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"New Issues in Quality of Service Measuring and Monitoring“

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Interactive workshop 1: QoS/QoE frameworks for converged services and applications

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QoS/QoE from the ITU perspective

Introduction

- The term **Quality of Service (QoS)** is extensively used today in the telecommunication/ICT world in which it has its roots
  - including the current developments in the field regarding broadband, wireless/mobile and multimedia services.
- In general, all services from the second decade of the 21st century converge toward **Internet**, including:
  - **IP-based networks** (access, core/backbone, and transit) and
  - **IP based services**, including
    - QoS-enabled i.e. managed services; and
    - OTT (Over-The-Top) services, which are provided in best-effort manner, without end-to-end QoS, and based on network neutrality principle in current Internet.
- So, QoS is moving from its initial definitions targeted to traditional telecommunication networks (e.g., **PSTN/ISDN**, **broadcast networks**) to **QoS** in **IP** networks and services.

QoS and its Understanding

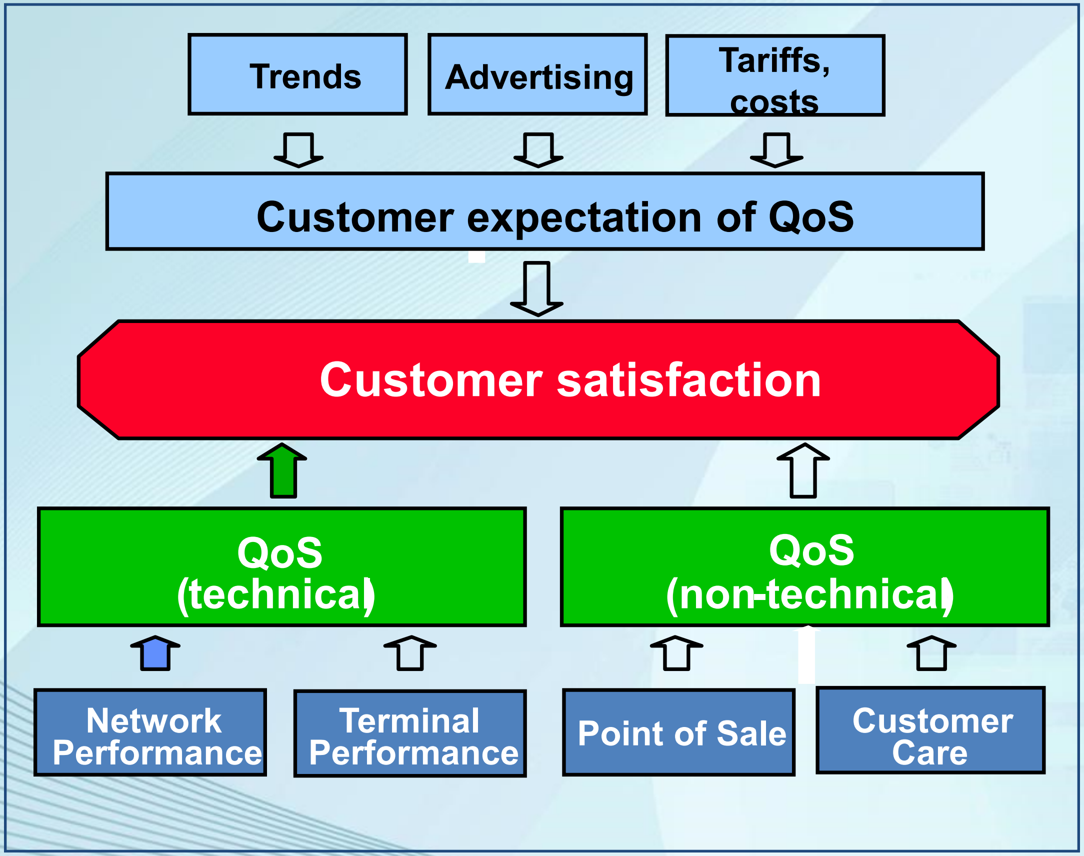
- Networks and systems are gradually being designed in consideration of the **end-to-end performance** required by user applications;
  - however, the **term "QoS" is usually not well-defined**, is used loosely or, worst of all, misused.

- Depending on what aspects of quality are examined and what kind of services/technologies are involved, **different definitions** and concepts of quality are often used.
  - The variety of different definitions demonstrates the difficulties in assessing all aspects related to the term "QoS".

- In many industry standards, reports and specifications, QoS is not clearly defined, or else reference is made to ITU-T Rec. **E.800**.

User Perception of Services

- End-user perception of telecommunication services is influenced also by trends, advertising, tariffs and costs, which are interrelated to the customer expectation of the QoS.

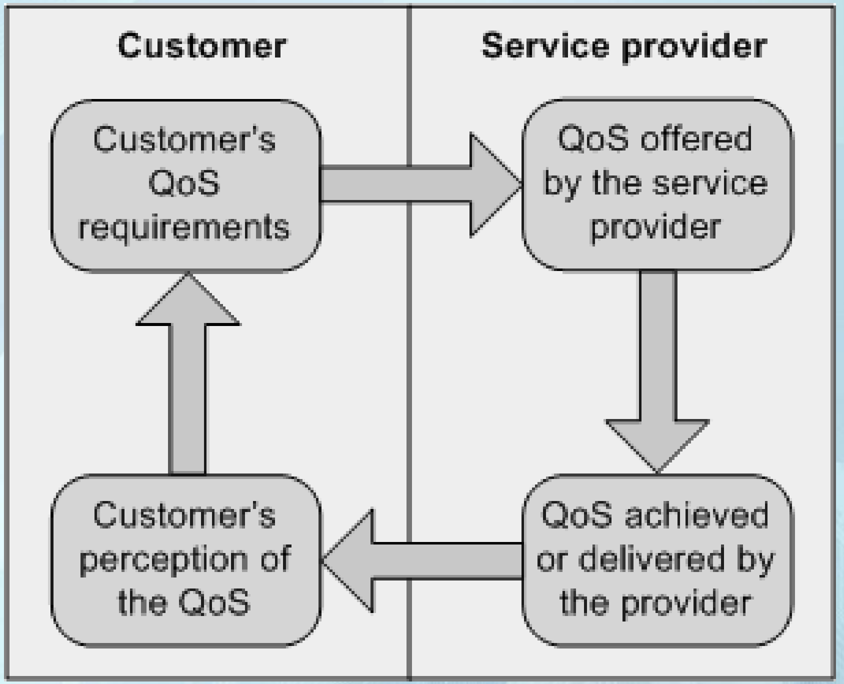


- User Perception of quality is not limited to the objective characteristics at the man-machine interface.

- For end-users also counts the quality that they personally experience during their use of a telecommunication service.

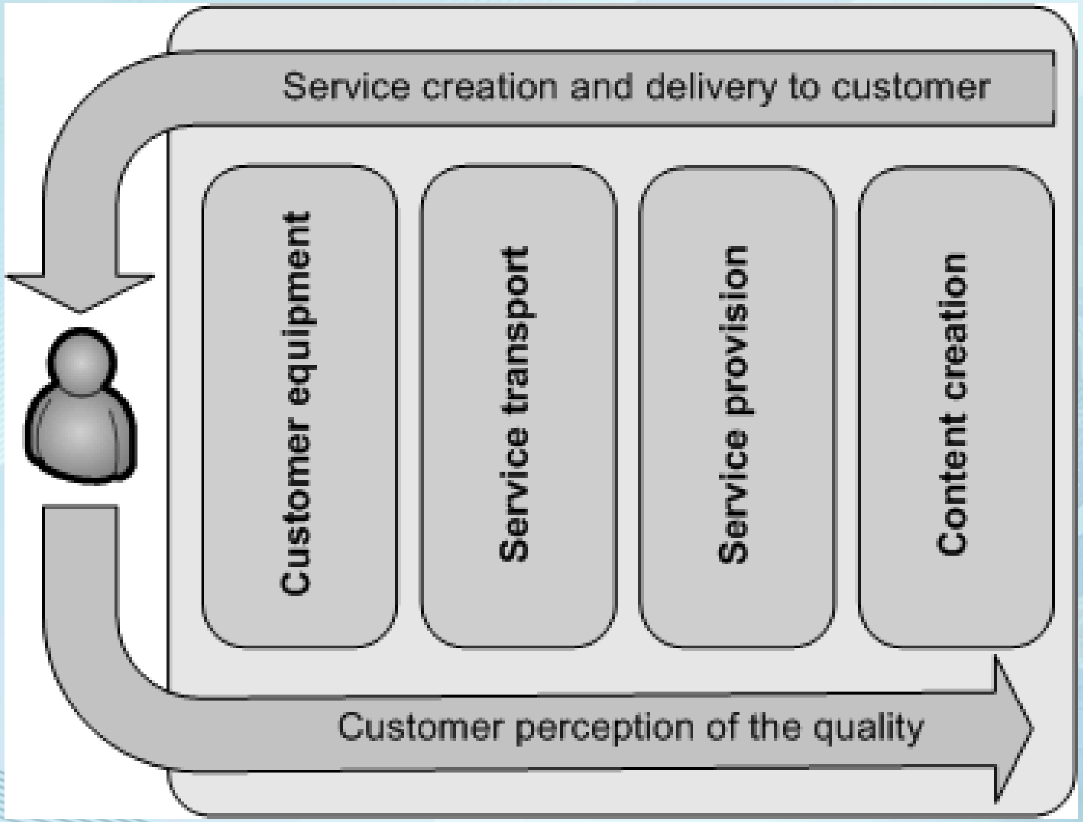
Four Viewpoints of QoS

- **QoS** can be divided into **four viewpoints** (ITU-T G.1000):
  - Customer viewpoints on:
    - Requirements,
    - Perception.
  - Service provider viewpoints on:
    - QoS offered,
    - QoS achieved.



Four Market Model

- The given four-market model provides possibility to identify QoS criteria for one or more components in the model.

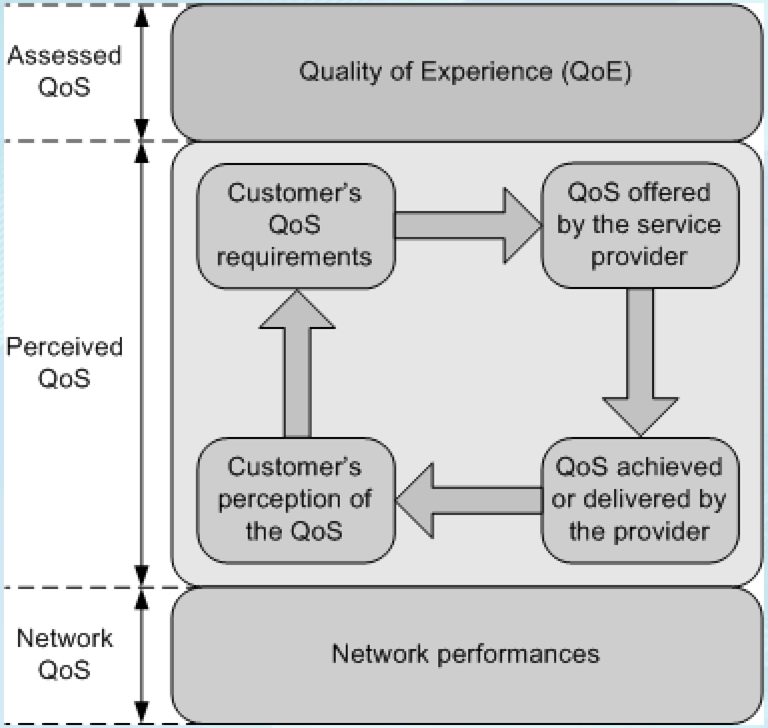


ITU QoS Framework and Regulation

- The given ITU-T QoS framework, including the four viewpoints as well as four-market model, provides basis for definition of both:
  - **QoS-enabled** Internet regulation (e.g., Next Generation Networks – NGN) and
  - **best-effort** Internet regulation (i.e., **network neutral** approach, which is without QoS support by default).
- In the second decade of the 21st century QoS regulation regarding the access to the Internet targets mainly Internet access bitrates and particularly is concerned with regulation of the broadband access to Internet.
- In fact, there are two possible aspects of **QoS regulation**:
  - QoS regulation between operators **at interconnection**, and
  - QoS regulation **between operators and end-users**.

QoE and QoS relation

- One may consider QoE on the edge between the perceived and assessed service quality by the end user:



Quality of Experience (QoE) and Quality of Service (QoS) by ITU-T

Service Quality Criteria

- To provide QoS support for a given service one needs definition of **QoS criteria** and parameters.
- Such definitions are given in ITU-T recommendations **G.1000**, which gives general QoS framework.
- It specifies 7 QoS criteria:
  - **speed** (refers to all service functions),
  - **accuracy** (e.g., speech quality, call success ratio, bill correctness, etc.),
  - **availability** (e.g., coverage, service availability, etc.),
  - **reliability** (e.g., dropped calls ratio, number of billing complaints, etc.),
  - **security** (e.g., fraud prevention),
  - **simplicity** (e.g., easy of software updates, easy of contract termination, etc.), and
  - **flexibility** (e.g., easy of change in contract, availability of different billing methods such as online billing, etc.).

QoE vs. QoS discussion

- On one side, it includes the QoS perceived by the customer and QoS that is required by the customer (something that belongs to the ITU-T QoS model).
- On the other side, QoE also includes qualitative terms that refer to the user satisfaction from the provided service as well as the user attraction with the services.

- In general, QoE is influenced by all **7 QoS criteria**.
  - For example, **speed** influences the available throughput and latencies and it is of crucial importance for the QoE.
    - That is why going towards broadband access and higher access bit rates (including fixed and mobile broadband) the overall QoE improves.

QoE Influenced by QoS Criteria

- **Availability** and **reliability** are also very important, which depends upon the capability of the network to recover from a failure (e.g., SON solutions in 4G, resilience solutions in optical networks, etc.) as well as appropriate planning and dimensioning of the network (to suit to the expected number of users for a given service or services).
  - For example, typical quality metrics for network availability from the SDH-era onwards are so-called “five 9s”, i.e., 99.999% of the time service to be available to end users, which request certain survivability mechanisms to be implemented in the network (e.g., re-routing of the traffic in a case of failure over alternative or reserved paths in the network).
- Also, **security** aspects, **accuracy**, **simplicity** to use the service, and **flexibility** regarding the services, influence the QoE.

Relationship among Network Performance, QoS and QoE

- **QoE is quite different with QoS and NP**, because it has subjective feature in the definition.
  - QoE has a dependency of end user perception as well as features of services, thus it could have quite different ways to specify the value.
  - But it is clear **QoE should be impacted from the QoS and NP** even though end user subjective.
- Taking into account those differences given by definitions of NP, QoS and QoE, key features of these three should be summarized as given below (based on ITU-T Recommendation **I.350**).

Quality of Experience (QoE)	Quality of Service (QoS)	Network Performance (NP)
User oriented		Provider oriented
User behaviour attribute	Service attribute	Connection/Flow element attribute
Focus on user- expected effects	Focus on user-observable effects	Focus on planning, development (design), operations and maintenance
User subject	Between (at) service access points	End-to-end or network elements capabilities

Some Overview on Internet QoS

Internet QoS Introduction

- **Internet** is created initially for **best-effort** service, which means that every connection is admitted in the network and every packet is transferred from source to destination with the best effort by the network, without any guarantees regarding the **QoS**.
  - However, Internet designers have allocated possibility for QoS support even in Internet Protocol (IP) in both versions, **IPv4** (or simply IP) and **IPv6**.
- The whole **telecommunication** world **is transiting to Internet** as single networking platform for all telecommunication services,
  - Including native Internet services (e.g., WWW, email, etc.) and traditional telecommunication services (e.g., telephony, television, etc.).
- Therefore, understanding the Internet technologies and standardized mechanisms by **IETF (Internet Engineering Task Force)** has high importance for QoS issues and solutions.

About the Internet QoS Goal

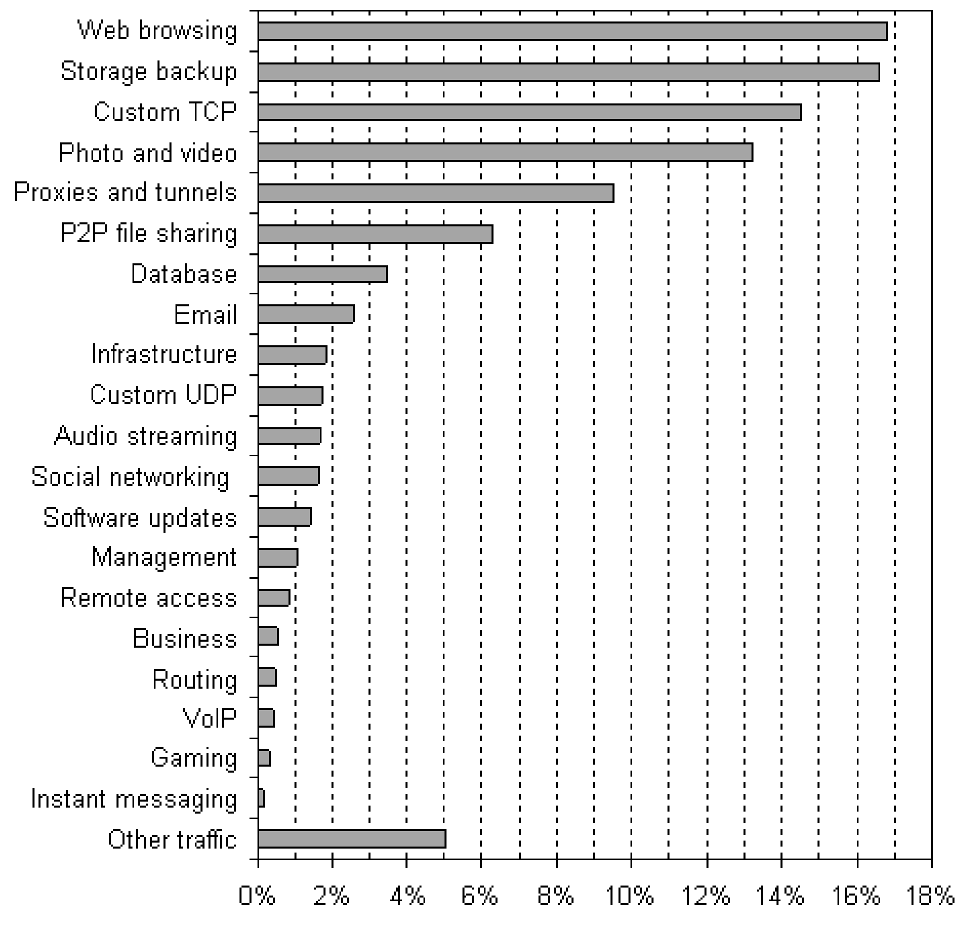
”The Holy Grail of computer networking is to design a network that has the flexibility and low cost of the Internet, yet offers the end-to-end quality-of-service guarantees of the telephone network.”

- S. Keshav

Internet traffic characteristics

- Traffic characteristic influence the network performances and QoS solutions.
- Typically there are the following types of traffic in Internet:
  - **Voice** traffic
    - Has constant bit rate when sending;
    - Requires relatively small IP packets (e.g., 50 – 200 bytes).
  - **Video** traffic
    - Has generally high variable bit rate;
    - Controlled by codec efficiency on picture;
    - Message size is generally the Message Transfer Unit (MTU).
  - **Data** traffic
    - This is typically non-real-time traffic in Internet (e.g., WWW, email);
    - It is typically TCP-based.

Bandwidth Usage of the Internet Applications



Source: Toni Janevski, "Internet Technologies for Fixed and Mobile Networks", Artech House, USA, Dec. 2015.

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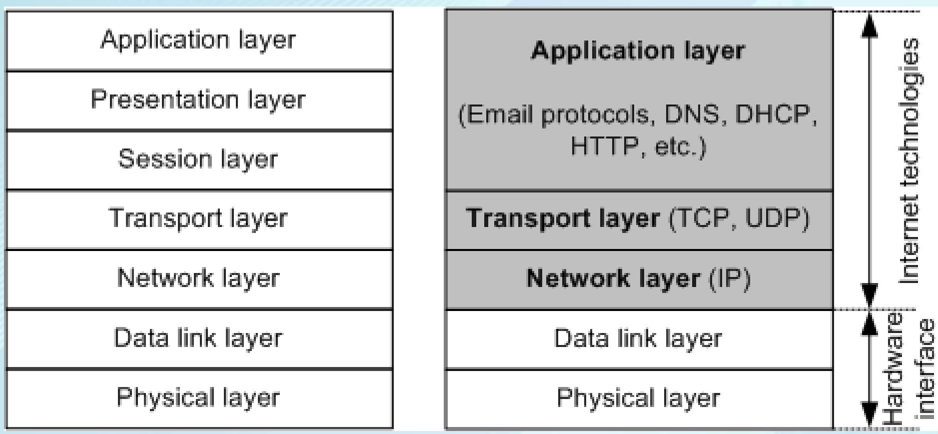
What to do with Different Traffic Types in Internet?

- **Internet** is initially **designed** to provide **best-effort service**, i.e., all IP packets are treated in the same manner.
- However, **not all packets are the same**,
  - Web as interactive application is delay sensitive;
  - Voice/Video streaming is delay and jitter sensitive;
  - Online Games are delay and jitter sensitive;
  - BitTorrent is generally insensitive (delay, jitter, bandwidth do not matter), file transfer will finish eventually (higher bandwidth will help)
  - and so on...
- When all traffic in multiplexed onto the same links and networks, including traditional telephony (as VoIP) and television (as IPTV), then the network needs to have techniques to give **better quality to some packets** for certain types of **applications/services**.

Protocol Layering Model

- To understand the QoS in Internet, one needs to know the protocols layering stack, going from physical layer at the bottom up to application layer on the top.

OSI protocol model | **Internet protocol model**



Comparison of traditional Internet protocol model with the OSI layering model

Internet technologies are used from the network layer (there is placed IP) up to the application layer

Different access and transport technologies have different interfaces (e.g., Ethernet, WiFi, 3G, 4G, ADSL, etc.)

Source: Toni Janevski, “NGN Architectures, Protocols and Services”, Wiley, UK, 2014.

Transport Requirements of Common Internet Applications

Application	Data loss	Bandwidth	Delay Sensitive
File transfer	no loss	elastic	no
E-mail	no loss	elastic	no
Web	no loss	elastic	yes, few secs
Real-time audio/video (VoIP/video telephony)	loss-tolerant	audio: 5kbps-1Mbps video:10kbps-5Mbps	yes, <150 msec
Stored audio/video	loss-tolerant	same as above	yes, few secs
Online games	loss-tolerant	few kbps up	yes, <100 msec
instant messaging	no loss	elastic	yes, few secs

Applications that are **loss tolerant** and **delay sensitive** use **UDP** (it provides lower end-to-end delay because UDP has no retransmissions).
Applications that require **no loss** use **TCP** as transport layer protocol (it uses retransmissions of lost segments, but that results in higher average delays than UDP).

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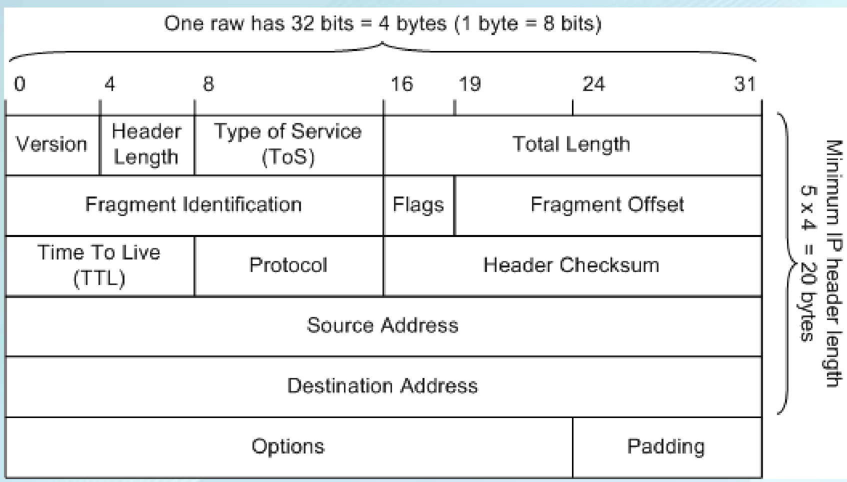
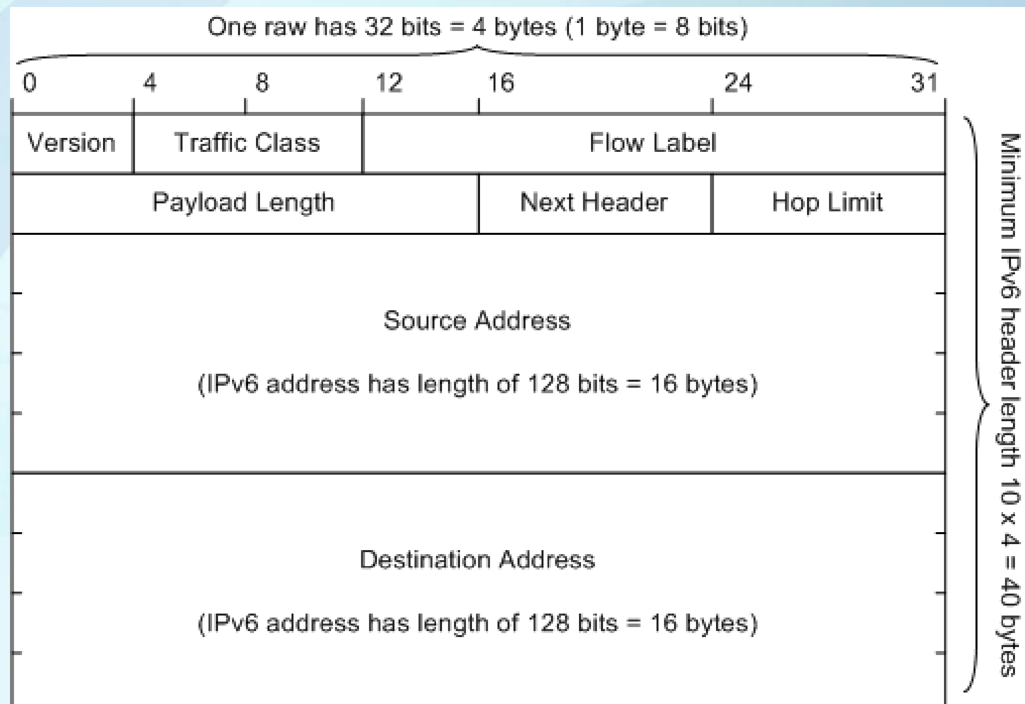
IPv4 vs. IPv6 Header

- **Internet Protocol (IP)** is standardized in two versions:
  - Internet Protocol version 4 (**IPv4** or simply IP), IETF **RFC 791** (from 1981);
  - Internet Protocol version 6 (**IPv6**), IETF **RFC 2460** (from 1998).



IPv4 header



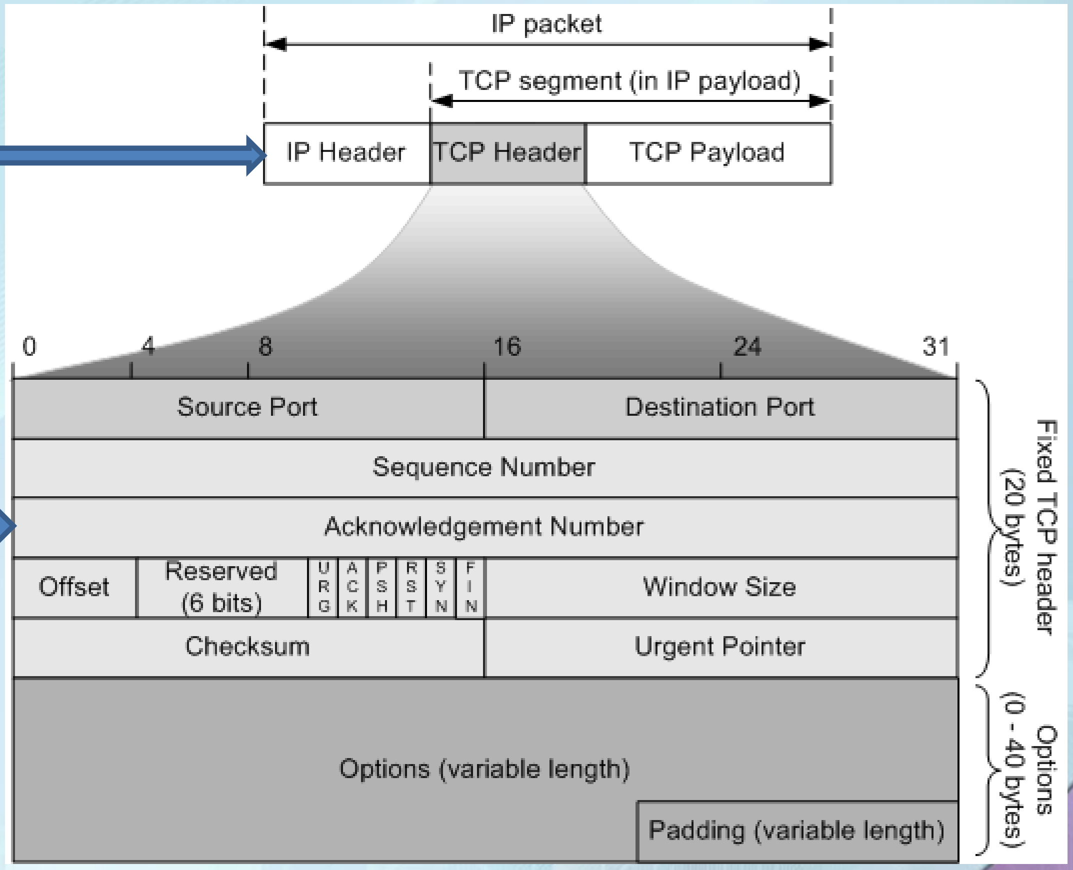
IPv6 header

Source: Toni Janevski, "NGN Architectures, Protocols and Services", Wiley, UK, 2014.

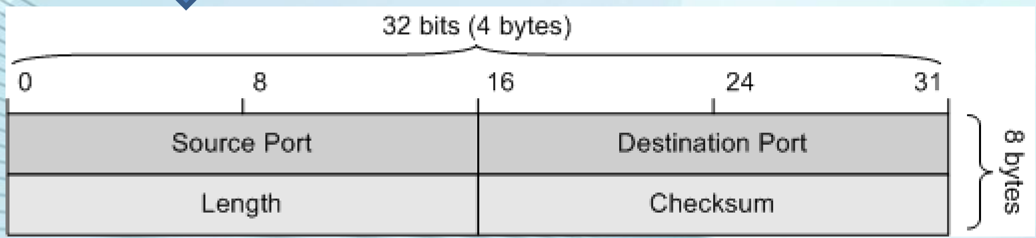
IP Packet

IP packet travels end-to-end. The given example is based on TCP as transport protocol and IPv4 (i.e., TCP/IP). TCP payload can come from any application protocol that uses TCP (e.g., Web i.e. HTTP, email protocols, FTP, etc.)

TCP header



UDP header – UDP/IP is typically used for real-time data (e.g., VoIP, IPTV) and certain control traffic (e.g., DNS).



Source: Toni Janevski, "Internet Technologies for Fixed and Mobile Networks", Artech House, USA, Dec. 2015.

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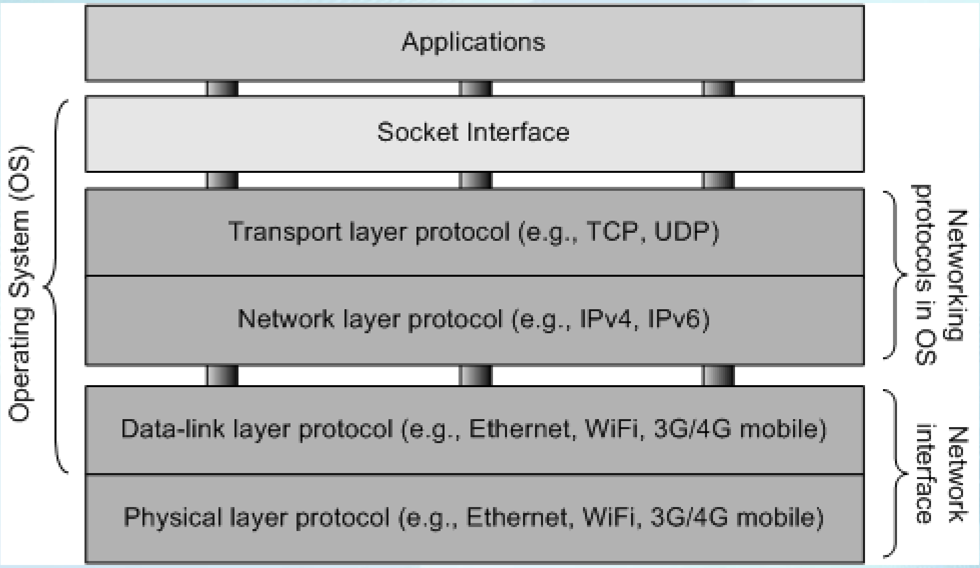
Internet Protocol Stack

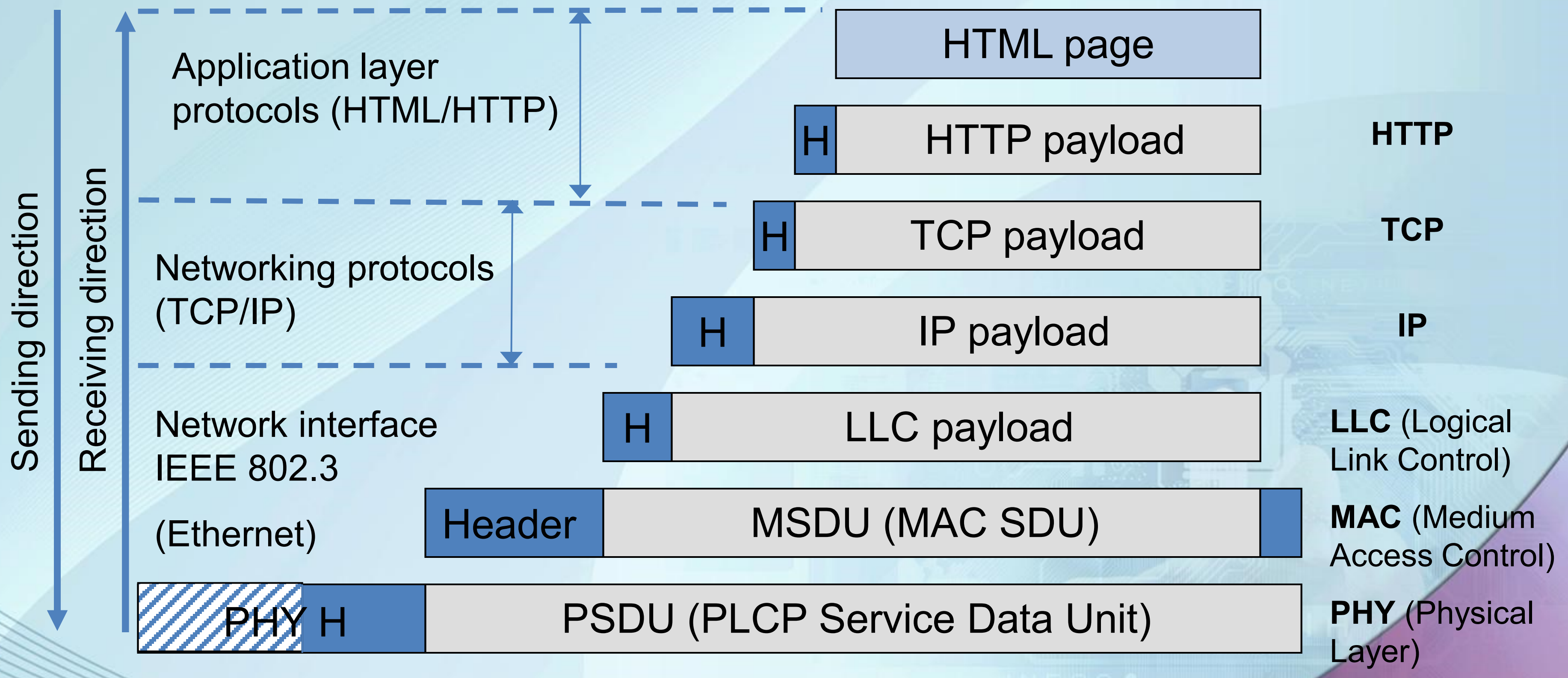
- Internet Protocol stack can be grouped into three main groups (bottom-up): **network interface**, **networking protocols** (e.g., TCP/IP, UDP/IP), and **applications**.



Source: Toni Janevski, "Internet Technologies for Fixed and Mobile Networks", Artech House, USA, Dec. 2015.

Internet Headers and Payloads

- This is a protocol unit structure for sending/receiving a Web page:



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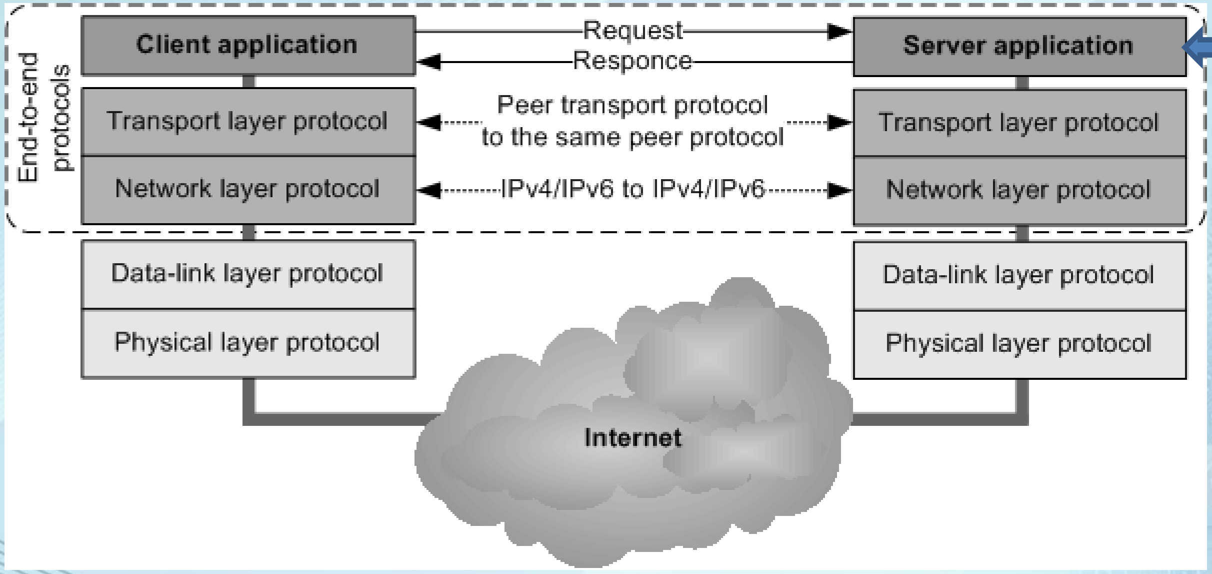
Client-Server Communication

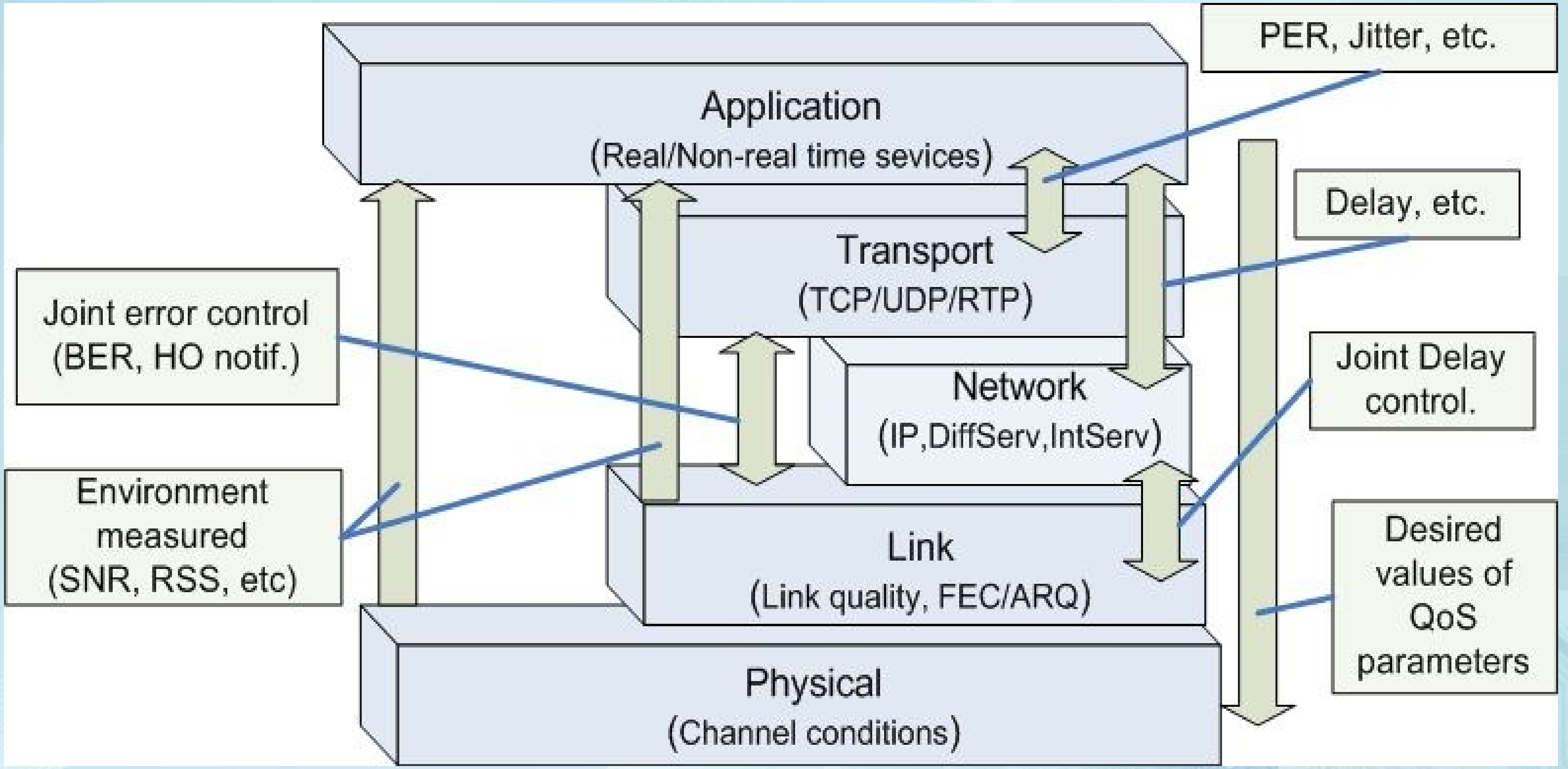
- Main principle in **Internet communication** is **client-server**:
  - **Server**: provides service through well defined server interface.
  - **Client**: requests a service from the server through well defined client interface.
  - **Both endpoints** (i.e., hosts) in communication over client-server network architecture must use the **same transport protocol** (e.g., TCP, UDP).



The **peer applications on both end hosts** in each communication must use the **same type of applications** (e.g., Web clients communicate with Web servers, FTP clients communicate with FTP servers, etc.).

Source: Toni Janevski, "Internet Technologies for Fixed and Mobile Networks", Artech House, USA, Dec. 2015.

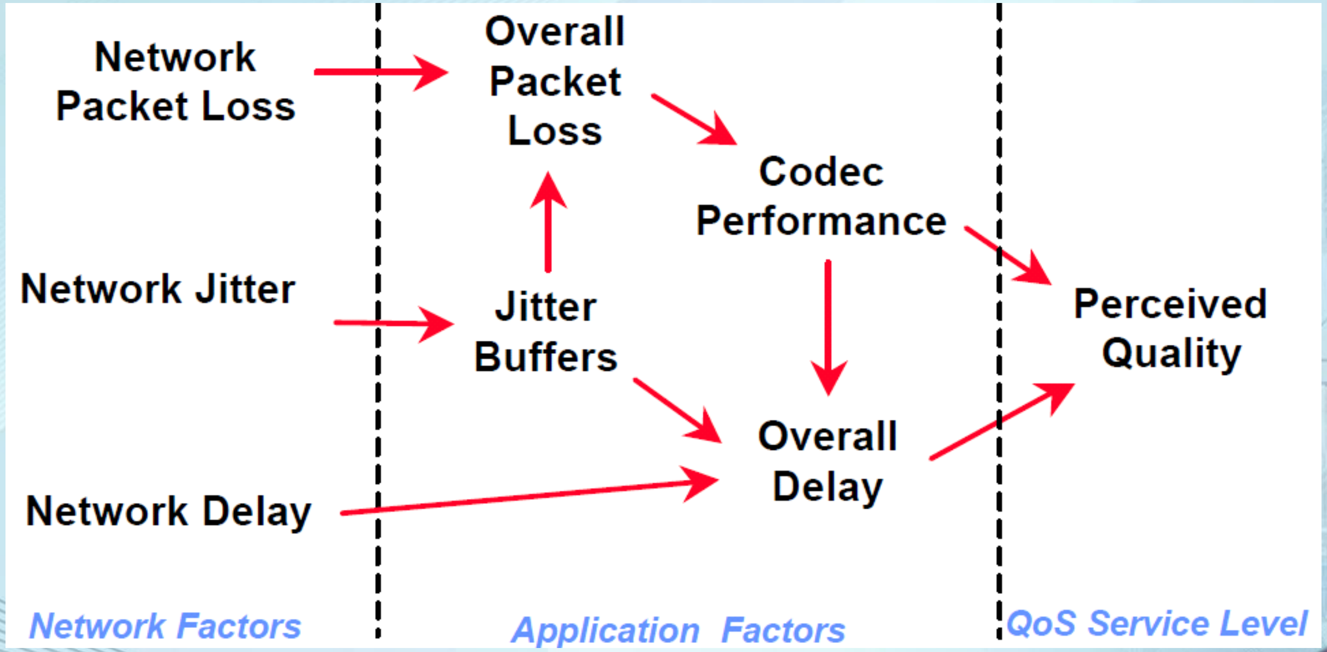
QoS on Different Protocol Layers



ARQ – Automatic Repeat reQuest (error control on data-link layer)
BER – Bit Error Ratio (QoS parameter on physical layer
DiffServ – Differentiated Service (IETF QoS mechanism on network layer)
HO – Handover (in mobile networks)
FEC – Forward Error Correction (channel coding technique over noisy channels)
IntServ – Integrated Services (IETF QoS mechanism on network layer)
IP – Internet Protocol (networking protocol on network layer
PER – Packet Error Ratio (from network layer up to the application layer)
RSS – Received Signal Strength (typically in mobile networks)
SNR – Signal-to-Noise Ratio (physical layer)

Inter-relationship of QoS Parameters

- Some QoS parameters specifying network factors can be impacted to application factors.
- Similarly some parameters belong to application factors also can be impacted to service level of QoS which lead QoE.
- QoS parameters have inter-relationship among themselves as shown:



How do we Classify Packets?

- It depends on the approach, there are different options on the table:
  - Classification **based on ports** (port are used by transport layer protocols such as TCP and UDP to identity applications on the top)
    - For example, port 80 (HTTP, i.e., Web) takes precedence over port 21 (FTP).
  - Classification **based on application type**
    - For example, carrier grade VoIP takes precedence over HTTP, BitTorrent.
  - Classification **based on user type**
    - For example, home and business users get normal service, but hospitals/policy/fire department get highest priority service.
  - Classification **based on subscription**:
    - For example, 50 USD for high speed Internet (guaranteed maximum access bitrates in downstream and upstream) vs. 10 USD for fair-usage policy based Internet (e.g., bitrate is proportionally downgraded with higher usage).
  - etc.

Packet Classification

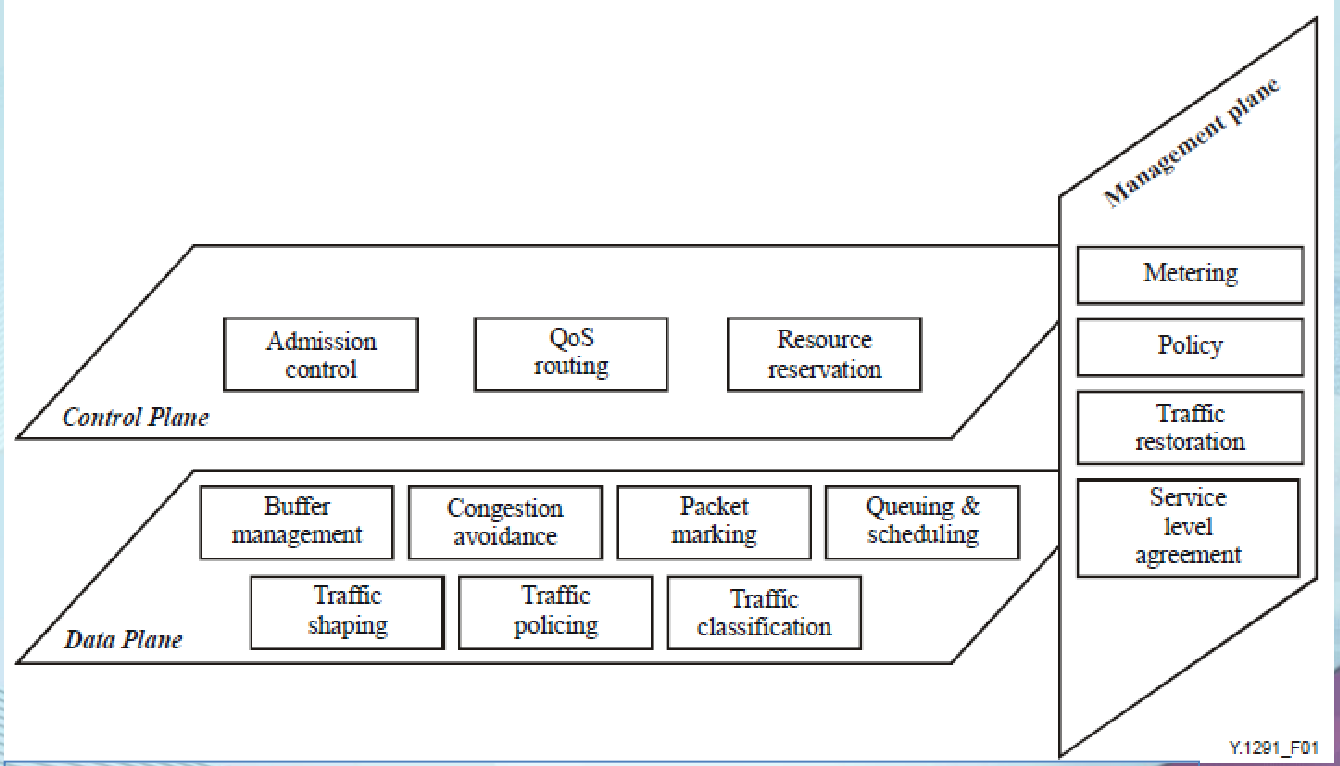
- Packet classification is needed to sort packets into flows (per class).
- This is needed for scheduling, such WFQ or PQ.
- Usually the following fields are used for classification (5-tuple):
  - **Source address** (from IP header);
  - **Destination address** (from IP header);
  - **Protocol number** (from IP header);
  - **Source port** (from transport protocol header, e.g., TCP, UDP);
  - **Destination port** (from transport protocol header, e.g., TCP, UDP).
- In IPv6 networks classification can be performed with 3-tuple (if Flow Label in IPv6 header is used):
  - {**Source address, Destination Address, Flow Label**} (from IPv6 header).
- Packet marking:
  - Packets classified at the edge router;
  - Core router check the mark.

Internet QoS Framework by IETF

- **Best effort**
  - This is traditional Internet model, without any QoS guarantees.
  - The IP networks just route packets until they reach the destination.
- **Integrated services (IntServ)**
  - This is first standardized mechanism by IETF, which is based on resource reservation in routers on the path by using signaling.
  - So routers have to store traffic and QoS information per connection (i.e., flow).
  - It is end-to-end QoS mechanism.
- **Differentiated services (DiffServ)**
  - This is the most commonly used method for traffic differentiation in Internet, in which all packets are classified into limited number of classes,
  - So routers have to store only information per class (not per connection, i.e., per flow).
  - It is hop-by-hop QoS mechanism.
- **Multi-Protocol Label Switching (MPLS)**
  - This is "default" approach for QoS provisioning in transport IP networks, which may be combined with DiffServ as well as other protocols such as BGP (Border Gateway Protocol), VPN (Virtual Private Networks) protocols.
- **Policy-based QoS**
  - This is typically used for QoS provisioning between network providers (e.g., BGP policies).

QoS Architectural Framework by ITU-T

- QoS architectural framework by ITU-T is organized into three planes (Y.1291):
  - **Control Plane**: admission control, QoS routing, and resource reservation.
  - **Data Plane**: buffer management, congestion avoidance, packet marking, queuing and scheduling, traffic classification, traffic policing and traffic shaping.
  - **Management Plane**: SLA, traffic restoration, metering and recording, and policy.



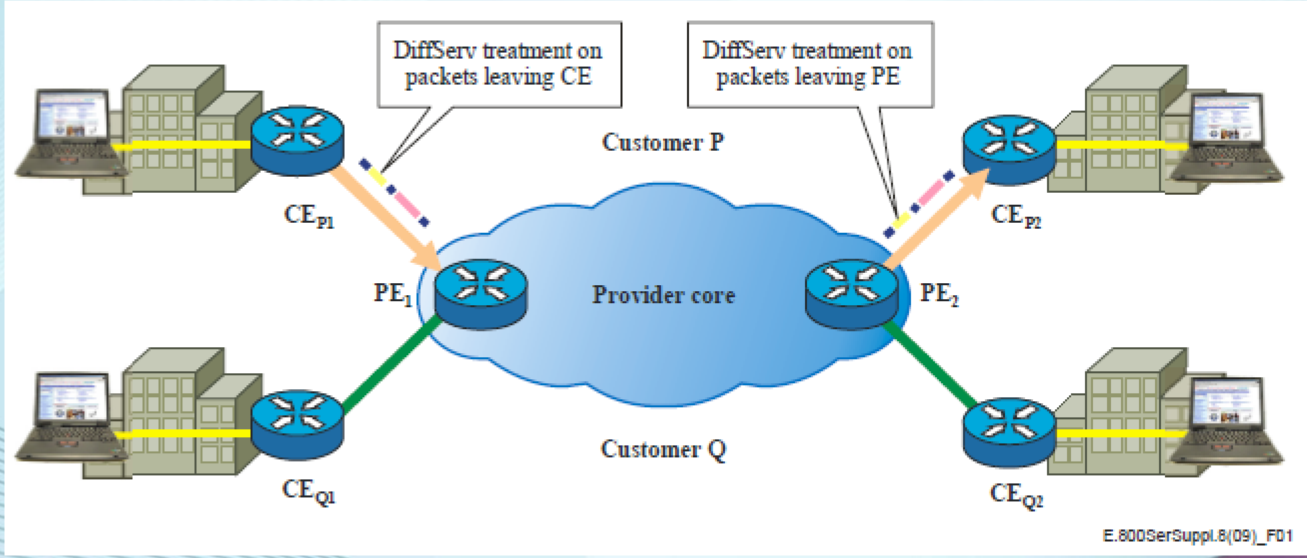
Source: ITU-T Rec. Y.1291, “An architectural framework for support of Quality of Service in packet networks”, 2004.

Comparison: Best-Effort, DiffServ, IntServ

	Best-Effort	DiffServ	IntServ
Service	Connectivity No isolation No guarantees	Per aggregate isolation Per aggregate guarantee	Per flow isolation Per flow guarantee
Service scope	End-to-end	Domain	End-to-end
Complexity	No setup	Long term setup	Per flow setup
Scalability	Highly scalable (nodes maintain only routing state)	Scalable (edge routers maintains per aggregate state; core routers per class state)	Not scalable (each router maintains per flow state)

Basic DiffServ Model for a Single Provider

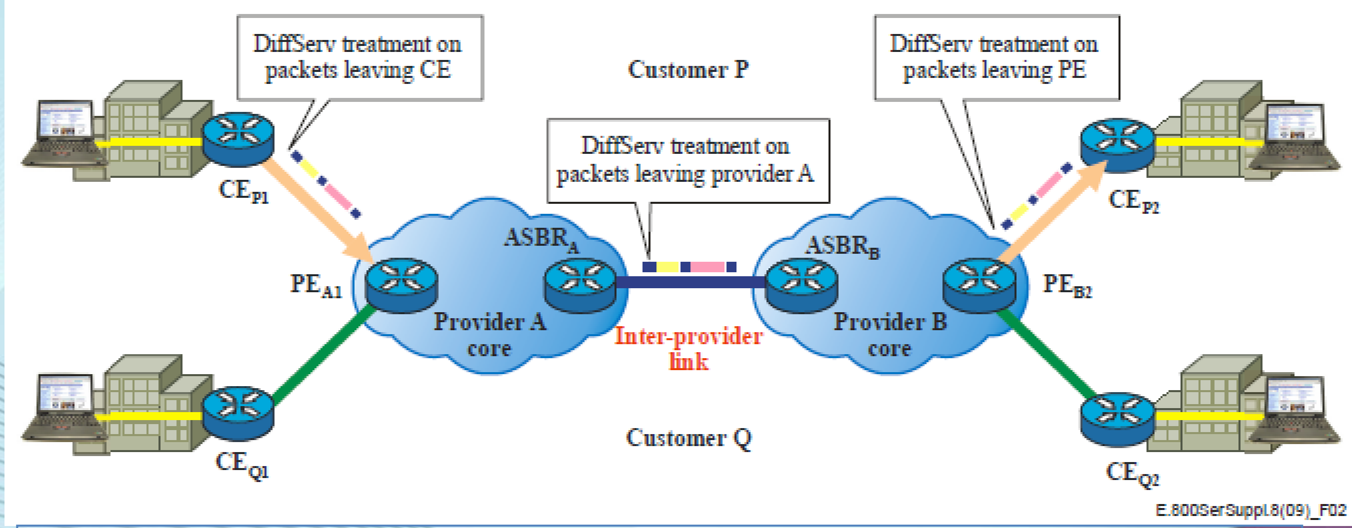
- In this model, customer sites connect to the provider via a **CE (Customer Edge)** device, and the provider's routers that connect to customer sites are PE (provider edge) devices (ITU-T Supplement 8 to E.800-series):
  - The **CE router** can therefore **prioritize and police** traffic put onto the CE to PE link to treat differently various classes of traffic.
  - The basic single provider reference model places no restrictions on the mechanisms that are deployed by the provider within his access and core networks. It can be **customer-managed** or **provider-managed** CE device.



Source: ITU-T Supplement 8 to E.800 series, "Guidelines for inter-provider quality of service", November 2009.

Basic Inter-Provider Model

- This is **Diffserv model** extended to a simple **inter-provider** scenario.
  - But, there are now two providers in the path between the two sites of each customer.
  - **Packets** should be **correctly marked** on inter-provider link, avoid modifications of packets, providers A and B should have agreement for **end-to-end service** (with appropriate QoS mechanism), and monitoring of customer in such case is likely to involve **both providers**.
  - The interconnection should be possible with MPLS VPN (RFC 4364), simple IP interconnect , as well as layer-2 interconnect (e.g., Ethernet, ATM).



Source: ITU-T Supplement 8 to E.800 series, "Guidelines for inter-provider quality of service", November 2009.

QoS Classes by ITU-T

- Based on the requirements of the key applications such as conversational telephony, reliable data applications based on TCP (e.g., WWW, email, etc.), and digital television, network **QoS classes** are specified by ITU-T (Rec. **Y.1541**).

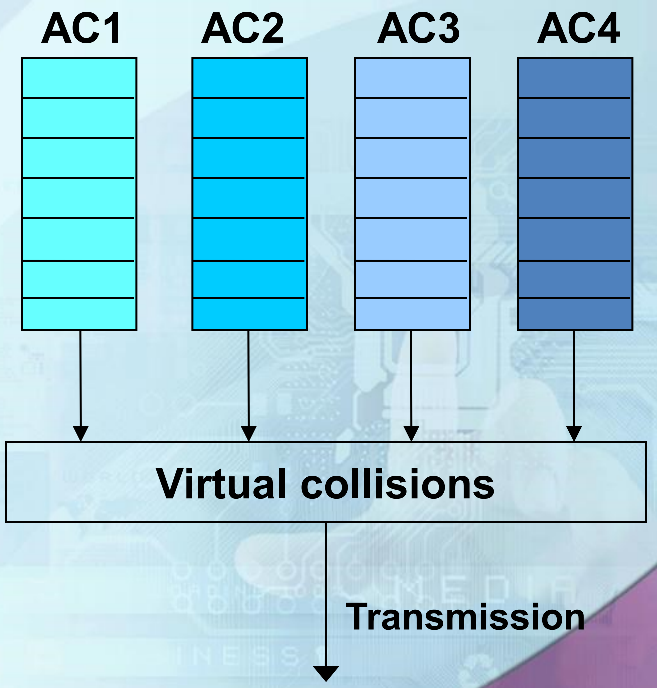
QoS Class	Upper bound on IPTD	Upper bound on IPDV	Upper bound on IPLR	Upper bound on IPER
Class-0	100 msec	50 msec	10^{-3}	10^{-4}
Class-1	400 msec	50 msec	10^{-3}	10^{-4}
Class-2	100 msec	Unspecified	10^{-3}	10^{-4}
Class-3	400 msec	Unspecified	10^{-3}	10^{-4}
Class-4	1 sec	Unspecified	10^{-3}	10^{-4}
Class-5	Unspecified	Unspecified	Unspecified	Unspecified
Class-6	100 msec	50 msec	10^{-5}	10^{-6}
Class-7	400 msec	50 msec	10^{-5}	10^{-6}

IPDV – IP packet Delay Variation
IPER – IP packet Error Ratio
IPLR – IP packet Loss Ratio
IPTD – IP packet Transfer Delay

WiFi QoS Support

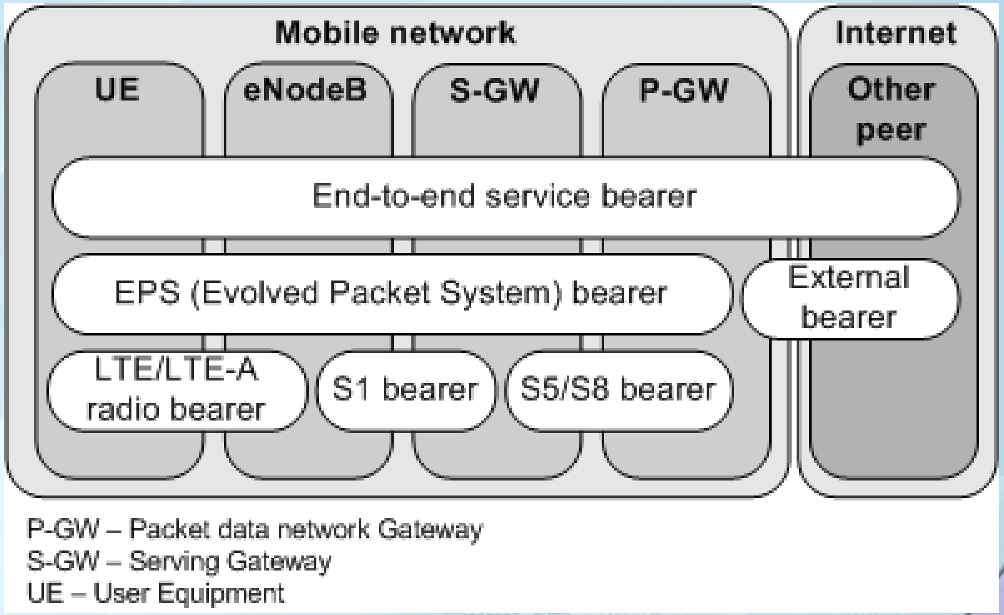
- QoS support in WiFi in provided with IEEE 802.11e standard.
  - Typically based on Enhanced DCF Channel Access (EDCA) which provides service differentiation of traffic into 8 different classes, where each wireless station has 4 access categories to provide service differentiation.

Priority	Access Category (AC)	Designation (Informative)
0	0	Best Effort
1	0	Best Effort
2	0	Best Effort
3	1	Video Probe
4	2	Video
5	2	Video
6	3	Voice
7	3	Voice



SAE Quality of Service

- In the heterogeneous service environment and all-IP network in SAE (System Architecture Evolution), crucial part becomes the **Quality of Service (QoS)** support.
  - The **QoS** concept in **SAE** is directly **related to bearers**.
- In the EPS there are three main bearers:
  - **Radio bearer** (on the LTE/LTE-Advanced radio interface);
  - **S1 bearer** (on S1 interface, between eNodeB and S-GW);
  - **S5/S8 bearer** (on S5/S8 interface, between S-GW and P-GW).



Source: Toni Janevski, “NGN Architectures, Protocols and Services”, John Wiley & Sons, April 2014.

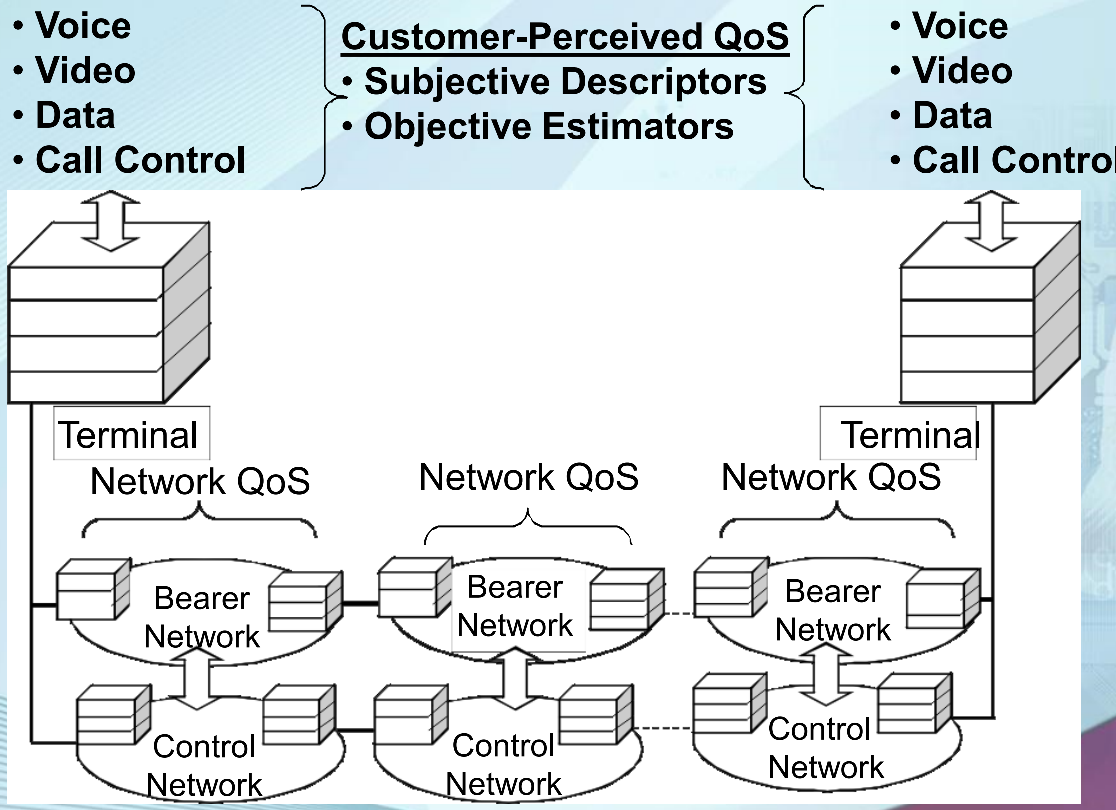
LTE QoS Class Identifiers

- LTE bearer is assigned a scalar value referred to as a QoS Class Identifier (**QCI**):
  - **Guaranteed bit rate (GBR)**
  - **Non-guaranteed bit rate (non-GBR)**: a non-GBR bearer is referred to as the default bearer, which is also used to establish IP connectivity.

QCI	Resource Type	Priority	Delay budget	Loss rate	Example application
1	GBR	2	100 ms	10^{-2}	VoIP
2		4	150 ms	10^{-3}	Video call
3		5	300 ms	10^{-6}	Video streaming
4		3	50 ms	10^{-3}	Real-time gaming
5	Non-GBR	1	100 ms	10^{-6}	IMS signaling
6		7	100 ms	10^{-3}	Voice, live video, Interactive gaming
7		6	300 ms	10^{-6}	TCP applications (web, email, p2p file sharing, http video, chat, buffered video streaming, etc.)
8		8			
9		9			

Customer Perceived QoS

- End user aspects of QoS including QoE should be a set of QoS and performance measurements
  - the measurements will be taken from each of the segments of the measurement network model and may be combined to form multi-segment, site-to-site, edge-to- edge or terminal-to-terminal metrics.



QoS Measurement Objectives

- Enhancement of QoS is contributed to increase the level of confidence in the **expected service characteristics** of the networks.
  - This shall will enable new applications, services and revenue streams.
- The **objective** of **QoS measurements** is to provide information for customers, potential customers and service providers, including:
  - For **customers** and **potential customers**:
    - Reports to customers of what service has been delivered;
    - Reports to potential customers to support marketing claims on service characteristics.
  - For **service providers** and **third party delivery** assurance entities:
    - Reports to design service offerings;
    - Reports for troubleshooting;
    - Data for marketing collateral;
    - Reports to enable capacity planning and service development.

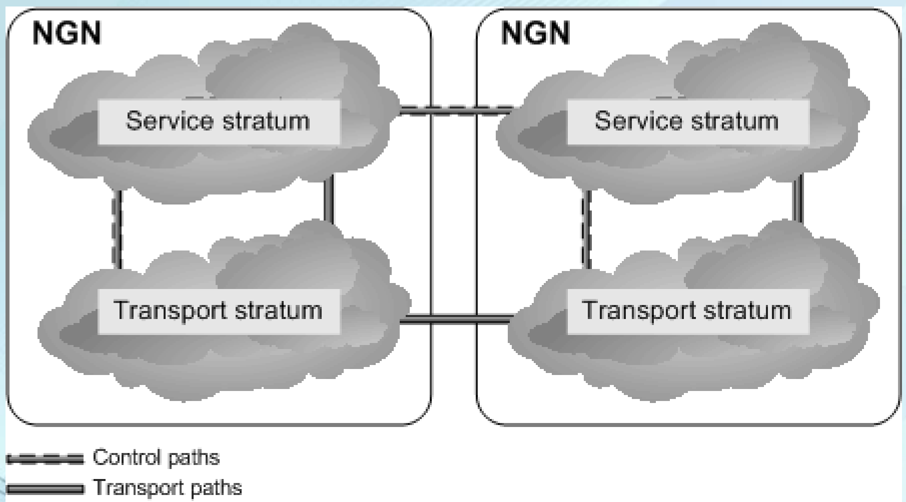
Main Views on QoS Assessment

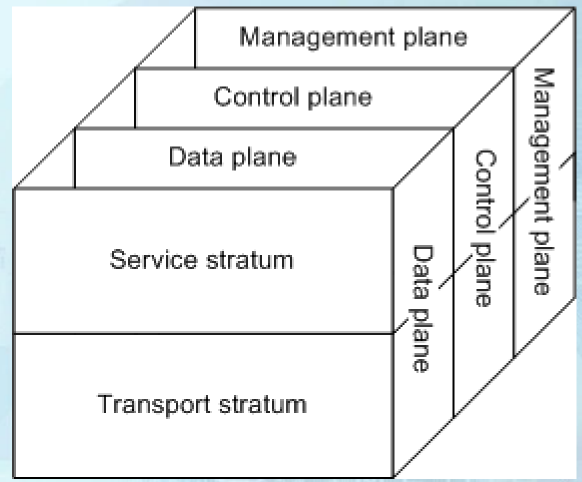
- The **assessment of QoS** is normally done by checking **QoS criteria** against reference values.
- QoS parameters are measured either **objectively** by technical means (by measuring attributes of networks and signals) or **subjectively** (perceived QoS) via surveys and subjective tests amongst users.
- Basis for **QoS parameter assessment** are given in ITU-T Rec. E.803, which also include guidance to selection of appropriate data source and sample sizes as well as presentation of the results.

Convergence of traditional telecom and Internet worlds to NGN

NGN Transport and Service Stratums

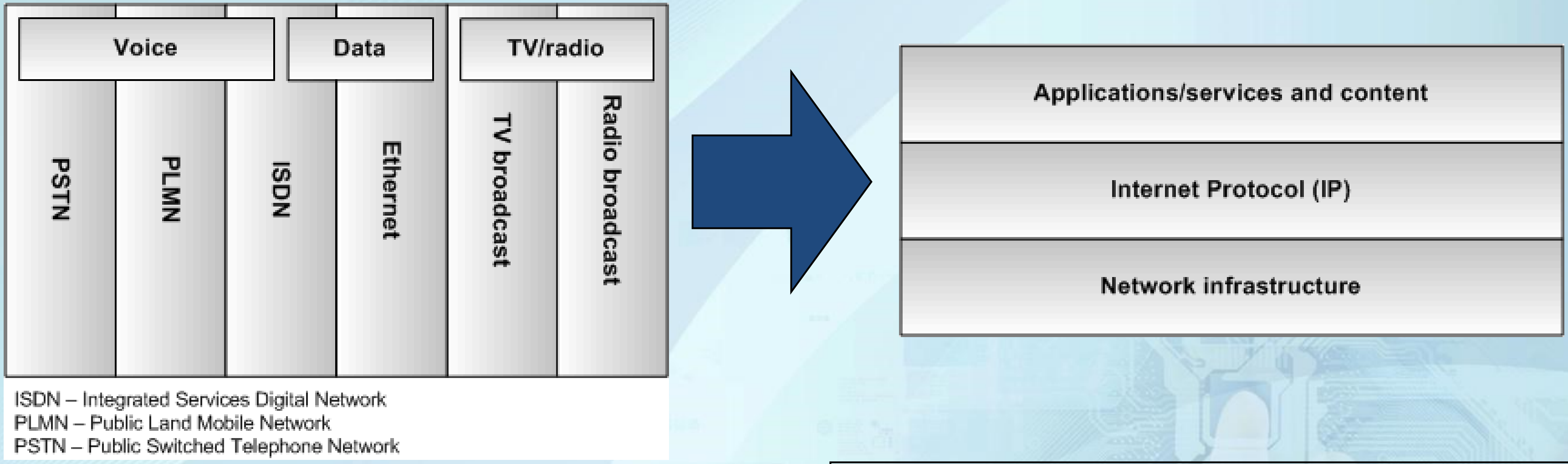
- The leading idea and main driver for NGN is separation between transport on one side (transport stratum), and services and applications on the other side (service stratum).
  - Including data plane, control plane and management plane.





Source: Toni Janevski, “NGN Architectures, Protocols and Services”, John Wiley & Sons, April 2014.

The "Old Way" and the "New Way"



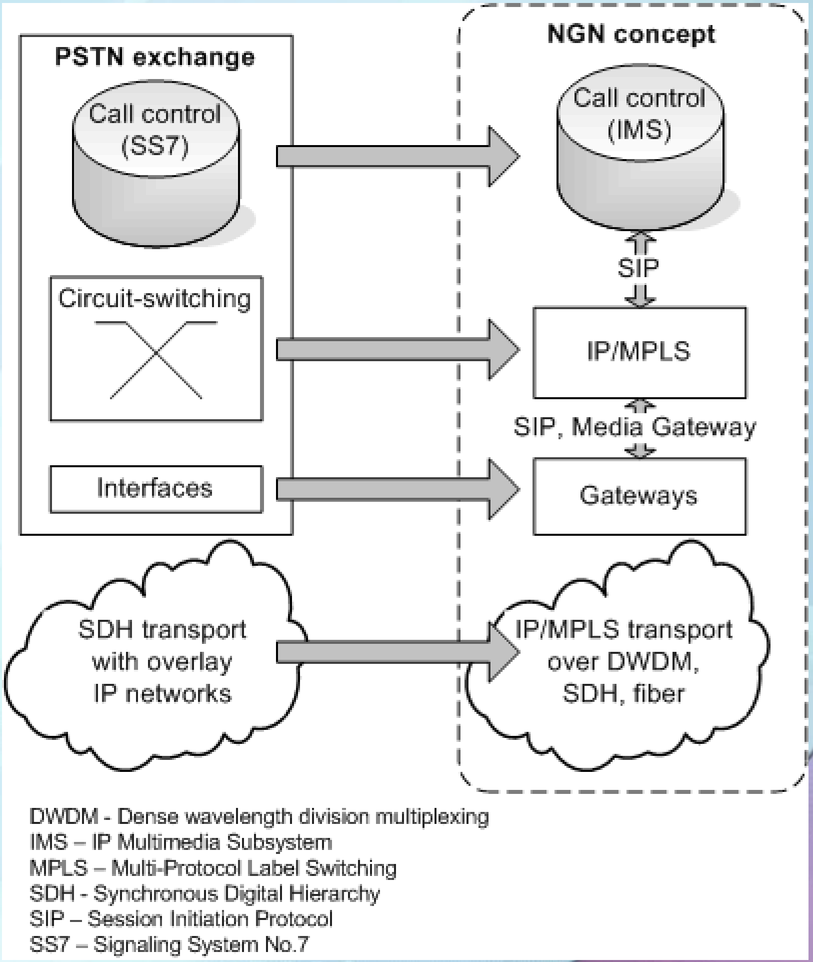
Separation of networks for voice, TV, and data (the old way)

Horizontal separation of services/applications and networks (broadband IP networks – the new way)

<u>Source</u>: Toni Janevski, "NGN Architectures, Protocols and Services", John Wiley & Sons, April 2014.

The NGN Concept

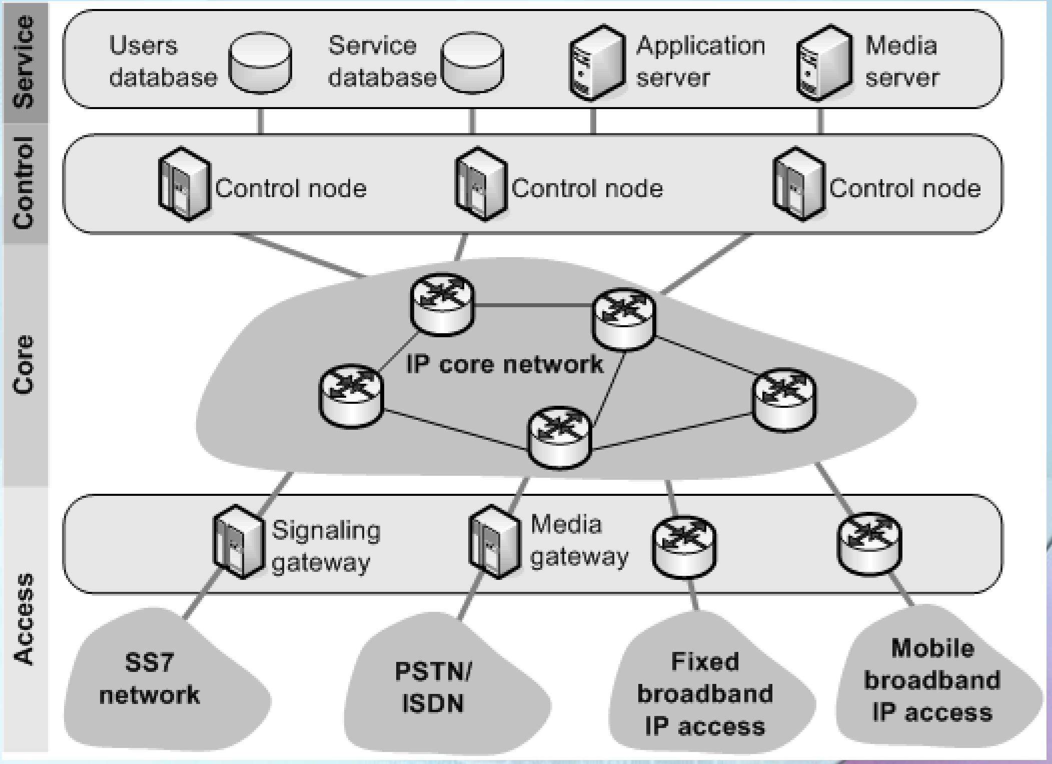
- The convergence of Telecom and Internet worlds results in NGN (Next Generation Networks)
- NGN are all-IP networks.
- NGN separates:
  - Services,
  - Transport (i.e., networks).



Source: Toni Janevski, "NGN Architectures, Protocols and Services", John Wiley & Sons, April 2014.

All-IP Network Concept

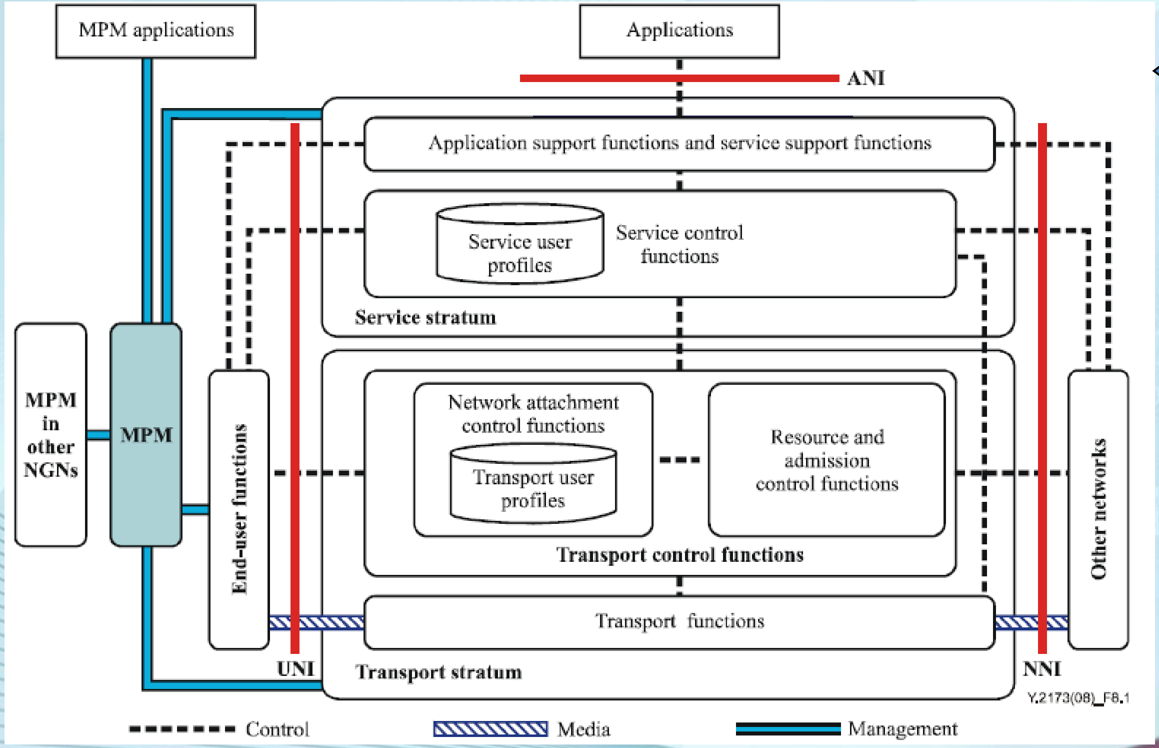
- NGN specifies IP on network layer end-to-end, and such requirement defines the all-IP network concept.
  - That means that all access, core (or backhaul) and transit networks in NGN must be IP based.



Source: Toni Janevski, "NGN Architectures, Protocols and Services", John Wiley & Sons, April 2014.

Overall Architecture for NGN Performance Management

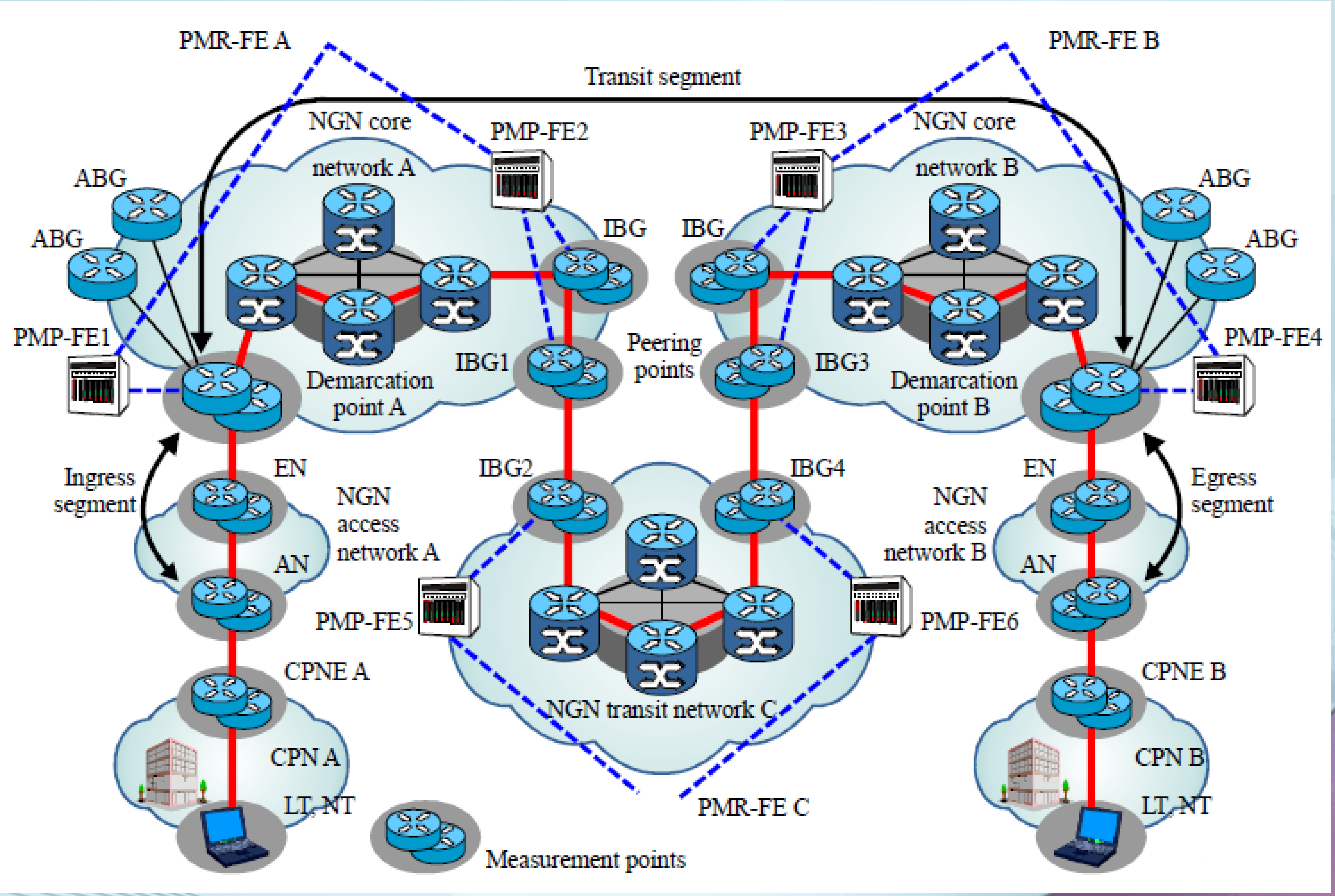
- Transport control traffic measurement is important for ensuring the performance of NGN transport control functionality which is consisted with network access control and RACF.
  - RACFs require reasonably accurate real-time network resource performance and usage data to enable effective resource-based admission control decisions.
  - NGN performance management functions can provide such information to the RACF.



MPM (Management of Performance Measurement) interacts with various NGN functional entities to collect and analyze performance of NGN networks and services.

Measurement points for NGN

- Measurements are done using probes (probe stations) with PMP-FEs.



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Regulation and administration of QoS and QoE

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Scope of QoS Regulation

Main purposes of **QoS regulation** are the following (ITU-T Supplement 9 of E.800 Series):

- **helping customers** to make informed **choices**;
- **checking claims** by operators;
- **understanding** the state of the **market**;
- maintaining or improving **quality** in the **presence of competition**;
- maintaining or improving **quality** in the **absence of competition**;
- **helping** operators to achieve **fair competition**; and
- **making** interconnected **networks work** well together.

ITU’s Guidelines for QoS Regulation

- The main guidelines for QoS regulation is published in **Supplement 9 to ITU-T E.800-series** Recommendations.
- According to the ITU there are four possible elements in a regulator's approach to QoS:
  - **Obtaining appropriate information** on the level of QoS and identifying the problem areas. This is essential since without the appropriate information the other elements cannot be undertaken;
  - **Publishing information on QoS** performance so that customers can be better informed;
  - **Imposing regulations on performance** such as required minimum levels and fines or compensation;
  - **Undertaking a constructive dialogue** with the operator concerned to encourage and foster improvements.

Topics for Discussion

Interactive workshop 1: Topics for discussion

- How is the delivery of interactive Internet multi-media services different from voice communications, internet access or traditional broadcasting?
- Quality of Experience vs Quality of Service
- Business models, sharing arrangements and regulatory requirements
- Traffic management practices for NGNs
- Country experiences

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