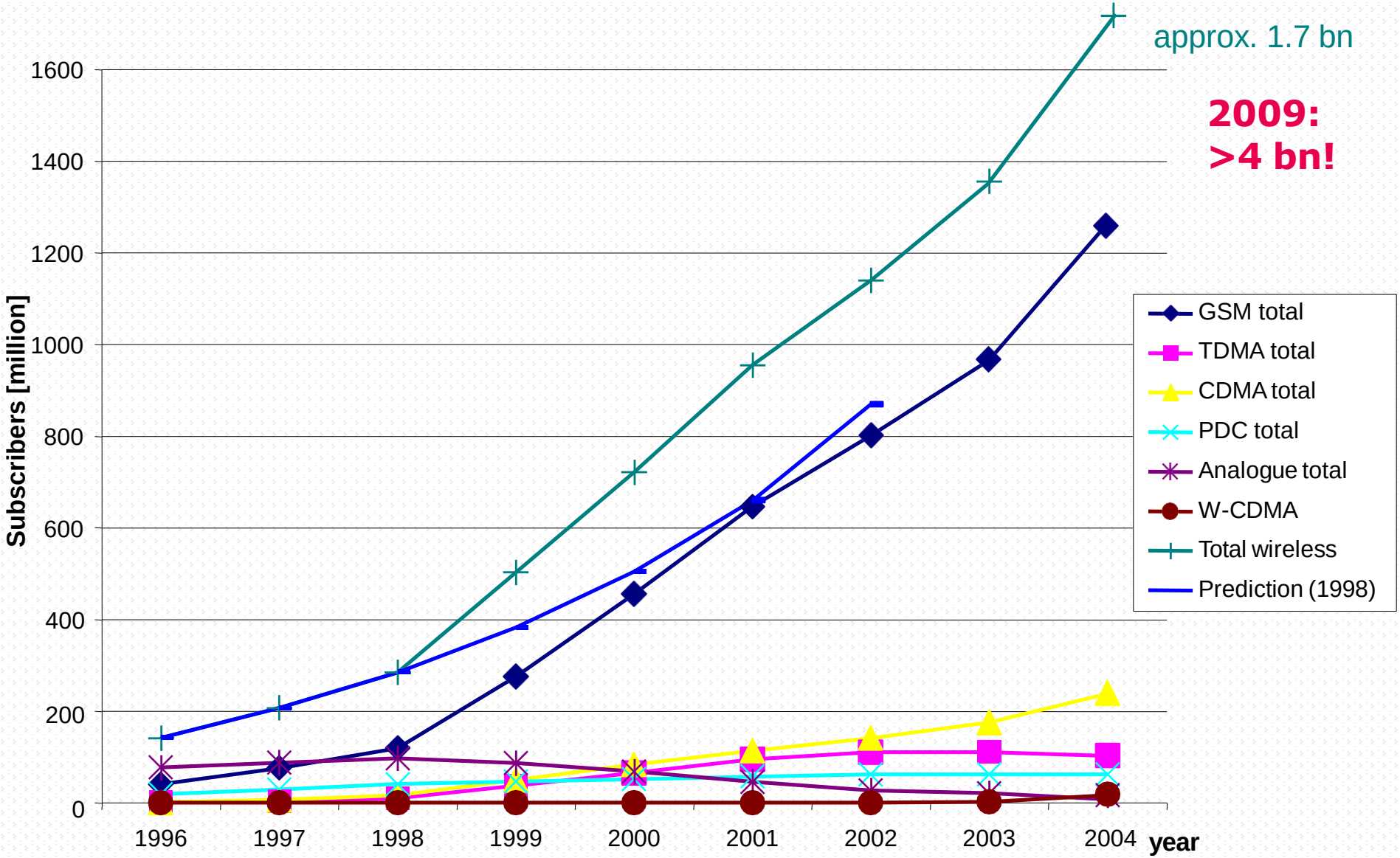
UNIT-2

Telecommunication Systems

- Market
- GSM

- **Digital cellular networks** are the segment of the market for mobile and wireless devices which are growing most rapidly.
- The **worldwide market** figures for cellular networks are as follows:
- The most popular digital system is GSM, with approx. 70 per cent market share.
- In **Europe**
- almost everyone uses the digital GSM system (over 370 million) with almost no analog systems left.
- The situation is different in the **US** and some other countries that have adopted US technology (e.g., South Korea, Canada). Here, the digital market is split into TDMA, CDMA, and GSM systems with 107 million
- TDMA, 135 million CDMA, and only 16 million GSM users (North America only). While only one digital system exists in Europe, the US market is divided into several systems

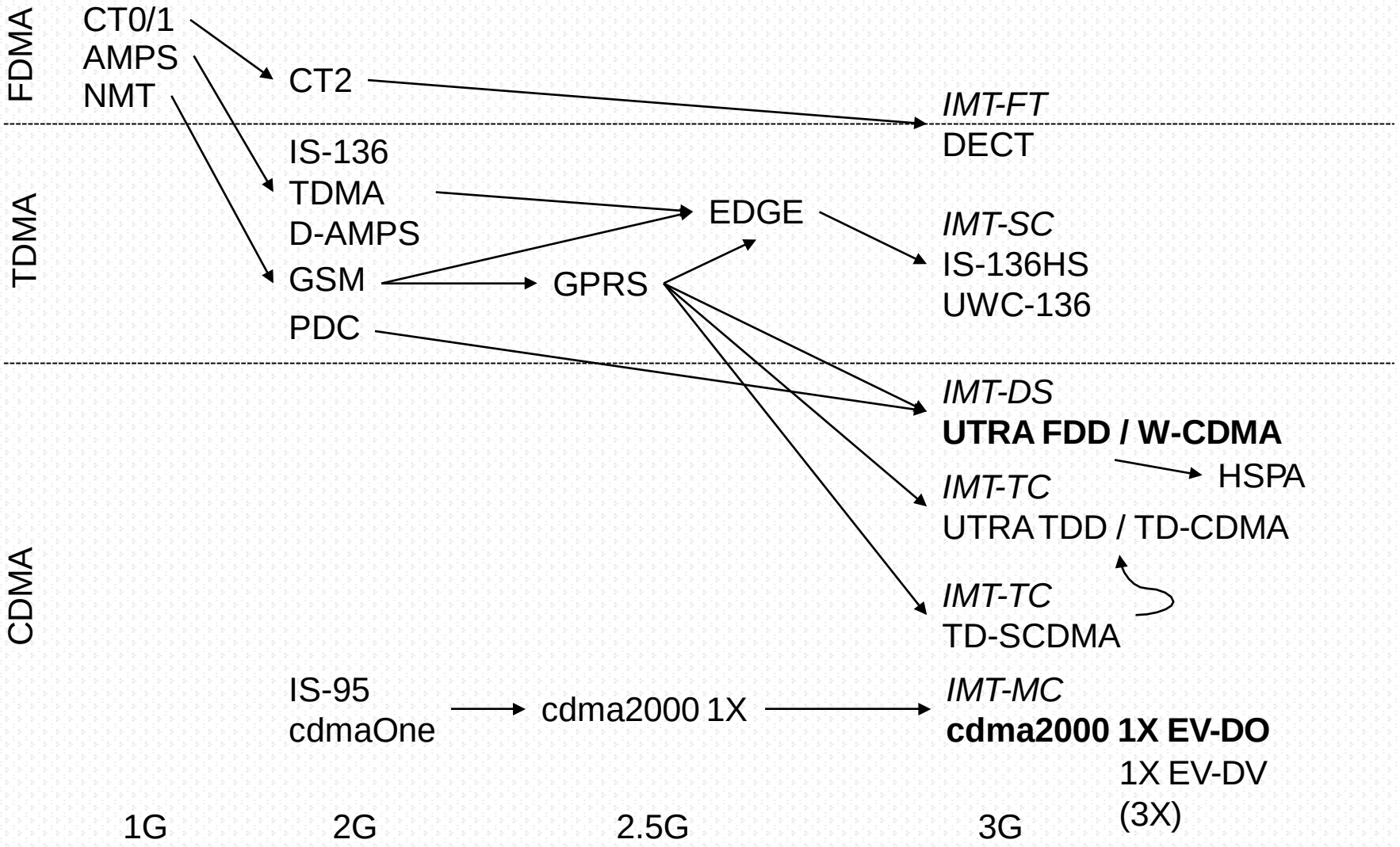

approx. 1.7 bn
2009:
>4 bn!
Subscribers [million]
1600
1400
1200
1000
800
600
400
200
0
1996
1997
1998
1999
2000
2001
2002
2003
2004
year
GSM total
TDMA total
CDMA total
PDC total
Analogue total
W-CDMA
Total wireless
Prediction (1998)

Some press news...

- **16th April 2008**: The GSMA, the global trade group for the mobile industry, announced that total connections to GSM mobile communications networks have now passed the **3 Billion** mark globally. The third billion landmark has been reached just four years after the GSM industry surpassed its first billion, and just two years from the second billionth connection. The 3 Billion landmark has been surpassed just 17 years after the first GSM network launch in 1991. Today more than 700 mobile operators across 218 countries and territories of the world are adding **new connections at the rate of 15 per second, or 1.3 million per day**.
- **11 February 2009**: The GSMA today announced that the mobile world has celebrated its **four billionth connection**, according to Wireless Intelligence, the GSMA's market intelligence unit. This milestone underscores the continued strong growth of the mobile industry and puts the global market on the path to reach a staggering **six billion connections by 2013**.

- Figure 4.2 shows several development and migration paths for different mobile telecommunication systems presented in this chapter. The diagram is divided into the three main multiplexing schemes, FDMA, TDMA, and CDMA. The figure classifies the technologies into three generations

Development of mobile telecommunication systems



- GSM :**groupe spéciale mobile (GSM)**founded in 1988.
- This system was soon named the **global system for mobile communications (GSM)**, with the specification process lying in the hands of ETSI (ETSI, 2002), (GSM Association, 2002).
- In the context of UMTS and the creation of 3GPP (Third generation partnership project, 3GPP, 2002a) the whole development process of GSM was transferred to 3GPP and further development is combined with 3G development.
- 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 not offering the high worldwide data rates that the third generation systems,

- GSM has initially been deployed in Europe using 890–915 MHz for uplinks and 935–960 MHz for downlinks – this system is now also called **GSM 900**
- **Other** versions comprise GSM at 1800 MHz (1710–1785 MHz uplink, 1805–1880 MHz downlink), also called **DCS (digital cellular system) 1800**, and
- GSM system mainly used in the US at 1900 MHz (1850–1910 MHz uplink, 1930–1990 MHz downlink), also called **PCS (personal communications service) 1900**.
- Two more versions of GSM exist. **GSM 400** is a proposal to deploy GSM at 450.4–457.6/478.8–486 MHz for uplinks and 460.4–467.6/488.8–496 MHz for downlinks.
- A GSM system that has been introduced in several European countries for railroad systems is **GSM-Rail.**
- GSM-R offers 19 exclusive channels for railroad operators for voice and data traffic

- Special features of this system are, e.g., emergency calls with acknowledgements, voice group call service (VGCS), voice broadcast service (VBS). These so-called advanced speech call items (ASCI) resemble features typically available in trunked radio systems only.
- The most sophisticated use of GSM-R is the control of trains, switches, gates, and signals. Trains going not faster than 160 km/h can control all gates, switches, and signals themselves. If the train goes faster than 160 km/h (many trains are already capable of going faster than 300 km/h) GSM-R can still be used to maintain control.
- The coming slides describes the architecture, services, and protocols of GSM that are common to all three major solutions, **GSM 900**, **GSM 1800**, and **GSM 1900**

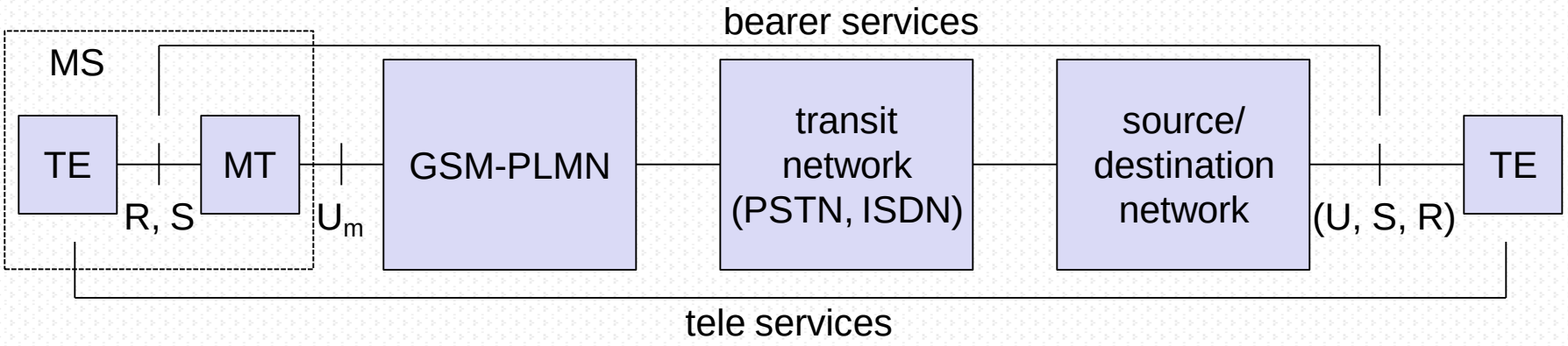
Performance characteristics of GSM

- 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

- 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 permits the integration of different voice and data services and the interworking with existing networks
- GSM has defined three different categories of services: bearer, tele, and supplementary services
- Figure shows a reference model for GSM services
- A **mobile station MS** is connected to the **GSM public land mobile network (PLMN)** via the Um interface. (GSM-PLMN is the infrastructure needed for the GSM network.)



- The **U interface** or **U reference point** is a Basic Rate Interface (BRI) in the local loop of an Integrated Services Digital Network (ISDN), connecting the network terminator (NT1/2) on the customer's premises to the line termination (LT) in the carrier's local exchange, in other words providing the connection from subscriber to central office.
- The **S interface** or **S reference point**, also known as **S_0**, is a user–network interface reference point in an ISDN BRI environment, characterized by a four-wire circuit using 144 kbit/s (2 bearer and 1 signaling channel; 2B+D) user rate.
- The S interface is the connection between ISDN terminal equipment (TE) or terminal adapters (TAs) and an NT1 (network terminator, type 1.)
- **R interface** or **R reference point** defines the point between a non-ISDN device and a terminal adapter (TA) which provides translation to and from such a device.

- This network is connected to transit networks, e.g., **integrated services digital network (ISDN)** or traditional **public switched telephone network (PSTN)**
- There might be an additional network, the source or destination network, before another **terminal TE** is connected.
- **Bearer services** now comprise all services that enable the transparent transmission of data between the interfaces to the network, i.e., S in case of the mobile station, and a similar interface for the other terminal (e.g., S0 for ISDN terminals). Interfaces like U, S, and R in case of ISDN have not been defined for all networks, so it depends on the specific network which interface is used as a reference for the transparent transmission of data. In the classical GSM model, bearer services are connection-oriented and circuit- or packet-switched.
- These services only need the lower three layers of the ISO/OSI reference model

- Within the mobile station MS, the **mobile termination (MT)** performs all network specific tasks (TDMA, FDMA, coding etc.) and offers an interface for data transmission (S) to the terminal TE which can then be network independent.
- Depending on the capabilities of TE, further interfaces may be needed, such as R, according to the ISDN reference model (Halsall, 1996).
- **Tele services** are application specific and may thus need all seven layers of the ISO/OSI reference model. These services are specified end-to-end, i.e., from one terminal TE to another.

- Bearer services
- GSM specifies different mechanisms for data transmission, the original GSM allowing for data rates of up to 9600 bit/s for non-voice services.
- Bearer services permit transparent and non-transparent, synchronous or asynchronous data transmission.
- **Transparent bearer services** only use the functions of the physical layer (layer 1) to transmit data. Data transmission has a constant delay and throughput if no transmission errors occur
- The only mechanism to increase transmission quality is the use of **forward error correction (FEC)**, Depending on the FEC, data rates of 2.4, 4.8, or 9.6 kbit/s are possible.
- **Non-transparent bearer services** use protocols of layers two and three to implement error correction and flow control. These services use the transparent bearer services, adding a **radio link protocol (RLP)**. This protocol comprises mechanisms of **high-level data link control (HDLC)**,

- and special selective-reject mechanisms to trigger retransmission of erroneous data. The achieved bit error rate is less than 10–7, but now throughput and delay may vary depending on transmission quality.
- Data transmission can be full-duplex, synchronous with data rates of 1.2, 2.4, 4.8, and 9.6 kbit/s or full-duplex, asynchronous from 300 to 9,600 bit/s.
- **Tele services**
- as the main service is **telephony**, the primary goal of GSM was the provision of high-quality digital voice transmission, offering at least the typical bandwidth of 3.1 kHz of analog phone systems. Special codecs (coder/decoder) are used for voice transmission.
- other codecs are used for the transmission of analog data for communication with traditional computer modems used in, e.g., fax machines. Another service offered by GSM is the **emergency number. Other services are....**

- A useful service for very simple message transfer is the **short message service (SMS)**, which offer transmission of messages of up to 160 characters.
- **SMS** messages do not use the standard data channels of GSM but exploit unused capacity in the signalling channels.
- Sending and receiving of SMS is possible during data or voice transmission. SMS was in the GSM standard from the beginning
- **Enhanced message service (EMS)**, offers a larger message size (e.g., 76 characters, concatenating several SMs), formatted text, and the transmission of animated pictures, small images and ring tones in a standardized way
- **Multimedia message service (MMS)** was available. MMS offers the transmission of larger pictures (GIF, JPG WBMP), short video clips etc. and comes with mobile phones that integrate small cameras.

Additional services

Non-Voice-Teleservices

fax
voice mailbox
electronic mail

Supplementary services

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