GSM

- Example of a PLMN (Public Land Mobile Network)
- At present most successful cellular mobile system (over 200 million subscribers worldwide)
- Digital (2nd Generation) cellular mobile system operating in several frequency bands (GSM 900, GSM 1800 = DCS 1800, GSM 1900 = PCS 900)
- ETSI Specifications (<u>www.etsi.org</u>)
- Future evolution?

GSM

Course requirements: "Understanding Telecommunications" book by Ericsson (Part D – PLMN) + supporting material (= these slides)

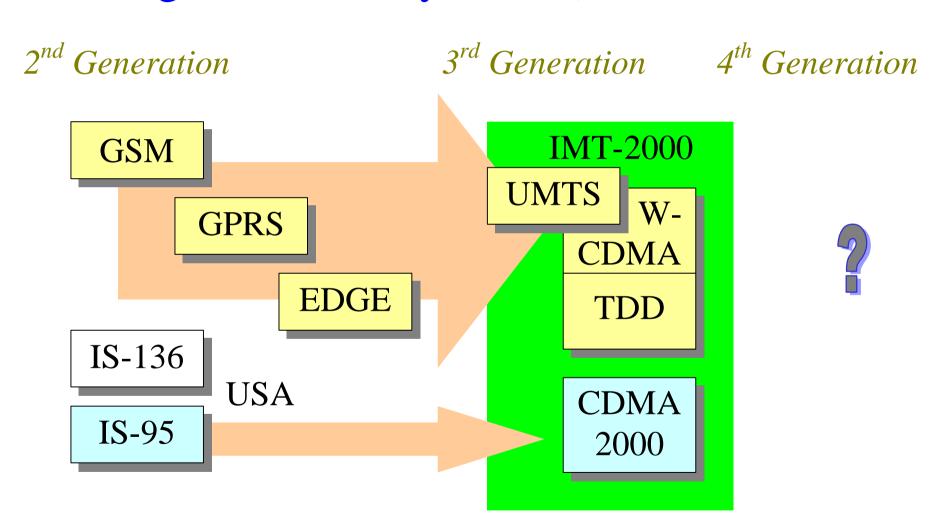
GPRS

Course requirements: "GPRS: Architecture, Protocols, and Air Interface" article by Bettstetter *et al.*, available at

www.comsoc.org/pubs/surveys/3q99issue/bettstetter.html

If you have problems obtaining this article, please contact the course assistant (Mika Nupponen)

Digital PLMN systems (status 2001)



Digital PLMN systems

- GSM Global System for Mobile communications: (FDMA/)TDMA-based system specified by ETSI
- Several evolution steps towards 3rd generation systems:
- HSCSD High Speed Circuit Switched Data (possibility of combining up to 4 time slots for a data connection)
- GPRS General Packet Radio Service (packet switching overlay on TDMA radio access network)
- EDGE Enhanced Data rates for GSM Evolution (change at the air interface: GMSK => 8 PSK modulation)
- IS-95 American CDMA system
- IS-136 American TDMA system

UMTS – Universal Mobile Telecommunications System UTRA FDD mode (UMTS Terrestrial Radio Access, Frequency Division Duplex mode) ⇔ W-CDMA UTRA TDD mode

CDMA2000 – American 3rd Generation CDMA system

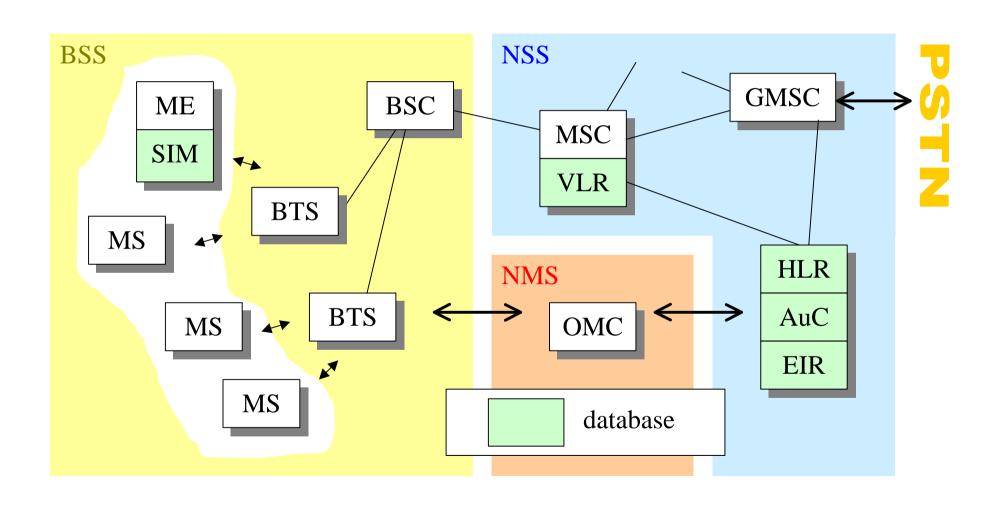


IMT-2000 – International Mobile Telecommunications (ITU)

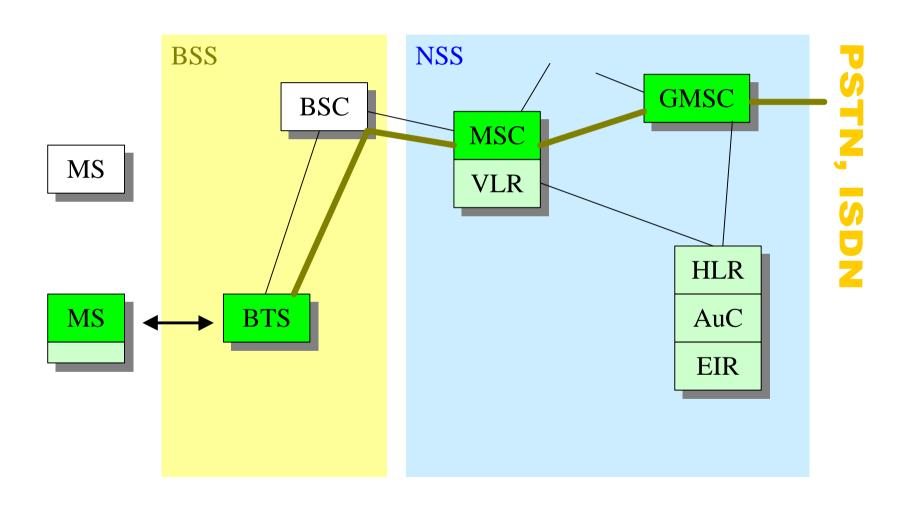
Other wireless systems & networks:

DECT (no roaming), TETRA (not public), HIPERLAN et al., UPT concept, GPS, mobile satellite systems ...

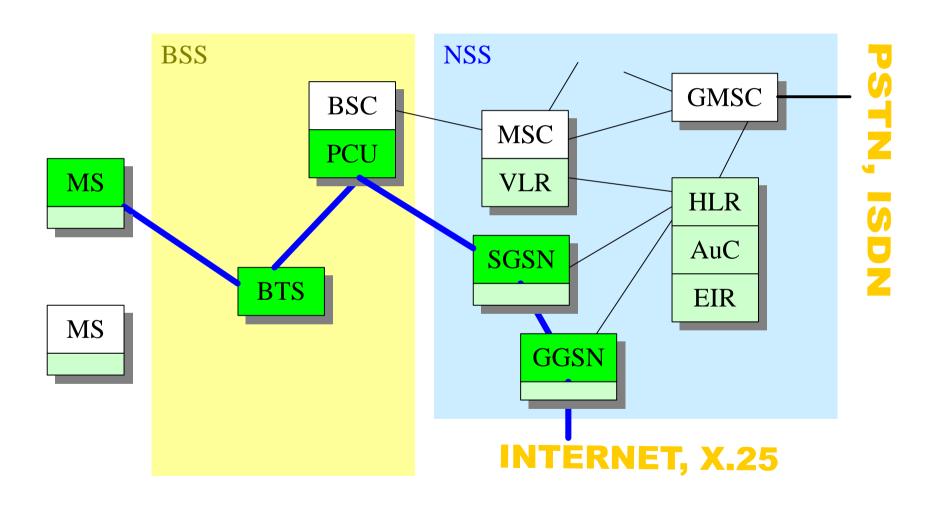
GSM system architecture



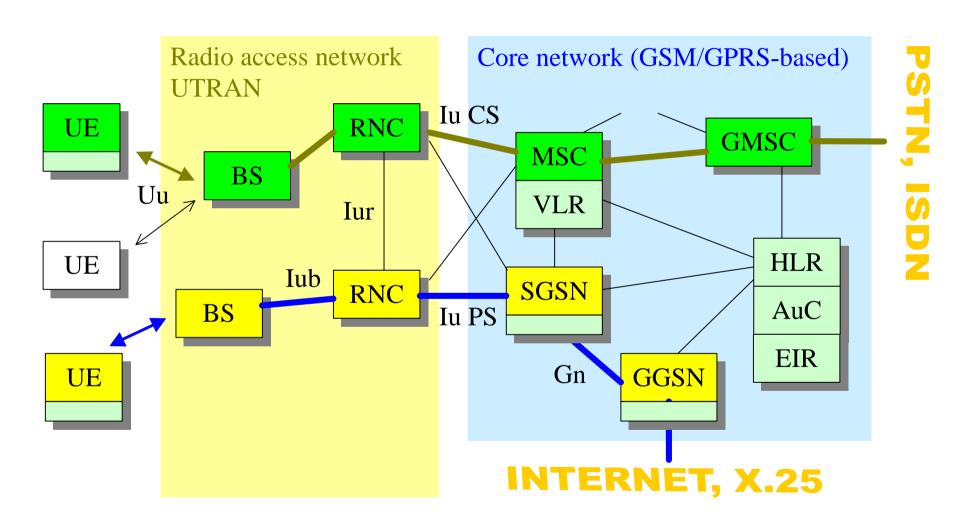
GSM: circuit switched connections



GPRS: packet switched connections



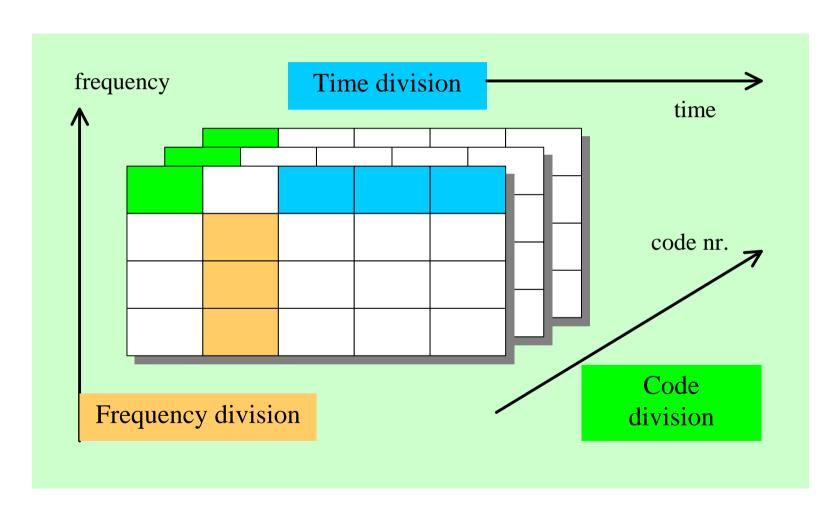
UMTS network architecture



Radio interface aspects

- Radio access techniques (FDMA / TDMA / CDMA)
- Physical / logical channel structure / GSM "burst"
- Modulation method (GMSK, 8-PSK)
- Source coding / channel coding / interleaving
- Radio channel estimation & equalization techniques (constructive use of the multipath channel)
- Diversity techniques
- Circuit vs. packet switched access
- Protocols: random access, power control, handover (with associated measurement procedures)

Radio interface – multiple access techniques



Radio interface – channel structure

Physical channel:

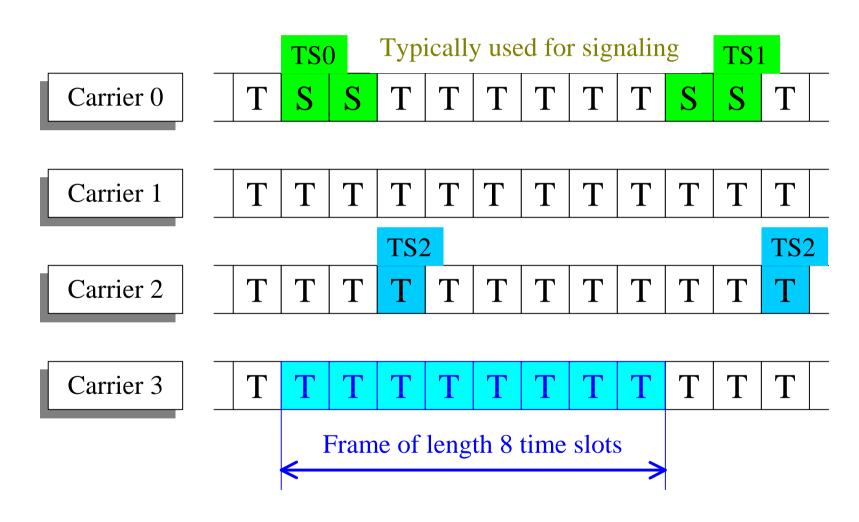
Repetitive timeslot (e.g. TS3) on a certain carrier (e.g. Carrier 4) with capacity of 22.8 kbit/s

Logical channel:

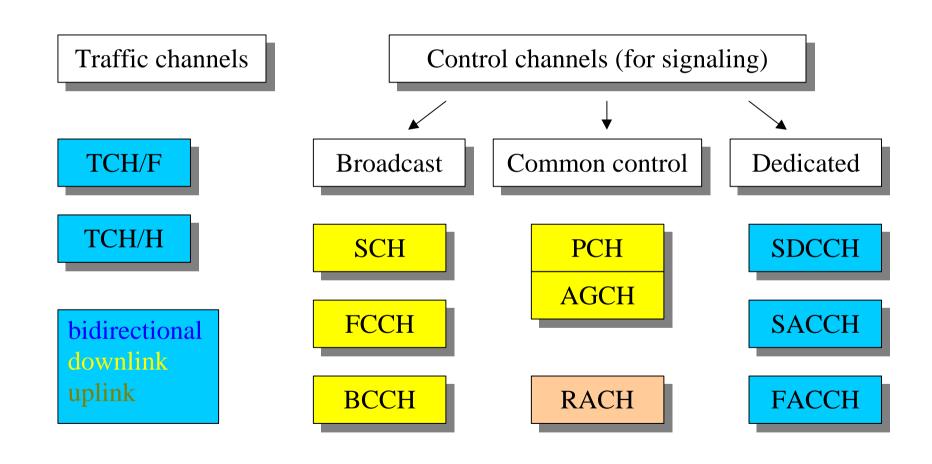
A physical channel can contain (several combinations of) one or more logical channels

In 3G, we have physical channels, transport channels and logical channels

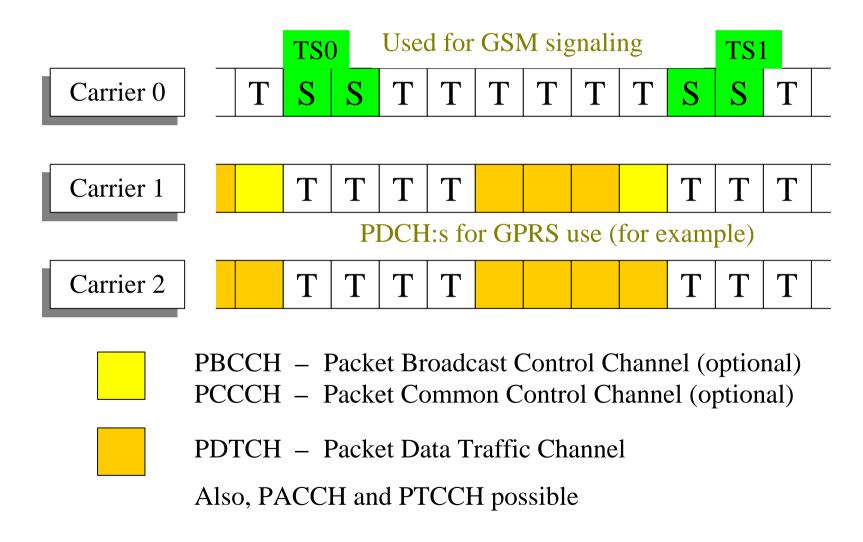
Radio interface - physical channels



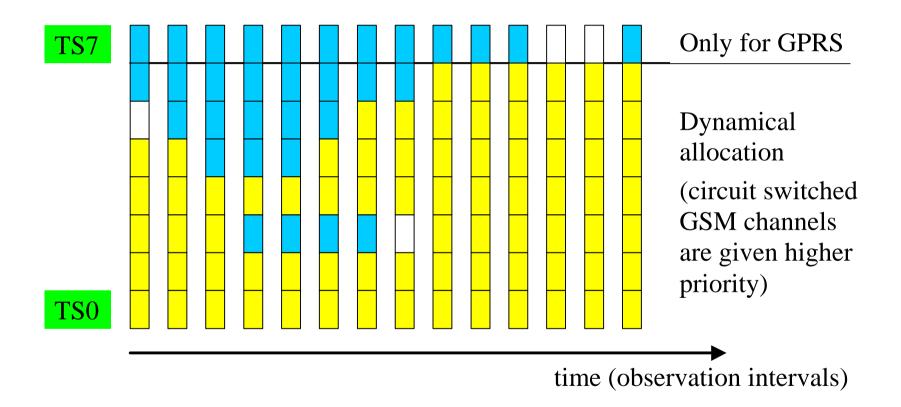
Radio interface – logical channels



GPRS channel structure

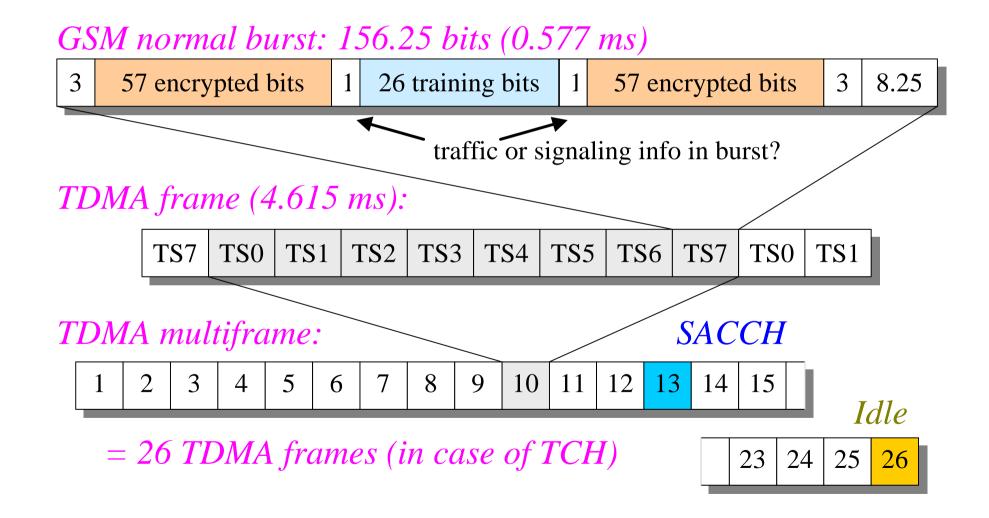


GSM/GPRS channel allocation example



Allocation schemes are network operator dependent

GSM radio interface



GSM speech encoding

Voice coding: 260 bits in 20 ms blocks (13 kbit/s) MS - TRAU

260 bits 260 bits

Channel coding: 456 coded bits (22.8 kbit/s)

MS - BTS

456 bits

Interleaving: 8 x 57 bits (22.8 kbit/s)

bits 4, 12, 20, 28, 36, 44, etc. from the 456 bit frame

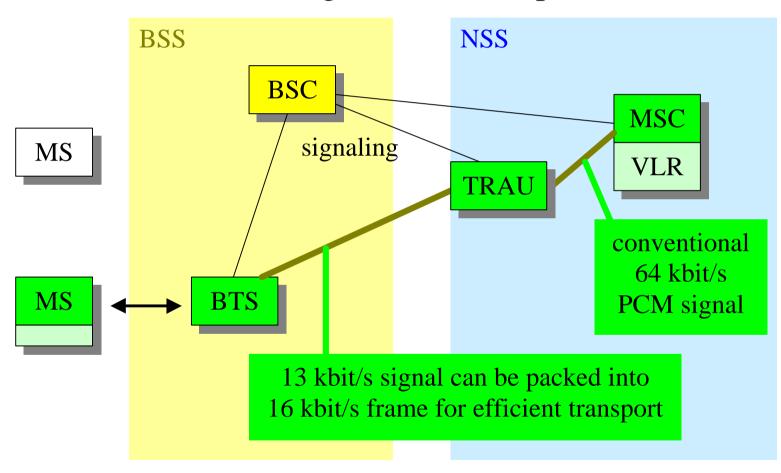
57 bits

57 bits

57 bits

Task division between BSC and TRAU

(TRAU = Transcoding and Rate Adaptation Unit)



GSM signaling message encoding

Signaling message is segmented into blocks of 184 bits:

184 bits

Each block is coded into 456 bits (22.8 kbit/s)

456 bits

Interleaving: 8 x 57 bits (22.8 kbit/s)

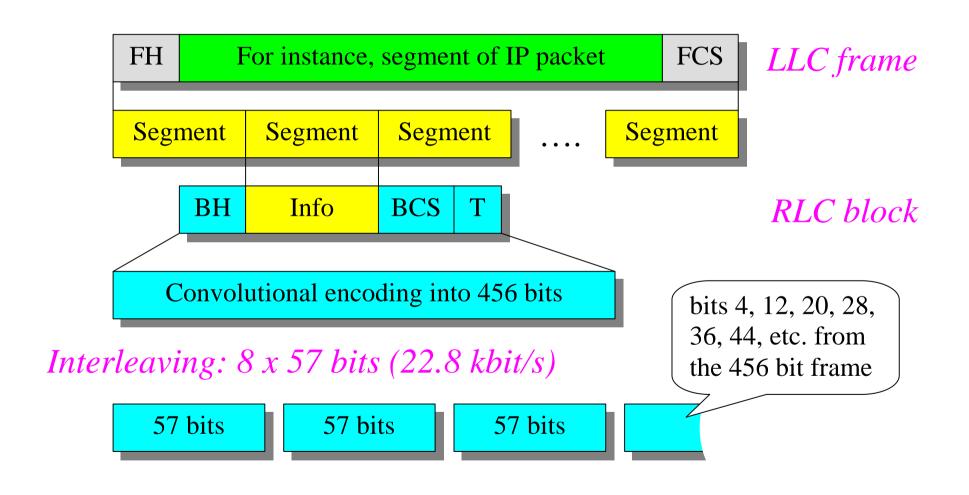
bits 4, 12, 20, 28, 36, 44, etc. from the 456 bit frame

57 bits

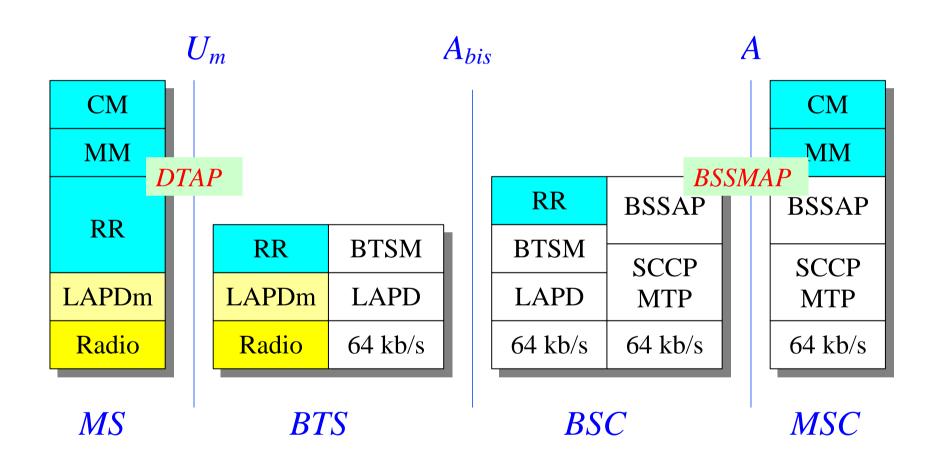
57 bits

57 bits

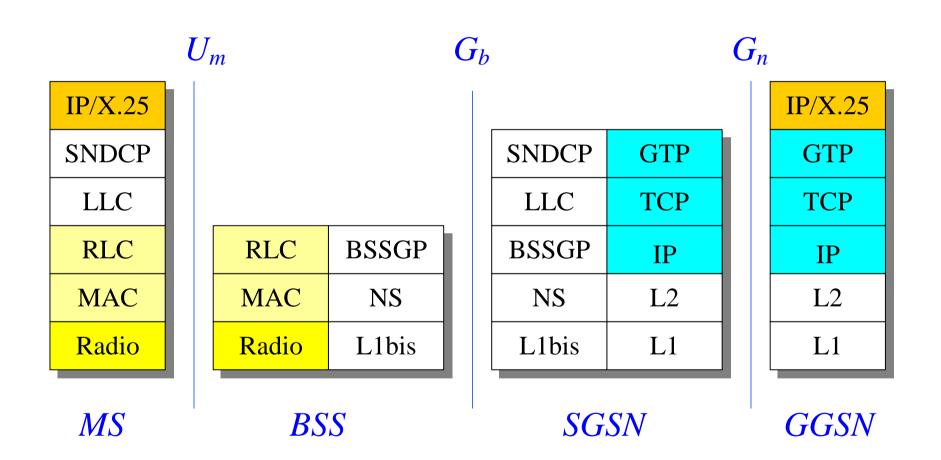
GPRS packet encoding



GSM protocols (MS ⇔ MSC)



GPRS protocols (user plane)



GSM signaling at "layer 3"

RR (Radio Resource management)

- Random access and initial assignment (reserving a SDCCH for signaling purposes)
- Handover management
- Ciphering (encryption) over radio interface

MM (Mobility Management)

- "IMSI Attach" (MS power switch on)
- "IMSI Detach" (MS power switched off)
- Location updating (MS moves to other Location Area)
- Authentication

GSM signaling at "layer 3"

CM (Connection Management)

• Signaling for management of circuit and packet switched connections, can be divided into:

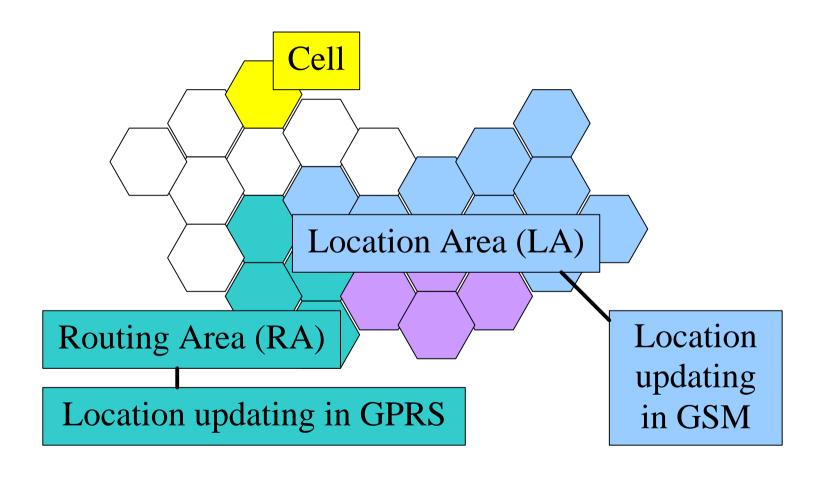
CC (Call Control)

• Signaling for setting up and releasing circuit switched connections (very similar to DSS 1 in N-ISDN)

SM (Session Management)

• Signaling for management of "PDP Contexts" (packet switched connections in GPRS)

MM "Areas" in GSM and GPRS



Connectivity types in GSM and GPRS

GSM:

Disconnected

Idle

Connected

MS is switched off (circuit mode)

location updates on LA basis

handovers in c.s. connection

GPRS:

Idle

Standby

Ready

MS is switched off (packet mode)

location updates on RA basis

location updates on cell-by-cell basis

Trade-off when choosing LA/RA size

LA/RA size is very large (e.g. whole mobile network)

- + location updates not needed very often
- paging load is very heavy

Affects capacity

LA/RA size is very small (e.g. single cell)

- + small paging load
- location updates must be done very often

Affects signaling load

Random access in GSM / GPRS

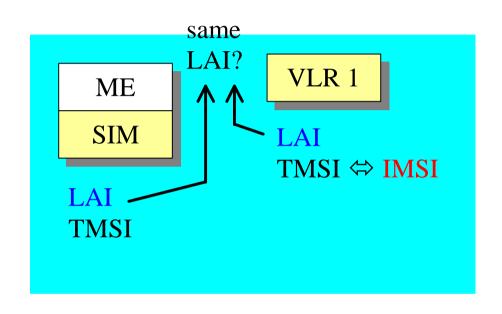
No communication between MS and network can be started without first using the *random access* procedure in

- network originated activity (paging, e.g. for MTC)
- MS originated activity (MOC, location updating, registration, de-registration at power switch-off)
- MS sends a short access burst over the RACH (uplink),
 (Slotted Aloha, collision possibility ⇔ retransmission)
- 2) Network (BSC) returns "permission" message including:
 - allocated channel (frequency, time slot)
 - timing advance for correct time slot alignment

Important identifiers in GSM

- IMSI International Mobile Subscriber Identity (global)
- TMSI Temporary Mobile Subscriber Identity (local and temporary)
- LAI Location Area Identity (global)
- MSISDN Mobile Subscriber ISDN number (E.164 address of GMSC and pointer to subscriber database in HLR)
- PIN Personal Identification Number (only within MS)
- IMEI International Mobile Equipment Identity (global)
- Temporary, local numbers for routing (MSRN, HON ...)

Case study: location updating (1)



(most generic scenario is described here)



IMSI LAI => VLR 1

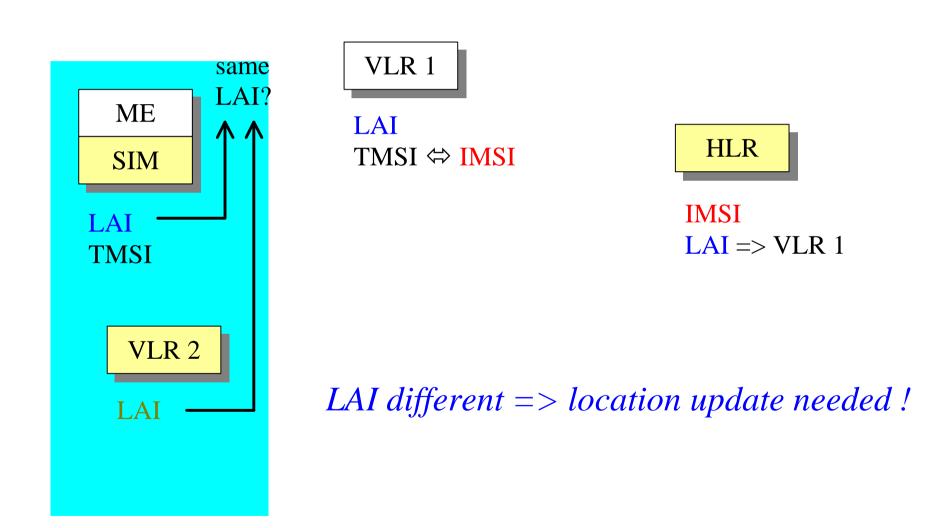
VLR 2

Last LAI and TMSI stored in SIM.

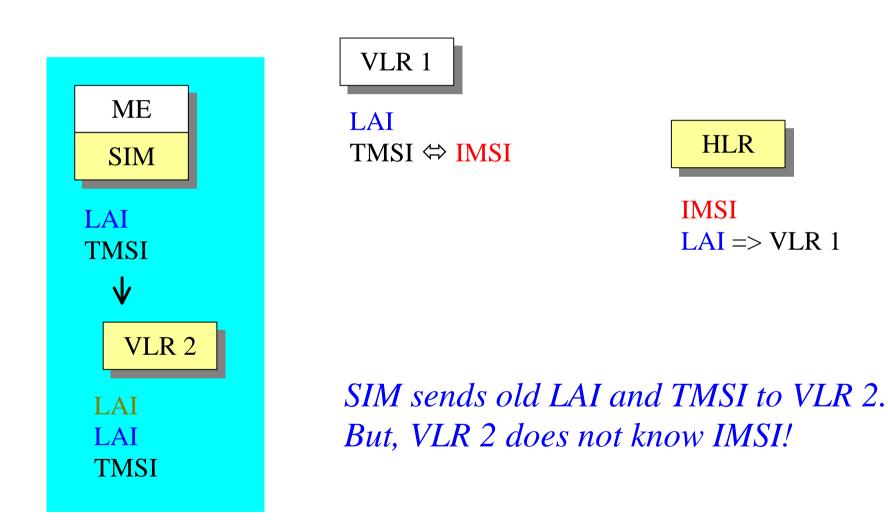
MS monitors broadcast LAI.

LAI comparison in MS => ok!

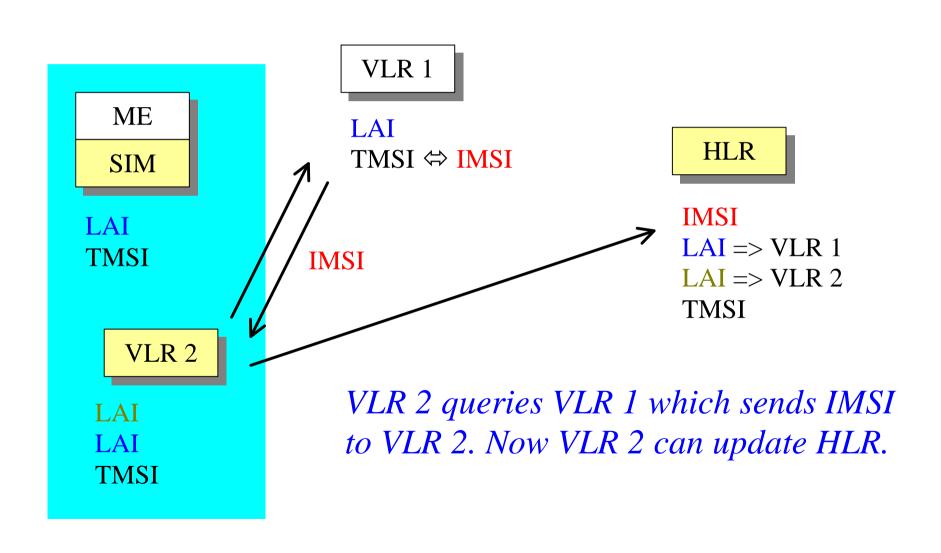
Case study: location updating (2)



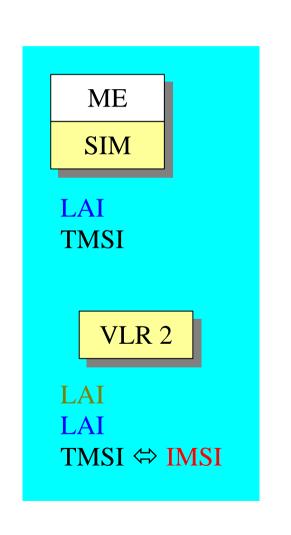
Case study: location updating (3)

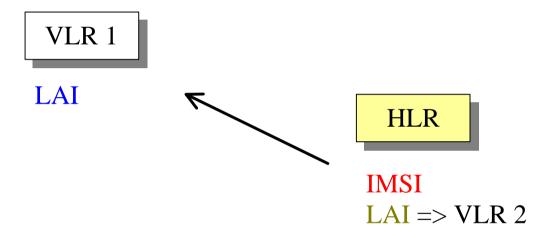


Case study: location updating (4)



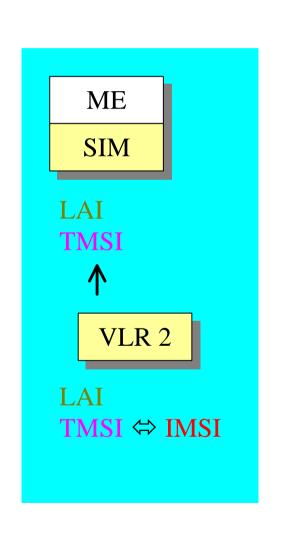
Case study: location updating (5)





HLR cancels subscriber data in VLR 1.

Case study: location updating (6)



VLR 1

LAI

HLR

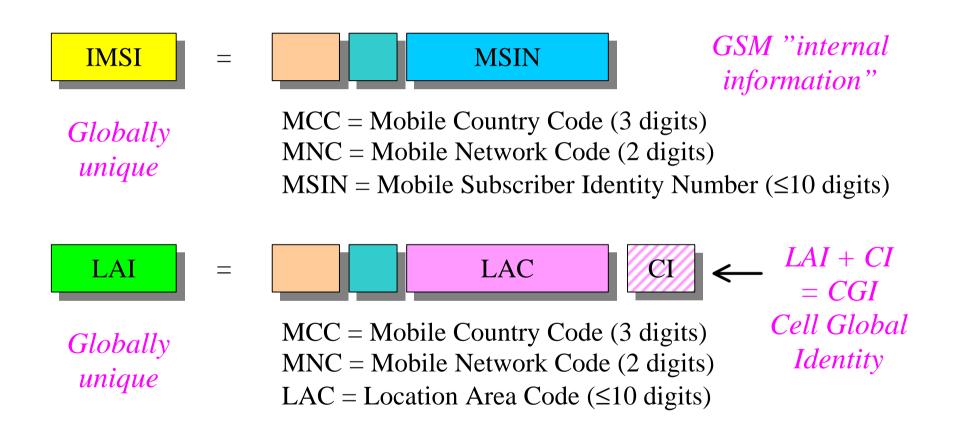
IMSI

LAI – VLR 2

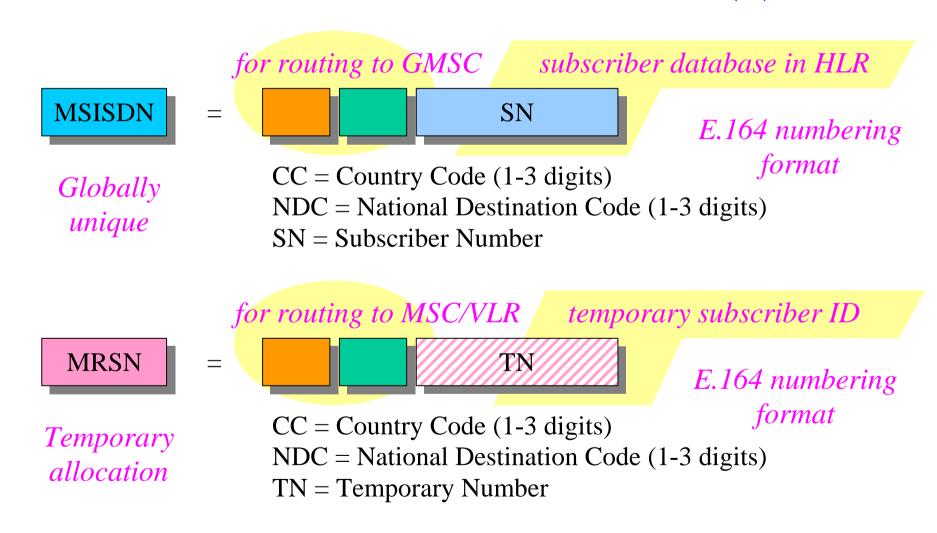
Important information for MTC (see below)

VLR 2 sends new TMSI to MS (SIM). MS also updates LAI. Compare with slide (1). Location update successful!

Structure of GSM identifiers (1)

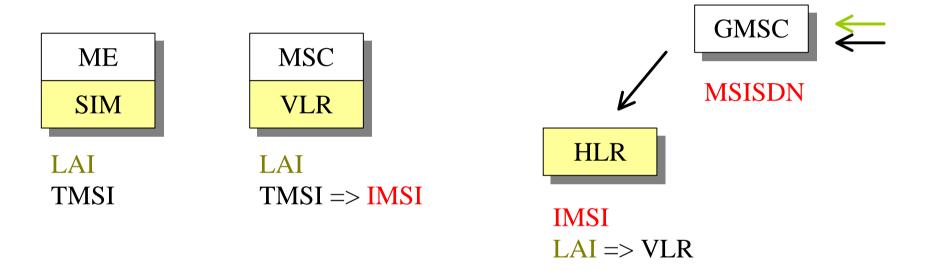


Structure of GSM identifiers (2)



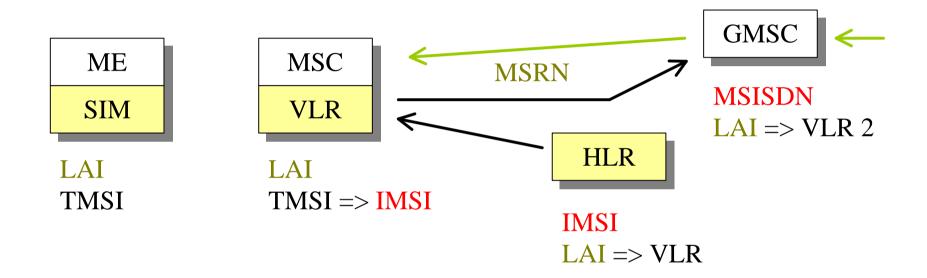
Case study: mobile terminated call (1)

(mobile terminated call = MTC)



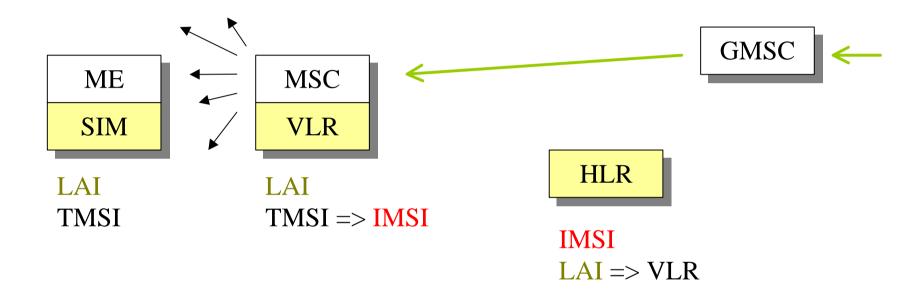
MTC is directed through PSTN to GMSC using MSISDN. GMSC contacts HLR (MSISDN in fact points to the HLR database of this subscriber containing IMSI, LAI, etc.)

Case study: mobile terminated call (2)



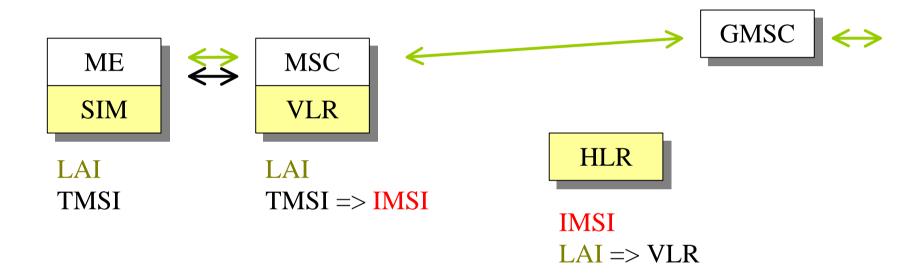
Using LAI, HLR can query the correct VLR for an MSRN which is sent to GMSC. The GMSC can now route the call (using MSRN) to the MSC/VLR serving the subscriber

Case study: mobile terminated call (3)



The MSC broadcasts a paging message (including TMSI) within the location area defined by LAI

Case study: mobile terminated call (4)



Only the mobile subscriber with the corresponding TMSI reacts to the paging. A connection between MS and MSC is established and the call set-up is completed.