2. QoS in UMTS cellular systems as defined in the standards

Dr. David Soldani

(david.soldani@nokia.com, tel. +358.50.3633527)

S-38.3215 Special Course on Networking Technology for Ph.D. students at TKK

Contents

- GPRS network architecture
- QoS in transport network layer
- 3GPP organization and specifications
- IETF organization
- Spectrum allocation
- QoS concept and architecture
  - R97/98, R99, R5, R6 and R7

Applications and bearers categories

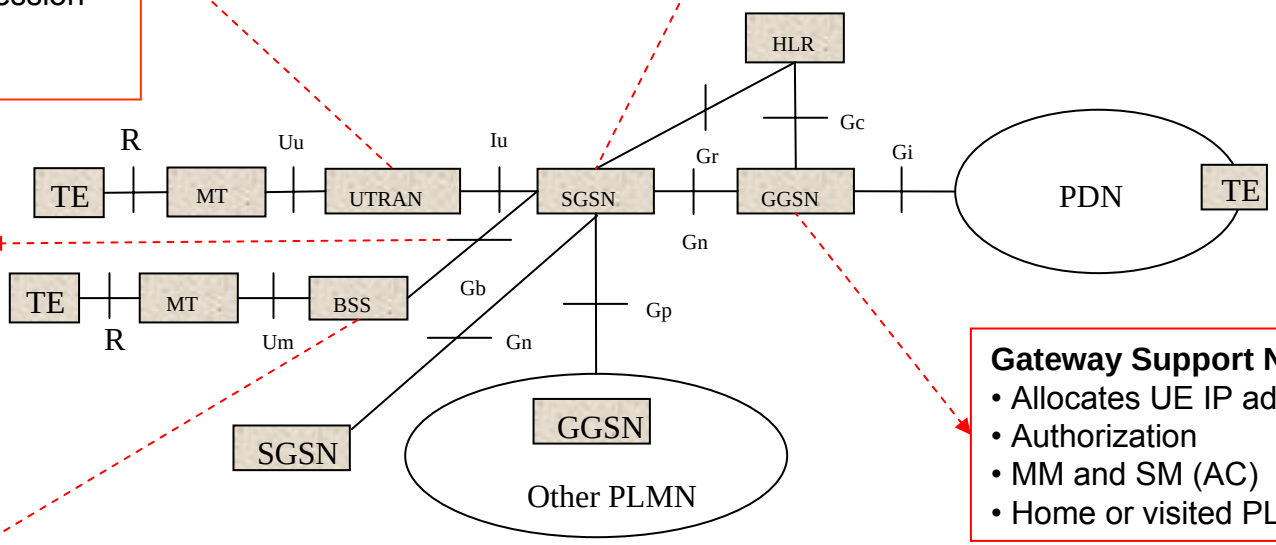
- In 3GPP, RT (conversational and streaming) and NRT (interactive and background) are used to describe both applications and bearer services
- In this course, RT/NRT are used for service applications, and for bearer services RT bearer or Guaranteed Bit Rate (GB or GBR) and NRT bearer or Non-GB (NGB or NGBR) are used instead of just RT and NRT, respectively

General Packet Radio Service architecture

UTRA FDD/TDD
- WCDMA 128/384 kb/s
- HSDPA (R5) 14.4 Mb/s
- HSUPA (R6) 5.76 Mb/s
- Encryption
- Header compression
- Cell level MM
- PS Handovers

Serving Support Node
- Registration, Authentication, Authorization
- MM, SM (AC), Visited PLMN as the RAN/BSS
- 2G: Encryption, Header compression, Cell level MM

Gb/Iu mode
- Gb R97/98 (NRT) – 2G SGSN
- Gb R99 – PFC and RT (str.)
- Iu-ps R5 – RT (str.)
- R6/7 – RT (str. and conv.)



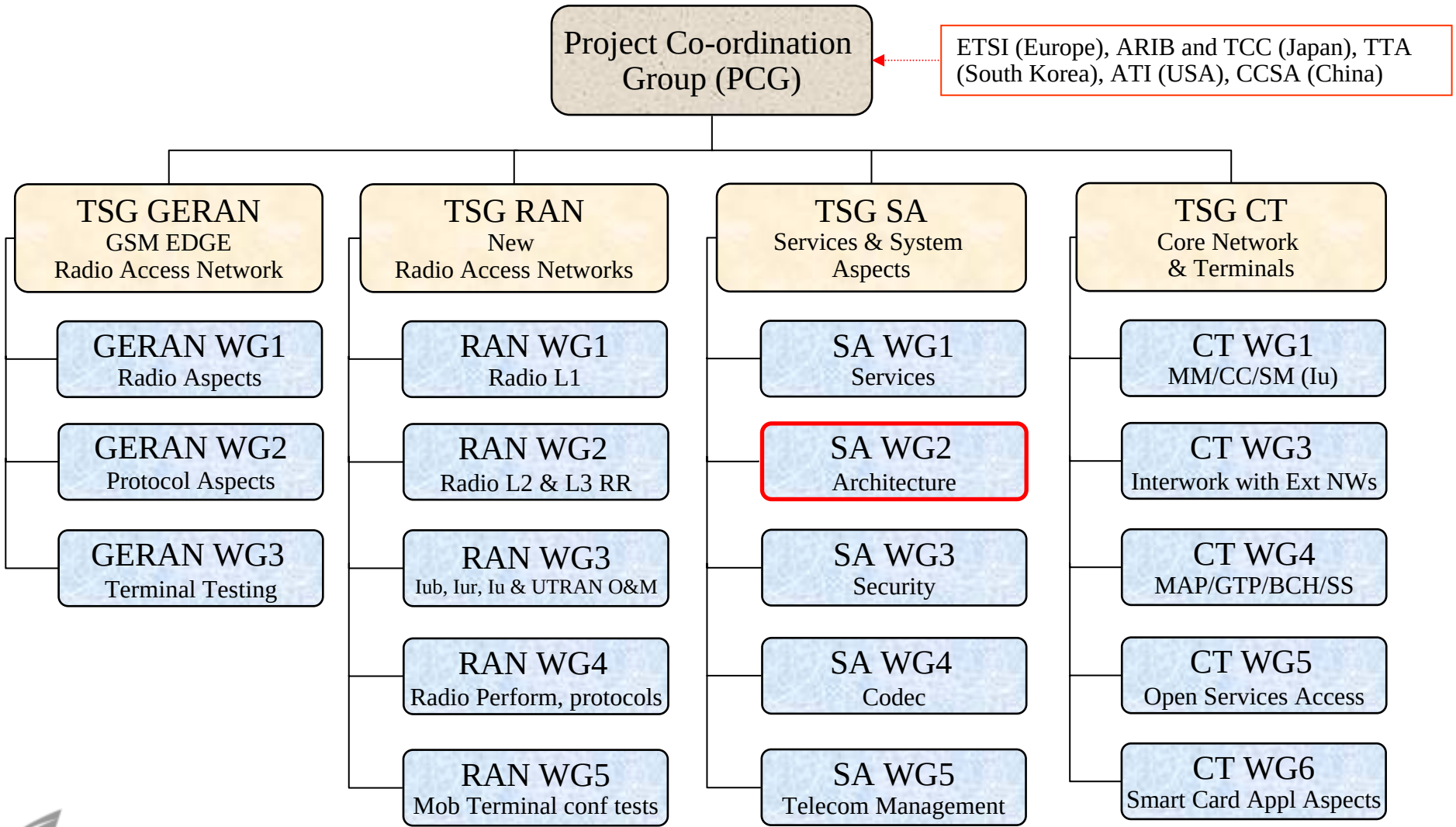
Gateway Support Node
- Allocates UE IP address
- Authorization
- MM and SM (AC)
- Home or visited PLMN

GERA FDMA/TDMA
- GSM/HSCSD GMSK, 9.6/14.4 kb/s
- GPRS CS1-4 GSMK, 20 kb/s per TS
- EDGE MCS1-9, 8-PSK, 48 kb/s per TS
- NACC and Enhanced TBF (R4)
- PS Handovers (R6)

QoS in transport network

- Not fully standardized in 3GPP
- Multiprotocol Label Switching (MPLS) can be used with IP transport
- Mapping of 3GPP QoS onto IP QoS/MPLS not standardized
- **The L2 and L1** below the IP layer are not defined in 3GPP
  - Ethernet and its virtual local area network (VLAN) feature can be used
- **Gn interface (GPRS CN nodes)**
  - IP QoS based on differentiated services (DiffServ)
- **Gb interface (SGSN-BSS)**
  - Frame relay (FR) connections and IP-based from R4 and later releases
- **Iu-ps (SGSN-RAN)**
  - IP QoS based on differentiated services (DiffServ)
- **Iub (RNC-Node B)**
  - ATM over TDM and IP-based over ATM/Ethernet from R5 onwards

3GPP Technical Specification Group (TSG)



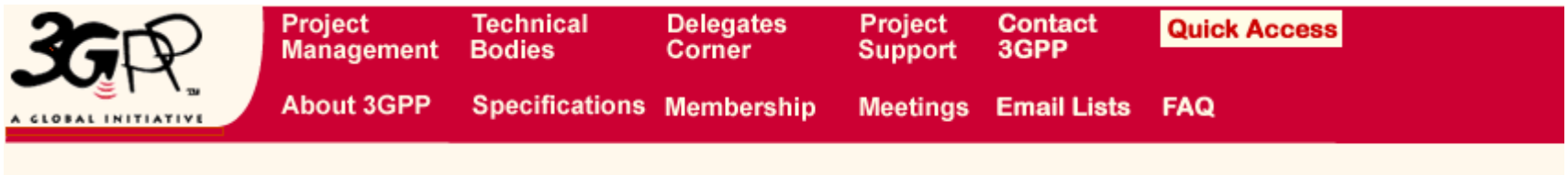
3GPP specification series numbering (1/2)

Subject of specification series	3G/GSM (R99 and later)	GSM only (R4 and later)	GSM only (before R4)
General information (long defunct)			00 series
Requirements	21 series	41 series	01 series
Service aspects (stage 1)	22 series	42 series	02 series
Technical realisation (stage 2)	23 series	43 series	03 series
Signalling protocol (stage 3) – user equipment to network	24 series	44 series	04 series
Radio aspects	25 series	45 series	05 series
CODECs	26 series	46 series	06 series
Data	27 series	47 series (none exists)	07 series
Signalling protocols (stage 3) – RSS - CN	28 series	48 series	08 series
Signalling protocols (stage 3) – infra – fixed network	29 series	49 series	09 series
Programme management	30 series	50 series	10 series
Subscriber Identity Module (SIM/USIM), IC cards, test specs	31 series	51 series	11 series
OAM&P and Charging	32 series	52 series	12 series
Access requirements and test specifications		13 series (1)	13 series (1)
Security aspects	33 series	(2)	(2)
UE and (U)SIM test specifications	34 series	(2)	*11 series*
Security algorithms (3)	35 series	55 series	(4)

1. The 13 series GSM specifications relate to European-Union-specific regulatory standards. On the closure of ETSI TC SMG, responsibility for these specifications was transferred to ETSI TC MSG (Mobile Specification Group) and they do not appear on the 3GPP file server.
2. The specifications of these aspects are spread throughout several series.
3. Algorithms may be subject to export licensing conditions. See the relevant 3GPP page. See also the relevant ETSI pages.
4. The original GSM algorithms are not published and are controlled by the GSM Association.

3GPP specification series numbering (2/2)

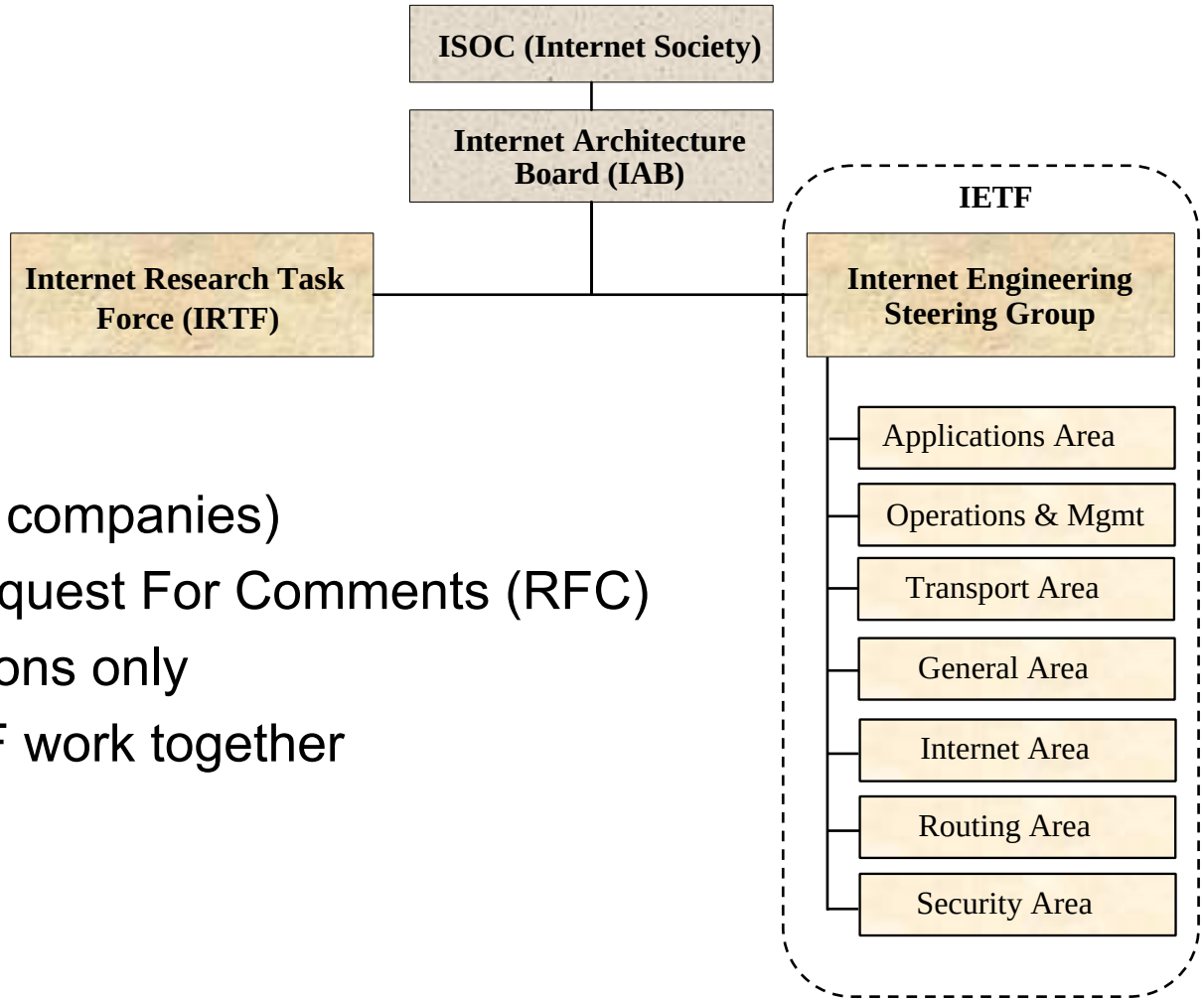
- R97/98/99 for GSM-only specifications
  - 4-digit numbers: e.g., 03.60
  - Version number: 6.x.x (R97), 7.x.x (R98) and 8.x.x (R99)
  - Example: TS 03.60 v. 6.11.0 is an R97 specification
- Newer 3GPP specifications
  - 5-digit numbers: e.g. 3GPP TS **2**3.060 ← GSM TS 03.60
  - Version number: 3.x.x (R99), 4-7.x.x. (R4-7)
- See www.3gpp.org



3GPP technical specification process

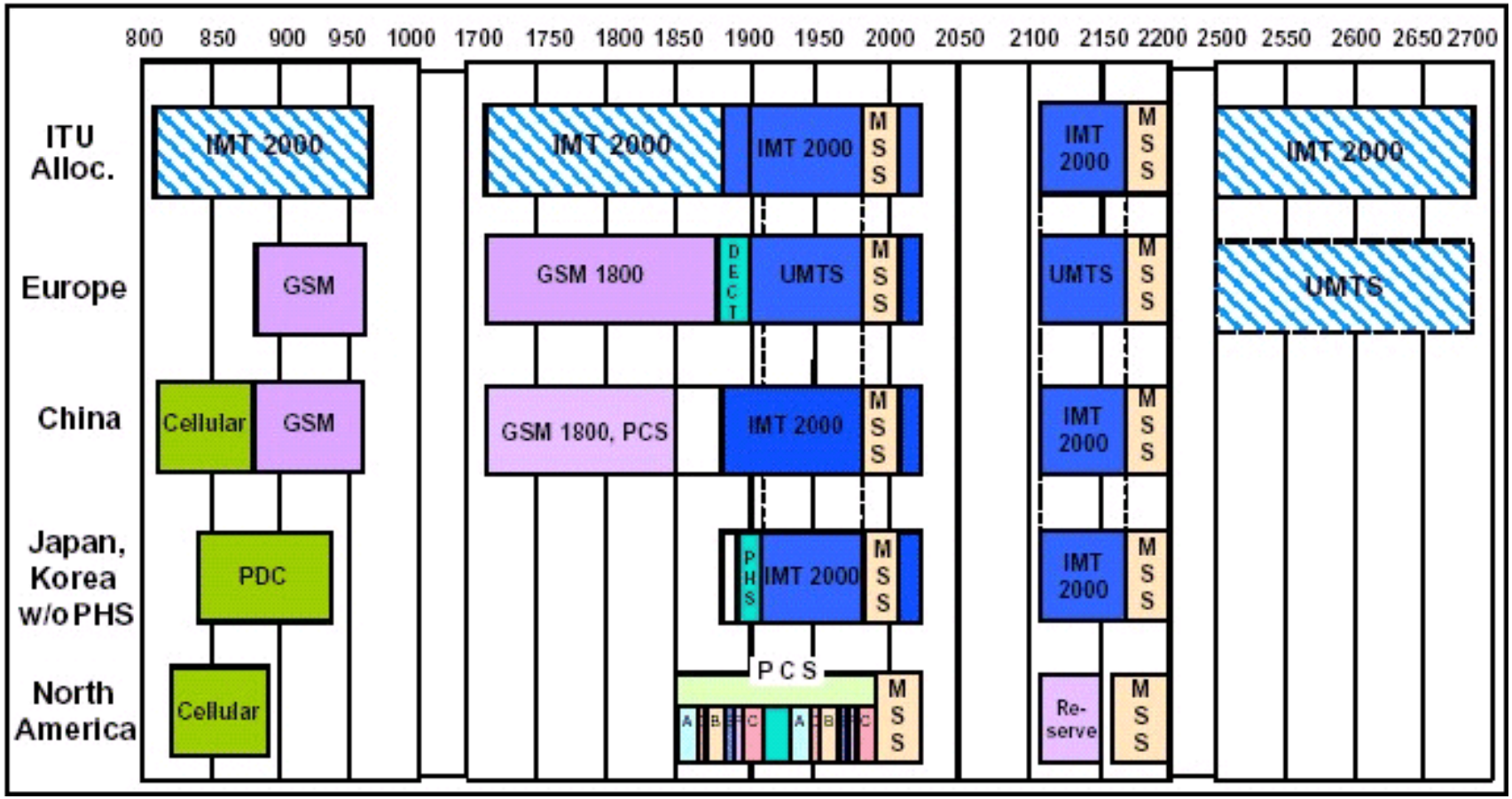
- Technical Report (TR) → Technical Speciation (TS)
  - **Stage 1**: high-level user requirements (service aspects from the user's perspective)
  - **Stage 2**: architecture, key functionality and overall message exchange
  - **Stage 3**: contains the protocol (detailed message and procedure descriptions)
  - Amendments using the CR process
- 3GPP specifications language
  - *"Shall"* (mandatory), "*Should*" (recommendation), "*May*" (optional), and "*Can*" (possible situation or action)

IETF organization



- Individuals (not companies)
- WG draft → Request For Comments (RFC)
- Recommendations only
- 3GPP and IETF work together

WARC-2000 IMT-2000 frequencies



3GPP planned operating bands

Operating band	Uplink (MHz)	Downlink (MHz)	Total	Channels
GSM400	478.8–486	488.8–496	2 × 7.2 MHz	35
GSM400	450.4–457.6	460.4–467.6	2 × 7.2 MHz	35
GSM850	824–849	869–894	2 × 25 MHz	124
RGSM	876–915	921–960	2 × 39 MHz	194
EGSM	**880–915**	**925–960**	**2 × 35 MHz**	**173**
GSM900	**890–915**	**935–960**	**2 × 25 MHz**	**124**
GSM1800 (DCS)	**1710–1785**	**1805–1880**	**2 × 75 MHz**	**374**
GSM1900 (PCS)	1850–1910	1930–1990	2 × 60 MHz	299
UMTS-FDD (I)[a]	**1920–1980**	**2110–2170**	**2 × 60 MHz**	**12**
UMTS-FDD (II)	1850–1910	1930–1990	2 × 60 MHz	12
UMTS-FDD (III)	1710–1785	1805–1880	2 × 75 MHz	15
UMTS-FDD (IV)	1710–1755	2110–2155	2 × 45 MHz	9
UMTS-FDD (V)	824–849	869–894	2 × 25 MHz	5
UMTS-FDD (VI)[b]	830–840	875–885	2 × 10 MHz	2
UMTS-FDD (VII)	2500–2570	2620–2690	2 × 70 MHz	14
UMTS-TDD	1900–1920 and	2010–2025	20 + 15 MHz	7

a) Core band; b) Japan.

Packed Data Protocol (PDP) context

- Virtual communication pipe established between the UE and the GGSN for delivering user data traffic stream
- Defined in the HLR, UE (MS), SGSN and GGSN by
  - A **PDP context identifier** (index of the PDP context)
  - A PDP type (e.g., PPP or **IP**)
  - A PDP address (e.g., an **IP address**)
  - An **Access Point Name (APN)** (label describing the access point to the packet data network)
  - A **QoS profile** (bearer service attributes)
- Secondary PDP context in R99 and later releases
  - Associate to a primary PDP context
  - May have **only** a different QoS profile

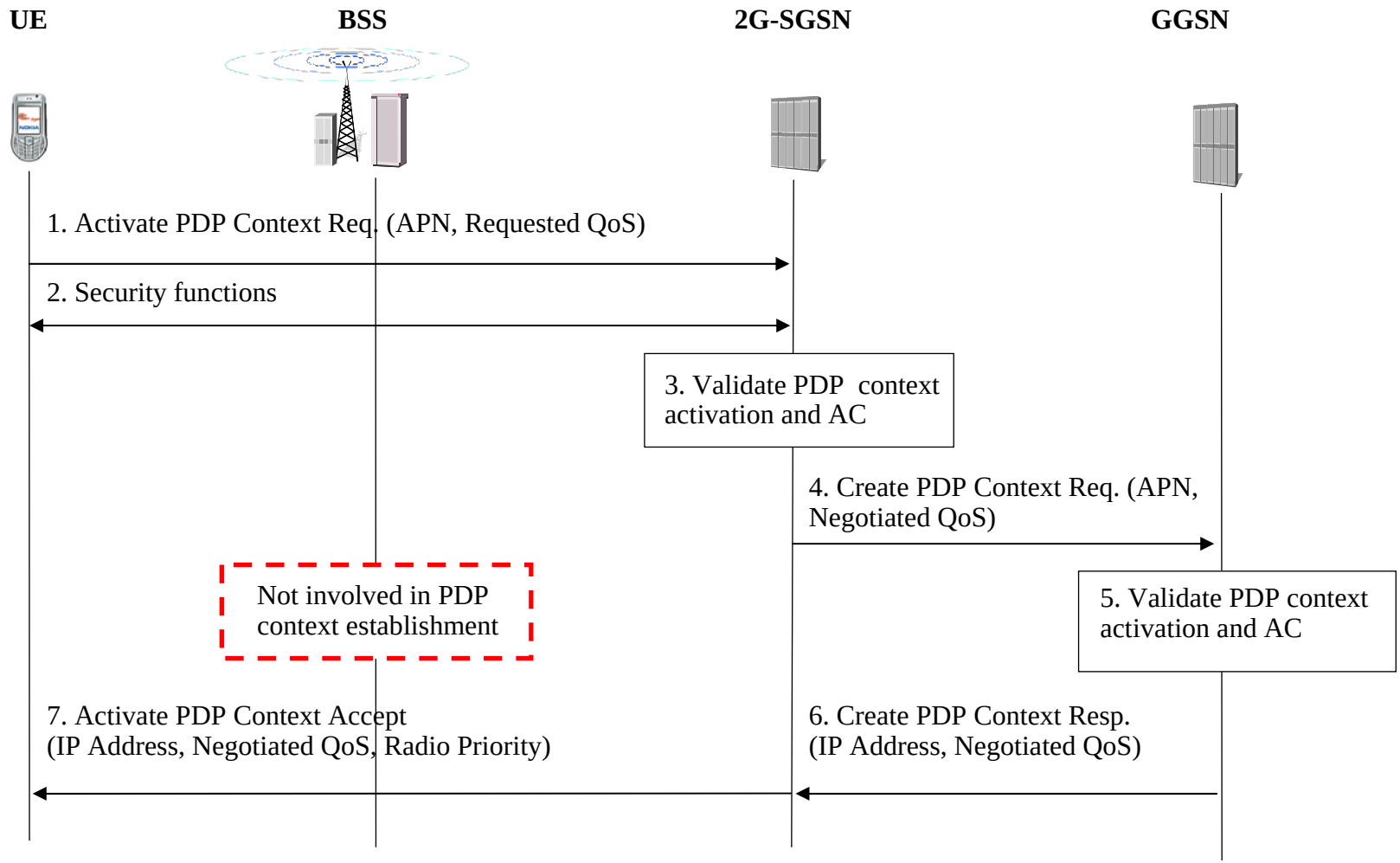
Packed Flow Context (PFC)

- **Provide QoS handling** between the **SGSN and BSS** in R9 and later release
- The 3GPP specifications are not very clear on whether one PFC can be shared by several UEs or only used by one UE
- A given PFC can be shared by one or more activated PDP contexts (**aggregated packet flow**) with identical or similar negotiated QoS requirements (**aggregate BSS QoS profile**)
- The **aggregate BSS QoS profiles** specify the QoS that the BSS needs to provide for a given packet flow **between the UE and SGSN including the radio and Gb interfaces**
- In R5, the PFC was further evolved by adding **UE-specific flow control functionality (SGSN – BSC)**

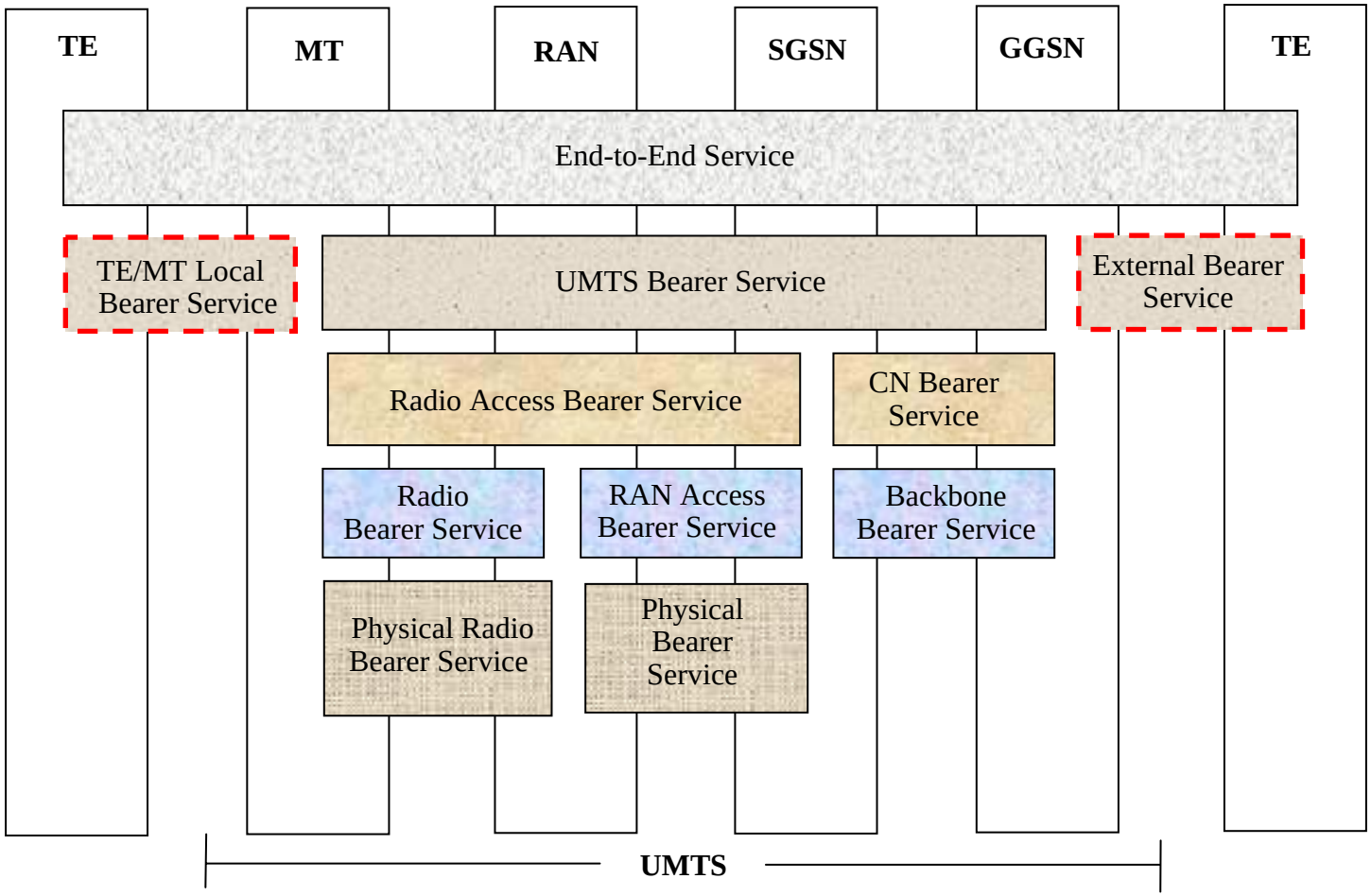
QoS profile in R97/98

- **Precedence class (1-3)**
  - Indicates the priority for maintaining the bearer service
  - The possible values are high, normal and low level
- **Delay class (1-4)**
  - Refers to end-to-end transfer delay through the GPRS system
  - There are three predictive delay classes and one best-effort class
- **Reliability class**
  - Defines data reliability in terms of residual error rates for the probability of data loss, data delivery out of sequence, duplicate data delivery and corrupted data
- **Throughput (peak and mean) class**
  - User data throughput that characterize the expected bandwidth required for a PDP context
  - (There is no guarantee that the level can be sustained, especially as UE capability and radio resource availability have an impact on throughput)

R97/98: PDP context establishment

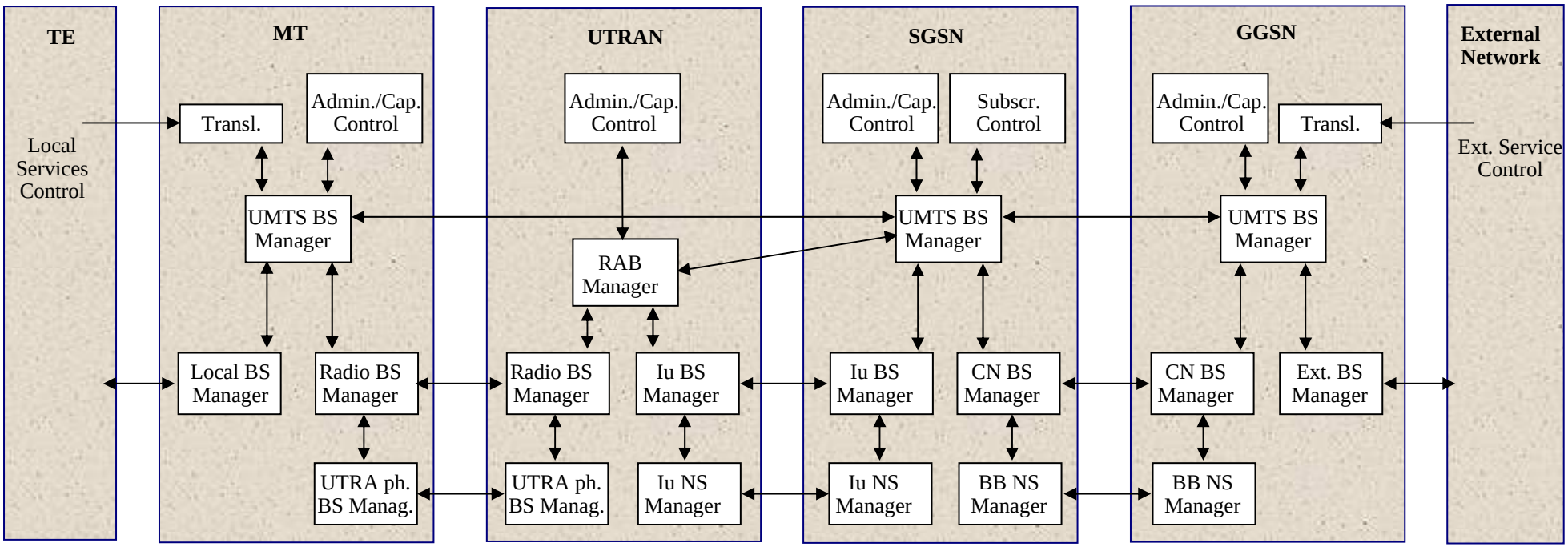


R99: End-to-end QoS architecture



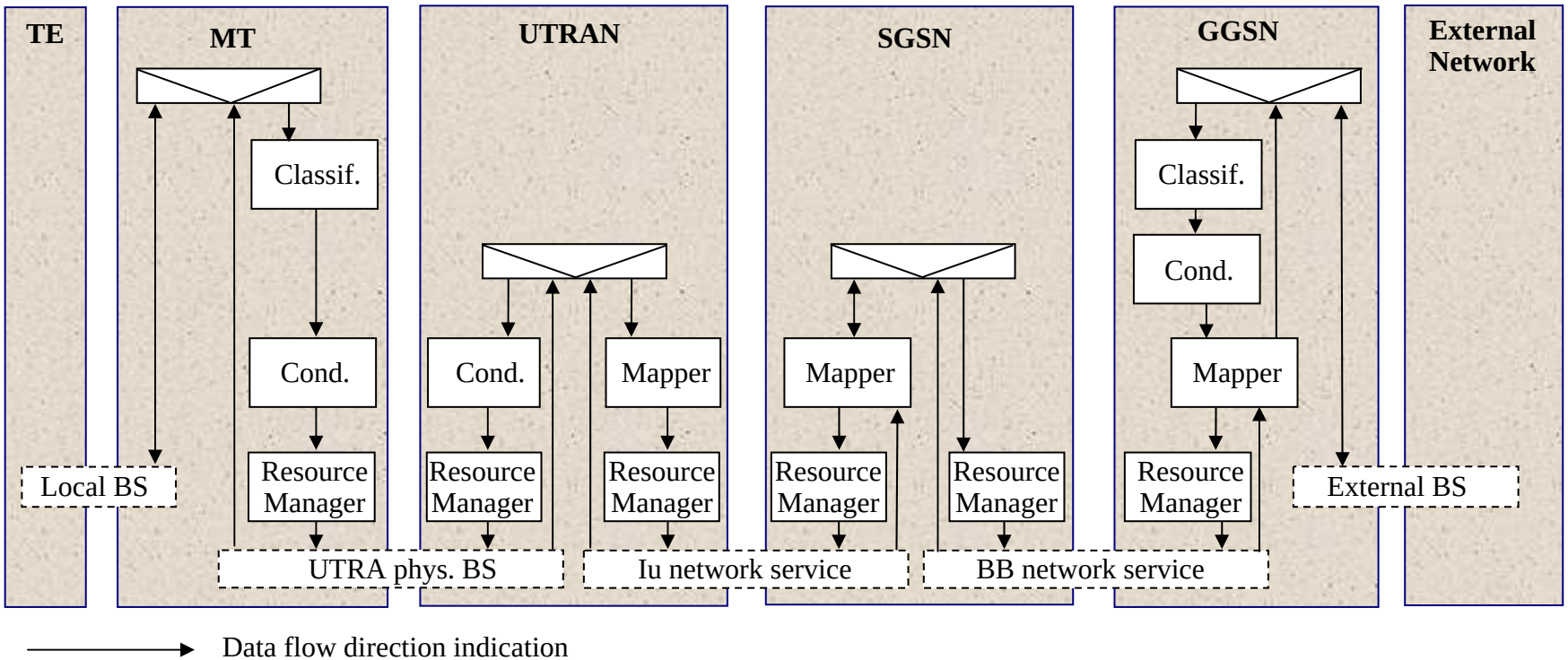
R99: QoS functions in the control plane

- Establishment and modification of bearer service



R99: QoS functions in the user plane

- Provisioning of QoS negotiated and maintenance of data transfer characteristics



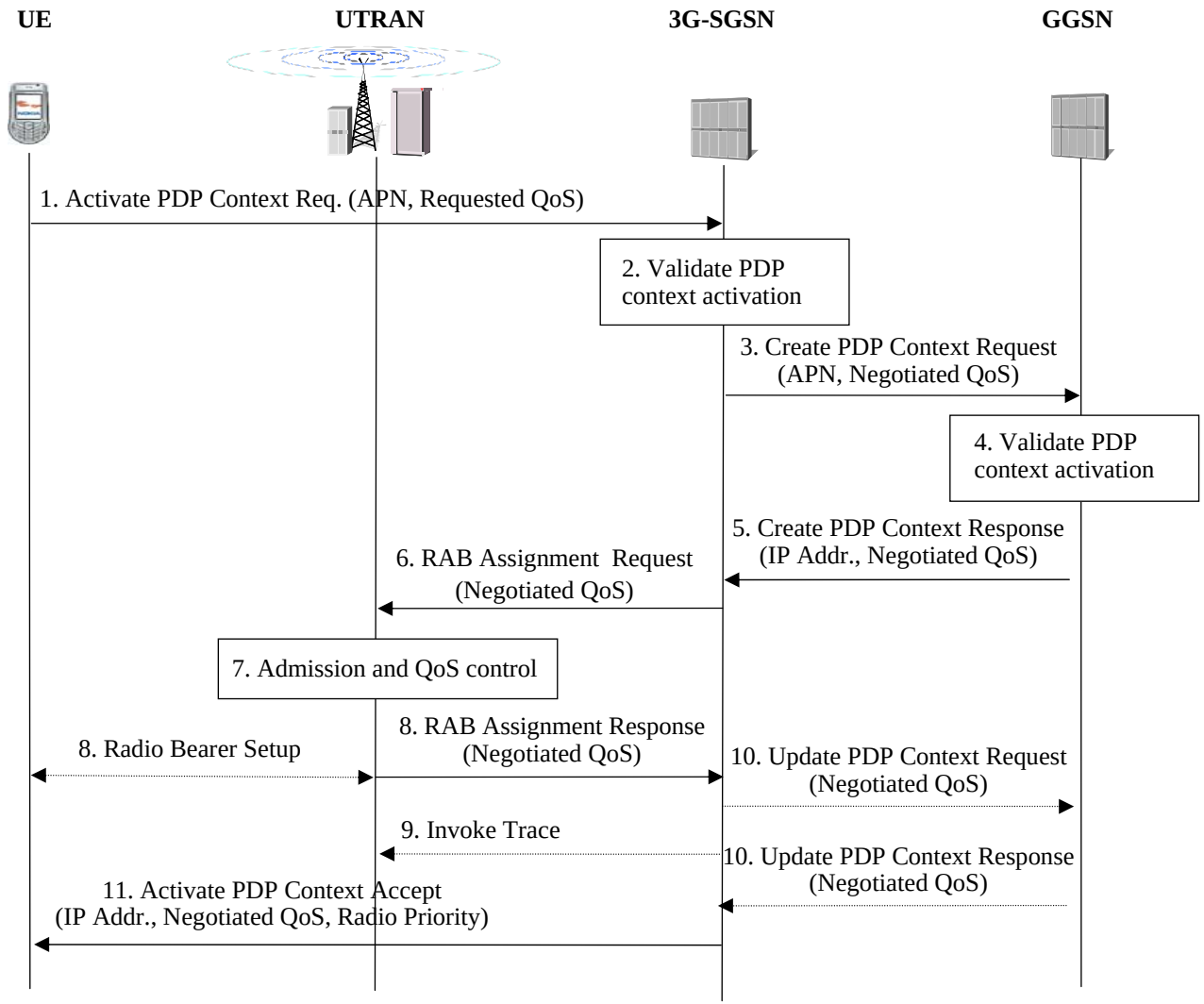
QoS profile in R99 and later releases

- **Traffic class**
  - Conversational, Streaming, Interactive and Background
- **Maximum bit rate (kb/s)**
  - Peak bit rate of the bearer service
- **Guaranteed bit rate (kb/s)**
  - GBR for conversational and streaming bearer services
- **Delivery order (yes/no)**
  - Order of data packets maintenance
- **Maximum SDU size**
  - Maximum size for which the network needs to satisfy the negotiated QoS
- **SDU error ratio**
  - Fraction of SDUs lost or detected as erroneous
- **Residual bit error ratio**
  - Undetected BER in the delivered SDUs
- **Delivery of erroneous SDUs (y/n/–)**
  - For values ‘yes’ and ‘no’ error detection is applied, but for the value ‘–’ it is not done
- **Transfer delay (ms)**
  - Maximum delay for the 95th percentile of the delay distribution for all delivered SDUs during the lifetime of a bearer service
- **Traffic Handling Priority (THP)**
  - Relative importance of the SDUs belonging to the Interactive class
- **Allocation/Retention priority (ARP)**
  - Relative importance of a UMTS bearer compared with other UMTS bearers for allocation/retention of the UMTS bearer
- **Source statistics descriptor**
  - For RAB service only
  - “Speech” or “unknown”

QoS mapping in R99

- The mapping of QoS attributes between the **application attributes** and the **UMTS bearer service attributes** is not standardized
- In similar manner, the mapping from **UMTS bearer service attributes** to **CN bearer service attributes** in not standardized
- On the other hand, the **mapping between UMTS bearer** and **RAB service attributes** and their values is specified: one to one mapping

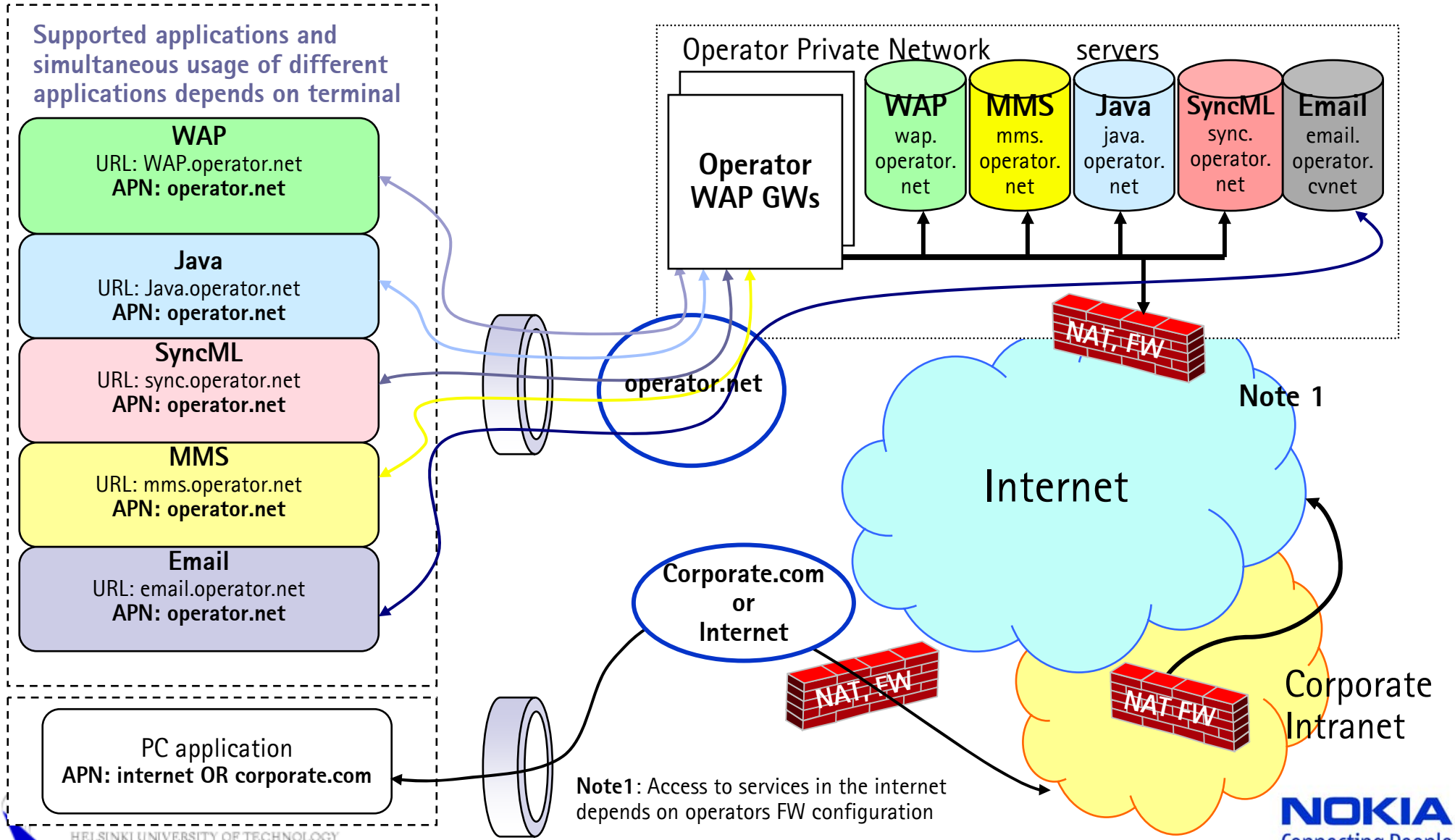
R99: PDP context activation for Iu-ps



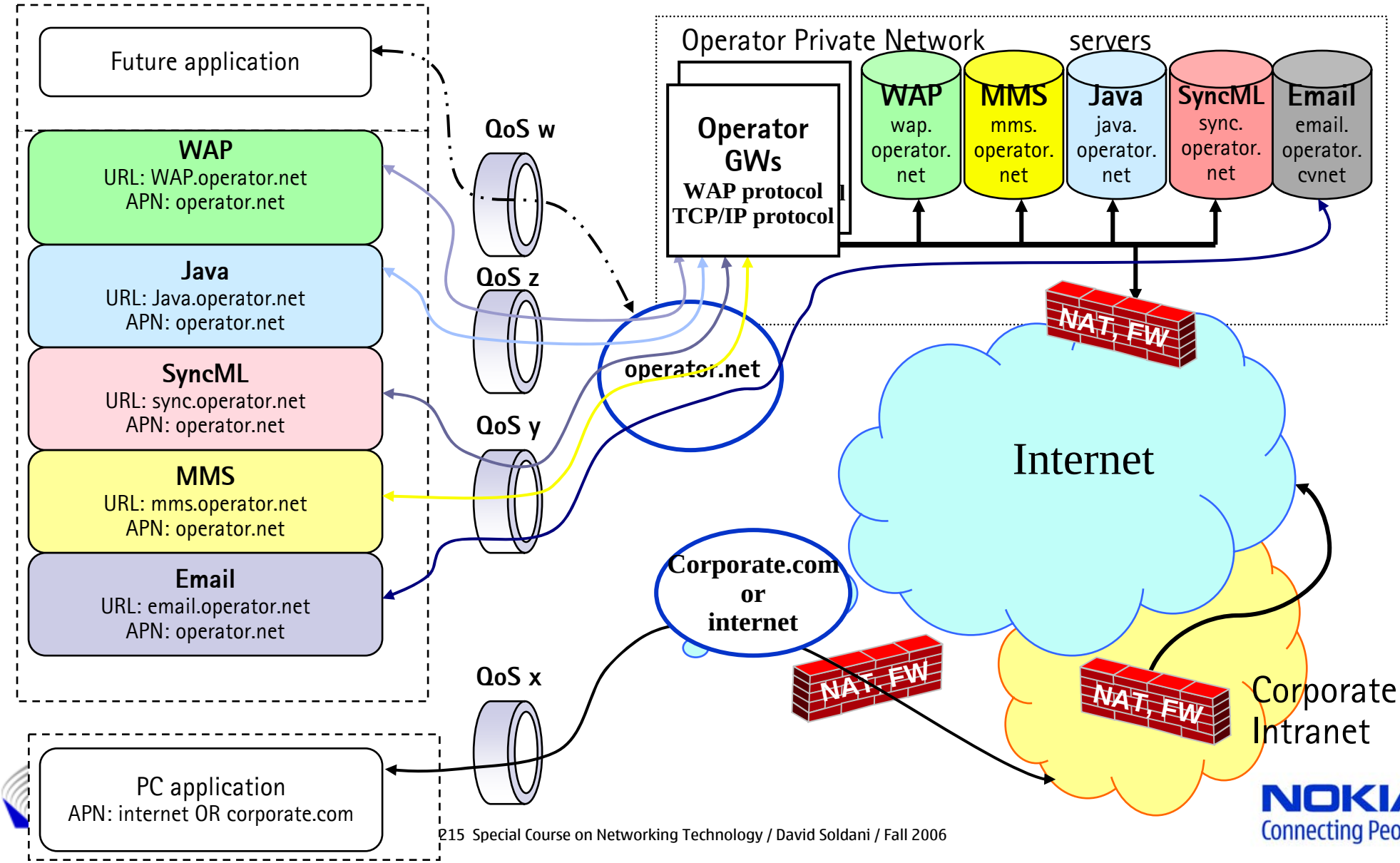
R99 attributes from R97/98 attributes

Resulting R99 Attribute		Derived from R97/98 Attribute	
Name	**Value**	**Value**	**Name**
Traffic class	Interactive	1, 2, 3	Delay class
	Background	4	
Traffic handling priority	1	1	Delay class
	2	2	
	3	3	
SDU error ratio	10^{-6}	1, 2	Reliability class
	10^{-4}	3	
	10^{-3}	4, 5	
Residual bit error ratio	10^{-5}	1, 2, 3, 4	Reliability class
	$4*10^{-3}$	5	
Delivery of erroneous SDUs	'no'	1, 2, 3, 4	Reliability class
	'yes'	5	
Maximum bit rate [kb/s]	8	1	Peak throughput class
	16	2	
	32	3	
	64	4	
	128	5	
	256	6	
	512	7	
	1024	8	
	2048	9	
Allocation/Retention priority (not relevant for the UE)	1	1	Precedence class
	2	2	
	3	3	
Delivery order	yes'	yes'	Reordering Required (Information in the SGSN and the GGSN PDP Contexts)
	'no'	'no'	
Maximum SDU size	1 500 octets	(Fixed value)	

Initial GPRS networks – no QoS



GPRS networks – with QoS



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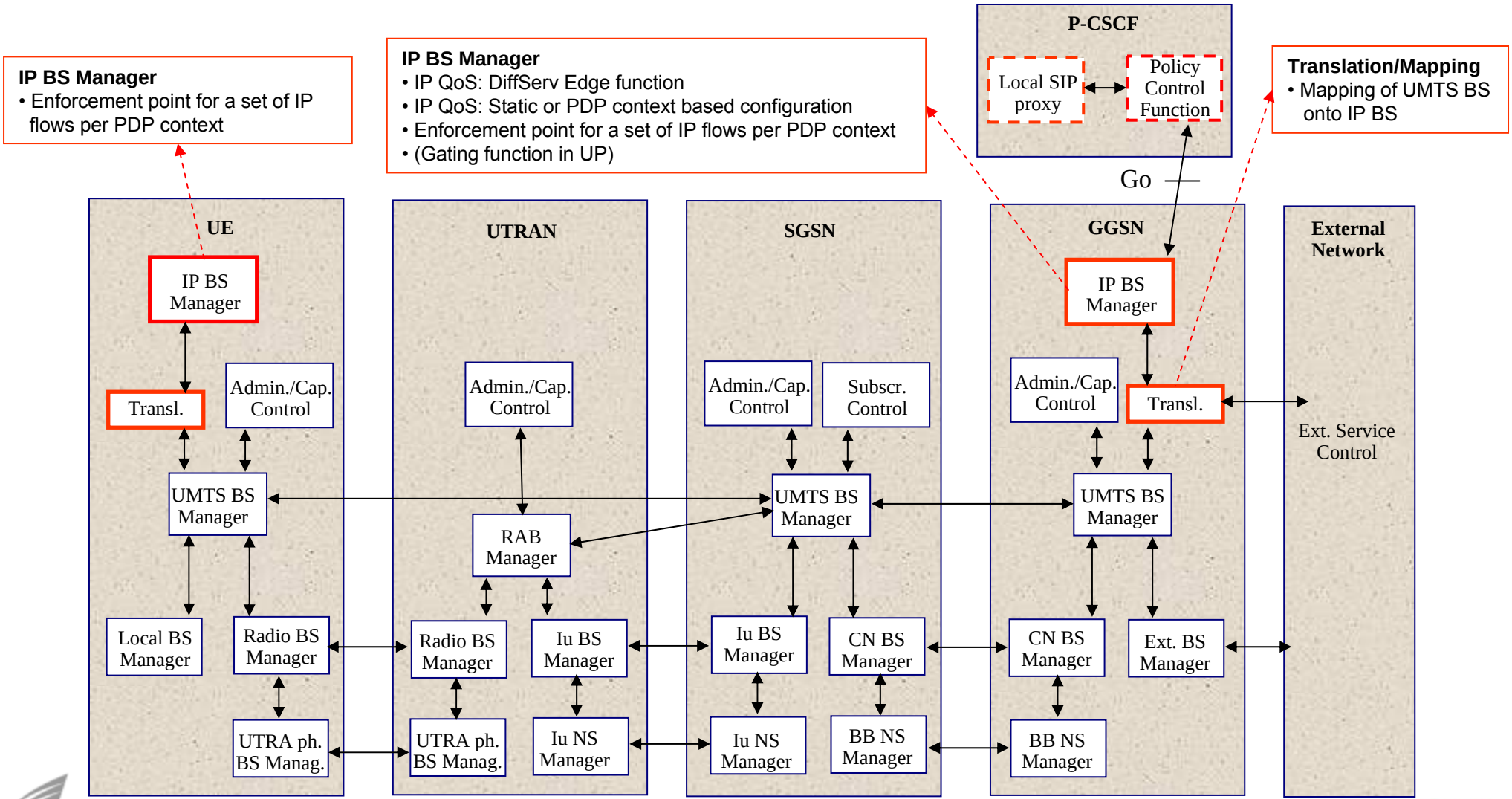
R5: Main **end-to-end** QoS amendments

- **Service Based Local Policy (SBLP) functionality**
  - IMS application session characteristics (SDP attributes) used for bearer service QoS authorization
- **IMS/P-CSCF: Policy Decision Function (PDF)**
  - QoS authorization
- **GGSN: Policy Enforcement Point (PEP)**
  - Enforces (executes) policy decision
- **QoS parameter mapping**
  - Defined for the UE, GGSN/PEP and P-CSCF/PDF
- **GGSN: Dynamic provision of "Gating info" from "IMS session info"**
  - Gating allows user packets to flow through or to be discarded
  - Only authorized traffic passes through GGSN (to and from the UE)
- **GPRS and IMS domains are able to exchange charging identifiers as part of QoS authorization**

R5: End-to-end QoS architecture for CP



R5: Go interface (1/2)

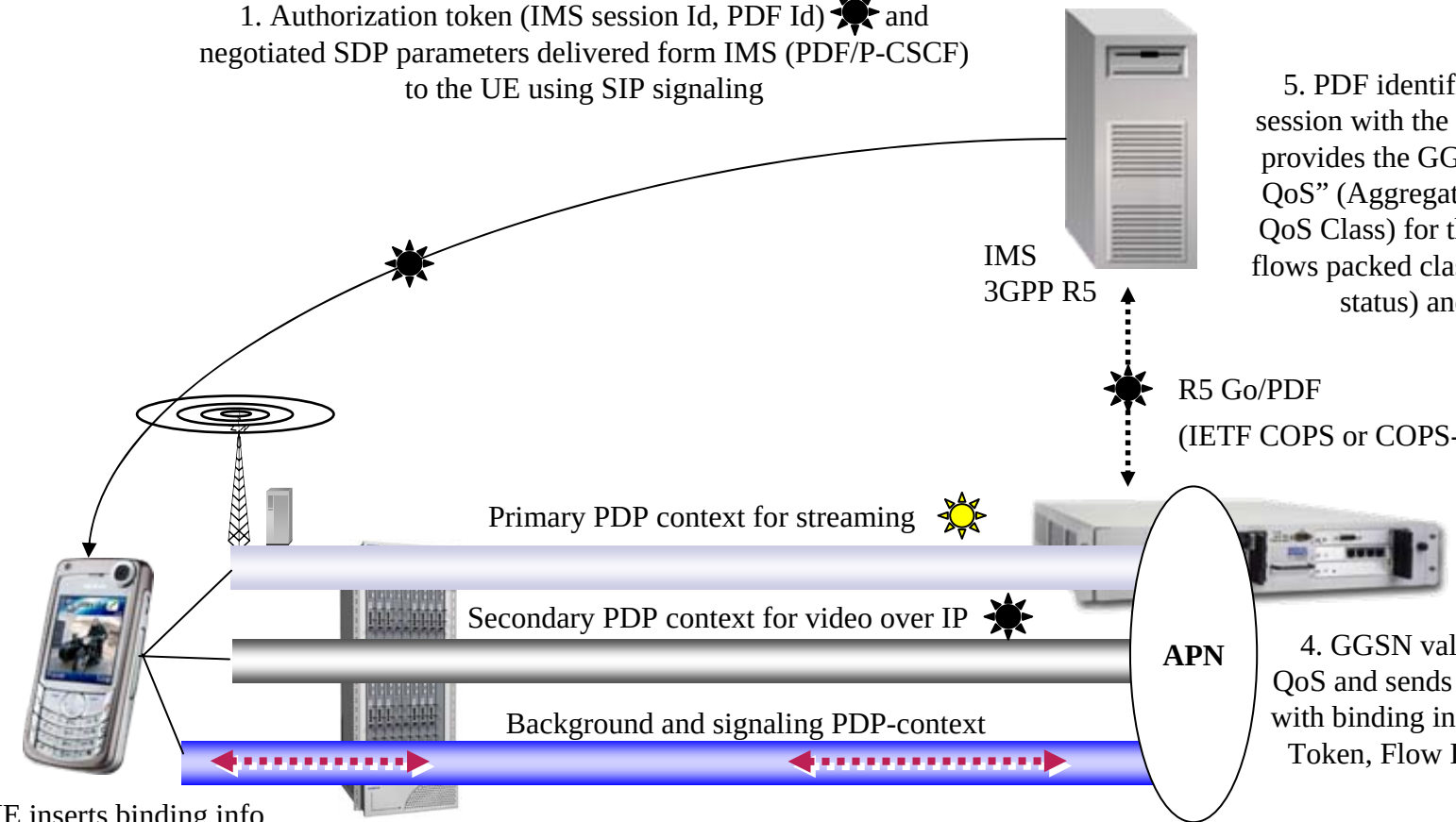
- **Binding information**
  - Authorization token Id (‘*IMS session* Id and *PDF* Id’)
  - Flow Ids for IP flows within the same IMS application session (media component or multimedia session)
- **‘Authorized QoS’ for the PDP context (bearer)**
  - Data Rate (i.e., Max Bit Rate for NGB or Guaranteed Bit Rate for GB bearer services)
  - Maximum QoS Class (i.e., the highest class that can be used for the bearer)
  - (Derived from authorized QoS info for IP flows of a media component, which is extracted from the SDP parameters)

R5: Go interface (2/2)

- **Gate description**
  - Packet classifiers (source and destination IP address, source and destination ports, protocol ID)
  - Gate status (opened/closed)
  - (IP packets matching an SBLP-supplied filter are subject to the gate associated with that packet filter)
- **Charging identifiers**
  - GPRS and IMS charging identifiers (GCID and ICID)
  - (The operator may correlate the corresponding IMS and GPRS charging records to each other)

R5: QoS handling – Go interface

1. Authorization token (IMS session Id, PDF Id) and negotiated SDP parameters delivered form IMS (PDF/P-CSCF) to the UE using SIP signaling



5. PDF identifies the appropriate IMS session with the Authorization Token, and provides the GGSN with the "Authorized QoS" (Aggregated QoS = Data rate, Max QoS Class) for the bearer, Gating info (IP flows packed classifiers and corresponding status) and IMS Charging Id

4. GGSN validates the PDP context QoS and sends the authorization request with binding information (Authorization Token, Flow Id(s)) to the PDF via Go

2. UE inserts binding info (Authorization Token, Flow Id(s)), APN, "Requested QoS", in the PDP context activation request

3. SGSN controls "Requested QoS" with "Subscribed QoS" from HLR, and negotiates the QoS with GGSN

6. GGSN maps the "Authorized QoS" onto Authorized UMTS QoS information, and returns the "Negotiated QoS" profile for the bearer to the SGSN

7. SGSN setups the radio access bearer and provides the Negotiated QoS profile to RAN and UE

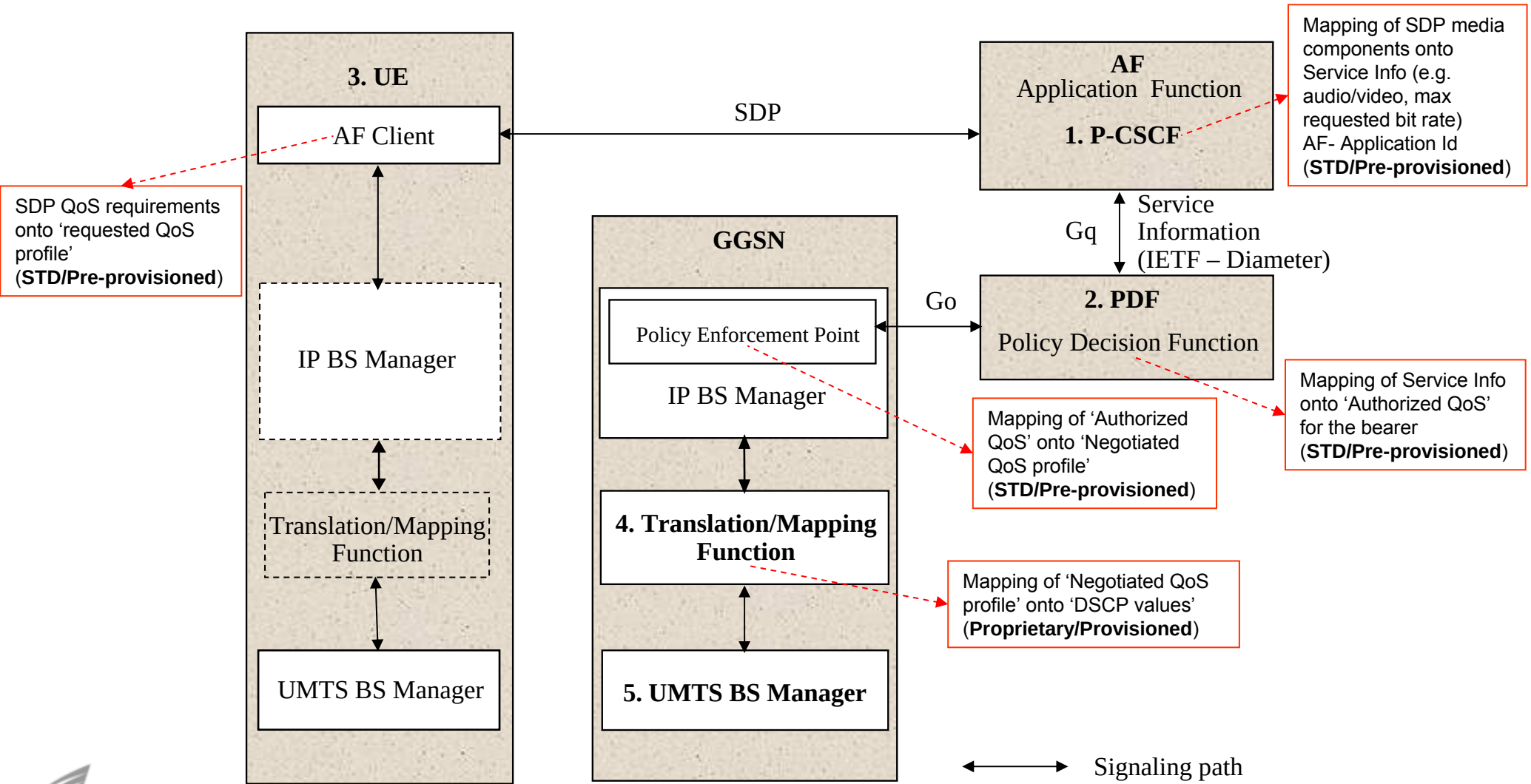
R6: Main QoS amendments

- **Gq interface**
  - Between the PDF and Application Function (AF)
  - PDF is a stand-alone element
- R5 Go interface is not changed
- **Possibility to multiplex several service applications' data flows** (application sessions or media components or multimedia sessions) **into one PDP context**
  (i.e., an *AF session* description can consist of more than one media component)

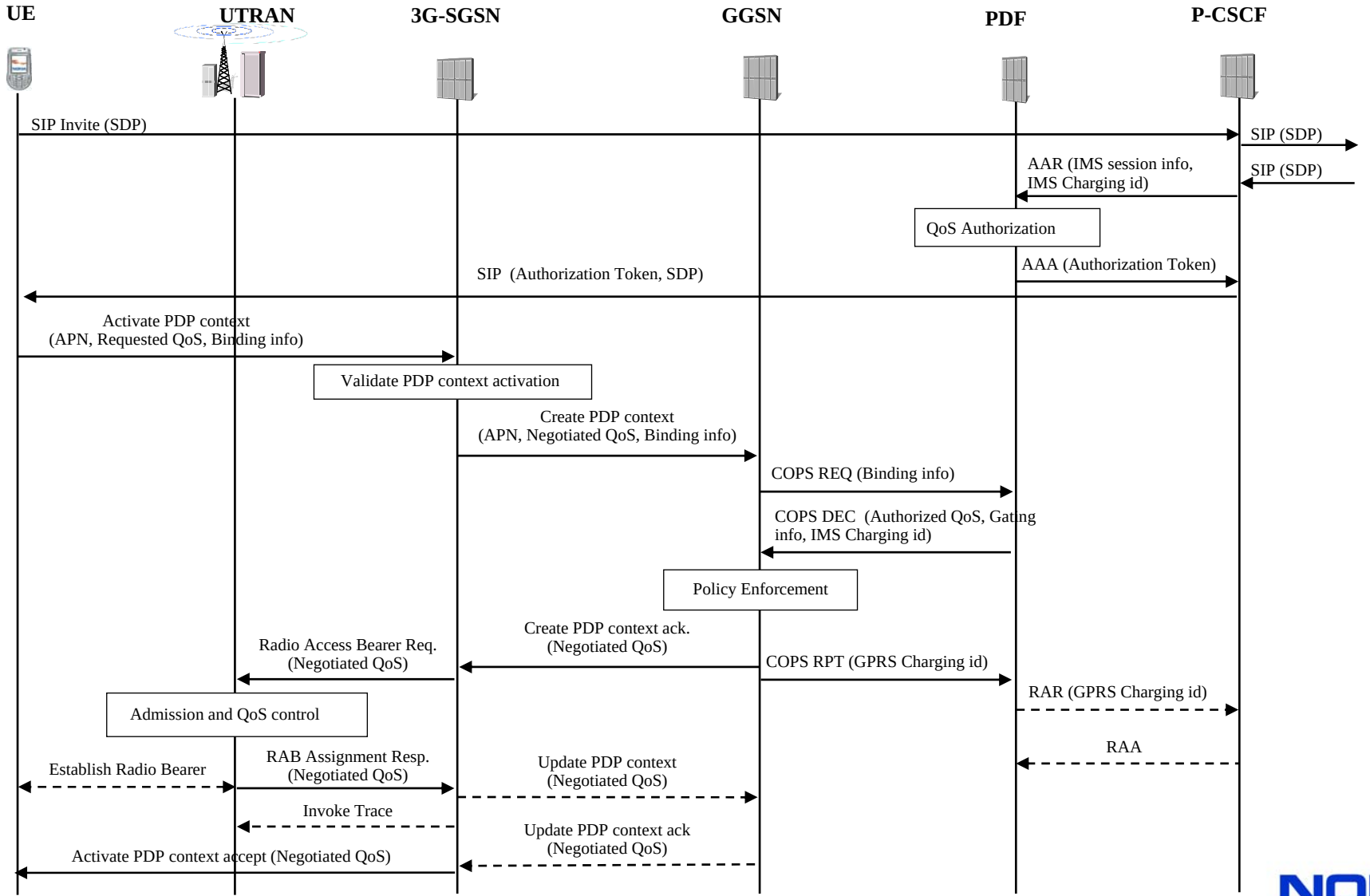
R6: Gq interface

- **Authorization token (in accordance with R5)**
  - Used as binding information between an application session and related bearer session (PDP context)
  - Provides the GGSN with the PDF address
- **Media component description**
  - Part of an AF session description (e.g., SDP) conveying information about the media of the application session
  - (The PDF uses this information for the QoS authorization and gating decision)
- **AF-Application Identifier**
  - Provides additional application information to the PDF for QoS authorization
  - (The parameter values and the logic that AF uses to determine the application identifier are not standardized)
- **Charging identifiers**
  - GPRS and IMS charging identifiers (GCID and ICID, respectively), as described in R5 for the Go interface

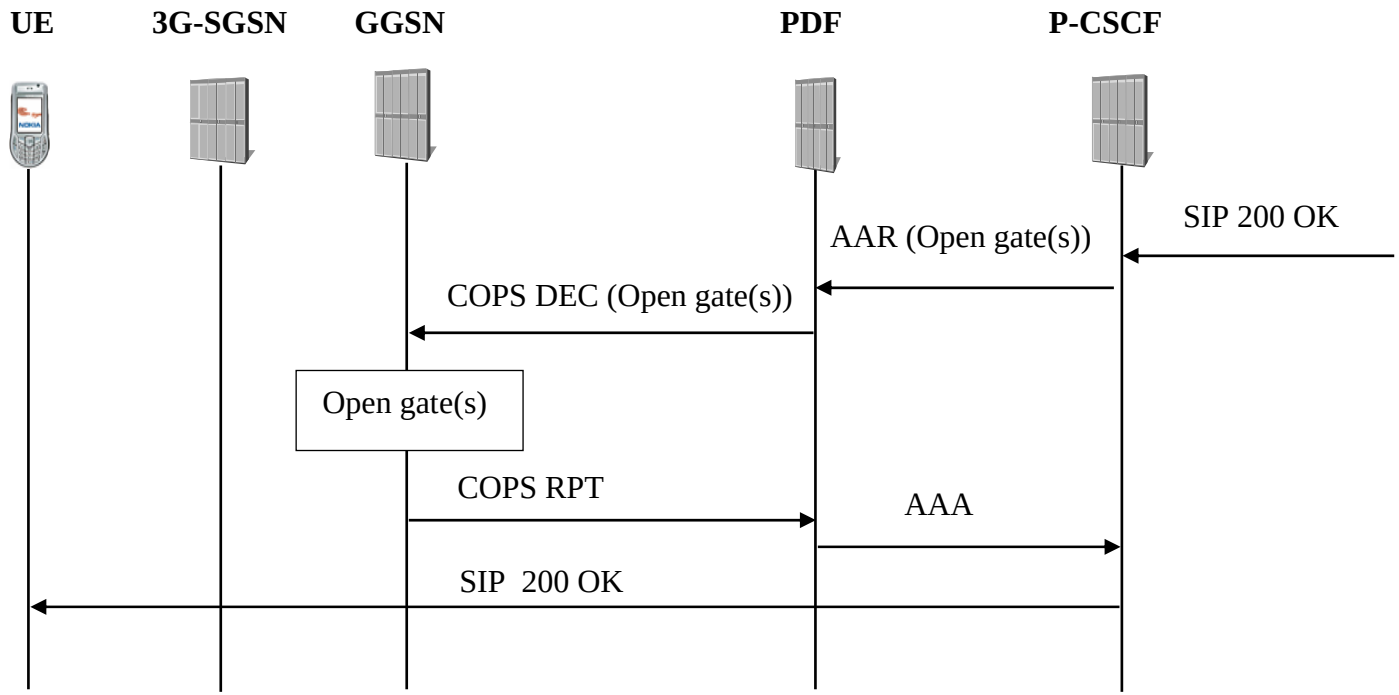
R6: QoS architecture and QoS mapping



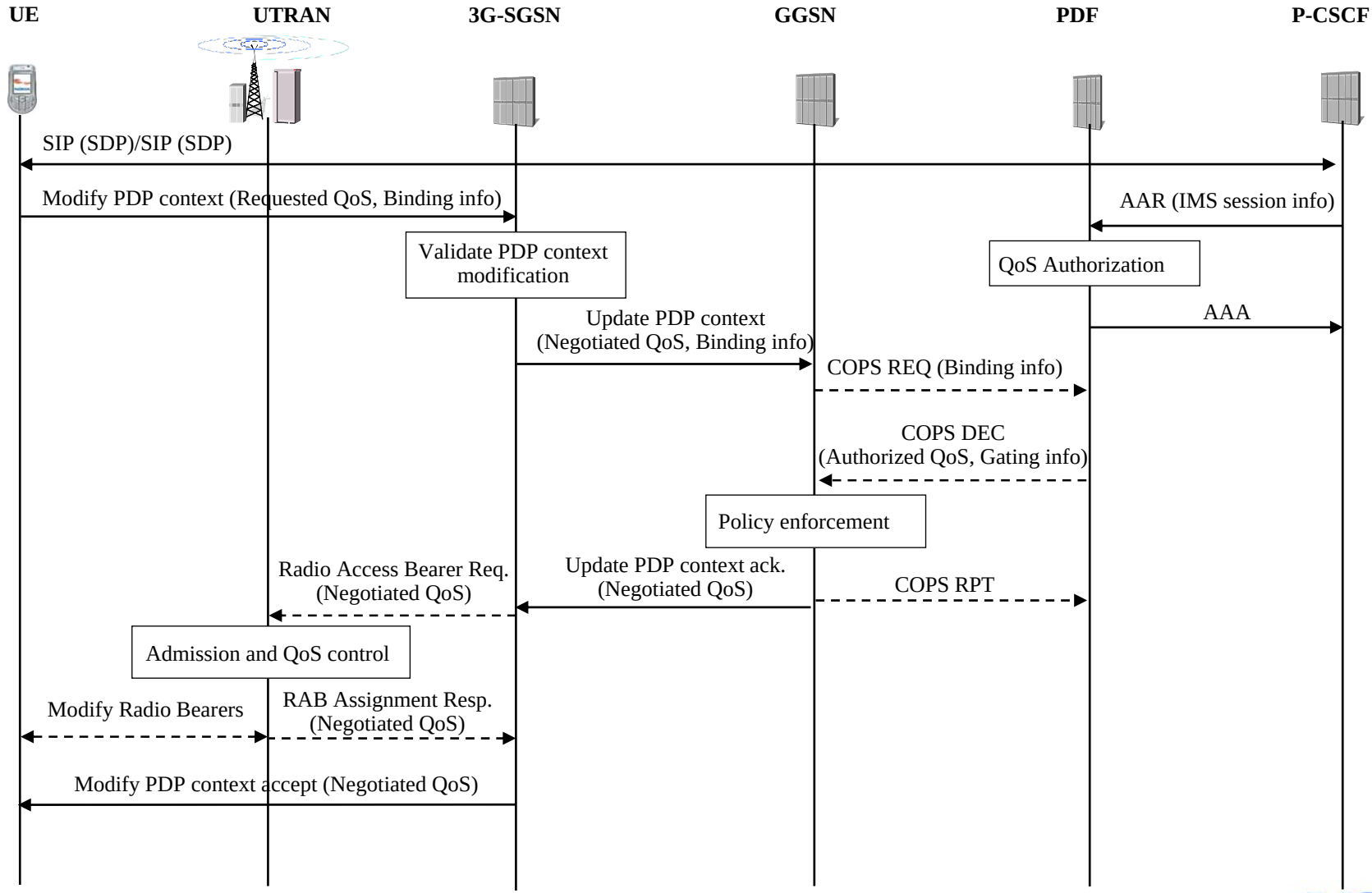
R6: Resource authorization and reservation



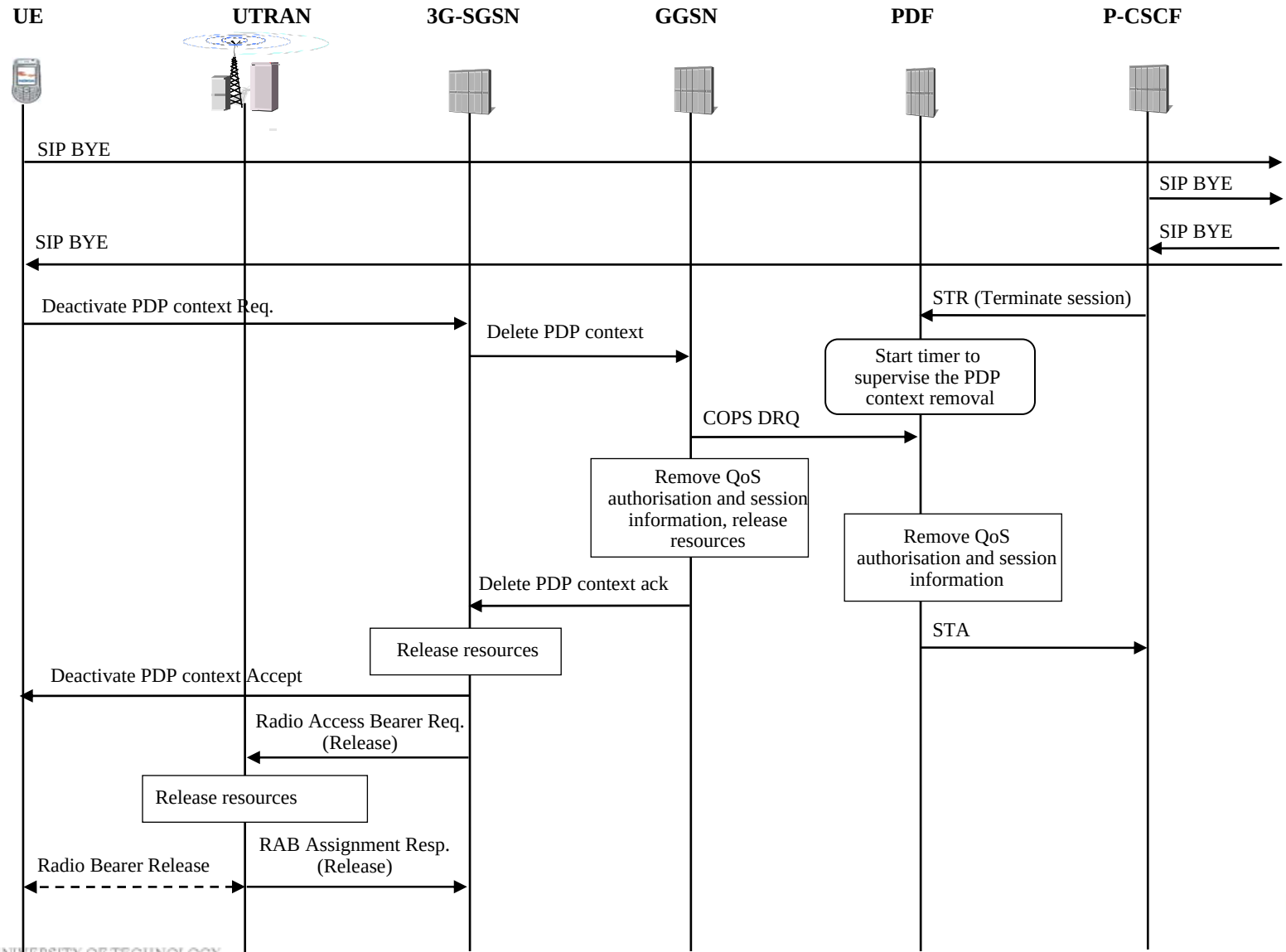
R6: Opening and closing the gate



R6: UE initiated PDP context modification



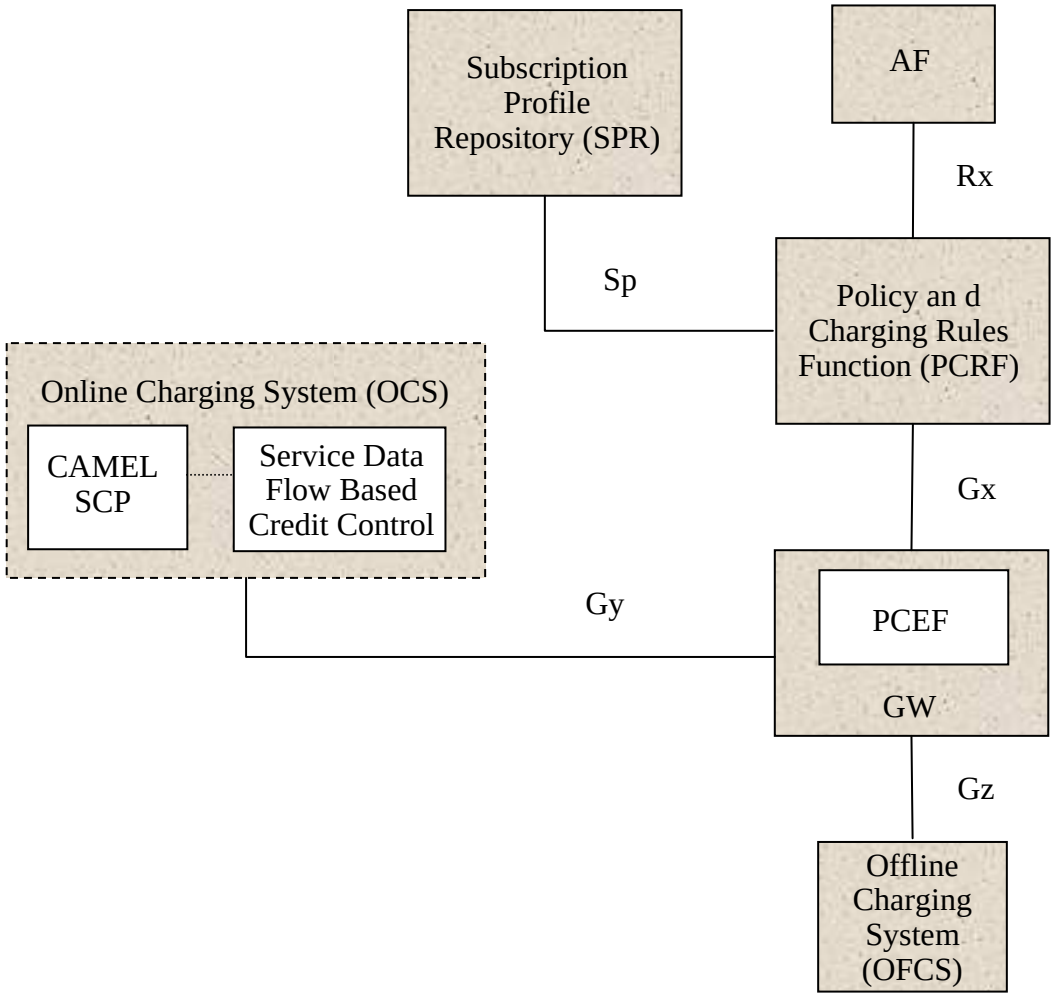
R6: PDP context deactivation



Main QoS amendments in R7

- A new work item called ‘policy and charging control’ (PCC) is established to combine R5 and R6 QoS and policy control functionality with R6’s flow-based charging (FBC) functionality
- Whereas QoS and policy control provides QoS authorization for the bearer based on dynamic service requirements, the FBC provides the possibility to give rules for differentiated charging

R7: Draft PCC overall architecture



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  - http://eu.wiley.com/WileyCDA/WileyTitle/productCd-0470016396.html
  - http://www.connecting.nokia.com/NOKIA/nns.nsf/a/78786C61AB5A7C5AC225718F0026BAA3

    (Contact Mr. Geoff Farrell @ Wiley gfarrell@wiley.co.uk)

See also:

- http://lib.tkk.fi/Diss/2005/isbn9512278340/