APPLICATION PROGRAMMING: MOBILE COMPUTING [INEA00112W]

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Wireless Telecommunication (W6/2013)

Choose yourself and new technologies

HUMAN CAPITAL
HUMAN – BEST INVESTMENT!

Wrocław University of Technology

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What is Wireless Communication?

Transmitting/receiving voice and data using electromagnetic waves in open space

Types of Wireless Communication:

- Mobile → e.g. mobile phone
- Portable → e.g. wireless interaction between laptop and printer
- Fixed → e.g. Metropolitan Area Network

Milestones – a little of history

1895	→	Guglielmo Marconi first demonstration of wireless telegraphy (digital!)
1928	→	TV broadcast trials
1973	→	Martin Cooper, Motorola, develops first handheld cellular phone
1984	→	CT-1 standard (Europe) for cordless telephones
1991	→	Specification of DECT (Digital European Cordless Telephone) 1880-1900MHz
1992	→	GSM , 900MHz, cellular roaming in Europe, data 9.6kbit/s, FAX, voice,
1997	→	Wireless LAN - IEEE802.11
2000	→	GPRS, WAP, MMS (2.5G)
2001	→	UMTS/CDMA2000 (3G)
2006	→	WiMAX (~4G)
2009	→	LTE (4G)
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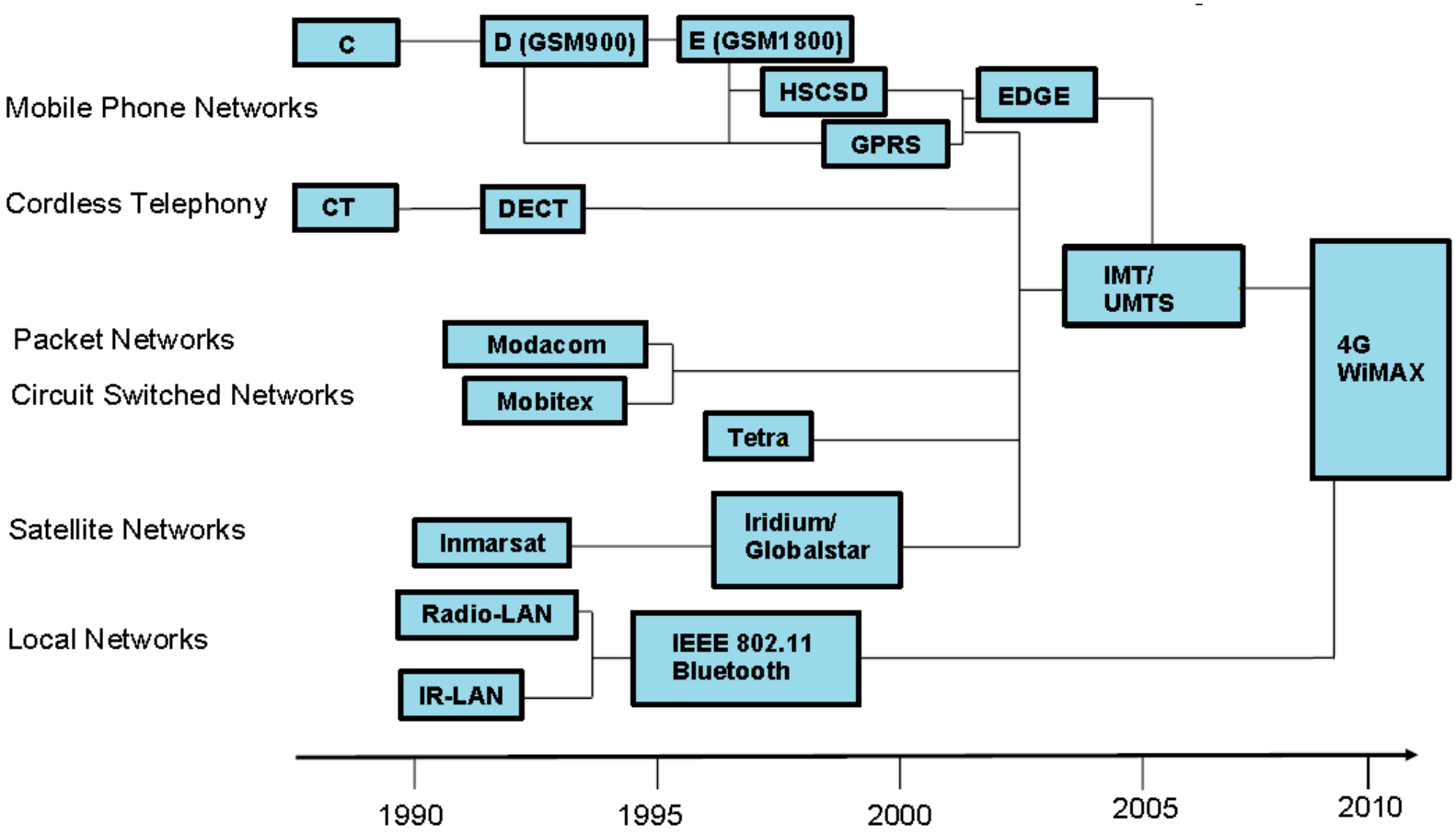
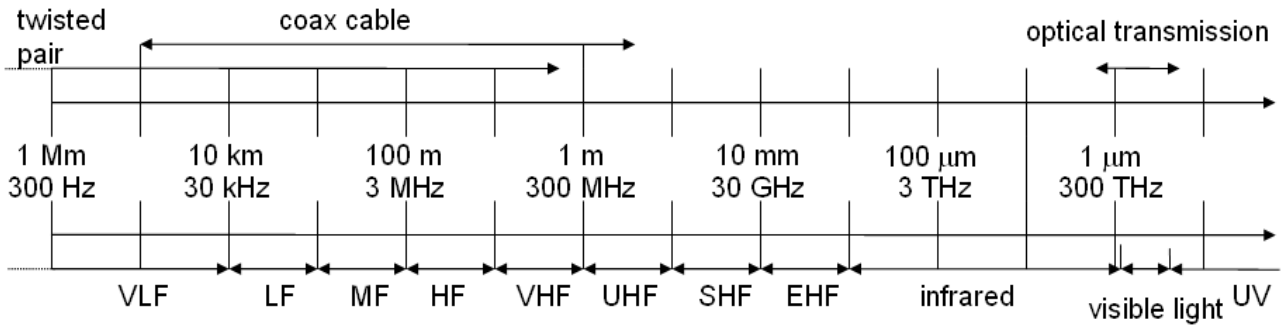
Wireless Evolution Tree

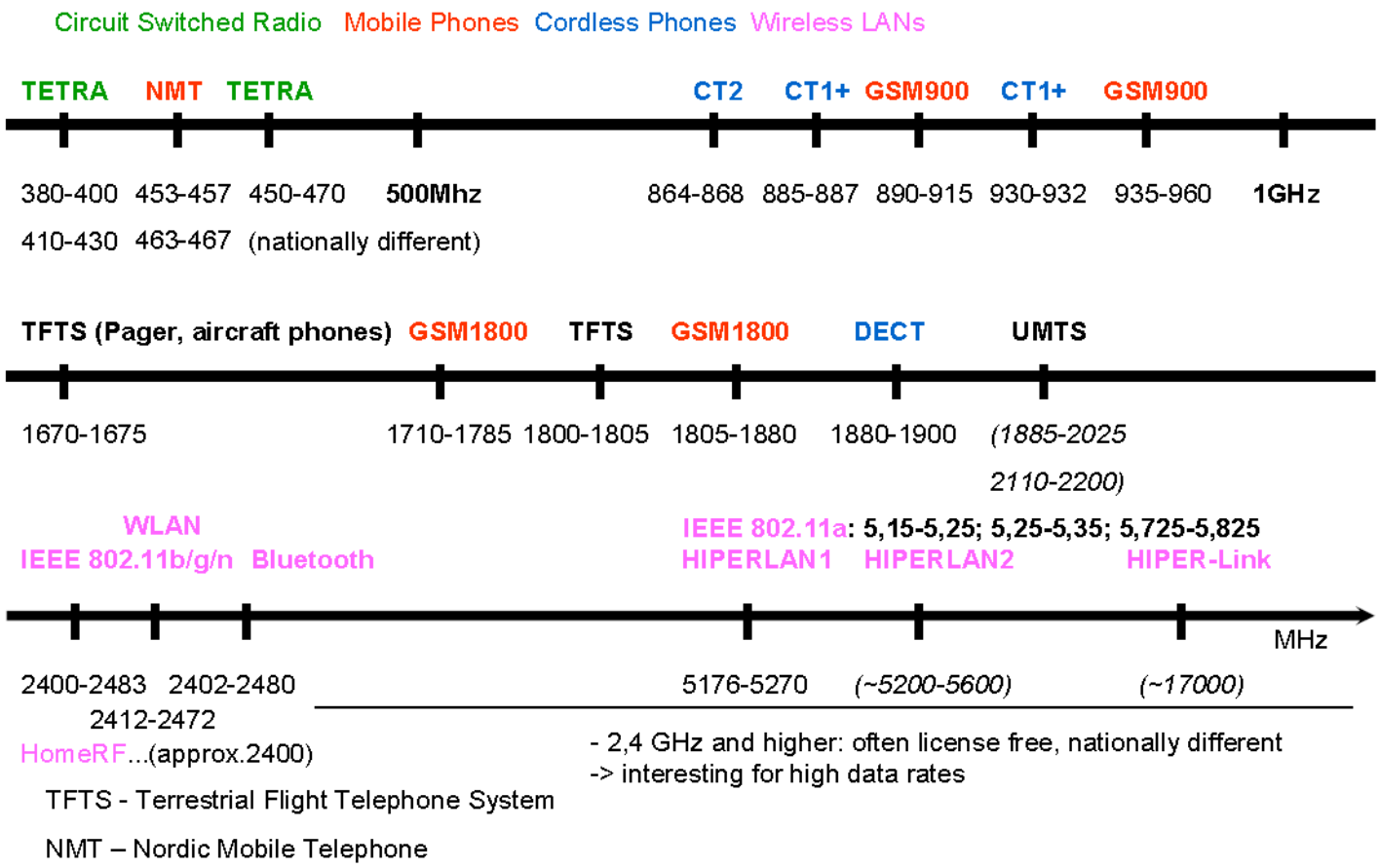


Frequencies for Communication

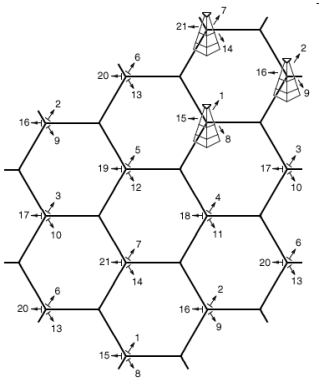


- VHF/UHF (Very High Frequency/Ultra High Frequency)
  → ranges for mobile radio
- SHF (SHF = Super High Frequency) and higher
  → for directed radio links, satellite communication
- Wireless LANs use frequencies in UHF to SHF spectrum

Radio Frequency Assignment



Cellular Networks



- Well known from mobile networks (GSM, UMTS)
- Base station (BS) covers at least one cell,
  a combination of multiple cells is also called a cellular structure
- Provides different kinds of handovers between cells
- Higher capacity and better coverage than non-cellular networks
- Medium Access
  - controls user access to medium
  - implemented by combining and exploiting multiplex methods

Media Access Methods

(SDMA/FDMA/TDMA)

- **SDMA** (Space Division Multiple Access)
  - divide segment space into sectors, use directed antennas,
  - cell structure.
- **FDMA** (Frequency Division Multiple Access)
  - Assign a certain frequency to a transmission channel between a sender and a receiver
  - permanent (e.g., radio broadcast), slow hopping (e.g., GSM), fast hopping (FHSS, Frequency Hopping Spread Spectrum)
- **TDMA** (Time Division Multiple Access)
  - assign the fixed sending frequency to a transmission channel between a sender and a receiver for a certain amount of time
- **Combination**: FDMA and TDMA, for instance in GSM
  - GSM uses combination of FDMA and TDMA for better use of narrow resources

Media Access Methods (2)

(CDMA/MACA)

CDMA (Code Division Multiple Access):

- definite Codes are assigned to transmission channels
  (these can be on the same Frequency for the same Time)
- uses cost-efficient VLSI components
- high security level using spread spectrum techniques
- exact synchronization is required, code of transmitting station must be known to receiving station, noise should not be very high

MACA (Multiple Access with Collision Avoidance):

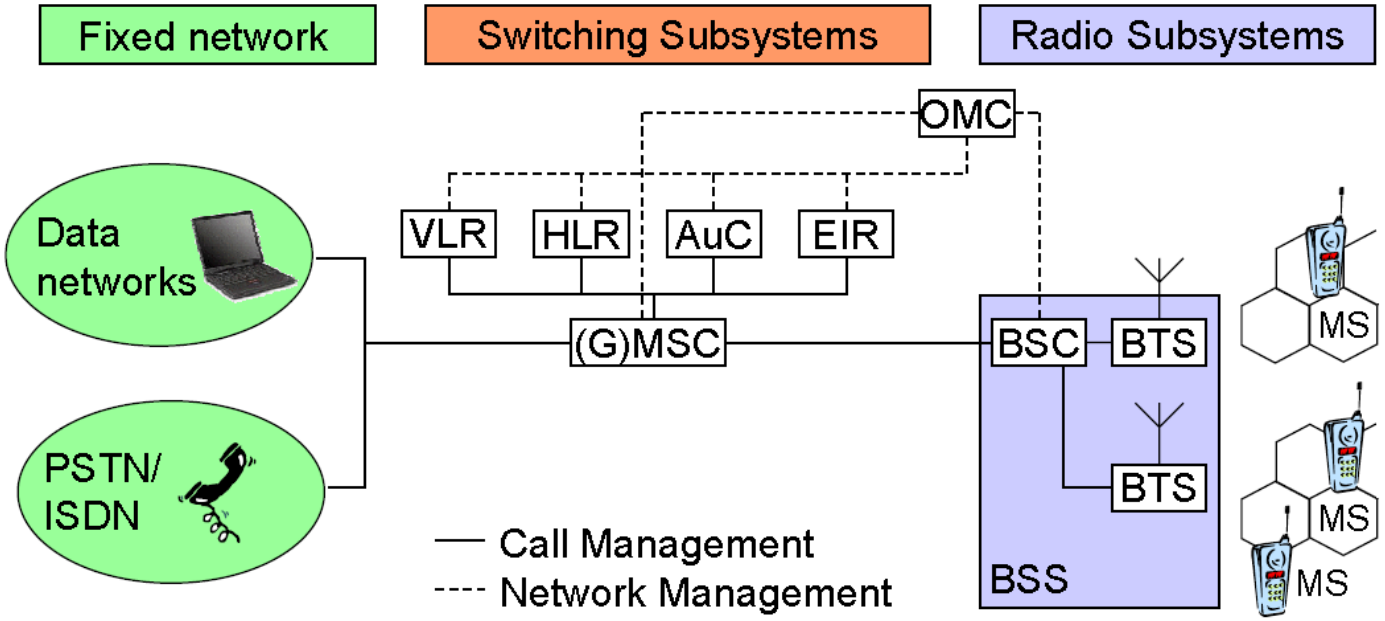
- uses short signaling packets for collision avoidance
- RTS (request to send): a sender requestS the right to send from a receiver
  with a short RTS packet before it sends a data packet
- CTS (clear to send): the receiver grants the right to send as soon as it is ready to receive
- Signaling packets contain
  - sender address
  - receiver address
  - packet size

GSM

(Global System for Mobile Communications)

- Formerly: Groupe Speciale Mobile (founded 1982)
- Now: Global System for Mobile Communication
- Mobile - wireless communication, support for voice and data services (SMS, dial-up Internet)
- Pan-European standard (ETSI, European Telecommunications Standardisation Institute)
- Introduction of services in three phases (1991, 1994, 1996)
- International access, chip-card enables use of access points of different providers
- Security access control - authentication via chip-card and PIN

GSM structure



GSM Data Transmission

- Each GSM-channel configurable as data channel like ISDN
- Data transmission standardized with only 9.6 kbit/s
  - advanced coding allows 14,4 kbit/s
  - not enough for Internet and multimedia applications
- Speech channels have higher priority than data channels
- SMS (Short-Message-Service) – connectionless transmission (160 Byte) on signaling channel
- CB (Cell Broadcast) – connectionless transmission (up to 80 Byte) on signaling channel to all participants in one cell

Short Messaging Service

- Short Messaging Service (SMS) provides a mechanism in GSM for transmitting short messages to and from mobile devices.
- SMS uses a Short Messaging Service Center (SMSC) to store and forward short messages.
- Some of the benefits of SMS:
  - Asynchronous connectionless message transmission
  - Alert / Notification
  - Support for diverse information such as news, sport, etc
  - Delivery of messages to multiple subscribers

GSM Security Aspects

- Access control/authentication
  - user → SIM (Subscriber Identity Module): secret PIN (personal identification number)
  - SIM → network: challenge response method
- Session key generation: Algorithm A8
  - Stored on SIM and in AuC
  - can be determined by network operator
- Anonymity
  - temporary identity TMSI (Temporary Mobile Subscriber Identity)
  - newly assigned at each new location update (LUP)
- Data encryption with algorithm A5:
  - stored in the Mobile Station
  - standardized in Europe and world wide
  - enhancement: A5/3 and 128 Bit key length

Mobility Management

- Mobility management is concerned with:
  - handling connection handoffs
  - tracking mobile devices
  - registering appropriate information in network databases
- Connection Handoff can be done between:
  - channels in the same cell
  - channels in different cells under the same BSS
  - cells under the coverage of different BSSs
  - cells under the coverage of different MSC

GSM - 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)

HSCSD

(High Speed Circuit Switched Data)

- GSM extension for higher data rates
  (evolutionary migration from 2G to 3G → backward compatibility)
- Parallel usage of several time slots limited to one frequency
- Channel bundling with asymmetric transmission
  (1TS Uplink / 3TS or 4 TS Downlink)
- Data rates up to 4 * 14,4 kbit/s = 57,6 kbit/s (theoretically)
- Existing network structure and accounting model maintained,
  only small changes necessary
- Limited international acceptance (Roaming)

GPRS

(General Packet Radio Service)

- GSM extension based on packet switching service and channel bundling based on multiple (1÷8) GSM time slots
- Data rates up to 171,2 kbit/s (theoretical, in practice ≈ HSCSD)
- Dynamic sharing of resources with GSM speech services
- Advantages:
  - billing and accounting according to data volume,
  - „always on" data service (Internet, email, etc.)
  - more suitable carrier for services like WAP
- Disadvantage: more investment needed

EDGE

(Enhanced Data rates for GSM Evolution)

- New air interface to enable 3G data rates
  - Edge uses 8-PSK within the existing GSM slot structure.
  - Each GSM slot has a maximum data rate of 59 kbps
  - This is more than three times the maximum of GPRS
- Obtaining these data rates depends on the quality of the signal between the base station and the mobile device
- Thus to achieve the above mentioned data rates a higher concentration of base stations are needed to ensure signal quality (only urban or suburban areas)

3G

(third generation cellular networks)

- The goal of 3G is to provide higher data rates than existing 2G system
- 3G Partnership Project (3GPP) was formed to coordinate the specification of the 3G standard:
  - European Telecommunication Standard Institute
  - Telecommunication Technology Committee (Japan)
  - T1 (Standardisation Telecommunications Committee) US
  - Standardisation organisation from Korea and China
- In Europe - UMTS (Universal Mobile Telecommunications System) implementation of IMT (International Mobile Telecommunications) by ETSI (European Telecommunication Standards Institute)
- Known as IMT2000 in Japan and US

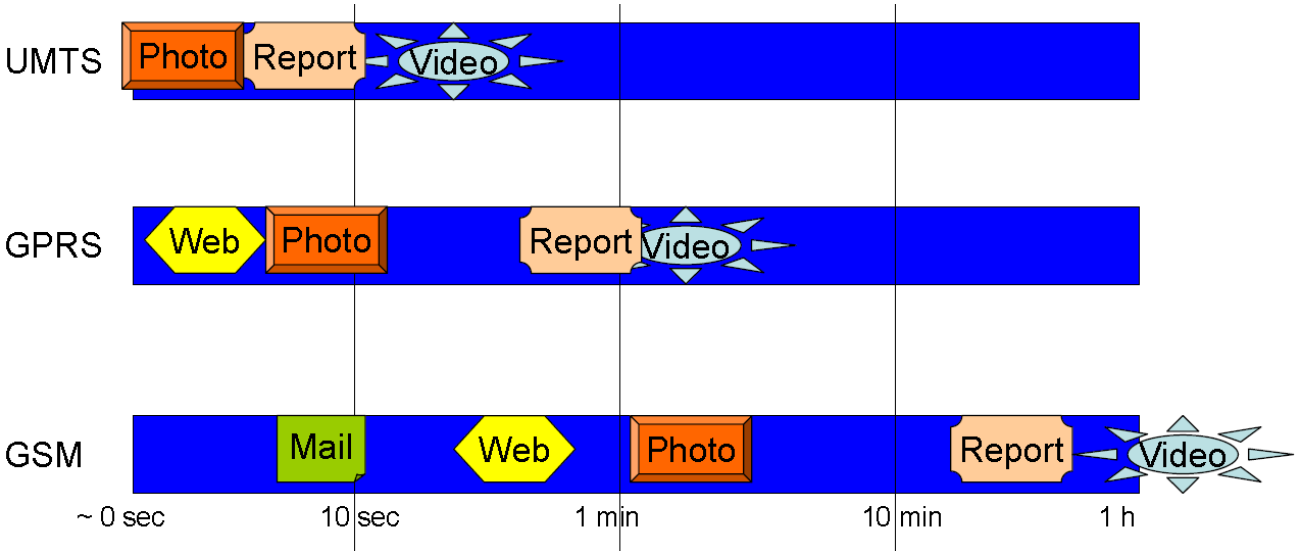
UMTS

(Universal Mobile Telecommunications System)

- Voice traffic expected to decline with increased use of data - Internet based applications.
- UMTS provides relatively high data rates:
  - 144 kbit/s mobile (rural outdoor),
  - up to 2 Mbit/s in local area (urban indoor)
- Data traffic is typically asymmetric $\rightarrow$ UMTS provides asymmetrical data rates on up-/downlink, use of CDMA
- integration of different mobile radio communications, wireless and pager-systems into one common system
- information services independent of network access
- Roaming between UMTS, GSM/GPRS and satellite networks

UMTS – Performance

(compared with GSM/GPRS)



High-performance is usually limited to urban areas, otherwise GPRS has to be used

HSDPA

(High-speed Downlink Packet Access)

- extension of UMTS
- Data rates up to 14,4 Mbit/s (10,8 Mbit/s with errorcorrection encoding) on downlink channel
- Combination of channel bundling (TDMA), wideband code multiplex (W-CDMA) and improved coding (adaptive modulation and coding with advanced scheduling)
- Separate control channel
- Basis for mobile internet and mobile multimedia applications (videophone, movies, games etc.)

Comparison of wireless/tele communication technologies