Routing performance LCOS 10.80

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Applications for communications and entertainment are increasingly based on IP networks. In order to ensure that the necessary bandwidth performance can be provided reliably, it is important for the infrastructure's networking components to be tested thoroughly and intensively. In this techpaper, LANCOM Systems presents the methods of measuring routing and VPN performance for central site and VPN gateways as well as the respective results.

We have examined a variety of aspects for consideration when measuring the router performance. This includes transmission speeds of connections between the LAN and the Internet (WAN), and the internal data transmission in the network (LAN-LAN). Many business processes rely on secure WAN connections, which is why we have focused on determining the performance of encrypted data connections over VPN.

Test system

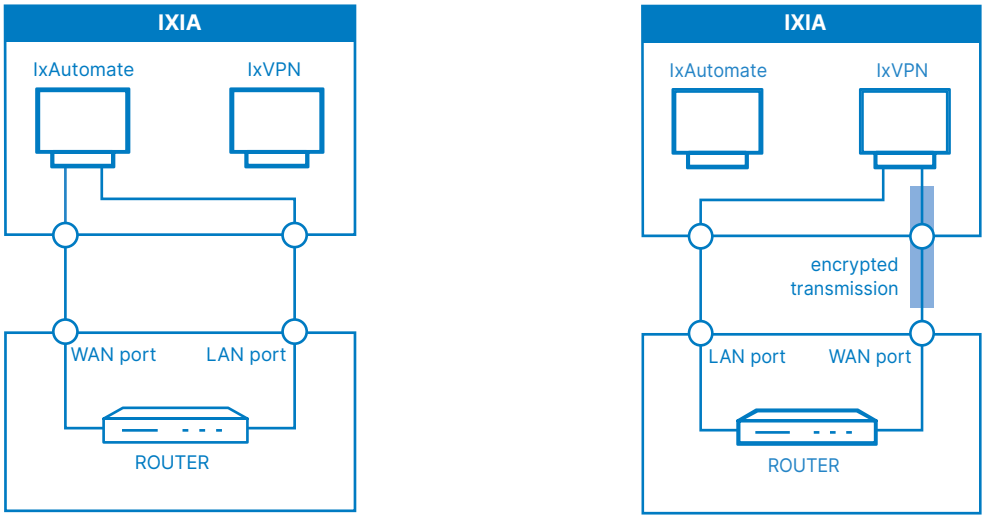

Figure 1:
IXIA test system for routing connections and encrypted VPN connections between LAN and WAN

All of the performance values were measured in the LANCOM test laboratory. Tests were conducted with an IXIA test system. IXIA uses so-called test suites, which enable the simulation of different applications. This allows, for example, the investigation of data throughput over automatically established VPN tunnels, or the measurement of pure LAN-WAN routing performance for unidirectional and bidirectional data connections. IXIA is a leading supplier of systems which test IP-based services and infrastructures. Test systems from IXIA are employed all over the world by network component manufacturers and other organizations to help assure the functionality and reliability of complex IP networks, devices, and applications.

The measurement of data transmission itself uses either a fixed frame size or a combination of frame sizes which reflects a typical flow of data. These combinations are known as “Internet Mix”, or IMIX for short. The type of IMIX which is applied significantly affects the test results because packet size has a strong influence on a connection’s performance. By selecting the appropriate ports on the router being tested, it is possible to test connections between the LAN and the WAN, and also pure LAN-LAN connections.

The setup for measuring transfer rates > 1 GBit/s represents a large central-site scenario. In this scenario, several central sites can also work as a network, which is why an intermediate router with BGP ensures that the packets for each tunnel pass through the respective central site (see UDP measurement values for devices with 10 Gbps interfaces).

Routing performance (UDP)

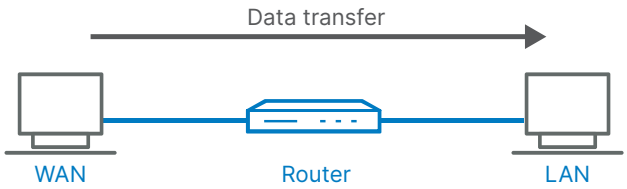

Figure 2: Schematic view of the test system

The measurement of routing performance involves the determination of the maximum data throughput which can be achieved before a router starts rejecting packets. This measurement uses UDP packets of various sizes in order to simulate the performance with different applications. Ethernet frame sizes range from 64 bytes for the smallest to 1518 bytes for the largest frames. Tests on different router models demonstrate the influence of the different hardware platforms (processor, interfaces).

Measurements initially determine the frame rate, which is a good performance indicator of the tested hardware. With normal routing, the frame rate is fairly constant even with different frame sizes. This is because only the header is inspected during routing, a process which is largely independent of the size of the frames being routed. For this reason, only the typical frame rates are given in the tables.

The throughput for a certain frame size (or even a mix of sizes, see IMIX) can be approximately calculated by multiplication with the frame rate. When the frame rate is constant, data throughput depends directly on the frame size because the larger the frames, the larger is the data volume that can be transmitted. The maximum number of frames transmitted per second is limited by the performance of the interfaces and the transmission medium.

Measurement of the routing performance relates to the size of the Ethernet frames. To compare packet sizes for particular applications, it is necessary to subtract the header. For a frame of 512 bytes, the result is a UDP datagram size of 474 bytes (512 bytes - 14 bytes Ethernet header - 4 bytes FCS trailer - 20 bytes IP header) and, after subtracting the UDP header (8 bytes), the UDP payload is 466 bytes.

To investigate routing performance, in this paper two different applications are considered.

→ For WAN-LAN routing, data received from the WAN is forwarded to a peer in the LAN.

→ For LAN-LAN routing, data remains within the local-area network and is passed from one LAN port to another.

The measurements show that the throughput increases almost linearly with the frame size until the limit of the Gigabit interface is reached.

Routing performance (TCP)

UDP measurements show very well what maximum performance can be achieved. However, since a large part of the data traffic is also handled via TCP, it is important to investigate corresponding scenarios.
TCP measurements are more dependent on the structure of the endpoints used, such as the PC, the network adapter (NIC) or its offloading, the TCP stack of the operating system used, the browser, and so on.
In the same way, the properties of a WAN link also affect the TCP (e.g. delay, jitter, packet loss).
The measurements shown are intended to provide an initial orientation with regard to the performance for different routing / tunnel variants, in order to determine the appropriate device class for the required performance on this basis.

Considered are in each case
Two scenarios:
→ A single device
→ Two devices of the same type coupled via a WAN link, with different tunnel types configured on the WAN link
Two measurement types:
→ TCP measurement values with iperf3 (measurement tool)
→ HTTP measurement values with transfers between nginx (web server) and siege (measurement tool)

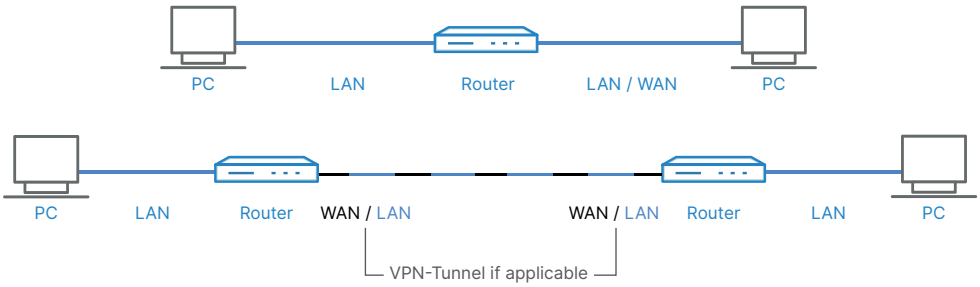

Figure 3:
Schematic view of the test setup scenarios

Notes:
→ On 1G or 10G interfaces, no more than approx. 940 Mbps or 9.40 Gbps, respectively, is possible in terms of user data.
→ Only a single tunnel is established over the WAN link. The LANCOM devices ISG-5000 and ISG-8000 achieve higher total throughputs when multiple tunnels are used simultaneously.

IPSec routing performance

Other than with pure routing performance, IPSec-VPN routing actually changes the frames which are being passed from one interface to the next. When data is encrypted for the VPN tunnel, the original frame is encapsulated and it is supplemented with additional information.

This has two important effects when considering the performance of IPSec routing:

→ Encrypted frames are larger than unencrypted frames. Consequently, any results have to indicate which frame size was observed at which interface, and/or whether frames were encrypted or unencrypted. The values presented here always relate to an unencrypted frame size. An IP packet of 46 bytes is transported unencrypted, e.g. in a frame of 64 bytes. In the event of AES encryption, the frame grows for example to 122 bytes (46 byte IP packet + 14 byte Ethernet + 4 byte FCS + 20 byte IP + 8 byte ESP + 16 byte initialization vector (IV) + 0 byte padding (0-15 byte) + 1 byte padding length + 1 byte next header + 12 byte authentication).

→ The processes of encryption and decryption in the router take up computing time. These processes take place in two steps which, in the case of encryption, must be sequential. With decryption, on the other hand, these steps can be executed in parallel. Router models with VPN hardware acceleration provide significantly better performance with decryption than with encryption. This explains why the results display a significant difference in performance between the decryption and encryption directions. All of the IPSec-routing values given here are for a single VPN tunnel. With up to 1,000 tunnels established under laboratory conditions, the frame rate remained almost constant over all of the active tunnels. However, under actual operating conditions an increasing number of tunnels will cause the frame rate to drop due to the processes running for each tunnel (for example renewal of the key being used).

IPSec routing with different IMIX (decryption and encryption)

As an alternative to measurements with fixed frame sizes, series of measurements were performed with different IMIX patterns. The IMIX patterns simulate „real“ data traffic composed of different frame sizes. There is no binding guideline for the composition of the frame sizes used, so in addition to the default setting of the IXIA test system (IMIX 0), two other common patterns were used for the measurement (IMIX 1 and IMIX 2).

The individual patterns use the following frame compositions:
→ IMIX 0: 45% 64 bytes, 20% 128 bytes, 5% 256 bytes, 3% 512 bytes, 2% 1024 bytes, 1% 1280 bytes, 24% 1364 bytes.
→ IMIX 1: 7× 64 bytes, 4× 570 bytes, 1× 1418 bytes.
→ IMIX 2: 58% 90 bytes, 2% 92 bytes, 24% 594 bytes, 16% 1418 bytes.

Assuming an overhead of 100 bytes, 1418 bytes is the maximum frame size that can be transmitted encrypted on the Ethernet (with a maximum frame size for IEEE 802.3 of 1518 bytes).

Once again, it can be seen in these measurements that the decryption of the data is usually faster than the encryption.

Category assignment of the devices under test (DUT) for clear presentation of the test results

Locate your LANCOM device in the left column of the table and note the device category assigned in the right column of the table.
In the tables on the following pages, you can assign the performance values for your device based on this device category.

LANCOM device name	Device category
730VA, 883 VoIP, 884 VoIP 1640E 1780EW-4G+ 1781EW+, 1781VA, 1781VAW 1783VA, 1783VAW, 1784VA 1790-4G, 1790EF, 1790VA, 1790VA-4G, 1790VAW 1793VA, 1793VA-4G, 1793VAW IAP-1781VAW+ IAP-4G+	**A**
1800EF, 1800EF-5G, 1800EFW	**B**
1800VA 1800VA-4G 1800VAW 1800VAW-4G 750-5G IAP-5G	**C**
1900EF, 1900EF-5G 1906VA, 1906VA-4G 1926VAG, 1926VAG-4G, 1926VAG-5G	**E**
WLC-1000	**F**
ISG-5000	**G**
ISG-8000	**H**
vRouter	**I**

UDP measurement values for devices with 1 Gbps interfaces

Note: For large frames or TCP, the measured performance may not be determined by the performance of the device, but is limited by the Ethernet interfaces (1G or 10G).

Table 1 - WAN-LAN routing

		Throughput [Mbps] @ frame size [bytes] and frame rate [fps]							
Device category (reference device)	**LCOS**	**64**	**128**	**256**	**512**	**1024**	**1280**	**1518**	
A (1790EF)	10.80	**57.0** 110,000	**113** 110,000	**221** 108,000	**437** 106,000	**841** 102,000	**982** 95,800	**984** 81,000	**Mbps** Frames/s
B (1800EF)	10.80	**121** 236,000	**222** 217,000	**406** 198,000	**831** 202,000	**977** 119,000	**982** 95,800	**984** 81,000	**Mbps** Frames/s
C (1800VAW-4G)	10.80	**89.4** 174,000	**179** 174,000	**358** 174,000	**709** 173,000	**981** 119,000	**985** 96,100	**987** 81,200	**Mbps** Frames/s
E (1900EF)	10.80	**97.6** 190,000	**195** 190,000	**390** 190,000	**776** 189,000	**977** 119,000	**982** 95,800	**984** 81,000	**Mbps** Frames/s
F (WLC-1000)	10.80	**80.4** 157,000	**160** 156,000	**322** 157,000	**642** 156,000	**981** 119,000	**985** 96,100	**987** 81,200	**Mbps** Frames/s

Table 2 - LAN-LAN routing

		Throughput [Mbps] @ frame size [bytes] and frame rate [fps]							
Device category (reference device)	**LCOS**	**64**	**128**	**256**	**512**	**1024**	**1280**	**1518**	
A (1790EF)	10.80	**63.2** 123,000	**125** 122,000	**244** 119,000	**480** 117,000	**926** 113,000	**982** 95,800	**984** 81,000	**Mbps** Frames/s
B (1800EF)	10.80	**142** 277,000	**271** 264,000	**504** 246,000	**952** 232,000	**977** 119,000	**982** 95,800	**984** 81,000	**Mbps** Frames/s
C (1800VAW-4G)	10.80	**103** 200,000	**204** 199,000	**413** 201,000	**818** 199,000	**981** 119,000	**985** 96,100	**987** 81,200	**Mbps** Frames/s
E (1900EF)	10.80	**108** 211,000	**218** 212,000	**435** 212,000	**865** 211,000	**977** 119,000	**982** 95,800	**984** 81,000	**Mbps** Frames/s
F (WLC-1000)	10.80	**105** 204,000	**210** 204,000	**418** 204,000	**839** 204,000	**981** 119,000	**985** 96,100	**987** 81,200	**Mbps** Frames/s

Table 3 - IPSec routing AES-CBC UDP decryption

		Throughput [Mbps] @ frame size [bytes] and frame rate [fps]							
Device category (reference device)	**LCOS**	**64**	**128**	**256**	**512**	**1024**	**1280**	**1418**	
A (1790EF)	10.80	**33.7** 65,900	**67.1** 65,500	**132** 64,400	**258** 63,000	**505** 61,600	**621** 60,600	**681** 60,000	**Mbps** Frames/s
B (1800EF)	10.80	**101** 198,000	**200** 195,000	**387** 188,000	**775** 189,000	**916** 111,000	**928** 90,600	**925** 81,500	**Mbps** Frames/s
C (1800VAW-4G)	10.80	**58** 113,000	**115** 112,000	**231** 112,000	**462** 112,000	**918** 112,000	**943** 92,100	**946** 83,400	**Mbps** Frames/s
E (1900EF)	10.80	**58.2** 113,000	**117** 114,000	**234** 114,000	**465** 113,000	**920** 112,000	**929** 90,700	**929** 81,800	**Mbps** Frames/s
F (WLC-1000)	10.80	**62.4** 121,000	**124** 121,000	**248** 121,000	**494** 120,000	**896** 109,000	**929** 90,600	**926** 81,500	**Mbps** Frames/s

Table 4 - IPSec routing AES-CBC UDP encryption

		Throughput [Mbps] @ frame size [bytes] and frame rate [fps]							
Device category (reference device)	**LCOS**	**64**	**128**	**256**	**512**	**1024**	**1280**	**1418**	
A (1790EF)	10.80	**31.6** 61,800	**63.3** 61,800	**125** 61,000	**246** 60,000	**482** 58,800	**591** 57,600	**657** 57,900	**Mbps** Frames/s
B (1800EF)	10.80	**100** 195,000	**197** 191,000	**374** 182,000	**728** 177,000	**842** 102,000	**941** 91,900	**947** 83,400	**Mbps** Frames/s
C (1800VAW-4G)	10.80	**82.1** 160,000	**164** 160,000	**329** 160,000	**657** 160,000	**918** 112,000	**932** 90,900	**948** 83,500	**Mbps** Frames/s
E (1900EF)	10.80	**63.1** 124,000	**127** 124,000	**250** 122,000	**508** 124,000	**926** 112,000	**940** 91,700	**945** 83,300	**Mbps** Frames/s
F (WLC-1000)	10.80	**51.2** 100,000	**102** 99,600	**206** 100,000	**407** 99,300	**816** 99,600	**941** 91,800	**948** 83,500	**Mbps** Frames/s

Table 5 - IPSec routing decryption / encryption

		Throughput [Mbps]					
Device category (reference device)	**LCOS**	**Decryption**			**Encryption**		
		IMIX 0	**IMIX 1**	**IMIX 2**	**IMIX 0**	**IMIX 1**	**IMIX 2**
A (1790EF)	10.80	**219**	**172**	**212**	**210**	**163**	**200**
B (1800EF)	10.80	**692**	**501**	**650**	**600**	**472**	**576**
C (1800VAW-4G)	10.80	**521**	**405**	**436**	**563**	**442**	**527**
E (1900EF)	10.80	**398**	**308**	**377**	**456**	**343**	**428**
F (WLC-1000)	10.80	**416**	**326**	**398**	**349**	**269**	**331**

UDP measurement values for devices with 10 Gbps interfaces

Note: For large frames or TCP, the measured performance may not be determined by the performance of the device, but is limited by the Ethernet interfaces (1G or 10G).

Table 6 - IPSec AES256-GCM UDP decryption

		Throughput [Mbps] @ frame size [bytes] and frame rate [fps]							
Device category (reference device)	**LCOS**	**64**	**128**	**256**	**512**	**1024**	**1280**	**1418**	
G (ISG-5000)	10.80	**297** 579,000	**582** 567,000	**1,130** 551,000	**2,150** 526,000	**3,720** 454,000	**4,250** 415,000	**4,410** 389,000	**Mbps** Frames/s
H (ISG-8000)	10.80	**654** 1,270,000	**1,300** 1,270,000	**2,580** 1,260,000	**5,140** 1,250,000	**9,320** 1,130,000	**9,450** 923,000	**9,480** 835,000	**Mbps** Frames/s
I (vRouter)	10.80	**374** 731,000	**817** 797,000	**1,530** 747,000	**2,440** 595,000	**5,490** 671,000	**6,030** 589,000	**6,280** 554,000	**Mbps** Frames/s

Table 7 - IPSec AES256-GCM UDP encryption

		Throughput [Mbps] @ frame size [bytes] and frame rate [fps]							
Device category (reference device)	**LCOS**	**64**	**128**	**256**	**512**	**1024**	**1280**	**1418**	
G (ISG-5000)	10.80	**295** 539,000	**599** 567,000	**1,150** 550,000	**2,030** 488,000	**3,400** 412,000	**4,130** 398,000	**4,350** 379,000	**Mbps** Frames/s
H (ISG-8000)	10.80	**633** 1,160,000	**1,230** 1,160,000	**2,500** 1,190,000	**5,090** 1,220,000	**9,450** 1,130,000	**9,540** 923,000	**9,500** 835,000	**Mbps** Frames/s
I (vRouter)	10.80	**424** 778,000	**741** 701,000	**1,260** 603,000	**2,910** 705,000	**4,730** 571,000	**5,330** 519,000	**5,830** 513,000	**Mbps** Frames/s

Table 8 - IPSec AES256-CBC SHA256 UDP decryption

		Throughput [Mbps] @ frame size [bytes] and frame rate [fps]							
Device category (reference device)	**LCOS**	**64**	**128**	**256**	**512**	**1024**	**1280**	**1418**	
G (ISG-5000)	10.80	**152** 297,000	**277** 270,000	**487** 237,000	**778** 190,000	**1,110** 136,000	**1,210** 118,000	**1,270** 112,000	**Mbps** Frames/s
H (ISG-8000)	10.80	**416** 811,000	**823** 803,000	**1,600** 784,000	**2,760** 675,000	**3,850** 470,000	**4,210** 411,000	**4,380** 386,000	**Mbps** Frames/s
I (vRouter)	10.80	**283** 553,000	**523** 510,000	**686** 334,000	**1,410** 345,000	**1,510** 184,000	**2,180** 213,000	**2,270** 200,000	**Mbps** Frames/s

Table 9 - IPSec AES256-CBC SHA256 UDP encryption

		Throughput [Mbps] @ frame size [bytes] and frame rate [fps]							
Device category (reference device)	**LCOS**	**64**	**128**	**256**	**512**	**1024**	**1280**	**1418**	
G (ISG-5000)	10.80	**73.8** 135,000	**135** 127,000	**229** 109,000	**354** 85,700	**491** 59,600	**542** 52,700	**558** 49,000	**Mbps** Frames/s
H (ISG-8000)	10.80	**206** 379,000	**370** 350,000	**634** 304,000	**1,000** 242,000	**1,410** 170,000	**1,520** 148,000	**1,590** 140,000	**Mbps** Frames/s
I (vRouter)	10.80	**221** 406,000	**411** 386,000	**697** 334,000	**1,100** 268,000	**1,560** 189,000	**1,700** 166,000	**1,760** 155,000	**Mbps** Frames/s

Table 10 - IPSec IMIX AES256-GCM UDP decryption / encryption
Throughput [Mbps]

Device category (reference device)	LCOS	Decryption			Encryption		
		IMIX 0	IMIX 1	IMIX 2	IMIX 0	IMIX 1	IMIX 2
G (ISG-5000)	10.80	1,860	1,540	1,860	1,930	1,480	1,680
H (ISG-8000)	10.80	4,510	3,460	4,180	4,470	3,330	4,120
I (vRouter)	10.80	2,590	2,100	2,510	2,320	1,800	2,230

Table 11 - IPSec IMIX AES256-CBC SHA256 UDP decryption / encryption
Throughput [Mbps]

Device category (reference device)	LCOS	Decryption			Encryption		
		IMIX 0	IMIX 1	IMIX 2	IMIX 0	IMIX 1	IMIX 2
G (ISG-5000)	10.80	753	617	716	339	278	323
H (ISG-8000)	10.80	2,690	2,110	2,480	941	784	894
I (vRouter)	10.80	1,310	1,100	1,300	998	826	961

TCP measurement values for all devices

Note: For large frames or TCP, the measured performance may not be determined by the performance of the device, but is limited by the Ethernet interfaces (1G or 10G).

Table 12 - iPerf single DUT routing TCP

		Throughput [Mbps] for 5 parallel transmissions		
Device category (reference device)	**LCOS**	**LAN download / upload**	**WAN download**	**WAN upload**
A (1790EF)	10.80	**926**	**926**	**924**
B (1800EF)	10.80	**938**	**938**	**938**
C (1800VAW-4G)	10.80	**940**	**940**	**940**
E (1900EF)	10.80	**929**	**929**	**928**
G (ISG-5000)	10.80	**8,250**	**6,750**	**5,580**
H (ISG-8000)	10.80	**9,400**	**9,400**	**9,400**
I (vRouter)	10.80	**9,400**	**9,390**	**9,310**

Table 13 - HTTP single DUT routing HTTP TCP

		Throughput [Mbps] for 5 parallel transmissions		
Device category (reference device)	**LCOS**	**LAN download / upload**	**WAN download**	**WAN upload**
A (1790EF)	10.80	**918**	**909**	**911**
B (1800EF)	10.80	**929**	**920**	**923**
C (1800VAW-4G)	10.80	**928**	**930**	**928**
E (1900EF)	10.80	**919**	**913**	**915**
G (ISG-5000)	10.80	**4,830**	**4,810**	**4,820**
H (ISG-8000)	10.80	**9,390**	**9,390**	**9,390**
I (vRouter)	10.80	**9,390**	**9,390**	**9,390**

Table 14 - iPerf DUT2DUT WAN routing TCP

Throughput [Mbps] for 5 parallel transmissions

Device category (reference device)	LCOS	IPv4	PPP	PPP NAT	L2TP	EOGRE tunnel	IPSec tunnel AES-CBC	IPSec tunnel AES-GCM	L2TPv3 tunnel in IPSec tunnel AES-GCM
A (1790EF)	10.80	**890**	**840**	**665**	**522**	**454**	**373**	**441**	**251**
B (1800EF)	10.80	**940**	**935**	**935**	**738**	**916**	**890**	**903**	**649**
C (1800VAW-4G)	10.80	**940**	**935**	**935**	**792**	**802**	**808**	**790**	**461**
E (1900EF)	10.80	**912**	**910**	**912**	**883**	**831**	**767**	**821**	**448**
G (ISG-5000)	10.80	**5,530**	**5,230**	**4,720**	**2,680**	**2,330**	**479**	**2,070**	**1,470**
H (ISG-8000)	10.80	**9,400**	**9,350**	**9,350**	**6,340**	**5,390**	**1,340**	**5,720**	**3,330**
I (vRouter)	10.80	**7,880**	**7,800**	**7,430**	**5,200**	**5,160**	**1,280**	**3,220**	**2,350**

Table 15 - HTTP DUT2DUT WAN routing TCP

Throughput [Mbps] for 5 parallel transmissions

Device category (reference device)	LCOS	IPv4	PPP	PPP NAT	L2TP tunnel	EOGRE tunnel	IPSec tunnel AES-CBC	IPSec tunnel AES-GCM	L2TPv3 tunnel in IPSec tunnel AES-GCM
A (1790EF)	10.80	**904**	**907**	**840**	**512**	**463**	**388**	**456**	**249**
B (1800EF)	10.80	**931**	**921**	**924**	**792**	**909**	**878**	**896**	**783**
C (1800VAW-4G)	10.80	**926**	**926**	**926**	**888**	**886**	**866**	**884**	**504**
E (1900EF)	10.80	**912**	**911**	**911**	**888**	**884**	**867**	**879**	**509**
G (ISG-5000)	10.80	**3,930**	**3,680**	**3,530**	**2,410**	**2,170**	**462**	**1,770**	**1,410**
H (ISG-8000)	10.80	**9,390**	**9,270**	**9,320**	**6,460**	**5,530**	**1,350**	**4,670**	**4,250**
I (vRouter)	10.80	**8,040**	**7,880**	**8,290**	**5,410**	**5,370**	**1,270**	**3,590**	**2,530**

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