



# Mobile Communications

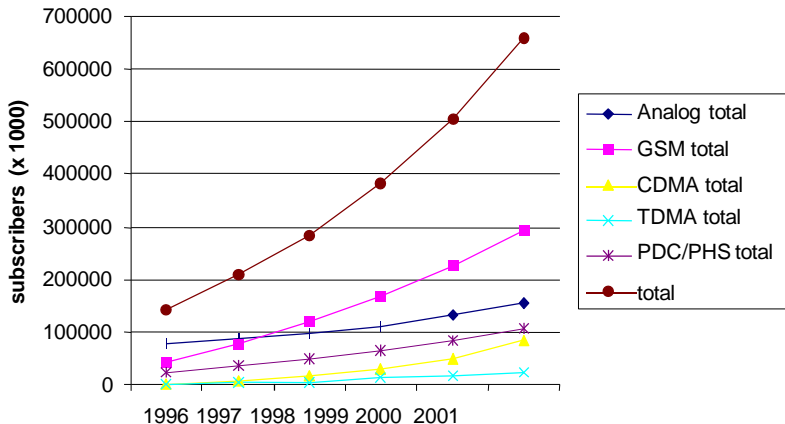
## GSM

- ❑ Market
- ❑ GSM
  - ❑ Overview
  - ❑ Services
  - ❑ Sub-systems
  - ❑ Components
- ❑ DECT
- ❑ TETRA
- ❑ UMTS/IMT-2000





# Mobile phone subscribers worldwide





# GSM: Overview

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## GSM

- ❑ formerly: Groupe Spéciale Mobile (founded 1982)
- ❑ now: Global System for Mobile Communication
- ❑ Pan-European standard (ETSI, European Telecommunications Standardisation Institute)
- ❑ simultaneous introduction of essential services in three phases (1991, 1994, 1996) by the European telecommunication administrations (Germany: D1 and D2)
  - <sup>3</sup> seamless roaming within Europe possible
- ❑ today 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

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## Communication

- ❑ mobile, wireless 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 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

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There is no perfect system!!

- ❑ no end-to-end encryption of user data
- ❑ no full ISDN bandwidth of 64 kbit/s to the user, no transparent B-channel
  
- ❑ 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





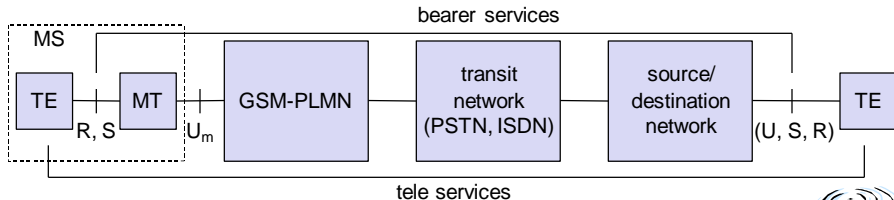
# GSM: Mobile Services

## GSM offers

- ❑ several types of connections
  - voice connections, data connections, short message service
- ❑ multi-service options (combination of basic services)

## Three service domains

- ❑ Bearer Services
- ❑ Telematic Services
- ❑ Supplementary Services





## Bearer Services

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- ❑ 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 I

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- ❑ 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







### Additional services

#### □ Non-Voice-Teleservices

- group 3 fax
- 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 using the signaling channel, thus allowing simultaneous use of basic services and SMS





## Supplementary services

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- ❑ 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)
  - ❑ ...





# Architecture of the GSM system

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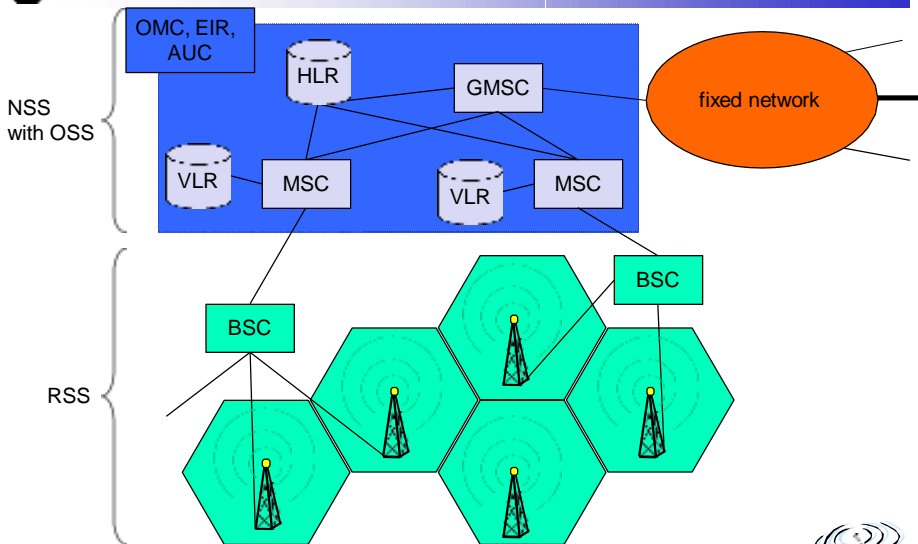
## GSM is a PLMN (Public Land Mobile Network)

- ❑ 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



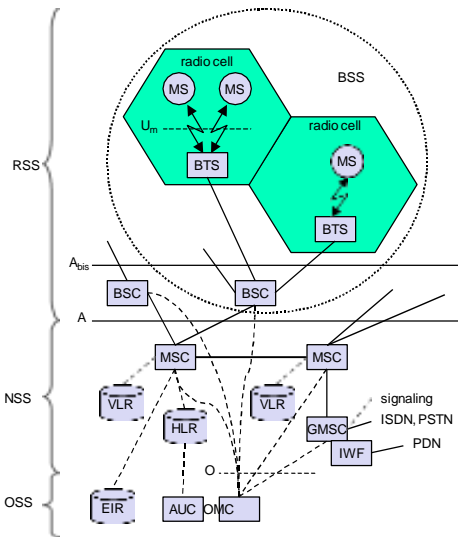


# GSM: overview



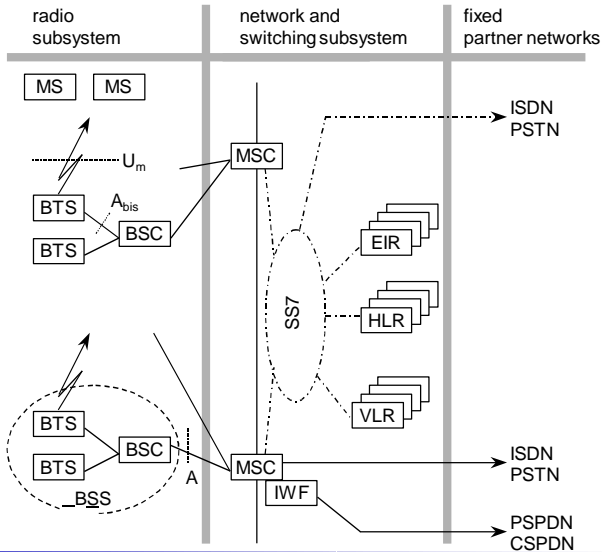


# GSM: elements and interfaces



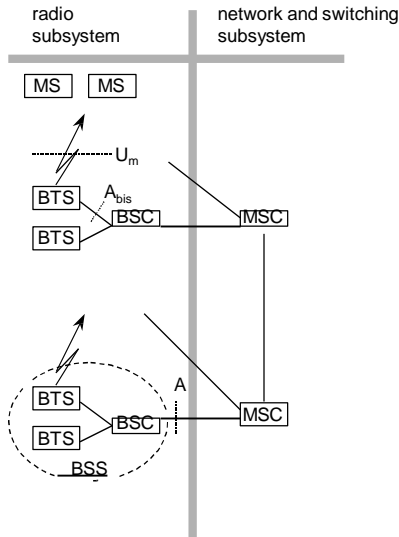


# GSM: system architecture





# 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

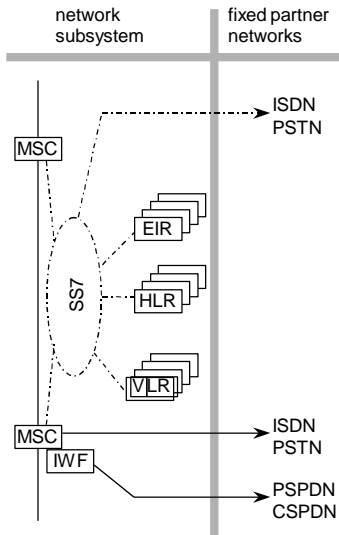
## Interfaces

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





# 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 Register)
- VLR* (Visitor Location Register)
- EIR* (Equipment Identity Register)







## Radio subsystem

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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)
  
- $BSS = BSC + \text{sum}(BTS) + \text{interconnection}$

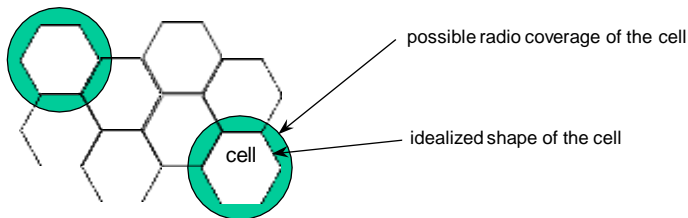
□ Mobile Stations (MS)





# GSM: cellular network

segmentation of the area into cells



- ❑ 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





## Base Transceiver Station and Base Station Controller

Tasks of a BSS are distributed over BSC and BTS

- ❑ BTS comprises radio specific functions
- ❑ BSC is the switching center for radio channels

Functions	BTS	BSC
Management of radio channels		X
Frequency hopping (FH)	X	X
Management of terrestrial channels		X
Mapping of terrestrial onto radio channels		X
Channel coding and decoding	X	
Rate adaptation	X	
Encryption and decryption	X	X
Paging	X	X
Uplink signal measurements	X	
Traffic measurement		X
Authentication		X
Location registry, location update		X
Handover management		X

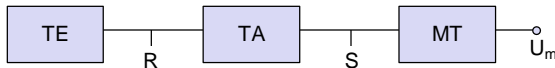




# Mobile station

## 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 (Terminal Equipment):
    - peripheral device of the MS, offers services to a user
    - does not contain GSM specific functions
  - ❑ SIM (Subscriber Identity Module):
    - personalization of the mobile terminal, stores user parameters





## Network and switching subsystem

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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, including data about all user currently in the domain of the VLR





# Mobile Services Switching Center

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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

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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

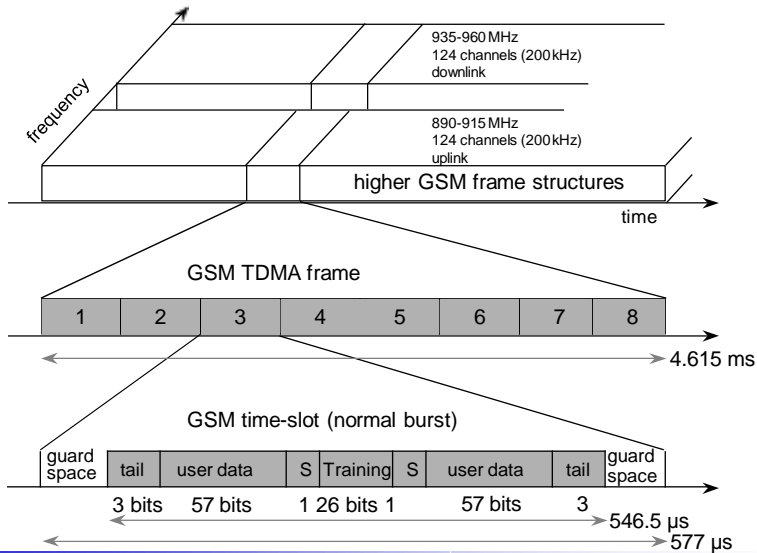
#### ❑ Operation and Maintenance Center (OMC)

- different control capabilities for the radio subsystem and the network subsystem





# GSM - TDMA/FDMA







# GSM hierarchy of frames

