End-to-end IP Service Quality and Mobility
- Lecture #5 -

Special Course in Networking Technology

S-38.215

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Planned contents & draft schedule

1.	Introduction	Jan 13th
2.	Characteristics of mobile applications	Jan 20th
3.	Service quality requirement characterizations	Jan 27th
4.	Challenges of mobile environment	Feb 3rd
5.	**Mobility and QoS in GPRS**	Feb 10th
6.	Mobility and QoS in 3GPP systems	Feb 17th
7.	Mobility and QoS with Mobile IP	(Feb 24th)
8.	Mobile IP QoS enhancements	(Mar 3rd)
9.	Edge mobility	(Mar 10th)
10.	Inter-system mobility	(Mar 17th)
11.	End-to-end QoS management	(Mar 31st)
12.	Summary	(Apr 7th)

Dates in parentheses to be confirmed

Agenda

- Taxonomy of GSM data.
- Design principles of GPRS.
- GPRS architecture.
  - Mobility management
- GPRS R97/98 QoS model.
- GPRS R99 QoS model.
- Services
- Summary

Goals for this lecture

- Understanding of GPRS.
  - Background
  - Design principles
  - Architecture
  - QoS model
- Service quality support with GPRS.
- End-to-end service quality performance with GPRS.

- **Note! What is explained in this lecture is the minimum standards-compliant solution.**

GSM data taxonomy

- **GSM data**: 9.6 – 14.4 kbit/s.
- **HSCSD (GSM modulation)**: depends on number of timeslots, up to 43.2 kbit/s.
- **GPRS (GSM modulation)**: depends on coding mode, 10-12 kbit/s per TSL, 1+ timeslots.
- **GPRS (EDGE modulation)**: depends on coding mode, 40-50 kbit/s throughput per TSL.
- **GERAN**: throughput as with GPRS/EDGE.

GPRS releases – QoS viewpoint

- **GPRS R97/98**: first GPRS release.
  – Packet support architecture.
- **GPRS R99**: enhanced service quality support.
  – Two traffic classes + prioritisation.
  – Real support for flow prioritisation.
- **GERAN**: support for all 3GPP traffic classes.
  – An alternative radio interface for UTRAN (TDD/FDD WCDMA) in UMTS architecture.
  – UMTS will be discussed in the next lecture.

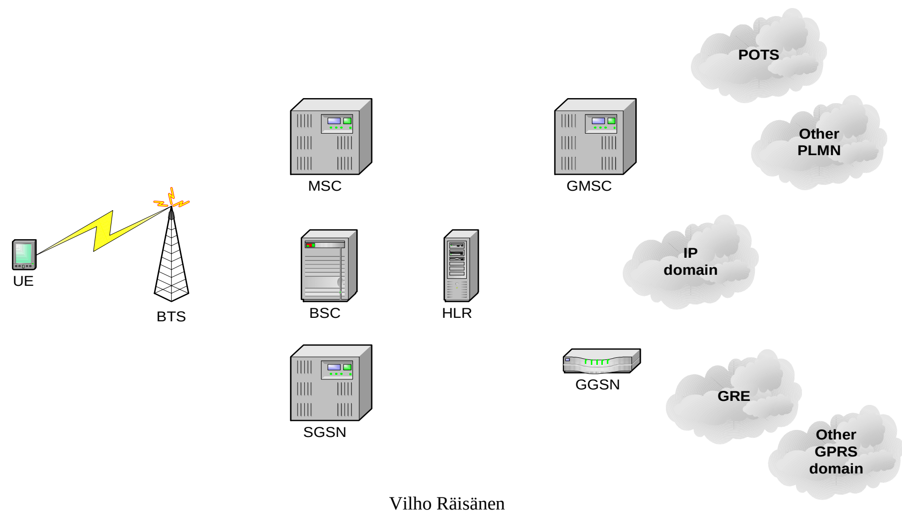
Why GPRS? End user viewpoint

- **Example 1**: WAP connection using GSM data.
  - Connection set-up slow – up to 25 seconds.
  - User pays for the connection time.
  - For most of the time, little data is transferred.
  - When WAP session is “on”, no calls can be received.
- **Example 2**: WAP connection using GPRS.
  - Connection set-up typically a couple of seconds.
  - User typically pays either flat rate or for the amount of data transferred.
  - Connection can be “on” for hours.
  - Calls can be received during WAP sessions (class A or class B terminals).

GPRS design principles

- **Suitable for bursty data**.
  - TCP/IP traffic.
  - Also supports X.25…
  - Uplink and downlink channel reservations independent.
  - Resources allocated only when data is sent.
- **Utilize multiplexing gain also in radio interface**.
  - Sharing of TSLs.
  - GPRS and CS GSM can share timeslots.
- **Services can be activated separately**.
  - HLR does not need to be separately contacted for each packet transmission.
- **Easy to connect to data networks**.

Architecture



Main architectural elements

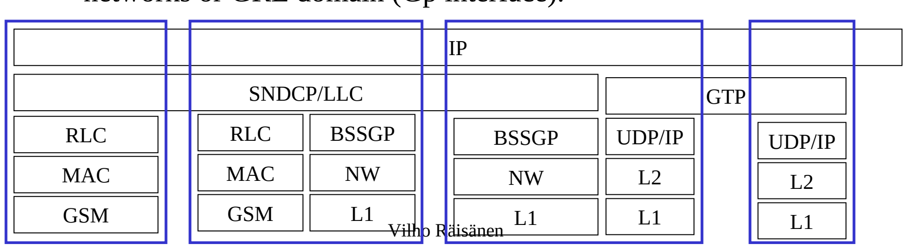
- **MS**: can activate GPRS sessions.
- **BSC**: can interface towards SGSN for packet data.
- **SGSN**: handles terminal mobility and authentication, radio and GPRS QoS, temporary storage of subscription data.
- **GGSN**: “edge router” for GPRS, IP address allocation, GPRS QoS.
- **HLR**: permanent storage of subscription data (including QoS profiles).
- **BG**: interfacing to other PLMNs.

Mobile station

- **MS types**:
  - Phone + GPRS enhancements.
  - “PDA phone”.
  - Laptop PC + GPRS MT.
  - Dedicated GPRS MT.
- **Terminal types**:
  - Class A: can use GPRS and GSM services simultaneously.
  - Class B: can use either GPRS or GSM an any given time, can interrupt GPRS for an incoming GSM call.
  - Class C: GPRS only.

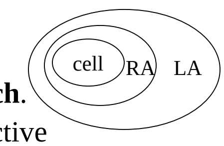
Major interfaces

- GPRS users in a single cell (sector) share available radio interface packet data capacity (Um interface MS-BSS).
- GPRS packet data routed from BSC to SGSN over FR network (Gb interface).
- Between SGSN and GGSN, packets are transmitted on top of IP capable network using GTP/UDP tunnelling (Gn interface).
- Border gateway interfaces GPRS domain to other GPRS networks or GRE domain (Gp interface).



Mobility

- When MS wants to use GPRS services, it performs **GPRS attach**.
  - Terminal must initiate a PDP context once attached.
- **Location updates** sent to network when changing cells.
  - Standby state (not active): granularity of RA.
  - Active state: granularity of cell.
- MS stops using GPRS services using **GPRS detach**.
- SGSN tracks user at the granularity of a cell for active sessions, RA for standby state terminals.
- GGSN tracks user at the granularity of a SGSN.



PDP contexts

- A **PDP context** is needed to send or receive packet data.
- Properties of a PDP context:
  - Addressing is defined per PDP context (IP assumed in what follows, both IPv4 and IPv6 supported).
  - PDP context terminates at an Access Point Name (APN) in GGSN, defining the interfacing point to extra-PLMN networks.
  - QoS is negotiated per PDP context.
- A MS may support one or more simultaneous PDP contexts.
- PDP context expires after certain time if no data have been sent.

PDP context activation

- MS initiates PDP context with "Activate PDP context request".
  - PDP type: IP assumed here.
  - The rest is optional, including QoS parameters.
- SGSN
  - Checks that MS is allowed to activate PDP context.
  - Fills in missing parameters.
  - Performs "Create PDP context request" to GGSN.
- If activation permissible, GGSN replies with "create PDP context" message, including IP address.
- SGSN performs "activate PDP context" to MS if everything OK.
- Both SGSN and GGSN can downgrade QoS parameters.

PDP context cont'd

- **Addressing types**:
  - Static addressing: Home PLMN operator assigns PDP addressing permanently to the MS (e.g., IPv4/IPv6 address).
  - Dynamic addressing.
    - Addressing by HPLMN or VPLMN when PDP context activated.
- **Access Point Name (APN)**:
  - Defines GGSN and exit point to external networks.
  - Static addressing uses APN defined in HLR.
  - Dynamic addressing APN selection tree:
    - APN from HLR (when available)
    - APN from user (if provided)
    - APN from SGSN.

HLR subscription data

Per IMSI

IMSI
MSISDN
SGSN number (SS7)
SGSN address
SMS parameters
MS purged for GPRS
MNRG
GGSN list

Per PDP context

IPDP type (IP/X.25)
PDP address
QoS profile subscribed
VPLMN address allowed?
Access Point Name

GPRS R97/98 QoS

- **GPRS R97/98**:
  - One QoS profile per PDP context.
  - Parameters of QoS profile are not specified in sufficient detail in the standards.
  - Means of resource control in BSS are limited => radio interface support for packet traffic limited (GPRS Rel.1: best effort).
  - Precedence per PDP context.
- R97/98 OK when cell GPRS load low, otherwise end user experienced service quality variable.

⇒ Service quality support depends on local network load level.

GPRS R97/98 QoS profile

- The QoS parameters of a PDP context are:
  - **Precedence class**: 1, 2, 3. Class 1 gets precedence service over classes 2 and 3, ditto for class 2 vs. 3.
  - **Delay class**: 1-4, 4 = best effort.
  - **Reliability class**:
    - 1: GTP ACK, LLC ACK/protected, RLC ACK.
    - 2: GTP UNACK, LLC ACK/protected, RLC ACK.
    - 3: GTP UNACK, LLC UNACK/protected, RLC ACK.
    - 4: GTP UNACK, LLC UNACK/protected, RLC UNACK.
    - 5: GTP UNACK, LLC UNACK/non-protected, RLC UNACK.
  - **Peak throughput class**: 1-9 => 8-2048 kbit/s.
  - **Mean throughput class**: 1-19 => 0.22 bit/s-111 kbit/s.

GPRS R99 QoS profile

- GPRS R99: subset of “full” 3GPP QoS profile for GPRS.
  - **Allocation/retention priority (ARP)**.
  - **Traffic class + traffic handling priority (THP)**.
    - Interactive: THP1-3.
    - Background.
  - **Reliability parameters**:
    - residual BER
    - SDU error ratio
    - delivery of erroneous SDUs.
  - **Maximum bit rate**.
- Can differentiate between BE and interactive services, implement prioritisation also in radio interface.

GPRS R99 services

- These services can also be used with R97/98, but R99 provides for better means of prioritising between services.
- Services:
  - WAP.
  - MMS
    - Text.
    - Picture.
    - Video clips.
  - E-mail.
  - Data downloading.
  - …
- TSLs still shared, but support for traffic classes possible.

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Admission control in GPRS

- GPRS specifications define the architecture and QoS model.
  - PDP context activation is requested by MS, accepted/rejected by network.
  - PDP context modification initiated by MS or by the network.
    - New service requirements.
    - Based on resource usage.
  - PDP context deactivation can be made by MS and network.
- Admission control procedures are not defined.
  - Vendor-specific.
  - Operator-specific.
- No admission control procedures towards external networks have been defined.

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Core network QoS

- Transport between SGSN and GGSN: user data GTP tunnelled over UDP/IP.
- Core network IP QoS can be provided by provisioning + mapping of GPRS QoS to IP QoS based on QoS profile data.
- Mapping performed by SGSN (uplink) and GGSN (downlink).
- **Example**: standard DiffServ.
  - Interactive THP1 -> AF21.
  - Interactive THP2 -> AF22.
  - Interactive THP3 -> AF23.
  - Background -> AF33.

Summary

- GPRS uses GSM radio infrastructure.
- Architectural support for bursty packet based data.
- Basic GPRS does not support RT services.
- QoS defined per PDP context.
  - Terminal-initiated PDP context activation / deactivation / modification.
  - Network can terminate or modify PDP context.
- Supports data downloading and interactive type applications.
- GSM evolution radio interface GERAN also exists for UMTS => next lecture.