Routing performance LCOS 10.50 / 10.60

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

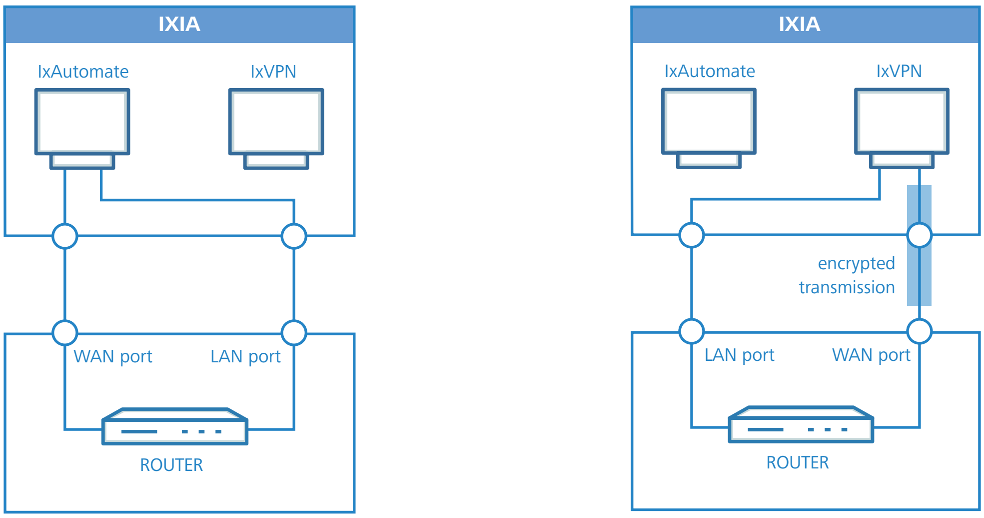

Figure 1:
IXIA test system for routing connections and encrypted VPN connections between LAN and WAN

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 (measured values from Table 11).

Two scenarios are used for the vRouter measurements. One is the transmission from a PC in the LAN to a PC in another LAN or WAN by using the vRouter in between. The second scenario adds two vRouters which are connected over WAN and use a VPN tunnel for encrypted data transfer.

Firmware on the devices under test is LCOS 10.50 (unless otherwise stated).

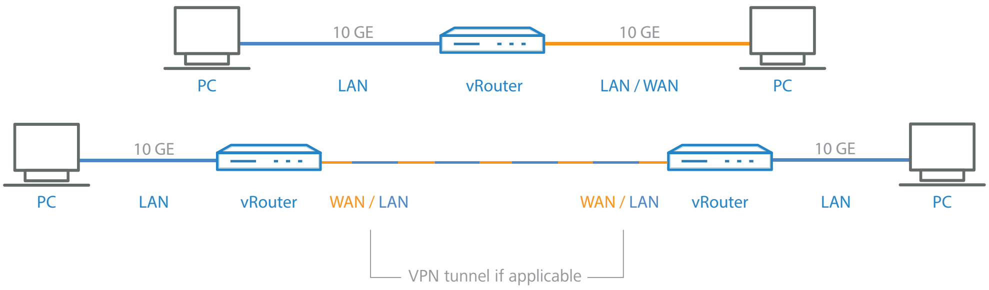

Figure 2:
Schematic view of the vRouter test system scenarios

Routing performance (UDP)

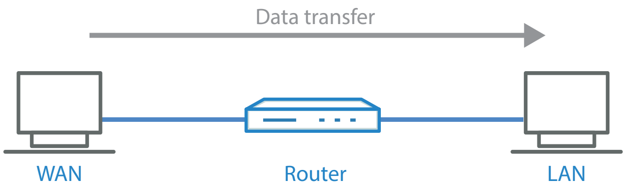

Figure 3: Schematic view of the test system

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 on page 05) 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)

Using UDP, the maximum performance is easily measured. However, a large portion of data transfers utilizes TCP. Therefore, it is important to take a closer look at those scenarios as well.
The TCP measurement is accomplished by using iperf, a program used to measure the data throughput between two computers. They are connected to a LANCOM router. One computer acts as a server in the WAN, sending data packets to the other, which acts as a client in the LAN, representing a typical download scenario.
The TCP measurement done with iperf did not use NAT since no direct measurement with NAT is possible using iperf. The correlation between the test results and the results seen at a WAN connection including NAT in a live environment is very high. The causes are the differences of the traffic structure of iperf compared to an HTTP download and the LCOS firewall which offers a similar performance with NAT or without.
Both computers used in the test system have a similar hardware and software:
→ Intel Core i7 CPU
→ Intel PRO/1000 nic
→ Ubuntu 12.04 / Kernel 3.8.0

The measurement was run using iperf 2.05. The TCP window size was set to 256 kb and five sessions were run simultaneously.
vRouter measurements were done with the following hardware:
→ PCs: Core i7-6700, Intel X540 10GE interfaces
→ ESXi Server: Dell PowerEdge R330 with Xeon E3-1230v5, 3.4 GHz, Intel X710 10GE interfaces as uplink to the ESXi vSwitches
→ vRouter: VMXNET3 with virtual interfaces

IPerf was used without window parameter for the vRouter tests

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.

Bridging performance (L2TPv3 Ethernet tunnel)

The bridging performance (table 10) examines the maximum data throughput that can be achieved via a transparent Ethernet tunnel established over an L2TPv3 pseudowire. Here, IPerf is used to perform a measurement with five parallel TCP streams through the Ethernet tunnel.
The hardware described under „Routing performance (TCP)“ was used for the vRouter measurements.
A WAN-WAN connection is used for the vRouter measurements. A LAN-LAN connection is used for the remaining measurements.

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 – data throughput [Mbps] at frame size [bytes] and frame rate [fps]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	
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+	10.50	**61,0** 119,000	**122** 119,000	**238** 116,000	**473** 115,000	**933** 113,000	**982** 95,800	**984** 81,000	**Mbps** fps
1800EF, 1800EF-5G, 1800EFW	10.60	**124** 242,000	**238** 232,000	**444** 217,000	**831** 202,000	**977** 119,000	**982** 95,800	**984** 81,000	**Mbps** fps
1900EF, 1900EF-5G 1906VA, 1906VA-4G 1926VAG, 1926VAG-4G, 1926VAG-5G	10.50	**84,7** 165,000	**169** 165,000	**339** 165,000	**674** 164,000	**977** 119,000	**982** 95,800	**984** 81,000	**Mbps** fps
ISG-1000 WLC-1000	10.50	**92,2** 180,000	**184** 180,000	**368** 179,000	**736** 179,000	**981** 119,000	**985** 96,100	**987** 81,200	**Mbps** fps

Table 2

LAN-LAN routing – data throughput [Mbps] at frame size [bytes] and frame rate [fps]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	
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+	10.50	**73,7** 144,000	**145** 141,000	**290** 141,000	**580** 141,000	**977** 119,000	**982** 95,800	**984** 81,000	**Mbps** fps
1800EF, 1800EF-5G, 1800EFW	10.60	**157** 306,000	**298** 290,000	**540** 263,000	**955** 233,000	**977** 119,000	**982** 95,800	**984** 81,000	**Mbps** fps
1900EF, 1900EF-5G 1906VA, 1906VA-4G 1926VAG, 1926VAG-4G, 1926VAG-5G	10.50	**99,1** 193,000	**198** 193,000	**398** 194,000	**793** 193,000	**977** 119,000	**982** 95,800	**984** 81,000	**Mbps** fps
ISG-1000 WLC-1000	10.50	**125** 245,000	**249** 243,000	**504** 246,000	**962** 234,000	**981** 119,000	**985** 96,100	**987** 81,200	**Mbps** fps

Table 3

WAN-LAN routing – data throughput [Mbps]

LANCOM	LCOS	Throughput with 5 TCP sessions
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+	10.50	**833**
1800EF, 1800EF-5G, 1800EFW	10.60	**938**
1900EF, 1900EF-5G 1906VA, 1906VA-4G 1926VAG, 1926VAG-4G, 1926VAG-5G	10.50	**909**

Table 4

TCP data throughput [Mbps], simultaneous measurement in both directions

LANCOM	LCOS	Method	Throughput with 1 TCP session
1800EF, 1800EF-5G, 1800EFW	10.60	WAN-LAN routing	**1,370**
1800EF, 1800EF-5G, 1800EFW	10.60	LAN-LAN routing	**1,570**

Table 5

IPSec routing AES-CBC UDP - decryption – data throughput [Mbps] at frame size [bytes] and frame rate [fps]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	
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+	10.50	**25,5** 49,700	**52,1** 50,800	**102** 50,000	**203** 49,600	**400** 48,800	**494** 48,200	**535** 47,200	**Mbps** fps
1800EF, 1800EF-5G, 1800EFW	10.60	**50,4** 98,300	**99,5** 97,100	**192** 93,900	**387** 94,500	**758** 92,500	**914** 89,200	**921** 81,100	**Mbps** fps
1900EF, 1900EF-5G 1906VA, 1906VA-4G 1926VAG, 1926VAG-4G, 1926VAG-5G	10.50	**40,3** 78,600	**80,5** 78,500	**161** 78,600	**316** 77,100	**638** 77,800	**794** 77,500	**875** 77,100	**Mbps** fps
ISG-1000 WLC-1000	10.50	**37,2** 72,600	**74,8** 73,000	**149** 72,700	**299** 73,000	**595** 72,600	**743** 72,500	**821** 72,300	**Mbps** fps

Table 6

IPSec routing AES-CBC UDP - encryption – data throughput [Mbps] at frame size [bytes] and frame rate [fps]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	
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+	10.50	**29,4** 57,500	**58,6** 57,100	**116** 56,800	**230** 56,100	**449** 54,700	**550** 53,700	**606** 53,400	**Mbps** fps
1800EF, 1800EF-5G, 1800EFW	10.60	**59,0** 115,000	**117** 114,000	**229** 111,000	**458** 111,000	**858** 104,000	**942** 92,000	**948** 83,500	**Mbps** fps
1900EF, 1900EF-5G 1906VA, 1906VA-4G 1926VAG, 1926VAG-4G, 1926VAG-5G	10.50	**43,9** 85,500	**89,2** 87,100	**178** 86,900	**353** 86,200	**700** 85,400	**873** 85,200	**945** 83,300	**Mbps** fps
ISG-1000 WLC-1000	10.50	**42,0** 82,000	**85,7** 83,700	**171** 83,700	**343** 83,800	**684** 83,500	**853** 83,200	**944** 83,200	**Mbps** fps

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IPSec routing decryption / encryption – data throughput [Mbps]

LANCOM	LCOS	Decryption			Encryption		
		IMIX 0	IMIX 1	IMIX 2	IMIX 0	IMIX 1	IMIX 2
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+	10.50	174	135	165	202	158	194
1800EF, 1800EF-5G, 1800EFW	10.60	343	275	323	413	326	389
1900EF, 1900EF-5G 1906VA, 1906VA-4G 1926VAG, 1926VAG-4G, 1926VAG-5G	10.50	261	204	249	306	237	292
ISG-1000 WLC-1000	10.50	252	197	241	296	230	282

Table 9
TCP data throughput [Mbps]

LANCOM	LCOS	Method	Throughput with 5 TCP sessions
ISG-1000	10.50	LAN - WAN (IPoE) routing	**940**
ISG-1000	10.50	LAN - LAN routing	**940**

Table 10
L2TPv3 bridging – data throughput [Mbps]

LANCOM	LCOS	Throughput with 5 TCP sessions
ISG-1000 WLC-1000	10.50	**991**

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 11

IPSec AES256-GCM - UDP - decryption – data throughput [Mbps] at frame size [bytes] and frame rate [fps]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	
ISG-4000	10.50	**44,9** 87,600	**93,8** 91,600	**189** 92,300	**380** 92,700	**754** 92,000	**940** 91,700	**1,040** 92,000	**Mbps** fps
ISG-8000 Multicore	10.50	**551** 1,070,000	**1,100** 1,070,000	**2,170** 1,060,000	**4,210** 1,020,000	**8,120** 992,000	**9,450** 923,000	**9,470** 835,000	**Mbps** fps
vRouter	10.50	**399** 778,000	**817** 797,000	**1,520** 745,000	**2,860** 698,000	**4,990** 610,000	**5,870** 573,000	**6,250** 551,000	**Mbps** fps

Table 12

IPSec AES256-GCM - UDP - encryption – data throughput [Mbps] at frame size [bytes] and frame rate [fps]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	
ISG-4000	10.50	**58,7** 107,000	**114** 107,000	**224** 107,000	**443** 107,000	**882** 107,000	**1,090** 106,000	**1,210** 106,000	**Mbps** fps
ISG-8000 Multicore	10.50	**560** 1,020,000	**1,100** 1,040,000	**2,140** 1,020,000	**4,170** 1,000,000	**7,680** 928,000	**9,540** 923,000	**9,500** 835,000	**Mbps** fps
vRouter	10.50	**357** 656,000	**602** 570,000	**1,280** 618,000	**2,490** 603,000	**4,170** 508,000	**4,670** 455,000	**4,660** 409,000	**Mbps** fps

Table 13

IPSec AES256-CBC SHA256 - UDP - decryption – data throughput [Mbps] at frame size [bytes] and frame rate [fps]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	
ISG-4000	10.50	**44,9** 87,600	**90,8** 88,600	**185** 90,100	**369** 90,000	**736** 89,800	**911** 88,900	**1,010** 89,300	**Mbps** fps
ISG-8000 Multicore	10.50	**186** 362,000	**353** 334,000	**632** 308,000	**1,060** 259,000	**1,570** 192,000	**1,740** 170,000	**1,830** 161,000	**Mbps** fps
vRouter	10.50	**220** 429,000	**415** 405,000	**723** 353,000	**1,000** 244,000	**1,760** 215,000	**1,840** 179,000	**2,040** 180,000	**Mbps** fps

Table 14

IPSec AES256-CBC SHA256 - UDP - encryption – data throughput [Mbps] at frame size [bytes] and frame rate [fps]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	
ISG-4000	10.50	**58,7** 107,000	**114** 107,000	**225** 107,000	**446** 108,000	**886** 107,000	**1,100** 107,000	**1,220** 107,000	**Mbps** fps
ISG-8000 Multicore	10.50	**170** 311,000	**314** 294,000	**547** 263,000	**891** 215,000	**1,280** 155,000	**1,410** 137,000	**1,480** 130,000	**Mbps** fps
vRouter	10.50	**188** 345,000	**301** 285,000	**617** 296,000	**927** 224,000	**1,440** 173,000	**1,580** 153,000	**1,640** 144,000	**Mbps** fps

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IPSec IMIX AES256-GCM - UDP - decryption / encryption – data throughput [Mbps]

LANCOM	LCOS	Decryption			Encryption		
		IMIX 0	IMIX 1	IMIX 2	IMIX 0	IMIX 1	IMIX 2
ISG-4000	10.50	**335**	**252**	**303**	**397**	**295**	**356**
ISG-8000 Multicore	10.50	**3,820**	**2,890**	**3,210**	**3,790**	**2,840**	**2,730**
vRouter	10.50	**2,600**	**2,050**	**2,520**	**1,680**	**1,440**	**1,840**

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IPSec IMIX AES256-CBC SHA256 - UDP - decryption / encryption – data throughput [Mbps]

LANCOM	LCOS	Decryption			Encryption		
		IMIX 0	IMIX 1	IMIX 2	IMIX 0	IMIX 1	IMIX 2
ISG-4000	10.50	**333**	**252**	**300**	**396**	**294**	**358**
ISG-8000 Multicore	10.50	**985**	**795**	**931**	**830**	**681**	**787**
vRouter	10.50	**1,140**	**924**	**1,060**	**926**	**771**	**732**

Table 19

TCP data throughput [Mbps]

LANCOM	LCOS	Method	Throughput with 5 TCP-Sessions
ISG-4000	10.50	LAN - LAN	**3,542**
ISG-4000	10.50	LAN - WAN (IPoE)	**2,069**
ISG-4000	10.50	WAN - LAN (IPoE)	**2,201**
ISG-8000 Multicore	10.50	LAN - LAN	**9,400**
ISG-8000 Multicore	10.50	LAN - WAN (IPoE)	**9,400**
ISG-8000 Multicore	10.50	WAN - LAN (IPoE)	**9,400**
vRouter	10.50	LAN - LAN	**9,400**
vRouter	10.50	LAN - WAN (IPoE)	**9,400**
vRouter	10.50	WAN - LAN (IPoE)	**9,400**

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