EURO-VIEW 2007, Wuerzburg, July 23-24, Germany

Towards the QoS Internet

Wojciech Burakowski and Halina Tarasiuk

Telecommunication Network Technologies Group

Warsaw University of Technology, Poland

tnt.tele.pw.edu.pl

Plan

- Vision of QoS Internet
- QoS mechanisms, algorithms and protocols
- Tested approaches for IP QoS
  - AQUILA: single domain DiffServ
  - EuQoS: end-to-end QoS over heterogeneous networks
- Summary

Vision of QoS Internet (1)

- Evolution steps of the Internet
  - best effort networks
  - DiffServ architecture
  - PHB mechanisms in commercial routers (schedulers, classifiers, markers, policers..)
  - MPLS technology

  - IP Premium in GEANT and some NRENs
  - prototype solutions, as developed e.g. in European projects (EuQoS, Daidalos, MUSE, NETQOS, AQUILA TEQUILA, CADENUS, etc...)

Vision of QoS Internet (2)

- Why we need QoS ?
  - to open new market – QoS Internet
    - natural step of evolution
    - new applications for users
    - real business
  - QoS is really required for new challenges as
    - e-health systems
      - for transferring life-critical information

Vision of QoS Internet (3)

- Target QoS Internet : multi-service QoS network
  - areas
    - multi-domain
    - heterogeneous networks
    - supporting a set of QoS Classes of Services
    - providing absolute QoS
  - in the future
    - user-oriented, e.g. QoS negotiations...

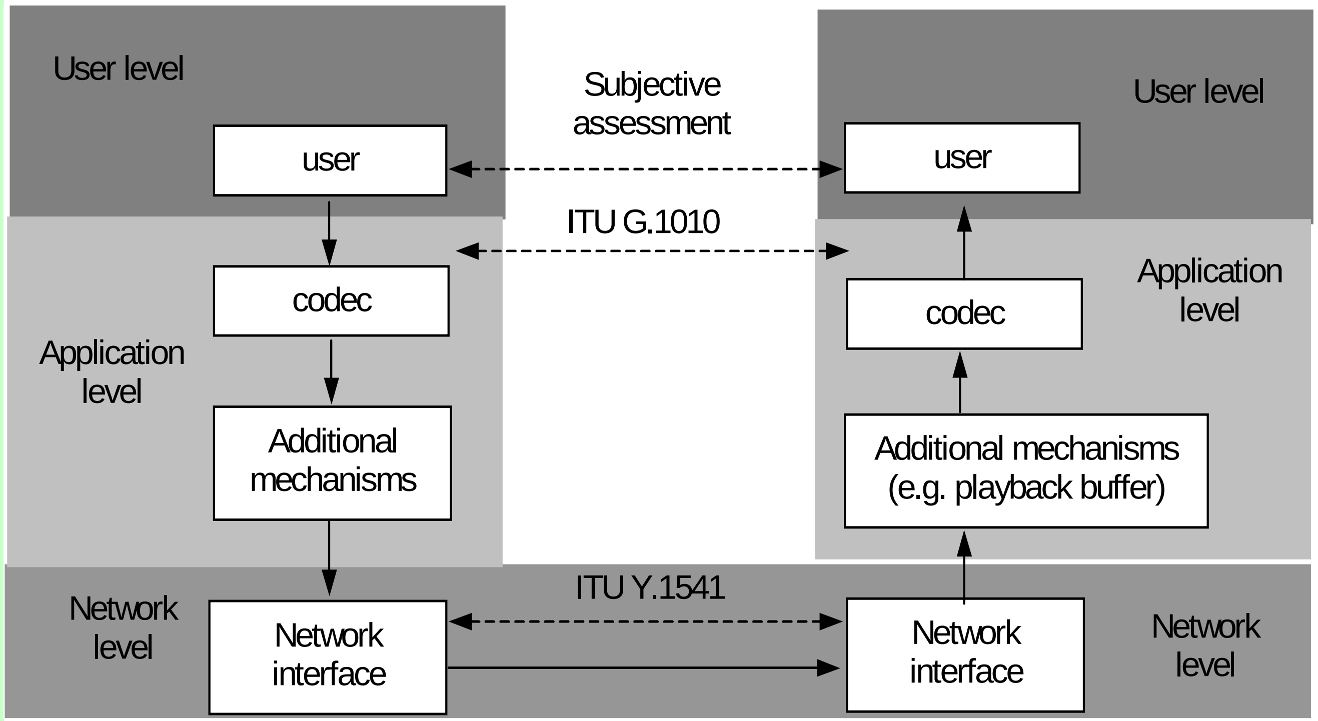
IETF Recommendations

- RFC2474
  - K. Nichols, et al., Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers, December 1998.
- RFC2475
  - S. Blake, et al., An Architecture for Differentiated Services, December 1998.
- RFC2597
  - J. Heinanen, et al., Assured Forwarding PHB Group, June 1999.
- RFC2638
  - K. Nichols, et al., A Two-bit Differentiated Services Architecture for the Internet, July 1999.
- RFC3246
  - B. Davie, et al., An Expedited Forwarding PHB (Per-Hop-Behavior), March 2002.
- RFC3260
  - D. Grossman, New Terminology and Clarifications for Diffserv, April 2002.
- RFC3290
  - Y. Bernet, et al., An Informal Management Model for Diffserv Routers, May 2002.
- RFC4594
  - J. Babiarz, et al., Configuration Guidelines for DiffServ Service Classes, Internet RFC 4594, August 2006.

ITU-T QoS Standards for NGN

- ITU-T Rec. Y.1540
  - IP Packet Transfer and Availability Performance Parameters, December 2002.
- ITU-T Rec. Y.1541
  - Network Performance objectives for IP-based services, 2002.
- ITU-T Rec. Y.2001
  - General Overview of NGN, 2004.
- ITU-T TR Q-Series Supplement 51 (12/04)
  - Signalling requirements for IP QoS.
- ITU-T Rec. Y.2111
  - Resource and Admission Control Functions in Next Generation Networks, 2006.

Vision of QoS Internet (4)



User satisfaction of using given application

Offered a number of Classes of Service

For guarantying appropriate level of packet losses, delays etc.

End-to-end CoSs: in the last Recommendation (RFC4594)

Treatment aggregate	End-To-End Service Class	QoS Objectives		
		IPLR	Mean IPTD	IPDV
CTRL	Network Control	10^{-3}	100 ms	50 ms
Real Time	Telephony	10^{-3}	100/350 ms (local/long distance)	50 ms
	Signalling	10^{-3}	100 ms	U
	MM Conferencing	10^{-3}	100 ms	50 ms
	RT Interactive	10^{-3}	100/350 ms (local/long distance	50 ms
	Broadcast Video	10^{-3}	100 ms	50 ms
Non-Real Time/Assured elastic	MM Streaming	10^{-3}	1 s non critical	U
	Low Latency Data	10^{-3}	400 ms	U
	OAM	10^{-3}	400 ms	U
	High Throughput Data	10^{-3}	1 s not critical	U
Elastic	**Standard**	U	U	U
	Low-Priority Data	U	U	U

Plan

- Vision of QoS Internet
- QoS mechanisms, algorithms and protocols
- Tested approaches for IP QoS
  - AQUILA: single domain DiffServ
  - EuQoS: end-to-end QoS over heterogeneous networks
- Summary

QoS mechanisms, algorithms and protocols

- What do we need for providing QoS ?
  - At the Packet level
    - QoS mechanisms for handling packets
    - Connection Admission Control
  - QoS aware applications – for sending QoS Request to the network containing information about
    - Type of CoSs
    - Required bandwidth
  - QoS path - QoS routing for inter- and intra- domains

Control mechanisms in the network

Traffic Engineering
Resource allocation
Network dimensioning
Setting routing paths i

Charging

For encourage users in using the network in a rational way

Network management

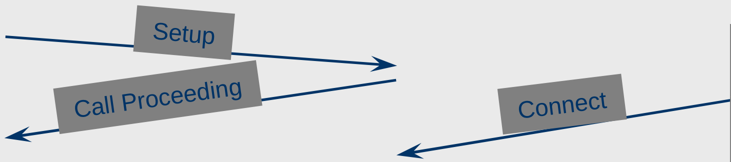
For operator to make control on the network

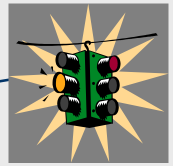
Signalling

For setting the connection and for sending the QoS requirements

Admission Control

For controlling the traffic in the network

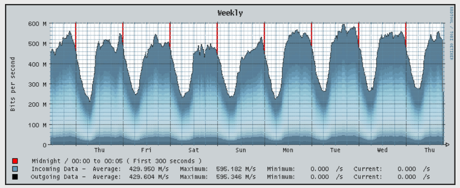




Monitoring and measurements

To support network functionalities

To get information about network state – load, anomalies detection

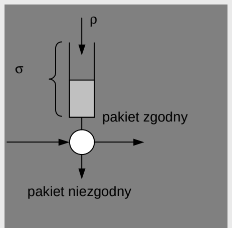


Control

Data transfer

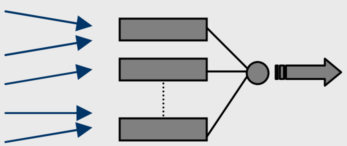
Mechanisms for policing traffic

Traffic policing at the network entry point



Packet scheduling mechanisms

To regulate the access to the transmission line for streams belonging to different CoSs



Time scale

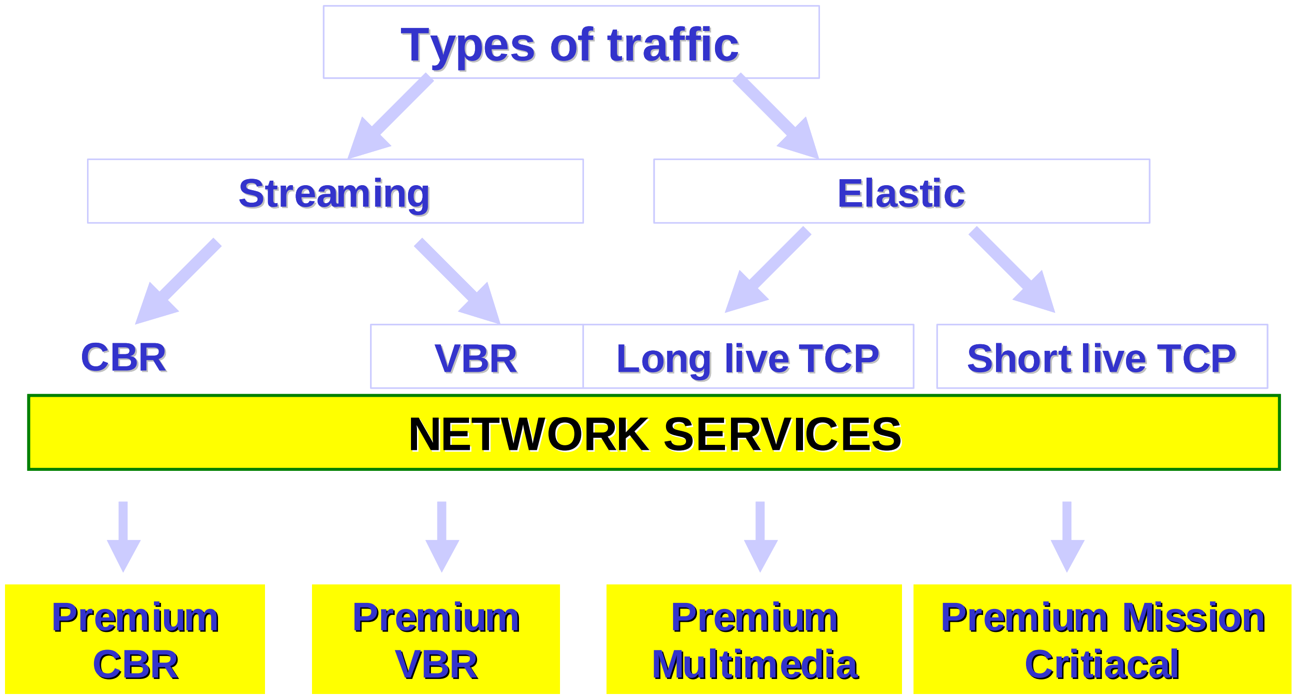
Plan

- Vision of QoS Internet
- QoS mechanisms, algorithms and protocols
- Tested approaches for IP QoS
  - AQUILA: single domain DiffServ
  - EuQoS: end-to-end QoS over heterogeneous networks
- Summary

AQUILA (IST-1999-10077)

Adaptive Resource Control for QoS Using an IP-based Layered Architecture

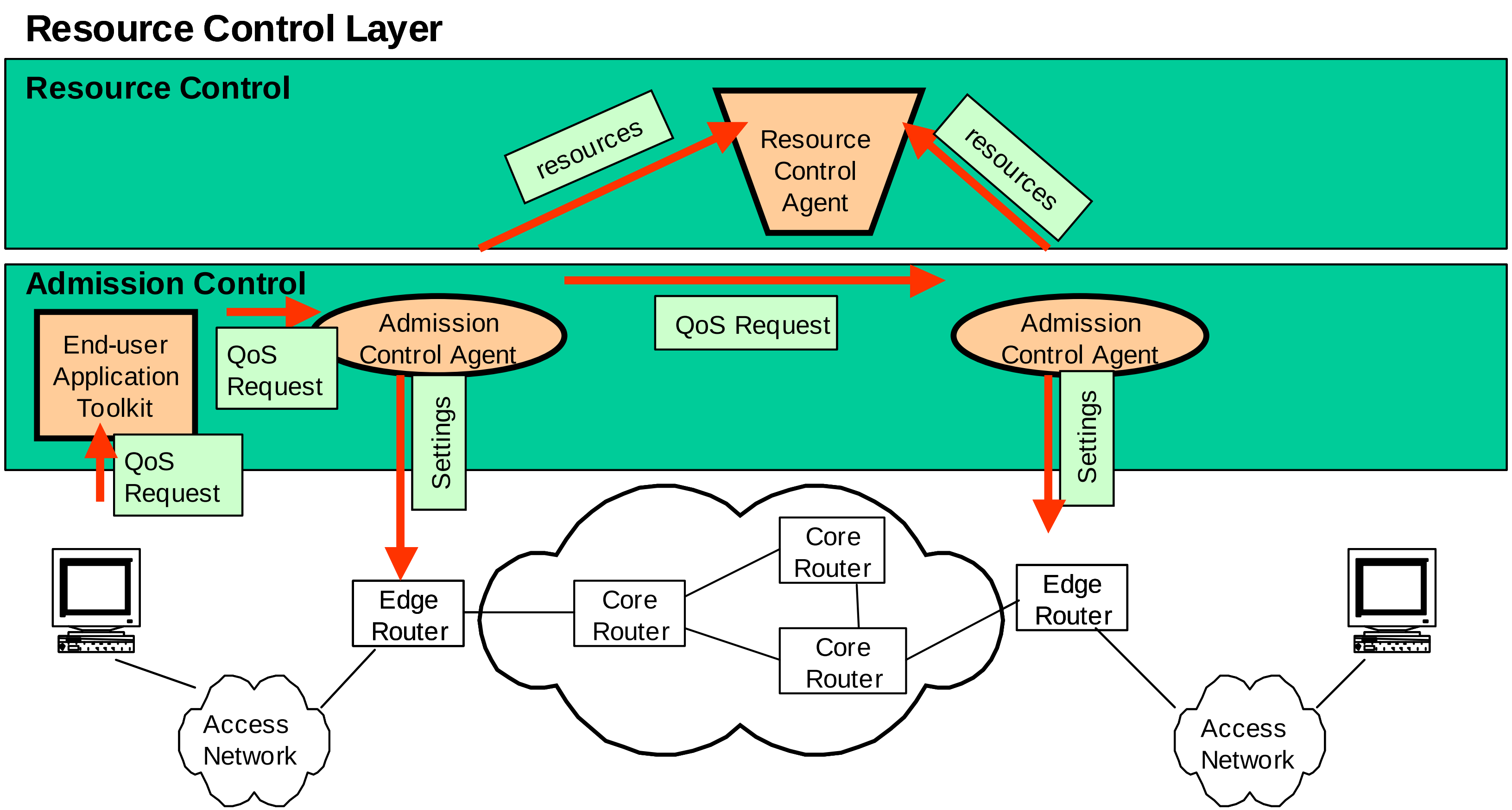
2000-2003



AQUILA architecture and concepts

- Network services:
  - Premium CBR for IP Telephony and Voice Trunking
    - very low delay and jitter, very low loss, hard bandwidth guarantee.
  - Premium VBR for Video Streaming and Teleconferencing
    - low delay and jitter, low loss, bandwidth guarantee.
  - Premium Multimedia for adaptive applications (TCP), e.g. ftp
    - bandwidth guarantee, moderate delay.
  - Premium Mission Critical for interactive games, online banking
    - very low loss, non-greedy flows and rather small packets.
  - Standard
    - classical best effort traffic.

AQUILA architecture and concepts



QoS mechanisms, algorithms and protocols

- Conclusions from AQUILA
  - It was proved and tested that providing QoS was possible
  - We needed new functionalities
    - QoS aware applications
    - CAC

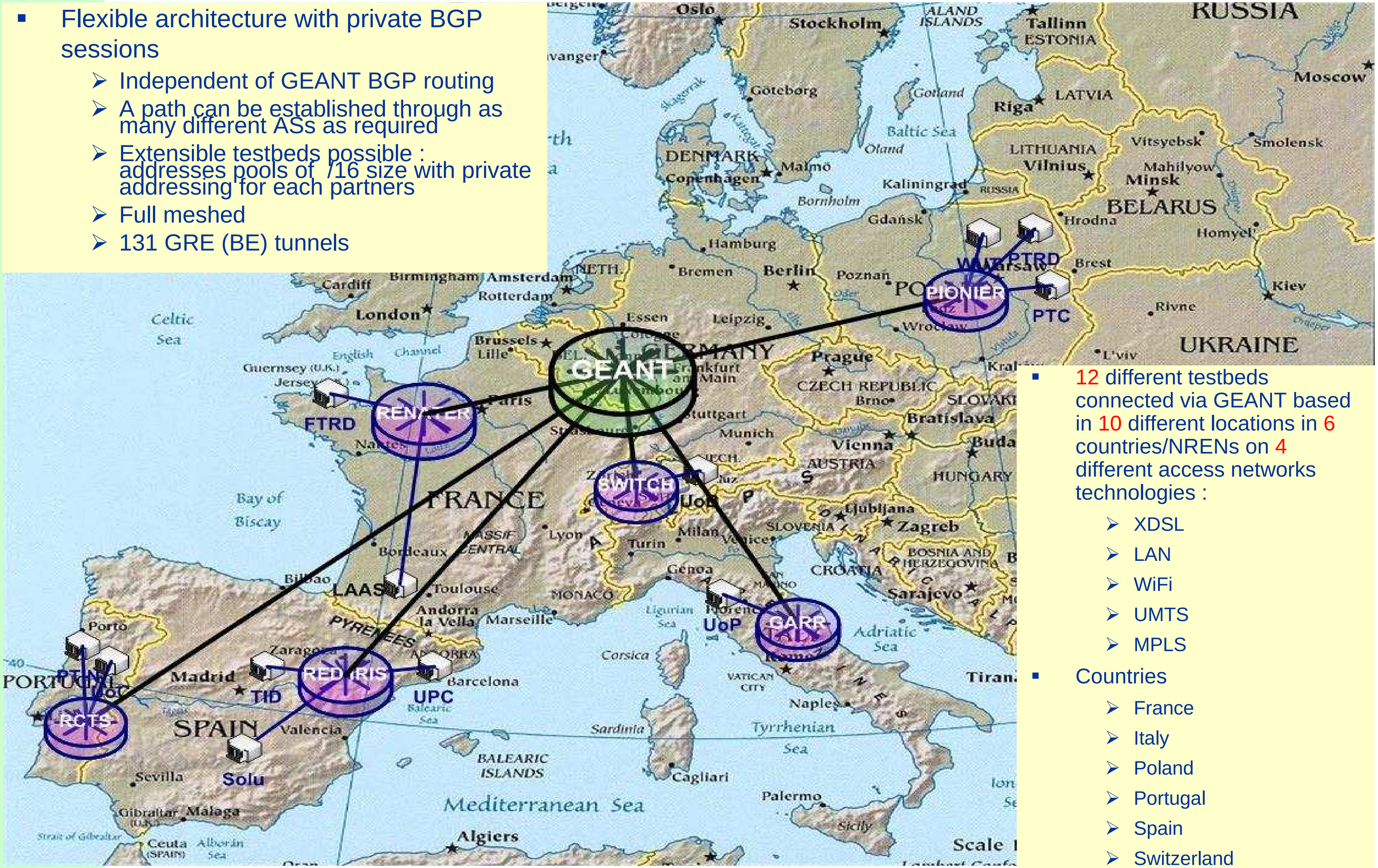
End-to End QoS over Heterogeneous Networks

2004-2007

Exhibitions: Brussels CER 2005, Helsinki IST 2006

EuQoS Network General Overview

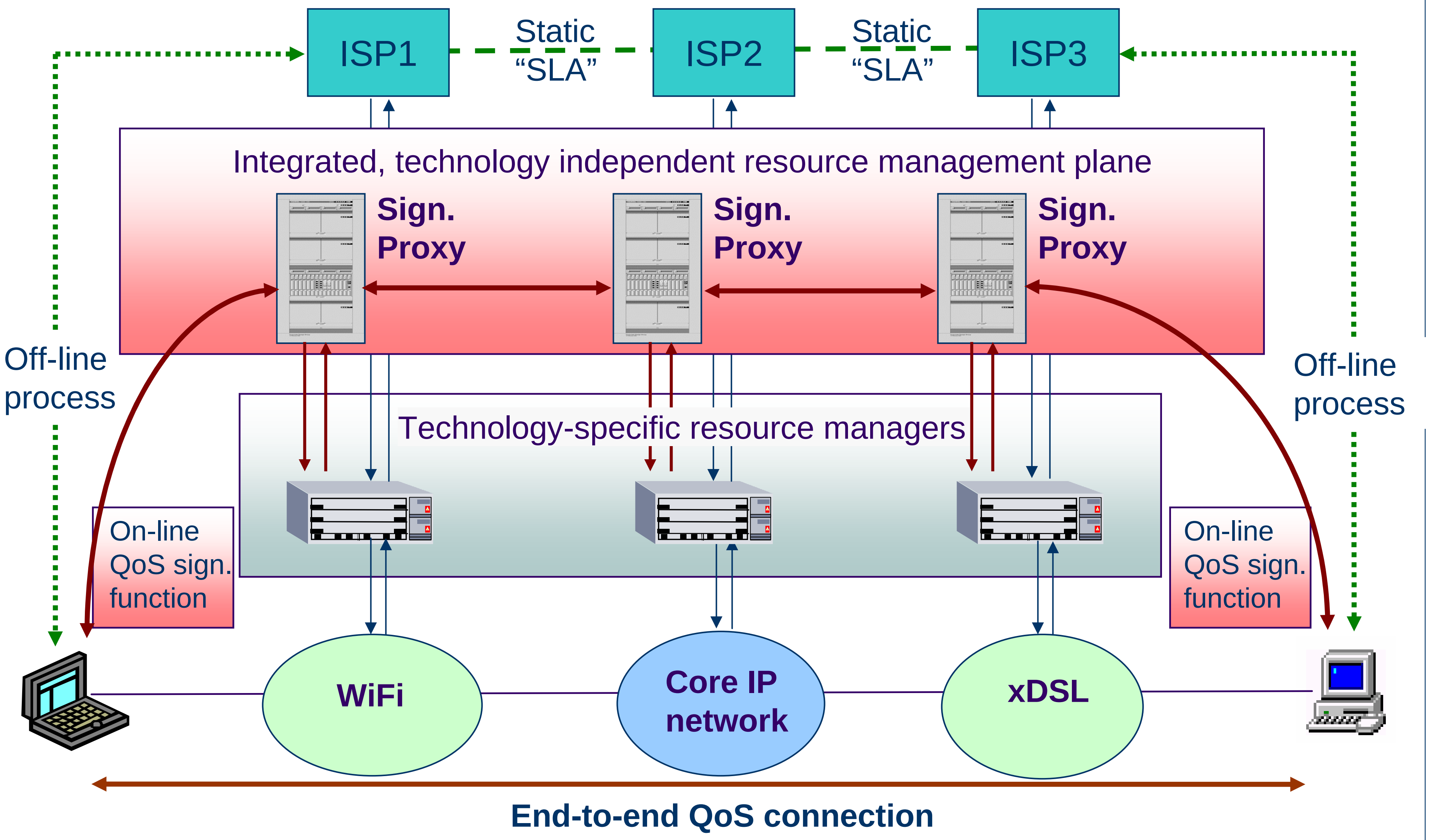
- Flexible architecture with private BGP sessions
  - Independent of GEANT BGP routing
  - A path can be established through as many different ASs as required
  - Extensible testbeds possible : addresses pools of /16 size with private addressing for each partners
  - Full meshed
  - 131 GRE (BE) tunnels



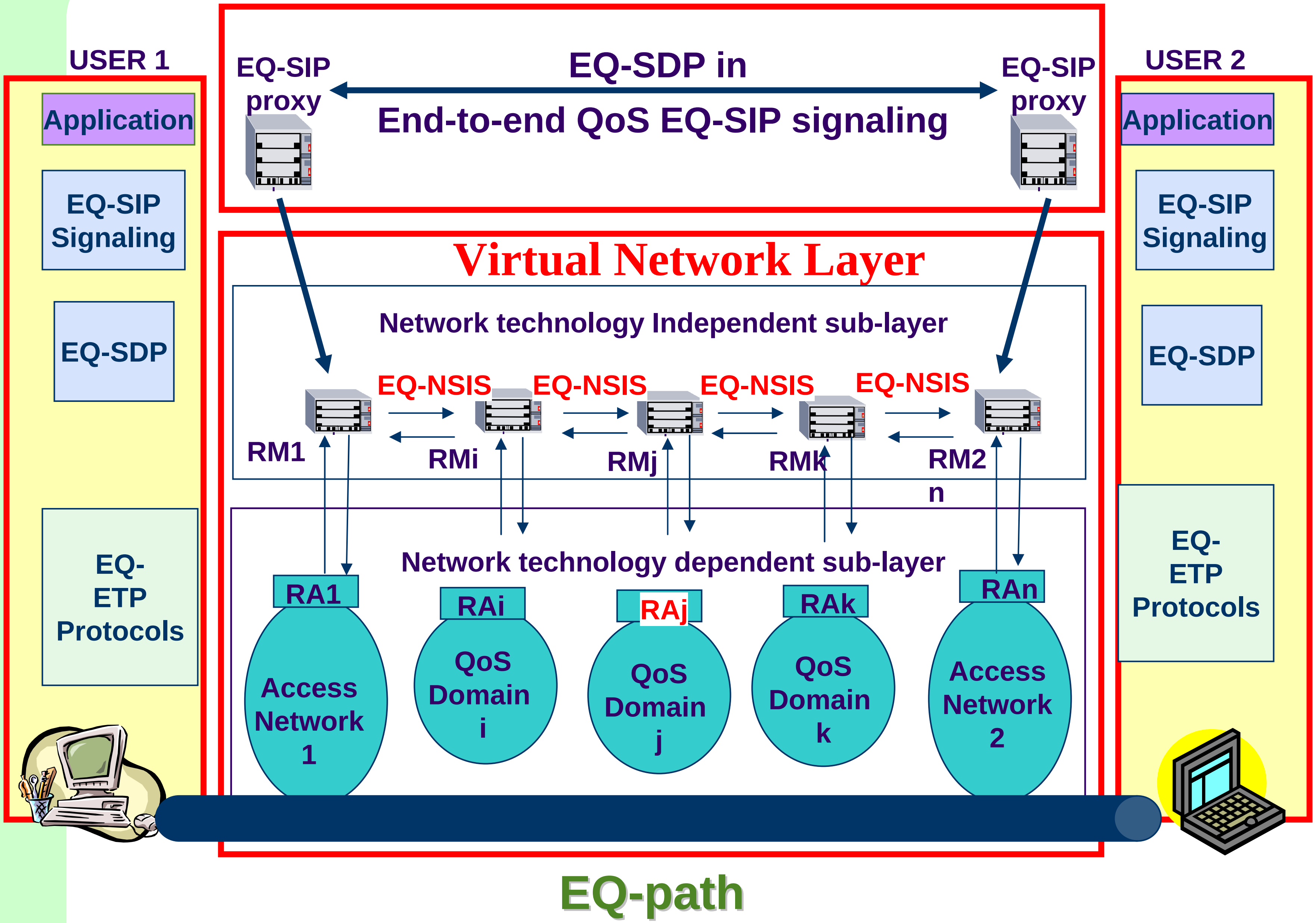
- 12 different testbeds connected via GEANT based in 10 different locations in 6 countries/NRENs on 4 different access networks technologies :
  - XDSL
  - LAN
  - WiFi
  - UMTS
  - MPLS
- Countries
  - France
  - Italy
  - Poland
  - Portugal
  - Spain
  - Switzerland

EuQoS solution:

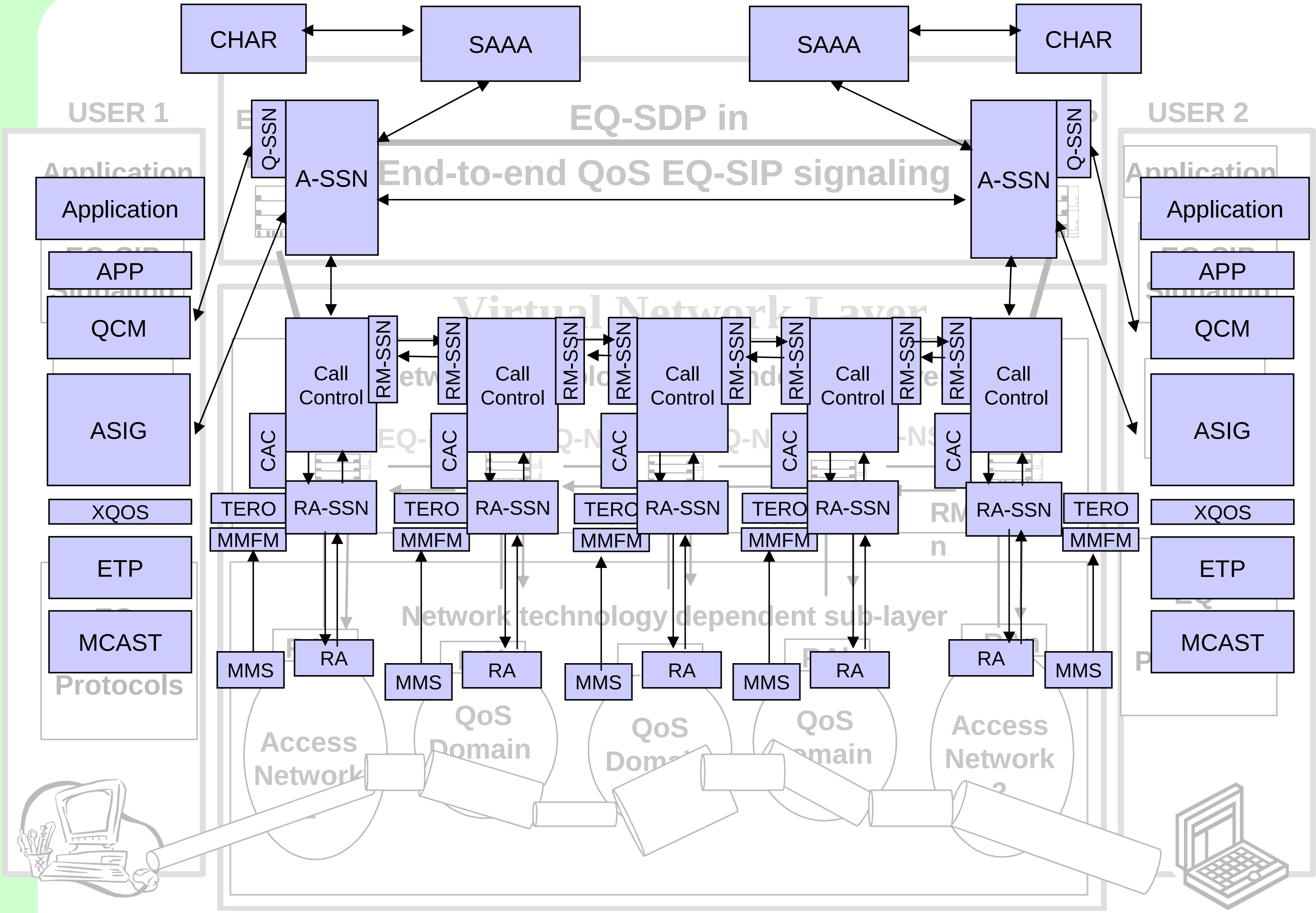
- technology-independent layer added
- QoS signalling capabilities added to the applications (terminals)



EuQoS Architecture: Physical View



Software mapping over architecture



Selected problems from EuQoS (1)

- QoS BGP: QoS Border Gateway Protocol
  - To add QoS objectives to BGP
  - QoS objectives:
  - Classes of Services and the values of the parameters IPTD, IPTV and IPLR
  - In the source domain to perform e2e CAC – checking if there exists QoS path between source-destination domains

---

  - Solution implemented and tested in the EuQoS testbeds

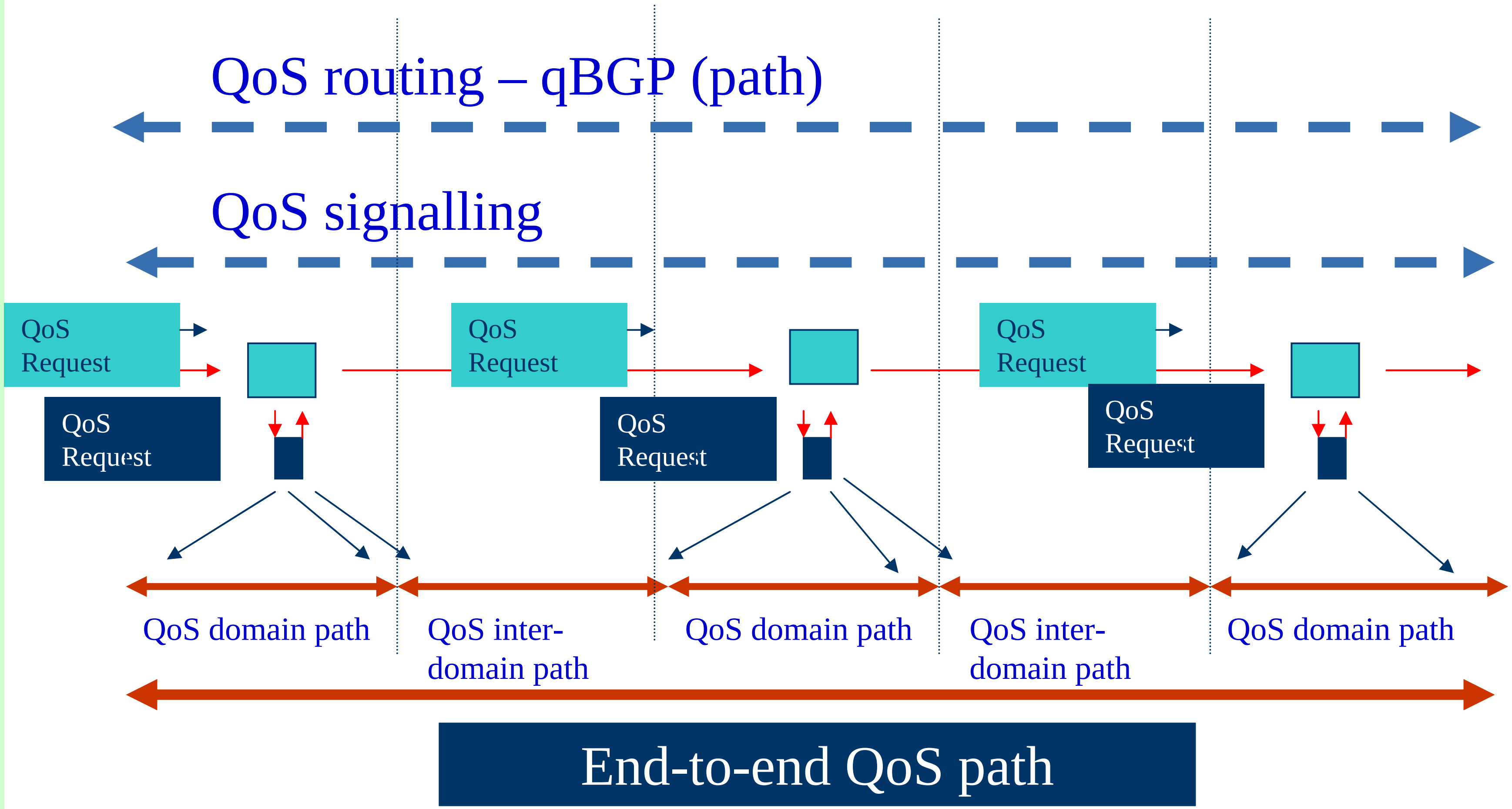
Selected problems from EuQoS (2)

- QoS Framework implementation
  - To define end-to-end Classes of services
  - To implement end-to-end Classes of Services in particular network technologies:
    - WiFi, LAN/Ethernet, xDSL, UMTS and inter-domain links

....

  - Solution implemented and tested

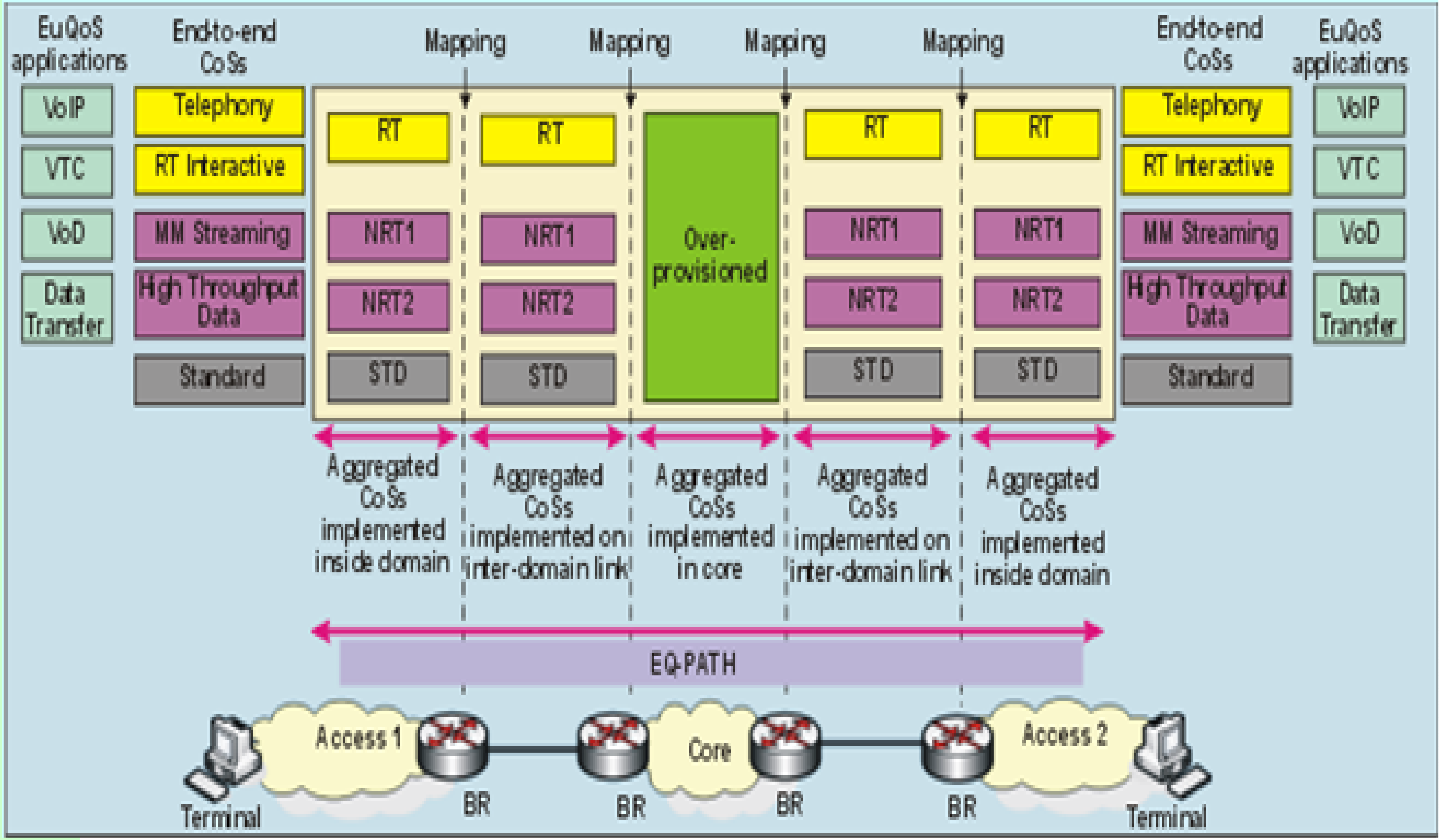
Provisioning and call handling processes



End-to-end CoSs in EuQoS

Treatment aggregate	End-To-End Service Class	QoS Objectives		
		IPLR	Mean IPTD	IPDV
CTRL	Network Control	10^{-3}	100 ms	50 ms
Real Time	Telephony	10^{-3}	100/350 ms (local/long distance)	50 ms
	Signalling	10^{-3}	100 ms	U
	MM Conferencing	10^{-3}	100 ms	50 ms
	RT Interactive	10^{-3}	100/350 ms (local/long distance)	50 ms
	Broadcast Video	10^{-3}	100 ms	50 ms
Non-Real Time/Assured elastic	MM Streaming	10^{-3}	1 s non critical	U
	Low Latency Data	10^{-3}	400 ms	U
	OAM	10^{-3}	400 ms	U
	High ThruPut Data	10^{-3}	1 s not critical	U
Elastic	**Standard**	U	U	U
	Low-Priority Data	U	U	U

Implementation of CoS concept



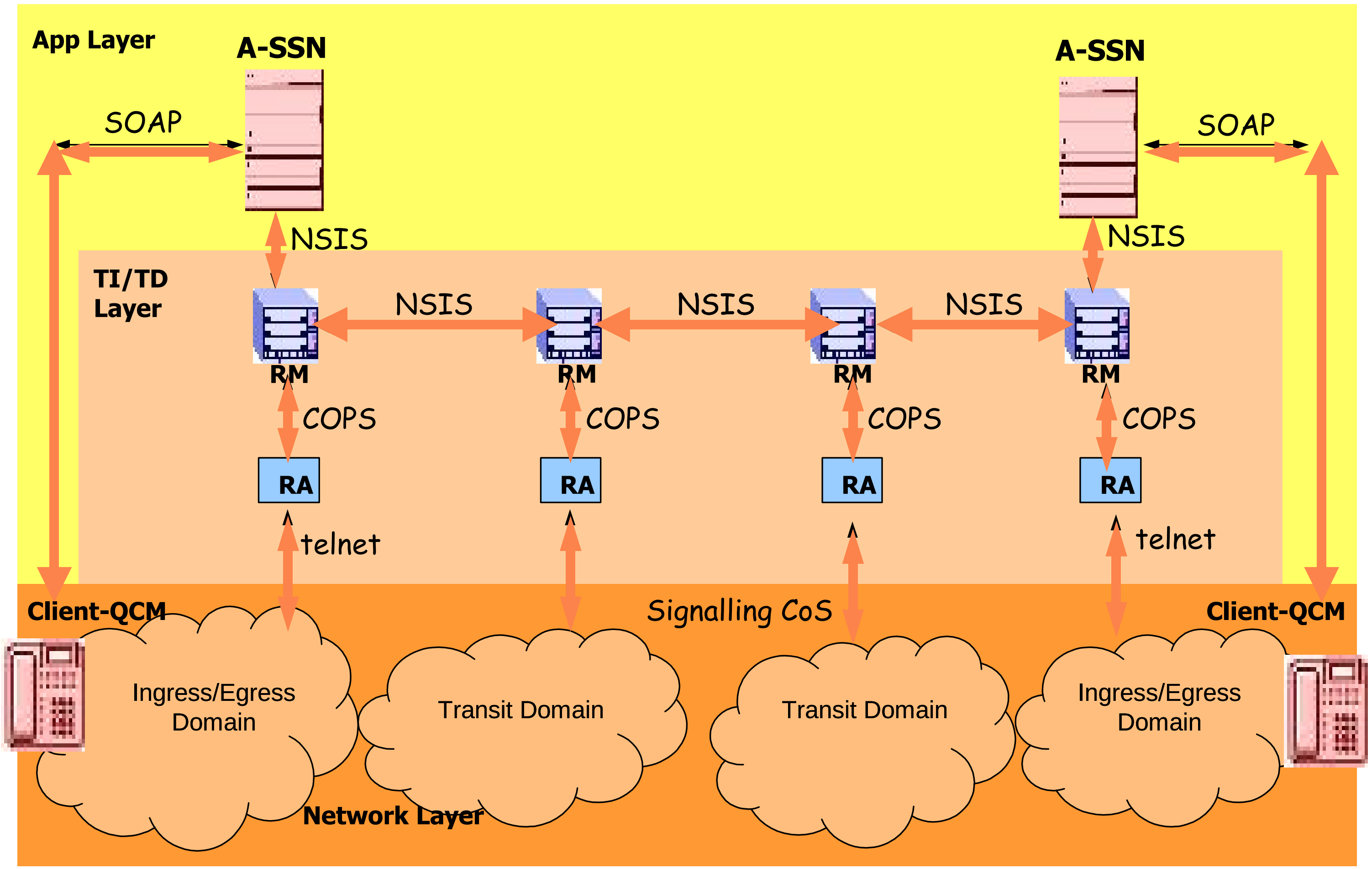
Selected problems from EuQoS (3)

- Signalling system including scalability assessment
  - Signalling: for transferring QoS request along the QoS path – for resource reservations
  - Signalling in the system:
    - At different levels: application, technology independent and in particular domains

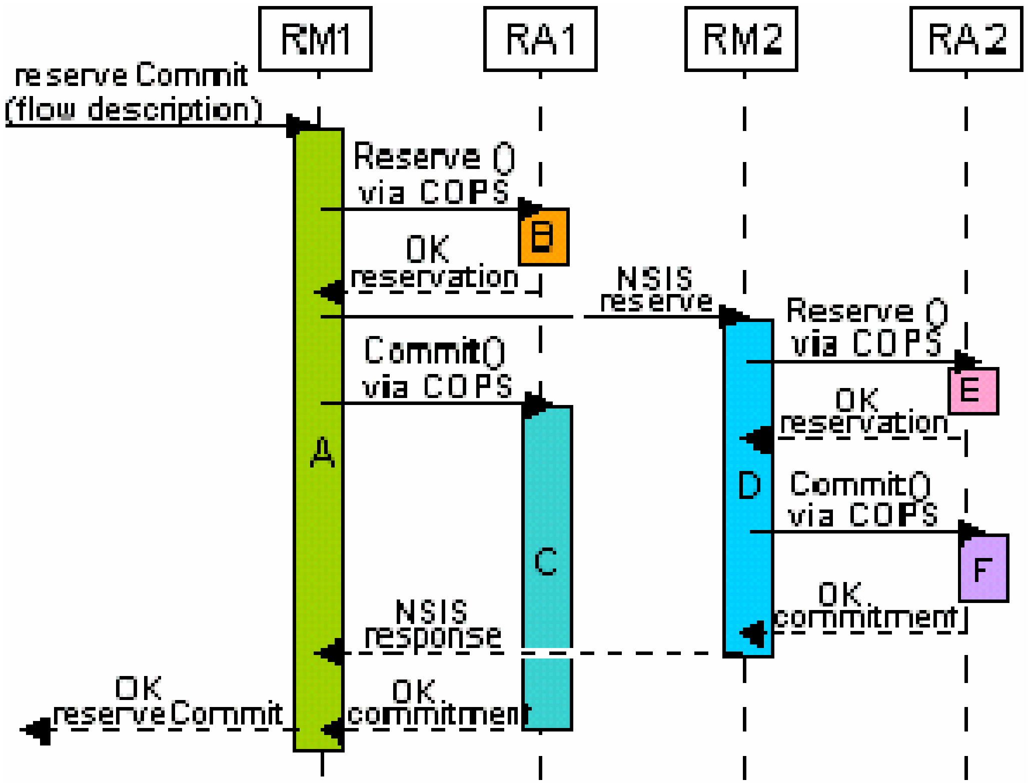
---

  - Evaluation of performances of signalling system

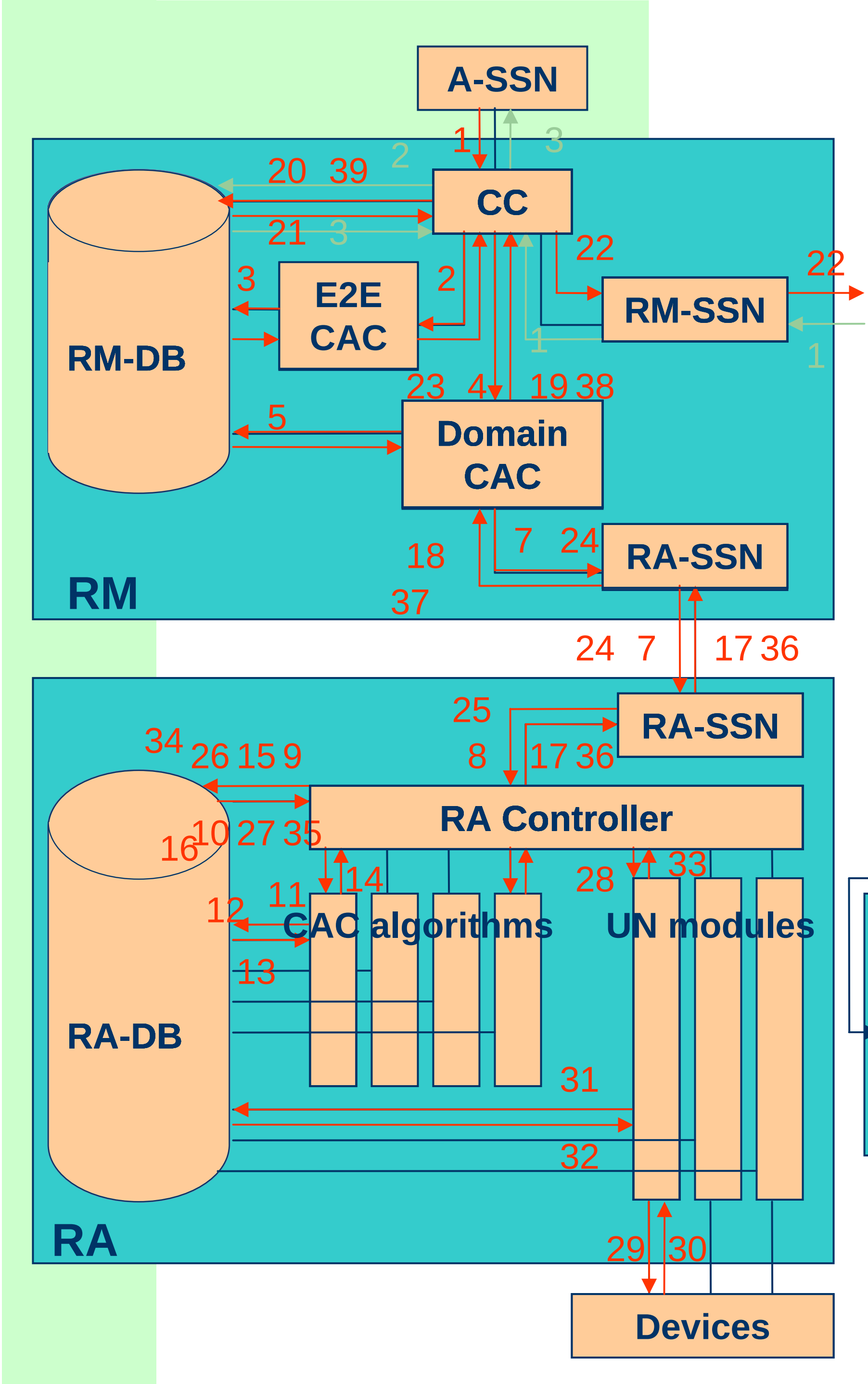
Signalling system – call handling

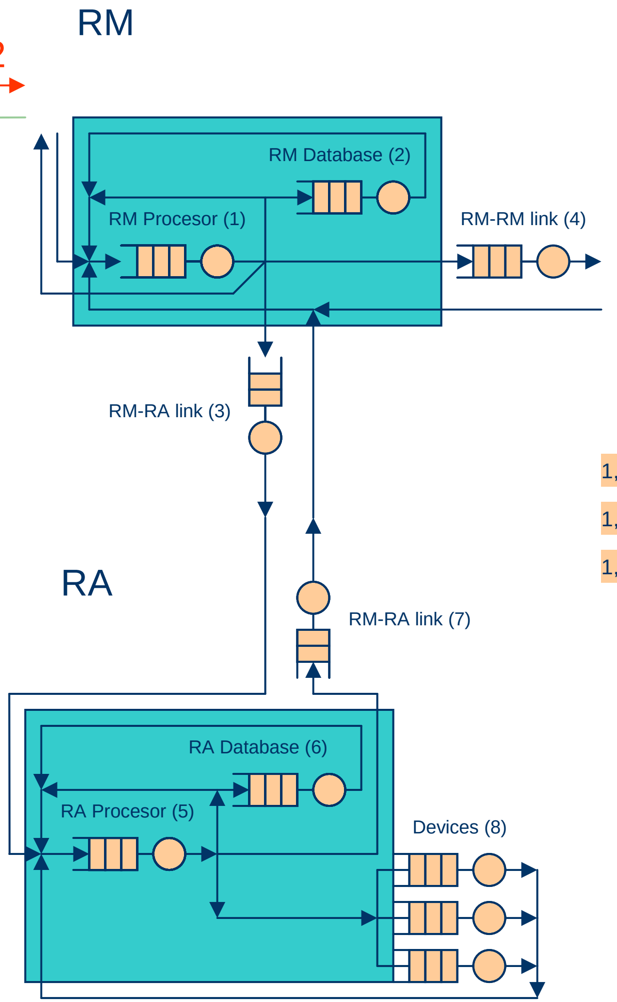


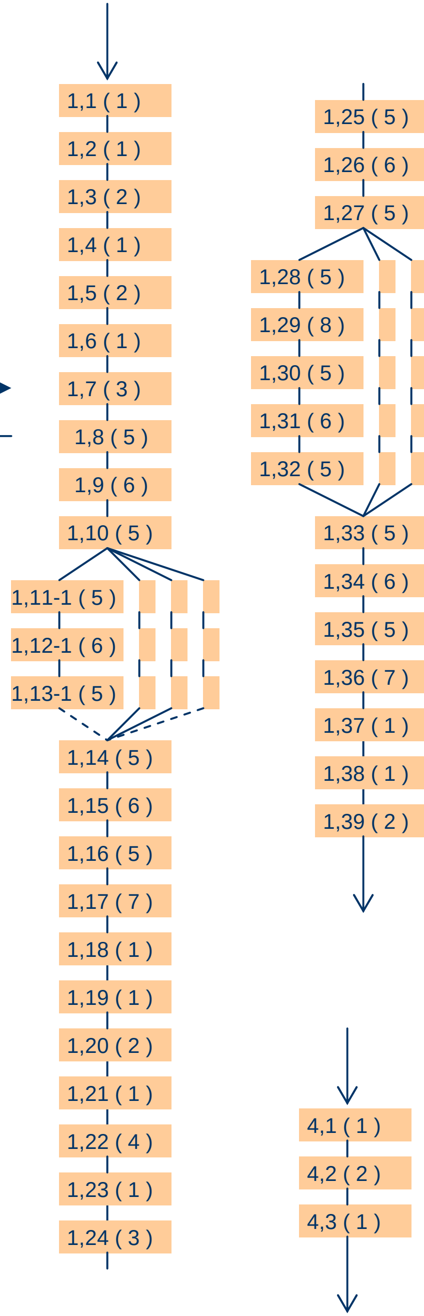
Call scenario for two domains (TI/TD layer)



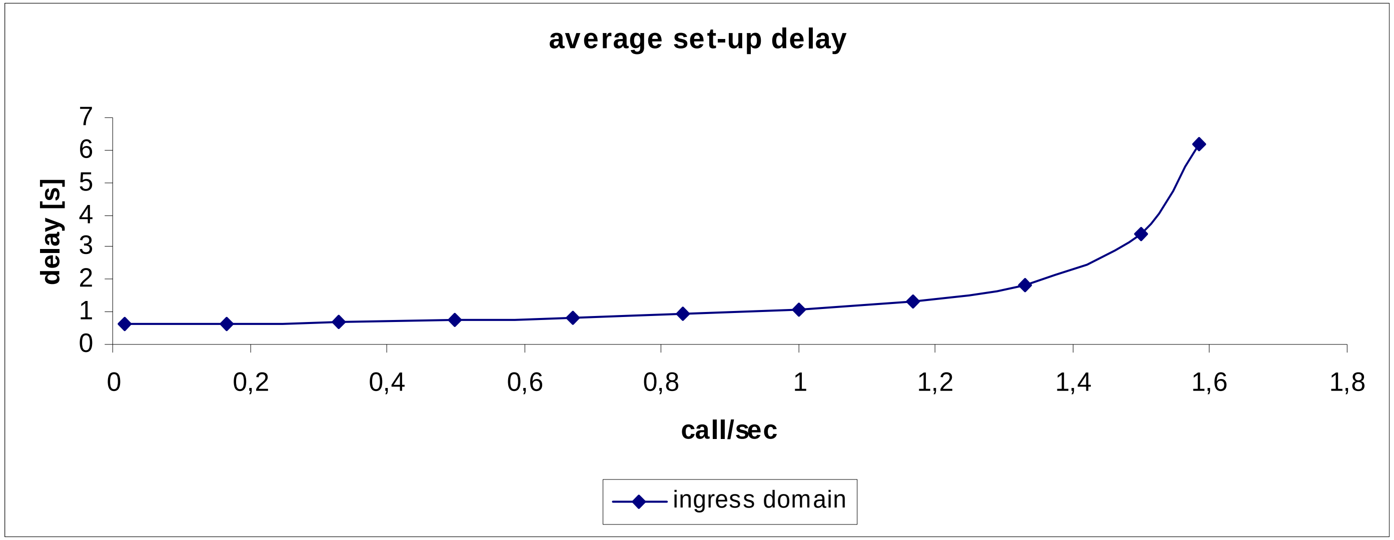
Ingress domain







Exemplary results referring to setup delay



- Preliminary conclusions about signalling:
  - we can expect the same performances as for signalling system in PSTN
  - rather to shift network complexity to the access while maintain simply core
  - handling signalling in access looks that is not so critical

Plan

- Vision of QoS Internet
- QoS mechanisms, algorithms and protocols
- Tested approaches for IP QoS
  - AQUILA: single domain DiffServ
  - EuQoS: end-to-end QoS over heterogeneous networks
- Summary

Summary

- There is a lot of activities in ITC area based on the assumption that QoS at the network level is solved (but is not solved)
- Some of unsolved problems related to QoS;
  - End-to-end Classes of Services are quite well defined but not direct mapping to the Classes of Services defined for each technology
  - Not available QoS-aware applications
- Not fully tested solutions
  - Signalling for resource reservations

References

- X. Masip-Bruin, et al., The EuQoS System: A solution for QoS Routing in Heterogeneous Networks, IEEE Communications Magazine, Vol.45 No.2, February 2007.
- J. Mongay Batalla and R. Janowski, Provisioning dedicated class of service for reliable transfer of signaling traffic, ITC20, Canada, June 2007.
- W. Burakowski, et al., On Multi-Domain Connection Admission Control in the EuQoS System, In Proc. of 15th IST Mobile Summit, Greece 2006.
- O. Dugeon, et al., End to End Quality of Service over Heterogeneous Networks (EuQoS), In Proc. of NetCon'05, France, November 2005.
- H. Tarasiuk, R. Janowski, W. Burakowski, Admissible traffic load of real time class of service for inter-domain peers, In Proc. of ICAS/ICNS 2005, October 2005.