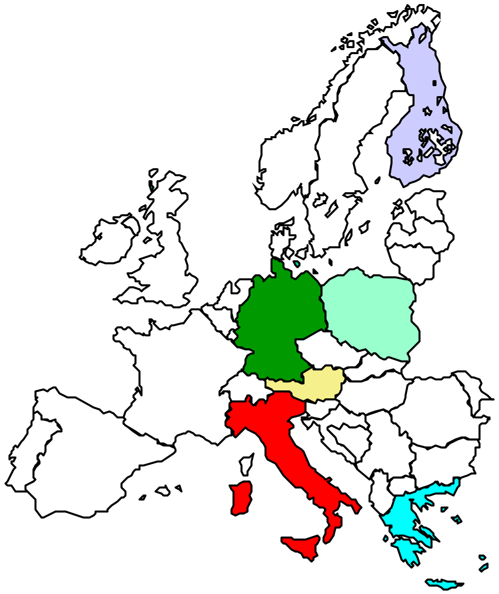
AQUILA (IST-1999-10077)

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



QofIS 2001

## A QoS Architecture with Adaptive Resource Control: The AQUILA Approach

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

# Consortium

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NTUA, Greece

Elisa Communications, Finland

CoRiTeL, Italy

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Telekom Austria, Austria

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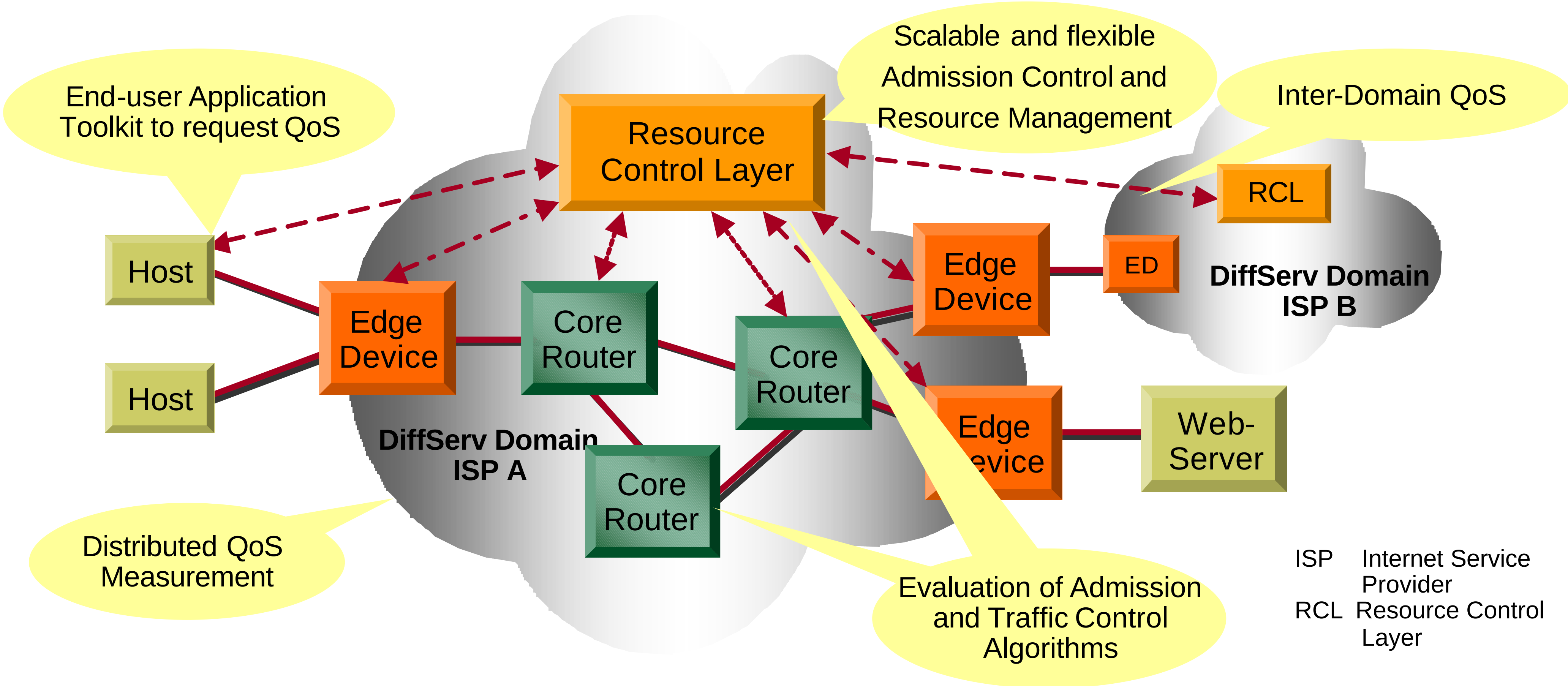
# Main Objectives

- 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

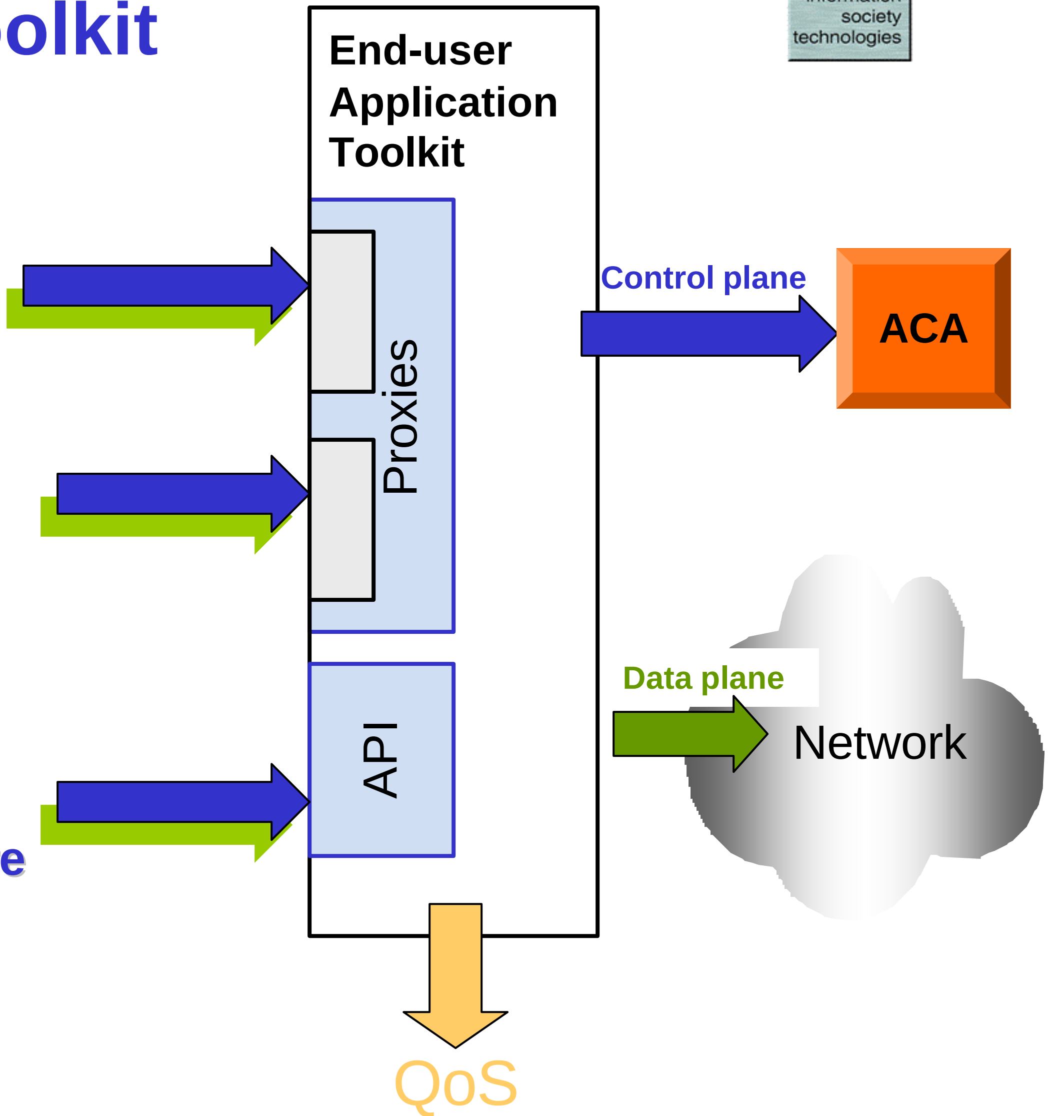



ISP Internet Service Provider
RCL Resource Control Layer

## Þ end-to-end Quality of Service

# 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



# Design Goals

## Scalable Architecture

- Distributed building blocks
- Autonomous operation of elements

## Failure Proof

- Failure of an element should only degrade (if at all), not disable the operation of other elements

## Based on DiffServ Core Network

- Use of existing, commercial routers
- Enable migration path from current networks

# Traffic Classes

Customer

The network operator offers the NS to the customer

Network Services

Network services are mapped into traffic classes

Network operator

Traffic Classes

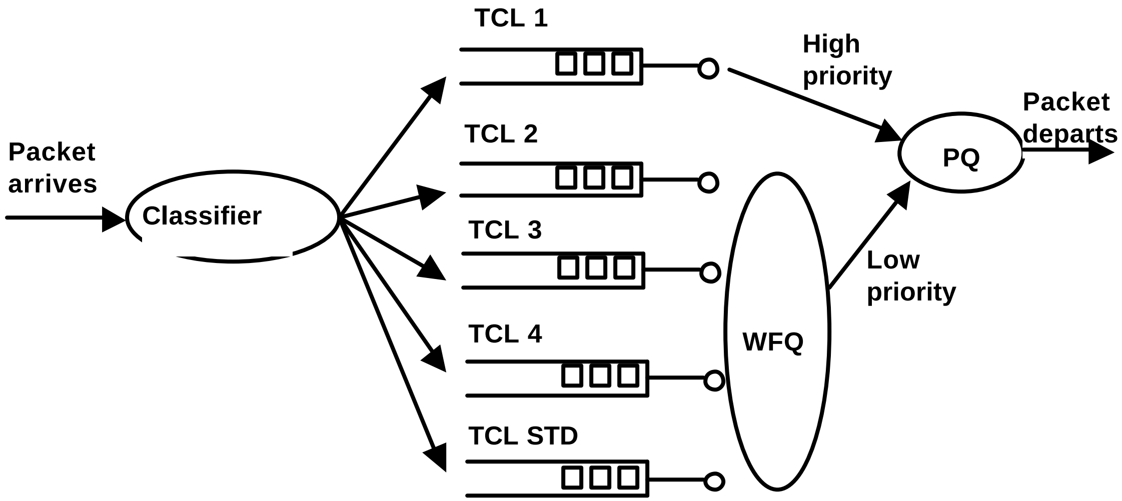
DSCP, scheduling and queuing algorithms (e.g. WFQ, RED), router configuration, admission control rules

# 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 |

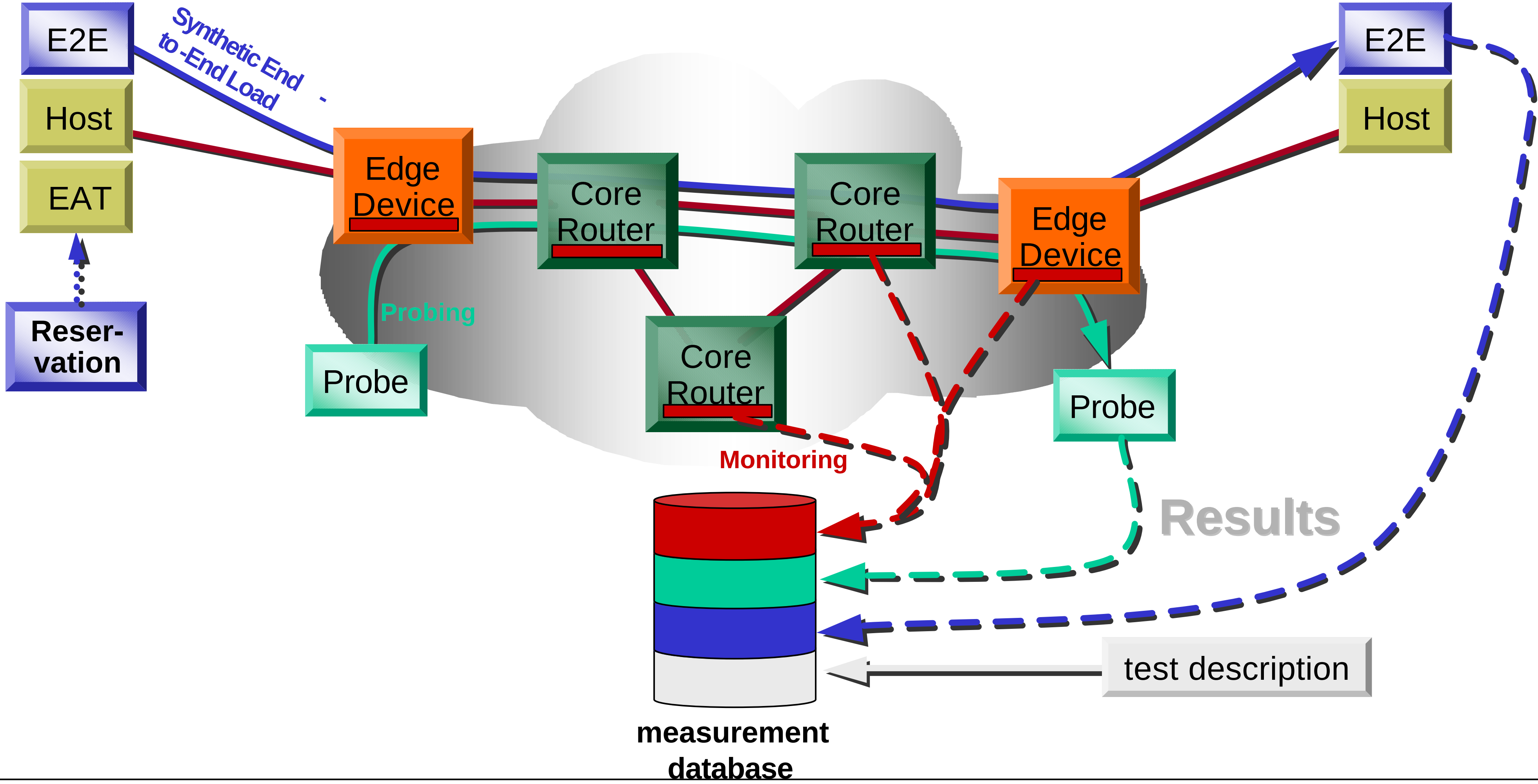
- **… as well as the related Traffic Control Mechanisms in the Routers**



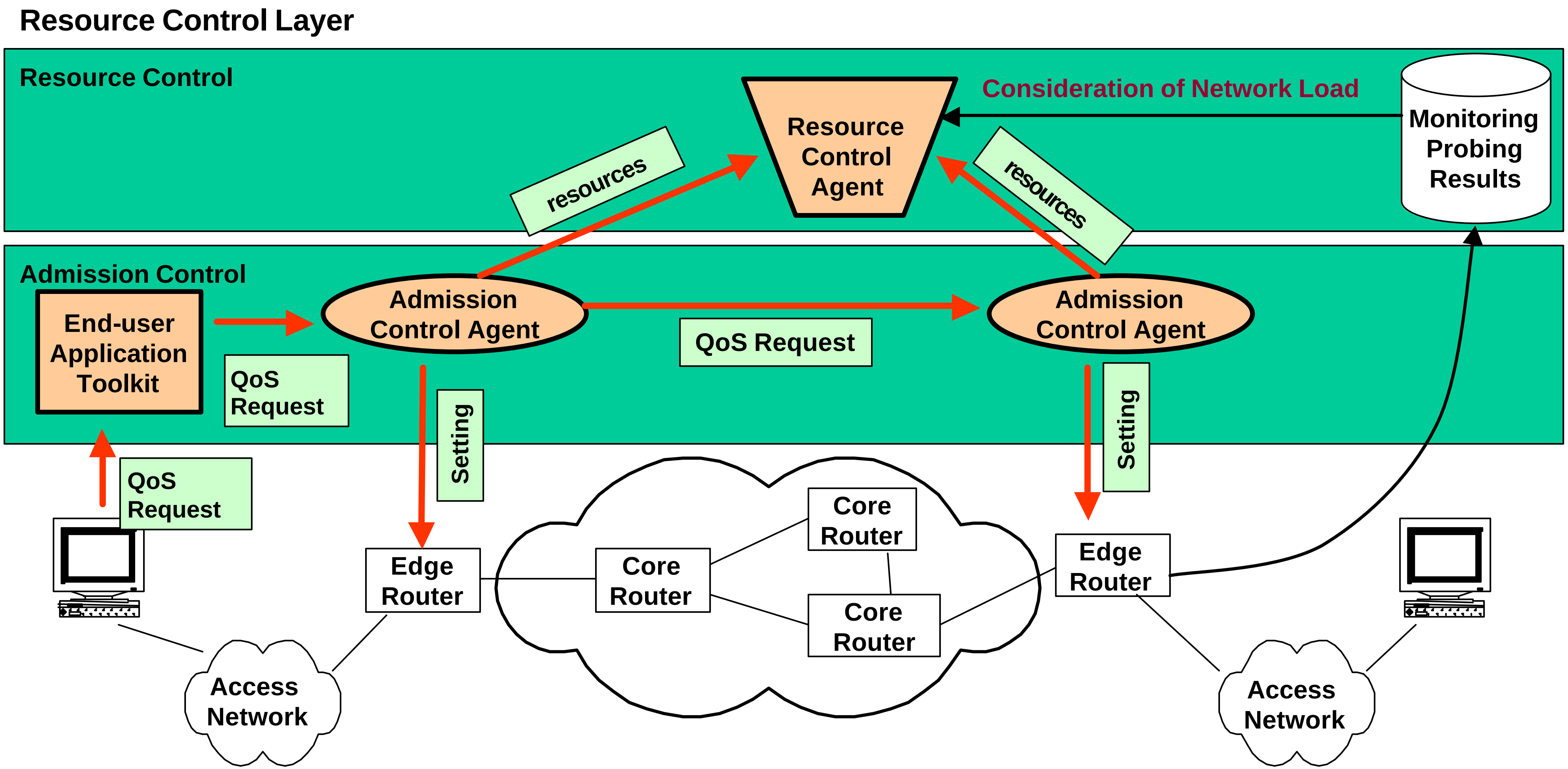
# Distributed QoS Measurements Packet Level

- **Measurement of end-to-end Parameters via Probes**
  - Examples: one-way delay, delay variation, packet loss
- **Collection of Performance Monitoring and QoS Parameters from Routers**
- **Definition and Implementation of Synthetic Flow Load Generators for Measurements of end-to-end QoS**
- **Storage of all Measurement Data in Measurement Database**

# Measurements



# 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

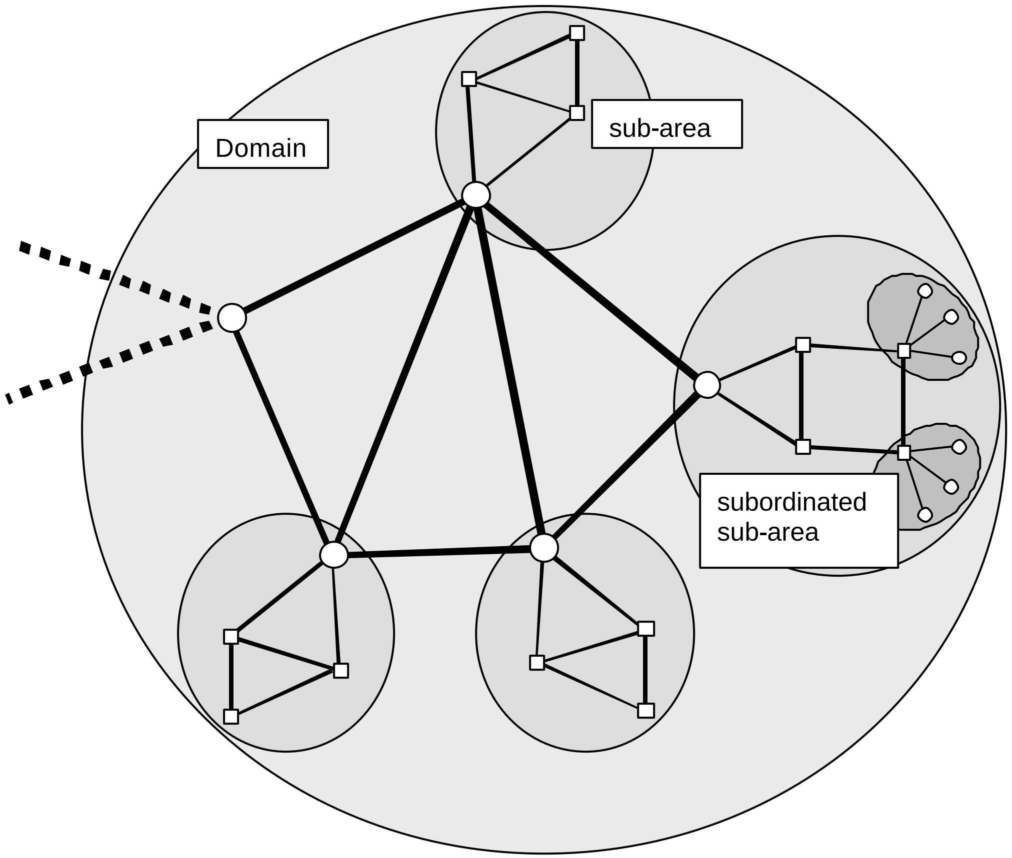
- Authenticates user
- Authorises and checks request
- Locates ingress and/or egress edge router ( Þ roles)
- Requests resources from the resource control agent
- Admits / rejects new flows
- Installs policies in ingress router

## Resource Control Agent

- Manages resources
- Checks availability of requested resources
- (Re-)distributes resources as needed

# Resource Pools

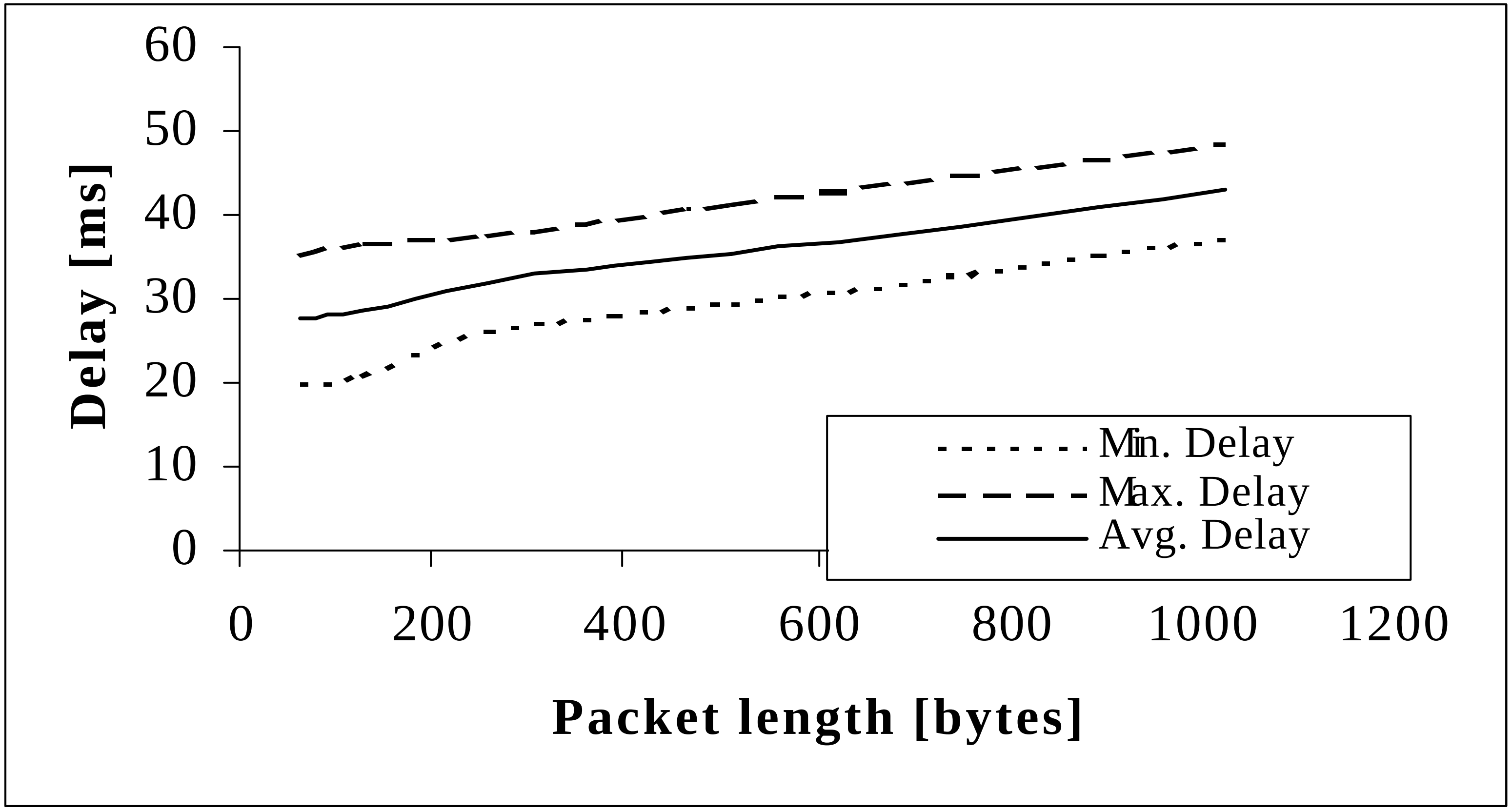
- **Resource Limits**
  - Limit amount of QoS traffic from each edge router
- **Group neighboured Routers**
  - Limit amount of QoS traffic from each group
- **Dynamic Distribution**
  - Dynamically shift resources within group
- **Hierarchical Structure**
  - “Groups of groups”



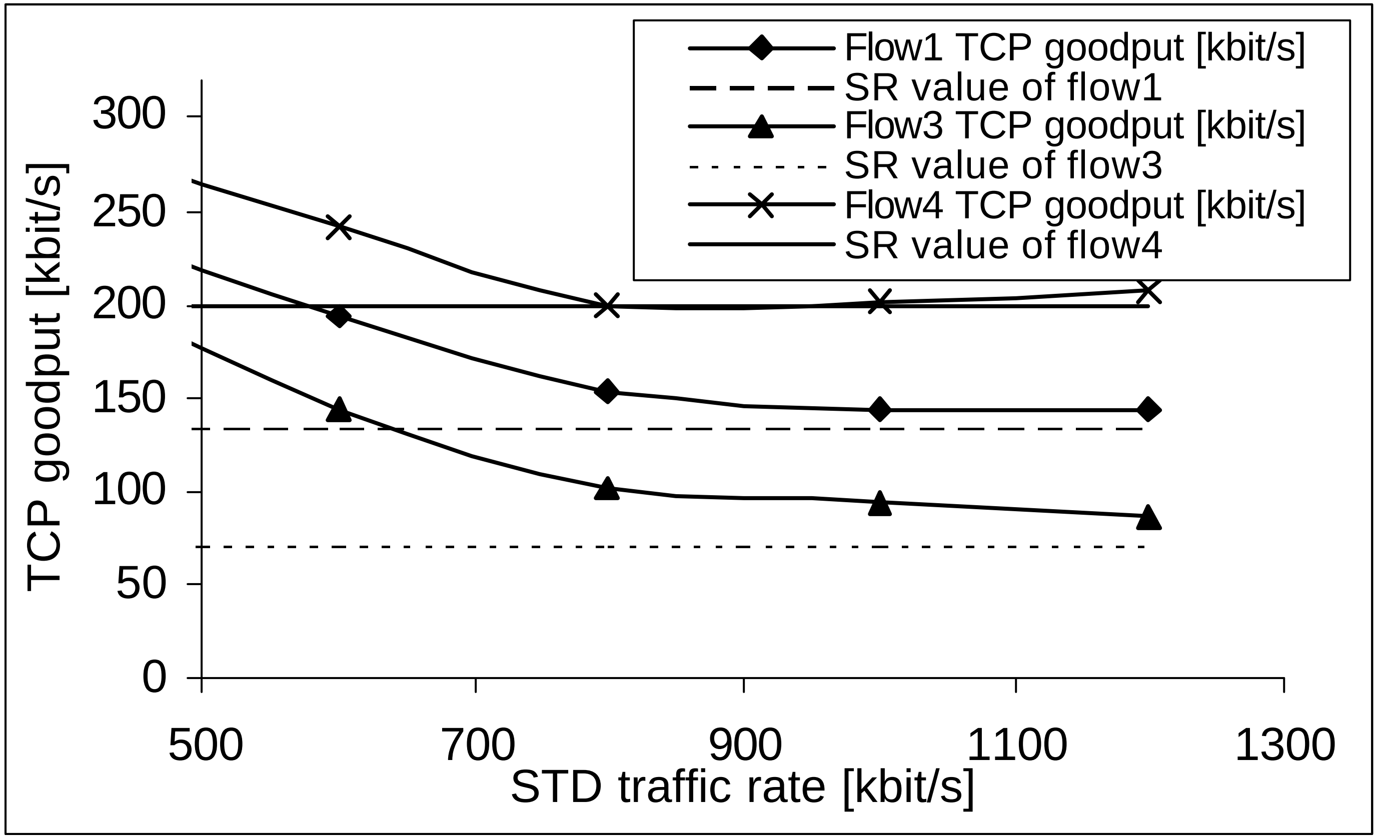
# Results

- **Network services**
  - fulfils 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
    - still more evaluations and simulations (large networks) necessary
  - Ongoing work on effective bandwidth calculations
    - not always correct and not manageable at the moment
- **Router**
  - WFQ noticeably degrades performance of Cisco routers

# PCBR: Delay experiment



# Goodput of TCP flows with different SR



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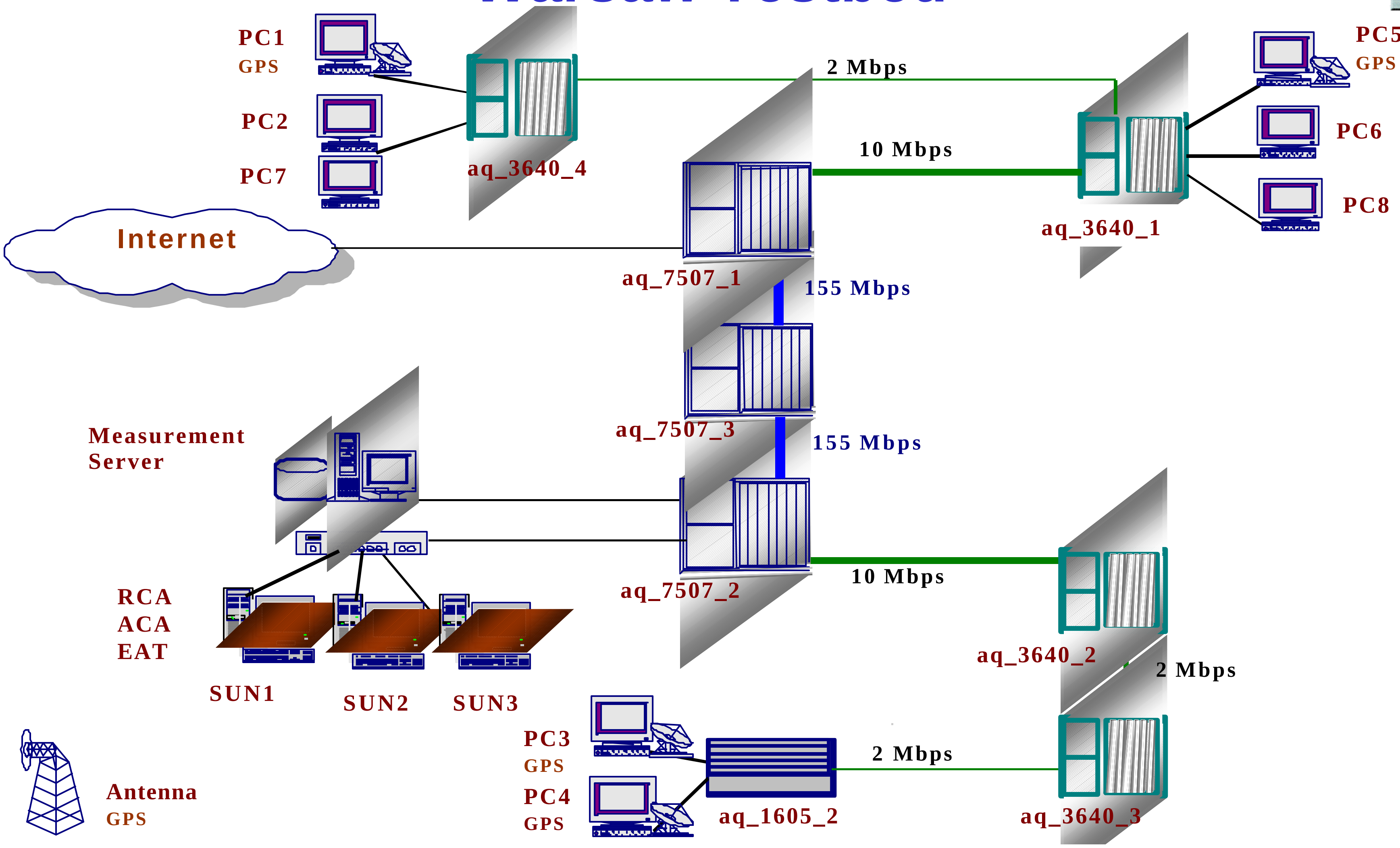
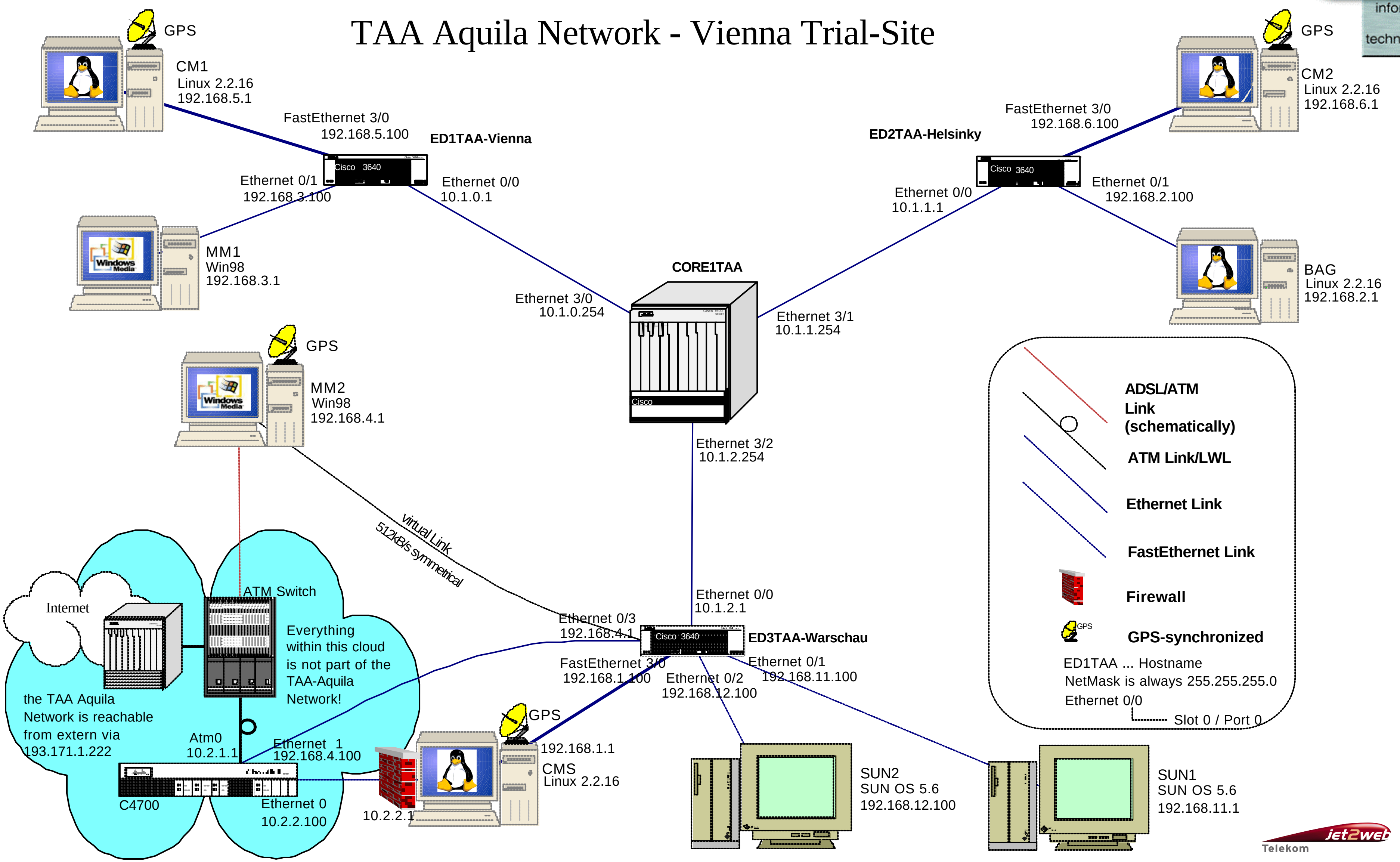
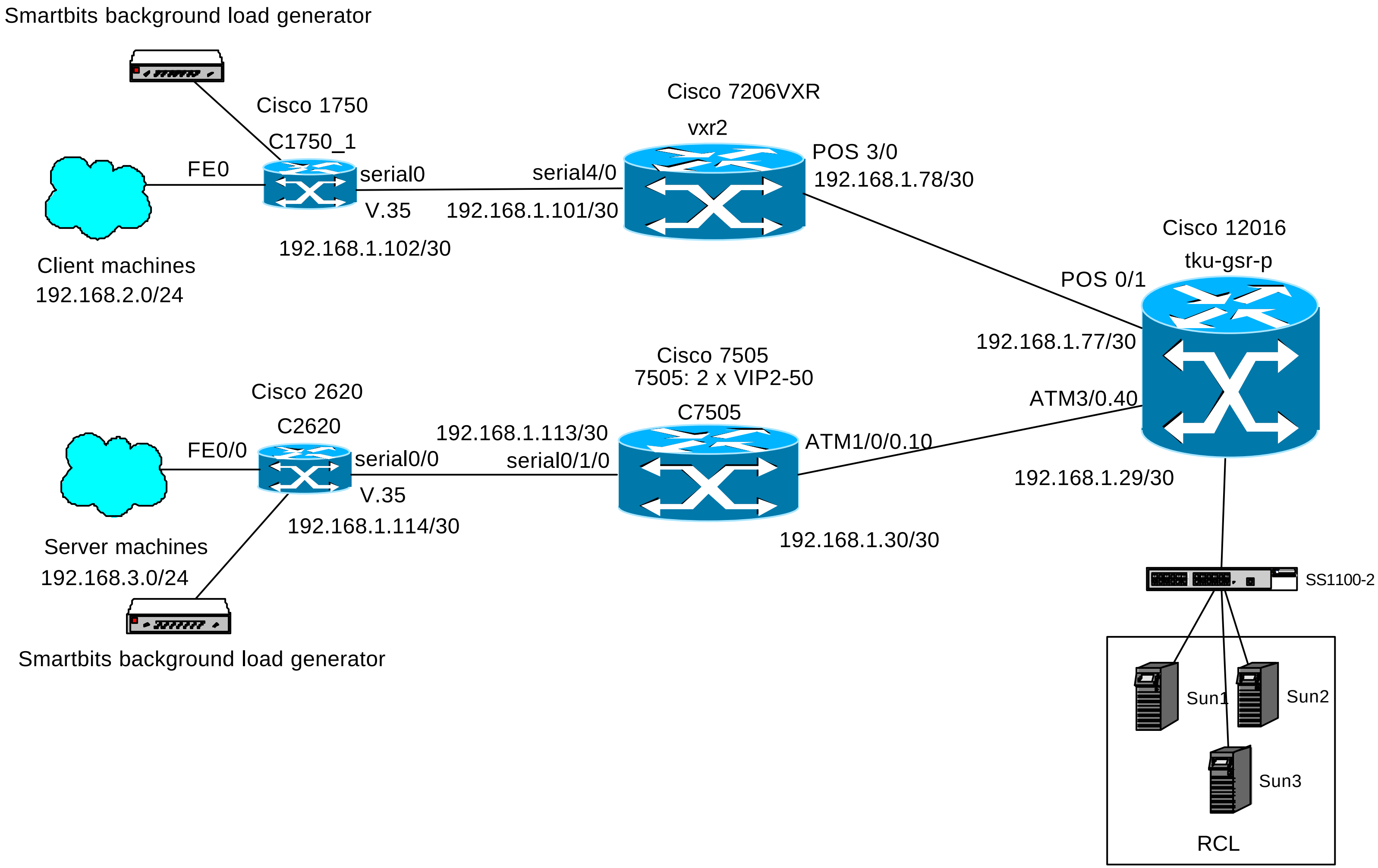
# Warsaw Testbed



# TAA Aquila Network - Vienna Trial-Site



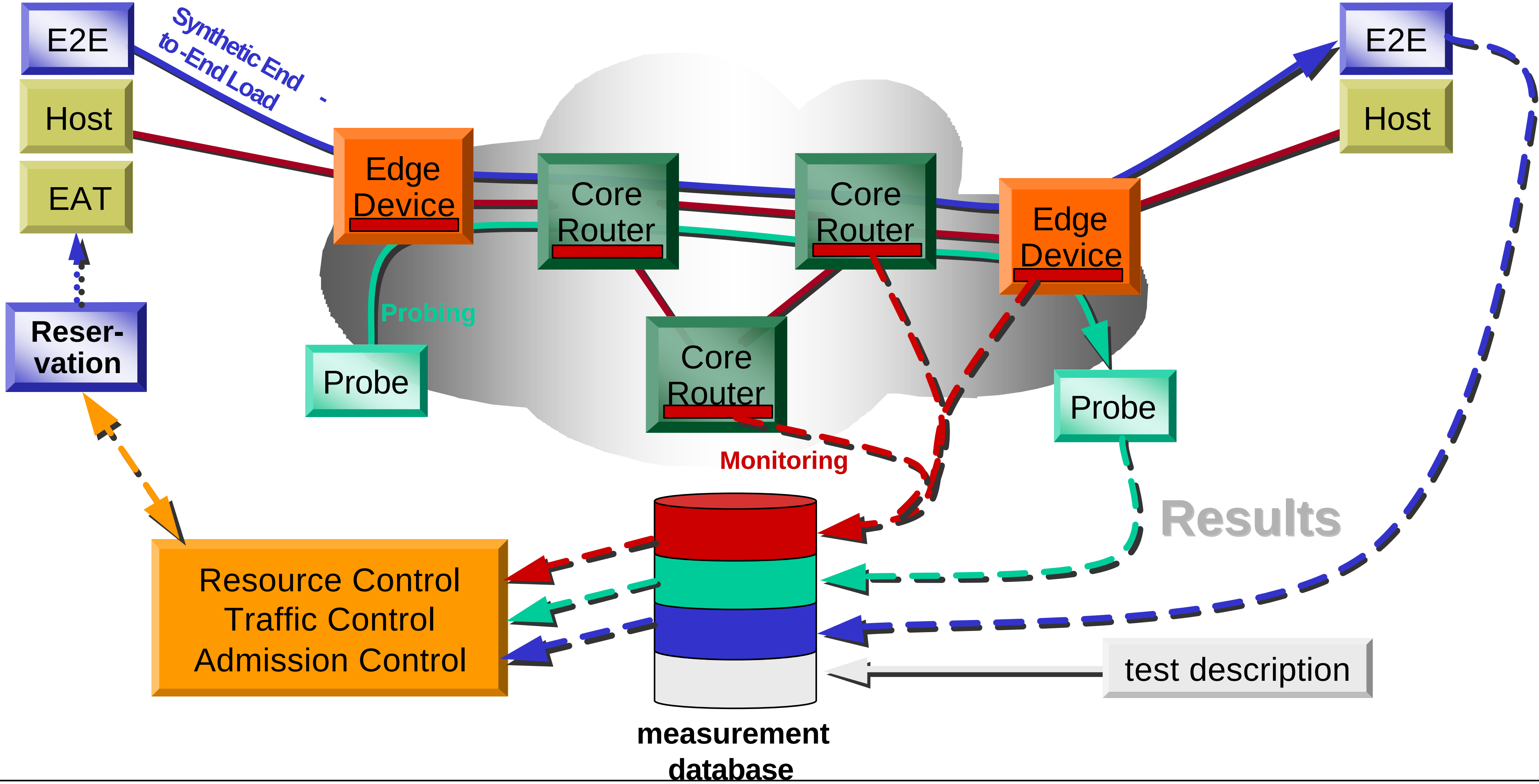
# Helsinki Testbed (Elisa Communications)



# Future work

- **Control loops**
  - for provisioning
  - for admission control
- **Inter-domain resource allocation**
- **Management tool**
- **Interoperation with MPLS**
- **SIP protocol gateway**

# Control loops (1)



# Control loops (2)

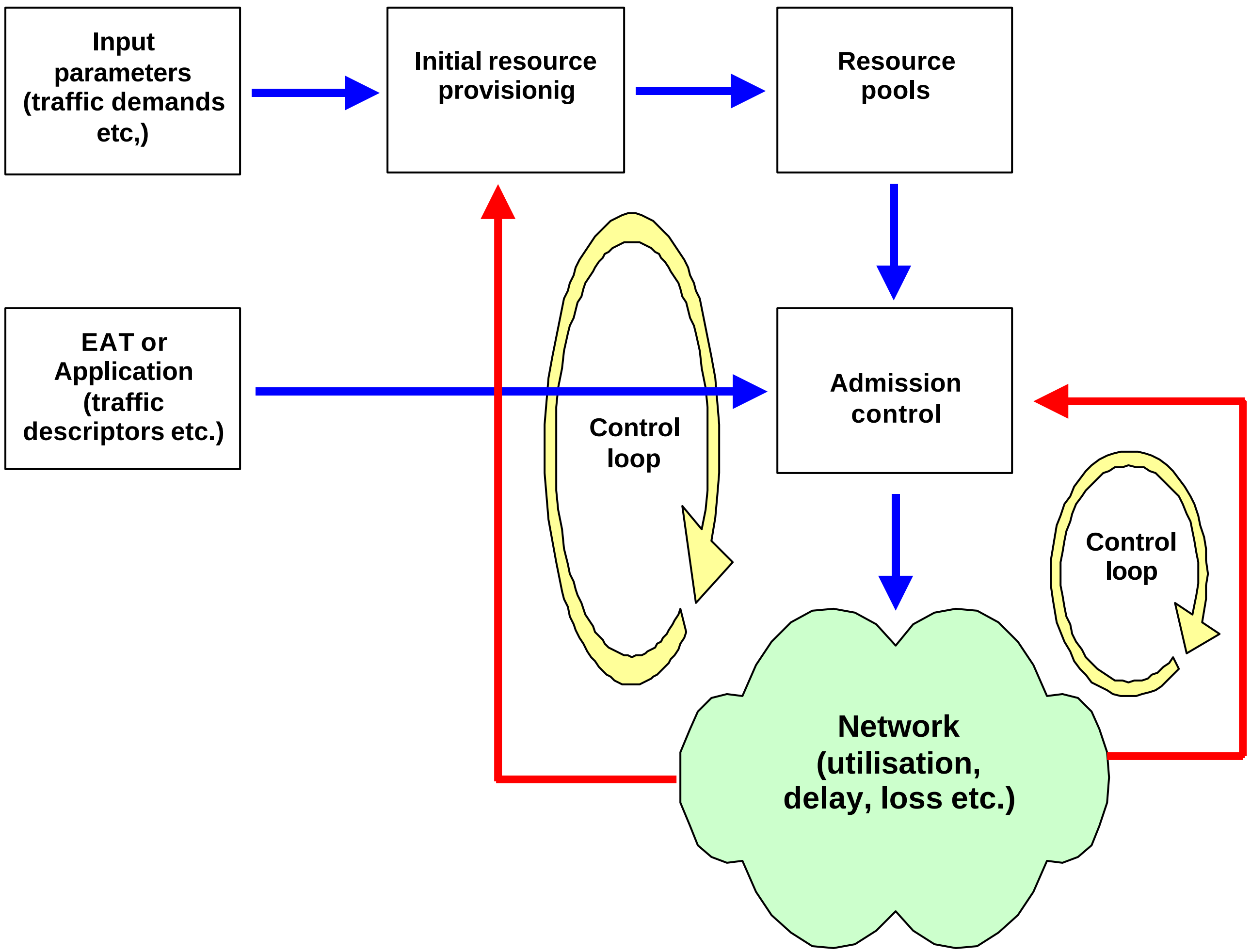
## Open loop

- Resource distribution on the basis of a priori specified parameters
- User declarations for admission control
- Assumed traffic demand for resource provisioning

## Closed loop

- Resource distribution on the basis of parameters obtained from the network
- Feedback from measurements
- Resource control loop
- Admission control loop (MBAC)

# Control loops (3)



# Internet domain architecture

- **Domains, autonomous systems (AS)**
  - Currently, the Internet consists of about 10.000 AS
  - Each AS is operated and managed by a network operator
- **Internet routing**
  - Internally, each AS may use any routing protocol
  - For routing between AS, BGP (Border Gateway Protocol) is used world-wide
- **Independent, but co-operating routing mechanisms**
  - Same is required for resource allocation
  - Inter-domain resource control architecture must not depend on any particular resource control mechanism within the AS

# BGRP: Tackling the scalability problem

## Microflow reservation

- At a core router, there might be more than 1 Mio individual flows at the same time

## AS (autonomous system) pair reservation

- We could aggregate reservations starting and ending at the same AS pair into one inter-domain reservation
- This would still yield in the order of 10.000 reservations on a core router at the same time
- In general, the problem remains, that the number of reservations grows $O(N^2)$ with the number of AS in the internet

# BGRP: Sink tree based aggregation

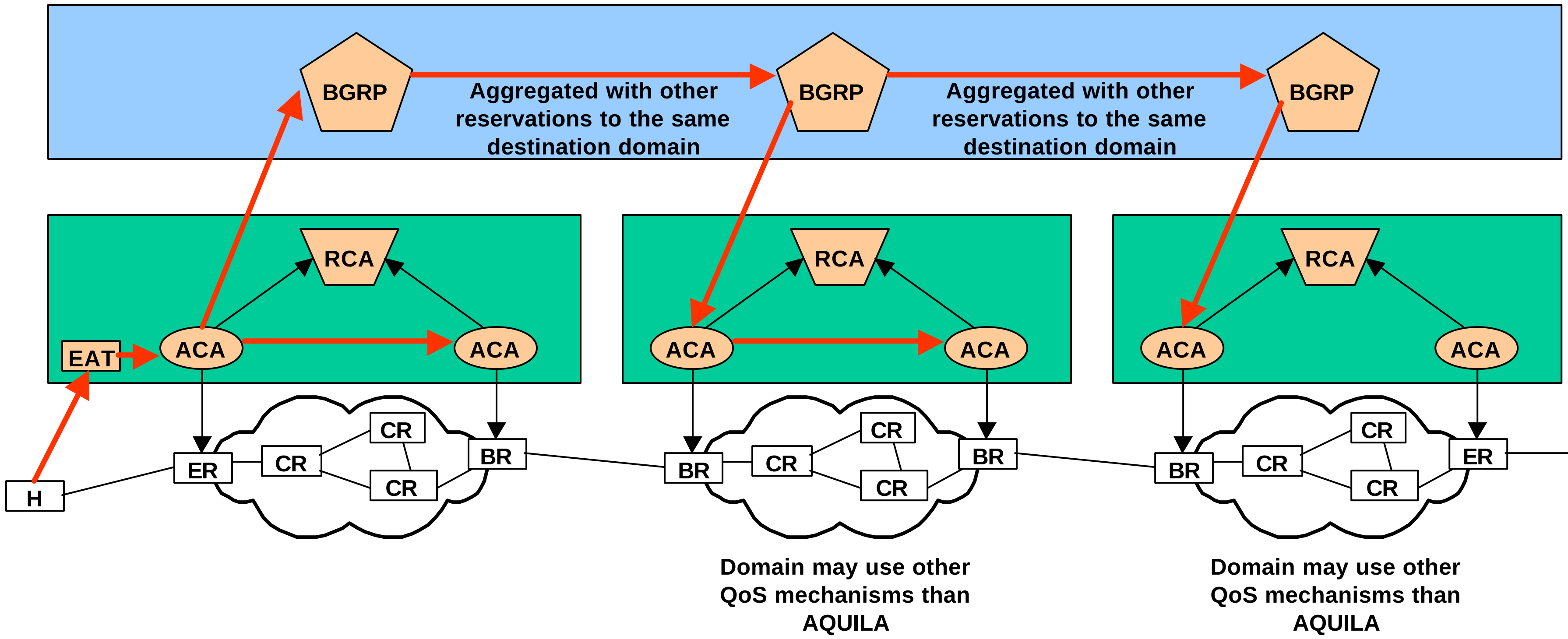
## Sink tree: definition of term

- An BGP router sends all traffic for the same destination AS to the same next hop AS (property of the BGP routing protocol)
- This guarantees the construction of a so called sink tree for a destination AS
- The root of the sink tree is the destination AS
- The traffic from all other AS travels along the links of this sink tree to the destination AS

## Aggregation

- Reservations from various AS to a common destination AS can be aggregated, as they merge along the sink tree

# Inter-domain Resource Control



# BGRP: Relation to intra-domain reservations

- **Operates on the boundaries between ISPs**
  - Each ISP is free to operate its own domain independently
  - Additional layer above the intra-domain resource control

- **Relation to AQUILA phase 1**
  - AQUILA phase 1 ACA requests inter-domain resources from the BGRP bandwidth broker at the initiating domain
  - BGRP bandwidth broker requests intra-domain resources from the AQUILA phase 1 architecture at subsequent domains

# 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**

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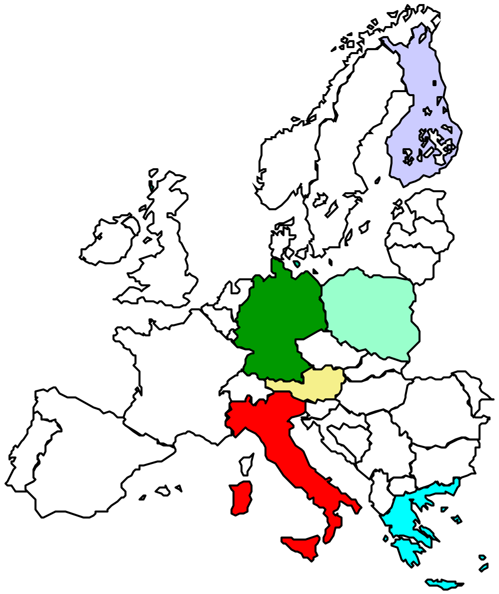

# Thank you for your attention !

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