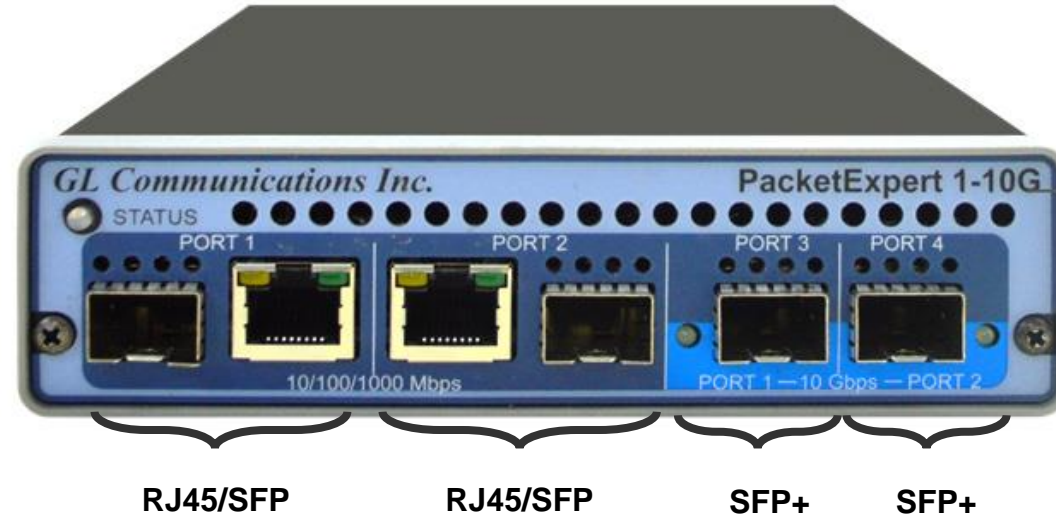

Ethernet Tester – PacketExpert 10 Gbps, 2.5 Gbps, or 1 Gbps™



818 West Diamond Avenue - Third Floor, Gaithersburg, MD 20878
Phone: (301) 670-4784 Fax: (301) 670-9187 Email: info@gl.com
Website: <https://www.gl.com>

PacketExpert™ 10GX - Portable Unit (PXN100, PXN101)



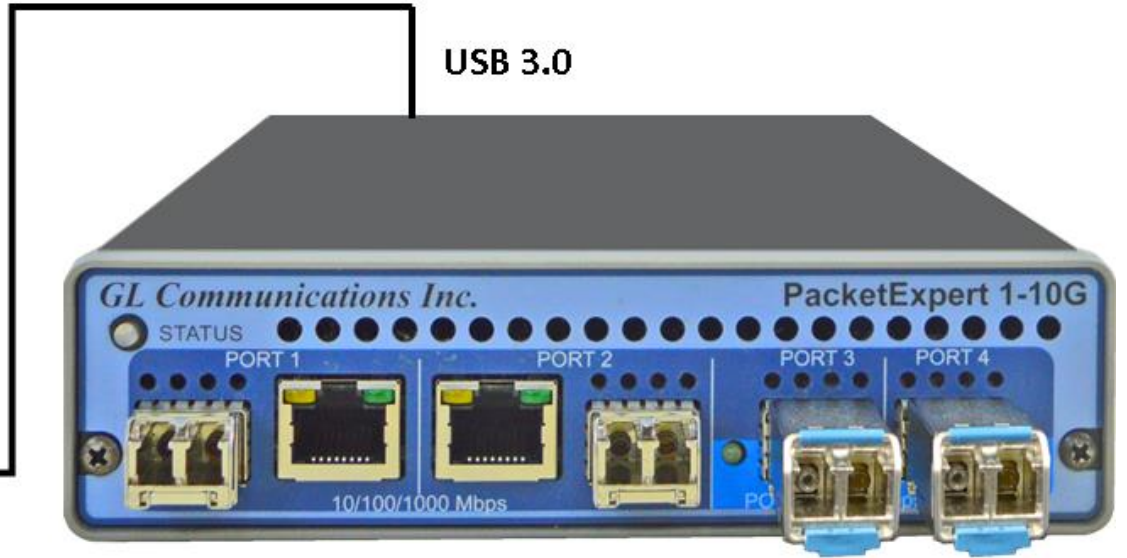
Physical Specifications	<ul style="list-style-type: none"> • Length: 8.45 in (214.63 mm) • Width: 5.55 in (140.97 mm) • Height: 1.60 in (40.64 mm) • Weight: 1.713 lbs
External Power Supply	<ul style="list-style-type: none"> • +12 Volts (Medical Grade), 3 Amps (For portable units having serial number \geq 188400) • +9 Volts, 2 Amps (For portable units having serial number $<$ 188400)
BUS Interface	<ul style="list-style-type: none"> • USB 3.0 • Optional 4-Port SMA Jack Trigger Board(TTL Input/Output)
Protocols	<ul style="list-style-type: none"> • IEEE 802.3ae LAN PHY compliance • RFC 2544 compliance

PacketExpert™ Software



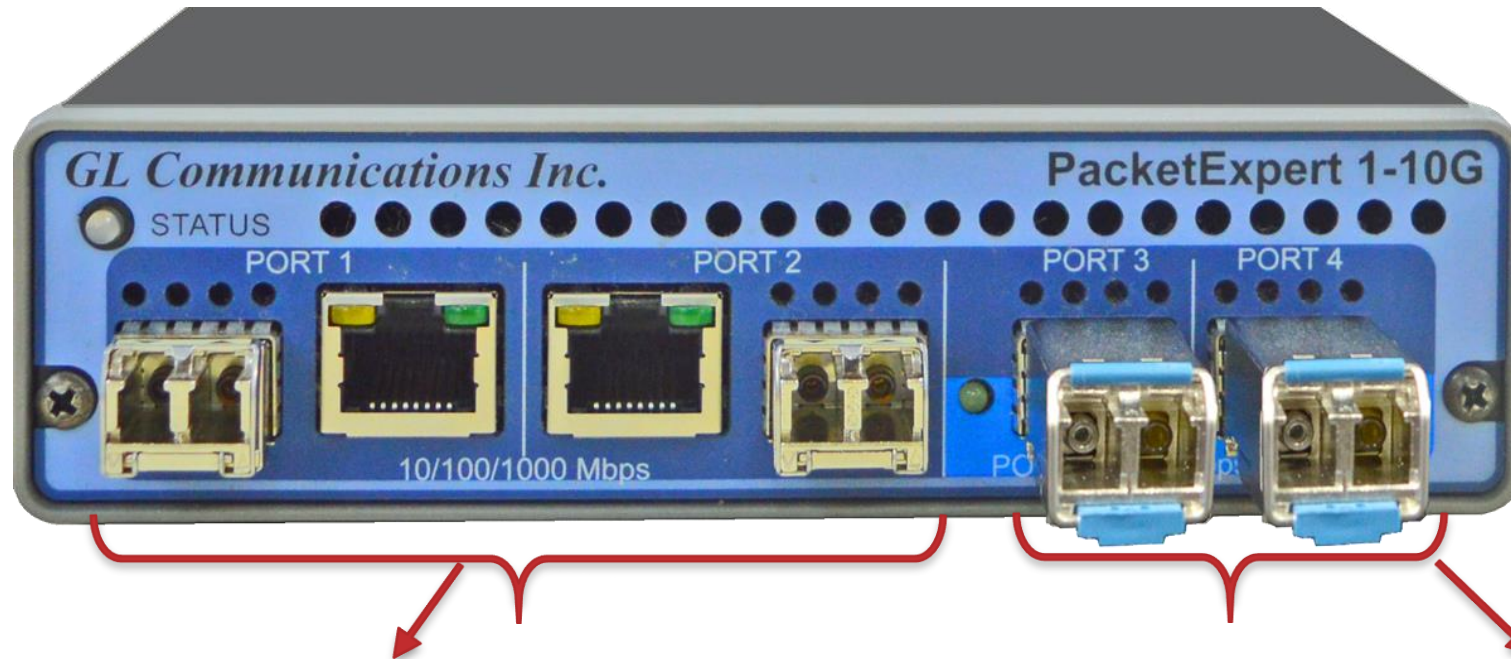
USB 3.0

Windows 7/8/10 64-bit OS



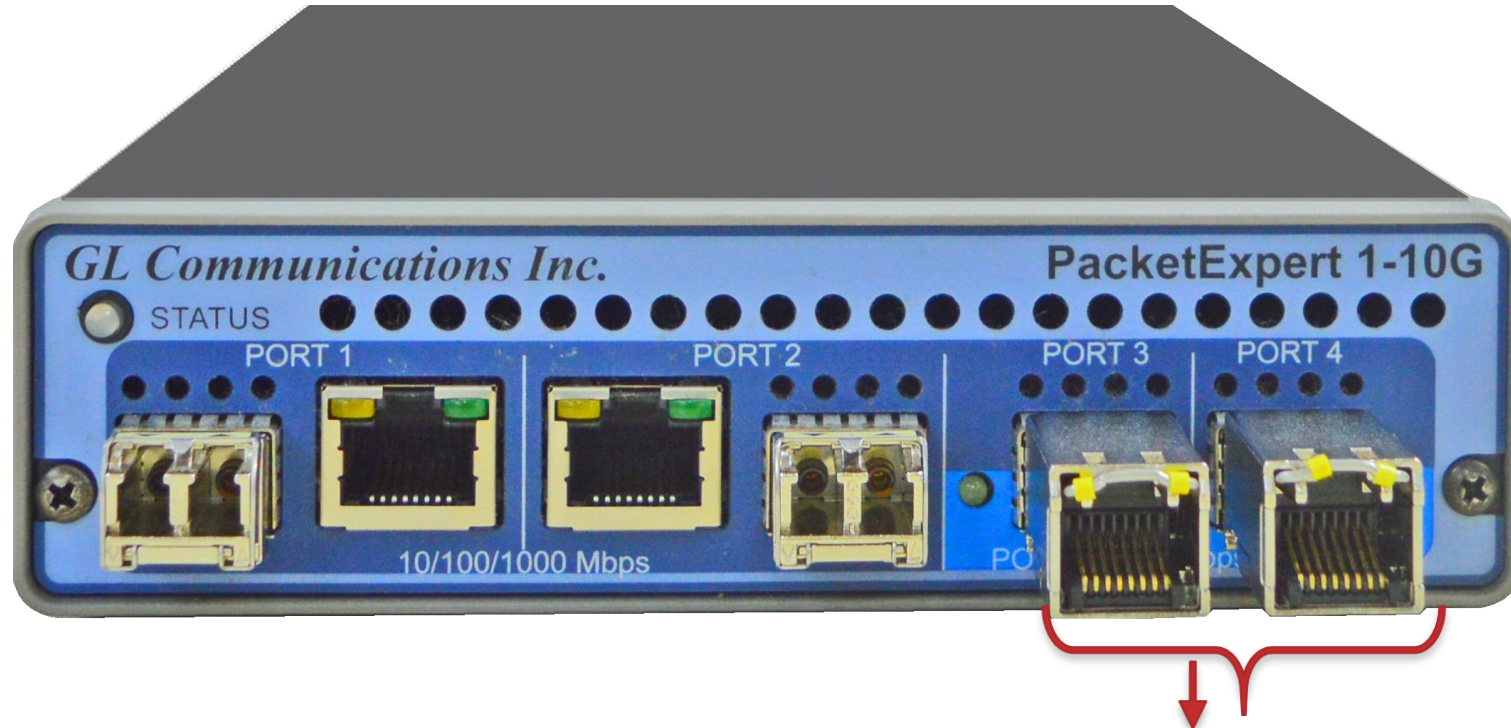
USB 3.0

PacketExpert™ 10GX – 1 Gbps Mode



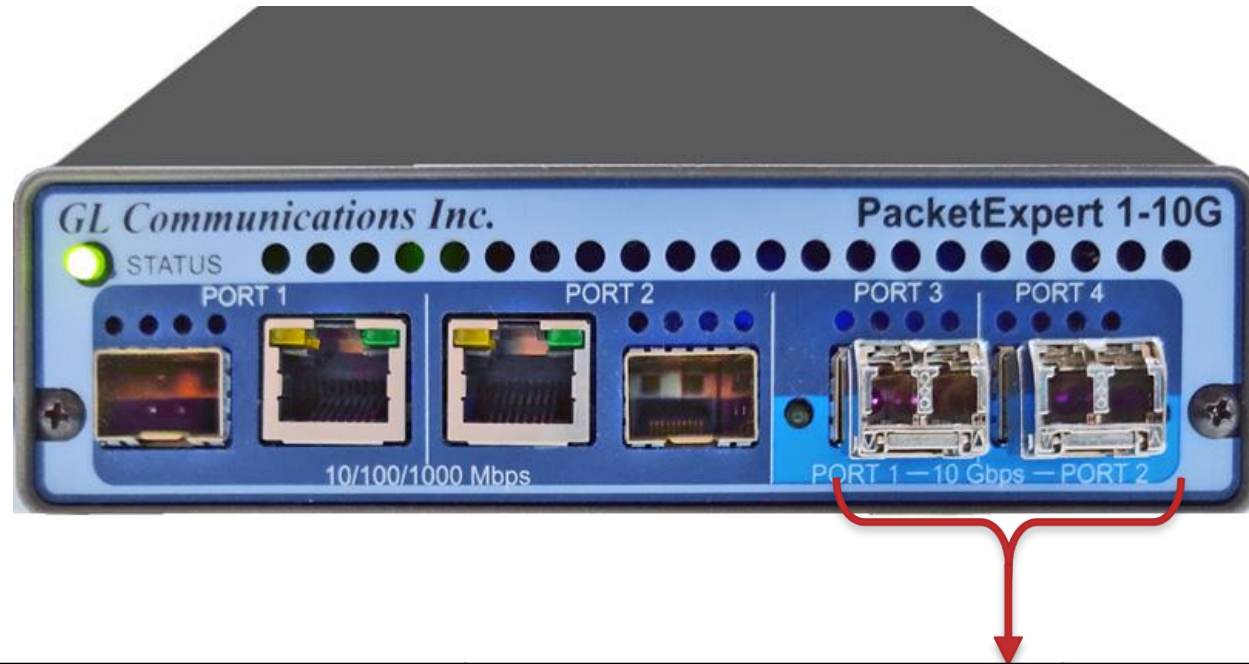
Ports		Port 1		Port 2		Port 3	Port 4
Interface Type		SFP	RJ45	SFP	RJ45	SFP+	SFP+
Electrical	Speeds	10/100/1000 Mbps		10/100/1000 Mbps		10/100/1000 Mbps	10/100/1000 Mbps
	Designations	10BASE-T		10BASE-T		10BASE-T	10BASE-T
		100BASE-TX		100BASE-TX		100BASE-TX	100BASE-TX
		1000BASE-T		1000BASE-T		1000BASE-T	1000BASE-T
Optical	Speeds	100/1000 Mbps		100/1000 Mbps		1000 Mbps	1000 Mbps
	Designations	100BASE-FX		100BASE-FX		1000BASE-X	1000BASE-X
		1000BASE-X		1000BASE-X			

PacketExpert™ 10GX – 2.5 Gbps Mode



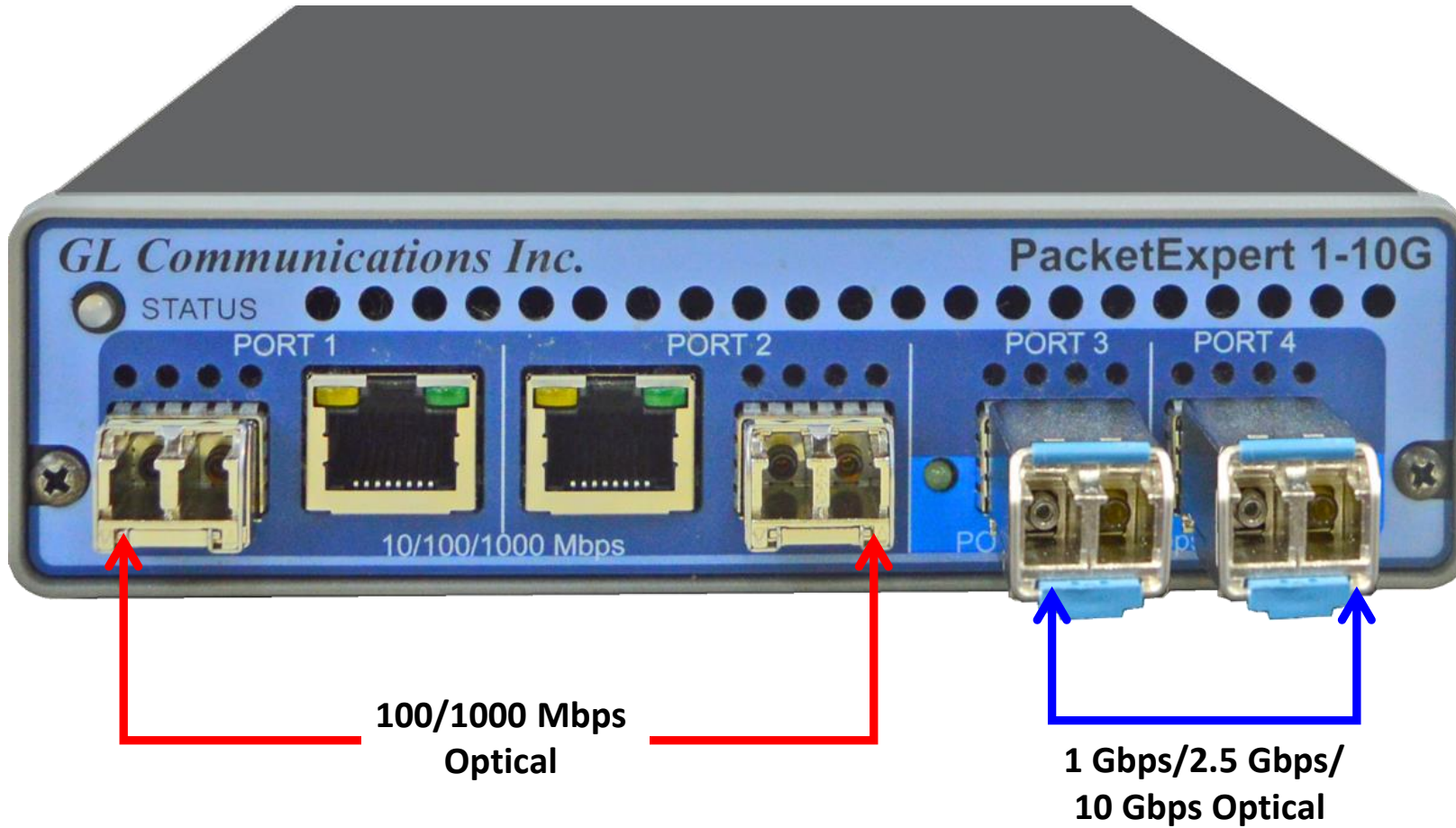
Ports		Port 1	Port 2
Interface Type		SFP+	SFP+
Electrical	Speeds	2.5 Gbps	2.5 Gbps
	Designations	2500BASE-T	2500BASE-T
Optical	Speeds	2.5 Gbps	2.5 Gbps
	Designations	2500BASE-X	2500BASE-X

PacketExpert™ 10GX – 10 Gbps Mode

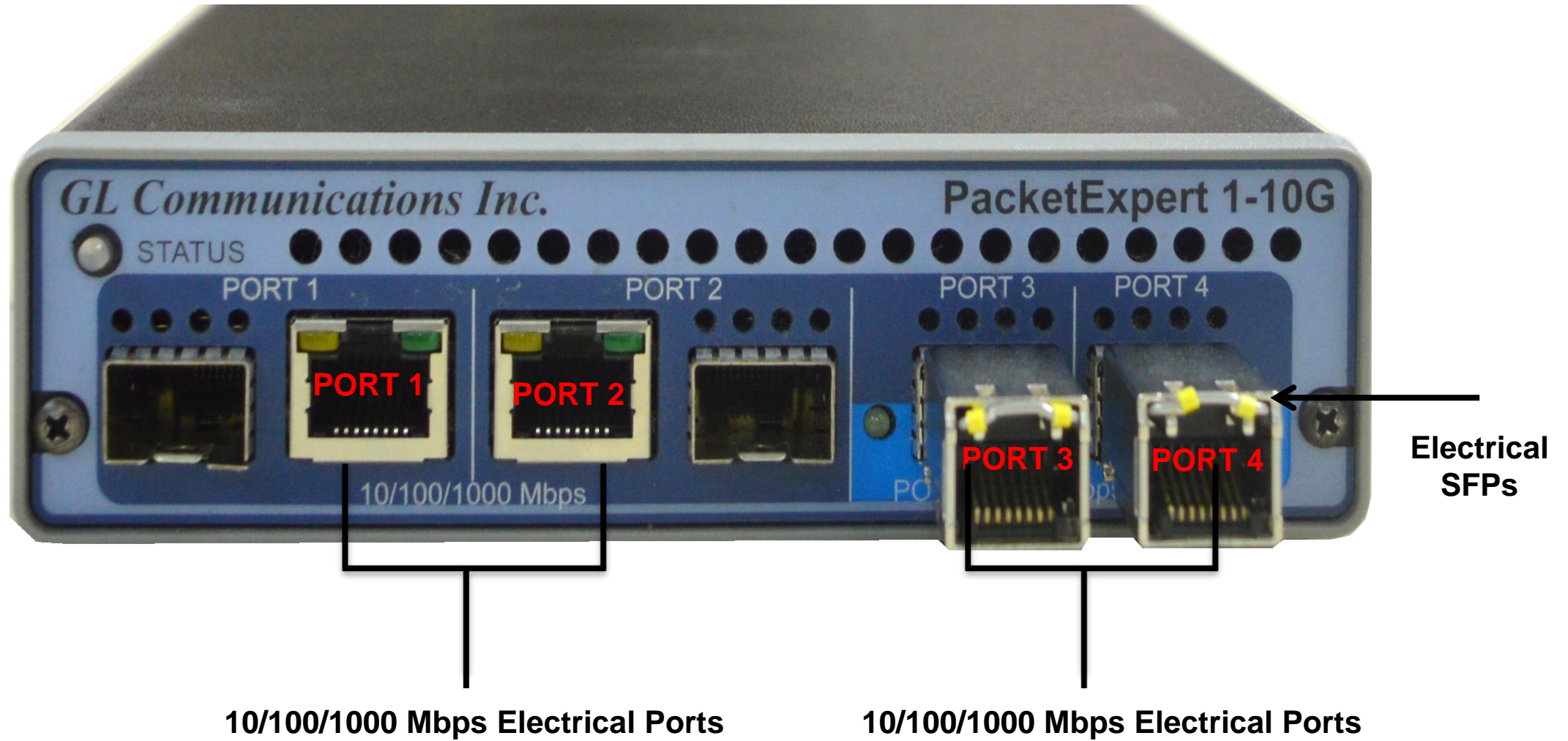


Port		Port 1	Port 2
Interface Type		SFP+	SFP+
Electrical	Speeds	10 Gbps	10 Gbps
	Designations	10GBASE-T	10GBASE-T
Optical	Speeds	10 Gbps	10 Gbps
	Designations	10GBASE-R	10GBASE-R

PacketExpert™ 10GX - Optical Ports



PacketExpert™ 10GX - Electrical Ports

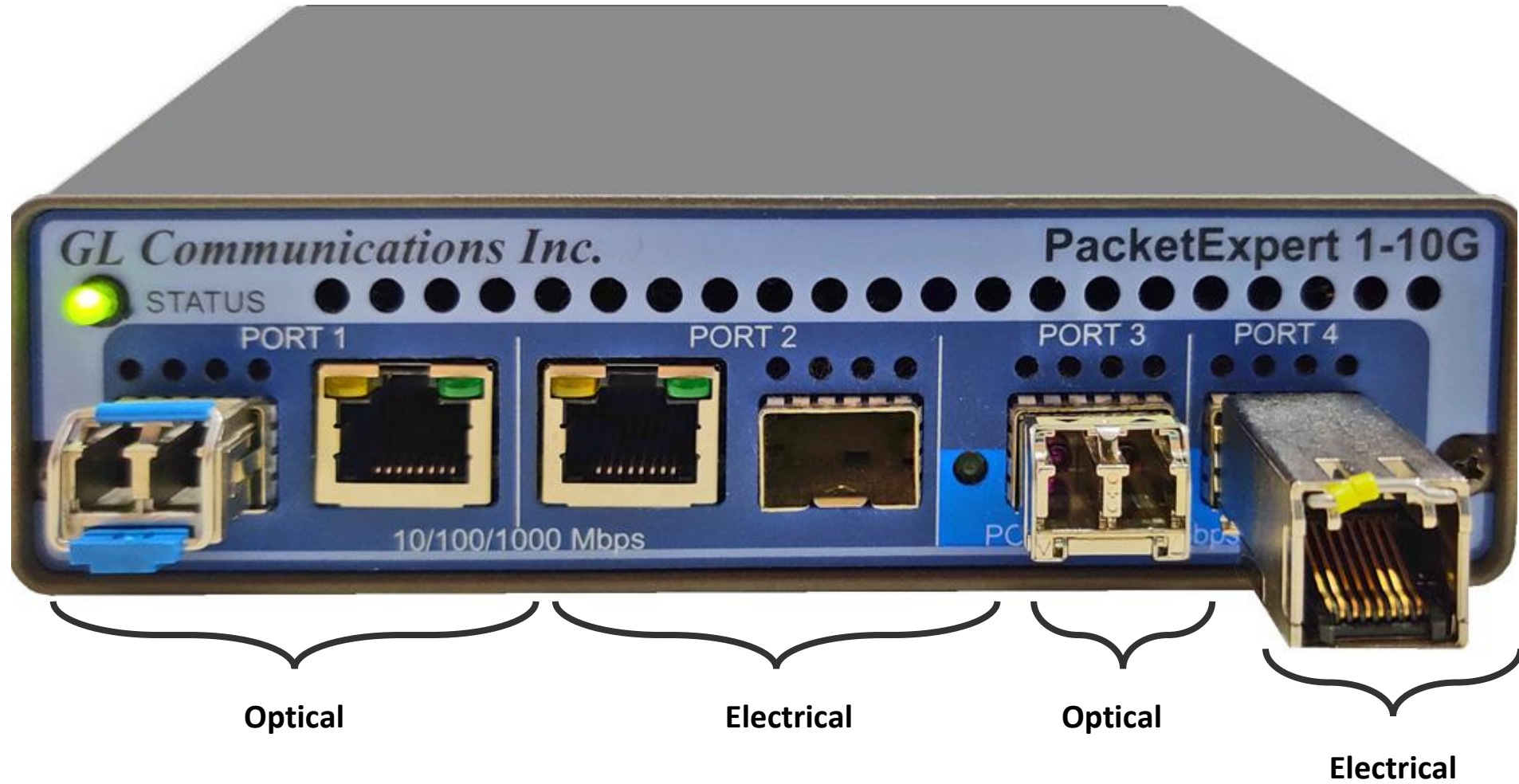


10/100/1000 Mbps Electrical Ports

10/100/1000 Mbps Electrical Ports

Electrical SFPs

PacketExpert™ 10GX – Mix and Match



MTOP™ Rack Units



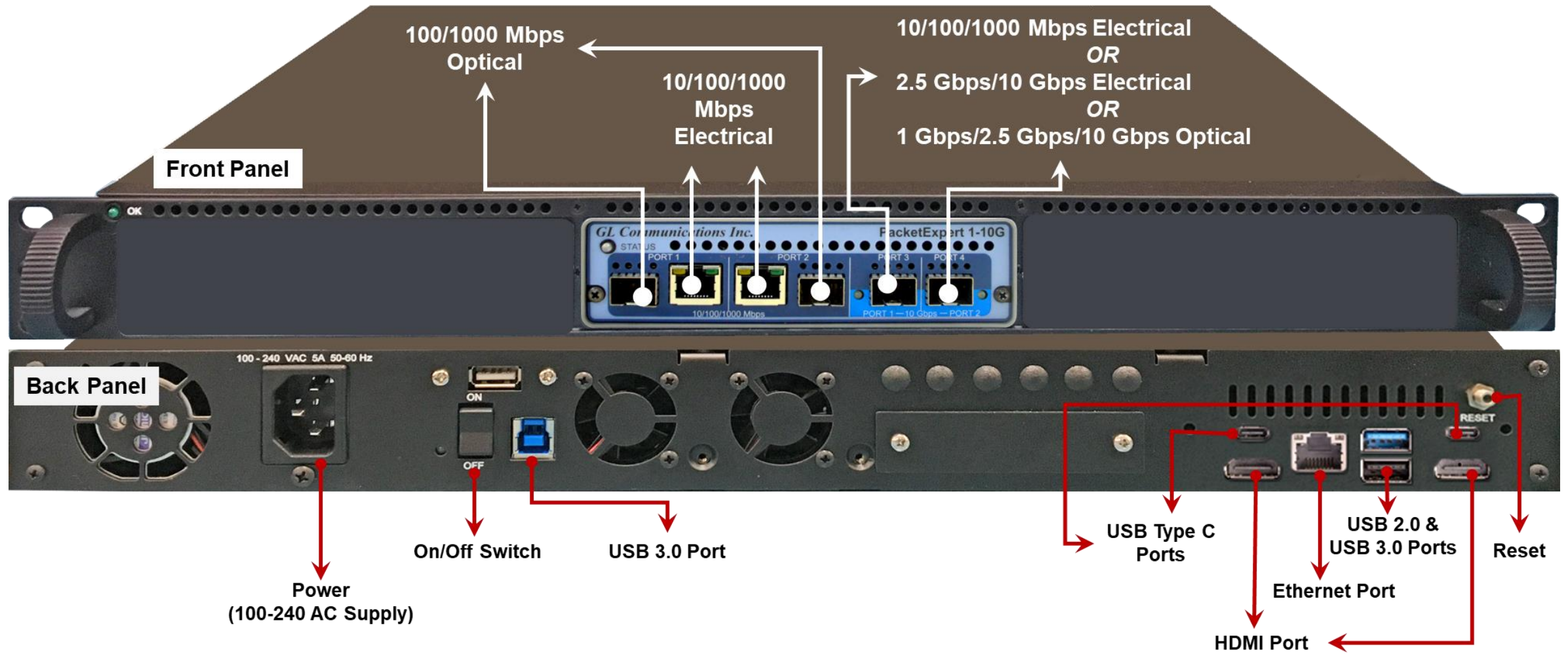
High Density 1U Rack option



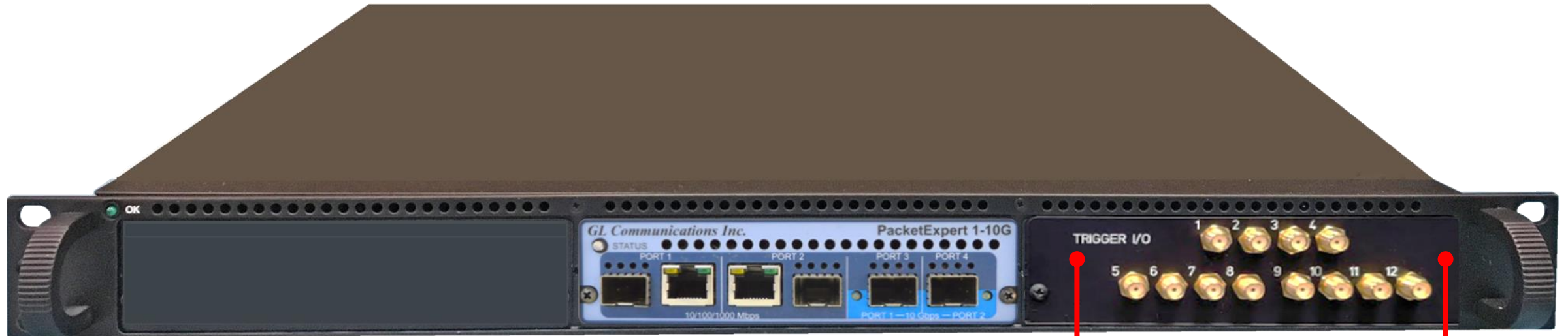
Stacked High Density 1U Rack option

Physical Specifications	<ul style="list-style-type: none"> • Length: 16 in (406.4) • Width: 19 in (482.6) • Height: 1U / 2U
External Power Supply	<ul style="list-style-type: none"> • ATX Power Supply
BUS Interface	<ul style="list-style-type: none"> • 1U mTOP™ (MT001 + 3x PXN100) <ul style="list-style-type: none"> ➢ Rackmount Enclosure can support up to 3 PXN100s • 2U Rack Mount (with 6x PXN100) <ul style="list-style-type: none"> ➢ Rackmount Enclosure can support up to 6 PXN100s • Optional 4 to 12 Port SMA Jack Trigger Board (TTL Input/Output)
SBC Specifications	<ul style="list-style-type: none"> • Intel Core i3, Windows® 11 Pro 64-bit OS • USB 3.0 and USB 2.0 Hub, ATX Power Supply • USB Type C ports, Ethernet 2.5GigE port • Min 256GB Hard drive, 8G Memory • Two HDMI ports

mTOP™ 1U Rack Option with Built in SBC

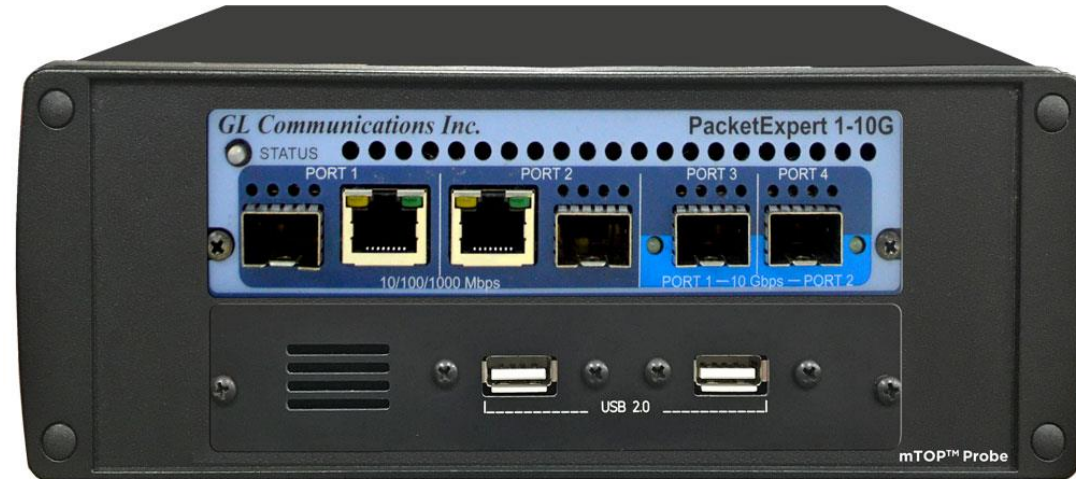


mTOP™ 1U Rack Option with 12 TTL



1 to 12 TTL
Programmable I/O

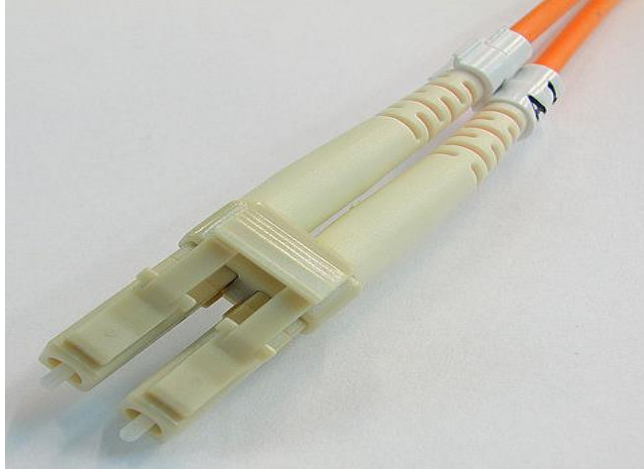
mTOP™ Probe with 10GX Hardware Unit + SBC



Physical Specifications	<ul style="list-style-type: none">• Length: 10.4 in. (264.16 mm)• Width: 8.4 in. (213.36 mm)• Height: 3.0 in. (76.2 mm)• Optional 4-Port SMA Jack Trigger Board (TTL Input/Output)• External USB based Wi-Fi adaptor
External Power Supply	<ul style="list-style-type: none">• +12 Volts (Medical Grade), 3 Amps
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/3Amps Power Supply• USB Type C ports, Ethernet 2.5GigE port• 256 GB Hard drive, 8G Memory (Min)• Two HDMI ports

Optical Connectors and SFP Transceivers

LC Connectors



850nm /1310nm/1550nm

SFP Modules



- PacketExpert™ 10GX supports LC connectors and 850nm/1310nm/1550nm SFP (Small Factor Pluggable) modules

Note: In case customer have different type of connectors, then we need converters like LC-to-SC, LC-to-FC and vice-versa.

Applications

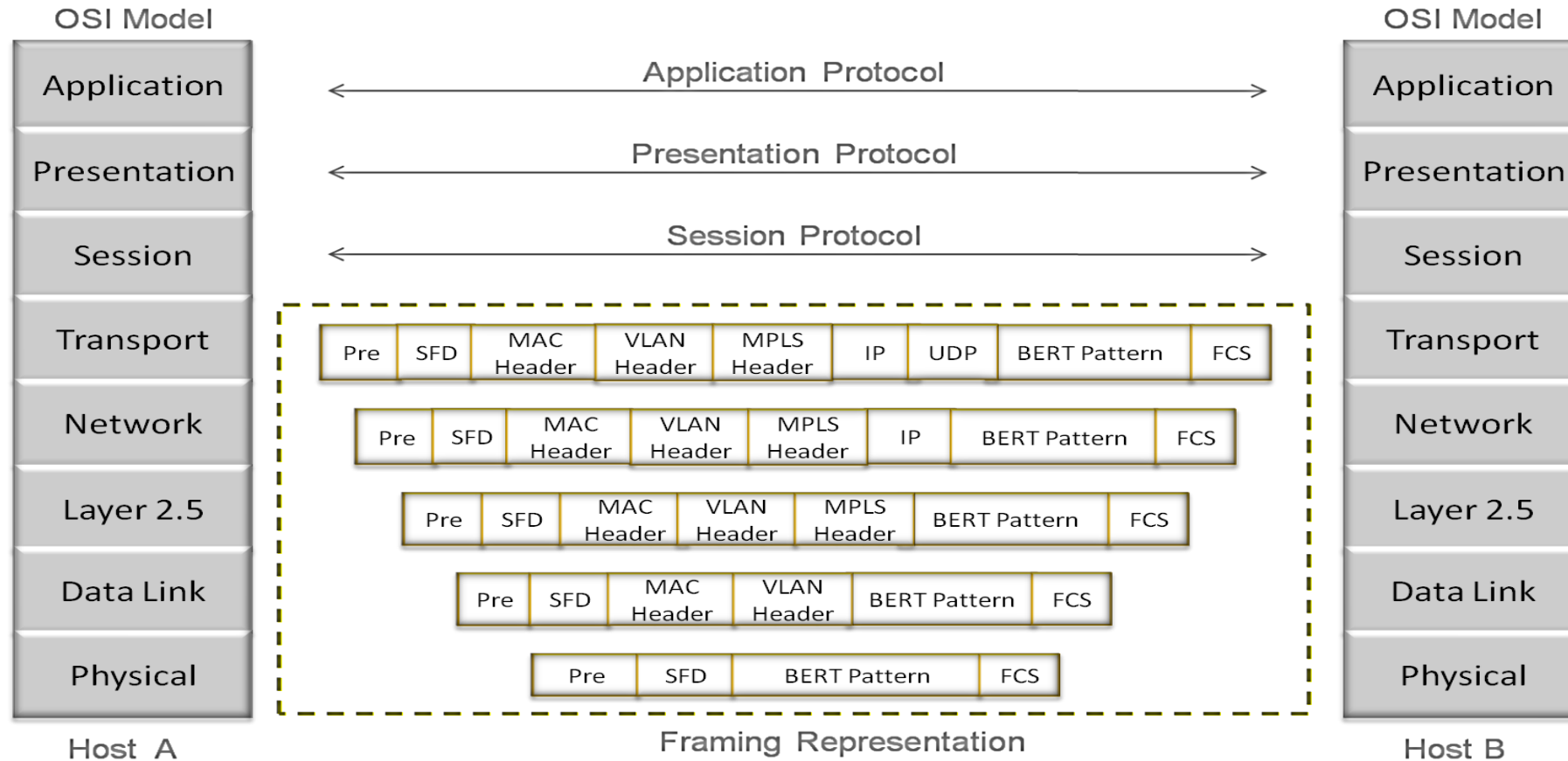
- Test and verify QoS Parameters of network devices like Switches/Routers etc.
- End to end testing of network paths for QoS parameters
- In-depth troubleshooting of the Carrier network in the event of network failures or impairments
- QoS testing of Triple-play services to ensure that they fully qualify SLA parameters
- Terrestrial wireless, satellite, and other WAN technologies network validations
- Test VoIP network in real-time conditions to verify if it meets the quality requirements before you deploy
- Testing video on IP networks by emulating the loss and congestion characteristics
- SPF support can be used for Broadband aggregation applications, Metro edge switching, Metro and access multi-service platforms, and are suitable for Fast Ethernet applications

PacketExpert™10GX-Ethernet / IP Tester

- BERT
- RFC 2544
- Smart Loopback
- ITU-T Y.1564 (ExpertSAM™)
- Multi-Stream Traffic Generator Analyzer
- RFC-6349 based TCP Throughput Testing (ExpertTCP™)
- WAN Emulation (Single stream) - IPLinkSim
- WAN Emulation (Multi-Stream) - IPNetSim
- Wire-Speed Record / Playback
- PacketBroker

Wirespeed BERT

OSI Model



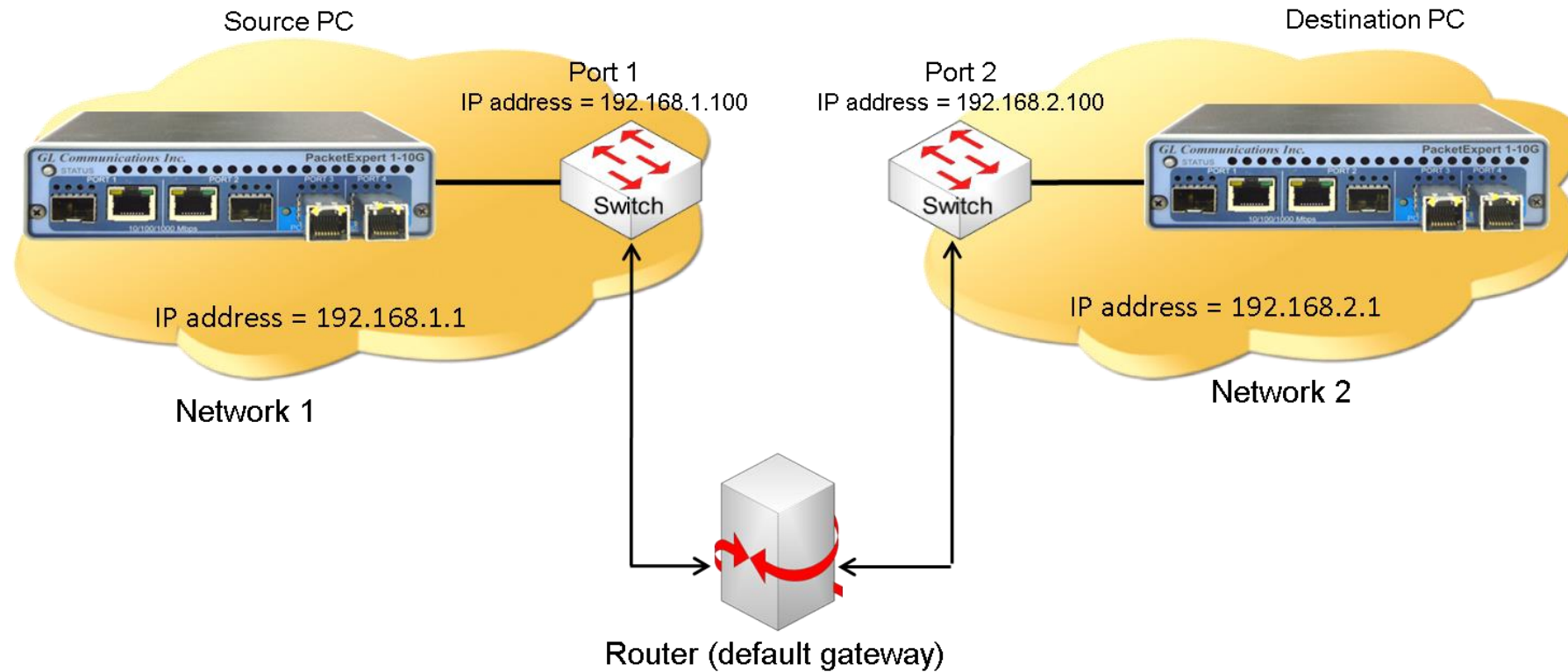
- Preamble – 7 Bytes
- Start Frame Delimiter – (SFD)- 1 Byte
- MAC Header –
 - Dest/Src MAC Address – 6 Bytes
 - Ether Length/Type – 2 Bytes (0x0800)
- IP
- VLAN Header – 4 bytes each

- MPLS Header – 4 bytes each
- IP Header – 20 Bytes
- UDP Header – 8 Bytes
- Payload – BER Test Pattern
- Frame Check Sum – (FCS) – 4 Bytes

Ethernet Payload

BER Test Setup at Layer 3 / 4

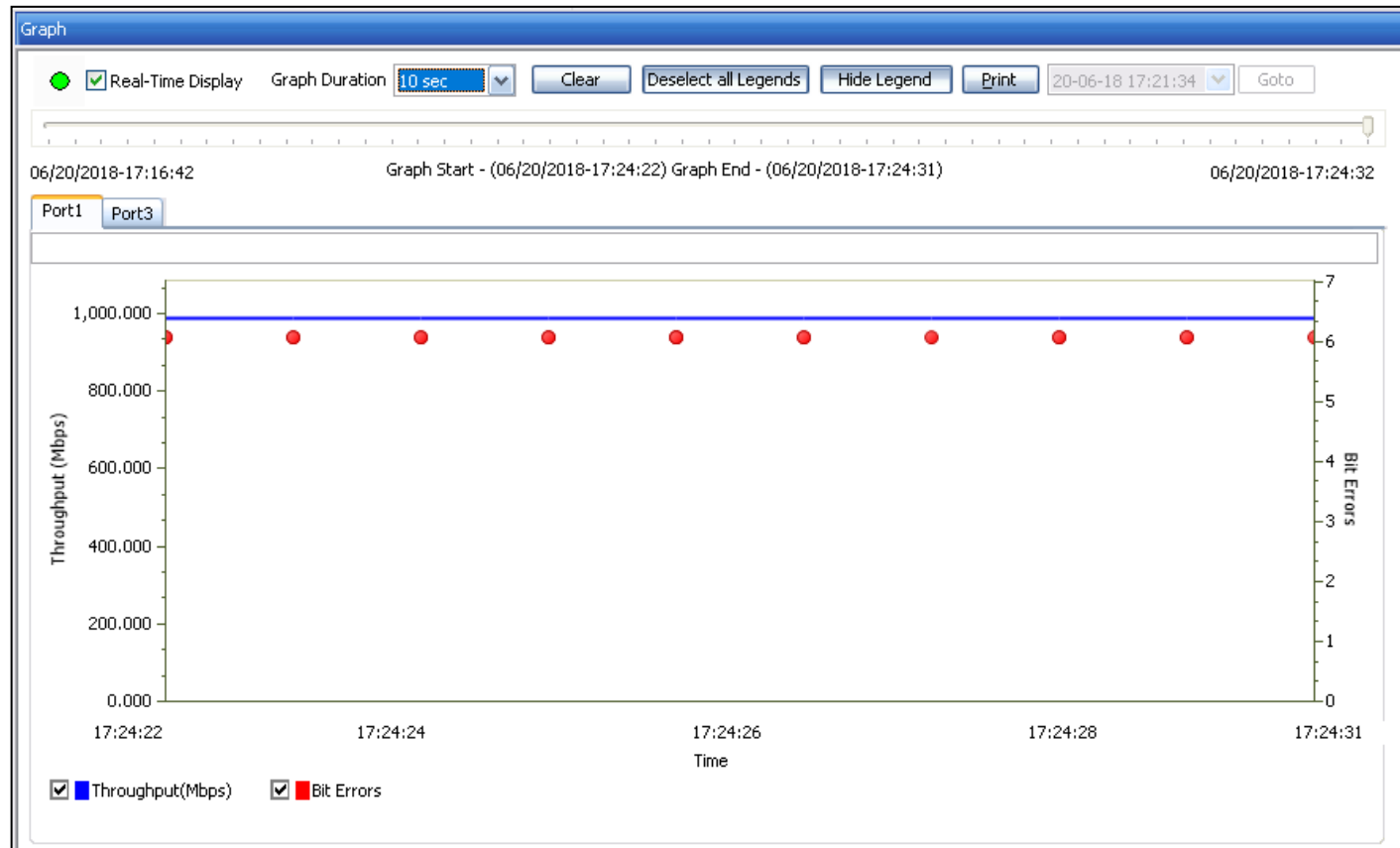
Layer 3 Testing between PacketExpert™ located in different IP Networks



In this case, Source and the Destination PacketExpert™ applications are located in different IP networks. These 2 networks are connected through a router. A simple example above shows 2 LANs connected through a router.

BERT Results (with LEDs) and Graph

- Optional Sequence number insertion allows detecting Out-of-sequence packets and packet loss
- Detailed BERT statistics like the Bit Error Count, Bit Error Rate, Bit Error Seconds etc., are provided
- Bit Error Count is displayed in both Tabular and Graphical formats

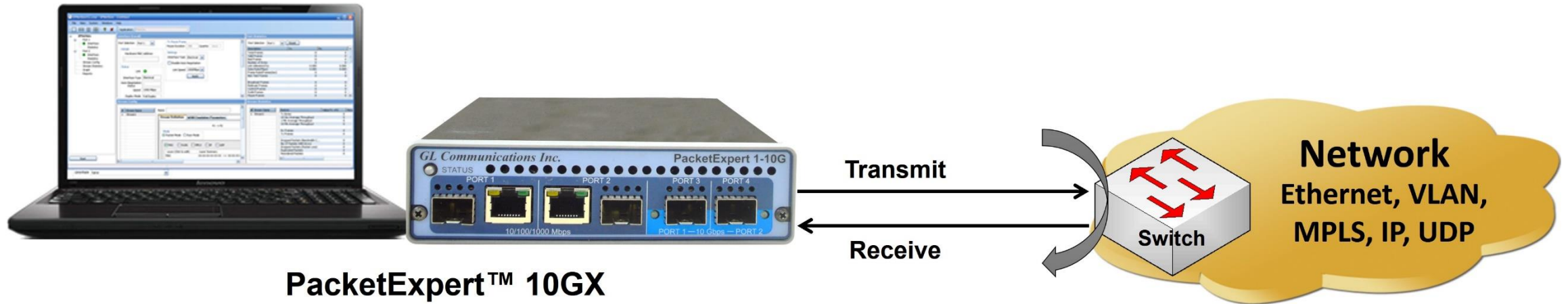


All Ports Result

All Ports			
Options			
Tx	Port 1	Port 2	
Total Frames	48 397 778	48 465 000	
Valid Frames	48 398 858	48 466 070	
Bad Frames	0	0	
Number of Bytes	73 277 416 806	73 379 206 032	
Link Utilisation(%)	100.000	100.000	
Data Rate(Mbps)	9869.621	9869.621	
Frame Rate(Frames/sec)	814864	814863	
Mon Test Frames	0	0	
Rx	Port 1	Port 2	
Total Frames	48 414 936	48 485 825	
Valid Frames	48 415 988	48 486 885	
Bad Frames	0	0	
Number of Bytes	73 304 838 352	73 412 173 404	
Link Utilisation(%)	100.000	100.000	
Data Rate(Mbps)	9869.621	9869.621	
Frame Rate(Frames/sec)	814863	814863	
Mon Test Frames	0	0	
Bert Status	Port 1	Port 2	
Rx Traffic	●	●	
Sync Status	●	●	
Bit Errors	●	●	
Out Of Sequence Packets	●	●	
Bert Statistics	Port 1	Port 2	
Bert Status	Sync	Sync	
Test Time	00:00:59	00:00:59	
Bits Received	562 588 769 680	562 895 355 984	
Bit Error Count	0	0	
Bit Error Rate	0.000E+000	0.000E+000	
Bit Error Seconds	0	0	
Sync Loss Count	0	0	
Sync Loss Seconds	0	0	

RFC 2544 Testing

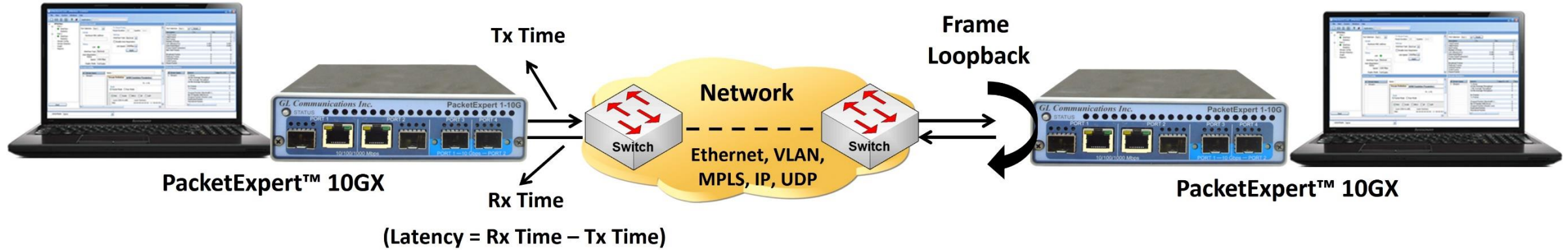
Dual RFC 2544 Testing



RFC 2544 test application includes the following tests:

- **Throughput** - Maximum number of frames per second that can be transmitted without any error
- **Latency** - Measures the time required for a frame to travel from the originating device through the network to the destination device
- **Frame Loss** - Measures the network's response in overload conditions
- **Back-to-Back** - It measures the maximum number of frames received at full line rate before a frame is lost

Single Port RFC 2544



In single port RFC 2544 test,

- For PacketExpert™ 1G, the RFC 2544 test can be done either on Port #2 or Port #3 at a time and it is not possible to run RFC 2544 test on both the ports (Port #2, Port #3) simultaneously
- For PacketExpert™ 10G or 10GX, the RFC 2544 test can be done either on Port #1 or Port #2 at a time and it is not possible to run RFC 2544 test on both the ports (Port #1, Port #2) simultaneously

Highlights

- Throughput, back-to-back, latency and frame loss testing supporting uni-directional and bi-directional traffic between ports
- Supports RFC 2544 on electrical / optical (1000Mbps) ports and optical only (10G) ports
- Includes various parameter configurations such as Test Selection, Frame Sizes selection, Unidirectional/Bidirectional, Number of trials, Trial Duration, and many more
- User-defined options to configure various packet header parameters, like MAC addresses, IP addresses, UDP ports, VLAN ID, MPLS Labels, and more
- Results are displayed in both tabular as well as graphical format

Global Configurations

Global Configuration

Port Selection P1 -> P2

Minimum Frame Length 64

Max Frame Length 16000

Frame Size

Quantity 20

64	352	640	928	1216
136	424	712	1000	1288
208	496	784	1072	1360
280	568	856	1144	1432

Test Procedure

- Throughput
- Latency
- Frame Loss
- Back-ToBack

Port Selection

East Port	Direction	West Port
P1	<-->	P2

Individual Test Configuration Details

Throughput

Throughput

Configuration

Trial Duration (sec)

Number Of Trials

P1 To P2

Min Bandwidth %

Max Bandwidth %

P2 To P1

Min Bandwidth %

Max Bandwidth %

Latency

Latency

Port Selection

Tx Configuration

Trial Duration (sec)

Number Of Trials

Use Throughput Value

Port 2 To Port 2

Bandwidth %

Frame Loss

Frame Loss

Configuration

Trial Duration (sec)

Number Of Trials

P1 To P2

Min Bandwidth %

Max Bandwidth %

P2 To P1

Min Bandwidth %

Max Bandwidth %

Back-to-Back

Back To Back

Configuration

Trial Duration (sec)

Number Of Trials

P1 To P2

Burst Size msec

No Of bursts

P2 To P1

Burst Size msec

No Of Bursts

Results

- **Throughput** – Both relative (% of link speed) and absolute (in Mbps) throughput values are displayed
- **Latency** – displayed in Microseconds
- **Back-to-Back** – Displayed in Frames/Burst
- **Frame Loss** – Displays the Frame Loss Rate (in %) against attempted Frame Rate (in % of link speed)

RFC 2544 Results

View: Statistics Dir: P1-->P2

Status: Throughput Latency Frameloss Backtoback

Frame Size	P1-->P2	P2-->P1
64	100.00% 7619.05 Mbps	100.00% 7619.05 Mbps
128	100.00% 8648.65 Mbps	100.00% 8648.65 Mbps
256	100.00% 9275.36 Mbps	100.00% 9275.36 Mbps
512	100.00% 9624.06 Mbps	100.00% 9624.06 Mbps
1024	100.00% 9808.43 Mbps	100.00% 9808.43 Mbps
1280	100.00% 9846.15 Mbps	100.00% 9846.15 Mbps
1518	100.00% 9869.96 Mbps	100.00% 9869.96 Mbps

RFC 2544 Results

View: Statistics Dir: P1-->P2

Status: Throughput Latency Frameloss Backtoback

Frame Size	P1-->P2	P2-->P1
64	14 880 952 Frames\Burst	14 880 952 Frames\Burst
128	8 445 945 Frames\Burst	8 445 945 Frames\Burst
256	4 528 985 Frames\Burst	4 528 985 Frames\Burst
512	2 349 624 Frames\Burst	2 349 624 Frames\Burst
1024	1 197 318 Frames\Burst	1 197 318 Frames\Burst
1280	961 538 Frames\Burst	961 538 Frames\Burst
1518	812 743 Frames\Burst	812 743 Frames\Burst

RFC 2544 Results

View: Statistics Dir: P1-->P2

Status: Throughput Latency Frameloss Backtoback

Frame Size	P1-->P2 (Store And Forward , Bit Forward)	P2-->P1 (Store And Forward , Bit Forward)
64	100.000% 1.306 us, 1.363 us	100.000% 1.280 us, 1.338 us
128	100.000% 1.408 us, 1.517 us	100.000% 1.274 us, 1.382 us
256	100.000% 1.299 us, 1.510 us	100.000% 1.267 us, 1.478 us
512	100.000% 1.293 us, 1.709 us	100.000% 1.254 us, 1.670 us
1024	100.000% 1.312 us, 2.138 us	100.000% 1.274 us, 2.099 us
1280	100.000% 1.261 us, 2.291 us	100.000% 1.248 us, 2.278 us
1518	100.000% 1.331 us, 2.554 us	100.000% 1.293 us, 2.515 us

RFC 2544 Results

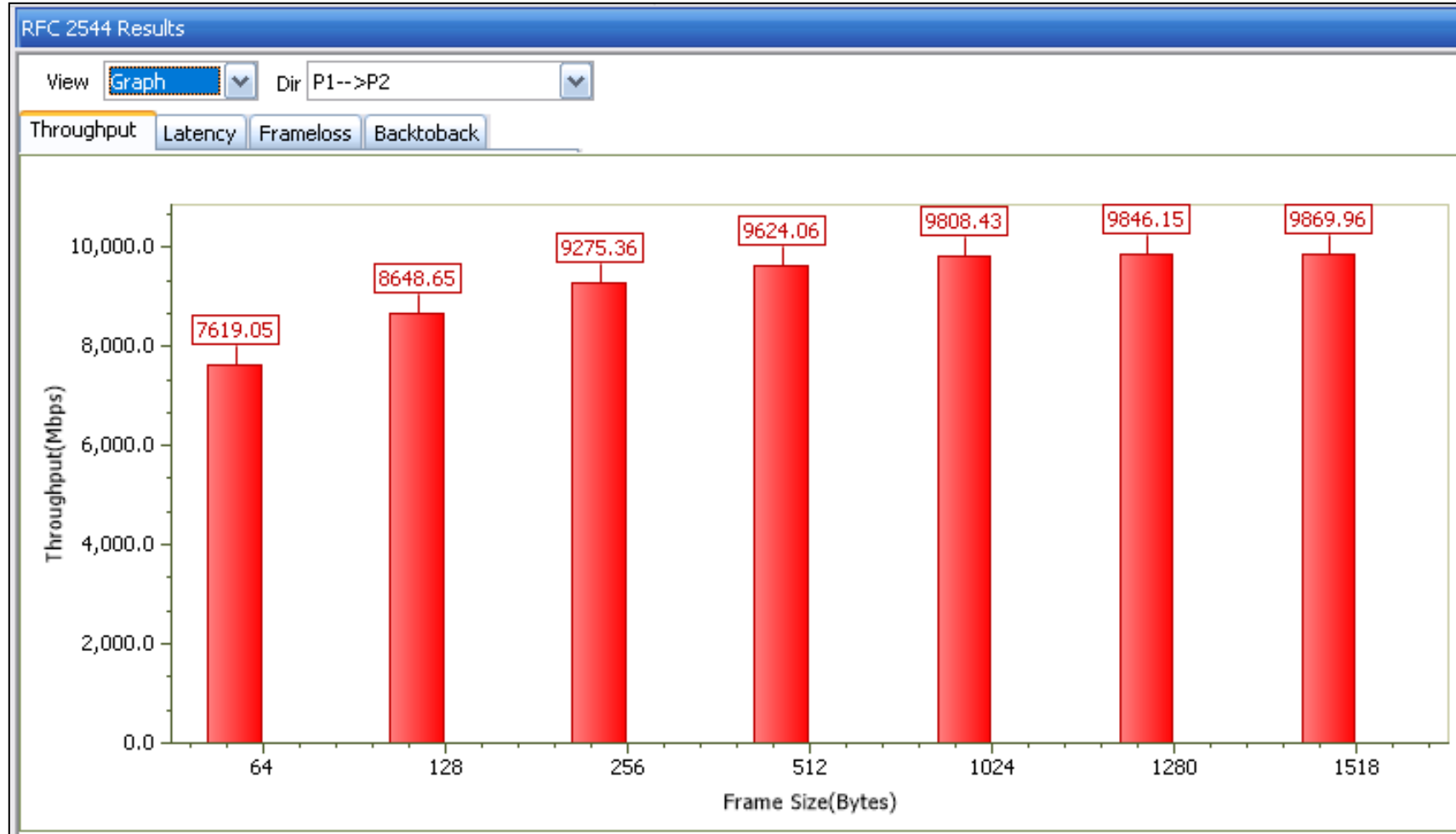
View: Statistics Dir: P1-->P2

Status: Throughput Latency Frameloss Backtoback

Frame Size	P1-->P2	P2-->P1
64	100.00 % 0.000 %	100.00 % 0.000 %
	90.00 % 0.000 %	90.00 % 0.000 %
	80.00 % 0.000 %	80.00 % 0.000 %
	70.00 % 0.000 %	70.00 % 0.000 %
	60.00 % 0.000 %	60.00 % 0.000 %
	50.00 % 0.000 %	50.00 % 0.000 %
	40.00 % 0.000 %	40.00 % 0.000 %
	30.00 % 0.000 %	30.00 % 0.000 %
	20.00 % 0.000 %	20.00 % 0.000 %
	10.00 % 0.000 %	10.00 % 0.000 %
	1.00 % 0.000 %	1.00 % 0.000 %
128	100.00 % 0.000 %	100.00 % 0.000 %
	90.00 % 0.000 %	90.00 % 0.000 %
	80.00 % 0.000 %	80.00 % 0.000 %
	70.00 % 0.000 %	70.00 % 0.000 %
	60.00 % 0.000 %	60.00 % 0.000 %
	50.00 % 0.000 %	50.00 % 0.000 %
	40.00 % 0.000 %	40.00 % 0.000 %
	30.00 % 0.000 %	30.00 % 0.000 %
	20.00 % 0.000 %	20.00 % 0.000 %
	10.00 % 0.000 %	10.00 % 0.000 %
	1.00 % 0.000 %	1.00 % 0.000 %
256	100.00 % 0.000 %	100.00 % 0.000 %
	90.00 % 0.000 %	90.00 % 0.000 %
	80.00 % 0.000 %	80.00 % 0.000 %
	70.00 % 0.000 %	70.00 % 0.000 %
	60.00 % 0.000 %	60.00 % 0.000 %
	50.00 % 0.000 %	50.00 % 0.000 %
	40.00 % 0.000 %	40.00 % 0.000 %
	30.00 % 0.000 %	30.00 % 0.000 %
	20.00 % 0.000 %	20.00 % 0.000 %
	10.00 % 0.000 %	10.00 % 0.000 %
	1.00 % 0.000 %	1.00 % 0.000 %
512	100.00 % 0.000 %	100.00 % 0.000 %
	90.00 % 0.000 %	90.00 % 0.000 %
	80.00 % 0.000 %	80.00 % 0.000 %
	70.00 % 0.000 %	70.00 % 0.000 %
	60.00 % 0.000 %	60.00 % 0.000 %
	50.00 % 0.000 %	50.00 % 0.000 %
	40.00 % 0.000 %	40.00 % 0.000 %
	30.00 % 0.000 %	30.00 % 0.000 %
	20.00 % 0.000 %	20.00 % 0.000 %
	10.00 % 0.000 %	10.00 % 0.000 %
	1.00 % 0.000 %	1.00 % 0.000 %

Graphs

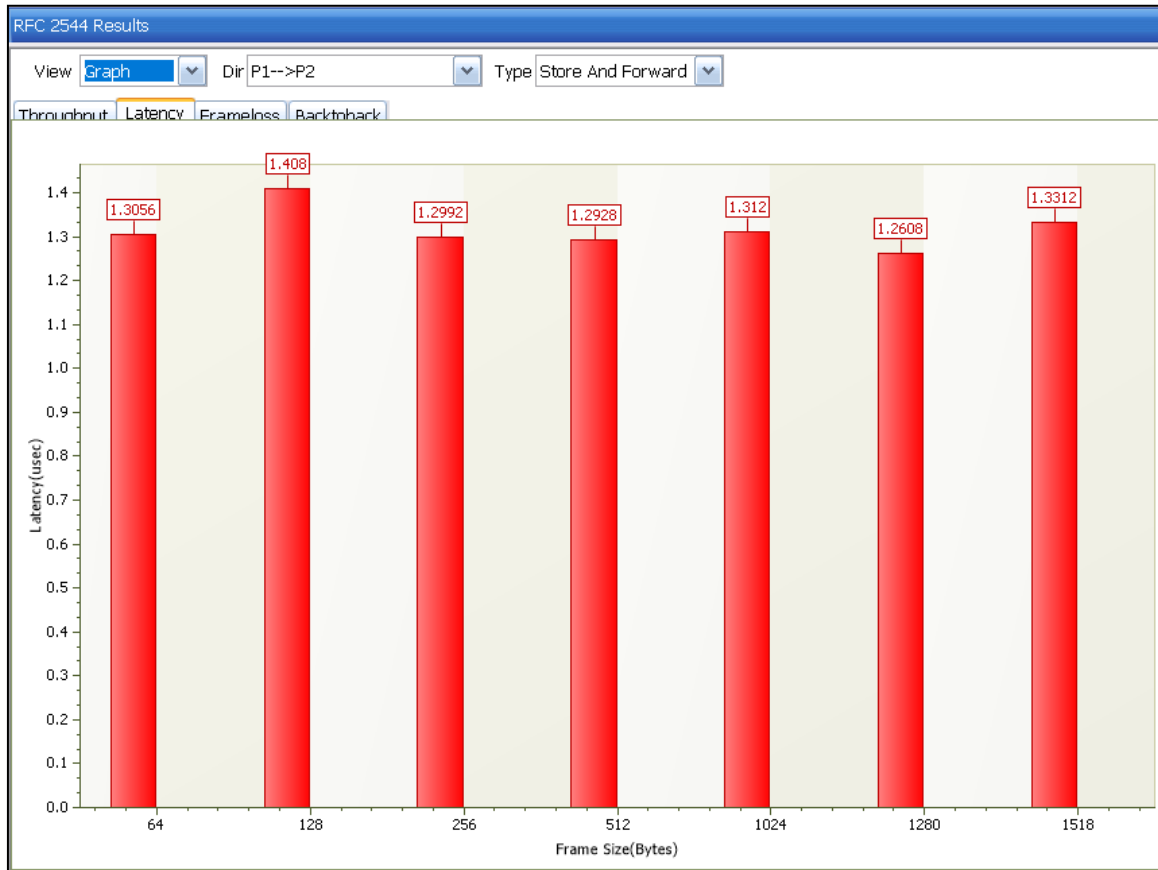
Throughput



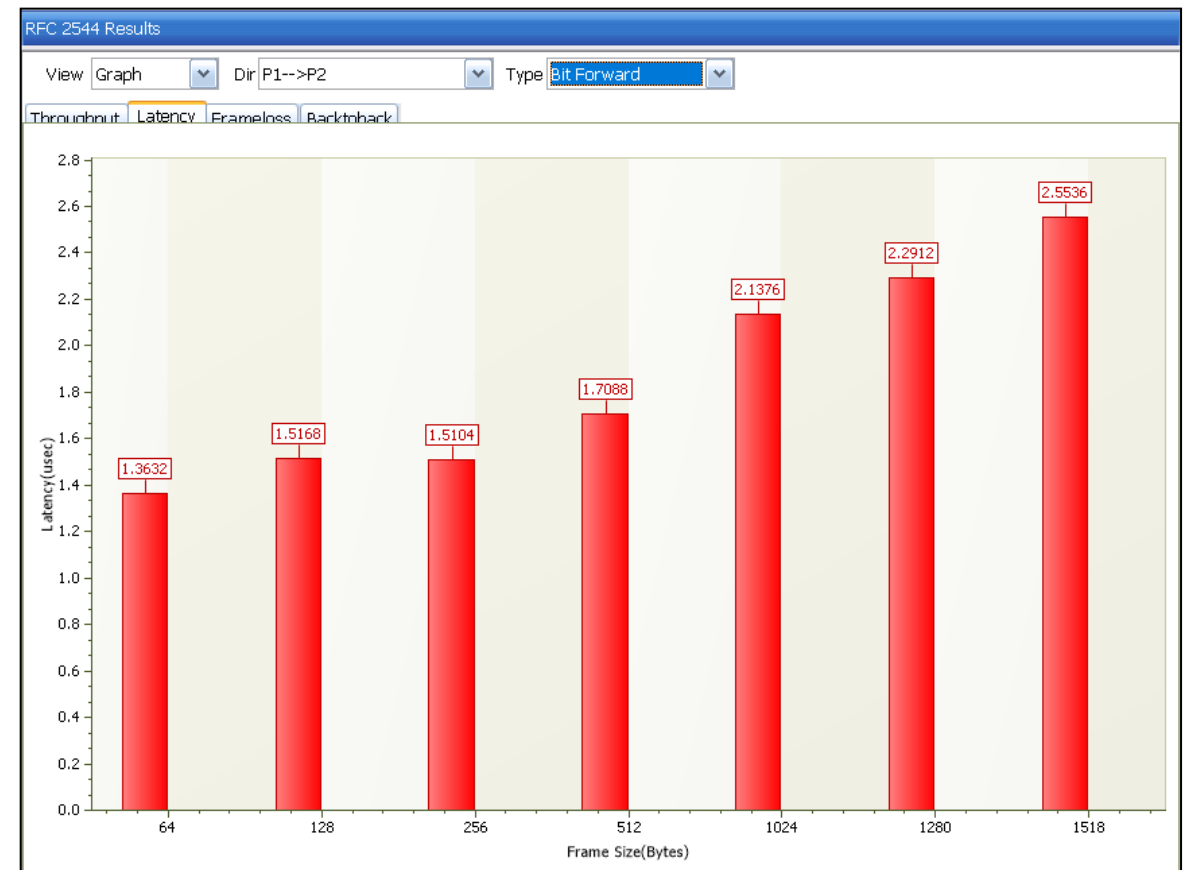
Graphs

Latency

Store and Forward Latency Test Graph

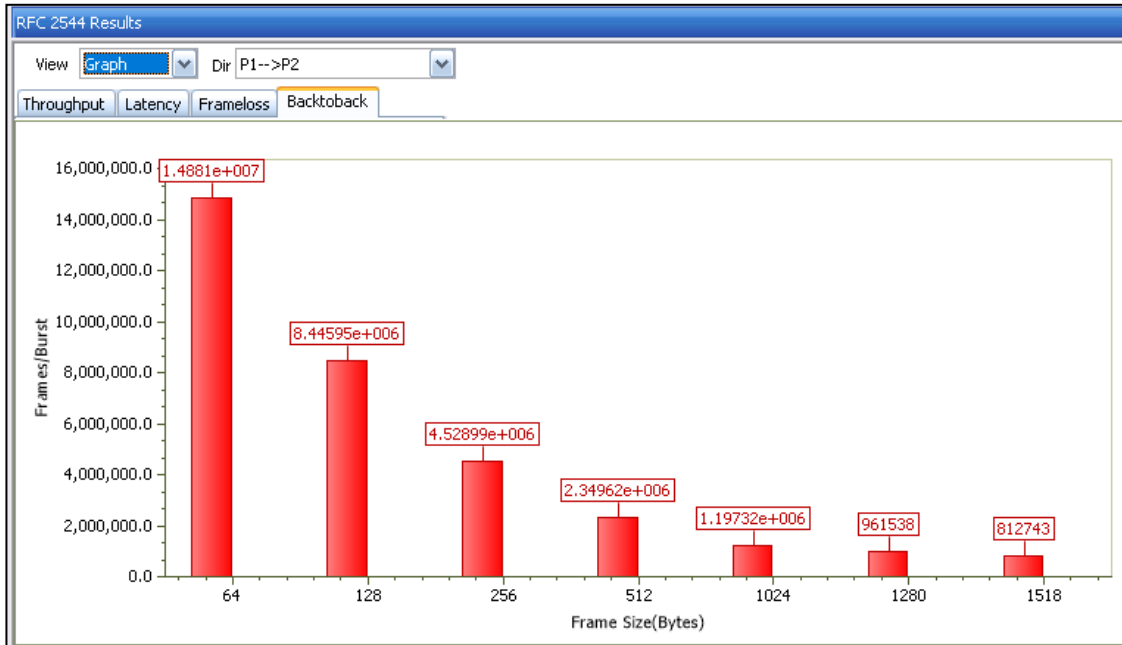


Bit Forward Latency Test Graph

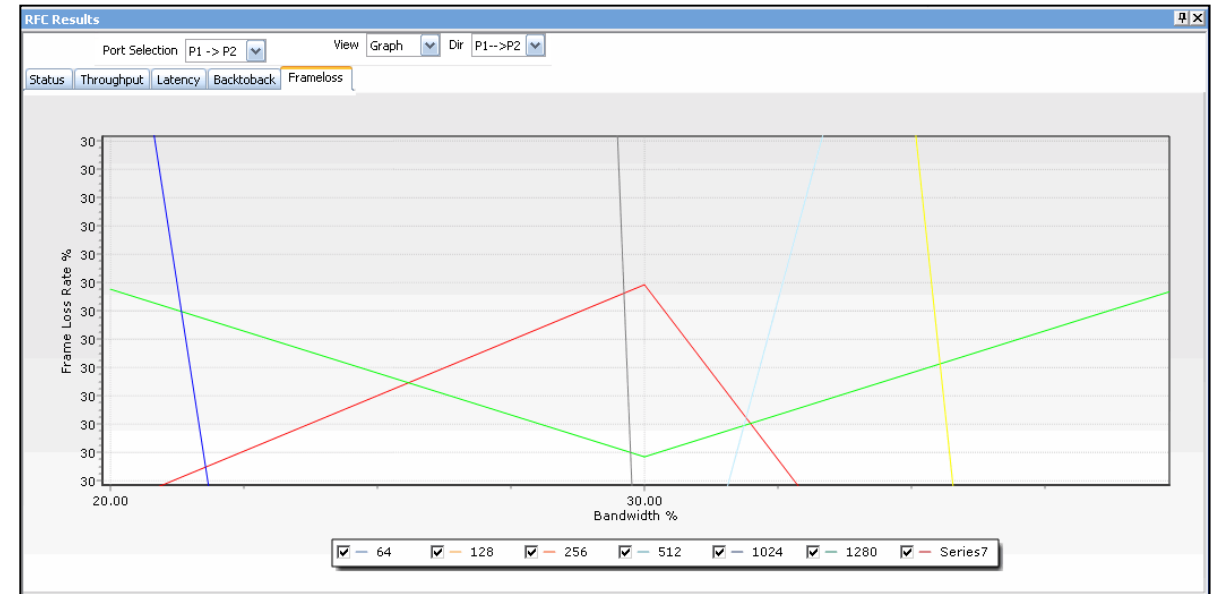


Graphs

Back-to-Back



Frame Loss



Port Statistics

- Per port detailed statistics are provided –
 - Tx / Rx Frame count
 - Number of Bytes transmitted & received
 - Tx & Rx Frame Rate
 - Broadcast, Multicast, Control, VLAN, Pause Frame count
 - Frame count for byte lengths 64/65-127
 - MPLS and VLAN Frame count for various stack level
 - IPv4/ UDP packet count
 - Oversized / Undersized Error frame count
 - FCS error count
 - IP/UDP checksum error count and others

Description	Tx	Rx
Total Frames	104 076 192	104 516 451
Valid Frames	104 076 192	104 516 451
Bad Frames	0	0
Number Of Bytes	12 750 702 144	12 778 878 720
Link Utilisation(%)	0.000	0.000
Data Rate(Mbps)	0.000	0.000
Frame Rate(Frames/sec)	0	0
Non Test Frames	0	104 513 878
Broadcast Frames	0	0
Multicast Frames	104 076 192	0
Control Frames	0	0
VLAN Frames	0	0
Pause Frames	0	0
Wrong Opcode Frames	0	0
Out of Bound Frames	0	0
Length Type Out of Range Frames	0	0
64 Byte Length Frames	76 221 601	76 661 860
65-127 Byte Length Frames	0	0
128-255 Byte Length Frames	14 239 206	14 239 206
256-511 Byte Length Frames	7 635 517	7 635 517
512-1023 Byte Length Frames	3 961 281	3 961 281
1024-1518 Byte Length Frames	2 018 587	2 018 587
Oversized Frames	0	0
Undersized Frames	-	0
FCS Error Frames	-	0
1 Level Stacked VLAN Frames	-	0
2 Level Stacked VLAN Frames	-	0
3 Level Stacked VLAN Frames	-	0
1 Level Stacked MPLS Frames	-	0
2 Level Stacked MPLS Frames	-	0
3 Level Stacked MPLS Frames	-	0
IP Checksum Errors	-	0
IPv4 Packets	-	104 513 878
IPv6 Packets	-	0
IP in IP Packets	-	0
UDP in IP Packets	-	104 513 878
TCP in IP Packets	-	0
ICMP in IP Packets	-	0
IGMP in IP Packets	-	0
IGRP in IP Packets	-	0
Other Protocol in IP Packets	-	0
UDP Checksum Errors	-	0
UDP Packets	-	104 513 878

Generate Reports

Reports

Choose Format: PDF

Title: PacketExpert

User Comments: Generate RFC 2544 result

Header: RFC2544-Throughput

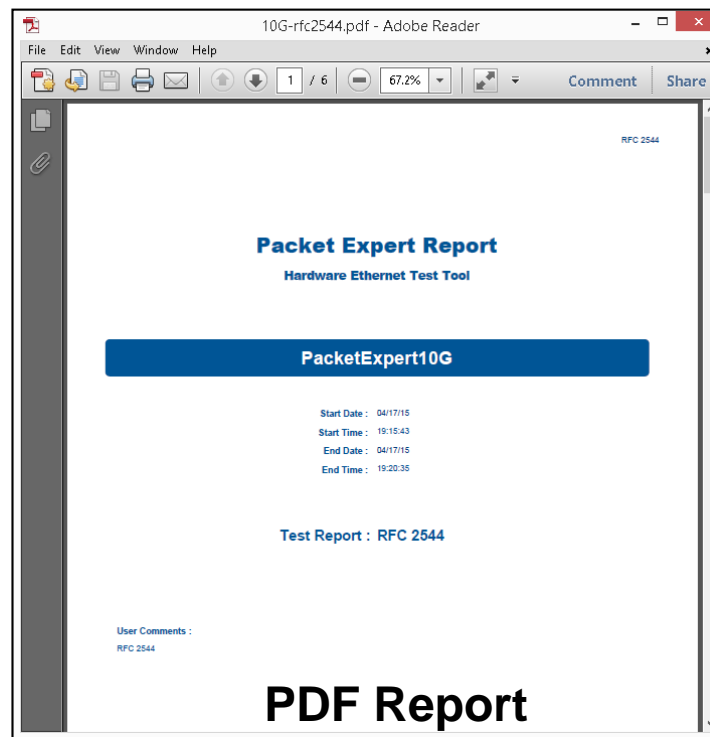
Footer: GL Communications

User Logo: Expert\GL_Logo.JPG

File name: PacketExpert\report1

Generate Report

Configuration



PDF Report

10g-rfc2544.csv - Excel

FILE HOME INSERT PAGE LAYOUT FORMULAS DATA REVIEW VIEW ADD-INS

A1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1		THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi	THP_Throi
2	P1->P2	8304.25	100	9125.72	100	9464.29	100	9613.68	100	9697.82	100	9751.8	100	9789.37	100	9817.03	100	9838.24
3																		
4																		
5																		
6																		
7																		
8																		

10g-rfc2544

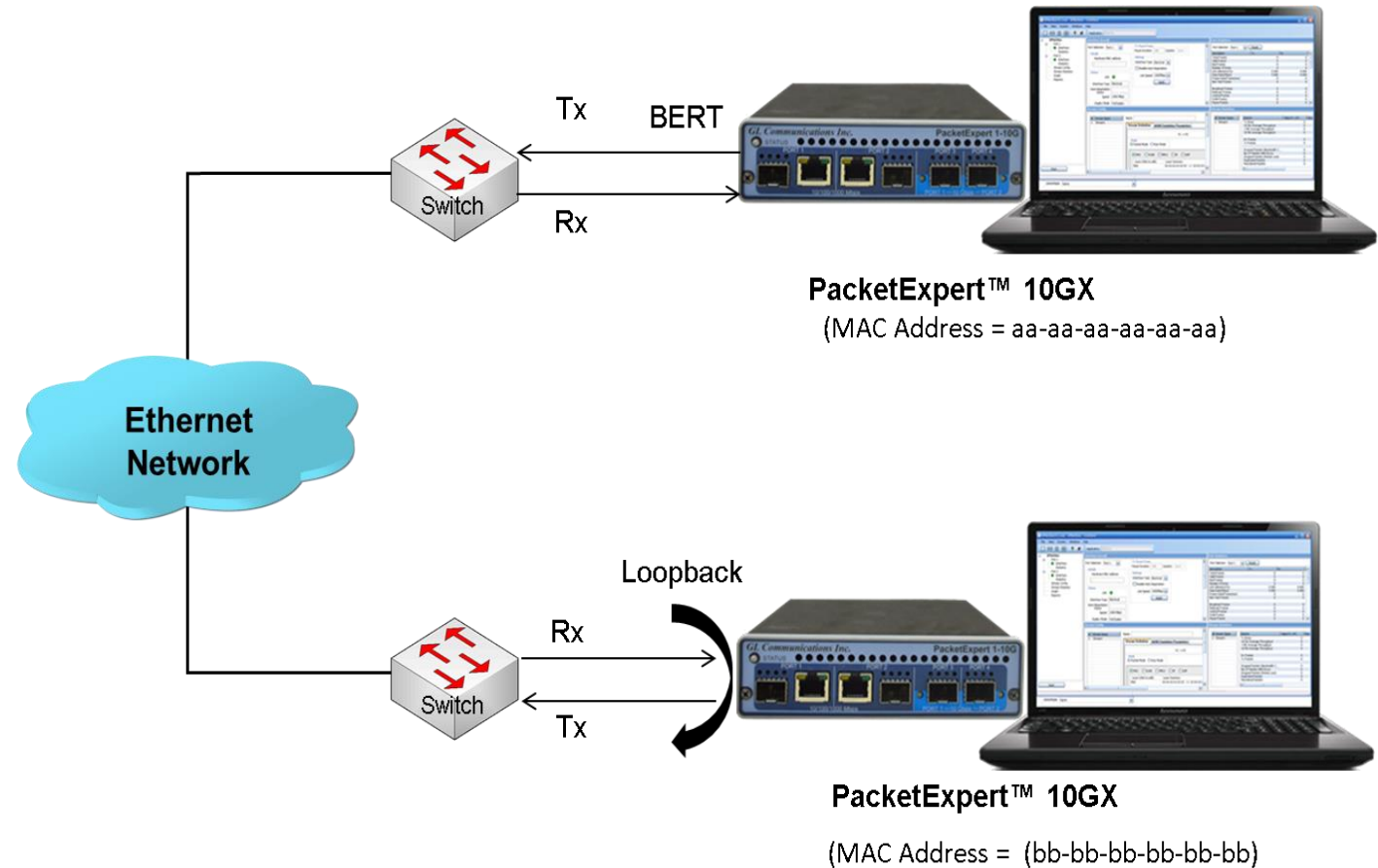
READY

CSV Report

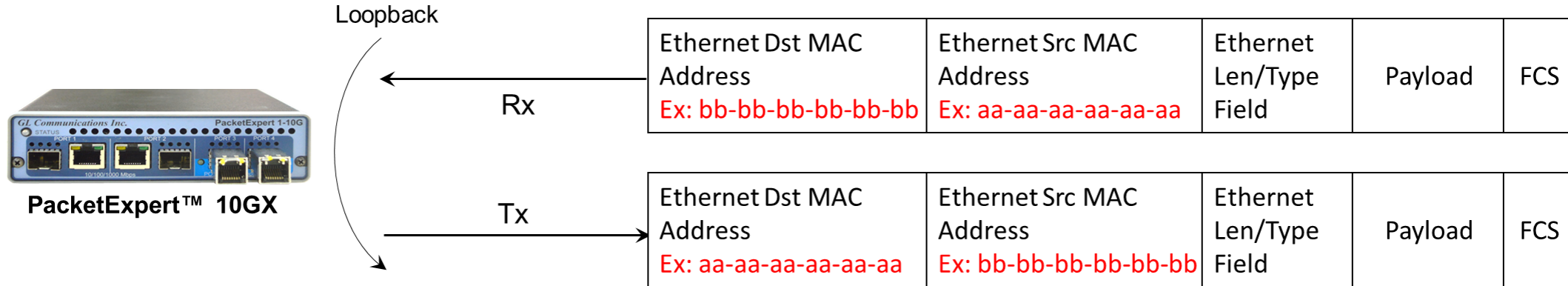
Smart Loopback

2 Ports BERT and Loopback

- Loopback helps in easy test setup, especially in end-to-end testing, when the other end is in a remote place
- In such cases, one PacketExpert™ 10GX can be put in constant Loopback at the remote end, and BERT tests can be started / stopped anytime at the local end

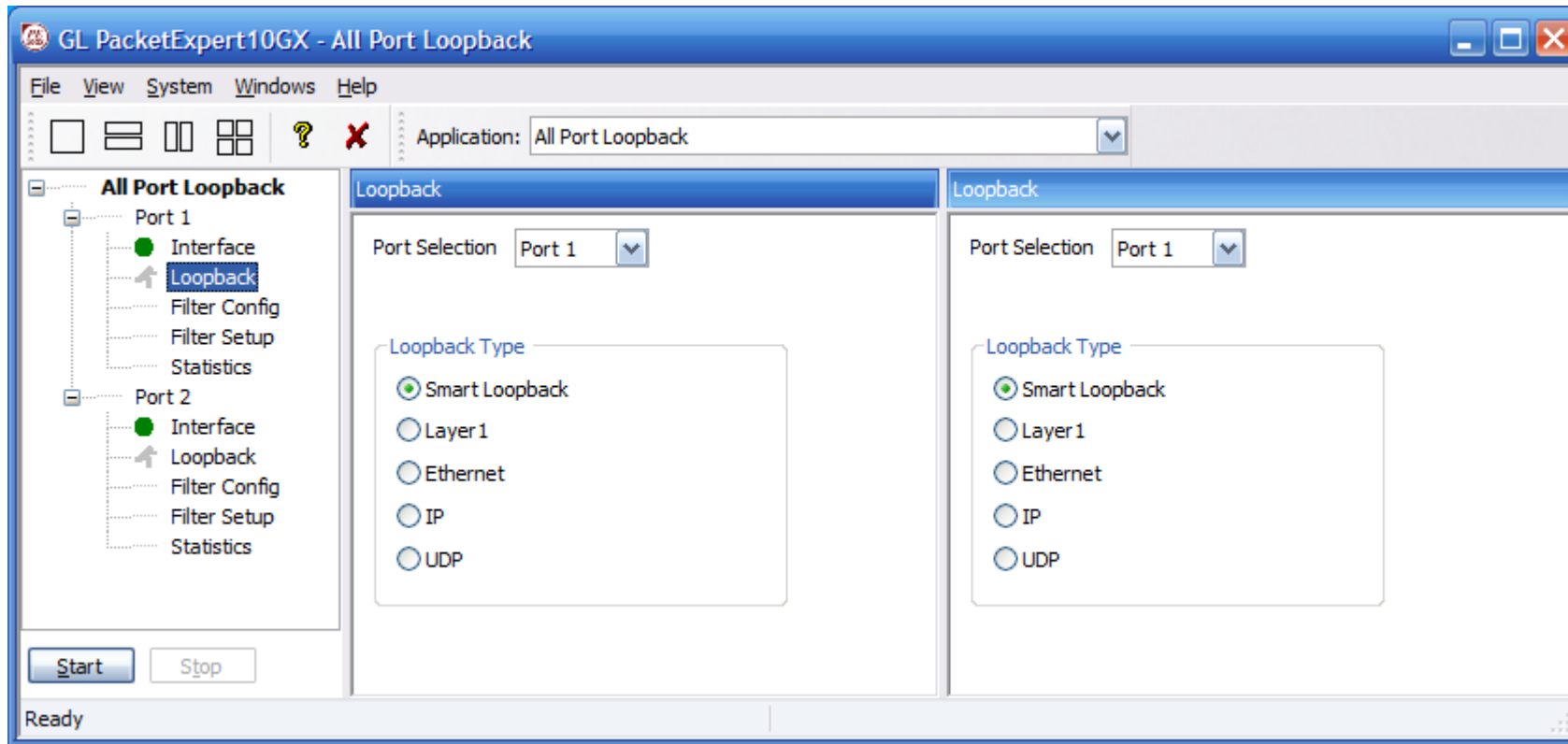


Layer 2 - Ethernet Loopback Types



- PacketExpert™ 10GX has all ports or 2 ports Loopback capability
- PacketExpert™ 10GX supports Layer-wise Loopback as well as Smart Loopback
- The above picture depicts the Ethernet Loopback type, swaps Source and Destination MAC addresses before sending back the packet

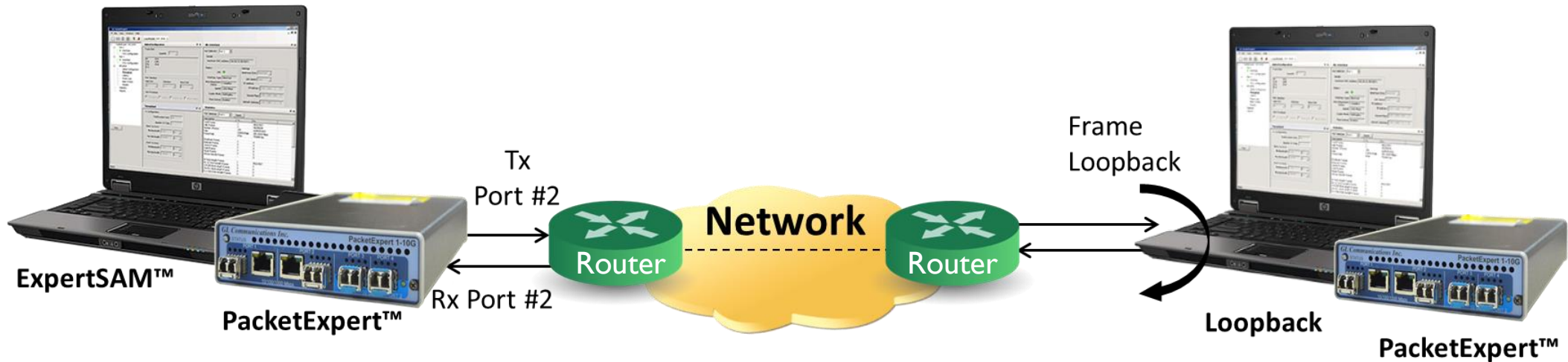
Loopback Testing (all ports or 2 ports)



- Supports Loopback on 10G / 1G ports
- Loopback Types – Smart Loopback, Layer 1, Ethernet, IP, UDP
- General statistics per port (similar to BERT port level statistics)

ITU-T Y.1564 (ExpertSAM™)

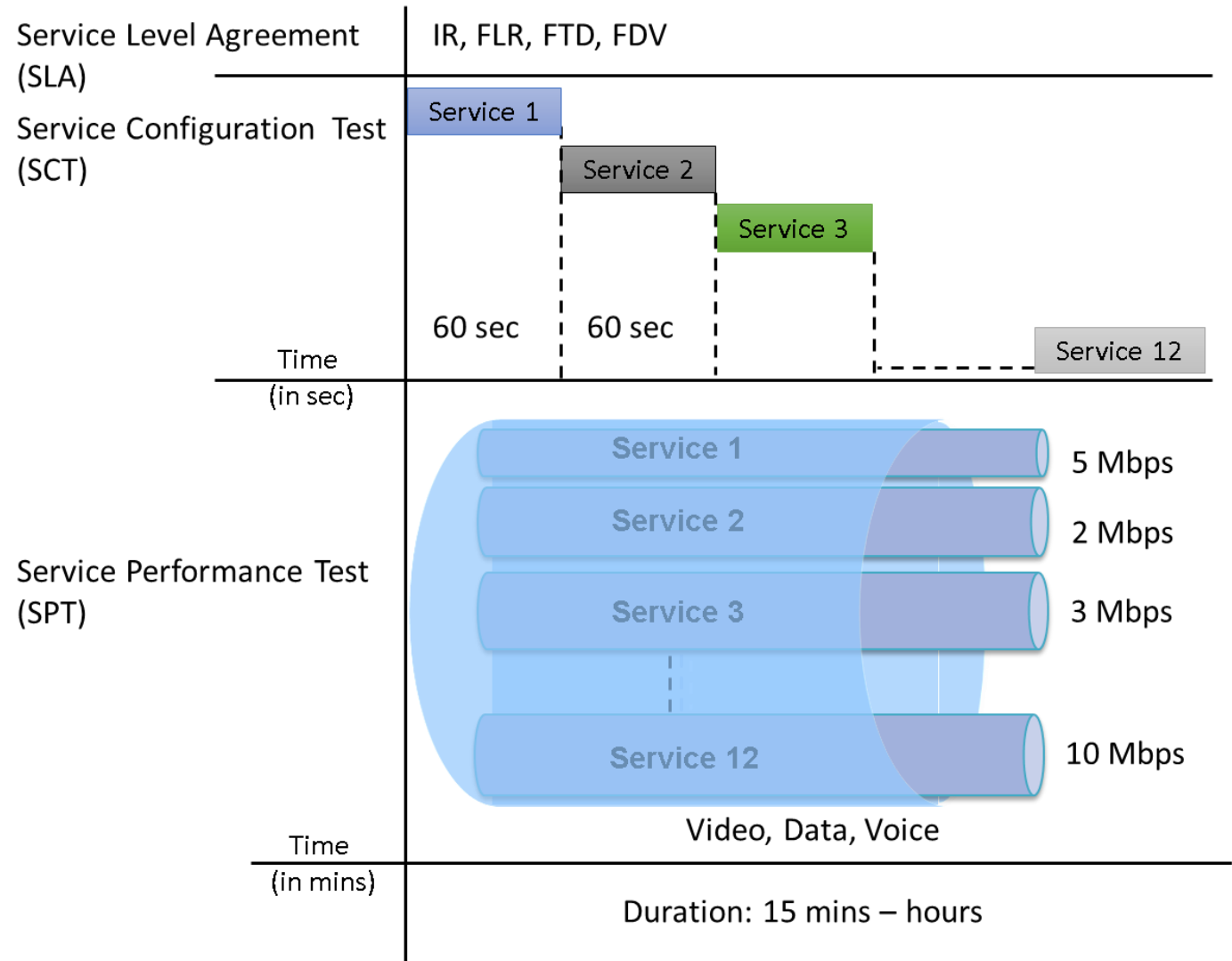
Ethernet Network Testing



- A single test to validate service-level agreements (SLAs) as per ITU-T Y.1564 standard.
- ITU-T Y.1564 completes this testing in two phases based on the SLA parameters:
 - Service Level Agreement Parameters: Information Rate (IR), Frame Transfer Delay (FTD), Frame Delay Variation (FDV), Frame Loss Ratio (FLR)
 - Service Configuration Test
 - Service Performance Test

ITU-T Y.1564 (ExpertSAM™)

- **Service Configuration Test** - confirms the end-to-end configuration with the SLA parameters for all configured traffic streams
- **Service Performance Test** - transmits all configured traffic streams simultaneously CIR confirming all traffic is able to transverse the network under full load with the above-mentioned parameters.



Highlights

- Complete validation of Ethernet service-level agreements (SLAs) in a single test
- ITU-T Y.1564 standard compliance
- Service Configuration and Service Performance tests methodology supported
- KPIs like Information Rate (IR) or Throughput, Frame Loss Ratio (FLR), Frame Transfer Delay (FTD) or Latency, and Frame Delay Variation (FDV) or Jitter, measured simultaneously for multi streams, and Pass/Fail verdict declared.
- Capability to generate traffic at throughput of CIR (guaranteed traffic), EIR (best effort bandwidth), and traffic policing (dropped bandwidth) rates ensuring Key performance indicators (KPI) validation
- EMIX frame sizes supported per service – up to 7 frame sizes can be defined per service
- Supports multiple services with varying performance requirements that meets full load conditions
- Stacked VLAN supported – C-Tag and S-Tag to simulate Carrier Ethernet traffic
- Simultaneous validation of all the services quality over time

RFC 2544 VS Y.1564 (ExpertSAM™)

	RFC 2544	Y.1564
Measurements	Throughput, burstability, frame loss and latency	Throughput, burstability, frame loss, latency, packet jitter, QoS
Services	Link level	Multiple concurrent service levels
Performance	Measuring maximum performance	Key performance indicators (KPI) validation
Throughput	No separation of the committed and excess traffic	CIR, EIR and Traffic Policing constantly ensuring that KPI are met during the test
Frame Delay	Tests one frame in every test time and does not consider any latency variation that might occur over a longer test period.	Latency is measured during the test on all the generated frames measuring any deviation out of the defined range
Frame loss	Frame loss is measured during rate distribution throughput test where the frame loss distribution doesn't align with committed rate without complying to the KPI	Frame loss measurement during throughput test
Frame Delay Variation	Frame delay variation is not measured	Frame delay variation is measured for traffic generated up to the CIR ensuring proper traffic prioritization

Service Configurations

Service Configuration Collapsed Summary View

Services

Service Services 1 Copy

Frame Size - Fixed,512

Layer - Ethernet,VLAN,IPv4,UDP

Ethernet - 00-21-c2-00-2c-80 -> 00-00-00-00-01-01, Len/Type(08-00)

VLAN - C-Tag,S-Tag

IPv4 - 192.168.1.101 -> 192.168.1.12 Protocol (UDP)

UDP - 1101 -> 1201

Payload - Fixed Pattern, 12-34

BW Profile - CIR = 60.000 Mbps,EIR = 80.000 Mbps,Policing Rate = 100.000

Color Aware = On, Color Method = VLAN S-Tag PCP

SAC Parameters - FLR = 1.000 %,FTD = 5.000 msec,FDV = 5.000 msec

Service Configuration Expanded View

Services

Service Services 1 Copy

Frame Size - Fixed,512

Layer - Ethernet,VLAN,IPv4,UDP

Ethernet

MAC

Source MAC Address 00-21-c2-00-2d-11

Destination MAC Address 00-00-00-00-01-01 Resolve

Length/Type 08-00 IPv4

VLAN

VLAN Enable

C-Tag Type 81-00 ID 6 Priority 6

S-Tag Type 88-A8 ID 12 Priority 7

IPv4 - 192.168.1.101 -> 192.168.1.11 Protocol (UDP)

UDP - 1101 -> 1201

Payload - Fixed Pattern, 12-34

BW Profile

CIR 625.00 Mbps

EIR 650.00 Mbps

Traffic Policing Rate 700.00 Mbps

Color Aware = On, Color Method = VLAN S-Tag PCP

Color Aware

Color Method VLAN S-Tag PCP

Green Frames 7

Yellow Frames 3

SAC Parameters


Frame Loss Ratio 1.00 %

Frame Transfer Delay 5.000 msec


Frame Delay Variation 5.000 msec

Service Configuration Test Results



Service Result Overview

Service Configuration Results Overview							
Overview 							
#	Service Name	Verdict	Current Step	Max IR(Mbps)	FLR(%)	Max FTD(msec)	Max FDV(msec)
1	↑ Service 1	✓	-	625.00	0.000	0.0014	0.000038
2	↑ Service 2	✓	-	625.00	0.000	0.0014	0.000038
3	↑ Service 3	✓	-	625.00	0.000	0.0014	0.000038
4	↑ Service 4	✓	-	625.00	0.000	0.0014	0.000038
5	↑ Service 5	✓	-	625.00	0.000	0.0014	0.000038
6	↑ Service 6	✓	-	625.00	0.000	0.0014	0.000038
7	↑ Service 7	✓	-	625.00	0.000	0.0014	0.000038
8	↑ Service 8	✓	-	625.00	0.000	0.0014	0.000038
9	↑ Service 9	✓	-	625.00	0.000	0.0014	0.000038
10	↑ Service 10	✓	-	625.00	0.000	0.0014	0.000038
11	↑ Service 11	✓	-	625.00	0.000	0.0014	0.000038
12	↑ Service 12	✓	-	625.00	0.000	0.0014	0.000038
13	↑ Service 13	✓	-	625.00	0.000	0.0014	0.000038
14	↑ Service 14	✓	-	625.00	0.000	0.0014	0.000038
15	↑ Service 15	✓	-	625.00	0.000	0.0014	0.000038
16	↑ Service 16	✓	-	625.00	0.000	0.0014	0.000038






Service Detail Results

Service Configuration Results Details																
Service	Service1	IR(Mbps), FLR(%), FTD(ms), FDV(ms)					Vertical 	FTD Unit	msec	FDV Unit	msec					
Test	Verdict	IR (Curr)	IR (Min)	IR (Avg)	IR (Max)	FL (Count)	FLR (Rate)	FTD (Curr)	FTD (Min)	FTD (Avg)	FTD (Max)	FDV (Curr)	FDV (Min)	FDV (Avg)	FDV (Max)	
CIR	PASS	624.99	624.99	625.00	625.00	0	0.000	0.001	0.001	0.002	0.001	< 1us	0.000	< 1us	< 1us	
EIR	PASS	649.99	649.99	650.00	650.00	1	0.000	0.001	0.001	0.002	0.001	< 1us	0.000	< 1us	< 1us	

Service Performance Test Overall Status

Overall Status  Global Verdict PASS 

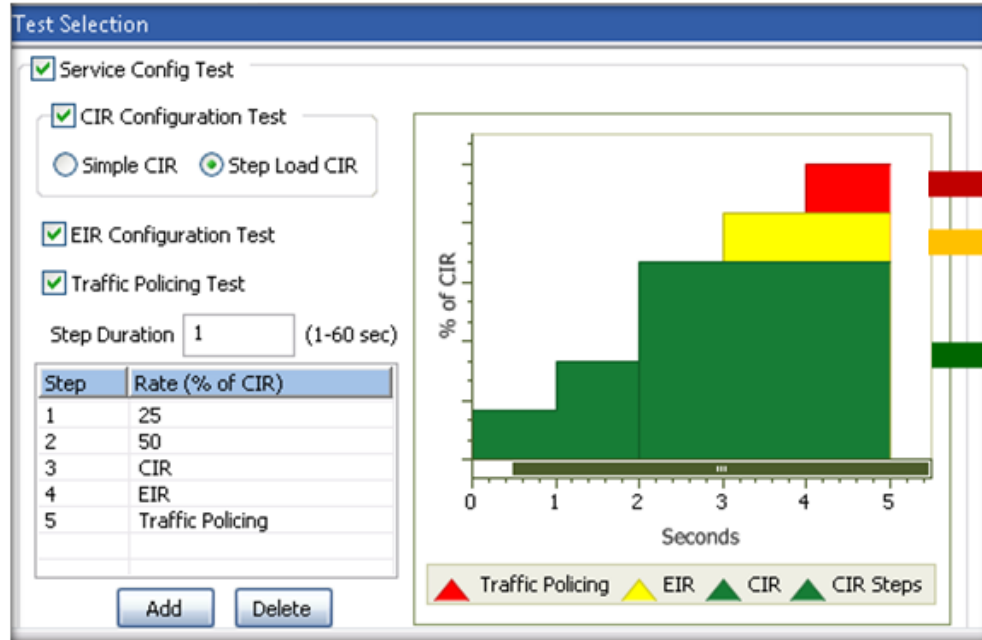
Test	Stream No	Subtest	Step No
Service Performance Test	-	-	-

Alarm	Status
Link Status	
IR	
FLR	
FTD	
FDV	

Service Performance Test Results

Service Performance Results															
IR(Mbps), FLR(%), FTD(msec), FDV(msec)		Test Time 00:00:16		Vertical		FTD Unit msec		FDV Unit usec							
Service	Verdict	IR (Curr)	IR (Min)	IR (Avg)	IR (Max)	FL (Count)	FLR (Rate)	FTD (Curr)	FTD (Min)	FTD (Avg)	FTD (Max)	FDV (Curr)	FDV (Min)	FDV (Avg)	FDV (Max)
1	PASS	625.00	625.00	625.00	625.00	2	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.122000
2	PASS	625.00	625.00	625.00	625.00	2	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.115000
3	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.115000
4	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.122000
5	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.122000
6	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.128000
7	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.115000
8	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.122000
9	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.122000
10	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.122000
11	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.115000
12	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.122000
13	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.122000
14	PASS	625.00	625.00	625.00	625.00	3	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.122000
15	PASS	625.00	625.00	625.00	625.00	2	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.122000
16	PASS	624.95	624.94	624.95	624.95	2	0.000	0.018	0.001	0.015	0.021	0.003000	0.003000	0.003000	8.128000

ITU-T Y.1564 (ExpertSAM™) Graph

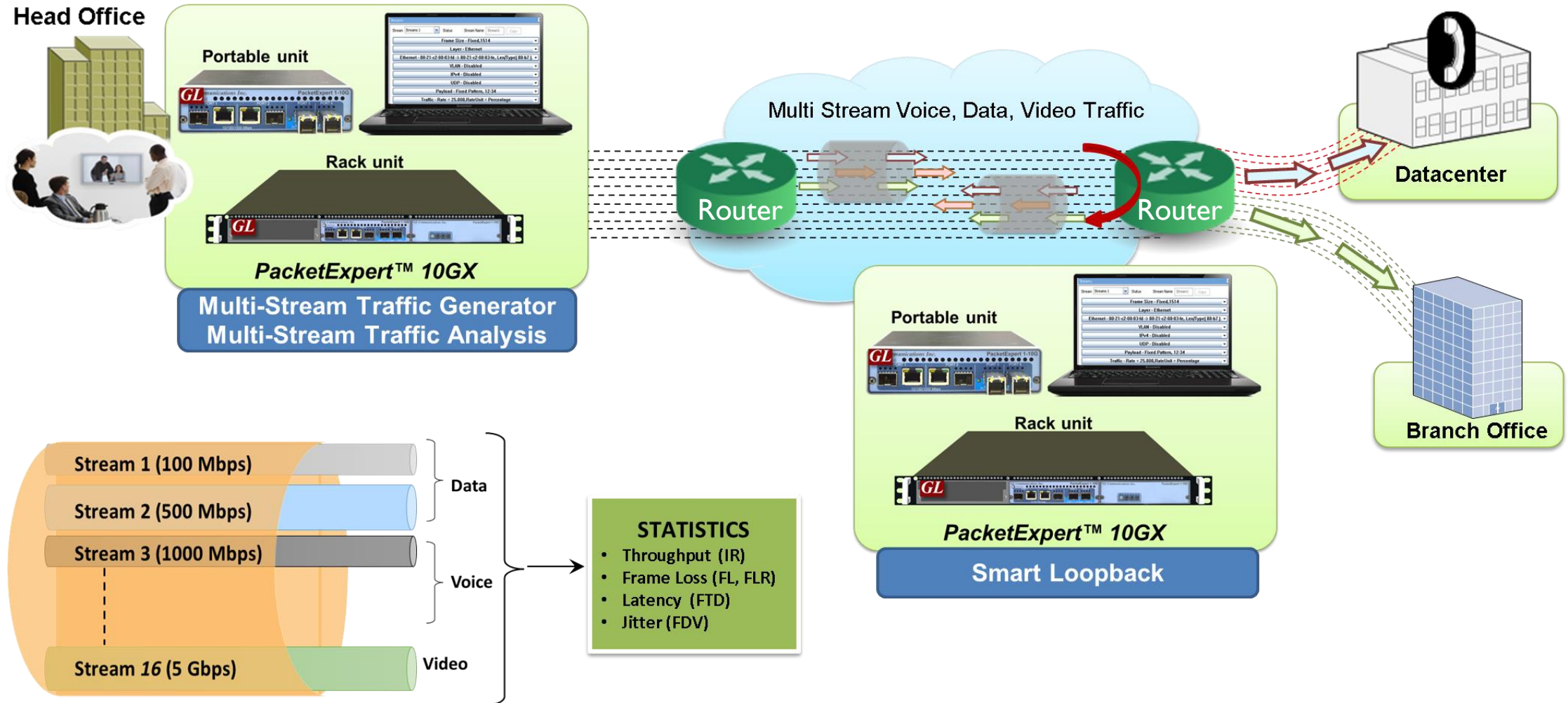


→ Dropped bandwidth (everything over EIR)
→ Best effort bandwidth (everything between CIR and EIR)
→ Guaranteed bandwidth (everything under CIR)

- Committed information rate or CIR is the average bandwidth guaranteed by a service provider. At any given time, the bandwidth should not fall below this committed figure.
- Excess Information Rate or EIR is the CIR plus excess rate that service provider claims to provide on a 'best-effort' basis.

Multi-Stream Traffic Generator and Analyzer

Multi-Stream Traffic Generator and Analyzer (1 Gbps, 2.5 Gbps, or 10 Gbps)



Multi-Stream Traffic Generator & Analyzer Results

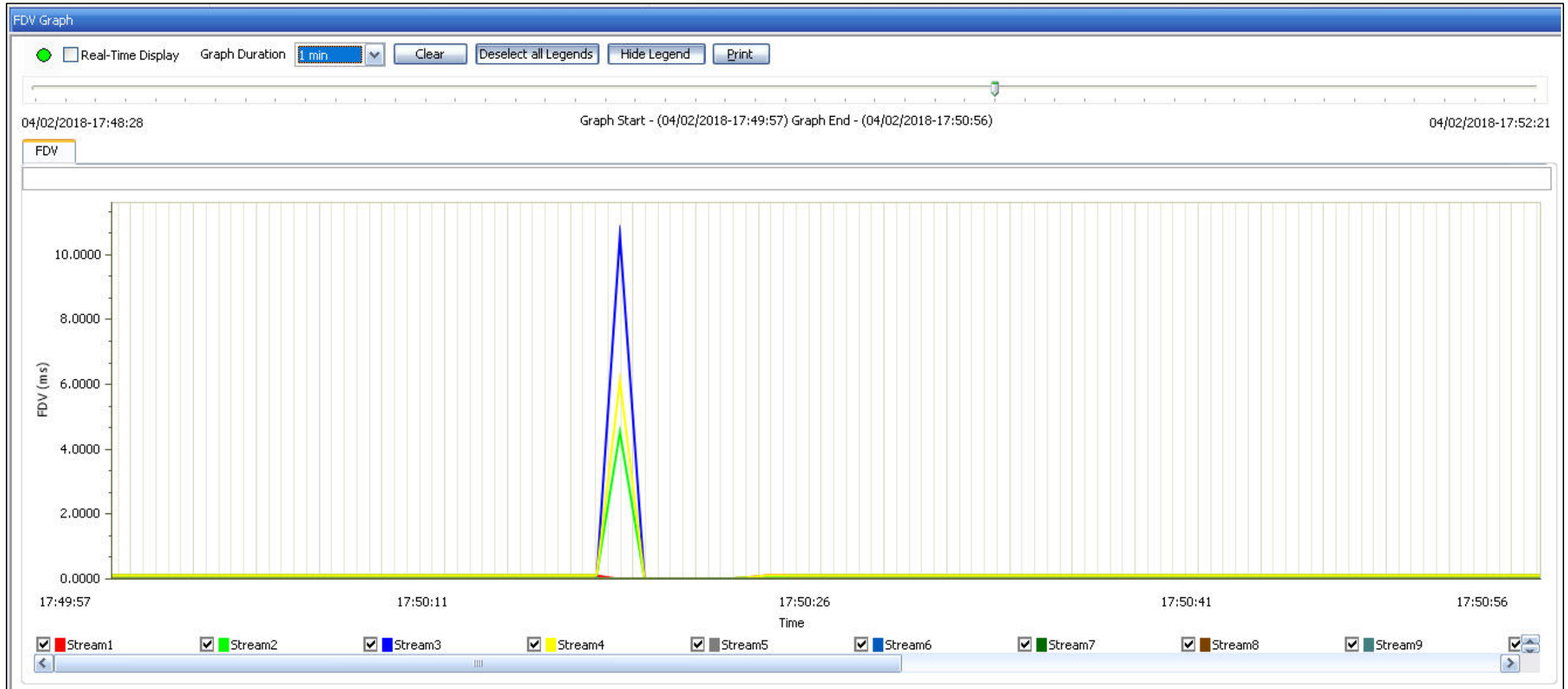
(Horizontal View)

Multi-Stream Traffic Generator & Analyzer Results																			
IR(Mbps), FLR(%), FTD(msec), FDV(msec)		Test Time	00:00:53		Vertical		FTD Unit	msec	FDV Unit	msec	Activate All	DeActivate All							
Stream No	Seconds	TxFrames	RxFrames	RxBytes	FL Count	FLR	IR (Curr)	IR (Min)	IR (Max)	IR (Avg)	FTD	FTD	FTD	FTD	FDV (Curr)	FDV (Min)	FDV (Max)	FDV (Avg)	
<input checked="" type="checkbox"/>	1	55	1 146 226	1 125 387	679 852 618	20 839	1.818	104.05	104.03	104.06	133.78	0.002	0.001	0.003	0.002	< 1us	0.000	0.001	< 1us
<input checked="" type="checkbox"/>	2	55	1 278 940	1 255 686	642 911 232	23 254	1.818	98.97	98.94	98.97	127.24	0.002	0.001	0.003	0.002	< 1us	0.000	0.001	< 1us
<input checked="" type="checkbox"/>	3	55	5 832 149	5 726 109	7 902 030 420	106 040	1.818	1187.65	1187.30	1187.65	1526.96	0.002	0.002	0.003	0.002	< 1us	0.000	< 1us	< 1us
<input checked="" type="checkbox"/>	4	55	1 214 894	1 192 804	1 646 069 520	22 090	1.818	247.40	247.33	247.41	318.08	0.002	0.002	0.003	0.002	< 1us	< 1us	< 1us	< 1us
<input checked="" type="checkbox"/>	5	55	155 163	152 342	157 521 628	2 821	1.818	23.79	23.79	23.80	30.58	0.002	0.002	0.003	0.002	< 1us	< 1us	< 1us	< 1us
<input checked="" type="checkbox"/>	6	55	18 212 176	17 881 043	2 324 535 590	331 133	1.818	397.36	397.24	397.36	510.89	0.002	0.001	0.003	0.002	< 1us	0.000	0.001	< 1us
<input checked="" type="checkbox"/>	7	55	14 585 983	14 320 782	19 762 679 160	265 201	1.818	2970.25	2969.39	2970.26	3818.88	0.002	0.002	0.003	0.002	< 1us	0.000	< 1us	< 1us
<input checked="" type="checkbox"/>	8	55	5 216 779	5 121 928	5 244 854 272	94 851	1.818	792.20	791.97	792.20	1018.53	0.002	0.002	0.003	0.002	< 1us	0.000	< 1us	< 1us
<input checked="" type="checkbox"/>	9	55	1 535 124	1 507 212	771 692 544	27 912	1.818	118.79	118.76	118.79	152.73	0.002	0.001	0.003	0.002	< 1us	0.000	0.001	< 1us
<input checked="" type="checkbox"/>	10	55	3 434 715	3 372 265	674 453 000	62 450	1.818	109.91	109.88	109.91	141.31	0.002	0.001	0.003	0.002	< 1us	0.000	0.001	< 1us
<input checked="" type="checkbox"/>	11	55	3 176 550	3 118 794	405 443 220	57 756	1.818	69.31	69.29	69.31	89.11	0.002	0.001	0.003	0.002	< 1us	0.000	0.001	< 1us
<input checked="" type="checkbox"/>	12	55	9 085 290	8 920 101	1 159 613 130	165 189	1.818	198.22	198.17	198.23	254.86	0.002	0.002	0.003	0.002	< 1us	0.000	< 1us	< 1us
<input checked="" type="checkbox"/>	13	55	9 844 599	9 665 605	5 841 891 662	178 994	1.818	894.11	893.85	894.12	1149.56	0.002	0.001	0.003	0.002	< 1us	0.000	0.001	< 1us
<input checked="" type="checkbox"/>	14	55	27 539 785	27 039 059	16 342 406 346	500 726	1.818	2501.23	2500.50	2501.23	3215.84	0.002	0.001	0.003	0.002	< 1us	0.000	0.001	< 1us
<input checked="" type="checkbox"/>	15	55	395 501	388 310	793 705 640	7 191	1.818	118.74	118.71	118.74	152.66	0.003	0.002	0.003	0.003	< 1us	0.000	< 1us	< 1us
<input checked="" type="checkbox"/>	16	55	1 090 764	1 090 764	658 606 880	0	0.000	98.97	98.94	98.98	129.60	0.002	0.002	0.003	0.002	< 1us	0.000	< 1us	< 1us

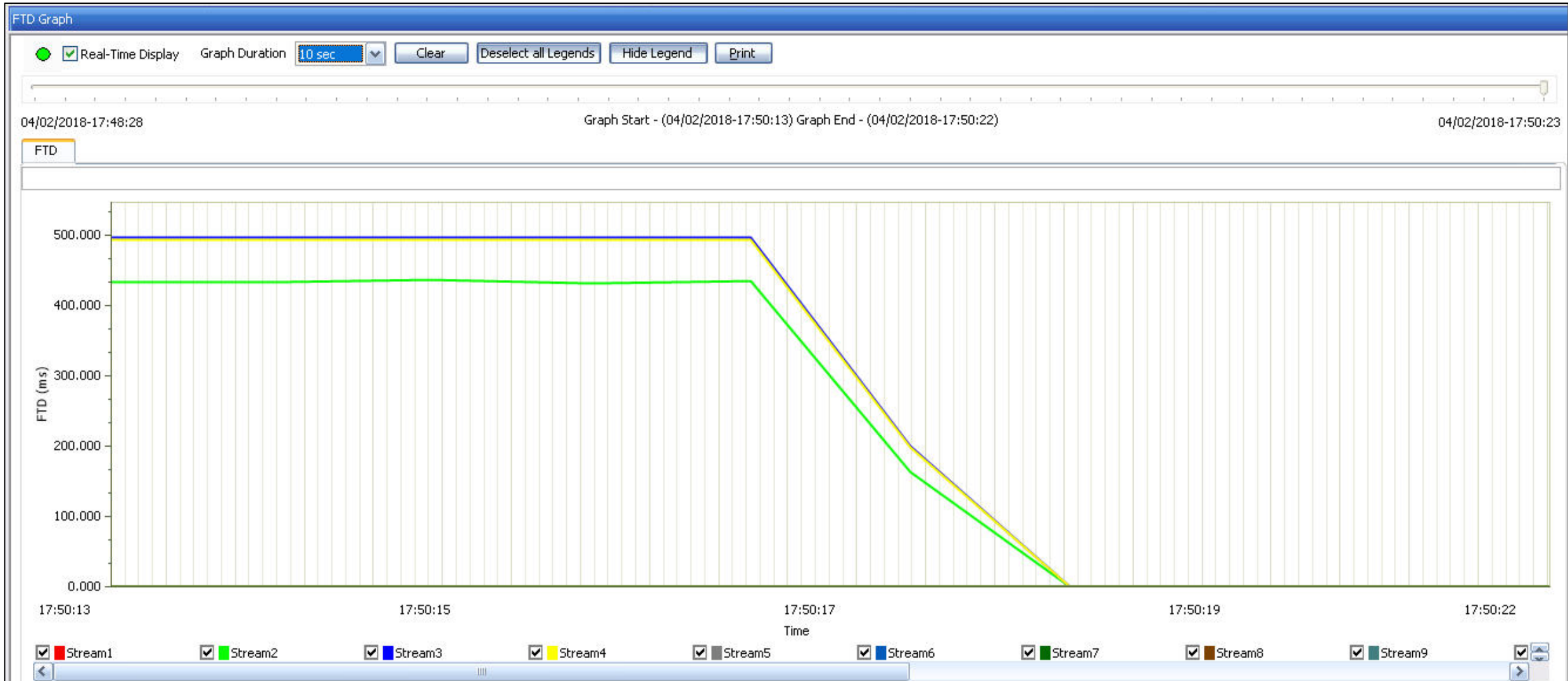
Throughput (IR) Graph



Frame Delay Variation – FDV Graph



Frame Transfer Delay – FTD Graph



Report Generation in PDF and CSV Format

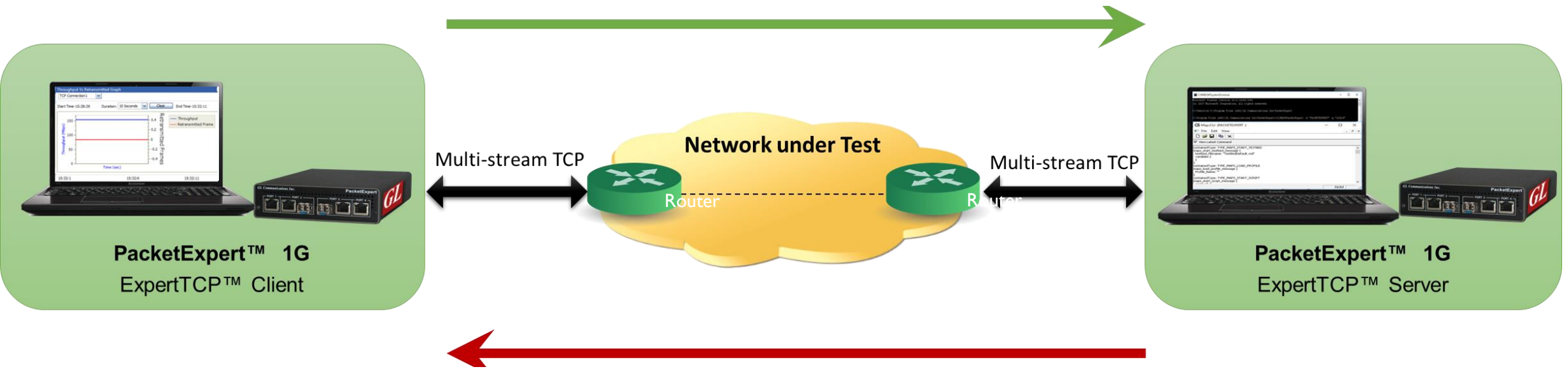
The image displays two overlapping windows. The background window is an Adobe Reader showing a PDF report titled 'Expert Analyzer'. The report is titled 'Stream - 16 Configuration' and contains several sections: 'Framesize', 'Layer', 'Ethernet', and 'VLAN'. The 'Framesize' section shows 'Framesize Type: Fixed' and 'Framesizes: 700'. The 'Layer' section shows 'Layer: UDP'. The 'Ethernet' section shows 'Src MAC Address: 00-21-c2-00-23-93', 'Dest MAC Address: 18-18-18-18-18-18', and 'Len/Type: 08-00'. The 'VLAN' section shows 'VLAN C Tag: Disabled', 'VLAN S Tag: 88-a8', and 'VLAN ID: 13'. The report ends with 'End Of Report'.

The foreground window is an Excel spreadsheet titled 'Test.csv.csv - Excel'. It contains a table with 14 columns and 19 rows. The columns are labeled A through M, and the rows are labeled 1 through 19. The data in the table is as follows:

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Stream	TxFrames	RxFrames	RxBytes	IR(Min)	IR(Max)	IR(Avg)	FTD(Min)	FTD(Max)	FTD(Avg)	FDV(Min)	FDV(Max)	FDV(Avg)
2													
3	Stream1	67087646	67087646	5232836388	455.876	1007.866	992.391	0.001	0.002	0.002	0.000004	0.000004	0.000004
4	Stream2	432739	432739	56256070	4.5	9.95	9.798	0.001	0.002	0.002	0.000021	0.000022	0.000021
5	Stream3	298307	298307	156312868	11.25	24.88	24.495	0.001	0.002	0.002	0.000026	0.000027	0.000027
6	Stream4	11971	11971	6272804	0.453	0.997	0.983	0.001	0.002	0.002	0.000508	0.000533	0.000528
7	Stream5	6148	6148	6357032	0.455	0.995	0.978	0.002	0.002	0.002	0.000006	0.000008	0.000007
8	Stream6	17378151	17378151	2259159630	180.748	399.604	393.468	0.001	0.002	0.002	0.000004	0.000005	0.000004
9	Stream7	139124	139124	191991120	13.507	29.859	29.4	0.002	0.002	0.002	0.000004	0.000005	0.000005
10	Stream8	4977550	4977550	5097011200	360.322	796.614	784.387	0.002	0.002	0.002	0.000005	0.000005	0.000005
11	Stream9	1464518	1464518	749833216	54.021	119.436	117.604	0.001	0.002	0.002	0.00001	0.00001	0.00001
12	Stream10	118093	118093	23618600	1.8	3.983	3.922	0.001	0.002	0.002	0.000039	0.00004	0.000039
13	Stream11	302998	302998	39389740	3.151	6.968	6.86	0.001	0.002	0.002	0.000027	0.000028	0.000028
14	Stream12	389546	389546	50640980	4.051	8.957	8.82	0.001	0.002	0.002	0.000025	0.000025	0.000025
15	Stream13	1081929	1081929	432771600	31.51	69.66	68.59	0.001	0.002	0.002	0.000012	0.000013	0.000012
16	Stream14	834741	834741	626055750	44.568	98.535	97.019	0.002	0.002	0.002	0.000014	0.000015	0.000014
17	Stream15	18118	18118	12682600	0.904	1.999	1.969	0.002	0.002	0.002	0.000133	0.00014	0.000137
18	Stream16	9059	9059	6341300	0.449	1.002	0.985	0.002	0.002	0.002	0.000318	0.000326	0.000322
19													

ExpertTCP™-TCP Throughput Testing (RFC 6349)

ExpertTCP™ (RFC-6349 Testing)



ExpertTCP™ Main Screen

The screenshot displays the ExpertTCP main interface with the following sections:

- Interface - Local (Port1):**
 - Details: Hardware MAC address: 00-21-C2-00-2C-81
 - Settings: Interface Type: Electrical, Link Speed: 1000Mbps
 - Status: Link: ●, Interface Type: Optical, Auto-Negotiation Status: -, Speed: 10 Gbps, Duplex Mode: Full Duplex, Flow Control: Enabled
- TCP Setup:**
 - No of TCP Connection: 16
 - TCP Port Configuration: Automatic, Manual

TCP Connection No.	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
9	5008	6008
10	5009	6009
11	5010	6010
12	5011	6011


- Network Setup:**
- Diagram: Client (Local) connected to Network Under Test
- MAC Address: User Defined, Value: 00-21-c2-00-2c-81
- Link Type: Symmetrical, Asymmetrical
- Upstream CIR: 1000.00 Mbps, Downstream CIR: 1000.00 Mbps
- IP Address: 192.168.1.111, Subnet Mask: 255.255.255.0, Default Gateway: 192.168.1.1
- Test Setup:**
- Direction: Upstream ↑, Downstream ↓, Upstream and Downstream ↑↓
- Transfer Size: 12500.000 MBytes
- Test Selection:
 - Run Throughput Test
 - Run Path MTU Test: Upstream MTU: 850 Bytes, Downstream MTU: 850 Bytes
 - Run Baseline RTT Test: Upstream RTT: 0.056 msec, Downstream RTT: 0.056 msec

Network Setup

All settings configured locally on the client side

Remote

Remote Server IP Address: 192 . 168 . 1 . 232


Status: Connected 

Interface - Local (Port1)

Details

Hardware MAC address: 00-21-C2-00-2C-81

Status

Link 

Interface Type: Optical

Auto-Negotiation Status: -

Speed: 10 Gbps

Duplex Mode: Full Duplex

Flow Control: Enabled

Settings

Interface Type: Optical


Link Speed: 10000Mbps

Interface - Remote(Port1)

Details

Hardware MAC address: 00-21-C2-00-2D-11

Status

Link 

Interface Type: Optical

Auto-Negotiation Status: -

Speed: 10 Gbps

Duplex Mode: Full Duplex

Flow Control: Enabled

Settings

Interface Type: Optical

Link Speed: 10000Mbps

Status and Results

Overall Status

Test Status: Done

Current Direction: -

Current Test

Test	Status	Result
Path MTU (Upstream)	<input type="button" value="↑"/>	<input checked="" type="checkbox"/>
Baseline RTT (Upstream)	<input type="button" value="↑"/>	<input checked="" type="checkbox"/>
Throughput (Upstream)	<input type="button" value="↑"/>	<input checked="" type="checkbox"/>

TCP Connection Status:

Connection No.	Source Port	Destination Port	Status
0	5000	6000	Connection Closed

Path MTU results

Upstream Downstream

Path MTU: Bytes

Baseline RTT Results

Upstream Downstream

Trial Duration:

Average RTT: msec

Minimum RTT: msec

Maximum RTT: msec

Baseline RTT Value Selected: msec

Test Parameter Summary

Upstream Downstream

Baseline RTT: msec

Calculated BDP: KBytes

TCP Window: Bytes

Path MTU: Bytes

MSS Used: Bytes

No of TCP Connection:

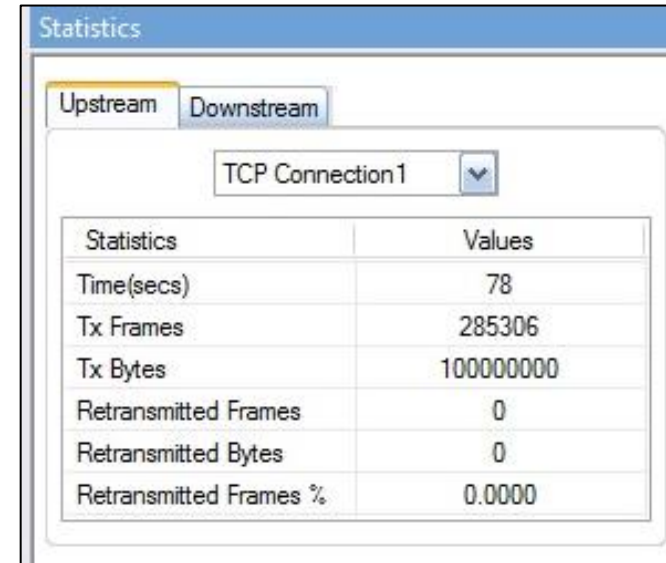
Transfer Size: MBytes

Statistics and Periodic Results

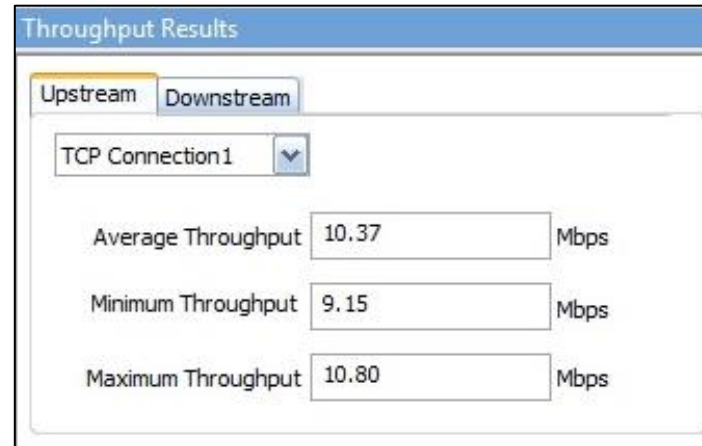
Statistics are updated every second and includes -

- TCP Transmitted Frames/Bytes
- TCP Retransmitted Frames/Bytes
- Retransmitted Bytes Percentage

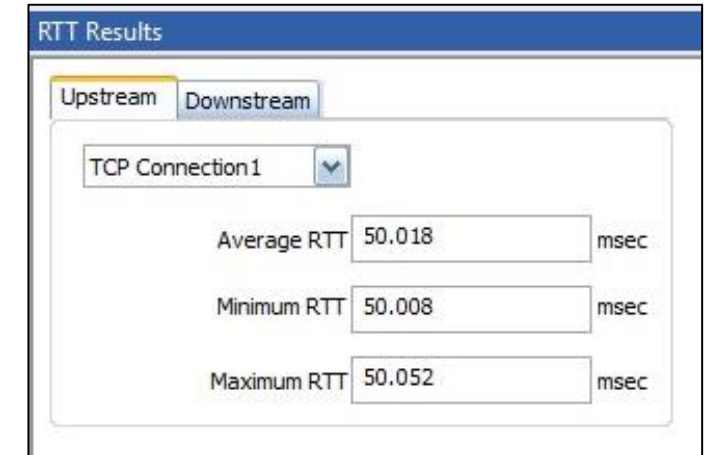
Throughput and RTT values are calculated every second and displayed. Minimum, Maximum and Average Values are displayed



Statistics	Values
Time(secs)	78
Tx Frames	285306
Tx Bytes	100000000
Retransmitted Frames	0
Retransmitted Bytes	0
Retransmitted Frames %	0.0000



Average Throughput	10.37	Mbps
Minimum Throughput	9.15	Mbps
Maximum Throughput	10.80	Mbps



Average RTT	50.018	msec
Minimum RTT	50.008	msec
Maximum RTT	50.052	msec

Final Results

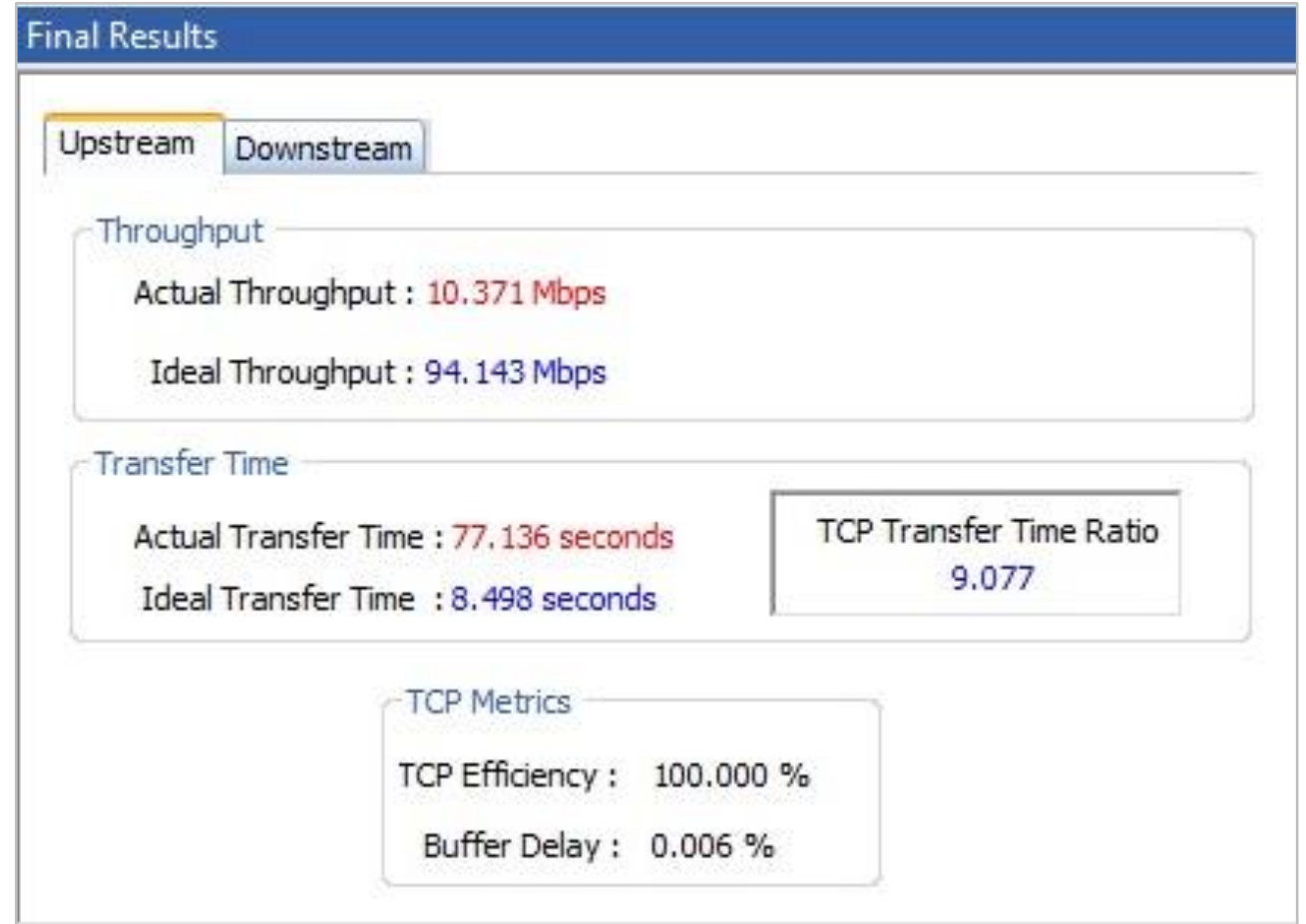
Ideal Throughput - the maximum possible TCP throughput for the given CIR

Ideal Transfer Time - the time taken to transfer the test data size at the ideal throughput

TCP Transfer Time Ratio - Measure of how much Actual transfer time is greater than the Ideal transfer time

TCP Efficiency - measure of the number of Transmitted bytes compared to the retransmitted bytes

Buffer Delay - measure of how much the RTT increases during the actual TCP Throughput test compared to the Baseline RTT

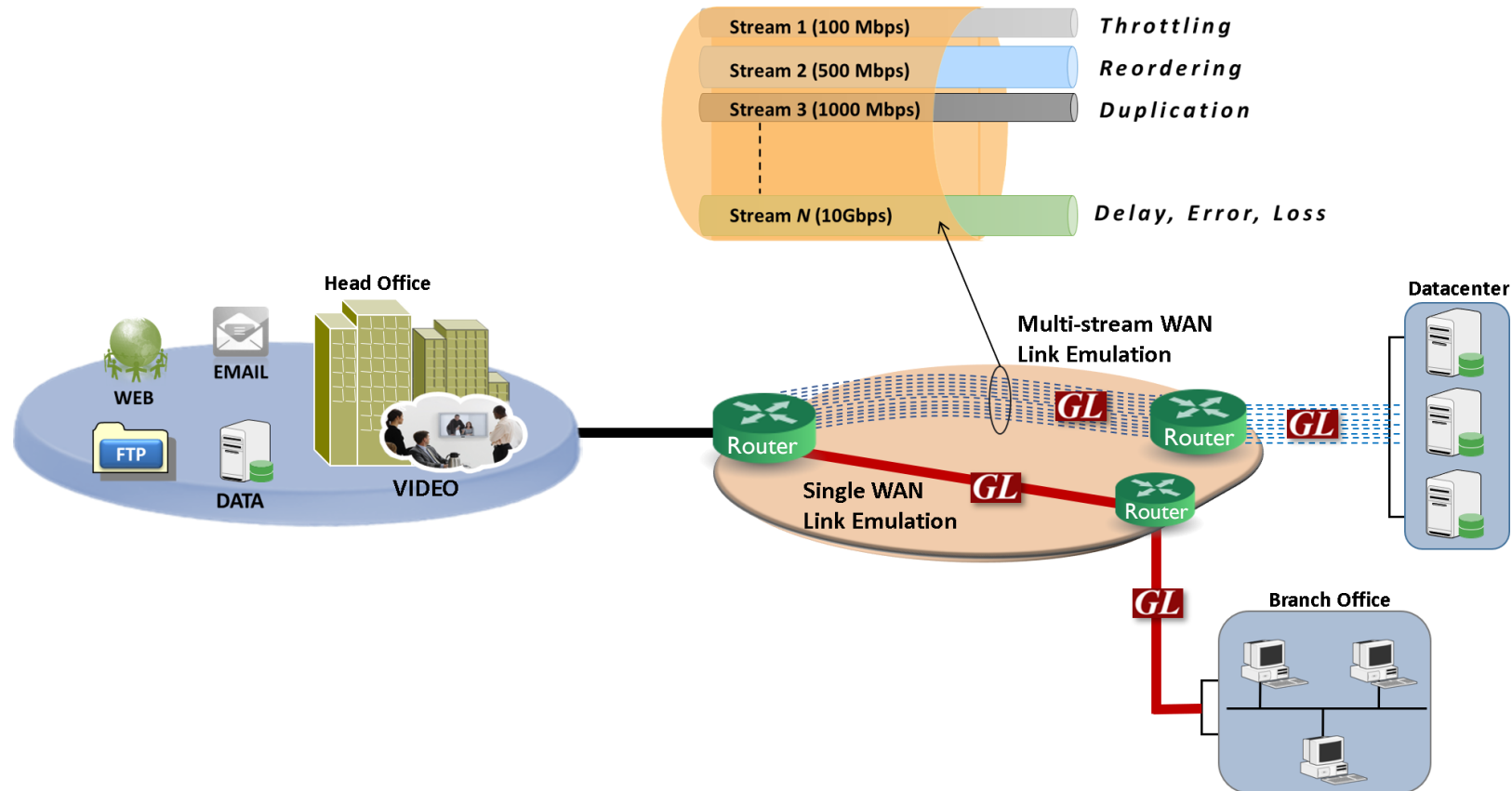


Simulate Real-World IP Network Impairments, Delay, Errors, Loss, Optical, Electrical

Overview

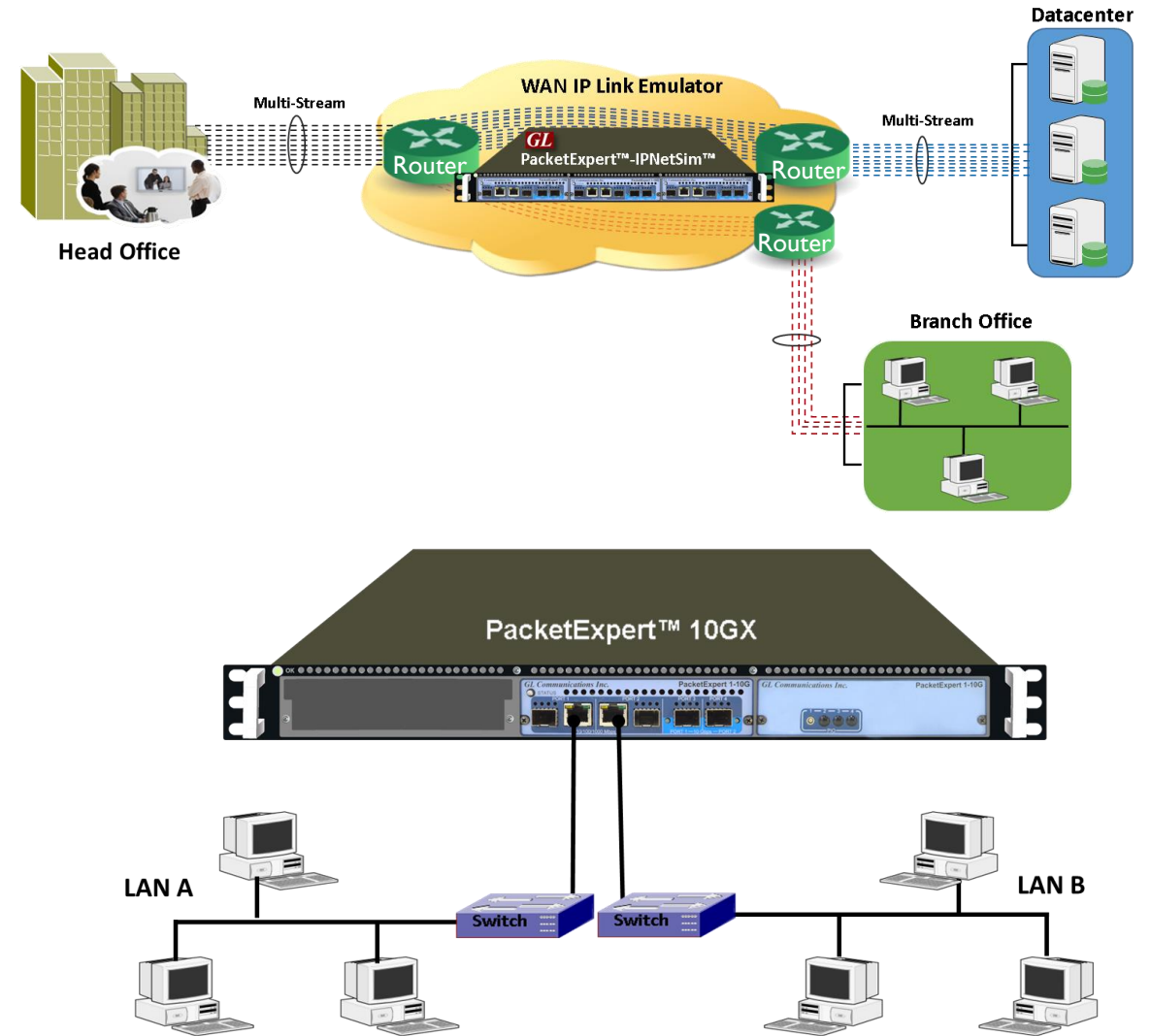
How does GL simulate real-world IP Networks? What is GL's IPNetSim?

- Lab Testing Solution - application and automation
- Emulate Full Duplex 1 Gbps and 10 Gbps networks
- Real-world network conditions by imposing impairments
- Multiple streams independently configured

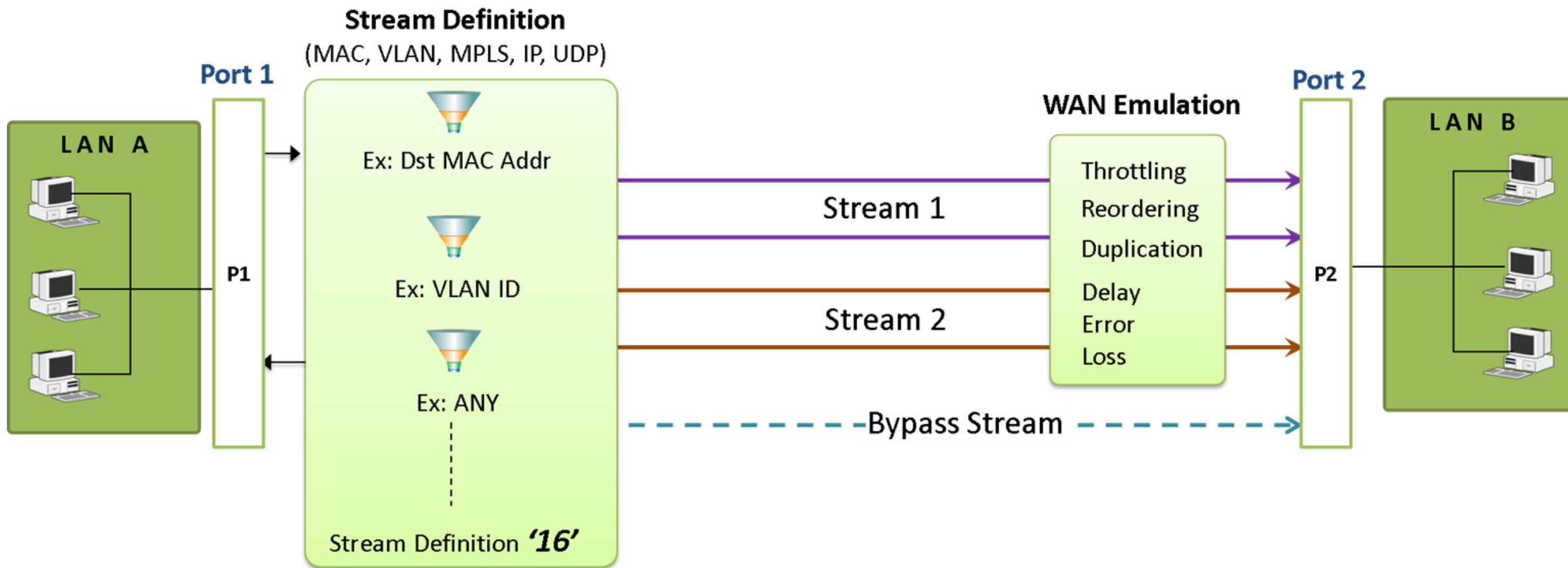


Application Overview

- Test Enterprise and Individual-level applications...
 - Audio and video streaming (VoIP, IMS, HDT, IPTV)
 - Storage services (Critical Data Access)
 - Cloud and web services
 - FTP / HTTP
- Simulate backhaul network
 - Static and dynamic networks
 - Satellite + other long delay networks
- Test Quality of Service (QoS) and Quality of Experience (QoE)
- Evaluate the stability of network devices (switches, VoIP Phones, VoIP PBXs, Set-top boxes and VoD Servers)



“Stream” Overview



Define Streams in Packet Mode

Stream Definition WAN Emulation Parameters Scheduler

P1 -> P2

Filter Mode
 Packet Mode Raw Mode

MAC VLAN MPLS IP UDP

Layer (Click to edit)	Layer Summary
MAC	00-00-00-00-01-01 -> 00-00-00-00-01-02, Len/Type = XX-XX
VLAN	VLAN Id = 0 , VLAN Stack = 1
MPLS	MPLS Label = 0 , MPLS Stack = 1
IP	192.168.1.11 - 192.168.1.16 --> 192.168.2.11 - 192.168.2.16

IPv4 IPv6

Source IP Address
 Fixed Range Any
From To

Destination IP Address
 Fixed Range Any
IP Address

Apply

Define Streams in Raw Mode

Stream Definition | WAN Emulation Parameters | Scheduler

P1 -> P2

Filter Mode

Packet Mode Raw Mode Offset

Bytes	0	1	2	3	4	5	6	7
Value	00	00	00	00	01	02	00	00
Mask	FF	FF	FF	FF	FF	FF	FF	FF

Apply

Bytes	Value	Mask
0-7	00 00 00 00 01 02 00 00	FF FF FF FF FF FF FF FF
8-15	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
16-23	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
24-31	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
32-39	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
40-47	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
48-55	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
56-63	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
64-71	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
72-79	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
80-87	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
88-95	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
96-103	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
104-111	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
112-119	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00

Traffic Bandwidth

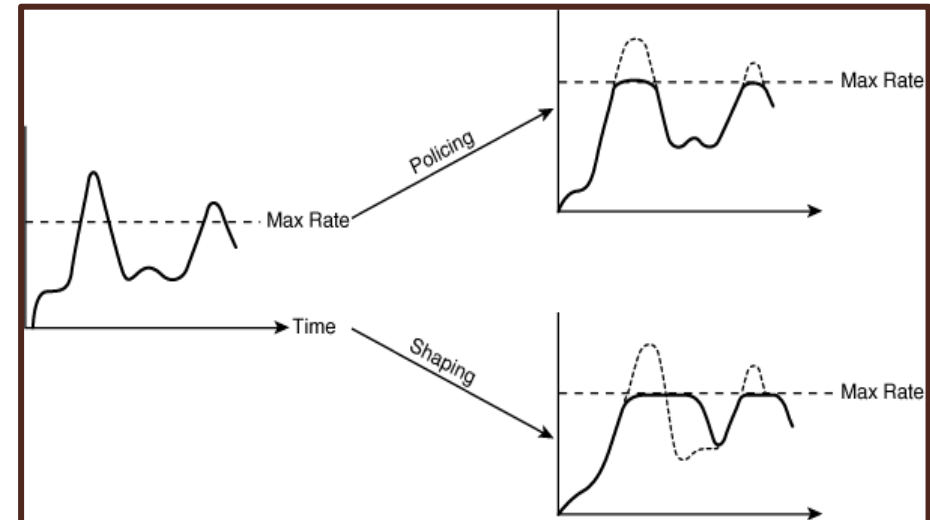
- Traffic which exceeds the stated rate is **silently dropped**
- UDP Applications will experience **data loss**
- TCP Applications should adapt via **congestion-avoidance algorithms**

Parameters	P1 -> P2	P2 -> P1
Traffic Bandwidth	10000.00 Mbps	10000.00 Mbps
Latency	None	None
Packet Loss	None	None
Packet Reordering	None	None
Packet Duplication	None	None
Logic Error Insertion	None	None

P1 -> P2 Traffic Bandwidth: 10000.000000 Mbps

P2 -> P1 Traffic Bandwidth: 10000.000000 Mbps

- Simulate WAN Applications where **Traffic Policing Policies** may be in effect, i.e. **Service Level Agreements** between Provider and Customer



Latency / Jitter

- Apply **Static** Delay, or a **Uniform** or **Exponential** distribution between a minimum and maximum
- Delay a packet **up to 8000 ms** in 1ms increments

Stream Definition | **WAN Emulation Parameters** | Scheduler

WAN Stream Type Symmetrical Asymmetrical

Parameters	P1 -> P2	P2 -> P1
Traffic Bandwidth	10000.00 Mbps	10000.00 Mbps
Latency	Uniform, 0.000 msec - 500.000 msec	Single Delay, 100.000 msec
Packet Loss	None	None
Packet Reordering	None	None
Packet Duplication	None	None
Logic Error Insertion	None	None

P1 -> P2

Latency

Single Delay Min msec

Uniform Distribution Max msec

Random Exponential Distribution

P2 -> P1

Latency

Single Delay Min msec

Uniform Distribution Max usec

Random Exponential Distribution

Packet Reordering

- Reorder 1 out of every X packets
- Set a minimum time in ms to hold the reordered packet
- Set a maximum time in ms to hold the reordered packet

Stream Definition | **WAN Emulation Parameters** | Scheduler

WAN Stream Type Symmetrical Asymmetrical

Parameters	P1 -> P2	P2 -> P1
Traffic Bandwidth	10000.00 Mbps	10000.00 Mbps
Latency	Uniform, 0.000 msec - 500.000 msec	Single Delay, 100.000 msec
Packet Loss	10.000 %	20.000 %
Packet Reordering	1 out of 10 packets	1 out of 20 packets
Packet Duplication	None	None
Logic Error Insertion	None	None

P1 -> P2

Packet Reordering

Periodic Random

Reorder 1 packet out of packets

Delay Offset

Time Frames

Min ms Max ms

P2 -> P1

Packet Reordering

Periodic Random

Reorder 1 packet out of packets

Delay Offset

Time Frames

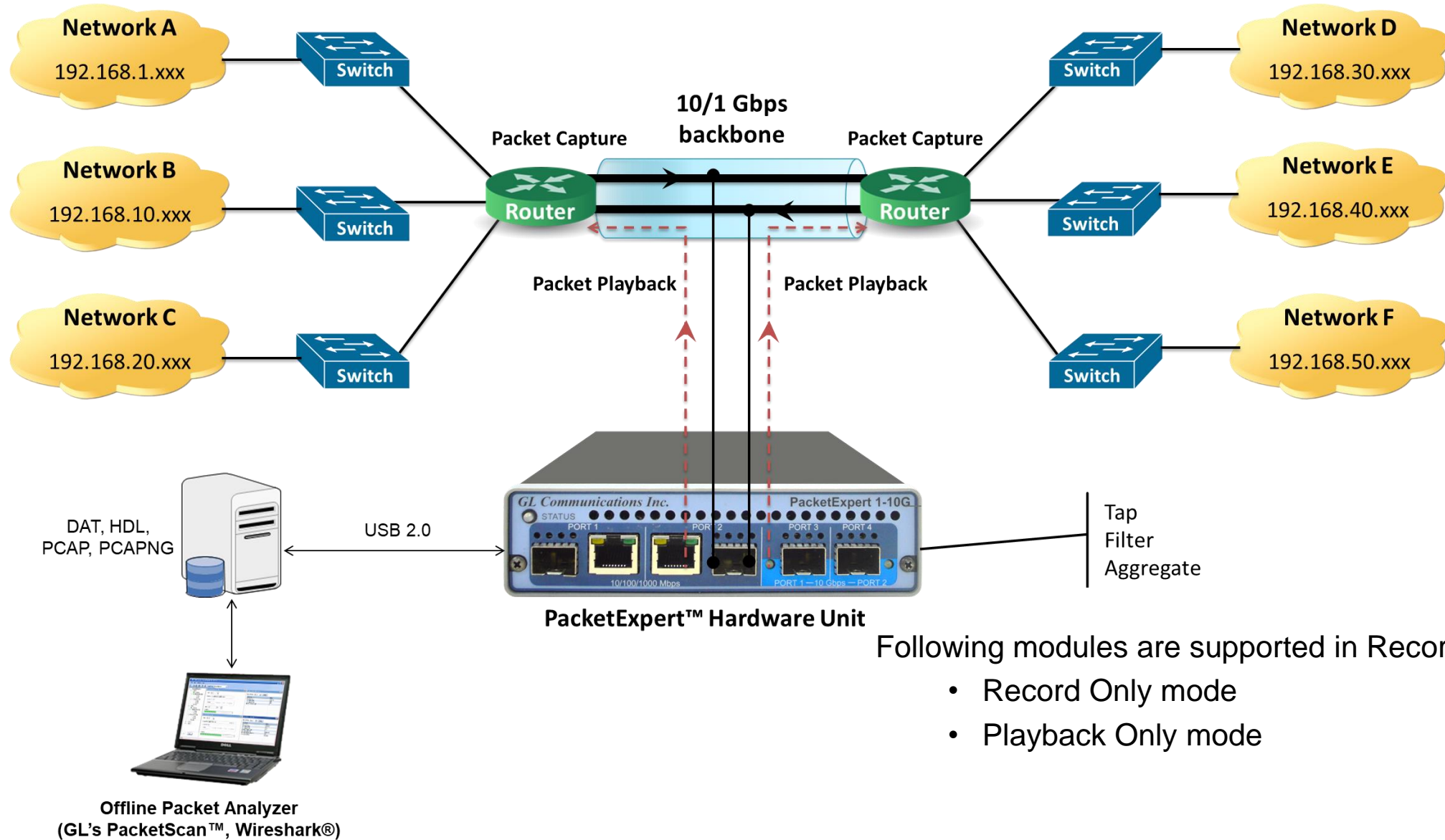
Min ms Max ms

Software Specification

Multi-streams WAN Emulation - IPNetSim™	Single-stream WAN Emulation - IPLinkSim™
<p>Stream Definition</p> <ul style="list-style-type: none"> • Hardware wire-speed filters (up to 16 links) <ul style="list-style-type: none"> ➤ Packet Mode (field headers) ➤ Raw Mode (bit level) <p>Parameters</p> <ul style="list-style-type: none"> • IP Source and Destination Address Range • UDP Source and Destination Port Range • MAC Addresses • VLAN ID • MPLS Label 	<p>-NA-</p>
<p>WAN Emulation Parameters</p> <ul style="list-style-type: none"> • Bandwidth control – 1 Kbps up to 10 Gbps • Latency/Delay <ul style="list-style-type: none"> ➤ 0 milliseconds up to 1.25 seconds (1250 msec) per stream (for 1Gbps link) ➤ 0 milliseconds up to 0.5 seconds (500 msec) per stream (for 10 Gbps link) ➤ single delay, uniform, random distributions • Packet Loss Rate - 0–100% • Packet Reordering Rate - 0-100% with Delay range of up to 2 seconds • Packet Duplication Rate - 0 - 100% • Logic Error Insertion Rate - 10^{-1} to 10^{-9} • Maximum Frame Size Supported – 2048 bytes 	<p>WAN Emulation Parameters</p> <ul style="list-style-type: none"> • Bandwidth control - 10 Kbps up to 1000 Mbps • Latency/Delay <ul style="list-style-type: none"> ➤ 0 milliseconds to 8 seconds (8000 milliseconds) (for 1G/10 Gbps link) ➤ single delay, uniform, random distributions • Congestion Emulation with Background traffic (% of total bandwidth) <ul style="list-style-type: none"> ➤ Link Utilization Rate –0 – 100% ➤ Burst Size - 64 – 1,000,000 bytes • Packet Loss Rate - 0–100% • Packet Reordering Rate - 0-100% with Delay range of up to 8 seconds • Packet Duplication Rate - 0 - 100% • Logic Error Insertion Rate - 10^{-1} to 10^{-9} • FCS Error insertion Rate - 10^{-1} to 10^{-9}

Wirespeed Ethernet Packet Capture and Playback with Hardware Filtering

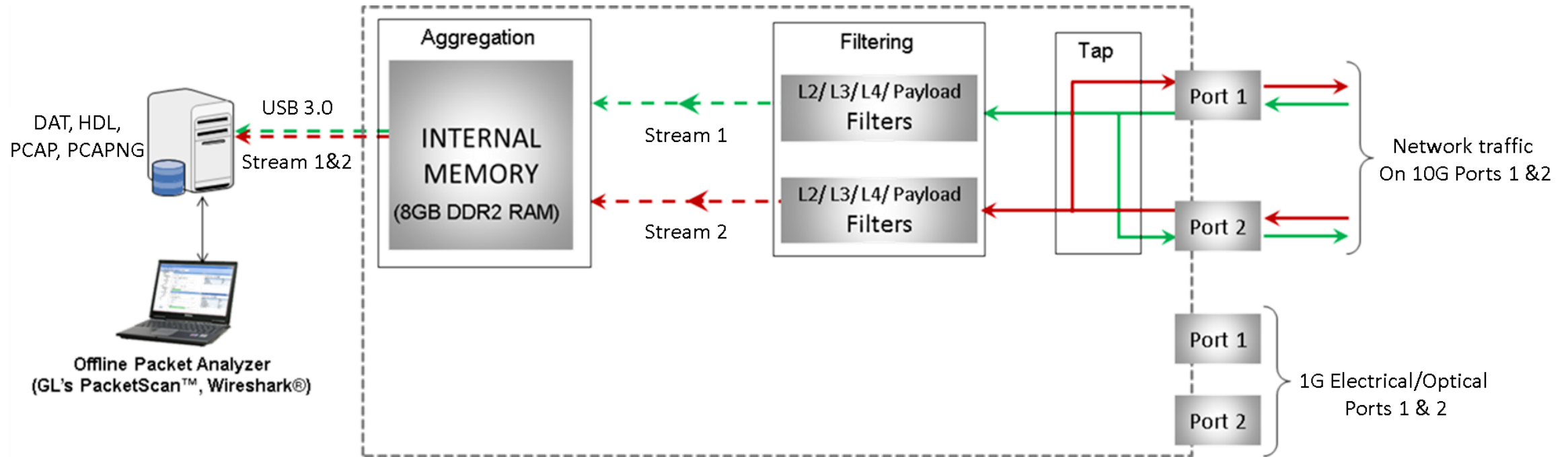
Wire-Speed Record/Playback



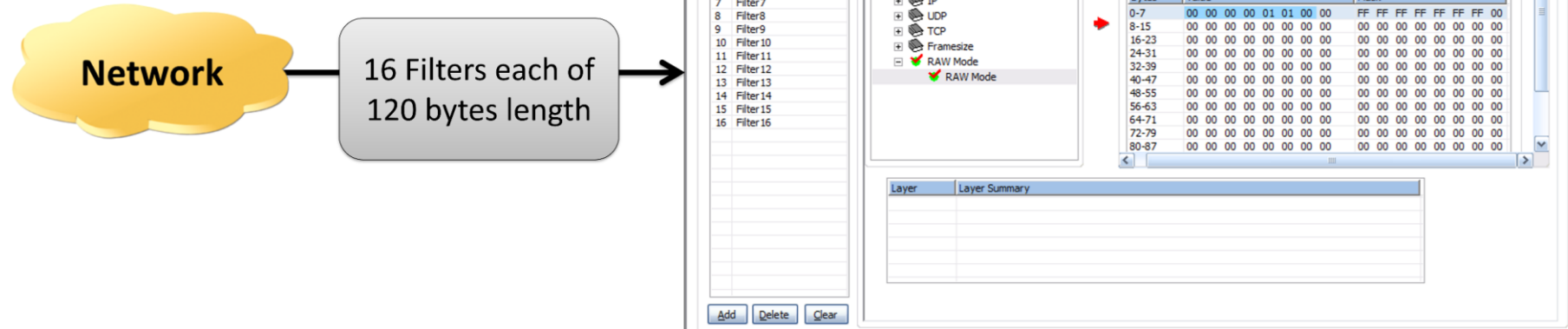
Following modules are supported in Record/Playback:

- Record Only mode
- Playback Only mode

Working Principle

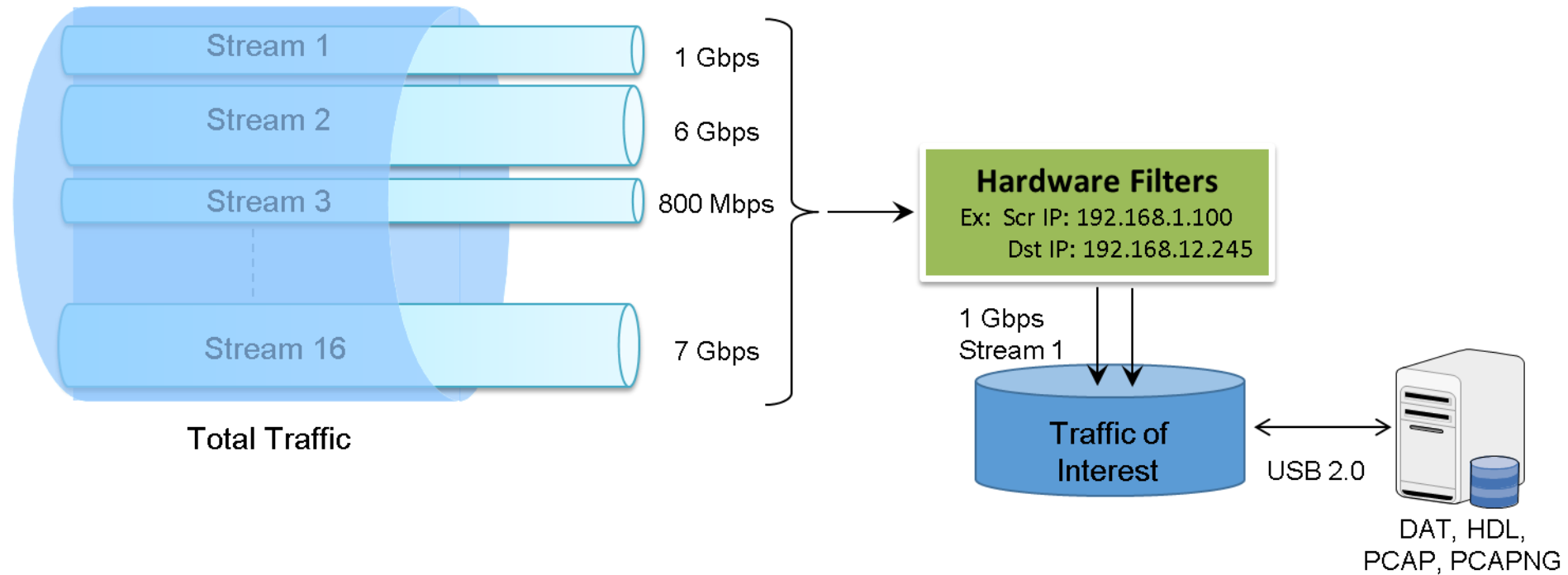


Wireshark Packet Filters and Triggers



- Filter packets and record only packets of interest
- Capture simultaneously on 2 ports with 120 bytes deep filter per port (for record application) and set filter on any one of the ports or all ports
- Packet filtering can be based on all Layer 2 (Ethernet), Layer 3 (IP) Layer 4 (UDP/TCP) Headers
- Up to 16 filters can be defined per port. Each filter is up to 120 bytes wide
- Filter can be set to each bit in the packet (Raw mode) or each field (Packet Mode)
- Generates a trigger (1 Microsecond pulse) for each packet that passes the filter
- Filter on various header fields like Source/Destination MAC Address, VLAN Id, MPLS Label, Source/Destination Ipv4 Address, Source/Destination UDP ports

Capture Traffic of Interest

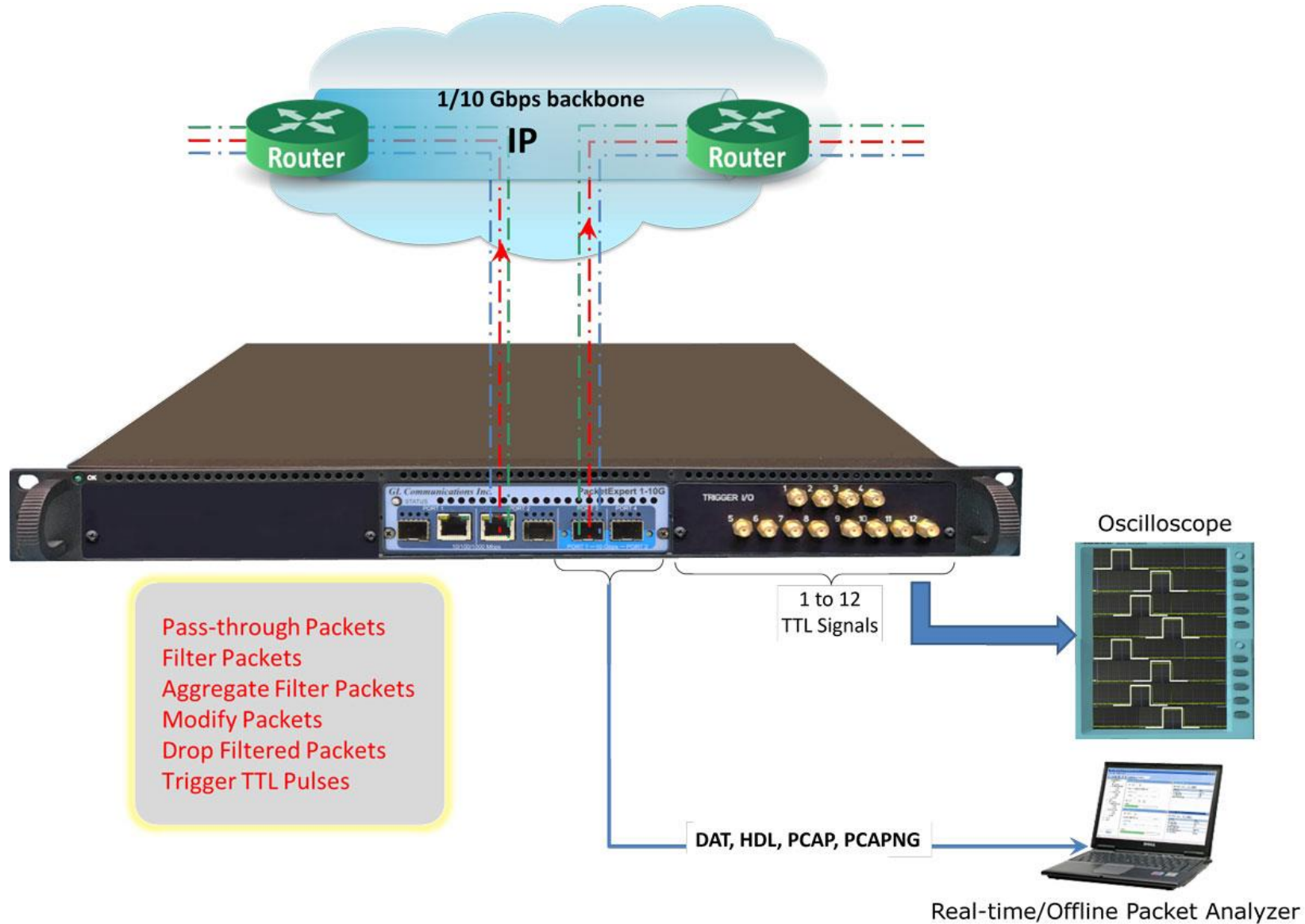


The network traffic containing n streams of varying data rate is filtered at the PacketExpert™ hardware as per the filter settings. The overall transmit rate is limited to the USB 2.0 transfer rate.

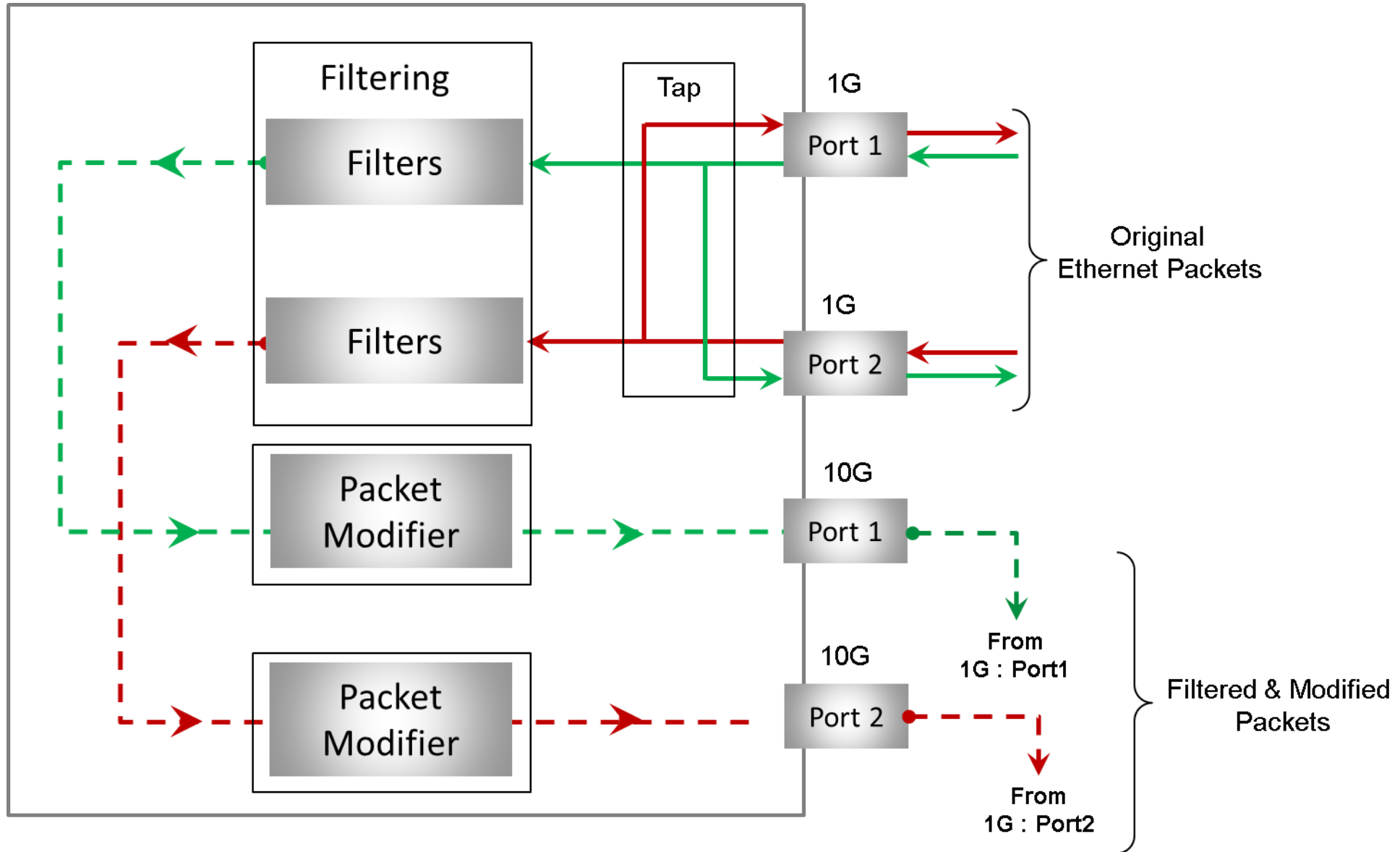
Transmit rate can go up to 350 Mbps depending on the host PC configuration.

PacketBroker™ – Passive Ethernet Tap

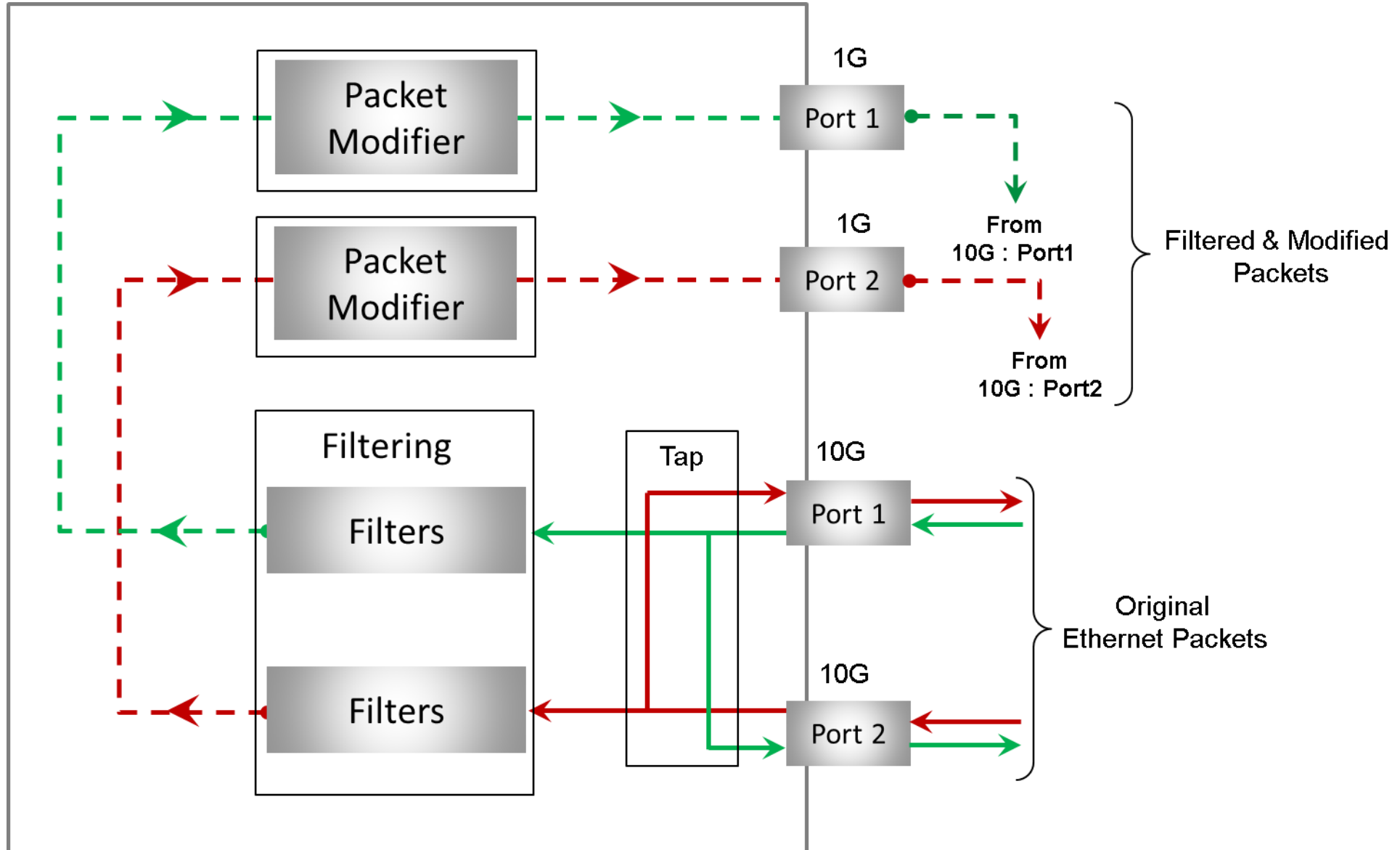
PacketBroker™ in Network



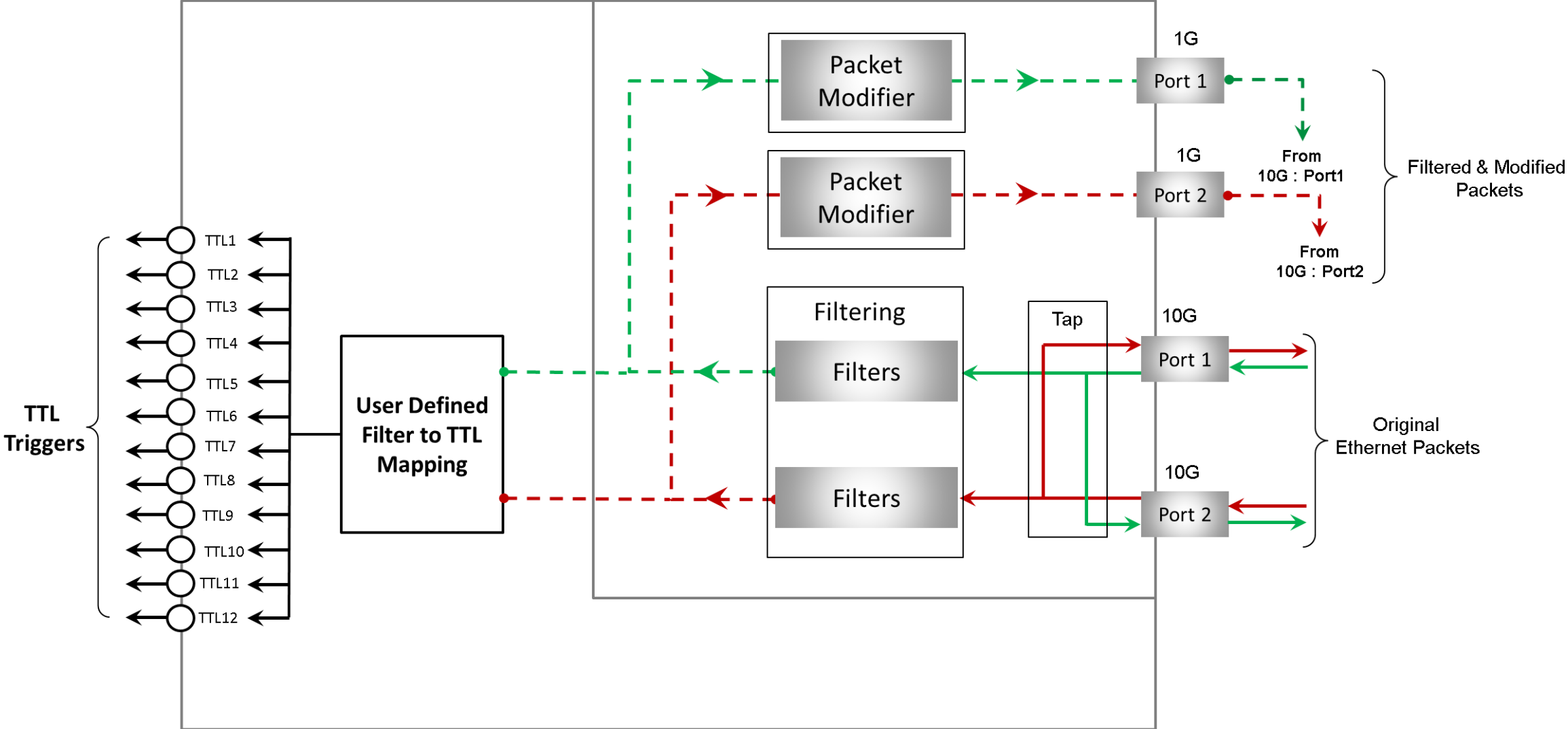
Packet Tap, Filter, Modification, and Output



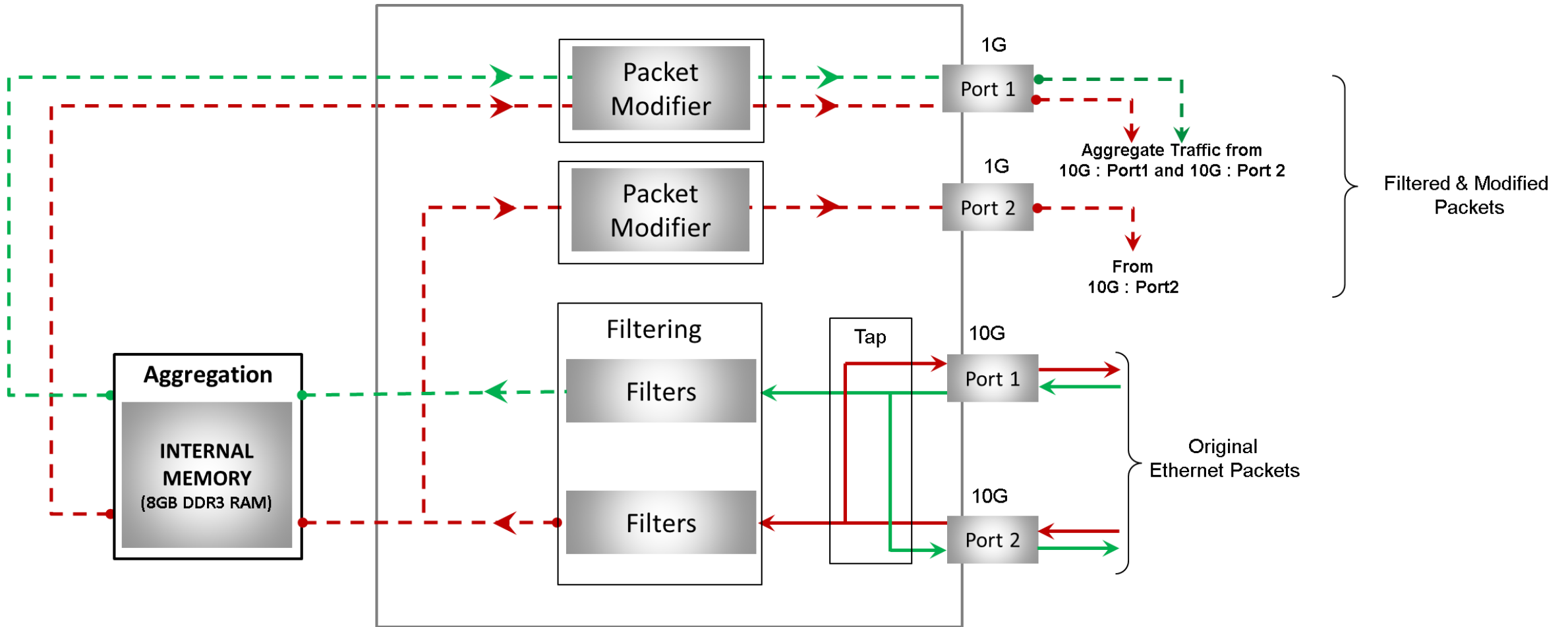
PacketBroker 10G mode



Filtering with TTL Generation

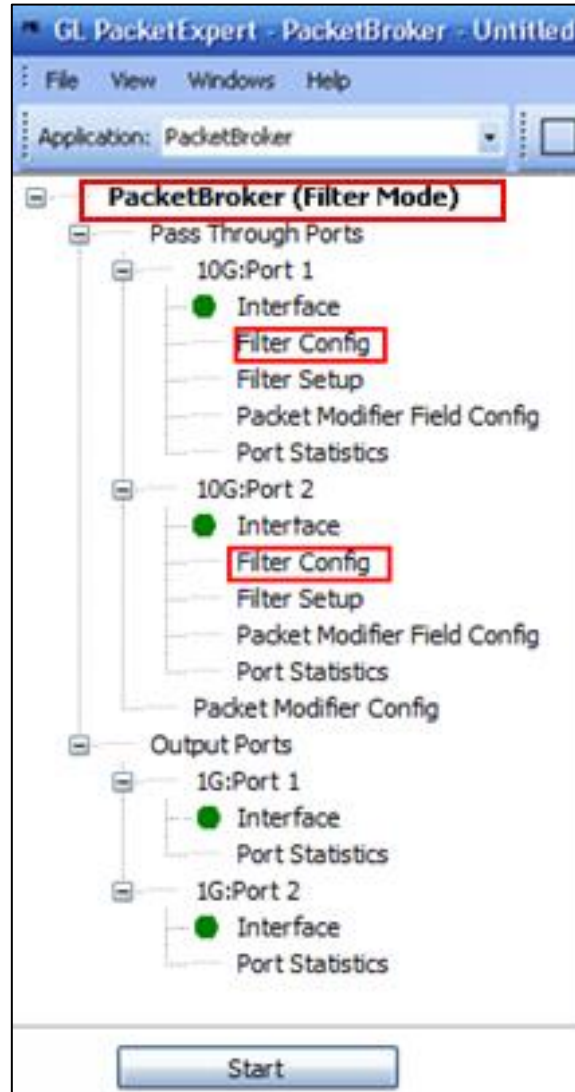


Aggregation

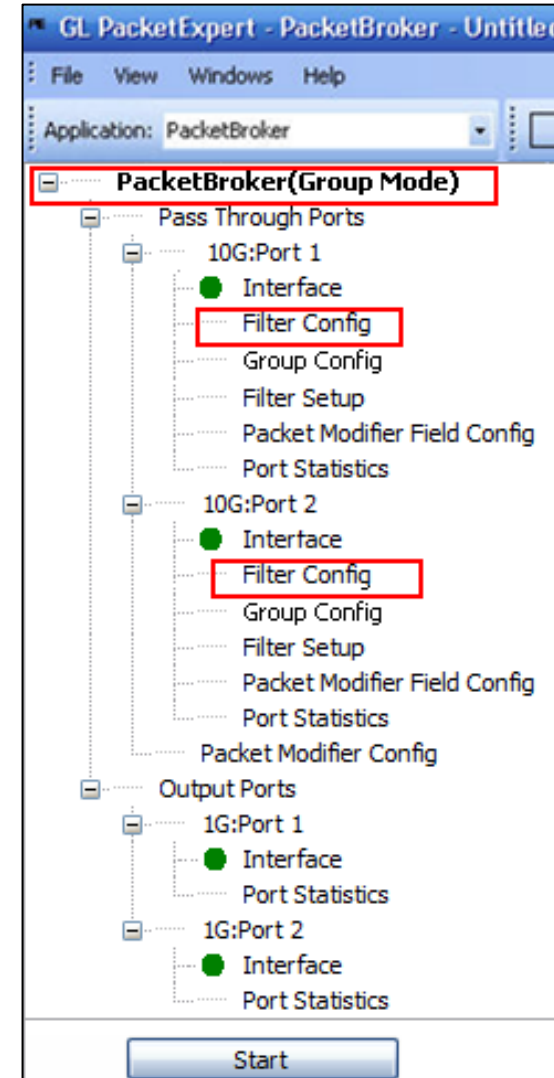


Filter Configuration Menu

Basic Mode Filtering



Group Mode Filtering



Filter Configuration

Packet Mode Filtering

The screenshot displays the 'Filter Config' window for '10G:Port 1'. On the left, a list of 16 filters is shown, with a red bracket indicating '16 Filters'. The main area is divided into 'Filter Selection' and 'Filters' sections. The 'Filter Selection' section, labeled 'Packet Layers', shows a tree view of layers: MAC, VLAN Layer, MPLS Layer, IP, UDP, TCP, TCP Source Port, and TCP Destination Port. The 'Filters' section, labeled 'Header fields', shows 'Enable TCP Source Port' checked and 'TCP Source Port' set to 'Range' from 2000 to 3000. At the bottom, a 'Layer Summary' table provides details for each layer.

Layer	Layer Summary
MAC	Src MAC = 00-00-00-00-01-02, Dst MAC = 00-00-00-00-01-03, Len/Type =
VLAN	VLAN Id = 12 , VLAN Priority = 0 - 7
MPLS	MPLS Label = 0 - 1048575
IPv4	Src IP = 192.168.1.11, Dst IP = 192.168.1.12, TOS = 0, Protocol = X
UDP	Src UDP Port = 400 - 600, Dst UDP Port = 5500 - 6000
TCP	Src TCP Port = 2000 - 3000, Dst TCP Port = 2123

Filter Configuration

Raw Mode Filtering

The screenshot displays the 'Filter Config' window for '10G:Port 1'. On the left, a list of 16 filters is shown, with a red bracket indicating '16 Filters'. The 'Filter Selection' panel shows various layers with checkboxes, and 'RAW Mode' is selected and highlighted with a red box. The 'Filters' panel shows 'Enable RAW Mode' checked and 'Offset' set to 0, with a red arrow pointing to the text 'Offset (0 - 15999)'. Below this is a table of raw data/mask bytes:

Bytes	Value	Mask
0-7	00 00 00 00 01 02 00 00	FF FF FF FF FF 00 00
8-15	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
16-23	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
24-31	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
32-39	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
40-47	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
48-55	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
56-63	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
64-71	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
72-79	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00
80-87	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00

A red bracket on the right side of the table indicates '120 Bytes Raw Data/Mask Bytes'. At the bottom, a 'Layer Summary' table provides details for MAC, VLAN, MPLS, IPv4, and UDP layers.

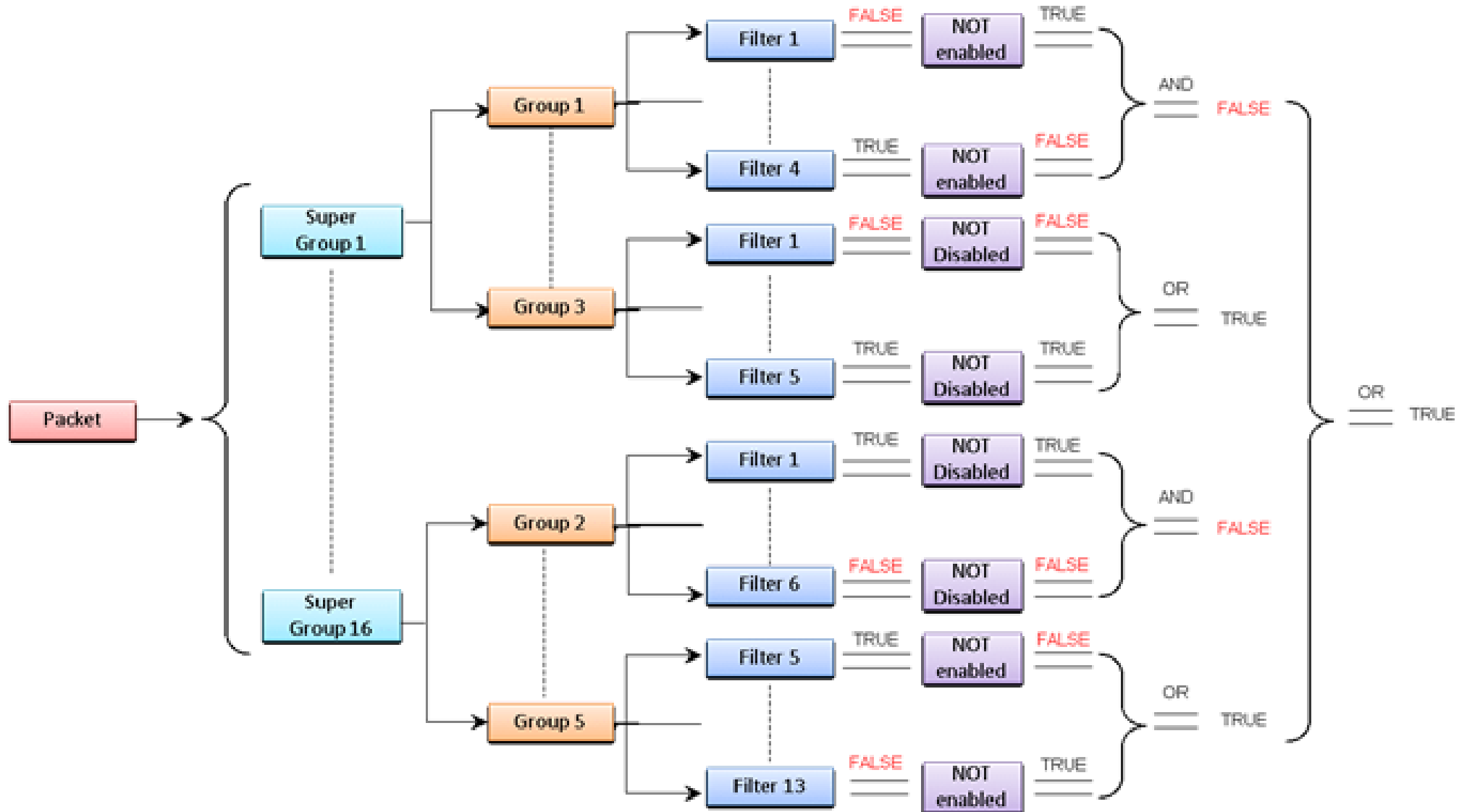
Group Mode Filter configuration

- PacketBroker™ includes an option to group the configured filters
- Any number of individual filters can be selected to form a group. Using “AND” and “OR” operators and any combination of filter groups can be created
- The multiple filter Groups created can be further grouped to form Super Groups using “AND” or “OR” operators
- The result of all the filters within the group is taken and either “OR”ed or “AND”ed and a final single Group result - TRUE or FALSE is obtained

The screenshot displays two configuration windows. The top window, titled "Group Config", shows a "Port Selection" dropdown set to "10G:Port 1". It features a "Group Config" table with 16 rows, where "Group2" is selected. To the right is a "Filter Selection" tree with 16 filters, with Filter 1, 5, 6, 10, and 12 checked. An "Operation" section shows "AND" selected. A "Summary" box contains "(Filter 1 & Filter 5 & Filter 6 & Filter 10 & Filter 12)". A "Hide Super Group" button is visible at the bottom right.

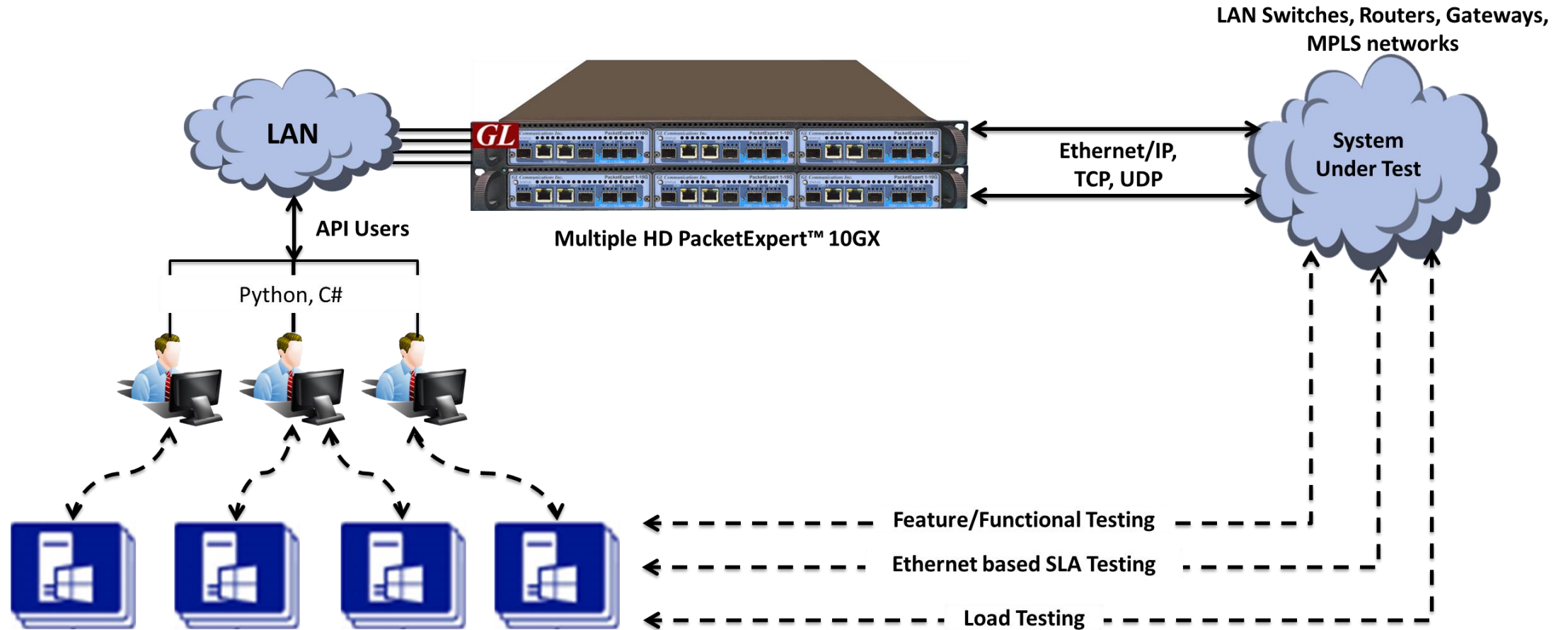
The bottom window, titled "Super Group Config", has the "Enable Super Group" checkbox checked. It shows a "Super Group Config" table with 16 rows, where "SuperGroup1" is selected. To the right is a "Group Selection" tree with 16 groups, with Group 1, 4, 6, and 8 checked. An "Operation" section shows "OR" selected. A "Summary" box contains "(Group1 || Group4 || Group6 || Group8)".

Working Principle of Filter, Group and Super Group



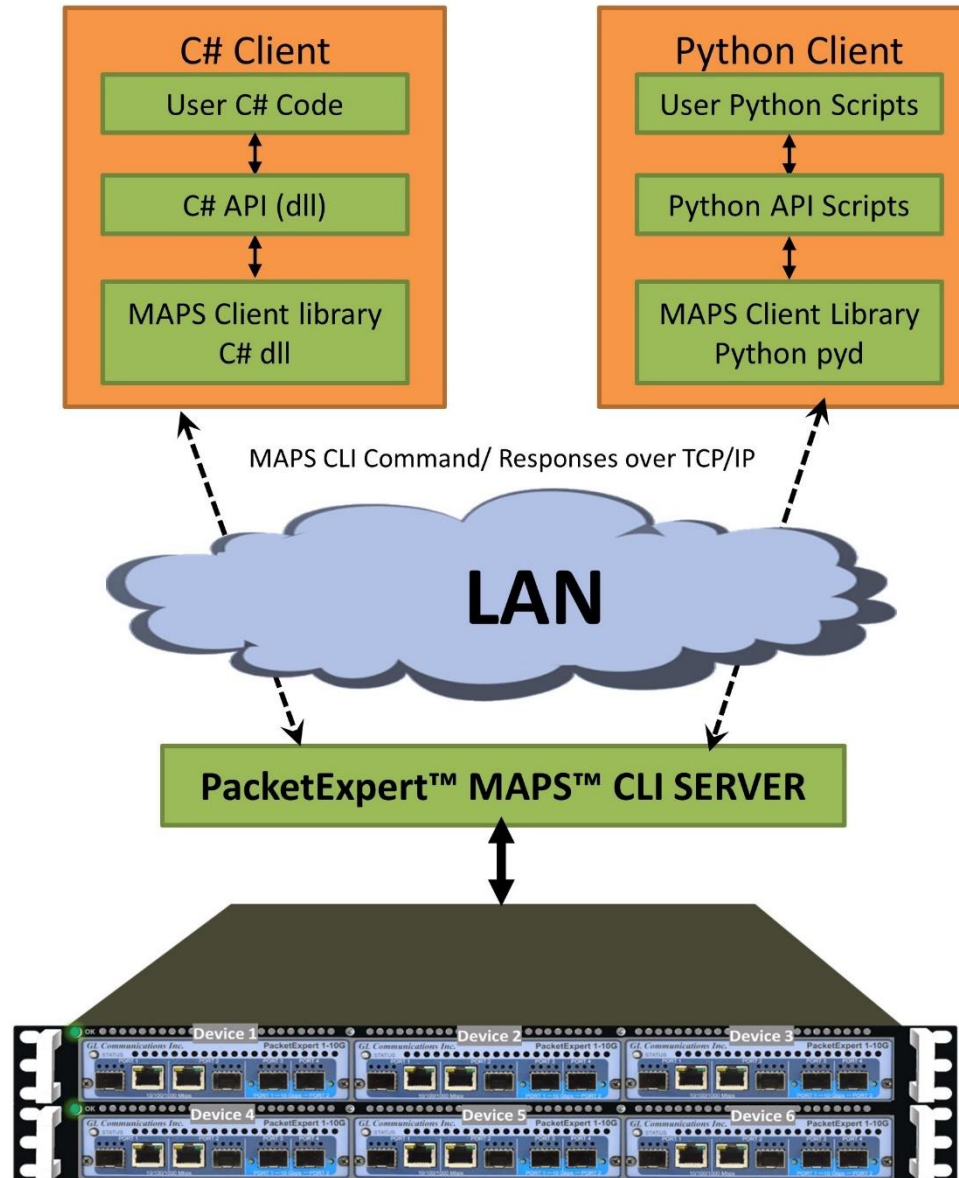
Command Line Interface (CLI)

MAPS™ CLI Client/Server Architecture

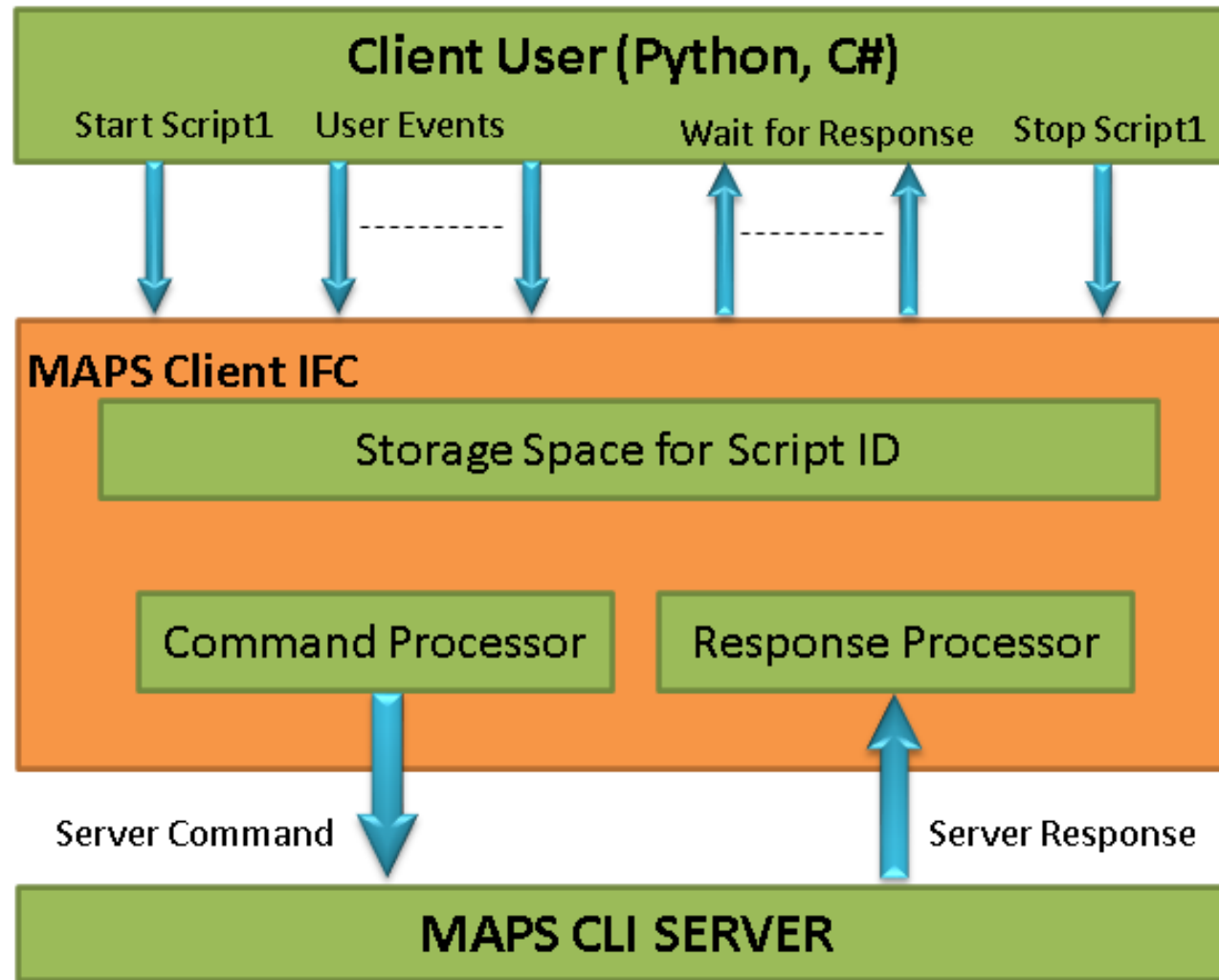


- PacketExpert™ 10GX also supports Command line Interface (CLI) to access all the functionalities remotely such as Bert, Loopback, RFC 2544, Record Playback, IPNetSim™, ExpertSAM™, PacketBroker™, and Multi Stream Traffic Generator and Analyzer using Python, C# client APIs and MAPS™ CLI Client/Server architecture

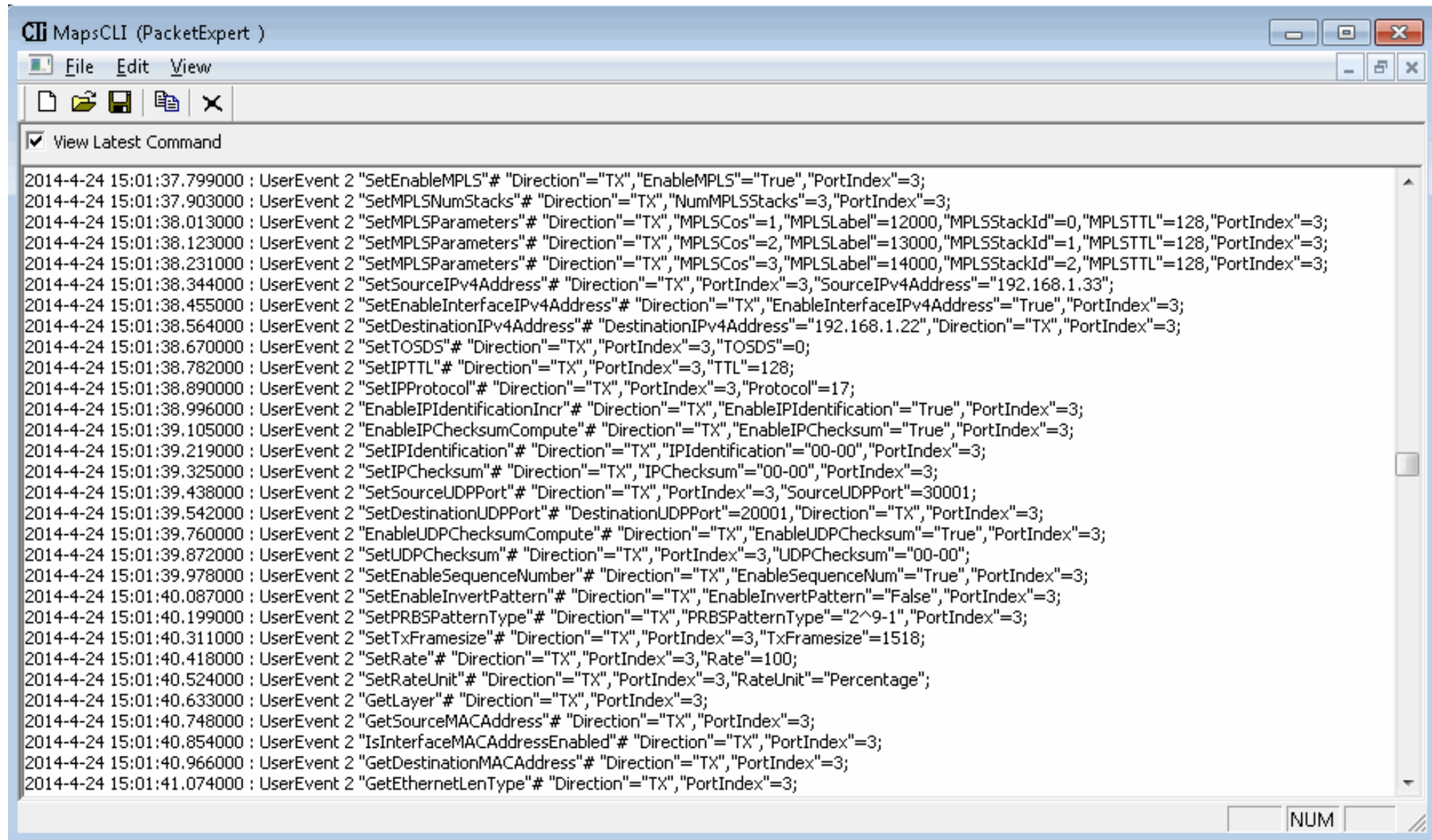
Working Principle of MAPS™ CLI



Working Principle of MAPS™ CLI



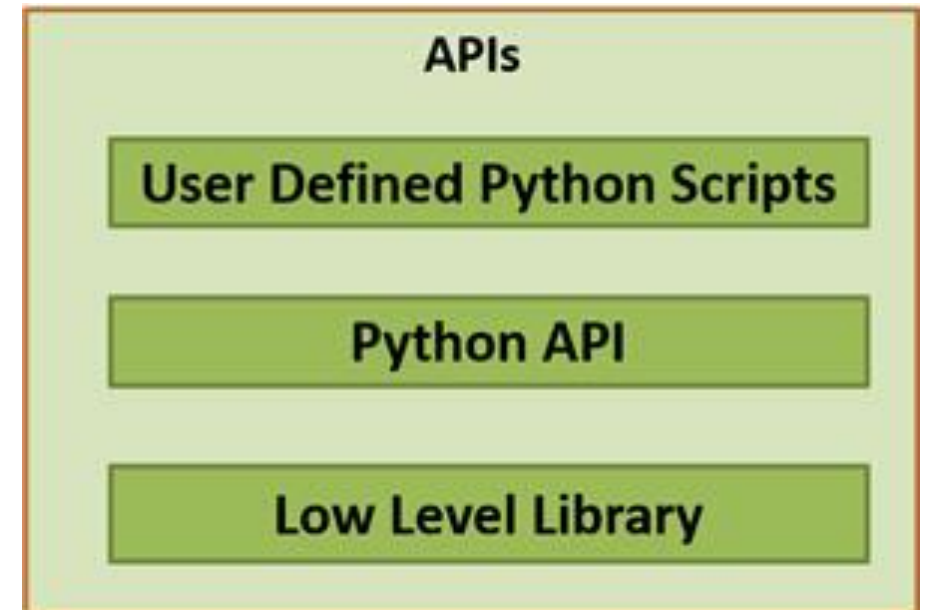
MAPS™ CLI Server



```
CLI MapsCLI (PacketExpert )
File Edit View
View Latest Command
2014-4-24 15:01:37.799000 : UserEvent 2 "SetEnableMPLS"# "Direction"="TX","EnableMPLS"="True","PortIndex"=3;
2014-4-24 15:01:37.903000 : UserEvent 2 "SetMPLSNumStacks"# "Direction"="TX","NumMPLSStacks"=3,"PortIndex"=3;
2014-4-24 15:01:38.013000 : UserEvent 2 "SetMPLSParameters"# "Direction"="TX","MPLSCos"=1,"MPLSLabel"=12000,"MPLSStackId"=0,"MPLSTTL"=128,"PortIndex"=3;
2014-4-24 15:01:38.123000 : UserEvent 2 "SetMPLSParameters"# "Direction"="TX","MPLSCos"=2,"MPLSLabel"=13000,"MPLSStackId"=1,"MPLSTTL"=128,"PortIndex"=3;
2014-4-24 15:01:38.231000 : UserEvent 2 "SetMPLSParameters"# "Direction"="TX","MPLSCos"=3,"MPLSLabel"=14000,"MPLSStackId"=2,"MPLSTTL"=128,"PortIndex"=3;
2014-4-24 15:01:38.344000 : UserEvent 2 "SetSourceIPv4Address"# "Direction"="TX","PortIndex"=3,"SourceIPv4Address"="192.168.1.33";
2014-4-24 15:01:38.455000 : UserEvent 2 "SetEnableInterfaceIPv4Address"# "Direction"="TX","EnableInterfaceIPv4Address"="True","PortIndex"=3;
2014-4-24 15:01:38.564000 : UserEvent 2 "SetDestinationIPv4Address"# "DestinationIPv4Address"="192.168.1.22","Direction"="TX","PortIndex"=3;
2014-4-24 15:01:38.670000 : UserEvent 2 "SetTOSDS"# "Direction"="TX","PortIndex"=3,"TOSDS"=0;
2014-4-24 15:01:38.782000 : UserEvent 2 "SetIPTTL"# "Direction"="TX","PortIndex"=3,"TTL"=128;
2014-4-24 15:01:38.890000 : UserEvent 2 "SetIPProtocol"# "Direction"="TX","PortIndex"=3,"Protocol"=17;
2014-4-24 15:01:38.996000 : UserEvent 2 "EnableIPIdentificationIncr"# "Direction"="TX","EnableIPIdentification"="True","PortIndex"=3;
2014-4-24 15:01:39.105000 : UserEvent 2 "EnableIPChecksumCompute"# "Direction"="TX","EnableIPChecksum"="True","PortIndex"=3;
2014-4-24 15:01:39.219000 : UserEvent 2 "SetIPIdentification"# "Direction"="TX","IPIdentification"="00-00","PortIndex"=3;
2014-4-24 15:01:39.325000 : UserEvent 2 "SetIPChecksum"# "Direction"="TX","IPChecksum"="00-00","PortIndex"=3;
2014-4-24 15:01:39.438000 : UserEvent 2 "SetSourceUDPPort"# "Direction"="TX","PortIndex"=3,"SourceUDPPort"=30001;
2014-4-24 15:01:39.542000 : UserEvent 2 "SetDestinationUDPPort"# "DestinationUDPPort"=20001,"Direction"="TX","PortIndex"=3;
2014-4-24 15:01:39.760000 : UserEvent 2 "EnableUDPChecksumCompute"# "Direction"="TX","EnableUDPChecksum"="True","PortIndex"=3;
2014-4-24 15:01:39.872000 : UserEvent 2 "SetUDPChecksum"# "Direction"="TX","PortIndex"=3,"UDPChecksum"="00-00";
2014-4-24 15:01:39.978000 : UserEvent 2 "SetEnableSequenceNumber"# "Direction"="TX","EnableSequenceNum"="True","PortIndex"=3;
2014-4-24 15:01:40.087000 : UserEvent 2 "SetEnableInvertPattern"# "Direction"="TX","EnableInvertPattern"="False","PortIndex"=3;
2014-4-24 15:01:40.199000 : UserEvent 2 "SetPRBSPatternType"# "Direction"="TX","PRBSPatternType"="2^9-1","PortIndex"=3;
2014-4-24 15:01:40.311000 : UserEvent 2 "SetTxFramesize"# "Direction"="TX","PortIndex"=3,"TxFramesize"=1518;
2014-4-24 15:01:40.418000 : UserEvent 2 "SetRate"# "Direction"="TX","PortIndex"=3,"Rate"=100;
2014-4-24 15:01:40.524000 : UserEvent 2 "SetRateUnit"# "Direction"="TX","PortIndex"=3,"RateUnit"="Percentage";
2014-4-24 15:01:40.633000 : UserEvent 2 "GetLayer"# "Direction"="TX","PortIndex"=3;
2014-4-24 15:01:40.748000 : UserEvent 2 "GetSourceMACAddress"# "Direction"="TX","PortIndex"=3;
2014-4-24 15:01:40.854000 : UserEvent 2 "IsInterfaceMACAddressEnabled"# "Direction"="TX","PortIndex"=3;
2014-4-24 15:01:40.966000 : UserEvent 2 "GetDestinationMACAddress"# "Direction"="TX","PortIndex"=3;
2014-4-24 15:01:41.074000 : UserEvent 2 "GetEthernetLenType"# "Direction"="TX","PortIndex"=3;
NUM
```

Python Client and Scripting

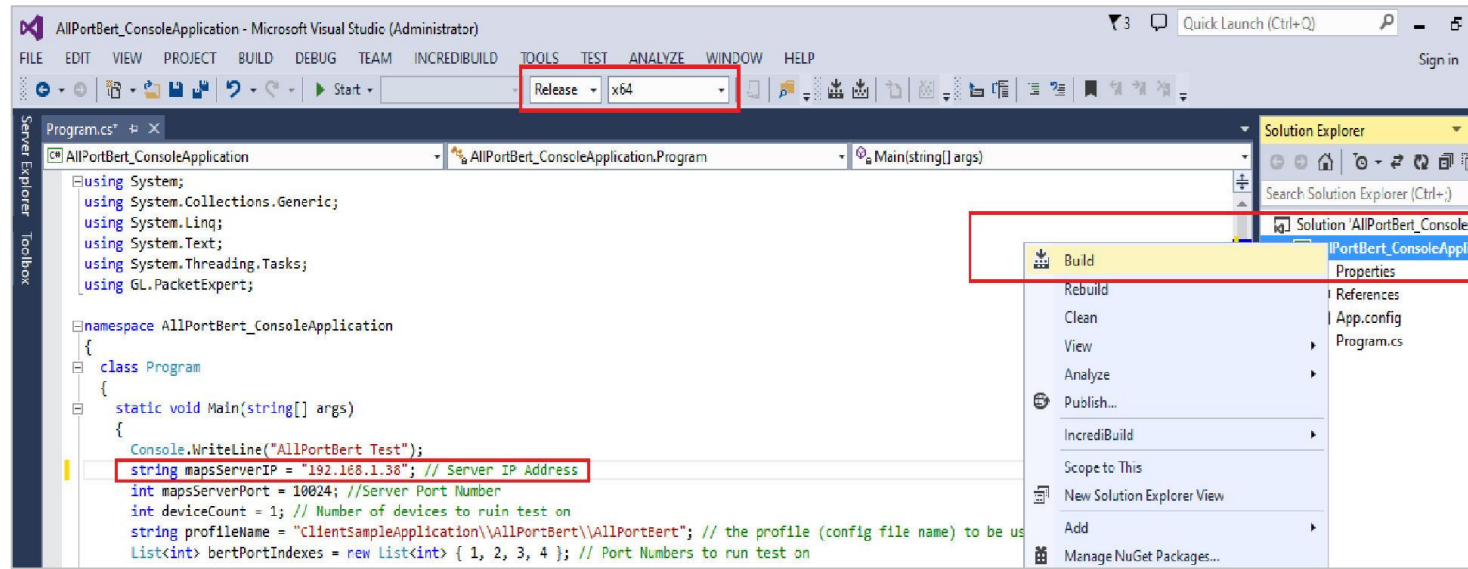
- The Python Client consists of following components:
- Python API scripts, that provide High Level APIs, using which all the PacketExpert™ functionalities are accessible to the users
- These APIs in turn use a low level library to communicate with the PacketExpert™ MAPS™ server



Python Client

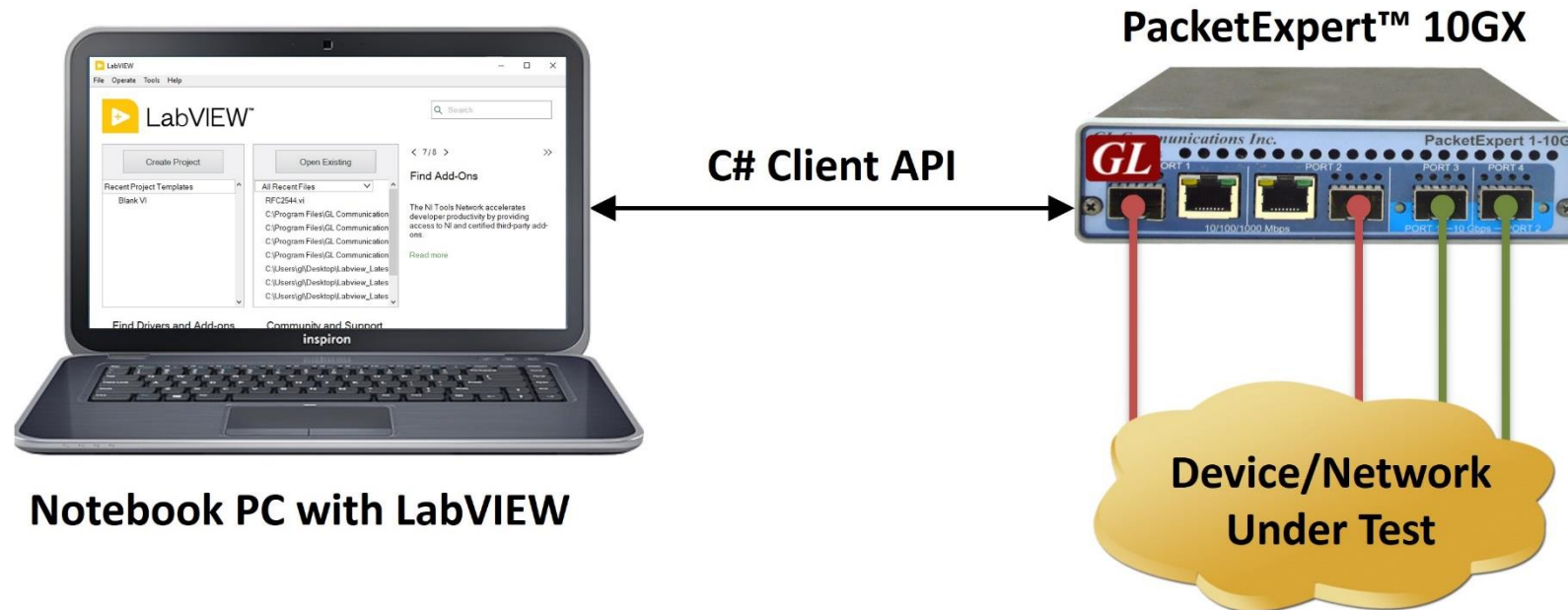
```
*Python 3.6.7rc2 Shell*
File Edit Shell Debug Options Window Help
RESTART: C:\Users\glitteam\Desktop\PythonClient3_6\AllPortBertSampleApplication.py
ALLPortBERT Test
Press any key to continue , 'q' to quit
a
Running BERT Test
Device Initialised
Module Initialised
Loading Configuration
Load Configuration Done
Start Bert.....
Bert Started
BERT STATISTICS
*****
TrafficStatus = No Rx Traffic
SyncStatus = Idle
BitErrorStatus = Idle
OutOfSequenceStatus = Idle
BERTStatus = No Rx Data
BERTTestTime = 00:00:00
BitsReceived = 0
BitErrorCount = 0
BitErrorRate = 0.000E+000
BitErrorSeconds = 0
SyncLossCount = 0
SyncLossSeconds = 0
OOSCount = 0
OOSSeconds = 0
ErrorFreeSeconds = 0
*****
PORT TX STATISTICS
-----
Total Frames = 0
Valid Frames = 0
Number of Bytes = 0
Link Utilisation = 0.0
Data Rate = 0.0
Frame Rate = 0.0
Broadcast Frames = 0
Multicast Frames = 0
Control Frames = 0
VLAN Frames = 0
```

C# Client



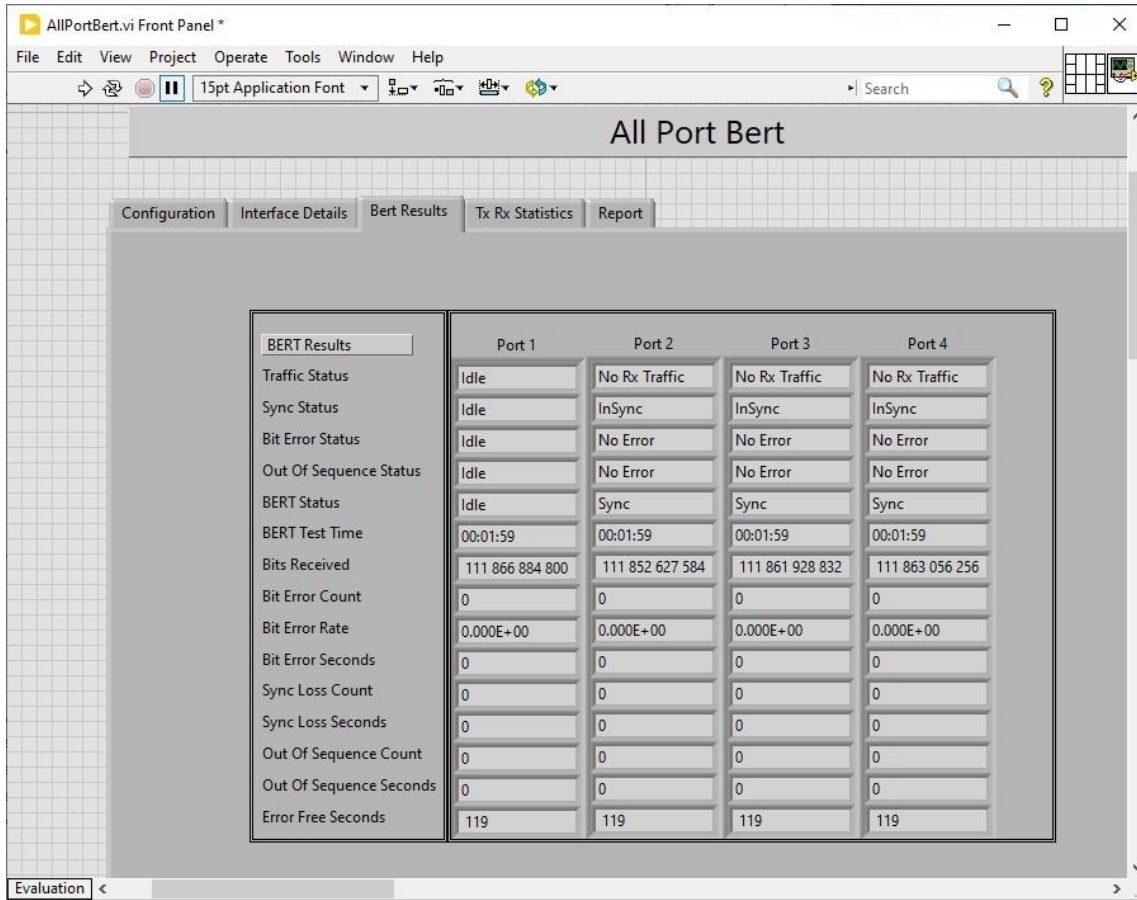
PacketExpert™ Integration with LabVIEW using C# Client

PacketExpert™ Integration with LabVIEW



PacketExpert™ Integration with LabVIEW using C# Client

BERT Results



BERT Statistics



Thank you