ERR          *perr);
```

### ARGUMENTS

conn_id_tcp TCP connection handle ID to configure transmit window size.

win_size Desired transmit window size.

perr Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_CONN_NOT_USED
NET_TCP_ERR_INVALID_CONN_STATE
NET_TCP_ERR_INVALID_CONN_OP
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's transmit window size successfully configured, if no errors.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) { /* If NO errors, ...                                */
                                /* ... configure TCP connection receive window size. */
    NetTCP_ConnCfgTxWinSize(conn_id_tcp, (4u * 1460u));
}
```

NetTCP_ConnCfgTxWindowsSize() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-7 NetTCP_ConnCfgTxAckImmedRxdPushEn()

Configure TCP connection's transmit immediate acknowledgement for received and pushed TCP segments.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgTxAckImmedRxdPushEn(NET_TCP_CONN_ID  conn_id_tcp,
                                              CPU_BOOLEAN      tx_immed_ack_en,
                                              NET_ERR         *perr);
```

### ARGUMENTS

conn_id_tcp — TCP connection handle ID to configure transmit immediate acknowledgement for received and pushed TCP segments.

tx_immed_ack_en — Desired value for TCP connection transmit immediate acknowledgement for received and pushed TCP segments:

| | |
|---|---|
| DEF_ENABLED | TCP connection acknowledgements immediately transmitted for any pushed TCP segments received. |
| DEF_DISABLED | TCP connection acknowledgements *not* immediately transmitted for any pushed TCP segments received. |

perr — Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's transmit immediate acknowledgement for received and pushed TCP segments successfully configured, if no errors.

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) {
                    /* If NO errors, ...                                                    */
                    /* ... configure TCP connection transmit immediate ACK for received PUSH. */
    NetTCP_ConnCfgTxAckImmedRxdPushEn(conn_id_tcp, DEF_NO);
}
```

NetTCP_ConnCfgTxAckImmedRxdPushEn() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-8 NetTCP_ConnCfgTxNagleEn()

Configure TCP connection's transmit Nagle algorithm enable.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgTxNagleEn(NET_TCP_CONN_ID  conn_id_tcp,
                                    CPU_BOOLEAN      nagle_en,
                                    NET_ERR         *perr);
```

### ARGUMENTS

conn_id_tcp Handle identifier of TCP connection to configure transmit Nagle enable.

nagle_en Desired value for TCP connection transmit Nagle enable :

| | |
|---|---|
| DEF_ENABLED | TCP connections delay transmitting next data segment(s) until all unacknowledged data is acknowledged *or* an MSS-sized segment can be transmitted. |
| DEF_DISABLED | TCP connections transmit all data segment(s) when permitted by local & remote hosts' congestion controls. |

perr Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's transmit Nagle enable successfully configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) { /* If NO errors, ...                              */
                                /* ... configure TCP connection Nagle algorithm. */
    NetTCP_ConnCfgTxNagleEn(conn_id_tcp, DEF_DISABLED, &err);
}
```

NetTCP_ConnCfgTxNagleEn() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-9 NetTCP_ConnCfgTxKeepAliveEn()

Configure TCP connection's transmit keep-alive enable.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgTxKeepAliveEn(NET_TCP_CONN_ID  conn_id_tcp,
                                        CPU_BOOLEAN      keep_alive_en,
                                        NET_ERR         *perr);
```

### ARGUMENTS

conn_id_tcp — Handle identifier of TCP connection to configure transmit keep-alive.

keep_alive_en — Desired value for TCP connection transmit keep-alive enable:

| | |
|---|---|
| DEF_ENABLED | TCP connections transmit periodic keep-alive segments if no data segments have been received within the keep-alive timeout. |
| DEF_DISABLED | TCP connections transmit a reset segment and close if no data segments have been received within the keep-alive timeout. |

perr — Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's transmit keep-alive enable successfully configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) { /* If NO errors, ...                              */
                                /* ... configure TCP connection Nagle algorithm. */
    NetTCP_ConnCfgTxKeepAliveEn(conn_id_tcp, DEF_ENABLED, &err);
}
```

NetTCP_ConnCfgTxKeepAliveEn() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-10 NetTCP_ConnCfgTxKeepAliveTh()

Configure TCP connection's maximum number of consecutive keep-alives to transmit.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgTxKeepAliveTh(NET_TCP_CONN_ID  conn_id_tcp,
                                        NET_PKT_CTR      nbr_max_keep_alive,
                                        NET_ERR         *perr);
```

### ARGUMENTS

conn_id_tcp — Handle identifier of TCP connection to configure transmit keep-alive threshold.

keep_alive_en — Desired maximum number of consecutive keep-alives to transmit.

perr — Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's transmit keep-alive enable successfully configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) { /* If NO errors, ...                              */
                                /* ... configure TCP connection Nagle algorithm. */
    NetTCP_ConnCfgTxKeepAliveTh(conn_id_tcp, 15u, &err);
}
```

NetTCP_ConnCfgTxKeepAliveTh() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-11 NetTCP_ConnCfgTxKeepAliveRetryTimeout()

Configure TCP connection's transmit keep-alive retry timeout.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgTxKeepAliveRetryTimeout(NET_TCP_CONN_ID      conn_id_tcp,
                                                  NET_TCP_TIMEOUT_SEC  timeout_sec,
                                                  NET_ERR             *perr);
```

### ARGUMENTS

conn_id_tcp — Handle identifier of TCP connection to configure transmit keep-alive retry timeout.

timeout_sec — Desired value for TCP connection transmit keep-alive retry timeout (in seconds).

perr — Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's transmit keep-alive retry timeout successfully configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) { /* If NO errors, ...                              */
                                /* ... configure TCP connection Nagle algorithm. */
    NetTCP_ConnCfgTxKeepAliveRetryTimeout(conn_id_tcp, 20u, &err);
}
```

NetTCP_ConnCfgTxKeepAliveRetryTimeout() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-12 NetTCP_ConnCfgTxAckDlyTimeout()

Configure TCP connection's transmit acknowledgement delay timeout.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgTxAckDlyTimeout(NET_TCP_CONN_ID     conn_id_tcp,
                                          NET_TCP_TIMEOUT_MS  timeout_ms,
                                          NET_ERR            *perr);
```

### ARGUMENTS

conn_id_tcp — Handle identifier of TCP connection to configure transmit acknowledgement delay timeout.

timeout_sec — Desired value for TCP connection transmit acknowledgement delay timeout (in milliseconds).

perr — Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's transmit acknowledgement delay timeout successfully configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The conn_id_tcp argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) { /* If NO errors, ...                              */
                                /* ... configure TCP connection Nagle algorithm. */
    NetTCP_ConnCfgTxAckDlyTimeout(conn_id_tcp, 20u, &err);
}
```

NetTCP_ConnCfgTxAckDlyTimeout() is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "net.h Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-13 NetTCP_ConnCfgMSL_Timeout()

Configure TCP connection's maximum segment lifetime (MSL) timeout.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
CPU_BOOLEAN NetTCP_ConnCfgMSL_Timeout(NET_TCP_CONN_ID      conn_id_tcp,
                                      NET_TCP_TIMEOUT_SEC  timeout_sec,
                                      NET_ERR             *perr);
```

### ARGUMENTS

conn_id_tcp — Handle identifier of TCP connection to configure transmit acknowledgement delay timeout.

timeout_sec — Desired value for TCP connection MSL timeout (in seconds).

perr — Pointer to variable that will receive the return error code from this function:

NET_TCP_ERR_NONE
NET_TCP_ERR_INVALID_ARG
NET_TCP_ERR_INVALID_CONN
NET_TCP_ERR_CONN_NOT_USED
NET_ERR_INIT_INCOMPLETE
NET_OS_ERR_LOCK

### RETURNED VALUE

DEF_OK, TCP connection's MSL timeout successfully configured;

DEF_FAIL, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

The `conn_id_tcp` argument represents the TCP connection handle – *not* the socket handle. The following code may be used to get the TCP connection handle and configure TCP connection parameters (see also section C-13-38 "NetSock_GetConnTransportID()" on page 644):

```
NET_SOCK_ID     sock_id;
NET_TCP_CONN_ID conn_id_tcp;
NET_ERR         err;

sock_id     = Application's TCP socket ID; /* Get application's TCP socket     ID. */
                                           /* Get socket's      TCP connection ID. */
conn_id_tcp = (NET_TCP_CONN_ID)NetSock_GetConnTransportID(sock_id, &err);

if (err == NET_SOCK_ERR_NONE) { /* If NO errors, ...                              */
                                /* ... configure TCP connection Nagle algorithm. */
    NetTCP_ConnCfgMSL_Timeout(conn_id_tcp, 20u, &err);
}
```

`NetTCP_ConnCfgMSL_Timeout()` is called by application function(s) and *must not* be called with the global network lock already acquired. It *must* block *all* other network protocol tasks by pending on and acquiring the global network lock (see "`net.h` Note #3"). This is required since an application's network protocol suite API function access is asynchronous to other network protocol tasks.

## C-14-14 NetTCP_ConnPoolStatGet()

Get TCP connections' statistics pool.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
NET_STAT_POOL NetTCP_ConnPoolStatGet(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

TCP connections' statistics pool, if no errors.

NULL statistics pool, otherwise.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-14-15 NetTCP_ConnPoolStatResetMaxUsed()

Reset TCP connections' statistics pool's maximum number of entries used.

### FILES

net_tcp.h/net_tcp.c

### PROTOTYPE

```
void NetTCP_ConnPoolStatResetMaxUsed(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

None.

## C-14-16 NetTCP_InitTxSeqNbr()

Application-defined function to initialize TCP's Initial Transmit Sequence Number Counter.

### FILES

net_tcp.h/net_bsp.c

### PROTOTYPE

```
void NetTCP_InitTxSeqNbr(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755).

### NOTES / WARNINGS

If TCP module is included, the application is required to initialize TCP's Initial Transmit Sequence Number Counter. Possible initialization methods include:

- Time-based initialization is one preferred method since it more appropriately provides a pseudo-random initial sequence number.
- Hardware-generated random number initialization is *not* a preferred method since it tends to produce a discrete set of pseudo-random initial sequence numbers – often the same initial sequence number.
- Hard-coded initial sequence number is *not* a preferred method since it is *not* random.

## C-15 NETWORK TIMER FUNCTIONS

### C-15-1 NetTmr_PoolStatGet()

Get Network Timers' statistics pool.

#### FILES

net_tmr.h/net_tmr.c

#### PROTOTYPE

```
NET_STAT_POOL NetTmr_PoolStatGet(void);
```

#### ARGUMENTS

None.

#### RETURNED VALUE

Network Timers' statistics pool, if no errors.

NULL statistics pool, otherwise.

#### REQUIRED CONFIGURATION

None.

#### NOTES / WARNINGS

None.

## C-15-2 NetTmr_PoolStatResetMaxUsed()

Reset Network Timers' statistics pool's maximum number of entries used.

### FILES

net_tmr.h/net_tmr.c

### PROTOTYPE

```
void NetTmr_PoolStatResetMaxUsed(void);
```

### ARGUMENTS

None.

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

None.

# C-16 UDP FUNCTIONS

## C-16-1 NetUDP_RxAppData()

Copy up to a specified number of bytes from received UDP packet buffer(s) into an application memory buffer.

### FILES

net_udp.h/net_udp.c

### PROTOTYPE

```
CPU_INT16U    NetUDP_RxAppData(NET_BUF    *pbuf,
                               void       *pdata_buf,
                               CPU_INT16U  data_buf_len,
                               CPU_INT16U  flags,
                               void       *pip_opts_buf,
                               CPU_INT08U  ip_opts_buf_len,
                               CPU_INT08U *pip_opts_len,
                               NET_ERR    *perr);
```

### ARGUMENTS

pbuf Pointer to network buffer that received UDP datagram.

pdata_buf Pointer to application buffer to receive application data.

data_buf_len Size of application receive buffer (in bytes).

flags Flag to select receive options; bit-field flags logically **OR**'d:

| | |
|---|---|
| NET_UDP_FLAG_NONE | No UDP receive flags selected. |
| NET_UDP_FLAG_RX_DATA_PEEK | Receive UDP application data without consuming the data; i.e., do *not* free any UDP receive packet buffer(s). |

pip_opts_buf Pointer to buffer to receive possible IP options, if no errors.

`ip_opts_buf_len` Size of IP options receive buffer (in bytes).

`pip_opts_len` Pointer to variable that will receive the return size of any received IP options, if no errors.

`perr` Pointer to variable that will receive the return error code from this function:

`NET_UDP_ERR_NONE`
`NET_UDP_ERR_NULL_PTR`
`NET_UDP_ERR_INVALID_DATA_SIZE`
`NET_UDP_ERR_INVALID_FLAG`
`NET_ERR_INIT_INCOMPLETE`
`NET_ERR_RX`

### RETURNED VALUE

Positive number of bytes received, if successful;

`0`, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

`NetUDP_RxAppData()` *must* be called with the global network lock already acquired. Expected to be called from application's custom `NetUDP_RxAppDataHandler()` (see section C-16-2 on page 704).

Each UDP receive returns the data from exactly one send but datagram order and delivery is not guaranteed. Also, if the application memory buffer is not large enough to receive an entire datagram, the datagram's data is truncated to the size of the memory buffer and the remaining data is discarded. Therefore, the application memory buffer should be large enough to receive either the maximum UDP datagram size (i.e., 65,507 bytes) *or* the application's expected maximum UDP datagram size.

Only some UDP receive flag options are implemented. If other flag options are requested, an error is returned so that flag options are *not* silently ignored.

## C-16-2 NetUDP_RxAppDataHandler()

Application-defined handler to demultiplex and receive UDP packet(s) to application without sockets.

### FILES

net_udp.h/net_bsp.c

### PROTOTYPE

```
void NetUDP_RxAppDataHandler(NET_BUF          *pbuf,
                             NET_IP_ADDR       src_addr,
                             NET_UDP_PORT_NBR  src_port,
                             NET_IP_ADDR       dest_addr,
                             NET_UDP_PORT_NBR  dest_port,
                             NET_ERR          *perr);
```

### ARGUMENTS

pbuf Pointer to network buffer that received UDP datagram.

src_addr Receive UDP packet's source IP address.

src_port Receive UDP packet's source UDP port.

dest_addr Receive UDP packet's destination IP address.

dest_port Receive UDP packet's destination UDP port.

perr Pointer to variable that will receive the return error code from this function:

NET_APP_ERR_NONE
NET_ERR_RX_DEST
NET_ERR_RX

### RETURNED VALUE

None.

### REQUIRED CONFIGURATION

Available only if NET_UDP_CFG_APP_API_SEL is configured for application demultiplexing (see section D-13-1 on page 756).

### NOTES / WARNINGS

NetUDP_RxAppDataHandler() *already* called with the global network lock acquired and expects to call NetUDP_RxAppData() to copy data from received UDP packets (see section C-16-1 on page 702).

If NetUDP_RxAppDataHandler() services the application data immediately within the handler function, it should do so as quickly as possible since the network's global lock remains acquired for the full duration. Thus, no other network receives or transmits can occur while NetUDP_RxAppDataHandler() executes.

NetUDP_RxAppDataHandler() may delay servicing the application data but *must* then:

- Acquire the network's global lock *prior* to calling NetUDP_RxAppData()
- Release the network's global lock *after* calling NetUDP_RxAppData()

If NetUDP_RxAppDataHandler() successfully demultiplexes the UDP packets, it should eventually call NetUDP_RxAppData() to deframe the UDP packet application data. If NetUDP_RxAppData() successfully deframes the UDP packet application data, NetUDP_RxAppDataHandler() *must not* call NetUDP_RxPktFree() to free the UDP packet's network buffer(s), since NetUDP_RxAppData() already frees the network buffer(s). And if the UDP packets were successfully demultiplexed and deframed, NetUDP_RxAppDataHandler() must return NET_APP_ERR_NONE.

However, if NetUDP_RxAppDataHandler() does *not* successfully demultiplex the UDP packets and therefore does *not* call NetUDP_RxAppData(), then NetUDP_RxAppDataHandler() should return NET_ERR_RX_DEST but must *not* free or discard the UDP packet network buffer(s).

But if NetUDP_RxAppDataHandler() or NetUDP_RxAppData() fails for any other reason, NetUDP_RxAppDataHandler() should call NetUDP_RxPktDiscard() to discard the UDP packet's network buffer(s) and should return NET_ERR_RX.

## C-16-3 NetUDP_TxAppData()

Copy bytes from an application memory buffer to send via UDP packet(s).

### FILES

net_udp.h/net_udp.c

### PROTOTYPE

```
CPU_INT16U
NetUDP_TxAppData(void             *p_data,
                 CPU_INT16U        data_len,
                 NET_IP_ADDR       src_addr,
                 NET_UDP_PORT_NBR  src_port,
                 NET_IP_ADDR       dest_addr,
                 NET_UDP_PORT_NBR  dest_port,
                 NET_IP_TOS        TOS,
                 NET_IP_TTL        TTL,
                 CPU_INT16U        flags_udp,
                 CPU_INT16U        flags_ip,
                 void             *popts_ip,
                 NET_ERR          *perr);
```

### ARGUMENTS

p_data Pointer to application data.

data_len Length of application data (in bytes).

src_addr Source IP address.

src_port Source UDP port.

dest_addr Destination IP address.

dest_port Destination UDP port.

TOS Specific TOS to transmit UDP/IP packet.

TTL — Specific TTL to transmit UDP/IP packet:

| | | | |
|---|---|---|---|
| NET_IP_TTL_MIN | 1 | minimum | TTL transmit value |
| NET_IP_TTL_MAX | 255 | maximum | TTL transmit value |
| NET_IP_TTL_DFLT | | default | TTL transmit value |
| NET_IP_TTL_NONE | 0 | replace with default TTL | |

flags_udp — Flags to select UDP transmit options; bit-field flags logically **OR**'d:

| | |
|---|---|
| NET_UDP_FLAG_NONE | No UDP transmit flags selected. |
| NET_UDP_FLAG_TX_CHK_SUM_DIS | Disable UDP transmit check-sums. |
| NET_UDP_FLAG_TX_BLOCK | Transmit UDP application data with blocking, if flag set; without blocking, if flag clear. |

flags_ip — Flags to select IP transmit options; bit-field flags logically **OR**'d:

| | |
|---|---|
| NET_IP_FLAG_NONE | No IP transmit flags selected. |
| NET_IP_FLAG_TX_DONT_FRAG | Set IP 'Don't Frag' flag. |

popts_ip — Pointer to one or more IP options configuration data structures:

| | |
|---|---|
| NULL | No IP transmit options configuration. |
| NET_IP_OPT_CFG_ROUTE_TS | Route and/or Internet Timestamp options configuration. |
| NET_IP_OPT_CFG_SECURITY | Security options configuration. |

perr — Pointer to variable that will receive the return error code from this function:

NET_UDP_ERR_NONE
NET_UDP_ERR_NULL_PTR
NET_UDP_ERR_INVALID_DATA_SIZE
NET_UDP_ERR_INVALID_LEN_DATA
NET_UDP_ERR_INVALID_PORT_NBR
NET_UDP_ERR_INVALID_FLAG
NET_BUF_ERR_NULL_PTR
NET_BUF_ERR_NONE_AVAIL

NET_BUF_ERR_INVALID_TYPE
NET_BUF_ERR_INVALID_SIZE
NET_BUF_ERR_INVALID_IX
NET_BUF_ERR_INVALID_LEN
NET_UTIL_ERR_NULL_PTR
NET_UTIL_ERR_NULL_SIZE
NET_UTIL_ERR_INVALID_PROTOCOL
NET_ERR_TX
NET_ERR_INIT_INCOMPLETE
NET_ERR_INVALID_PROTOCOL
NET_OS_ERR_LOCK

### RETURNED VALUE

Positive number of bytes sent, if successful;

`0`, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

Each UDP datagram is sent atomically – i.e., each call to send data *must* be sent in a single, complete datagram. Since µC/TCP-IP does *not* currently support IP transmit fragmentation, if the application attempts to send data greater than a single UDP datagram, then the send is aborted and no data is sent.

Only some UDP transmit flag options are implemented. If other flag options are requested, an error is returned so that flag options are *not* silently ignored.

# C-17 GENERAL NETWORK UTILITY FUNCTIONS

## C-17-1 NET_UTIL_HOST_TO_NET_16()

Convert 16-bit integer values from CPU host-order to network-order.

### FILES

`net_util.h`

### PROTOTYPE

```
NET_UTIL_HOST_TO_NET_16(val);
```

### ARGUMENTS

`val` 16-bit integer data value to convert.

### RETURNED VALUE

16-bit integer value in network-order.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

For microprocessors that require data access to be aligned to appropriate word boundaries, val and any variable to receive the returned 16-bit integer *must* start on appropriately-aligned CPU addresses. This means that all 16-bit words *must* start on addresses that are multiples of 2 bytes.

## C-17-2 NET_UTIL_HOST_TO_NET_32()

Convert 32-bit integer values from CPU host-order to network-order.

### FILES

`net_util.h`

### PROTOTYPE

```
NET_UTIL_HOST_TO_NET_32(val);
```

### ARGUMENTS

`val` 32-bit integer data value to convert.

### RETURNED VALUE

32-bit integer value in network-order.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

For microprocessors that require data access to be aligned to appropriate word boundaries, val and any variable to receive the returned 32-bit integer *must* start on appropriately-aligned CPU addresses. This means that all 32-bit words *must* start on addresses that are multiples of 4 bytes.

## C-17-3 NET_UTIL_NET_TO_HOST_16()

Convert 16-bit integer values from network-order to CPU host- order.

### FILES

net_util.h

### PROTOTYPE

```
NET_UTIL_NET_TO_HOST_16(val);
```

### ARGUMENTS

| | |
|---|---|
| val | 16-bit integer data value to convert. |

### RETURNED VALUE

16-bit integer value in CPU host-order.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

For microprocessors that require data access to be aligned to appropriate word boundaries, val and any variable to receive the returned 16-bit integer *must* start on appropriately-aligned CPU addresses. This means that all 16-bit words *must* start on addresses that are multiples of 2 bytes.

## C-17-4 NET_UTIL_NET_TO_HOST_32()

Convert 32-bit integer values from network-order to CPU host- order.

### FILES

net_util.h

### PROTOTYPE

```
NET_UTIL_NET_TO_HOST_32(val);
```

### ARGUMENTS

| | |
|---|---|
| val | 32-bit integer data value to convert. |

### RETURNED VALUE

32-bit integer value in CPU host-order.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

For microprocessors that require data access to be aligned to appropriate word boundaries, val and any variable to receive the returned 32-bit integer *must* start on appropriately-aligned CPU addresses. This means that all 32-bit words *must* start on addresses that are multiples of 4 bytes.

## C-17-5 NetUtil_TS_Get()

Application-defined function to get the current Internet Timestamp.

### FILES

net_util.h/net_bsp.c

### PROTOTYPE

```
NET_TS NetUtil_TS_Get (void);
```

### ARGUMENTS

None.

### RETURNED VALUE

Current Internet Timestamp, if available;

NET_TS_NONE, otherwise.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

RFC #791, Section 3.1 'Options: Internet Timestamp' states that "the [Internet] Timestamp is a right-justified, 32-bit timestamp in milliseconds since midnight UT [Universal Time]".

The application is responsible for providing a real-time clock with correct time-zone configuration to implement the Internet Timestamp, if possible. In order to implement this feature, the target hardware must usually include a real-time clock with the correct time zone configuration. However, NetUtil_TS_Get() is not absolutely required and may return NET_TS_NONE if real-time clock hardware is not available.

## C-17-6 NetUtil_TS_Get_ms()

Application-defined function to get the current millisecond timestamp.

### FILES

net_util.h/net_bsp.c

### PROTOTYPE

```
NET_TS_MS NetUtil_TS_Get_ms (void);
```

### ARGUMENTS

None.

### RETURNED VALUE

Current millisecond timestamp.

### REQUIRED CONFIGURATION

None.

### NOTES / WARNINGS

The application is responsible for providing a millisecond timestamp clock with adequate resolution and range to satisfy the minimum/maximum TCP RTO values (see 'net_bsp.c NetUtil_TS_Get_ms() Note #1a').

µC/TCP-IP includes µC/OS-II and µC/OS-III implementations which use their OS tick counters as the source for the millisecond timestamp. These implementations can be found in the following directories:

\Micrium\Software\uC-TCPIP-V2\BSP\Template\OS\uCOS-II

\Micrium\Software\uC-TCPIP-V2\BSP\Template\OS\uCOS-III

# C-18 BSD FUNCTIONS

## C-18-1 accept() (TCP)

Wait for new socket connections on a listening server socket. See section C-13-1 on page 572 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
int accept(int              sock_id,
           struct sockaddr *paddr_remote,
           socklen_t       *paddr_len);
```

## C-18-2 bind() (TCP/UDP)

Assign network addresses to sockets. See section C-13-2 on page 574 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
int bind(int              sock_id,
         struct sockaddr *paddr_local,
         socklen_t        addr_len);
```

## C-18-3 close() (TCP/UDP)

Terminate communication and free a socket. See section C-13-31 on page 632 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
int close(int sock_id);
```

## C-18-4 connect() (TCP/UDP)

Connect a local socket to a remote socket address. See section C-13-32 on page 634 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
int connect(int              sock_id,
            struct sockaddr *paddr_remote,
            socklen_t        addr_len);
```

## C-18-5 FD_CLR() (TCP/UDP)

Remove a socket file descriptor ID as a member of a file descriptor set. See section C-13-33 on page 637 for more information.

### FILES

net_bsd.h

### PROTOTYPE

```
FD_CLR(fd, fdsetp);
```

### REQUIRED CONFIGURATION

Available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

## C-18-6 FD_ISSET() (TCP/UDP)

Check if a socket file descriptor ID is a member of a file descriptor set. See section C-13-36 on page 641 for more information.

### FILES

net_bsd.h

### PROTOTYPE

```
FD_ISSET(fd, fdsetp);
```

### REQUIRED CONFIGURATION

Available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

## C-18-7 FD_SET() (TCP/UDP)

Add a socket file descriptor ID as a member of a file descriptor set. See section C-13-37 on page 643 for more information.

### FILES

net_bsd.h

### PROTOTYPE

```
FD_SET(fd, fdsetp);
```

### REQUIRED CONFIGURATION

Available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

## C-18-8 FD_ZERO() (TCP/UDP)

Initialize/zero-clear a file descriptor set. See section C-13-35 on page 640 for more information.

### FILES

net_bsd.h

### PROTOTYPE

```
FD_ZERO(fdsetp);
```

### REQUIRED CONFIGURATION

Available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

## C-18-9 getsockopt() (TCP/UDP)

Get a specific option value on a specific TCP socket. See section C-13-42 on page 653 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
int getsockopt(int         sock_id,
               int         level,
               int         opt_name,
               void       *popt_val,
               sock_len_t *popt_len);
```

### ARGUMENTS

| | |
|---|---|
| sock_id | This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted. |
| level | Protocol level from which to retrieve the socket option. |
| opt_name | Socket option to set the value. |
| popt_val | Pointer to the socket option value to set. |
| popt_len | Pointer to the socket option value to get. |

### RETURNED VALUE

0, if successful;

-1, otherwise.

### REQUIRED CONFIGURATION

getsockopt() is available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756), and if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

The supported options are:

- Protocol level SOL_SOCKET:
  - SO_TYPE
  - SO_KEEPALIVE
  - SO_ACCEPTCONN
  - SO_SNDBUF / SO_RCVBUF
  - SO_SNDTIMEO / SO_RCVTIMEO
- Protocol level IPPROTO_IP:
  - IP_TOS
  - IP_TTL
  - IP_RECVIF
- Protocol level IPPROTO_TCP:
  - TCP_NODELAY
  - TCP_KEEPCNT
  - TCP_KEEPIDLE
  - TCP_INTVL

## C-18-10 htonl()

Convert 32-bit integer values from CPU host-order to network-order. See section C-17-2 on page 710 for more information.

### FILES

net_bsd.h

### PROTOTYPE

```
htonl(val);
```

### REQUIRED CONFIGURATION

Available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

## C-18-11 htons()

Convert 16-bit integer values from CPU host-order to network-order. See section C-17-1 on page 709 for more information.

### FILES

net_bsd.h

### PROTOTYPE

```
htons(val);
```

## C-18-12 inet_addr() (IPv4)

Convert a string of an IPv4 address in dotted-decimal notation to an IPv4 address in host-order. See section C-4-3 on page 457 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
in_addr_t inet_addr(char *paddr);
```

### ARGUMENTS

paddr Pointer to an ASCII string that contains a dotted-decimal IPv4 address.

### RETURNED VALUE

Returns the IPv4 address represented by ASCII string in host-order, if no errors.

-1 (i.e., 0xFFFFFFFF), otherwise.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756) *and* if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

RFC 1983 states that "dotted decimal notation… refers [to] IP addresses of the form A.B.C.D; where each letter represents, in decimal, one byte of a four byte IP address". In other words, the dotted-decimal notation separates four decimal byte values by the dot, or period, character ('.'). Each decimal value represents one byte of the IP address starting with the most significant byte in network order.

### IPv4 Address Examples

| DOTTED DECIMAL NOTATION | HEXADECIMAL EQUIVALENT |
|---|---|
| 127.0.0.1 | 0x7F000001 |
| 192.168.1.64 | 0xC0A80140 |
| 255.255.255.0 | 0xFFFFFF00 |
| MSB ..... LSB | MSB .... LSB |

MSB Most Significant Byte in Dotted-Decimal IP Address

LSB Least Significant Byte in Dotted-Decimal IP Address

The IPv4 dotted-decimal ASCII string *must* include *only* decimal values and the dot, or period, character ('.'); all other characters are trapped as invalid, including any leading or trailing characters. The ASCII string *must* include exactly four decimal values separated by exactly three dot characters. Each decimal value *must not* exceed the maximum byte value (i.e., 255), or exceed the maximum number of digits for each byte (i.e., 3) including any leading zeros.

## C-18-13 inet_aton() (IPv4)

Convert an IPv4 address in ASCII dotted-decimal notation to a network protocol IPv4 address in network-order. See section C-4-3 on page 457 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
int inet_aton(       char    *paddr_in,
              struct in_addr *paddr);
```

### ARGUMENTS

`paddr_in` Pointer to an ASCII string that contains a dotted-decimal IPv4 address.

`paddr` Pointer to an IPv4 address that will receive the converted address.

### RETURNED VALUE

1, if no errors.

`0`, otherwise.

### REQUIRED CONFIGURATION

Available only if either `NET_CFG_TRANSPORT_LAYER_SEL` is configured for TCP (see section D-12-1 on page 755) and/or `NET_UDP_CFG_APP_API_SEL` is configured for sockets (see section D-13-1 on page 756) *and* if `NET_BSD_CFG_API_EN` is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

RFC 1983 states that "dotted decimal notation... refers [to] IP addresses of the form A.B.C.D; where each letter represents, in decimal, one byte of a four-byte IP address". In other words, the dotted-decimal notation separates four decimal byte values by the dot, or period, character ('.'). Each decimal value represents one byte of the IP address starting with the most significant byte in network order.

### IPv4 Address Examples

| DOTTED DECIMAL NOTATION | HEXADECIMAL EQUIVALENT |
|---|---|
| 127.0.0.1 | 0x7F000001 |
| 192.168.1.64 | 0xC0A80140 |
| 255.255.255.0 | 0xFFFFFF00 |
| MSB ..... LSB | MSB .... LSB |

MSB Most Significant Byte in Dotted-Decimal IP Address

LSB Least Significant Byte in Dotted-Decimal IP Address

Values specified using IPv4 dotted decimal notation take one of the following forms:

a.b.c.d When a four parts address is specified, each shall be interpreted as a byte of data and assigned, from left to right, to the four bytes of an internet address.

a.b.c When three parts address is specified, the last part shall be interpreted as a 16-bit quantity and placed in the rightmost two bytes of the network address. This makes the three part address format convenient for specifying Class B network addresses as "128.net.host".

a.b When two parts address is specified, the last part shall be interpreted as a 24-bit quantity and placed in the rightmost three bytes of the network address. This makes the two part address format convenient for specifying Class A network addresses as "net.host".

a When one part address is specified, the value shall be stored directly in the network address without any byte rearrangement.

The dotted-decimal ASCII string *must*:

- Include only decimal values and the dot, or period, character (".."). All other characters are trapped as invalid, including any leading or trailing characters.
- Included up to four decimal values, separated bu UP to three dot characters.

- Ensure that each decimal value does not exceed the maximum value for its form:
  - a.b.c.d - 255.255.255.255
  - a.b.c - 255.255.255.65535
  - a.b - 255.16777215
  - a - 4294967295
- Ensure that each decimal value does *not* exceed leading zeros.

## C-18-14 inet_ntoa() (IPv4)

Convert an IPv4 address in host-order into an IPv4 dotted-decimal notation ASCII string. See section C-4-1 on page 453 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
char *inet_ntoa(struct in_addr addr);
```

### ARGUMENTS

in_addr IPv4 address (in host-order).

### RETURNED VALUE

Pointer to ASCII string of converted IPv4 address (see Notes / Warnings), if no errors.

Pointer to NULL, otherwise.

### REQUIRED CONFIGURATION

Available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756) *and* if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

RFC 1983 states that "dotted decimal notation... refers [to] IP addresses of the form A.B.C.D; where each letter represents, in decimal, one byte of a four-byte IP address". In other words, the dotted-decimal notation separates four decimal byte values by the dot, or period, character ('.'). Each decimal value represents one byte of the IP address starting with the most significant byte in network order.

### IPv4 Address Examples

| DOTTED DECIMAL NOTATION | HEXADECIMAL EQUIVALENT |
|---|---|
| 127.0.0.1 | 0x7F000001 |
| 192.168.1.64 | 0xC0A80140 |
| 255.255.255.0 | 0xFFFFFF00 |
| MSB ..... LSB | MSB .... LSB |

MSB Most Significant Byte in Dotted-Decimal IP Address

LSB Least Significant Byte in Dotted-Decimal IP Address

Since the returned ASCII string is stored in a single, global ASCII string array, this function is *not* reentrant or thread-safe. Therefore, the returned string should be copied as soon as possible before other calls to inet_ntoa() are needed.

## C-18-15 listen() (TCP)

Set a socket to accept incoming connections. See section C-13-40 on page 648 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
int listen(int sock_id,
           int sock_q_size);
```

## C-18-16 ntohl()

Convert 32-bit integer values from network-order to CPU host-order. See section C-17-4 on page 712 for more information.

### FILES

net_bsd.h

### PROTOTYPE

```
ntohl(val);
```

### REQUIRED CONFIGURATION

Available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

## C-18-17 ntohs()

Convert 16-bit integer values from network-order to CPU host-order. See section C-17-3 on page 711 for more information.

### FILES

net_bsd.h

### PROTOTYPE

```
ntohs(val);
```

### REQUIRED CONFIGURATION

Available only if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

## C-18-18 recv() / recvfrom() (TCP/UDP)

Copy up to a specified number of bytes received from a remote socket into an application memory buffer. See section C-13-46 on page 659 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPES

```
ssize_t recv(int     sock_id,
             void   *pdata_buf,
            _size_t  data_buf_len,
             int     flags);

ssize_t recvfrom(int              sock_id,
                 void            *pdata_buf,
                _size_t           data_buf_len,
                 int              flags,
                 struct sockaddr *paddr_remote,
                 socklen_t       *paddr_len);
```

## C-18-19 select() (TCP/UDP)

Check if any sockets are ready for available read or write operations or error conditions. See section C-13-47 “NetSock_Sel() / select() (TCP/UDP)” on page 663 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
int select(int             desc_nbr_max,
           struct fd_set  *pdesc_rd,
           struct fd_set  *pdesc_wr,
           struct fd_set  *pdesc_err,
           struct timeval *ptimeout);
```

## C-18-20 send() / sendto() (TCP/UDP)

Copy bytes from an application memory buffer into a socket to send to a remote socket. See section C-13-48 on page 666 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPES

```
ssize_t send (int     sock_id,
              void   *p_data,
             _size_t  data_len,
              int     flags);

ssize_t sendto(int              sock_id,
               void            *p_data,
              _size_t           data_len,
               int              flags,
               struct sockaddr *paddr_remote,
               socklen_t        addr_len);
```

## C-18-21 setsockopt() (TCP/UDP)

Set a specific option on a specific TCP socket. See section C-13-43 on page 655 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
int setsockopt(int         sock_id,
               int         level,
               int         opt_name,
               void       *popt_val,
               sock_len_t  opt_len);
```

### ARGUMENTS

sock_id — This is the socket ID returned by NetSock_Open()/socket() when the socket was created *or* by NetSock_Accept()/accept() when a connection was accepted.

level — Protocol level from which to retrieve the socket option.

opt_name — Socket option to set the value.

popt_val — Pointer to the socket option value to set.

opt_len — Option length.

### RETURNED VALUE

0, if successful;

-1, otherwise.

### REQUIRED CONFIGURATION

setsockopt() is available only if either NET_CFG_TRANSPORT_LAYER_SEL is configured for TCP (see section D-12-1 on page 755) and/or NET_UDP_CFG_APP_API_SEL is configured for sockets (see section D-13-1 on page 756), and if NET_BSD_CFG_API_EN is enabled (see section D-17-1 on page 767).

### NOTES / WARNINGS

The supported options are:

- Protocol level SOL_SOCKET:
  - SO_KEEPALIVE
  - SO_SNDBUF / SO_RCVBUF
  - SO_SNDTIMEO / SO_RCVTIMEO
- Protocol level IPPROTO_IP:
  - IP_TOS
  - IP_TTL
- Protocol level IPPROTO_TCP:
  - TCP_NODELAY
  - TCP_KEEPCNT
  - TCP_KEEPIDLE
  - TCP_INTVL

## C-18-22 socket() (TCP/UDP)

Create a datagram (i.e., UDP) or stream (i.e., TCP) type socket. See section C-13-41 on page 650 for more information.

### FILES

net_bsd.h/net_bsd.c

### PROTOTYPE

```
int socket(int protocol_family,
           int sock_type,
           int protocol);
```

Appendix

# D

# µC/TCP-IP Configuration and Optimization

µC/TCP-IP is configurable at compile time via approximately 70 `#defines` in an application's `net_cfg.h` and `app_cfg.h` files. µC/TCP-IP uses `#defines` because they allow code and data sizes to be scaled at compile time based on enabled features and the configured number of network objects. This allows the ROM and RAM footprints of µC/TCP-IP to be adjusted based on application requirements.

Most of the `#defines` should be configured with the default configuration values. A handful of values may likely never change because there is currently only one configuration choice available. This leaves approximately a dozen values that should be configured with values that may deviate from the default configuration.

It is recommended that the configuration process begins with the recommended or default configuration values which are shown in **bold**.

Unlike Appendix C on page 417, the sections in this appendix are organized following the order in µC/TCP-IP's template configuration file, `net_cfg.h`.

# D-1 NETWORK CONFIGURATION

## D-1-1 NET_CFG_INIT_CFG_VALS

NET_CFG_INIT_CFG_VALS is used to determine whether internal TCP/IP parameters are set to default values or are set by the user:

| | |
|---|---|
| **NET_INIT_CFG_VALS_DFLT** | µC/TCP-IP initializes all parameters with default values |
| NET_INIT_CFG_VALS_APP_INIT | Application initializes all µC/TCP-IP parameters with application-specific values |

**NET_INIT_CFG_VALS_DFLT**

Configure µC/TCP-IP's network parameters with default values. The application only needs to call Net_Init() to initialize both µC/TCP-IP and its configurable parameters. This configuration is highly recommended since configuring network parameters requires in-depth knowledge of the protocol stack. In fact, most references recommend many of the default values we have selected.

| Parameter | Units | Min | Max | Default | Configuration Function |
|---|---|---|---|---|---|
| Interface's Network Buffer Low Threshold | % of the Total Number of an Interface's Network Buffers | 5% | 50% | 5% | NetDbg_CfgRsrcBufThLo() |
| Interface's Network Buffer Low Threshold Hysteresis | % of the Total Number of an Interface's Network Buffers | 0% | 15% | 3% | NetDbg_CfgRsrcBufThLo() |
| Interface's Large Receive Buffer Low Threshold | % of the Total Number of an Interface's Large Receive Buffers | 5% | 50% | 5% | NetDbg_CfgRsrcBufRxLargeThLo() |
| Interface's Large Receive Buffer Low Threshold Hysteresis | % of the Total Number of an Interface's Large Receive Buffers | 0% | 15% | 3% | NetDbg_CfgRsrcBufRxLargeThLo() |
| Interface's Small Transmit Buffer Low Threshold | % of the Total Number of an Interface's Small Transmit Buffers | 5% | 50% | 5% | NetDbg_CfgRsrcBufTxSmallThLo() |

| Parameter | Units | Min | Max | Default | Configuration Function |
|---|---|---|---|---|---|
| Interface's Small Transmit Buffer Low Threshold Hysteresis | % of the Total Number of an Interface's Small Transmit Buffers | 0% | 15% | 3% | NetDbg_CfgRsrcBufTxSmallThLo() |
| Interface's Large Transmit Buffer Low Threshold | % of the Total Number of an Interface's Large Transmit Buffers | 5% | 50% | 5% | NetDbg_CfgRsrcBufTxLargeThLo() |
| Interface's Large Transmit Buffer Low Threshold Hysteresis | % of the Total Number of an Interface's Large Transmit Buffers | 0% | 15% | 3% | NetDbg_CfgRsrcBufTxLargeThLo() |
| | | | | | |
| Network Timer Low Threshold | % of the Total Number of Network Timers | 5% | 50% | 5% | NetDbg_CfgRsrcTmrLoTh() |
| Network Timer Low Threshold Hysteresis | % of the Total Number of Network Timers | 0% | 15% | 3% | NetDbg_CfgRsrcTmrLoTh() |
| Network Connection Low Threshold | % of the Total Number of Network Connections | 5% | 50% | 5% | NetDbg_CfgRsrcConnLoTh() |
| Network Connection Low Threshold Hysteresis | % of the Total Number of Network Connections | 0% | 15% | 3% | NetDbg_CfgRsrcConnLoTh() |
| ARP Cache Low Threshold | % of the Total Number of ARP Caches | 5% | 50% | 5% | NetDbg_CfgRsrcARP_CacheLoTh() |
| ARP Cache Low Threshold Hysteresis | % of the Total Number of ARP Caches | 0% | 15% | 3% | NetDbg_CfgRsrcARP_CacheLoTh() |
| TCP Connection Low Threshold | % of the Total Number of TCP Connections | 5% | 50% | 5% | NetDbg_CfgRsrcTCP_ConnLoTh() |
| TCP Connection Low Threshold Hysteresis | % of the Total Number of TCP Connections | 0% | 15% | 3% | NetDbg_CfgRsrcTCP_ConnLoTh() |
| Socket Low Threshold | % of the Total Number of Sockets | 5% | 50% | 5% | NetDbg_CfgRsrcSockLoTh() |
| Socket Low Threshold Hysteresis | % of the Total Number of Sockets | 0% | 15% | 3% | NetDbg_CfgRsrcSockLoTh() |
| | | | | | |

| Parameter | Units | Min | Max | Default | Configuration Function |
|---|---|---|---|---|---|
| Resource Monitor Task Time | Seconds | 1 | 600 | 60 | NetDbg_CfgMonTaskTime() |
| | | | | | |
| Network Connection Accessed Threshold | Number of Network Connections | 10 | 65000 | 100 | NetConn_CfgAccessTh() |
| | | | | | |
| Network Interface Physical Link Monitor Period | Milliseconds | 50 | 60000 | 250 | NetIF_CfgPhyLinkPeriod() |
| Network Interface Performance Monitor Period | Milliseconds | 50 | 60000 | 250 | NetIF_CfgPerfMonPeriod() |
| | | | | | |
| ARP Cache Timeout | Seconds | 60 | 600 | 600 | NetARP_CfgCacheTimeout() |
| ARP Cache Accessed Threshold | Number of ARP Caches | 100 | 65000 | 100 | NetARP_CfgCacheAccessedTh() |
| | | | | | |
| ARP Request Timeout | Seconds | 1 | 10 | 5 | NetARP_CfgReqTimeout() |
| ARP Request Maximum Number of Retries | Maximum Number of Transmitted ARP Request Retries | 0 | 5 | 3 | NetARP_CfgReqMaxRetries() |
| | | | | | |
| IP Receive Fragments Reassembly Timeout | Seconds | 1 | 15 | 5 | NetIP_CfgFragReasmTimeout() |
| | | | | | |
| ICMP Transmit Source Quench Threshold | Number of Transmitted ICMP Source Quenches | 1 | 100 | 5 | NetICMP_CfgTxSrcQuenchTh() |

Table D-1 **µC/TCP-IP Internal Configuration Parameters**

**NET_INIT_CFG_VALS_APP_INIT**

It is possible to change the parameters listed in by calling the above configuration functions. These values could be stored in non-volatile memory and recalled at power up (*e.g.*, using EEPROM or battery-backed RAM) by the application. Similarly the values could be hard-coded directly in the application. Regardless of how the application configures the values, if this option is selected, the application must initialize *all* of the above configuration parameters using the configuration functions listed above.

Alternatively, the application could call `Net_InitDflt()` to initialize all of the internal configuration parameters to their default values and then call the configuration functions for only the values to be modified.

## D-1-2 NET_CFG_OPTIMIZE

Select portions of µC/TCP-IP code may be optimized for better performance or for smallest code size by configuring NET_CFG_OPTIMIZE:

| | |
|---|---|
| **NET_OPTIMIZE_SPD** | Optimizes µC/TCP-IP for best speed performance |
| NET_OPTIMIZE_SIZE | Optimizes µC/TCP-IP for best binary image size |

## D-1-3 NET_CFG_OPTIMIZE_ASM_EN

Select portions of µC/TCP-IP code may even call optimized assembly functions by configuring NET_CFG_OPTIMIZE_ASM_EN:

| | |
|---|---|
| **DEF_DISABLED** | No optimized assembly files/functions are included in the µC/TCP-IP build |
| or | |
| DEF_ENABLED | Optimized assembly files/functions are included in the µC/TCP-IP build |

## D-1-4 NET_CFG_BUILD_LIB_EN

µC/TCP-IP can be compiled on some toolchains into a linkable library by configuring NET_CFG_BUILD_LIB_EN:

| | |
|---|---|
| **DEF_DISABLED** | µC/TCP-IP **not** compiled as a linkable library |
| or | |
| DEF_ENABLED | Build µC/TCP-IP as a linkable library |

## D-2 DEBUG CONFIGURATION

A fair amount of code in µC/TCP-IP has been included to simplify debugging. There are several configuration constants used to aid debugging.

### D-2-1 NET_DBG_CFG_INFO_EN

NET_DBG_CFG_INFO_EN is used to enable/disable µC/TCP-IP debug information:

- Internal constants assigned to global variables
- Internal variable data sizes calculated and assigned to global variables

NET_DBG_CFG_INFO_EN can be set to either **DEF_DISABLED** or DEF_ENABLED.

### D-2-2 NET_DBG_CFG_STATUS_EN

NET_DBG_CFG_STATUS_EN is used to enable/disable µC/TCP-IP run-time status information:

- Internal resource usage – low or lost resources
- Internal faults or errors

NET_DBG_CFG_STATUS_EN can be set to either **DEF_DISABLED** or DEF_ENABLED.

## D-2-3 NET_DBG_CFG_MEM_CLR_EN

NET_DBG_CFG_MEM_CLR_EN is used to clear internal network data structures when allocated or de-allocated. By clearing, all bytes in internal data structures are set to '0' or to default initialization values. NET_DBG_CFG_MEM_CLR_EN can be set to either **DEF_DISABLED** or DEF_ENABLED. This configuration is typically set it to DEF_DISABLED unless the contents of the internal network data structures need to be examined for debugging purposes. Having the internal network data structures cleared generally helps to differentiate between "proper" data and "pollution".

## D-2-4 NET_DBG_CFG_TEST_EN

NET_DBG_CFG_TEST_EN is used internally for testing/debugging purposes and can be set to either **DEF_DISABLED** or DEF_ENABLED.

## D-3 ARGUMENT CHECKING CONFIGURATION

Most functions in µC/TCP-IP include code to validate arguments that are passed to it. Specifically, µC/TCP-IP checks to see if passed pointers are NULL, if arguments are within valid ranges, etc. The following constants configure additional argument checking.

### D-3-1 NET_ERR_CFG_ARG_CHK_EXT_EN

NET_ERR_CFG_ARG_CHK_EXT_EN allows code to be generated to check arguments for functions that can be called by the user and, for functions which are internal but receive arguments from an API that the user can call. Also, enabling this check verifies that µC/TCP-IP is initialized before API tasks and functions perform the desired function.

NET_ERR_CFG_ARG_CHK_EXT_EN can be set to either DEF_DISABLED or **DEF_ENABLED**.

### D-3-2 NET_ERR_CFG_ARG_CHK_DBG_EN

NET_ERR_CFG_ARG_CHK_DBG_EN allows code to be generated which checks to make sure that pointers passed to functions are not NULL, and that arguments are within range, etc. NET_ERR_CFG_ARG_CHK_DBG_EN can be set to either **DEF_DISABLED** or DEF_ENABLED.

## D-4 NETWORK COUNTER CONFIGURATION

µC/TCP-IP contains code that increments counters to keep track of statistics such as the number of packets received, the number of packets transmitted, etc. Also, µC/TCP-IP contains counters that are incremented when error conditions are detected. The following constants enable or disable network counters.

### D-4-1 NET_CTR_CFG_STAT_EN

NET_CTR_CFG_STAT_EN determines whether the code and data space used to keep track of statistics will be included. NET_CTR_CFG_STAT_EN can be set to either DEF_DISABLED or **DEF_ENABLED**.

### D-4-2 NET_CTR_CFG_ERR_EN

NET_CTR_CFG_ERR_EN determines whether the code and data space used to keep track of errors will be included. NET_CTR_CFG_ERR_EN can be set to either **DEF_DISABLED** or DEF_ENABLED.

## D-5 NETWORK TIMER CONFIGURATION

µC/TCP-IP manages software timers used to keep track of timeouts and execute callback functions when needed.

### D-5-1 NET_TMR_CFG_NBR_TMR

`NET_TMR_CFG_NBR_TMR` determines the number of timers that µC/TCP-IP will be managing. Of course, the number of timers affect the amount of RAM required by µC/TCP-IP. Each timer requires 12 bytes plus 4 pointers. Timers are required for:

- The Network Debug Monitor task1 total
- The Network Performance Monitor1 total
- The Network Link State Handler1 total
- Each ARP cache entry1 per ARP cache
- Each IP fragment reassembly1 per IP fragment chain
- Each TCP connection7 per TCP connection

It is recommended to set `NET_TMR_CFG_NBR_TMR` with at least **12 timers**, but a better starting point may be to allocate the maximum number of timers for all resources.

For instance, if the Network Debug Monitor task is enabled (see section 11-2 "Network Debug Monitor Task" on page 297), 20 ARP caches are configured (`NET_ARP_CFG_NBR_CACHE = 20`), & 10 TCP connections are configured (`NET_TCP_CFG_NBR_CONN = 10`); the maximum number of timers for these resources is 1 for the Network Debug Monitor task, 1 for the Network Performance Monitor, 1 for the Link State Handler, (`20 * 1`) for the ARP caches and, (`10 * 7`) for TCP connections:

```
# Timers = 1 + 1 + 1 + (20 * 1) + (10 * 7) = 93
```

## D-5-2 NET_TMR_CFG_TASK_FREQ

NET_TMR_CFG_TASK_FREQ determines how often (in Hz) network timers are to be updated. This value *must not* be configured as a floating-point number. NET_TMR_CFG_TASK_FREQ is typically set to **10 Hz**.

## D-6 NETWORK BUFFER CONFIGURATION

µC/TCP-IP manages Network Buffers to read data to and from network applications and network devices. Network Buffers are specially configured with network devices as described in section 5-1 "Buffer Management" on page 77.

## D-7 NETWORK INTERFACE LAYER CONFIGURATION

### D-7-1 NET_IF_CFG_MAX_NBR_IF

NET_IF_CFG_MAX_NBR_IF determines the maximum number of network interfaces that µC/TCP-IP may create at run-time. The default value of **1** is for a single network interface.

### D-7-2 NET_IF_CFG_LOOPBACK_EN

NET_IF_CFG_LOOPBACK_EN determines whether the code and data space used to support the loopback interface for internal-only communication only will be included. NET_IF_CFG_LOOPBACK_EN can be set to either **DEF_DISABLED** or DEF_ENABLED.

### D-7-3 NET_IF_CFG_ETHER_EN

NET_IF_CFG_ETHER_EN determines whether the code and data space used to support Ethernet interfaces and devices will be included. NET_IF_CFG_ETHER_EN can be set to either DEF_DISABLED or **DEF_ENABLED**, but must be enabled if the target expects to communicate over Ethernet networks.

### D-7-4 NET_IF_CFG_WIFI_EN

NET_IF_CFG_WIFI_EN determines whether the code and data space used to support wireless interfaces and devices will be included. NET_IF_CFG_WIFI_EN can be set to either DEF_DISABLED or **DEF_ENABLED**, but must be enabled if the target expects to communicate over wireless networks.

## D-7-5 NET_IF_CFG_ADDR_FLTR_EN

NET_IF_CFG_ADDR_FLTR_EN determines whether address filtering is enabled or not:

DEF_DISABLED  Addresses are *not* filtered

or

**DEF_ENABLED**  Addresses are filtered

## D-7-6 NET_IF_CFG_TX_SUSPEND_TIMEOUT_MS

NET_IF_CFG_TX_SUSPEND_TIMEOUT_MS configures the network interface transmit suspend timeout value. The value is specified in integer milliseconds. It is recommended to initially set NET_IF_CFG_TX_SUSPEND_TIMEOUT_MS with a value of **1 millisecond**.

## D-8 ARP (ADDRESS RESOLUTION PROTOCOL) CONFIGURATION

ARP is only required for some network interfaces such as Ethernet.

### D-8-1 NET_ARP_CFG_HW_TYPE

The current version of µC/TCP-IP only supports Ethernet-type networks, and thus `NET_ARP_CFG_HW_TYPE` should *always* be set to **`NET_ARP_HW_TYPE_ETHER`**.

### D-8-2 NET_ARP_CFG_PROTOCOL_TYPE

The current version of µC/TCP-IP only supports IPv4, and thus `NET_ARP_CFG_PROTOCOL_TYPE` should *always* be set to **`NET_ARP_PROTOCOL_TYPE_IP_V4`**.

### D-8-3 NET_ARP_CFG_NBR_CACHE

ARP caches the mapping of IP addresses to physical (i.e., MAC) addresses. `NET_ARP_CFG_NBR_CACHE` configures the number of ARP cache entries. Each cache entry requires approximately `18` bytes of RAM, plus five pointers, plus a hardware address and protocol address (`10` bytes assuming Ethernet interfaces and IPv4 addresses).

The number of ARP caches required by the application depends on how many different hosts are expected to communicate. If the application *only* communicates with hosts on remote networks via the local network's default gateway (i.e., router), then only a single ARP cache needs to be configured.

To test µC/TCP-IP with a smaller network, a default number of 3 ARP caches should be sufficient.

## D-8-4 NET_ARP_CFG_ADDR_FLTR_EN

NET_ARP_CFG_ADDR_FLTR_EN determines whether to enable address filtering:

DEF_DISABLED Addresses are *not* filtered

or

**DEF_ENABLED** Addresses are filtered

## D-9 IP (INTERNET PROTOCOL) CONFIGURATION

### D-9-1 NET_IP_CFG_IF_MAX_NBR_ADDR

NET_IP_CFG_IF_MAX_NBR_ADDR determines the maximum number of IP addresses that may be configured per network interface at run-time. It is recommended to set NET_IP_CFG_IF_MAX_NBR_ADDR to the initial, default value of **1 IP address** per network interface and increased if the µC/TCP-IP target requires more addresses on each interface.

### D-9-2 NET_IP_CFG_MULTICAST_SEL

NET_IP_CFG_MULTICAST_SEL is used to determine the IP multicast support level. The allowable values for this parameter are:

| | |
|---|---|
| **NET_IP_MULTICAST_SEL_NONE** | No multicasting |
| NET_IP_MULTICAST_SEL_TX | Transmit multicasting only |
| NET_IP_MULTICAST_SEL_TX_RX | Transmit and receive multicasting |

## D-10 ICMP (INTERNET CONTROL MESSAGE PROTOCOL) CONFIGURATION

### D-10-1 NET_ICMP_CFG_TX_SRC_QUENCH_EN

ICMP transmits ICMP source quench messages to other hosts when the Network Resources are low (see section 11-2 "Network Debug Monitor Task" on page 297). NET_ICMP_CFG_TX_SRC_QUENCH_EN can be set to either:

**DEF_DISABLED** ICMP does not transmit any Source Quenches

or

DEF_ENABLED ICMP transmits Source Quenches when necessary

### D-10-2 NET_ICMP_CFG_TX_SRC_QUENCH_NBR

NET_ICMP_CFG_TX_SRC_QUENCH_NBR configures the number of ICMP transmit source quench entries. Each source quench entry requires approximately 12 bytes of RAM plus two pointers.

The number of entries depends on the number of different hosts to communicate with. It is recommended to set NET_ICMP_CFG_TX_SRC_QUENCH_NBR with an initial value of **5** and adjusted if the µC/TCP-IP target communicates with more or less hosts.

## D-11 IGMP (INTERNET GROUP MANAGEMENT PROTOCOL) CONFIGURATION

### D-11-1 NET_IGMP_CFG_MAX_NBR_HOST_GRP

NET_IGMP_CFG_MAX_NBR_HOST_GRP configures the maximum number of IGMP host groups that may be joined at any one time. Each group entry requires approximately 12 bytes of RAM, plus three pointers, plus a protocol address (4 bytes assuming IPv4 address).

The number of IGMP host groups required by the application depends on how many host groups are expected to be joined at a given time. Since each configured multicast address requires its own IGMP host group, it is recommended to configure at least one host group per multicast address used by the application, plus one additional host group. Thus for a single multicast address, it is recommended to set NET_IGMP_CFG_MAX_NBR_HOST_GRP with an initial value of **2**.

## D-12 TRANSPORT LAYER CONFIGURATION

### D-12-1 NET_CFG_TRANSPORT_LAYER_SEL

µC/TCP-IP allows you to include code for either UDP alone or for both UDP and TCP. Most application software requires TCP as well as UDP. However, enabling UDP only reduces both the code and data size required by µC/TCP-IP. `NET_CFG_TRANSPORT_LAYER_SEL` can be set to either:

**`NET_TRANSPORT_LAYER_SEL_UDP_TCP`** UDP and TCP transport layers included

or

`NET_TRANSPORT_LAYER_SEL_UDP` Only UDP transport layer included

## D-13 UDP (USER DATAGRAM PROTOCOL) CONFIGURATION

### D-13-1 NET_UDP_CFG_APP_API_SEL

NET_UDP_CFG_APP_API_SEL is used to determine where to send the de-multiplexed UDP datagram. Specifically, the datagram may be sent to the socket layer, to a function at the application level, or both. NET_UDP_CFG_APP_API_SEL can be set to one of the following values:

| | |
|---|---|
| **NET_UDP_APP_API_SEL_SOCK** | De-multiplex receive datagrams to socket layer only |
| NET_UDP_APP_API_SEL_APP | De-multiplex receive datagrams to the application only |
| NET_UDP_APP_API_SEL_SOCK_APP | De-multiplex receive datagrams to socket layer first, then to the application |

If either NET_UDP_APP_API_SEL_APP or NET_UDP_APP_API_SEL_SOCK_APP is configured, the application must define NetUDP_RxAppDataHandler() to de-multiplex receive datagrams by the application (see section C-16-2 on page 704).

## D-13-2 NET_UDP_CFG_RX_CHK_SUM_DISCARD_EN

NET_UDP_CFG_RX_CHK_SUM_DISCARD_EN is used to determine whether received UDP packets without a valid checksum are discarded or are handled and processed. Before a UDP Datagram Check-Sum is validated, it is necessary to check whether the UDP datagram was transmitted with or without a computed Check-Sum (see RFC #768, Section 'Fields: Checksum').

NET_UDP_CFG_RX_CHK_SUM_DISCARD_EN can be set to either:

**DEF_DISABLED** UDP Layer processes but flags all UDP datagrams received without a checksum so that "an application may optionally discard datagrams without checksums" (see RFC #1122, Section 4.1.3.4).

or

DEF_ENABLED All UDP datagrams received without a checksum are discarded.

## D-13-3 NET_UDP_CFG_TX_CHK_SUM_EN

NET_UDP_CFG_TX_CHK_SUM_EN is used to determine whether UDP checksums are computed for transmission to other hosts. An application MAY optionally be able to control whether a UDP checksum will be generated (see RFC #1122, Section 4.1.3.4).

NET_UDP_CFG_TX_CHK_SUM_EN can be set to either:

DEF_DISABLED All UDP datagrams are transmitted without a computed checksum

or

**DEF_ENABLED** All UDP datagrams are transmitted with a computed checksum

## D-14 TCP (TRANSPORT CONTROL PROTOCOL) CONFIGURATION

### D-14-1 NET_TCP_CFG_NBR_CONN

NET_TCP_CFG_NBR_CONN configures the maximum number of TCP connections that µC/TCP-IP can handle concurrently. This number depends entirely on how many simultaneous TCP connections the application requires. Each TCP connection requires approximately 220 bytes of RAM plus 16 pointers. It is recommended to set NET_TCP_CFG_NBR_CONN with an initial value of **10** and adjust this value if more or less TCP connections are required.

### D-14-2 NET_TCP_CFG_RX_WIN_SIZE_OCTET

NET_TCP_CFG_RX_WIN_SIZE_OCTET configures each TCP connection's receive window size. It is recommended to set TCP window sizes to integer multiples of each TCP connection's maximum segment size (MSS). For example, systems with an Ethernet MSS of 1460, a value 5840 (4 * 1460) is probably a better configuration than the default window size of **4096** (4K).

### D-14-3 NET_TCP_CFG_TX_WIN_SIZE_OCTET

NET_TCP_CFG_TX_WIN_SIZE_OCTET configures each TCP connection's transmit window size. It is recommended to set TCP window sizes to integer multiples of each TCP connection's maximum segment size (MSS). For example, systems with an Ethernet MSS of 1460, a value 5840 (4 * 1460) is probably a better configuration than the default window size of **4096** (4K).

### D-14-4 NET_TCP_CFG_TIMEOUT_CONN_MAX_SEG_SEC

NET_TCP_CFG_TIMEOUT_CONN_MAX_SEG_SEC configures TCP connections' default maximum segment lifetime timeout (MSL) value, specified in integer seconds. It is recommended to start with a value of **3 seconds**.

If TCP connections are established and closed rapidly, it is possible that this timeout may further delay new TCP connections from becoming available. Thus, an even lower timeout value may be desirable to free TCP connections and make them available as quickly as possible. However, a 0 second timeout prevents µC/TCP-IP from performing the complete TCP connection close sequence and will instead send TCP reset (RST) segments.

## D-14-5 NET_TCP_CFG_TIMEOUT_CONN_FIN_WAIT_2_SEC

NET_TCP_CFG_TIMEOUT_CONN_FIN_WAIT_2_SEC configures the TCP connection default FIN-WAIT-2 timeout (in seconds *or* no timeout if configured with NET_TMR_TIME_INFINITE). On a typical connection close (FIN/ACK/FIN/ACK), this timeout defines the maximum delay between the ACK/FIN packets sent by the remote host. It is recommended to set NET_TCP_CFG_TIMEOUT_CONN_FIN_WAIT_2_SEC with a value of 15 seconds.

## D-14-6 NET_TCP_CFG_TIMEOUT_CONN_ACK_DLY_MS

NET_TCP_CFG_TIMEOUT_CONN_ACK_DLY_MS configures the TCP acknowledgement delay in integer milliseconds. It is recommended to configure the default value of **500 milliseconds** since RFC #2581, Section 4.2 states that "an ACK *must* be generated within 500 ms of the arrival of the first unacknowledged packet".

## D-14-7 NET_TCP_CFG_TIMEOUT_CONN_RX_Q_MS

NET_TCP_CFG_TIMEOUT_CONN_RX_Q_MS configures each TCP connection's receive timeout (in milliseconds *or* no timeout if configured with NET_TMR_TIME_INFINITE). It is recommended to start with a value of 3000 milliseconds *or* the no-timeout value of **NET_TMR_TIME_INFINITE**.

## D-14-8 NET_TCP_CFG_TIMEOUT_CONN_TX_Q_MS

NET_TCP_CFG_TIMEOUT_CONN_TX_Q_MS configures each TCP connection's transmit timeout (in milliseconds *or* no timeout if configured with NET_TMR_TIME_INFINITE). It is recommended to start with a value of 3000 milliseconds *or* the no-timeout value of **NET_TMR_TIME_INFINITE**.

## D-15 NETWORK SOCKET CONFIGURATION

µC/TCP-IP supports BSD 4.x sockets and basic socket API for the TCP/UDP/IP protocols.

### D-15-1 NET_SOCK_CFG_FAMILY

The current version of µC/TCP-IP only supports IPv4 BSD sockets, and thus NET_SOCK_CFG_FAMILY should *always* be set to **NET_SOCK_FAMILY_IP_V4**.

### D-15-2 NET_SOCK_CFG_NBR_SOCK

NET_SOCK_CFG_NBR_SOCK configures the maximum number of sockets that µC/TCP-IP can handle concurrently. This number depends entirely on how many simultaneous socket connections the application requires. Each socket requires approximately 28 bytes of RAM plus three pointers. It is recommended to set NET_SOCK_CFG_NBR_SOCK with an initial value of **10** and adjust this value if more or less sockets are required.

## D-15-3 NET_SOCK_CFG_BLOCK_SEL

NET_SOCK_CFG_BLOCK_SEL determines the default blocking (or non-blocking) behavior for sockets:

| | |
|---|---|
| NET_SOCK_BLOCK_SEL_DFLT | Sockets will be blocking by default, but may be individually configured in a future release |
| **NET_SOCK_BLOCK_SEL_BLOCK** | Sockets will be blocking by default |
| NET_SOCK_BLOCK_SEL_NO_BLOCK | Sockets will be non-blocking by default |

If blocking mode is enabled, a timeout can be specified. The amount of time for the timeout is determined by various timeout functions implemented in net_sock.c:

| | |
|---|---|
| NetSock_CfgTimeoutRxQ_Set() | Configure datagram socket receive timeout |
| NetSock_CfgTimeoutConnReqSet() | Configure socket connection timeout |
| NetSock_CfgTimeoutConnAcceptSet() | Configure socket accept timeout |
| NetSock_CfgTimeoutConnClOSset() | Configure socket close timeout |

## D-15-4 NET_SOCK_CFG_SEL_EN

NET_SOCK_CFG_SEL_EN determines whether or not the code and data space used to support socket select() functionality is enabled:

| | |
|---|---|
| **DEF_DISABLED** | BSD select() API disabled |

or

| | |
|---|---|
| DEF_ENABLED | BSD select() API enabled |

## D-15-5 NET_SOCK_CFG_SEL_NBR_EVENTS_MAX

NET_SOCK_CFG_SEL_NBR_EVENTS_MAX is used to configure the maximum number of socket events/operations that the socket `select()` functionality can wait on. It is recommended to set NET_SOCK_CFG_SEL_NBR_EVENTS_MAX with an initial value of at least **10** and adjust this value if more or less socket `select()` events are required.

## D-15-6 NET_SOCK_CFG_CONN_ACCEPT_Q_SIZE_MAX

NET_SOCK_CFG_CONN_ACCEPT_Q_SIZE_MAX is used to configure the absolute maximum queue size of `accept()` connections for stream-type sockets. It is recommended to set NET_SOCK_CFG_CONN_ACCEPT_Q_SIZE_MAX with an initial value of at least **5** and adjust this value if more or less socket connections need to be queued.

## D-15-7 NET_SOCK_CFG_PORT_NBR_RANDOM_BASE

NET_SOCK_CFG_PORT_NBR_RANDOM_BASE is used to configure the starting base socket number for "ephemeral" or "random" port numbers. Since two times the number of random ports are required for each socket, the base value for the random port number must be:

```
Random Port Number Base <= 65535 - (2 * NET_SOCK_CFG_NBR_SOCK)
```

The arbitrary default value of **65000** is recommended as a good starting point.

## D-15-8 NET_SOCK_CFG_RX_Q_SIZE_OCTET

NET_SOCK_CFG_RX_Q_SIZE_OCTET configures datagram sockets default receive queue buffer size in integer number of octets. According to 4.3BSD, it is recommended to set NET_SOCK_CFG_RX_Q_SIZE_OCTET with a value of 4096 octets. However, systems such as 4.4BSD use larger default buffer sizes, such as 8192 or 16384 bytes. This configuration does not impact TCP default receive windows size.

## D-15-9 NET_SOCK_CFG_TX_Q_SIZE_OCTET

NET_SOCK_CFG_TX_Q_SIZE_OCTET configures datagram sockets default transmit queue buffer size in integer number of octets. According to 4.3BSD, it is recommended to set NET_SOCK_CFG_TX_Q_SIZE_OCTET with a value of 4096 octets. However, systems such as 4.4BSD use larger default buffer sizes, such as 8192 or 16384 bytes. This configuration does not impact TCP default transmit windows size.

## D-15-10 NET_SOCK_CFG_TIMEOUT_RX_Q_MS

NET_SOCK_CFG_TIMEOUT_RX_Q_MS configures socket timeout value (in milliseconds *or* no timeout if configured with NET_TMR_TIME_INFINITE) for UDP datagram socket recv() operations. It is recommended to set NET_SOCK_CFG_TIMEOUT_RX_Q_MS with a value of 3000 milliseconds *or* the no-timeout value of **NET_TMR_TIME_INFINITE**.

## D-15-11 NET_SOCK_CFG_TIMEOUT_CONN_REQ_MS

NET_SOCK_CFG_TIMEOUT_CONN_REQ_MS configures socket timeout value (in milliseconds *or* no timeout if configured with NET_TMR_TIME_INFINITE) for stream socket connect() operations. It is recommended to set NET_SOCK_CFG_TIMEOUT_CONN_REQ_MS with a value of 3000 milliseconds *or* the no-timeout value of **NET_TMR_TIME_INFINITE**.

## D-15-12 NET_SOCK_CFG_TIMEOUT_CONN_ACCEPT_MS

NET_SOCK_CFG_TIMEOUT_CONN_ACCEPT_MS configures socket timeout value (in milliseconds *or* no timeout if configured with NET_TMR_TIME_INFINITE) for socket accept() operations. It is recommended to set NET_SOCK_CFG_TIMEOUT_CONN_ACCEPT_MS with a value of 3000 milliseconds *or* the no-timeout value of **NET_TMR_TIME_INFINITE**.

## D-15-13 NET_SOCK_CFG_TIMEOUT_CONN_CLOSE_MS

NET_SOCK_CFG_TIMEOUT_CONN_CLOSE_MS configures socket timeout value (in milliseconds *or* no timeout if configured with NET_TMR_TIME_INFINITE) for socket close() operations. It is recommended to set NET_SOCK_CFG_TIMEOUT_CONN_CLOSE_MS with a value of **10000 milliseconds** *or* the no-timeout value of NET_TMR_TIME_INFINITE.

# D-16 NETWORK SECURITY MANAGER CONFIGURATION

## D-16-1 NET_SECURE_CFG_EN

NET_SECURE_CFG_EN determines whether or not the network security manager is enabled. When the network security manager is enabled, a network security module (e.g., µC/SSL) must be present in the build. NET_SECURE_CFG_EN can be set to either:

**DEF_DISABLED** Network security manager and security port layer disabled

or

DEF_ENABLED Network security manager and security port layer enabled

## D-16-2 NET_SECURE_CFG_FS_EN

NET_SECURE_CFG_FS_EN determines whether or not file system operations can be used to install keying material. When NET_SECURE_CFG_FS_EN is enabled, a file system (e.g., µC/FS) must be present in the build. NET_SECURE_CFG_FS_EN can be set to either:

**DEF_DISABLED** Keying material cannot be installed from file system

or

DEF_ENABLED Keying material can be installed from file system

## D-16-3 NET_SECURE_CFG_MAX_NBR_SOCK_SERVER

NET_SECURE_CFG_MAX_NBR_SOCK configures the maximum number of sockets server that can be secured. If your application is a simple TCP server, you need to have two secure sockets (one listening socket and one accepted socket). It is recommended to set NET_SECURE_CFG_MAX_NBR_SOCK_SERVER to the initial value of **5 sockets** and adjust this value if more or less sockets are required. However, the maximum number of secure sockets must be less than or equal to NET_SOCK_CFG_NBR_SOCK (see section D-15-2 on page 760).

## D-16-4 NET_SECURE_CFG_MAX_NBR_SOCK_CLIENT

NET_SECURE_CFG_MAX_NBR_SOCK configures the maximum number of sockets client that can be secured. If your application is a simple TCP client, you will only need to have one secure socket to connect. It is recommended to set NET_SECURE_CFG_MAX_NBR_SOCK_CLIENT to the initial value of **5 sockets** and adjust this value if more or less sockets are required. However, the maximum number of secure sockets must be less than or equal to NET_SOCK_CFG_NBR_SOCK (see section D-15-2 on page 760).

## D-16-5 NET_SECURE_CFG_MAX_CERT_LEN

NET_SECURE_CFG_MAX_CERT_LEN configures the maximum length (in bytes) of a server certificate. It is recommended to set NET_SECURE_CFG_MAX_CERT_LEN to the default value of **1500** for standard certificate and adjust this value if required. You can find the size of any certificate by right clicking on the DER or PEM file on a Windows environment and by choosing 'Properties'. Usually DER encoded keying material is smaller than PEM encoded keying material.

## D-16-6 NET_SECURE_CFG_MAX_KEY_LEN

NET_SECURE_CFG_MAX_KEY_LEN configures the maximum length (in bytes) of a certificate server key. It is recommended to set NET_SECURE_CFG_MAX_KEY_LEN to the default value of **1500** for standard key and adjust this value if required. You can find the size of any key by right clicking on the DER or PEM file on a Windows environment and by choosing 'Properties'. Usually DER encoded keying material is smaller than PEM encoded keying material.

## D-16-7 NET_SECURE_CFG_MAX_NBR_CA

NET_SECURE_CFG_MAX_NBR_CA configures the maximum number of certificate authorities (CAs) that can be installed. If many CAs are installed, they are saved into a linked-list. When the client receives the server public key certificate, it scans the linked-list to see if it is trusted by one of the installed CAs.

## D-16-8 NET_SECURE_CFG_MAX_CA_CERT_LEN

NET_SECURE_CFG_MAX_CERT_LEN configures the maximum length (in bytes) of a certificate authority's certificate. It is recommended to set NET_SECURE_CFG_MAX_CA_CERT_LEN to the default value of **1500** for standard certificate and adjust this value if required. You can find the size of any certificate by right clicking on the DER or PEM file on a Windows environment and by choosing 'Properties'. Usually DER encoded keying material is smaller than PEM encoded keying material.

# D-17 BSD SOCKETS CONFIGURATION

## D-17-1 NET_BSD_CFG_API_EN

NET_BSD_CFG_API_EN determines whether or not the standard BSD 4.x socket API is included in the build:

| | |
|---|---|
| DEF_DISABLED | BSD 4.x layer API disabled |

or

| | |
|---|---|
| **DEF_ENABLED** | BSD 4.x layer API enabled |

## D-18 NETWORK APPLICATION INTERFACE CONFIGURATION

### D-18-1 NET_APP_CFG_API_EN

NET_APP_CFG_API_EN determines whether or not a simplified network application programming interface (API) is included in the build:

DEF_DISABLED Network API layer disabled

or

**DEF_ENABLED** Network API layer enabled

# D-19 NETWORK CONNECTION MANAGER CONFIGURATION

## D-19-1 NET_CONN_CFG_FAMILY

The current version of µC/TCP-IP only supports IPv4 connections, and thus `NET_CONN_CFG_FAMILY` should *always* be set to **`NET_CONN_FAMILY_IP_V4_SOCK`**.

## D-19-2 NET_CONN_CFG_NBR_CONN

`NET_CONN_CFG_NBR_CONN` configures the maximum number of connections that µC/TCP-IP can handle concurrently. This number depends entirely on how many simultaneous connections the application requires and *must* be at least greater than the configured number of application (socket) connections and transport layer (TCP) connections. Each connection requires approximately `28` bytes of RAM, plus five pointers, plus two protocol addresses (`8` bytes assuming IPv4 addresses). It is recommended to set `NET_CONN_CFG_NBR_CONN` with an initial value of **`20`** and adjust this value if more or less connections are required.

## D-20 APPLICATION-SPECIFIC CONFIGURATION

This section defines the configuration constants related to µC/TCP-IP but that are application-specific. Most of these configuration constants relate to the various ports for µC/TCP-IP such as the CPU, OS, device, or network interface ports. Other configuration constants relate to the compiler and standard library ports.

These configuration constants should be defined in an application's `app_cfg.h` file.

### D-20-1 Operating System Configuration

The following configuration constants relate to the µC/TCP-IP OS port. For many OSs, the µC/TCP-IP task priorities, stack sizes, and other options will need to be explicitly configured for the particular OS (consult the specific OS's documentation for more information).

The priority of µC/TCP-IP tasks is dependent on the network communication requirements of the application. For most applications, the priority for µC/TCP-IP tasks is typically lower than the priority for other application tasks.

For µC/OS-II and µC/OS-III, the following macros must be configured within `app_cfg.h`:

```
NET_OS_CFG_IF_TX_DEALLOC_PRIO            10   (highest priority)
NET_OS_CFG_TMR_TASK_PRIO                 51
NET_OS_CFG_IF_RX_TASK_PRIO               52   (lowest  priority)
```

The arbitrary task priorities of **10**, **51**, and **52** are a good starting point for most applications, where the network interface Transmit De-allocation task is assigned a higher priority than all application tasks that use µC/TCP-IP network services but the Network Timer task and network interface Receive task are assigned lower priorities than almost all other application tasks.

```
NET_OS_CFG_IF_TX_DEALLOC_TASK_STK_SIZE  1000
NET_OS_CFG_IF_RX_TASK_STK_SIZE          1000
NET_OS_CFG_TMR_TASK_STK_SIZE            1000
```

The arbitrary stack size of **1000** is a good starting point for most applications.

The only guaranteed method of determining the required task stack sizes is to calculate the maximum stack usage for each task. Obviously, the maximum stack usage for a task is the total stack usage along the task's most-stack-greedy function path plus the (maximum) stack usage for interrupts. Note that the most-stack-greedy function path is not necessarily the longest or deepest function path.

The easiest and best method for calculating the maximum stack usage for any task/function should be performed statically by the compiler or by a static analysis tool since these can calculate function/task maximum stack usage based on the compiler's actual code generation and optimization settings. So for optimal task stack configuration, we recommend to invest in a task stack calculator tool compatible with your build toolchain.

## D-20-2 µC/TCP-IP Configuration

The following configuration constants relate to the µC/TCP-IP OS port. For many OSs, the µC/TCP-IP maximum queue sizes may need to be explicitly configured for the particular OS (consult the specific OS's documentation for more information).

For µC/OS-II and µC/OS-III, the following macros must be configured within `app_cfg.h`:

**`NET_OS_CFG_IF_RX_Q_SIZE`**

**`NET_OS_CFG_IF_TX_DEALLOC_Q_SIZE`**

The values configured for these macros depend on additional application dependent information such as the number of transmit or receive buffers configured for the total number of interfaces.

The following configuration for the above macros are recommended:

`NET_OS_CFG_IF_RX_Q_SIZE` should be configured such that it reflects the total number of DMA receive descriptors on all physical interfaces. If DMA is not available, or a combination of DMA and I/O based interfaces are configured then this number reflects the maximum number of packets than can be acknowledged and signaled for during a single receive interrupt event for all interfaces.

For example, if one interface has 10 receive descriptors and another interface is I/O based but is capable of receiving 4 frames within its internal memory and issuing a single interrupt request, then the NET_OS_CFG_IF_RX_Q_SIZE macro should be configured to 14. Defining a number in excess of the maximum number of receivable frames per interrupt across all interfaces would not be harmful, but the additional queue space will not be utilized.

NET_OS_CFG_IF_TX_DEALLOC_Q_SIZE should be defined to be the total number of small and large transmit buffers declared for all interfaces.

# D-21 µC/TCP-IP OPTIMIZATION

## D-21-1 Optimizing µC/TCP-IP for Additional Performance

There are several configuration combinations that can improve overall µC/TCP-IP performance. The following items can be used as a starting point:

1 Enable the assembly port optimizations, if available in the architecture.

2 Configure the µC/TCP-IP for speed optimization.

3 Configure optimum TCP window sizes for TCP communication. Disable argument checking, statistics and error counters.

### ASSEMBLY OPTIMIZATION

First, if using the ARM architecture, or other supported optimized architecture, the files `net_util_a.asm` and `lib_mem_a.asm` may be included into the project and the following macros should be defined and enabled:

```
app_cfg.h: #define LIB_MEM_CFG_OPTIMIZE_ASM_EN
net_cfg.h: Set NET_CFG_OPTIMIZE_ASM_EN to DEF_ENABLED
```

These files are generally located in the following directories:

```
\Micrium\Software\uC-LIB\Ports\ARM\IAR\lib_mem_a.asm
\Micrium\Software\uC-TCPIP-V2\Ports\ARM\IAR\net_util_a.asm
```

### ENABLE SPEED OPTIMIZATION

Second, you may compile the Network Protocol Stack with speed optimizations enabled.

This can be accomplished by configuring the `net_cfg.h` macro `NET_CFG_OPTIMIZE` to `NET_OPTIMIZE_SPD`.

### TCP OPTIMIZATION

Third, the two net_cfg.h macros NET_TCP_CFG_RX_WIN_SIZE_OCTET and NET_TCP_CFG_TX_WIN_SIZE_OCTET should configure each TCP connection's receive and transmit window sizes. It is recommended to set TCP window sizes to integer multiples of each TCP connection's maximum segment size (MSS). For example, systems with an Ethernet MSS of 1460, a value 5840 (4 * 1460) is probably a better configuration than the default window size of 4096 (4K).

### DISABLE ARGUMENT CHECKING

Finally, once the application has been validated, argument checking, statistics and error counters may optionally be disabled by configuring the following macros to DEF_DISABLED:

```
NET_ERR_CFG_ARG_CHK_EXT_EN
NET_ERR_CFG_ARG_CHK_DBG_EN
NET_CTR_CFG_STAT_EN
NET_CTR_CFG_ERR_EN
```

Appendix

# E

# µC/TCP-IP Error Codes

This appendix provides a brief explanation of µC/TCP-IP error codes defined in `net_err.h`. Any error codes not listed here may be searched in `net_err.h` for both their numerical value and usage.

Each error has a numerical value. The error codes are grouped. The definition of the groups are:

| **Error code group** | **Numbering serie** |
|---|---|
| NETWORK-OS LAYER | 1000 |
| NETWORK UTILITY LIBRARY | 2000 |
| ASCII LIBRARY | 3000 |
| NETWORK STATISTIC MANAGEMENT | 4000 |
| NETWORK TIMER MANAGEMENT | 5000 |
| NETWORK BUFFER MANAGEMENT | 6000 |
| NETWORK CONNECTION MANAGEMENT | 6000 |
| NETWORK BOARD SUPPORT PACKAGE (BSP) | 10000 |
| NETWORK DEVICE | 11000 |
| NETWORK PHYSICAL LAYER | 12000 |
| NETWORK INTERFACE LAYER | 13000 |
| ARP LAYER | 15000 |
| NETWORK LAYER MANAGEMENT | 20000 |
| IP LAYER | 21000 |
| ICMP LAYER | 22000 |
| IGMP LAYER | 23000 |
| UDP LAYER | 30000 |

| Error code group | Numbering serie |
|---|---|
| TCP LAYER | 31000 |
| APPLICATION LAYER | 40000 |
| NETWORK SOCKET LAYER | 41000 |
| NETWORK SECURITY MANAGER LAYER | 50000 |
| NETWORK SECURITY LAYER | 51000 |

## E-1 NETWORK ERROR CODES

| | | |
|---|---|---|
| 10 | NET_ERR_INIT_INCOMPLETE | Network initialization *not* complete. |
| 20 | NET_ERR_INVALID_PROTOCOL | Invalid/unknown network protocol type. |
| 30 | NET_ERR_INVALID_TRANSACTION | Invalid/unknown network buffer pool type. |
| 400 | NET_ERR_RX | General receive error. Receive data discarded. |
| 450 | NET_ERR_RX_DEST | Destination address and/or port -number not available on this host. |
| 500 | NET_ERR_TX | General transmit error. No data transmitted. A momentarily delay should be performed to allow additional buffers to be de-allocated before calling `send()`, `NetSock_TxData()` or `NetSock_TxDataTo()`. |

## E-2 ARP ERROR CODES

| | | |
|---|---|---|
| 15000 | NET_ARP_ERR_NONE | ARP operation completed successfully. |
| 15020 | NET_ARP_ERR_NULL_PTR | Argument(s) passed NULL pointer. |
| 15102 | NET_ARP_ERR_INVALID_HW_ADDR_LEN | Invalid ARP hardware address length. |
| 15105 | NET_ARP_ERR_INVALID_PROTOCOL_LEN | Invalid ARP protocol address length. |
| 15150 | NET_ARP_ERR_CACHE_NONE_AVAIL | No ARP cache entry structures available. |
| 15151 | NET_ARP_ERR_CACHE_INVALID_TYPE | ARP cache type invalid or unknown. |
| 15155 | NET_ARP_ERR_CACHE_NOT_FOUND | ARP cache entry not found. |
| 15156 | NET_ARP_ERR_CACHE_PEND | ARP cache resolution pending. |

## E-3 NETWORK ASCII ERROR CODES

| | | |
|---|---|---|
| 3000 | NET_ASCII_ERR_NONE | ASCII operation completed successfully. |
| 3020 | NET_ASCII_ERR_NULL_PTR | Argument(s) passed NULL pointer. |
| 3100 | NET_ASCII_ERR_INVALID_STR_LEN | Invalid ASCII string length. |
| 3101 | NET_ASCII_ERR_INVALID_CHAR_LEN | Invalid ASCII character length. |
| 3102 | NET_ASCII_ERR_INVALID_CHAR_VAL | Invalid ASCII character value. |
| 3103 | NET_ASCII_ERR_INVALID_CHAR_SEQ | Invalid ASCII character sequence. |
| 3200 | NET_ASCII_ERR_INVALID_CHAR | Invalid ASCII character. |

## E-4 NETWORK BUFFER ERROR CODES

| | | |
|---|---|---|
| 6010 | NET_BUF_ERR_NONE_AVAIL | No network buffers of required size available. |
| 6031 | NET_BUF_ERR_INVALID_SIZE | Invalid network buffer pool size. |
| 6032 | NET_BUF_ERR_INVALID_IX | Invalid buffer index outside data area. |
| 6033 | NET_BUF_ERR_INVALID_LEN | Invalid buffer length specified outside of data area. |
| 6040 | NET_BUF_ERR_POOL_INIT | Network buffer pool initialization failed. |
| 6050 | NET_BUF_ERR_INVALID_POOL_TYPE | Invalid network buffer pool type. |
| 6051 | NET_BUF_ERR_INVALID_POOL_ADDR | Invalid network buffer pool address. |
| 6053 | NET_BUF_ERR_INVALID_POOL_QTY | Invalid number of pool buffers configured. |

## E-5 ICMP ERROR CODES

## E-6 NETWORK INTERFACE ERROR CODES

| | | |
|---|---|---|
| 13000 | NET_IF_ERR_NONE | Network interface operation completed successfully. |
| 13010 | NET_IF_ERR_NONE_AVAIL | No network interfaces available. The value of NET_IF_CFG_MAX_NBR_IF should be increased in net_cfg.h. |
| 13020 | NET_IF_ERR_NULL_PTR | Argument(s) passed NULL pointer. |
| 13021 | NET_IF_ERR_NULL_FNCT | NULL interface API function pointer encountered. |
| 13100 | NET_IF_ERR_INVALID_IF | Invalid network interface number specified. |
| 13101 | NET_IF_ERR_INVALID_CFG | Invalid network interface configuration specified. |
| 13110 | NET_IF_ERR_INVALID_STATE | Invalid network interface state for specified operation. |
| 13120 | NET_IF_ERR_INVALID_IO_CTRL_OPT | Invalid I/O control option parameter specified. |
| 13200 | NET_IF_ERR_INVALID_MTU | Invalid hardware MTU specified. |
| 13210 | NET_IF_ERR_INVALID_ADDR | Invalid hardware address specified. |
| 13211 | NET_IF_ERR_INVALID_ADDR_LEN | Invalid hardware address length specified. |

## E-7 IP ERROR CODES

| | | |
|---|---|---|
| 21000 | NET_IP_ERR_NONE | IP operation completed successfully. |
| 21020 | NET_IP_ERR_NULL_PTR | Argument(s) passed NULL pointer. |
| 21115 | NET_IP_ERR_INVALID_ADDR_HOST | Invalid host IP address. |
| 21117 | NET_IP_ERR_INVALID_ADDR_GATEWAY | Invalid gateway IP address. |
| 21201 | NET_IP_ERR_ADDR_CFG_STATE | Invalid IP address state for attempted operation. |
| 21202 | NET_IP_ERR_ADDR_CFG_IN_PROGRESS | Interface address configuration in progress. |
| 21203 | NET_IP_ERR_ADDR_CFG_IN_USE | Specified IP address currently in use. |
| 21210 | NET_IP_ERR_ADDR_NONE_AVAIL | No IP addresses configured. |
| 21211 | NET_IP_ERR_ADDR_NOT_FOUND | IP address not found. |
| 21220 | NET_IP_ERR_ADDR_TBL_SIZE | Invalid IP address table size argument passed. |

| | | |
|---|---|---|
| 21221 | NET_IP_ERR_ADDR_TBL_EMPTY | IP address table empty. |
| 21222 | NET_IP_ERR_ADDR_TBL_FULL | IP address table full. |

## E-8 IGMP ERROR CODES

| | | |
|---|---|---|
| 23000 | NET_IGMP_ERR_NONE | IGMP operation completed successfully. |
| 23100 | NET_IGMP_ERR_INVALID_VER | Invalid IGMP version. |
| 23101 | NET_IGMP_ERR_INVALID_TYPE | Invalid IGMP message type. |
| 23102 | NET_IGMP_ERR_INVALID_LEN | Invalid IGMP message lenth. |
| 23103 | NET_IGMP_ERR_INVALID_CHK_SUM | Invalid IGMP checksum. |
| 23104 | NET_IGMP_ERR_INVALID_ADDR_SRC | Invalid IGMP IP source address. |
| 23105 | NET_IGMP_ERR_INVALID_ADDR_DEST | Invalid IGMP IP destination address. |
| 23106 | NET_IGMP_ERR_INVALID_ADDR_GRP | Invalid IGMP IP host group address |
| 23200 | NET_IGMP_ERR_HOST_GRP_NONE_AVAIL | No host group available. |
| 23201 | NET_IGMP_ERR_HOST_GRP_INVALID_TYPE | Invalid or unknown IGMP host group type. |
| 23202 | NET_IGMP_ERR_HOST_GRP_NOT_FOUND | No IGMP host group found. |

## E-9 OS ERROR CODES

| | | |
|---|---|---|
| 1010 | NET_OS_ERR_LOCK | Network global lock access *not* acquired.<br>OS-implemented lock may be corrupted. |

## E-10 UDP ERROR CODES

| | | |
|---|---|---|
| 30040 | NET_UDP_ERR_INVALID_DATA_SIZE | UDP receive or transmit data does not fit into the receive or transmit buffer.In the case of receive, excess data bytes are dropped; for transmit, no data is sent. |
| 30105 | NET_UDP_ERR_INVALID_FLAG | Invalid UDP flags specified. |
| 30101 | NET_UDP_ERR_INVALID_LEN_DATA | Invalid protocol/data length. |
| 30103 | NET_UDP_ERR_INVALID_PORT_NBR | Invalid UDP port number. |
| 30000 | NET_UDP_ERR_NONE | UDP operation completed successfully. |
| 30020 | NET_UDP_ERR_NULL_PTR | Argument(s) passed NULL pointer. |
| | NET_UDP_ERR_NULL_SIZE | Argument(s) passed NULL size. |

## E-11 NETWORK SOCKET ERROR CODES

| | | |
|---|---|---|
| 41072 | NET_SOCK_ERR_ADDR_IN_USE | Socket address (IP / port number) already in use. |
| 41020 | NET_SOCK_ERR_CLOSED | Socket already/previously closed. |
| 41106 | NET_SOCK_ERR_CLOSE_IN_PROGRESS | Socket already closing. |
| 41130 | NET_SOCK_ERR_CONN_ACCEPT_Q_NONE_AVAIL | Accept connection handle identifier not available. |
| 41110 | NET_SOCK_ERR_CONN_FAIL | Socket operation failed. |
| 41100 | NET_SOCK_ERR_CONN_IN_USE | Socket address (IP / port number) already connected. |
| 41122 | NET_SOCK_ERR_CONN_SIGNAL_TIMEOUT | Socket operation not signaled before specified timeout. |
| 41091 | NET_SOCK_ERR_EVENTS_NBR_MAX | Number of configured socket events is greater than the maximum number of socket events. |
| 41021 | NET_SOCK_ERR_FAULT | Fatal socket fault; close socket immediately. |
| 41070 | NET_SOCK_ERR_INVALID_ADDR | Invalid socket address specified. |
| 41071 | NET_SOCK_ERR_INVALID_ADDR_LEN | Invalid socket address length specified. |
| 41055 | NET_SOCK_ERR_INVALID_CONN | Invalid socket connection. |
| 41040 | NET_SOCK_ERR_INVALID_DATA_SIZE | Socket receive or transmit data does not fit into the receive or transmit buffer.In the case of receive, excess data bytes are dropped; for transmit, no data is sent. |
| 41054 | NET_SOCK_ERR_INVALID_DESC | Invalid socket descriptor number. |
| 41050 | NET_SOCK_ERR_INVALID_FAMILY | Invalid socket family; close socket immediately. |

| | | |
|---|---|---|
| 41058 | NET_SOCK_ERR_INVALID_FLAG | Invalid socket flags specified. |
| 41057 | NET_SOCK_ERR_INVALID_OP | Invalid socket operation; e.g., socket not in the correct state for specified socket call. |
| 41080 | NET_SOCK_ERR_INVALID_PORT_NBR | Invalid port number specified. |
| 41051 | NET_SOCK_ERR_INVALID_PROTOCOL | Invalid socket protocol; close socket immediately. |
| 41053 | NET_SOCK_ERR_INVALID_SOCK | Invalid socket number specified. |
| 41056 | NET_SOCK_ERR_INVALID_STATE | Invalid socket state; close socket immediately. |
| 41059 | NET_SOCK_ERR_INVALID_TIMEOUT | Invalid or no timeout specified. |
| 41052 | NET_SOCK_ERR_INVALID_TYPE | Invalid socket type; close socket immediately. |
| 41000 | NET_SOCK_ERR_NONE | Socket operation completed successfully. |
| 41010 | NET_SOCK_ERR_NONE_AVAIL | No available socket resources to allocate; NET_SOCK_CFG_NBR_SOCK should be increased in net_cfg.h. |
| 41011 | NET_SOCK_ERR_NOT_USED | Socket not used; do not close or use the socket for further operations. |
| 41030 | NET_SOCK_ERR_NULL_PTR | Argument(s) passed NULL pointer. |
| 41031 | NET_SOCK_ERR_NULL_SIZE | Argument(s) passed NULL size. |
| 41085 | NET_SOCK_ERR_PORT_NBR_NONE_AVAIL | Random local port number not available. |
| 41400 | NET_SOCK_ERR_RX_Q_CLOSED | Socket receive queue closed (received FIN from peer). |
| 41401 | NET_SOCK_ERR_RX_Q_EMPTY | Socket receive queue empty. |
| 41022 | NET_SOCK_ERR_TIMEOUT | No socket events occurred before timeout expired. |

## E-12 NETWORK SECURITY MANAGER ERROR CODES

| | | |
|---|---|---|
| 50005 | NET_SECURE_MGR_ERR_FORMAT | Invalid keying material format. |
| 50002 | NET_SECURE_MGR_ERR_INIT | Failed to initialize network security manager. |
| 50000 | NET_SECURE_MGR_ERR_NONE | Network security manager operation successful. |
| 50001 | NET_SECURE_MGR_ERR_NOT_AVAIL | Network security manager not available. |
| 50003 | NET_SECURE_MGR_ERR_NULL_PTR | Argument(s) passed NULL pointer. |
| 50004 | NET_SECURE_MGR_ERR_TYPE | Invalid keying material type. |

## E-13 NETWORK SECURITY ERROR CODES

| | | |
|---|---|---|
| 51011 | NET_SECURE_ERR_BLK_FREE | Failed to free block from memory pool. |
| 51010 | NET_SECURE_ERR_BLK_GET | Failed to get block from memory pool. |
| 51013 | NET_SECURE_ERR_HANDSHAKE | Failed to perform secure handshake. |
| 51002 | NET_SECURE_ERR_INIT_POOL | Failed to initialize memory pool. |
| 51020 | NET_SECURE_ERR_INSTALL | Failed to install keying material. |
| 51024 | NET_SECURE_ERR_INSTALL_CA_SLOT | No more CA slot available. |
| 51023 | NET_SECURE_ERR_INSTALL_DATE_CREATION | Keying material creation date is invalid. |
| 51022 | NET_SECURE_ERR_INSTALL_DATE_EXPIRATION | Keying material is expired. |
| 51021 | NET_SECURE_ERR_INSTALL_NOT_TRUSTED | Keying material is not trusted. |
| 50000 | NET_SECURE_ERR_NONE | Network security operation successful. |
| 51001 | NET_SECURE_ERR_NOT_AVAIL | Failed to get secure session from memory pool. |
| 51012 | NET_SECURE_ERR_NULL_PTR | Argument(s) passed NULL pointer. |

Appendix

# F

# µC/TCP-IP Typical Usage

This appendix provides a brief explanation to a variety of common questions regarding how to use µC/TCP-IP.

## F-1 µC/TCP-IP CONFIGURATION AND INITIALIZATION

### F-1-1 µC/TCP-IP STACK CONFIGURATION

Refer to Appendix D, "µC/TCP-IP Configuration and Optimization" on page 735 for information on this topic.

### F-1-2 µC/LIB MEMORY HEAP INITIALIZATION

The µC/LIB memory heap is used for allocation of the following objects:

1 Transmit small buffers

2 Transmit large buffers

3 Receive large buffers

4 Network Buffers (Network Buffer header and pointer to data area)

5 DMA receive descriptors

6 DMA transmit descriptors

7 Interface data area

8 Device driver data area

In the following example, the use of a Network Device Driver with DMA support is assumed. DMA descriptors are included in the analysis. The size of Network Buffer Data Areas (1, 2, 3) vary based on configuration. Refer to Chapter 9, "Buffer Management" on page 277. However, for this example, the following object sizes in bytes are assumed:

- Small transmit buffers: 152
- Large transmit buffers: 1594 for maximum sized TCP packets
- Large receive  buffers: 1518
- Size of DMA receive descriptor: 8
- Size of DMA transmit descriptor: 8
- Ethernet interface data area: 7
- Average Ethernet device driver data area: 108

With a 4-byte alignment on all memory pool objects, it results in a worst case disposal of three leading bytes for each object. In practice this is not usually true since the size of most objects tend to be even multiples of four. Therefore, the alignment is preserved after having aligned the start of the pool data area. However, this makes the case for allocating objects with size to the next greatest multiple of four in order to prevent lost space due to misalignment.

The approximate memory heap size may be determined according to the following expressions:

```
nbr buf per interface     = nbr small Tx buf +
                            nbr large Tx buf +
                            nbr large Rx buf

nbr net buf per interface = nbr buf per interface
```

```
nbr objects   =  nbr buf per interface     +
                 nbr net buf per interface +
                 nbr Rx descriptors        +
                 nbr Tx descriptors        +
                 1 Ethernet      data area +
                 1 Device driver data area

interface mem = (nbr small Tx buf       *  152) +
                (nbr large Tx buf       * 1594) +
                (nbr large Rx buf       * 1518) +
                (nbr Rx descriptors     *    8) +
                (nbr Tx descriptors     *    8) +
                (Ethernet IF  data area *    7) +
                (Ethernet Drv data area *  108) +
                (nbr objects            *    3)

total mem required = nbr interfaces * interface mem
```

### EXAMPLE

With the following configuration, the memory heap required is:

- 10 small transmit buffers
- 10 large transmit buffers
- 10 large receive buffers
- 6 receive descriptors
- 20 transmit descriptors
- Ethernet interface (interface + device driver data area required)

```
nbr     buf per interface = 10 + 10 + 10               = 30
nbr net buf per interface = nbr buf per interface      = 30
nbr objects               = (30 + 30 + 6 + 20 + 1 + 1) = 88
interface mem             = (10 *  152) +
                            (10 * 1594) +
                            (10 * 1518) +
                            ( 6 *    8) +
                            (20 *    8) +
                            ( 1 *    7) +
                            ( 1 *  108) +
                            (88 *    3) = 33,227 bytes

total mem required = 33,227 ( + localhost memory, if enabled)
```

The localhost interface, when enabled, requires a similar amount of memory except that it does not require Rx and Tx descriptors, an IF data area, or a device driver data area.

The value determined by these expressions is only an estimate. In some cases, it may be possible to reduce the size of the µC/LIB memory heap by inspecting the variable `Mem_PoolHeap.SegSizeRem` after all interfaces have been successfully initialized and any additional application allocations (if applicable) have been completed.

Excess heap space, if present, may be subtracted from the lib heap size configuration macro, `LIB_MEM_CFG_HEAP_SIZE`, present in `app_cfg.h`.

## F-1-3 µC/TCP-IP TASK STACKS

In general, the size of µC/TCP-IP task stacks is dependent on the CPU architecture and compiler used.

On ARM processors, experience has shown that configuring the task stacks to 1024 `OS_STK` entries (4,096 bytes) is sufficient for most applications. Certainly, the stack sizes may be examined and reduced accordingly once the run-time behavior of the device has been analyzed and additional stack space deemed to be unnecessary.

The only guaranteed method of determining the required task stack sizes is to calculate the maximum stack usage for each task. Obviously, the maximum stack usage for a task is the total stack usage along the task's most-stack-greedy function path plus the (maximum) stack usage for interrupts. Note that the most-stack-greedy function path is not necessarily the longest or deepest function path.

The easiest and best method for calculating the maximum stack usage for any task/function should be performed statically by the compiler or by a static analysis tool since these can calculate function/task maximum stack usage based on the compiler's actual code generation and optimization settings. So for optimal task stack configuration, we recommend to invest in a task stack calculator tool compatible with your build toolchain.

See also section D-20-1 "Operating System Configuration" on page 770.

## F-1-4 µC/TCP-IP TASK PRIORITIES

We recommend to configure the Network Protocol Stack task priorities as follows:

```
NET_OS_CFG_IF_TX_DEALLOC_TASK_PRIO  (highest priority)
NET_OS_CFG_TMR_TASK_PRIO
NET_OS_CFG_IF_RX_TASK_PRIO          (lowest  priority)
```

We recommend that the µC/TCP-IP Timer task and network interface Receive task be lower priority than almost all other application tasks; but we recommend that the network interface Transmit De-allocation task be higher priority than all application tasks that use µC/TCP-IP network services.

See also section D-20-1 "Operating System Configuration" on page 770.

## F-1-5 µC/TCP-IP QUEUE SIZES

Refer to section D-20-2 "µC/TCP-IP Configuration" on page 771.

## F-1-6 µC/TCP-IP INITIALIZATION

The following example code demonstrates the initialization of two identical network interface devices via a local, application developer provided function named `AppInit_TCPIP()`. Another example of this method can also be found in section 4-3 "Application Code" on page 69

The first interface is bound to two different sets of network addresses on two separate networks. The second interface is configured to operate on one of the same networks as the first interface, but could easily be plugged into a separate network that happens to use the same address ranges.

```
static void AppInit_TCPIP (void)
{
  NET_IF_NBR   if_nbr;
  NET_IP_ADDR  ip;
  NET_IP_ADDR  msk;
  NET_IP_ADDR  gateway;
  CPU_BOOLEAN  cfg_success;
  NET_ERR      err;

  Mem_Init();                                                                  (1)
  err = Net_Init();                                                            (2)
  if (err != NET_ERR_NONE) {
      return;
  }

  if_nbr = NetIF_Add((void    *)&NetIF_API_Ether,                              (3)
                     (void    *)&NetDev_API_FC,
                     (void    *)&NetDev_BSP_FC_0,
                     (void    *)&NetDev_Cfg_FC_0,
                     (void    *)&NetPHY_API_Generic,
                     (void    *)&NetPhy_Cfg_FC_0,
                     (NET_ERR *)&err);
```

```
  if (err == NET_IF_ERR_NONE) {
      ip          = NetASCII_Str_to_IP((CPU_CHAR *)"192.168.1.2",   &err);             (4)
      msk         = NetASCII_Str_to_IP((CPU_CHAR *)"255.255.255.0", &err);
      gateway     = NetASCII_Str_to_IP((CPU_CHAR *)"192.168.1.1",   &err);
      cfg_success = NetIP_CfgAddrAdd(if_nbr, ip, msk, gateway, &err);                  (5)

      ip          = NetASCII_Str_to_IP((CPU_CHAR *)"10.10.1.2",     &err);             (6)
      msk         = NetASCII_Str_to_IP((CPU_CHAR *)"255.255.255.0", &err);
      gateway     = NetASCII_Str_to_IP((CPU_CHAR *)"10.10.1.1",     &err);
      cfg_success = NetIP_CfgAddrAdd(if_nbr, ip, msk, gateway, &err);                  (7)

      NetIF_Start(if_nbr, &err);                                                       (8)
  }

  if_nbr = NetIF_Add((void    *)&NetIF_API_Ether,                                      (9)
                     (void    *)&NetDev_API_FC,
                     (void    *)&NetDev_BSP_FC_1,
                     (void    *)&NetDev_Cfg_FC_1,
                     (void    *)&NetPHY_API_Generic,
                     (void    *)&NetPhy_Cfg_FC_1,
                     (NET_ERR *)&err);

  if (err == NET_IF_ERR_NONE) {
      ip          = NetASCII_Str_to_IP((CPU_CHAR *)"192.168.1.3",   &err);            (10)
      msk         = NetASCII_Str_to_IP((CPU_CHAR *)"255.255.255.0", &err);
      gateway     = NetASCII_Str_to_IP((CPU_CHAR *)"192.168.1.1",  &err);
      cfg_success = NetIP_CfgAddrAdd(if_nbr, ip, msk, gateway, &err);                  (11)

      NetIF_Start(if_nbr, &err);                                                       (12)
  }
}
```

Listing F-1 **Complete Initialization Example**

LF-1(1) Initialize µC/LIB memory management. Most applications call this function PRIOR to `AppInit_TCPIP()` so that other parts of the application may benefit from memory management functionality prior to initializing µC/TCP-IP.

LF-1(2) Initialize µC/TCP-IP. This function must only be called once following the call to µC/LIB `Mem_Init()`. The return error code should be checked for `NET_ERR_NONE` before proceeding

LF-1(3) Add the first network interface to the system. In this case, an Ethernet interface bound to a Ethernet controller (EC) hardware device and generic (MII or RMII) compliant physical layer device is being configured. The interface uses a

different device configuration structure than the second interface being added in Step 8. Each interface requires a unique device BSP interface and configuration structure. Physical layer device configuration structures however could be re-used if the Physical layer configurations are exactly the same. The return error should be checked before starting the interface.

LF-1(4) Obtain the hexadecimal equivalents for the first set of Internet addresses to configure on the first added interface.

LF-1(5) Configure the first added interface with the first set of specified addresses.

LF-1(6) Obtain the hexadecimal equivalents for the second set of Internet addresses to configure on the first added interface. The same local variables have been used as when the first set of address information was configured. Once the address set is configured to the interface, as in Step 4, the local copies of the configured addresses are no longer necessary and can be overwritten with the next set of addresses to configure.

LF-1(7) Configure the first added interface with the second set of specified addresses.

LF-1(8) Start the first interface. The return error code should be checked, but this depends on whether the application will attempt to restart the interface should an error occur. This example assumes that no error occurs when starting the interface. Initialization for the first interface is now complete, and if no further initialization takes place, the first interface will respond to ICMP Echo (ping) requests on either of its configured addresses.

LF-1(9) Add the second network interface to the system. In this case, an Ethernet interface bound to a Ethernet controller (EC) hardware device and generic (MII or RMII) compliant physical layer device is being configured. The interface uses a different device configuration structure than the first interface added in Step 2. Each interface requires a unique device BSP interface and configuration structure. Physical layer device configuration structures, however, could be re-used if the Physical layer configurations are exactly the same. The return error should be checked before starting the interface.

LF-1(10) Obtain the hexadecimal equivalents for the first and only set of Internet addresses to configure on the second added interface.

LF-1(11) Configure the second interface with the first and only set of specified addresses.

LF-1(12) Start the second interface. The return error code should be checked, but this depends on whether the application will attempt to restart the interface should an error occur. This example assumes that no error occurs when starting the interface. Initialization for the second interface is now complete and it will respond to ICMP Echo (ping) requests on its configured address.

# F-2 NETWORK INTERFACES, DEVICES, AND BUFFERS

## F-2-1 NETWORK INTERFACE CONFIGURATION

### ADDING AN INTERFACE

Interfaces may be added to the stack by calling `NetIF_Add()`. Each new interface requires additional BSP. The order of addition is critical to ensure that the interface number assigned to the new interface matches the code defined within `net_bsp.c`. See section 16-1 "Network Interface Configuration" on page 361 for more information on configuring and adding interfaces.

### STARTING AN INTERFACE

Interfaces may be started by calling `NetIF_Start()`. See section 16-2-1 "Starting Network Interfaces" on page 366 for more information on starting interfaces.

### STOPPING AN INTERFACE

Interfaces may be started by calling `NetIF_Stop()`. See section 16-2-2 "Stopping Network Interfaces" on page 367 for more information on stopping interfaces.

### CHECKING FOR ENABLED INTERFACE

The application may check if an interface is enabled by calling `NetIF_IsEn()` or `NetIF_IsEnCfgd()`. See section C-9-10 "NetIF_IsEn()" on page 517 and section C-9-11 "NetIF_IsEnCfgd()" on page 518 for more information.

## F-2-2 NETWORK AND DEVICE BUFFER CONFIGURATION

### LARGE TRANSMIT BUFFERS ARE 1594 BYTES

Refer to the section 9-3 “Network Buffer Sizes” on page 279 for more information.

### NUMBER OF RX PR TX BUFFERS TO CONFIGURE

The number of large receive, small transmit and large transmit buffers configured for a specific interface depend on several factors.

1 Desired level of performance.

2 Amount of data to be either transmitted or received.

3 Ability of the target application to either produce or consume transmitted or received data.

4 Average CPU utilization.

5 Average network utilization.

The discussion on the bandwidth-delay product is always valid. In general, the more buffers the better. However, the number of buffers can be tailored based on the application. For example, if an application receives a lot of data but transmits very little, then it may be sufficient to define a number of small transmit buffers for operations such as TCP acknowledgements and allocate the remaining memory to large receive buffers. Similarly, if an application transmits and receives little, then the buffer allocation emphasis should be on defining more transmit buffers. However, there is a caveat:

If the application is written such that the task that consumes receive data runs infrequently or the CPU utilization is high and the receiving application task(s) becomes starved for CPU time, then more receive buffers will be required.

To ensure the highest level of performance possible, it makes sense to define as many buffers as possible and use the interface and pool statistics data in order to refine the number after having run the application for a while. A busy network will require more receive buffers in order to handle the additional broadcast messages that will be received.

In general, at least two large and two small transmit buffers should be configured. This assumes that neither the network or CPU are very busy.

Many applications will receive properly with four or more large receive buffers. However, for TCP applications that move a lot of data between the target and the peer, this number may need to be higher.

Specifying too few transmit or receive buffers may lead to stalls in communication and possibly even dead-lock. Care should be taken when configuring the number of buffers. µC/TCP-IP is often tested with configurations of 10 or more small transmit, large transmit, and large receive buffers.

All device configuration structures and declarations are in the provided files named `net_dev_cfg.c` and `net_dev_cfg.h`. Each configuration structure must be completely initialized in the specified order. The following listing shows where to define the number of buffers per interface as calculated

```
const  NET_DEV_CFG_ETHER  NetDev_Cfg_Processor_0 = {
    ,
    1518,                                               (1)
      10,                                               (2)
      16,
       0,

    NET_IF_MEM_TYPE_MAIN,
    1594,                                               (3)
       5,                                               (4)
     256,                                               (5)
       5,                                               (6)
      16,
       0,

    0x00000000,
             0,

    10,                                                 (7)
     5,                                                 (8)

    0x40001000,
             0,

   "00:50:C2:25:60:02"
};
```

Listing F-2 **Network Device Driver buffer configuration**

LF-2(1) Receive buffer size. This field sets the size of the largest receivable packet and may be set to match the application's requirements.

LF-2(2) Number of receive buffers. This setting controls the number of receive buffers that will be allocated to the interface. This value *must* be set greater than or equal to one buffer if the interface is receiving *only* UDP. If TCP data is expected to be transferred across the interface, then there *must* be the minimum of receive buffers as calculated by the BDP.

LF-2(3) Large transmit buffer size. This field controls the size of the large transmit buffers allocated to the device in bytes. This field has no effect if the number of large transmit buffers is configured to zero. Setting the size of the large transmit buffers below 1594, bytes may hinder the stack's ability to transmit full-sized IP

datagrams since IP transmit fragmentation is not yet supported. Micrium recommends setting this field to 1594 bytes in order to accommodate µC/TCP-IPs internal packet building mechanisms.

LF-2(4) Number of large transmit buffers. This field controls the number of large transmit buffers allocated to the device. The developer may set this field to zero to make room for additional small transmit buffers, however, the size of the maximum transmittable UDP packet will depend on the size of the small transmit buffers, (see #5).

LF-2(5) Small transmit buffer size. For devices with a minimal amount of RAM, it is possible to allocate small transmit buffers as well as large transmit buffers. In general, Micrium recommends 256 byte small transmit buffers, however, the developer may adjust this value according to the application requirements. This field has no effect if the number of small transmit buffers is configured to zero.

LF-2(6) Number of small transmit buffers. This field controls the number of small transmit buffers allocated to the device. The developer may set this field to zero to make room for additional large transmit buffers if required.

### NUMBER OF DMA DESCRIPTORS TO CONFIGURE

If the hardware device is an Ethernet MAC that supports DMA, then the number of configured receive descriptors will play an important role in determining overall performance for the configured interface.

For applications with 10 or less large receive buffers, it is desirable to configure the number of receive descriptors to that of 60% to 70% of the number of configured receive buffers.

In this example, 60% of 10 receive buffers allows for four receive buffers to be available to the stack waiting to be processed by application tasks. While the application is processing data, the hardware may continue to receive additional frames up to the number of configured receive descriptors.

There is, however, a point in which configuring additional receive descriptors no longer greatly impacts performance. For applications with 20 or more buffers, the number of descriptors can be configured to 50% of the number of configured receive buffers. After this point, only the number of buffers remains a significant factor; especially for slower or busy CPUs and networks with higher utilization.

In general, if the CPU is not busy and the µC/TCP-IP Receive task has the opportunity to run often, the ratio of receive descriptors to receive buffers may be reduced further for very high numbers of available receive buffers (e.g., 50 or more).

The number of transmit descriptors should be configured such that it is equal to the number of small plus the number of large transmit buffers.

These numbers only serve as a starting point. The application and the environment that the device will be attached to will ultimately dictate the number of required transmit and receive descriptors necessary for achieving maximum performance.

Specifying too few descriptors can cause communication delays. See Listing F-2 for descriptors configuration.

LF-2(7) Number of receive descriptors. For DMA-based devices, this value is utilized by the device driver during initialization in order to allocate a fixed-size pool of receive descriptors to be used by the device. The number of descriptors *must* be less than the number of configured receive buffers. Micrium recommends setting this value to approximately 60% to 70%f of the number of receive buffers. Non DMA based devices may configure this value to zero.

LF-2(8) Number of transmit descriptors. For DMA-based devices, this value is utilized by the device driver during initialization in order to allocate a fixed-size pool of transmit descriptors to be used by the device. For best performance, the number of transmit descriptors should be equal to the number of small, plus the number of large transmit buffers configured for the device. Non DMA based devices may configure this value to zero.

### CONFIGURING TCP WINDOW SIZES

Once number and size of the transmit and receive buffers are configured, as explained in the previous section, the last thing that need to be done is to configure the TCP Transmit and Receive Window sizes. These parameters are found in the `net_cfg.h` file in the `TRANSMISSION CONTROL PROTOCOL LAYER CONFIGURATION` section.

```
#define  NET_TCP_CFG_RX_WIN_SIZE_OCTET   4096  /* Configure TCP connection receive  window size.
*/  (1)
#define  NET_TCP_CFG_TX_WIN_SIZE_OCTET   4096  /* Configure TCP connection transmit window size.
*/  (2)
```

Listing F-3 **TCP Transmit and Receive Window Size configuration**

LF-3(1) This `#define` configures the TCP Receive Window size. It is recommended to set this parameter to the number of receive descriptors in the case of DMA or to the number of receive buffers in the case of non-DMA, multiplied by the MSS. For example, if 4 descriptors or 4 receive buffers are required, the TCP Receive WIndow size is 4 * 1460 = 5840 bytes.

LF-3(2) This `#define` configures the TCP Transmit Window size. It is recommended to set this parameter to the number of transmit descriptors in the case of DMA or to the number of transmit buffers in the case of non-DMA, multiplied by the MSS. For example, if 2 descriptors or 2 receive buffers are required, the TCP Receive WIndow size is 2 * 1460 = 2920 bytes.

## WRITING OR OBTAINING ADDITIONAL DEVICE DRIVERS

Contact Micrium for information regarding obtaining additional device drivers. If a specific driver is not available, Micrium may develop the driver by providing engineering consulting services.

Alternately, a new device driver may be developed by filling in a template driver provided with the µC/TCP-IP source code.

See Chapter 7, “Device Driver Implementation” on page 139 for more information.

## F-2-3 ETHERNET MAC ADDRESS

### GETTING AN INTERFACE MAC ADDRESS

The application may call `NetIF_AddrHW_Get()` to obtain the MAC address for a specific interface.

### CHANGING AN INTERFACE MAC ADDRESS

The application may call `NetIF_AddrHW_Set()` in order to set the MAC address for a specific interface.

### GETTING A HOST MAC ADDRESS ON MY NETWORK

In order to determine the MAC address of a host on the network, the Network Protocol Stack must have an ARP cache entry for the specified host protocol address. An application may check to see if an ARP cache entry is present by calling `NetARP_CacheGetAddrHW()`.

If an ARP cache entry is not found, the application may call `NetARP_ProbeAddrOnNet()` to send an ARP request to all hosts on the network. If the target host is present, an ARP reply will be received shortly and the application should wait and then call `NetARP_CacheGetAddrHW()` to determine if the ARP reply has been entered into the ARP cache.

The following example shows how to obtain the Ethernet MAC address of a host on the local area network:

```
void AppGetRemoteHW_Addr (void)
{
  NET_IP_ADDR   addr_ip_local;
  NET_IP_ADDR   addr_ip_remote;
  CPU_CHAR    *paddr_ip_remote;
  CPU_CHAR      addr_hw_str[NET_IF_ETHER_ADDR_SIZE_STR];
  CPU_INT08U    addr_hw[NET_IF_ETHER_ADDR_SIZE];
  NET_ERR       err;

                                    /* ------------- PREPARE IP ADDRs ------------- */
  paddr_ip_local = “10.10.1.10”;   /* MUST be one of host’s configured IP addrs.   */
   addr_ip_local = NetASCII_Str_to_IP((CPU_CHAR *) paddr_ip_local,
                                      (NET_ERR  *)&err);
  if (err != NET_ASCII_ERR_NONE) {
    printf(“ Error #%d converting IP address %s”, err, paddr_ip_local);
    return;
  }

  paddr_ip_remote = “10.10.1.50”;   /* Remote host’s IP addr to get hardware addr. */
   addr_ip_remote = NetASCII_Str_to_IP((CPU_CHAR *) paddr_ip_remote,
                                       (NET_ERR  *)&err);
  if (err != NET_ASCII_ERR_NONE) {
    printf(“ Error #%d converting IP address %s”, err, paddr_ip_remote);
    return;
  }

  addr_ip_local  = NET_UTIL_HOST_TO_NET_32(addr_ip_local);
  addr_ip_remote = NET_UTIL_HOST_TO_NET_32(addr_ip_remote);

                                    /* ------------ PROBE ADDR ON NET ------------- */
  NetARP_ProbeAddrOnNet((NET_PROTOCOL_TYPE) NET_PROTOCOL_TYPE_IP_V4,
                        (CPU_INT08U      *)&addr_ip_local,
                        (CPU_INT08U      *)&addr_ip_remote,
                        (NET_ARP_ADDR_LEN ) sizeof(addr_ip_remote),
                        (NET_ERR         *)&err);
  if (err != NET_ARP_ERR_NONE) {
    printf(“ Error #%d probing address %s on network”, err, addr_ip_remote);
    return;
  }

  OSTimeDly(2);                     /* Delay short time for ARP to probe network.   */
```

```
                                    /* ---- QUERY ARP CACHE FOR REMOTE HW ADDR ---- */
(void)NetARP_CacheGetAddrHW((CPU_INT08U     *)&addr_hw[0],
                            (NET_ARP_ADDR_LEN) sizeof(addr_hw_str),
                            (CPU_INT08U     *)&addr_ip_remote,
                            (NET_ARP_ADDR_LEN) sizeof(addr_ip_remote),
                            (NET_ERR        *)&err);
  switch (err) {
    case NET_ARP_ERR_NONE:
       NetASCII_MAC_to_Str((CPU_INT08U *)&addr_hw[0],
                           (CPU_CHAR   *)&addr_hw_str[0],
                           (CPU_BOOLEAN ) DEF_NO,
                           (CPU_BOOLEAN ) DEF_YES,
                           (NET_ERR    *)&err);
       if (err != NET_ASCII_ERR_NONE) {
         printf(“ Error #%d converting hardware address”, err);
         return;
       }

       printf(“ Remote IP Addr %s @ HW Addr %s\n\r”, paddr_ip_remote, &addr_hw_str[0]);
       break;

    case NET_ARP_ERR_CACHE_NOT_FOUND:
       printf(“  Remote IP Addr %s NOT found on network\n\r”, paddr_ip_remote);
       break;

    case NET_ARP_ERR_CACHE_PEND:
       printf(“  Remote IP Addr %s NOT YET found on network\n\r”, paddr_ip_remote);
       break;

    case NET_ARP_ERR_NULL_PTR:
    case NET_ARP_ERR_INVALID_HW_ADDR_LEN:
    case NET_ARP_ERR_INVALID_PROTOCOL_ADDR_LEN:
    default:
       printf(“ Error #%d querying ARP cache”, err);
       break;
  }
}
```

Listing F-4 **Obtaining the Ethernet MAC address of a host**

## F-2-4 ETHERNET PHY LINK STATE

### INCREASING THE RATE OF LINK STATE POLLING

The application may increase the µC/TCP-IP link state polling rate by calling -NetIF_CfgPhyLinkPeriod() (see section C-9-6 on page 508). The default value is 250ms.

### GETTING THE CURRENT LINK STATE FOR AN INTERFACE

µC/TCP-IP provides two mechanisms for obtaining interface link state.

1 A function which reads a global variable that is periodically updated.

2 A function which reads the current link state from the hardware.

Method 1 provides the fastest mechanism to obtain link state since it does not require communication with the physical layer device. For most applications, this mechanism is suitable and if necessary, the polling rate can be increased by calling NetIF_CfgPhyLinkPeriod(). In order to utilize Method 1, the application may call NetIF_LinkStateGet() which returns NET_IF_LINK_UP or NET_IF_LINK_DOWN.

The accuracy of Method 1 can be improved by using a physical layer device and driver combination that supports link state change interrupts. In this circumstance, the value of the global variable containing the link state is updated immediately following a link state change. Therefore, the polling rate can be reduced further if desired and a call to NetIF_LinkStateGet() will return the actual link state.

Method 2 requires the application to call NetIF_IO_Ctrl() with the option parameter set to either NET_IF_IO_CTRL_LINK_STATE_GET or NET_IF_IO_CTRL_LINK_STATE_GET_INFO.

- If the application specifies NET_IF_IO_CTRL_LINK_STATE_GET, then NET_IF_LINK_UP or NET_IF_LINK_DOWN will be returned.

- Alternatively, if the application specifies NET_IF_IO_CTRL_LINK_STATE_GET_INFO, the link state details such as speed and duplex will be returned.

The advantage to Method 2 is that the link state returned is the actual link state as reported by the hardware at the time of the function call. However, the overhead of communicating with the physical layer device may be high and therefore some cycles may be wasted

waiting for the result since the connection bus between the CPU and the physical layer device is often only a couple of MHz.

### FORCING AN ETHERNET PHY TO A SPECIFIC LINK STATE

The generic PHY driver that comes with µC/TCP-IP does not provide a mechanism for disabling auto-negotiation and specifying a desired link state. This restriction is required in order to remain MII register block compliant with all (R)MII compliant physical layer devices.

However, µC/TCP-IP does provide a mechanism for coaching the physical layer device into advertising only the desired auto-negotiation states. This may be achieved by adjusting the physical layer device configuration as specified in `net_dev_cfg.c` with alternative link speed and duplex values.

The following is an example physical layer device configuration structure.

```
NET_PHY_CFG_ETHER NetPhy_Cfg_Generic_0 = {
   0,
   NET_PHY_BUS_MODE_MII,
   NET_PHY_TYPE_EXT,
   NET_PHY_SPD_AUTO,
   NET_PHY_DUPLEX_AUTO
};
```

The parameters `NET_PHY_SPD_AUTO` and `NET_PHY_DUPLEX_AUTO` may be changed to match any of the following settings:

`NET_PHY_SPD_10`
`NET_PHY_SPD_100`
`NET_PHY_SPD_1000`
`NET_PHY_SPD_AUTO`
`NET_PHY_DUPLEX_HALF`
`NET_PHY_DUPLEX_FULL`
`NET_PHY_DUPLEX_AUTO`

This mechanism is only effective when both the physical layer device attached to the target and the remote link state partner support auto-negotiation.

# F-3 IP ADDRESS CONFIGURATION

## F-3-1 CONVERTING IP ADDRESSES TO AND FROM THEIR DOTTED DECIMAL REPRESENTATION

µC/TCP-IP contains functions to perform various string operations on IP addresses.

The following example shows how to use the NetASCII module in order to convert IP addresses to and from their dotted-decimal representations:

```
NET_IP_ADDR ip;
CPU_INT08U  ip_str[16];
NET_ERR   err;
ip = NetASCII_Str_to_IP((CPU_CHAR *)”192.168.1.65”, &err);
NetASCII_IP_to_Str(ip, &ip_str[0], DEF_NO, &err);
```

## F-3-2 ASSIGNING STATIC IP ADDRESSES TO AN INTERFACE

The constant `NET_IP_CFG_IF_MAX_NBR_ADDR` specified in `net_cfg.h` determines the maximum number of IP addresses that may be assigned to an interface. Many IP addresses may be added up to the specified maximum by calling `NetIP_CfgAddrAdd()`.

Configuring an IP gateway address is not necessary when communicating only within your local network.

```
CPU_BOOLEAN cfg_success;


ip          = NetASCII_Str_to_IP((CPU_CHAR *)”192.168.1.65”, perr);
msk         = NetASCII_Str_to_IP((CPU_CHAR *)”255.255.255.0”, perr);
gateway     = NetASCII_Str_to_IP((CPU_CHAR *)”192.168.1.1”,  perr);
cfg_success = NetIP_CfgAddrAdd(if_nbr, ip, msk, gateway, perr);
```

## F-3-3 REMOVING STATICALLY ASSIGNED IP ADDRESSES FROM AN INTERFACE

Statically assigned IP addresses for a specific interface may be removed by calling `NetIP_CfgAddrRemove()`.

Alternatively, the application may call `NetIP_CfgAddrRemoveAll()` to remove all configured static addresses for a specific interface.

## F-3-4 GETTING A DYNAMIC IP ADDRESS

µC/DHCPc must be obtained and integrated into the application to dynamically assign an IP address to an interface.

## F-3-5 GETTING ALL THE IP ADDRESSES CONFIGURED ON A SPECIFIC INTERFACE

The application may obtain the protocol address information for a specific interface by calling `NetIP_GetAddrHost()`. This function may return one or more configured addresses.

Similarly, the application may call `NetIP_GetAddrSubnetMask()` and `NetIP_GetAddrDfltGateway()` in order to determine the subnet mask and gateway information for a specific interface.

# F-4 SOCKET PROGRAMMING

## F-4-1 USING µC/TCP-IP SOCKETS

Refer to Chapter 9, “Socket Programming” on page 273 for code examples on this topic.

## F-4-2 JOINING AND LEAVING AN IGMP HOST GROUP

µC/TCP-IP supports IP multicasting with IGMP. In order to receive packets addressed to a given IP multicast group address, the stack must have been configured to support multicasting in `net_cfg.h`, and that host group has to be joined.

The following examples show how to join and leave an IP multicast group with µC/TCP-IP:

```
NET_IF_NBR  if_nbr;
NET_IP_ADDR group_ip_addr;
NET_ERR     err;


if_nbr        = NET_IF_NBR_BASE_CFGD;
group_ip_addr = NetASCII_Str_to_IP("233.0.0.1", &err);
if (err != NET_ASCII_ERR_NONE) {
  /* Handle error. */
}
NetIGMP_HostGrpJoin(if_nbr, group_ip_addr, &err);
if (err != NET_IGMP_ERR_NONE) {
  /* Handle error. */
}
[...]
NetIGMP_HostGrpLeave(if_nbr, group_ip_addr, &err);
if (err != NET_IGMP_ERR_NONE) {
  /* Handle error. */
}
```

## F-4-3 TRANSMITTING TO A MULTICAST IP GROUP ADDRESS

Transmitting to an IP multicast group is identical to transmitting to a unicast or broadcast address. However, the stack must be configured to enable multicast transmit.

## F-4-4 RECEIVING FROM A MULTICAST IP GROUP

An IP multicast group must be joined before packets can be received from it from it (see section F-4-2 “Joining and Leaving an IGMP Host Group” on page 805 for more information). Once this is done, receiving from a multicast group only requires a socket bound to the NET_SOCK_ADDR_IP_WILDCARD address, as shown in the following example:

```
NET_SOCK_ID       sock;
NET_SOCK_ADDR_IP  sock_addr_ip;
NET_SOCK_ADDR     addr_remote;
NET_SOCK_ADDR_LEN addr_remote_len;
CPU_CHAR          rx_buf[100];
CPU_INT16U        rx_len;
NET_ERR           err;


sock = NetSock_Open((NET_SOCK_PROTOCOL_FAMILY) NET_SOCK_ADDR_FAMILY_IP_V4,
                    (NET_SOCK_TYPE           ) NET_SOCK_TYPE_DATAGRAM,
                    (NET_SOCK_PROTOCOL       ) NET_SOCK_PROTOCOL_UDP,
                    (NET_ERR                *)&err);
if (err != NET_SOCK_ERR_NONE) {
  /* Handle error. */
}
Mem_Set(&sock_addr_ip, (CPU_CHAR)0, sizeof(sock_addr_ip));
sock_addr_ip.AddrFamily = NET_SOCK_ADDR_FAMILY_IP_V4;
sock_addr_ip.Addr       = NET_UTIL_HOST_TO_NET_32(NET_SOCK_ADDR_IP_WILDCARD);
sock_addr_ip.Port       = NET_UTIL_HOST_TO_NET_16(10000);
NetSock_Bind((NET_SOCK_ID      ) sock,
             (NET_SOCK_ADDR   *)&sock_addr_ip,
             (NET_SOCK_ADDR_LEN) NET_SOCK_ADDR_SIZE,
             (NET_ERR         *)&err);
if (err != NET_SOCK_ERR_NONE) {
  /* Handle error. */
}

rx_len = NetSock_RxDataFrom((NET_SOCK_ID        ) sock,
                            (void              *)&rx_buf [0],
                            (CPU_INT16U         ) BUF_SIZE,
                            (CPU_INT16S         ) NET_SOCK_FLAG_NONE,
                            (NET_SOCK_ADDR     *)&addr_remote,
                            (NET_SOCK_ADDR_LEN *)&addr_remote_len,
                            (void              *) 0,
                            (CPU_INT08U         ) 0,
                            (CPU_INT08U        *) 0,
                            (NET_ERR           *)&err);
```

## F-4-5 THE APPLICATION RECEIVES SOCKET ERRORS IMMEDIATELY AFTER REBOOT

Immediately after a network interface is added, the physical layer device is reset and network interface and device initialization begins. However, it may take up to three seconds for the average Ethernet physical layer device to complete auto-negotiation. During this time, the socket layer will return NET_SOCK_ERR_LINK_DOWN for sockets that are bound to the interface in question.

The application should attempt to retry the socket operation with a short delay between attempts until network link has been established.

## F-4-6 REDUCING THE NUMBER OF TRANSITORY ERRORS (NET_ERR_TX)

The number of transmit buffer should be increased. Additionally, it may be helpful to add a short delay between successive calls to socket transmit functions.

## F-4-7 CONTROLLING SOCKET BLOCKING OPTIONS

Socket blocking options may be configured during compile time by adjusting the net_cfg.h macro NET_SOCK_CFG_BLOCK_SEL to the following values:

NET_SOCK_BLOCK_SEL_DFLT
NET_SOCK_BLOCK_SEL_BLOCK
NET_SOCK_BLOCK_SEL_NO_BLOCK

NET_SOCK_BLOCK_SEL_DFLT selects blocking as the default option, however, allows run-time code to override blocking settings by specifying additional socket.

NET_SOCK_BLOCK_SEL_BLOCK configures all sockets to always block.

NET_SOCK_BLOCK_SEL_NO_BLOCK configures all sockets to non blocking.

See the section C-13-46 on page 659 and section C-13-48 on page 666 for more information about sockets and blocking options.

## F-4-8 DETECTING IF A SOCKET IS STILL CONNECTED TO A PEER

Applications may call `NetSock_IsConn()` to determine if a socket is (still) connected to a remote socket (see section C-13-39 on page 646).

Alternatively, applications may make a non-blocking call to `recv()`, `NetSock_RxData()`, or `NetSock_RxDataFrom()` and inspect the return value. If data or a non-fatal, transitory error is returned, then the socket is still connected; otherwise, if '0' or a fatal error is returned, then the socket is disconnected or closed.

## F-4-9 RECEIVING -1 INSTEAD OF 0 WHEN CALLING RECV() FOR A CLOSED SOCKET

When a remote peer closes a socket, and the target application calls one of the receive socket functions, µC/TCP-IP will first report that the receive queue is empty and return a -1 for both BSD and µC/TCP-IP socket API functions. The next call to receive will indicate that the socket has been closed by the remote peer.

This is a known issue and will be corrected in subsequent versions of µC/TCP-IP.

## F-4-10 DETERMINE THE INTERFACE FOR RECEIVED UDP DATAGRAM

If a UDP socket server is bound to the "any" address, then it is not currently possible to know which interface received the UDP datagram. This is a limitation in the BSD socket API and therefore no solution has been implemented in the µC/TCP-IP socket API.

In order to guarantee which interface a UDP packet was received on, the socket server must bind a specific interface address.

In fact, if a UDP datagram is received on a listening socket bound to the "any" address and the application transmits a response back to the peer using the same socket, then the newly transmitted UDP datagram will be transmitted from the default interface. The default interface may or may not be the interface in which the UDP datagram originated.

# F-5 µC/TCP-IP STATISTICS AND DEBUG

## F-5-1 PERFORMANCE STATISTICS DURING RUN-TIME

µC/TCP-IP periodically measures and estimates run-time performance on a per interface basis. The performance data is stored in the global µC/TCP-IP statistics data structure, `Net_StatCtrs` which is of type `NET_CTR_STATS`.

Each interface has a performance metric structure which is allocated within a single array of `NET_CTR_IF_STATS`. Each index in the array represents a different interface.

In order to access the performance metrics for a specific interface number, the application may externally access the array by viewing the variable `Net_StatCtrs.NetIF_StatCtrs[if_nbr].field_name`, where `if_nbr` represents the interface number in question, 0 for the loopback interface, and where `field_name` corresponds to one of the fields below.

Possible field names:

```
NetIF_StatRxNbrOctets
NetIF_StatRxNbrOctetsPerSec
NetIF_StatRxNbrOctetsPerSecMax
NetIF_StatRxNbrPktCtr
NetIF_StatRxNbrPktCtrPerSec
NetIF_StatRxNbrPktCtrPerSecMax
NetIF_StatRxNbrPktCtrProcessed
NetIF_StatTxNbrOctets
NetIF_StatTxNbrOctetsPerSec
NetIF_StatTxNbrOctetsPerSecMax
NetIF_StatTxNbrPktCtr
NetIF_StatTxNbrPktCtrPerSec
NetIF_StatTxNbrPktCtrPerSecMax
NetIF_StatTxNbrPktCtrProcessed
```

See Chapter 12, “Statistics and Error Counters” on page 298 for more information.

## F-5-2 VIEWING ERROR AND STATISTICS COUNTERS

In order to access the statistics and error counters, the application may externally access the global µC/TCP-IP statistics array by referencing the members of the structure variable `Net_StatCtrs`.

See Chapter 12, “Statistics and Error Counters” on page 298 for more information.

## F-5-3 USING NETWORK DEBUG FUNCTIONS TO CHECK NETWORK STATUS CONDITIONS

Example(s) demonstrating how to use the network debug status functions include:

```
NET_DBG_STATUS net_status;
CPU_BOOLEAN   net_fault;
CPU_BOOLEAN   net_fault_conn;
CPU_BOOLEAN   net_rsrc_lost;
CPU_BOOLEAN   net_rsrc_low;

net_status     = NetDbg_ChkStatus();
net_fault      = DEF_BIT_IS_SET(net_status, NET_DBG_STATUS_FAULT);
net_fault_conn = DEF_BIT_IS_SET(net_status, NET_DBG_STATUS_FAULT_CONN);
net_rsrc_lost  = DEF_BIT_IS_SET(net_status, NET_DBG_STATUS_RSRC_LOST);
net_rsrc_lo    = DEF_BIT_IS_SET(net_status, NET_DBG_STATUS_RSRC_LO);
net_status     = NetDbg_ChkStatusTmrs();
```

## F-6 USING NETWORK SECURITY MANAGER

The network security manager requires the presence of a network security layer such as µC/SSL. The port layer developed for the network security layer is reponsible of securing the sockets and applying the security strategy over typical socket programming functions. From an application point of view, the usage of µC/TCP-IP network security manager is very simple. It requires two basic step. The application code shipped with µC/TCP-IP includes a project that shows how to use the network security manager.

## F-6-1 KEYING MATERIAL INSTALLATION

In order to acheive secure handshake connections, some keying material must be installed before performing any secure socket operation. With µC/SSL, the client side needs to install certificates authorities to validate the identity of the public key certificate sent by the server side. On the opposite, a server needs to install a public key certificare / private key pair to send the the clients that wants to connect. This keying material can be installed using the network security manager APIs decribed in section C-13-8 on page 586 and section C-13-9 on page 588 of µC/TCP-IP user manual. The following example demonstrates how to install a PEM certificate authority from a constant buffer.

```
CPU_SIZE_T  Micrium_Ca_Cert_Pem_Len = 994;
CPU_CHAR    Micrium_Ca_Cert_Pem[] =
"-----BEGIN CERTIFICATE-----\r\n"
"MIICpTCCAg4CCQDNdHgFKaYRWDANBgkqhkiG9w0BAQUFADCBljELMAkGA1UEBhMC\r\n"
"Q0ExDzANBgNVBAgMBlF1ZWJlYzERMA8GA1UEBwwITW9udHJlYWwxFTATBgNVBAoM\r\n"
"DE1pY3JpdW0gSW5jLjEZMBcGA1UECwwQRW1iZWRkZWQgU3lzdGVtczEQMA4GA1UE\r\n"
"AwwHTWljcml1bTEfMB0GCSqGSIb3DQEJARYQaW5mb0BtaWNyaXVtLmNvbTAeFw0x\r\n"
"aXVtMR8wHQYJKoZIhvcNAQkBFhBpbmZvQG1pY3JpdW0uY29tMIGfMA0GCSqGSIb3\r\n"
[...]
"CZFtP3vbY0SA6gFrCvCcKjTWRapzQKwSYknMu1QorP4mdwZDeCYsikkn8bI5//zn\r\n"
"CInLCmrWdbrCEtj23t0wefw8fyNQxkKi9JdbzLVwxjIQt8wMq1CnTOQRa7aGX5Uw\r\n"
"QQIDAQABMA0GCSqGSIb3DQEBBQUAA4GBACqyJeSDQ3j5KohXIvV+iBOrl5qbI1PS\r\n"
"WAHf4PSyiTX0Spa58VSdhM4sestd/FELBWo/MHKIfBdoLMhg2frDZE5e7m8Ftq1R\r\n"
"1YBKNbTzIJNjwTajkUPz38BjXb5sqLyPK8wRbjadm2pOlw1f7bIFunpbHpV+1XA1\r\n"
"tk3W32BqKfzy\r\n"
"-----END CERTIFICATE-----\r\n";

void  Task (void)
{
    NET_ERR  err;


    NetSecureMgr_InstallBuf((CPU_INT08U *)Micrium_Ca_Cert_Pem,
                                          NET_SECURE_INSTALL_TYPE_CA,
                                          NET_SECURE_INSTALL_FORMAT_PEM,
                                          Micrium_Ca_Cert_Pem_Len,
                                         &err);
    if (err != NET_SECURE_MGR_ERR_NONE) {
        APP_TRACE_INFO(("    uC/TCP-IP:NetSecureMgr_InstallBuf() error %d \n", err));
        return;
    }
}
```

The following example demonstrates how to install a DER certificate authority, PEM public key certificate and a DER private key from the file system.

```
#define  Micrium_Ca_Cert_File_Der             "\\ca-cert.der"
#define  Micrium_Srv_Cert_File_Pem            "\\server-cert.pem"
#define  Micrium_Srv_Key_File_Der             "\\server-key.der"
void  Task (void  *p_arg)
{
    NET_ERR  err;


    NetSecureMgr_InstallFile(Micrium_Ca_Cert_File_Der,
                             NET_SECURE_INSTALL_TYPE_CA,
                             NET_SECURE_INSTALL_FORMAT_DER,
                            &err);
    if (err != NET_SECURE_MGR_ERR_NONE) {
        APP_TRACE_INFO(("    uC/TCP-IP:NetSecureMgr_InstallFile() error %d \n", err));
        return;
    }

    NetSecureMgr_InstallFile(Micrium_Srv_Cert_File_Pem,
                             NET_SECURE_INSTALL_TYPE_CERT,
                             NET_SECURE_INSTALL_FORMAT_PEM,
                            &err);
    if (err != NET_SECURE_MGR_ERR_NONE) {
        APP_TRACE_INFO(("    uC/TCP-IP:NetSecureMgr_InstallFile() error %d \n", err));
        return;
    }

    NetSecureMgr_InstallFile(Micrium_Srv_Key_File_Der,
                             NET_SECURE_INSTALL_TYPE_KEY,
                             NET_SECURE_INSTALL_FORMAT_DER,
                            &err);
    if (err != NET_SECURE_MGR_ERR_NONE) {
        APP_TRACE_INFO(("    uC/TCP-IP:NetSecureMgr_InstallFile() error %d \n", err));
        return;
    }
}
```

## F-6-2 SECURING A SOCKET

Once the appropriate keying material is installed, a TCP socket can be secured if it has been successfully open. A simple function call is used to setup the secure flag on the socket. This function is documented in section C-13-7 on page 584 of µC/TCP-IP user manual. With this simple API, you can secure your custom TCP client or server application. Pleae note that all Micrium applications running over TCP has already been modified to support secure sockets (µC/HTTPs, µC/TELNETs, µC/FTPs, µC/FTPc, µC/SMTPc, µC/POP3c). The following example demonstrates how to open and secure a TCP socket

```
void  Task (void  *p_arg)
{
    NET_ERR  net_err;
    sock_id = NetSock_Open(NET_SOCK_ADDR_FAMILY_IP_V4,
                           NET_SOCK_TYPE_STREAM,
                           NET_SOCK_PROTOCOL_TCP,
                          &net_err);
    if (net_err == NET_SOCK_ERR_NONE) {

#ifdef  NET_SECURE_MODULE_PRESENT
        (void)NetSock_CfgSecure((NET_SOCK_ID   ) sock_id,
                                (CPU_BOOLEAN   ) DEF_YES,
                                (NET_ERR      *)&net_err);
        if (net_err != NET_SOCK_ERR_NONE) {
            APP_TRACE_INFO(("Open socket failed. No secure socket available.\n"));
            return (DEF_FAIL);
        }
#endif
    }
}
```

## F-7 MISCELLANEOUS

### F-7-1 SENDING AND RECEIVING ICMP ECHO REQUESTS FROM THE TARGET

From the user application, µC/TCP-IP does not support sending and receiving ICMP Echo Request and Reply messages However, the target is capable of receiving externally generated ICMP Echo Request messages and replying them accordingly. At this time, there are no means to generate an ICMP Echo Request from the target.

### F-7-2 TCP KEEP-ALIVES

µC/TCP-IP does not currently support TCP Keep-Alives. If both ends of the connection are running different Network Protocol Stacks, you may attempt to enable TCP Keep-Alives on the remote side. Alternatively, the application will have to send something through the socket to the remote peer in order to ensure that the TCP connection remains open.

### F-7-3 USING µC/TCP-IP FOR INTER-PROCESS COMMUNICATION

It is possible for tasks to communicate with sockets via the localhost interface which must be enabled.

Appendix

# G

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