WWL Internet AG

Networking 2000

Quality-of-Service (QoS) in heterogeneous networks:
CLIP, LANE , and MPOA performance test

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- TCP/IP-over-ATM
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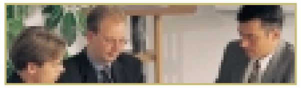
- TCP/IP-over-ATM performance
- Summary and conclusion

WWL Internet AG
- Short introduction -

Internet Full-Service Company



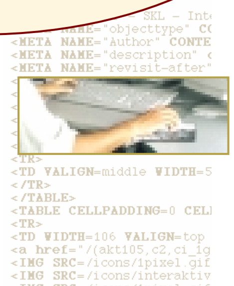
WWL consults as
a **Management Consultancy**

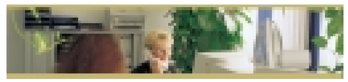
WWL arranged as
a **Advertising Agency**

WWL is one of the top addresses in Germany

WWL support the
technique a a **Provider**

WWL programs as
a **Software Developer**





WWL develops Network Solutions
as a **System House**

» WWL is a One-Stop-Source for trend-setting Internet technologies «

Short Profil

Marker-orientated Consultancy, Realisation, and Support of the Internet appearance

wwl interactive

- web consulting
- design
- technology
- emarketing
- eCommerce

Technical service in the areas of network and communication

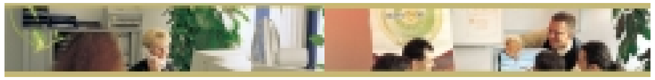
wwl network

- network consulting
- internet services
- network services
- security

Development and Sales of innovative web-based products

wwl products

- GateCop (Firewall)
- FlowChief (Prozeßleitsystem)
- net24 (Privatkundencenter)
- mainstreet (Shopping-System)



Support of the customers by wwl interactive, wwl network, and wwl products

wwl services

- Site Service
- Hotline/ Troubleshooting
- Customer Care
- Service & Support

» The Porttfolio of the WWL makes the completely support of companies possible. «

MPOA and LANE
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

LAN Emulation (LANE)

- Migration of legacy LANs to ATM: Ethernet switch (layer 2) and router (layer 3) coupling
- Universal implementation (MAC layer is emulated): arbitrary LAN protocols
- Using of the application layer without ATM configuration
- Support of PVC/SVC connections
- AAL-5 packet encapsulation
- IP multicasting
- D-MTU: 1500 byte

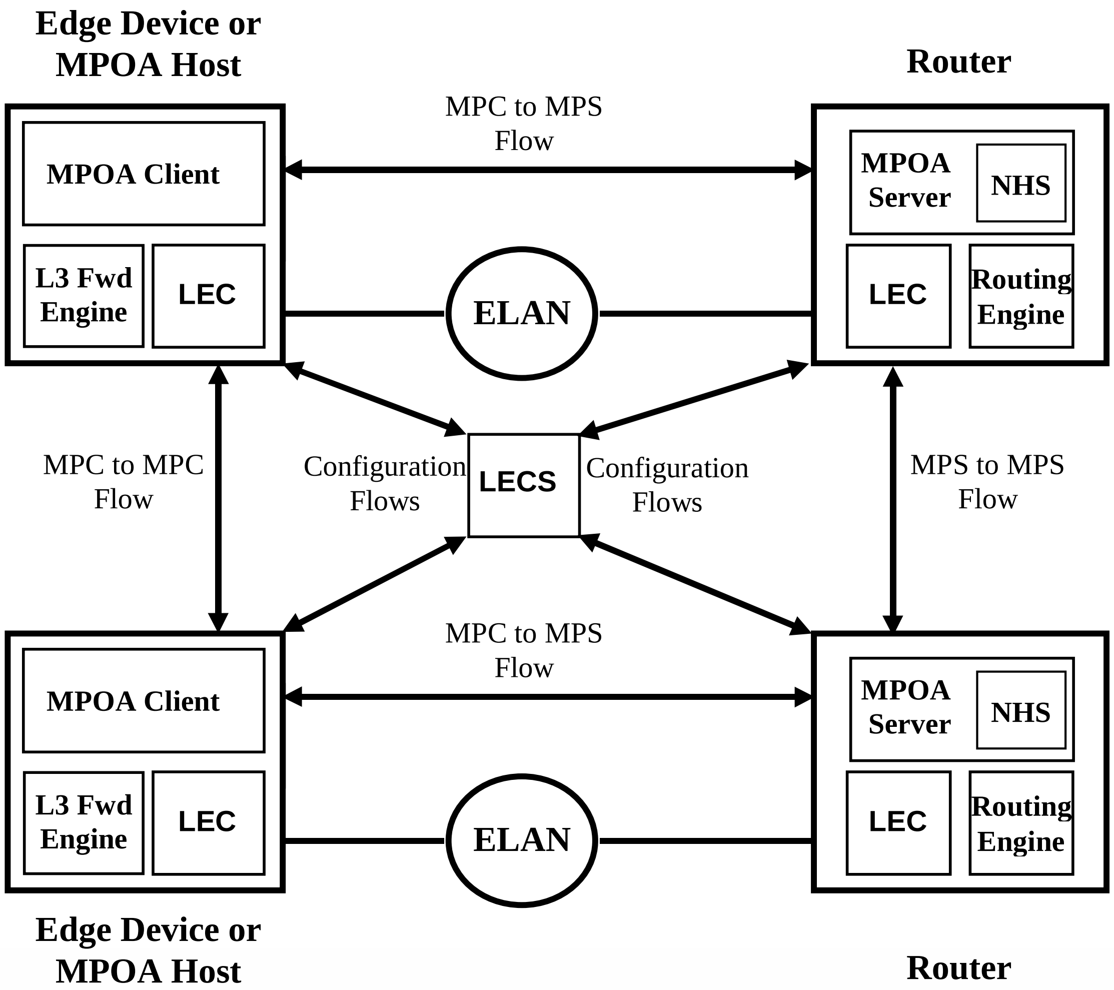
Disadvantages of this approach

- No QoS support
- High functionality of LANE (complex: IP- MAC-ATM)
- Router bottleneck between LIS or ELAN
- Legacy LAN bottleneck (old drivers, infrastructure)
- BUS limited the LANE performance
- No redundancy and recovery mechanisms in LANE 1.0 (not in LANE 2.0)
- Bad scalability and bigger overhead of LANE

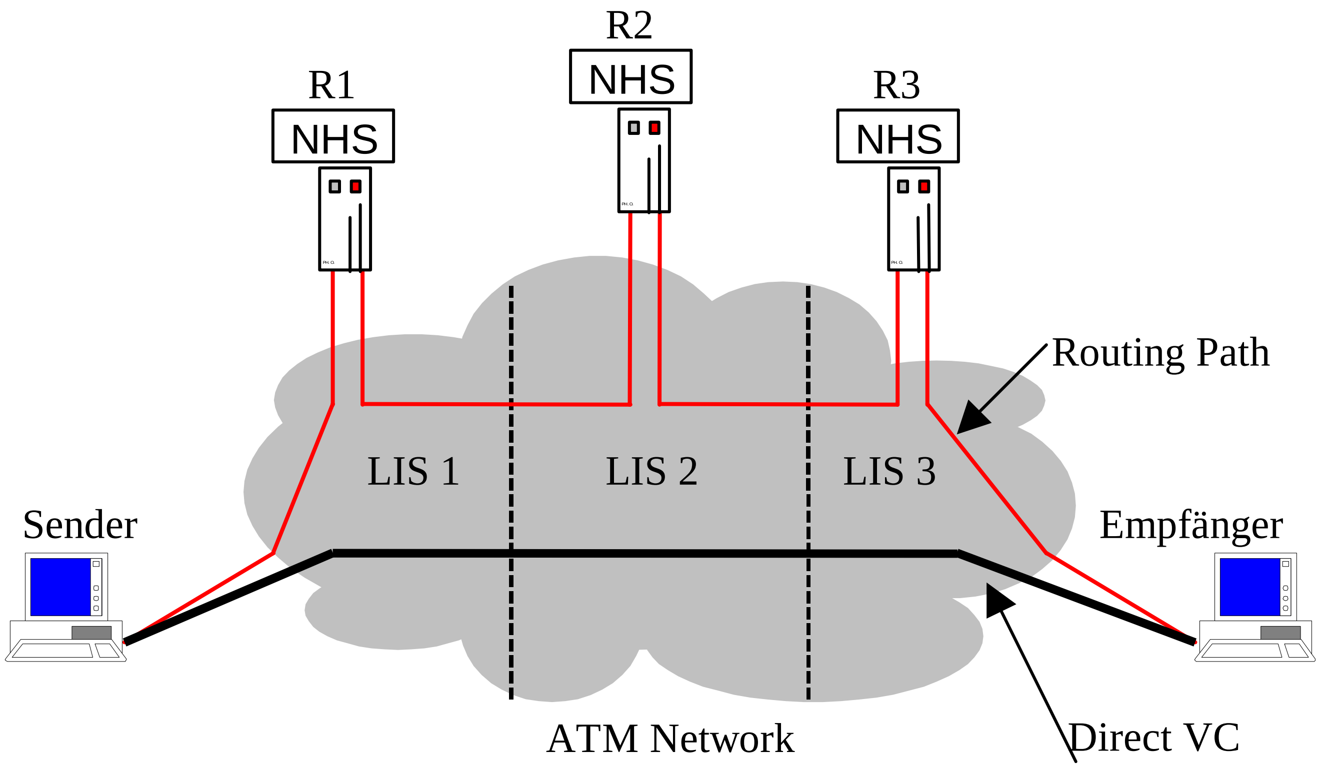
Multiprotocol-over-ATM (MPOA)

- 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

Redundancy structure



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 LANE, MPOA, and TCP/IP

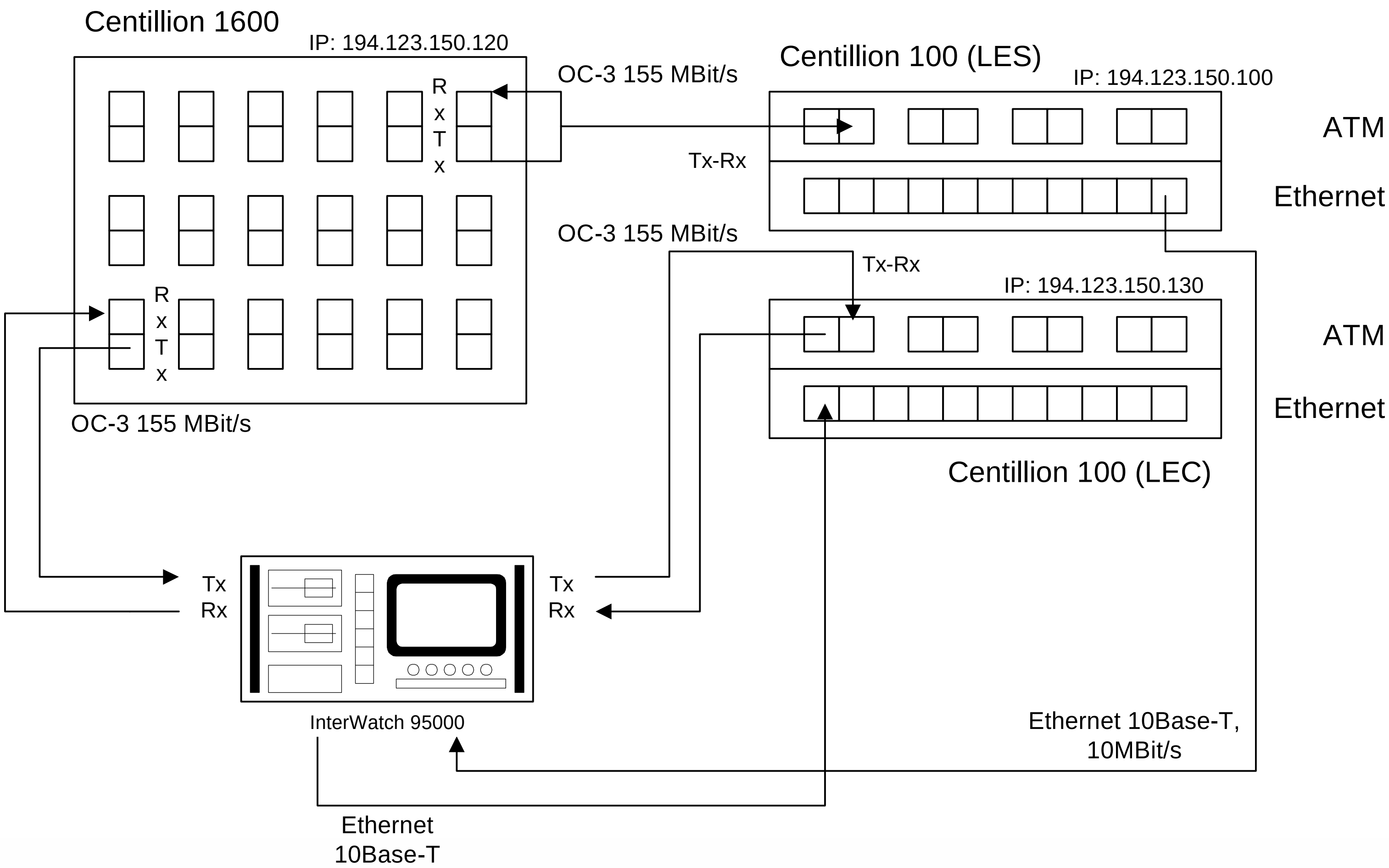
Goals of the measurements

- Get to know of the available products in the area of LAN and WAN
- Co-operations with the manufactures
- 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

- ATM-Switch Centillion 100 (Bay/Nortel)
- ATM-Switch Centillion 1600 (Bay/Nortel)
- ATM-Switch CS3000 (Newbridge Networks)
- VIVID Route Server (Newbridge Networks) with Routing Protocols RIP, OSPF, NHRP and support of IP, IPX, etc.
- VIVID Orange Ridge (Newbridge Networks)
- ATM adapter boards from ForeRunnerLE series with throughput of 155 Mbps
- Cabletron SmartSwitch2000 ATM Switch (Cabletron)

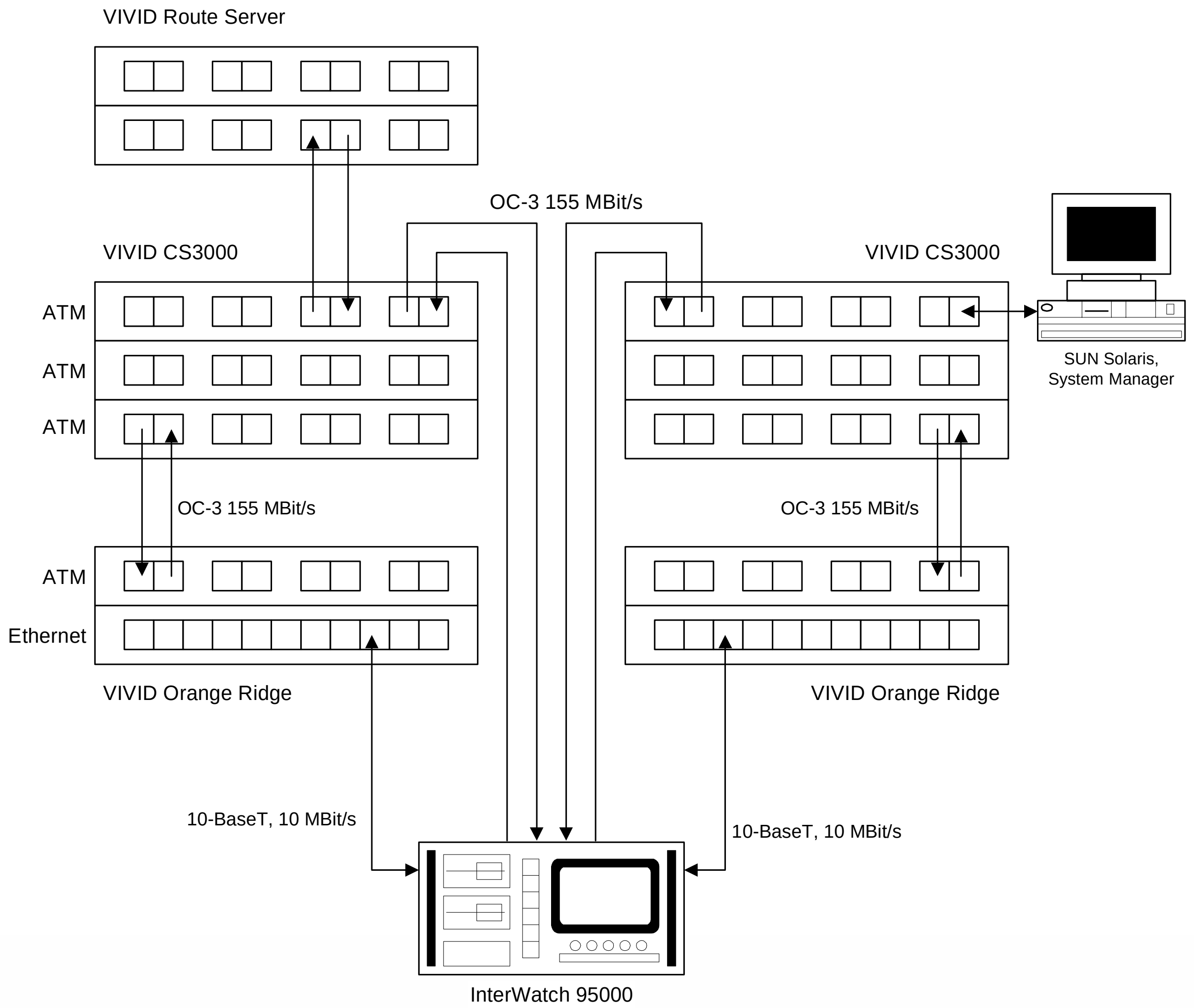
LANE test scenario



LANE test scenario

- LANE was tested without any router as there has been just one ELAN used, because of optimal traffic measurement
- Spanning Tree and dynamical routing were not tested and turned off
- LANE were tested by a pure Bay/Nortel Networks scenario
- Two edge devices and one core ATM switch have been used
- Unknown addresses have been used for the measurement to get real results

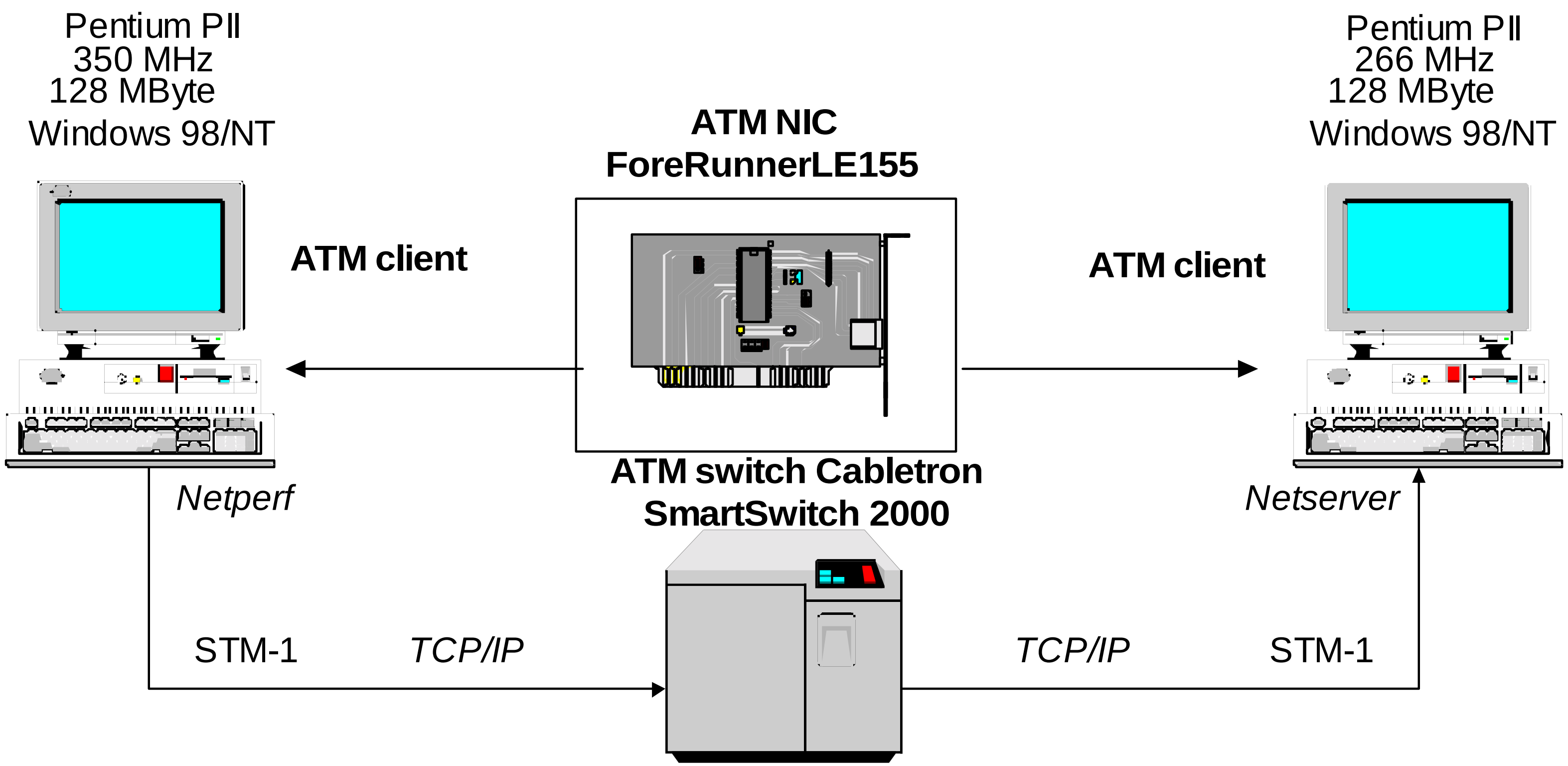
MPOA test scenario



MPOA test scenario

- MPOA scenario was different to LANE, because Logical IP Subnets (LIS) were needed in order to use the forwarding and routing functionality of MPOA
- The VIVID components included LANEv1.0 and NHRP
- Two edge devices and core ATM switches
- P-NNI has been configured for automatically dynamical routing
- VIVID Route Server for establishing shortcuts if data flows appears

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

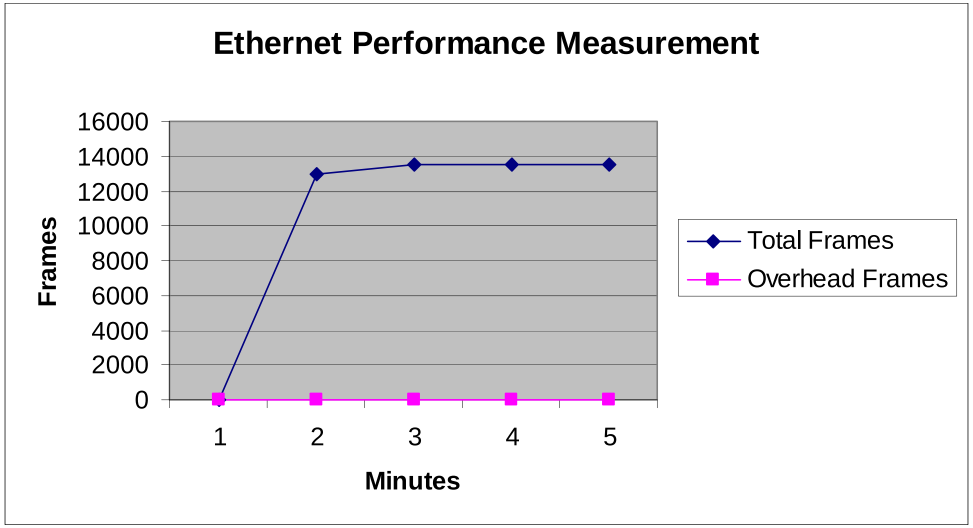


TCP/IP-over-ATM test scenario

- 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

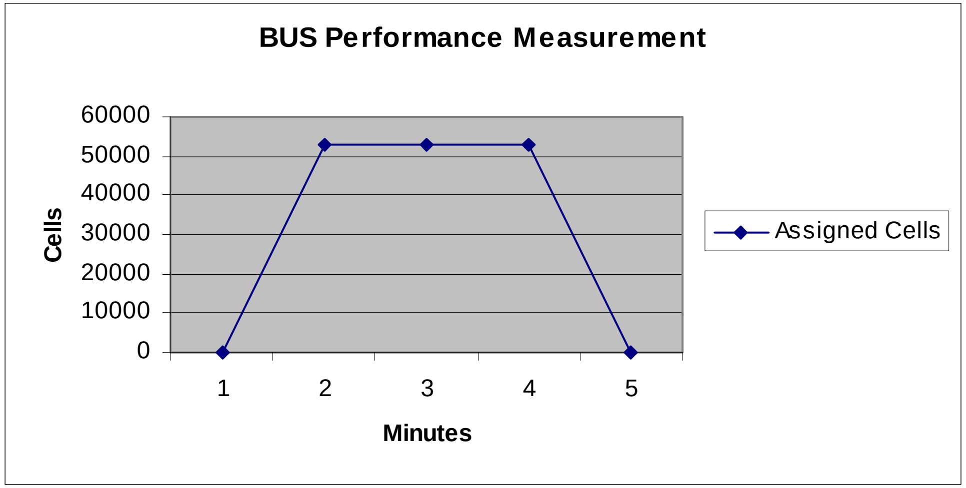
LANE and MPOA test results

LANE test results, part 1



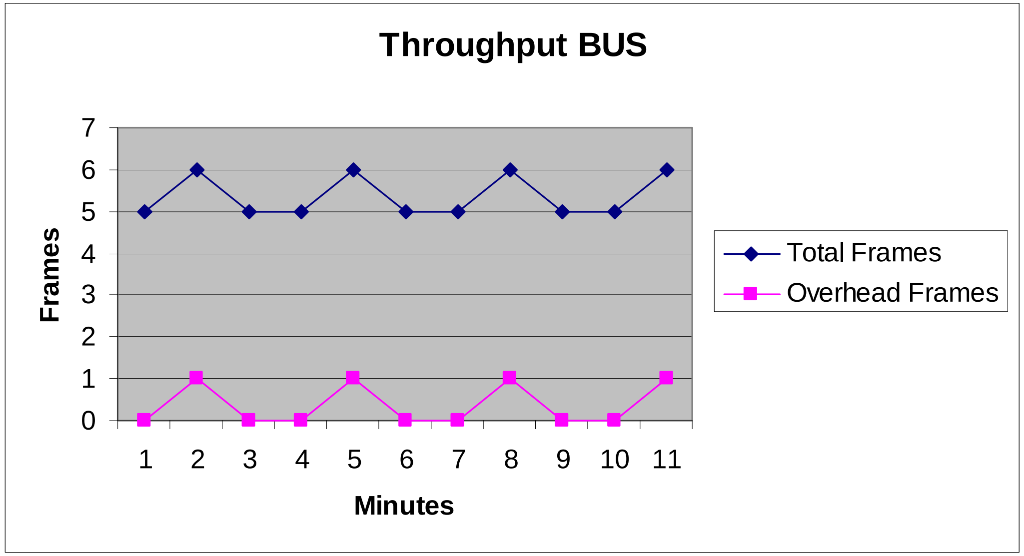
In order to measure the performance of the Ethernet side, a PING was sent in both directions. In doing so, the measurements could be limited to one port. Furthermore, an exploitation of 100% was adjusted. The figure clearly shows that the throughput of the Frames after a very short time climbs up to 13.500 frames/sec and remains at that level. This figure demonstrate an effective exploitation of 99,4%. Yet, the payload is included and that means you have to add some collisions (27) and the overhead.

LANE test results, part 2



In a next step, the BUS performance on the ATM side was tested. The maximum BUS throughput is approx. 53.000 cells per second. This represents a data rate of 22,4 Mbps. Full duplex was chosen as the full possible data rate plus overhead had been reached. This result has got independence from the data rate and can be hold only approx. one minute.

LANE test results, part 3

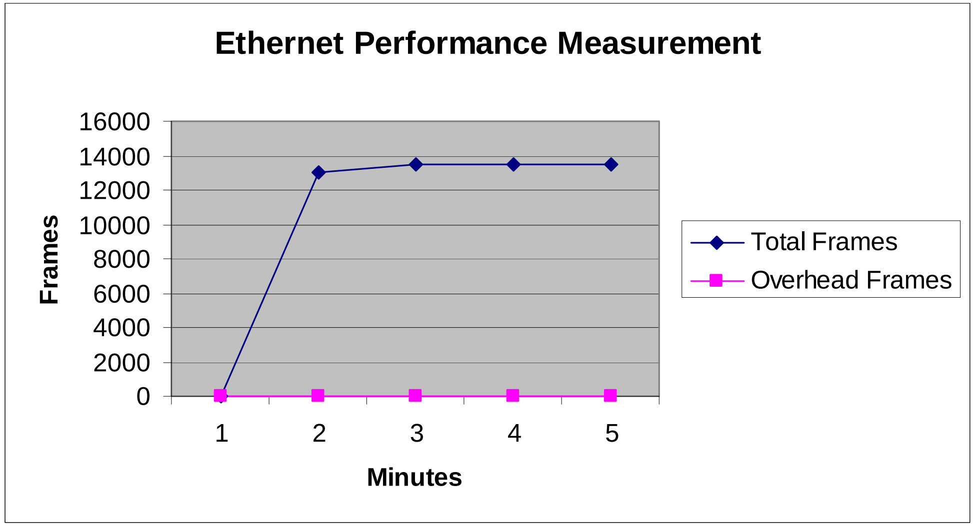


This figure shows the unknown packet throughput that was responsible for the allocation of the addresses. The unknown packets did not load the BUS as the figure illustrates. The BUS sent only 5-6 frames with 0-1 frames overhead.

LANE final test results

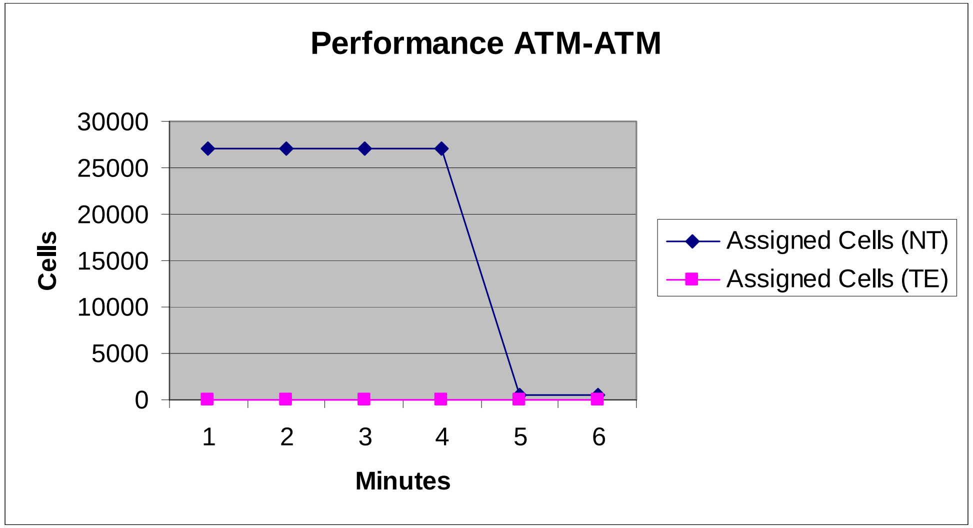
- An exploitation of 100% was adjusted
- Throughput of the Frames after a very short time climbs up to 13.500 frames/sec and remains at that level
- Effective exploitation of 99,4% (collisions and overhead)
- Maximum BUS throughput is approx. 53.000 cells per second
- This represents a data rate of 22,4 Mbps
- The BUS does not need to have a high performance and works with short bursts
- The unknown packets did not load the BUS

MPOA test results, part 1



Ethernet-to-Ethernet performance: The measurements showed the same result as the aforementioned with LANE. Changes of the packet sizes from 100 byte to 1000 byte and 64 kbyte did not influence the test results. The explanation to that is the 10 Mbps data rate. The exploitation was 99,4% with 1.100 collisions.

MPOA test results, part 2



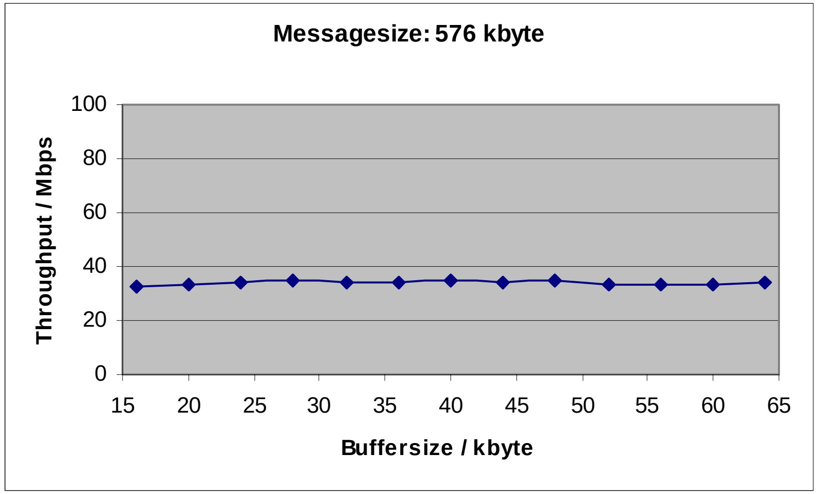
ATM-to-ATM performance: The second measurement has been conducted with 100% exploitation. After a defined period of time, the route server also had to be restarted, similarly to the BUS at LANE.

MPOA final test results

- This test has been conducted with more than two subnets in order to force the router to route and to forward the packets
- The measurements showed the same result as the aforementioned with LANE
- Changes of the packet sizes from100 bytes to 1000 bytes and 64 kbytes did not influence the test results
- The exploitation was 99,4% with 1.100 collisions (more collisions)
- 27.000 cells/s (11,45 Mbps) as the maximum throughput was measured (unidirectional)

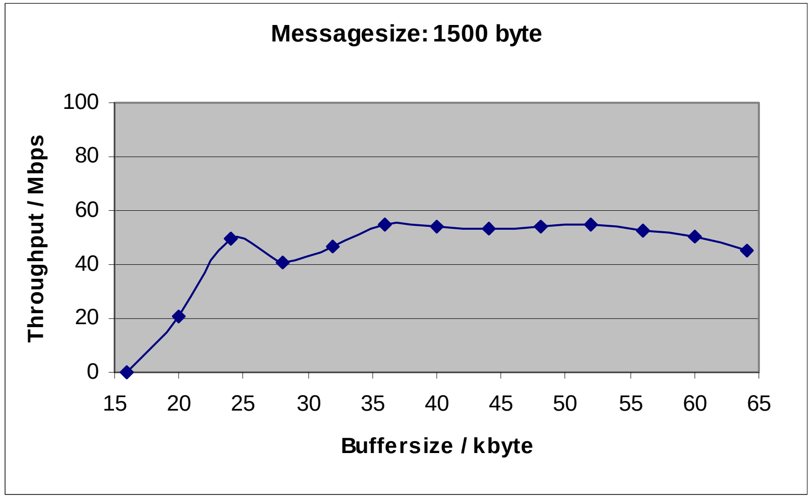
TCP/IP
test results

TCP/IP-over-ATM test results, part 1



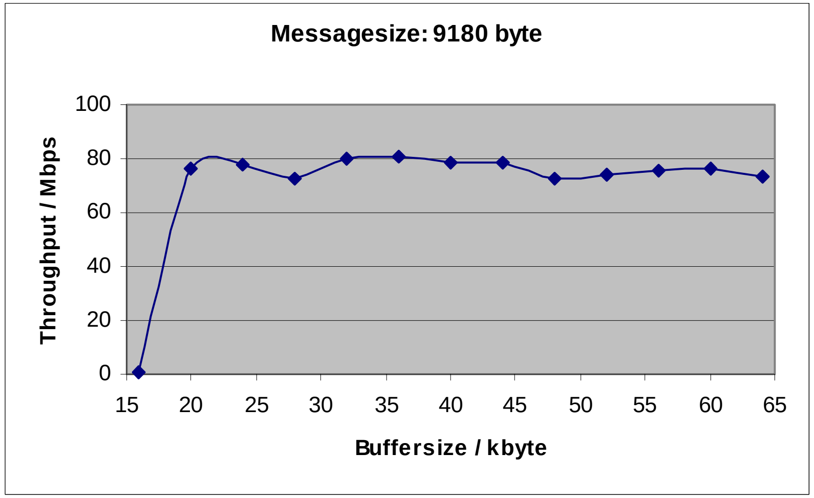
The buffer varies from 15-64 Kbytes. The packet size of 576 byte represents a normal datagram in the Internet environment. This figure demonstrates the effectiveness of the achieved throughput during a normal point-to-point session with minimal overhead. By the less datagram size the effectiveness went down to approx. 35 Mbps.

TCP/IP-over-ATM test results, part 2



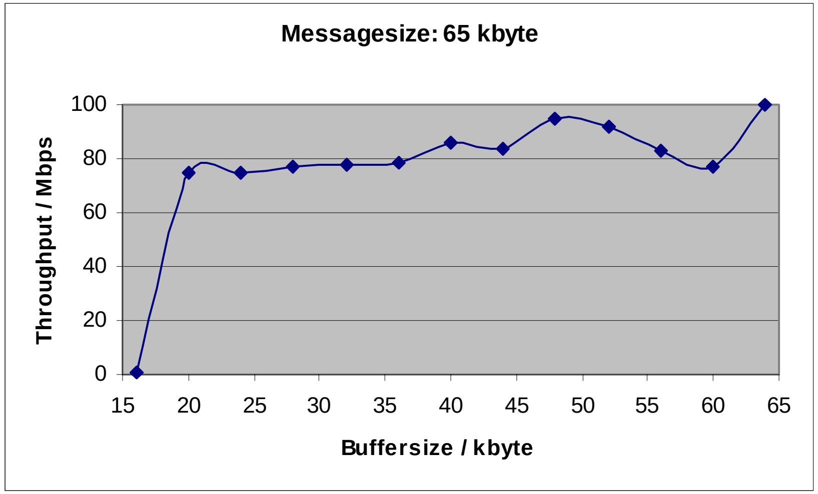
Additional breaks and interruptions happened with small and big packet sizes. The MTU of 1.500 byte required a fragmentation of the packets and this has to be considered the reason for it. If the fragmentation was increased the performance went down. This figure shows a differing result. In this case, 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, part 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, part 4



65 kbytes triggered several fluctuations as the figure 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

- LANE is a very stable standard and simply to configure
- LANE and MPOA have the same performance in one ELAN between LECs
- LANE supports only UBR; MPOA: QoS
- WWL tests continuously MPOA from different manufactures (e.g. Cisco, Cabletron, Nortel)
- High-end workstations has a very better throughput as Legacy PCs
- TCP has been extended and further developed for better and more efficient mechanisms in high-speed networks
- QoS mechanisms work in MPOA environment, if the ATM client is directly connected with the ATM switch

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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