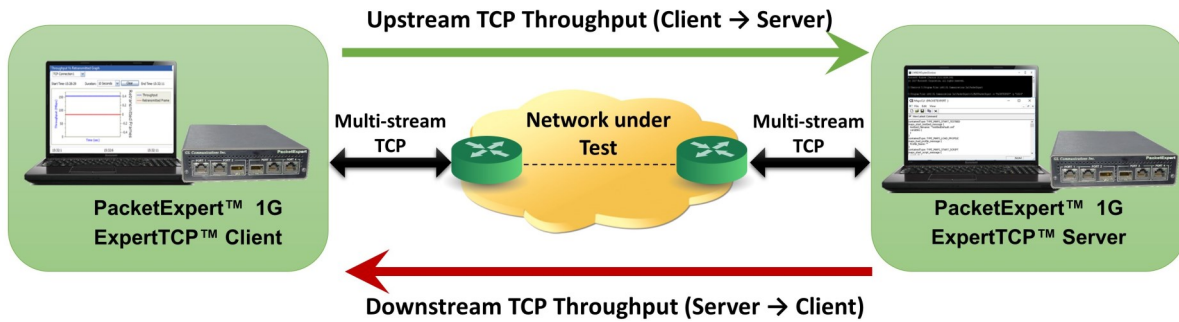


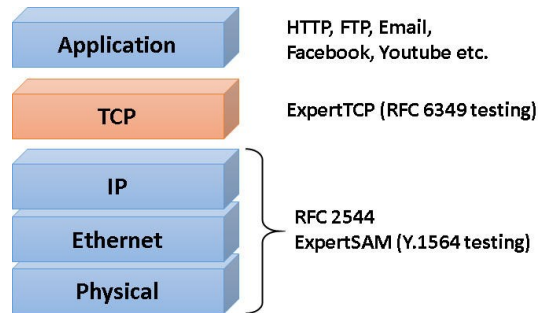
ExpertTCP™ - TCP Throughput Testing (RFC 6349)



Overview

IP Network operators and Service providers need to verify that their networks are performing well and meet the Service Level Agreements (SLA) with the customers. To verify Ethernet/IP based networks, current widely used standards are RFC 2544 or Y.1564. However, both these standards are meant for testing at Layer2 or Layer3 (Ethernet or IP layers).

Though these tests are necessary, they are not sufficient, because they do not cover testing at TCP layer. Most web based applications like HTTP, FTP, E-mail etc. run over TCP. Even many modern web applications like Facebook, YouTube, and the like use TCP.



Even if service provider networks are tested using RFC 2544 or Y.1564, customers may still face problems with TCP throughput. The TCP throughput may not match the throughput at the Ethernet/IP layer. This is because TCP throughput depends on factors like the TCP Window Size, buffer size of intermediate network nodes etc. Also, impairments like latency and packet drops causes TCP retransmissions, severely affecting the TCP throughput. So, there is a gap in the current testing methods and to cover the gap, RFC 6349 frame work has been devised.

GL's PacketExpert™ 1G and PacketExpert™ 10G platforms have been enhanced to support RFC 6349 based TCP Throughput test methodology referred to as ExpertTCP™ for both 10Gbps and 1Gbps networks.

ExpertTCP™ testing is performed using the **RFC 6349** standard to measure TCP throughput, RTT and optimal window size. To conduct this test, users need two PacketExpert™ devices — one as the client and the other as the server. The ExpertTCP™ test covers both upload (Client to Server) and download (Server to Client), measuring TCP throughput and efficiency.

The application has capability to generate and analyze up to 12 UDP streams of traffic of various packet lengths. It also performs bi-directional TCP throughput measurements in combination with another unit at the remote location (other end of the network), that acts as the TCP server, as depicted in the figure above. Many real-world networks are not symmetrical. There may be significant differences between upstream and downstream directions.

Simultaneous bi-directional testing/unidirectional testing can be performed. Results are reported for both directions. The server at the remote location is completely controlled by the client side (located locally). User configures both client and server locally, and the results are displayed locally, avoiding the hassles of configuring the test at multiple locations.

For more information, refer to [ExpertTCP™ 1G/10G](#) webpage.



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Features

- Supports Path MTU, Baseline RTT and TCP Throughput tests
- Hardware FPGA based TCP implementation supports full duplex bidirectional wirespeed TCP (up to 1 Gbps in both directions simultaneously)
- Supports multiple TCP connections (up to 16 TCP connections)
- Upstream (Local to Remote), Downstream (Remote to Local) and Bi-directional tests supported
- Test asymmetrical path with separate set of configurations for Upstream and Downstream
- Complete remote control - user needs to interact only with Local side - all results/statistics (both local and remote side) provided on local side
- Detailed run time statistics with Graphs for easy visualizations
- RFC 6349 specified metrics - TCP Efficiency, Buffer Delay Percentage, TCP Transfer Time ratio
- Command Line Interface for automated testing and remote accessibility using API clients C#, Python and MAPS™ Client Server architecture

Functional Procedures

ExpertTCP™ (RFC 6349) specifies the TCP Throughput test to be conducted in 3 steps:

- Path MTU Discovery
- Determine Baseline RTT
- Conduct TCP Throughput test

ExpertTCP™ supports all 3 tests in a seamless one touch way. User can configure the parameters and simply start the test. ExpertTCP™ will run through all the three tests and report the results. It also includes an option to configure the Upstream and Downstream test direction.

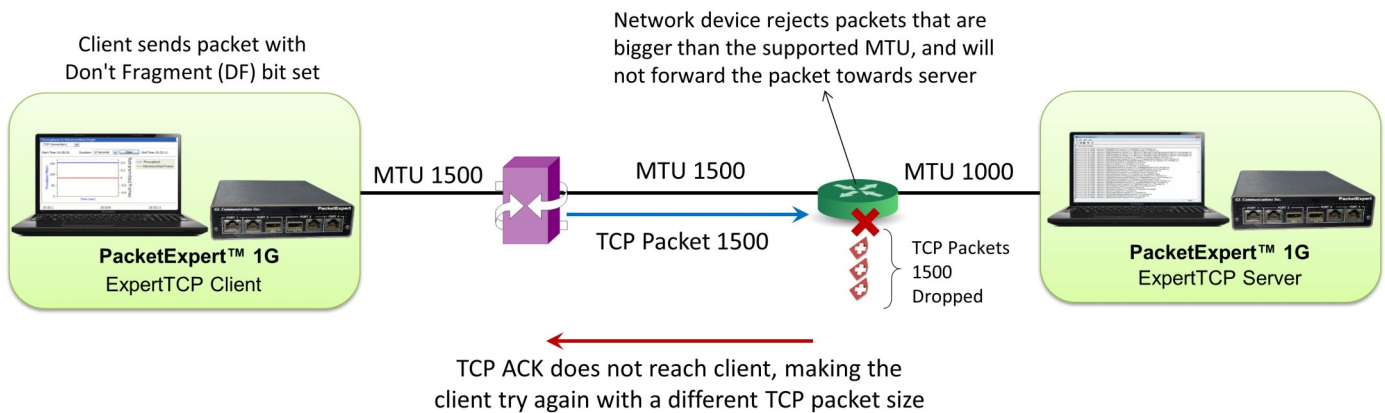
The screenshot shows a 'Test Setup' window with the following configuration:

- Direction:** Three radio buttons are present: 'Upstream' (selected with a green arrow pointing up), 'Downstream' (with a green arrow pointing down), and 'Upstream and Downstream' (with two green arrows pointing in opposite directions).
- Transfer Size:** A text box contains '100.000' and a dropdown menu is set to 'MBytes'.
- Test Selection:** Three checkboxes are all checked:
 - 'Run Throughput Test'
 - 'Run Path MTU Test': Below this, 'Upstream MTU' is set to '1500' Bytes and 'Downstream MTU' is set to '1500' Bytes.
 - 'Run Baseline RTT Test': Below this, 'Upstream RTT' is set to '250.049' msec and 'Downstream RTT' is set to '250.030' msec.

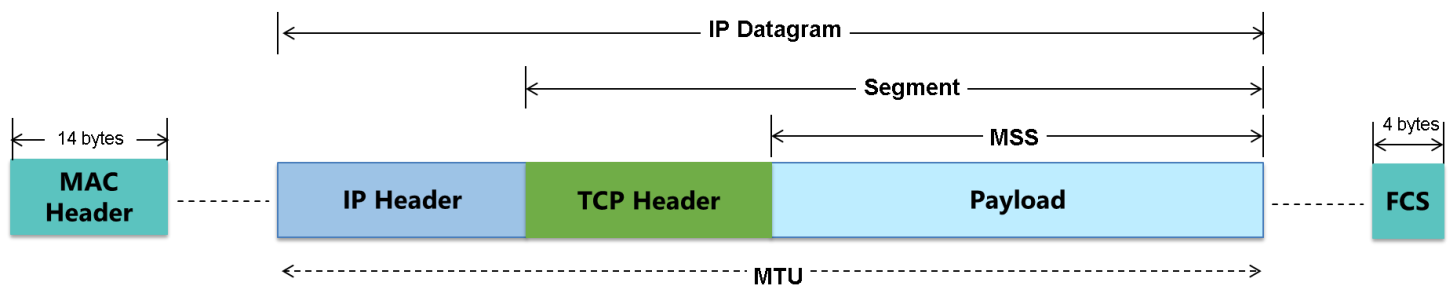
Figure: Test Selection and Status

Path MTU Discovery

As per RFC 6349, the first step is to discover the Path Maximum Transmission Unit (MTU). This is because the TCP Throughput test has to be conducted at the Path MTU, else the TCP segments can fragment, adversely affecting the test results.

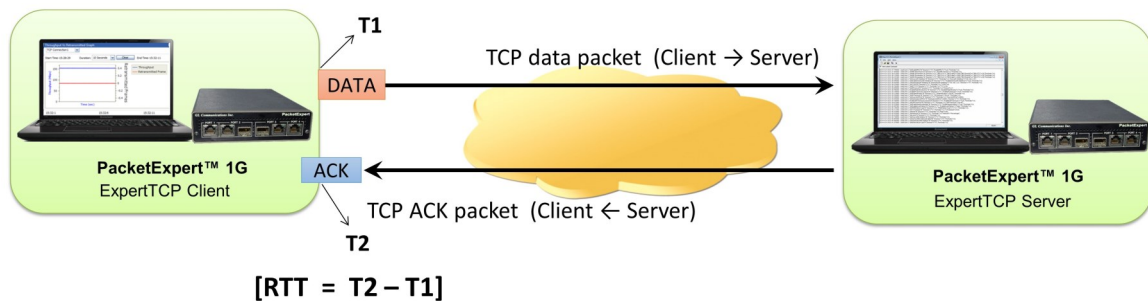


ExpertTCP™ discovers the Path MTU for both directions (Upstream/Downstream) separately. It follows a method similar to the one specified in the RFC 4821 (Packetization Layer Path MTU Discovery) standard, but uses TCP instead of ICMP. Path MTU determines the Maximum Segment Size (MSS) that TCP can use during the test.



Determine Baseline RTT

This step establishes the inherent, non-congested Round-Trip Time (RTT) of the end-to-end network path. TCP RTT is the time taken for a TCP data packet to reach the other end, and for the corresponding ACK packet to reach the sender.



The RTT is an important metric in TCP, as the path RTT determines how much data can be sent out on the wire before an ACK can be received. This measurement is used to provide estimates of the TCP Receiver Window (TCP RWND) that should be used during subsequent Throughput test.

ExpertTCP™ performs Baseline RTT test separately for each direction and automatically calculates the optimum TCP RWND size based on the results. The Bandwidth Delay Product (BDP) and the RWND are displayed for user reference.

Test Parameter Summary		
Upstream		
Downstream		
Baseline RTT	50.015	msec
Calculated BDP	625.190	KBytes
TCP Window	65535	Bytes
Path MTU	1500	Bytes
MSS Used	1448	Bytes
No of TCP Connection	1	
Transfer Size	100.000	MBytes

Figure: Upstream Downstream Test Parameter Summary

Conduct TCP Throughput Test

In this step, single/multiple TCP connection Throughput tests are conducted and the TCP Throughput is determined. The TCP RWND (Receiver Window) used during this step, is calculated from the Baseline RTT value measured during the previous Baseline RTT test. For multiple TCP connections, the calculated RWND is distributed among the connections. Up to 8 TCP connections are supported on 1G platform, whereas up to 16 TCP connections are supported on 10G platform.

TCP Setup

No of TCP Connection: ▼

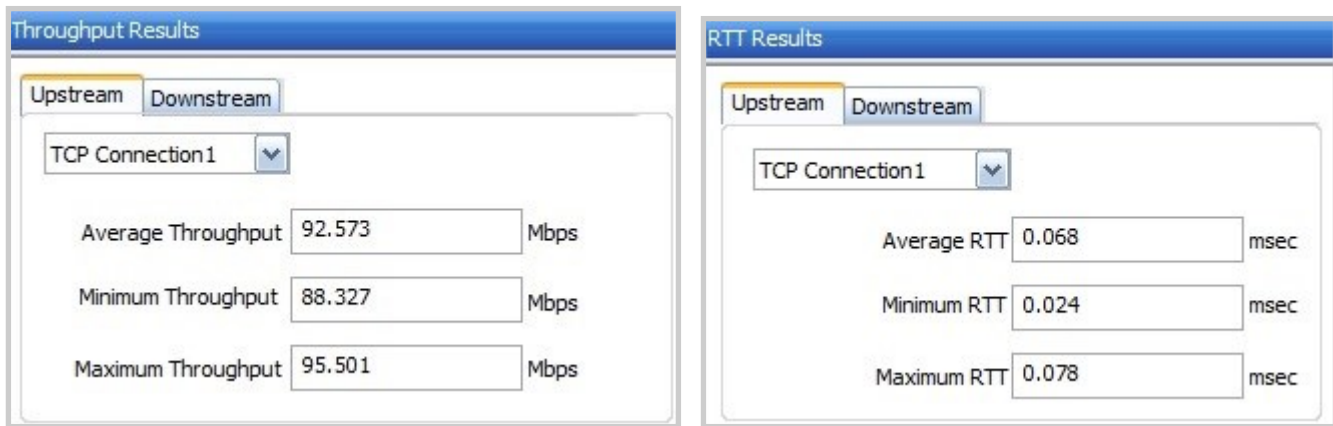
TCP Port Configuration: ☒ Automatic ☐ Manual

TCP Connection...	Client Port	Server Port
1	5000	6000
2	5001	6001
3	5002	6002
4	5003	6003
5	5004	6004
6	5005	6005
7	5006	6006
8	5007	6007

Figure: Conduct TCP Throughput Test

Statistics and Results

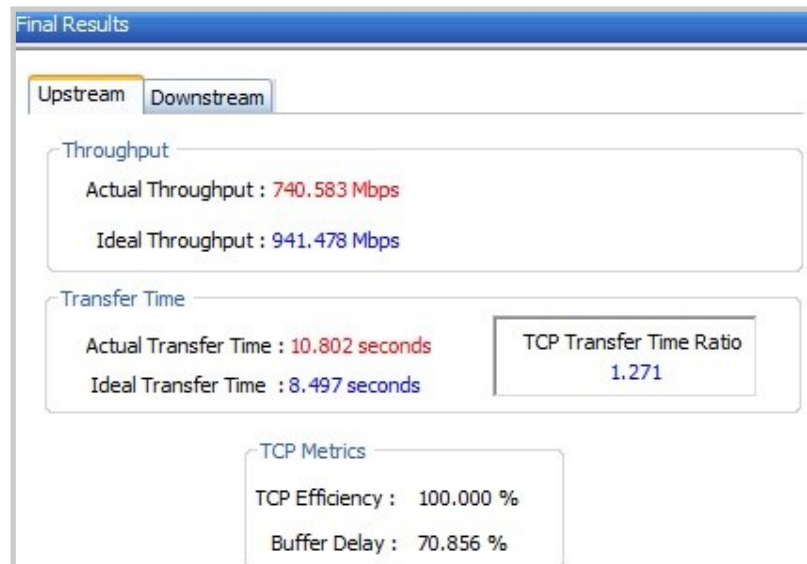
Various statistics at runtime such as minimum, maximum and average Throughput, and RTT measurements per connection provide detail insight into the performance.



The statistics information on number of frames and bytes Transmitted, and Retransmitted per connection, gives a snapshot of the performance.

Statistics	
Upstream Downstream	
TCP Connection 1	
Statistics	Values
Time(secs)	11
Tx Frames	86 687
Tx Bytes	125 000 300
Retransmitted Frames	0
Retransmitted Bytes	0
Retransmitted Frames %	0.00

The final Results include the comparison of the actual Throughput/Transfer time with the ideal values. The three RFC 6349 TCP metrics defined in the specification - Transfer Time Ratio, TCP Efficiency and Buffer Delay are reported here.



Statistics and Results (Contd.)

The following overall test statistics are displayed -

- Path MTU (Upstream, Downstream)
- Baseline RTT (Upstream, Downstream)
- Throughput (Upstream, Downstream)
- TCP status
 - Connecting
 - Unreachable IP
 - Destination Port busy
 - Connected
 - Connection close

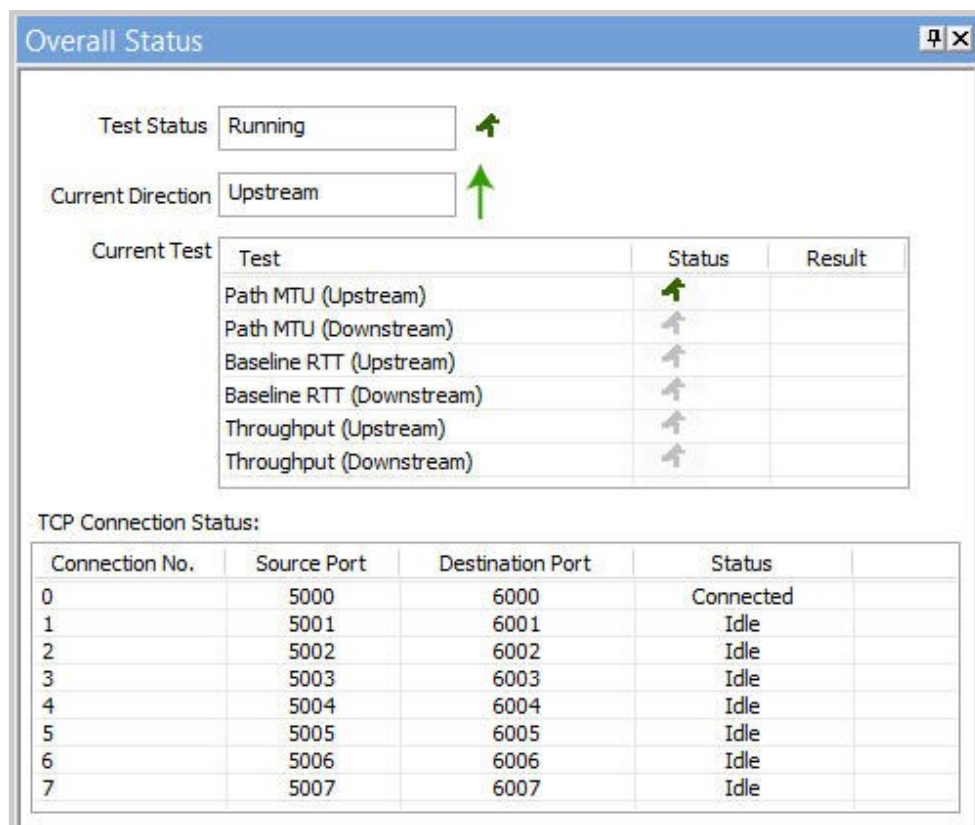


Figure: Upstream, Downstream Results

Command Line Interface (CLI)

PacketExpert™ is enhanced to support Command Line Interface (CLI) requires additional license (CXE100) to access all the functionalities remotely using C#, Python clients and MAPS™ CLI Server/Client architecture.

The CLI supports all the PacketExpert™ test modules including - All Port Bert, Bert Loopback, All Port Loopback, RFC 2544, Record Playback, ExpertSAM™, PacketBroker, Multi Stream Traffic Generator and Analyzer.

Graphs

Various graphs are available for visualizations. Throughput graph plots the Throughput over time. All connections are plotted in a single graph for a comprehensive view of the overall performance.

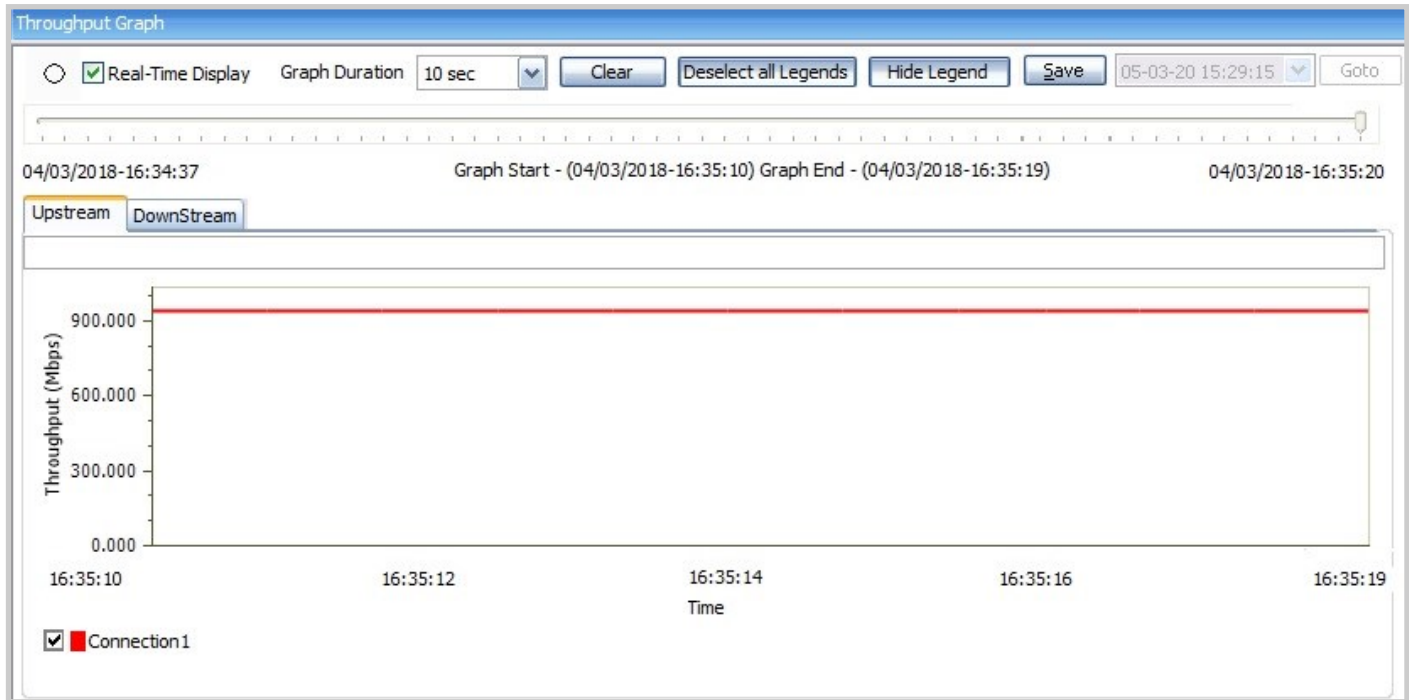


Figure: Throughput Graph

Throughput vs. Retransmissions graph provides insight into how Retransmissions are affecting the Throughput.

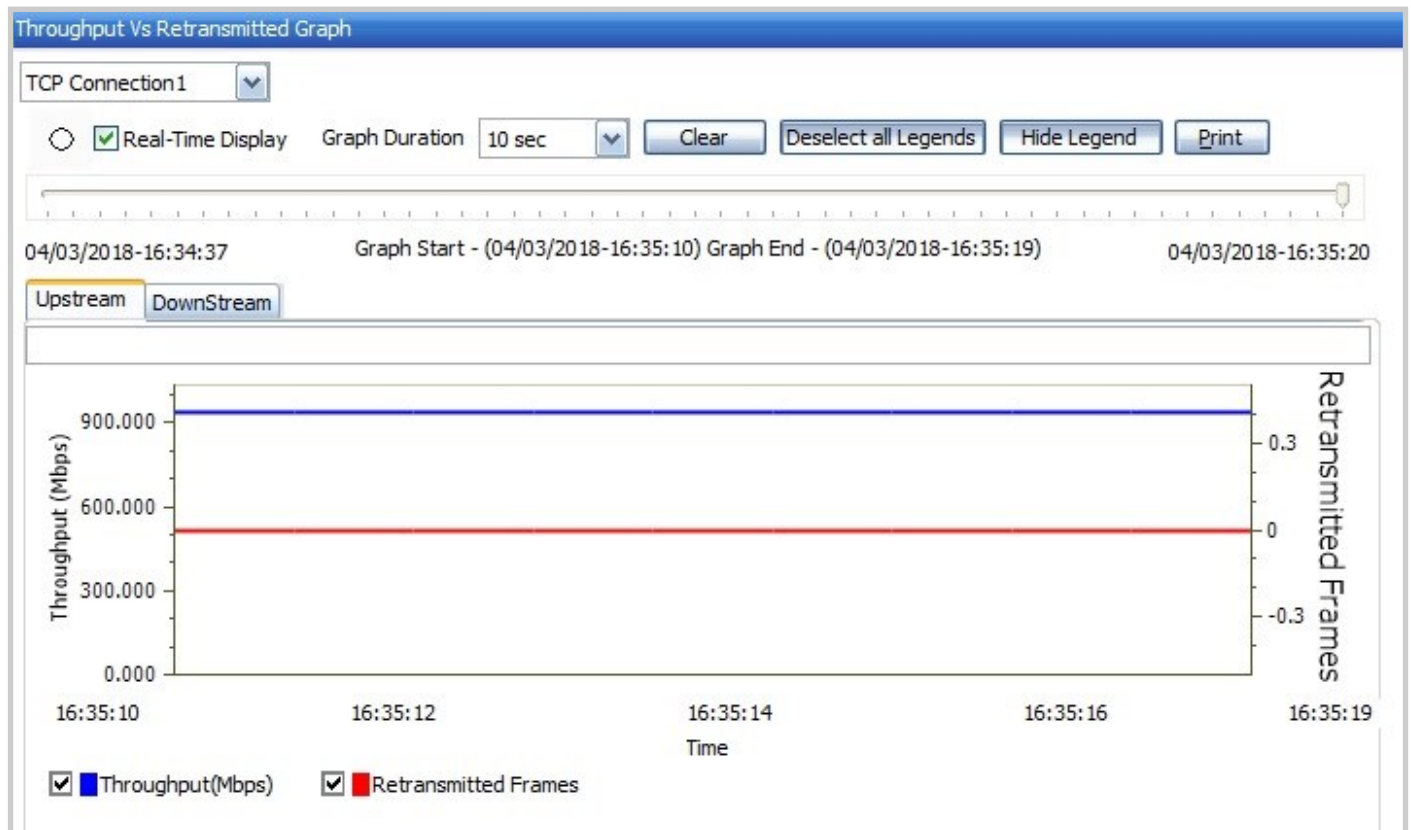


Figure: Throughput vs. Retransmitted Graph

Graphs (Contd.)

The Throughput vs. RTT graph visualizes how the RTT variation affects the TCP Throughput.

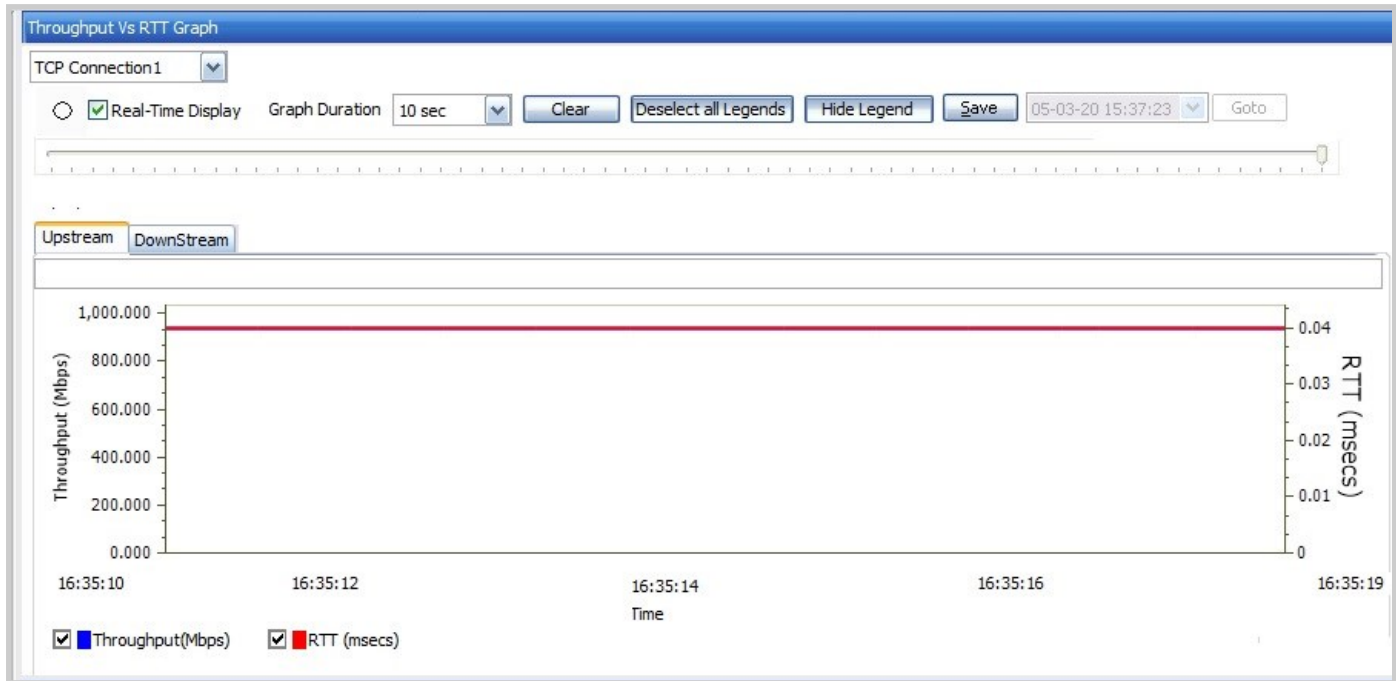
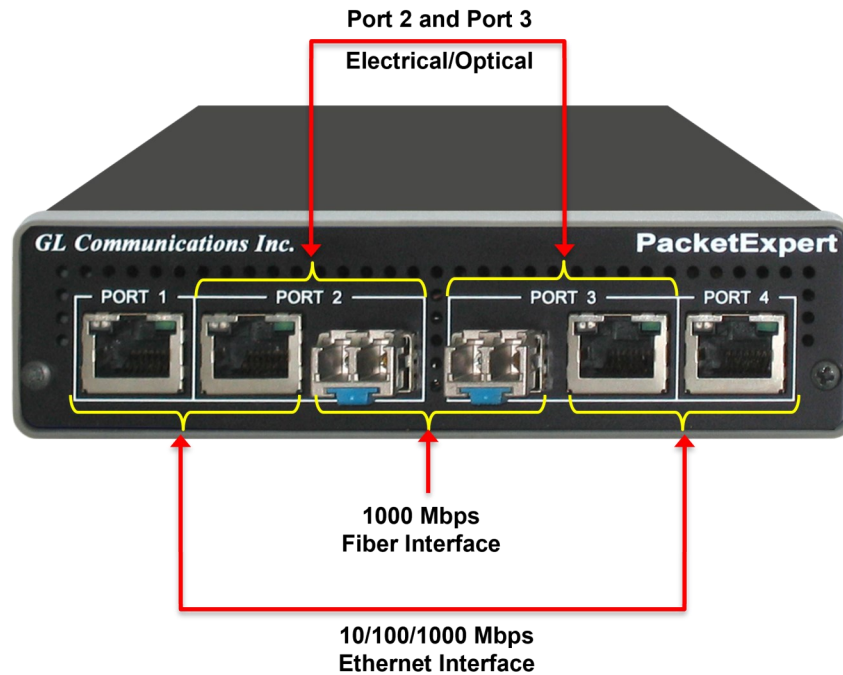


Figure: Throughput vs. RTT Graph

Portable PacketExpert™ 1G Specifications



Interfaces	<ul style="list-style-type: none"> • 2 x 10 / 100 / 1000 Base-T Electrical only • 2 x 1000 Base-X Optical OR 10/100/1000 Base-T Electrical • Single Mode or Multi Mode Fiber SFP support with LC connector
Protocols	<ul style="list-style-type: none"> • RFC 2544 compliance
Bus Interface	<ul style="list-style-type: none"> • USB 2.0 or USB 3.0
Power	<ul style="list-style-type: none"> • +12 Volts (Medical Grade), 3 Amps
Temperature	<ul style="list-style-type: none"> • Operating Temperature: +5 to +40C • Non-Operating Temperature: -30 to +60C
Humidity	<ul style="list-style-type: none"> • Operating Humidity: 0% to 80% RH • Non-Operating Humidity: 0% to 95% RH
Altitude	<ul style="list-style-type: none"> • Operating Altitude: Up to 10,000 feet • Non-Operating Altitude: Up to 50,000 feet
Physical Specification	<ul style="list-style-type: none"> • Length: 8.45 in. (214.63 mm) • Width: 5.55 in. (140.97 mm) • Height: 1.60 in (40.64 mm) • Weight: 1.66 lbs. (0.75 kg)

mTOP™ PacketExpert™ 1G Rack Specifications

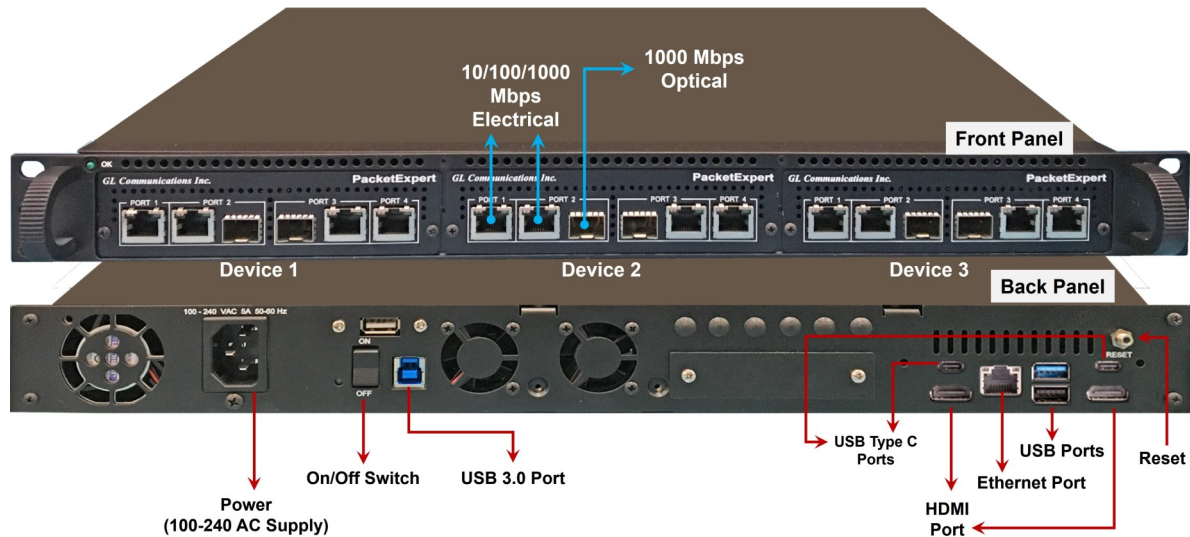


Figure: 1U mTOP™ Rack Based 1G Hardware Unit (3 PXE100s)

Interfaces	<p>12 Total Ethernet Ports (HD-PacketExpert-12)</p> <ul style="list-style-type: none"> mTOP™ System (embedded SBC, 3x PXE100) PacketExpert™ 1G (PXE100) interfaces - <ul style="list-style-type: none"> 6x 1000 Base-X Optical OR 10/100/1000 Base-T Electrical 6x (10/100/1000) Base-T Electrical <p>24 Total Ethernet Ports (HD-PacketExpert-24)</p> <ul style="list-style-type: none"> mTOP™ System (embedded SBC, 6x PXE100) PacketExpert™ 1G (PXE100) interfaces - <ul style="list-style-type: none"> 12x 1000 Base-X Optical OR 10/100/1000 Base-T Electrical
SBC Specifications	<ul style="list-style-type: none"> Intel Core i3 or optional i7 NUC Equivalent, Windows® 11 64-bit Pro Operating System USB 3.0 and USB 2.0 Ports, ATX Power Supply USB Type C Ports, Ethernet 2.5GigE port 256 GB Hard drive, 8G Memory (Min) Two HDMI ports
External Dimension	<ul style="list-style-type: none"> Length: 16 Inches Width: 19 Inches Height: 2x 1U mTOP™ (HD-PacketExpert-24) or 1U mTOP™ (HD-PacketExpert-12)
Power Supply	<ul style="list-style-type: none"> ATX Power Supply
Order Information	<ul style="list-style-type: none"> PXE100 - PacketExpert™ Options MT001/MT001E (1U) MT001+MT002/ MT001E+MT002 (Stacked 1U)

mTOP™ 1G Probe Specifications



Figure: mTOP™ Probe with 1G Hardware Unit + SBC

Interfaces	<ul style="list-style-type: none"> • 4x Total Ethernet ports • 2x 10/100/1000 Base-T Electrical only • 2x 1000 Base-X Optical OR 10/100/1000 Base-T Electrical • Single Mode or Multi Mode Fiber SFP support with LC connector
SBC Specifications	<ul style="list-style-type: none"> • Intel Core i3 or optional i7 NUC Equivalent, • Windows® 11 64-bit Pro Operating System • USB 3.0 and USB 2.0 Ports, 12V/3A Power Supply • USB Type C Ports, Ethernet 2.5GigE port • 256 GB Hard drive, 8G Memory (Min) • Two HDMI ports
External Dimension	<ul style="list-style-type: none"> • Length: 10.4 inches • Height: 3 inches • Width: 8.4 inches
Power Supply	<ul style="list-style-type: none"> • 12 volts (Medical Grade), 3 Amps
Order Information	<ul style="list-style-type: none"> • PXE100 • MT005/MT005E

Pelican Carry On Case

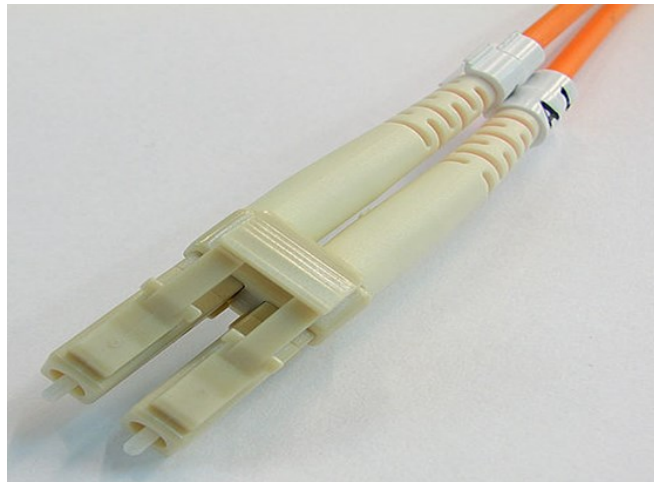


Supported SFP Modules

PacketExpert™ supports LC connectors and 850/1310 nm SFP (Small Form-Factor Pluggable) modules. For users with different connector types, appropriate adapters such as LC-to-SC, LC-to-FC, or their reverse equivalents are required.

The following SFP modules are supported in 1G:

- **1000BaseLX** - Long range, MM and SM
- **1000BaseSX** - Short range, MM and SM
- **1000BaseT** - Copper and many more



LC Connectors



850/1310 nm SFP Module

Buyer's Guide

Item No	Product Description
PXE108	ExpertTCP™ 1G
CXE100	CLI support for PXE100

Item No	Related Software
PXE105	Wire speed Record/Playback 1G
PXE107	PacketBroker 1G
PXE108	Multi Stream Traffic Generator and Analyzer 1G
ETH100	PacketCheck™
PKV100	PacketScan™ (Online and Offline)

Item No	Related Hardware
PXE100	PacketExpert™ 1G Portable
PXE104	PacketExpert™ - SA (4 ports) 1G
PXE112	PacketExpert™ -SA (12 Ports) 1G
PXE124	PacketExpert™ -SA (24 Ports) 1G
PKV100	PacketScan™ (Online and Offline)

Note: PCs which include GL hardware/software require Intel or AMD processors for compliance.

For more information, refer to [ExpertTCP™ 1G/10G](#) webpage.



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