Micriμm

μC/TTCP

Test TCP

User's Manual

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Empowering Embedded Systems

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1.00 Introduction

Test TCP or TTCP, is a test tool to perform TCP/IP or UDP/IP performance tests. TTCP is a command-line sockets-based benchmarking tool for measuring performance between two systems. It was originally developed in 1984 by Mike Muuss and Terry Slattery for the BSD operating system. The original TTCP and sources are in the public domain, and copies are available from many anonymous FTP sites.

This document describes how to configure and use the µC/TTCP module in a µC/TCP-IP and µC/OS-II environment.

We used the Cogent CSB337 single-board computer and IAR's Embedded Workbench to demonstrate the examples but other embedded platforms and tool chains can be used.

1.01 Directories and Files

The code and documentation of the µC/TTCP module are placed in a directory structure according to "AN-2002, µC/OS-II Directory Structure". Specifically, the files are placed in the following directories:

`\Micrium\Software\uC-TTCP\Doc`

This directory contains the µC/TTCP documentation files, including this one.

`\Micrium\Software\uC-TTCP\Source`

This directory contains the µC/TTCP source files (`ttcp.c` and `ttcp.h`).

`\Micrium\Software\uC-LIB`

This directory contains the µC/LIB source files, the Micrium version of the C library most used utilities. The goal of this library is to ease a certification process by providing the source code and documentation for all the functions. This directory contains:

```
lib_def.h
lib_mem.c
lib_mem.h
lib_str.c
lib_str.h
```

`\Micrium\Software\uC-CPU`

This directory contains the µC/CPU source files (`cpu_def.h`). This file provides definition for byte alignment, endianess and critical section handling.

`\Micrium\Software\uC-CPU\ARM\IAR`

This directory contains the files to configure standard data types, cpu word configuration, critical section configuration and cpu data types for the IAR compiler used for this sample project. (`cpu.h` and `cpu_a.s`)

`\Micrium\Software\EvalBoards\Cogent\CSB337\IAR\uC-APPs\Ex1`

This directory contains the source code for Example #1 running on a Cogent CSB337 with IAR tools. This directory contains:

```
app_cfg.c
includes.h
net_cfg.h
os_cfg.h
```

- app_cfg.c contains the application OS task priorities and stack space;
- includes.h contains a master include file used by the application;
- net_cfg.h is the µC/TCP-IP configuration file;
- os_cfg.h is the µC/OS-II configuration file;

This directory also contains the IAR EWARM 4.31a project workspace files:

```
Ex1.ewd
Ex1.ewp
Ex1.eww
```

\Micrium\Software\EvalBoards\Cogent\CSB337\IAR\BSP

This directory contains the Board Support Package (BSP) files and linker file for the project and target development board used for the example used to demonstrate TTCP. This directory contains:

```
bsp.c
bsp.h
CSB33z_lnk_ram.xcl
net_bsp.c
```

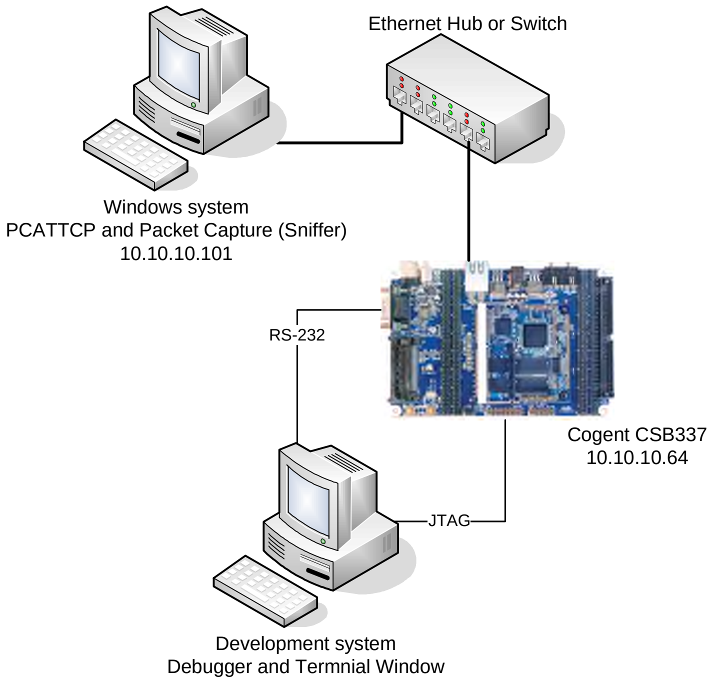
- bsp.c contains the board support functions for Interrupts, Timers, LEDs and Serial port;
- bsp.h contains the header definition for bsp.c;
- CSB33x_lnk_ram.xcl is the linker file for the IAR tool;
- net_bsp.c contains the low level interface functions for the Ethernet controller used in the sample project;

2.00 Network setup

Even if TTCP stands for Test TCP, the TTCP module can perform the following tests:

- Transmitting TCP segments : also called TCP Client mode
- Receiving TCP segments : also called TCP Server mode
- Transmitting UDP datagrams : also called UDP Client mode
- Receiving UDP datagrams : also called UDP Server mode

TTCP always work in a peer to peer configuration.
In developing µC/TTCP we were always running on a Cogent CSB337 and we were using PCATTCP on a PC.



F2-1
Network set-up

The target system is running Micrium µC/TTCP.
The Windows station also needs to run a TTCP application. The next section describes the Windows TTCP implementation Micrium has selected.

3.00 PCATTCP

For our development, Micrium has selected the PCAUSA port of TTCP to Windows Sockets for the TTCP module running on the Windows host. It is called pcattcp. The following directory contains pcattcp:

`\Micrium\Software\uC-TTCP\pcattcp`

This directory contains the following files:

```
PCATTCP.chm
PCATTCP.exe
RELEASE.TXT
sourcesv2.zip
ttcpzip.exe
```

- `PCATTCP.chm` is the pcattcp html help file;
- `PCATTCP.exe` is the tool itself;
- `RELEASE.TXT` contains release information for the pcattcp versions;
- `sourcesv2.zip` is a winzip file containing the pcattcp sources;
- `ttcpzip.exe` a self-extract zip file containing the 4 files above (the download result).

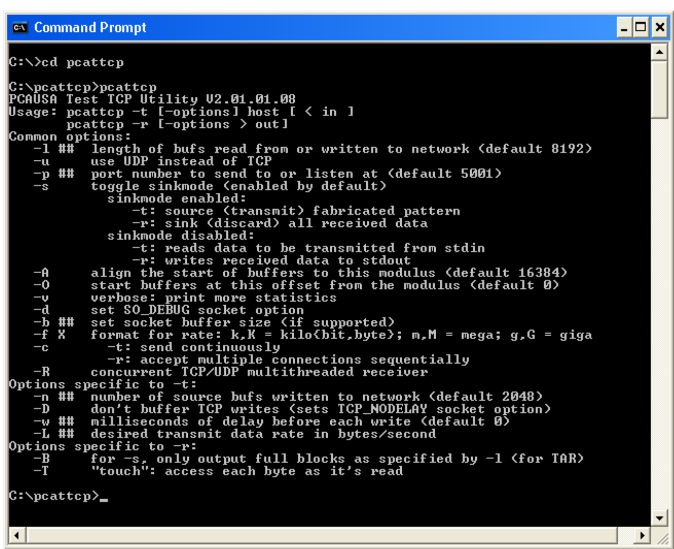
You can also download pcattcp from ftp://ftp.pcausa.com/utilities/ttcpzip.exe

You will find more information about pcattcp at http://www.pcausa.com/Utilities/pcattcp.htm

Running pcattcp

- Copy the content of ttcpzip.exe to a directory (C:\pcattcp for example).
- Open a DOS prompt window
- Change directory to the directory now containing pcattcp.exe
- From the DOS prompt, start pcattcp: C:\pcattcp>pcattcp

Without any arguments, pcattcp will output the command usage. For more detailed information about the pcattcp commands, please refer to the html help file by double clicking on PCATTCP.chm. This will automatically open a help file.



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3.01 Network Analyzer (Sniffer)

In our test setup, we also used a Software based Network Analyzer (sometimes called a Sniffer). Micrium used Etherpeek. Though you can see global network statistics without capturing packets, for some analysis sessions you'll want to capture packets.

Etherpeek is a commercial product of WildPackets Inc. To find more information about Etherpeek, please use the following link: http://www.wildpackets.com/products/etherpeek_nx

Public domain Network Analyzers are also available. One of the most popular that we can also recommend is Ethereal. You can download Ethereal from http://www.ethereal.com/

4.00 µC/TTCP

µC/TTCP is compliant with the other TTCP tools available in the public domain. It was written for target systems running µC/OS-II and µC/TCP-IP. This section describes the µC/TTCP usage.

4.01 µC/TTCP command line

As soon as the application is launched on the target, via a JTAG interface or other means, the Terminal Window running on the Development system will display the application status and a command line. The user controls µC/TTCP by entering parameters on the command line.

The command usage is displayed if the user makes an error entering the command line or by pressing ENTER at the “>” command prompt. Here is the command usage:

```
Usage: -t [-options] host
       -r [-options]
Common options: \r\n");
    -l ##   length of buffers read from or written to network (default 8192)
    -u      use UDP instead of TCP
    -p ##   port number to send to or listen at (default 5001)
    -s  -t: source a pattern to network
        -r: sink (discard) all data from network
    -d      set SO_DEBUG socket option (not supported)
    -b ##   set socket buffer size (not supported)
    -f X    format for rate: k,K = kilo{bit,byte}; m,M = mega; g,G = giga
Options specific to -t:
    -n ##   number of source buffers written to network (default 2048)
    -D      don't buffer TCP writes (sets TCP_NODELAY socket option)
Options specific to -r:
    -B      for -s, only output full blocks as specified by -l
    -T      "touch": access each byte as it is read
```

As an example, to start the TTCP TCP Receive Test start µC/TTCP with the "-r" option.

```
>-r
```

The TCP server will start and then wait until a remote TTCP client makes a connection attempt.

Instead of explaining all of the µC/TTCP options, we will be going through a few examples that illustrate basic usage.

Sinkmode (-s)

The simplest and most popular TTCP mode of operation is called "sinkmode". In this mode of operation the TTCP transmitter sends a fabricated data pattern and the TTCP receiver simply sinks (discards) any data that it receives.

This is the default TTCP mode of operation.

Standard Streams

Alternatively, TTCP can use what is called "standard streams" or "standard I/O". With µC/TTCP, the Serial port is used as the standard I/O.

Standard stream has only been implemented in Receiver mode. The code for Transmitter mode still needs to be developed.

Defaults

The µC/TTCP defaults for the command parameters are:

Parameter	**Value**	**Command line parameter**
Buffer Length	8192	-l
Number of buffers used	2048	-n
Transport layer protocol	TCP	-u
Layer 4 port number	5001	-p
Receiver/Transmitter	Receiver mode	-r or –t
Sink mode	Enabled	-s
Block read	Disabled	-B
Output format	'Kilobits per second'	-f
Received data processing	Disabled	-T
Socket options	Not supported	-d
Buffer TCP writes	Not supported	-D

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4.02 TCP Transmit Test

Target

To start the TTCP TCP Transmit Test start µC/TTCP with the "-t" option followed by the dotted IP address of the remote TTCP client.

```
>-t 10.10.10.101
```

```
ttcp-t: BufLen=8192, NumBuf=2048, port=5001  tcp  -> 10.10.10.101
ttcp-t: Client socket 9 opened
ttcp-t: Client socket 9 connected
ttcp-t: Client socket 9 closed
ttcp-t: 16777216 bytes in 41.87 real seconds = 3130.30 Kbit/sec +++
ttcp-t: 2099 I/O calls, msec/call = 19.95, calls/sec = 50.13

uC/TCP-IP Performance measurements
Type the TTCP parameters and parameter values and press Enter
>
```

These messages are generated as the test starts up:

```
ttcp-t: BufLen=8192, NumBuf=2048, port=5001 tcp  -> 10.10.10.101
ttcp-t: Client socket 9 opened
```

These messages indicate that a connection has been established with the remote host:

```
ttcp-t: Client socket 9 connected
```

When the test exits it displays the test results:

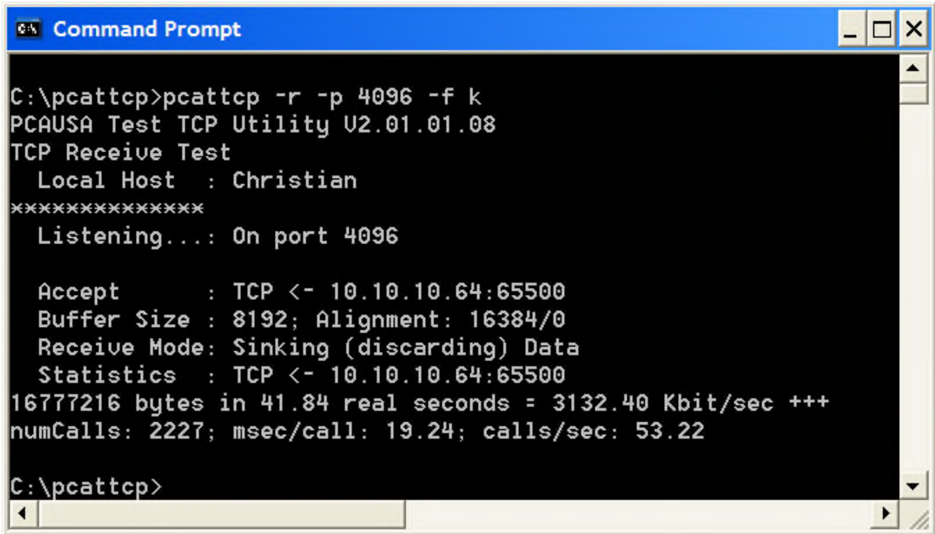
```
ttcp-t: Client socket 9 closed
ttcp-t: 16777216 bytes in 38.38 real seconds = 3415.38 Kbit/sec +++
ttcp-t: 2111 I/O calls, msec/call = 18.18, calls/sec = 55.01
```

As you can see all the default parameters are used:

- TCP is the default Layer 4 protocol used.
- Sinkmode is enabled by default
- Number of buffers : 2048
- Length of buffers : 8192
- TCP port : 5001 (Note: public domain TTCP uses default port 5001. If a firewall blocks this port, please choose another).

Windows host TTCP session

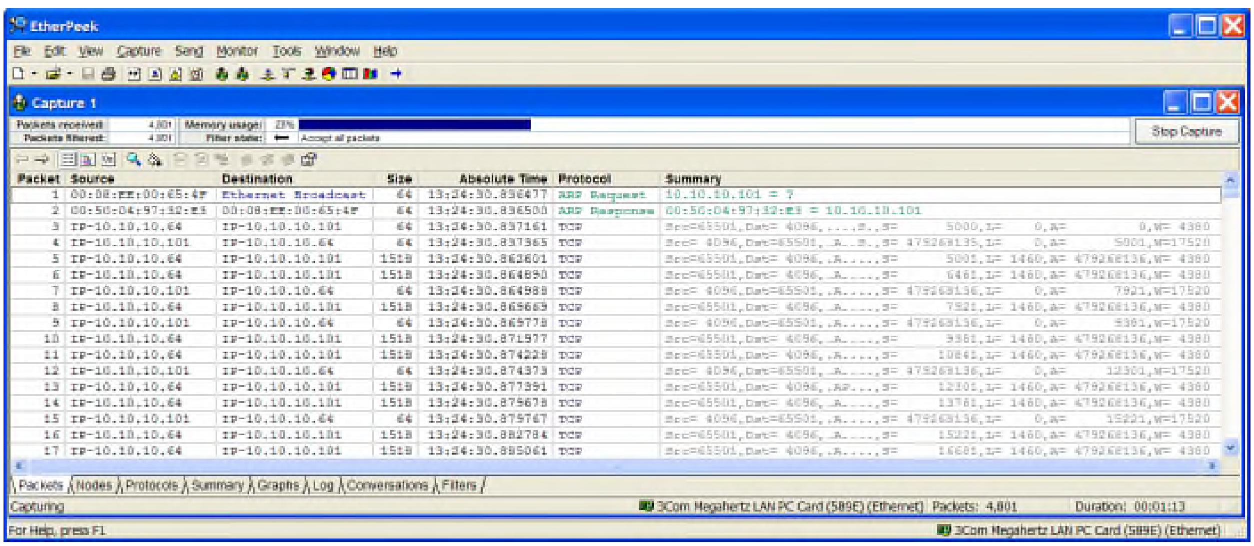
The Windows host running pcattcp must initiate the Receiver part of this test. Figure 4-1 shows the command used:



F4-1

Windows host packet capture

Using Etherpeek, here is a screen shot of the Transmit test:



F4-2

4.03 TCP Receive Test

Target

To start the TTCP TCP Receive Test start µC/TTCP with the "-r" option.

```
>-r
```

The TCP receiver will start and then wait until a remote TTCP client makes a connection attempt. Here is an example of the output you would see:

```
ttcp-r: BufLen=8192, NumBuf=2048, port=5001  tcp
ttcp-r: Listening socket opened = 9
ttcp-r: Waiting for client to request connection.
ttcp-r: Server socket 8 active
ttcp-r: Client socket 8 closed
ttcp-r: Listen socket 9 closed
ttcp-r: 16777216 bytes in 45.34 real seconds = 2891.06 Kbit/sec +++
ttcp-r: 9093 I/O calls, msec/call = 4.99, calls/sec = 200.56

uC/TCP-IP Performance measurements
Type the TTCP parameters, parameter values and press Enter
>
```

These messages are generated as the test starts up:

```
ttcp-r: BufLen=8192, NumBuf=2048, port=5001  tcp
ttcp-r: Listening socket opened = 9
ttcp-r: Waiting for client to request connection.
```

These messages indicate that a TCP connection has been accepted from a remote host:

```
ttcp-r: Server socket 8 active
```

When the test exits it displays the test results:

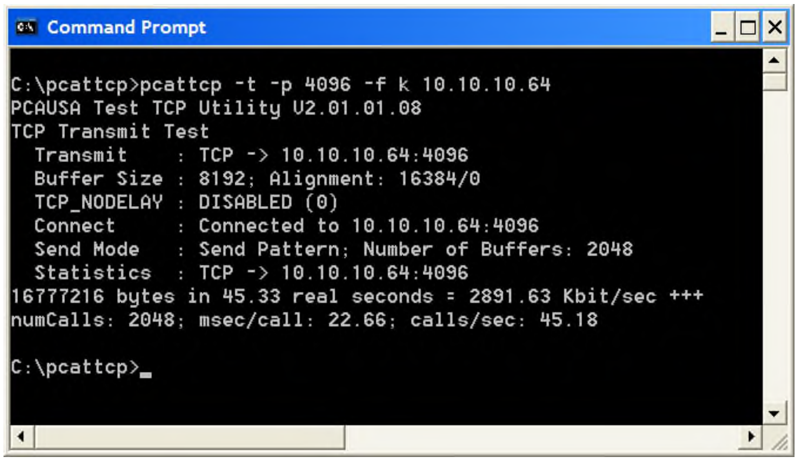
```
ttcp-r: Client socket 8 closed
ttcp-r: Listen socket 9 closed
ttcp-r: 16777216 bytes in 45.34 real seconds = 2891.06 Kbit/sec +++
ttcp-r: 9093 I/O calls, msec/call = 4.99, calls/sec = 200.56
```

As you can see all the default parameters are used:

- TCP is the default Layer 4 protocol used.
- Sinkmode is enabled by default
- Number of buffers : 2048
- Length of buffers : 8192
- TCP port : 5001 (Note: public domain TTCP uses default port 5001. If a firewall blocks this port, please choose another.)

Windows host TTCP session

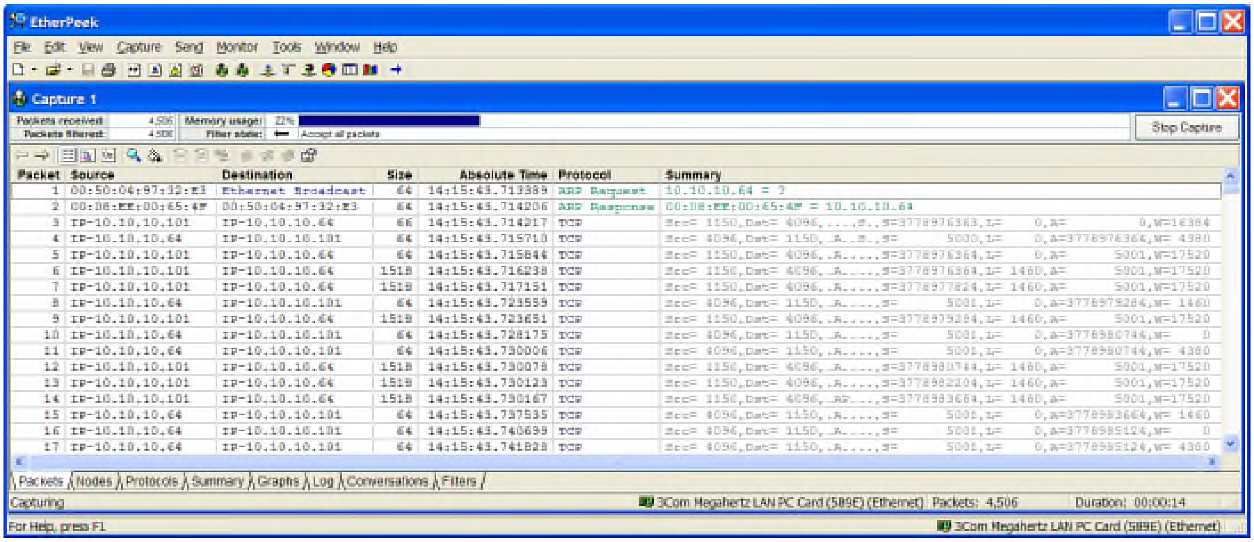
The Windows host running pcattcp must initiate the Transmitter part of this test. Figure 4-1 shows the command used:



F4-3

Windows host packet capture

Using Etherpeek, here is a screen shot of the Receive test:



F4-4

4.04 UDP Transmit Test

Target

To start the TTCP UDP Transmit Test start µC/TTCP with the "-t" option followed by the "-u " option followed finally by the dotted IP address of the remote TTCP client.

```
>-t –u 10.10.10.101
```

The UDP transmitter will start. Here is an example of the output you would see:

```
ttcp-t: BufLen=8192, NumBuf=2048, port=5001  udp  -> 10.10.10.101
ttcp-t: Client socket 9 opened
ttcp-t: Client socket 9 connected
ttcp-t: Client socket 9 closed
ttcp-t: 16777216 bytes in 30.06 real seconds = 4361.07 Kbit/sec +++
ttcp-t: 12288 I/O calls, msec/call = 2.45, calls/sec = 408.85

uC/TCP-IP Performance measurements
Type the TTCP parameters, parameter values and press Enter
>
```

These messages are generated as the test starts up:

```
ttcp-t: BufLen=8192, NumBuf=2048, port=5001  udp  -> 10.10.10.101
ttcp-t: Client socket 9 opened
```

These messages indicate that a UDP transmission is in progress toward the remote host:

```
ttcp-t: Client socket 9 connected
```

When the test exits it displays the test results:

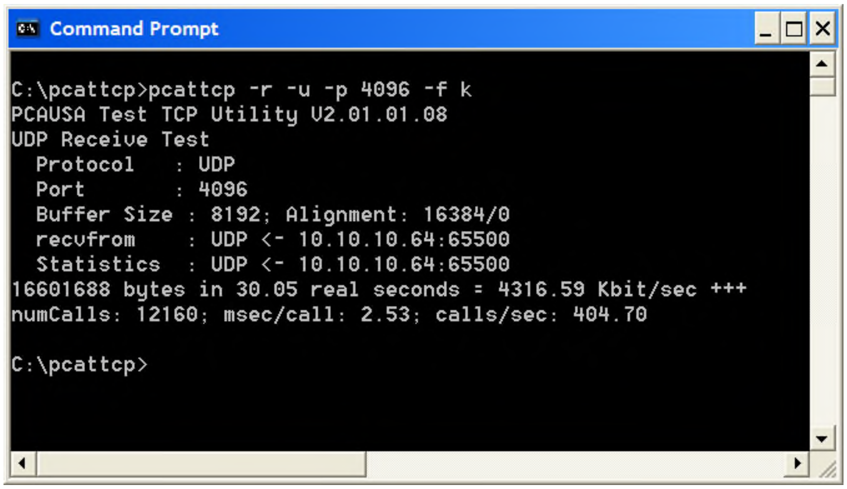
```
ttcp-t: Client socket 9 closed
ttcp-t: 16777216 bytes in 30.06 real seconds = 4361.07 Kbit/sec +++
ttcp-t: 12288 I/O calls, msec/call = 2.45, calls/sec = 408.85
```

As you can see all the default parameters are used:

- Sinkmode is enabled by default
- Number of buffers : 2048
- Length of buffers : 1432 (Note: because µC/TCP-IP does not presently support transmission fragmentation, µC/TTCP limits the buffer size to 1432 bytes. See the limitations section for the explanation of this buffer size choice.)
- UDP port : 5001 (Note: public domain TTCP uses default port 5001. If a firewall blocks this port, please choose another).

Windows host TTCP session

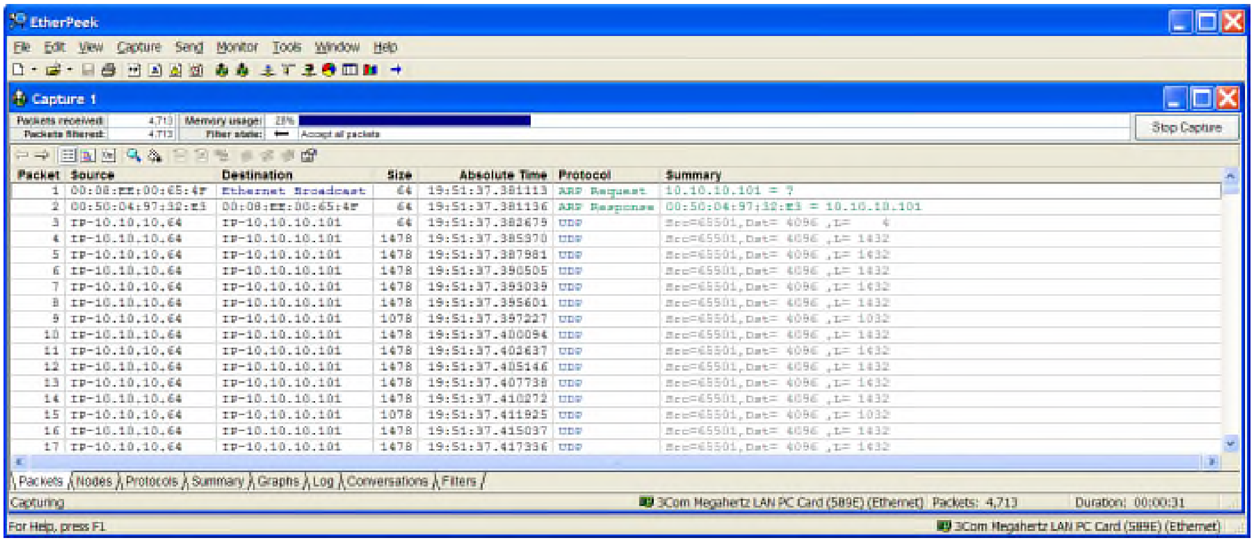
The Windows host running pcattcp must initiate the UDP Receiver part of this test. Figure 4-5 shows the command used:



F4-5

Windows host packet capture

Using Etherpeek, here is a screen shot of the UDP Transmit test:



F4-6

4.05 UDP Receive Test

Target

To start the TTCP UDP Receive Test start µC/TTCP with the "-r" option followed by the "-u " option and the “-l” option (see note below).

```
>-r -u -l 1432
```

The UDP receiver will start and then wait until a remote TTCP client makes a connection attempt. Here is an example of the output you would see:

```
ttcp-r: BufLen=1432, NumBuf=2048, port=5001  udp
ttcp-r: UDP socket 9 opened
ttcp-r: Waiting for client to send UDP datagrams.
ttcp-r: Client socket 9 closed
ttcp-r: 1241544 bytes in 2.47 real seconds = 3928.54 Kbit/sec +++
ttcp-r: 867 I/O calls, msec/call = 2.85, calls/sec = 351.15

uC/TCP-IP Performance measurements
Type the TTCP parameters, parameter values and press Enter
>
```

These messages are generated as the test starts up:

```
ttcp-r: BufLen=1432, NumBuf=2048, port=5001  udp
ttcp-r: UDP socket 9 opened
ttcp-r: Waiting for client to send UDP datagrams.
```

These messages indicate that a UDP connection has received the last signaling packet (less than 4 bytes) from the remote host:

```
ttcp-r: Client socket 9 closed
```

When the test exits it displays the test results:

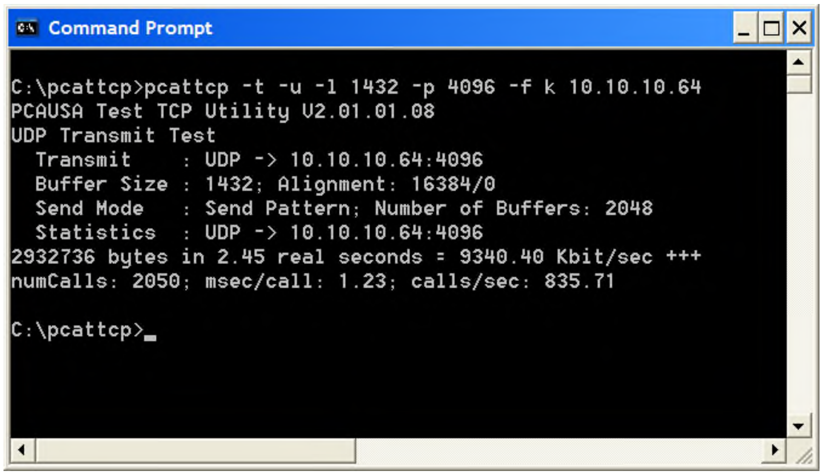
```
ttcp-r: 1241544 bytes in 2.47 real seconds = 3928.54 Kbit/sec +++
ttcp-r: 867 I/O calls, msec/call = 2.85, calls/sec = 351.15
```

As you can see all the default parameters are used:

- Sinkmode is enabled by default
- Number of buffers : 2048
- Length of buffers : 1432 (Note: The transmission buffer size is fixed as the maximum UDP datagram to allow time for target to retrieve a maximum of data because of the absence of flow control in UDP. See the limitations section for the explanation of this buffer size choice.)
- UDP port : 5001 (Note: public domain TTCP uses default port 5001. If a firewall blocks this port, please choose another.)

Windows host TTCP session

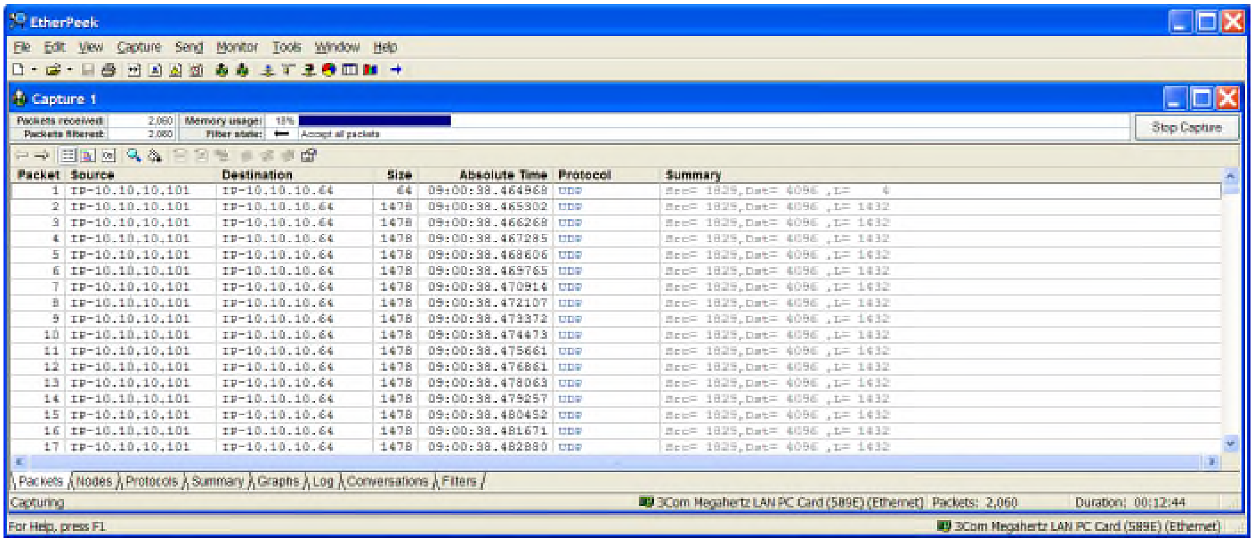
The Windows host running pcattcp must initiate the UDP Transmitter part of this test. Figure 4-7 shows the command used:



F4-7

Windows host packet capture

Using Etherpeek, here is a screen shot of the UDP Receive test:



5.00 µC/TTCP

The TTCP code is found in the following directory and will be briefly described:

\Micrium\Software\uC-TTCP\Source

The files are:

```
ttcp.c
ttcp.h
```

5.01 TTCP Code, ttcp.c

This file contains the TTCP code. `ttcp.c` is written to exercise the capabilities of the TTCP testing application. The code begins by initializing µC/OS-II, µC/TCP-IP and the serial port used for user interface. It also creates a few tasks and other kernel objects that will inform you about the state of the system.

5.02 TTCP startup code : main()

Listing 5-1, main()

```
int  main (void)
{
#if (OS_TASK_NAME_SIZE >= 16)
    CPU_INT08U  err;
#endif


    BSP_Init();                         /* Initialize BSP.      (1)                        */

    APP_TRACE_DEBUG("Initialize OS...\n");
    OSInit();                           /* Initialize OS.                                  */

                                        /* Create start task.                              */
    OSTaskCreateExt( AppTaskStart,
                    (void *)0,
                    (OS_STK *)&AppStartTaskStk[APP_START_OS_CFG_TASK_STK_SIZE - 1],
                     APP_START_OS_CFG_TASK_PRIO,
                     APP_START_OS_CFG_TASK_PRIO,
                    (OS_STK *)&AppStartTaskStk[0],
                     APP_START_OS_CFG_TASK_STK_SIZE,
                    (void *)0,
                     OS_TASK_OPT_STK_CHK | OS_TASK_OPT_STK_CLR);

                                        /* Give a name to tasks.                           */
#if (OS_TASK_NAME_SIZE >= 16)
    OSTaskNameSet(OS_TASK_IDLE_PRIO,   "Idle task",  &err);
    OSTaskNameSet(OS_TASK_STAT_PRIO,   "Stat task",  &err);
    OSTaskNameSet(APP_START_OS_CFG_TASK_PRIO, "Start task", &err);
#endif

    APP_TRACE_DEBUG("Start OS...\n");
    OSStart();                          /* Start OS.                                       */
}
```

L5-1(1) Initialize the on-board I/Os: Interrupts, Timers, LEDs, and the serial port used for the command line interface.

5.03 TTCP startup code : AppStartTask()

Note that some lines of the listings have been removed to help you focus on the µC/TTCP usage.

Listing 5-2, AppStartTask

```
static  void  AppTaskStart (void  *p_arg)
{
    (void)p_arg;                        /* Prevent compiler warning.                                */


    APP_TRACE_DEBUG("Initialize interrupt controller...\n");
    BSP_InitIntCtrl();                  /* Initialize interrupt controller.                         */

    APP_TRACE_DEBUG("Initialize OS timer...\n");
    Tmr_Init();                         /* Initialize OS timer.                                     */

    APP_TRACE_DEBUG("Initialize OS statistic task...\n");
    OSStatInit();                       /* Initialize OS statistic task.        (1)                 */

    AppInit_TCPIP();                    /* Initialize TCP/IP stack.             (2)                 */

    AppInit_DHCPc();                    /* Initialize DHCP client (if present). (3)                 */

    APP_TRACE_DEBUG("Create application task...\n");
    AppTaskCreate();                    /* Create application task.             (4)                 */

    APP_TRACE_DEBUG("\n*******************************************************************");
    APP_TRACE_DEBUG("\n*                                                    (5)      *");
    APP_TRACE_DEBUG("\n*         Micrium uC/TCP-IP TTCP Performance measurement      *");
    APP_TRACE_DEBUG("\n*                AT91RM9200 on Cogent CSB337 SDK               *");
    APP_TRACE_DEBUG("\n*                                                             *");
    APP_TRACE_DEBUG("\n*******************************************************************");
    APP_TRACE_DEBUG("\n");
    TTCP_Init();                        /* Initialize TTCP application                              */

    LED_Off(1);                                                                 (6)
    LED_Off(2);
    LED_Off(3);

    while (DEF_YES) {                   /* Task body, always written as an infinite loop.           */
        OSTimeDlyHMSM(0, 0, 0, 100);
    }
}
```

L5-2(1) Start the uC/OS-II task responsible to collect OS statistics in case we want to analyse the performance of the application with a Kernel Awareness module or uC/OS-View.

L5-2(2) Initialization of the µC/TCP-IP stack.

L5-2(3) Configuration of the TCP/IP stack using DHCP service. The application could also be modified to use static values.

L5-2(4) The task #1 toggles LED #3 on the CSB337 board. This activity can tell you that the application is running (i.e. the OS is doing its job).

L5-2(5) Output the TTCP application banner with the first command line prompt. The application is ready to take user commands.

L5-2(6) Clear all LED so that their state is known at the beginning of the idle task loop.

6.00 µC/TTCP module limitations

Designed for embedded systems in mind, µC/TCP-IP works with the usually resource constrained platforms available. At this stage, µC/TCP-IP does not support some functionality. For example, µC/TCP-IP now only supports a single Network Interface.

µC/TTCP must work with these limitations, mainly for UDP, with the absence of IP transmit fragmentation and the performance of the target versus a PC.

6.01 IP transmit fragmentation

The absence of IP transmit fragmentation has an impact on the UDP transmit test. Because µC/TCP-IP can not fragment a packet on transmission the maximum size of UDP datagram is then limited by the maximum size of the Network Interface frame size.

The Maximum UDP datagram is based on the IP packet size to which the UDP header size is removed (8 bytes). The IP packet size is the minimum between the configured Maximum Transmission Unit and the Large buffer size.
In our tests, we have set the MTU to 1500 which is standard for any Ethernet based Network Interface. Our Large Buffer Size was set to 1596 bytes.
From this minimum, we also have to remove the maximum IP header size, which is 60 bytes.

```
NET_IP_MTU      = Minimum(1500, 1596) - IP header size
                = 1500 - 60
                = 1440

NET_UDP_MTU     = IP MTU - UDP header size
                = 1440   - 8
                = 1432
```

Depending on your configuration you may want to modify the uC/TTCP code to accommodate your NET_UDP_MTU.

6.02 Target performance

Again, this is an issue that affects UDP, particularly the UDP receive test. uC/TCP-IP re-assembles fragmented IP packets. This issue here is how fast can the target retrieve fragmented packets to reassemble them.

As a matter of fact, with a buffer size to 8192 bytes, no data is received by µC/TTCP, the PC being able to transmit al lot faster than the target can receive.

We could find a compromise between 8192 and 1432 bytes.
The sample we provided in this user manual (section 4.05) used a buffer size of 1432 bytes. Each UDP datagram transmitted by the PC fills one buffer on our target. No re-assembly is required.

References

µC/OS-II, The Real-Time Kernel, 2nd Edition
Jean J. Labrosse
R&D Technical Books, 2002
ISBN 1-57820-103-9

Embedded Systems Building Blocks
Jean J. Labrosse
R&D Technical Books, 2000
ISBN 0-87930-604-1

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