



*Master Degree in Telecommunications Engineering*

*“Mobile Radio Networks” Class*

3 – From 2G to 3G (part 1)

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## Mobile Radio Networks

### ❑ Historical notes on GSM

## Historical notes (1)

- 1982: the CEPT (Conférence Européenne des Administrations des Postes et des Télécommunications) establishes a special group to study a uniform set of rules for the development of a future pan-European cellular network: the Groupe Spécial Mobile from which GSM
- 1984: establishment of 3 Working Parties (WP1-3) for the definition of services to be offered in GSM: the radio interface, transmission formats and signaling protocols, interfaces and network architecture

## Historical notes (2)

- 1985: definition of the list of recommendations that GSM must produce (they will end up being about 130: 1500 pages in 12 volumes! ... plus all those relating to the evolution, i.e. phases 2+ and 3 of GSM)
- 1986: the so-called permanent nucleus is established with the aim of coordinating the work of the GSM, especially given the strong interest from industry

## Historical notes (1)

- 1987: a first Memorandum of Understanding (MoU) is signed between Telecom operators representing 12 (European) nations with the following objectives:
  - coordinate the temporal development of European GSM networks and verify their standard
  - plan the introduction of services
  - agree routing policies and pricing (methods and prices)

## Historical notes (4)

- 1988: with the establishment of ETSI (European Telecommunication Standards Institute) the work on GSM is "moved" to this forum
- 1990: it is decided to apply the GSM specifications also to the DCS1800 system (Digital Cellular System on 1800 MHz), a PCN (Personal Communication Networks) type system initially developed in the U.K.
- 1991: (July) the commercial launch of GSM, planned for this date, is postponed to 1992 due to the lack of mobile handsets complying with the standard

## Historical notes (5)

- 1992: the definitive standard relating to *GSM* is released, which at this point becomes the acronym of *Global System for Mobile Communications*
- 1992: Official introduction of commercial *GSM* systems
- 1993: the MoU brings together 62 members from 39 countries; in addition, another 32 organizations representing 19 countries participate as observers waiting to sign the MoU

## Historical notes (6)

- 1994-95: introduction of SMS
- 1995-97: Introduction of 1800 MHz services
- 1996: Standardization of both full and half-rate enhanced encoders
- 1997: Dual-band terminals with enhanced encoder
- 1999: GPRS standard for packet transmission and first circuit-switched Wireless Access Protocol (WAP) terminals
- 2000/01: introduction of GPRS services

## Historical notes (7)

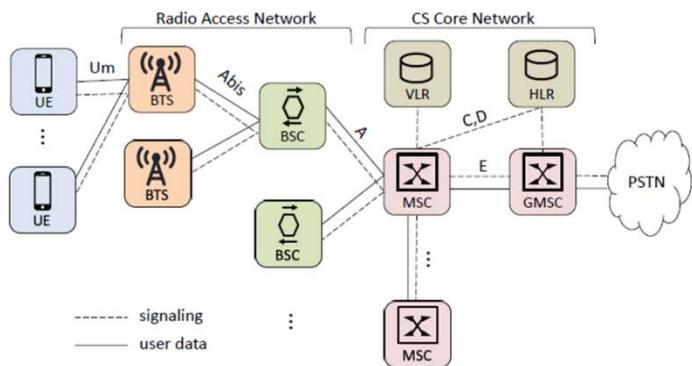
- 1993-2001: GSM becomes the most widespread cellular network in the world, with almost 80M users in Europe and 200M worldwide (almost 40M in China alone), a non-marginal penetration also in the USA with almost 10 operators, which have a market second only to AMPS/D-AMPS.
- In fact it has become a worldwide standard, significantly influencing the evolution towards 3rd generation networks and helping to determine the momentary commercial failure of satellite networks

## Mobile Radio Networks

- ❑ GSM System Architecture and evolution towards 3G

## The first network architecture of GSM

- The first network architecture of GSM was for [circuit switched](#) (CS) services only, and [telephone service](#) in particular



## GSM architecture: RAN elements

- UE (User Equipment):** also known as Mobile Station in GSM terminology is the user mobile device and it includes a Terminal Equipment (TE) and a Subscriber Identity Module (SIM) card
  - TE is just the hardware, identified by IMEI (International Mobile Equipment Identifier)
  - SIM is the part that activates the terminal for a user with all the necessary information
- BTS (Base Transceiver Station):** is the GSM base station that manages physical layer connections with the UEs and the BSC and executes resource allocation commands received by the BSC
- BSC (Base Station Controller):** implements higher layers protocols and manages all transmission resources of the connected BTs

## RAN elements: Terminal Equipment

- It is the terminal owned by the User
- Three categories according to the rated power:
  - **vehicular**: can emit up to 20 W at the antenna
  - **portable**: up to 8 W at the antenna, they are transportable, but need a considerable power source for operation (e.g. laptop PCs, fax machines, etc.)
  - **personal** (hand-terminal): up to 2 W to the antenna, it is the "mobile phone"

## RAN elements: Information stored in the SIM card

- *Serial number*
  - identifies the SIM card **univocally**
- *International Mobile Subscriber Identity (IMSI)*
  - identifies the User univocally in the network
- Security authentication and cyphering information
  - A3 and A8 algorithm (procedures to perform authentication and encryption)
  - $K_i$ ,  $K_c$  (the keys for authentication and encryption)
- Temporary Network information
  - *LAI (Location Area Identifier)*, identifier of the last location area visited
  - *TMSI (Temporary Mobile Subscriber Identity)*, identifier assigned by the network and used instead of IMSI



## RAN elements: Information stored in the SIM card



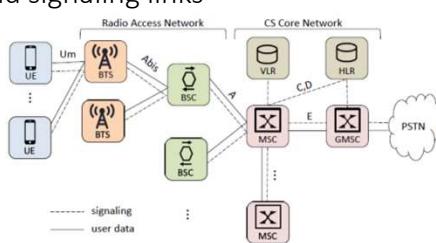
- List of services to which the user is subscribed
- Personal Identity Number (PIN)
- Personal Unblocking Number (PUK)
- Access rights
- Prohibited networks
- Call messages
- Phone numbers

## GSM architecture: CS Core network elements

- **MSC (Mobile Switching Center)**: is the equivalent of a telephone station for the mobile network and includes all control and signaling functions for managing calls and mobility
- **Visitor Location Register (VLR)**: is logically (and often physically) associated to a MSC and stores temporary information on users visiting the area covered by all base stations connected to the MSC
- **GMSC (Gateway MSC)**: is the MSC connecting the mobile network to the external telephone networks (PSTN) and that implements all signaling interworking functions
- **HLR (Home Location Register)**: is the central data base of the network used for storing permanent user information and dynamic location information; it also includes and **AuC (Autentication Center)** for security procedures
- **Equipment Identity Register (EIR)**: contains the IMEI of all the devices authorized for the service

## GSM architecture: interfaces

- The **Um** radio interface of GSM is based on a TDMA scheme described in detail later
- The **A** and **Abis** interfaces are based on classical telephone transport networks with 64 kb/s circuits and E1 links at 2.048 Mb/s (32 circuits)
- The interfaces between the elements (MSCs, HLR, GMSC) of the CS core network are based on classical telephone transport networks with circuits and signaling links



## GSM: Operation and Maintenance Subsystem (OMSS)

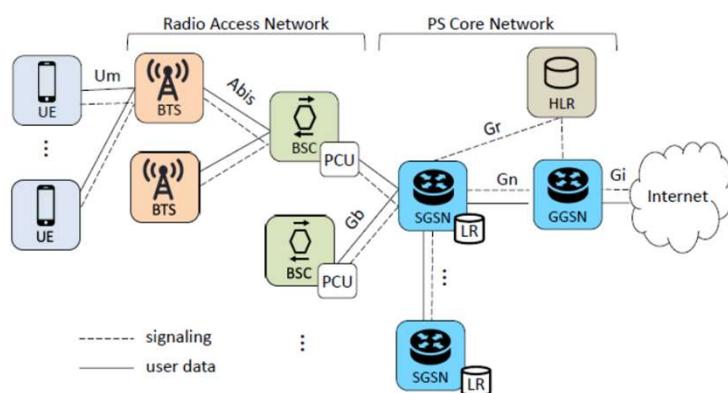
- It includes the units responsible for **network operator control, maintenance and remote management**
- In the OMSS:
  - functions of all network devices are configured
  - malfunction alarms are displayed
  - traffic statistics are displayed
  - etc.

## GSM: Defined Areas

- *PLMN (Public Land Mobile Network) Area:*
  - Service area of a network
- *MSC/VLR Area:*
  - area managed by an MSC. The data of the users present in the area are stored in the VLR associated with the MSC
- *Location Area:*
  - one MSC/VLR area is logically split into one or more Location Area (LA). If a user changes LA she/he must perform a location update. The LAs are identified by a *LAI (Location Area Identifier)*, broadcasted by each BTS in the area on the broadcast control channel
- *Cell:*
  - area covered by a BTS. It is identified by a *BSIC (Base Station Identity Code)*, also transmitted by the BTS on the broadcast control channel

## Architecture evolution of GPRS for data services

- With the introduction of packet switched data services of GPRS/EDGE, the architecture evolved to include a PS Core



## GPRS/EDGE architecture: nodes

- **PCU (Packet Control Unit)**: it is an additional module of the BSC for managing protocols and resources of the packet service in the radio access
- **SGSN (Serving GPRS Support Node)**: It is basically an IP router that plays in the packet core network of the GPRS the same role of the MSC in the circuit switched core; it has additional functionalities wrt a standard IP router for the management of the interfaces and protocols towards the BSS, for mobility support, and for the forwarding of packets to GGSN
- **GGSN (Gateway GPRS Support Node)**: It is the interworking node between the GPRS network (cellular packet core) and an external PDN (Packet Data Network), typically an IP network; it manages the activation of external connectivity for UEs (typically assigning them an IP address)

## GPRS/EDGE architecture: interfaces

- The interfaces of the RAN are the same of GSM with just additional functionalities for managing the shared channels used by the packet switched service
- The other interfaces are based on IP connectivity and different types of lower layer technologies
- Packet transport of both user data and signaling is based on tunneling protocols that are also used to manage mobility

## Combined 2G architecture

