Communication Networks 2

Mobile networks

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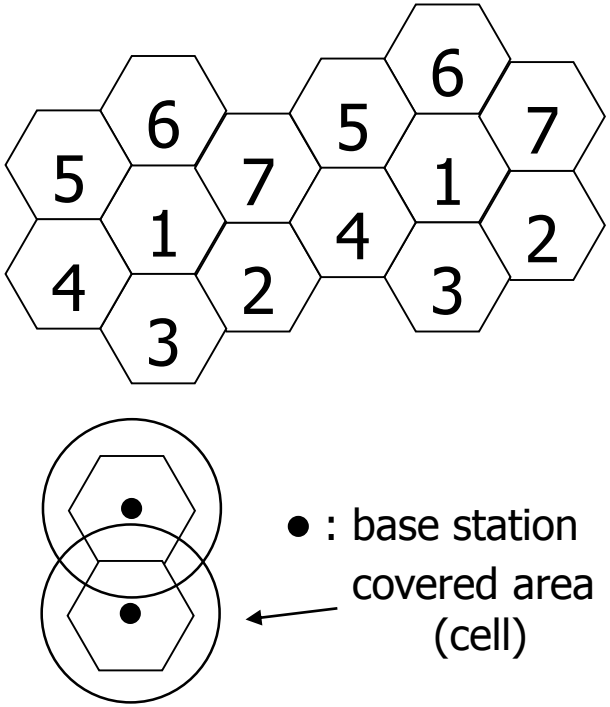
Earth surface mobile networks

- 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



GSM

GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

- 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.

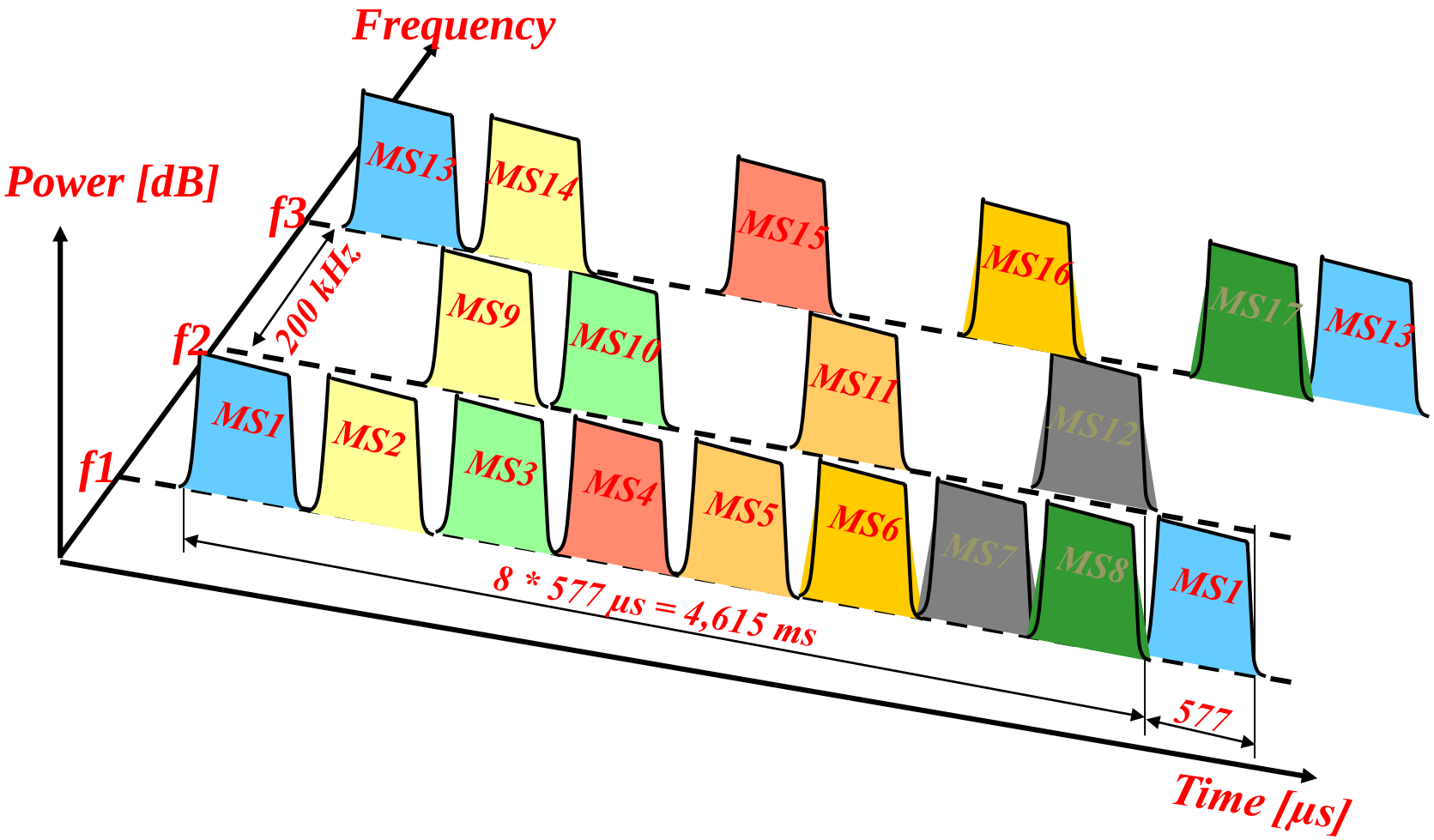
GSM

- 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

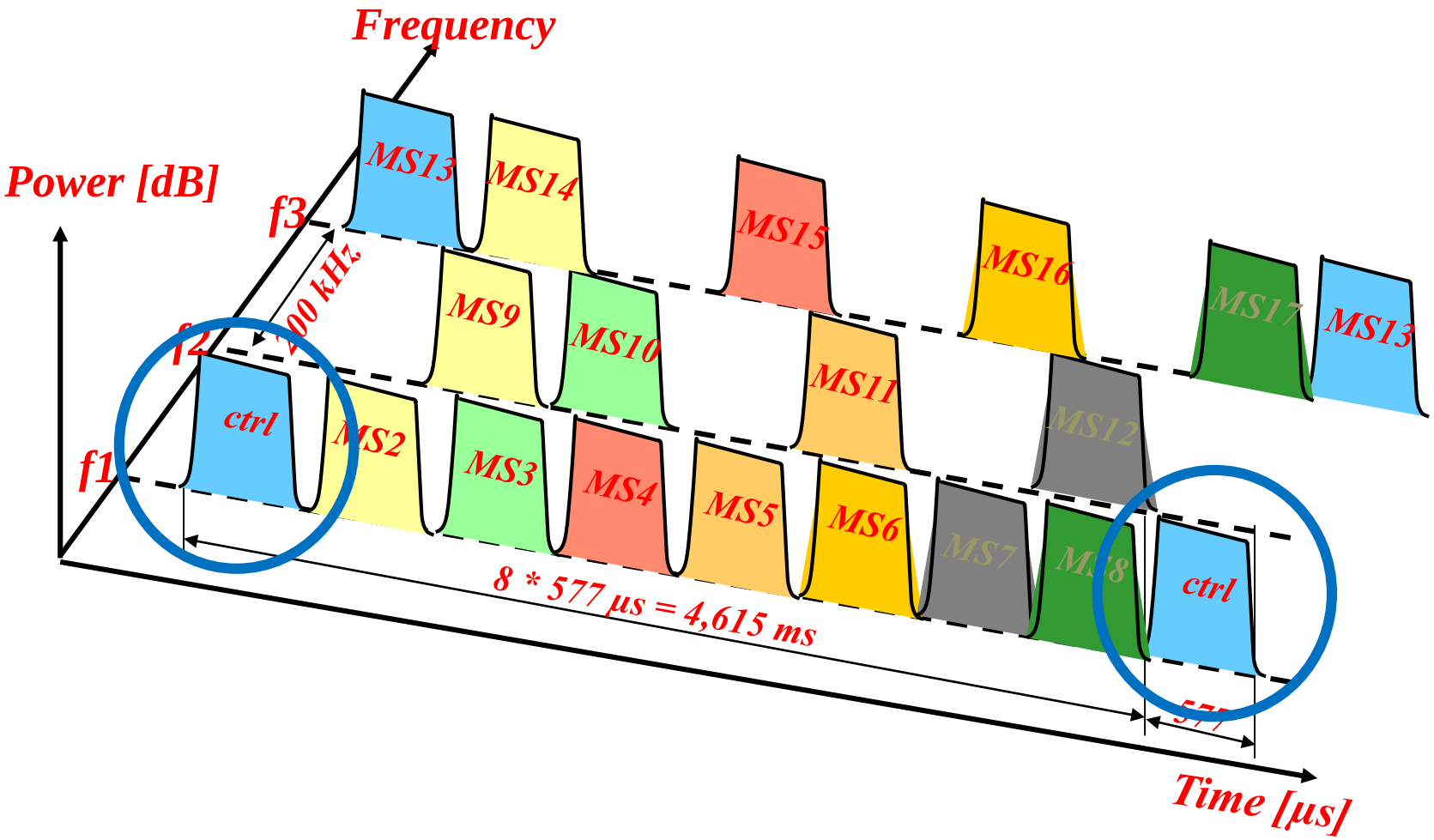
GSM

- 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*8/10 ≈ 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



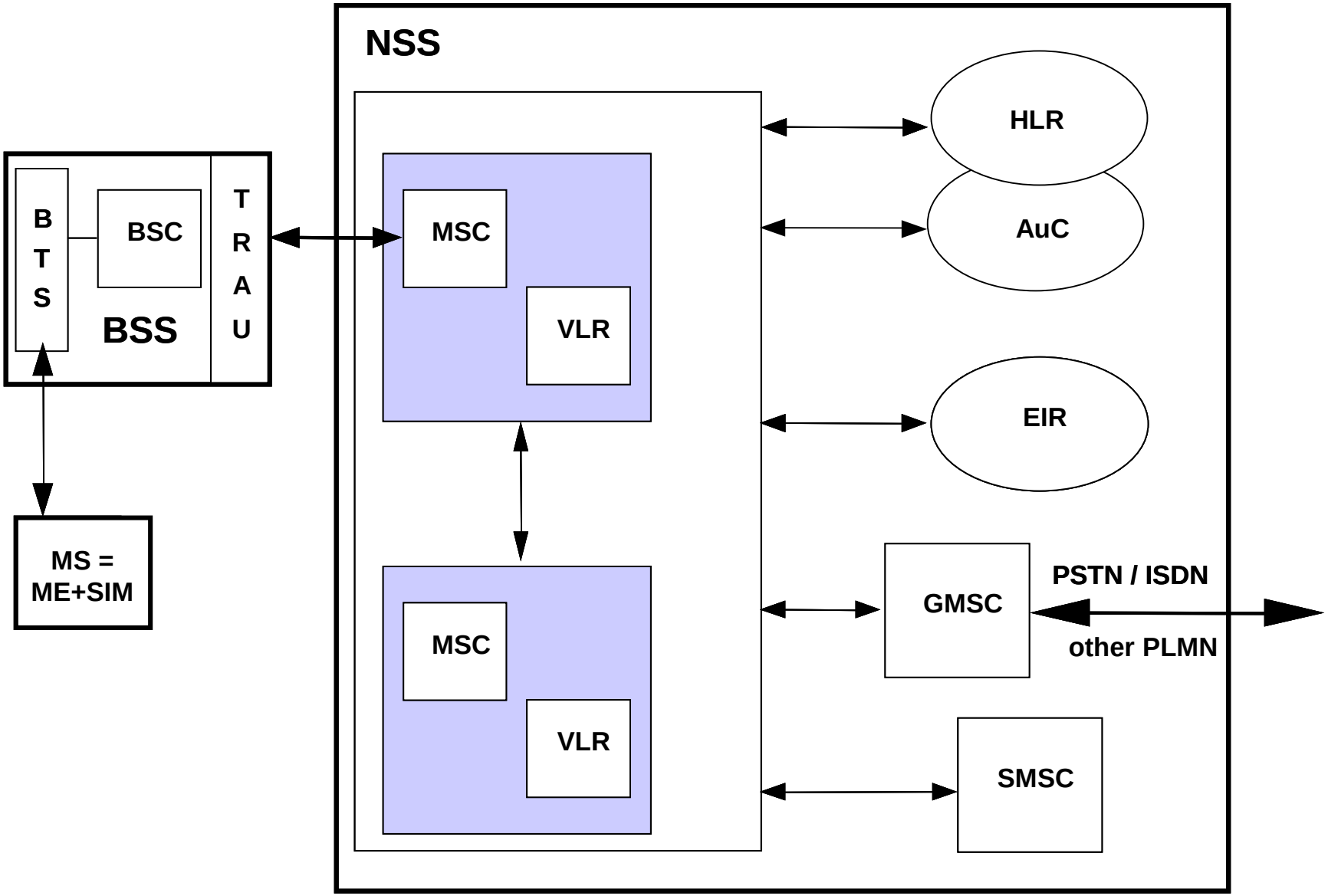
GSM

- 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



Base Station Subsystem (BSS)

- Base Transciever Station (BTS)
  - One or more elementary transmitter/receiver
  - Transcoder/Rate Adapter Unit, TRAU
    - FR, HR, EFR codec ⇔ 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 ⇔ 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

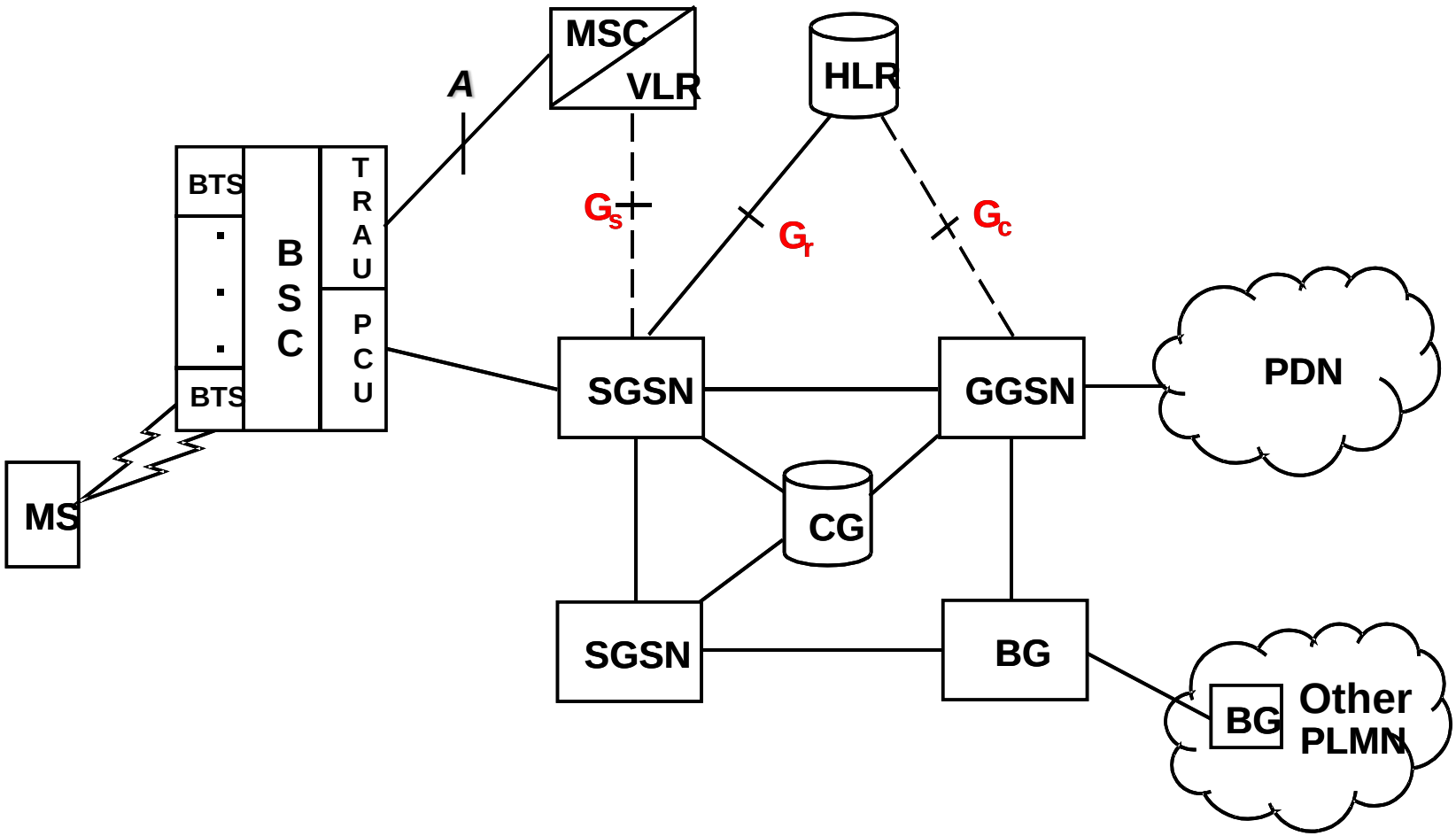
GSM services – 2

- EMS (Enhanced Messaging Service)
  - simple pictures
- MMS (Multimedia Messaging Service)
  - multimedia message: picture, text, voice together
  - since 2002
- 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 x 20 = 160 kbps
    - typically 60-80 kbps downlink, 20-40 kbps uplink
      - fewer channels used in uplink direction
  - usage:
    - Internet access
  - requires significant extensions in the network (next slide)

GPRS architecture



GSM/GPRS

CS: Circuit Switched Subsystem

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)
- CG: Charging Gateway