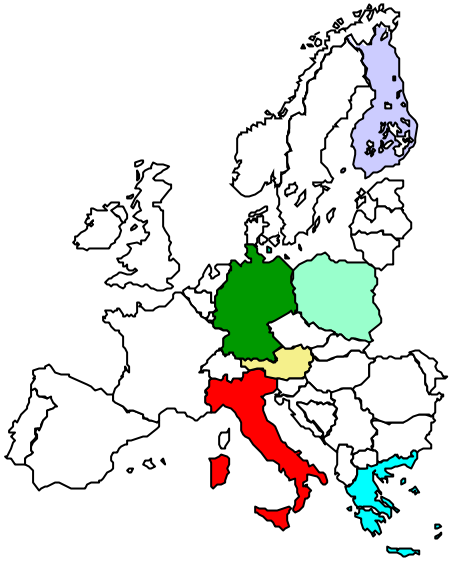
AQUILA (IST-1999-10077)

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



Art-QoS 2003
Warsaw, March 25, 2003

Bert F. Koch
AQUILA Project Management
Heinrich Hußmann
Dresden University of Technology

http://www.ist-aquila.org/

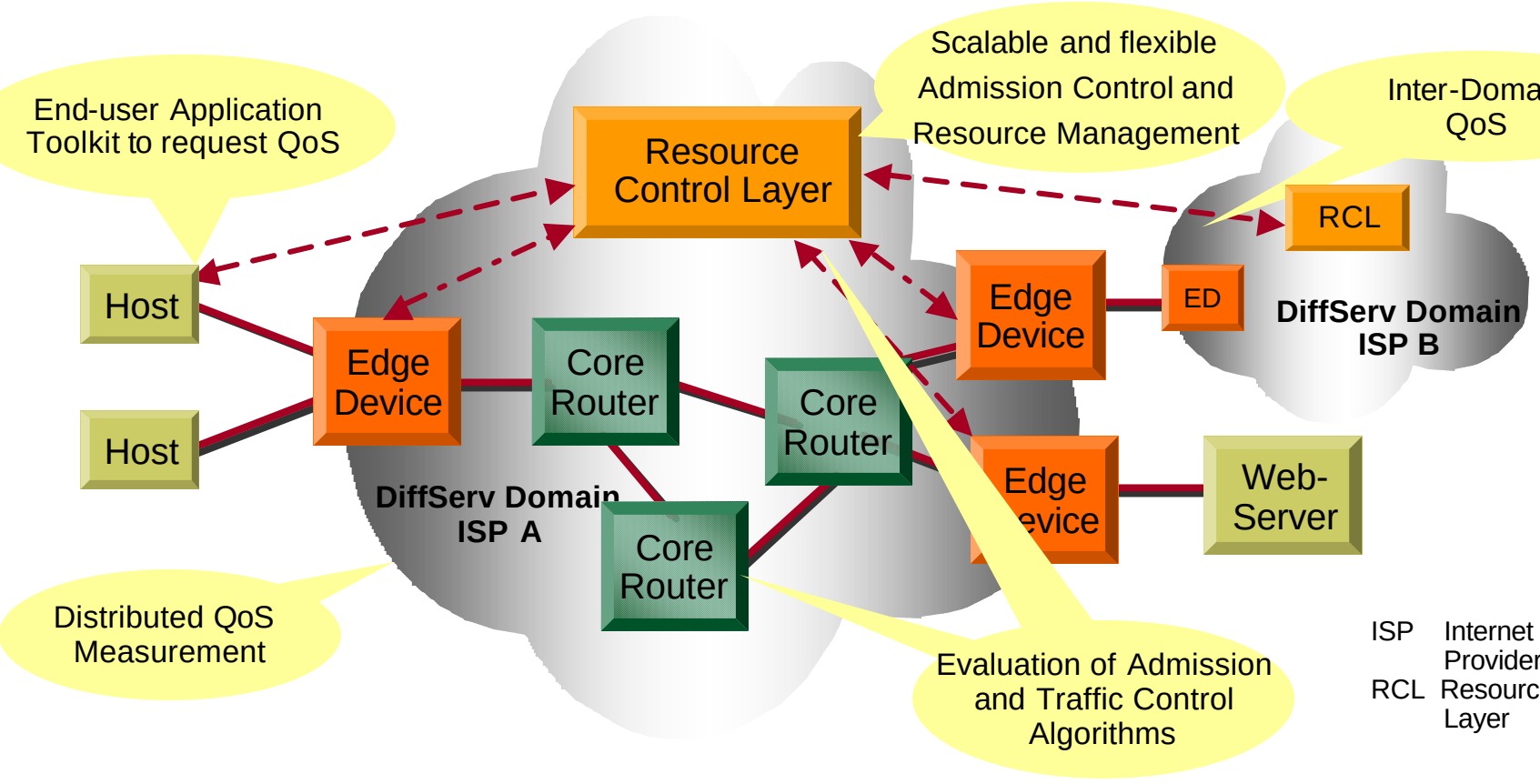
Consortium

- Siemens, Germany
- arvato systems, Germany
- Dresden Univ. of Technology, Germany
- Salzburg Research, Austria
- T-Systems Nova, Germany
- Polish Telecom, Poland
- NTUA, Greece
- Elisa Communications, Finland
- CoRiTeL, Italy
- Q-Systems, Greece
- Telekom Austria, Austria
- Warsaw Univ. of Technology, Poland

Main Objectives

- Investigate dynamic end-to-end QoS Provisioning in IP Networks
- Implement Prototypes of a QoS Architecture for a Carrier Grade DiffServ Core Network
- Support a wide Range of Applications by providing a QoS Toolkit / API
- Continuously analyse Customer Requirements, Market Situations and Technological Trends and develop Business Models
- Contribute to Standardisation Bodies like IETF, ITU, ETSI, etc.

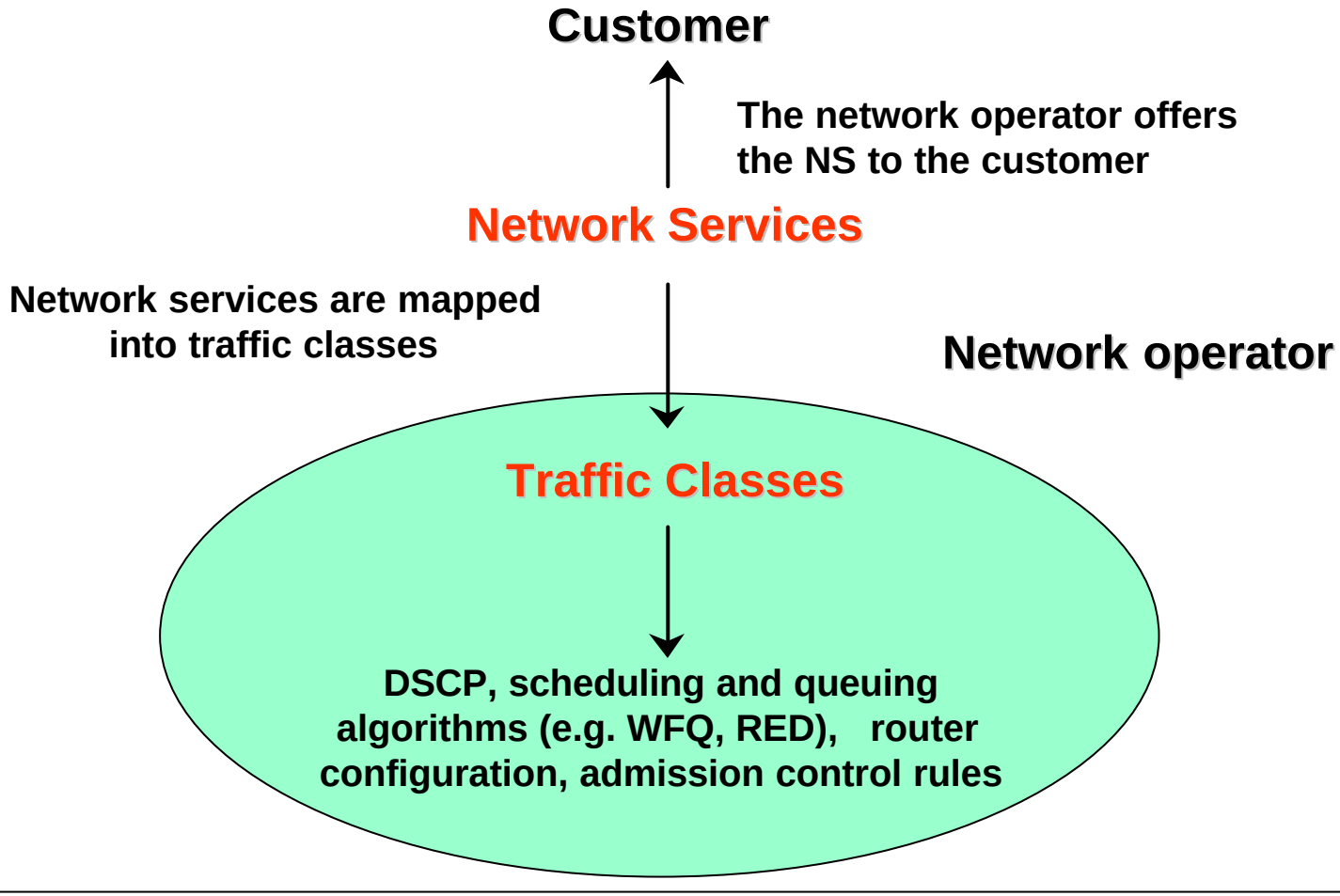
Main Innovations



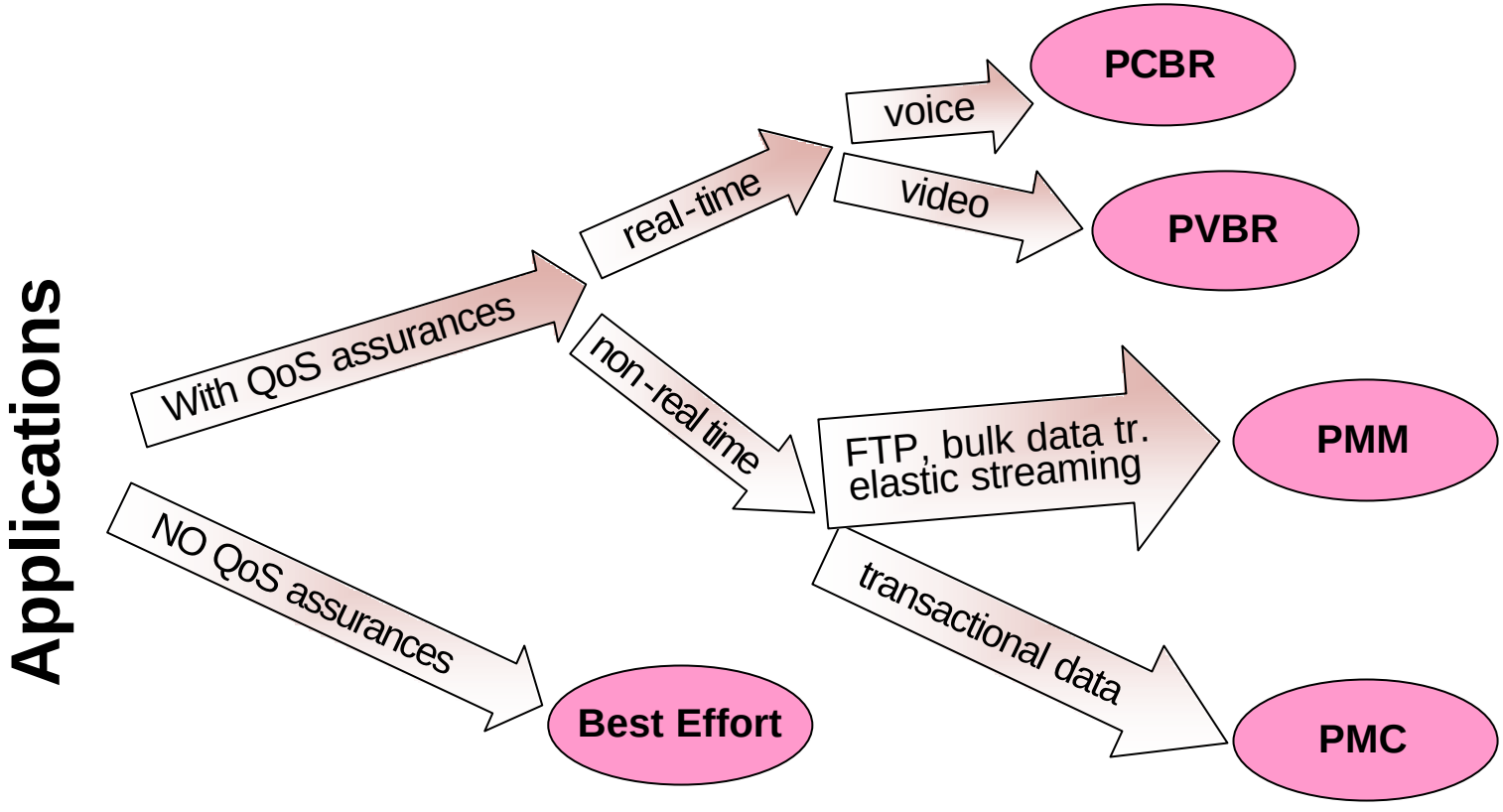
ISP Internet Service Provider
RCL Resource Control Layer

Þ **end-to-end Quality of Service**

Traffic Classes



Why Different Network Services ?
An Application-oriented Perspective…



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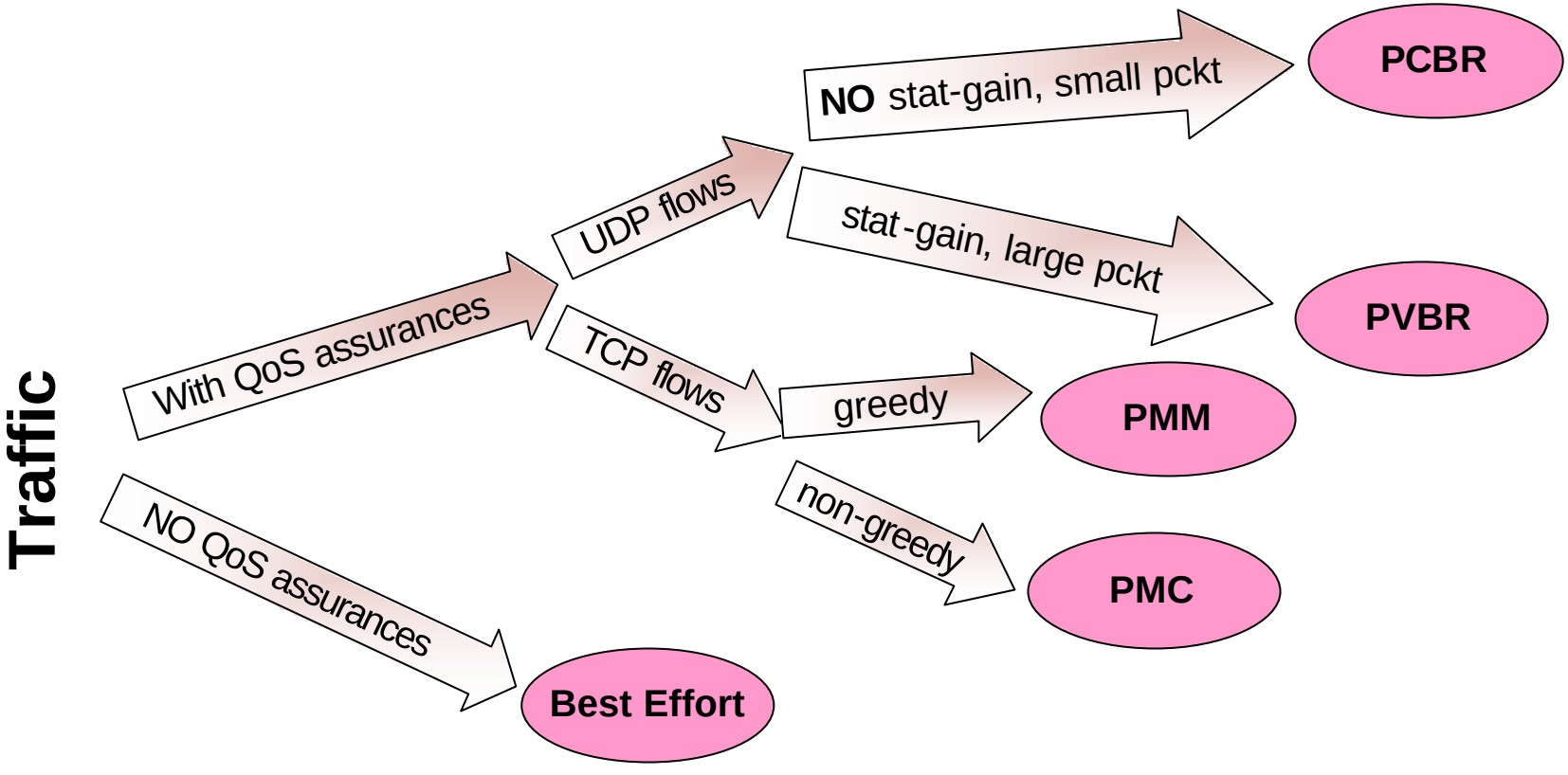
A Traffic-oriented Perspective…

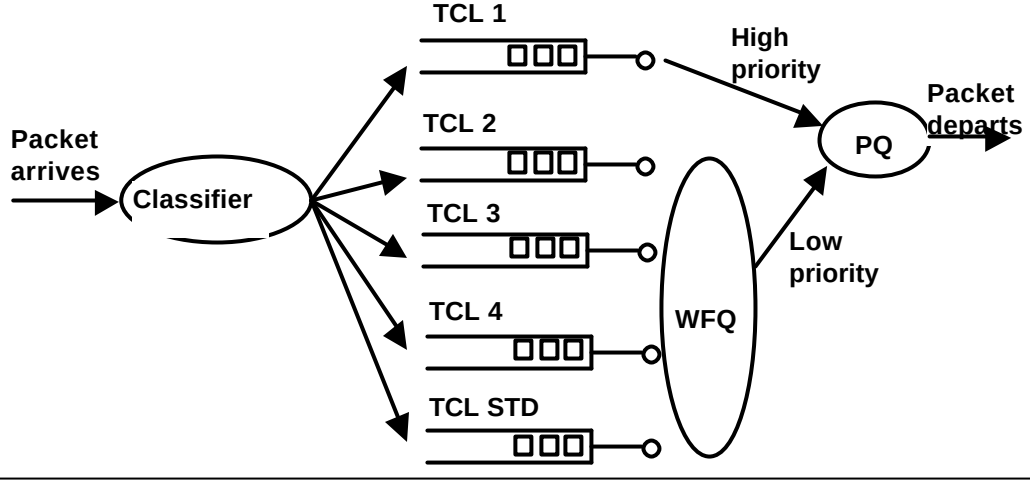


Traffic Classes

- **Five Traffic Classes have been specified**

Network service	Premium CBR	Premium VBR	Premium MultiMedia	Premium Mission Critical	Standard
Traffic class	TCL 1	TCL 2	TCL 3	TCL 4	TCL STD

- **… as well as the related Traffic Control Mechanisms in the Routers**

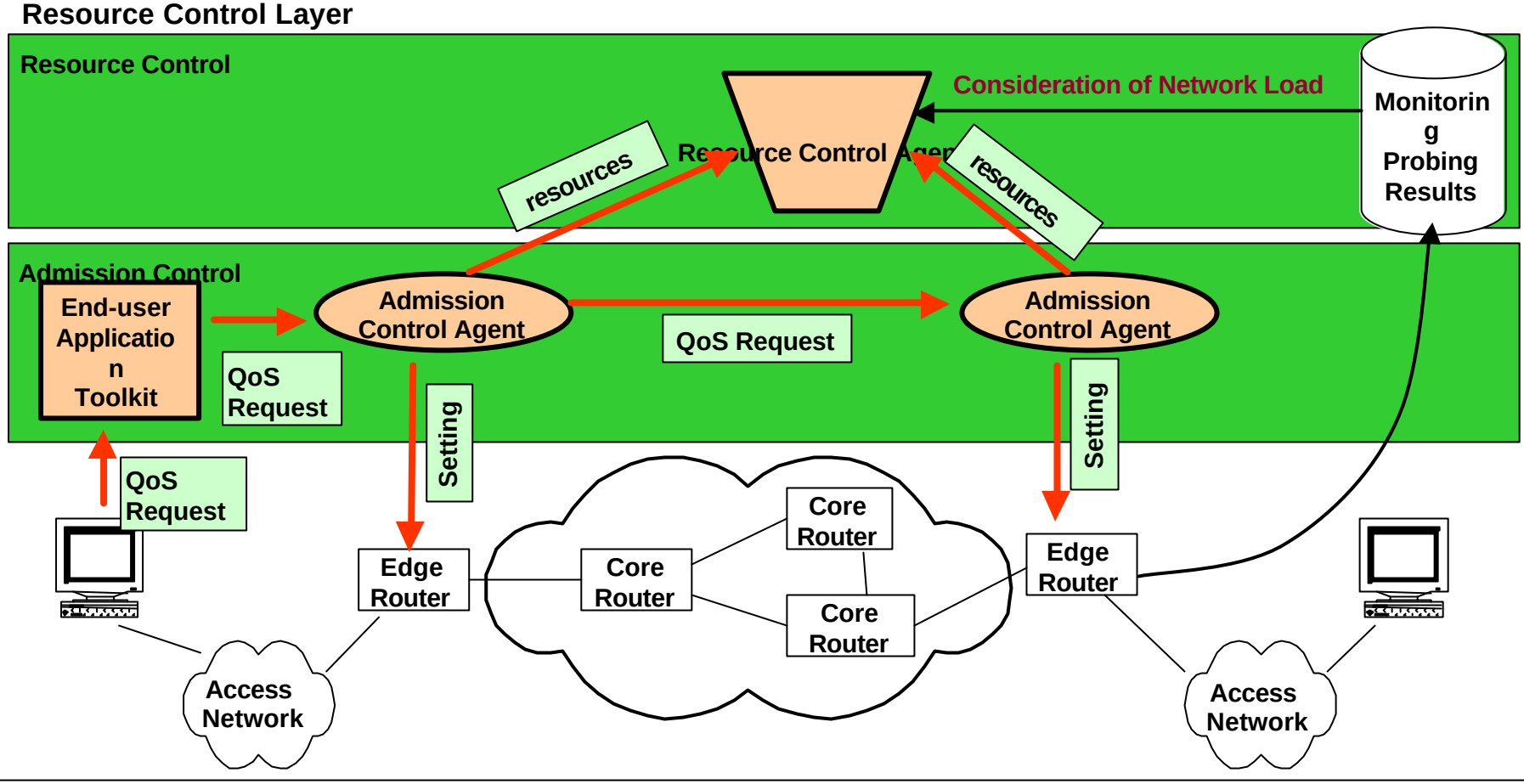


AQUILA Set of Pre-defined Network Services

Network service	Traffic type	Characteristic examples	Application example
• Premium CBR	constant	small packets low loss	SIP VoIP
• Premium VBR	variable	large packets low loss	SIP Video
• Premium MM	adaptive	moderate delay	Streaming Video
• Premium MC	bursty	very low delay & loss	online Game
• Standard	best effort	classical	the rest

Goal: only a *few* network services to allow clear service differentiation

Architecture



Resource Control Layer (1)

- **Basic Idea of DiffServ Network**
  - Provide some (fixed) prioritised traffic classes within the network
  - Guarantee QoS by limiting amount of prioritised traffic at the network edge (limited resources)

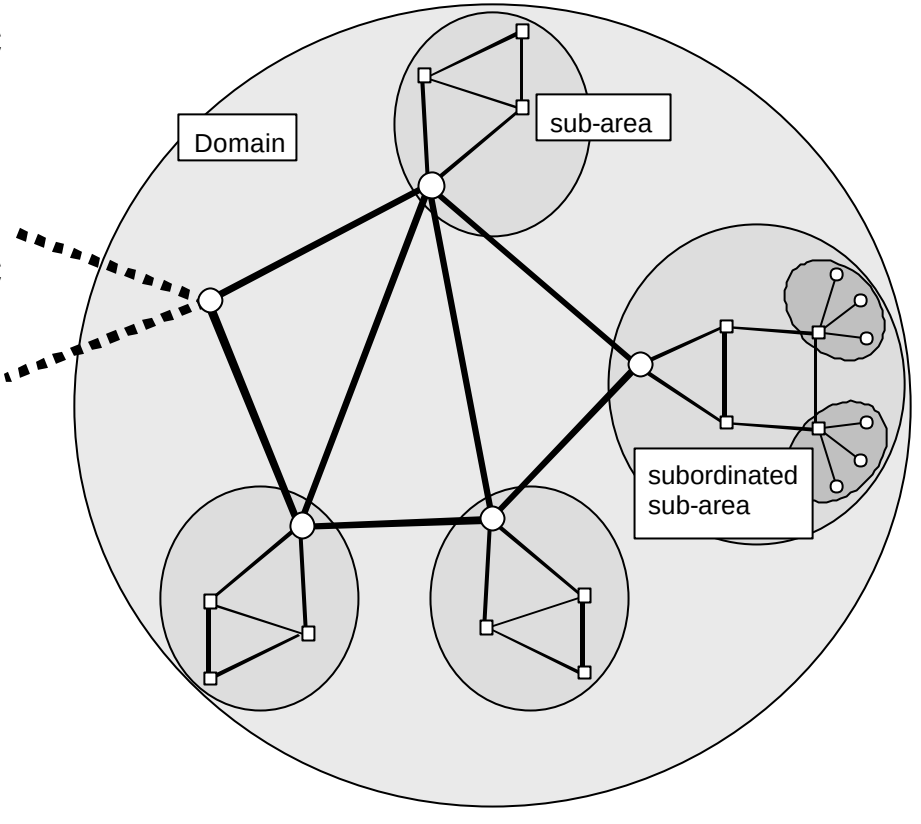
- **Additional Benefit of the Resource Control Layer**
  - Dynamically shift resources between network edges (Þ resource pools)
  - Take into account the actual resource usage of the network (2nd Trial)

Resource Control Layer (2)

- **Admission Control Agent**
  - Authenticates user
  - Authorises and checks request
  - Locates ingress and/or egress edge router (Þ roles)
  - Requests resources from the resource control agent
  - Admits / rejects new flows
  - Installs policies in ingress router
- **Resource Control Agent**
  - Manages resources
  - Checks availability of requested resources
  - (Re-)distributes resources as needed

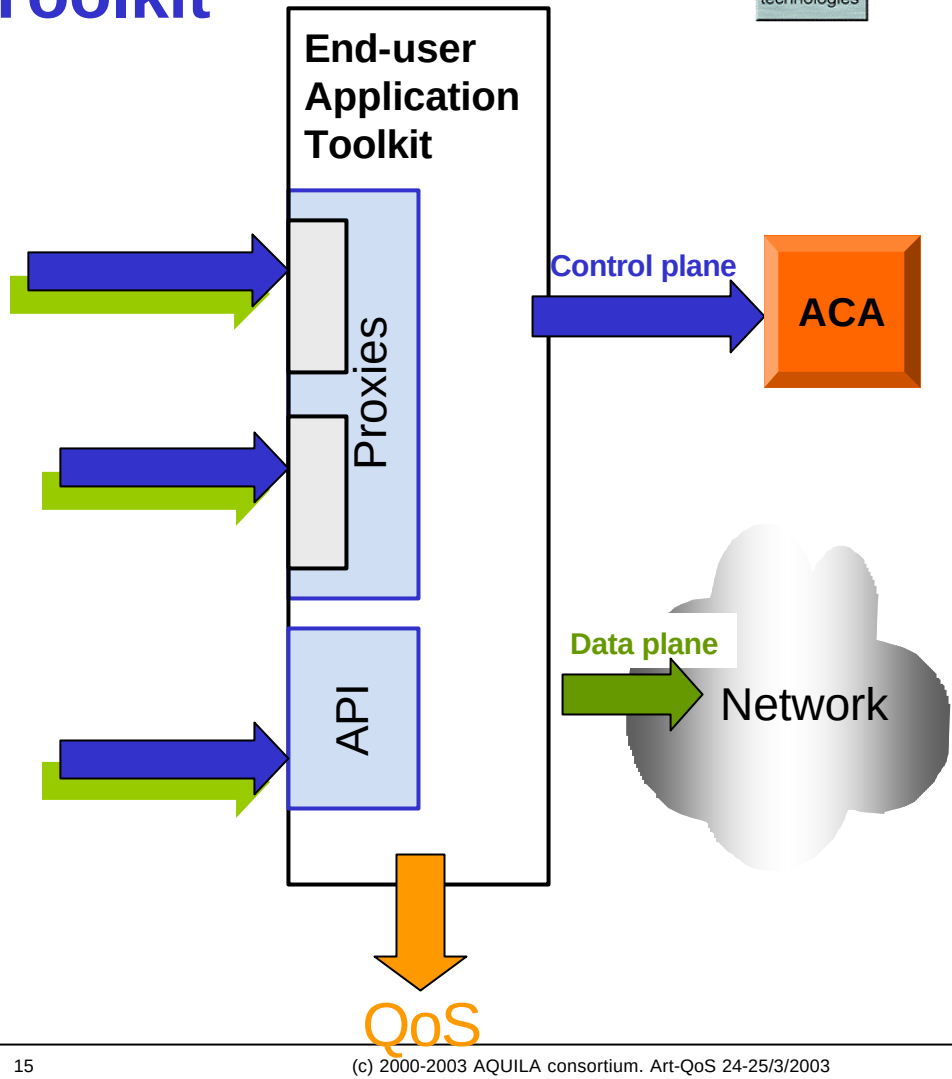
Resource Pools

- **Resource Limits**
  - Limit amount of QoS traffic from each edge router
- **Group neighboured Routers**
  - Limit amount of QoS traffic from each group
- **Dynamic Distribution**
  - Dynamically shift resources within group
- **Hierarchical Structure**
  - “Groups of groups”

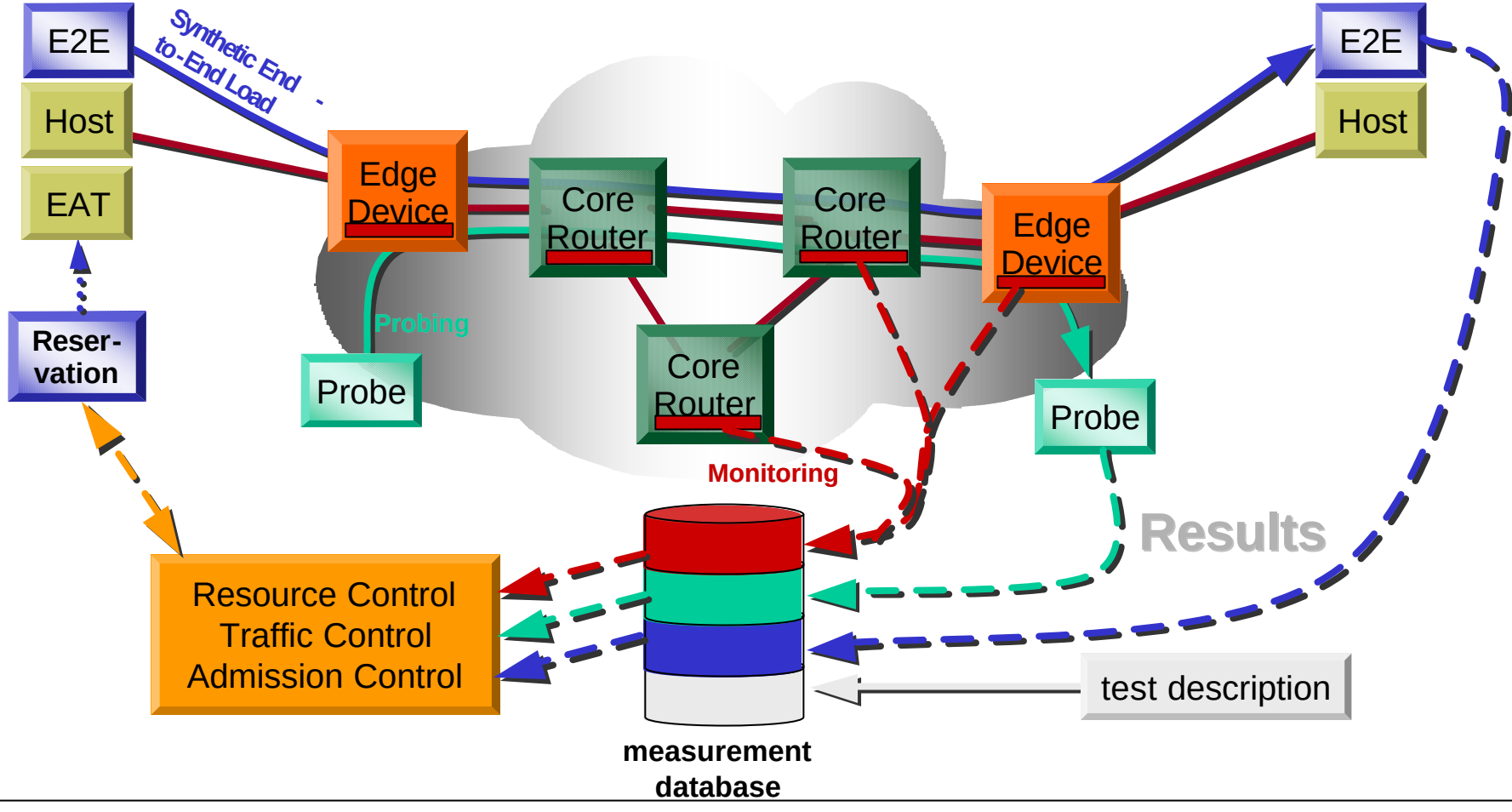


End-user Application Toolkit Objectives

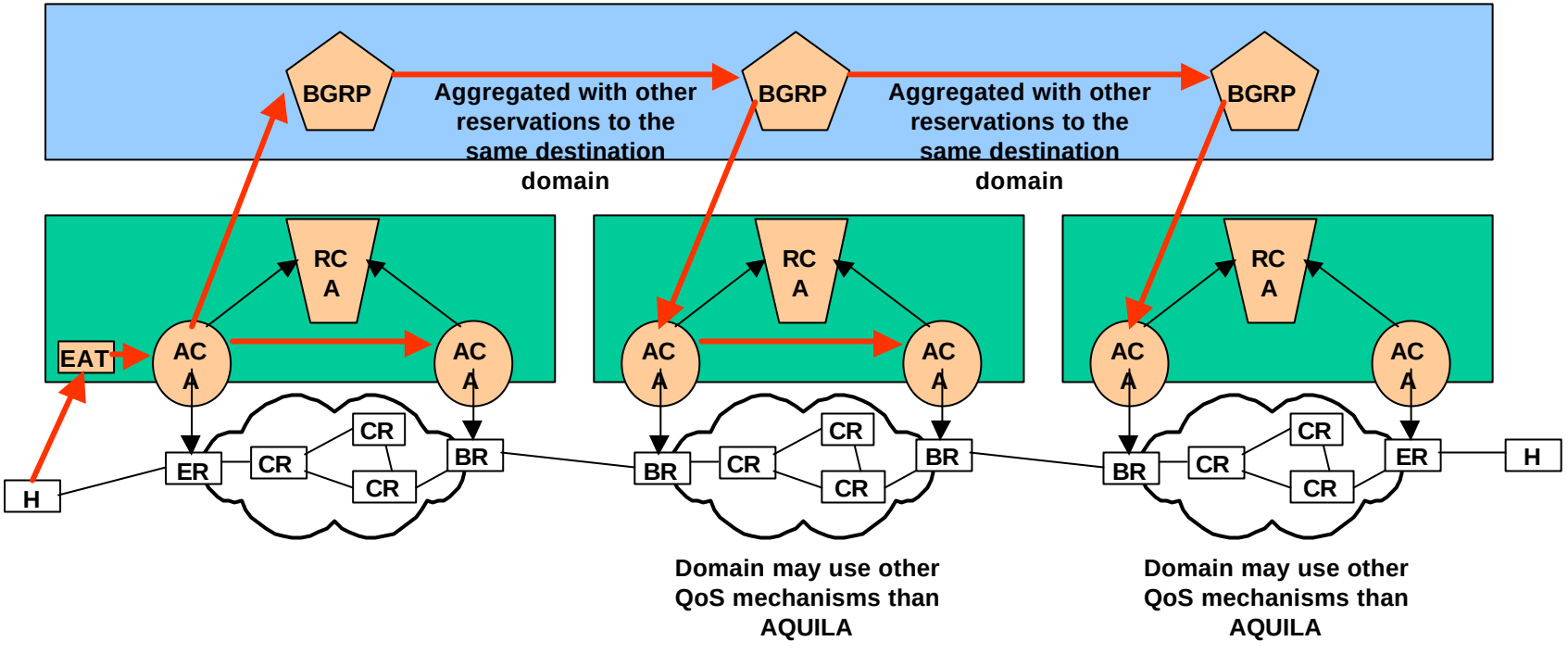
- Enable Access to QoS to non QoS aware Legacy Applications
- Support QoS aware Applications (RSVP, DiffServ) / Support various QoS Request Methods
- Provide a Methodology and a Programming Interface to support the Construction of new QoS aware Applications
- Provide an End-user friendly QoS Access



Distributed QoS Measurement (2)



Inter-domain Resource Control



Comparison: Sink Trees vs. Resource Pools

- **Intra-domain advantages of resource pools**
  - Resource pools can be used for ingress and egress admission control
  - Resource pools scale for networks with many sources and sinks (Scales better than O(hosts))
  - Configuration and administration based on an overall picture of the domain.
- **Inter-domain advantages of BGRP sink trees**
  - BGRP considers the full network topology at the AS level
  - BGRP can be independently configured and administered at each AS

➔ **Both approaches are well positioned within an overall AQUILA architecture**

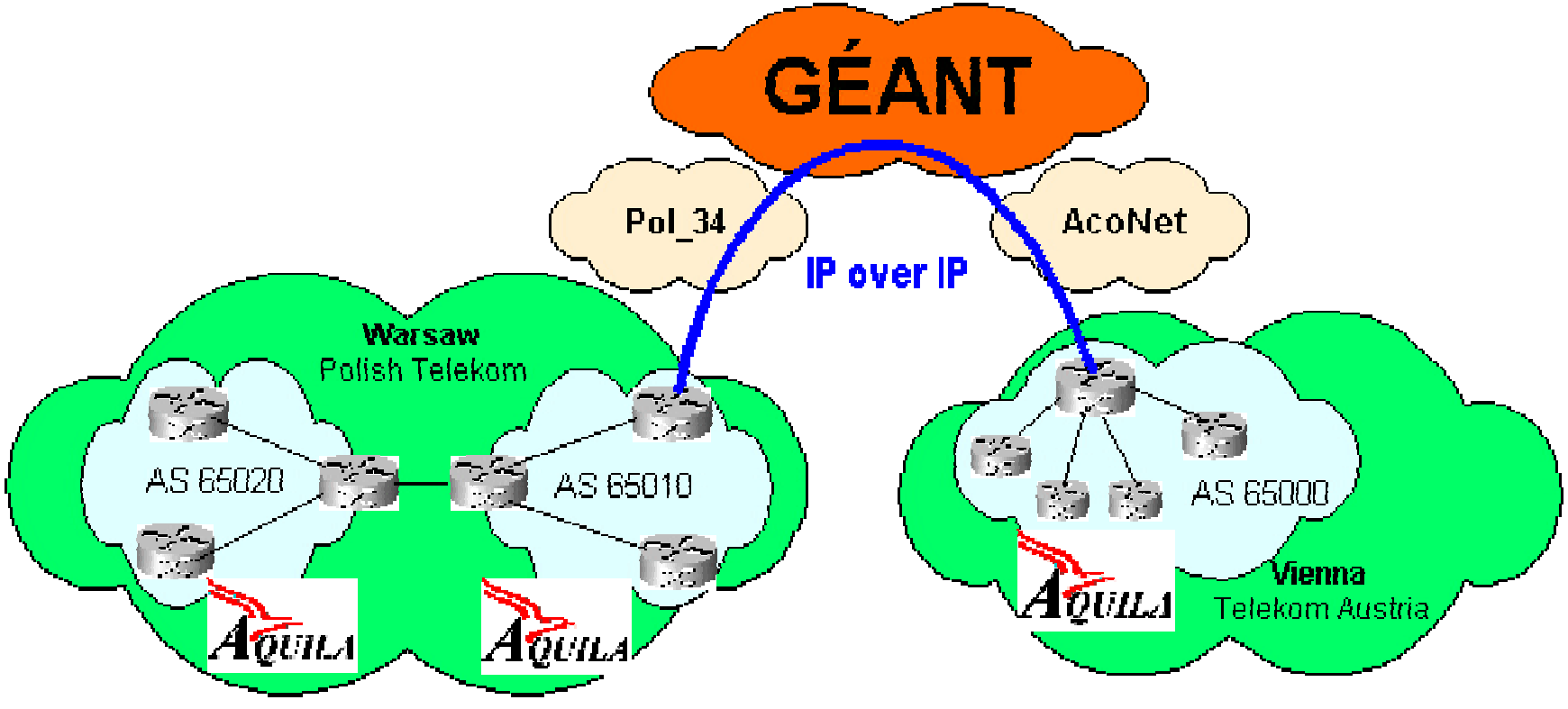
Lessons Learnt from 1st Trial

- **Verification of AQUILA QoS intra-domain architecture**
- **Network services**
  - fulfil assumptions
    - Delay, packet loss <= specification
  - do not mix streaming and elastic traffic in one service
    - else UDP will degrade TCP
    - UDP will not reach QoS
  - Fair bandwidth sharing for TCP flows
- **Resource and admission control**
  - General mechanisms work
- **Router**
  - WFQ noticeably degrades performance of Cisco routers

Main 2nd Trial Features

- **Evaluation of Measurement Based Admission Control (MBAC)**
  - Feedback for improved network utilisation
- **Real user involvement in Warsaw, Vienna and Salzburg**
  - Subjective and objective tests
- **Inter-domain QoS provisioning**
  - Near-to-reality, scalability, BGRP

Overall Topology for 2nd Trial



2nd Trial Objectives

- **Evaluation of Network Services incl. Joint AC & MBAC**
  - Practical verification of AQUILA architecture capabilities for supporting the defined set
  - QoS verification of Network Services corresponding to different network topologies
- **Real users trials, subjective and objective evaluation**
  - Voice
  - Audio-, Video streaming
- **RCL performance trials (inter- and intra-domain)**
  - Signalling load between different components
  - Transaction processing delay
- **Evaluation of resource pool management**
  - Dynamic trial scenario with resource pools
  - Dynamic trial scenario with Joint AC

Results from 2nd Trial

- **Network services**
  - Intra-domain trials
    - PCBR service meets QoS specified requirements
    - PVBR service with Joint AC algorithm guarantees specified QoS parameters
    - PMM: both AC approaches work properly (some limitations by routers)
    - PMC is able to guarantee low packet loss
  - Inter-domain trials
    - PCBR: measured QoS parameters corresponding to packet loss ratio and packet delay as expected

Results from 2nd Trial

- **Real user trials**
  - VoIP application:
    - MOS on PCBR very similar (to reference) and quality acceptable
    - MOS on STD service much worse and quality unacceptable
  - PVBR supports real-time services (e.g. videoconference) sufficiently
    - non-optimal setting of reservation parameters can lead to unsatisfactory results
  - PMM supports non-real-time streaming services sufficiently

Results from 2nd Trial

- **RCL performance**
  - General
    - increasing number of reservations does not increase reservation set-up time
    - processing delay of initial request is longer than of subsequent requests
    - processing delay of release operation is shorter than request operation

Results from 2nd Trial

- **RCL performance (contd.)**
  - Intra-domain
    - processing delay is independent of AC scheme
    - router contribution to total delay changes with different operations
      - » about 20% for initial requests
      - » about 70% of total delay for subsequent requests
  - Inter-domain
    - relatively large contribution to total reservation set-up times by router configuration and BGRP agent
    - joining an existing sink-tree decreases the reservation set-up time significantly

Results from 2nd Trial

- **Resource Pool Mechanism**
  - In case of resource requests by one host: algorithm stability achieved, it works properly
  - In case of resource requests by different hosts: need for further algorithm development and testing
- **AQUILA Measurement Tools**
  - Useful and necessary components for the trials in addition to other existing measurement equipment
  - Extensively applied for a wide range of trial scenarios due to their flexibility

Lessons Learnt from 2nd Trial

- Verification of AQUILA QoS inter-domain architecture
- Network services fulfilled expectations
- Inter-domain scenario tests using GÉANT very helpful
- Trials proof that prototype design & development is fully justified
- Scalability issues are still not to be neglected, but there are promising indications, particularly in inter-domain scenario
- Supporting measurement tools are also necessary trial utilities

Lessons Learnt from 2nd Trial

- **Management point of view**
  - Design, implementation & test in a multi-national, multi-cultural "pan-European" environment
    - Personal discipline, acceptance of efficient rules
    - Strict use of commonly agreed tools
  - Three years experience of perfect European team work
    - Countless joint publications
    - Strong contributions to IETF
  - Benefit not only for industrial partners (exploitation)
    - Several PH.D.s, support or build-up of courses & seminars
  - Co-operation between IST projects (Premium IP cluster)
    - Coaching by EC PO, guidance by stable team of reviewers

It was worth it: besides all excellent results, we had a lot of fun, and we would do it again this way !

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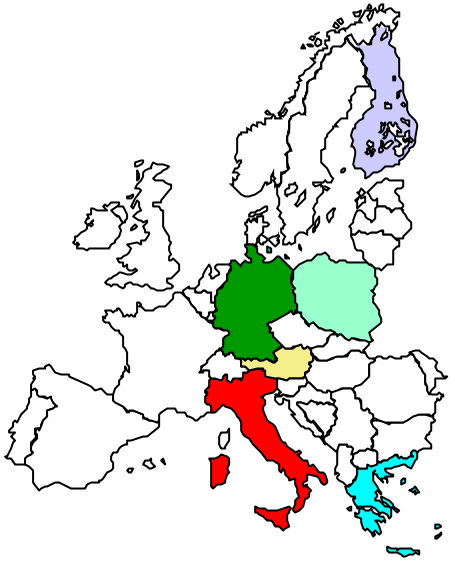

Thank you for your attention !

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