QoS in UMTS

emphasis on the IP-based part of the UMTS core network

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What is „QoS in UMTS“ ?

- UMTS is the upcoming technology for mobile communication
  - to replace todays GSM and GPRS
  - whereas GSM is circuit-switched, UMTS is (partly) packet-switched
- Quality of Service (QoS) is the quality of a communication session
  - Measurable as bandwidth, delay, jitter, packet loss,...
- QoS is never a problem in circuit-switched systems,...
- ... classically, packet-switched systems (Internet) don‘t provide QoS
- UMTS needs to provide QoS
- A variety of techniques have been developed for QoS in packet switched systems.
- How can they be utilized in UMTS?

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Overview „QoS in UMTS“

- Architecture UMTS Network
- QoS technology
- QoS in the UMTS Core Network
- Standardization Issues
- QoS in Real-life UMTS Networks

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Overview UMTS Architecture

- Scenarios and Applications
- Comparison of UMTS and WLAN
- UMTS and IP standardization
- Evolution of GSM -> GPRS -> UMTS
  - GSM architecture
  - GPRS architecture
  - UMTS (Release 5) architecture
- UMTS / GPRS protocol stack example
- How a mobile goes about sending something
  - PDP context activation
- Illustration of PDP context activation

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Scenarios and Applications

UMTS will offer:

- anywhere, anytime communication
- multimedia services
  - telephony
  - videoconferencing
  - entertainment
    - interactive gaming, music on demand, video streaming,...
  - remote monitoring and control e.g. of the home
  - mobile banking
  - ...
- personalized services
  - same environment on all mobile devices and in all networks
- location-based services
  - what movies are playing here?
  - where is the next italian restaurant / McDonalds / ...
- mobile Internet access
- mobile Intranet access

Convergence of Information Technology and Mobile Telecommunication Systems

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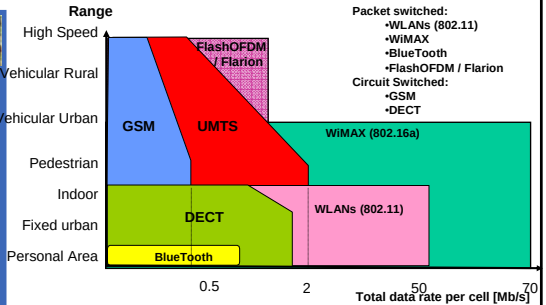
Comparison with related technologies I



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Architecture UMTS Network
Comparison to WLANs

- At first glance, UMTS, WLAN and WiMAX have the same goal: broadband wireless access
- However, requirements on UMTS are much higher:
  - seamless handover
  - high security standard
  - tight control over network resources by network owner
  - sophisticated charging functionality
  - high coverage, also at high user speeds
  - backwards compatibility with GSM / GPRS
  - *simultaneous transmission of data and voice*
    - *with voice quality as good as in GSM*
- UMTS solves these issues with a highly developed integrated control plane
- In the beginning, WLAN was perceived as competition to UMTS (WiMAX came later)
- Now perceived as complementing technologies

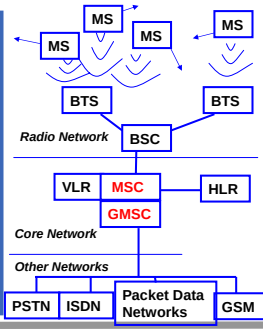
UMTS standardization

- UMTS is being developed and standardized simultaneously
  - standardization important because
    - equipment produced by different companies must interwork
    - networks of different operators must interwork
- UMTS standardization performed by 3GPP
  - standards written down in „Technical Specifications“ (TS)

Evolution
GSM -> GPRS -> UMTS I
- GSM -

- GSM is a *circuit switched* network
  (GSM - Global System for Mobile Communication)
  - as opposed to packet switched networks based e.g. on IP
  - for all services (e.g. voice, fax, wap) an end-to-end connection is established
  - all services are reserved the identical bandwidth
    - wasteful particularly on radio interface
  - all services are charged on a per-time unit basis
- since an overall increase of data traffic is expected, GSM was evolved to become more flexible -> GPRS

Simplified Architecture GSM I



- MS - Mobile Station
- BTS - Base Transceiver Station (incl. antenna)
- BSC - Base Station Controller
- (G)MSC - (Gateway) Mobile Services Switching Center
- HLR - Home Location Register
- VLR - Visited Location Register
- plus more security functionality (not shown)

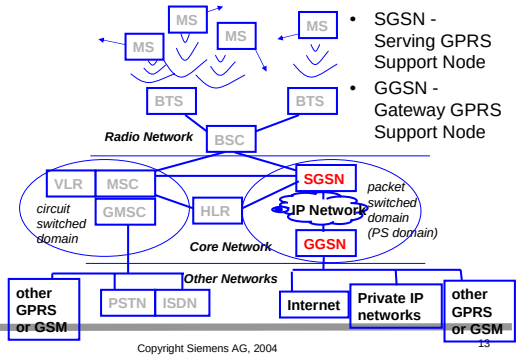
Simplified Architecture GSM II

- BTS - Base Transceiver Station (incl. antenna)
  - receives / sends data units from / to MN via radio interface
- BSC - Base Station Controller
  - controls radio network specific signaling
  - manages radio network resources
- MSC - Mobile Services Switching Center
  - routing, signaling, collection of charging info, mobility management
- GMSC - Gateway MSC
  - a MSC in contact with an external network (ISDN, PSTN, ...)
- HLR - Home Location Register
  - storage of subscriber profiles e.g. for authentication / authorisation
  - storage of current MSC
- VLR - Visited Location Register
  - temporary storage of data on subscribers currently attached to an MSC

Evolution
GSM -> GPRS -> UMTS II
- GPRS -

- GSM is a *circuit switched* network,
  GPRS adds a packet switched network, in parallel, on both the radio link and in the fixed part of the network
  GPRS - General Packet Radio Service
  - higher transmission rates (max 171,2 kb/s)
    - GSM originally had up to 14,4 kb/s
  - data traffic shares a radio channel
  - more efficient usage of resources,because of *statistical multiplexing*
    - All applications share the same resource
      - Efficient for applications with variable rates
    - Can take away resources from each other
  - allows a direct connection to e.g. the Internet
  - charging per data volume possible
    - in GSM always charging per time unit
  - *IP QoS issues arise*

Simplified Architecture GPRS I



- SGSN - Serving GPRS Support Node
- GGSN - Gateway GPRS Support Node

Simplified Architecture GPRS II

- SGSN - Serving GPRS Support Node
  - analogous to MSC plus VLR, but packet switched:
    - routing, signaling, collection of charging info, mobility management
    - temporary storage of data on subscribers currently attached to an MSC
- GGSN - Gateway GPRS Support Node
  - analogous to GMSC, but packet switched
    - gateway to other packet data networks
      - conversion of protocols
      - routing functionality

Simplified Architecture GPRS III

- SGSN and GGSN may or may not be colocated, there doesn't need be a 1:1 relationship
  - SGSNs and GGSNs of one operator are connected by an IP-based network
- the air interface is unchanged in GPRS, however, a „shared channel“ is introduced for packet switched data
  - in GSM, each session is assigned its own dedicated channel
- the packet switched domain is used exclusively for data services

Evolution
GSM -> GPRS -> UMTS III
- UMTS Release `99 -

- GSM is a *circuit switched* network, GPRS adds a packet switched network, in parallel, on both the radio link and in the fixed part of the network
  UMTS Release `99 replaces the GSM radio network by the UTRAN
  UMTS - Universial Mobile Telecommunication System
  UTRAN - UMTS Terrestrial Radio Access Network
  - employs WCDMA instead of TDMA
    WCDMA - Wide Band Code Division Multiple Access
    TDMA - Time Division Multiple Access
  - UTRAN and GSM radio network can coexist and connect to the same core network
- UMTS is continuously being worked on (as was GSM)
  - first release was Release `99
  - yearly releases could not be realized, hence the next one was called Release 4 (closed in 03/01)
  - Release 6 closed in fall spring 04
  - Currently Release 7

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Evolution
GSM -> GPRS -> UMTS III
- UMTS Release 4/5 -

- The „circuit switched domain“ may also be based on packet based transport
  - slow evolution towards „all-IP“ -- may be some day abandon the circuit switched domain all together
- Introduction of the IMS
  IMS - IP Multimedia Subsystem
  - supports IP-based multimedia services
    - multimedia services are e.g.
      Video, voice, possibly simultaneously with data etc.
    - the PS domain serves as access system to the IMS
      - the IMS in principle is access-system independent
        » Also ETSI is interested
      - the PS domain hides mobility from the IMS

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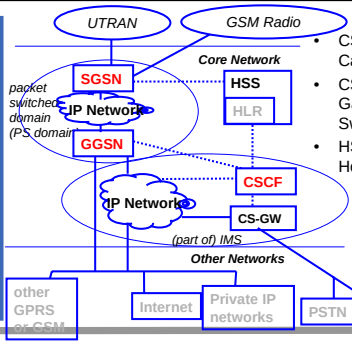
Simplified Architecture
UMTS Release 5 - I



- CSCF -
  Call State Control Function
- CS-GW -
  Gateway to Circuit Switched Networks
- HSS -
  Home Subscriber Server

- Radio network (UTRAN etc) not shown in detail
- Circuit switched domain not shown
- dashed lines carry solely control traffic

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Simplified Architecture UMTS Release 5 - II

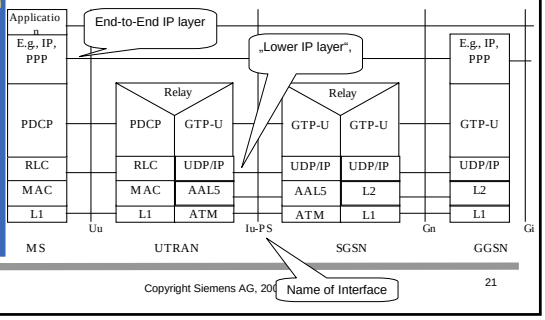
- CSCF - Call State Control Functions
  - first contact point of a mobile node setting up a multimedia session
  - session control (e.g. Policing) and service provisioning
- CS-GW - Gateway to Circuit Switched Networks
  - consisting of three separate entities not shown in detail
  - supports a direct connection to PSTN / ISDN from packet domain
    - allows connecting IP-based voice calls to „normal“ phones
- HSS - home subscriber server, extension of HLR

Simplified Architecture UMTS Release 5 - II

- PS Domain has direct access to external packet-based networks, as before
- multimedia sessions are controlled and policed by CSCF
  - The GGSN is a Policy Enforcement Point controlled by the CSCF
- IMS and PS domain may belong to separate operators, or IMS may offer 3rd party services

Protocol stack UMTS PS domain - user plane I

- Slightly modified from TS 23.060 (3GPP standardization document for UMTS)
- explanation see next slide



Protocol stack UMTS PS domain - user plane II

In the figure on the last slide lots of information is provided, not all of which is important here. Only what is relevant later will be explained:

- only the application layer and the „upper“ IP layer are an end-to-end layer

now we concentrate on what is between SGSN and GGSN:

- GTP-U - GPRS tunneling protocol, user plane:
  - tunnels data between SGSN and GGSNs
  - hides mobility to upper IP layer
  - gives network owner control over where traffic leaves its network
- below GTP-U, a normal IP protocol stack is employed
- L2 / L1 are unspecified Layer 2 / Layer 1 protocols

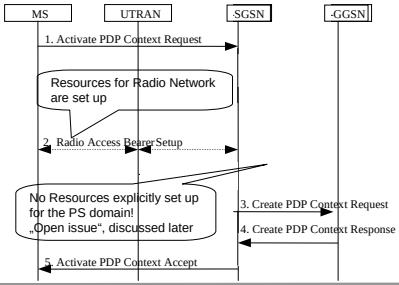
- *the QoS in both IP layers must be coordinated*

When a Mobile wishes to use PS domain services....

- ...it first makes its presence known to the SGSN by performing a attach procedure.
  - The SGSN subsequently stores information regarding mobility and security for this MS
- ...if IMS services are to be used, it contacts the CSCF
- ...in order to send and receive PS data, it activates a *PDP context* in SGSN and GGSN
  PDP context - Packet Data Protocol Context
  - containing all information necessary for transferring traffic between MS and GGSN across the PS domain, e.g.:
    - MS‘ (possibly temporary) IP address
    - name of desired service / external network
    - possibly description of traffic to be sent
    - *QoS profile*

Illustration: PDP context activation procedure

•Slightly modified from TS 23.060
(3GPP standardization document for UMTS)



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- QoS technology
- QoS in the UMTS Core Network
- Standardization Issues
- QoS in Real-life UMTS Networks

QoS technology – How to?

- In order to support QoS, two steps are necessary:
  - QoS requirements of a session must be made known to the network, end-to-end:

    Protocol for QoS Signaling
  - QoS must be realized. e.g. by reserving resources in all nodes:

    Resource Provisioning technique

Both are standardized by the IETF

QoS technology – QoS Signaling protocols

- today, no generally accepted solution exists:
- RSVP and its extensions
  - only QoS signaling protocol supported to any extent in commercial routers
  - RSVP is quite flexible, but this implies overhead for most (simple) uses
  - For this reason never widely deployed
- The IETF is currently working on a new QoS signaling protocol in the NSIS Working Group
  - Attempting to improve on RSVP
- Signaling of packet priority (via DSCPs)
- In the UMTS PS domain, can use PDP context signaling
  - Information however only transferred to SGSN / GGSN

QoS technology – Resource Provisioning I

- **Overprovisioning**
  - **Provide sufficient resources to handle any traffic**
  - **Can be combined with admission control at the ingress**
  - **Probabilistic QoS guarantee**
  - **No signaling needed (except may be to ingress routers)**
- **DiffServ**
  - prioritization of particular flows via Code Points (DSCP)
    - e.g. real-time packets are always handled first
  - **should be used together with admission control**
  - **because packet paths are unknown, results in probabilistic QoS guarantees**
  - resource requirements should be signaled to nodes performing admission control (ingress routers)

QoS technology – Resource Provisioning II

- **IntServ**
  - reservation of resources in each node
    - results in guaranteed QoS
    - not scalable
  - resource requirements (QoS) must be signaled to each node
- **MPLS**
  - reservation of paths (LSPs) with guaranteed resources possible
    - as in IntServ, results in guaranteed QoS
    - uses extension of RSVP for setting up paths
  - as in DiffServ, resource requirements should be signaled to ingress routers

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QoS in the UMTS Core Network

- Problem Definition
- High-Level Requirements on QoS
- Detailed Requirements on QoS
  - QoS Classes, Parameters, Values
- End-to-End QoS scenarios
  - signaling and resource provisioning
- QoS management functions defined for UMTS

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QoS in the UMTS Core Network
Problem Definition

- Obviously, to support e.g. voice or video across an IP network, considerations must be made how their QoS requirements can be supported
  - need to first define and parametrize QoS requirements
- QoS support in IP is a difficult problem
  - the UMTS core network is largely IP-based
  - need to define
    - end-to-end QoS signaling scenarios
    - end-to-end QoS provisioning scenarios
    - QoS management functions

Most of the information given here originates from the 3GPP standardization documents TS 23.107 and TS 23.207.
Since some figures are copied from the standard, they may contain more information than necessary, or unexplained details!

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Illustration:
High-Level Requirements on QoS
Excerpt from TS 23.207

- The UMTS QoS negotiation mechanisms used for providing end-to-end QoS shall not make any assumptions about
  - application layer signalling protocols
  - the situation in external networks which are not within the scope of 3GPP specifications.
  - applications which may be used on Mobile Station
- No changes to non-UMTS specific QoS negotiation mechanisms.
- Unnecessary signalling complexity and processing complexity in the network elements as well as the mobile terminal shall be avoided.
- Unnecessary signalling traffic due to end-to-end QoS negotiation shall be avoided.
- Etc.

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Detailed QoS requirements: QoS Classes, Parameters, Values I

- 4 QoS classes are defined:
  - conversational class (e.g. voice, video conferencing)
  - streaming class (e.g. video streaming)
  - interactive class (e.g. Web browsing, gaming)
  - background class (e.g. Background email download)
- These classes are characterized by e.g.:
  - Guaranteed / max. Bit rate
  - max SDU size
  - transfer delay
  - traffic handling priority

What does QoS mean in UMTS: QoS Classes, Parameters, Values II

Excerpt from TS 23.107:

Table 4: Value ranges for UMTS Bearer Service Attributes

Traffic class	Conversational class	Streaming class	Interactive class	Background class
Maximum bitrate (kbps)	< 2 048 (1) (2)	< 2 048 (1) (2)	< 2 048 - overhead (2) (3)	< 2 048 - overhead (2) (3)
Delivery order	Yes/No	Yes/No	Yes/No	Yes/No
Maximum SDU size (octets)	<=1 500 or 1 502 (4)	<=1 500 or 1 502 (4)	<=1 500 or 1 502 (4)	<=1 500 or 1 502 (4)
SDU format information	(5)	(5)		
Delivery of erroneous SDUs	Yes/No/- (6)	Yes/No/- (6)	Yes/No/- (6)	Yes/No/- (6)
Residual BER	$5*10^{-2}$, 10^{-2}, $5*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}	$5*10^{-2}$, 10^{-2}, $5*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}	$4*10^{-3}$, 10^{-5}, $6*10^{-8}$ (7)	$4*10^{-3}$, 10^{-5}, $6*10^{-8}$ (7)
SDU error ratio	10^{-2}, $7*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}	10^{-1}, 10^{-2}, $7*10^{-3}$, 10^{-3}, 10^{-4}, 10^{-5}	10^{-3}, 10^{-6}, 10^{-8}	10^{-3}, 10^{-4}, 10^{-6}
Transfer delay (ms)	100 – maximum value	250 – maximum value		
Guaranteed bit rate (kbps)	< 2 048 (1) (2)	< 2 048 (1) (2)		
Traffic handling priority			1,2,3 (8)	
Allocation/Retention priority	1,2,3 (8)	1,2,3 (8)	1,2,3 (8)	1,2,3 (8)

Further details to be studied later

End-to-End QoS Scenarios I Basics

- End-to-End QoS needs QoS signaling:
  - all network segments need be informed about the QoS that is to be provided
  - QoS signaling e.g. via
    - RSVP
    - DSCPs (DiffServ Code Points; limited information)
    - PDP context
- End-to-End QoS needs QoS provisioning via e.g.
  - Overprovisioning
  - DiffServ
  - IntServ
  - MPLS
- Signaling and provisioning mechanisms don't need be the same in all network segments
  - interworking possible

End-to-End QoS Scenarios II
Basics

- For UMTS, five end-to-end QoS signaling scenarios are standardized in Release 5
- Not much in standard about QoS provisioning (no interworking necessary)
- 3 scenarios with PDP context / DiffServ interworking, 2 additional scenarios with additional RSVP signaling, however they are not specified in detail
- App. layer signaling via SIP
  SIP - Session Initiation Protocol
  - necessary for e.g. IP telephony, not needed for web surfing
  - SIP allows applications to agree on codec, port etc.
  - Standardized in the „IP world“ (IETF)
  - this is a UMTS specific SIP dialect
    - additional functionality compared to IETF SIP

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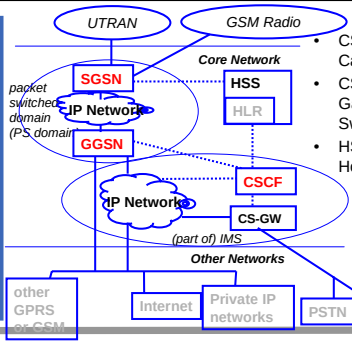
Reminder: Simplified Architecture
UMTS Release 5



- CSCF - Call State Control Function
- CS-GW - Gateway to Circuit Switched Networks
- HSS - Home Subscriber Server

- Radio network (UTRAN etc) not shown in detail
- Circuit switched domain not shown
- dashed lines carry solely control traffic

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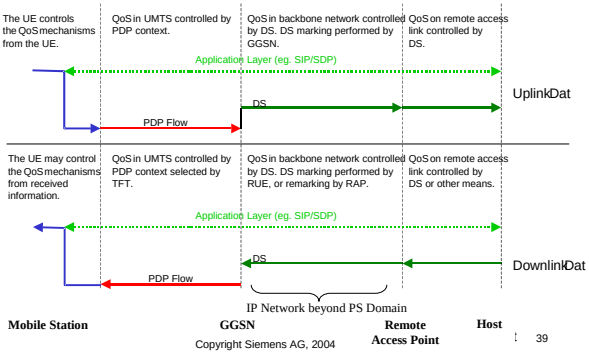
End-to-End QoS Scenarios III
Sign. Scenario A - no IMS support I



End-to-End QoS Scenarios III

Netzwerktechnologien und multimediale Teledienste

Sign. Scenario A - no IMS support II

- Mobile Station (UE) signals QoS via the PDP context
- GGSN translates between PDP context and DiffServ
  - this way QoS in both IP-layers is coordinated (cf. slide 19)
  - downlink data may however be re-classified because PDP context overrides external DiffServ marking
    - PDP context contains traffic description (TFT)
- IP network beyond PS domain is DiffServ enabled

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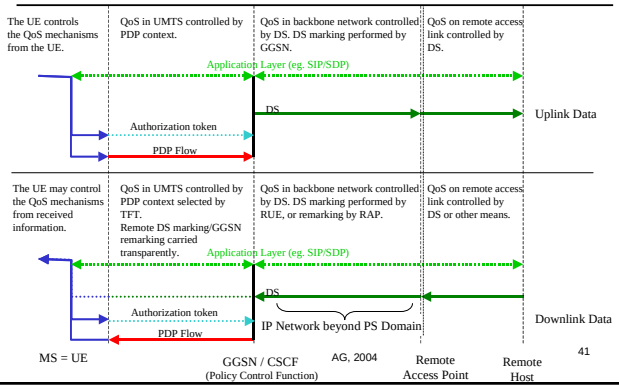
End-to-End QoS Scenarios IV

Netzwerktechnologien und multimediale Teledienste

Sign. Scenario B - IMS support I



End-to-End QoS Scenarios IV

Netzwerktechnologien und multimediale Teledienste

Sign. Scenario B - IMS support II

- Scenario B extends Scenario A in that it includes IMS services
- As mentioned on slide 20, for setting up an IMS session, the MS first contacts the CSCF:
  - its SIP signaling is intercepted by the CSCF
    - CSCF checks whether user is authorized for service and QoS desired
    - if yes, an *authorization token* is handed back to the MS
- subsequently to SIP signaling (CSCF contact), the MS sets up the PDP context
  - authorization token included in PDP context
  - auth. token used by GGSN to check user authorization with CSCF
    - CSCF contains policy control function (to be separated in R6)
  - this way unauthorized usage of IMS resources is not possible
  - this way QoS in both IP-layers is coordinated (cf. slide 19)

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QoS management functions for PS Domain

- The above scenarios are realised by QoS management functions, many of them known from the IP world
- QoS mgmt functions for user plane include everything necessary for
  - making user traffic adhere to the traffic profile agreed upon
  - managing the network resources such that QoS agreed upon is delivered
- QoS mgmt functions for the control plane include
  - limiting incoming traffic so QoS agreed upon can be delivered
  - policy enforcement / authorization

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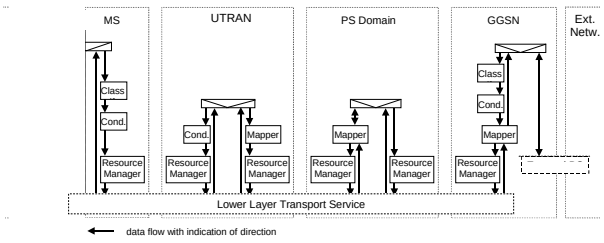
QoS management functions for PS Domain - user plane I



Class. - Classifier
Cond. - Conditioner

QoS management functions for PS Domain - user plane II

- User plane QoS management functions are similar to those known from IP (e.g. DiffServ)
- A user-plane packet originating from the MS,
  - is *classfied* as belonging to one of the PDP contexts open for this MS
  - is *conditionalized*, i.e. if need be dropped, demoted or delayed
    - according to the service described in PDP context
  - is scheduled, queued etc in the *resource manager*

  in MS
  - this last step is repeated (at least once) in each network segment
  - in each network segment a new mapping (DSCP marking, MPLS labeling) might be necessary
- user-plane packets entering the PS domain at the GGSN experience the same classification/conditioning etc.

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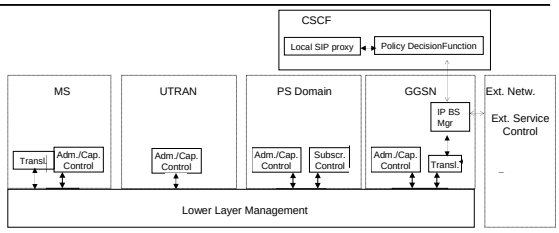
QoS management functions for PS Domain - control plane I



Adm./Cap. Control - Admission/Capability Ctrl.
Transl. - Translation
Subscr. Control - Subscription Control
IP BS Mgr - IP Bearer Service Manager

QoS management functions for PS Domain - control plane II

- Some control-plane QoS management functions are similar to those necessary in IP networks:
  - Admission and capability control
  - subscription control
- the Translation Function translates between IP-specific and UMTS-specific QoS attributes
  - e.g. between RSVP Tspec and PDP context QoS attributes
  - necessary because app. in MS provides IP specific info, but MS needs to signal PDP context
- IP Bearer Service Manager manages the upper IP-layer QoS
  - acts as policy enforcement point
  - performs DiffServ Codepoint marking

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QoS management functions for PS Domain - control plane III

More details on CSCF functions:

- In CSCF,
  - the SIP proxy intercepts SIP messages as described in end-to-end Scenario B (slide 33)
  - SIP proxy consults the Policy Decision Function
    - whether user is authorized to establish a session as described in SIP message
    - Policy Decision Function decides based on some *policy* provided by the network owner
  - when Policy Decision Function authorizes a session, the SIP proxy hands back the authorization token to the MS, as described above

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Standardization Issues

- Why is standardization necessary?
- Standardization Bodies
  - 3GPP
  - IETF
- IP Technology Standardization in the IETF
  - who standardizes
  - how, where, when, how often
- UMTS Standardization in 3GPP
  - who standardizes
  - how, where, when, how often
- 3GPP - IETF interworking

Why is standardization necessary?

- Applications must interwork across the network
- Equipment produced by different companies must interwork
- Networks of different operators must interwork

⇨ hence it is not a good idea for everybody to develop their own protocols / architectures

⇨ Network Experts sit together for this task

⇨ perform development and standardization simultaneously

What to standardize?

- What needs to be standardized? the "Essential What":
  - basic architecture
  - functionality of essential network elements
  - protocols and protocol stacks
  - interfaces
  - information storage
  - Everything else related to interworking
- What needs not be standardized?
  the "How" and everything not essential:
  - internal operation of network elements
  - intradomain solutions not related to core functionality
    - e.g. intra-domain resource management
  - ...
- Equipment vendors / operators have to come up with own solution for things not standardized

Standardization Bodies

- UMTS is being standardized by 3GPP
  3GPP - 3rd Generation Partnership Project
  - worldwide partnership of equipment providers and operators for developing UMTS
- IP Technology is being standardized by IETF
  IETF - Internet Engineering Task Force
  - loose organization of „independent“ engineers and researchers
  - e.g. IP, TCP, SIP, IntServ, MPLS etc. are all by IETF
- Philosophies of 3GPP and IETF are very different

UMTS Standardization in 3GPP

- www.3gpp.org
- each company nominates delegates to represent them (nobody else can participate)
- standardization process:
  - standardized is what all delegates agree upon
  - delegates pursue company interests
- standardization proceeds via mailing lists and meetings at least 6 times a year
- standardization topics are pursued with timely termination as a guiding principle
  - A lot of money is involved
- standardization ideas are presented to the community in writing as “Technical Documents” (Tdocs)
- standardization ideas agreed upon are published and updated as “Technical Specification” (TS)

IP Technology Standardization in the IETF

- www.ietf.org
- everybody may participate in IETF standardization
  - influence on standard based on technical knowledge and reputation. Employer in principle unimportant.
- Standardization process:
  IETF motto: "We believe in running code and rough consensus"
  - only what has been implemented can be standardized
- standardization proceeds via mailing lists and meetings 3 times a year
- standardization topics pursued depend on the interest of the people involved
- standardization ideas are presented to the community in writing as "Internet Drafts"
- standardization ideas agreed upon are published as "Request for Comment" (RFC)

3GPP - IETF interworking

- 3GPP and IETF are based on very different principles
  - 3GPP defines an entire system (-> cathedral)
  - IETF works one-protocol-at-a-time (-> bazaar)
- However, as Telecommunications and Internet converge, they need to collaborate
  - currently 3GPP needs collaboration from IETF more than vice-versa
    - e.g. SIP standardization
  - but IETF doesn't produce standards „on request"
  - 3GPP can't wait for standards that are produced „if people are interested and find a solution they are happy with"
- increasingly the same persons are active in both organizations
  - collaboration can be expected to improve

Overview „QoS in UMTS"

- Architecture UMTS Network
- QoS technology
- QoS in the UMTS (Core) Network
- Standardization Issues
- QoS in Real-life UMTS Networks

What is necessary beyond the standard presented so far? I

- Not everything is standardized by 3GPP
  - because time did not permit
    - may be done in later Releases
  - in order to allow differentiation between equipment providers and operators
  - Because IP does not offer a solution yet
- issues left open by the standard must be solved by equipment providers and operators

What is necessary beyond the standard presented so far? II

- Equipment providers deduce UMTS product specification from
  - 3GPP Standard
  - own work on open issues
- Factors influencing product specification
  - who are the customers?
    - „incumbent“ or „greenfield“? (incumbent operator already owns network)
      - „incumbents“ likely to be more conservative
      - already own equipment that needs to be integrated
    - what kind of networks do they operate?
  - continuous product „evolution“ important
    - as opposed to completely new design for each release
      - too expensive for all parties involved

Open issues

- A subset of open issues:
  - QoS signaling
  - QoS provisioning technique
  - Policy framework
  - Network resource management

QoS Signaling

- Within an operator's domain left to the operator (no need to standardize)
- Across non-3GPP IP networks: tackle in Rel7

QoS provisioning technique I

- the standard leaves open how QoS is provided
  - in PS domain and IMS
- problems similar to those in any IP network that is to provide QoS
- QoS provisioning possibilities:
  - overprov., DiffServ, MPLS
  - IntServ is not considered scalable, and therefore usually dropped from list
  - choice depends on
    - operator preferences
      - available network
      - service model
    - equipment provider implementation effort

QoS provisioning technique II

- Overprovisioning
  - simple to implement and manage
  - soft QoS guarantees
    - how much overprovisioning is necessary?
  - requires ample network resources
    - feasible e.g. for optic fibre backbone
    - unfeasible for leased-line network

QoS provisioning technique III

- DiffServ
  - not too complicated in implementation and management
  - semi-soft QoS guarantees (better than with overprovisioning)
    - dimensioning of queues?
    - how many different DiffServ classes?
    - DiffServ with Admission Control?
      - admission control based on what?
        - » ingress routers dont have complete view of network resources
  - feasible when
    - QoS guarantees don't need be absolute
    - network dimensioned carefully

QoS provisioning technique IV

- MPLS
  - management requires some effort
    - set-up and maintainance of LSPs
      LSP - Label Switched Path
  - hard QoS guarantees possible
    - because LSP bandwidth can be reserved
    - admission control no problem
      - ingress router has complete view of LSP resources
    - how many LSPs from where to where?
      - End-to-end mesh does not scale
  - resembles "tried and proven" circuit switching approach
    - safest bet for operators evolving from circuit switched networks

Policy framework

- CSCF serves as Policy Decision Point
  - based on policies it decides whether a particular MS may access a service or resource
- GGSN serves as Policy Enforcement Point
  - it is responsible for enforcing the decision of the CSCF
- it is not specified in UMTS standard
  - where are policies stored ?
  - how are policies managed?

Network resource management

- How do operators negotiate resources among themselves?
  - DiffServ
    - DiffServ Code Points must be mapped when crossing operator borders
      - mapping of QoS classes to Code Points not standardized
    - for a particular DiffServ class, for a particular destination, resources need be reserved in all networks passed
  - MPLS
    - LSPs terminate at Network Borders
      - end-to-end resources need be assigned properly
- How handle Admission Control in DiffServ?
  - Bandwidth Broker? Locally?

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Summary

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- QoS in Real-life UMTS Networks

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