

Telecommunication Networks and Services

Mobile networks

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2015



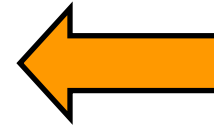
Content



- 1. Introduction
 - Voice digitalisation
- 2. Access to IP networks through telecommunication and cableTV networks
- 3. Switching
- 4. **Mobile networks** ←
- 5. Signalling


Mobile telecommunication systems


- Cellular Concept



- First generation mobile networks



- GSM (2G) 

- UMTS (3G) 

- Satellite mobile networks

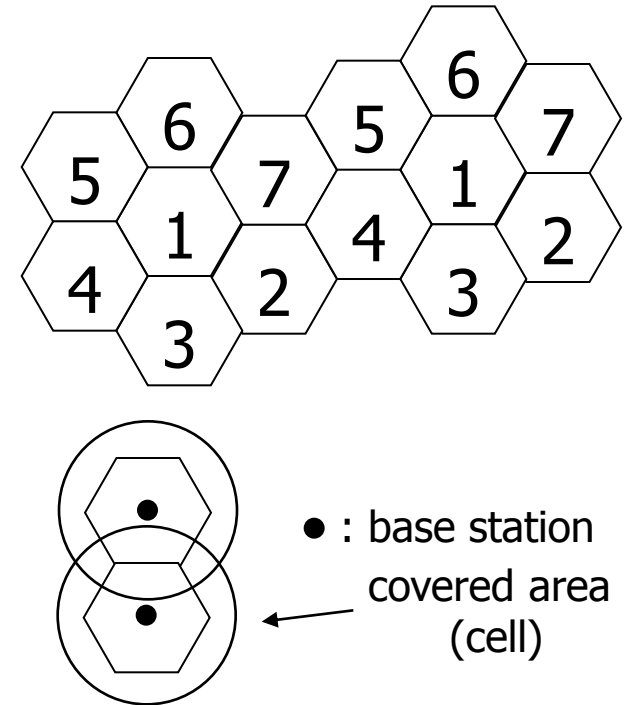


- Mobile, closed purpose networks



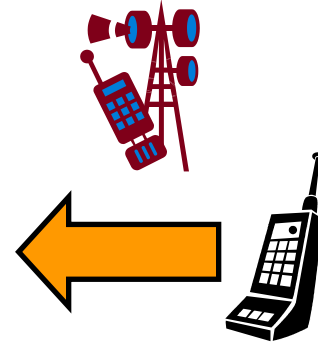
Earth surface mobile networks

- Cellular concept:
 - frequency range is divided into several (e.g. 7) parts
 - cellular coverage (see picture)
 - same frequency: distance of 2 cells – no interference
 - this is only theoretical – in practice more complicated situations (base station in the „corner” of the cell, cell divided into several sectors, etc.)
- Size of a cell?
- Advantages of small cells:
 - small transmitter power enough
 - minimisation of physiological risk
 - smaller power consumption
 - higher traffic density
- Disadvantages of small cells :
 - lot of base stations needed
 - more expensive
 - nasty



Mobile telecommunication systems

- Overview of mobile networks
- **First generation mobile networks**
- GSM (2G)
- UMTS (3G)
- Satellite mobile networks
- Mobile, closed purpose networks


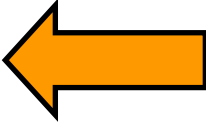



1G systems

- 1G: first generation mobile telecommunication systems
 - end of 1970s / beginning of 1980s
 - Analogue systems
 - Lot of not compatible systems
 - E.g.: NMT (Nordic Mobile Telephone System)
 - Scandinavia since 1981
 - In Hungary 1990-2003. (30th June) (Westel 0660)
 - Typically around 450 MHz frequency
 - Relatively large cells, with 30-50 km of diameter
 - Poor voice transmission quality, few services
 - More examples for 1G systems:
 - USA: Advanced Mobile Phone Service (AMPS),
 - GB: Total Access Communication System (TACS)
 - Germany: B-Network (C450)



Mobile telecommunication systems

- Overview of mobile networks
- First generation mobile networks
- **GSM (2G)**  
- UMTS (3G) 
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- World-wide spread, because:
 - research-development in proper time, quickly (4 years)
 - open, improvable standard (ETSI)
 - in Europe uniform from the beginning (not in USA ☹)
 - global system (roaming)
 - concept of SIM card is attractive (data of subscribers – equipment-independent)
 - only the caller pays (in USA both parties)
 - pre-paid (later from phase 2)
 - 900 MHz: countrywide coverage possible
- Incremental development:
 - phase 1 (1991)
 - voice transmission, SIM concept, SMS, roaming, encryption of voice, 9.6 kbps data transmission
 - phase 2 (1995)
 - backward compatibility, calling number presentation, call hold, call waiting, conference call, half rate (speed) codec, etc.
 - phase 2+ (1998)
 - mainly improvement in data transmission (HSCSD, EDGE, GPRS), push-to-talk, virtual private networks, improvement of SIM, enhanced codecs, etc.

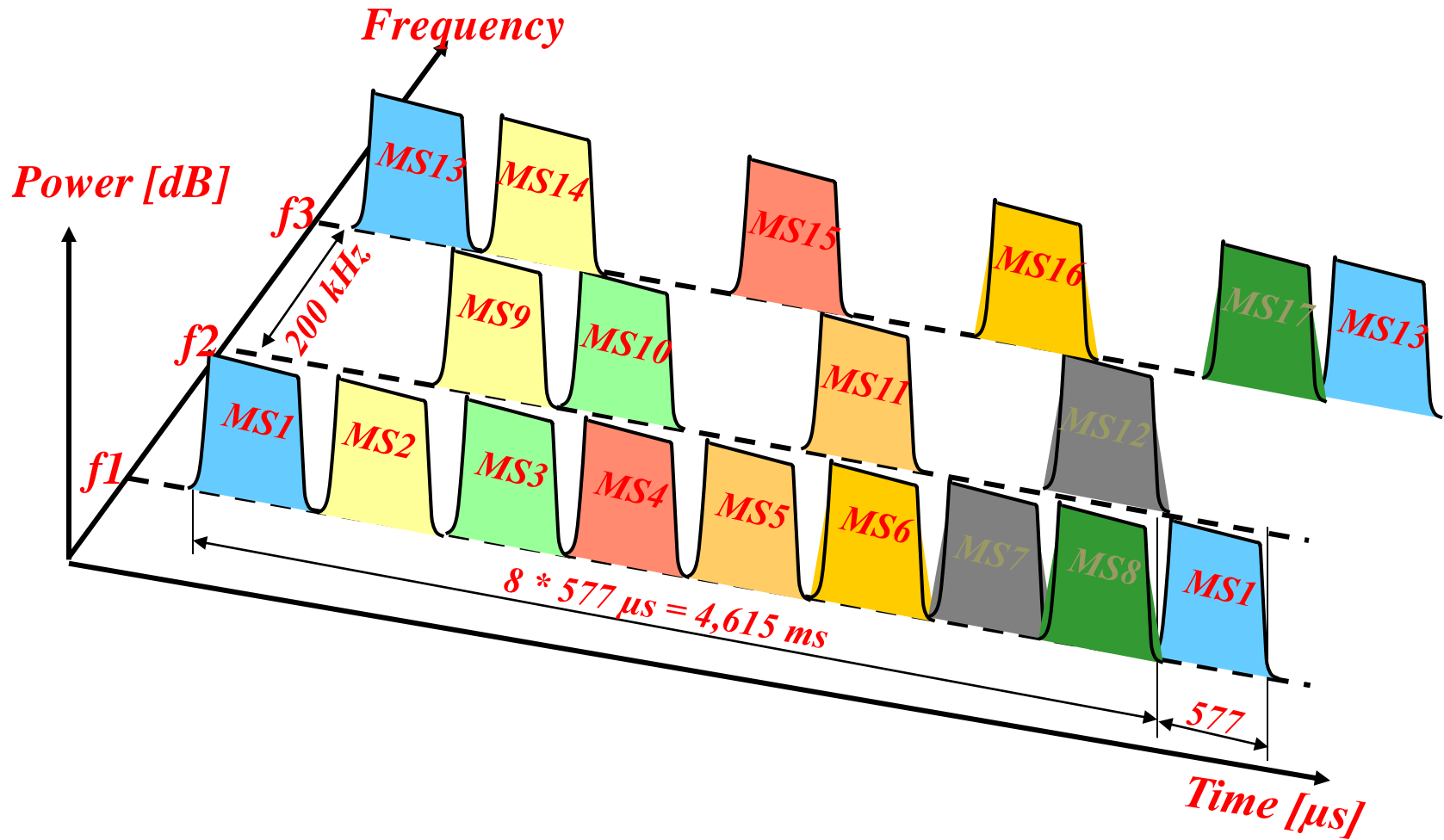
GSM

- Digital transmission:
 - voice codec in terminal
 - integrated services network: voice + data transmission
- Radiation output: max. 2W, adaptive: the terminal transmits with the minimally necessary power
 - save the battery
 - minimisation of physiological risk
 - not to disturb other cells
- Diameter of cells: 0,5 – 35 km
 - depends on frequency, traffic, propagation
 - design decision

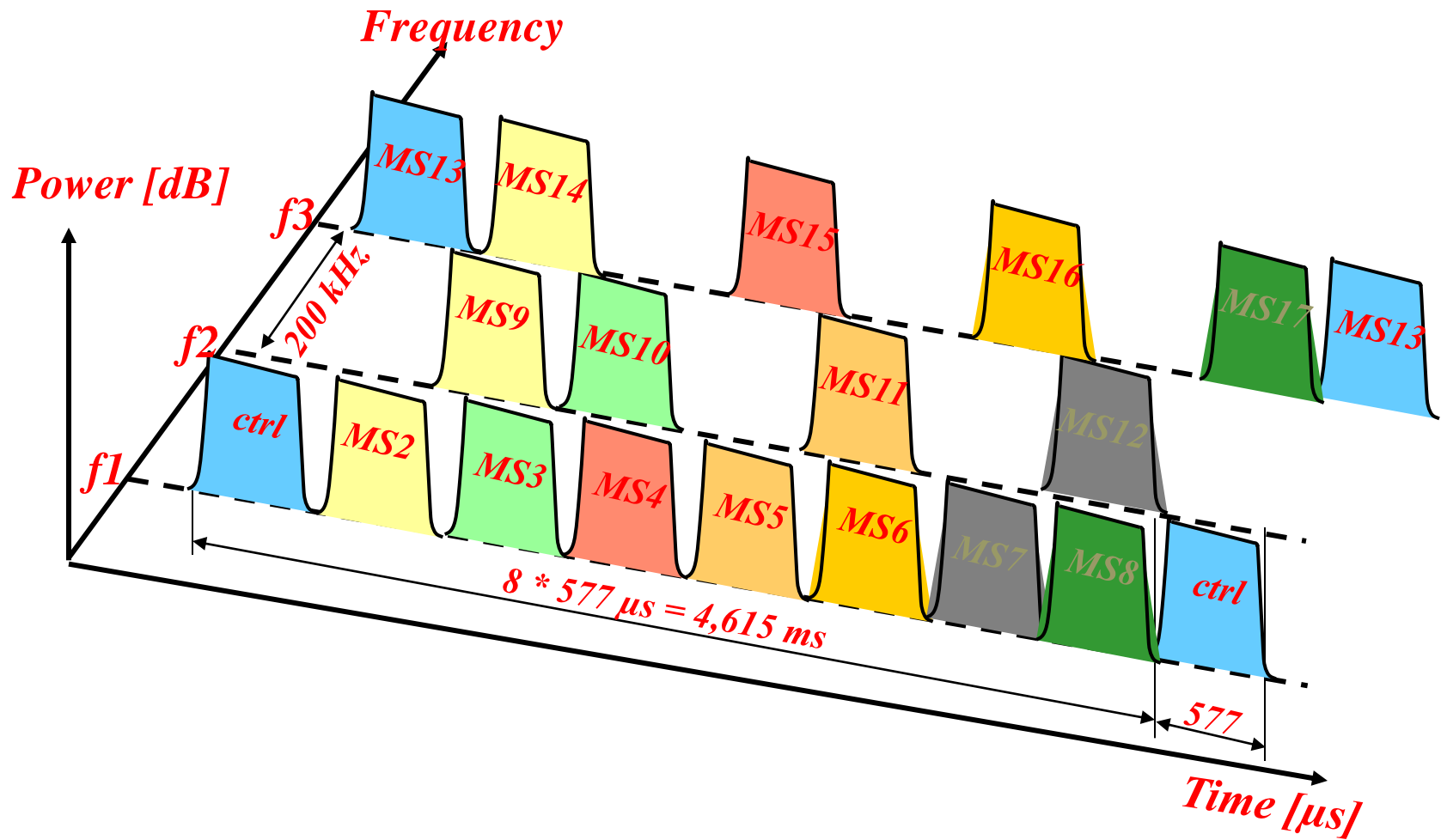
GSM

- Radio access: FDMA+TDMA (Frequency/Time Division Multiple Access)
- GSM 900 (Primary-GSM, P-GSM)
 - mobile station (uplink): 890-915 MHz,
 - base station (downlink) 935-960 MHz
 - in this frequency range the smaller frequency suffers smaller attenuation, so it requires less power -> mobiles have the smaller frequency band
 - 1 band = 25 MHz, 1 carrier = 200 kHz: 124 carriers (FDMA)
 - shared by every service provider
 - in Hungary: appr. 30 frequencies/service provider in this band
 - 8 time slots/carrier (TDMA)
 - $30 \cdot 8 / 10 \approx 24$ channels / cell
 - 10: typically ≈ 10 different frequencies used in cells (more realistic than 7 as we could see on slide 4)
 - with Half Rate encoding: twice as much
 - max 35 km cell diameter: 900 MHz waves follow the surface of the Earth more or less =>
 - countrywide coverage

FDMA – TDMA access



FDMA – TDMA access



GSM

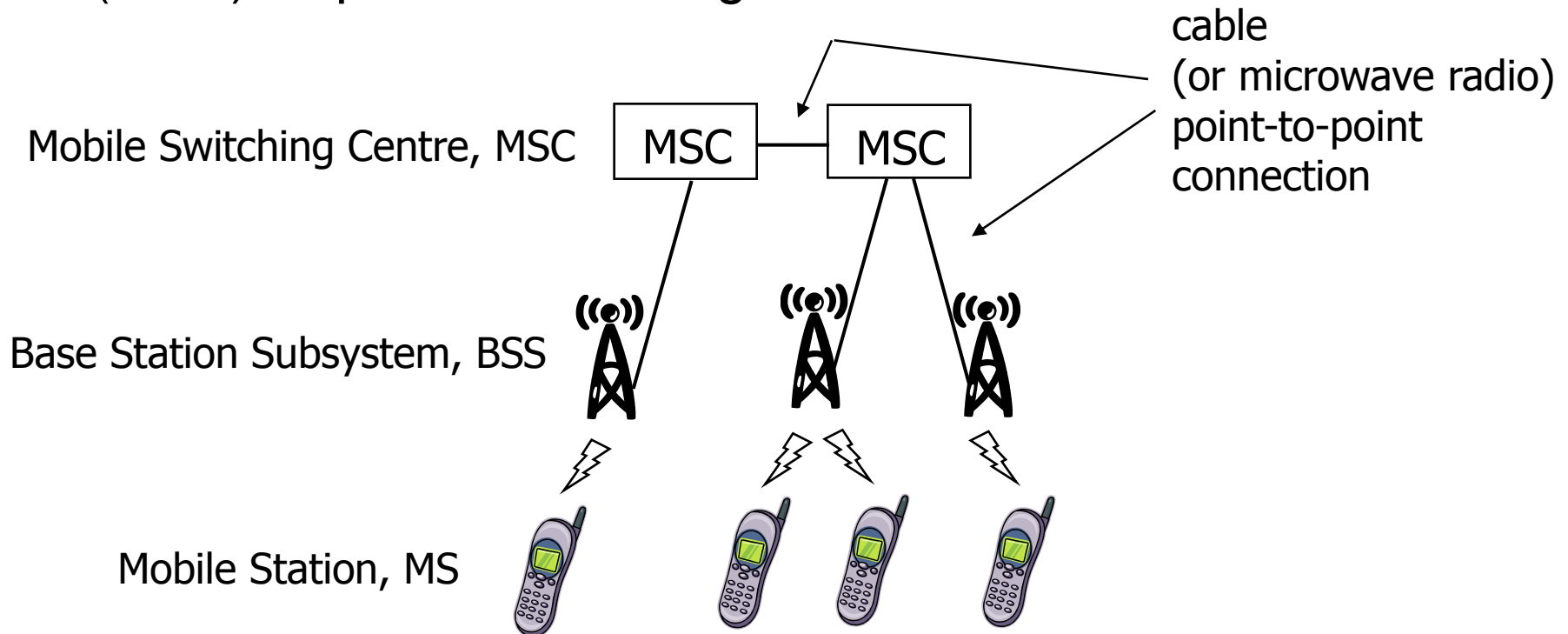
- GSM 1800
 - mobile: 1710-1785 MHz, base station: 1805-1880 MHz
 - 1 band = 75 MHz (three times larger capacity)
 - BUT: worse wave propagation
 - propagates straight
 - attenuates more quickly
 - not (so...) suitable for countrywide coverage, only for small cells (with high traffic)
- Several other: (not to learn, but interesting)
 - Extended-GSM 900, E-GSM: +10 MHz/direction: +50 carriers
 - R-GSM: Railways GSM: 876-880/921-925 MHz
 - GSM 1900: 1850-1910/1930-1990 MHz (USA)
 - GSM 850: 824-849/869-894 MHz (USA)
- Dual band equipments: automatically select/change frequency range
 - recently three band (900/1800/1900) and four band equipments (850/900/1800/1900)

GSM handover/handoff

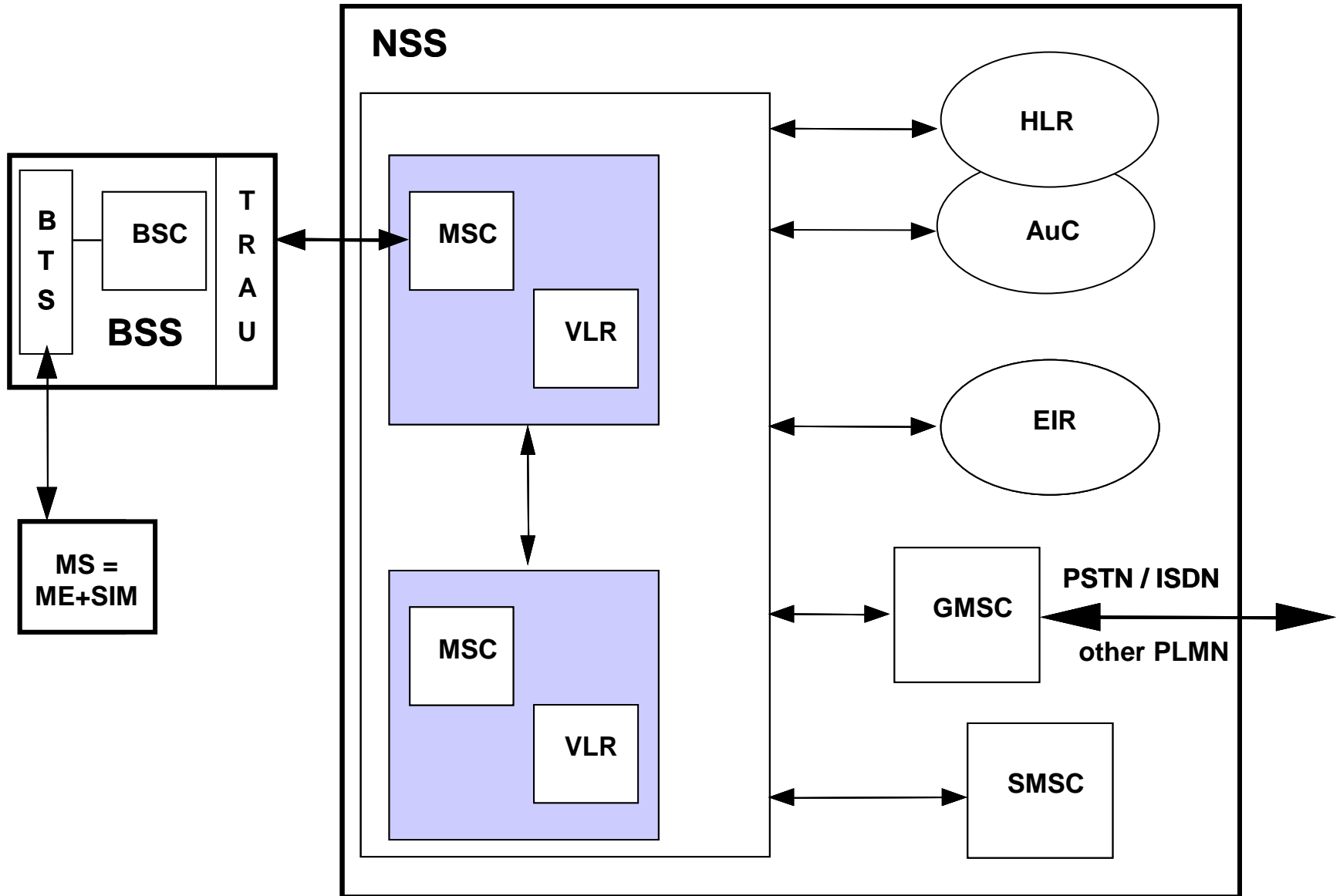
- GSM: circuit switching
- When the mobile station enters an other cell:
handover (handoff)
 - connection continuous
 - it can theoretically happen:
 - by control of the mobile station: measures, when the signal of the neighbouring cell is stronger
 - by control of the network: network decides on the signal strength and/or other pieces of info (e.g. load of the cell)
 - *by control of the network, with the help of mobile station: network asks the mobile station to send signal strength info, but the decision is made by the network – this is in GSM*
 - this way the network can enter the mobile station later if the „new” cell is overloaded

Architecture of GSM networks

- (Over)simplified block diagram:



Architecture of GSM networks



Base Station Subsystem (BSS)

□ Base Transceiver Station (BTS)

- One or more elementary transmitter/receiver
- Transcoder/Rate Adapter Unit, TRAU
 - FR, HR, EFR codec \Leftrightarrow 64 kbps PCM
 - Full Rate (13 kbps), Half Rate (5.6 kbps), Enhanced Full Rate (12.2 kbps, but better than FR)
 - Rate adaptation also at data transmission: 14.4 kbps \Leftrightarrow 64 kbps

□ Base Station Controller (BSC)

- Controls one or *more* BTSs
- Radio channel assignment
- Handover control

Network and Switching Subsystem

- Mobile Switching Centre (MSC)
 - a digital switch
 - with mobile specific extensions
 - authentication
 - location management (VLR)
 - inter-BSC handover
 - roaming
- Visitor Location Register (VLR)
 - Built-in the MSC
 - Stores temporarily some parts of the HLR info about the currently served mobile stations
- Home Location Register (HLR)
 - subscriber data, subscription information (services), current location
 - one HLR in every network
- Authentication Centre (AuC)
 - Typically integrated with HLR
 - It verifies that the subscriber is the same in reality as he is proposed to be

GSM services – 1

- Voice transmission
 - speed of codec 13 kbps (later: 5.6 kbps)
 - compromise: poorer quality of voice, but higher utilisation of frequency
- SMS (Short Message Service)
 - max. 160 character (1 character = 7 bits)
- Data transmission
 - originally 9.6 kbps, later 14.4 kbps
- HSCSD (High Speed Circuit Switched Data)
 - enhancement of data transmission: unites more 14.4 kbps channels
 - max. 8 theoretically
 - max. 4 practically, (to fit into one 64 kbps channel
 - typical speed: 43.2, 57.6 kbps
 - circuit switched, 4 channels simultaneously: EXPENSIVE!

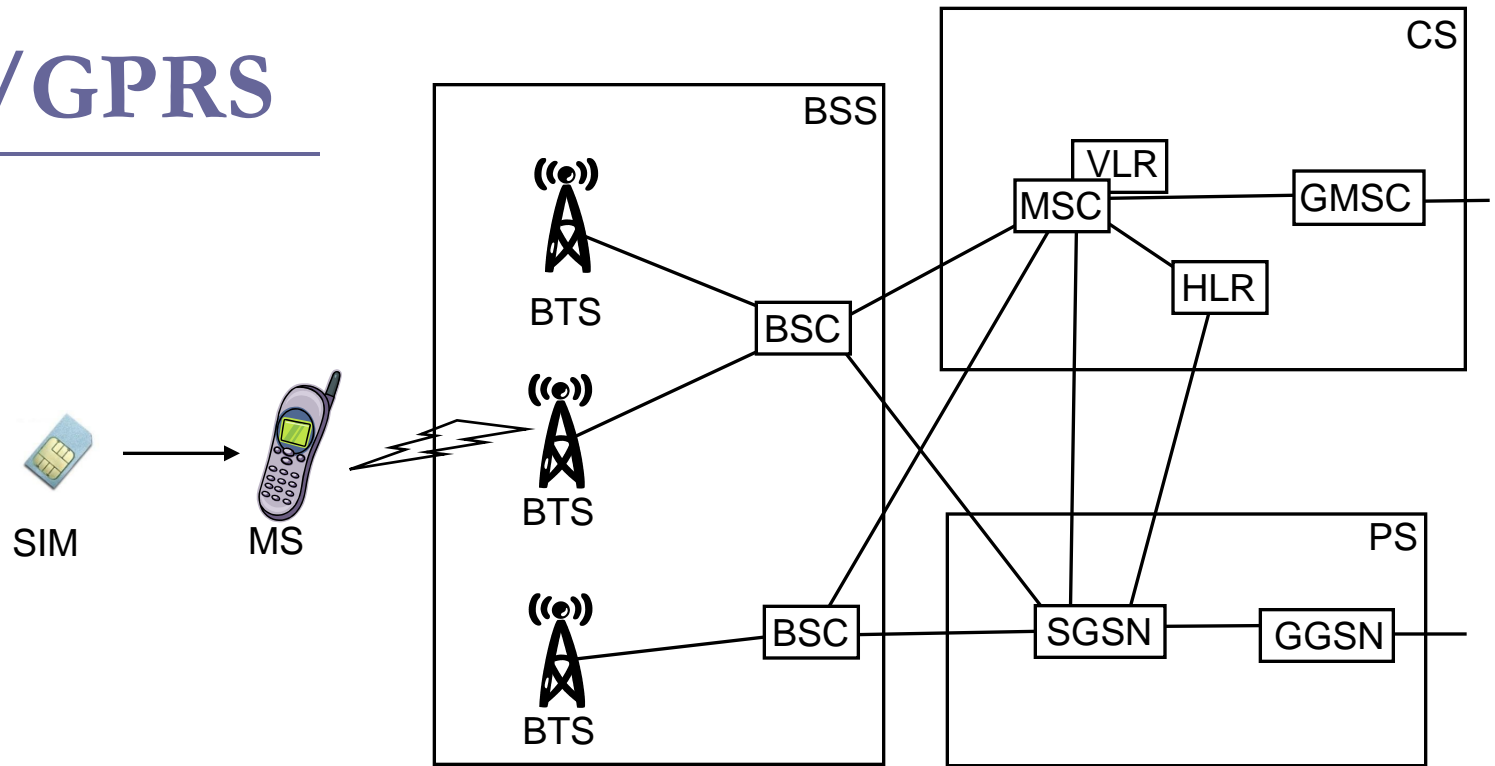
GSM services – 2

- EMS (Enhanced Messaging Service)
 - simple pictures
- MMS (Multimedia Messaging Service)
 - multimedia message: picture, text, voice together
 - since 2002
- WAP (Wireless Application Protocol)
 - simplified Web-like service
- Location Based Services
 - relatively imprecise (cell level!),
 - but it can be told e.g., where is a restaurant nearby

GSM/GPRS

- GPRS (General Packet Radio Service)
 - since 2001
 - packet switched data transmission, extension of GSM
 - advantage:
 - better utilisation of network, frequency
 - payment on basis of transmitted data amount (kB), not on basis of duration of the connection
 - speed
 - originally max. 56 kbps
 - theoretically max.: $8 \times 20 = 160$ kbps
 - typically 60-80 kbps downlink, 20-40 kbps uplink
 - fewer channels used in uplink direction
 - usage:
 - WAP
 - Internet access
 - requires significant extensions in the network (next slide)

GSM/GPRS



SIM: Subscriber Identity
Module,

MS: Mobile Station

BTS: Base Transceiver Station

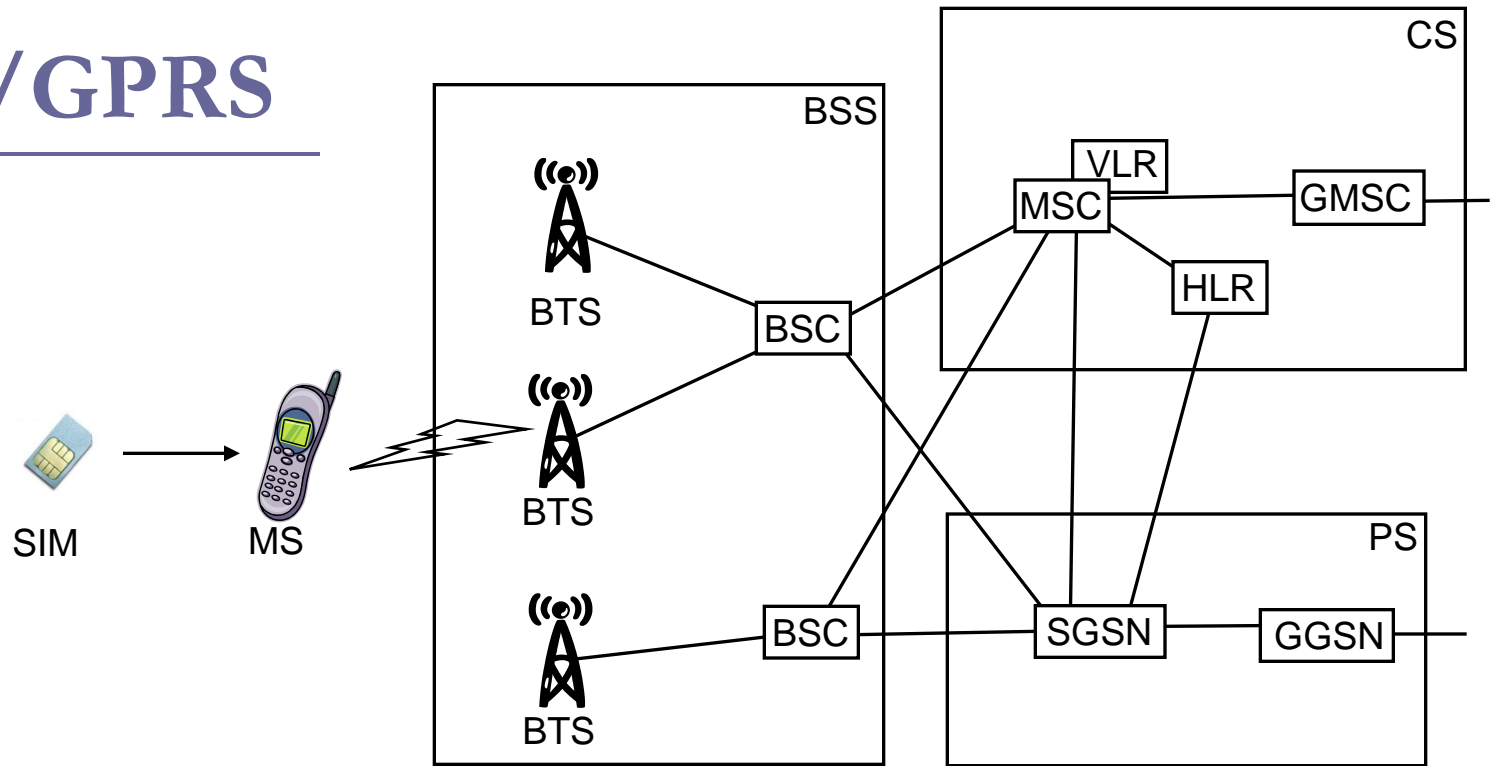
BSC: Base Station Controller

BSS: Base Station Subsystem

CS: Circuit Switched Subsystem

- MSC: Mobile Switching Centre
- VLR: Visitor Location Register
- HLR: Home Location Register
- GMSC: Gateway MSC
- + other units: AuC, EIR, SMSC

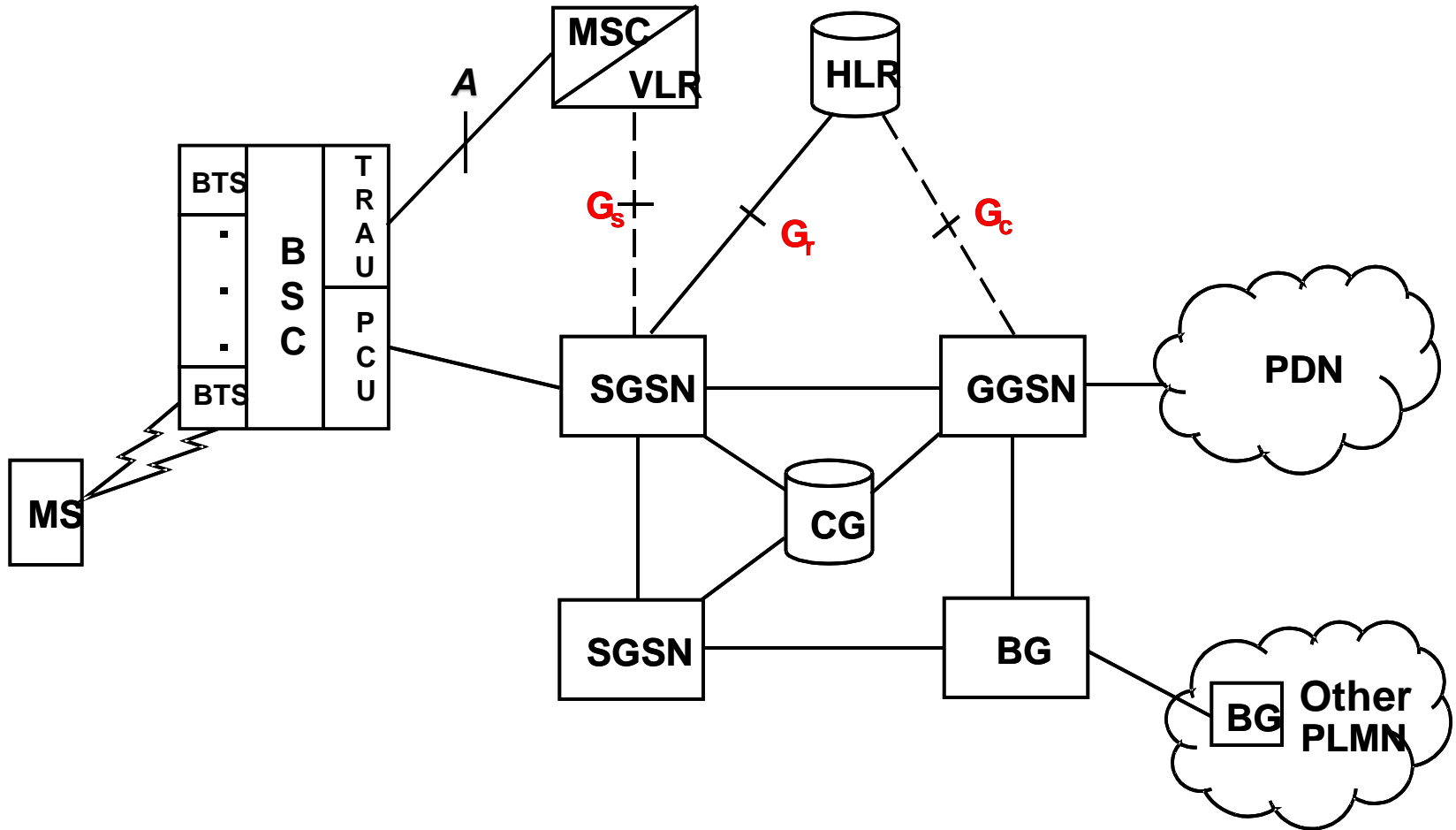
GSM/GPRS



PS: Packet Switched Subsystem

- SGSN: Serving GPRS Support Node
- GGSN: Gateway GPRS Support Node (to other data networks e.g. Internet)
- BG: Border Gateway (gateway to other GPRS service providers)

GPRS architecture



GSM/EDGE

- *EDGE* (Enhanced Data Rate for Global/GSM Evolution – no comment...)
 - since 2003
 - can be used for speeding up the
 - circuit-switched data transmission: Enhanced Circuit Switched Data (ECSD)
 - packet-switched data transmission: Enhanced GPRS (EGPRS)
 - improved modulation technology
 - originally 1 bit/symbol (Gaussian minimum shift keying, GMSK)
 - EDGE: 8PSK, 3 bit/symbol
 - three times larger data transmission speed
 - but worse signal-to-noise ratio
 - can only be used close to the base station, not in the whole cell
 - requires only a limited extensions in the network: EDGE card into the base station + BSC software upgrade