Comtech FX Series 7

WAN Optimization with Embedded Link Bonding and Balancing

FX5020e

FX1010e

FX1005ev

WAN Optimization: Delivering Fast Broadband QoE

When considering Internet access over satellite, high-speed connectivity does not necessarily equate to fast broadband as most end users expect when connected to 4G or 5G, wireless or wireline terrestrial networks. For end users, an efficient web browsing experience, responsive interaction and rapid content display are paramount for delivering a good Quality of Experience (QoE).

Due to the nature of the TCP protocol used for delivering Internet content, satellite latency and transmission impairments (packet drops), can negatively impact the user experience regardless of bandwidth capacity. Additionally, this obstacle is aggravated with feature-rich web page media content, an increased size on transferred files from HD pictures, video exchange on social media and HD video streaming. Without optimization, the display of high-definition content could represent a slow and, in some cases, non-responsive user experience over satellite.

Typical Users

- Internet Service Providers (ISPs)
- Mobile Network Operators (MNOs)
- Satellite Service Providers (SSPs)
- Communication Service Providers (CSPs)

Common Applications

- Satellite Broadband Internet Backhaul (Maritime, Rural, Mobility)
- 4G/LTE/5G Mobile Satellite Backhaul
- Corporate Networks Internet Access over Satellite (Oil & Gas, Mining, Govt.)

The Solution: Comtech WAN Optimization and SATCOM Bandwidth Optimization via Link Bonding and Balancing over GEO / MEO / LEO

To mitigate the adverse effect of satellite latency on file transfer, web browsing and HD media display (video streaming), a Protocol Enhancement Proxy server (PEP) is needed in-line at both ends of the satellite link to process user traffic. The PEP server shall ensure that overall QoE will meet end user's expectations (broadband-grade) across all applications (not only file transfer). Comtech's WAN Optimization (WANOp) Turbostreaming© solution employs a unique combination of techniques to deliver both fast file transfer and a true broadband user experience (QoE).

Specific to Comtech's WANOp solution is the focus on Communications Service Providers (CSPs). Technologies to mitigate satellite delay have been around for a while. Solutions currently used by most vendors are Layer 3 (IP/Routed) only, have limited performance, and does not support multiple network layers (MPLS, L2 or L3 tunnels). CSPs need large trunks supporting multiple thousands of users, and Layer 2 network services: Layer 2 VLANs or MPLS protocol are the most common approaches for delivering protocol- transparent transport services to other service providers such as ISPs, MNOs, or large corporate VPNs.

Comtech's WANOp offers a simple, performant, reliable transparent Layer 2 efficient solution, compatible with any protocol mix including MPLS, supporting L2/L3 VPNs with overlapping IP addressing space, 4G/5G cellular backhaul, and scales to very large trunk capacity (1.5 Gbps and beyond with Comtech's FX High-Capacity Load Balancing Option.

Features

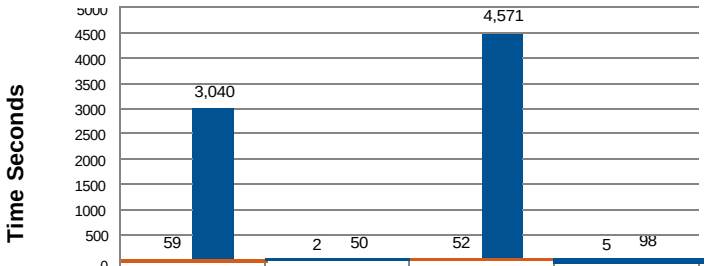
- Turbostreaming© dramatically improves file downloads and web browsing QoE across satellite links, enabling a terrestrial-like fast broadband user experience (>150 Mbps per user TCP session and up to 600 Mbps file transfer across 500ms GEO satellite links)
- DNS caching substantially shortens web page rendering by a factor up to two
- Deliver acceleration across ISP, Layer 2/Layer 3 corporate VPN and mobile (4G/5G) backhaul, Internet access traffic (including overlapping IP addresses)
- 100% end-to-end Layer 2/Layer 3 transparent ("Wire-like" operation: no Layer 3 IP routing information or processing required)
- Jumbo frames and multiple Layer 2 stacks support (VLANs, MPLS)
- Dual stack IPv4 and IPv6 support
- Layer 2/3/4 Quality of Service (QoS) – 2 level hierarchical queues with Priority, CIR, MIR settings
- Optional Layer 2-Layer 4 IP traffic generic Header Compression and Packet Aggregation (VoIP/2G/3G IP traffic optimization)
- Optional payload compression: Byte Caching and GZIP compression
- Real-time dynamic traffic shaping with ACM-enabled Comtech EF Data modems (for Ka- or Ku-band satellite links)
- Carrier-grade operation (1+1 system redundancy, line bypass, path redundancy)
- Scalability up to 1.5 Gbps throughput and 200k TCP sessions accelerated
- Simple license-based tiered pricing
- Bond separate satellite bandwidth segments into a virtual single contiguous bandwidth segment as option on FX5020e series

Turbostreaming©

Comtech's patented Turbostreaming technology is built around three concepts, ensuring faster content delivery for both small and large objects download through TCP connections, which is quite common on today's typical web pages. Turbostreaming enables a more efficient use of HTS larger satellite link capacity by increasing trunk traffic usage (for a given set of users) **by a factor 3 or more**.

- **TCP Connections Local Acknowledgment**: End user (Host) and Server TCP connections are terminated respectively at the remote and hub PEP servers. This enables fast local acknowledgment of the information received and faster connection setup. It also limits re-transmission in case of data loss at either end of the connection (last mile and Internet). Meanwhile, a proprietary protocol suited for satellite transmissions is used on the WAN segment, which mitigates the effect of satellite delay.
- **Persistent WAN Connections**: combined with TCP SYN/ACK spoofing, it significantly reduces the delivery time of web browsing content.
- **WAN TCP Connections Multiplexing**: Turbostreaming enables multiplexing of large object downloads (or uploads) like HD images/pictures and videos onto parallel WAN connections, effectively multiplying the speed of these object downloads/uploads across the WAN (available satellite link bandwidth permitting). Combined with expanded TCP window buffer size, Turbostreaming reduces download/upload time of large files by a factor 100.

Transfer Times Per Non-Compressible File (Seconds)



	GET Large Non-Compressible	GET Small Non-Compressible	PUT Large Non-Compressible	PUT Small Non-Compressible
Comtech FX	59	2	52	5
Direct	3,040	50	4,571	98

DNS Caching

DNS caching is an important feature for providing enhanced user QoE across satellite links. A single web page rendering can require access to 50-100 different hosts, which may result in DNS lookup time to represent a significant portion of the web page total download time. Having a DNS Cache server locally at the remote location allows typical time to be reduced by 50% or more. With Comtech's WANOp, the DNS Cache is embedded into the WANOp software, making it unnecessary to have a dedicated DNS Cache server. In addition, Comtech's DNS Cache operates on 4G/LTE mobile backhaul applications, as well as Layer 2 or Layer 3 VPNs (MPLS, GRE, mGRE), unlike external DNS Cache Servers.

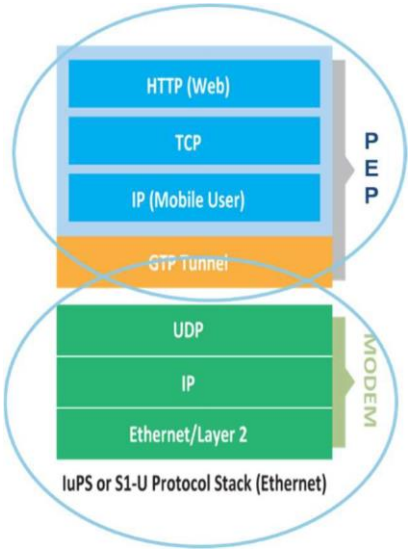
Layer 2-3 Transparency

Unlike ISPs, Communications Service Providers (CSPs) essentially provide Layer 1/ Layer 2 connectivity services. They do not control the format or protocol stacks in which the information is being delivered, and they don't necessarily have access to the routing information (IP Layer 3 protocol) of the traffic they carry through their networks. Therefore, CSPs need to ensure full transparency to the Layer 3 routing information of their clients' networks. As such, the CSP client traffic will often be tunneled into one or more Layer 2 protocol stacks:

- One or two VLAN tags (QinQ); VLAN tags could also be used to segregate traffic per remote destination
- MPLS tunnel with one or more stacked labels (used for traffic engineering, segregating traffic per customer or client's destination)
- GRE or mGRE tunnel Layer 3 VPNs

Contrary to most other vendors' PEP implementations, our WANOp "wire-like" operation is fully transparent to the CSP's client traffic, and operate on the different protocol stacks mentioned above, including MPLS:

- No Layer 3 IP routing information or configuration is required
- No Layer 2 or Layer 3 dependencies on the CSP or CSP's client networks (transparent bridge function)
- LAN to WAN Layer 2 – Layer 3 transparency (protocol headers remain unchanged)
- Note: Header and Data Compression when run in Layer 3 will require IP address configuration for each remote



Mobile Traffic: Support of GTP Tunnels and Dual Stack IPv6 and IPv4

4G/LTE and 5G user traffic, as well as 3G Packet Core traffic is not directly accessible above the IP network layer. It is instead encapsulated within another layer called GTP depicted on the right, therefore preventing standard TCP acceleration (PEP) implementation to be applied to that traffic.

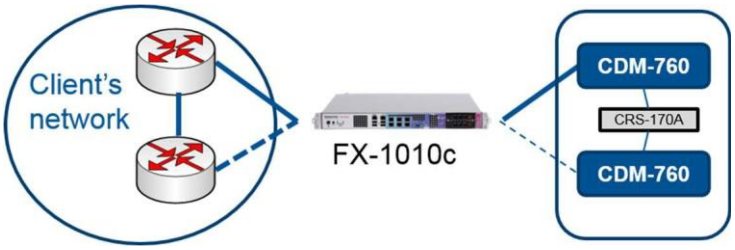
The FX WANOp PEP function can process the GTP layer to get access to and accelerate 3G at the Packet Core level and 4G/LTE or 5G mobile user (TCP) traffic regardless of whether the supporting IP layer (or client IP address) is IP v4 or IPv6. Both standard Internet traffic and 4G/LTE/5G (GTP) access traffic can be accelerated concurrently within the same appliance.

Note: A rapidly increasing numbers of MNOs are using IPv6 for the allocation of IP addresses to the mobile terminals, specifically smart phones, hence the importance of IPv6 support.

LAN/WAN Path Redundancy

When deploying a PEP server solution in-line (for transparency purpose), one of the challenges is to ensure path redundancy between the client's network switches or routers and the transmission network (satellite modems in this case). In order to solve the connectivity issue, the PEP server needs to offer two LAN interfaces, and two WAN interfaces, of which only one is active at any given time.
Selection of the active Ethernet interface is done through using port traffic and status monitoring and is compatible with major vendors Layer 2 standard mechanism (Cisco Flex link or EtherChannel for example).

The path redundancy works jointly with the fail to wire (line-bypass) feature in order to ensure continuous service availability (when in line bypass, traffic is passed through, but not accelerated). Both LAN/WAN interface pair are switched into line-bypass in case of system failure. The feature is also available when the units are configured as a 1+1 redundant system.



Front Page

Device Info

Hostname	FX-Hub
Serial number	FX1010-C001-1234
Firmware Version	7.0.1C.201811151937E4.x86_64

Status	
Memory Usage	45%
CPU Utilization	65%
Temperature	40 deg
LAN port Status	Up
WAN Port Status	Down
Acceleration Status	Active
Redundancy Status	Online

Statistics	
Users	2
LAN Connections	4
Link throughput (Mbps)	145

Simple Plug & Play Operation

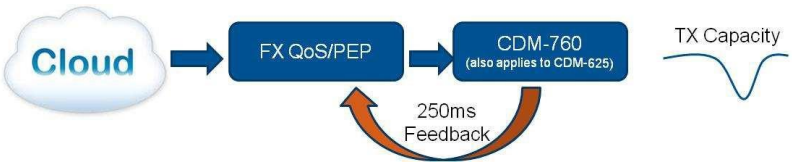
With the introduction of the v7.x software release, the setup of Comtech's PEP system has been greatly simplified. Only a few parameters need to be configured for basic operation, and key information is displayed in one single screen (see FX NetVue front page display on the left). Advanced configurations menus are available for optional features such as QoS, system redundancy, compression, or for tailoring the local PEP management interface configuration to the service provider's Operations & Management (O&M) control network. Configuration and monitoring functions are available through the system's local GUI, Comtech's NetVue NMS, standard SNMPv2/v3 driver interface, and CLI. Operator access and the management interface is secured through authentication, ACL and encryption (SSH/HTTPS).

QoS and Dynamic Traffic Shaping

The Comtech FX provides real-time dynamic traffic shaping on the WAN interface. Traffic shaping consists of a two-step processing, classification and drain. The FX supports many types of classification to allow working with multiple remote locations, multiple users and multiple types of traffic. Classifying can be done per VPN (VLAN tag, IP Subnet), per source/destination IP address, per protocol type, per Layer 4 port number, and per Layer 2 or Layer 3 QoS Label: DSCP, VLAN* p/q and MPLS EXP bits. Priority, CIRs and MIRs can be established at each of the levels of classification.

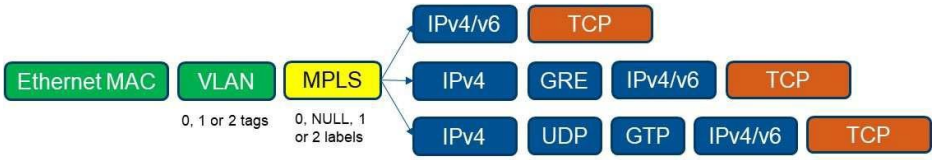
(*) Note: With QinQ traffic, only the outermost VLAN label tag is taken into consideration for QoS purpose.

Draining of the WAN link output queues (or shaping) can be static according to the preset WAN TX link bandwidth value at configuration, or it can be dynamic, with the FX having the ability to regularly poll the associated modem(s) to know the real-time data rate, using a configurable standard SNMP protocol OID. This is quite useful when working with ACM enabled satellite links where the WAN capacity changes rapidly and on a regular basis. Dynamic shaping oh the traffic therefore avoids random packet discards, which are detrimental to applications.



Detailed WANOp Software Feature List

- TCP PEP [Performance Enhancement Proxy]
  - Point-to-point and point-to-multipoint STAR ADC/REM Operation (Remote initiated TCP connection – download or upload)
  - Point-to-point and mesh network operation (two-way TCP operation)
  - Local TCP sessions acknowledgement (TCP ACK spoofing)
  - TCP/FTP Turbostreaming proprietary satellite link WAN acceleration protocol
  - Persistent WAN connections (TCP sessions multiplexing equivalent to HTTP-2 protocol)
  - Variable WAN TCP buffer window size per connection – automatically adjusted to fit link bandwidth.
  - Supports HTTP, HTTPS, HTTP/2, SSL, FTP and Generic TCP traffic acceleration
- TCP over Layer 3 IP acceleration
  - Support of TCP over GTP protocol acceleration (5G/4G/LTE access S1-U and 3G packet core – IuPS/Gn- interfaces)
  - Support of TCP over GRE and mGRE protocol acceleration (Layer 3 IP VPN)
  - Support TCP over concurrent dual stack IPv4/IPv6 acceleration
- Support L2/L3 VPNs and MNOs concurrent overlapping IP addressing space
- DNS Caching (including GTP and GRE encapsulated tunneled traffic)
- Full Layer-2 (L2) LAN-WAN transparency (transparent bridging) with L2/L3 QoS information preservation (VLAN p bits, EXP bits, DSCP field)
- One-touch network operation (No L2/L3 network information required or configuration)
- Multiple L2/L3protocol stacks combination acceleration support (non-encrypted)
  - VLANs (single tag)
  - QinQ (two VLAN tags)
  - MPLS (zero [NULL], one or two labels, per direction)



- Jumbo Ethernet Frame support (up to 9,000 bytes MTU) on WAN and LAN
- Standard to Jumbo frame/packets size conversion (LAN to WAN), to minimize packet overhead and PPS processing on WAN
- 3 Tier Layer 2/3/4 QoS
  - Per VPN (outermost VLAN tag qbits, outermost IP header subnet)
  - Per source / destination (IP SA/DA)
  - Per QoS label (VLAN p bits, MPLS EXP bits, DSCP field)
  - Per Protocol type
  - Per port number
- Dynamic shaping
  - Based on modem real-time baseband capacity (MODCOD, Symbol-rate)
- Optional traffic optimization and compression:
  - Layer- 2 to Layer 4 protocols Header Compression and Packet Aggregation (HC/PA) [1]
  - Apply to IPv4 and IPv6 as well as encapsulated (GRE, GTP) tunneled IP Traffic;
  - Generic Packet Payload Compression with history (ZLIB) [1]
  - FTP file transfer payload compression (GZIP) and Byte Caching (Block mode) traffic optimization
- HA (High Availability)
  - Automatic hardware fail-to-wire (line-bypass)
  - Optional 1+1 system redundancy (in-line)
  - 1+1 hot swap power supplies - Not available on FX1005e
  - Dual path (LAN/WAN) connectivity (for path redundancy) - Not available on FX1005ev
- Support TCP acceleration software Bypass (Filtering per flow, SA/DA, IP subnet or all TCP traffic)
- Traffic, PEP and DNS Cache Statistics
- Passive Traffic Monitoring (using Wireshark traffic capture)
- Management and Operation
  - Secured console and remote operator access (Operator Name, Password and White list)
  - Radius Client and Syslog support
  - Supported management interfaces: Web GUI (HTTP/HTTPS), Menu driven console (Telnet or SSH), SNMPv3
  - SNMP and MIBs are available for 3rd party NMS access and control.
  - Simple "one touch" configuration
  - Secured Out-of-band management interface
  - Network traffic statistics
  - Comtech NetVue operation (configuration, supervision)
  - Real-time LAN/WAN traffic capture (using standard PCAP format, readable by Wireshark software tool

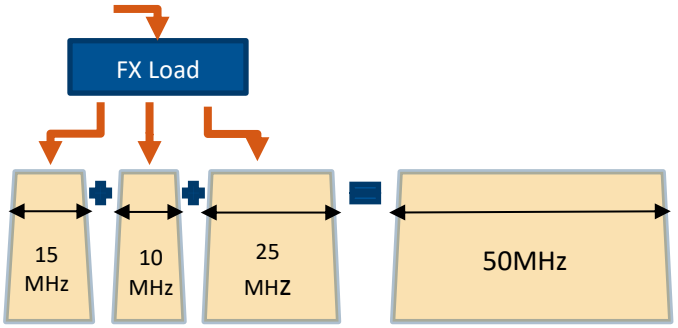
Note ([1]): Generic Header/Payload compression [HC/PC] is an optional feature and does not apply to the accelerated TCP traffic. Header and payload traffic optimization is embedded in the TCP traffic acceleration traffic processing. Use of the HC/PC feature may reduce the specified performances of TCP acceleration traffic processing (traffic throughput). Please, contact your Comtech's representative for more information.

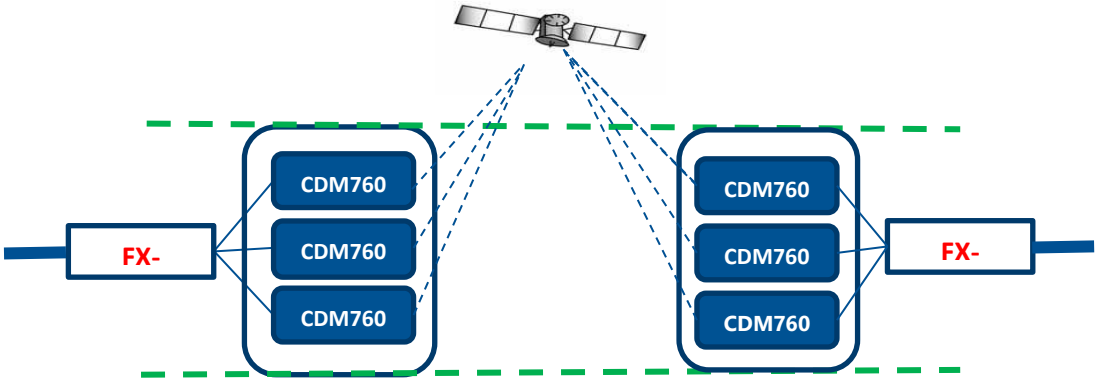
Powerful Satellite Link Bonding and Load Balancing Transponder Fragmentation and Link Bonding serving GEO/MEO/LEO Constellations

One major issue facing incumbent Satellite Service Providers operating GEO satellites is transponder fragmentation. Today customers require large transponder capacity which is not necessarily available as one piece, though the capacity might be available globally across the operator's satellite. This leaves Satellite Service Providers with stranded capacity and sub-optimal use of their assets. Comtech's FX5020e Series can solve this problem by aggregating individual smaller pieces of transponder capacity as one virtual transponder link (bonded link), which could even be located across different bands or satellites, thus offering solutions that meet customers demand and leverage.

Gigabit capacity backhaul links

Load-Balancing across multiple point-to-point paths (GEO/MEO/LEO/Terrestrial). Combined with PEP (TCP acceleration) enables end-user true broadband experience and ensures maximum full capacity usage of the aggregated link capacity.
Also enables GEO service providers to compete with MEO and LEO





Layer-2 Ethernet virtual link

Features:

- Support up to 12 ports GE load balanced
- GE or 10GE (optical, electrical) LAN connectivity
- Per flow session-based (Layer 4) dynamic load balancer
- Flow identification on IP address and port (if present) traversing VLANs, MPLS labels and GRE/GTP tunnel headers
- Support for asymmetric bandwidth (TX/RX) and different speed links
- Support of real-time individual variable link throughput (modem links with ACM)
- Flow capacity: 1,000,000 (flow aging based on a configurable time limit)
- Standalone operation or combined with WANOp (in a VM environment)
- Point to point or point to multipoint support
- Flows based load balancing. This load balancing can be used in front of multiple WanOP units
- Packets based load balancing.
  - On its own or after a WANOp operation (in VM or a separated unit).
  - Support multiple satellite links with different characteristics (bandwidth, latency, and jitter)
  - Packet reordering based on the input sequence
  - Direction configurable (TX/RX, TX only or RX only)
  - Smart bandwidth adjustment operation. It can increase or throttle back based on flow controlled by the modem
  - Support any Ethernet traffic, no packet content lookup
- Port configurations
  - 2 user ports, 2 balanced ports (with 2 link bypass capability when used with WANOp)
  - 2 user ports, 6 balanced ports (with or without link bypass capability)
  - 2 user ports, 12 balanced ports

Specifications

Model	FX-1005ev	FX-1010e
Form Factor	1RU	1RU
Weight	2.0 lbs. (1.2kg)	12 lbs (5.6 kg)
Dimensions (H x W x D)	1.73" x 9.09" x 7.87" (44 x 231 x 200 mm)	1.73" x 17.0" x 12.0" (44 x 432 x 305 mm)
Nb Ethernet ports	6 x GE RJ45 (2xLAN, 2xWAN, MGT, AUX)	4 or 6 x GE RJ45 (1 or 2xLAN, 1 or 2xWAN, MGT, AUX)
Nb ports Line bypass (fail to wire)	2 (2+2)	1 (1+1) or 2 (2+2)
Path Redundancy (LAN, WAN)	Yes	Yes
Rack Mount Kits	Yes	Built-in
Traffic processing capacity in Mb/s (aggregated throughput TX+RX)**	100	250
Licensing Tier* (in number of client TCP sessions accelerated)	2k, 4k, 10k, 20k	2k, 4k, 10k, 20k, 40K
Power Supply - UL Approved, FCC Compliant	Auto (100V-240V) AC Power with 40W external power supply Power consumption: 25W – Rack mount bracket optional	Redundant Hot Swap DC or AC Power consumption: 70W
Power Supply Safety/EMC Certifications	FCC Part 15 Subpart B Europe/CE Mark ROHS, UL (CA, US)	FCC Part 15 Subpart B Europe/CE Mark ROHS, UL (CA, US)
MTBF (non-redundant/without failsafe)	11.1 years	10.1 years
Environmental (values at sea level)	Operating temp 0 to 40°C Storage temp -20 to 70°C Operating relative humidity 5 - 90% (non-condensing)	Operating temp 0 to 50°C Storage temp -20 to 70°C Operating relative humidity 5 - 90% (non-condensing)

Model	FX-5020e	FX5020e Link Bonding
Form Factor	1RU	
Weight	15.5 lbs (7 kg)	
Dimensions (H x W x D)	1.7" x 17.2" x 16.9" (43 x 437 x 429 mm)	
Nb Ethernet ports	6 x GE RJ45 (2xLAN, 2xWAN, MGT, AUX)	16 x GE RJ45 (2xLAN,1 2xWAN, MGT, AUX)
Nb ports Line bypass (fail to wire)	2	2 (Only when combined with WANOp) None for Link Bonding only
Path Redundancy (LAN, WAN)	Yes	Yes (LAN only)
Rack Mount Kits	Built-in	
Traffic processing capacity in Mb/s (aggregated throughput TX+RX)**	1,500 (1,000 in VM)	8,000*** (1,000 in VM), up to 12 load balanced ports
Licensing Tier* (in number of client TCP sessions accelerated)	10k, 20k, 40k, 60k, 100k, 150k, 200k	100K
Power Supply - UL Approved, FCC Compliant	Hot Swap 1+1 48VDC Power consumption: 300W Optional AC power supply as a separate module. See factory for details	
Power Supply Safety/EMC Certifications	FCC Part 15 Subpart B Europe/CE Mark ROHS, UL (CA, US)	
MTBF (non-redundant/without failsafe) [years]	6.2	
Environmental (values at sea level)	Operating temp 0º to 40°C Storage temp -40 to 70°C Operating relative humidity. 8 - 90% (non-condensing)	

Notes: (*) The appliance does not limit the traffic throughput or number of TCP sessions based on license. Instead, traffic (or rather client TCP initiated sessions) in excess of the allocated license are simply pass through un-processed (not accelerated), within the limit of the appliance traffic forwarding capabilities.
(**) TCP Acceleration only (without Header/Payload Compression)
(***) Max configuration 4,000 per direction

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 FX 7.8 – Approved for Public Release 164-2024