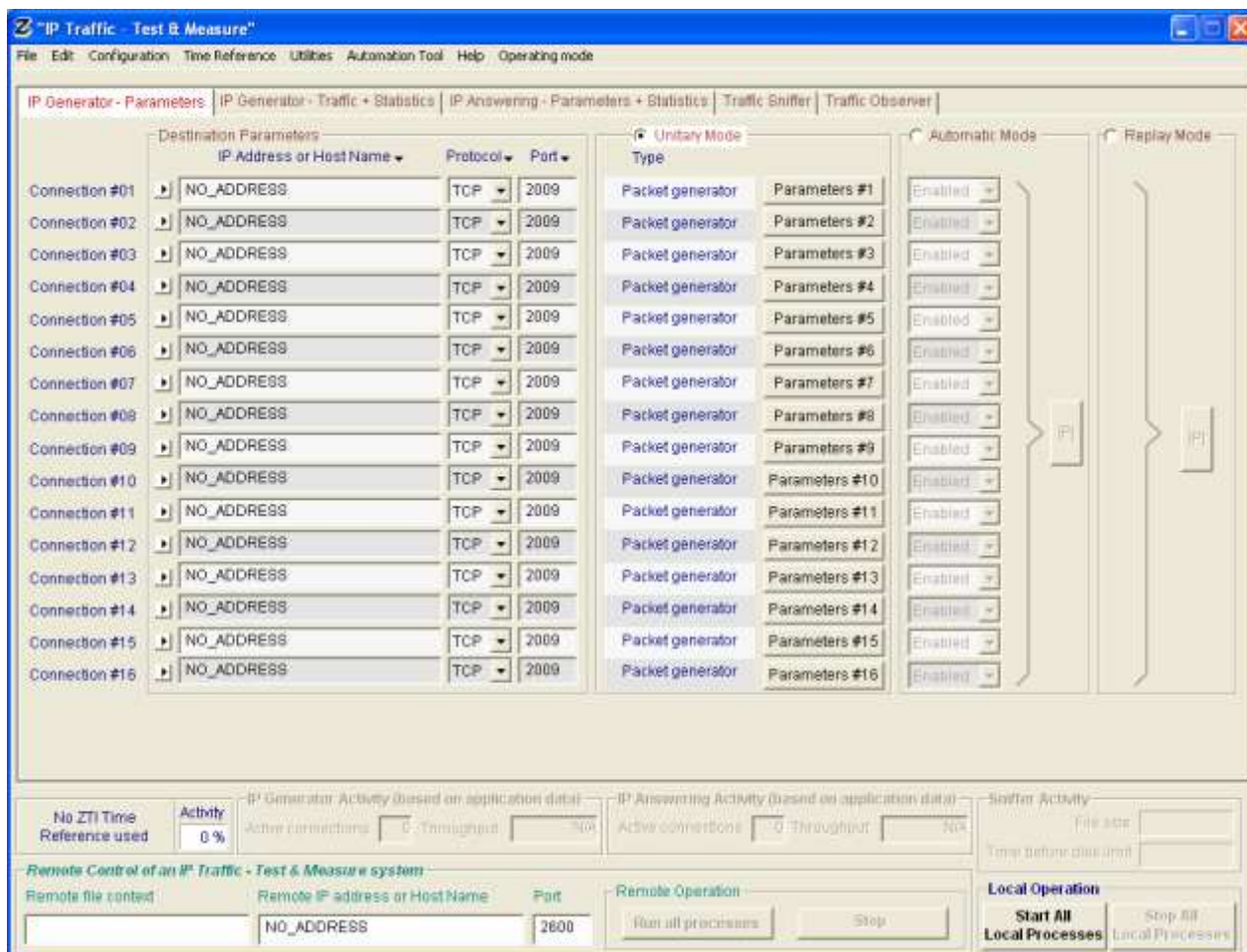


Version 2.5

Traffic Generator and Measurement Tool for IP Networks (IPv4 & IPv6)

*FTTx, LAN, MAN, WAN, WLAN, WWAN, Mobile, Satellite,
PLC, etc...*



Connection #	IP Address or Host Name	Protocol	Port
Connection #01	NO_ADDRESS	TCP	2009
Connection #02	NO_ADDRESS	TCP	2009
Connection #03	NO_ADDRESS	TCP	2009
Connection #04	NO_ADDRESS	TCP	2009
Connection #05	NO_ADDRESS	TCP	2009
Connection #06	NO_ADDRESS	TCP	2009
Connection #07	NO_ADDRESS	TCP	2009
Connection #08	NO_ADDRESS	TCP	2009
Connection #09	NO_ADDRESS	TCP	2009
Connection #10	NO_ADDRESS	TCP	2009
Connection #11	NO_ADDRESS	TCP	2009
Connection #12	NO_ADDRESS	TCP	2009
Connection #13	NO_ADDRESS	TCP	2009
Connection #14	NO_ADDRESS	TCP	2009
Connection #15	NO_ADDRESS	TCP	2009
Connection #16	NO_ADDRESS	TCP	2009

Performance Characteristics on Fast Ethernet and Gigabit networks

Abstract

To measure the performance of traffic generation software, one should consider multiple performance aspects. Major parameters are linked to:

- A- Physical throughput that corresponds to the percentage of the data link usage
- B- Number of packets sent per second
- C- Application throughput.

Item C is the most important for the user because it determines the throughput available for other applications. This document summarizes performance results with **"IP Traffic - Test & Measure"** through the following configurations: a standard Fast Ethernet LAN and a Gigabit Ethernet configuration - copper based interface. Tests were performed at the ZTI Communications Test Lab.

1 Introduction

In this document, you get an overview of performance that can be expected from **"IP Traffic - Test & Measure"** with the same configurations as tested in our lab. Users may achieve better performance than the one presented in this document with a more powerful PC, with other Ethernet architectures or NICs, for example if the TCP stack is embedded into the NIC.

For reference tests, both PC Desktops and Servers were used. The reasons are:

- A Gigabit network needs fast PCs to make tests. We have included tests with Gigabit Ethernet boards. We selected PCs that guarantee efficient CPU, memory and disk subsystem architecture. On these systems, we have installed Windows XP Pro with Service Pack 2 and Windows Seven
- For Fast Ethernet tests, common PC desktops with Pentium IV have been used.

The operating system is one of the most important parameters of the test bed. Windows Seven offers two new stacks (one IPv4 and one IPv6), containing many enhancements and improvements. Tests were performed with the two IP versions.

The Fast Ethernet tests and the Gigabit tests have been carried out with Windows XP Pro Service Pack 2 and Windows Seven. The Ethernet NICs used were made by BroadCom (used for the Fast Ethernet tests) and Intel (used for the Gigabit tests). Please refer to the appendix to get the complete hardware details of all computers used.

The **"IP Traffic - Test & Measure"** version used is 2.5.0. Do not activate any software other than **"IP Traffic - Test & Measure"** and **Automation Tool for "IP Traffic – Test & Measure"** to avoid decreasing the CPU availability. Note that antivirus software and/or Windows Firewall should be shutdown in order to obtain the optimum performance.



***Automation Tool for "IP Traffic – Test & Measure"** is used to run the performance scenarios provided with the software. This allows one to reuse configuration parameters in order to replay the same sequence of tests under different operating systems or different network architecture.*

This document is organized as follows:

- **Throughput Measurements Results**

This section shows the results obtained in our test labs.

- **Description of the three tests benches**

This section describes the architecture of the three tests benches used and the parameters used.

- **Appendix**

This section explains the calculation method used to estimate the link usage rate and provides additional information regarding hardware configurations.

2 Throughput Measurements Results

2.1 Description of the results tables content

Different tables of results provided herein show all throughput measurements realized. These measurements are based on the application level data, i.e. data without the MAC, IP and TCP or UDP headers. Data Throughput Measurements on Fast Ethernet Network (in Mb/s).

2.2 Data Throughput Measurements

These tests use the configuration 1 (Fast Ethernet tests. Refer to § 3.1) and use the configuration 2 (Gigabit tests. Refer to § 3.2)

Number of cnx	Windows XP	Windows Seven
1 UDP	93.3 Mb/s (96.2 %)	95.0 Mb/s (97.9 %)
1 TCP	92.8 Mb/s (96.4 %)	94.8 Mb/s (98.5 %)
16 UDP	95.7 Mb/s (98.7 %)	95.7 Mb/s (98.7 %)
16 TCP	94.9 Mb/s (98.6 %)	94.9 Mb/s (98.6 %)

Table 1 - Fast Ethernet measurements with IPv4

Number of cnx	Windows XP	Windows Seven
1 UDP	90.5 Mb/s (94.6 %)	94.2 Mb/s (98.4 %)
1 TCP	90.5 Mb/s (95.4 %)	93.5 Mb/s (98.5 %)
16 UDP	94.2 Mb/s (98.4 %)	94.2 Mb/s (98.4 %)
16 TCP	93.5 Mb/s (98.5 %)	93.5 Mb/s (98.5 %)

Table 2 - Fast Ethernet measurements with IPv6

Number of cnx	Windows XP	Windows Seven
1 UDP	809.8 Mb/s (83.5 %)	874.9 Mb/s (90.2 %)
1 TCP	806.6 Mb/s (83.8 %)	546.1 Mb/s (56.7 %)
16 UDP	930.2 Mb/s (95.9 %)	945.1 Mb/s (97.4 %)
16 TCP	834.1 Mb/s (86.7 %)	936.0 Mb/s (97.3 %)

Table 3 - Gigabit measurements with IPv4

Number of cnx	Windows XP	Windows Seven
1 UDP	836.0 Mb/s (87.4 %)	774.6 Mb/s (80.9 %)
1 TCP	828.3 Mb/s (87.3 %)	553.5 Mb/s (58.3 %)
16 UDP	926.2 Mb/s (96.8 %)	938.8 Mb/s (98.1 %)
16 TCP	849.0 Mb/s (89.5 %)	928.6 Mb/s (97.8 %)

Table 4 - Gigabit measurements with IPv6

Note: Estimated link usage rate is given in parenthesis. "IP Traffic - Test & Measure" uses the same Operating System on both sides (IP Generator and IP Answering sides). To get more details on the link usage rate estimates please refer to the appendix part.

Fast Ethernet performance is very similar under Windows Seven and Windows XP.

Tables show that the best link usage rate is very close for Windows Seven and Windows XP except for single connection where the Seven performs marginally better.

Multiple TCP connections are more efficient under Window Seven on gigabit networks.

Under Windows XP, the single connections (UDP and TCP) are more efficient. However with multiple connections the best performance is achieved with Windows Seven.

2.3 Packets Throughput Measurements

Table 5 shows the maximum number of UDP packets per second that "IP Traffic - Test & Measure" can send. Such values are useful for VoIP (Voice over IP) tests.

	Windows XP*	Windows Seven*	Windows XP**	Windows Seven**
Fast Ethernet IPv4	43250 packets/s	43494 packets/s	55315 packets/s	55357 packets/s
Fast Ethernet IPv6	42630 packets/s	42440 packets/s		
Gigabit IPv4	73556 packets/s	80567 packets/s	121474 packets/s	142848 packets/s
Gigabit IPv6	72382 packets/s	75236 packets/s		

Table 5 - Packets per second measurement

* These tests use the configuration 1 (Fast Ethernet) and the configuration 2 (Gigabit) (refer to § 3.1 and § 3.2)

** These tests use the configuration 3 (Fast Ethernet and Gigabit) (refer to § 3.3)

In those tests, the performances on Gigabit and Fast Ethernet network are very close on both operating systems.

Hardware component quality is crucial for optimum performance

For all tests the type of bus used by the NIC is the first and most important parameter. That is the main difference between Fast Ethernet and copper gigabit configurations.

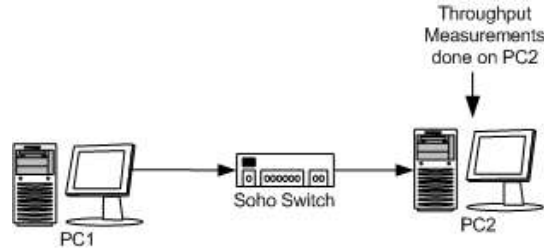
CPU and bus type are critical elements

The number of CPUs and the hyperthreading systems help to handle interruptions generated by packet exchanges. The capacity to handle interruptions limits the number of packets that can be exchanged. This might explain why performance is better on the Gigabit test bed rather than on the Fast Ethernet test bench.

3 Description of the two tests benches

3.1 Configuration 1: Performance Measurements on a Fast Ethernet network

On the Fast Ethernet test bed PC1 sends data to PC2. PC1 and PC2 are linked by a SOHO switch. CAT5 cables are used to link the NICs to the switch ports.



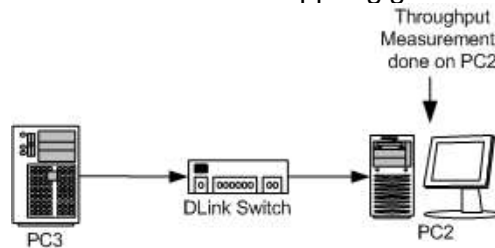
The "IP Traffic - Test & Measure" Unitary Testing Mode is selected and the default values (menu File/new) are kept except for these particular values listed herein:

	TCP Data Size	UDP Data Size
IPv4	1460 bytes	1472 bytes
IPv6	1440 bytes	1452 bytes

These are the maximum data size required to prevent from IP fragmentation which could decrease performance. Packet throughput evaluation uses a default UDP data size of 160 bytes (with a single connection).

3.2 Configuration 2: Performance Measurements on a Copper Gigabit network

On the Gigabit Ethernet test bed, PC3 sends data to PC2. PC2 and PC3 are linked by a DLink Gigabit Switch. Category 6 draft 10 cables are used to link the copper gigabit NICs to the switch ports.



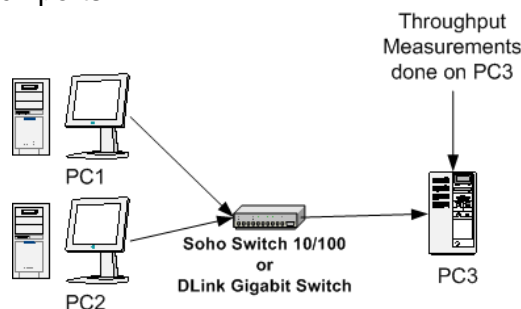
The "IP Traffic - Test & Measure" Unitary Testing Mode is selected and the default values (menu File/new) are kept except for these particular values listed herein:

	TCP Data Size	UDP Data Size
IPv4	1460 bytes	1472 bytes
IPv6	1440 bytes	1452 bytes

The packet throughput evaluation uses a default UDP data size of 160 bytes (with a single connection).

3.3 Configuration 3: Additional Performance Measurements for packet throughput

PC1 and PC2 send data to PC3. On Gigabit network, PC1, PC2 and PC3 are linked by a DLink Gigabit Switch and use Category 6 draft 10 cables to link the copper gigabit NICs. On the Fast Ethernet network, PC1, PC2 and PC3 are linked by a SOHO switch and use CAT5 cables to link the Fast Ethernet NICs to the switch ports.



The packet throughput evaluation uses a default UDP data size of 160 bytes (with a single connection per computer).

4 Appendix

4.1 How the link usage rate is calculated

The previous tables of results give an estimated value of the link usage rate that has been calculated from the throughput measurements which is obtained as follows:

The formulas with IPv4 for the Fast Ethernet tests are:

- For UDP: UDP payload throughput * 1.038
- For TCP: TCP payload throughput * 1.039

The formulas with IPv6 for the Fast Ethernet tests are:

- For UDP: UDP payload throughput * 1.054
- For TCP: TCP payload throughput * 1.046

The formulas with IPv4 for the Gigabit tests are:

- For UDP: UDP payload throughput * 0.1038
- For TCP: TCP payload throughput * 0.1039

The formulas with IPv6 for the Gigabit tests are:

- For UDP: UDP payload throughput * 0.1054
- For TCP: TCP payload throughput * 0.1046

These coefficients are the ratios of each packet, between the transport payload and its size on the Ethernet. This is possible by adding to the TCP or UDP payload size:

- the TCP or UDP header size
- and the IP header size
- and the Ethernet header size.

With IPv4, the coefficient has been calculated as follows:

- TCP coeff. = $(1460+20+20+18)/1460$
= 1518/1460
= 1.039
- UDP coeff. = $(1472+8+20+18)/1472$
= 1518/1472
= 1.031
- Where:
 - UDP header size = 8 bytes
 - TCP header size = 20 bytes
 - IPv4 header size = 20 bytes
 - Ethernet header size = 14 bytes + 4 bytes for CRC, so a total of 18 bytes

With IPv6, the coefficient has been calculated as follows:

- TCP coeff. = $(1440+20+40+18)/1440$
= 1518 / 1440
= 1.054
- UDP coeff. = $(1452+8+40+18) / 1452$
= 1518 / 1452
= 1.045
- Where:
 - UDP header size = 8 bytes
 - TCP header size = 20 bytes
 - IPv6 header size = 40 bytes
 - Ethernet header size = 14 bytes + 4 bytes for CRC, so a total of 18 bytes

For IPv6, the hypothesis is that no IPv6 extension header is located between the IPv6 general header and the TCP or UDP header.

4.2 Hardware of the computers used

PC1

- Manufacturer: DELL OptiPlex GX280
- Operating Systems:
 - o Windows XP Professional Version 2002, Service Pack 2
 - o Windows Seven
- CPU: Intel Pentium 4 - x86 family 15 Model 4 Stepping 1 GenuineIntel~3 Ghz with Hyper threading activated
- RAM: 1 GB
- NIC: Broadcom NetXtree 57xx Gigabit Controller (Embedded): used for Fast Ethernet Tests

PC2

- Manufacturer: DELL OptiPlex GX745
- Operating Systems:
 - o Windows XP Professional Version 2002, Service Pack 2
 - o Windows Seven
- CPU: Intel Dual Core 2 E6600 2.4 Ghz
- RAM: 1 GB
- NIC:
 - o Broadcom NetXtree Gigabit adapter (Embedded) used for the Fast Ethernet tests.
 - o Intel Pro/1000 PT Server Adapter (PCI Express) used for the Gigabit tests.

PC3

- Manufacturer: DELL Power Edged 1900
- Operating Systems:
 - o Windows XP Professional Version 2002, Service Pack 2
 - o Windows Seven
- CPU: 2 Intel Xeon Dual Core 5140
- RAM: 1 GB (667 Mhz)
- NIC: Intel Pro/1000 PT Server Adapter (PCI Express): used for the Gigabit tests

SOHO Fast Ethernet switch

- Ethernet/Fast Ethernet auto-sense
- Full duplex Fast Ethernet capabilities
- 8 ports 10/100 Mbps

DLink Gigabit switch DGS 1004T

- Ethernet/Fast Ethernet/Gigabit Ethernet auto-sense
- Full duplex 10/100/1000 capabilities
- 4 ports 10/100/1000 Mbps