Workshop on “New Technologies and Applications ”

Traffic Modeling and QoS in NGN

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Agenda

- Network design issues
  - Traffic related questions
  - Flow types
  - Design criteria and traffic processes

- IP Traffic Characterization for dimensioning
  - Statistical properties
  - Dimensioning
  - QoS

Traffic related questions

- Is traffic important in NGN and IP flows?
- What units to consider for dimensioning and engineering?
- Which traffic activities are needed in operation?
- Which units to consider for interconnection and SLA?
- Is QoS well defined and what parameters?
- Others...........?

Traffic flow types for Quality of Service based dimensioning

- **constant stream**: bandwidth transmission at a constant speed with a specified delivery and jitter (ie: video distribution)
- **variable stream** : bandwidth transmission at a variable speed derived from a user information and coding algorithm which requires guaranteed quality and specified jitter (ie: VoIP, Video streaming, audio streaming, etc.)
- **elastic:** bandwidth transmission at a variable speed without jitter restrictions and asynchronous delivery (ie: browsing, file transfer, mail, UMS, etc.)

Traffic elements in NGN Networks for QoS

- **Traffic Engineering Module**
  - Traffic Engineering refers to the process of selecting the paths (LSPs) in order to balance the traffic load on the various links, routers, and switches in the network. A major goal of Traffic Engineering is to facilitate efficient and reliable network operations with guarantee of QoS while simultaneously optimizing network resource utilization and traffic performance
- **CAC**
  - Call Acceptance Control function in order to accept/reject traffic in the network that allows guarantee of QoS for services with a given Service Level Agreement
- **CoS**
  - Class of Service. A feature that provides scalable, differentiated types of service across a label switched network. MPLS CoS offers packet classification, congestion avoidance, and congestion management

The Network Design Criteria

- A) Match realistic service demands and workloads for a given time
  - Node and links loads based on proper multiservice flow **characterization**, measurements and projections
- B) Consider equilibrium between QoS and cost
  - **Statistical behavior** for the flows
  - Traffic modeling for given **quality, efficiency and protection**
  - **Overload** protection and control
- C) Anticipate capacity as a function of service grow rate and needed installation time. **Reserve capacity**
- D) Follow **SLA** when different service classes coexist

Network Design and Dimensioning

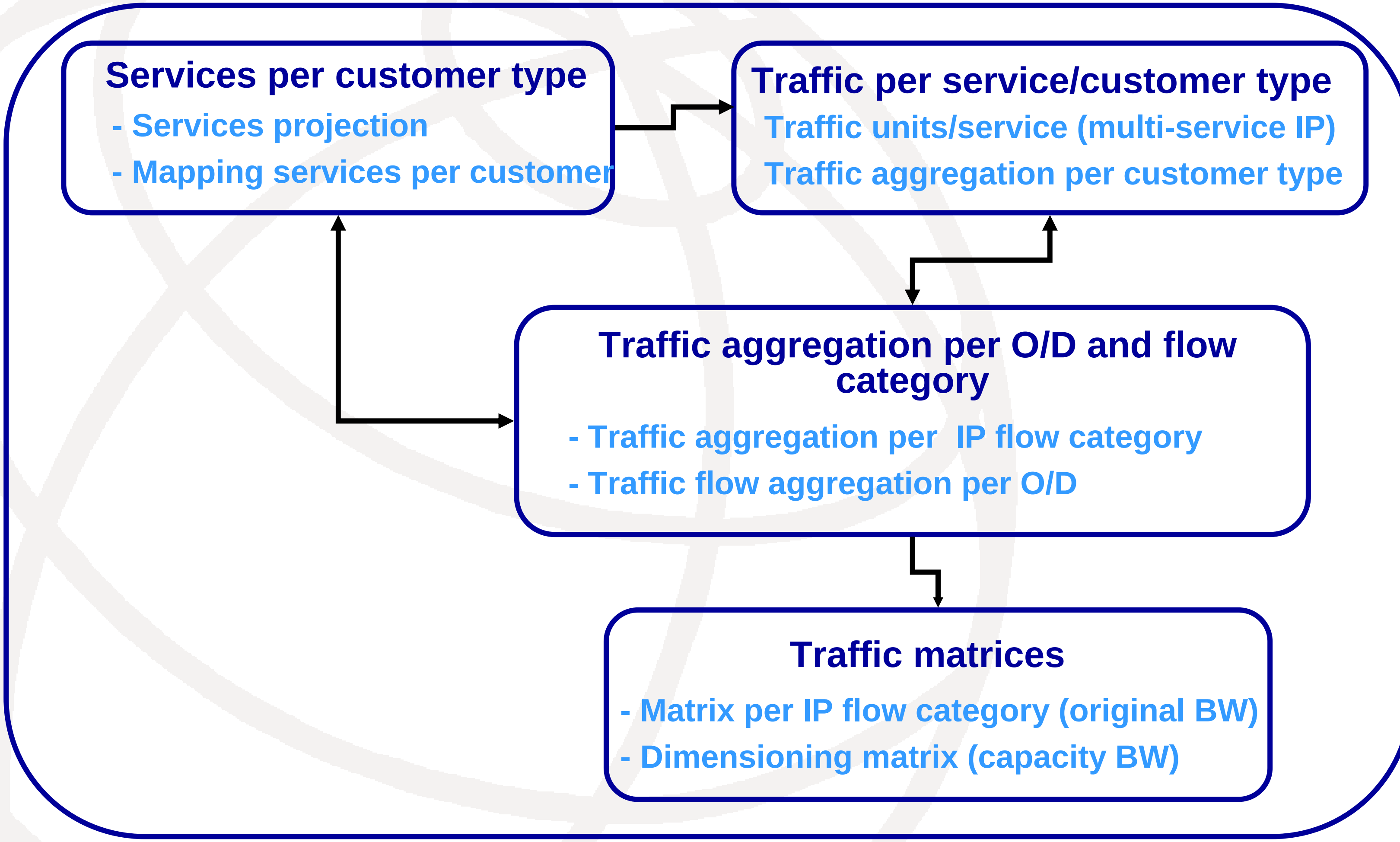
Service demand Characterization

- By a profile through days in a year / week
- By a busy period within a day
- By superposition of non-coincidence of busy periods (for inter-country traffic in different time zone)
- By aggregation or convolution of flows for different services
- By interest factors between areas (adjusting matrices in the two dimensions ie: Kruithof, affinity, correlation)

Network activities needing traffic characterization

- Traffic **Characterization** for Services and network flows
- Traffic **Demand** forecasting and aggregation at the user and Network interfaces
- Traffic **Dimensioning** for all network elements
- Traffic **Measurements** and Validation for SLA
- Traffic **Management** in focussed and generalized overload

NGN Service demand evaluation process



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- **Network design issues**
  - **Traffic related questions**
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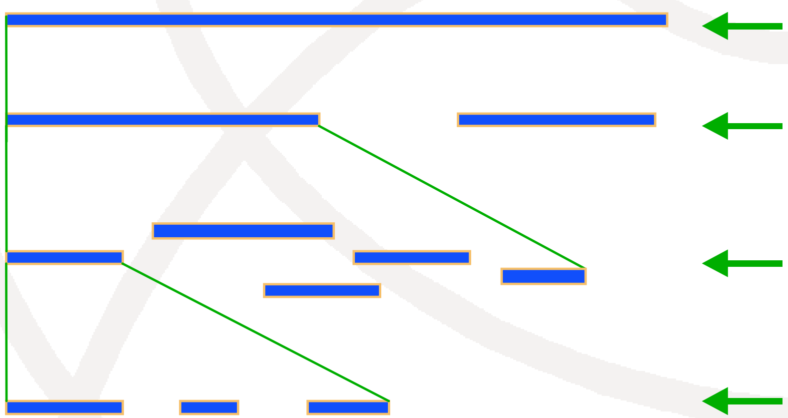
- **IP Traffic Characterization for dimensioning**
  - **Statistical properties**
  - **Dimensioning**
  - **QoS**

Traffic Characterization

- Hierarchical modelling for call driven communications generating traffic flows in NGN



Level 1: Customer Service time at "Call" level

Level 2: Activity/Communication times at Session/Application level

Level 3: Communication times at Flow/Burst leve

Level 4: Transmission times at Packet level

- Aggregated average traffic per level as a weighted average of the services categories (i) and customer classes (j) at that level.

Traffic Characterization for NGN

- **Which** units used to predict traffic demand ?

Traditional

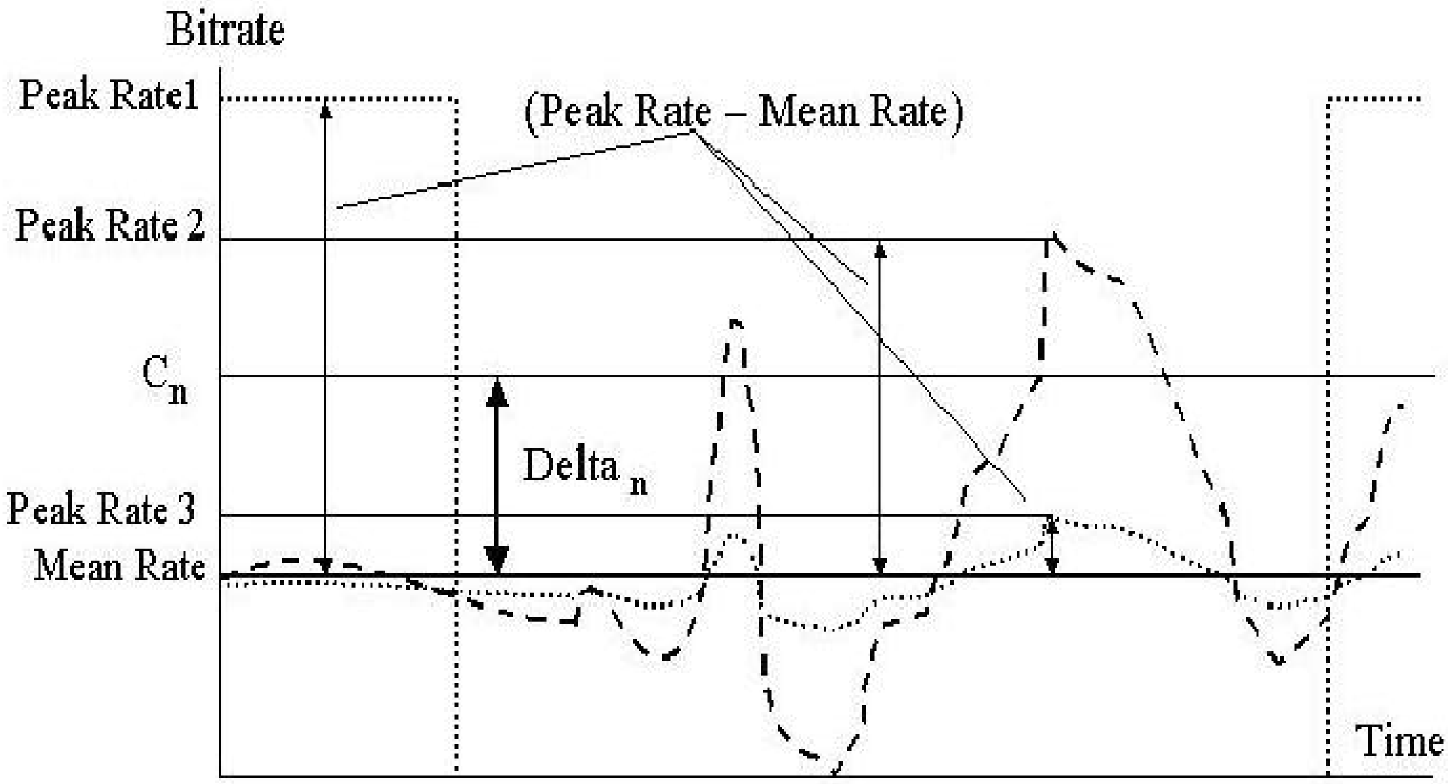
- Customers for given project (operator, country, region, worldwide)
- Ports associated to customers per class
- Calls generated at user interface
- Erlangs originated/terminated at user interface

New

- Sessions/Information/requests generated at user interface
- Packets handled at a given resource through the network
- Mbits transported through a given network link/path

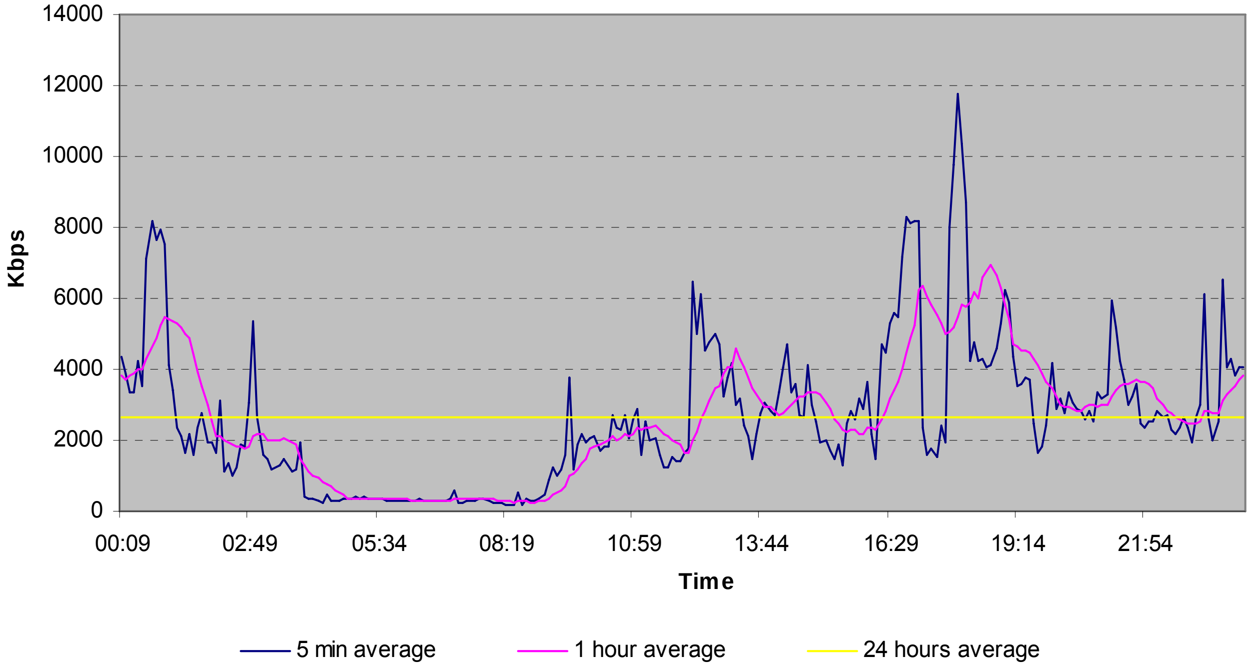
Traffic Characterization for NGN

- Different relation between peak traffic and average traffic per service classes: CBR (1), VBR(2), VBR(3)



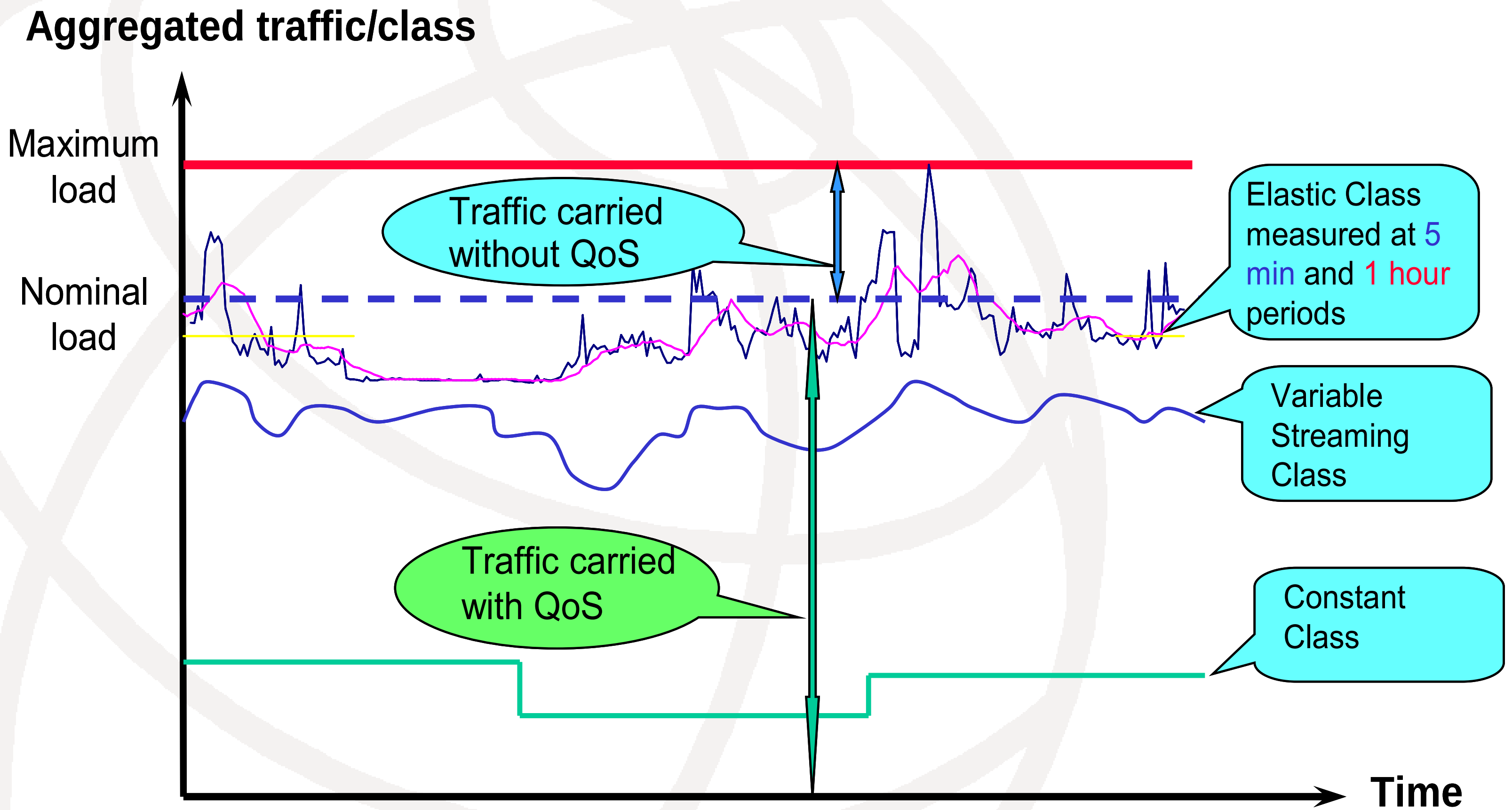
Example of time-scale influence on measurements

Variation per measurement averaging period at ENST campus measurements in 2001 for advanced internet applications



- Impact of averaging period
  - 1,8:1 ratio between “5 min” and “1 hour”
  - 2,3:1 ratio between “1 hour” and “24 hours”

Example of aggregated flows per category



Traffic units for aggregated flows

- Traffic Units definition for network dimensioning
  - Equivalent Sustained Bit Rate (ESBR) or aggregated equivalent rates for same QoS category flows in a common reference busy period (ie. 5 minutes)
  - Computed as weighted average of the services at QoS category (i) and customer classes (j) at each network element: $\sum_i \sum_j ESBR_{ij}$

Dimensioning Criteria

- **Stream traffics** need reserve capacity procedures like MPLS and Call Acceptance Control (CAC) in the access and may be modeled with equivalent bandwidth methods.

  ⇨ Available multi-rate formulas with different peakdness factors for a given quality.

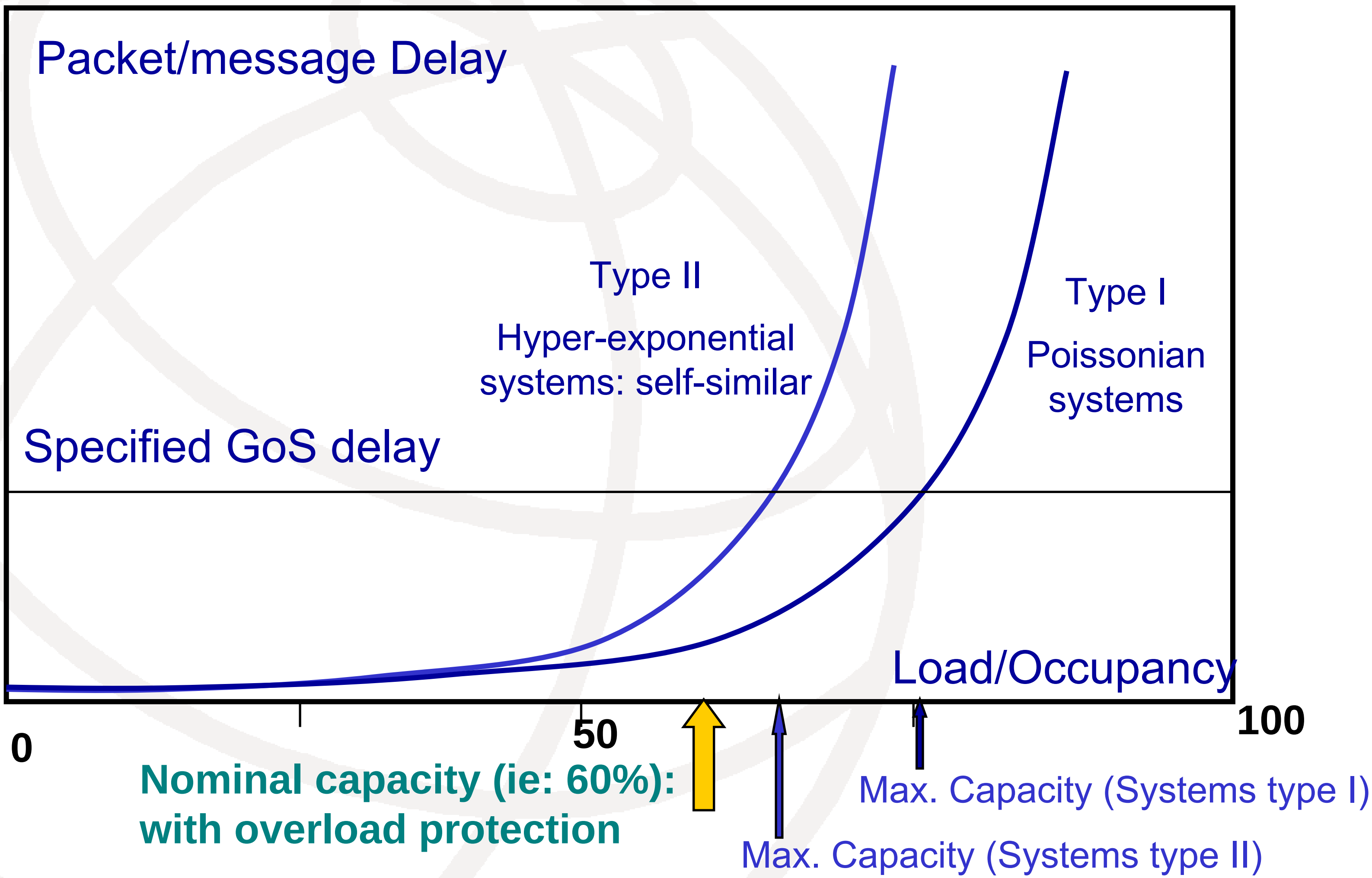
- **Elastic traffics** may be modeled with resource shared models.

  ⇨ Available "processor-sharing" one that provide a minimum capacity and a delivery speed as a function of simultaneous users

- **Constant rate** traffics need to be aggregated and reserved on top of the others with a given protection factor

- Overall dimensioning will be a combination of the previous procedures with different degrees of detail as a function of the model granularity

Typical dimensioning curves for delay based systems



How to define dimensioning and costing units for interconnection ?

- Which units to be used for dimensioning ?
- Which units to be used for billing ?
- Which units to be used for interconection and termination taxes ?
  - Usage time?
  - Bandwidth?
  - Information Volume?
  - Interface or link capacity?
  - Event driven?

How to define dimensioning and costing units for interconnection ?

- Requirements for service flow units:
  - Quantifiable with well defined engineering rules
  - Useful for interrelation between demand/dimensioning/costing for a given QoS and SLA
  - Reflecting service provisioning and market value across multiple networks
  - Applicable to multiservice/multimedia flows

How to define dimensioning and costing units for interconnection ?

Common units for dimensioning and costing applicable at different network interfaces and interconnection points

Proposal for NGN multiservice networks:

Equivalent Sustained Bit Rate (ESBR) effectively carried at the network interface or interconnection point for a given Quality level or Service Level Agreement (SLA)

ITU framework for QoS support to operation

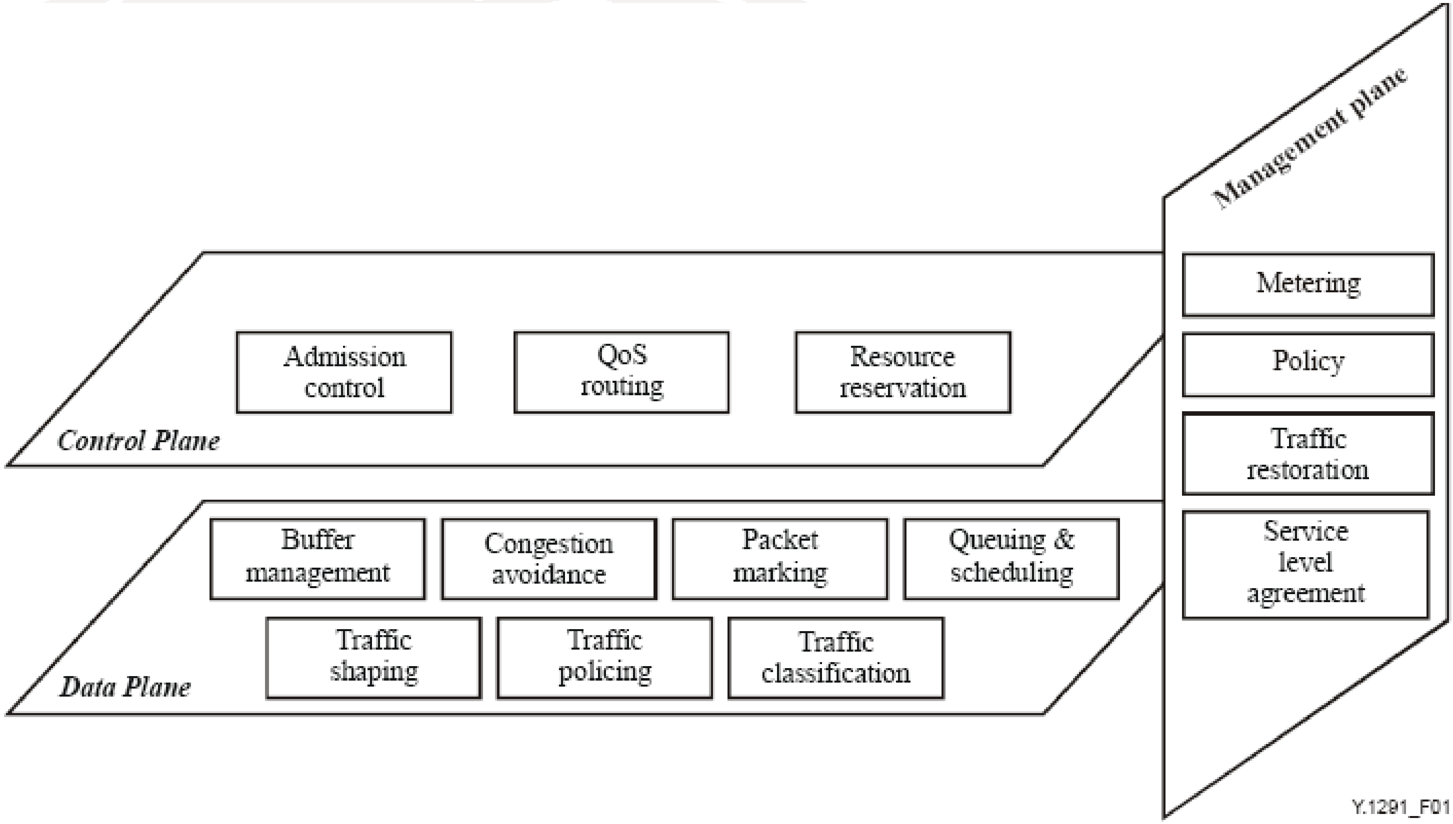


Figure 1/Y.1291 – Architectural framework for QoS support

QoS: Evaluation domains

- Quality of Service (QoS): Characterization of the service accessibility and quality both with quantitative and qualitative (user perception) parameters and values

- Domains for QoS evaluation:
  - **Grade of Service**
    - Service accessibility: capability to access a service
    - Connection establishment: Capability to get connection
    - Information transfer: Quality of information delivery
  - Reliability: Failure probability
  - Availability: Probability of system being active
  - Survivability: Capability to provide service in abnormal conditions
  - **Security:** Information and systems protection level
  - Qualitative: Intelligibility, audibility, visualization, etc. of information content as derived from user perception

QoS application phases and views

- \- Phases of the service life cycle to analyze like:
  - service provision, service enhancement, service support, service connection, service billing, service management, etc.
- \- Criteria for the quality observation like:
  - Availability, accuracy, speed, security, reliability, etc.
- \- Customer view: QoS requirements and perception
- \- Service provider view: QoS offering and achievement

QoS measurement procedures for voice services

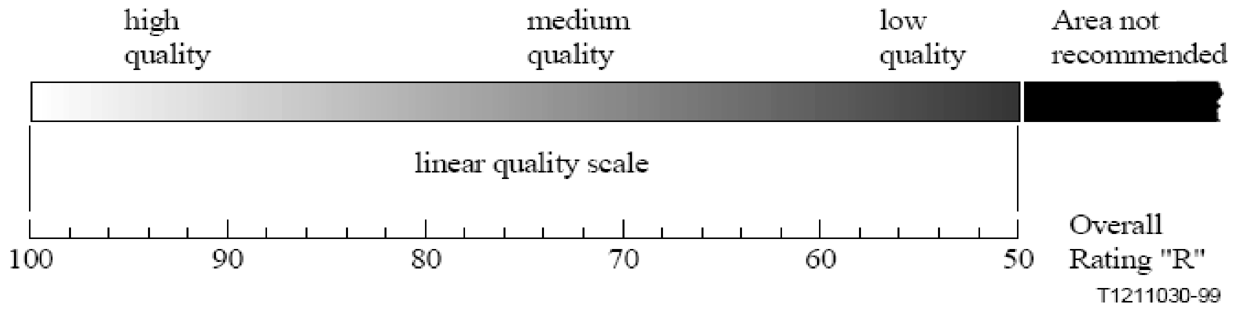
PESQ - (Perceptual Evaluation of Speech Quality). The ITU standard P.862. It measures speech quality in the ultimate terms - customer perception.

• PESQ is the most accurate speech quality standard against which many other speech quality algorithms are compared. It measures the effects of distortions such as noise and delay to model and predict subjective quality. It produces voice quality measurement scores based on the ITU Mean Opinion Score P.800.1 (MOS) scale which is representative of customers' perceptions of quality.

• PESQ measures end to end voice quality by comparing an input test signal with the signal output, and is effective across a range of network types, including PSTN, mobile, and VoIP.

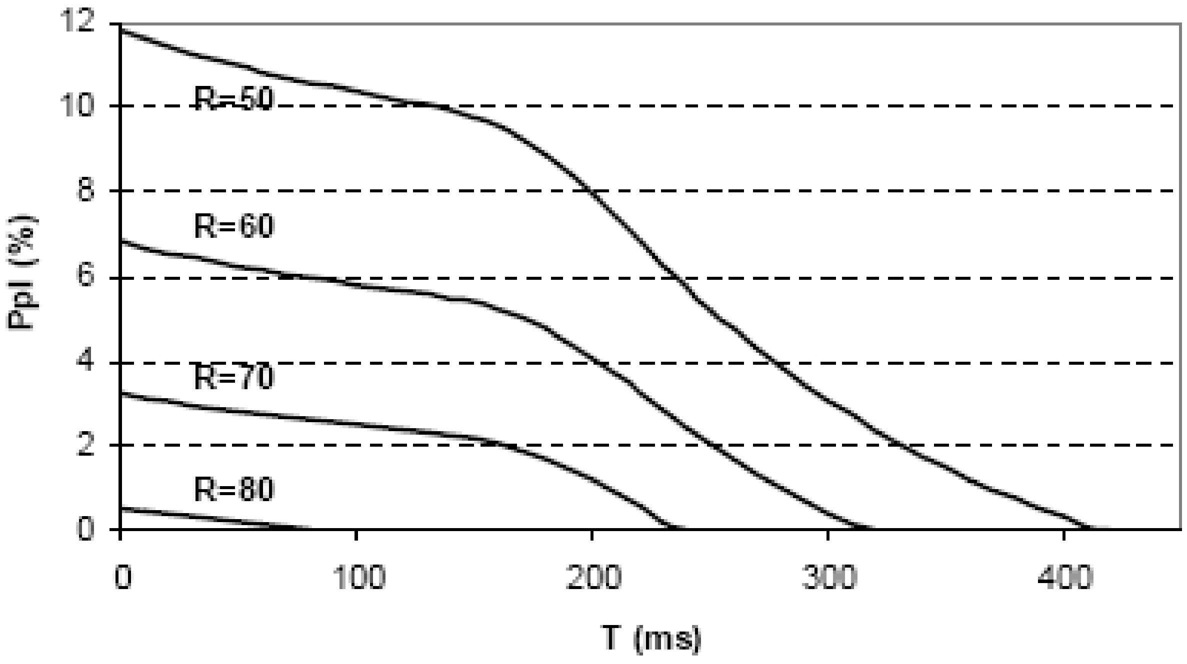
QoS performance rating for voice services

R-value range	Speech transmission quality category	User satisfaction
$90 \leq R < 100$	Best	Very satisfied
$80 \leq R < 90$	High	Satisfied
$70 \leq R < 80$	Medium	Some users dissatisfied
$60 \leq R < 70$	Low	Many users dissatisfied
$50 \leq R < 60$	Poor	Nearly all users dissatisfied



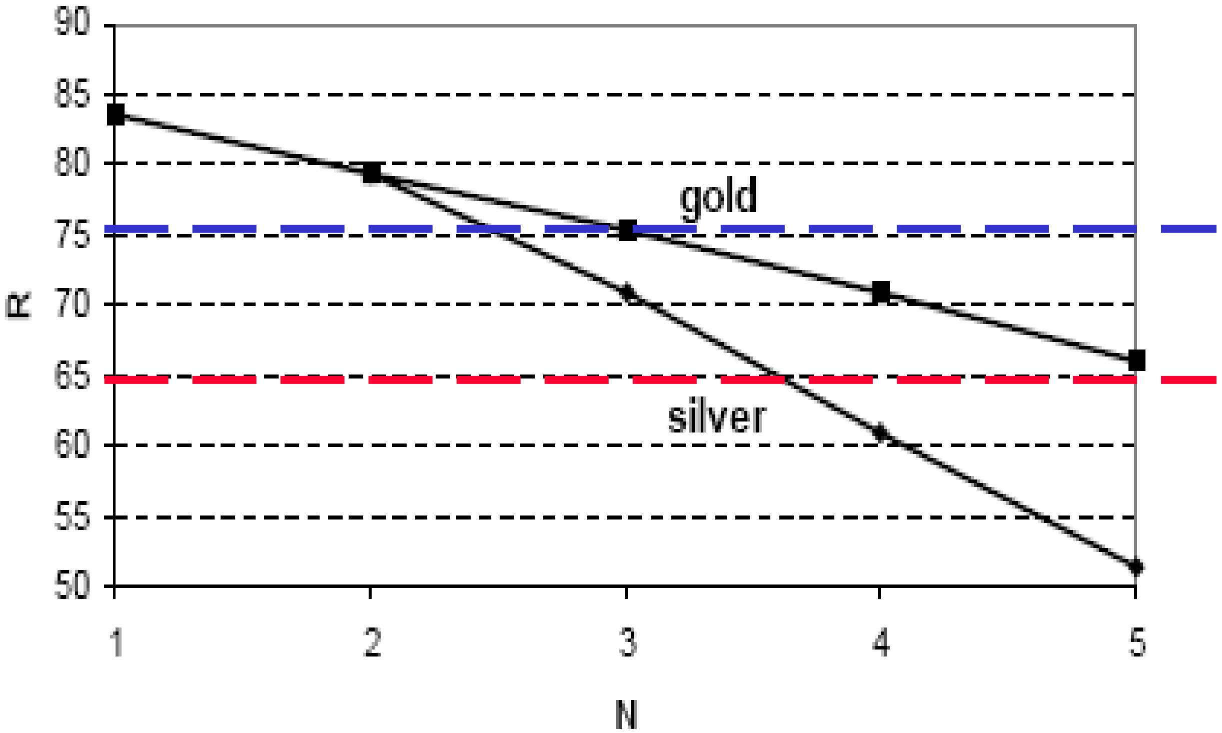
QoS rating for VoIP as function of packet loss and delay

Iso-quality curves as a function of packet delay and packet loss probability for G.729 (19th International Teletraffic Congress September 2005, Beijing)



QoS rating for VoIP as function of crossed hops

Perceived Quality of Service as a function of the number of crossed domains for the G.711+PLC coding with ppp = .01 and gold /silver SLA (19th International Teletraffic Congress September 2005, Beijing)



- **"Gold"** implies a T< 100ms, ppp< 1% and jitter <10ms (business customers)

- **"Silver"** implies a T< 150 ms. ppp< 2% and jitter < 30ms (residential customers)

QoS parameters and values for network design and planning

QoS	Priority	Bit loss Probability	Packet loss probability	Packet delay	Jitter	Availability
Stream constant	High	<10e-9	<10e-3	<150 ms	<10 ms	>99.999%
Stream Variable	High and medium	<10e-9 <10e-5	<10e-2 <5x10e-2	<150 ms < 400ms	<10 ms <30 ms	>99.999% >99.99%
Elastic	Low	<10e-3	Without guarantee	Without guarantee	Without guarantee	Without guarantee

Reference guide for QoS classes in IP operation

Table 2/Y.1541 – Guidance for IP QoS classes

QoS class	Applications (examples)	Node mechanisms	Network techniques
0	Real-time, jitter sensitive, high interaction (VoIP, VTC)	Separate queue with preferential servicing, traffic grooming	Constrained routing and distance
1	Real-time, jitter sensitive, interactive (VoIP, VTC).		Less constrained routing and distances
2	Transaction data, highly interactive (Signalling)	Separate queue, drop priority	Constrained routing and distance
3	Transaction data, interactive		Less constrained routing and distances
4	Low loss only (short transactions, bulk data, video streaming)	Long queue, drop priority	Any route/path
5	Traditional applications of default IP networks	Separate queue (lowest priority)	Any route/path
NOTE – Any example application listed in Table 2 could also be used in Class 5 with unspecified performance objectives, as long as the users are willing to accept the level of performance prevalent during their session.			

QoS reference parameters per call processing class

Table IV.1/Y.1530 – Call processing QoS class definitions and performance objectives

Call processing QoS class	Connection set-up parameters			Connection disengagement parameters	
	Connection set-up delay	Connection set-up error probability	Connection set-up failure probability	Connection disconnect delay	CPDP CCFP
QoS Class E (High or Excellent priority level)	Mean < 7500 ms 95%ile < 8450 ms (FFS)	Default (FFS)	Mean < A (FFS)	Defaults Mean = 3500 ms 95%ile = 4250 ms [I.352]	Defaults (FFS)
QoS Class 1 (Ordinary telephone level)	Mean = 7500 ms 95%ile = 8450 ms [I.352]		Mean = A (Value A is FFS) [I.359]		
QoS Class 2 (IP telephone level)	Mean > 7500 ms 95%ile > 8450 ms (FFS)		Mean > A (FFS)		
QoS Class U (Best effort level)	U	U	U	U	U

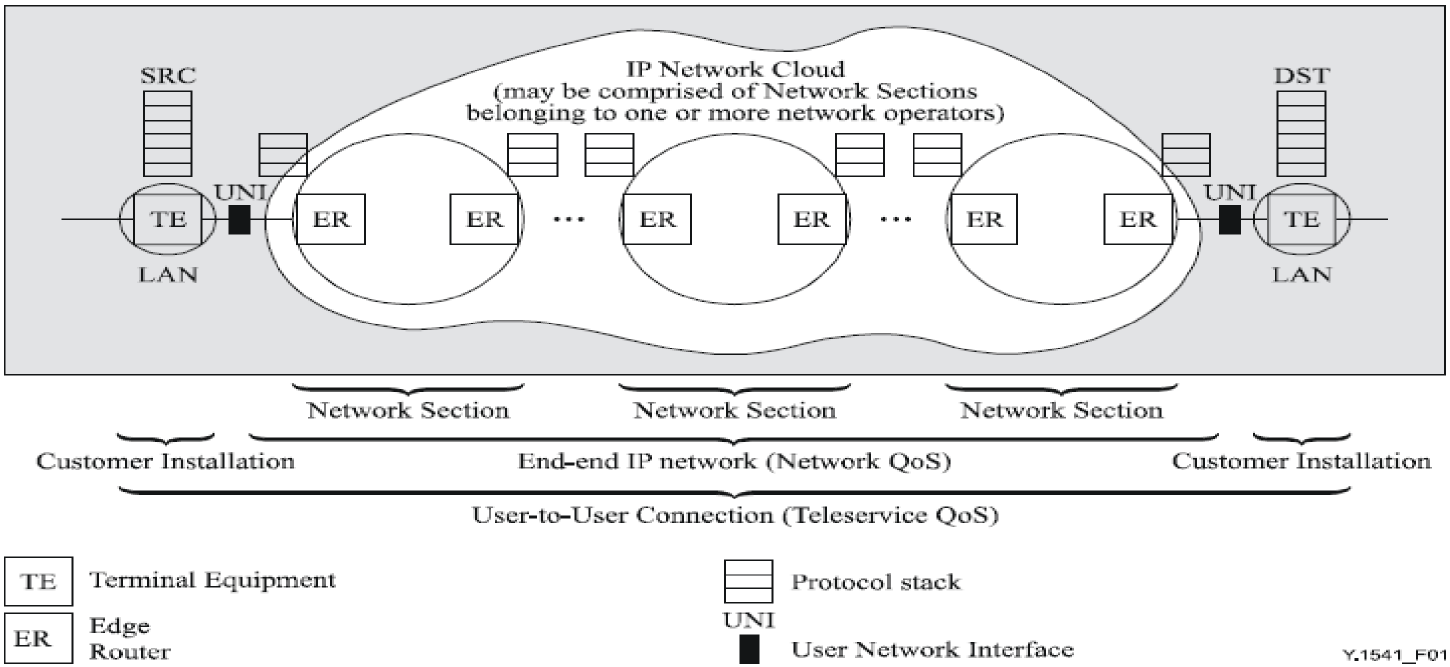
CPDP Connection Premature Disconnect Probability
CCFP Connection Clearing Failure Probability
U Unspecified or Unbound
FFS For further study

QoS reference values per call processing class

Table 1/Y.1541 – IP network QoS class definitions and network performance objectives

Network performance parameter	Nature of network performance objective	QoS Classes					
		Class 0	Class 1	Class 2	Class 3	Class 4	Class 5 Unspecified
IPTD	Upper bound on the mean IPTD (Note 1)	100 ms	400 ms	100 ms	400 ms	1 s	U
IPDV	Upper bound on the $1 - 10^{-3}$ quantile of IPTD minus the minimum IPTD (Note 2)	50 ms (Note 3)	50 ms (Note 3)	U	U	U	U
IPLR	Upper bound on the packet loss probability	1×10^{-3} (Note 4)	1×10^{-3} (Note 4)	1×10^{-3}	1×10^{-3}	1×10^{-3}	U
IPER	Upper bound	1×10^{-4} (Note 5)					U

Reference path for end to end QoS application



NOTE – Customer Installation equipment (shaded area) is for illustrative purposes only.

Figure 1/Y.1541 – UNI-to-UNI reference path for network QoS objectives

Reference points for inter-domain performance measurement

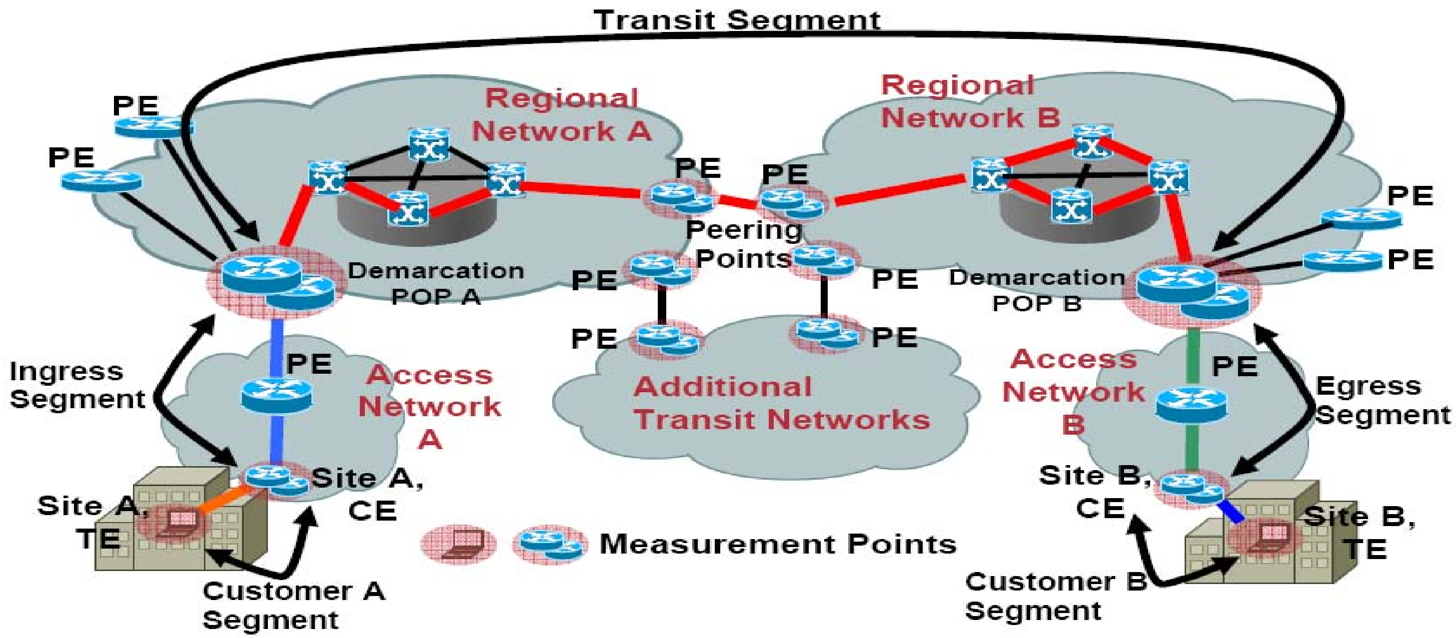


Figure 5/Y.1543 – TE-TE Model

Maturity of standards related to traffic and performance

- Standards well defined for NGN protocols and interfaces. Specific implementations may vary in additional features.
- Standards well defined for NGN intra-domain routing. Specific implementations may vary in additional features.
- Solutions defined for inter-domain routing but agreements on applicability and adoption at early stages. SLA negotiated on a bilateral basis
- Solutions for dimensioning and quality of service provisioning defined at intra-domain level and early definitions at end to end level.
- Traffic units and engineering rules available at scientific forums (i.e.: International Teletraffic Congress) but still not of extended applicability or standardization. Today case by case applications by experts.