LANCOM™ Techpaper
Performance

Introduction

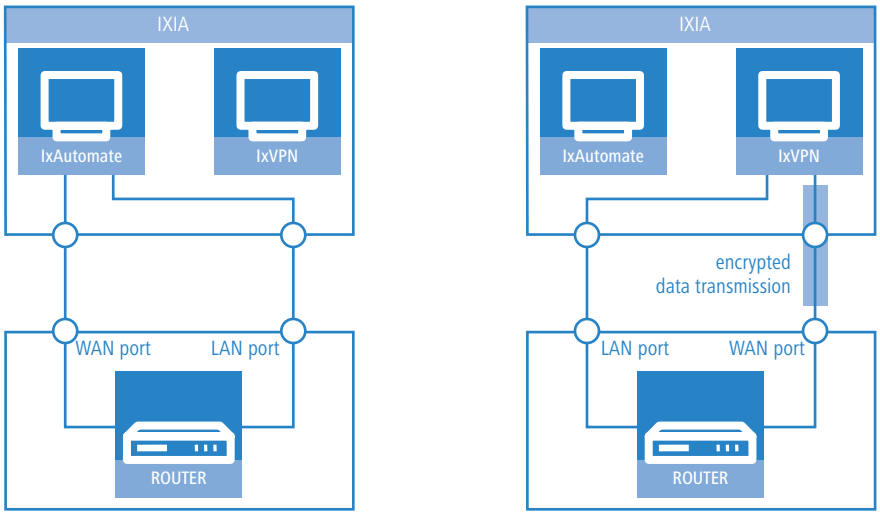
Applications for communications and entertainment are increasingly based on IP networks. In order to ensure that the necessary bandwidth performance can be provided reliably, it is important for the infrastructure's networking components to be tested thoroughly and intensively. In this Tech-Paper, LANCOM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

We examine a variety of aspects for consideration when measuring the performance of a router. This includes the 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 are focusing on determining the performance of encrypted data connections over VPN.

Test system

All of the performance values were measured in LANCOM's 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 purely LAN-LAN connections.



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

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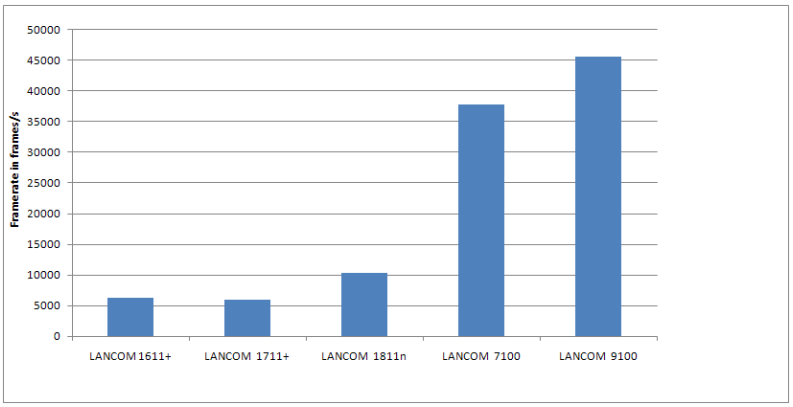
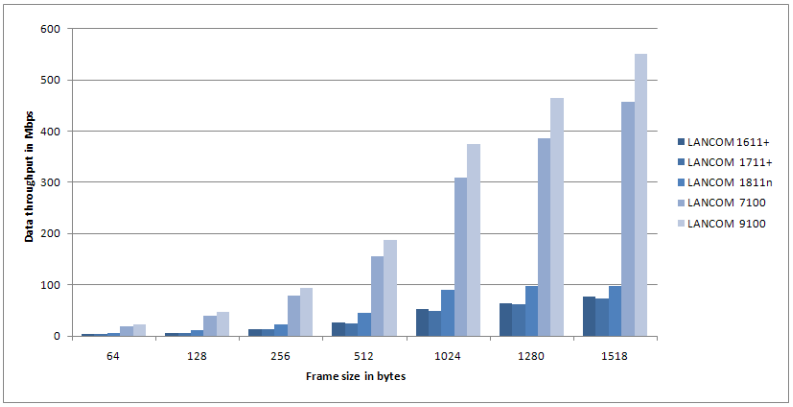
	WAN-LAN transmission							
	Data throughput in Mbps per frame size (byte)							Frame rate
Device (LCOS 7.70)	64	128	256	512	1024	1280	1518	[Frames/s]
LANCOM 1611+	3.20	6.42	12.86	25.75	51.73	64.14	76.43	6280
LANCOM 1711+ VPN	3.05	6.08	12.23	24.72	49.53	62.50	73.54	6015
LANCOM 1811n Wireless	5.66	10.73	22.83	45.78	90.74	98.08	98.40	10371
LANCOM 7100 VPN	19.38	38.88	77.90	155.15	309.55	385.78	456.95	37826
LANCOM 9100 VPN	23.09	47.34	94.26	188.1	374.54	464.44	550.4	45666





Routing performance

The measurement of routing performance involves the determination of the maximum data throughput which can be achieved before a router starts rejecting packets. 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 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 6) can be approximately calculated by multiplication with the frame rate. When frame rate is constant, data throughput depends directly on the frame size. 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 (e.g.Fast Ethernet with 100 Mbps).

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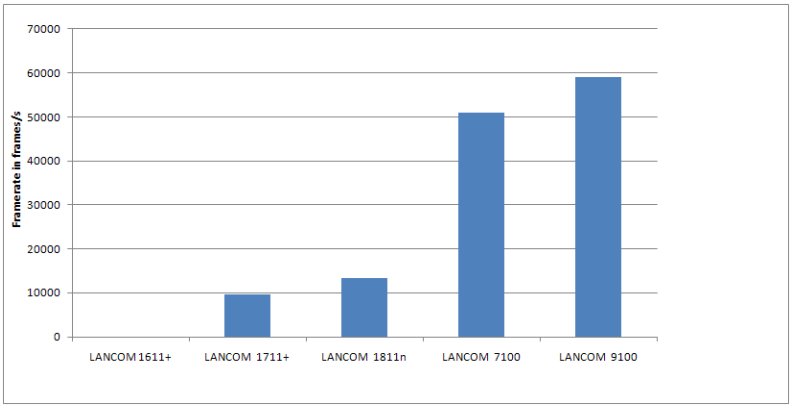
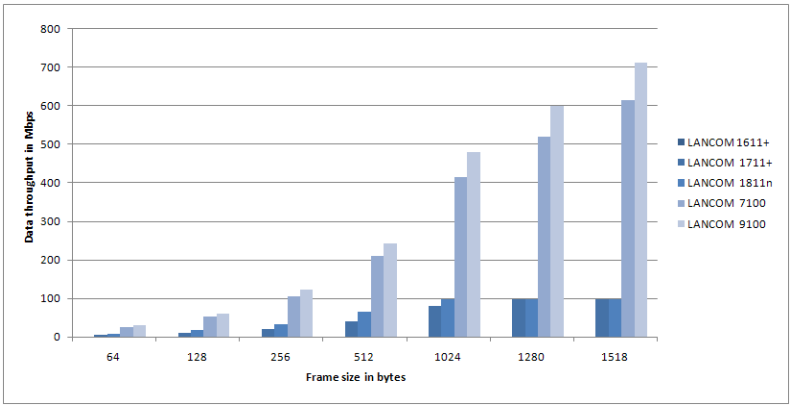
LAN-LAN transmission								
	Data throughput in Mbps per frame size (byte)							Frame rate
Device (LCOS 7.70)	64	128	256	512	1024	1280	1518	[Frames/s]
LANCOM 1611+	Not measured							
LANCOM 1711+ VPN	5.06	10.05	20.29	40.14	80.28	98.20	98.40	9557
LANCOM 1811n Wireless	8.19	16.56	33.16	65.14	97.71	98.08	98.40	13409
LANCOM 7100 VPN	26.06	52.37	105.09	209.66	415.92	519.48	614.08	50944
LANCOM 9100 VPN	30.53	60.84	122.37	242.65	481.20	600.38	711.34	59141





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 UDPdatagram size of 474 bytes (512 bytes - 18 bytes Ethernet header - 20 bytes IP header) and, after subtracting the UDP header (8 bytes), the UDP payload is 466 bytes.

To investigate routing performance, this paper considers two different applications:

- 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 devices with a 100 Mbps interface provide speeds which are limited by the interface. The maximum possible throughput is achieved with a frame size of ca. 1024 bytes. The throughput of Gigabit models increases almost linearly with the frame size. The LANCOM 9100 VPN achieved a peak value of over 700 Mbps.

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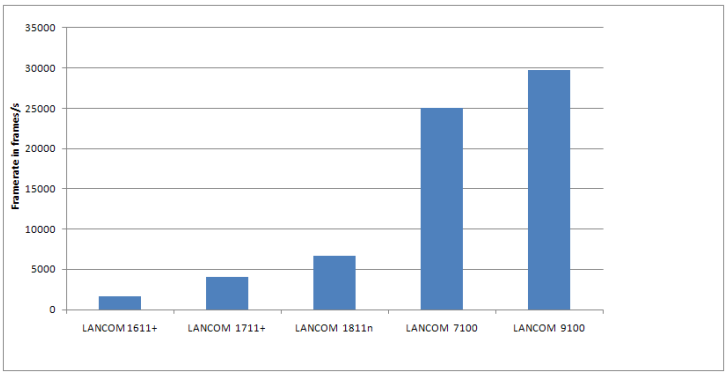
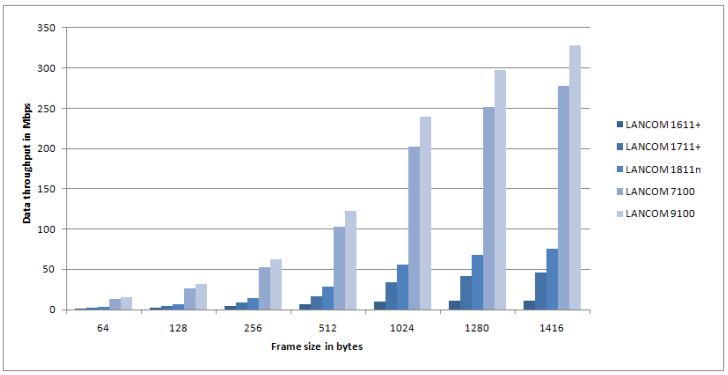
IPsec routing (decryption)								
	Data throughput in Mbps per frame size (byte)							Frame rate
Device (LCOS 7.70)	64	128	256	512	1024	1280	1416	[Frames/s]
LANCOM 1611+	1.31	2.13	4.32	6.78	9.93	10.54	11.17	1661
LANCOM 1711+ VPN	2	4.22	8.25	16.83	33.39	42.03	45.67	4053
LANCOM 1811n Wireless	3.18	6.46	14.22	28.87	55.99	68.23	74.94	6659
LANCOM 7100 VPN	12.76	26.66	52.6	102.98	202.35	251.17	278.14	25073
LANCOM 9100 VPN	15.48	31.26	62.32	122.67	239.21	297.32	328.22	29759





IPsec routing performance

Other than with pure routing performance, VPN and IPsec 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 the 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 + 18 byte Ethernet + 20 byte IP + 8 byte ESP + 16 byte initialization vector (IV) + 1 byte padding + 1 byte padding length + 12 byte authentication).

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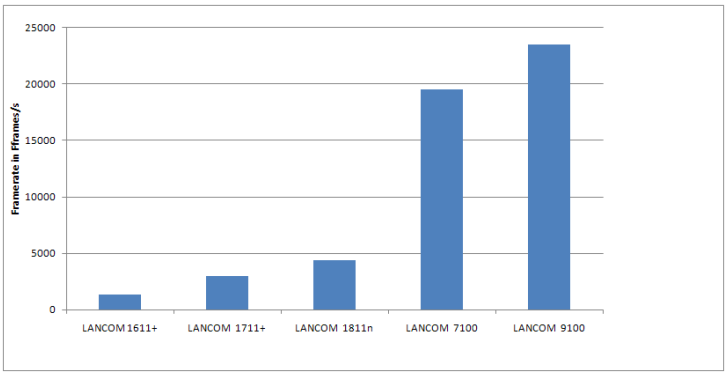
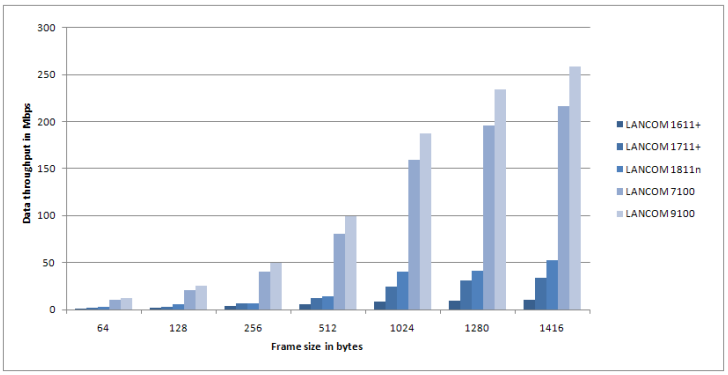
IPsec routing (encryption)								
	Data throughput in Mbps per frame size (byte)							Frame rate
Device (LCOS 7.70)	64	128	256	512	1024	1280	1416	[Frames/s]
LANCOM 1611+	0.79	2.03	3.59	5.67	8.07	9.54	9.78	1348
LANCOM 1711+ VPN	1.55	3.03	6.27	12.28	24.53	30.75	33.31	2998
LANCOM 1811n Wireless	2.4	5.36	6.88	14.46	40.52	41.5	52.76	4349
LANCOM 7100 VPN	9.97	20.51	40.66	80.97	159.48	195.91	216.94	19550
LANCOM 9100 VPN	11.84	25.24	49.22	99.05	187.06	234.47	258.48	23501





- 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. Conversely, models without VPN hardware acceleration (e.g.LANCOM 1611+) have to process the full package content. This is why the frame rate sinks with increasing frame size when carrying out decryption without hardware acceleration. The average frame rates in the table for this special case do not represent a constant frame rate which is independent of the frame size, but rather the true average value of the measurements.

All of the IPsec-routing values given here are for a single VPN tunnel. With up to 1000 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).

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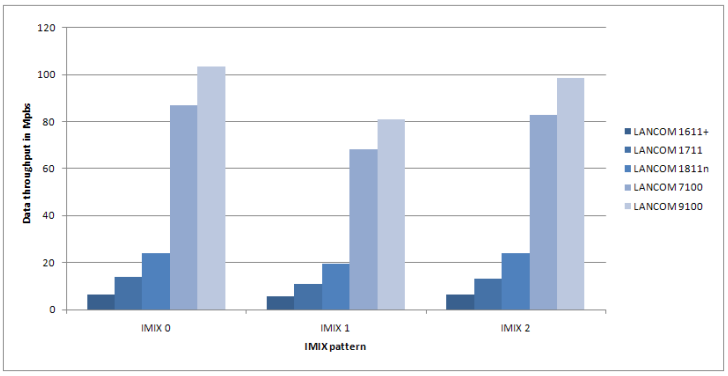
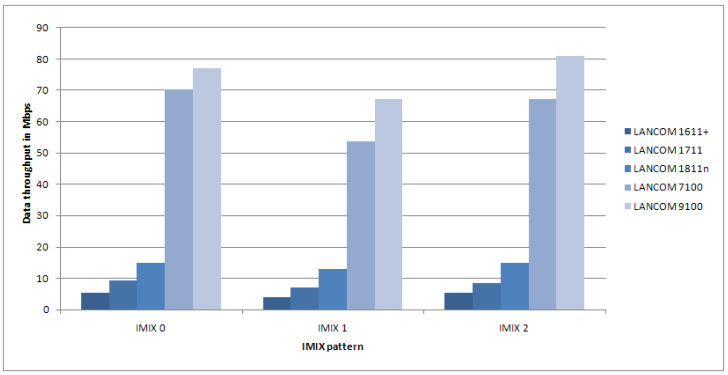
Data throughput for IPsec routing (decryption) in Mbps (LCOS 7.70)			
Device/IMIX pattern	IMIX 0	IMIX 1	IMIX 2
LANCOM 1611+	6.22	5.44	6.22
LANCOM 1711+ VPN	14.00	10.89	13.22
LANCOM 1811n Wireless	24.10	19.44	24.06
LANCOM 7100 VPN	86.88	68.32	82.98
LANCOM 9100 VPN	103.47	81.00	98.60



Data throughput for IPsec routing (encryption) in Mbps (LCOS 7.70)			
Device/IMIX pattern	IMIX 0	IMIX 1	IMIX 2
LANCOM 1611+	5.40	3.89	5.34
LANCOM 1711+ VPN	9.33	7.00	8.40
LANCOM 1811n Wireless	14.77	12.90	14.80
LANCOM 7100 VPN	70.28	53.68	67.36
LANCOM 9100 VPN	77.11	67.34	81.02



IPsec routing with different IMIX's (decryption and encryption)

As an alternative to measurement with fixed frame sizes, measurements were carried out with varying IMIX patterns. The IMIX patterns simulate "true" data traffic, which contains varying frame sizes. There are no fixed guidelines for the composition of the frame sizes, and for this reason the measurements supplemented the preset values in the IXIA test system (IMIX 0) with two other common patterns (IMIX 1 and IMIX 2). The patterns use the following frame compositions:

- IMIX0: 45% 64 byte, 20% 128 byte, 5% 256 byte, 3% 512 byte, 2% 1024 byte, 1% 1280 byte, 24% 1364 byte.
- IMIX1: 7x 64 byte, 4x 570 byte, 1x 1418 byte.
- IMIX2: 58% 90 byte, 2% 92 byte, 24% 594 byte, 16% 1418 byte.

When evaluating VPN throughput, the IMIX pattern should include the frame size 1418 bytes which, assuming an overhead of 100 bytes, is the maximum encrypted frame size transmittable via Ethernet (1518 bytes, the maximum IEEE 802.3 frame size).

AES-SHA encryption was used for the measurements, and the tunnels were established in the LAN-WAN direction. These measurements again show that data decryption is faster than encryption.