TECHNISCHE UNIVERSITÄT DRESDEN

Department of Computer Science Institute for System Architecture, Chair for Computer Networks

UMTS: Universal Mobile Telecommunications System

Mobile Communication and Mobile Computing

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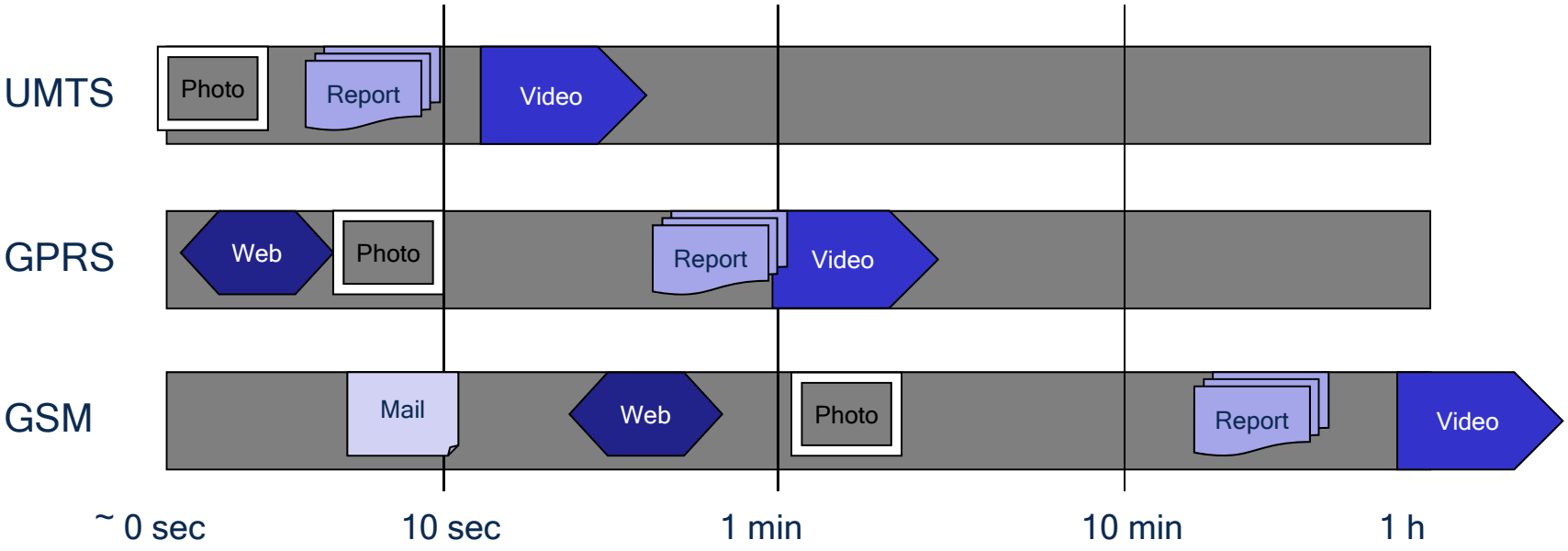
http://www.rn.inf.tu-dresden.de

UMTS: Characteristics

- UMTS is the European implementation of IMT (International Mobile Telecommunications) by ETSI (European Telecommunication Standards Institute)
- relatively high data rates: 144 kbit/s mobile, up to 2 Mbit/s in local area (and even higher with advanced extension protocols)
- integration of different mobile radio communications-, wireless- and pager-systems into one common system
- speech-, data-, and multimedia- information services independent of network access
- support of different carrier services:
  - real-time capable / not real-time capable
  - circuit switched / packet switched
- Roaming also between UMTS, GSM/GPRS and satellite networks
- Asymmetrical data rates on up-/downlink, use of CDMA

UMTS - Performance

Transmission	Real- time (Video)	Non Real-time (SMS etc.)
Bit error rate	10^{-3} … 10^{-7}	10^{-5} … 10^{-8}
Permitted delay	20ms … 300ms	> 150 ms



source: Mobilkom Austria

UMTS - Hardware

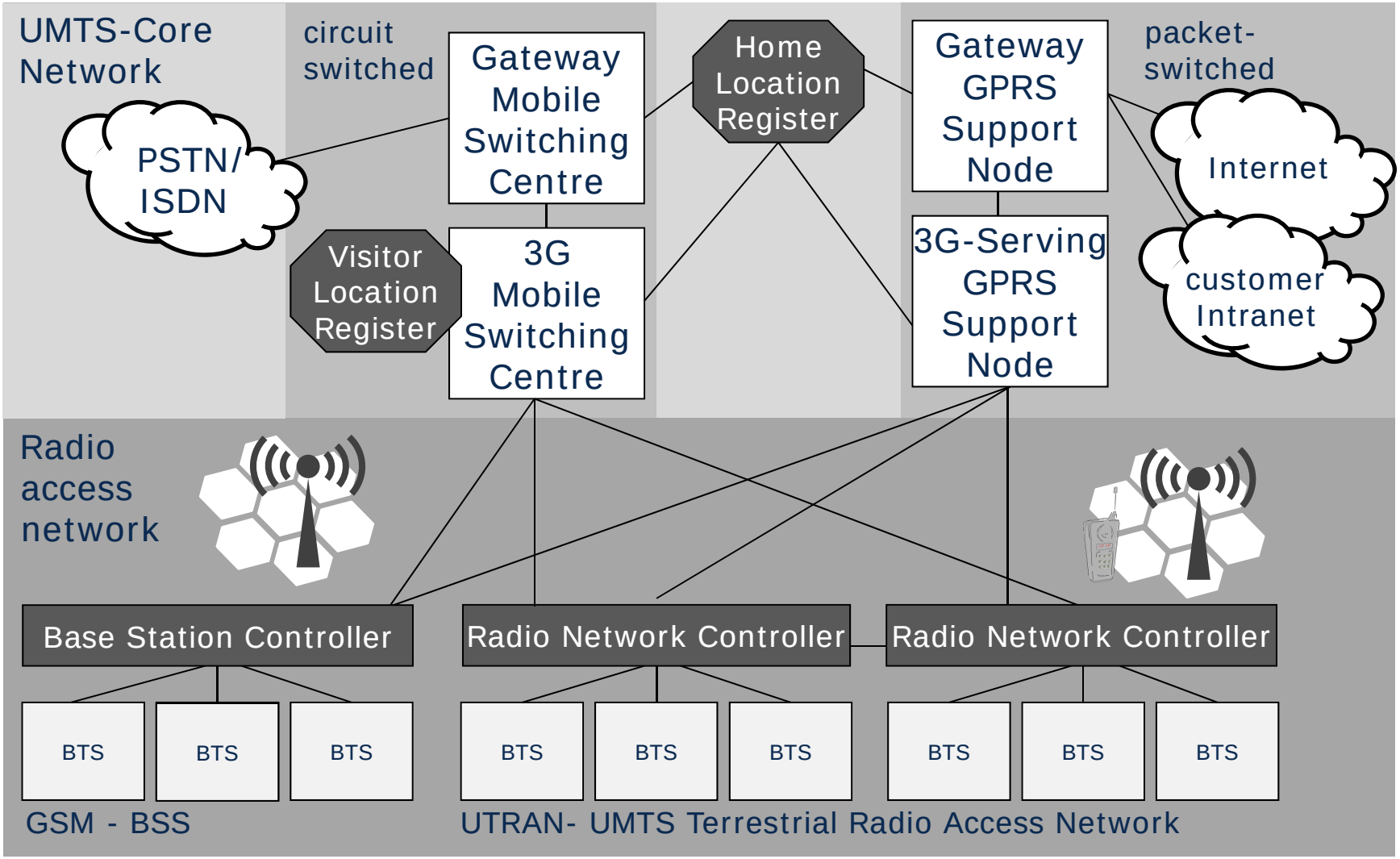
- big color displays
- high resolution
- True Color
- multitouch

Examples: Nokia, Apple, Blackberry

UMTS/WLAN-Router

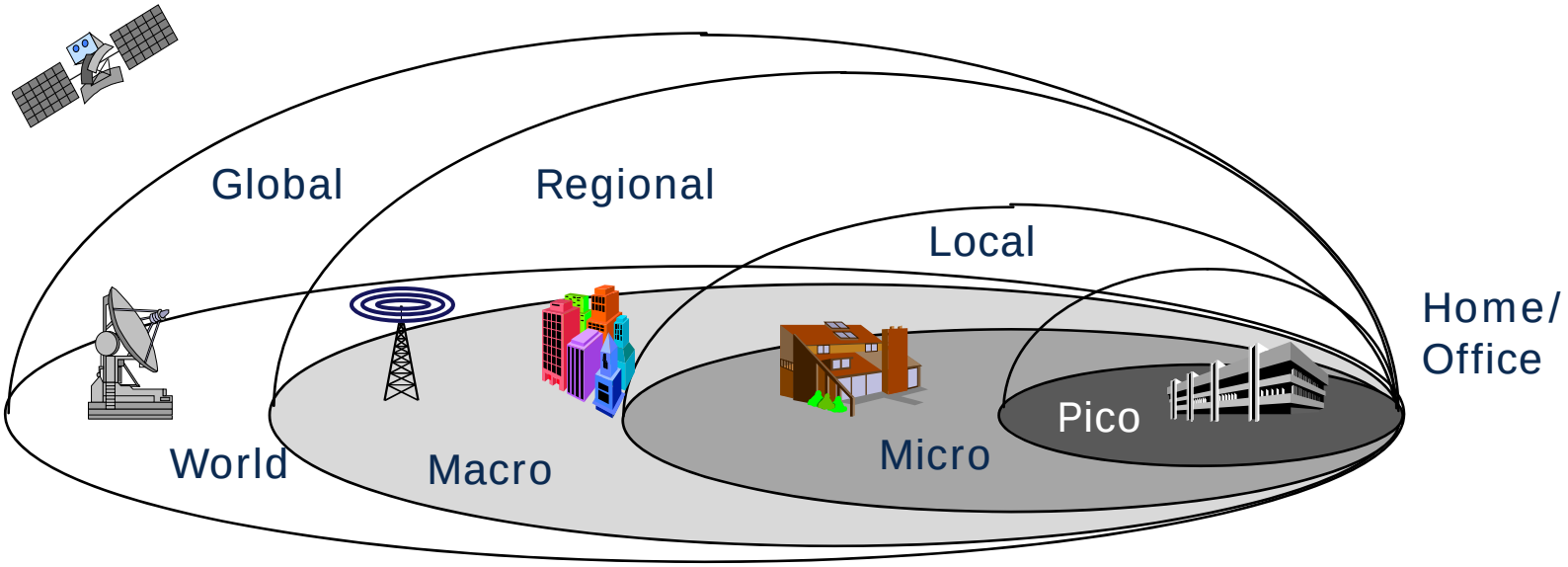
with 300 MBit/s W-LAN-Hotspot
PC Card Slot for Vodafone Mobile Connect Card UMTS
4 Port Ethernet Switch local networks

UMTS Network Structure



source: Mobilkom Austria

UMTS: Hierarchical Cell Structure



	expansion	Data rate (kbit/s)	Max. velocity (km/h)	Special features
World Cell	global	-		no UTRAN, special satellite technology
Macro Cell	several km	144	>300	complete national wide-area UMTS support
Micro Cell	several 100m	384	~100	Greater cities, commonly used
Pico Cell	ca. 100 m	2000	~10	„Hotspots“ – e.g. airport, station

Service concept

Virtual Home Environment (VHE)

- services are freely configurable, configuration globally available
- selection of service quality and corresponding costs
- behavior in case of bottlenecks (data rates, etc.) configurable
- dynamic adaptation according to connection quality

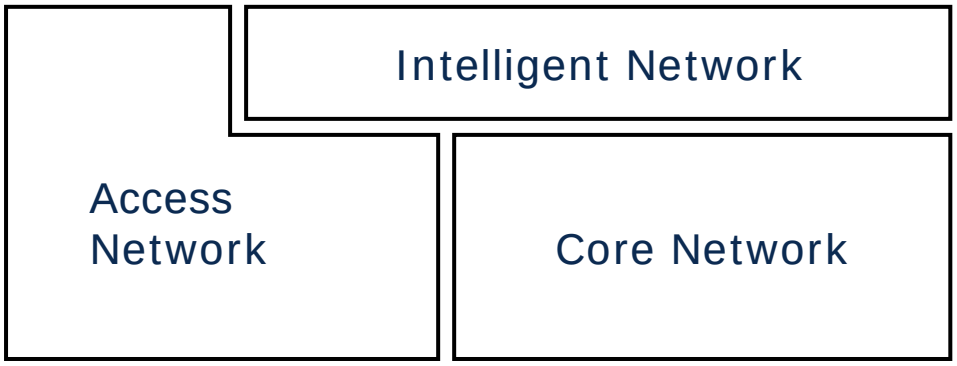
UPT: Universal Personal Telecommunication Service

- one phone number for several devices (Call-Management)
- subscriber localization e.g. based on SIM-card
- call forwarding; virtual mobility by changing between devices

UMTS: Basic Network Structure

- Access Network: base stations, responsible for radio transmission to mobile end devices
- Core Network (Fixed Network): responsible for internal connections
- Intelligent Network (IN): responsible for billing, subscriber localization, roaming, handover, added-value services (voice mailbox, video conferencing etc.)

User Equipment (UE)



General reference architecture

- **UTRA: UMTS Terrestrial Radio Access**
  - UTRAN (UTRA-Network) contains several Radio Network Subsystems (RNS) and contains functions for mobility management
  - RNS controls handover at cell change, implements functions for encoding and administrates the resources of the radio interface
  - U_u connects UTRAN with mobile end devices, so called User Equipment (UE), is comparable with U_m in GSM
  - UTRAN is connected over I_u with the Core Network, comparable with the GSM interface between BSC and MSC
  - CN contains the interfaces to other networks and mechanisms for connection handover to other systems

UMTS-radio interface UTRA (UMTS Terrestrial Radio Access)

Two modes defined:

UTRA/FDD (Frequency Division Duplex)

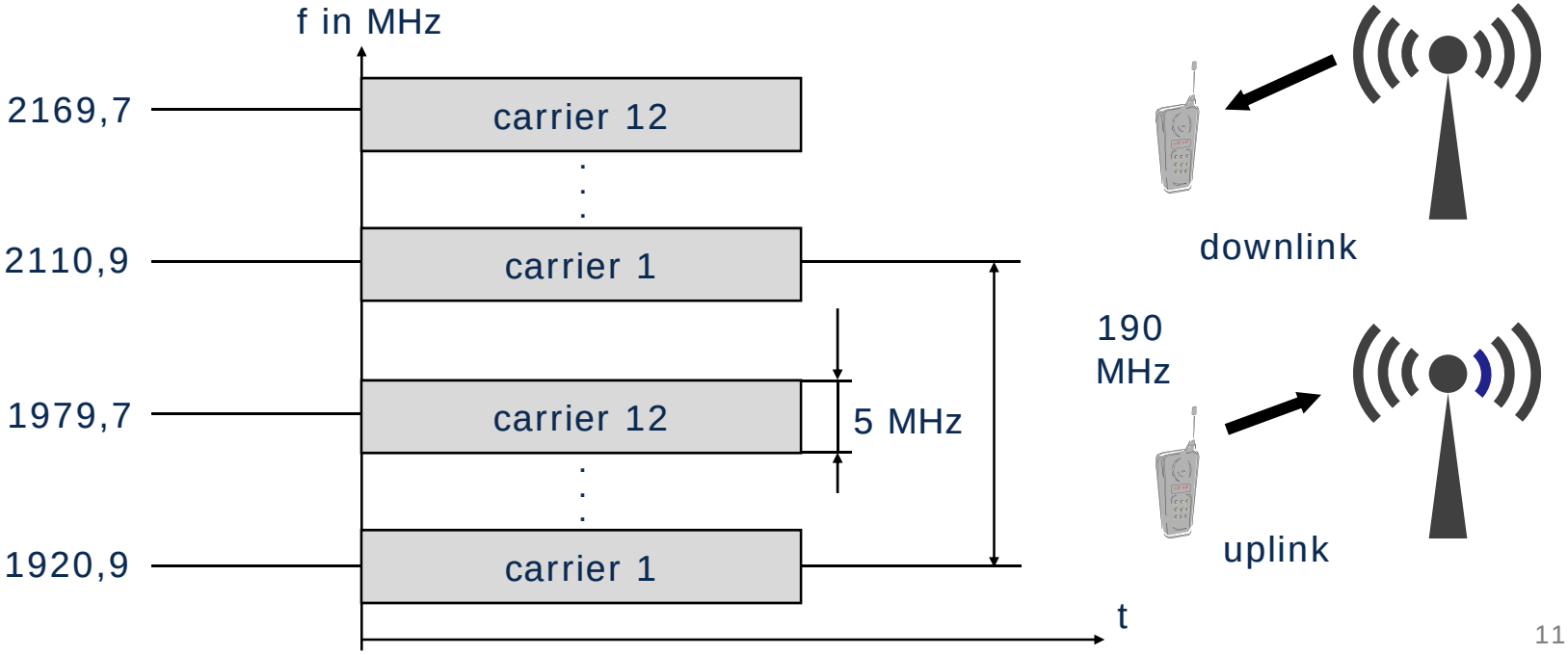
- mainly in suburban areas for symmetrical transmission of speech and video
- data rates up to 384 kbit/s, supra-regional roaming
- for circuit- and packet switched services in urban areas

UTRA/TDD (Time Division Duplex)

- mainly in households and other restricted areas (company premises, similar to DECT)
- for broadcast of speech and video, symmetrical: up to 384 kbit/s
- also asymmetrical: up to 2 Mbit/s

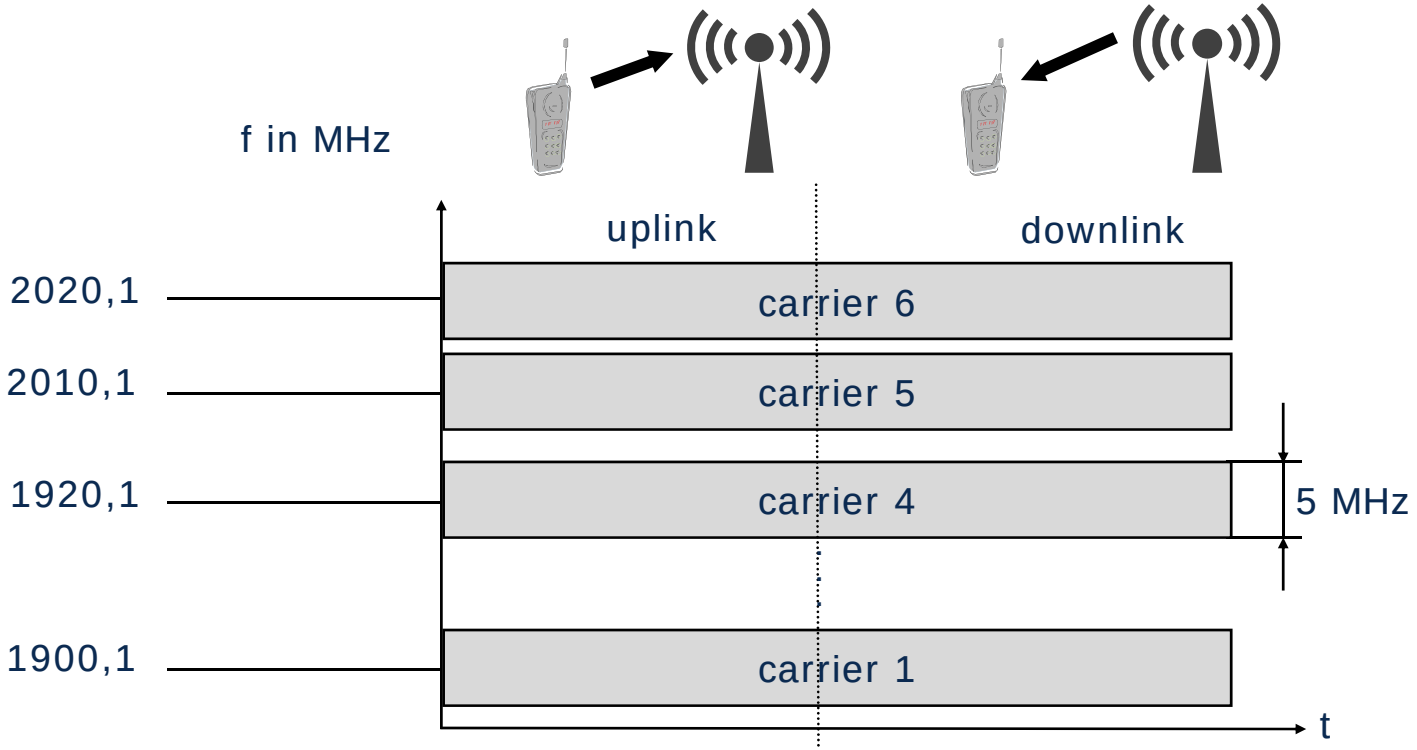
UTRA/FDD

- integrates wideband-CDMA (W-CDMA) and DSSS (Direct Sequence Spread Spectrum)
- channel separation by carrier frequencies, spreading code and phase position (only uplink)
- approx. 250 channels, data rates up to 384 kbit/s
- complex performance control necessary



UTRA/TDD

- integrates wideband-TDMA/CDMA and DSSS
- sends and receives on same carrier (TDD)
- approx. 120 channels, data rates up to 2 Mbit/s
- channel separation by spread code and time slots
- precise synchronization necessary



UMTS Enhancement: HSPA

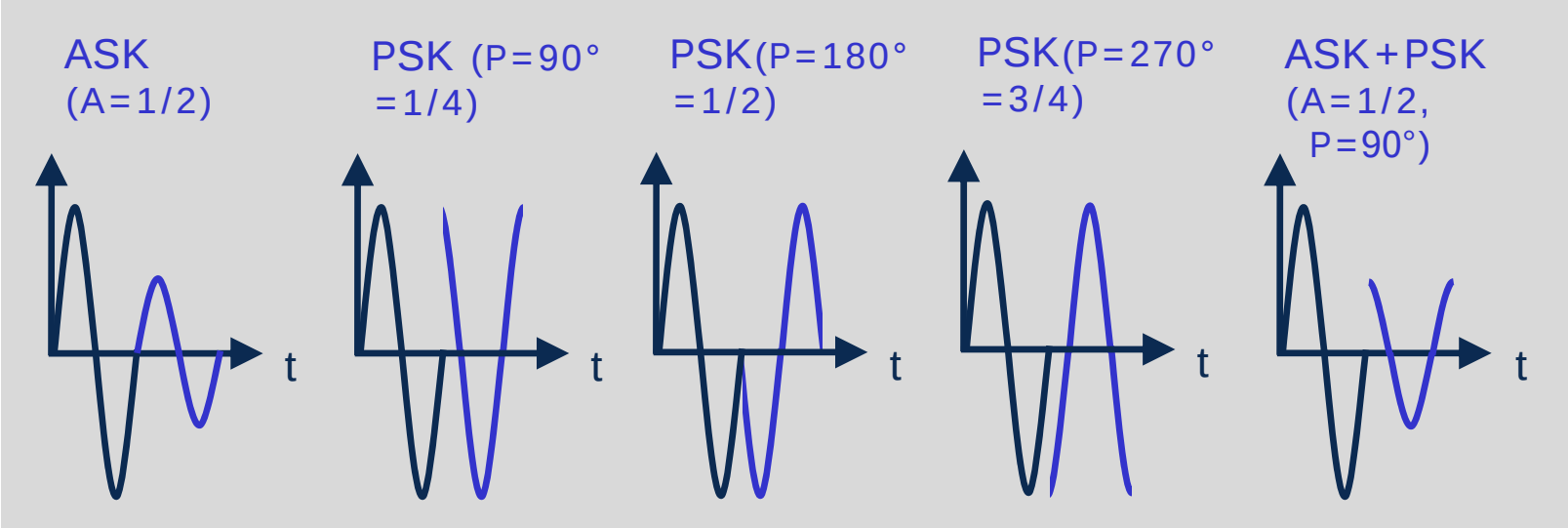
- **HSPA** (High-speed Packet Access) = **HSDPA**+**HSUPA**
- **HSDPA** (High-speed Downlink Packet Access), extension of UMTS
- Data rates up to 14,4 Mbit/s (10,8 Mbit/s with error-correction encoding) on downlink channel
  (even higher rates proposed for the future and tested under lab conditions)
- Combination of channel bundling (TDMA), wideband code multiplex (W-CDMA) and improved coding (adaptive modulation and coding with advanced scheduling)
- adaptive switching between 4 QAM (quadrature amplitude modulation) and 16 QAM (depending on channel quality)
- **HSUPA** (High-speed Uplink Packet Access) for upload

UMTS Enhancement: HSPA+

- **HSPA+** further enhancement of UMTS
- Data rates up to 28 Mbit/s on downlink channel
- Speed-up reached via 64 QAM and MIMO (multiple input / multiple output)
- Same as in HSPA:
  - Separate control channel
  - Basis for mobile internet and mobile multimedia applications (videophone, movies, games etc.)

HSPA+: Modulation basics of QAM

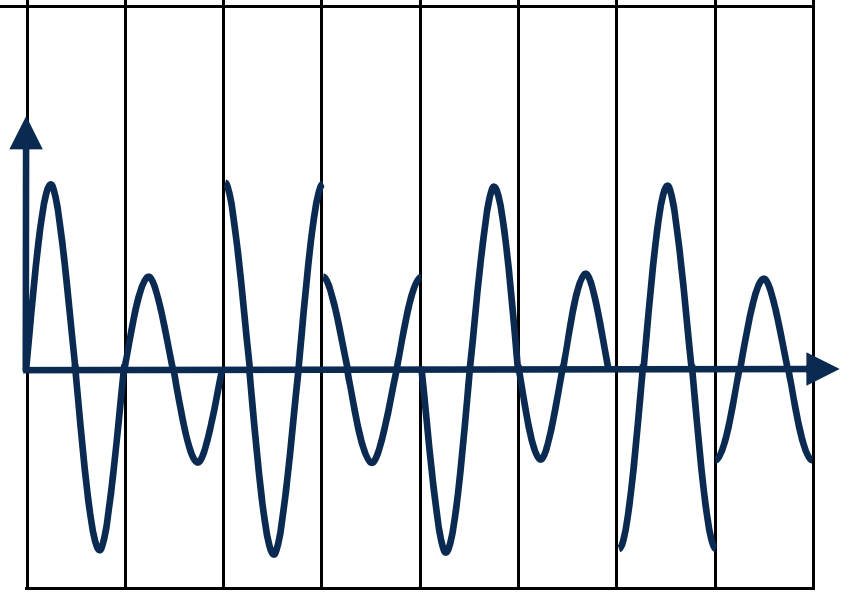
QAM (Quadrature Amplitude Modulation) is a combination of Amplitude Shift Keying **ASK** and Phase Shift Keying **PSK**



HSPA+: Modulation basics of QAM

- 8 QAM example: (3bits)

Bit value	**000**	**001**	**010**	**011**	**100**	**101**	**110**	**111**
Amplitude	1	1/2	1	1/2	1	1/2	1	1/2
Phase Shift	No	No	1/4	1/4	1/2	1/2	3/4	3/4

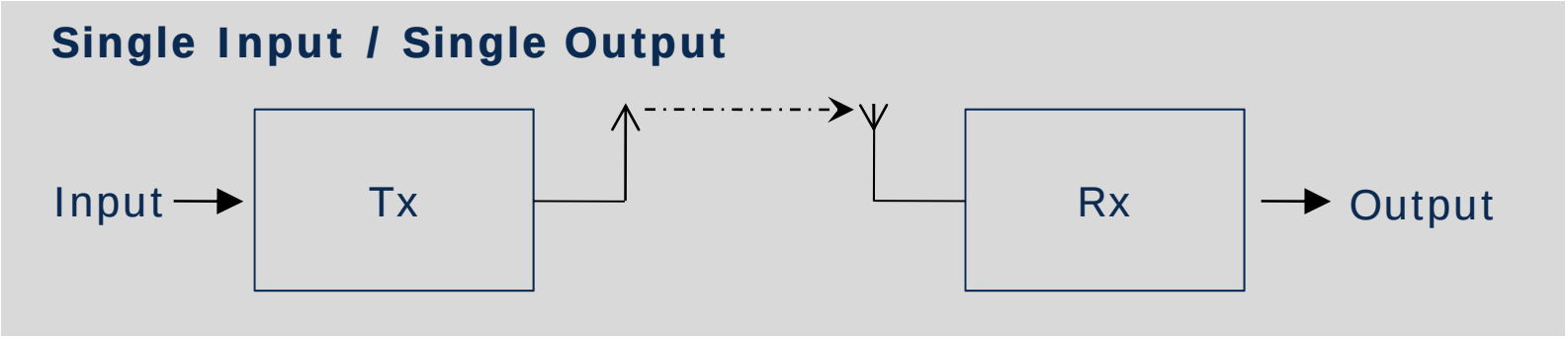


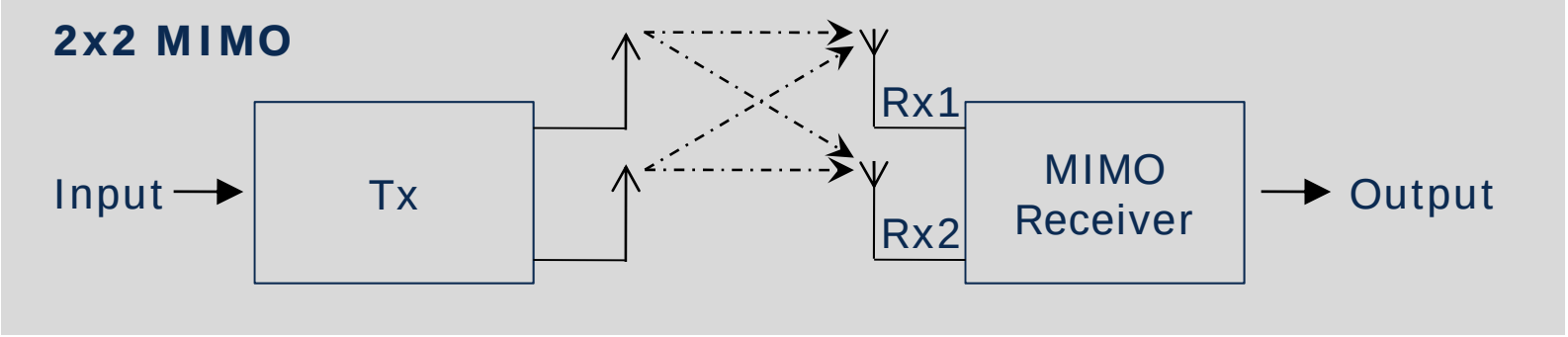
- In case of 8 QAM the 8 conforms to the highest possible number of codable states (the sensitivity to interference increases with the number of states)

* Quadrature Phase Shift Keying = 4 QAM (no info from amplitude) source: Fujitsu

HSPA+: MIMO antenna technique

- MIMO = Multiple Input / Multiple Output
- multiple antennas on sender and receiver side
- increase in spectral efficiency (and resulting data rate) and quality of transmission

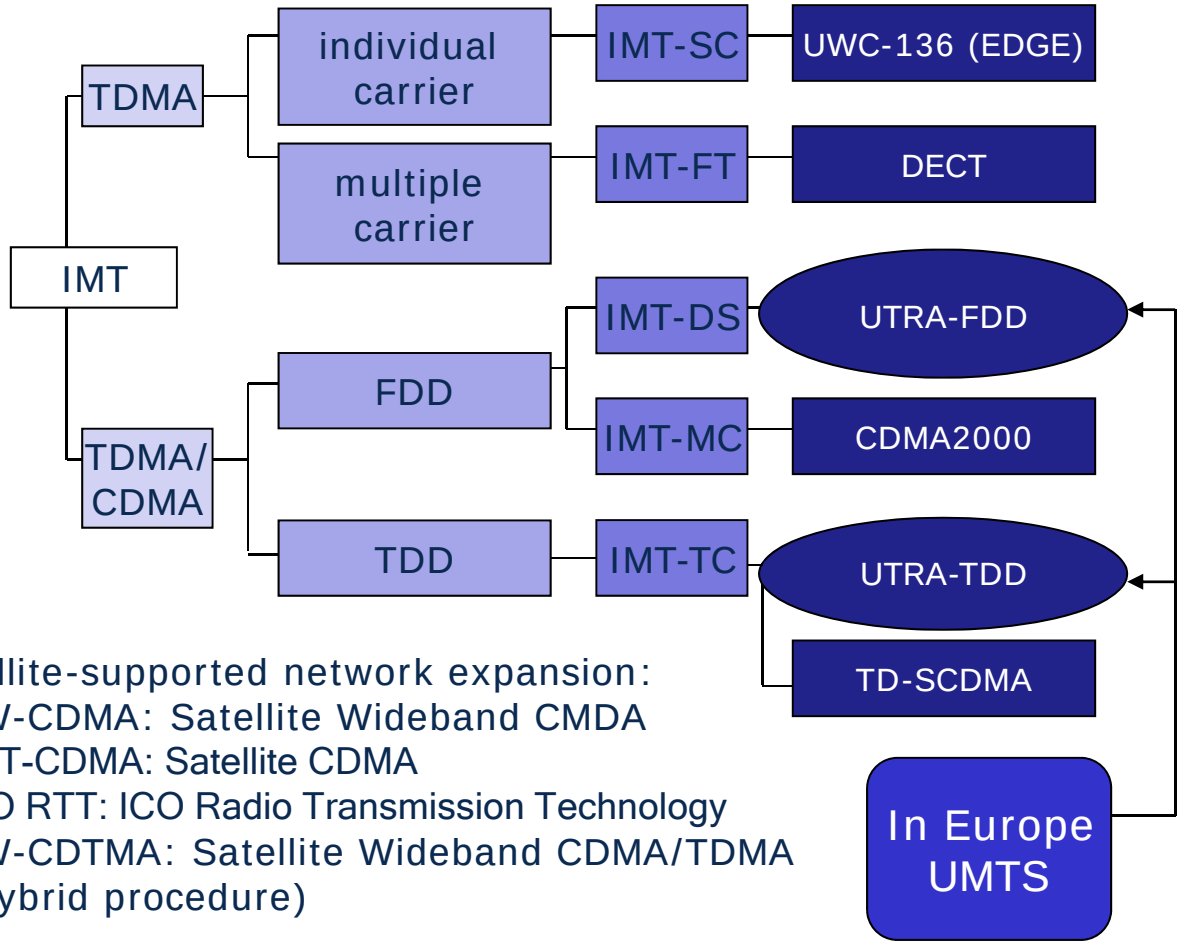




LTE: Long Term Evolution

- Further extension of HSDPA with even higher data rates and – nevertheless – compatibility with UMTS
- Use of OFDM (Orthogonal Frequency Division Multiplex) and MIMO (Multiple Input – Multiple Output Antennas); for details see the following chapter
- Flexible channel bandwidths ranging from 1.4 MHz to 20 MHz (UMTS: static bandwidth of 5 MHz per channel); therefore better adaptation to user requirements
- Data rates: up to 300 MBit/s downlink and 75 MBit/s uplink; very low latency under 5 ms
- Official standard with implementations by several providers worldwide

IMT - Structure



- 3 systems
  - UMTS
  - CDMA2000
  - UWC-136
- 2 core technologies
  - TDMA
  - TDMA/CDMA

IMT family of radio interfaces :

- IMT-DS (Direct Spread)
  - UTRA-FDD (UMTS)
- IMT-MC (Multi Carrier)
  - CDMA2000, USA
- IMT-TC (Time Code)
  - UTRA-TDD (UMTS), TD-SCDMA (Synchronous Code Division Multiple Access, China)
- IMT-SC (Single Carrier)
  - UWC-136, USA
- IMT-FT (Frequency time)
  - DECT

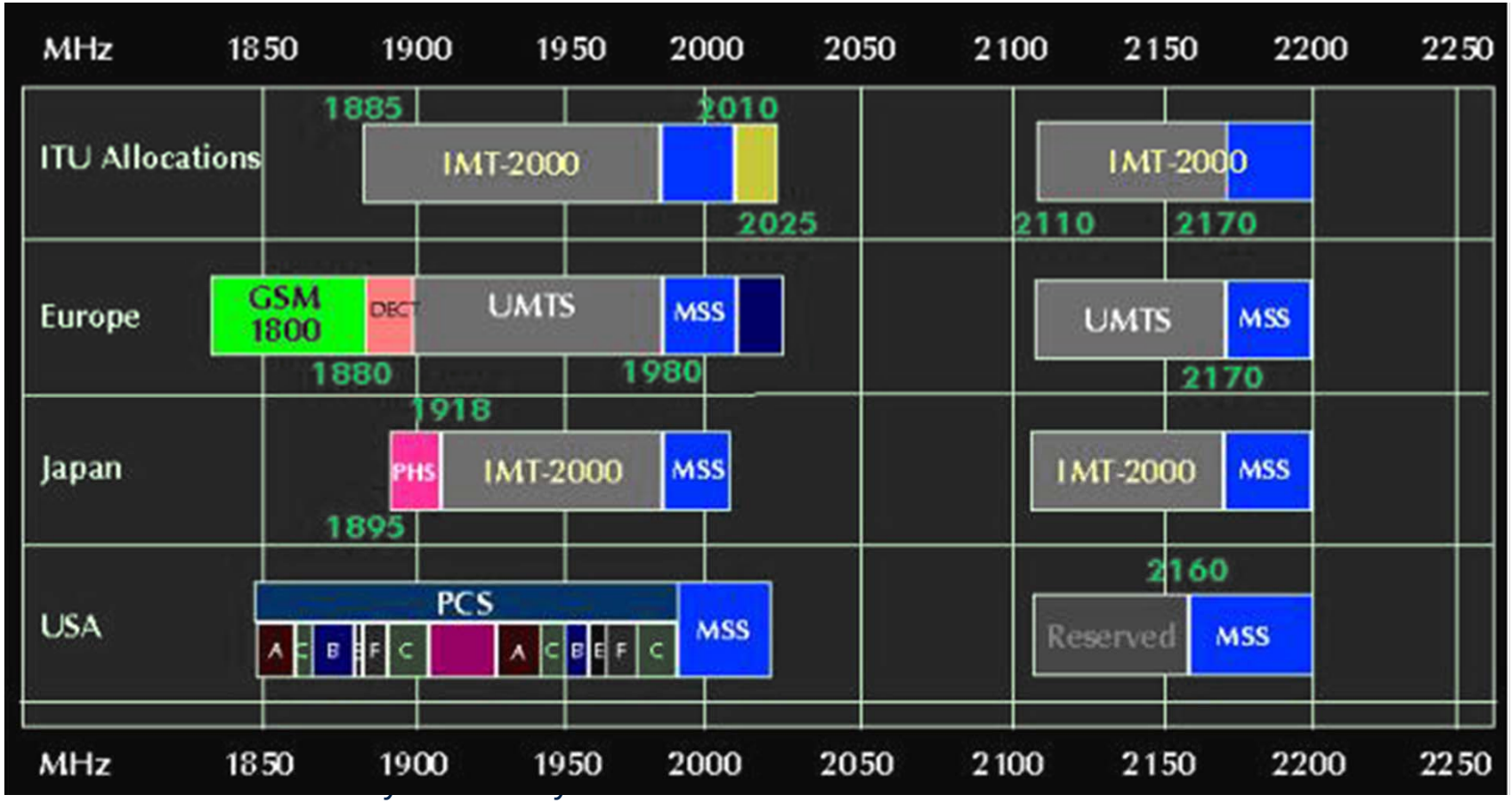
Satellite-supported network expansion:
- SW-CDMA: Satellite Wideband CMDA
- SAT-CDMA: Satellite CDMA
- ICO RTT: ICO Radio Transmission Technology
- SW-CDTMA: Satellite Wideband CDMA/TDMA (Hybrid procedure)

ICO RTT... Standard by ICO Global Communications
IMT ... International Mobile Telecommunications
UTRA ... Universal Terrestrial Radio Access
UWC ... Universal Wireless Communications

source: www.UMTS-Report.com

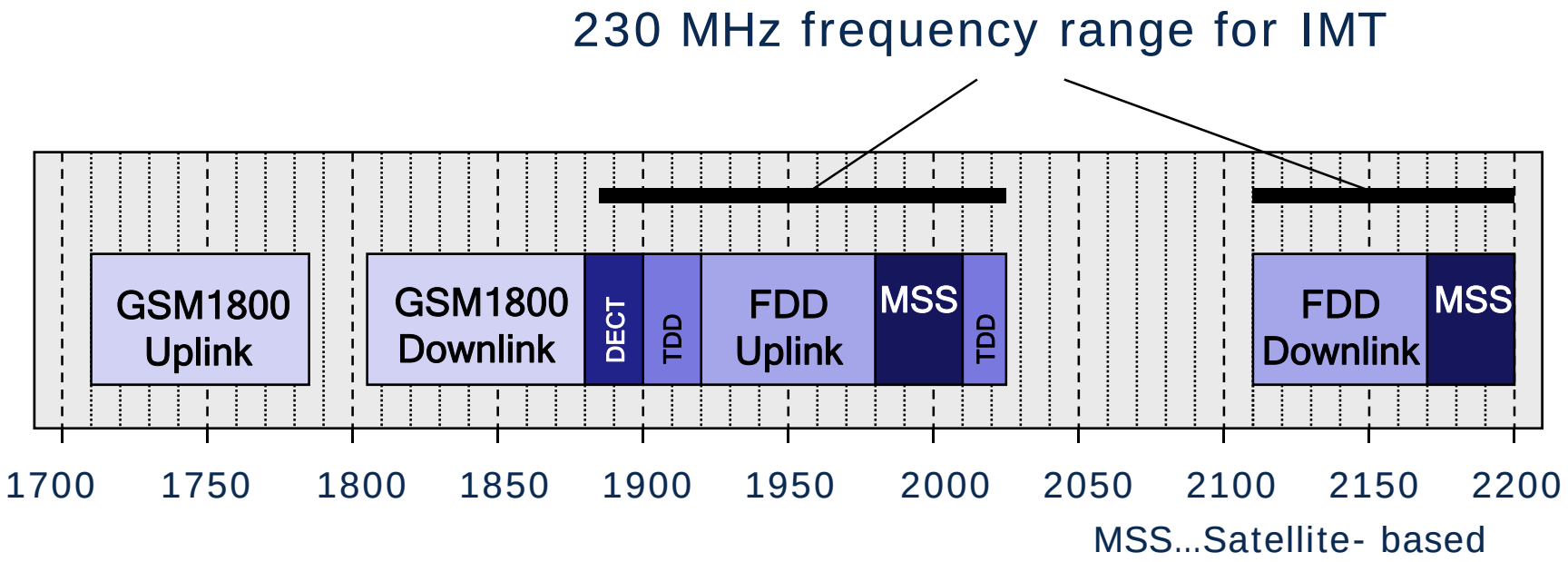
Worldwide frequency assignment for IMT

• developed by ITU



PCS... Personal Communication System

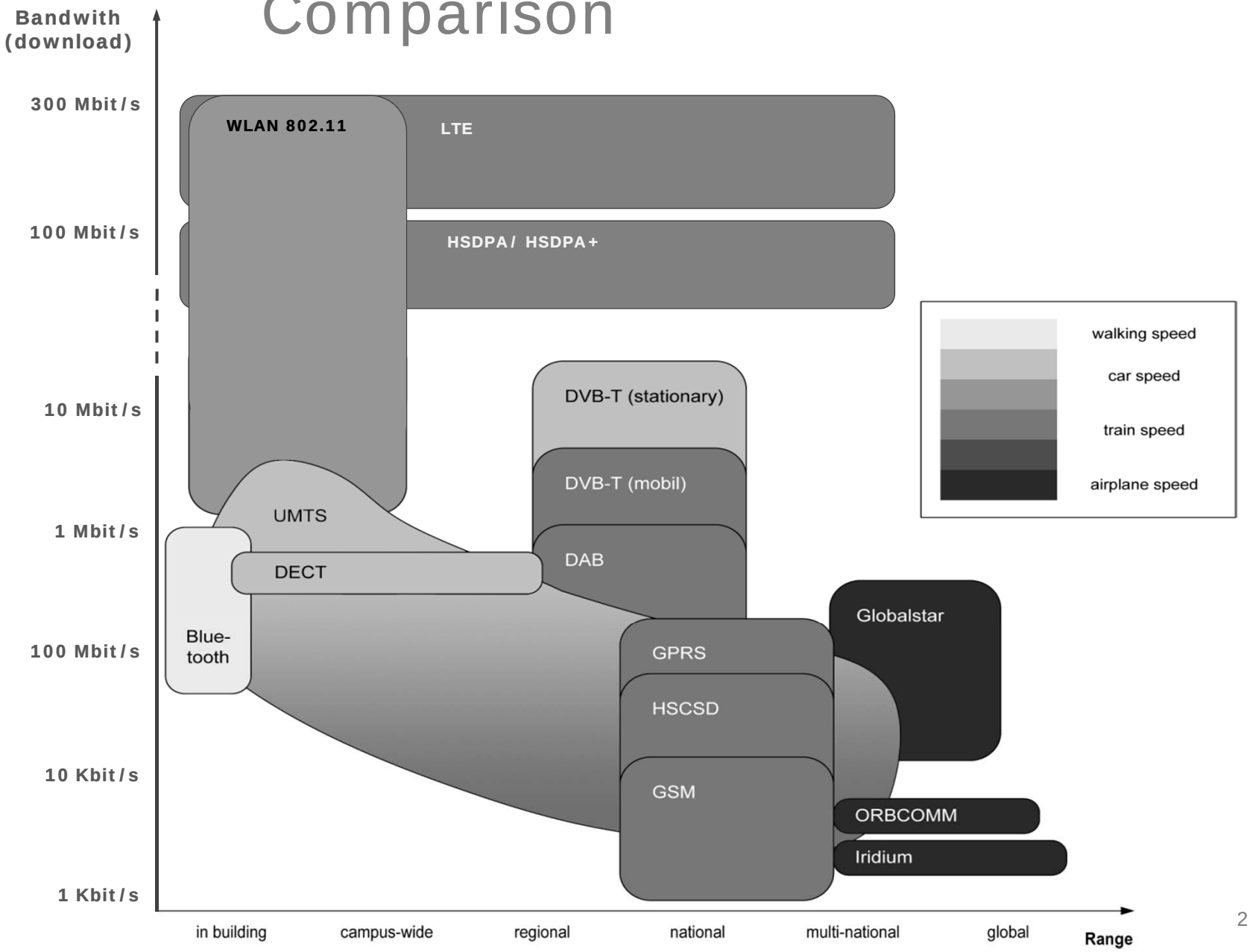
Frequency Assignment in Europe



- with **FDD** symmetrical spectrum is necessary, not with **TDD** (time slots at same frequency)
- gradual assignment of new wavebands - up to 300-500 MHz additional frequency range, e.g. in the 2.5-3 GHz area, but also in the 900 MHz band (as a gradual replacement of GSM)

source: www.UMTS-Report.com

Comparison


Bandwith (download)
300 Mbit/s
100 Mbit/s
10 Mbit/s
1 Mbit/s
100 Mbit/s
10 Kbit/s
1 Kbit/s
WLAN 802.11
LTE
HSDPA/ HSDPA+
DVB-T (stationary)
DVB-T (mobil)
DAB
UMTS
DECT
Blue-tooth
GPRS
HSCSD
GSM
Globalstar
ORBCOMM
Iridium
walking speed
car speed
train speed
airplane speed
in building
campus-wide
regional
national
multi-national
global
Range

UMTS: Summary

- After delayed implementation and introduction, UMTS caught up and is now widely used, especially for business applications
- High-performance service is mainly limited to urban areas, otherwise GPRS has to be used
- Worldwide accessibility can be realized only with multimode end devices (e.g. combining different CDMA variants)
- even in Europe, combined UTRA-FDD/UTRA-TDD/GPRS devices are necessary (however, this imposes no major hardware problems)
- Typical alternatives to UMTS are WLAN, LTE and WiMAX

Data rate enhancement: Summary

- Usage of improved transmission schemes such as 16QAM or 64QAM (quadrature amplitude modulation, with phase shift keying)
- CDMA to offer more channels in parallel
- Bundling of time slots, especially for downlink, in combination with asymmetric TDD
- Smaller (pico) cells, i.e. less participants compete for the same resources

+ enhancement in latency (GPRS: 700 ms, UMTS: 200-300 ms, HSPA: 100 ms, LTE: 5 ms)

Some further readings

- 3GPP (3rd generation partnership program):
  www.3gpp.org

- UMTS background information:
  www.umtsworld.com
  www.umtslink.at