Mobile Communications
Chapter 11 : Outlook

Mobile and wireless services – Always Best Connected

- **LAN, WLAN**: 100 Mbit/s
- **GSM 53 kbit/s**, **Bluetooth 500 kbit/s**
- **LTE, UMTS**: 2 Mbit/s
- **LAN**: 100 Mbit/s, **WLAN**: 54 Mbit/s
- **UMTS**: 2 Mbit/s
- **GSM/EDGE**: 384 kbit/s, **WLAN**: 5 Mbit/s
- **GSM 115 kbit/s**, **WLAN**: 11 Mbit/s
- **LTE**: 10 Mbit/s
Wireless systems: overview of the development

1981: NMT 450
1988: NMT 900
1992: GSM
1994: DCS 1800
1991: CDMA
1991: D-AMPS
1993: PDC
1992: Inmarsat-A
1998: Iridium
1991: DECT
1980: CT0
1984: CT1
1987: CT1+
1988: CT 2
1997: IEEE 802.11
1999: 802.11b, Bluetooth
2000: IEEE 802.11a

1989: CT 2
1991: DECT
1991: D-AMPS
1991: CDMA
1993: PDC
1998: Iridium
1992: Inmarsat-B Inmarsat-M
2001: IMT-2000
2000: GPRS

1982: Inmarsat-A
1998: Iridium
1992: Inmarsat-B Inmarsat-M
2001: IMT-2000
2000: GPRS

analogue
digital

1987: CT1+
1988: Inmarsat-A
1982: Inmarsat-A
1992: GSM
1988: AMPS
1993: PDC
1991: D-AMPS
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4...4.5...5G – fourth to fifth generation: when and how?
Currently rather 3.9 to 4G
Overlay Networks - the global goal

integration of heterogeneous fixed and mobile networks with varying transmission characteristics

vertical handover

horizontal handover

regional

metropolitan area

campus-based

in-car, in-house, personal area
Wireless access technologies

- **LTE**
- **DAB**
- **802.11a/g/n/ac**
- **DECT**
- **UMTS**
- **GSM, TETRA**
- **EDGE**
- **802.11b**
- **Bluetooth**
- **Point-to-multipoint distribution systems**

**Bandwidth**
- 10 kbit/s
- 2 Mbit/s
- 20 Mbit/s
- >300 Mbit/s

**Relative speed [km/h]**
- 250
- 100
- 50
- 5
- 0

**Physical/economic border**
Key features of future mobile and wireless networks

Improved radio technology and antennas
- smart antennas, beam forming, multiple-input multiple-output (MIMO) – see LTE, 802.11ac
  - space division multiplex to increase capacity, benefit from multipath
- software defined radios (SDR)
  - use of different air interfaces, download new modulation/coding/...
  - requires a lot of processing power (UMTS RF 10000 GIPS)
- dynamic spectrum allocation
  - spectrum on demand results in higher overall capacity

Core network convergence
- IP-based, quality of service, mobile IP

Ad-hoc technologies
- spontaneous communication, power saving, redundancy

Simple and open service platform
- intelligence at the edge, not in the network (as with IN)
- more service providers, not network operators only
Example IP-based 4G/Next G/… network
Software Defined Mobile network Controller

3GPP LTE standardization roadmap toward 5G

5G gets real in many places 2017/2018

At least some test installations, first devices – smooth transition

More realistic expectations in industry: „no fundamental difference between 4G and 5G“, „natural evolution“ – investment in 5G, but not big hype

Products that integrate 2G, 3G, 4G and 5G are available; smartphones expected 2019

Examples:
• Berlin, 70 basestations operating at 3.7 GHz (5G New Radio), 64 antenna massive MIMO, beamforming, > 2 Gbit/s per client, RTT 7-9 ms
• https://5g-ppp.eu/ for many more 5G trials
Some additional new wireless technologies for IoT I

LTE as scalable platform

Scaling up in performance and mobility

Scaling down in complexity and power

Today

New narrowband IoT technologies (3GPP Release 13+)

LTE Cat-4 and above
- >10 Mbps
- n x 20 MHz

LTE Cat-1
- Up to 10 Mbps
- 20 MHz

LTE Cat-M1 (eMTC)
- Variable rate up to 1 Mbps
- 1.4 MHz narrowband

Cat NB1 (NB-loT)
- 10s of kbps
- 200 kHz narrowband

In-band

Guard-band

Standalone

Regular LTE Data

Guard-band

Regular LTE Data

Guard-band

NB-loT
Some additional new wireless technologies for IoT II

Low power LTE – run-times > 10 years based on battery
Some additional new wireless technologies for IoT III

LoRaWAN
- Max. 250 mW, max. 1% duty cycle, ISM/SRD band (e.g. 433, 868 MHz)
- Open specification, based on proprietary chirp spread spectrum technology (LoRa, Semtech Corp.)
- Asymmetric, > 10km range, up to 50 kbit/s, star topology

LoRaAlliance
- 500+ member companies, solutions, products, services based on LoRaWAN
- https://www.lora-alliance.org/

Open issues
- LoRa closed, no open documentation
- Doubts regarding scalability: “Do LoRa Low-Power Wide-Area Networks Scale?” (Bor et. Al, MSWiM’16)
  - Typical smart city deployment supports only 3-4 nodes per 1000m² (20 byte packet every 16 min)
- No hard guarantees for QoS
Some additional new wireless technologies for IoT III

LoRaWAN
https://www.thethingsnetwork.org/
https://www.ttnmapper.org/
Some potential problems

Quality of service
- Today's Internet is best-effort
- Integrated services did not work out
- Differentiated services have to prove scalability and manageability
- What about the simplicity of the Internet? DoS attacks on QoS?

Internet protocols are well known...
- ...also to attackers, hackers, intruders
  - security by obscurity does not really work, however, closed systems provide some protection

Reliability, maintenance
- Open question if Internet technology is really cheaper as soon as high reliability (99.9999%) is required plus all features are integrated

Missing charging models
- Charging by technical parameters (volume, time) is not reasonable
- Pay-per-application may make much more sense – but applications controlled by content providers, not by carriers!

Killer application? There is no single killer application!
- Choice of services and (almost) seamless access to networks determine the success
Thanks, take care – and have fun with Mobile Communications!

Source: Ed Jones/AFP, Seoul, Südkorea, 22.06.2016