LANCOM Techpaper
Routing performance LCOS 10.40

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

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

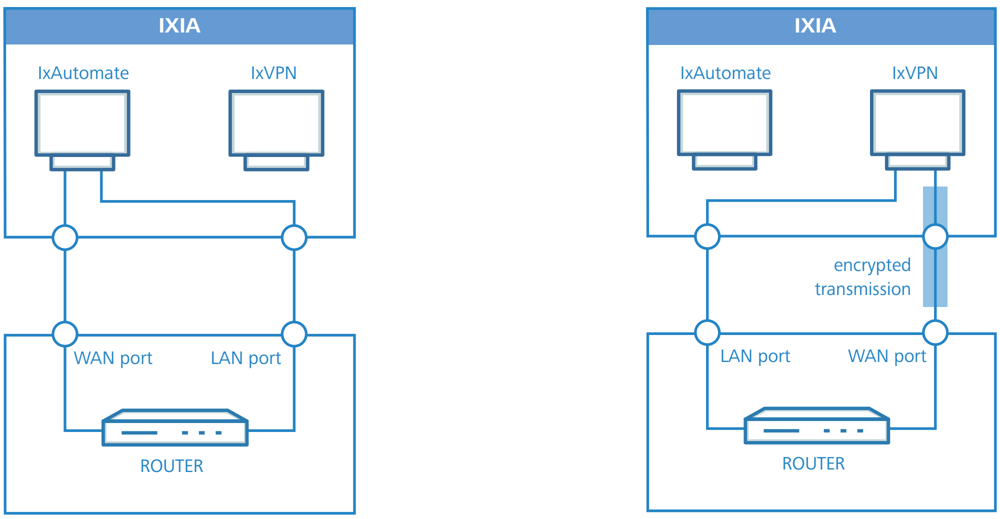

Figure 1: IXIA test system for routing connections and encrypted VPN connections between LAN and WAN

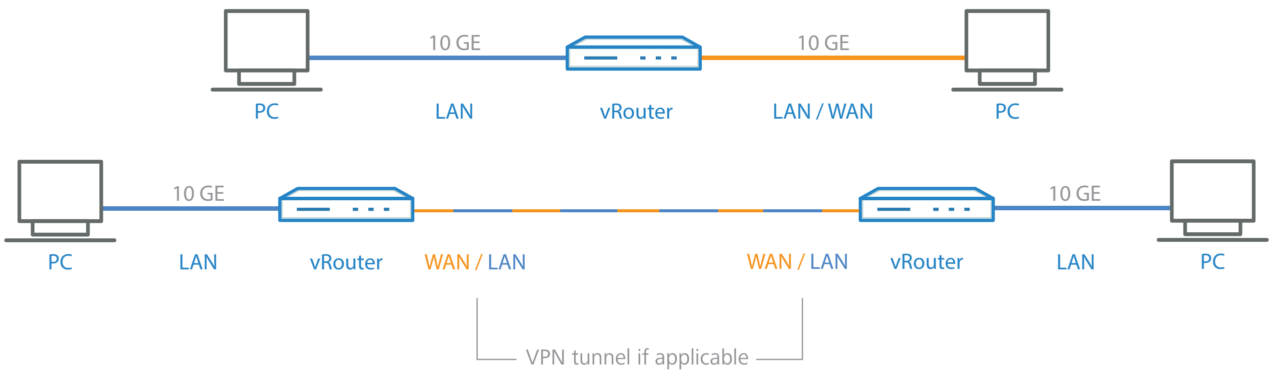

Figure 2: Schematic view of the vRouter test system scenarios

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 10).

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 10.40.

Routing Performance (UDP)

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

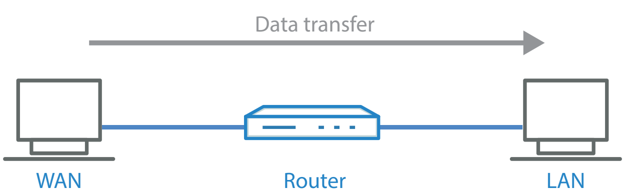

Figure 3: Schematic view of the test system

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 average frame rates are given in the tables. The throughput for a certain frame size (or even a mix of sizes, see IMIX on page 4) 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).

Measurement values for devices with 1 Gbps interfaces

Table 1:
WAN-LAN routing –
data throughput [Mbps] at frame size [bytes] and average frame rate [frames/s]

LANCOM	LCOS	64	128	256	512	1024	1280	1518	frame rate
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+	10.40	49.2	99.8	195.0	383.0	732.0	918.0	984.0	91686
1900EF 1906VA,1906VA-4G 1926VAG, 1926VAG-4G	10.40	82.3	165.0	330.0	658.0	977.0	982.0	984.0	133829
ISG-1000 WLC-1000	10.40	70.2	140.0	281.0	560.0	981.0	985.0	987.0	120471

*Test setup limited to 1 Gbps

Table 2:
LAN-LAN routing –
data throughput [Mbps] at frame size [bytes] and average frame rate [frames/s]

LANCOM	LCOS	64	128	256	512	1024	1280	1518	frame rate
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+	10.40	57.2	116.0	217.0	454.0	895	982.0	984.0	103685
1900EF 1906VA,1906VA-4G 1926VAG, 1926VAG-4G	10.40	83.1	165.0	334.0	661.0	977	982.0	984.0	134685
ISG-1000 WLC-1000	10.40	79.2	158.0	317.0	632.0	981	985.0	987.0	130329

*Test setup limited to 1 Gbps

Table 3:
WAN-LAN routing – data throughput [Mbps]

LANCOM	LCOS	Throughput 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+	10.40	739.0
1900EF 1906VA,1906VA-4G 1926VAG, 1926VAG-4G	10.40	908.0

Table 4:
IPSec routing AES-CBC UDP - decryption – data throughput [Mbps] at frame size [bytes] and average frame rate [frames/s]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	frame rate
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+	10.40	22.6	46.2	92.7	181.0	353.0	439.0	481.0	43843
1900EF 1906VA,1906VA-4G 1926VAG, 1926VAG-4G	10.40	35.2	70.8	142.0	284.0	654.0	705.0	790.0	69071
ISG-1000 WLC-1000	10.40	32.1	64.1	129.0	256.0	513.0	641.0	711.0	62586

Table 5:
IPSec routing AES-CBC UDP - encryption – data throughput [Mbps] at frame size [bytes] and average frame rate [frames/s]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	frame rate
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+	10.40	27.1	55.0	109.0	216.0	414.0	505.0	654.0	51714
1900EF 1906VA,1906VA-4G 1926VAG, 1926VAG-4G	10.40	42.0	84.9	170.0	338.0	672.0	832.0	921.0	82029
ISG-1000 WLC-1000	10.40	38.2	75.8	151.0	306.0	608.0	760.0	841.0	74171

*Test setup limited to 1 Gbps

Table 6:
IPSec routing decryption – data throughput [Mbps]

LANCOM	LCOS	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+	10.40	145	114	139
1900EF 1906VA,1906VA-4G 1926VAG, 1926VAG-4G	10.40	225	176	217
ISG-1000 WLC-1000	10.40	198	154	191

Table 7:
IPSec routing encryption – data throughput [Mbps]

LANCOM	LCOS	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+	10.40	185	146	177
1900EF 1906VA,1906VA-4G 1926VAG, 1926VAG-4G	10.40	292	228	278
ISG-1000 WLC-1000	10.40	261	204	252

Table 8:
TCP data throughput [Mbps]

LANCOM	Method	LCOS	Throughput 5 TCP sessions
ISG-1000	LAN - WAN (IPoE) routing	10.40	940*
ISG-1000	LAN - LAN routing	10.40	940*

*Limited by 1 Gbps ports of the ISG-1000

Table 9:
L2TPv3 bridging – data throughput [Mbps]

LANCOM	LCOS	Throughput 5 TCP sessions
ISG-1000 WLC-1000	10.40	991

Measurement values for devices with 10 Gbps interfaces

Table 10:
IPSec AES256-GCM - UDP - decryption – data throughput [Mbps] at frame size [bytes] and average frame rate [frames/s]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	frame rate
ISG-4000	10.40	41.9	85.7	171	336	661	847	904	82014
ISG-8000	10.40	239	482	935	1780	3260	3900	4200	425571
vRouter	10.40	243	490	882	1490	3330	4120	4350	419571

Table 11:
IPSec AES256-GCM - UDP - encryption – data throughput [Mbps] at frame size [bytes] and average frame rate [frames/s]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	frame rate
ISG-4000	10.40	58.1	114.0	224.0	451.0	891.0	1070.0	1050.0	104900
ISG-8000	10.40	173.0	334.0	646.0	1230.0	2300.0	2790.0	3070.0	295000
vRouter	10.40	181.0	356.0	700.0	1320.0	2400.0	3060.0	3100.0	312142

Table 12:
IPSec AES256-CBC SHA256 - UDP - decryption – data throughput [Mbps] at frame size [bytes] and average frame rate [frames/s]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	frame rate
ISG-4000	10.40	41.4	83.2	165.0	329.0	664.0	828.0	908.0	80686
ISG-8000	10.40	194.0	371.0	665.0	1080.0	1590.0	1770.0	1850.0	265571
vRouter	10.40	208.0	380.0	696.0	1130.0	1720.0	1880.0	2010.0	280286

Table 13:
IPSec AES256-CBC SHA256 - UDP - encryption – data throughput [Mbps] at frame size [bytes] and average frame rate [frames/s]

LANCOM	LCOS	64	128	256	512	1024	1280	1418	frame rate
ISG-4000	10.40	55.0	99.9	196.0	427.0	789.0	1070.0	1200.0	99771
ISG-8000	10.40	147.0	271.0	480.0	782.0	1190.0	1310.0	1380.0	191286
vRouter	10.40	162.0	295.0	497.0	865.0	1300.0	1450.0	1520.0	208143

Table 14:
IPSec IMIX AES256-GCM - UDP - decryption – data throughput [Mbps]

LANCOM	LCOS	IMIX 0	IMIX 1	IMIX 2
ISG-4000	10.40	222	215	220
ISG-8000	10.40	1560	1190	1400
vRouter	10.40	1700	1240	1440

Table 15: IPSec IMIX AES256-GCM - UDP - encryption – data throughput [Mbps]

LANCOM	LCOS	IMIX 0	IMIX 1	IMIX 2
ISG-4000	10.40	380	264	313
ISG-8000	10.40	1050	817	986
vRouter	10.40	1130	896	1080

Table 16: IPSec IMIX AES256-CBC SHA256 - UDP - decryption – data throughput [Mbps]

LANCOM	LCOS	IMIX 0	IMIX 1	IMIX 2
ISG-4000	10.40	218	209	214
ISG-8000	10.40	975	798	931
vRouter	10.40	1070	869	921

Table 17: IPSec IMIX AES256-CBC SHA256 - UDP - encryption – data throughput [Mbps]

LANCOM	LCOS	IMIX 0	IMIX 1	IMIX 2
ISG-4000	10.40	352	268	317
ISG-8000	10.40	712	592	681
vRouter	10.40	800	650	761

Table 18: TCP data throughput [Mbps]

LANCOM	Method	LCOS	Throughput 5 TCP sessions
ISG-4000	LAN - LAN	10.40	3159
ISG-4000	LAN - WAN (IPoE)	10.40	1693
ISG-4000	WAN - LAN (IPoE)	10.40	2223
ISG-8000	LAN - LAN	10.40	9400
ISG-8000	LAN - WAN (IPoE)	10.40	9400
ISG-8000	WAN - LAN (IPoE)	10.40	9400
vRouter	LAN - LAN	10.40	9400
vRouter	LAN - WAN (IPoE)	10.40	9400
vRouter	WAN - LAN (IPoE)	10.40	9400