



## EuQoS Classes of Service

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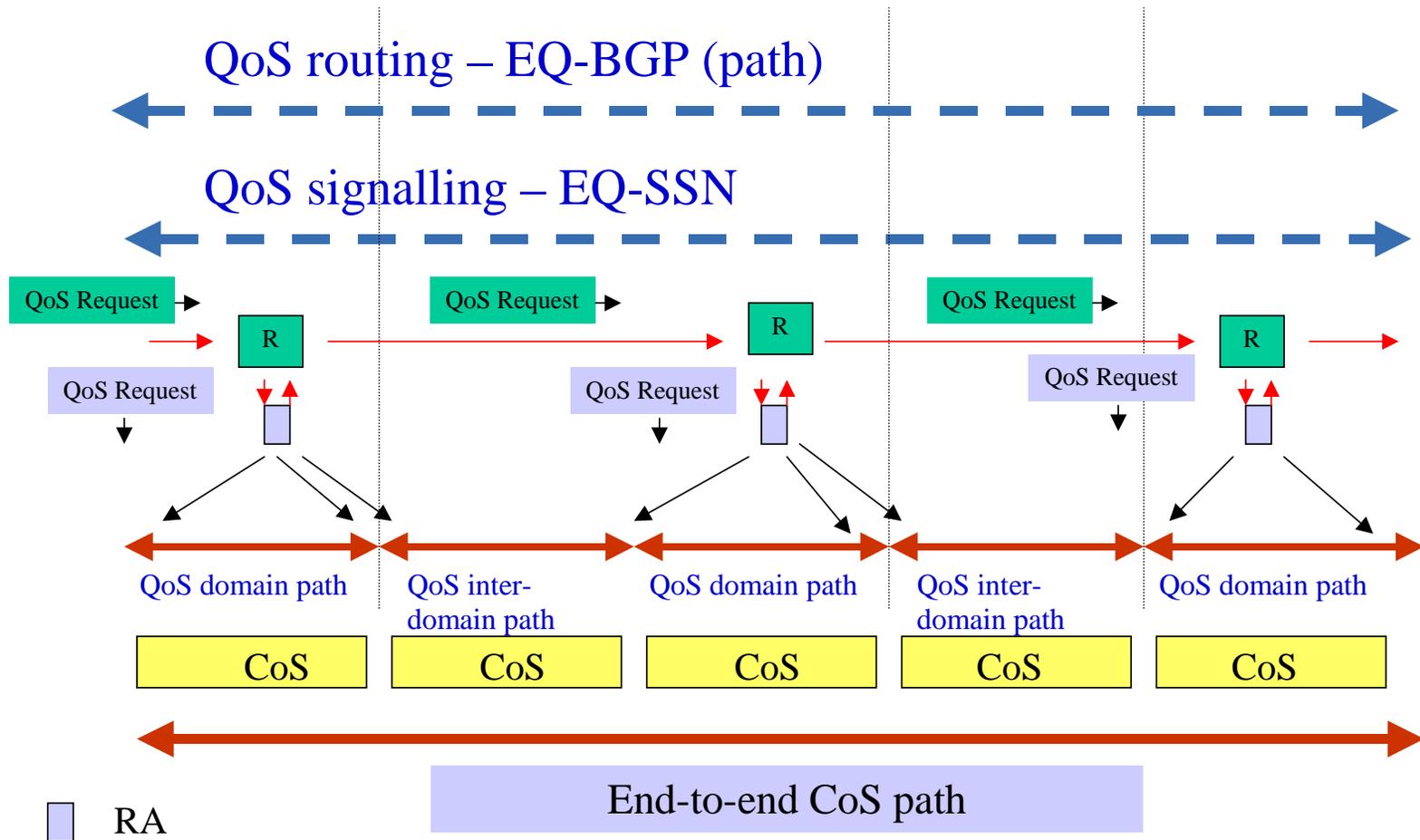
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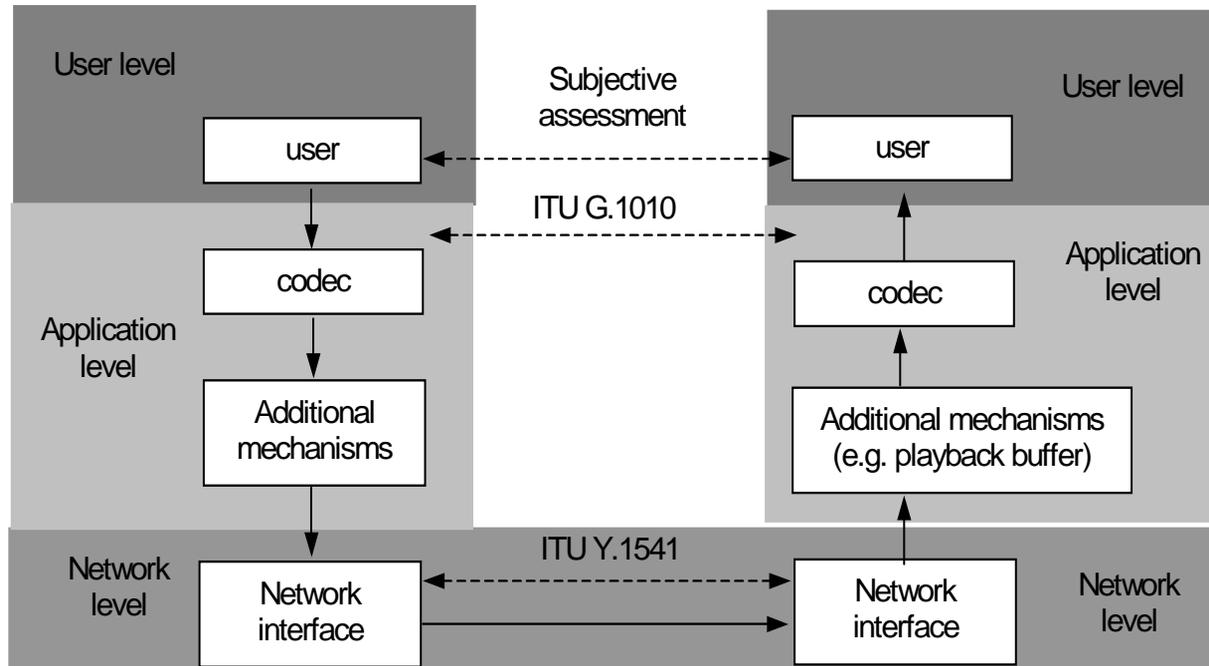
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- QoS Requirements for EuQoS system
  - EuQoS application requirements
  - Class of Service (CoS) concept
  - CoS concept in EuQoS System
  - Proposal for EuQoS CoSs
    - end\_to\_end (basic) CoSs in EuQoS
    - aggregated CoSs in EuQoS
  - Conclusions and further steps

- Designed for assuring end\_to\_end\_ QoS at the packet layer
- Strict QoS guarantees should be provided
- EuQoS environment: heterogenous and multiple-domain networks
  - many types of access networks
    - xDSL, UMTS, WiFi, LAN/Ethernet
  - IP core
- Different applications requiring different QoS guarantees (VoIP, VTC, VoD, Medigraf)



*QoS request is submitted to given CoS*



*QoS at the user level results from:*

- *QoS provided at the application level*
- *QoS provided at the network level*

|  |               | <i>VoIP</i>                                | <i>VTC (voice)</i>                         | <i>VTC (video)</i>                         | <i>VoD</i>        | <i>MEDI-GRAP (voice)</i>                   | <i>MEDI-GRAP (video)</i>                   | <i>MEDI-GRAP (data transfer)</i>                        | <i>MEDI-GRAP (chat)</i>                                   |
|--|---------------|--|--|--|-------------------|--|--|---|---|
| <b>Throughput</b>                                  |               | 8-64 kb/s                                  | 6-128 kb/s                                 | 64-2000 kb/s                               | 400-17000 kb/s    | 64 kb/s                                    | 384-1534 kbps                              | Depends on file size and acceptable transfer time       | N/A   |
| <b>End-to-end requirements (application level)</b> | <b>Delay</b>  | <150 ms (local)<br><400 ms (long-distance) | <150 ms (local)<br><400 ms (long-distance) | <150 ms (local)<br><400 ms (long-distance) | < 10s             | <150 ms (local)<br><400 ms (long-distance) | <150 ms (local)<br><400 ms (long-)         | File transfer time < 15s (preferred), <60s (acceptable) | Message transfer time < 2s (preferred), < 4s (acceptable) |
|  | <b>Jitter</b> | <1 ms                                      | < 1ms                                      | Negligible                                 | Negligible        | < 1ms                                      | Negligible                                 | N/A   | N/A   |
|  | <b>Loss</b>   | <3%  | < 3%                                       | <1%  | <1%               | < 3%                                       | <1%  | 0   | 0   |
| <b>Additional requirements</b>                     |               |  | Lip-synch < 80ms                           | Lip-synch < 80ms                           |                   | Lip-synch < 80ms                           | Lip-synch < 80ms                           |   |   |
| <b>End-to-end requirements (network level)</b>     | <b>IPTD</b>   | <100 ms (local)<br><350 ms (long-distance) | <100 ms (local)<br><350 ms (long-distance) | <100 ms (local)<br><350 ms (long-distance) | Not critical      | <100 ms (local)<br><350 ms (long-distance) | <100 ms (local)<br><350 ms (long-distance) | N/A   | N/A   |
|  | <b>IPDV</b>   | <50 ms                                     | <50 ms                                     | <50 ms                                     | Not critical      | <50 ms                                     | <50 ms                                     | N/A   | N/A   |
|  | <b>IPLR</b>   | <10 <sup>-3</sup>                          | <10 <sup>-3</sup>                          | <10 <sup>-3</sup>                          | <10 <sup>-3</sup> | <10 <sup>-3</sup>                          | <10 <sup>-3</sup>                          | N/A   | N/A   |
| <b>Additional requirements</b>                     |               |  | Lip-synch < ?                              | Lip-synch < ?                              |                   | Lip-synch < ?                              | Lip-synch < ?                              | Guaranteed throughput                                   |   |

Different QoS requirements with respect to:

- throughput
- delay
- delay variation
- loss ratio

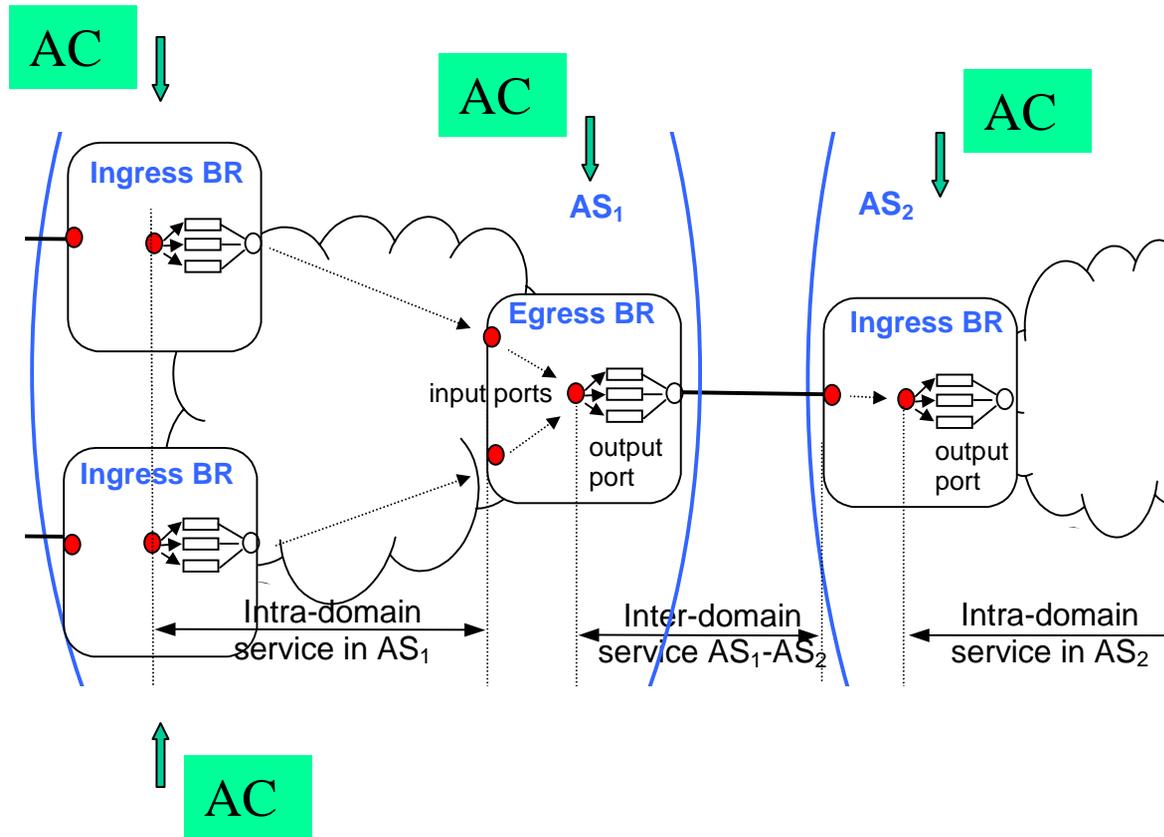
# Class of service concept for EuQoS (1)

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A „service class” represents a set of traffic that requires specific delay, loss and jitter characteristics from the network for which a consistent and defined per hop-behaviour applies

A service class pertains to applications with similar characteristics and performance requirements



## Intra- and inter-domain Classes of service

AC: admission control

1. QoS objectives: values of packet losses, delays...

2. Types of connections: p2p

3 Traffic descriptors: single-, double token bucket, more advanced

A. Provisioning of resources: static, dynamic

B. CAC: based on declarations, based on measurements

C. Tuning mechanisms at the packet level (PHB: classifiers, scheduling, marking, active queuing..)

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- To follow standardization activities
    - IETF proposal
    - ITU proposal
  - To take into account the experiences from implementation in some networks
    - GEANT
    - AQUILA
  - To take into account the capabilities of particular technologies

# CoSs: IETF proposal (1)



| Inter-Provider Service Class (Aggregate) | Tolerance To |       |        | PHB | End-To-End Service Class | Tolerance To |       |        | DSCP Name | DSCP Value |
|--|--------------|-------|--------|-----|--------------------------|--------------|-------|--------|-----------|------------|
|  | Loss         | Delay | Jitter |     |                          | Loss         | Delay | Jitter |           |            |
| Ctrl                                     | Low          | Low   | Yes    | CS  | Network Control          | Low          | Low   | Yes    | CS7       | 111000     |
| Real Time                                | VLow         | VLow  | VLow   | EF  | Telephony                | VLow         | Vlow  | VLow   | EF        | 101110     |
|  |              |       |        |     | Signalling               | Low          | Low   | Yes    | CS5       | 101000     |
|  |              |       |        |     | MM Conferencing          | L-M          | Vlow  | Low    | AF4x      | 100xx0*    |
|  |              |       |        |     | RT Interactive           | Low          | Vlow  | Low    | CS4       | 100000     |
|  |              |       |        |     | Broadcast Video          | VLow         | Med   | Low    | CS3       | 011000     |
| None Real Time                           | Low          | LIM   | Yes    | AF  | MM Streaming             | L-M          | Med   | Yes    | AF3x      | 011xx0*    |
|  |              |       |        |     | Low Latency Data         | Low          | L-M   | Yes    | AF2x      | 010xx0*    |
|  |              |       |        |     | OAM                      | Low          | Med   | Yes    | CS2       | 010000     |
|  |              |       |        |     | High ThruPut Data        | Low          | M-H   | Yes    | AF1x      | 001xx0*    |
| Best Effort                              | NS           | NS    | NS     | DF  | Standard                 | NS           | NS    | NS     | DF        | 000000     |

*11 Basic CoSs and 4 aggregated CoSs*

# CoSs: IETF proposal (2), exemplary applications



| Aggregated types of CoSs | Types of CoSs        | Examples of applications                      |
|--------------------------|----------------------|---|
| CTRL                     | Network control      | Network routing                               |
| Real Time                | Telephony            | IP telephony bearer                           |
|                          | Signalling           | IP telephony signaling                        |
|                          | MM conferencing      | H.323/V2 videoconferencing (elastic)          |
|                          | RT interactive       | Video conferencing and interactive gaming     |
|                          | Broadcast video      | Broadcast TV and live events                  |
| Non-Real Time            | MM streaming         | Streaming video and audio on demand           |
|                          | Low-latency data     | Client/Server transactions Web-based ordering |
|                          | OAM                  | Non-critical OAM&P                            |
|                          | High throughput data | Store and forward applications                |
| Best Effort              | Standard             | Undifferentiated applications                 |

# CoSs: ITU proposal (1)



| ITU Classes of Service        |  | Class 0                       | Class 1                       | Class 2                       | Class 3                       | Class 4                       | Class 5    | Class 6                            | Class 7                            |
|-------------------------------|--|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|------------|------------------------------------|------------------------------------|
| Network performance parameter | Nature of network performance objective  |                               |                               |                               |                               |                               |            |                                    |                                    |
| IPTD Delay                    | Upper bound on the mean IPTD (Note 1)  | 100ms (Note 3)                | 400ms                         | 100ms (Note 3)                | 400ms                         | 1s                            | U (Note 4) | 100ms (Note 3)                     | 400ms                              |
| IPDV Jitter                   | Upper bound on the 1 - 10 <sup>-3</sup> quantile of IPTD minus the minimum IPTD (Note 5) | 50ms (Note 6)                 | 50ms (Note 6)                 | U                             | U                             | U                             | U          | 50ms (ffs if this should be lower) | 50ms (ffs if this should be lower) |
| IPLR                          | Upper bound on the packet loss probability   | 1 x 10 <sup>-3</sup> (Note 7) | 1 x 10 <sup>-3</sup> (Note 7) | 1 x 10 <sup>-3</sup>          | 1 x 10 <sup>-3</sup>          | 1 x 10 <sup>-3</sup>          | U          | 1 x 10 <sup>-5</sup>               | 1 x 10 <sup>-5</sup>               |
| IPER                          | Upper bound  | 1 x 10 <sup>-4</sup> (Note 8) | U          | 1 x 10 <sup>-6</sup> (Note 8)      | 1 x 10 <sup>-6</sup> (Note 8)      |
| IPRR                          | Upper bound  |                               |                               |                               |                               |                               |            | 1 x 10 <sup>-6</sup> (Note 9)      | 1 x 10 <sup>-6</sup> (Note 9)      |

8 CoSs

# CoSs: ITU proposal, exemplary applications (2)



| ITU Classes of Service  | Class 0   | Class 1   | Class 2   | Class 3          | Class 4  | Class 5   | Class 6 | Class 7 |
|-------------------------|---|---|---|------------------|--|---|---------|---------|
| Applications (examples) | Real-time, jitter sensitive, high interaction (VoIP, VTC) | Real-time, jitter sensitive, high interaction (VoIP, VTC) | Transaction data, highly interactive (signalling) | Transaction data | Low loss only (short transactions, bulk data, video streaming) | Traditional applications of default IP networks |         |         |

# CoSs: mapping between IETF and ITU proposal



| Aggregated types of CoSs (IETF) | Types of CoSs (IETF) | Types of CoSs (ITU) |
|---------------------------------|----------------------|---------------------|
| CTRL                            | Network control      | Class 0             |
| Real Time                       | Telephony            | Class 0 or Class 1  |
|                                 | Signalling           | Class 2             |
|                                 | MM conferencing      | Class 0 or Class 1  |
|                                 | RT interactive       | Class 0 or Class 1  |
|                                 | Broadcast video      | Class 0             |
| Non-Real Time                   | MM streaming         | Class 4             |
|                                 | Low-latency data     | Class 3             |
|                                 | OAM                  | Class 3             |
|                                 | High throughput data | Class 4             |
| Best Effort                     | Standard             | Class 5             |

*Remark: no 1:1 mapping but not contrary proposals*

# QoS in core networks - IP prototype solutions: AQUILA



| Network service | Traffic type         | Characteristic examples                 | Application example    |
|-----------------|----------------------|---|------------------------|
| • Premium CBR   | Constant             | Small packets<br>low loss, low dela     | SIP VoIP               |
| • Premium VBR   | Variable             | Large packets<br>low loss, low<br>delay | SIP Video              |
| • Premium MM    | Adaptive             | required<br>throughput                  | File transfer<br>(FTP) |
| • Premium MC    | Very short<br>bursts | very low<br>delay & loss                | online games           |
| • Standard      | Best effort          | classical                               | the rest               |

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

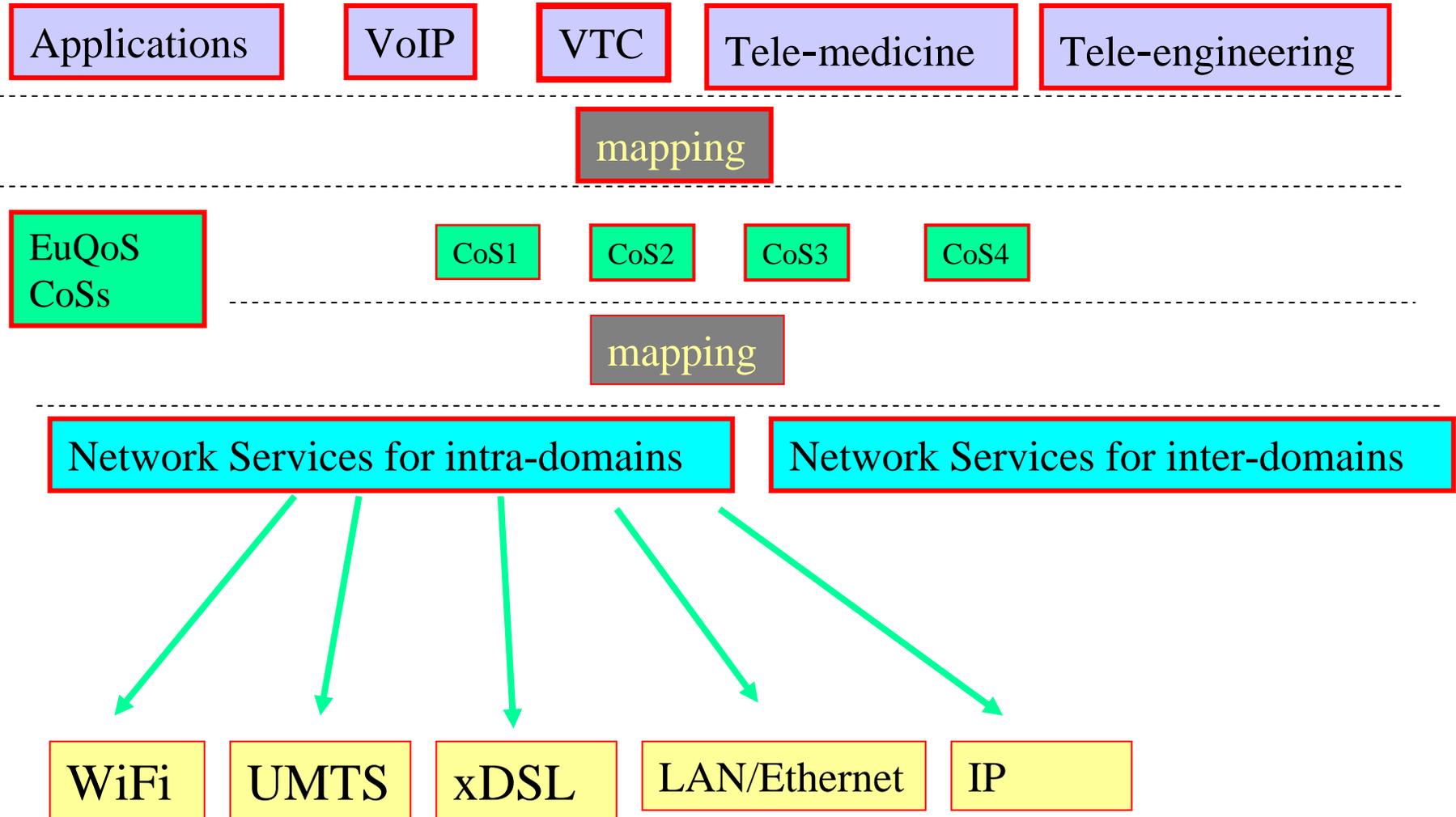
# CoSs in Geant and NRNs (IP core)

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- IP Premium service
- Best effort service
- Less than best effort

# Classes of service in EuQoS (general scheme)



# EuQoS applications and Classes of Service



| Types of Classes of Service | End-To-End Service Class | QoS Objectives   |           |       | EuQoS Applications (Phase 1) |     |     |          |               |               |      |  |   |
|-----------------------------|--------------------------|------------------|-----------|-------|------------------------------|-----|-----|----------|---------------|---------------|------|--|---|
|                             |                          | IPLR             | Mean IPTD | IPDV  | VoIP                         | VTC | VoD | Medigraf |               |               |      |  |   |
|                             |                          |                  |           |       |                              |     |     | VTC      | Collaboration | data transfer | chat |  |   |
| CTRL                        | Network Control          | 10 <sup>-3</sup> | 100 ms    | 50 ms |                              |     |     |          |               |               |      |  |   |
| <b>RT</b>                   | <b>Telephony</b>         | 10 <sup>-3</sup> | 100 ms    | 50 ms | X                            |     |     |          |               |               |      |  |   |
|                             | Signalling               | 10 <sup>-3</sup> | 100 ms    | U     |                              |     |     |          |               |               |      |  |   |
|                             | MM Conferencing          | 10 <sup>-3</sup> | 100 ms    | 50 ms |                              |     |     |          |               |               |      |  |   |
|                             | <b>RT Interactive</b>    | 10 <sup>-3</sup> | 100 ms    | 50 ms |                              | X   |     | X        |               |               |      |  |   |
|                             | Broadcast Video          | 10 <sup>-3</sup> | 100 ms    | 50 ms |                              |     |     |          |               |               |      |  |   |
| <b>NRT</b>                  | <b>MM Streaming</b>      | 10 <sup>-3</sup> | 1 s       | U     |                              |     | X   |          |               |               |      |  |   |
|                             | Low Latency Data         | 10 <sup>-3</sup> | 400 ms    | U     |                              |     |     |          |               |               |      |  |   |
|                             | OAM                      | 10 <sup>-3</sup> | 400 ms    | U     |                              |     |     |          |               |               |      |  |   |
|                             | <b>High ThruPut Data</b> | 10 <sup>-3</sup> | 1 s       | U     |                              |     |     |          |               |               | X    |  |   |
| <b>Best Effort</b>          | <b>Standard</b>          | U                | U         | U     |                              |     |     |          |               |               |      |  | X |

# Proposed set of Classes of Service

| Aggregated Types of Classes of Service | Basic End-To-End Service Class | QoS Objectives |           |       |
|--|--------------------------------|----------------|-----------|-------|
|  |                                | IPLR           | Mean IPTD | IPDV  |
| <b>RT</b>                              | <b>Telephony</b>               | $10^{-3}$      | 100 ms    | 50 ms |
|  | <b>RT Interactive</b>          | $10^{-3}$      | 100 ms    | 50 ms |
| <b>NRT</b>                             | <b>MM Streaming</b>            | $10^{-3}$      | 1 s       | U     |
|  | <b>High ThruPut Data</b>       | $10^{-3}$      | 1 s       | U     |
| <b>Best Effort</b>                     | <b>Standard</b>                | U              | U         | U     |

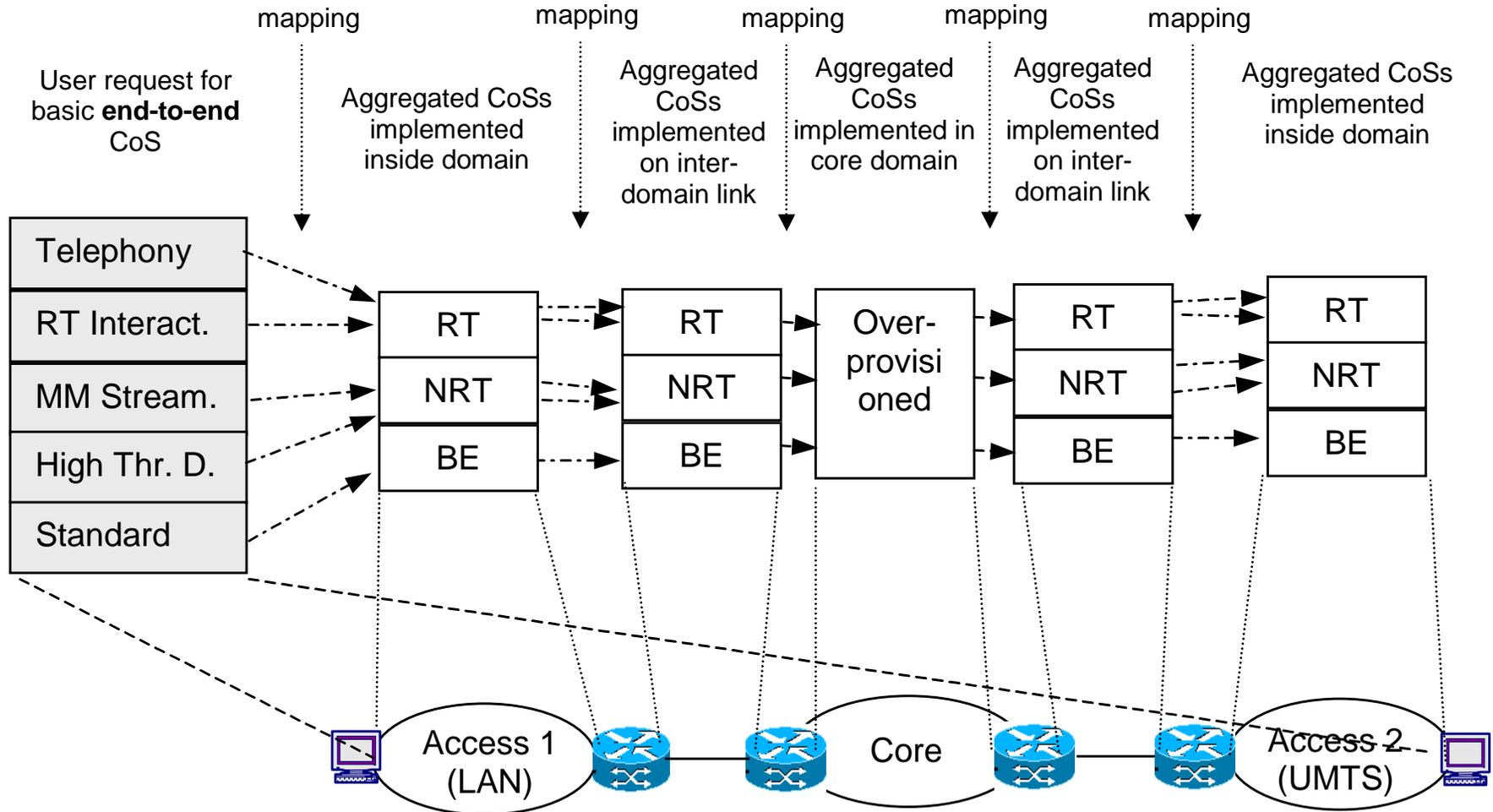
Basic CoSc – visible by the users and can be deployed in some access networks (e.g. In LAN/Ethrenet)

Aggregated CoSs – can be deployed in some parts of the networks (e.g. Inter-domain links, IP core)

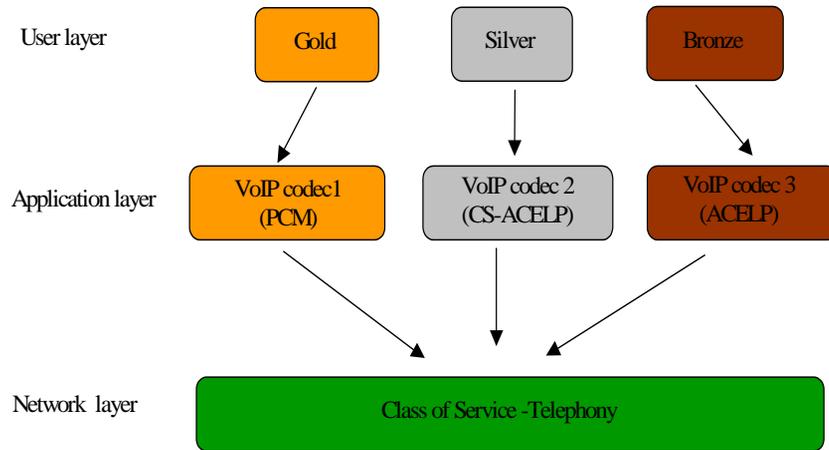
| End-to-end Class of Service | QoS Objectives |           |       | Type of connections | Traffic descriptors |
|-----------------------------|----------------|-----------|-------|---------------------|---------------------|
|                             | IPLR           | Mean IPTD | IPDV  |                     |                     |
| <b>Telephony</b>            | $10^{-3}$      | 100 ms    | 50 ms | p2p                 | Peak rate           |
| <b>RT Interactive</b>       | $10^{-3}$      | 100 ms    | 50 ms | p2p                 | Peak rate           |
| <b>MM Streaming</b>         | $10^{-3}$      | 1 s       | U     | p2p                 | Requested rate      |
| <b>High Thruput Data</b>    | $10^{-3}$      | 1 s       | U     | p2p                 | Requested rate      |
| <b>Standard</b>             | U              | U         | U     |                     |                     |

*As simple as possible traffic descriptors – peak rates, requested rates*

# An example for developing CoSs in EuQoS



# Example: One Telephony Class – 3 QoS levels (Gold, Silver and Bronze)



| Standard | Codec Type | Rate [kbps] | Frame [ms] | Lookahead [ms] | MOS <sub>intr</sub> |
|----------|------------|-------------|------------|----------------|---------------------|
| G.711    | PCM        | 64          |            | 0              | 4.43                |
| G.729    | CS-ACELP   | 8           | 10         | 5              | 4.18                |
| G.723.1  | ACELP      | 5.3         | 30         | 7.5            | 3.83                |
| G.723.1  | MP-MLQ     | 6.3         | 30         | 7.5            | 4.00                |

*Mapping between Gold, Silver and Bronze may corresponds to:*

- different codecs*
- different CoSs*

| <b>Application</b>     | <b>Basic CoSs</b>     | <b>Aggregated CoSc</b> | <b>Ethernet LAN</b>  | <b>UMTS</b>                         | <b>WLAN (802.11)</b> | <b>xDSL</b>                      | <b>GEANT/NRNs</b> |
|------------------------|-----------------------|------------------------|----------------------|-------------------------------------|----------------------|----------------------------------|-------------------|
| <b>VoIP</b>            | <b>telephony</b>      | <b>RT service</b>      | <b>Voice Service</b> | <b>Conversational traffic class</b> | <b>RT service</b>    | <b>Constant Bit Rate Service</b> | <b>Premium IP</b> |
| <b>VTC</b>             | <b>RT interactive</b> | <b>RT service</b>      | <b>Video Service</b> | <b>Streaming traffic class</b>      | <b>RT service</b>    | <b>Constant Bit Rate Service</b> | <b>Premium IP</b> |
| <b>Video streaming</b> | <b>MM streaming</b>   | <b>N-RT service</b>    | <b>Video Service</b> | <b>Streaming traffic class</b>      | <b>NRT service</b>   | <b>Constant Bit Rate Service</b> | <b>Premium IP</b> |

*Pending work*

- The next step is to specify in which way we implement each of required CoSc in particular networks (UMTS, xDSL, WiFi, LAN/Ethernte, IP core) and in the inter-domain links.
- Anyway, for each CoS we need specification of the QoS mechanism (schedulers, admission control rules) to meet the assumed QoS objectives
- Furthermore, for making adequate resource provisioning for particular part of networks we need to specify a scheme for QoS responsibilities for particular parts of end-to-end path