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 1900)
- ETSI Specifications (www.etsi.org)
- Future evolution ?

GSM

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

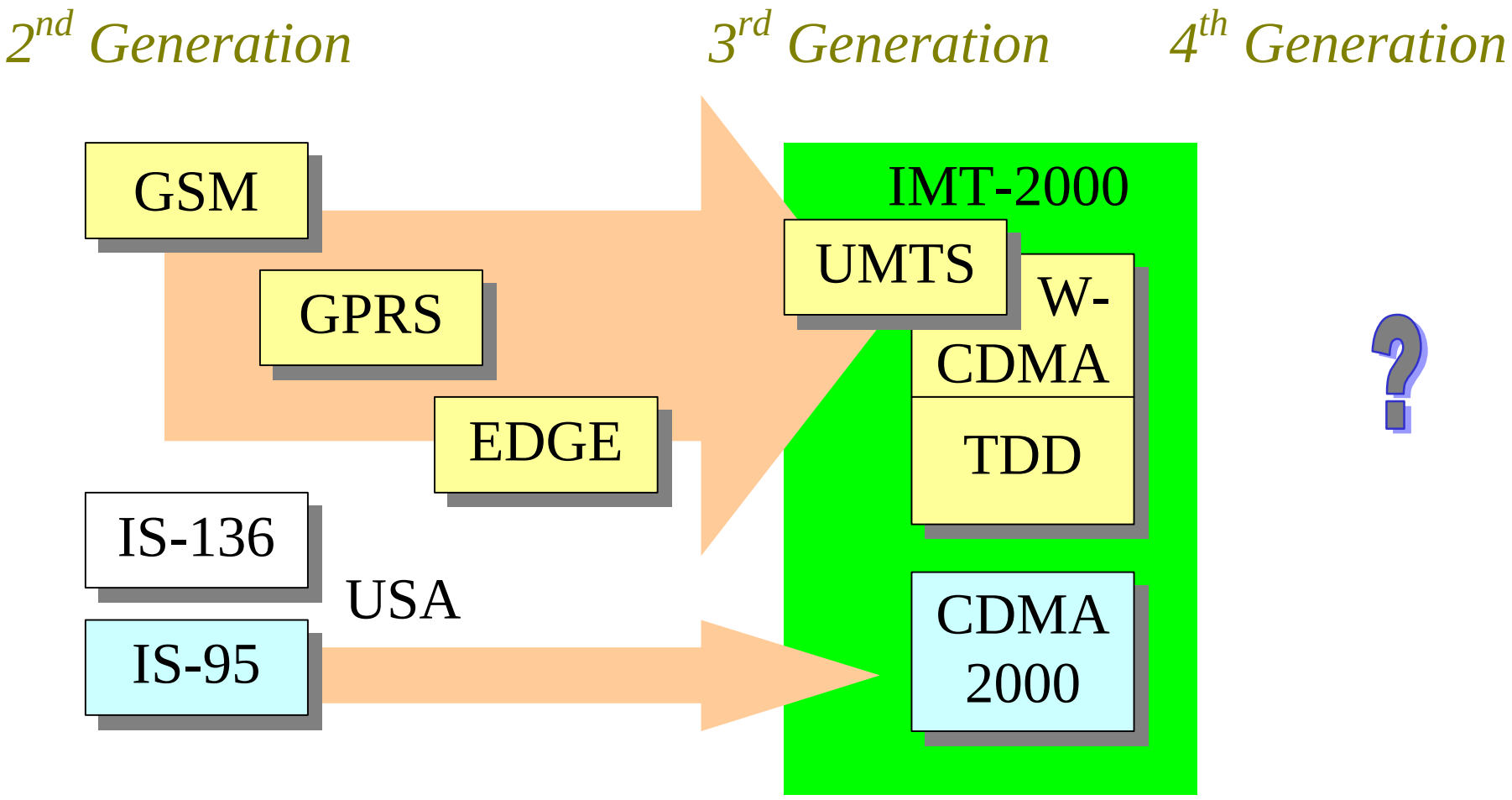
GPRS

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)

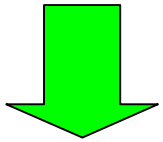
EDGE – Enhanced Data rates for GSM Evolution (change at the air interface: GMSK => 8 PSK modulation)

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

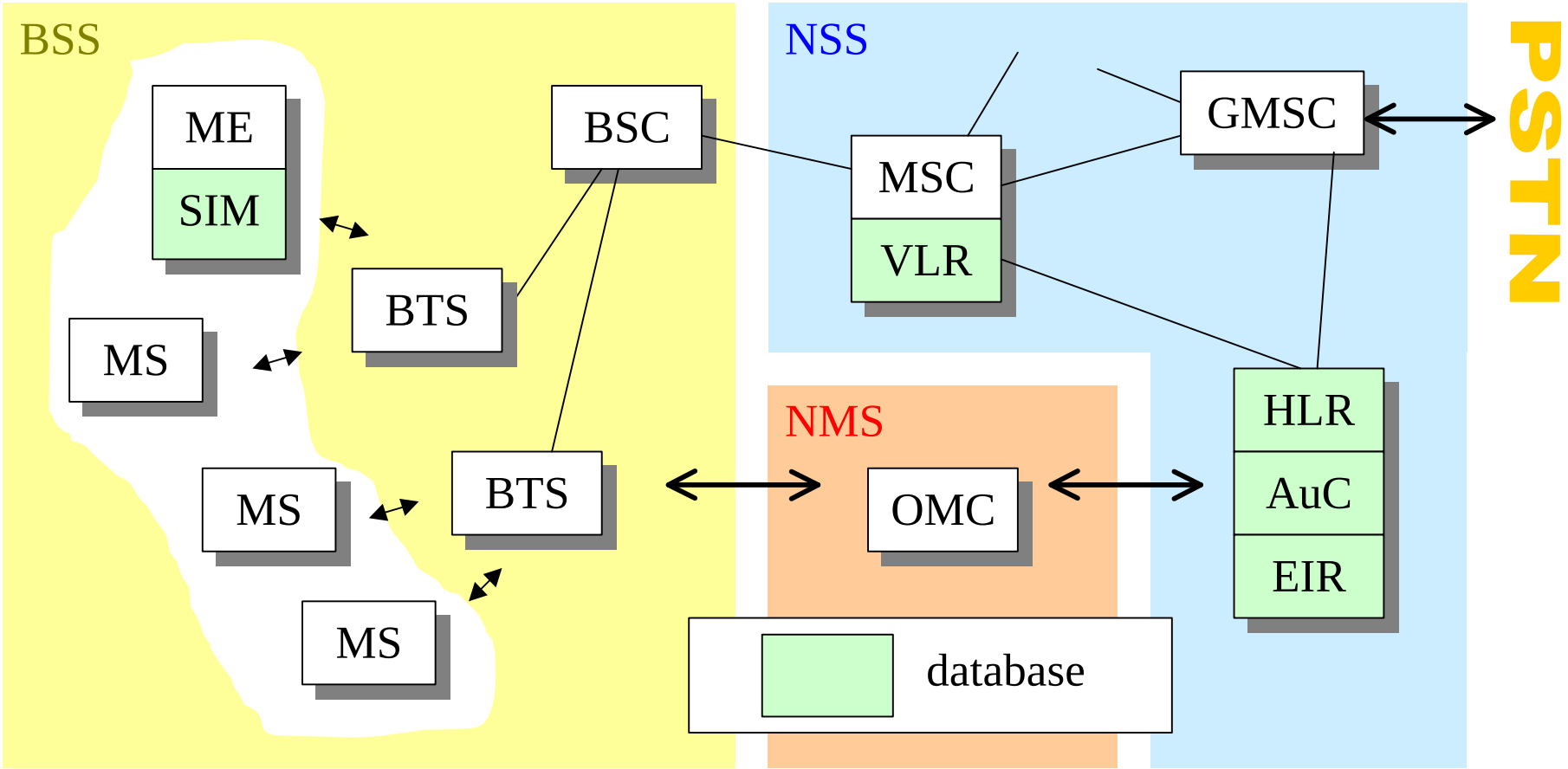


IMT-2000 – International Mobile Telecommunications (ITU)

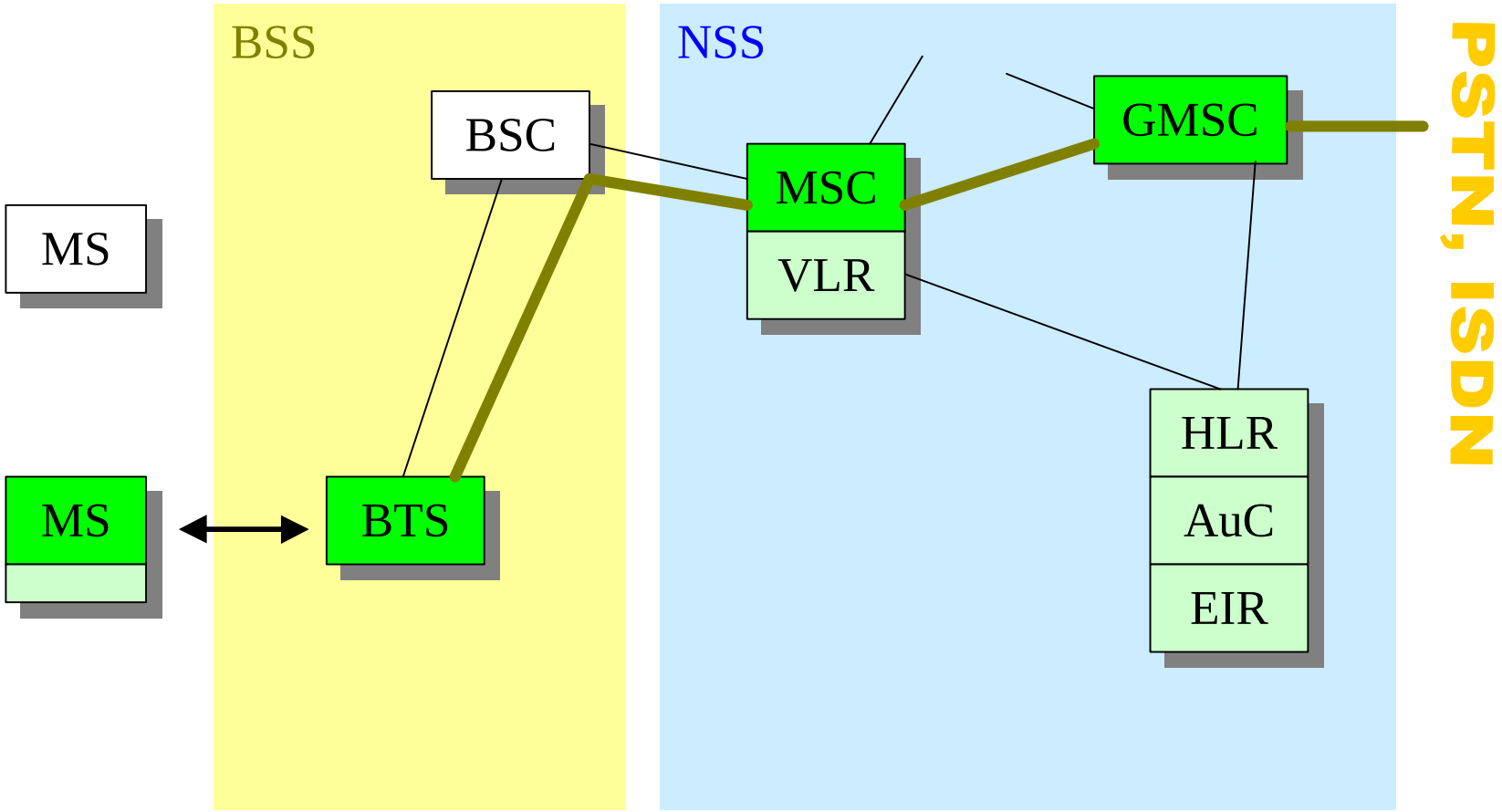
Other wireless systems & networks:

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

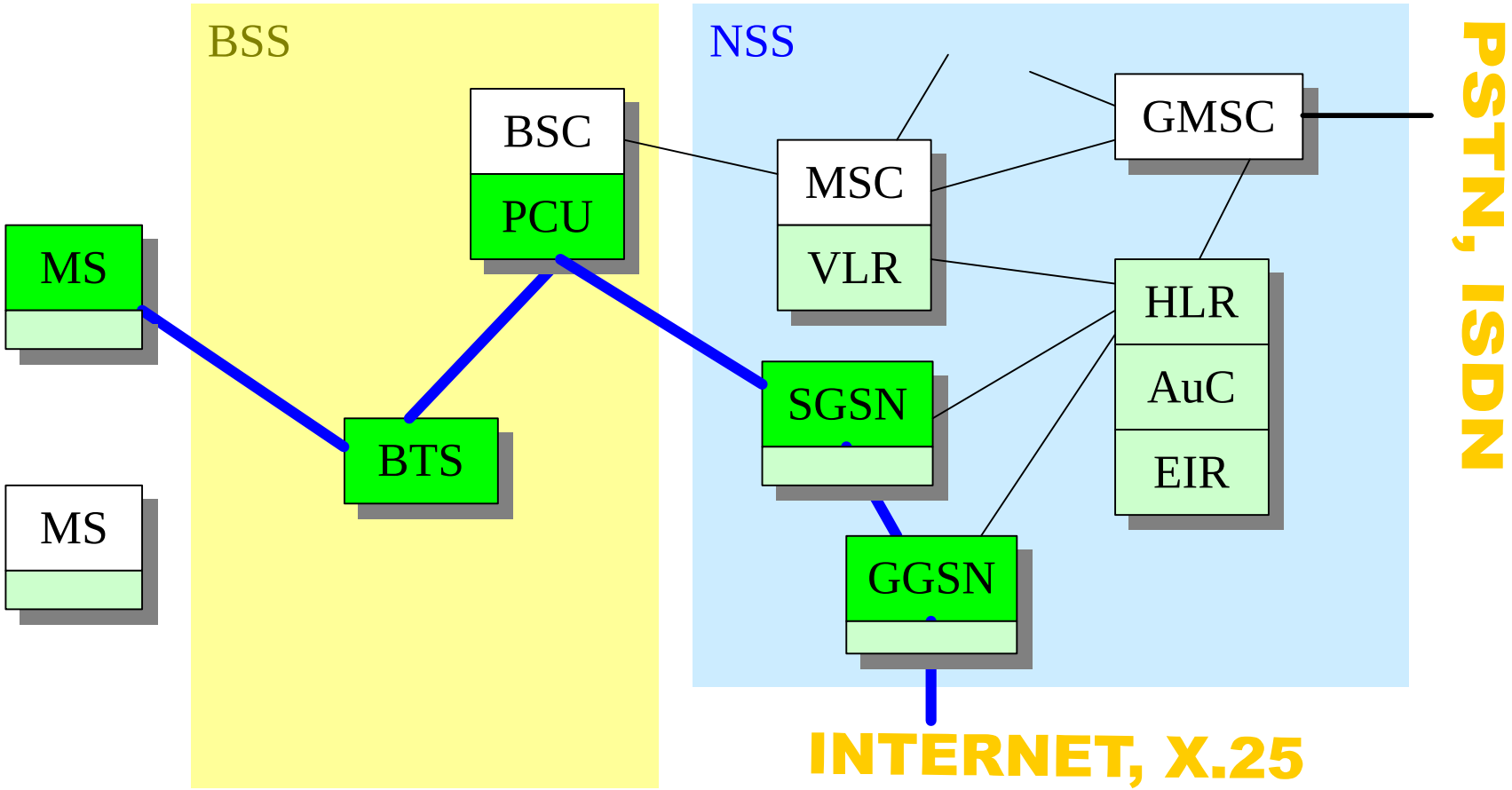
GSM system architecture



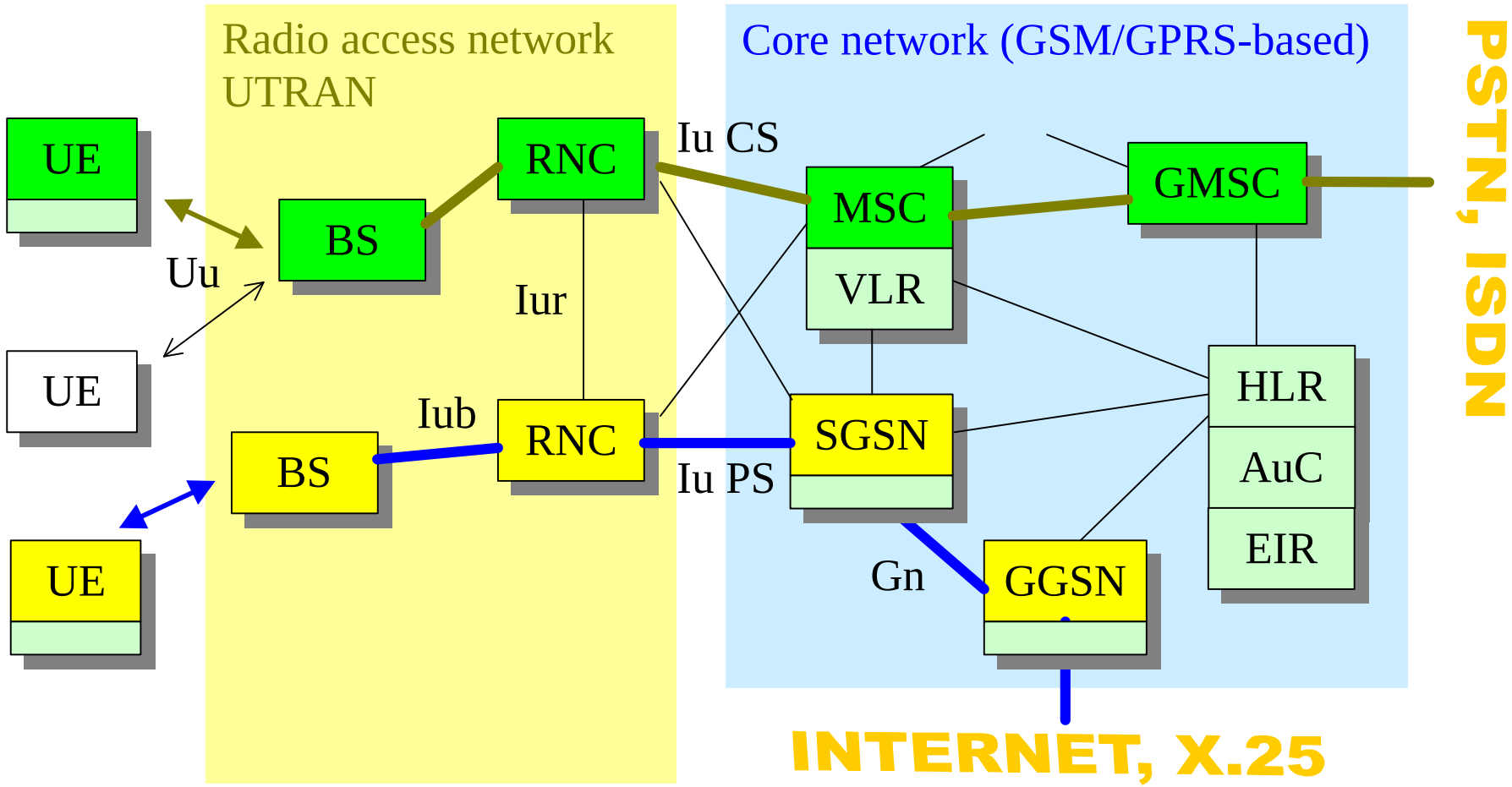
GSM: circuit switched connections



GPRS: packet switched connections



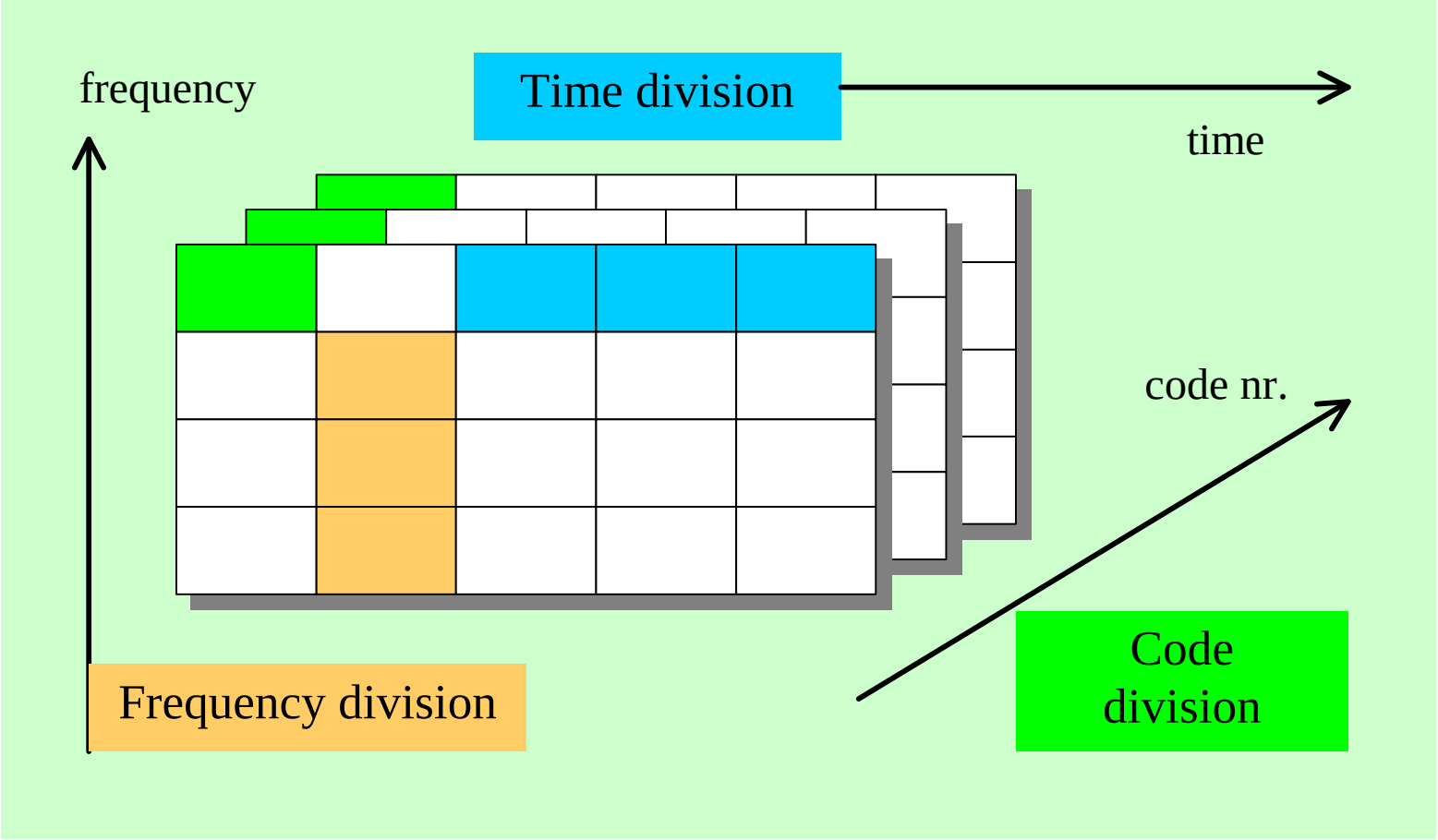
UMTS network architecture



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:

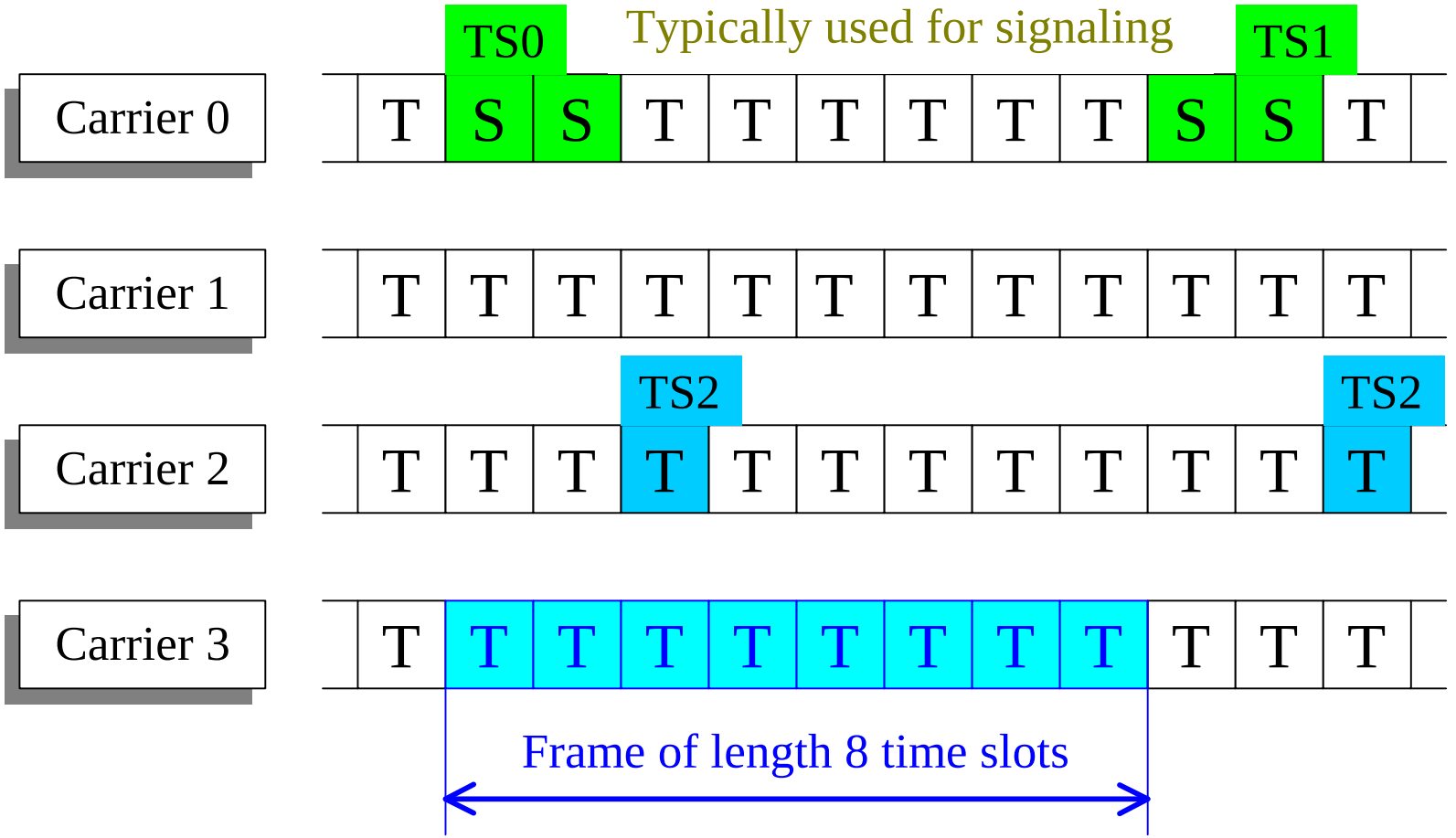
Repetitive timeslot (e.g. TS3) on a certain carrier (e.g. Carrier 4) with capacity of 22.8 kbit/s

Logical channel:

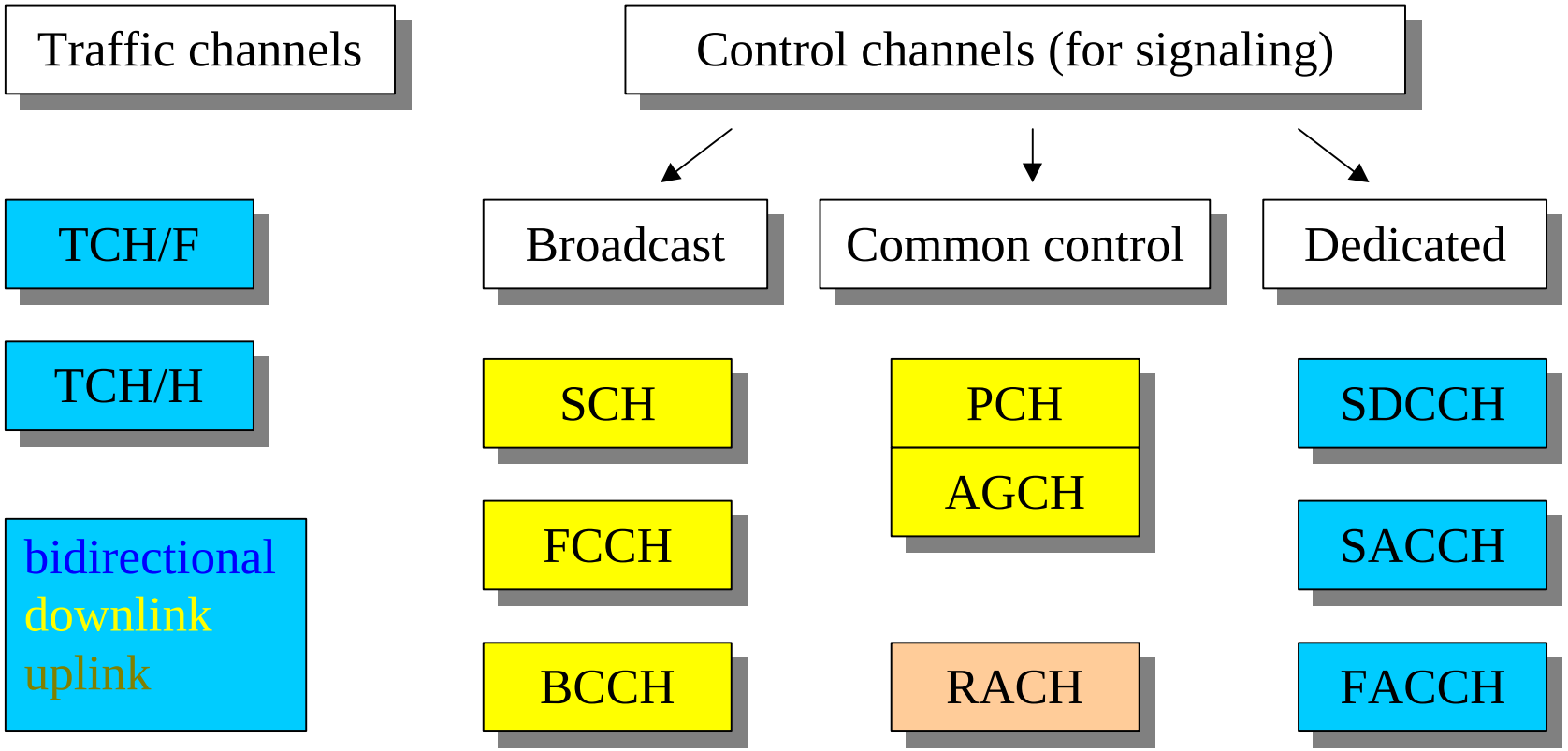
A physical channel can contain (several combinations of) one or more logical channels

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

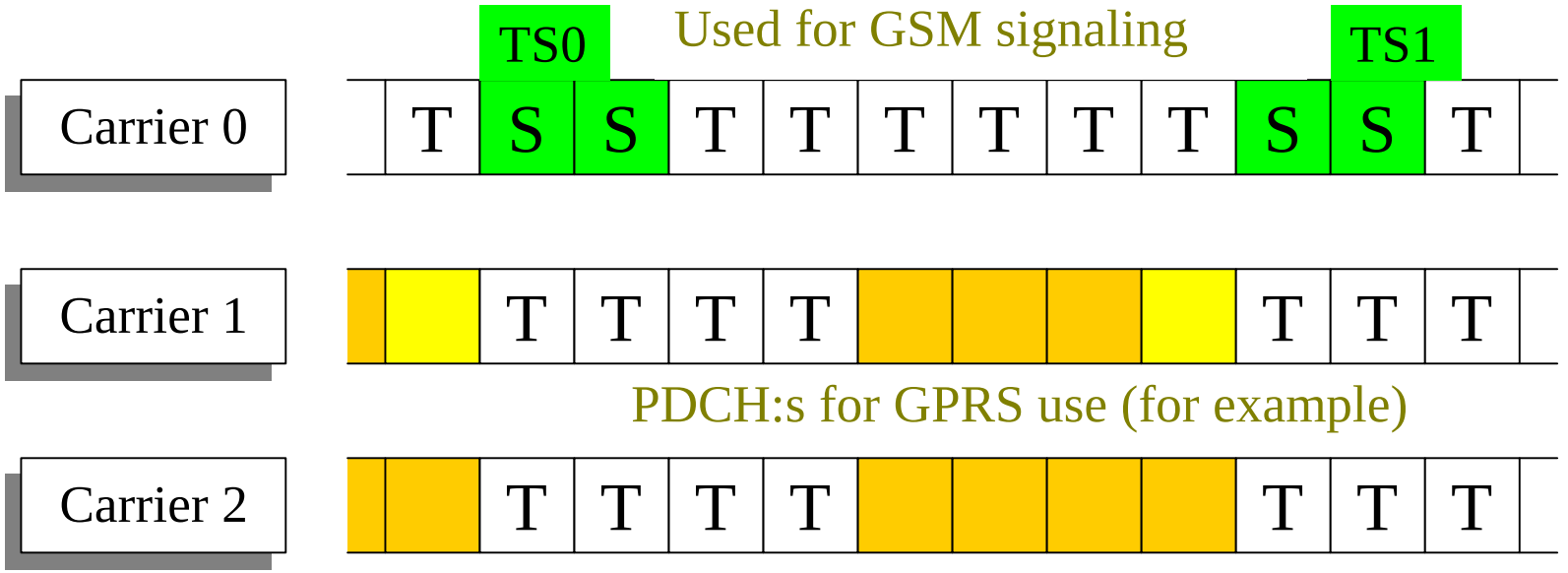
Radio interface - physical channels



Radio interface – logical channels



GPRS channel structure

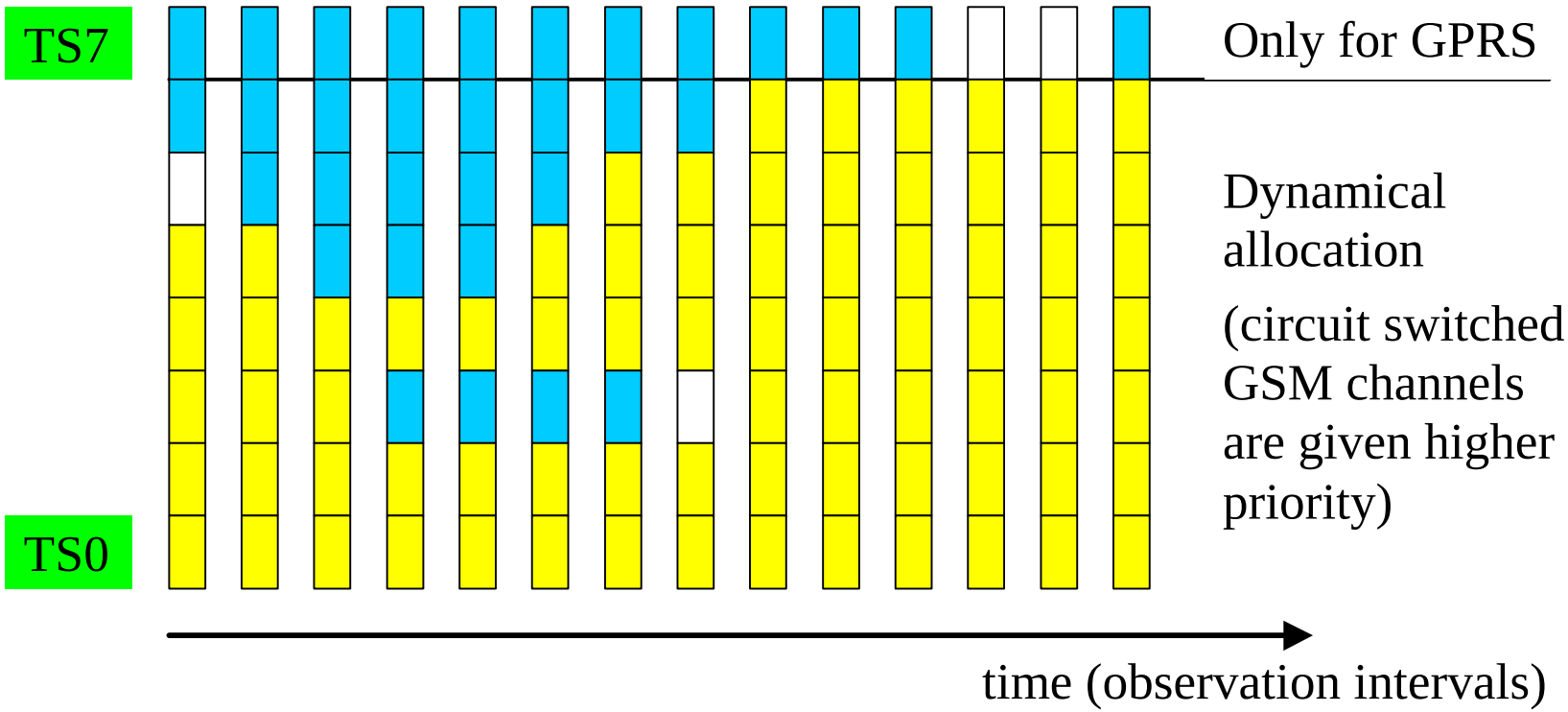


PBCCH – Packet Broadcast Control Channel (optional)
PCCCH – Packet Common Control Channel (optional)

PDTCH – Packet Data Traffic Channel

Also, PACCH and PTCCH possible

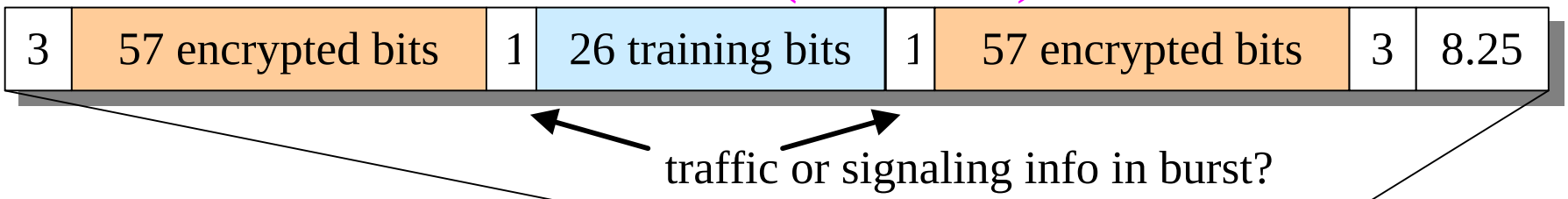
GSM/GPRS channel allocation example



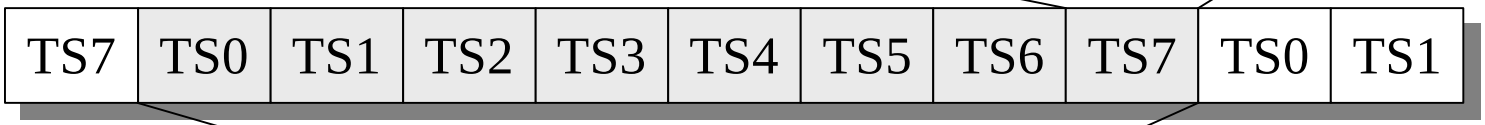
Allocation schemes are network operator dependent

GSM radio interface

GSM normal burst: 156.25 bits (0.577 ms)

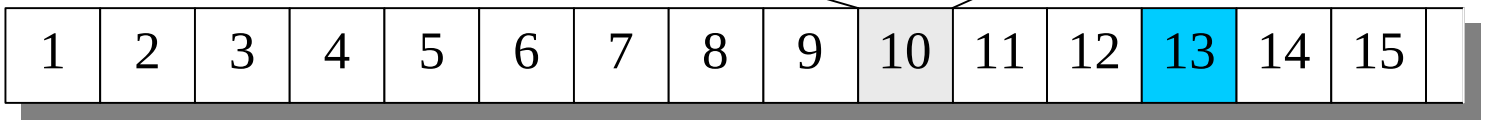


TDMA frame (4.615 ms):

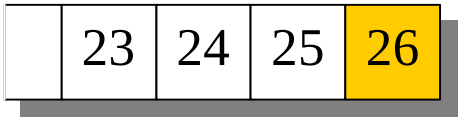


TDMA multiframe:

SACCH



Idle



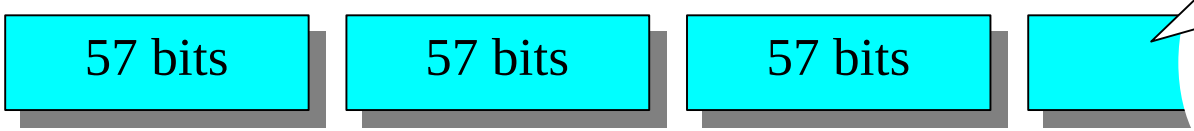
= 26 TDMA frames (in case of TCH)

GSM speech encoding

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

Channel coding: 456 coded bits (22.8 kbit/s) ***MS - BTS***

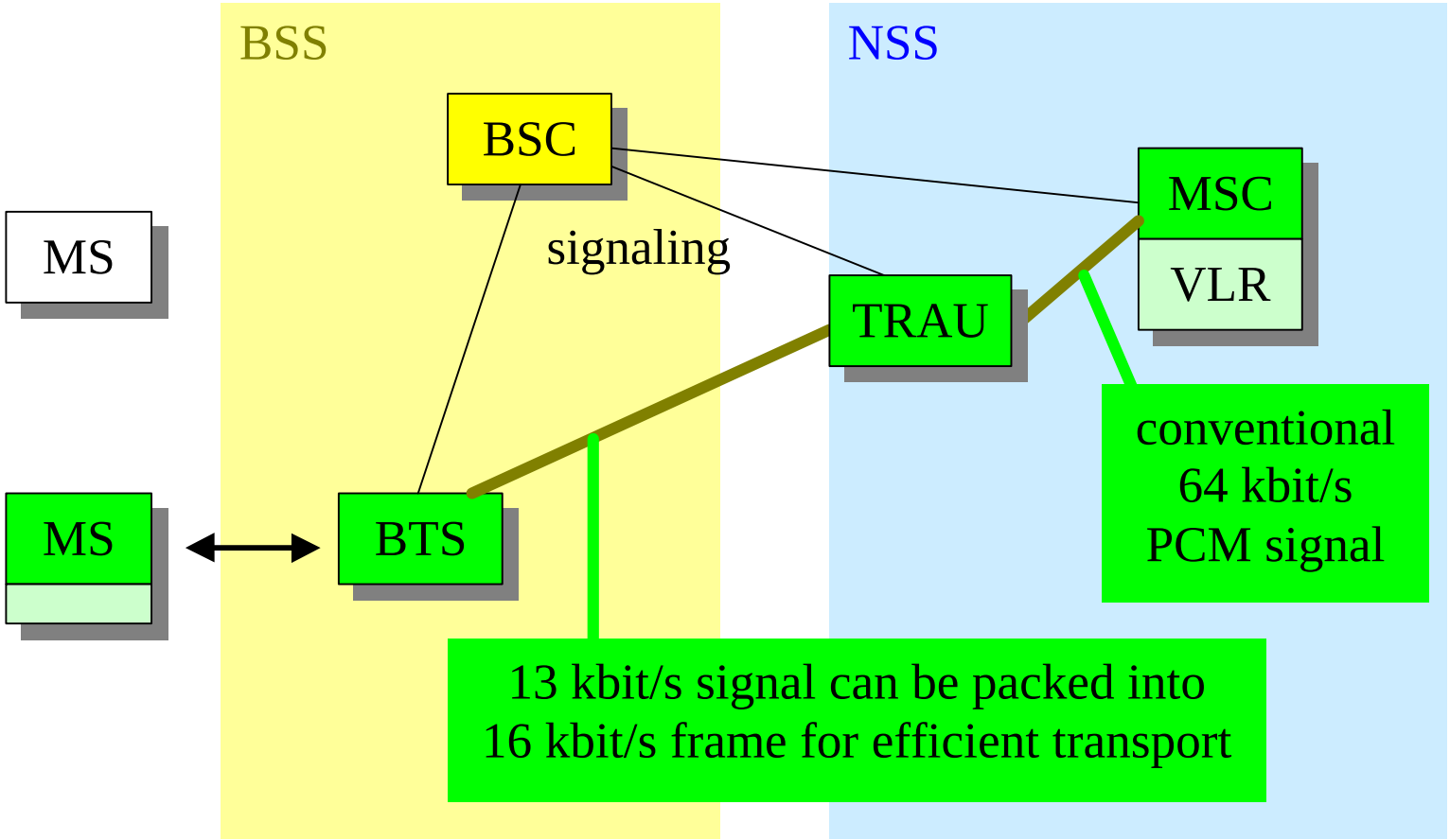
Interleaving: 8 x 57 bits (22.8 kbit/s)



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

Task division between BSC and TRAU

(TRAU = Transcoding and Rate Adaptation Unit)

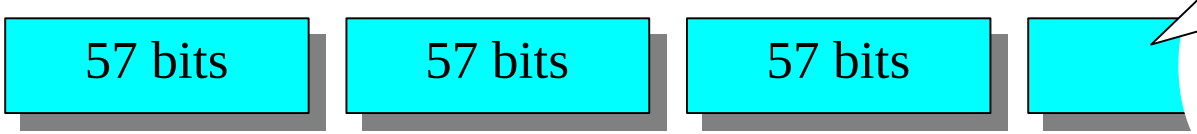


GSM signaling message encoding

Signaling message is segmented into blocks of 184 bits:

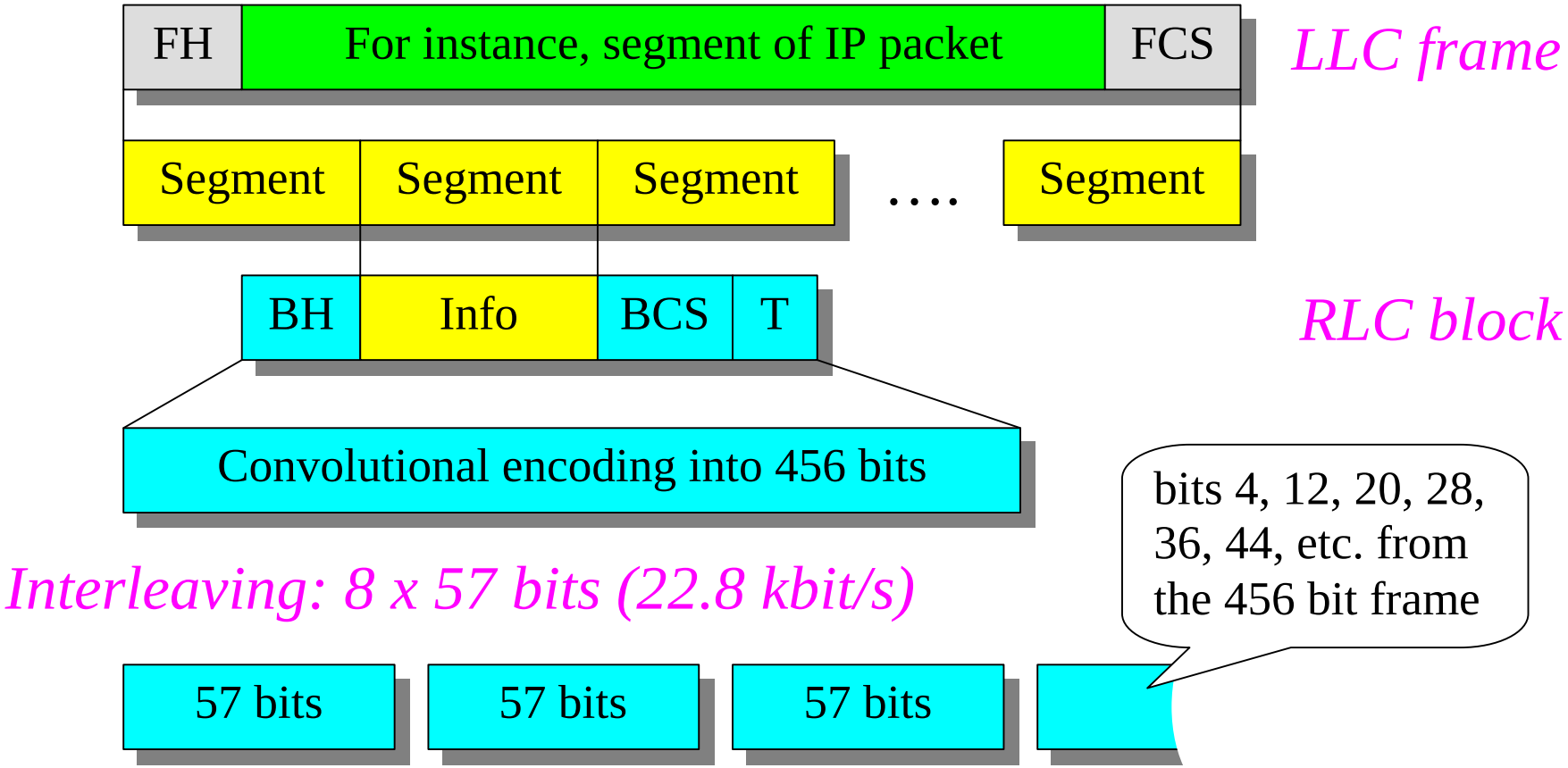
Each block is coded into 456 bits (22.8 kbit/s)

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

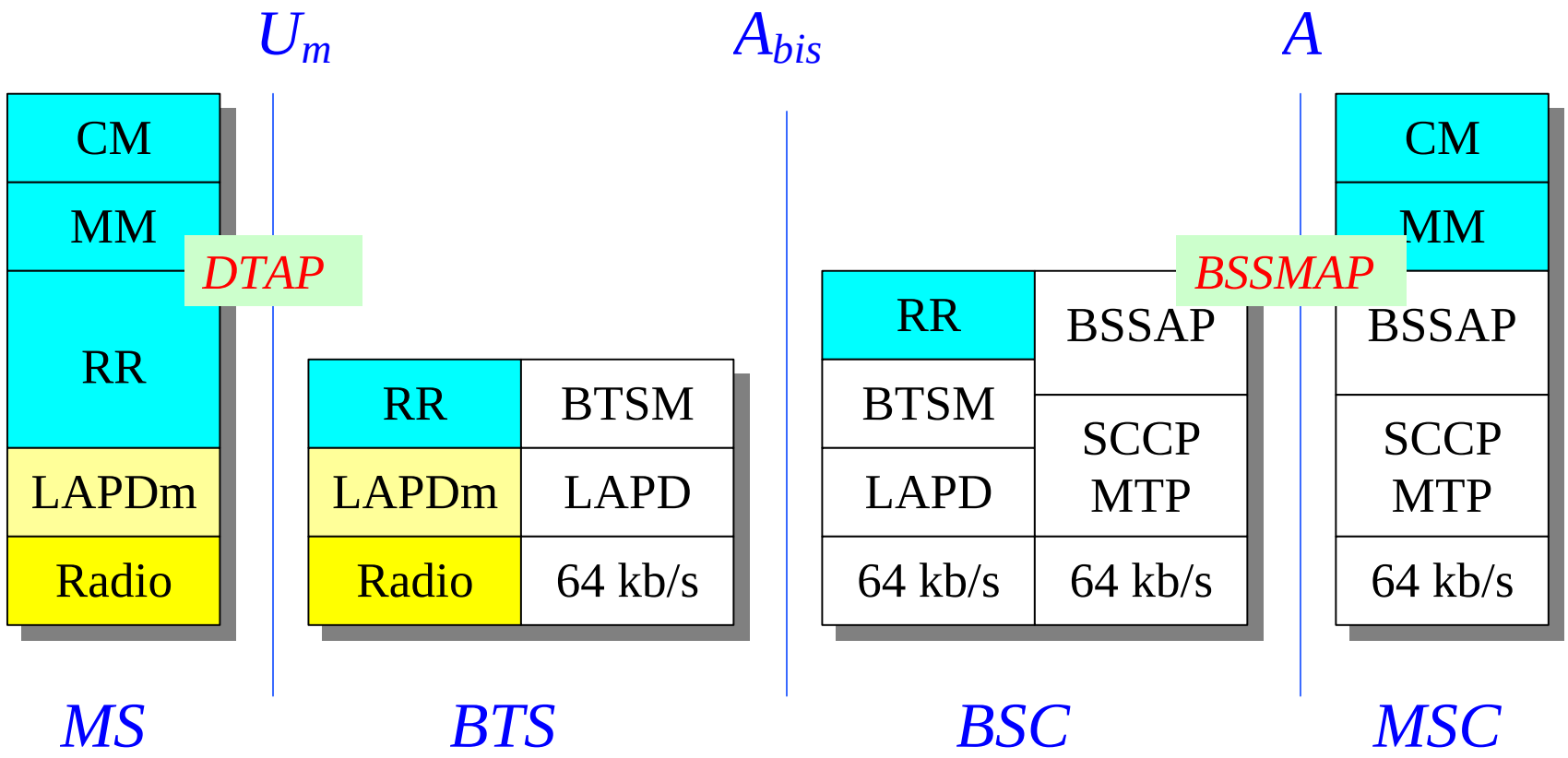


bits 4, 12, 20, 28, 36, 44, etc. from the 456 bit frame

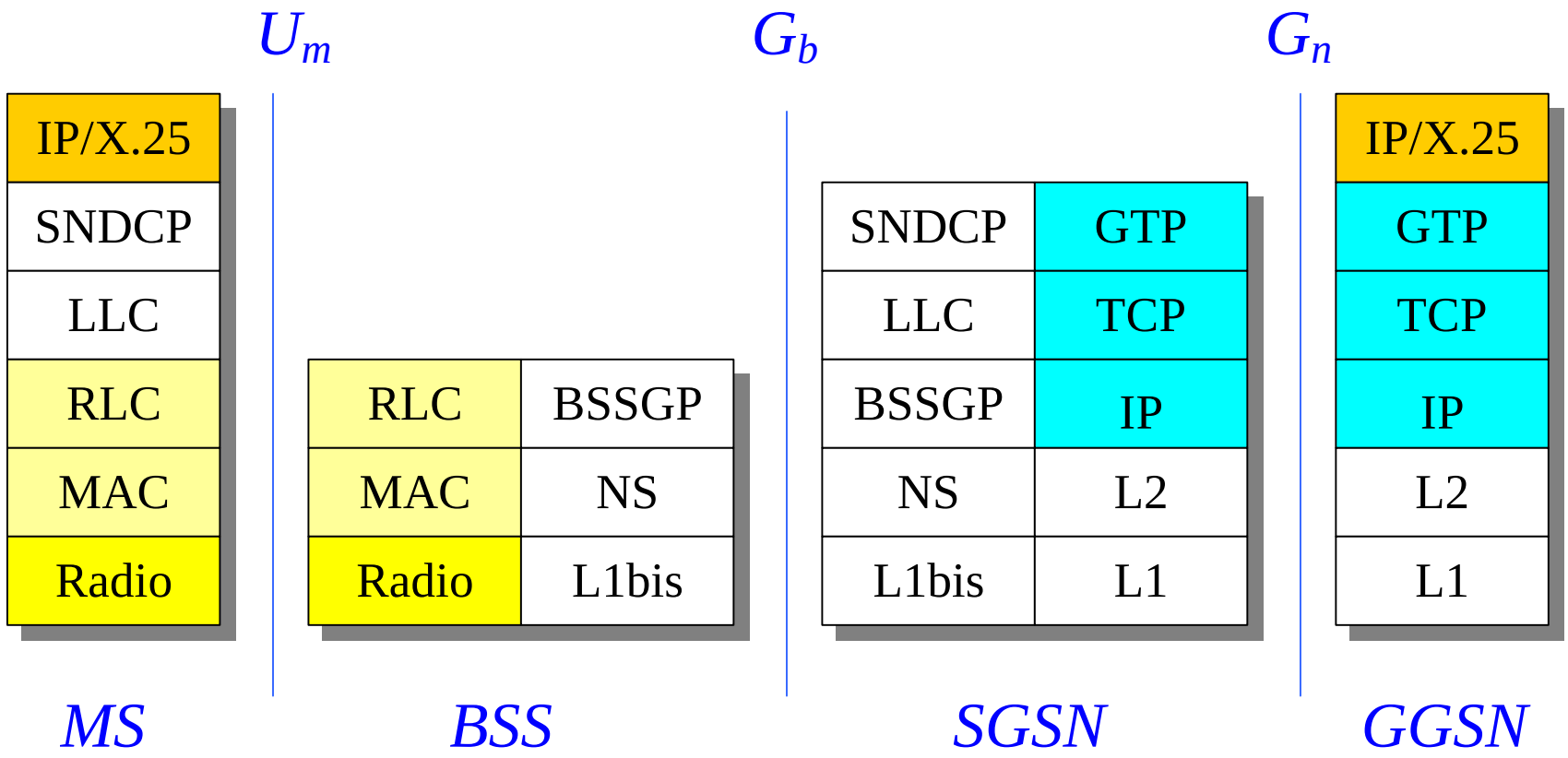
GPRS packet encoding



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:

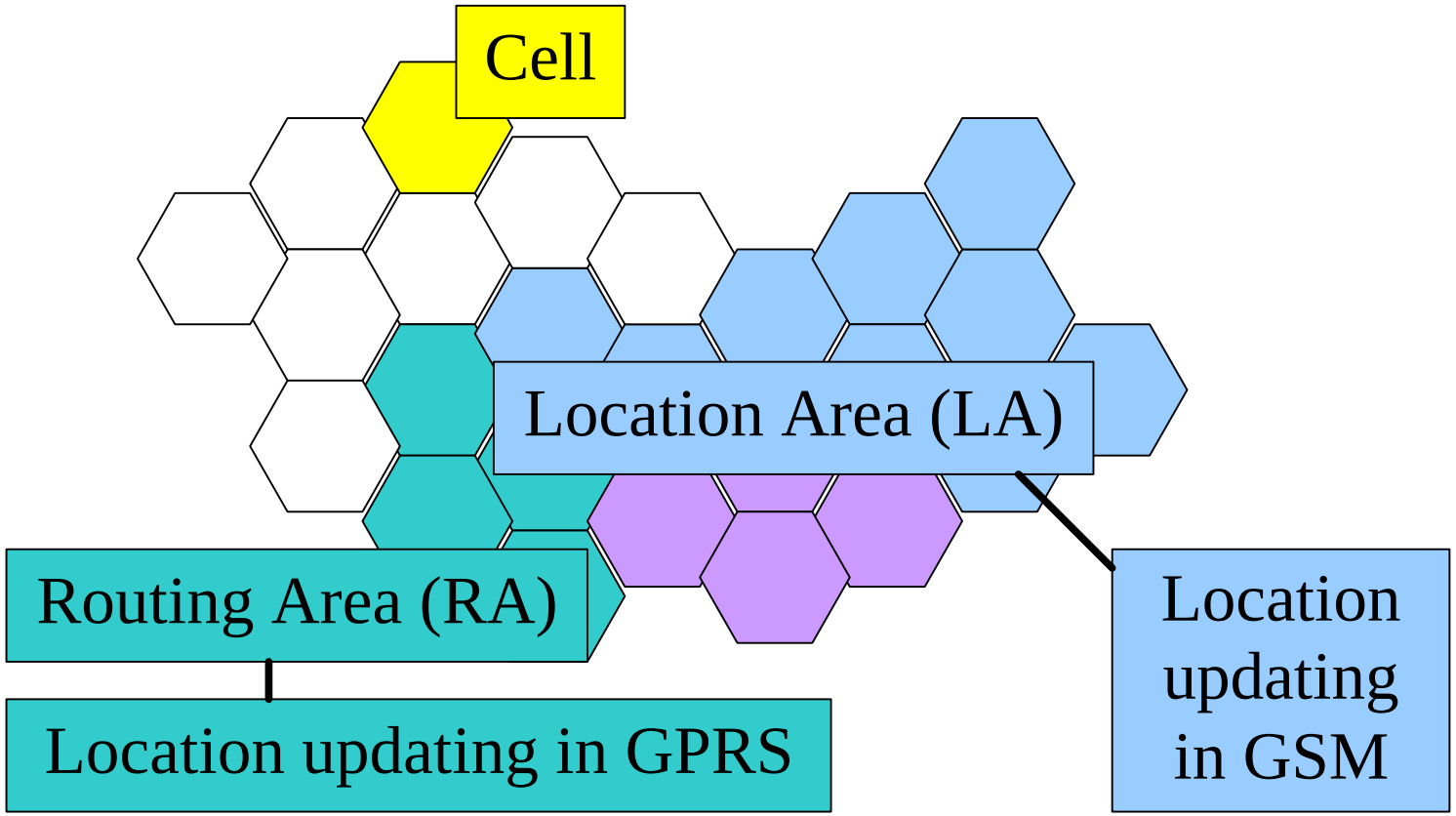
CC (Call Control)

- 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	MS is switched off (circuit mode)
Idle	location updates on LA basis
Connected	handovers in c.s. connection

GPRS:

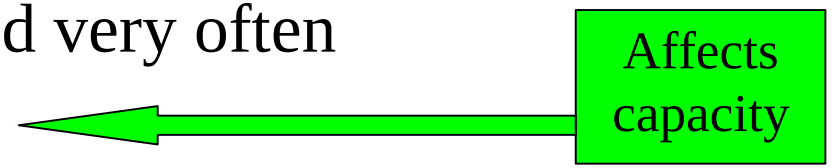
Idle	MS is switched off (packet mode)
Standby	location updates on RA basis
Ready	location updates on cell-by-cell basis

Trade-off when choosing LA/RA size

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

\+ location updates not needed very often

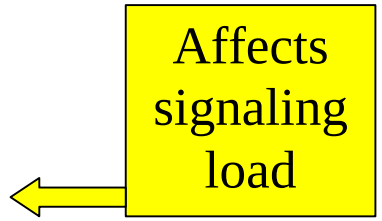
– paging load is very heavy



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

\+ small paging load

– location updates must be done very often



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)

1) 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 (address of subscriber HLR database)

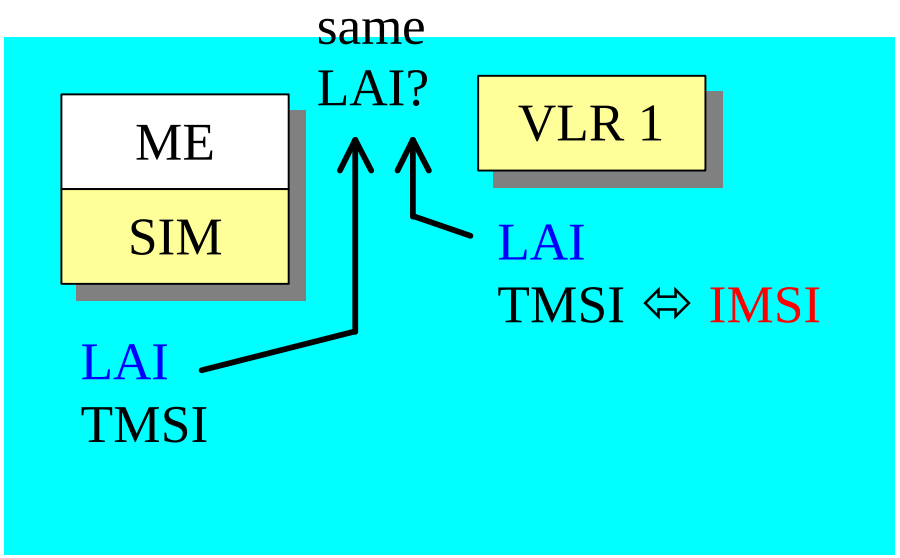
PIN – Personal Identification Number (only within MS)

IMEI – International Mobile Equipment Identity (global)

Temporary, local numbers for routing (MSRN, HON …)

Case study: location updating (1)

(most generic scenario is described here)



HLR

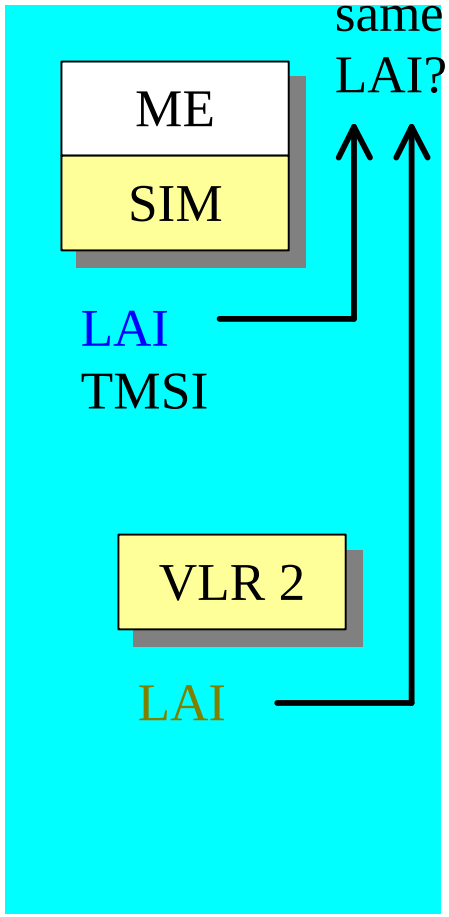
IMSI
LAI => VLR 1

VLR 2

LAI

Last LAI and TMSI stored in SIM.
MS monitors broadcast LAI.
LAI comparison in MS => ok !

Case study: location updating (2)



VLR 1

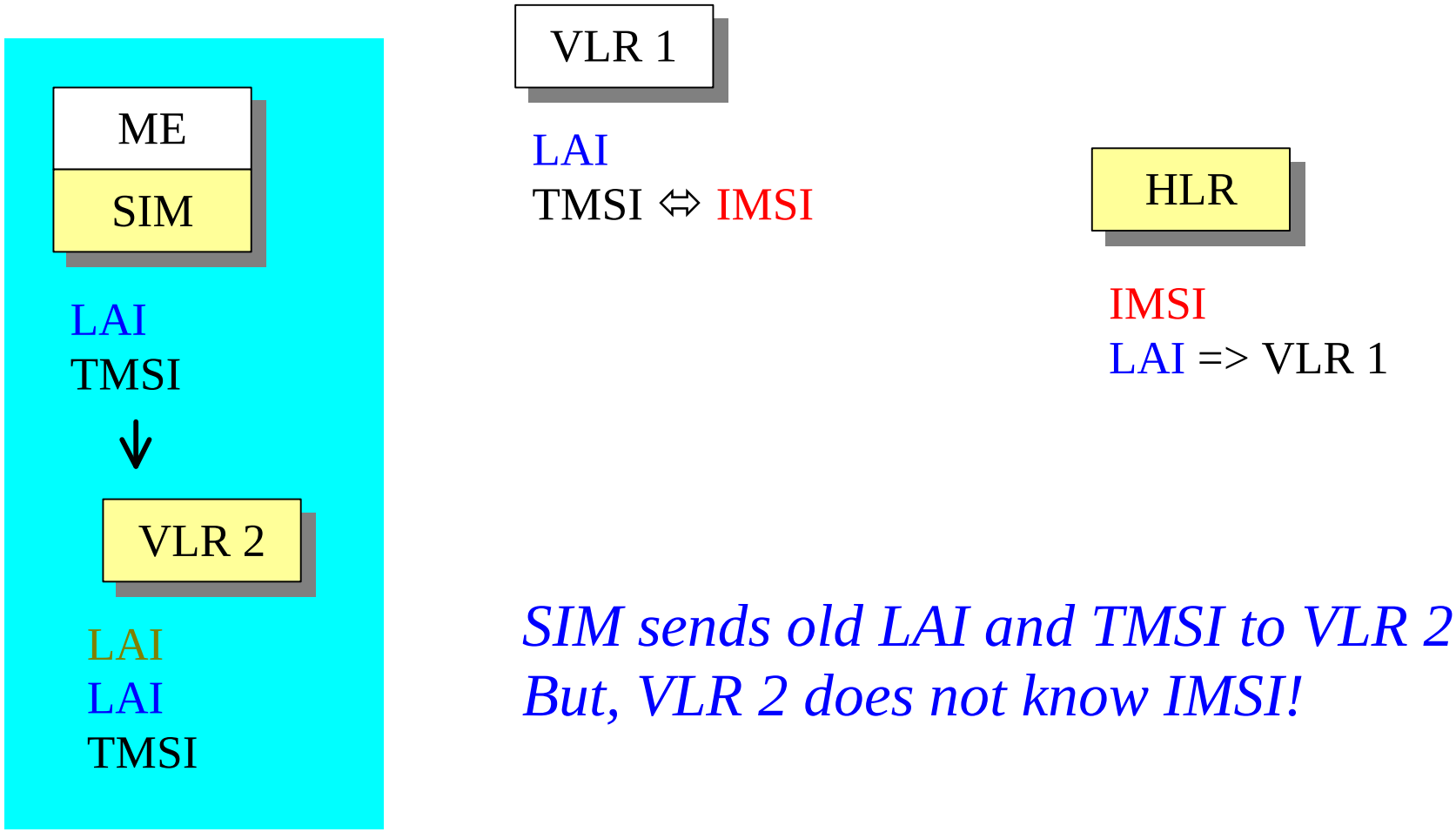
LAI
TMSI ⇔ IMSI

HLR

IMSI
LAI => VLR 1

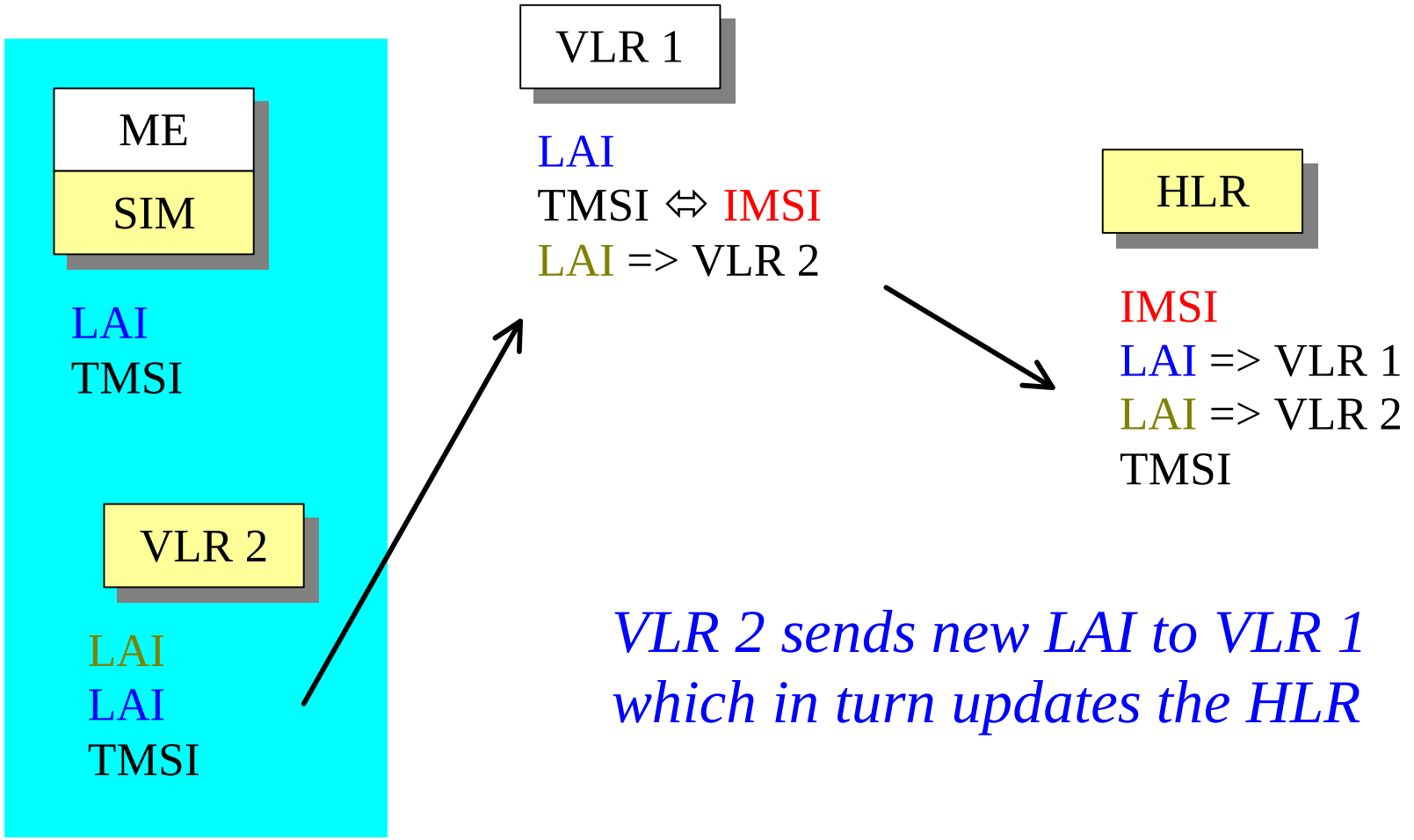
LAI different => location update needed !

Case study: location updating (3)

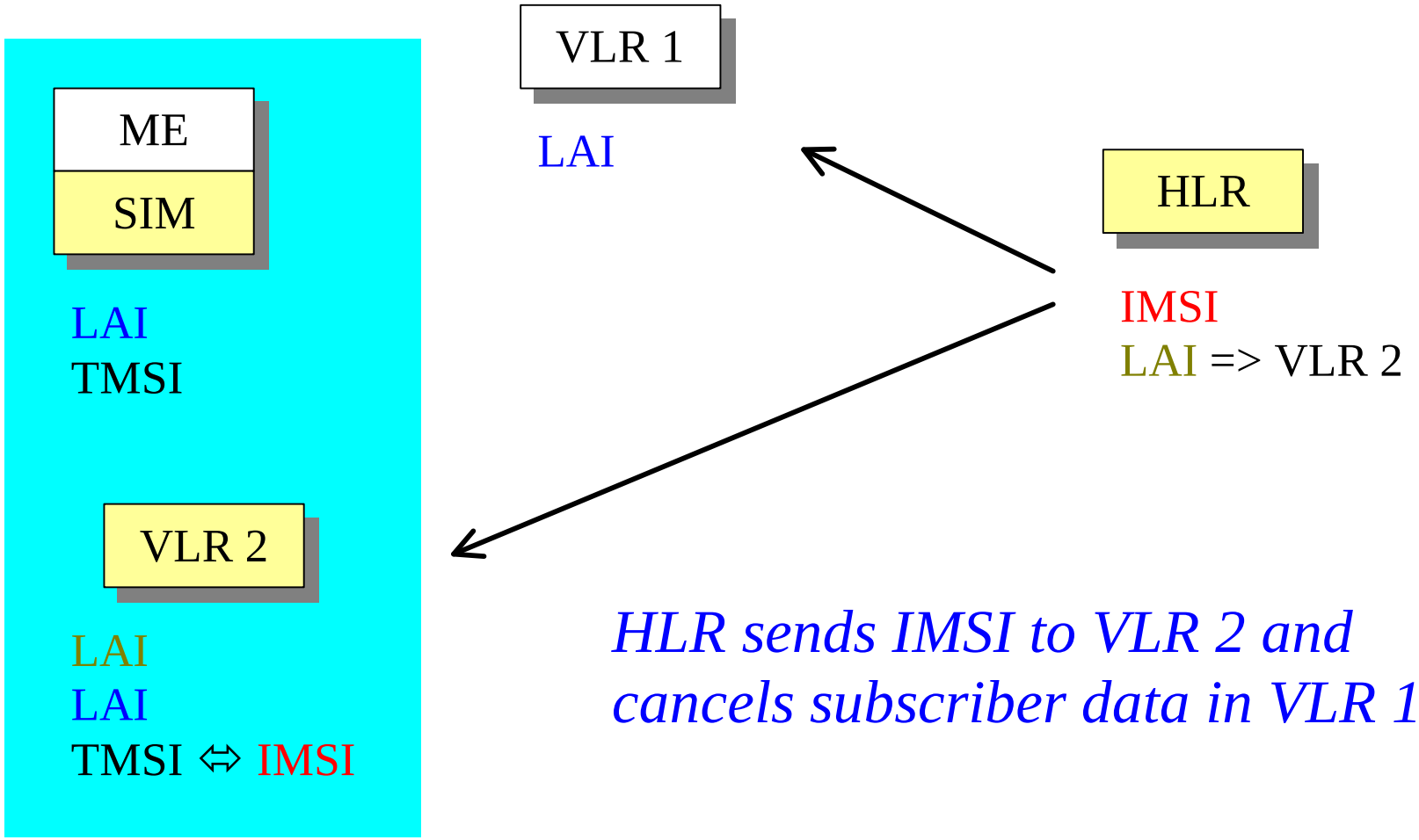


SIM sends old LAI and TMSI to VLR 2
But, VLR 2 does not know IMSI!

Case study: location updating (4)

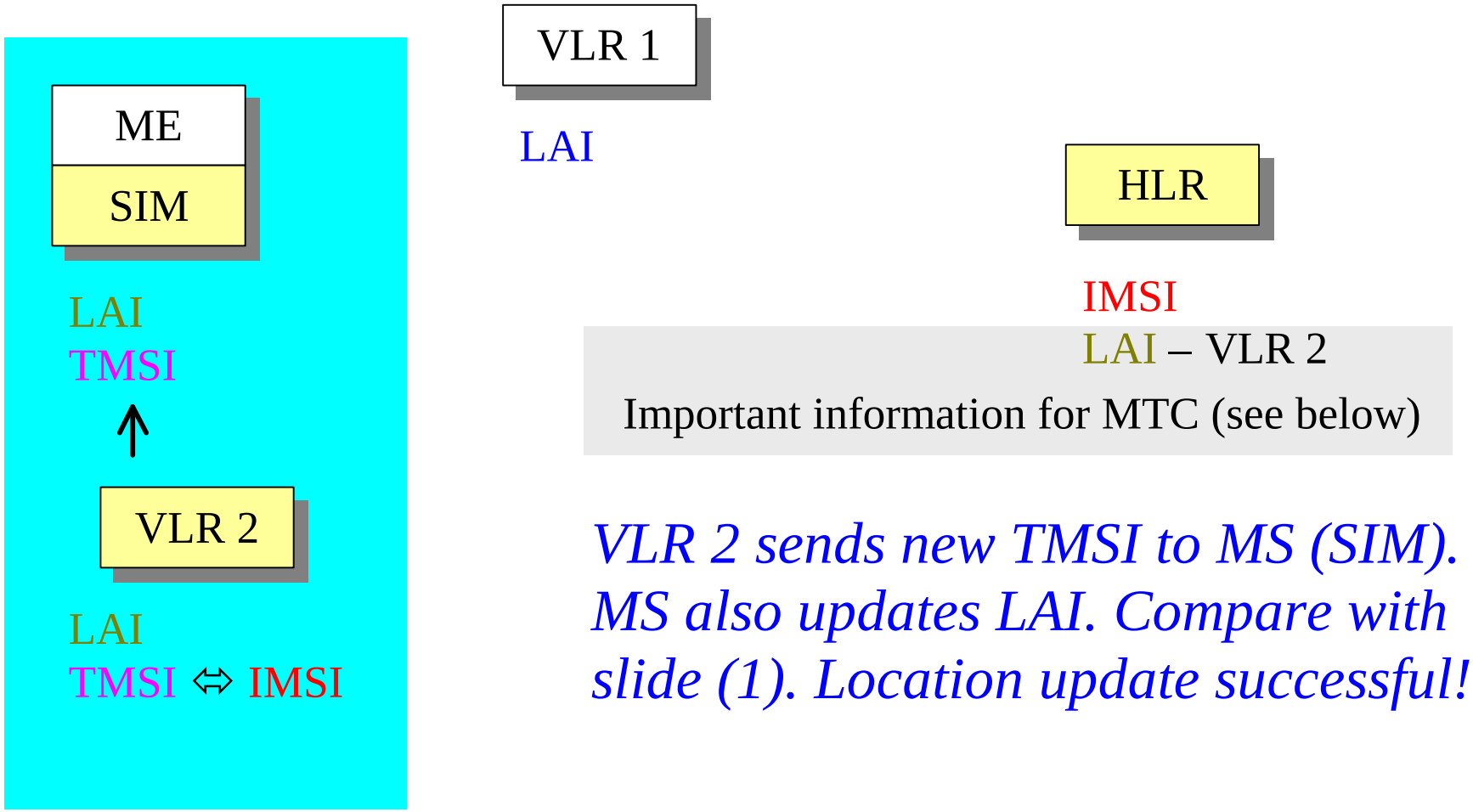


Case study: location updating (5)



HLR sends IMSI to VLR 2 and cancels subscriber data in VLR 1

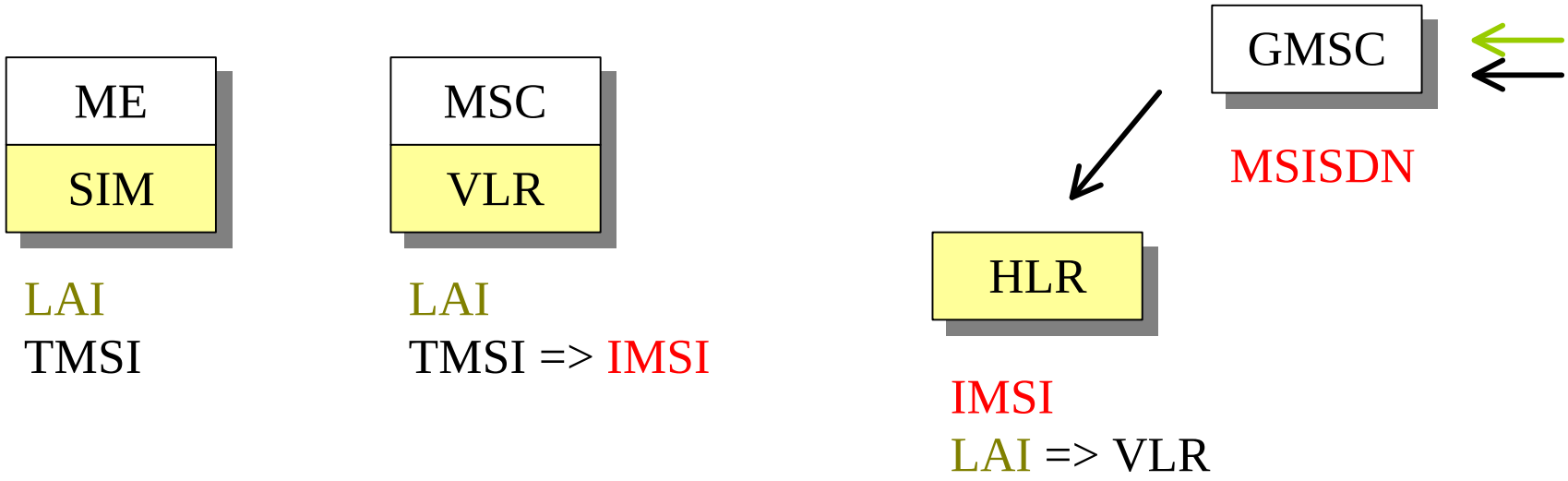
Case study: location updating (6)



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

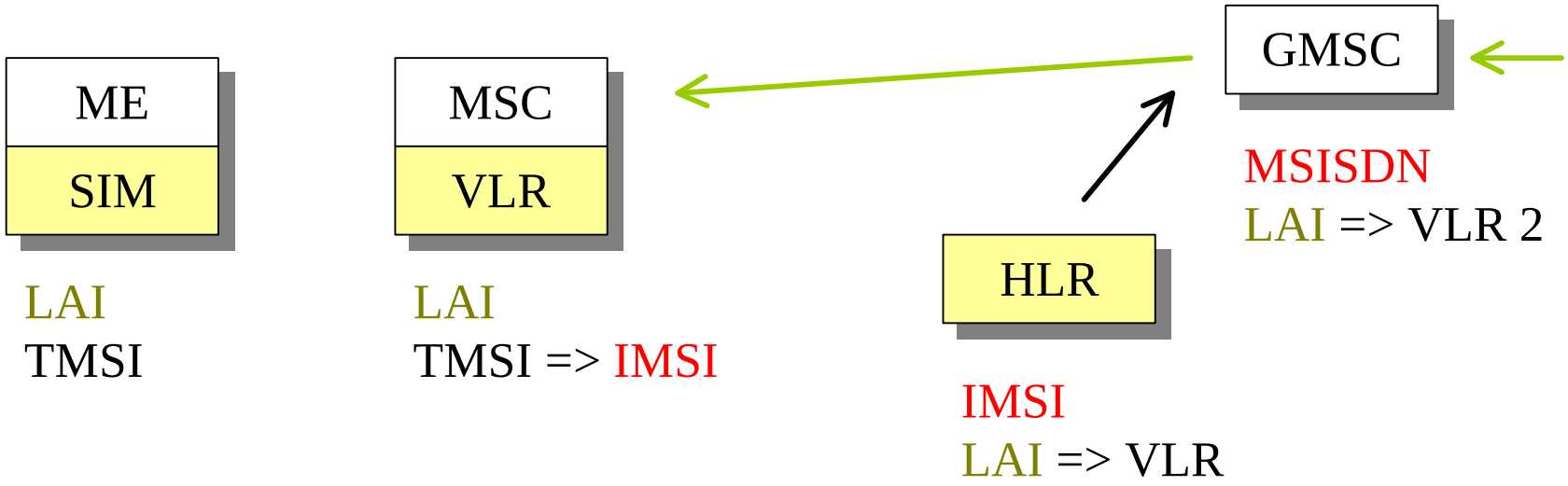
Case study: mobile terminated call (1)

(mobile terminated call = MTC)



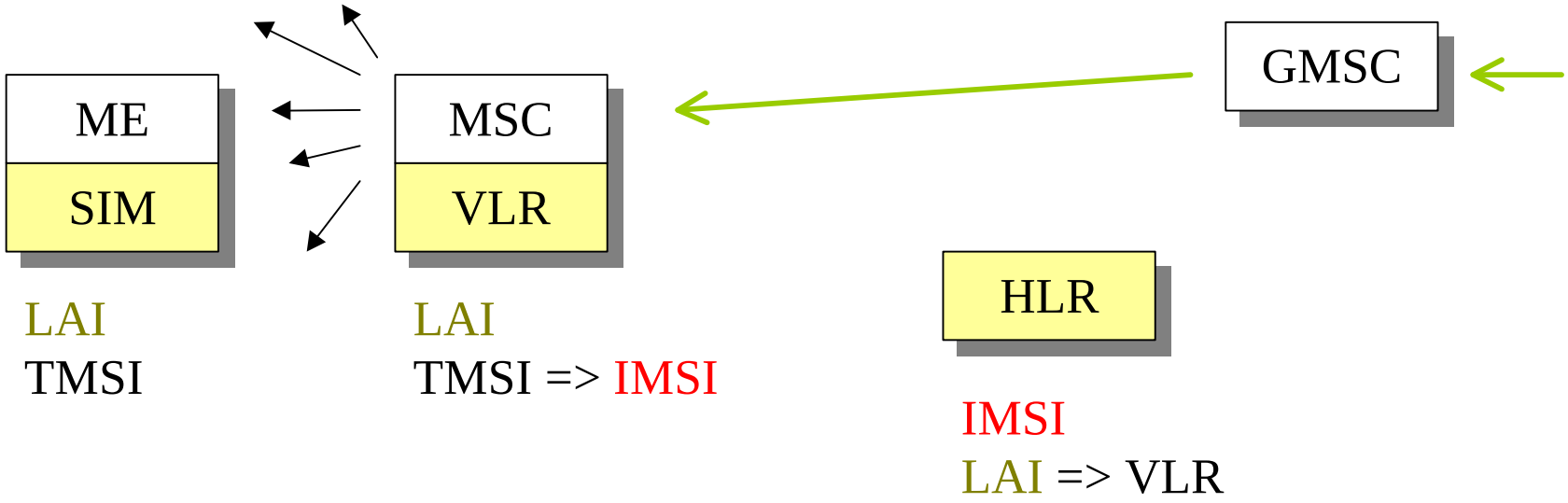
MTC is directed through PSTN to GMSC using MSISDN. GMSC contacts HLR (MSISDN in fact points to the HLR database of this subscriber containing IMSI, LAI, etc.)

Case study: mobile terminated call (2)



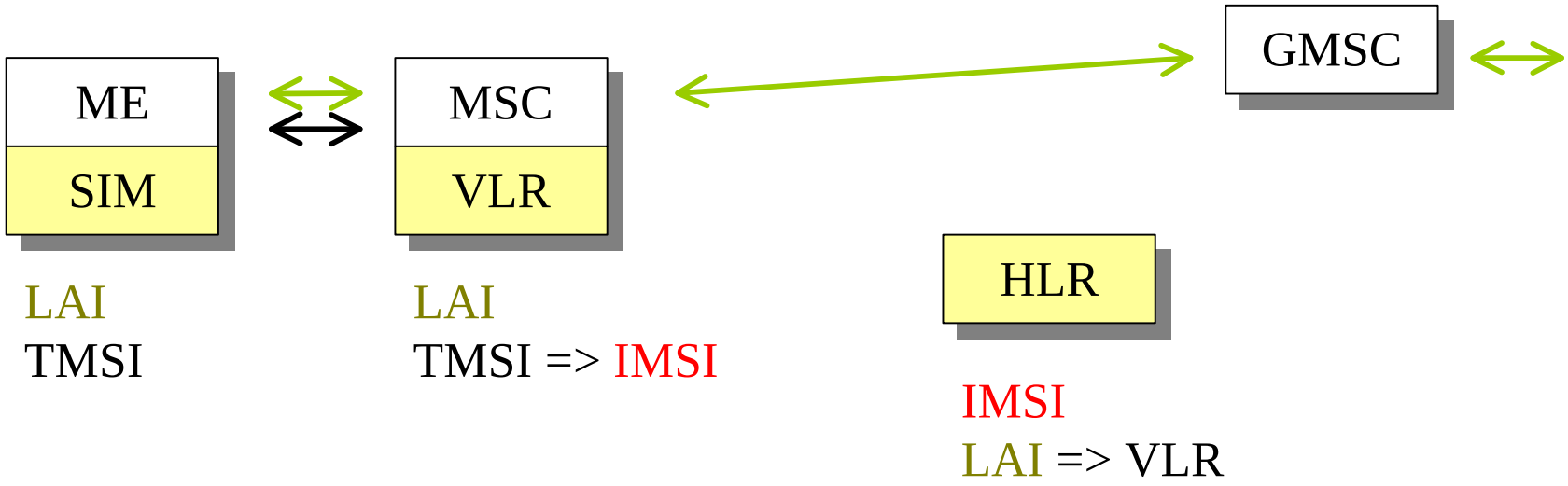
HLR returns to GMSC the current LAI of called mobile subscriber. The GMSC can now route the call to the MSC serving the subscriber

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 correct TMSI reacts to the paging. A connection between MS and MSC is established and the call set-up is completed.