Interworking2000

Measurement of the performance of IP packets over ATM environment via Multiprotocol-over-ATM (MPOA)

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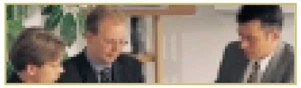
- Summary and conclusion

WWL vision2_market AG
- Short introduction -

Internet Full-Service Company



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MPOA
in a short overview

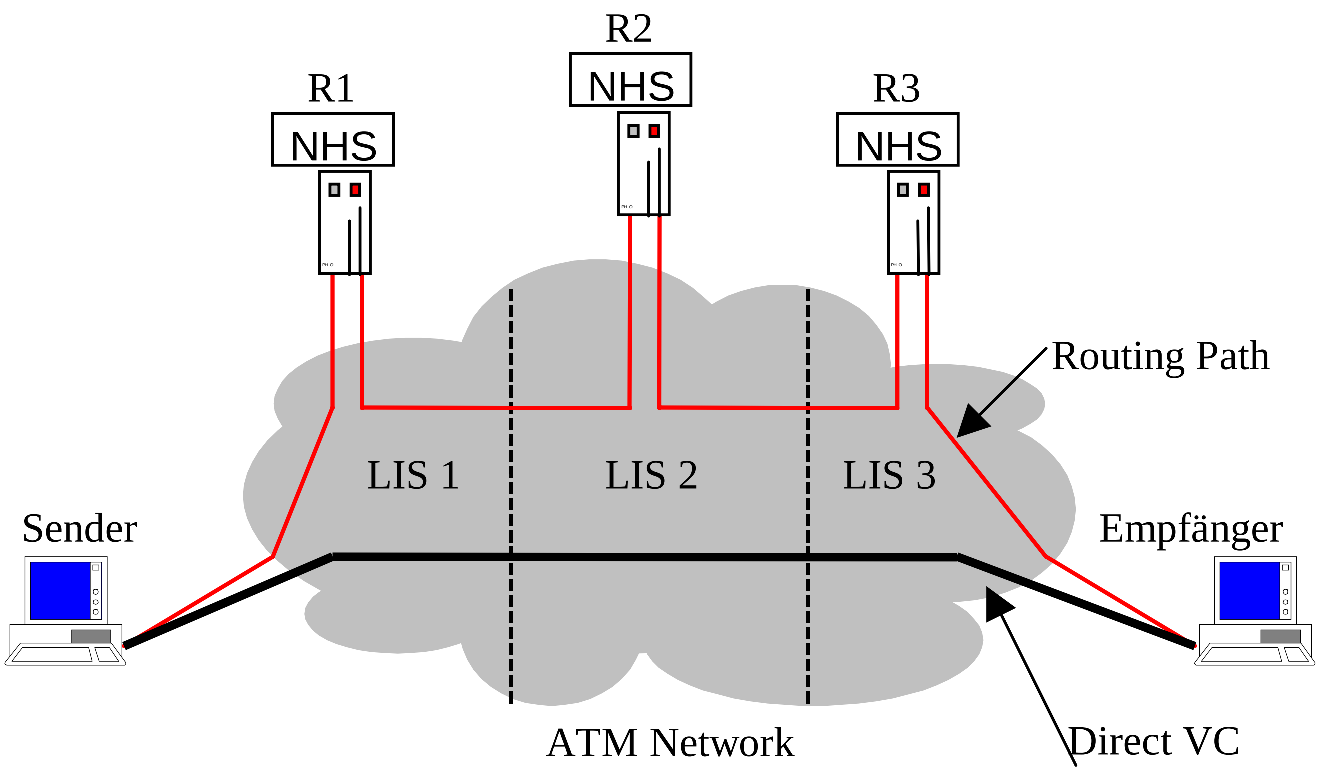
IP-over-ATM approaches

- Classical-IP (CLIP):
  - Specification in 1993 by the IETF
  - Adaptation of IP clients to ATM
- LANE-Emulation (LANE):
  - Specification in 1995 by the ATM-Forum
  - Integration of Legacy LANs
- Multiprotocol-over-ATM (MPOA):
  - Specification in 1997 by the ATM-Forum
  - Included IETF draft standards NHRP and MARS
- Multi-Protocol Label Switching (MPLS):
  - Actually draft specification of the IETF (status: informational)
  - Similar to Tag Switching of Cisco and ARIS of IBM
  - First components are available, based on ATM technology

Multiprotocol-over-ATM (MPOA)

- Emulates a fully routed layer 3 protocol over ATM
- Distribute the routing functions between route servers
- Separate routing from switching functions
- Leverage performance and QoS capabilities of ATM network
- Direct connections between ELANs rather than passing through traditional routers via VCCs
- Interworking with unified routers
- Enables subnet members to be distributed across the network

Shortcut functionality by NHRP



Disadvantages of MPOA

- Today MPOA based only of IP
- The original approach was not realised regarding MARS, RSVP, and CLIP
- The manufactories have to late realised MPOA implementations for their ATM components (see Cisco, Fore, Cabletron, Nortel Networks, Olicom etc.)
- Secure mechanisms are missing (only proprietary solutions are available)
- MPOA has to compare itself with Layer-3-Switching in Gigabit-Ethernet networks
- Scalability problems in huge networks

TCP/IP protocols

- IP protocols is today the most important protocol from the user point of view
- It is developed to achieve interoperability in heterogeneous networks
- Independent from the network layer
- Only best effort is currently available
- TCP/IP protocols were not designed for high speed networks
- Several extensions are available for TCP
- You have to tune your network for IP!

TCP/IP-over-ATM bottlenecks

- Send and receive socket buffer size
- Network: Maximum Transport Unit (MTU)
- Protocol: Maximum Segment Size (MSS)
- Transmitter: use of Nagle’s algorithm
- Round Trip Time (RTT)
- Receiver: delayed acknowledgement mechanisms
- Transmitter: Silly Window Syndrome (SWS)
- Copy strategy at the socket interface
- Network congestion and lost notice

QoS is necessary for future applications

- Guarantee of jitter
- Guarantee of latency
- Guarantee of bandwidth
- Limited delay variation
- No cell/packet loss
- End-to-end QoS for applications
- Policy for different user cases
- Different approaches today available (IntServ, DiffServ, ATM QoS, IP QoS, CoS, IEEE802.1p etc.)

Testscenarios of MPOA and TCP/IP

Goals of the measurements

- Get to know of the available products in the area of LAN and WAN
- Co-operations with the manufactures/vendors
- Test of the product and technology features
- Collect of experience with the handling of different switches, technologies, and adaptation methods
- Assessment of the tests for own customer projects
- Publication of the results in different publishing houses.
- Summarised the results in one report for customers and interest people.

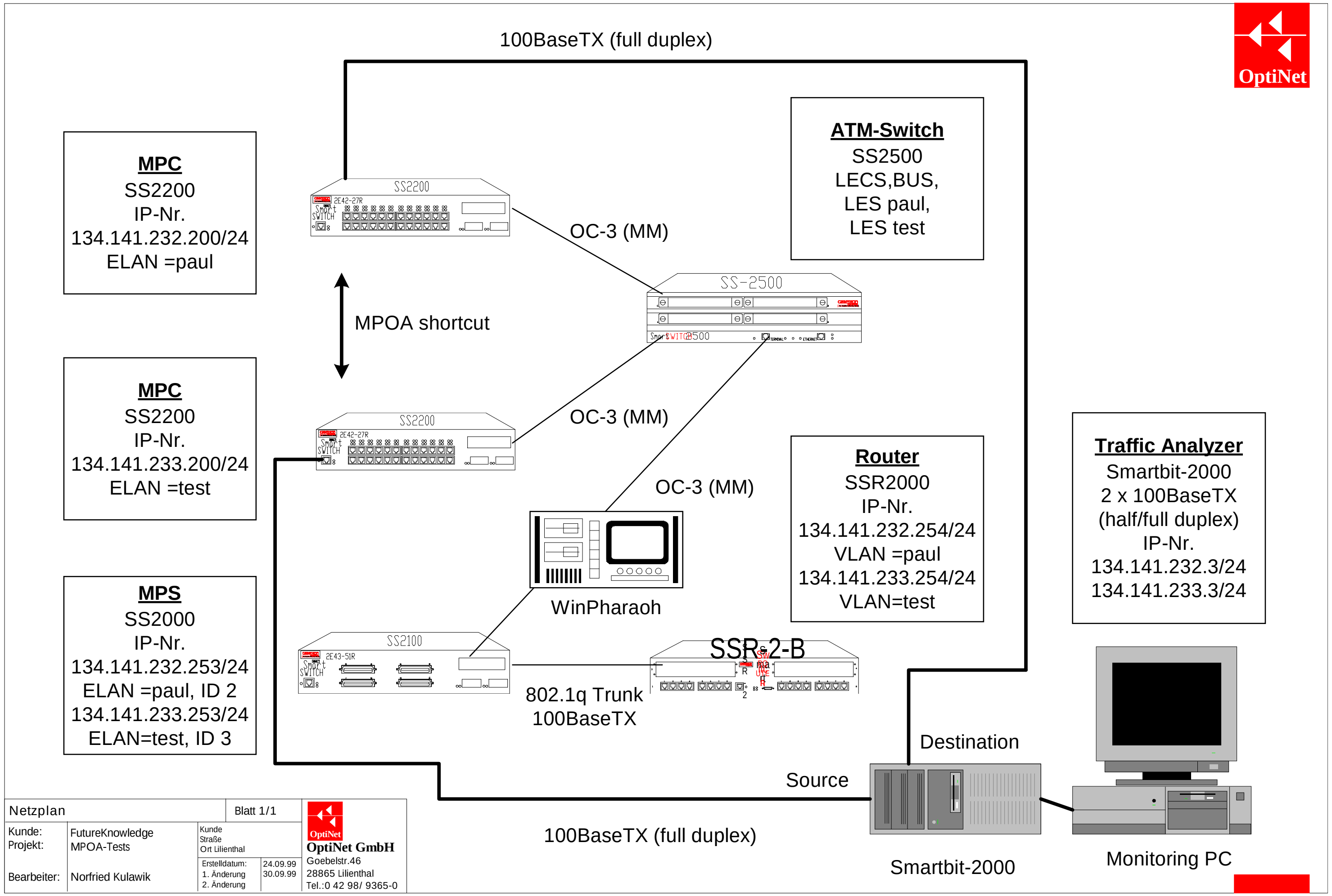
Test equipment

- Smart Switch 2200 (MPOA Client – MPC)
- Smart Switch 2000 (MPOA Server – MPS)
- Smart Switch Router 2000 (MPOA Router)
- Smart Switch 2500: ATM Switch with LECS, LES/BUS device
- Catalyst 5506 (LEC ELAN 1, MPC-A)
- Catalyst 5500 Inge (LEC ELAN 2, MPC-B)
- Catalyst 5500 "C50-01" (LECS, LES, BUS, MPS, Router)
- ATM NIC from ForeRunnerLE series with throughput of 155 Mbps, bus architecture PCI 2.0/2.1, 32-Bit, 33 MHz PCI Bus and Windows95/NT 3.51/4.0, NDIS 4.0 und NDIS 5.0
- ATM NIC from Olicom Rapid Fire OC-6162: 155 Mbps over MMF (SC Connector), NDIS 3.0 NIC driver

Measurement equipment

- Smartbits 2000 (SMB-2000): Firmware 6.220012; 2 x ML-7710 (Ethernet); 2 x AT-9155C(ATM); 1 x AT-9622(ATM); Software: SmartApplications ver. 2.22; Smart Flow 1.00.010 Beta
- Win Pharaoh: Hardware: LAN, WAN and ATM Line Interfaces, ISA-Bus; Prozessor: 10 MIPS RISC Prozessor; 16 MByte On-Board RAM; Software: based on Windows; works on a laptop, PC or Rack-Mount-PC; ATM Remote Software; ATM Site License; ATM Corporate License; Adapter: LAN: Fast-Ethernet, Token Ring and FDDI; WAN: RS-232, RS-422, RS-449, RS-530, V.35, X.21, V.10, V.11; ATM: 155 MBit/s OC3c/STM-1 single mode and multi mode, 155 MBit/s UTP-5, DS3/DS1, E3/E1

MPOA test scenario 1



MPOA test scenario 1

- MPOA scenario from Cabletron Systems (Enterasys)
- For the measurements with and without MPOA shortcuts, we used different shortcut frame counter for the MPOA devices
- This value is responsible for the number of frames per second (fps) for the threshold, which establish a shortcut. During the tests the shortcut threshold was 10.
- This scenario makes it possible to establish the shortcut directly between MPC 1 and 2. The traffic between the SSR and ATM switch has been controlled by the Win Pharaoh.
- The Smartbit equipment was responsible for the traffic generation and the analysis of the test information

MPOA test scenario 2

Hostname: C50-03 Function: LEC (elan-name: "Abteilung1"), MPC (mpc-name: MPC-C50-03)

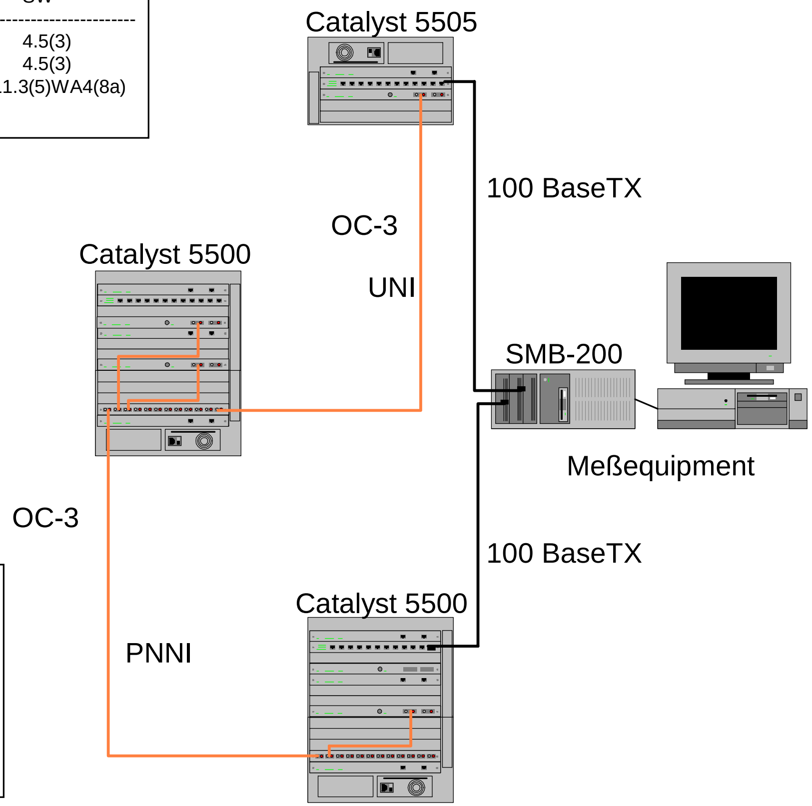
Mod	Ports	Module-Type	Model	HW	FW	SW
1	2	100BaseFX MM Supervis	WS-X5509	2.3	3.1(2)	4.5(3)
3	12	10/100BaseTX Ethernet	WS-X5213	1.2	1.4	4.5(3)
8	2	MM OC-3 Dual-Phy ATM	WS-X5167	3.0	3.0	11.3(5)WA4(8a)
13		ASP/SRP				

Hostname: C50-01 Function: LECS,LES/BUS, LEC (elan-name/elan-id:"Abteilung1"/10; "Abteilung2"/20), MPS (mps-name:MPS-C50-01), Router

Mod	Ports	Module-Type	Model	HW	FW	SW
1	2	100BaseFX MM Supervis	WS-X5506	2.2	3.1(2)	4.5(3)
3	12	10/100BaseTX Ethernet	WS-X5213	1.2	1.4	4.5(3)
4		Route Switch Ext Port	VIP2 + PA-A1			
5	1	Route Switch	WS-X5304	7.0	20.20	12.0(6.5)T
8	2	MM OC-3 Dual-Phy ATM	WS-X5167	2.0	1.1	11.3(10)WA4(13a)
13		ASP/SRP				

Hostname: Inge Function: LEC (elan-name: "Abteilung2"), MPC (mpc-name: MPC-Inge)

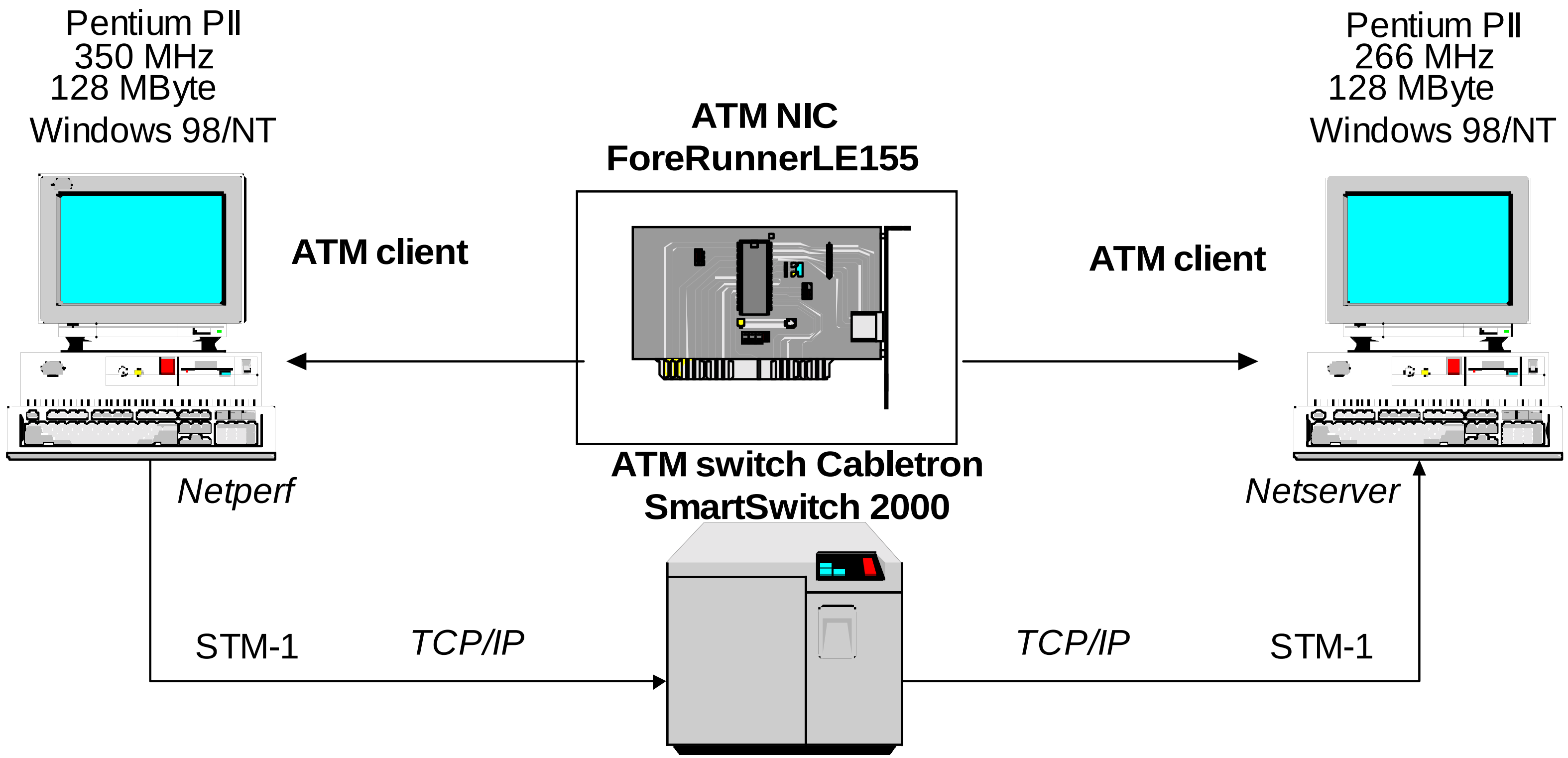
Mod	Ports	Module-Type	Model	HW	FW	SW
1	2	10/100BaseFX MM Supervis	WS-X5530	3.1	5.1(1)	4.5(2)
3	12	10/100BaseTX Ethernet	WS-X5213	1.2	1.4	4.5(2)
8	2	MM OC-3 Dual-Phy ATM	WS-X5167	2.0	1.1	11.3(8)WA4(11)
13		ASP/SRP				



MPOA test scenario 2

- MPOA scenario from Cisco Systems
- The measurements with the components from Cisco Systems were realised with the Catalyst5xxx series. This are the only switches from Cisco, which support MPOA.
- For the tests two Catalysts worked as MPC, LEC, and Ethernet access switch. Furthermore two devices worked as MPS, LECS, LES/BUS, and router.
- There was only a MPOA shortcut within the ATM switch possible. For the preparation of a MPS a RSM with VIP2 (Versatile Interface Processor) module with one ATM NIC (PA-Ax) is necessary. Two modules were devided one slot and were connected via the backplane with the Supervisor Engine and the RSM.

TCP/IP-over-ATM test scenario (CLIP)

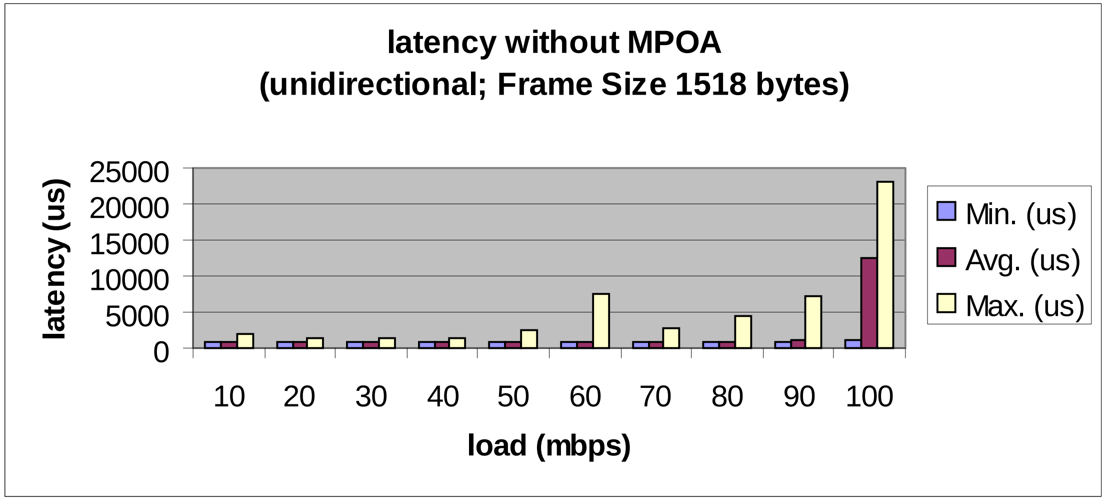


TCP/IP-over-ATM test scenario

- The buffer size varies from 15-64 kbytes
- The measurement used packet sizes of 576, 1500, 9180, and 65 kbyte
- Fragmentation of packets is needed
- ATM Network Interface Cards (NIC) from Fore Systems; ATM switch from Oliciom OC-9100
- Interfaces OC-3c (155 Mbps)
- AAL-5 for IP encapsulation via RFC-1483
- CLIP has been used without routing
- Netperf from Hewlett Packard as benchmark program for testing the network performance

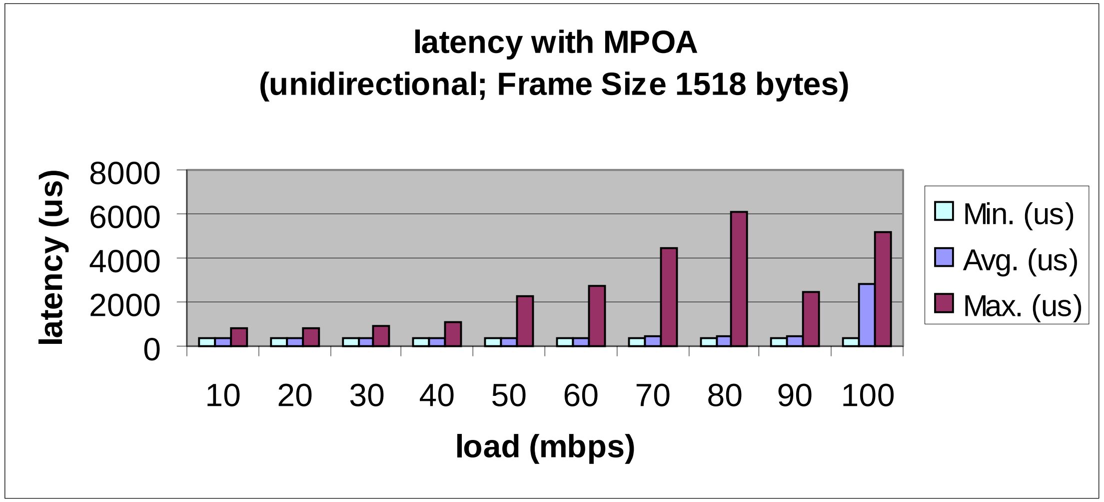
MPOA
test results

MPOA test results, part 1



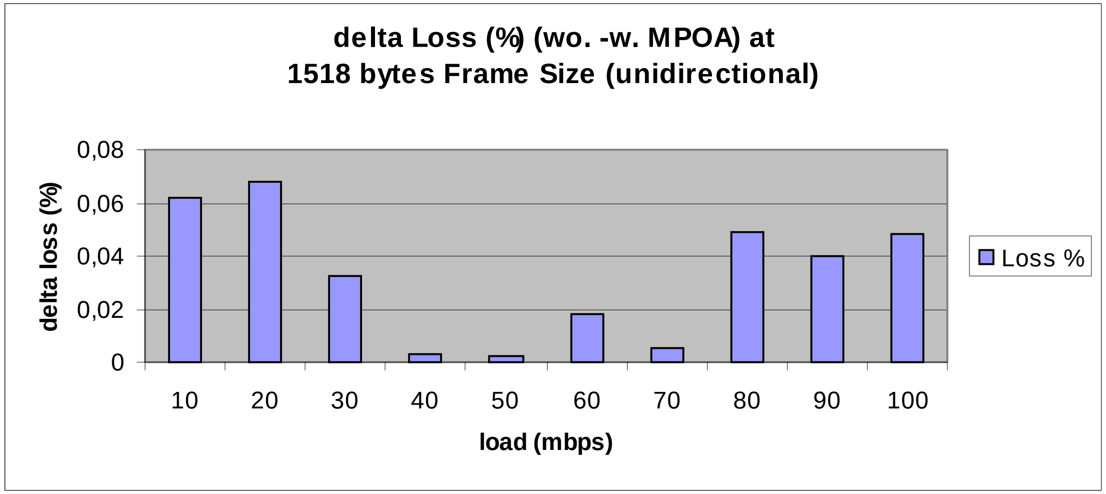
The frame size differ between 64 to 1518 byte. Here you see only the 1518 byte test results, because is the significant size in the network area. Appropriate without MPOA there should not appear high latency. This is the fact, because only at 90-100% load there were higher values. In this case, the test results differ between zero and approx. 23000 µsec.

MPOA test results, part 2



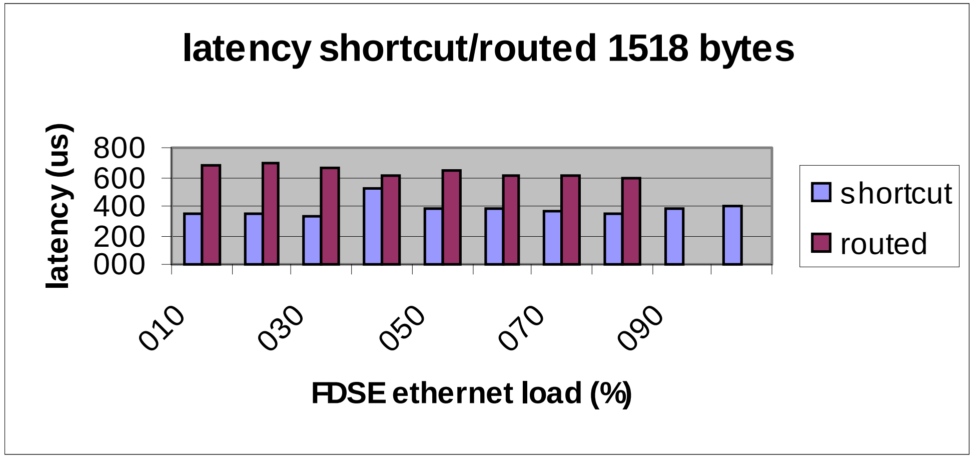
Cabletron Systems (Enterasys) latency test with MPOA: The direct connection between virtual clients is different, established by a shortcut with MPOA. Here were only approx. 6000 µsec latency measured as maximum delay time. This was noticed at a load of 80%. Therefore, the delay has been minimised by MPOA from approx. 23000 to 6000 µsec.

MPOA test results, part 3



Cabletron Systems (Enterasys) packet loss test with/without MPOA: If you measure the delay, you have also to keep in mind the frame losses. Here you can see the test results for Cabletron's components for MPOA (w. = with) and without MPOA (wo. = without). For packet sizes of 64 byte, there was no packet losses recorded. If there is a load of 70% there was in every case no packet losses. The value of packet losses was under 1% in every case of this measurement.

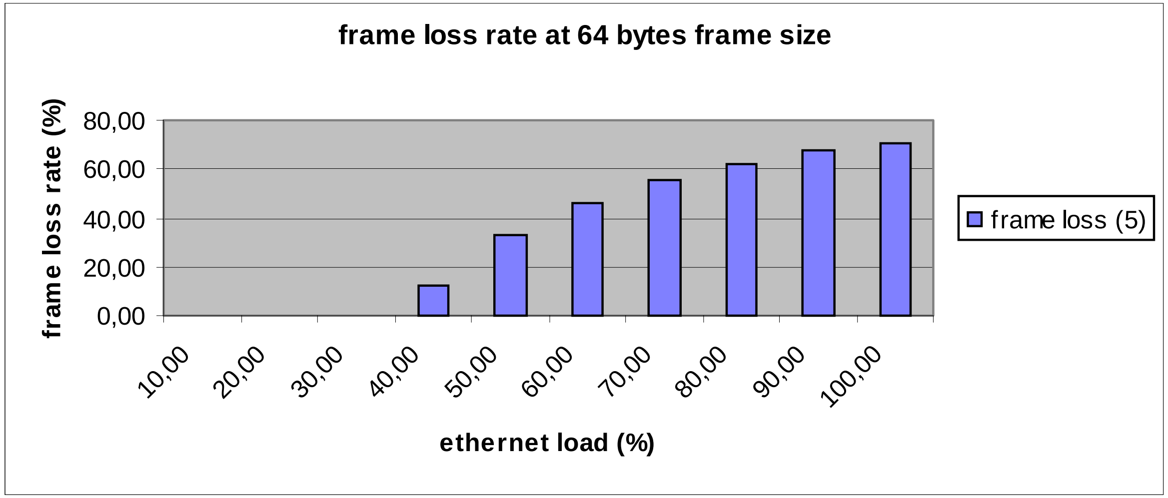
MPOA test results, part 4



Cisco Systems latency test with/without MPOA: In the first step, the latency was measured with MPOA and a load of 10-100%. Here we divided the packet sizes in 64, 128, 256, 512, 1024, 1280, and 1518 byte.

So-called Under-runs (frame sizes under 64 byte) were rejected, while Giants (frame sizes over 1518 byte) were ignored by the LANE module. In the second step, the latency of the routed path was measured. Here, the router showed after a frame frequency of approx. 65000 fps, that packets were deleted. This was the reason, why no test results are there. According to Cisco Systems, this behaviour was caused by the ATM module PA-A1, which has not sufficient performance

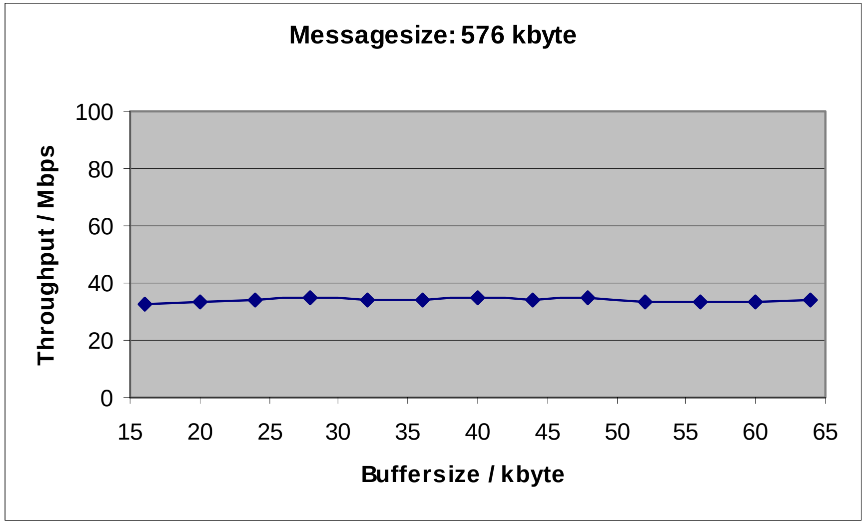
MPOA test results, part 5



Cisco Systems packet loss test with/without MPOA: In the direct comparison between with and without MPOA, you can see at 64 byte, that the routed packets need essential more time than the shortcut packets. After a load of 40% there were not measured any values, because of the frame losses.

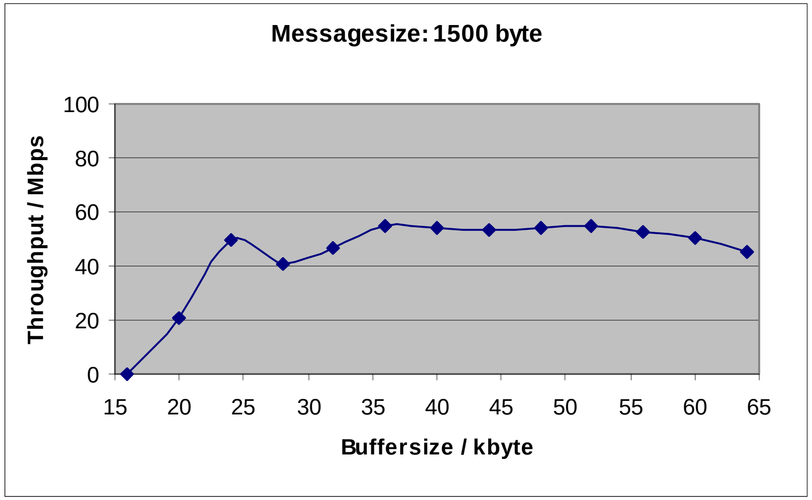
TCP/IP
test results

TCP/IP-over-ATM test results 1



This figure shows the TCP/IP measurements with a packet size of 576 byte via CLIP. The buffer varies from 15-64 kbyte. The packet size of 576 byte represents a normal datagram in the Internet environment. Figure 8 demonstrates the effectiveness of the achieved throughput during a normal point-to-point session with minimal overhead. By the less datagram size the effectiveness went down to approx. 35 Mbps

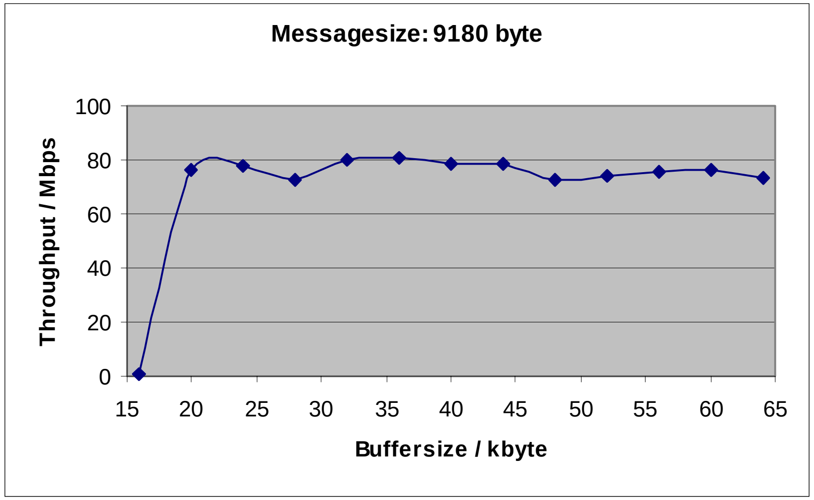
TCP/IP-over-ATM test results 2



Additional breaks and interruptions happened with small and big packet sizes. The MTU of 1.500 byte required a fragmentation of the packets and this has to be considered the reason for it.

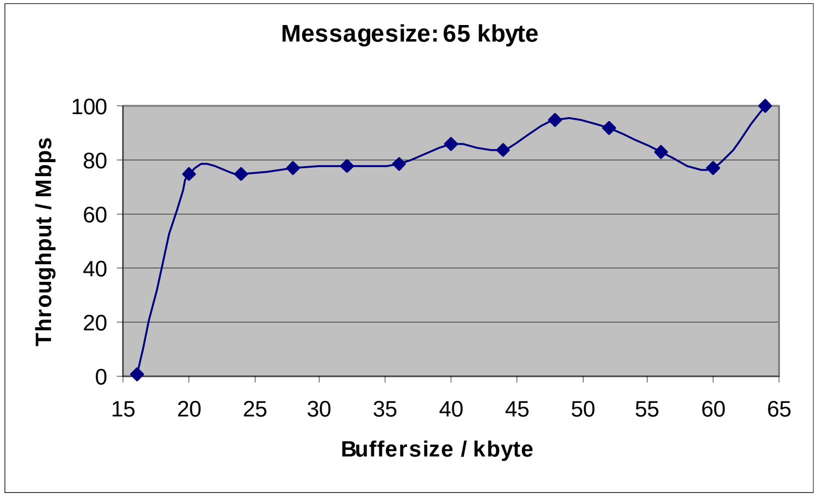
If the fragmentation was increased the performance went down. The figure shows a differing result. In this case, the packet size was 1.500 byte which allows higher data rates then before. The results are only limited to approx. 60 Mbps. The measurements show some fluctuations, because of the different buffer sizes, which was used.

TCP/IP-over-ATM test results 3



Fluctuations happened, especially at a buffer size of 55 kbyte. The best results were achieved at 40 and 65 kbyte. A fundamentally improved performance was achieved with a packet size of 9.180 byte. The throughput increased up to 80 Mbps. Fluctuations happened, again (especially on less buffer sizes), like during the other measurements. The small fragmentation of the packets has to be considered the reason as the MTU size was 9.180 byte

TCP/IP-over-ATM test results 4



For the last measurement a packet size of 65 kbyte was chosen. It triggered several fluctuations as figure 11 shows. At first the throughput went down to approx. 5 Mbps. This performance has to be considered poor and was not efficient enough to be used in practice. Otherwise this results show the best data rates till 100 Mbps. Concluding, the big packets are useful for data networks with big buffer sizes and the maximum transport unit (MTU) is responsible for an effective data throughput.

TCP/IP-over-ATM test results

- The measurement of TCP/IP-over-ATM was carried out by using various packet sizes in order to represent the effectiveness of IP-over-ATM
- Bad results with small buffer sizes on sender and receiver
- Small fluctuation of the throughput (between 1-2 Mbps)
- The throughput alone was not really interesting, the fluctuations and throughput breaks were more important
- If the fragmentation was increased the performance went down (see 65 kbyte)
- The best results were achieved at 40 and 65 kbytes buffers
- Big packets are not useful for data networks
- Operating systems are also responsible for the effectiveness

Summary and Conclusion

Summary

- Original, more vendors like Olicom, IBM, 3Com, and Nortel Networks promised to take part on the tests of the WWL. But on the one hand, some manufacturers developed at the time of the test MPOA, other companies go to MPLS instead of the MPOA approach.
- Cabletron‘s components worked sufficient and fast.
- Cisco‘s shortcut functionality worked also sufficient. Only the blockade of the router if the system was overloaded prevented to get the test results.
- TCP has been extended and further developed for better and more efficient mechanisms in high-speed networks. Yet in practice, TCP quite often does not have the optimal throughput.
- In order to implement IP-over-ATM effectively, it is necessary to assign enough time to the configuration of the participating devices and software.

Conclusions

- MPOA is efficient enough to work in big campus backbones
- MPOA has been specified good enough for interoperability
- MPOA components are relative simple to handle
- MPOA is able to work with QoS mechanisms
- MPOA supports all protocols in LAN environment, independent of the layer 2 or 3
- MPOA uses LANEv2.0 as basis, why a complex adaptation is necessary. This can be restricted during failure searching in main operations
- MPOA solutions are not on the market - to less manufactures work with MPOA
- The leading manufacture Cisco takes not MPOA in the core of a LAN network, but Gigabit-Ethernet with Layer-3-Switching.
- The further development of MPOA is questionable, because the main emphasis drifted from circuit switching to packet switching

Thank you for your attention

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