Communication Networks 2

Mobile networks

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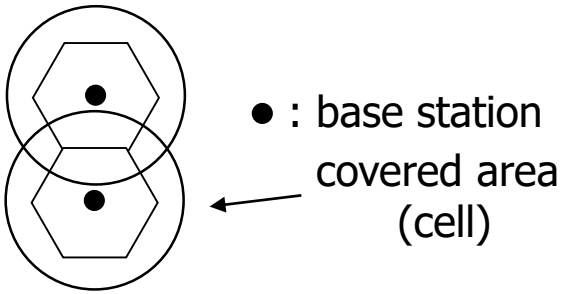
2020

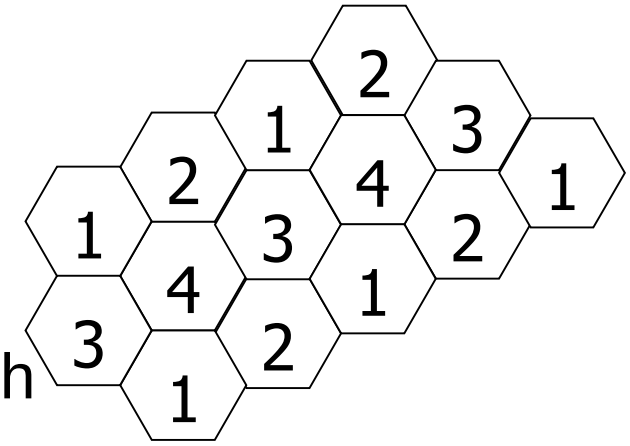
Earth surface mobile networks

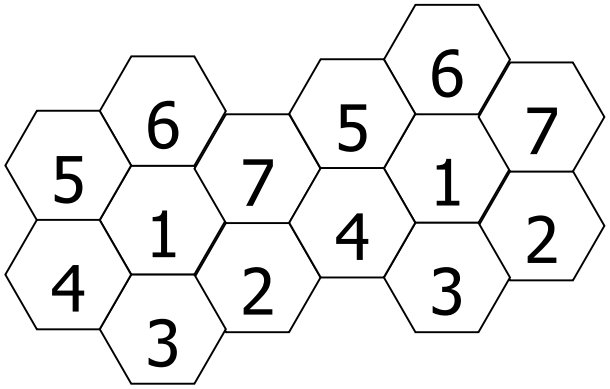
- Cellular concept
- Size of a cell?
  - Geography
  - Frequency
    - ~900 MHz – 30-35 km
      - Follow the surface of the Earth more or less
    - ~1800 MHz – 2-3 km
      - Straight propagation
  - Transmission power
  - Height of transmitter (tower)
  - Traffic (!!)
- Advantages of small cells:
  - small transmitter power enough
    - minimisation of physiological risk
    - smaller power consumption
      - longer battery life
  - higher traffic density
- Disadvantages of small cells :
  - lot of base stations needed
    - more expensive



Earth surface mobile networks

- Same frequency cannot be used in neighbouring cells – interference
  - 4 frequency set required as a minimum
  - Transmission power is large enough to cause interference in the second neighbouring cell
  - Frequency range is divided into 7 sets
  - This is only theoretical – in practice more complicated situations (base station in the „corner” of the cell, cell divided into several sectors, cells of different size, geographical circumstances, different traffic, etc.): ~10 sets required





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 (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)

GSM

GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

- World-wide spread, because:
  - research-development in proper time, quickly (4 years)
  - open, extendable standard (ETSI)
  - 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.

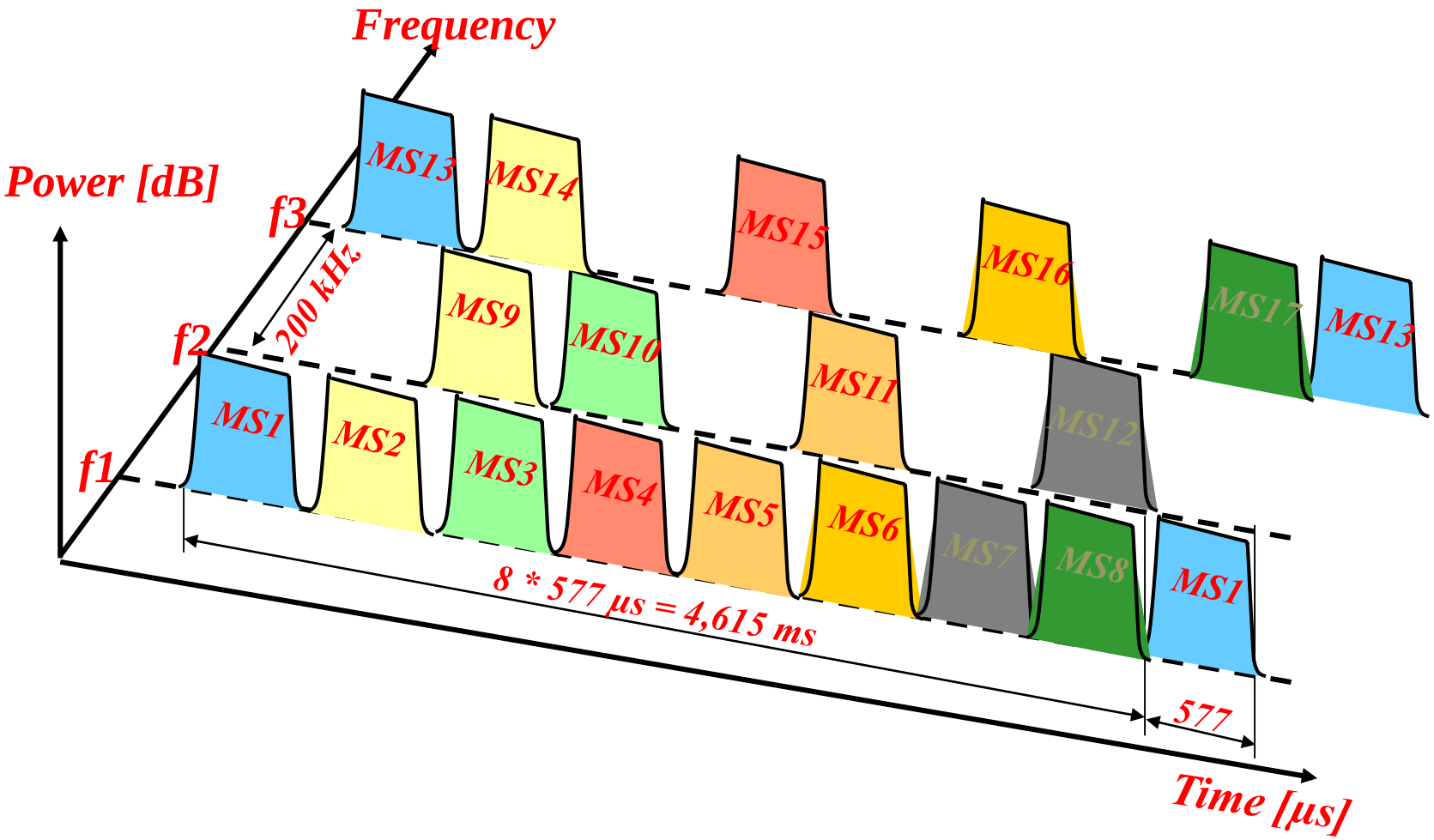
GSM

- Digital transmission:
  - voice codec in terminal
  - integrated services network: voice + data transmission
- Radiation output: max. 2W
  - Adaptive: the terminal transmits with the possibly minimal power
    - Longer battery life
    - Minimisation of physiological risk
    - Less influence on neighbouring cells
- Diameter of cells: 0,5 – 35 km

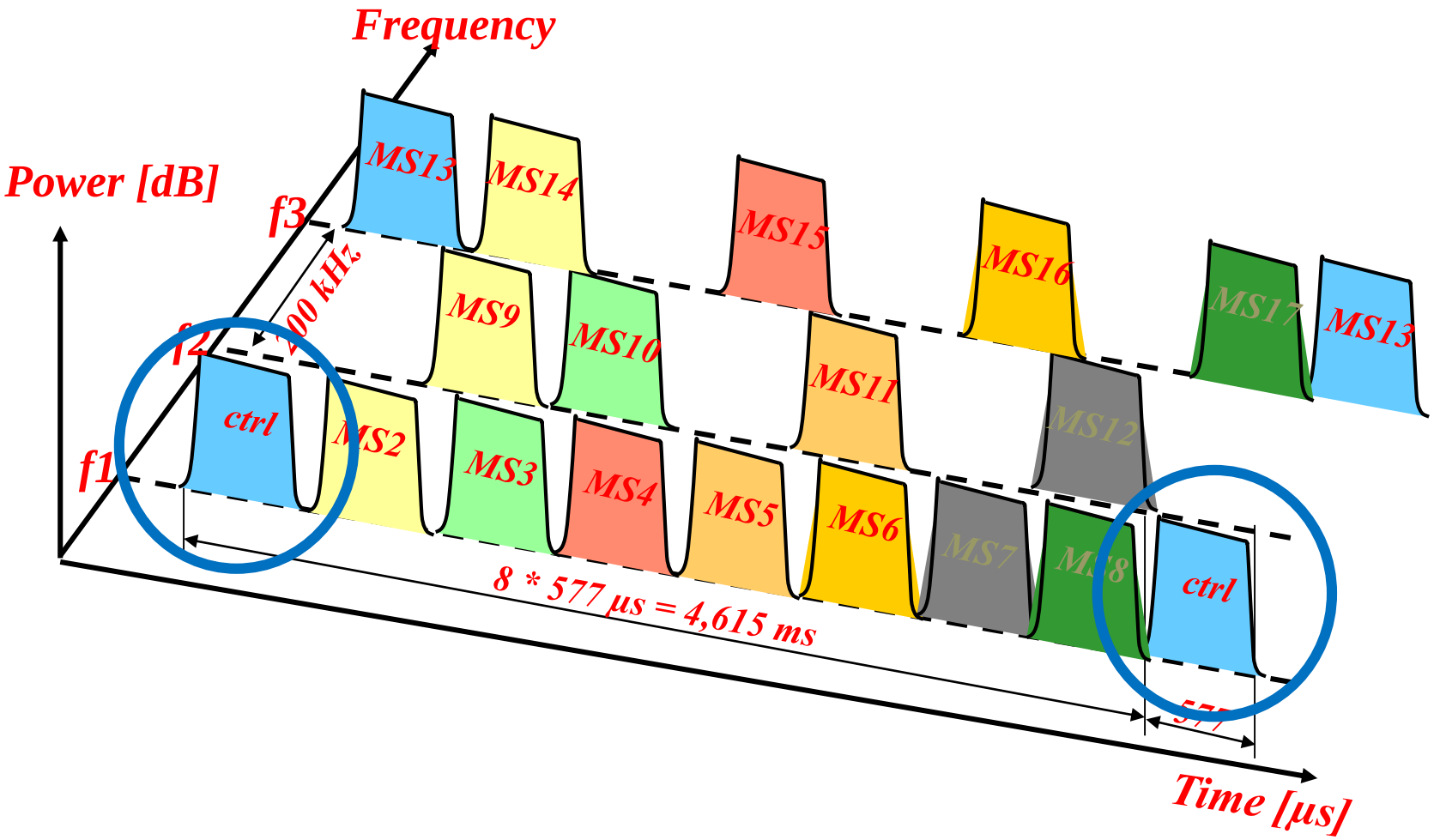
GSM

- 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
  - the smaller frequency suffers smaller attenuation, so it requires less power -> mobiles (uplink traffic) have the smaller frequency band
  - 1 band = 25 MHz, 1 carrier = 200 kHz: 124 carriers (FDMA)
    - shared among service providers
    - in a country with 4 providers: appr. 30 frequencies/service provider in this band
  - 8 time slots/carrier (TDMA)
  - (30/10)*8 ≈ 24 channels / cell
    - 10: typically ≈ 10 different frequencies used in cells (more realistic than 7 as we could see on slide 3)
    - with Half Rate encoding: twice as much

FDMA – TDMA access



FDMA – TDMA access



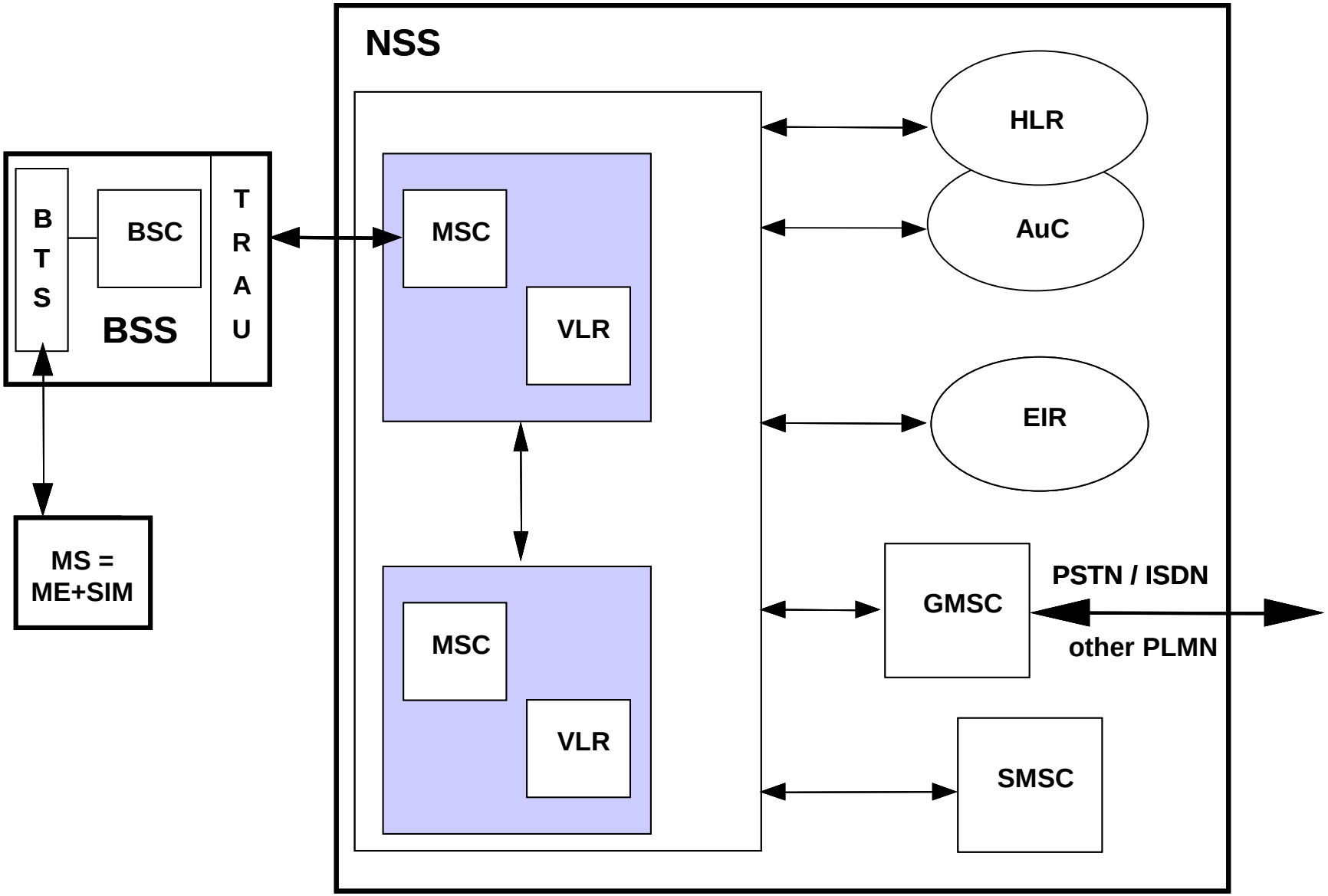
GSM

- 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 (where the traffic is high)
- Several other bands: (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 equipment: automatically select/change frequency range
  - three band (900/1800/1900) and four band equipment (850/900/1800/1900)

GSM handover/handoff

- GSM: circuit switching
- When the mobile station enters an other cell: handover (handoff)
  - Continuous connection
    - Mobile station: measures, when the signal of the neighbouring cell is stronger
    - Network controls
      - the network can postpone the cell change if the „new” cell is overloaded

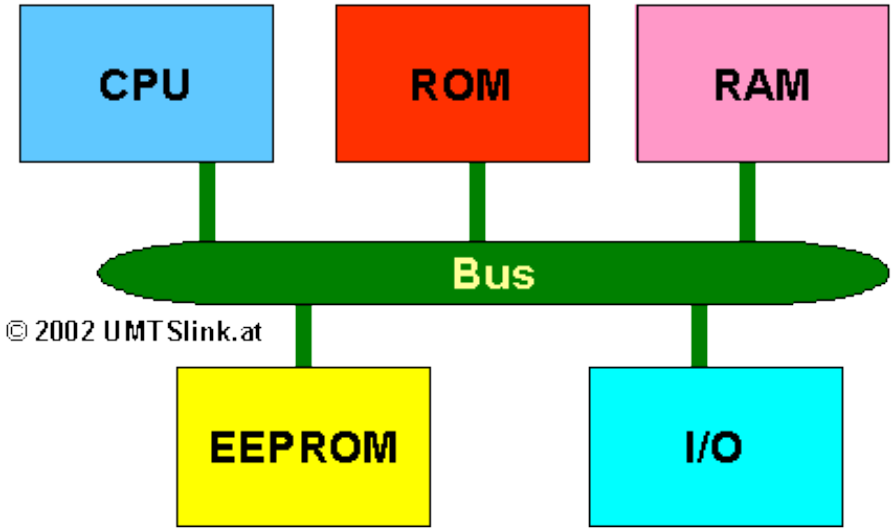
Architecture of GSM networks (PLMN)

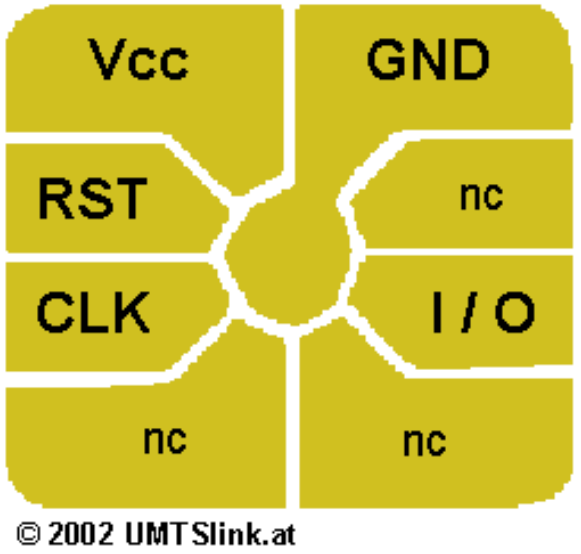


PLMN: Public Land Mobile Network

Mobile Station

- MS – Mobile Station
- ME – Mobile Equipment
- Subscriber Identity Module („SIM card”)
  - Identifiers
  - Authentication
  - Ciphering
  - User data (phone book)





Base Station Subsystem (BSS)

- Base Transciever Station (BTS)
  - One or more elementary transmitter/receiver
  - Transcoder/Transmission and 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)
  - Always integrated with 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
  - circuit switched (!!)
  - originally 9.6 kbps, later 14.4 kbps

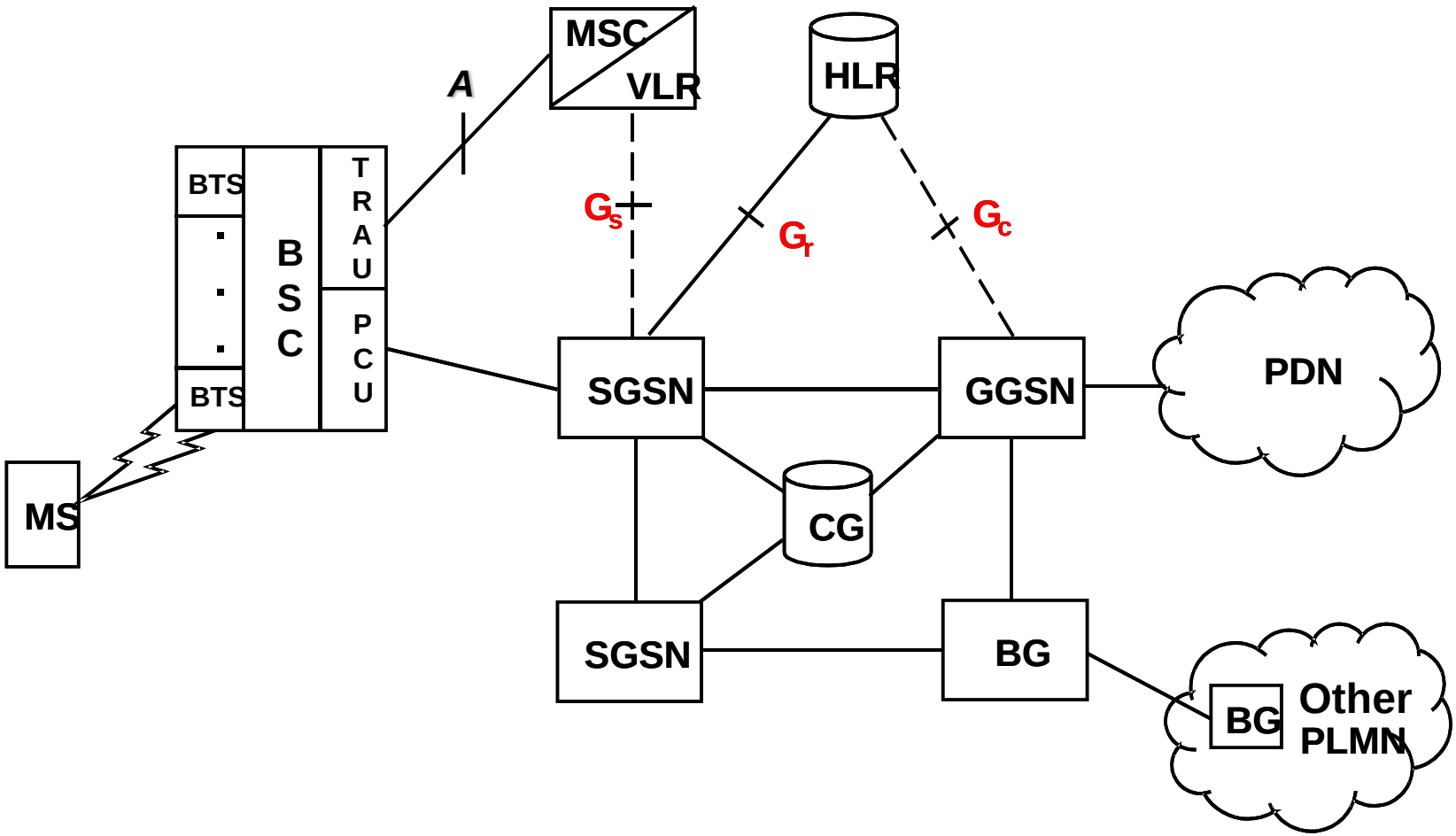
GSM services – 2

- 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 is enough e.g. to tell, where is a restaurant nearby

GSM/GPRS

- GPRS (General Packet Radio Service)
  - since 2001
  - packet switched data transmission, extension to GSM
  - advantage:
    - better utilisation of network, frequency
    - payment on basis of amount of transmitted data (kB), not on basis of duration of 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