CS 480: MOBILE NETWORKS

Telecommunication Systems

Topics Covered

- GSM
  - Introduction
  - Performance characteristics
  - Mobile services
  - System architecture
  - Radio Interface
  - Protocols
  - Localization and calling
  - Handover
  - Security
  - New Data Services
- DECT
  - System Architecture
  - Protocol Architecture
- TETRA
- UMTS and IMT-2000

Introduction (1)

- The most successful digital mobile telecommunication system in the world today.
- Used by over 800 million people in more than 190 countries.
- In the early 1980s, Europe had numerous coexisting analog mobile phone systems,
  - often based on similar standards, but ran on slightly different carrier frequencies.
- To avoid this situation for a second generation fully digital system, the Groupe Spéciale Mobile(GSM) was founded in 1982.
- This system was soon named the Global System for Mobile Communication (GSM).

Introduction (2)

- The specification process lies in the hands of European Telecommunications Standards Institute (ETSI).
- The primary goal of GSM was to
  - provide a mobile phone system that allows users to roam throughout Europe and provides voice services compatible to ISDN and other PSTN systems.
- GSM is a typical second generation system,
  - replacing the first generation analog systems
  - but offering the high worldwide data rates that the third generation systems, such as Universal Mobile Telecommunications System (UMTS) are promising.

Performance characteristics of GSM (with respect to analog systems)

- Communication
  - mobile, wireless communication; support for voice & 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 and reliability for wireless, uninterrupted phone calls at higher speeds (e.g., from cars, trains)
- Security functions
  - access control, authentication via chip-card and PIN

Disadvantages of GSM

- There is no perfect system!!
  - no end-to-end encryption of user data
  - no full ISDN bandwidth of 64 kbit/s to the user
- Reduced concentration while driving
- Electromagnetic radiation
- Abuse of private data possible
- Roaming profiles accessible
- High complexity of the system
- Several incompatibilities within the GSM standards

Mobile services

- GSM permits the integration of different voice and data services and the interworking with existing services.
- GSM has defined three categories of services:
  - bearer, tele and supplementary services.
- Figure 1 shows a reference model for GSM services.
- A mobile station **MS** is connected to the **GSM public land mobile network** (PLMN) via the U_m interface.
  - GSM-PLMN is the infrastructure needed for the GSM network.
- The GSM-PLMN is connected to transit networks,
  - e.g., ISDN or PSTN.
- There might be another network, the source/destination network, before another **terminal TE** is connected.
- Within the mobile station MS, **the mobile termination (MT)** performs all network specific tasks such as TDMA
  - and offers an interface for data transmission (S) to terminal TE

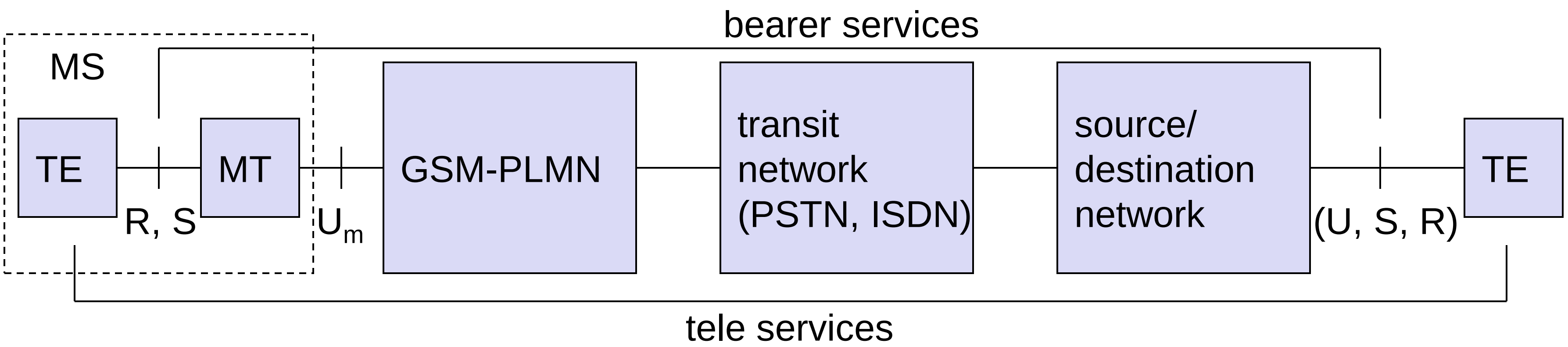


Figure 1: Bearer and tele services reference model

Bearer services

- Telecommunication services to transfer data between access points
- Specification of services up to the terminal interface (OSI layers 1-3)
- Different data rates for voice and data (original standard)
  - data service (circuit switched) :
    - synchronous: 2.4, 4.8 or 9.6 kbit/s
    - asynchronous: 300 - 1200 bit/s
  - data service (packet switched):
    - synchronous: 2.4, 4.8 or 9.6 kbit/s
    - asynchronous: 300 - 9600 bit/s

Tele services (1)

- Telecommunication services that enable voice communication via mobile phones
- All these basic services have to obey cellular functions, security measurements etc.
- Offered services
  - mobile telephony: primary goal of GSM was to enable mobile telephony offering the traditional bandwidth of 3.1 kHz
  - Emergency number: common number throughout Europe (112); mandatory for all service providers; free of charge; connection with the highest priority (preemption of other connections possible)
  - Multinumbering: several ISDN phone numbers per user possible

Tele services (2)

- Additional services (non-Voice-Teleservices)
  - group 3 fax: fax data transmitted as digital data over the analog telephone network
  - voice mailbox (implemented in the fixed network supporting the mobile terminals)
  - electronic mail (MHS, Message Handling System, implemented in the fixed network)
- Short Message Service (SMS): alphanumeric data transmission to/from the mobile terminal (160 characters) using the signaling channel,
  - thus allowing simultaneous use of basic services and SMS
  - SMS was almost ignored in the beginning now the most successful add-on!

Supplementary services

- Services in addition to the basic services, cannot be offered stand-alone
- Similar to ISDN services besides lower bandwidth due to the radio link
- May differ between different service providers, countries and protocol versions
- Important services
  - identification: forwarding of caller number
  - suppression of number forwarding
  - automatic call-back
  - conferencing with up to 7 participants
  - locking of the mobile terminal (incoming or outgoing calls)

System architecture (1)

- GSM comes with a hierarchical, complex system architecture comprising many entities, interfaces, and acronyms.
- Figure 2a shows a simplified overview of the GSM system
- Figure 2b shows a functional architecture of the GSM system

A GSM system consists of three subsystems:

  - *Radio subsystem* (RSS)
  - *Network and switching subsystem (NSS)*
  - *Operation subsystem (OSS)*

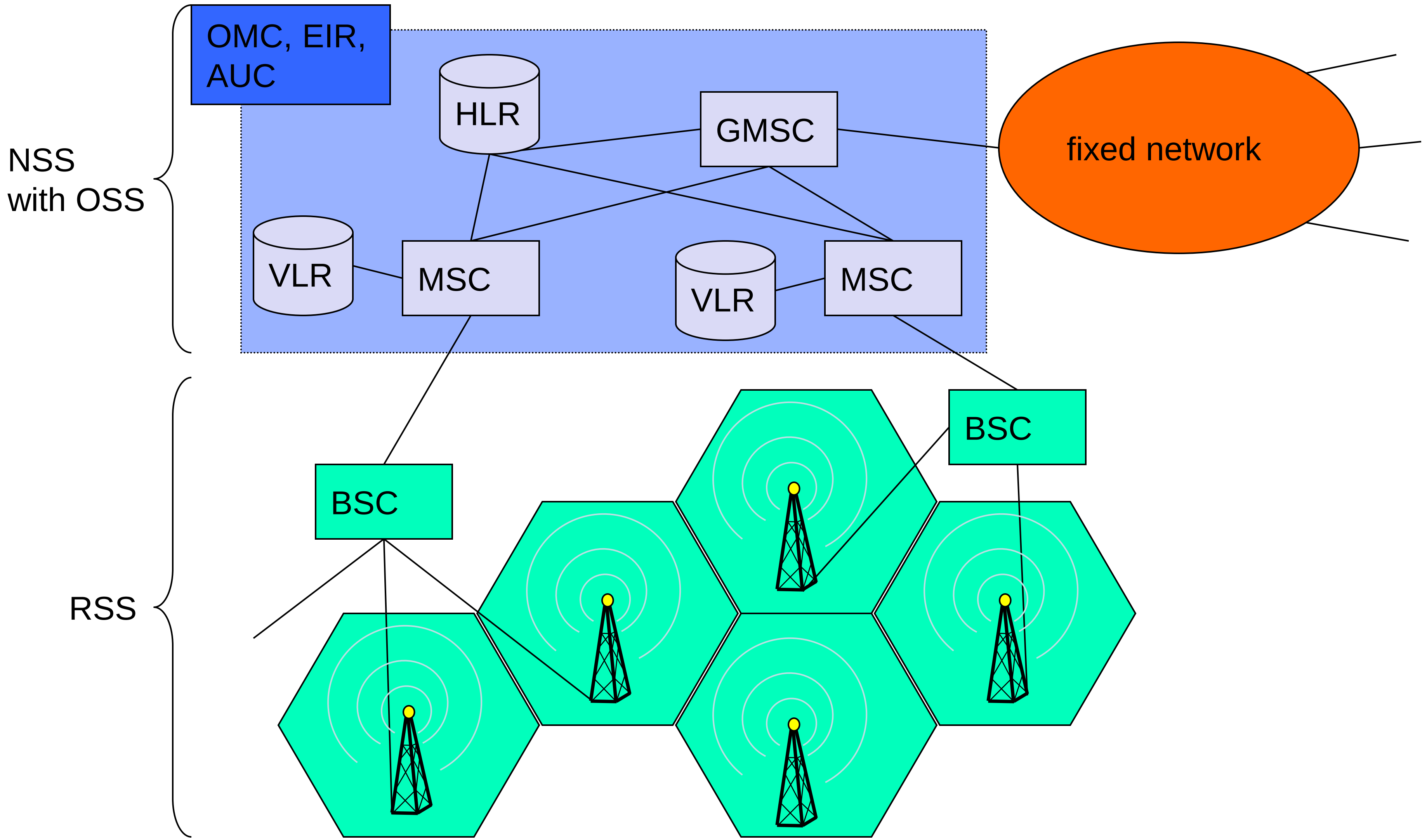


Figure 2 (a): GSM: overview

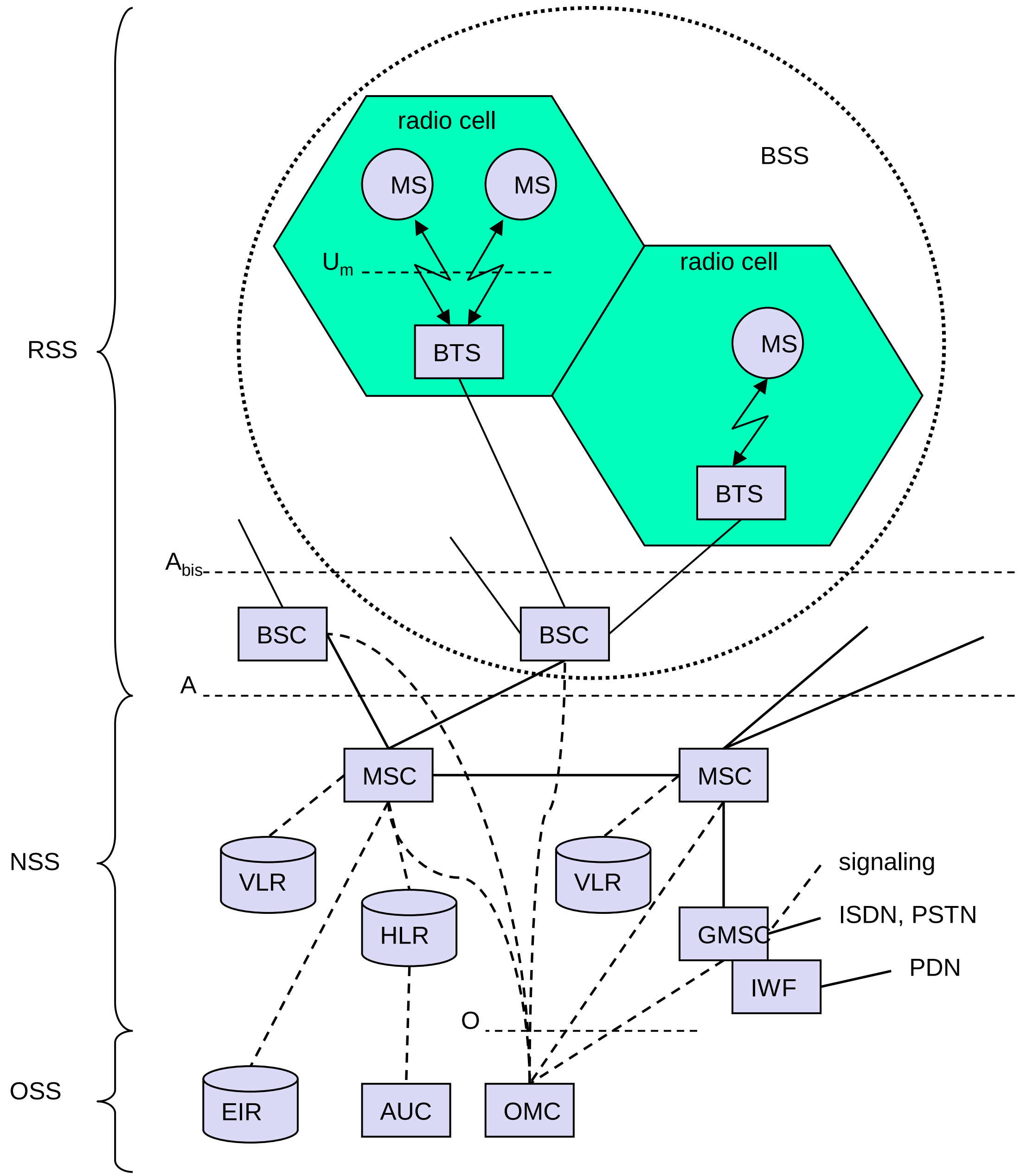


Figure 2 (b): Functional architecture of a GSM system.

Radio subsystem (RSS) (1)

- Comprises all radio specific entities, i.e., the mobile stations (MS) and the base station subsystem (BSS)
- Figure 2 (b) shows the connection between the RSS and NSS via the *A interface* (solid lines) and the connection to the OSS via the *O interface* (dashed lines).
- The *A* interface is typically based on circuit-switched PCM-30 (Pulse Code Modulation) systems.
- The *O interface* uses the Signaling System No 7 based on X.25 carrying management data to/from the RSS.
- Base station subsystem (BSS): A GSM network comprises many BSSs, each controlled by a base station controller (BSC).

Radio subsystem (RSS) (2)

- The BSS performs all functions necessary to maintain radio connections to an MS, coding/decoding of voice, and rate adaptation to/from the wireless network part.
- The BSS also contains several BTSs.
- Base transceiver station (BTS): A BTS comprises all radio equipment, i.e., antennas, signal processing, amplifiers necessary for radio transmission.
  - A BTS can form a radio cell or, using sectorized antennas, several cells and is connected to MS via the U_m interface and to the BSC via the A_{bis} interface (16 or 64k bit/s connections).
- U_m interface
  - ISDN U interface for mobile use which contains wireless transmission mechanisms such as TDMA, FDMA

Radio subsystem (RSS) (3)

- Base station controller (BSC): The BSC manages BTSs.
  - It receives radio frequencies, handles handover from one BTS to another within BSS.
  - The BSC also multiplexes radio channels onto fixed network connections at the A interface
- Mobile station (MS): The MS comprises all user equipment and software needed for communication with a GSM network.
  - It consists of user independent hardware and software of the subscriber identity module (SIM).
  - MS can be identified via the international mobile equipment identity (IMEI).

Network and switching subsystem (NSS) (1)

- The “heart” of the GSM
- The NSS
  - connects the wireless network with standard public networks,
  - performs handovers between different BSSs,
  - comprises functions for worldwide localization of users
  - and supports charging, accounting, and roaming between different providers in different countries.
- The NSS consists of the following switches and databases:
  - Mobile services switching center (MSC):
    - MSCs are high-performance digital ISDN switches.
    - They set up switches to other MSCs and to the BSCs via the A interface and form a fixed backbone network of a GSM system.
    - A gateway MSC (GMSC) has additional connections to other fixed networks, such as PSTN and ISDN.
    - Using additional interworking functions (IWF), an MSC can also connect to public data networks (PDN) such as X.25.

Network and switching subsystem (NSS) (2)

- Home location register (HLR):
  - The most important database in a GSM system as it stores all user-relevant information.
  - This comprises static information, such as the mobile subscriber ISDN number (MSISDN), subscribed services (e.g., call forwarding, roaming restrictions, GPRS), and the international mobile subscriber identity (IMSI).
  - Dynamic information is also needed, e.g., the current location area (LA) of the MS, the mobile subscriber roaming number (MSRN), the current VLR and MSC.
  - As soon as an MS leaves is current LA, the information in the HLR is updated (to localize the use in the worldwide GSM network).

Network and switching subsystem (NSS) (3)

- Visitor location register (VLR):
  - The VLR associated to each MSC is a dynamic database which stores all important information needed for the MS users currently in the LA associated to the MSC.
  - If a new MS comes into an LA the VLR responsible copies all relevant information for this user from the HLR.

Operation subsystem (OSS) (1)

This contains the necessary functions for network operation and maintenance.

- Operation and maintenance center (OMC):
  - This monitors and controls all other network entities via the O interface.
  - Typical OMC management functions are traffic monitoring, status reports of network entities, subscriber and security management, or accounting and billing.
- Authentication centre (AUC):
  - as the radio interface and mobile stations are particularly vulnerable, a separate AUC has been defined to protect user identity and data transmission.
  - The AUC contains algorithms for authentication as well as keys for encryption and generates the values needed for user authentication in the HLR.

Operation subsystem (OSS) (2)

- Equipment identity register (EIR):
  - Is a database for all IMEIs, i.e., it stores all device identifications registered for this network.
  - MSs are mobile and can be easily stolen. With a valid SIM, anyone could use the stolen MS.
  - The EIR has a blacklist of stolen (or locked) devices.
  - In theory an MS is useless as soon as the owner has reported a theft.
  - The EIR also contains a list of valid IMEIs (whitelist), and a list of malfunctioning devices (gray list).

Radio interface (U_m)

- The most interesting interface in a GSM system
- Comprises mechanisms for multiplexing and media access
- GSM implements SDMA using cells with BTS and assigns an MS to a BTS
- FDM is used to separate downlink an uplink
- Media access combines TDMA and FDMA

GSM protocol architecture (1)

- Figure 3 shows the protocol architecture of GSM
- Layer 1, the physical layer, handles all radio-specific functions.
  - Creation of bursts (small portions of data to be transmitted), multiplexing of bursts into a TDMA frame, synchronization with the BTS, detection of idle channels
  - Main tasks of physical layer comprise channel coding and error detection/correction
- The $LAPD_m$ protocol has been defined at the U_m interface for layer 2.
  - $LAPD_m$ (derived from link access procedure for the D-channel (LAPD) in ISDN systems) is a lightweight LAPD because it does not need synchronization flags or checksumming for error detection
  - $LAPD_m$ offers reliable data transfer over connections

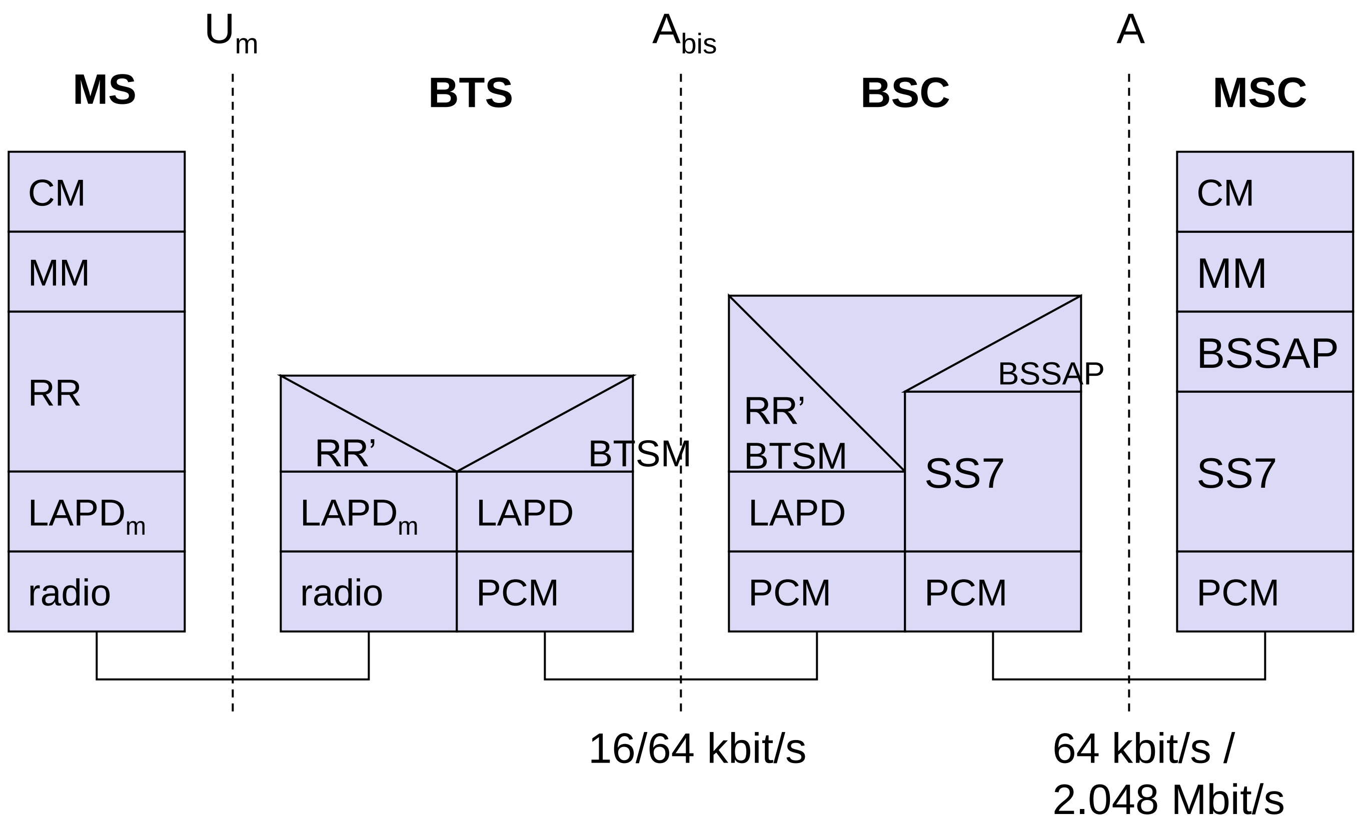


Figure 3: Protocol architecture for signalling

GSM protocol architecture (2)

- The network layer in GSM, layer 3, comprises several sublayers:
  - Lowest sublayer is radio resource management (RR). Only a part of this layer, RR’ is implemented in the BTS, the rest is situated in the BSC.
  - The functions of RR’ are supported by BSC via the BTS management (BTSM).
  - The main tasks of RR are setup, maintenance and release of radio channels.
- Mobility management (MM) contains functions for registration, authentication, identification, location updating.
- The call management (CM) layer contains three entities:
  - Call control (CC): provides a point-to-point connection between two terminals
  - Short message service (SMS): allows for transfer of messages
  - Supplementary service (SS)

GSM protocol architecture (3)

- Data transmission at the physical layer uses pulse code modulation (PCM) systems
- Signaling system No 7 (SS7) is used for signaling between an MSC and a BSC

Localization and calling (1)

- One fundamental feature of the GSM system is the automatic, worldwide localization of users.
  - The system always knows where a user currently is, and the same phone number is valid worldwide.
- To provide this service, GSM performs periodic location updates even if a user does not use the mobile phone
- The HLR always contains information about the current location and the VLR currently responsible for the MS informs the HLR about location changes.
- As soon as an MS moves into the range of a new VLR, the HLR sends all user data needed to the new VLR
- Changing VLRs with uninterrupted availability of all services is also called **roaming.**

Localization and calling (2)

- Roaming can take place
  - within the network of one provider,
  - between two providers in one country,
  - between different providers in different countries
- To locate an MS and to address the MS, several numbers are needed:
- **Mobile station international ISDN number (MSISDN)**:
  - The important number for a user of GSM is the phone number. The phone number is associated with the SIM
  - The MSISDN follows the ITU-T standard E.16 for addresses as it is also used in fixed networks.
  - This number consists of the country code **(CC)**, the **national destination code (NDC)**, and the subscriber number **(SN)**. E.g., +49 179 1234567 with 49 for Germany, 179 for the network provider, and 1234567 for the subscriber number.

Localization and calling (3)

- **International mobile subscriber identity (IMSI)**:
  - GSM uses the IMSI for internal unique identification of a subscriber.
  - IMSI consists of a **mobile country code (MCC)** (e.g., 240 for Sweden), the **mobile network code (MNC)** (i.e., the code of the network provider) and the **mobile subscriber identification number (MSIN)**.
- **Temporary mobile subscriber identity (TMSI)**:
  - To hide the IMSI, which would give away the exact identity of the user signaling over air interface, GSM uses a 4 byte TMSI for local subscriber identification.
  - TMSI is selected by the VLR and is only valid temporarily and within the location area of the VLR.

Localization and calling (4)

- **Mobile station roaming number (MSRN)**:
  - Another temporary address that hides the identity and location of a subscriber is MSRN.
  - The VLR generates this address on request from the MSC, and the address is also stored in the HLR.
  - MSRN contains the current **visitor country code** (**VCC**), the **visitor national destination code (VNDC)**, the identification of the current MSC together with the subscriber number.
  - The MSRN helps the HLR to find a subscriber for an incoming call.

Handover (1)

- Cellular systems require **handover** procedures,
  - as single cells do not cover the whole service area, but e.g., only up to 35 km around each antenna on the country side and some hundred meters in cities.
- The smaller the cell size and the faster the movement of a mobile station through cells (up to 250 km/h for GSM)
  - the more handovers of ongoing calls are required.
- Handover should not cause a cut-off, also called a call **drop**.
  - GSM aims at maximum handover duration of 60 ms.
- There are two basic reasons for a handover
  - The mobile station **moves out of range** of the BTS or a certain antenna of a BTS respectively.
    - The received signal level decreases continuously until it falls below the minimal requirements for communication.

Handover (2)

    - The error rate may grow due to interference, the distance to the BTS may be too high.
  - The wired infrastructure (MSC, BSC) may decide that the **traffic in one cell is too high** and shift some MS to other cells with lower load.
    - Handover may be due to **load balancing**.
- Fig. 4 shows four possible handover scenarios in GSM
  - **Intra-cell handover**:
    - Within a cell, narrowband interference could make transmission at a certain frequency impossible.
    - The BSC could decide to change the carrier frequency (scenario 1).
  - **Inter-cell, intra-BSC handover**:
    - This is a typical handover scenario.
    - The mobile station moves from one cell to another, but stays within the control of the same BSC.
    - The BSC then performs a handover, assigns a new radio channel in the new cell and releases the old one (scenario 2).

Handover (3)

- **Inter-BSC, intra-MSC handover**:
  - As a BSC only controls a limited number of cells; GSM also has to perform handovers between cells controlled by different BSCs. This handover then has to be controlled by the MSC (scenario 3).
- **Inter MSC handover**:
  - A handover could be required between two cells belonging to different MSCs.
  - Now both MSCs perform the handover together (scenario 4).

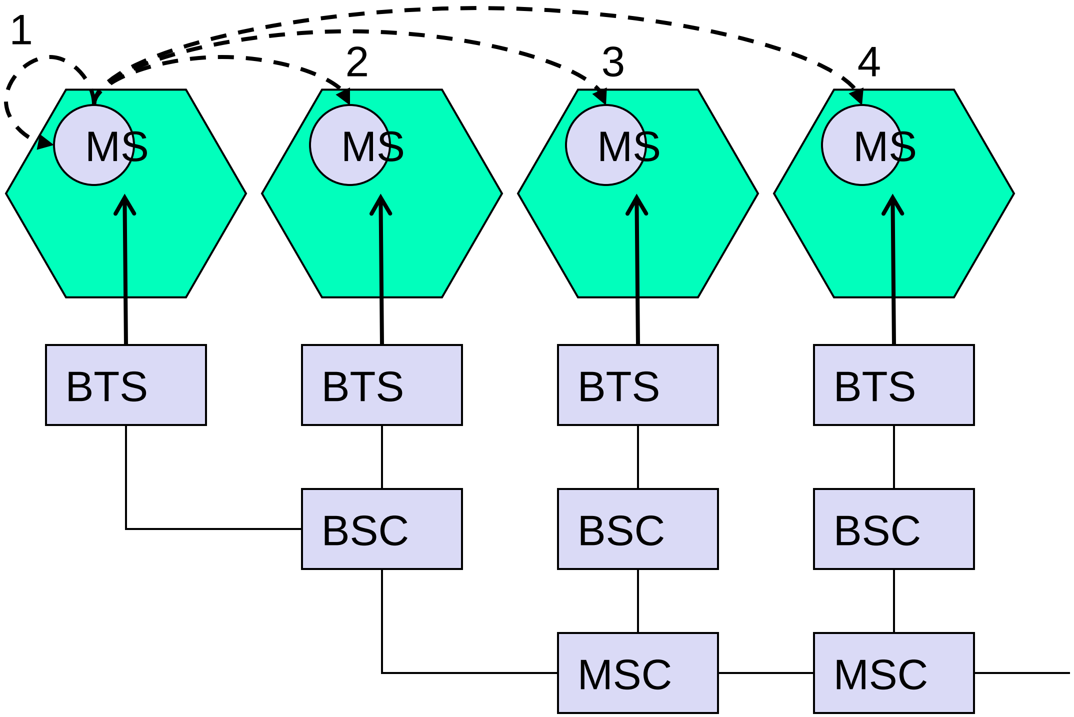


Figure 4: Types of handover in GSM

Security (1)

- GSM offers several security services using confidential information stored in
  - the AuC (Authentication Centre)
  - and in the individual SIM (which is plugged into an arbitrary MS).
- The SIM (Subscriber Identity Module) stores personal, secret data and is protected with a PIN against unauthorized use.
  - (For example, the secret key K_i used for authentication and encryption procedures is stored in the SIM).
- The security services offered by GSM are
  - **Access control and authentication**:
    - The first step includes the authentication of a valid user for the SIM.
    - The user needs a secret PIN to access the SIM.
    - The next step is subscriber authentication.

Security (2)

- **Confidentiality**:
  - All user-related data is encrypted.
  - After authentication, BTS and MS apply encryption to voice, data, and signaling.
  - This confidentiality exists only between MS and BTS, but it does not exist end-to-end or within the whole fixed GSM/telephone network.
- **Anonymity**:
  - To provide user anonymity, all data is encrypted before transmission, and user identifiers are not used over the air.
  - Instead, GSM transmits a temporary identifier (TMSI), which is newly assigned by the VLR after each location update.
  - Additionally, the VLR can change the TMSI at any time.

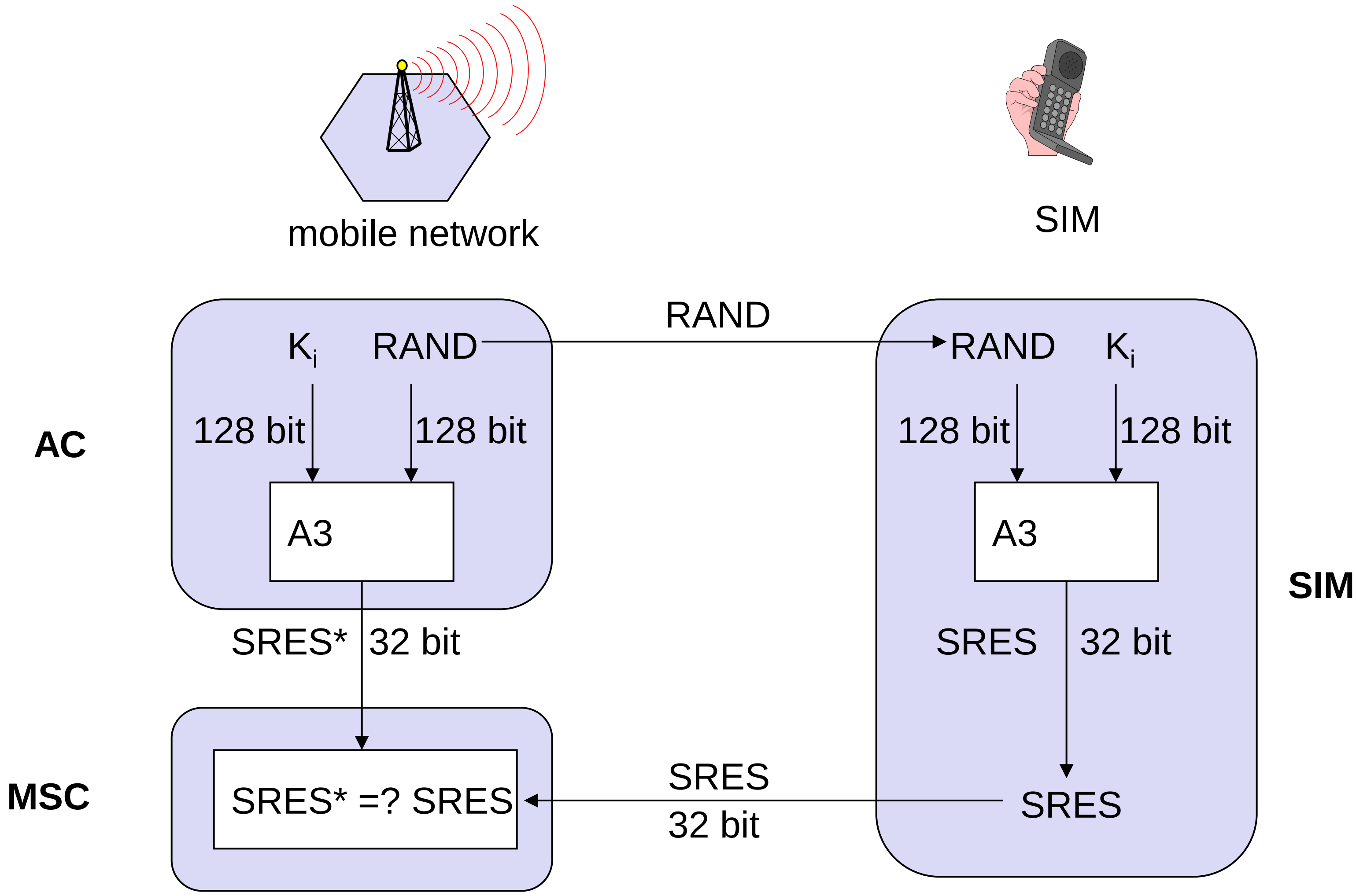
- Three algorithms have been specified to provide security services in GSM.
  - **Algorithm A3** is used for **authentication**, **A5** for **encryption**, and **A8** for the **generation of a cipher key**.

Security (3)

- Network providers can use stronger algorithms for authentication
  - or users can apply stronger end-to-end encryption.
- Algorithm A3 and A8 are located on the SIM and in the AuC and can be proprietary.

Authentication (1)

- Before a subscriber can use any service from the GSM network, he or she must be authenticated.
- Authentication is based on the SIM,
  – which stores the **individual authentication key K_i**, the **user identification IMSI**, and the algorithm used for authentication **A3**
- Authentication uses a challenge-response method:
  – the access control AC generates a random number **RAND as challenge,** and the SIM within the MS answers with **SRES** (signed response) as response (see Figure 5).
- The AuC performs the basic generation of
  – random values RAND, signed responses **SRES**, and cipher keys K_c for each IMSI, and then forwards this information to the HLR.
- The current VLR requests the appropriate values for RAND, SRES, and K_c from the HLR.



K_i: individual subscriber authentication key   SRES: signed response

Figure 5: Subscriber authentication

Authentication (2)

- For authentication, the VLR sends the random value RAND to the SIM.
- Both sides, network and subscriber module, perform the same operation with RAND and the key K_i, called A3.
- The MS sends back the SRES generated by the SIM; the VLR can now compare both values.
- If they are the same, the VLR accepts the subscriber, otherwise the subscriber is rejected.

Encryption

- To ensure privacy, all messages containing user-related information are encrypted in GSM over the air interface.
- After authentication, MS and BSS can start using encryption by applying the cipher key K_c.
- K_c is generated using the individual key K_i and a random value by applying the algorithm A8.
- The SIM in the MS and the network both calculate the same K_c based on the random value RAND.
- The key K_c is not transmitted over the air interface.
- MS and BTS can now encrypt and decrypt data using the algorithm A5 and the cipher key K_c.
- As Figure 6 shows, K_c should be a 64 bit key
  - which is not very strong, but is at least a good protection against eavesdropping.

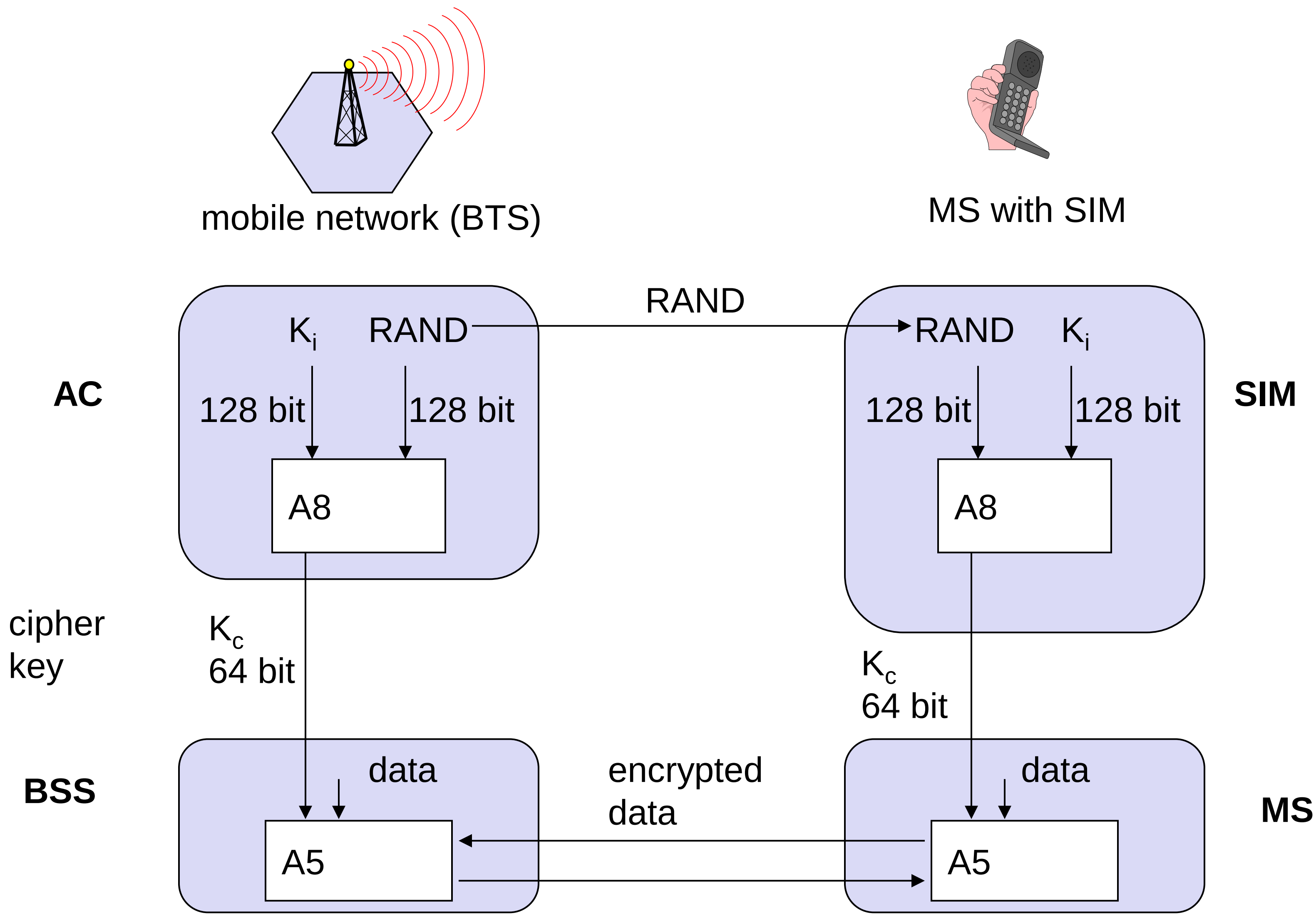


Figure 6: Data encryption

New Data services in GSM (1)

- Data transmission is standardized with only 9.6 kbit/s
  - advanced coding allows 14.4 kbit/s
  - not enough for Internet and multimedia applications
- To enhance the data transmission capabilities of GSM, two basic approaches are possible.
  - High speed circuit switched data (HSCSD)
    - mainly software update
    - bundling of several time-slots to get higher AIUR (Air Interface User Rate, e.g., 57.6 kbit/s using 4 slots @ 14.4)
    - advantage: ready to use, constant quality, simple
    - disadvantage: channels blocked for voice transmission
  - General packet radio service (GPRS)
    - Next step towards more flexible and powerful data transmission and that avoids problems of HSCSD by being packet-oriented.
    - The goal is to provide a more efficient and cheaper packet transfer service for typical internet applications that rely solely on packet transfer

New Data services in GSM (2)

    - using free slots only if data packets ready to send (e.g., 50 kbit/s using 4 slots temporarily)
    - standardization 1998, introduction 2001
    - advantage: one step towards UMTS, more flexible
    - disadvantage: more investment needed (new hardware)

- GPRS network elements
  - GSN (GPRS Support Nodes) which are in fact routers: GGSN and SGSN
  - GGSN (Gateway GSN)
    - interworking unit between GPRS and PDN (Packet Data Network)
    - this node contains routing information for GPRS users, performs address conversion.
  - SGSN (Serving GSN)
    - supports the MS (location, billing, security)
  - GR (GPRS Register)
    - contains user addresses

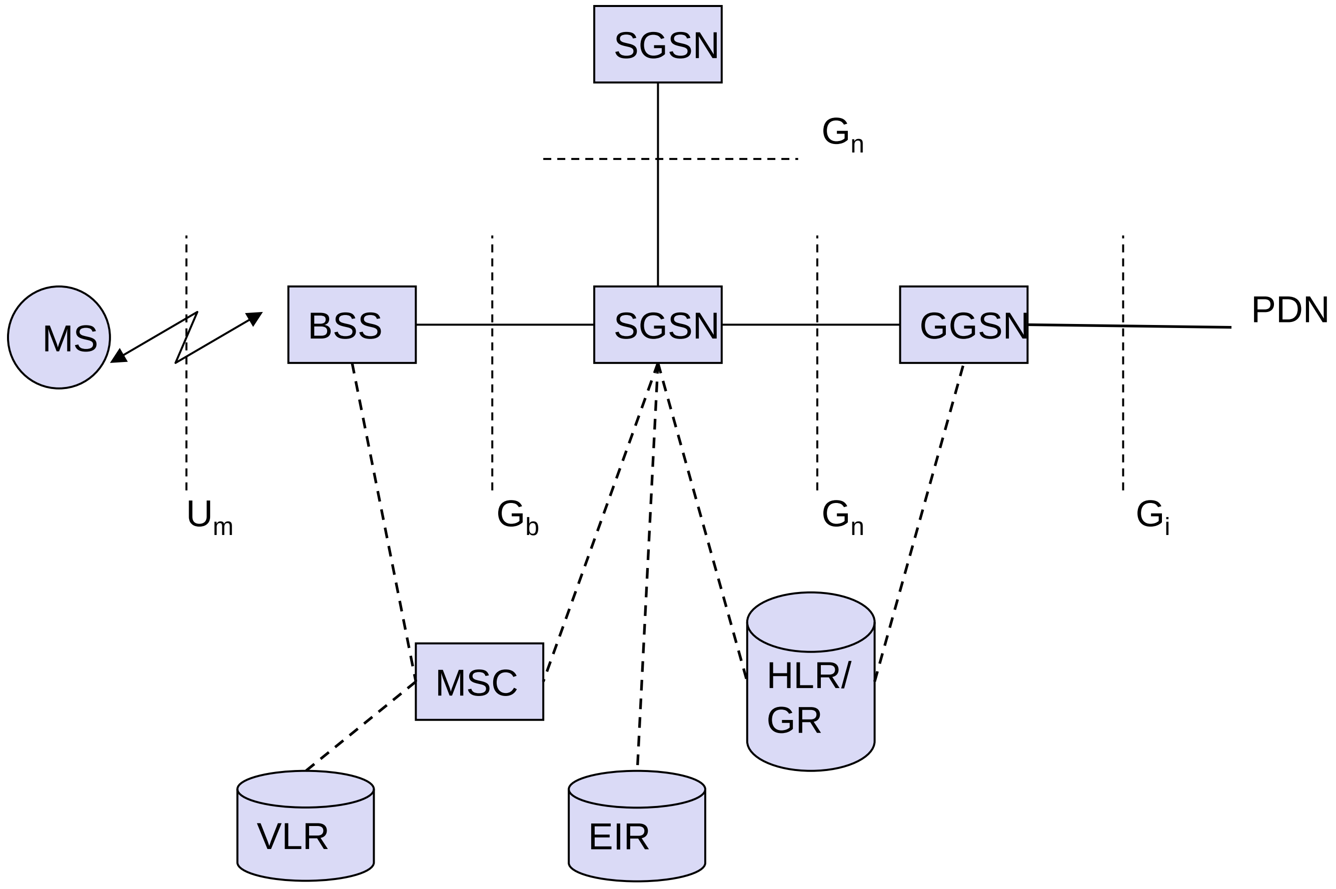


Figure 7: GPRS architecture reference model

DECT

DECT

- Another fully digital cellular network
- DECT (Digital European Cordless Telephone) standardized by ETSI (ETS 300.175-x) for cordless telephones
- Standard describes air interface between base-station and mobile phone
- DECT was renamed for international marketing reasons to Digital Enhanced Cordless Telecommunication
- DECT is mainly used in offices, on campus, at trade shows or in the home
- The big difference between DECT and GSM exists in terms of cell diameter and cell capacity
  - GSM is designed for outdoor use with a cell diameter of up to 70 km. DECT range is limited to about 300 m from the base station

DECT Characteristics

- frequency: 1880-1990 MHz
- channels: 120 full duplex
- duplex mechanism: TDD (Time Division Duplex) with 10 ms frame length
- multiplexing scheme: FDMA with 10 carrier frequencies, TDMA with 2x 12 slots
- modulation: digital, Gaussian Minimum Shift Key (GMSK)
- power: 10 mW average (max. 250 mW)
- range: approx. 50 m in buildings, 300 m open space

DECT System architecture (1)

- Figure 8 shows the DECT system architecture reference model
- Global network:
  - Connects the local communication structure to the outside world and offers its services via the interface D_1.
  - Global services could be ISDN, PSTN.
  - Services offered include transportation of data, translation of addresses and routing of data between local networks.
- Local networks:
  - Offer local telecommunication services from simple switching to intelligent call forwarding, address translation.
  - Examples of such networks include LANs following the IEEE 802.x family of LANs.

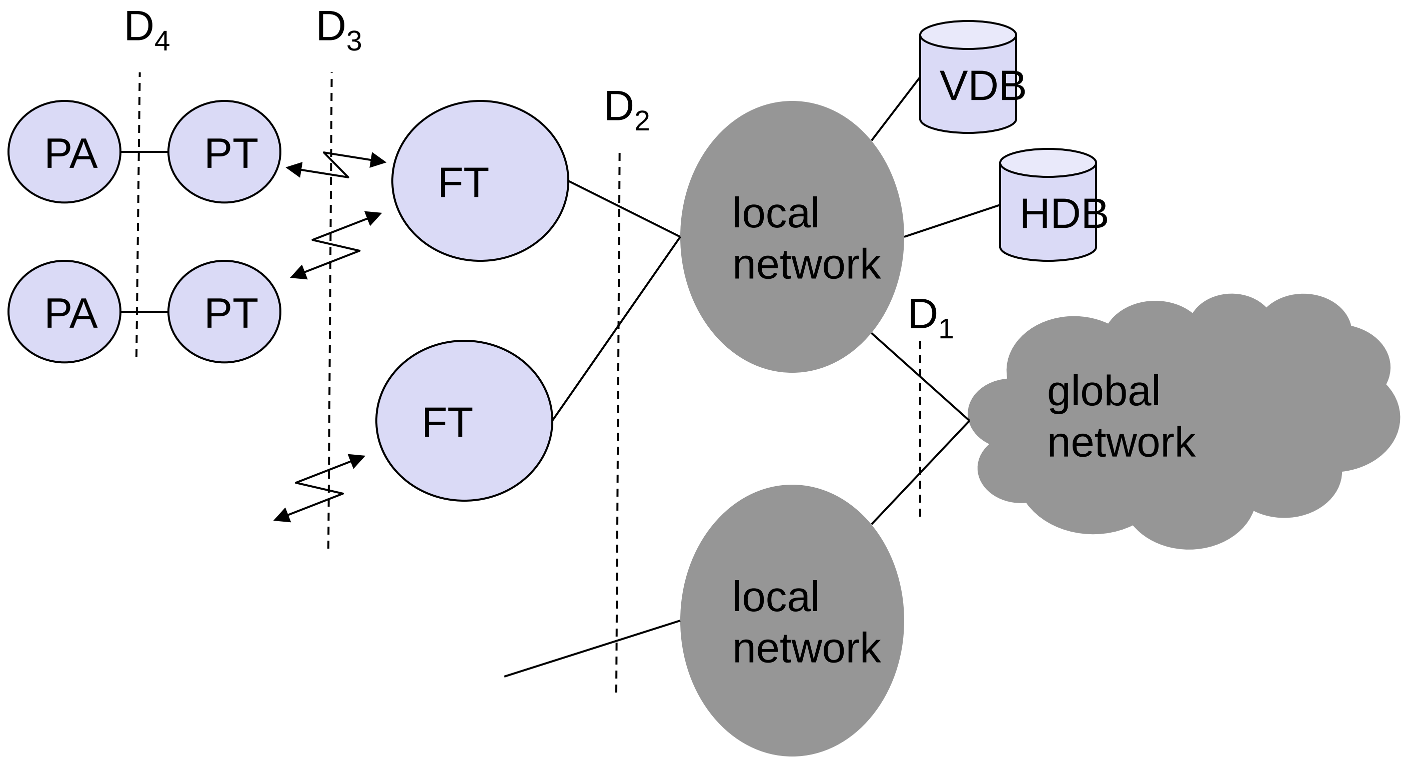


Figure 8: DECT system architecture reference model

DECT System architecture (2)

- Home database (HDB) and visitor database (VDB):
  - Support mobility with functions similar to HLR and VLR in GSM systems.
  - Incoming calls are automatically forwarded to the current subsystem responsible for the DECT user, and the current VDB informs the HDB about changes in location.
- The DECT core network consists of fixed radio termination (FT) and the portable radio termination (PT) which provides a multiplexing service.
- Several portable applications (PA) can be implemented on a device.

TETRA

TETRA (1)

- Trunked radio systems constitute another method of wireless data transmission
- The systems use many different radio carriers
  - but only assign a specific carrier to certain user for a short period of time according to demand
- Taxi services, transport companies with fleet management systems and rescue teams all have their own unique carrier frequency in traditional systems,
  - they can share a whole group of frequencies in trunked radio systems for better frequency reuse via FDM and TDM techniques
- These radio systems offer interfaces to fixed telephone networks but are not publicly accessible

TETRA (2)

- To allow a common system throughout Europe, ETSI standardized the TETRA system (terrestrial trunked radio) in 1991.
- TETRA offers two standards:
  - Voice+Data (V+D) service: offers circuit switched voice and data transmission
  - Packet data optimized (PDO) service: offers packet data transmission
- TETRA offers bearer services of up to 28.8 kbit/s for unprotected data transmission and 9.6 kbit/s for protected transmission.

TETRA (3)

- The system architecture of TETRA is very similar to GSM
  - Via the radio interface U_m, the mobile station (MS) connects to the switching and management infrastructure (SwMI) which contains user databases (HDB, VDB), base station and interfaces to PSTN, ISDN or PDN
  - TETRA offers traffic channels (TCH) and control channels (CCH) similar to GSM
- In contrast to GSM, TETRA offers additional services like group call, broadcast call and discreet listening

UMTS

UMTS (1)

- The European proposal for the international mobile telecommunications (IMT)-2000 prepared by ETSI is called universal mobile telecommunications system (UMTS)
- The specific proposal for the radio interface RTT (radio transmission technologies) is UMTS terrestrial radio access (UTRA)
- UMTS presents an evolution from the second generation GSM system to the third generation rather than a complete system

UMTS (2)

- Many solutions have been proposed for a smooth transition from GSM to UMTS
  - Enhanced data rates for global evolution (EDGE) which uses enhanced modulation schemes (8 PSK instead of GSM's GMSK) for data rates of up to 384 kbit/s using the same 200 kHz wide carrier and the same frequencies as GSM
  - Customized application for mobile enhanced logic (CAMEL) introduces intelligent network support. This system supports e.g. the creation of a virtual home environment (VHE) for visiting subscribers.
- UMTS fits into GMM (global multimedia mobility) initiative from ETSI
  - min. 144 kbit/s rural (goal: 384 kbit/s)
  - min. 384 kbit/s suburban (goal: 512 kbit/s)
  - up to 2 Mbit/s urban

UMTS system architecture (1)

- Figure 9 shows a simplified UMTS reference architecture
- The UTRA network (UTRAN) handles cell level mobility and comprises several radio network subsystems (RNS)
- The functions of the RNS include radio channel ciphering and deciphering, handover control, radio resource management etc.
- The UTRAN is connected to the user equipment (UE) via the radio interface U_u (comparable to the U_m interface in GSM).
- Via the I_u interface (similar to the A interface in GSM), the UTRAN communicates with the core network (CN).
- The CN contains functions for inter-system handover, gateways to other networks

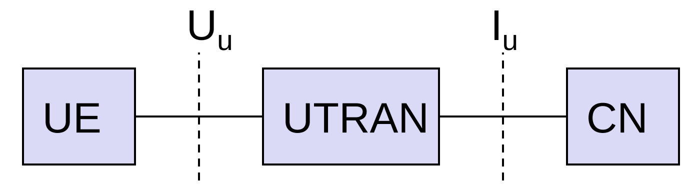


Figure 9: Main components of the UMTS reference architecture.

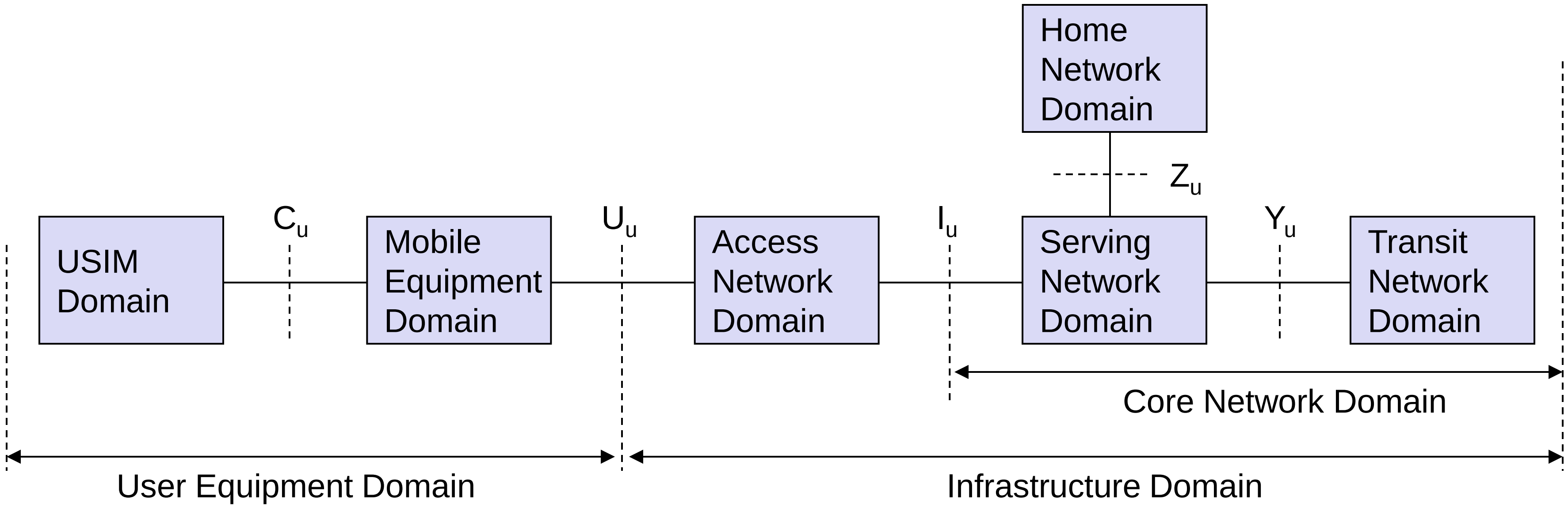


Figure 10: UMTS domains and interfaces

UMTS system architecture (2)

- UMTS further subdivides the above simplified architecture into domains (see Figure 10)
- The user equipment domain is assigned to a single user and comprises all functions needed to access UMTS services.
  - Within this domain are the USIM domain and the mobile equipment domain.
- The USIM domain contains the SIM for UMTS which performs functions for encryption and authentication of users and stores all necessary user-related data for UMTS.
- The end device itself is in the mobile equipment domain.
- All functions for radio transmission as well as user interfaces are located here.

UMTS system architecture (3)

- The infrastructure domain is shared among all users and offers UMTS services to all accepted users.
  - This domain consists of the access network domain which contains the radio access networks (RAN) and the core network domain which contains access network independent functions
- The core network domain can be separated into three domains with specific tasks.
  - The serving network domain comprises all functions currently used by a user for accessing UMTS services.
  - All functions related to the home network of a user, e.g., user data look-up, fall into the home network domain
  - The transit network domain may be necessary if, for example, the serving network cannot directly contact the home network
- The biggest difference between UMTS and GSM comes with the new radio interface (U_u)

  - The direct sequence CDMA used in UMTS is new

UTRAN (1)

- Figure 11 shows the basic architecture of the UTRA network (UTRAN)
- This consists of several radio network subsystems (RNS).
- Each RNS is controlled by a radio network controller (RNC) and comprises several components called node B (similar to a BTS)
- An RNC in UMTS can be compared with the BSC.
- Each node B can control several antennas which make a radio cell
- The mobile device, UE (user equipment) can be connected to one or more antennas.

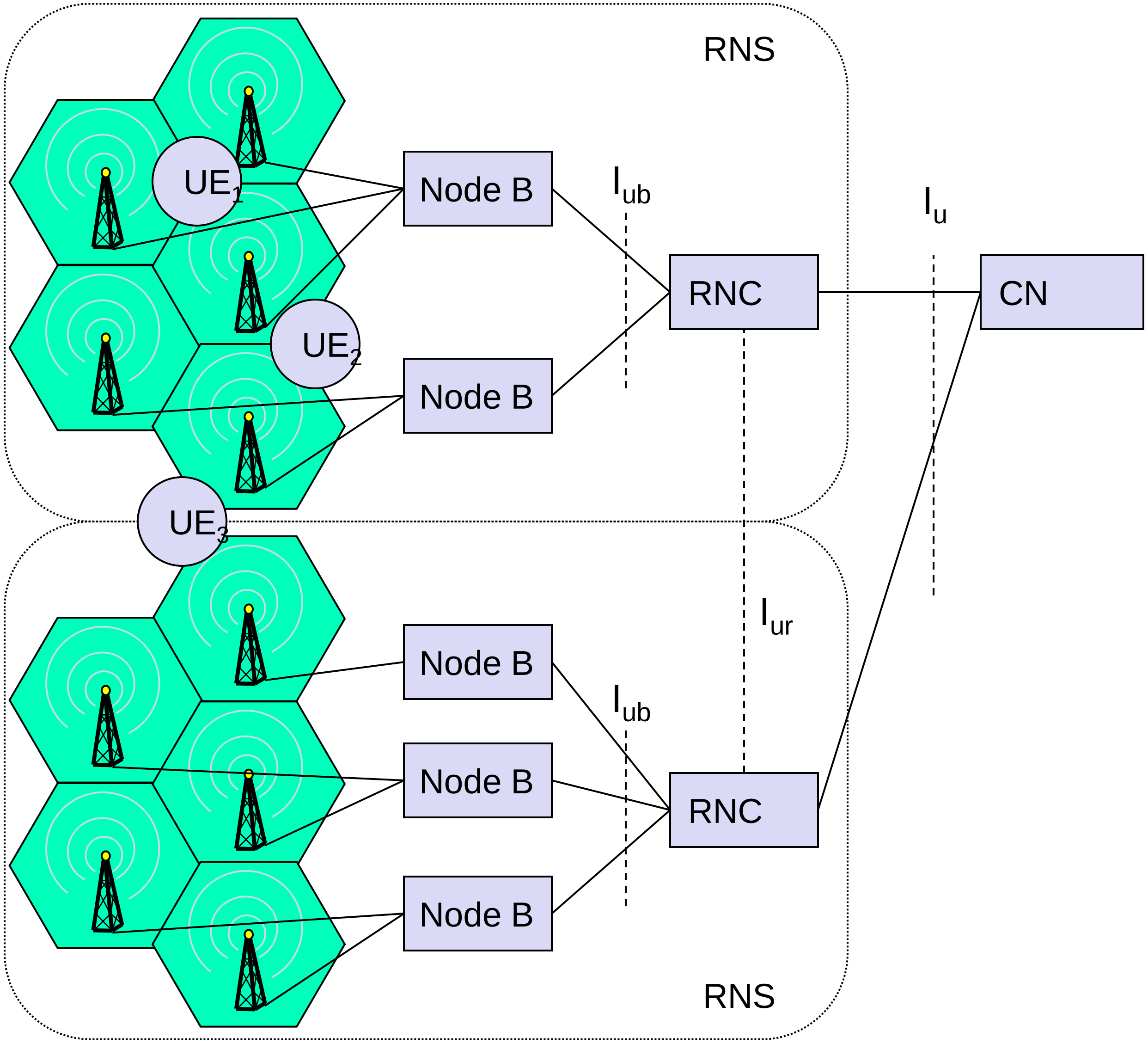


Figure 11: Basic architecture of the UTRA network

UTRAN (2)

- It performs spreading and modulation, signal quality measurements etc.
- Each RNC is connected with the core network (CN) over the interface I_u (similar to role of A interface in GSM) and with a node B over the interface I_{ub}
- A new interface, with no counterpart in GSM, is the interface I_{ur} connecting two RNCs with each other.