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Trends in Mobile communications

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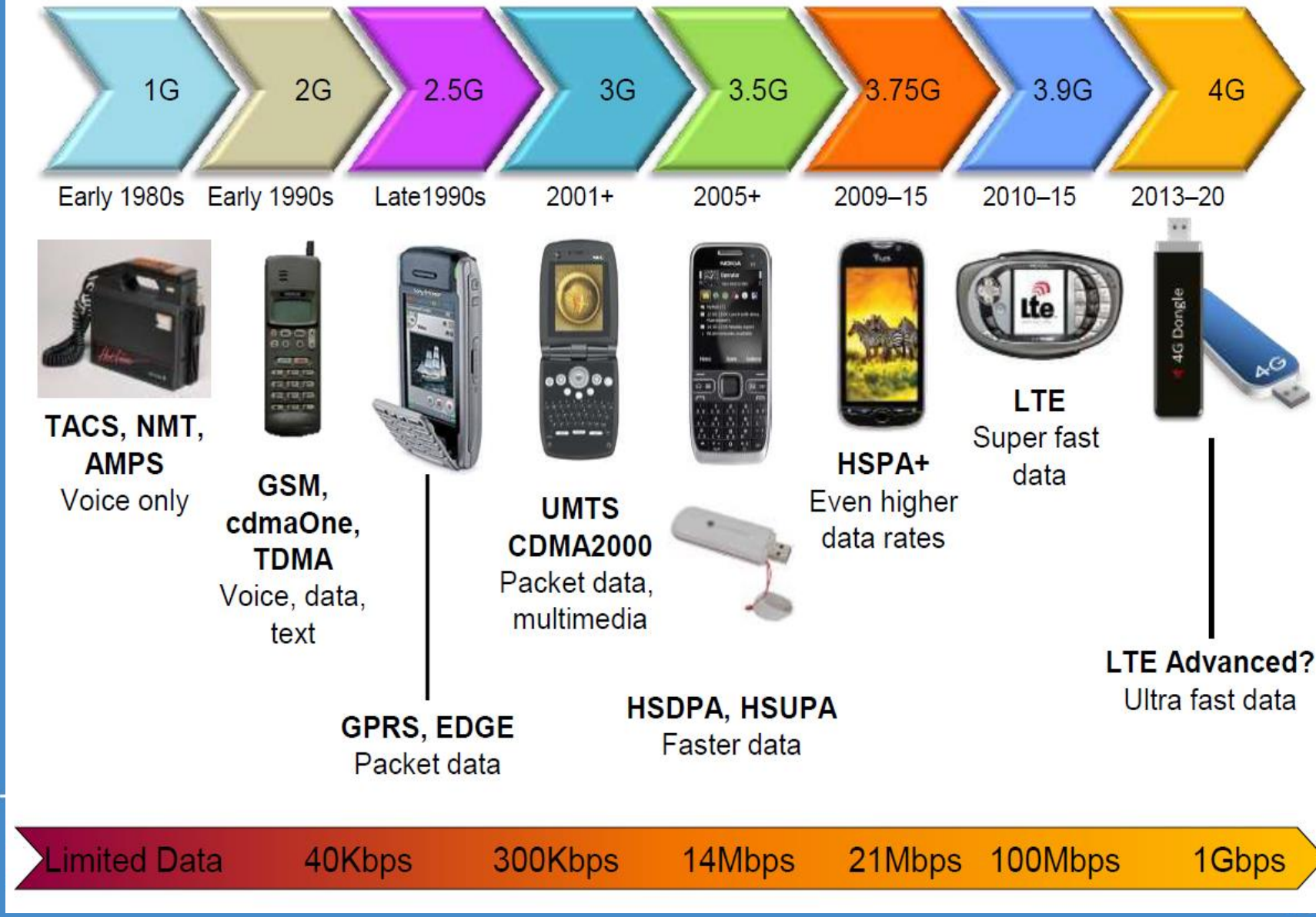
Outline of presentation

- Evolution of mobile communications
- Overview of evolving standards
  - 3G
  - UMTS HSDPA/HSUPA
  - HSPA+
  - LTE and LTE-Advanced
- Drivers of mobile broadband beyond 2020
- Technology trends in mobile broadband

History of mobile communications



ITU activities on standardization

Frequency bands identified for IMT by ITU

Frequency bands (bandwidth) in MHz	RR provisions identifying the band for IMT
450-470 (20)	5.286AA
694/698-960 (366)	5.312A, 5.313A, 5.316B, 5.317A
1 710-2 025 (315)	5.384A, 5.388
2 110-2 200 (90)	5.388
2300-2400 (100)	5.384A
2500-2690 (190)	5.384A
3400-3600 (200)	5.430A, 5.432A5.432B, 5.433A

IMT standards recommended by ITU

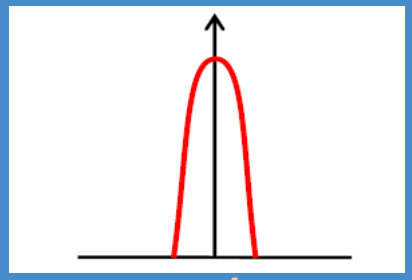
IMT-2000 (M.1457)	IMT-Advanced (M.2012)
a) IMT-2000 CDMA Direct Spread	a) LTE-Advanced (3GPP)
b) IMT-2000 CDMA Multi-Carrier	b) WirelessMAN-Advanced (IEEE)
c) IMT-2000 CDMA TDD	
d) IMT-2000 TDMA Single-Carrier	
e) IMT-2000 FDMA/TDMA	
f) IMT-2000 OFDMA TDD WMAN	

Wireless LAN in 2.4 GHz and 5 GHz bands
(See Rec. ITU-R M.1450, ETSI EN300 328, IEEE 802.11)
Giga bit WLAN (60 GHz bands)
(Rec. ITU-R M.2003 (ISO/IEC 13156, ETSI EN302 567) MBWA (IEEE 802.20)

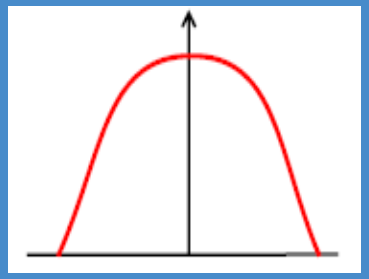
3G – beginning of mobile broadband (MBB)

- The current mobile broadband begins with 3G
- 3G requirements were defined in ITU standard IMT-2000
- General requirements:
  - Increased channel bandwidth
  - Packet switching
  - Efficient Radio Access
- Rates: up to 2 MBS (indoor), 384 kbps (city), 144 kbps (countryside)
- Types of information to be transmitted / services:
  - Voice, messaging
  - Internet, intranet, email, telemetry
  - Videos (RT, NRT), games, downloading music files

UMTS channel utilization

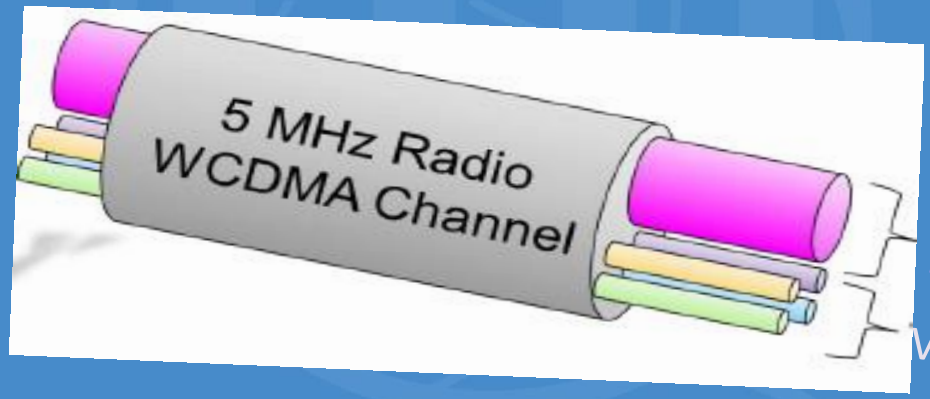


GSM/GPRS
Narrow bandwidth, limited data



UMTS
Wide bandwidth improved data

Node B



- UMTS Release 99 is W-CDMA (wideband code division multiple access)

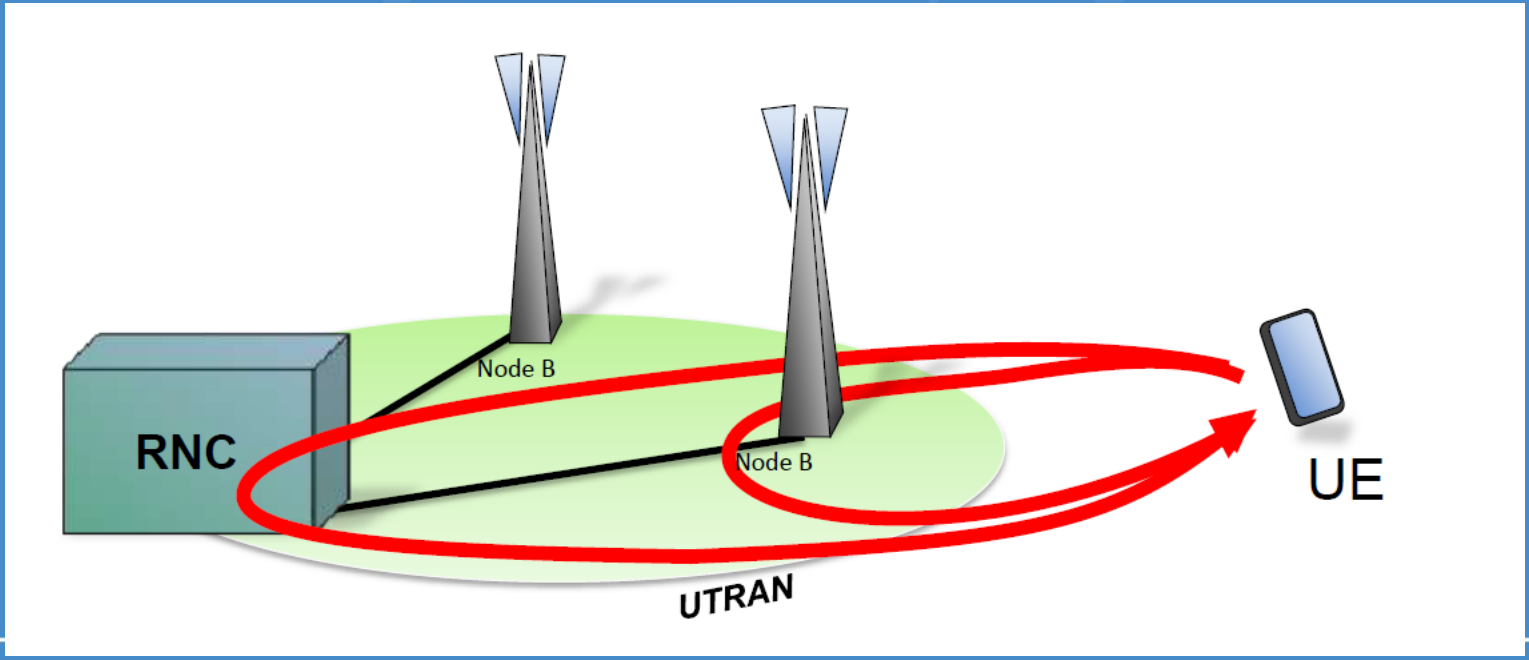
HSDPA/HSUPA

- Технология HSDPA/HSUPA = 3.5G High Speed Downlink/Uplink Packet Access contains any new features were introduced to increase **capacity**, increase **efficiency** and reduce **latency**

- HSDPA starts in R5 (2002)
- HSDPA/HSUPA defines a high speed channel (5x compared to UMTS)
- 16QAM modulation is introduced
- The technology uses more effective multiplexing, adaptive modulation and coding

Reduced Latency in HSDPA/HSUPA

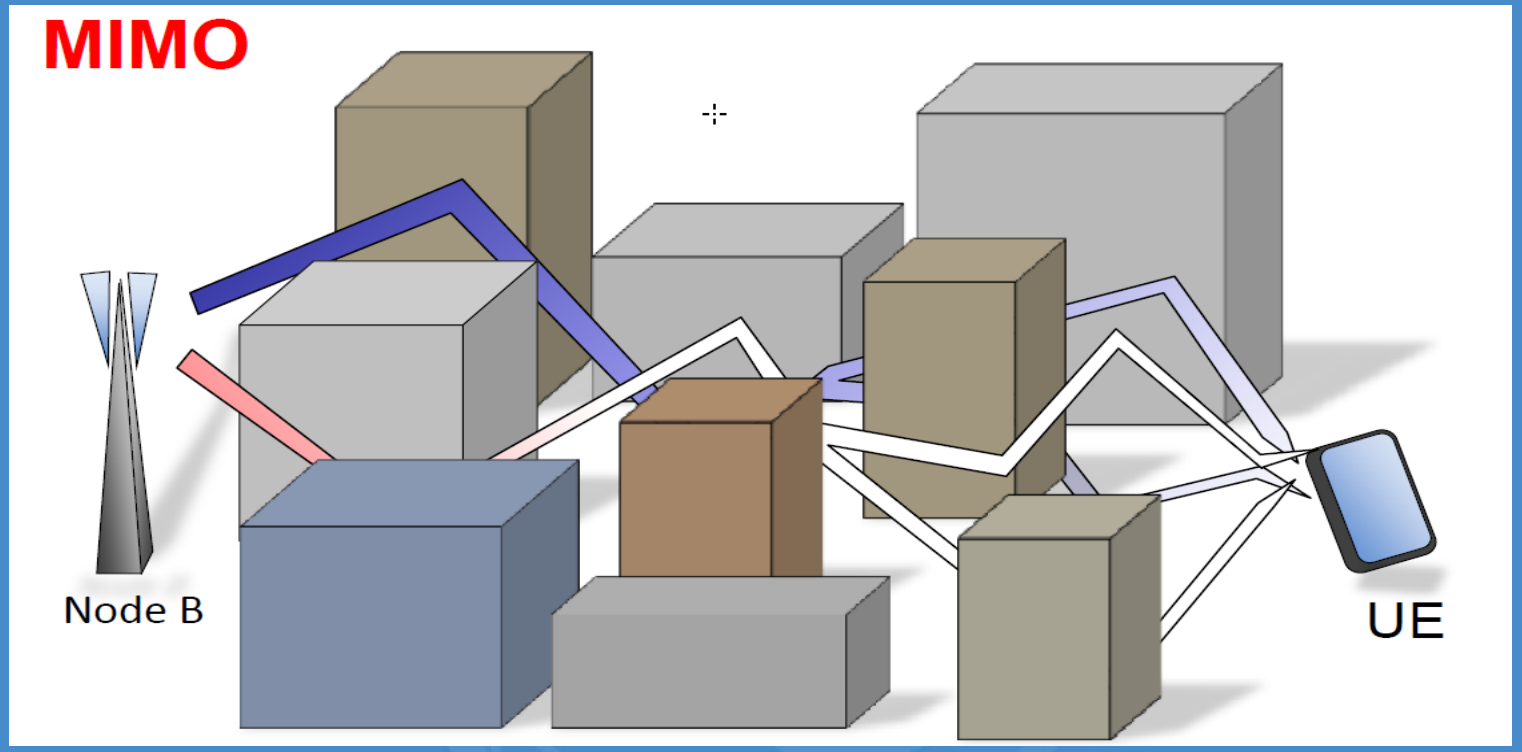
- R99 Retransmission of corrupted data at RNC (controller)
- R5 - Retransmission of corrupted data at Node B (base station)
- Latency is reduced from 150 ms (UMTS) to 100 ms: better support of real-time services



HSPA and HSPA+

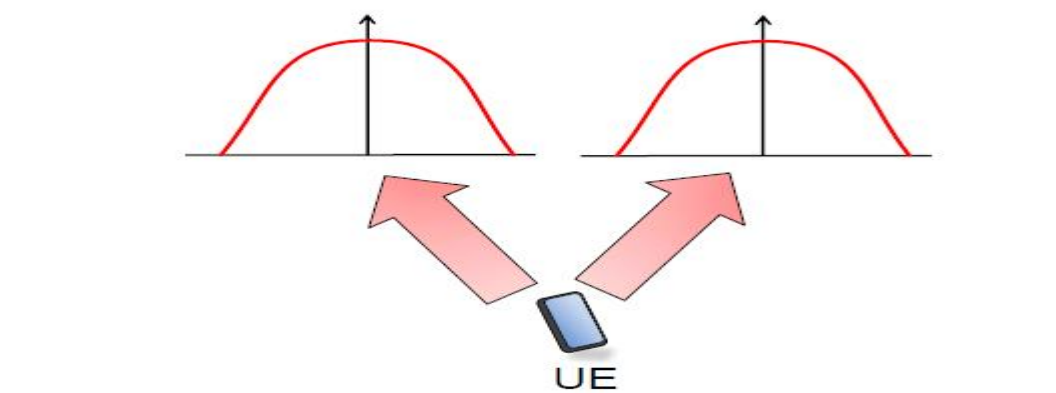
- HSDPA + HSUPA = HSPA
  - maximum 14.4Mbps DL
  - maximum 5.76Mbps UL
- HSPA+ (evolution of HSPA = R7= 3.75G)
  - maximum 21.6Mbps –> 42Mbps –> 84Mbps DL
  - maximum 11.6Mbps UL
- Характеристики HSPA+
  - higher-order modulation (64QAM)
  - multiple input, multiple output (MIMO) 2x2
  - layer-2 enhancements
  - Multi-Carrier Mode (MC- CDMA)
  - support of voice, SMS
  - multicast/broadcast single-frequency network (MBSFN)

MIMO in HSPA



- Downlink only: 2 transmitting antennas at base station and 2 receiving antennas at user equipment
- Spatial multiplexing increases data rate -> up to 2x capacity increase
- Requires urban environment

Carrier aggregation



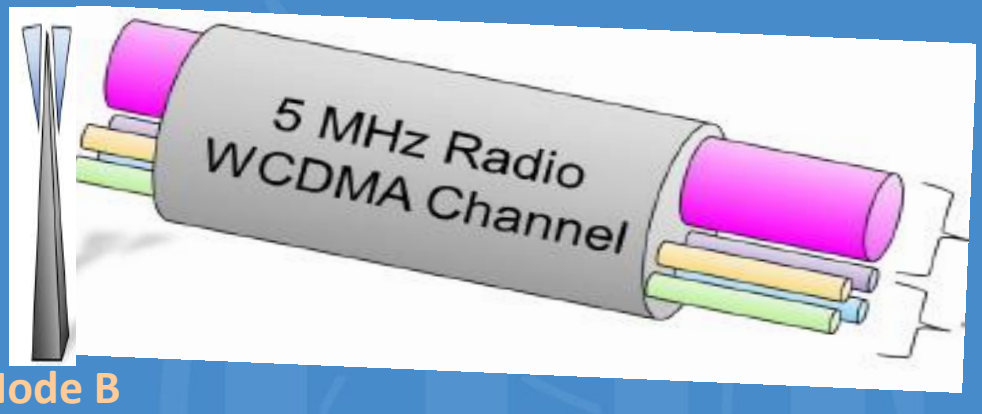
- UE usually works at one frequency channel
- Carrier aggregation (CA) allows for usage of several frequency channels in one UE
- CA may use adjacent channels or channels from other frequency bands
- Result: increase in data rates, for example:
  - Single-Carrier HSPA+ with MIMO 42Mbps
  - Multi-Carrier HSPA+ with MIMO 84Mbps

LTE overview (Release 8 - 3.9G)

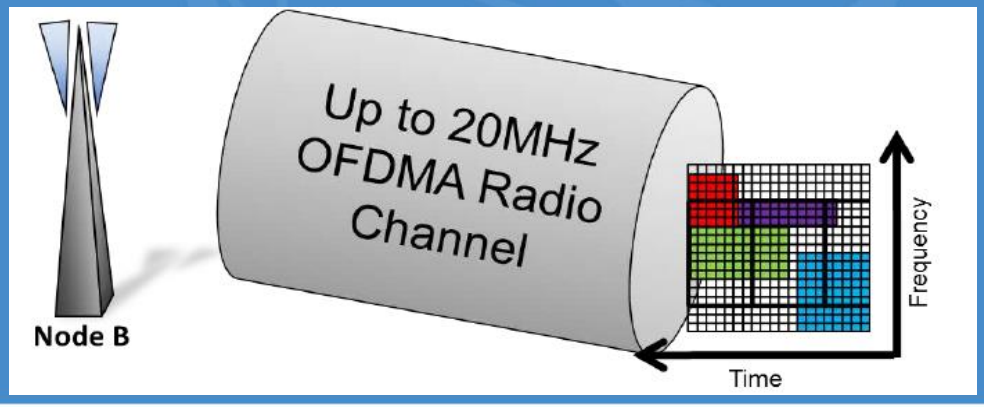
- Flexible bandwidth: 1.4 – 20MHz
- High order modulation and coding:QPSK, 16QAM and 64QAM
- Adaptive modulation and coding
- Robust **OFDMA** in downlink, efficient **SC-FDMA** in uplink (more power efficient than OFDMA and good for UE batteries)
- Good multipath performance
- Advanced antenna support: MIMO 2x2, 4x4
- Beamforming
- Compatibility with GSM and 3G

Advantages of LTE channel

- HSPA capacity is limited by 5 MHz channel



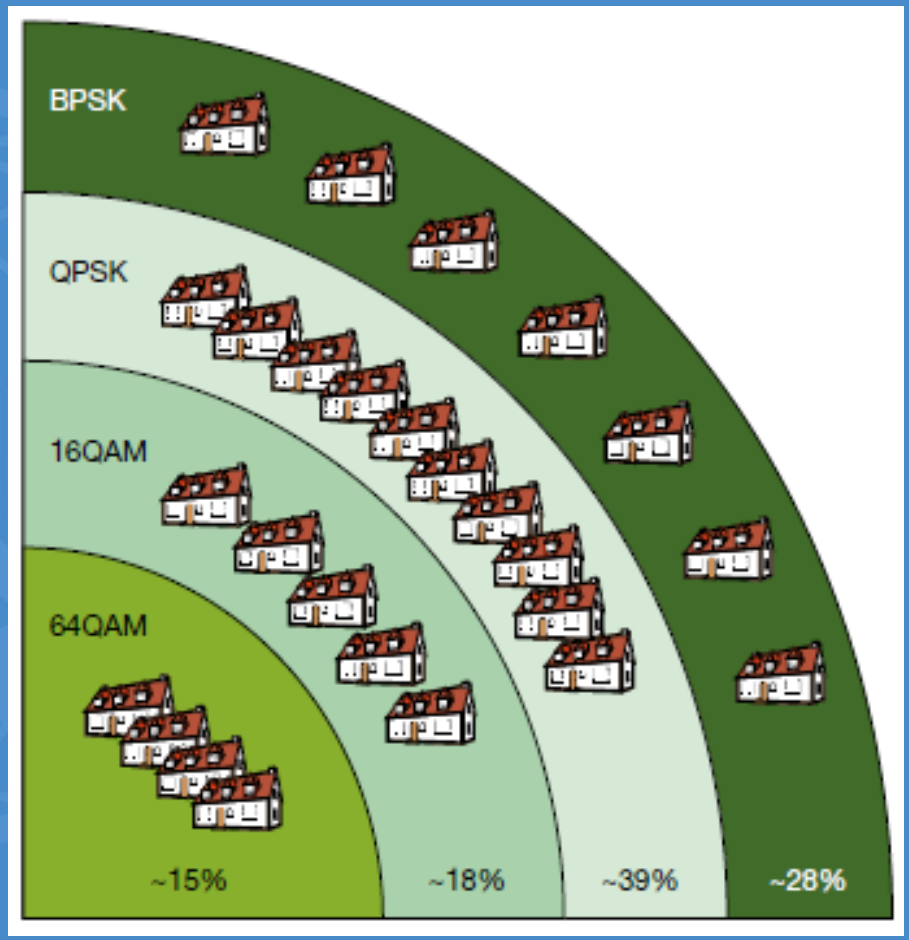
- LTE capacity обеспечивается каналом до 20 МГц, efficient multiplexing OFDMA, MIMO antennas and beamforming



Adaptive modulation and coding

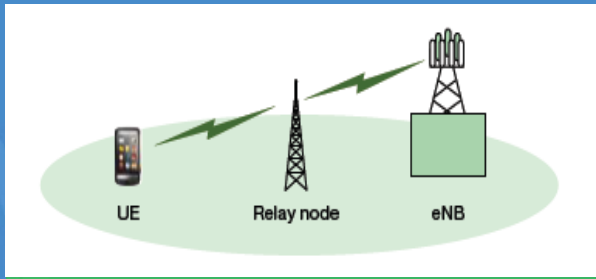
- Noise, interference, propagation affects signal quality
- Adaptive modulation optimizes data rate/signal quality
- AM – choice of modulation depending on channel conditions

- High level modulation16QAM and 64QAM (high rates) are used near base station
- Simple and robust modulation like QPSK are used towards cell edges



LTE-Advanced

- Published in R10 (2010)
- Peak rates: 1 Gbps downlink, 0.5 Gbps uplink
- Increase spectrum efficiency and better signal quality at cell edge
- Main features:
  - OFDMA/ SC-FDMA Multiplexing
  - 4x4 MIMO
  - Turbo coding (error correction)
  - Utilization of retranslators
  - Carrier aggregation -> up to 100 MHz channel



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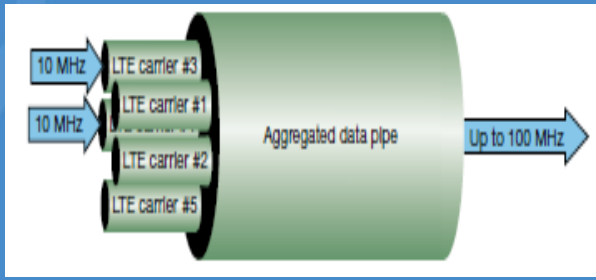

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Mobile broadband deployment (on 4.09.15)

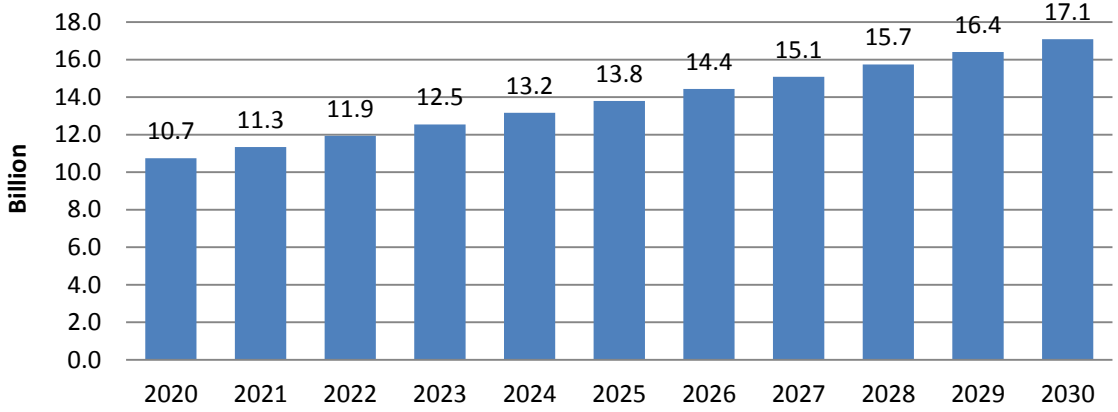
- HSPA: 582 networks in 203 countries
  - 88% support peak downlink rates of 7.2 Mbps
  - 69%) of the networks are HSPA+ in 168 countries
- LTE deployment - mainstream
  - 677 invested in LTE in 144 181 countries
  - 422 commercially lunched LTE networks in 143 countries (59 TDD)
- Subscriptions (2Q 2015)
  - 1 994 million WCDMA subscriptions, including HSPA and HSPA+
  - 755 million LTE subscriptions (10.4% of mobile connections)
- Devices: 3 253 LTE devices launched, 1 783 LTE smartphones
- Mostly used LTE band - 1800 MHz (44% networks)

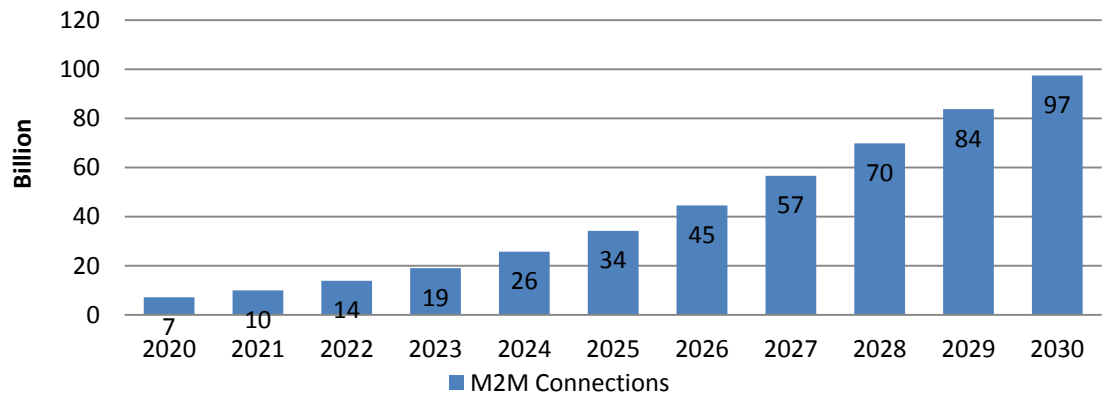
Drivers of MBB beyond 2020

- Broadcasting over MBB
  - Users may enjoy free-to-air TV/audio broadcasting through MBB as well as broadcasting networks
- Ultra dense M2M (machine-to-machine communication)
  - Traffic safety, smart grid, e-health, industry automation, augmented reality, tele-monitoring, tele-command, etc.
- Augmented and virtual reality
  - High resolution 3D video is essential
- User group communication and D2D
  (device-to-device communication) e.g. PPDR operations

Drivers of MBB beyond 2020

Estimation of global mobile subscriptions





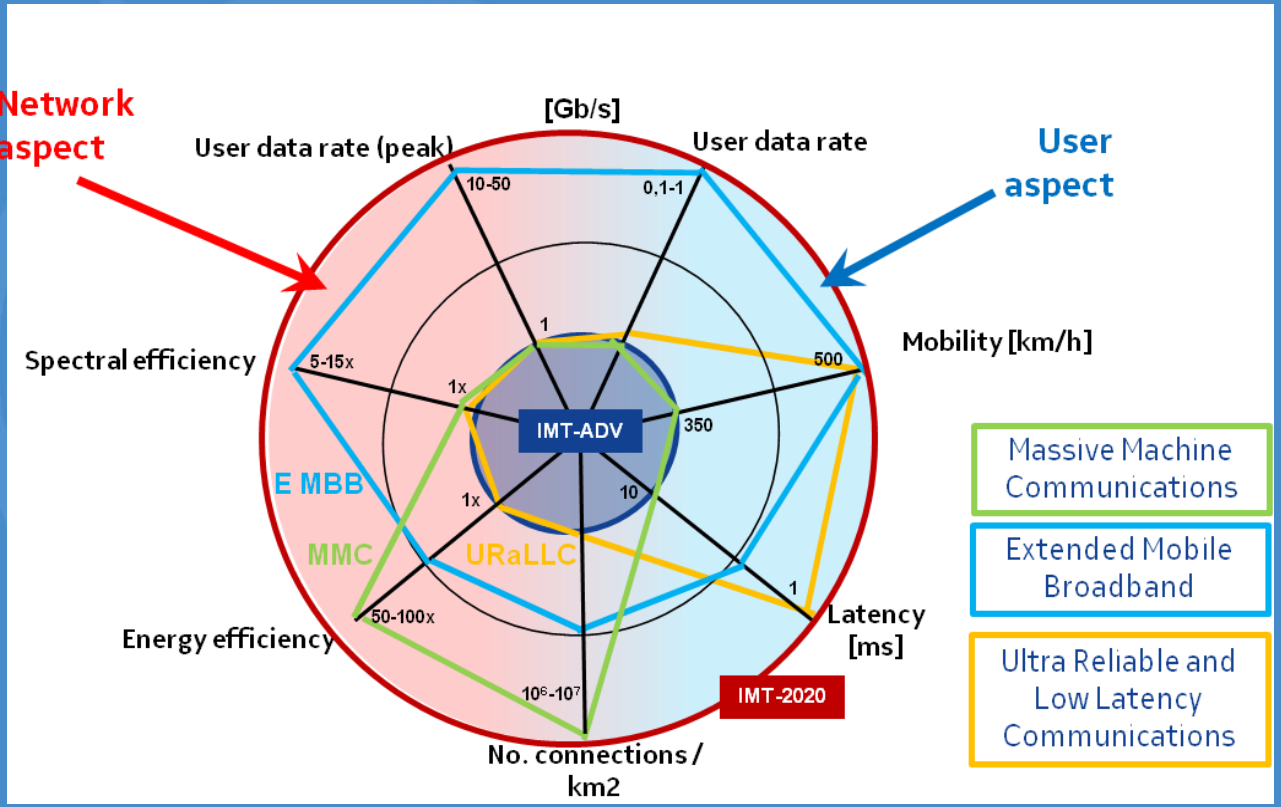
Estimation of global M2M nodes

ITU and MBB beyond 2020

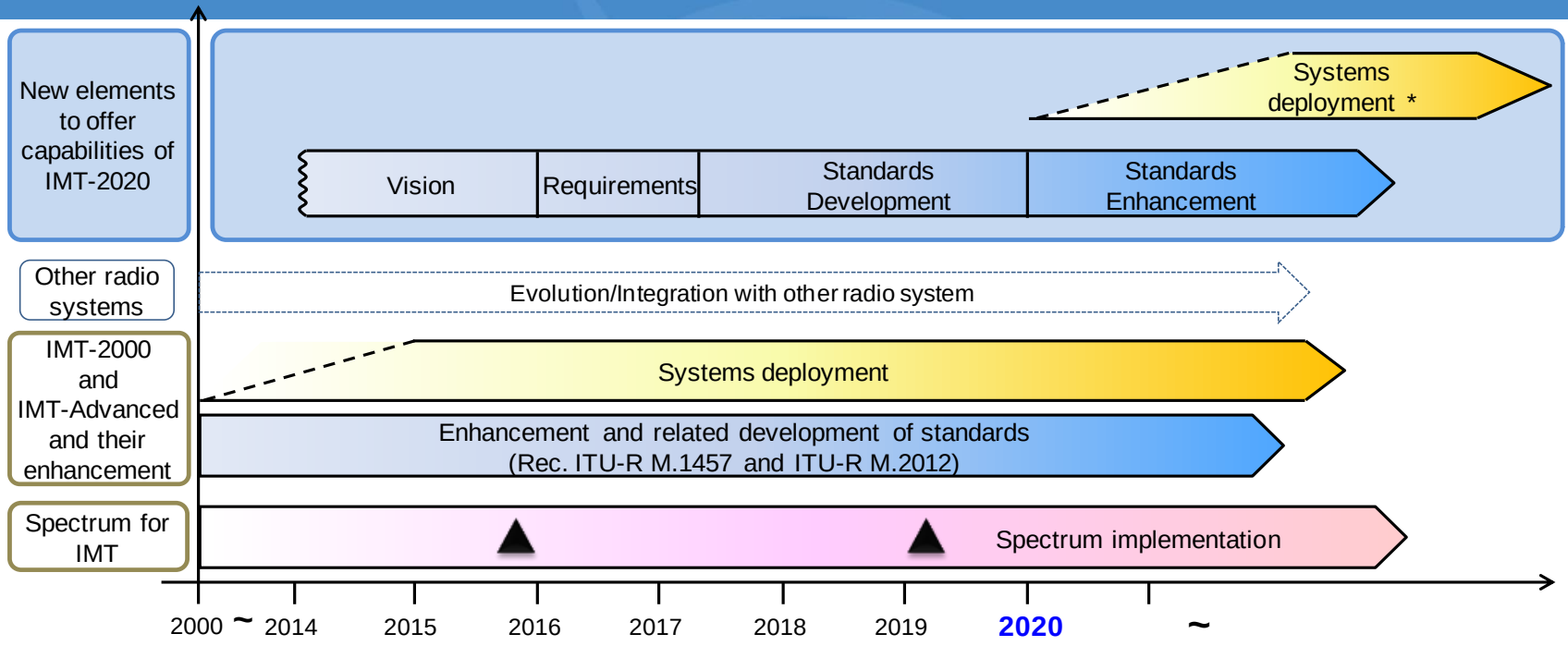
- ITU-R (WRC) ensures spectrum and regulatory framework
  - WRC-15 will discuss additional spectrum below 6.5 GHz
    - Agenda item 1.1 (Additional spectrum for IMT)
    - Agenda item 1.2 (Use of 700 MHz for IMT in Region 1)
  - WRC-19 may address the bands above [6/10/20] GHz
- SG5 of ITU-R developed draft IMT Vision and is developing GCS (Global Core Standards)
  - Vision and requirement (Doc. 5/199)
  - GCS (Rec. ITU-R M.1457, M.2012, M.1450, M.2003,…)

Key characteristics of MBB beyond 2020

Example of key parameters of IMT beyond 2020



Phase and expected timelines for IMT-2020



The sloped dotted lines in systems deployment indicate that the exact starting point cannot yet be fixed.

▲ : Possible spectrum identification at WRC-15 and WRC-19

* : Systems to satisfy the technical performance requirements of IMT-2020 could be developed before year 2020 in some countries.
: Possible deployment around the year 2020 in some countries (including trial systems)

Technology trends – radio access

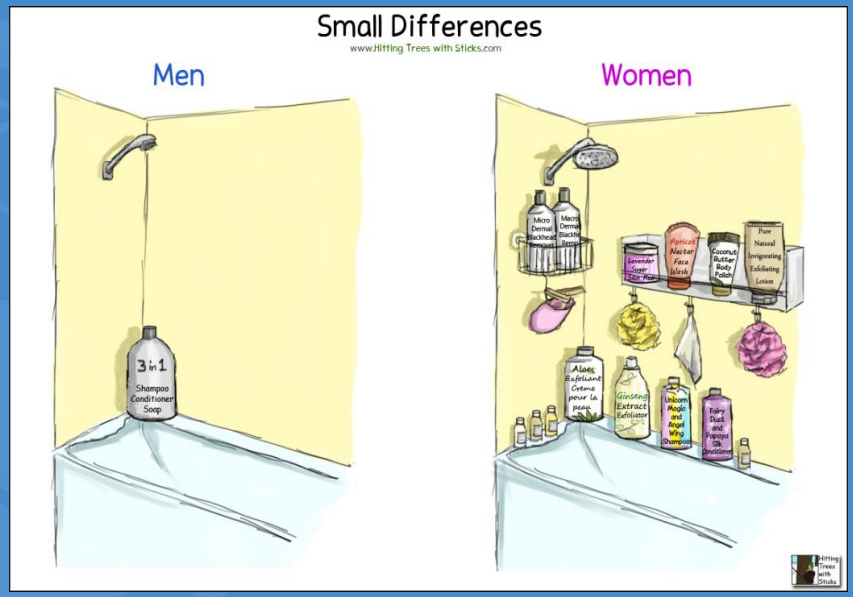
- Carrier aggregation (CA)
  - within same frequency block and
  - between discontinuous bands (e.g. 700 MHz / 900 MHz / 1.8 GHz / 2.3 GHz / 3.4 GHz…)
- Advancements in antenna
  - Massive MIMO, 3D-beamforming, higher order MU-MIMO
  - Network MIMO, Active antenna system (AAS)
- Advancements in modulation
  - Filtered OFDM (FOFDM)
  - Filter bank multi-carrier (FBMC) modulation

Technology trends – networks

- Heterogeneous radio access network
  - Cooperative operation between FDD and TDD, between different technologies such as IMT, RLAN, Broadcasting
  - By using Joint coordinated multipoint (CoMP) transmission, Dynamic radio access configuration, flexible backhaul resource management, etc.
- Ultra dense network with small cells
  - Cloud radio access network (C-RAN)
  - Self organized/optimized network (SOM)
  - Network function virtualization (NFV)
- Mobile relay (e.g. via access points in trains)
- Relay based multi-hop network
- Ultra broadband backhaul infra-structure (Fibres, Radios)

IMT-2020: many things to come

IMT-2020:
a technology for women
(requirements are not simple)



Thank you !