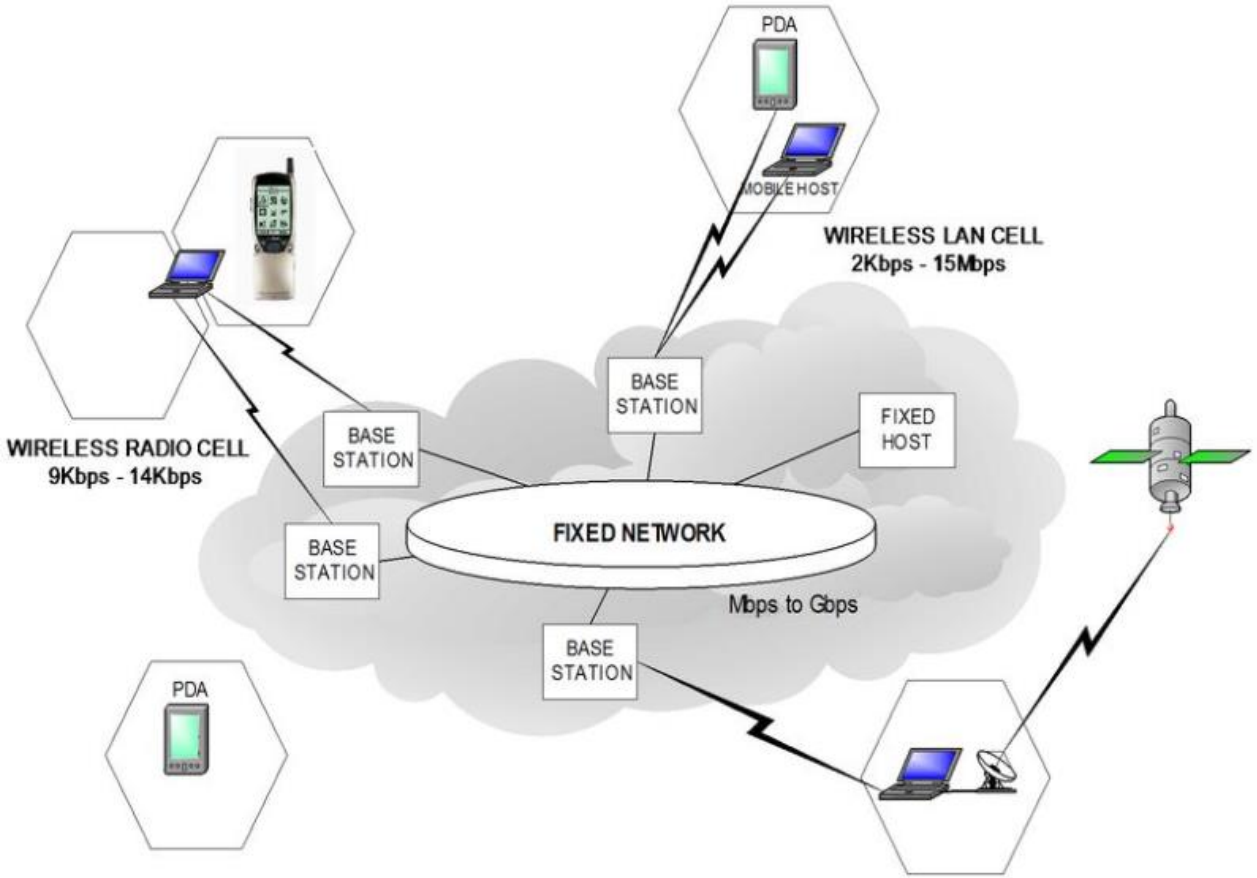
Module 2

Location and Handoff Management

Mobile Network Architecture



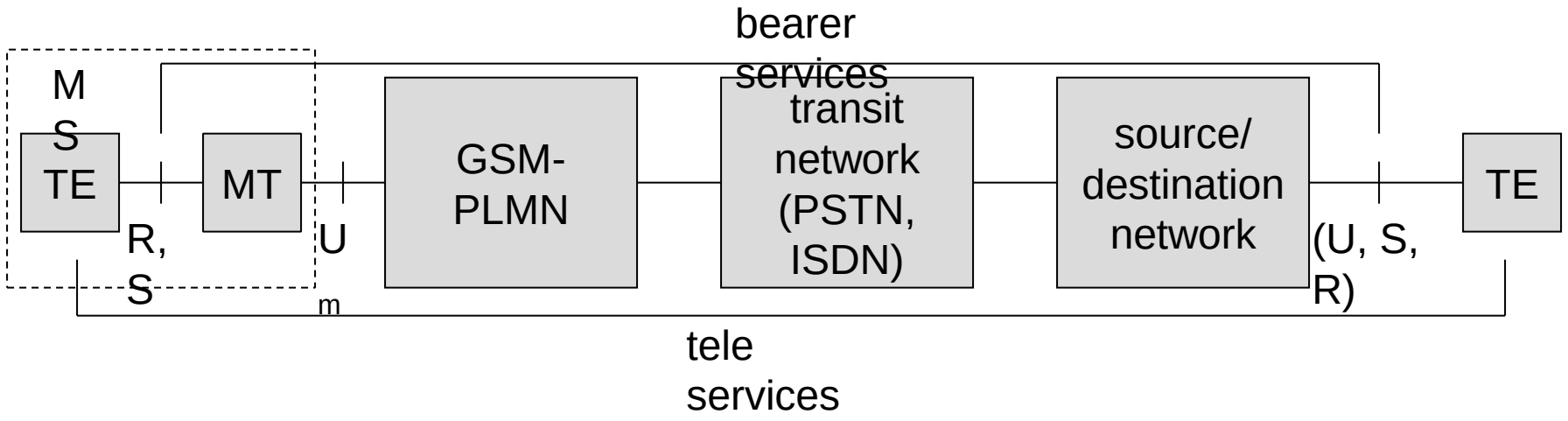
- GSM
  - formerly: Groupe Spéciale Mobile (founded 1982)
  - now: Global System for Mobile Communication
  - Pan-European standard (ETSI, European Telecommunications Standardisation Institute)
  - many providers all over the world use GSM (more than 130 countries in Asia, Africa, Europe, Australia, America)
  - more than 100 million subscribers

Performance characteristics of GSM

- Communication
  - mobile, wireless digital communication; support for voice and data services
- Total mobility
  - international access, chip-card enables use of access points of different providers
- Worldwide connectivity
  - one number, the network handles localization High capacity
  - better frequency efficiency, smaller cells, more customers per cell
- High transmission quality
  - high audio quality
  - uninterrupted phone calls at higher speeds (e.g., from cars, trains) – better handoffs and
- Security functions
  - access control, authentication via chip-card and PIN

GSM: Mobile Services

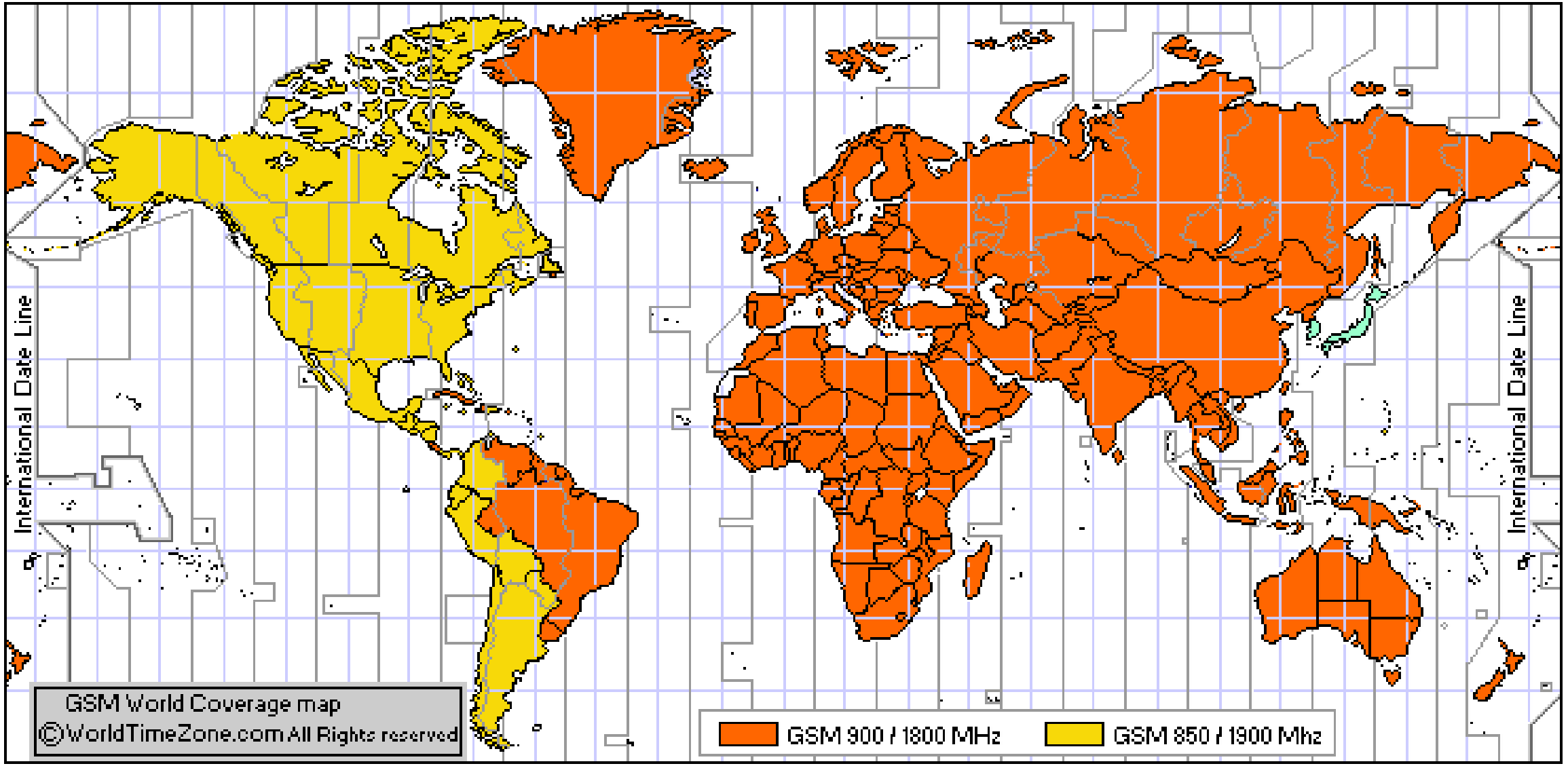
- GSM offers
- several types of connections
  voice connections, data connections, short message service
- Three service domains
- **Bearer Services** – interface to the physical medium (transparent for example in the case of voice or non transparent for data services)
- **Telematic Services** – services provided by the system to the end user (e.g., voice, SMS, fax, etc.)
- **Supplementary Services** – associated with the tele services: call forwarding, redirection, etc.



Architecture of the GSM system

- GSM is a PLMN (Public Land Mobile Network)
  - *several providers setup mobile networks following the GSM standard within each country*
  - components
    - MS (mobile station)
    - BS (base station)
    - MSC (mobile switching center)
    - LR (location register)
- subsystems
    - RSS (radio subsystem): covers all radio aspects
    - NSS (network and switching subsystem): call forwarding, handover, switching
    - OSS (operation subsystem): management of the network

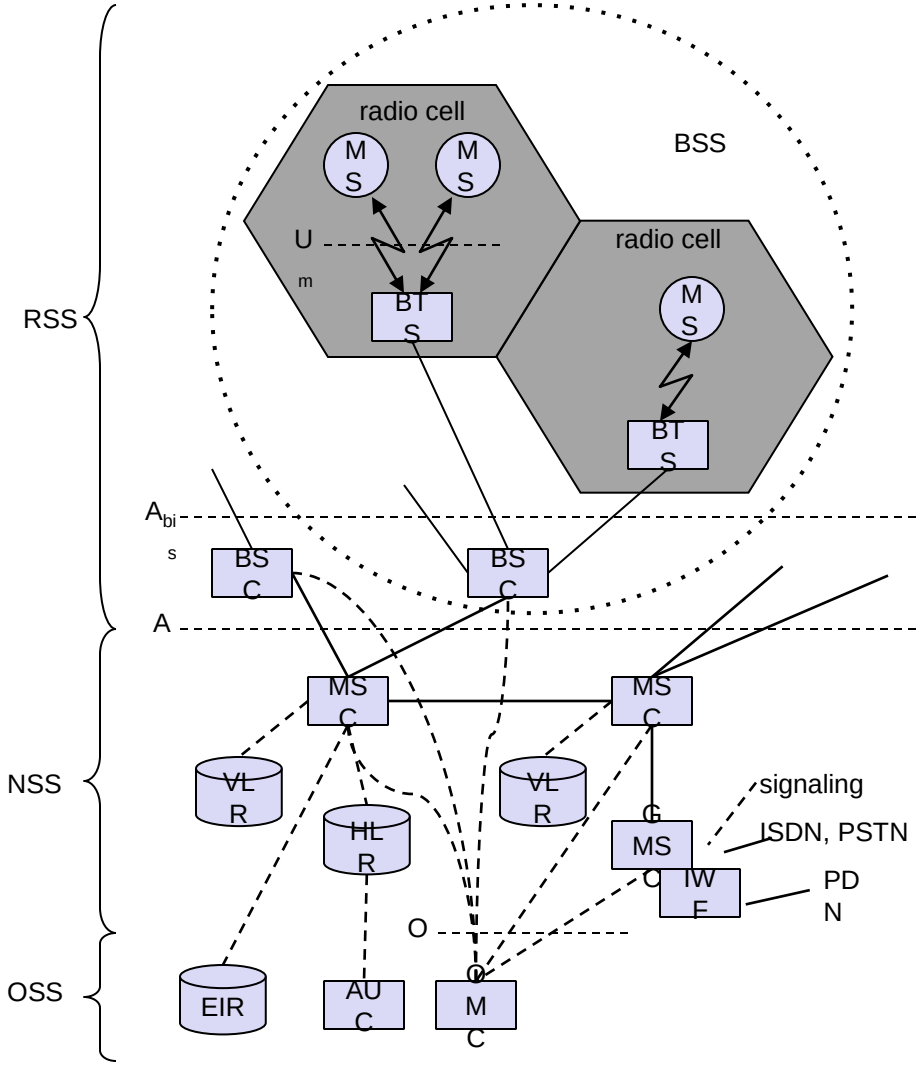
GSM World Coverage Map



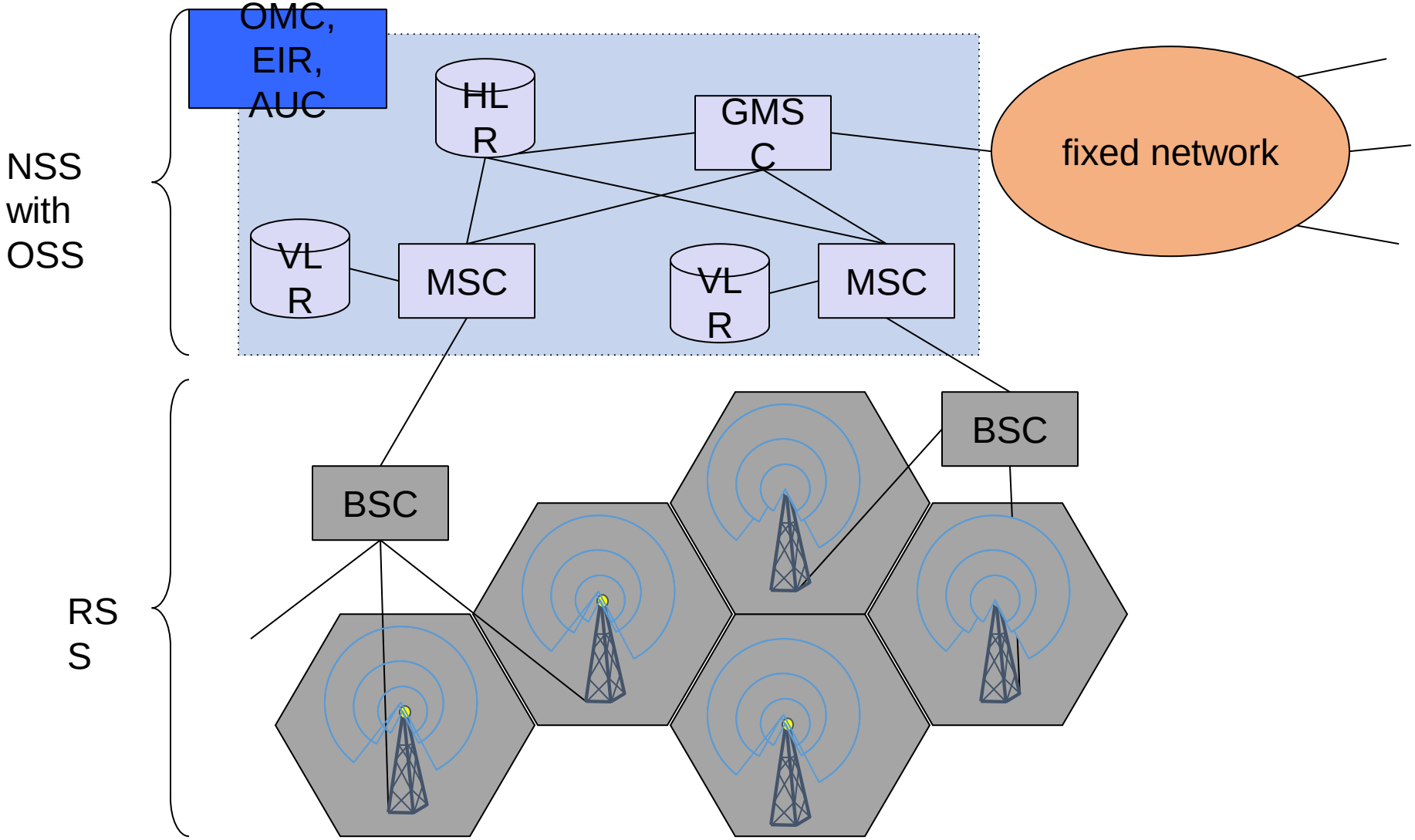
https://www.worldtimezone.com/gsm.html

India	900	1800	3G 900/2100 AirTel; 3G 2100 BSNL; 3G 2100 MTNL; 3G 2100 Tata Docomo; 3G 2100 Vodafone Idea LTD ;	4G LTE Vodafone Idea LTD 1800/2100/2500Mhz ; 4G LTE Bharti Airtel 1800/2100/2300Mhz; 4G LTE Jio 850/1800/2300mhz; 4G LTE BSNL 2500Mhz (trial); 4G LTE Tata DoCoMo Teleservices 900/1800/2100/2300Mhz ;

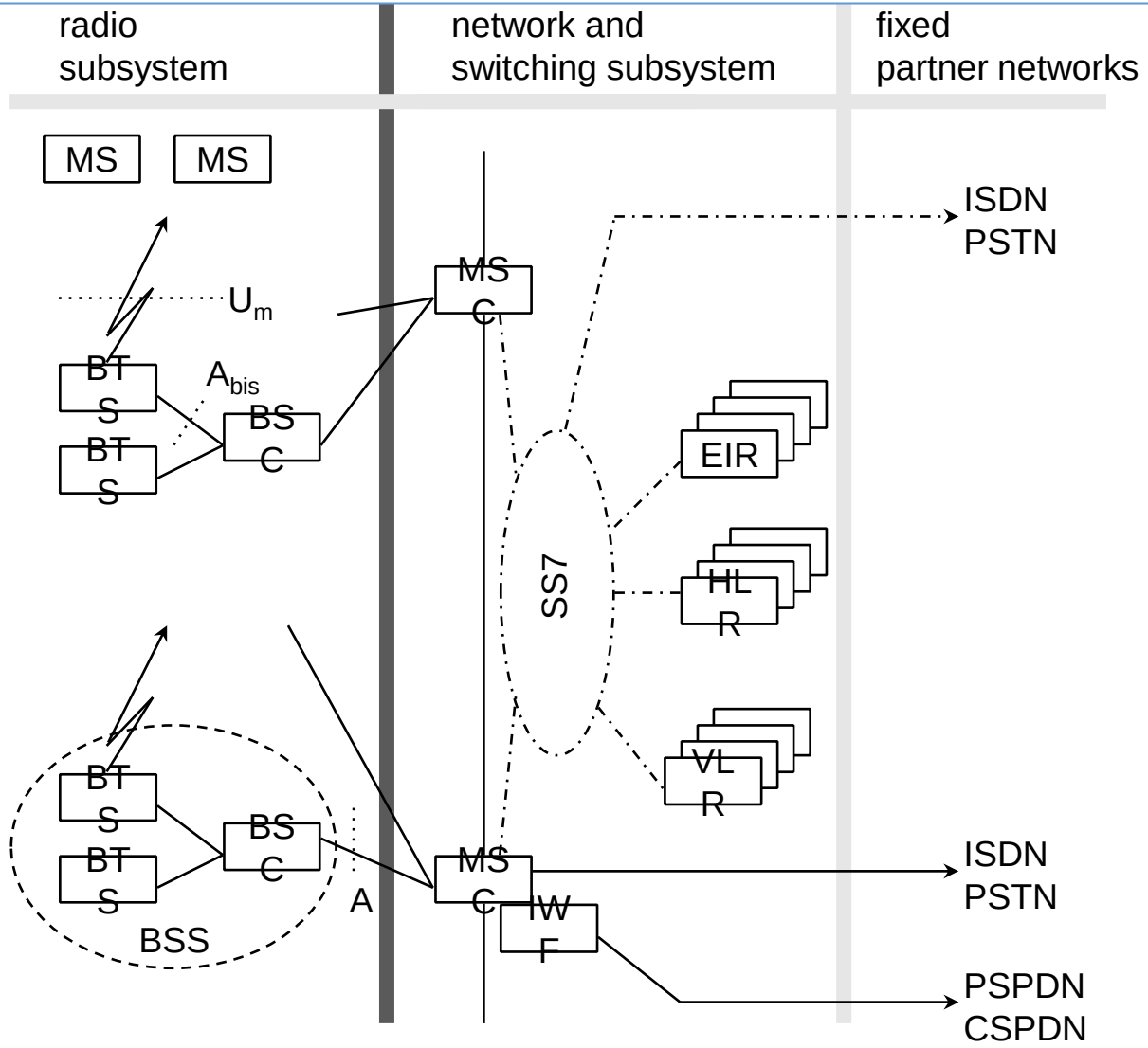
GSM: elements and interfaces



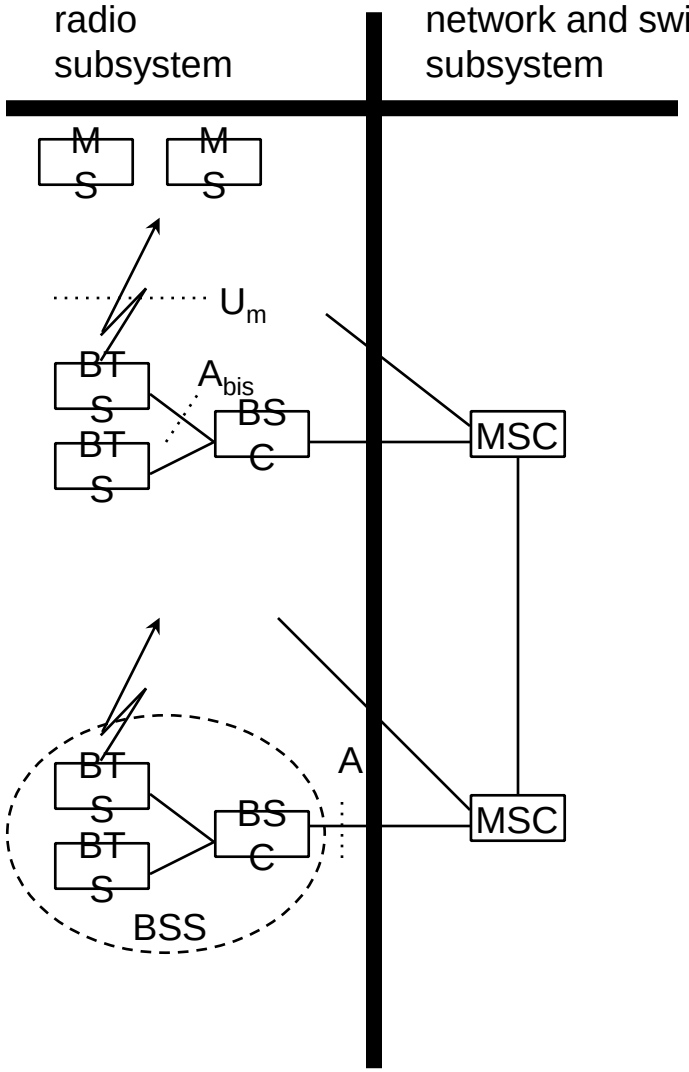
GSM: overview



GSM: System Architecture



System architecture: radio subsystem



- Components
  - *MS* (Mobile Station)
  - *BSS* (Base Station Subsystem): consisting of
    - *BTS* (Base Transceiver Station): sender and receiver
    - *BSC* (Base Station Controller): controlling several transceivers

- Interfaces
  - U_m : radio interface
  - A_{bis} : standardized, open interface with 16 kbit/s user channels
  - *A*: standardized, open interface with 64 kbit/s user channels

Radio subsystem

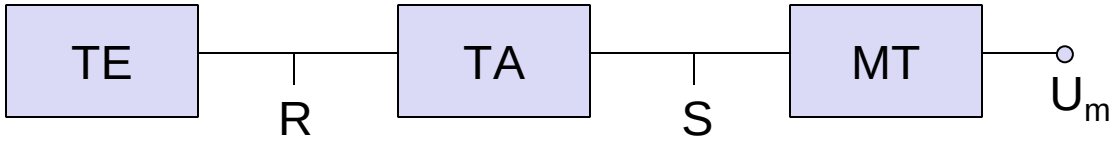
- *The Radio Subsystem (RSS) comprises the cellular mobile network up to the switching centers*
- **Components**
  - **Base Station Subsystem (BSS):**
    - Base Transceiver Station (BTS): radio components including sender, receiver, antenna - if directed antennas are used one BTS can cover several cells
    - Base Station Controller (BSC): switching between BTSs, controlling BTSs, managing of network resources, mapping of radio channels (U_m) onto terrestrial channels (A interface)
    - BSS = BSC + sum(BTS) + interconnection
  - **Mobile Stations (MS)**

Mobile station

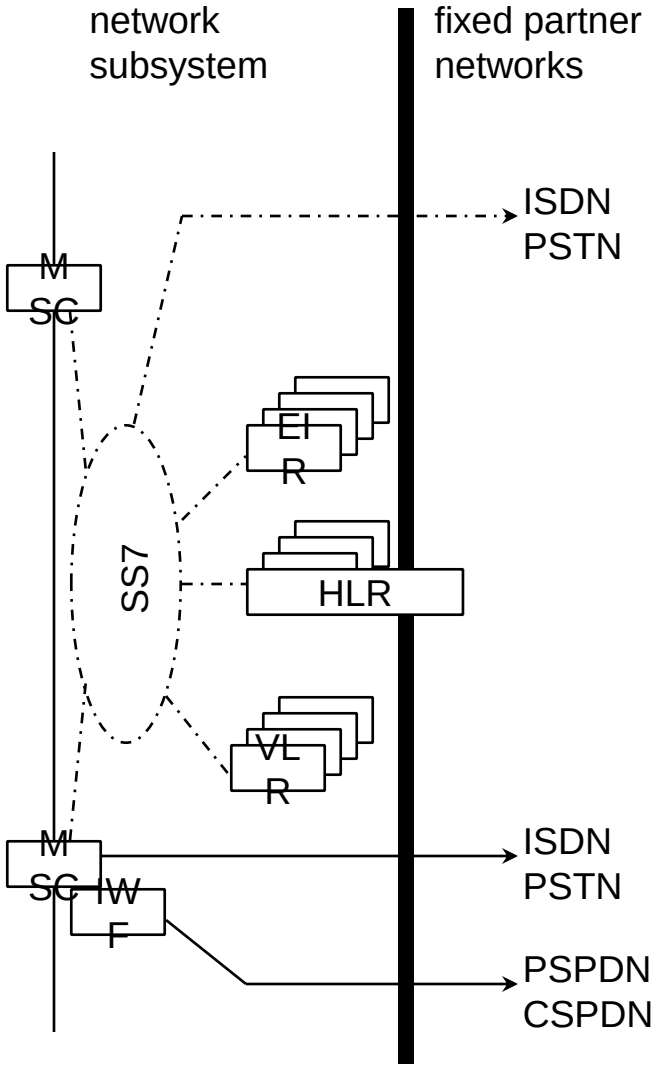
Terminal for the use of GSM services

A mobile station (MS) comprises several functional groups

- MT (Mobile Terminal):
    - offers common functions used by all services the MS offers
    - corresponds to the network termination (NT) of an ISDN access
    - end-point of the radio interface (U_m)
- TA (Terminal Adapter):
    - terminal adaptation, hides radio specific characteristics (TE connects via modem, Bluetooth, IrDA etc. to MT)
- TE (Terminal Equipment):
    - peripheral device of the MS, offers services to a user
    - Can be a headset, microphone, etc.
    - does not contain GSM specific functions
- SIM (Subscriber Identity Module):
    - personalization of the mobile terminal, stores user parameters



System architecture: network and switching subsystem



- Components
  - *MSC* (Mobile Services Switching Center):
  - *IWF* (Interworking Functions)
  - *ISDN* (Integrated Services Digital Network)
  - *PSTN* (Public Switched Telephone Network)
  - *PSPDN* (Packet Switched Public Data Net.)
  - *CSPDN* (Circuit Switched Public Data Net.)
- Databases
  - *HLR* (Home Location *R*egister)
  - *VLR* (Visitor Location *R*egister)
  - *EIR* (Equipment Identity Register)

Network and switching subsystem

- NSS is the main component of the public mobile network GSM
- switching, mobility management, interconnection to other networks, system control

Components

- **Mobile Services Switching Center (MSC)**
  controls all connections via a separated network to/from a mobile terminal within the domain of the MSC - several BSC can belong to a MSC
- **Databases** (important: scalability, high capacity, low delay)
  - **Home Location Register (HLR)**
    central master database containing user data, permanent and semi-permanent data of all subscribers assigned to the HLR (one provider can have several HLRs)
  - **Visitor Location Register (VLR)**
    local database for a subset of user data - data about all users currently visiting in the domain of the VLR

Mobile Services Switching Center

- **The MSC (mobile switching center) plays a central role in GSM**
    - switching functions
    - additional functions for mobility support
    - management of network resources
    - interworking functions via Gateway MSC (GMSC)
    - integration of several databases

- **Functions of a MSC**
    - specific functions for paging and call forwarding
    - termination of SS7 (signaling system no. 7)
    - mobility specific signaling
    - location registration and forwarding of location information
    - provision of new services (fax, data calls)
    - support of short message service (SMS)
    - generation and forwarding of accounting and billing information

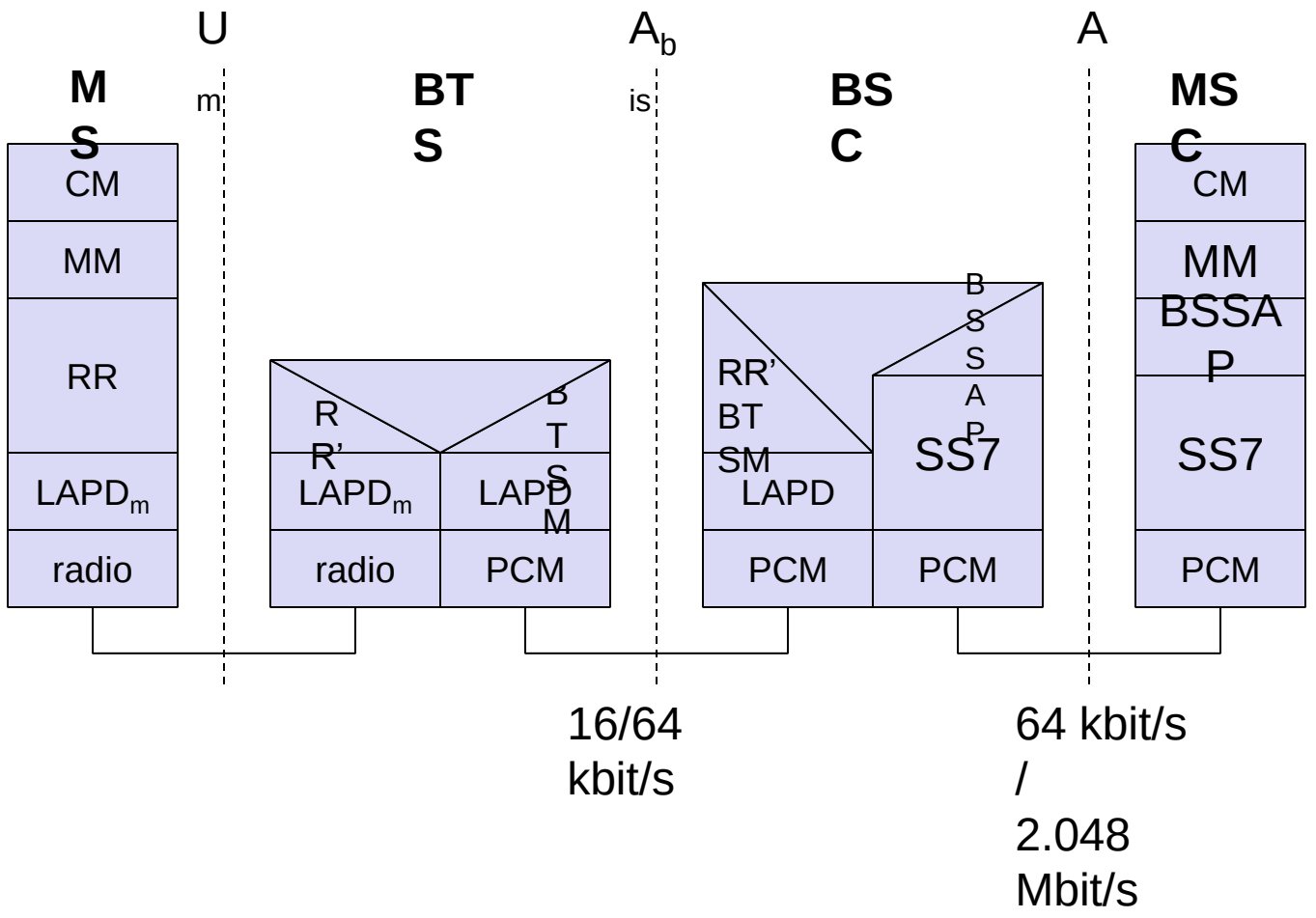
Operation subsystem

- The OSS (Operation Subsystem) enables centralized operation, management, and maintenance of all GSM subsystems

- Components

- **Authentication Center (AUC)**
  generates user specific authentication parameters on request of a VLR
- authentication parameters used for authentication of mobile terminals and encryption of user data on the air interface within the GSM system
- **Equipment Identity Register (EIR)**
  registers GSM mobile stations and user rights
  stolen or malfunctioning mobile stations can be locked and sometimes even localized
- **Operation and Maintenance Center (OMC)**
  different control capabilities for the radio subsystem and the network subsystem

GSM protocol layers for signaling



Layer 1, the physical layer

- handles all radio-specific functions
  -includes the creation of bursts according to the five different formats,
  multiplexing of bursts into a TDMA frame, synchronization with the BTS,
  detection of idle channels, and measurement of the channel quality on the downlink.

- The physical layer at Um uses GMSK for digital modulation and performs encryption/decryption of data, encryption is between MS and BSS over the air interface.

- The main tasks of the physical layer comprise
  channel coding and error detection/correction, which is directly combined with the coding mechanisms.
  Channel coding uses forward error correction (FEC) schemes.
- The physical layer also contains special functions, such as voice activity detection (VAD), which transmits voice data only when there is a voice signal
- During periods of silence the physical layer generates a comfort noise to fake a connection but no actual transmission takes place.

Layer 2, LAPDm

- The LAPDm protocol has been defined at the Um interface .
- LAPDm, link access procedure for the D-channel (LAPD) in ISDN systems, . LAPDm is a lightweight LAPD
- LAPDm offers reliable data transfer over connections, re-sequencing of data frames, and flow control
- LAPDm has to obey the frame structures recurrence patterns etc. defined for the Um interface as there is no buffering between layer one and two,
- LAPDm provides segmentation and reassembly of data and acknowledged/unacknowledged data transfer.

layer 3,network layer

Comprises several sublayers as

- Radio resource management (RR).

  Only a part of this layer, RR', is implemented in the BTS, the remainder is situated in the BSC.

  The functions of RR' are supported by the BSC via the BTS management (BTSM).

  The main tasks of RR are setup, maintenance, and release of radio channels.RR also directly accesses the physical layer for radio information and offers a reliable connection to the next higher layer.

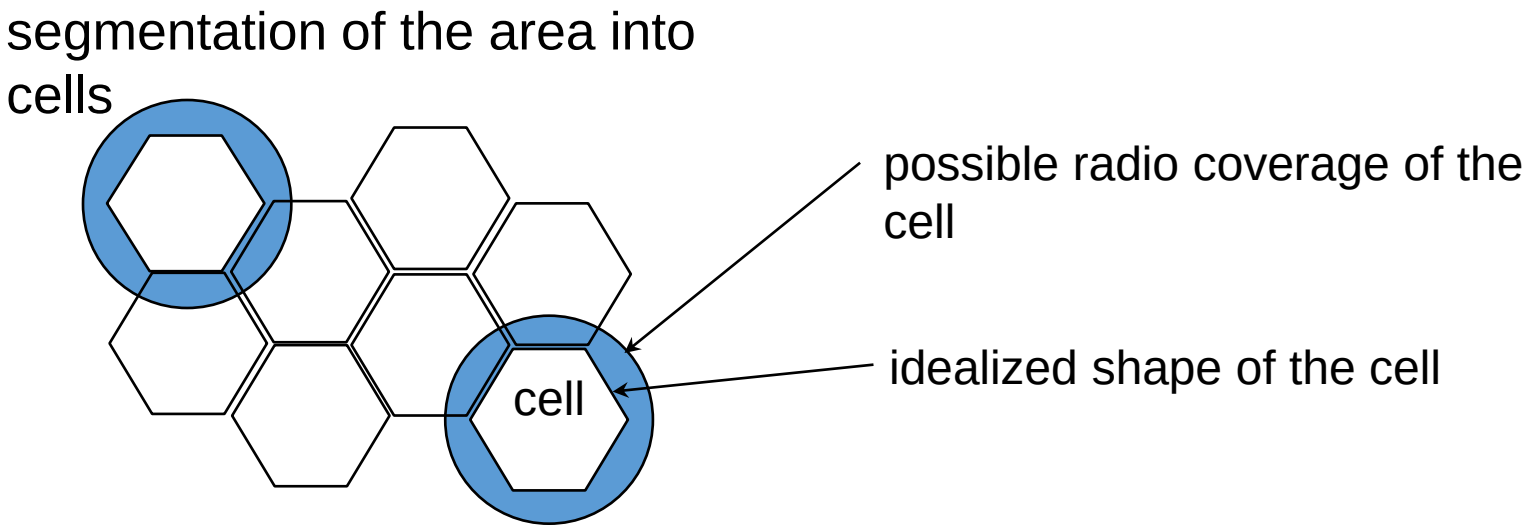
- Mobility management (MM)

  registration, authentication, identification, location updating, and the provision of a temporary mobile subscriber identity (TMSI) that replaces the international mobile subscriber identity (IMSI) and which hides the real identity of an MS user over the air interface. MM offers a reliable connection to the next higher layer.

Call management (CM) layer contains three entities:

- call control (CC), short message service (SMS), and supplementary service (SS).
- SMS allows for message transfer using the control channels SDCCH and SACCH .
- CC provides a point-to-point connection between two terminals and is used by higher layers for call establishment, call clearing and change of call parameters.
- This layer provides functions to send in-band tones, called dual tone multiple frequency (DTMF), over the GSM network.
- These tones are used,e.g., for the remote control of answering machines or the entry of PINs in electronic banking and are, also used for dialing in traditional analog telephone systems. These are transferred as signals and then converted into tones in the fixed network part of the GSM system.

GSM: cellular network



- use of several carrier frequencies
- not the same frequency in adjoining cells
- cell sizes vary from some 100 m up to 35 km depending on user density, geography, transceiver power etc.
- hexagonal shape of cells is idealized (cells overlap, shapes depend on geography)
- if a mobile user changes cells
  handover of the connection to the neighbor cell

GSM: Identification

- Identification of Mobile Subscriber
  - International Mobile Subscriber Identity (IMSI)
  - Temporary IMSI (TMSI)
  - Mobile Subscriber ISDN number (MSISDN)
- Identification of Mobile Equipment
  - International Mobile Station Equipment Identification (IMEI)
  - Mobile Station Roaming Number (MSRN)

MSISDN

- “real telephone number” of a MS
- It is stored centrally in the HLR
- MS can have several MSISDNs depending on SIM
- It follows international ISDN numbering plan
  - Country Code (CC): upto 3 decimal places
  - National Destination Code (NDC): 2-3 decimal places
  - Subscriber Number (SN) : maximal 10 decimal places
    - MSISDN = CC + NDC + SN

IMSI

- International Mobile Subscriber Identity
- Stored in SIM, not more than 15 digits
    - 3 digits for Mobile Country Code (MCC)
    - 3 digits for Mobile Network Code (MNC)
        - It uniquely identifies the home GSM PLMN of the mobile subscriber.
    - Not more than 10 digits for National Mobile Station Identity (MSIN)
        - The first 3 digits identify the logical HLR-ID of the mobile subscriber
- MNC+MSIN makes National Mobile Station Identity (NMSI)

TMSI and LMSI

- Temporary Mobile Subscriber Identity
  - Has only local and temporal significance
  - Is assigned by VLR and stored there only
  - Is used in place of IMSI for security reasons
- Local Mobile Subscriber Identity
  - Is an additional searching key given by VLR
  - It is also sent to HLR
- Both are assigned in an operator specific way

Mobility Models

- Mobility models **characterize the movements of mobile users with respect to their location, velocity and direction over a period of time**.
- These models play an vital role in the design of Mobile Ad Hoc Networks(MANET)