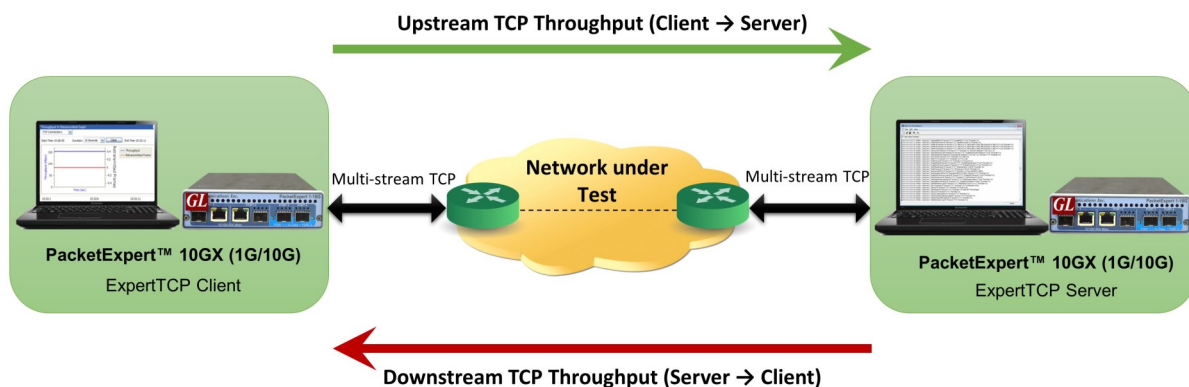


# ExpertTCP™ - TCP Throughput Testing (RFC 6349)

## PacketExpert™ 10GX



## Overview

GL's ExpertTCP™ is an optional application with [PacketExpert™ 10GX](#) platform. The application performs RFC 6349 based TCP Throughput testing on both 10Gbps and 1Gbps networks (**maximum TCP traffic generation rate is limited to 1 Gbps only**). Many real-world networks are not symmetrical. There may be significant differences between upstream and downstream directions.

ExpertTCP™ testing is performed using the RFC 6349 standard. 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 server at the remote location is completely controlled by the client side (located locally).

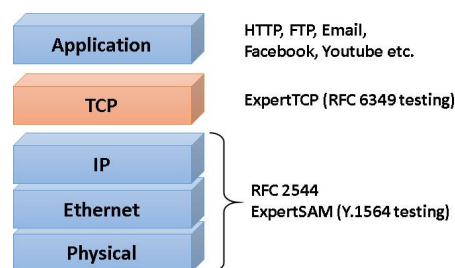
Simultaneous bi-directional testing/unidirectional testing can be performed. Results are reported for both directions. User configures both client and server locally, and the results are displayed locally, avoiding the hassles of configuring the test at multiple locations.

PacketExpert™ 10GX (PXN100) has two 10/1 Gbps Optical ports, and two 1000 Mbps Electrical/Optical ports. The 10 Gbps Optical ports can be down-shifted to 1Gbps using Electrical to SFP transceivers, thus offering all 4 Electrical/Optical 1G ports for testing. The same two 10 Gbps ports can now be converted to 2.5 Gbps ports with appropriate SFP. It requires additional **PXN101** license installation to run the tests on 10G ports and 2.5G Ports. PacketExpert™ 10GX is available in portable as well as mTOP™ rack mount platforms. Each GigE port provides independent Ethernet/IP testing at wire speed for applications such as BERT, RFC 2544, SmartLoopback, Record Playback, PacketBroker, ExpertSAM™ and Multi-stream Traffic Generator and Analyzer and ExpertTCP™.

The current widely used standards for verifying Ethernet/IP based networks for SLA parameters are RFC 2544 or Y.1564. 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. Many modern web applications such as Facebook, YouTube, and others use TCP.

Even if service provider networks are tested using RFC 2544 or Y.1564, customers may still face problems as 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 such as 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.



For more information, please visit [ExpertTCP™ - TCP Throughput Testing \(RFC 6349\)](#) webpage.



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## Features

- Supports Path MTU, Baseline RTT and TCP Throughput tests.
- Support for frame lengths from 64 bytes to Jumbo frames (up to 16000 bytes).
- Supports full duplex multiple TCP connections (up to 16 TCP connections on PXN100 and 8 TCP connections on PXE100).
- Test asymmetrical path with separate set of configurations for Upstream (Local to Remote), and Downstream (Remote to Local).
- Complete remote control - user needs to interact only with Local side - all results/statistics (both local and remote side) provided on local side.
- RFC 6349 specified metrics - TCP Efficiency, Buffer Delay Percentage, TCP Transfer Time ratio.
- With PXN101 licensing, the unit supports testing on 10G and 2.5G optical ports.

## 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.

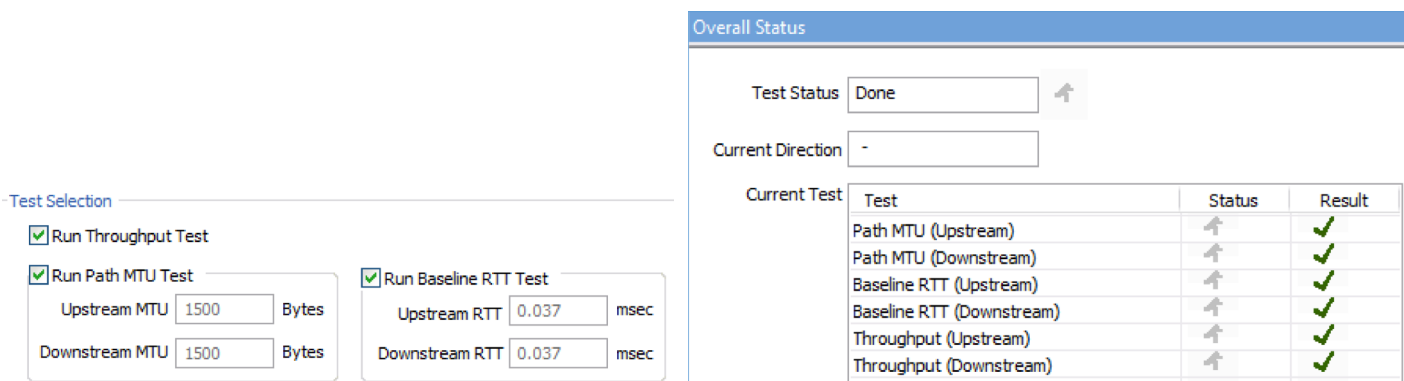
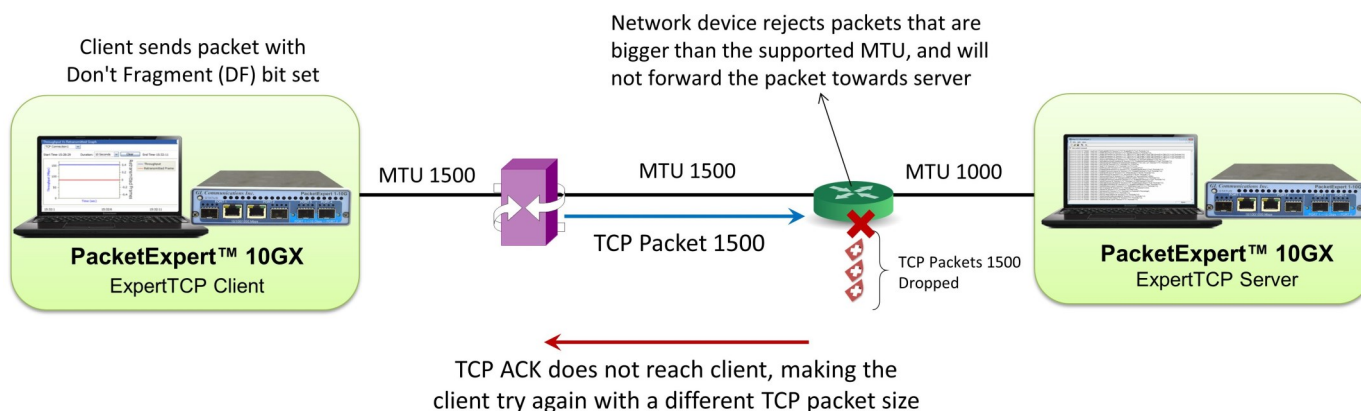


Figure: Test Selection and Status

## Path MTU Discovery

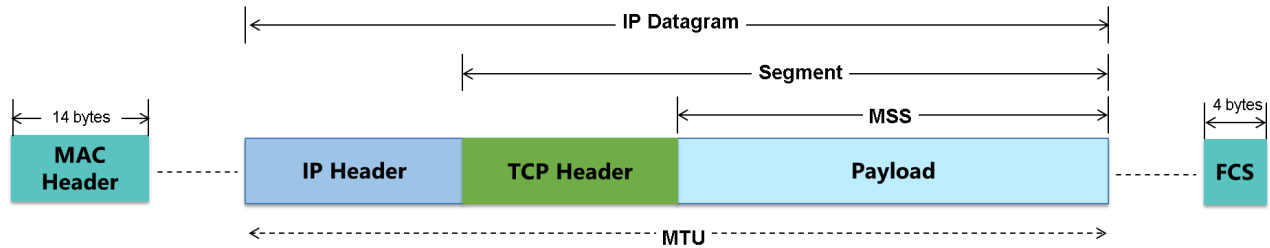
As per RFC 6349, the first step is to discover the Path Maximum Transmission Unit (MTU). This is because the TCP Throughput test has to be conducted at the Path MTU, else the TCP segments can fragment, adversely affecting the test results.



## Path MTU Discovery

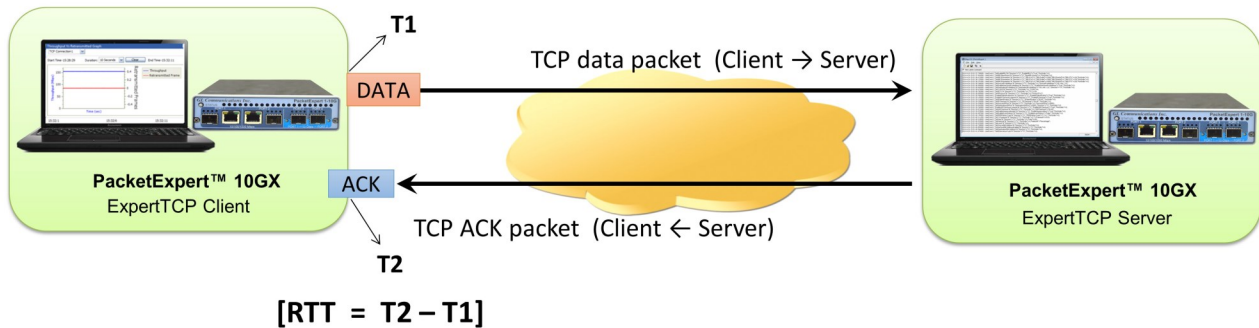
ExpertTCP™ discovers the Path MTU for both directions (Upstream/Downstream) separately. It follows a method similar to the one specified in the RFC 4821 (Packetization Layer Path MTU Discovery) standard, but uses TCP instead of ICMP.

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.



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	0.037 msec
Calculated BDP	4.625 KBytes
TCP Window	4625 Bytes
Path MTU	1500 Bytes
MSS Used	1448 Bytes
No of TCP Connection	1
Transfer Size	12500.000 MBytes

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 interface (PXE100), whereas up to 16 TCP connections are supported on 10G interface (PXN100).

TCP Setup		
No of TCP Connection	5	
TCP Port Configuration	<input checked="" type="radio"/> Automatic <input type="radio"/> 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

## 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.

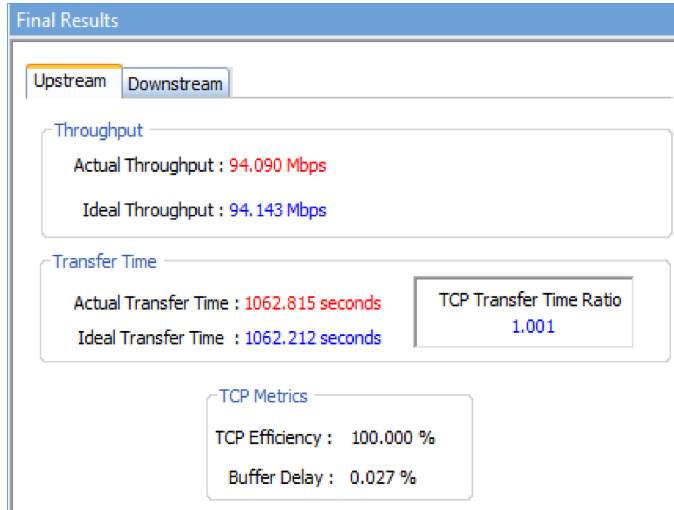
Throughput Results		RTT Results	
Upstream Downstream		Upstream Downstream	
TCP Connection1		TCP Connection1	
Average Throughput	94.09 Mbps	Average RTT	2.052 msec
Minimum Throughput	93.65 Mbps	Minimum RTT	2.008 msec
Maximum Throughput	94.37 Mbps	Maximum RTT	2.063 msec

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

Statistics	
Upstream Downstream	
TCP Connection1	
Statistics	Values
Time(secs)	137
Tx Frames	5364046
Tx Bytes	1564841346
Retransmitted Frames	0
Retransmitted Bytes	0
Retransmitted Frames %	0.0000

## Statistics and Results

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.



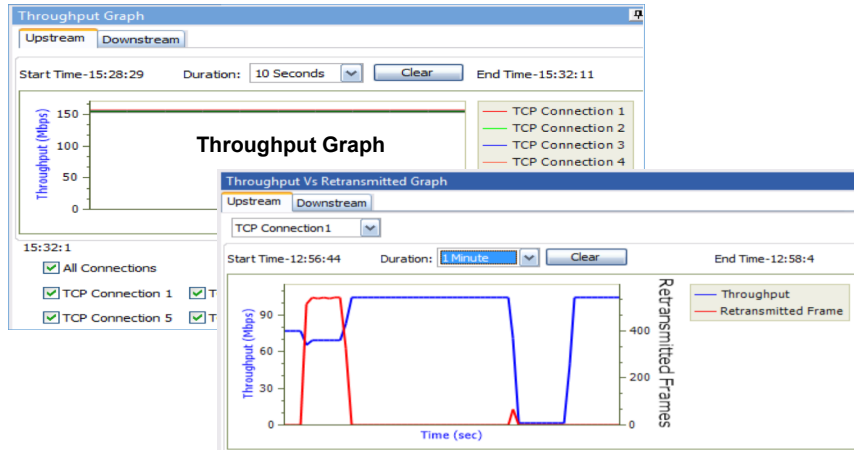
Upstream, Downstream Results

## Graphs

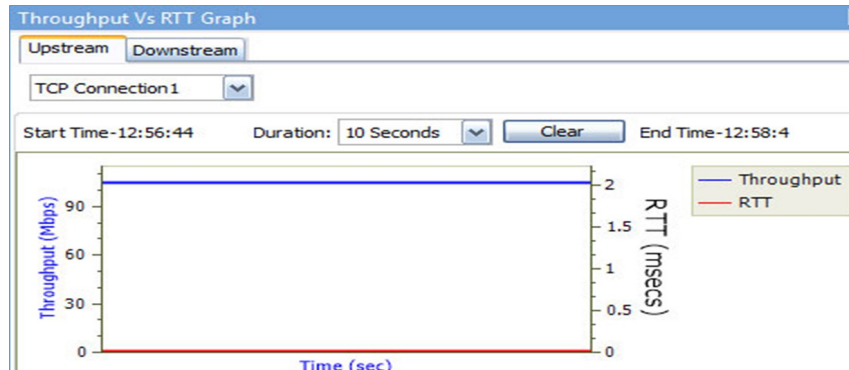
Various graphs are available for visualizations. Throughput graph plots the Throughput over time. All connections are plotted in a single graph for a comprehensive view of the overall performance.

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

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



Throughput vs. Retransmissions Graph



Throughput vs. RTT Graph

## Hardware Specifications

 <p><b>Portable 10GX Hardware Unit</b></p>	 <p><b>1U mTOP™ PacketExpert™ 10GX Rack Unit (3 PXN100s)</b></p> <p><b>Stacked 1U mTOP™ PacketExpert™ 10GX Rack Unit</b></p>	 <p><b>PacketExpert™ 10GX mTOP™ Probe</b></p>
<p><b>Physical Specification:</b>                  Length: 8.45 in. (214.63 mm)                  Width: 5.55 in. (140.97 mm)                  Height: 1.60 in. (40.64 mm)                  Weight: 1.713 lbs. (0.75 kg)</p>	<ul style="list-style-type: none"> <li>• <b>Dimension:</b> 1U/2U mTOP™ - 19" W x 16" L</li> <li>• 1U mTOP™ Rackmount Enclosure can support up to 3 PXN100s</li> <li>• 2U mTOP™ Rackmount Enclosure can support up to 6 PXN100s</li> <li>• Optional 4 to 12 Port SMA Jack Trigger Board (TTL Input/Output)</li> <li>• <b>Weight:</b> (not including the rails)                      1U with 3x PXN100 : 11 lbs                      2U with 6x PXN100 : 22 lbs</li> </ul>	<p><b>Physical Specification:</b>                  Length: 10.4 in. (264.16 mm)                  Width: 8.4 in. (213.36 mm)                  Height: 3.0 in. (76.2 mm)</p>
<p><b>Bus Interface:</b> USB 3.0  <b>External Power Supply:</b></p> <ul style="list-style-type: none"> <li>• +12 Volts (Medical Grade), 3 Amps (For portable units having serial number <math>\geq</math> 188400)</li> <li>• +9 Volts, 2 Amps (For portable units having serial number <math>&lt;</math> 188400)</li> <li>• Optional 4-Port SMA Jack Trigger Board (TTL Input/Output)</li> </ul>	<p><b>SBC Specifications:</b></p> <ul style="list-style-type: none"> <li>• Intel Core i3 or optional i7 Equivalent, Windows® 11 64-bit Pro OS</li> <li>• USB 2.0 and USB 3.0 Hub, ATX Power Supply</li> <li>• USB Type C ports, Ethernet 2.5GigE port</li> <li>• 256 GB Hard drive, 8G Memory (Min)</li> <li>• Two HDMI ports</li> </ul>	<p><b>SBC Specifications:</b></p> <ul style="list-style-type: none"> <li>• Intel Core i3 or optional i7 NUC Equivalent, Windows® 11 64-bit Pro OS</li> <li>• USB 2.0 and USB 3.0 Hub, Power Supply +12 Volts, 3 Amps</li> <li>• USB Type C ports, Ethernet 2.5GigE port</li> <li>• 256 GB Hard drive, 8G Memory (Min)</li> <li>• Two HDMI ports</li> </ul>
<p><b>Temperature:</b> Operating Temperature                  0° C to +50° C (only up to operating altitude of 5000 feet, and for Optical SFPs only i.e. Non Electrical SFPs)                  +5° to +40° C (for operating altitude up to 10,000 feet, and for both Electrical and Optical SFPs)                  Non-Operating Temperature: -30° to +60° C</p> <p><b>Humidity:</b> Operating Humidity: 0% to 80% RH                  Non-Operating Humidity: 0% to 95% RH</p> <p><b>Altitude:</b> Operating Altitude: up to 10,000 feet                  Non-Operating Altitude: up to 50,000 feet</p> <p><b>Interfaces:</b>                  4 x 1G Base-X Optical OR 10/100/1000 Base-T Electrical                  2 x 100Mbps Base-FX Optical                  2 x 2.5 Gbps Electrical Interface                  2 x 10G Base-SR, -LR -ER Optical only                  Single Mode or Multi Mode Fiber SFP support with LC connector</p> <p><b>Protocols:</b>                  IEEE 802.3ae LAN PHY compliance                  RFC 2544 compliance</p>		
		 <p><b>Pelican Carry Case</b></p>

## Buyer's Guide

Item No	Product Description
<a href="#">PXN108</a>	Multi-Stream UDP/TCP Traffic Generator and Analyzer – for PXN100
<a href="#">PXN101</a>	10G and 2.5G option for PXN100
<a href="#">CXN100</a>	CLI Server for PXN100

Item No	Related Hardware
<a href="#">PXN100</a>	PacketExpert™ 10GX
<a href="#">PXE100</a>	PacketExpert™ 1G
<a href="#">PXN112G</a>	PacketExpert™ 10GX (12-Port) - Rackmount
<a href="#">PXN124G</a>	PacketExpert™ 10GX (24-Port) - Rackmount
<a href="#">MT001</a>	mTOP™ 1U rackmount w/ SBC
<a href="#">MT002</a>	mTOP™ 1U rackmount w/o SBC

For more information, please visit [ExpertTCP™ - TCP Throughput Testing \(RFC 6349\)](#) webpage.



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