Towards 4G

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Overview

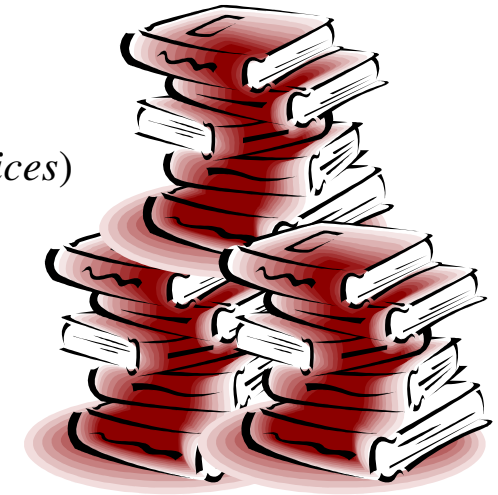
- Evolution of UMTS
- LTE
- WiMAX
- UMTS vs. LTE vs. WiMAX

Generation of mobile networks

Generation	Name	Features
1 (1980)	NMT (*Nordic Mobile Telephone*), …	Analog Voice
2 (1992)	GSM (*Global System for Mobile communications*) - GSM 900, GSM 1800 IS95 (*Interim Standard*) based on CDMA - IS95a,b …cdmaOne	Digital Voice + data
2,5 (1999)	GPRS (*General Packet Radio Service*) EGPRS/EDGE (*Enhanced GPRS/Enhanced Data rates for Global Evolution*)	
3 (2004)	UMTS (*Universal Mobile Telecommunication System*) cdma2000 (*code division multiple access*)	Multimedia
… 4		

Releases in 3GPP

- **Release 99** (1999)
  - 1st release
- **Release 4** (2001)
- **Release 5** (2002)
  - HSDPA (*High Speed Downlink Packet Access*)
  - IMS (*IP Multimedia Subsystem*)
- **Release 6** (2004)
  - MBMS (*Multimedia Broadcast/Multicast Services*)
  - HSUPA (*High Speed Uplink Packet Access*)
- **Release 7** (2007)
  - HSPA+
- **Release 8** (2009?)
  - …LTE (*Long Term Evolution*)

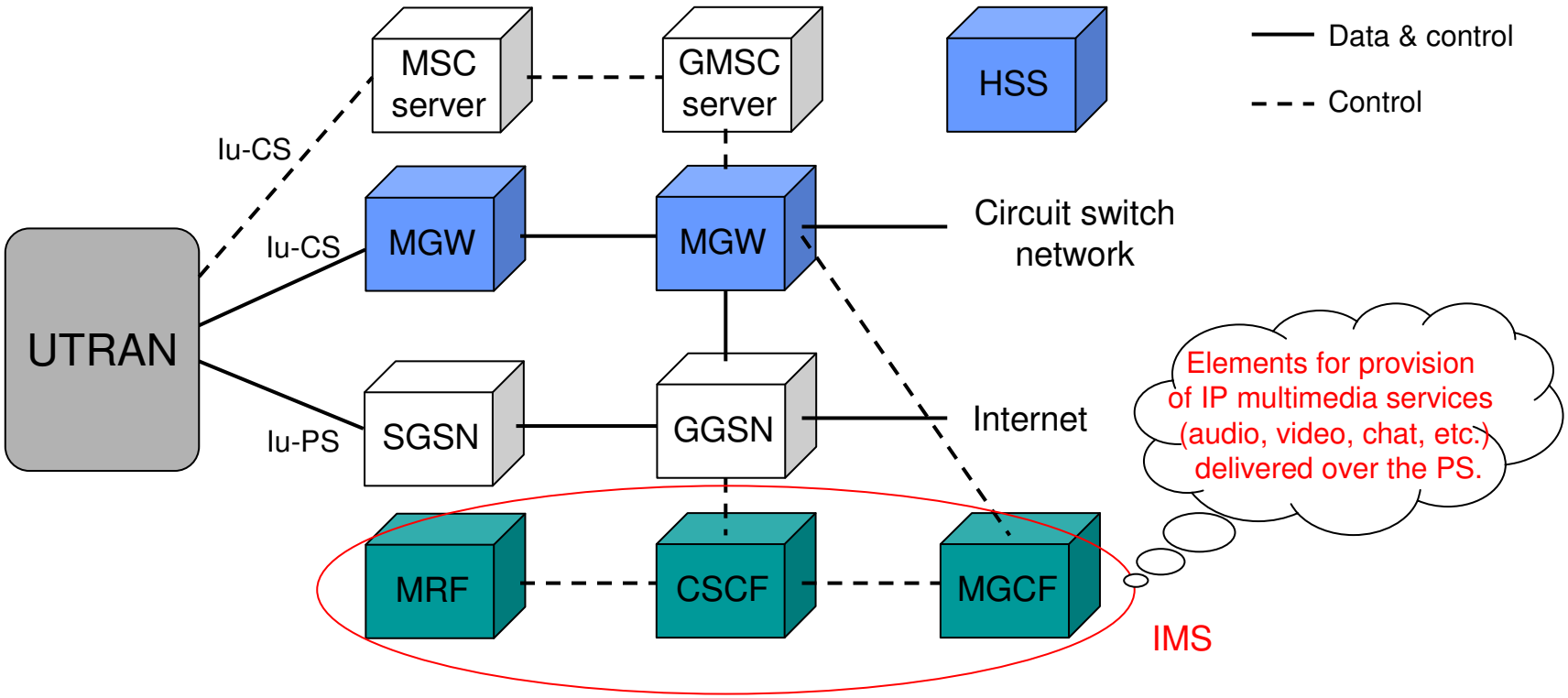


3GPP, 3GPP2

- 3GPP
  - Created 1998
  - Specification of UMTS
  - www.3gpp.org

- 3GPP2
  - Specification of cdma2000
  - www.3gpp2.org

CN evolutions



MGM: Media Gateway
HSS: Home Subscriber Server
IMS: IP Multimedia Subsystem

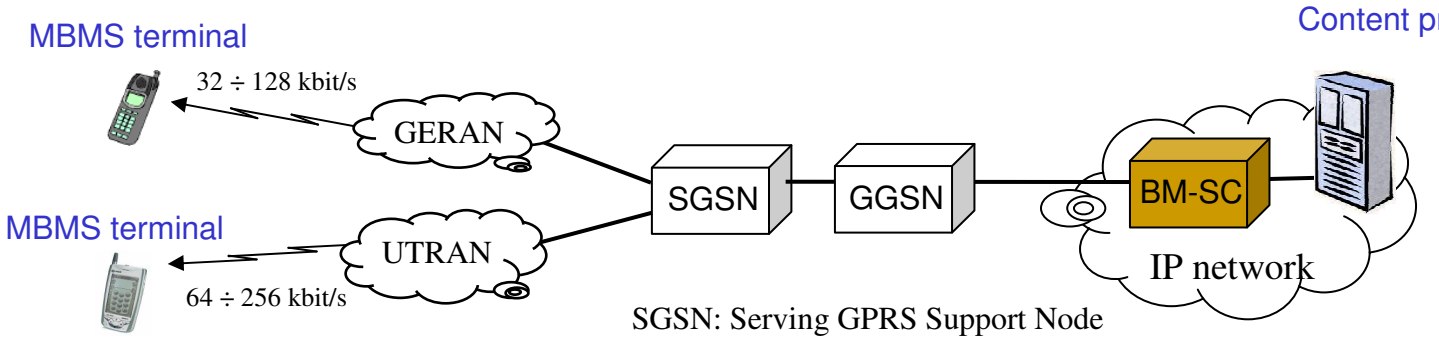
MRF: Media Resource Function
CSCF: Call Session Control Function
MGCF: Media Gateway Control Function

MBMS … *Multimedia Broadcast/Multicast Service*

- Release 6 (2004)

Aim: increase of transmission efficiency for multimedia services

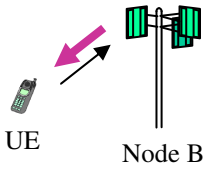
- Point-to-multipoint
- Applications
  - Mobile TV (…DVB-H)
  - Audio/ video (news, weather, etc.)
  - Specific information (about hotels, restaurants, etc.)



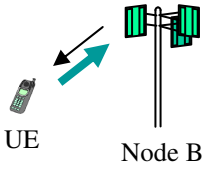
SGSN: Serving GPRS Support Node
GMSC: Gateway MSC
BM-SC: Broadcast Multicast Service Centre

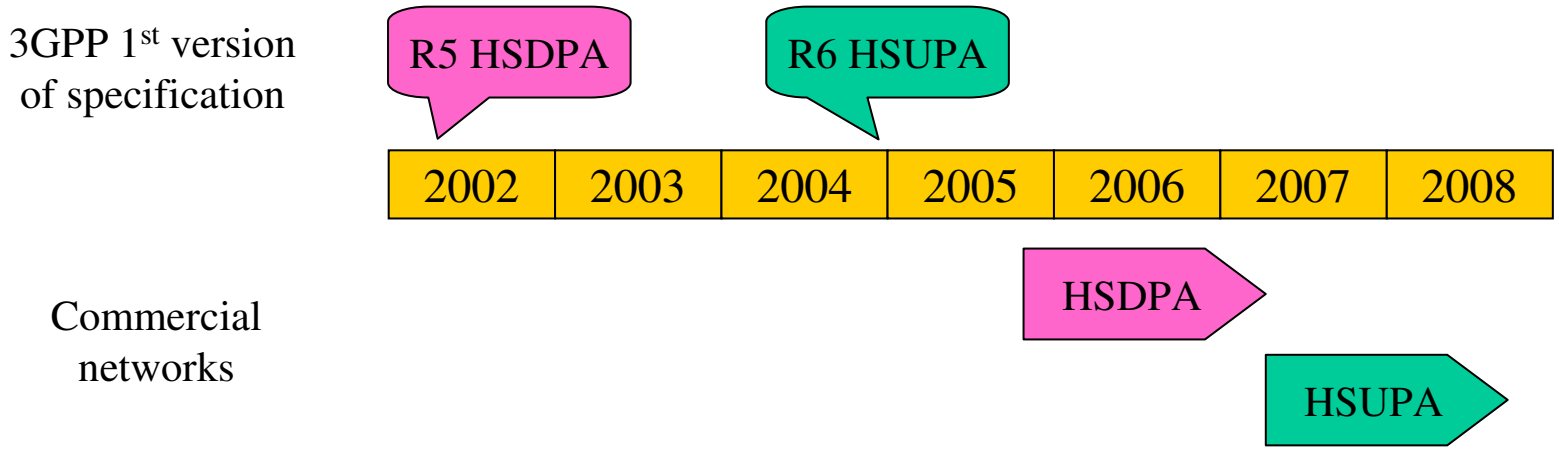
What is HSPA?

- **HSDPA** (**H**igh **S**peed **D**ownlink **P**acket **A**ccess)



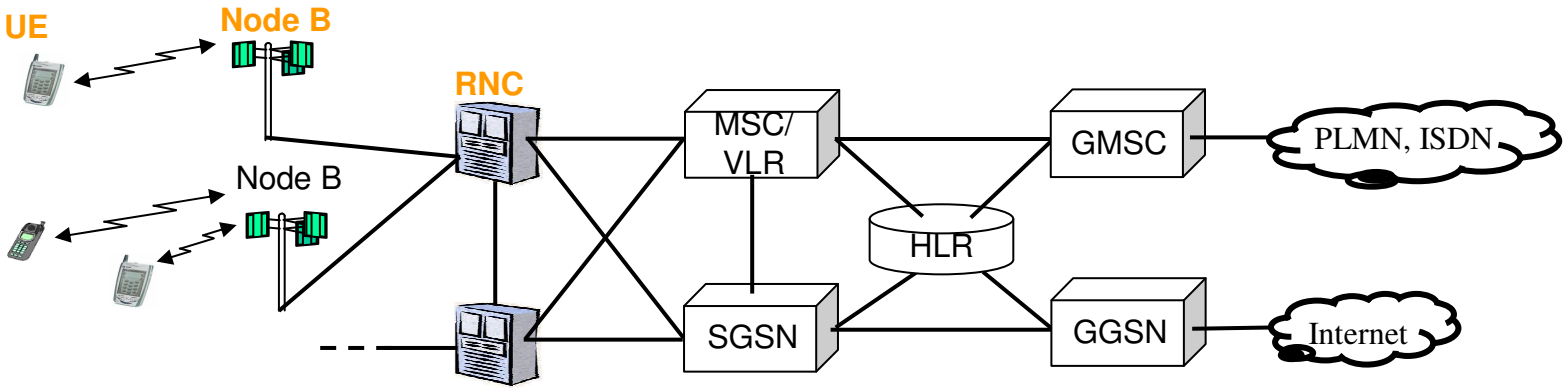
- **HSUPA** (**H**igh **S**peed **U**plink **P**acket **A**ccess)
  - E-DCH (Enhanced Uplink Dedicated Channel)





Basic features

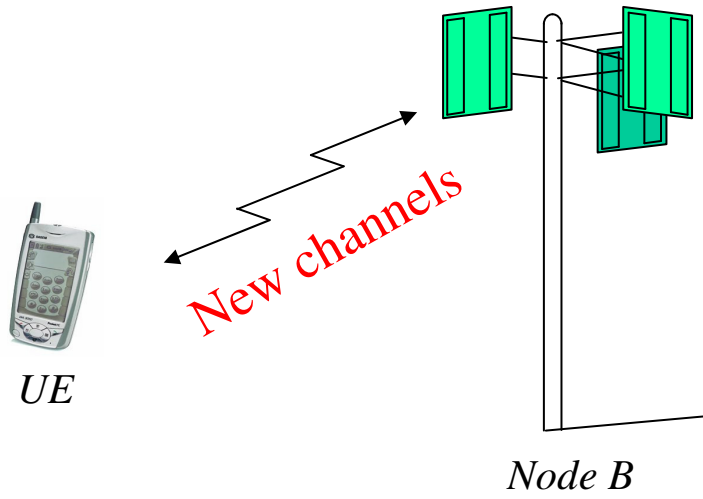
- Companies involved in the initial studies
  - Motorola, Nokia, Ericsson, T-Mobile, NTT DoCoMo, …
- Deployed of HSPA in the WCDMA network
  - Same carrier
  - Another carrier
- HSPA requires
  - Modification of Node B and RNC
  - HSPA terminals

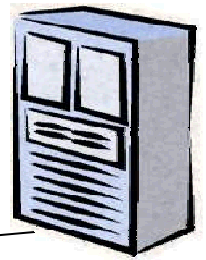


Modifications

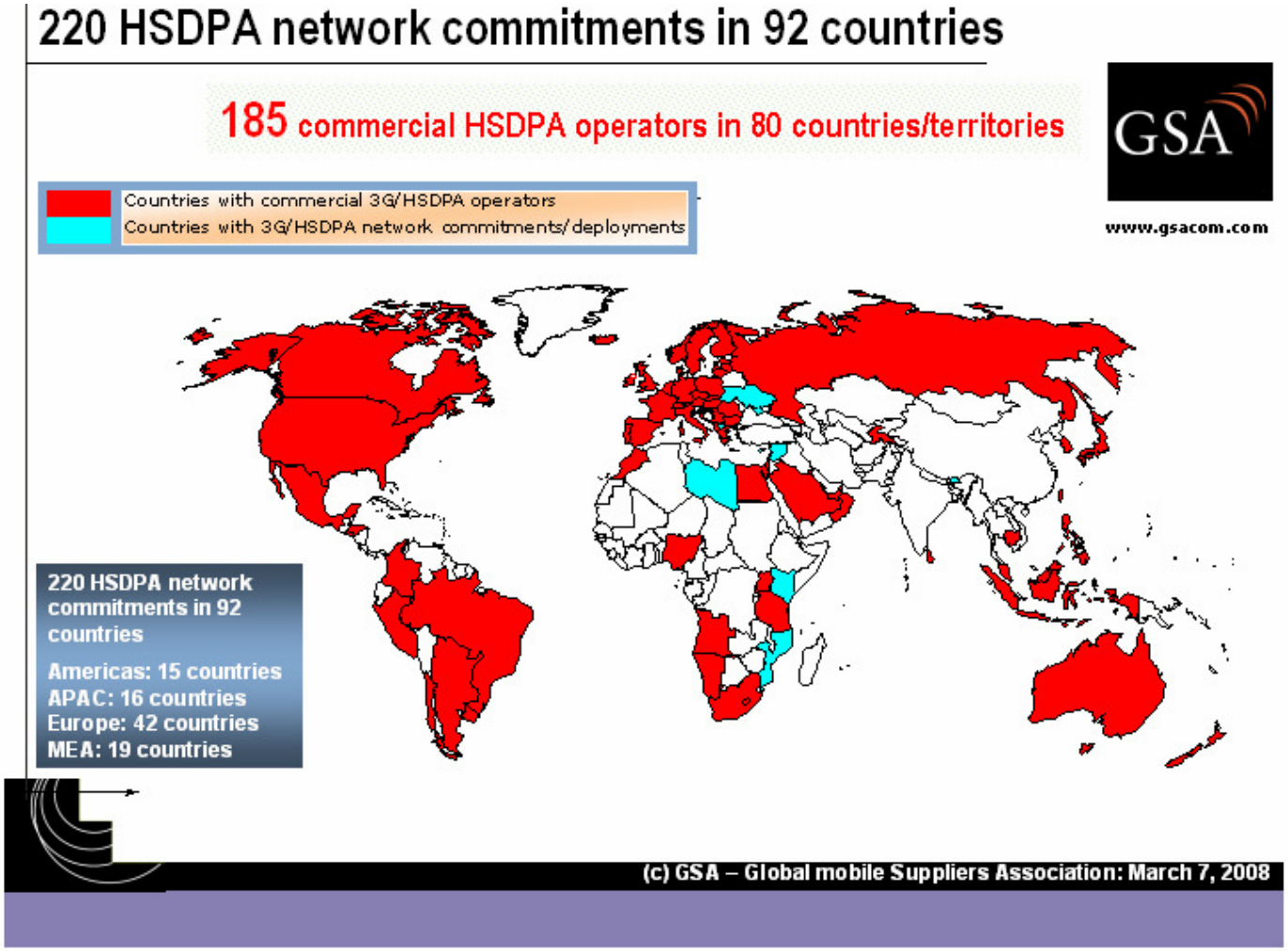
- Scheduling
- Fast Retransmission ($HARQ_{MAC}$)
- Adaptive Modulation and Coding

- Scheduling
- Retransmission (ARQ_{RLC})

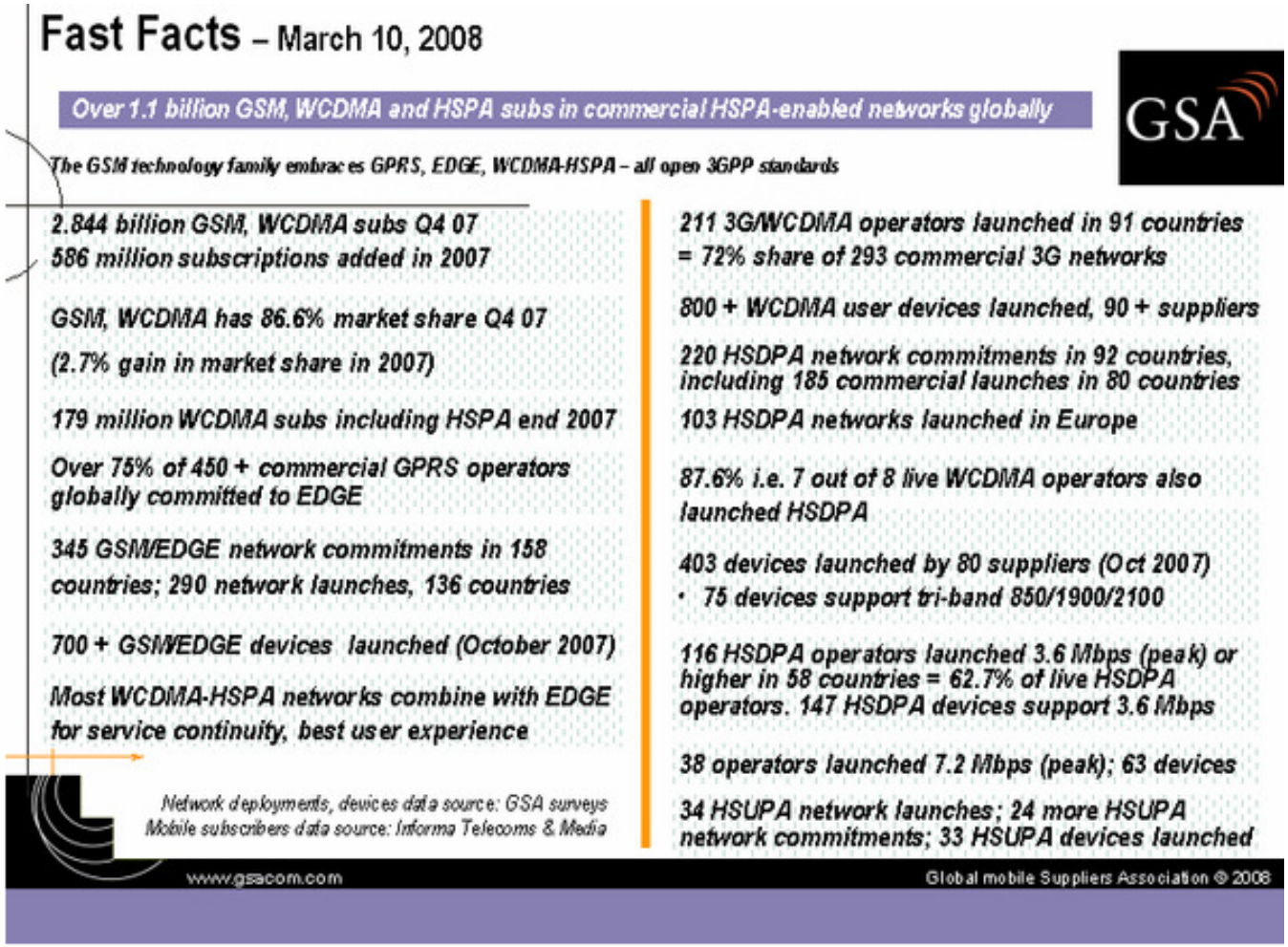




Commercial HSDPA networks



Statistics


Fast Facts – March 10, 2008
Over 1.1 billion GSM, WCDMA and HSPA subs in commercial HSPA-enabled networks globally
GSA
The GSM technology family embraces GPRS, EDGE, WCDMA-HSPA – all open 3GPP standards
2.844 billion GSM, WCDMA subs Q4 07
586 million subscriptions added in 2007
GSM, WCDMA has 86.6% market share Q4 07
(2.7% gain in market share in 2007)
179 million WCDMA subs including HSPA end 2007
Over 75% of 450 + commercial GPRS operators globally committed to EDGE
345 GSM/EDGE network commitments in 158 countries; 290 network launches, 136 countries
700 + GSM/EDGE devices launched (October 2007)
Most WCDMA-HSPA networks combine with EDGE for service continuity, best user experience
211 3G/WCDMA operators launched in 91 countries = 72% share of 293 commercial 3G networks
800 + WCDMA user devices launched, 90 + suppliers
220 HSDPA network commitments in 92 countries, including 185 commercial launches in 80 countries
103 HSDPA networks launched in Europe
87.6% i.e. 7 out of 8 live WCDMA operators also launched HSDPA
403 devices launched by 80 suppliers (Oct 2007)
• 75 devices support tri-band 850/1900/2100
116 HSDPA operators launched 3.6 Mbps (peak) or higher in 58 countries = 62.7% of live HSDPA operators. 147 HSDPA devices support 3.6 Mbps
38 operators launched 7.2 Mbps (peak); 63 devices
34 HSUPA network launches; 24 more HSUPA network commitments; 33 HSUPA devices launched
Network deployments, devices data source: GSA surveys
Mobile subscribers data source: Informa Telecoms & Media
www.gsacom.com
Global mobile Suppliers Association © 2008

HSDPA vs. HSUPA

	HSDPA	HSUPA
Introduced	Release 5	Release 6
Improve data rates	Downlink	Uplink
Peak data rate	14,4 Mbit/s	5,8 Mbit/s
Transport channel	Shared (HS-DSCH)	Dedicated (E-DCH)
	TTI = 2 ms	TTI = 2 ms, 10 ms
Features	HARQ	HARQ
	Scheduling	Scheduling
	Adaptive modulation and coding	-
Spreading factor	Fix (=16)	Variable
Modification	UE, Node B	UE, Node B, RNC
New MAC entities	MAC-hs	MAC-e, MAC-es

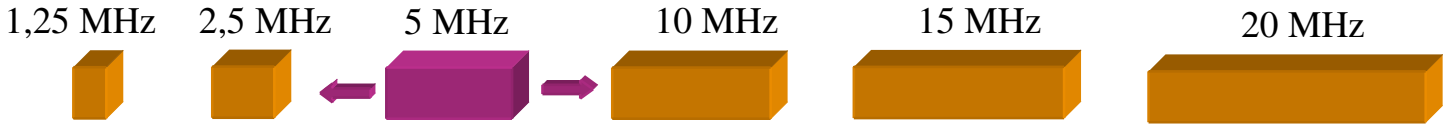
LTE

- 3G LTE (Long Term Evolution)
  - UTRAN LTE, Evolved UTRAN
  - 3GPP 25.913, 3GPP 25.813

- Why
  - HSPA …should be competitive for several years
  - **But**, to ensure competitiveness in an longer time (beyond 2015), a long-term evolution of the radio-access technique needs to be considered (… rates, latency, coverage, operator's cost, etc.)

Features of LTE (1/4)

- Scalable bandwidth



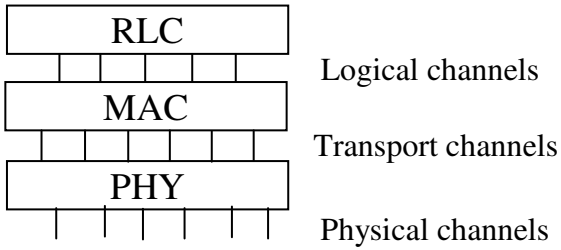
- Peak data rates
  - Downlink: 100Mbit/s (within 20 MHz)
  - Uplink: 50Mbit/s (within 20 MHz)

} not necessarily simultaneously

- Throughput
  - Downlink: 3x or 4x Release 6 (HSDPA)
  - Uplink: 2x or 3x Release 6 (HSUPA)

Features of LTE (2/4)

- No CS, only PS domain
  - Number of transport chs is reduced
  - Dedicated chs. → shared chs.



- Cell range
  - 5 km: optimal size
  - 30km: sizes with reasonable performance
  - Up to 100km cell sizes supported with acceptable performance

- Cell Capacity
  - Up to 200 active users per cell (5MHz)

Features of LTE (3/4)

- Mobility
  - Optimized for low mobility (0÷15 km/h) but
  - Also support high speed
- Latency
  - User-plane: < 5 ms
  - Control plane: < 100 ms (camped-to-active), < 50 ms (dormant-to-active)
- …
  - Enhanced IMS
  - Enhanced MBMS (Multimedia Broadcast Multicast Service)

Features of LTE (4/4)

- Radio interface
  - SC-FDMA (Uplink)
  - OFDM (Downlink)

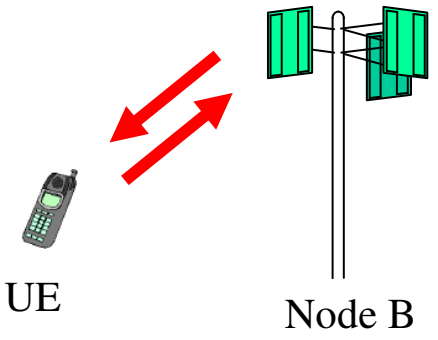
  …multi-carrier WCDMA is considered to be complicated (especially for UEs)

- Network architecture
  - User plane ⇒ fewer nodes (two nodes approach)
    - One node - Base station
    - Second node - Other (upper) node, handling CN + some radio functions
  - Control plane ⇒ more freedom
    - More intelligence implemented in Base station (…than currently with HSPA)

HSOPA

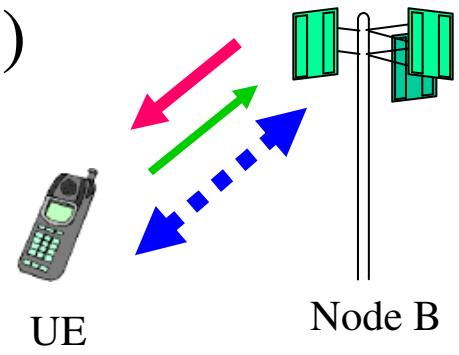
HSOPA ….High Speed OFDM Packet Access

- Provides HS downlink/uplink data channel
  - OFDM (Orthogonal Frequency Division Multiplexing
  - MIMO (Multiple-Input Multiple-Output)
- Introduce in future Release (…expected in 2008)



HSPA

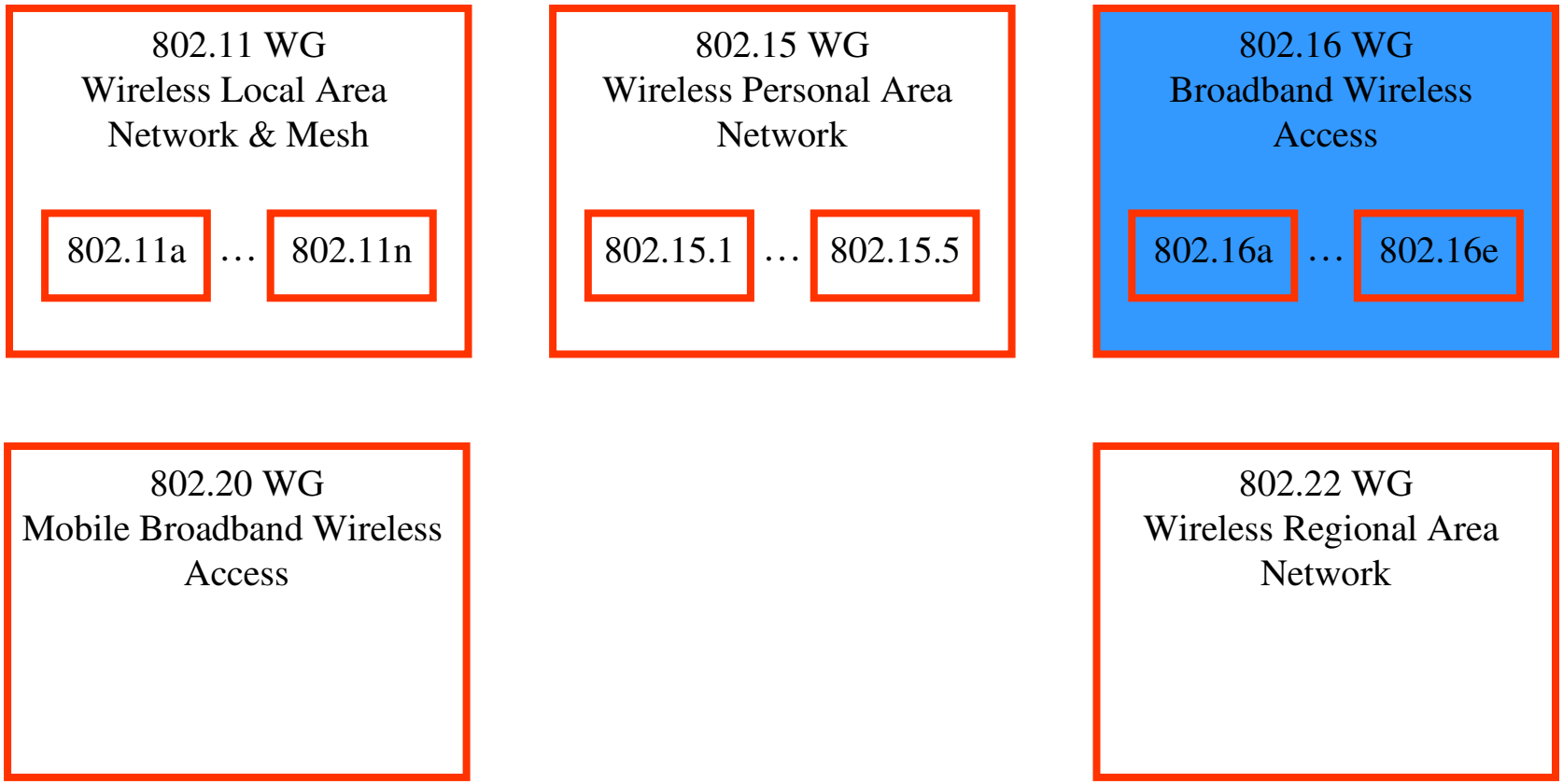
- HS**D**PA (HS **downlink** packet access)
  - Release 5 (2002)
- HS**U**PA (HS **uplink** packet access)
  - Release 6 (2004)
- HS**O**PA (HS **OFDM** packet access)
  - *Future Release*



Generation of mobile systems

Generation	Features	Features
3 (2003)	UMTS (*Universal Mobile Telecommunication System*) cdma2000 (*code division multiple access*)	Multimedia
3,5 (2005)	HSDPA (*High Speed Downlink Packet Access*)	High speed data rates
3,75 (2007)	HSUPA (*High Speed Uplink Packet Access*)	
3,9 (?)	HSOPA (*High Speed OFDM Packet Access*)	
4?		

IEEE wireless standards



*IEEE: Institute of Electrical and Electronics Engineers

WiMAX (1/2)

Access networks (last mile)

… metallic cables, optical cables, radio

WiMAX

a) Substitution of cables

b) …Mobile network

WiMAX (2/2)

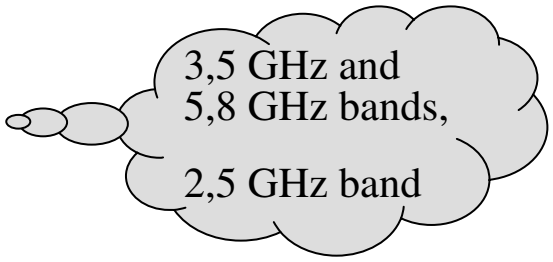
- WiMAX (*Worldwide Interoperability for Microwave Access)*
  - 2001
  - IEEE 802.16
  - BWA
  - Outdoor (…metropolitan access network)
  - Support of QoS

- WiMAX Forum
  - Promoting IEEE 802.16
  - Promotion & certification of equipments
  - Specification of tests, selection of labs for certification
  - www.wimaxforum.org

… WiMAX Forum continues, where IEEE ends

Frequency bands

- Unlicensed / licensed spectrum
- 10-66 GHz
  - Line of Sight (LOS)
  - Cell radius - up to 40÷50km
- 2-11 GHz
  - Non Line of Sight (NLOS)
  - Cell radius - up to 7÷9 km
  - …power management, MIMO



Note: Unlicensed spectrum

+ Free, allows quickly meet the needs of users

- To eliminate interferences, arrangement between providers is needed

IMT-2000

- International Mobile Telecommunications-2000
  - Global standard for 3G wireless communications, defined by ITU
- Approved standards
  - 1999: WCDMA, CDMA2000, TD-SCDMA, EDGE and DECT
  - 9/2007: WiMAX

WiMAX jointed IMT-2000

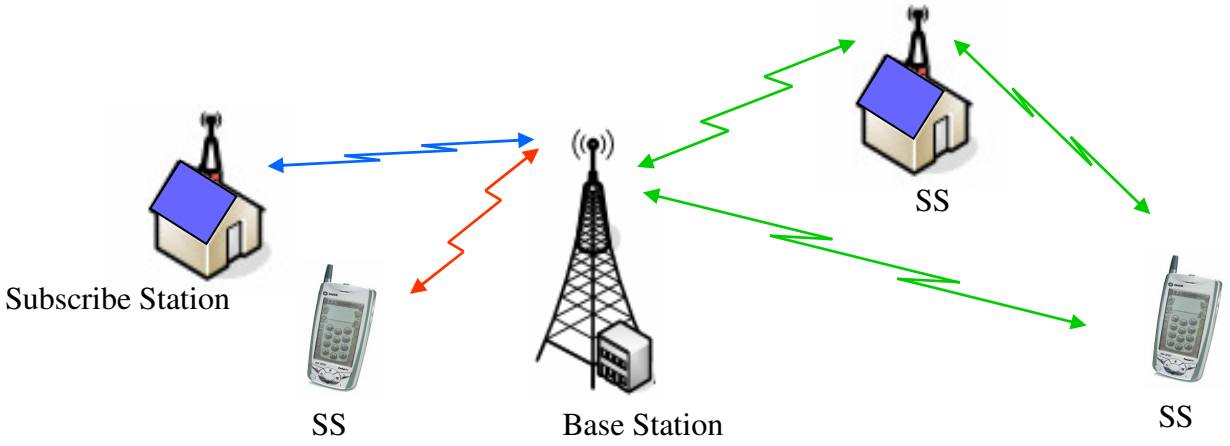
Consequence… access to frequencies that are reserved for 3G technologies by ITU

802.16 versions (1/2)

- 802.16 — 2001/12
  - LOS (10-66 GHz), up to 135 Mbit/s
- 802.16c — 2002
- 802.16a — 2003/01
  - NLOS (2-11 GHz), up to 75 Mbit/s
- 802.16REVd (**802.16-2004**) — 2004/10
- **802.16e** — 2005/12
  - *Mobility*
- 802.16j — 2008/?
  - Relay
- 802.16m — 2009?
  - …Advance WiMAX (1Gbit/s)

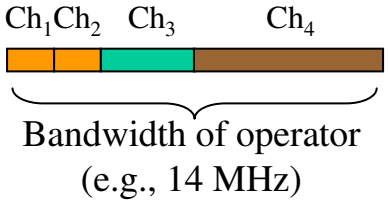
802.16 versions (2/2)

- Fixed WiMAX
  - 802.16-2004
- Mobile WiMAX
  - Amendment to 802.16-2004 → 802.16e …handover
  - WiBro (Wireless Broadband) …South Korean, 2006
- WiMAX
  - 802.16j …relay



Features

- Flexible channel size
  - 1,75 MHz ÷ 20, 28 MHz (…1,75; 3,5; 5; 7; 10;…)
  - ...increase of cell capacity in the network



- High data rates
  - Over 100 Mbit/s (depends on the channel bandwidth)
- QoS support
  - ..support low latency applications (e.g., voice or video)
- FDD/TDD modes

UMTS vs. 802.16e vs LTE

	UMTS	802.16e	LTE
Access method	CDMA	OFDMA, SOFDMA	SOFDMA
Frequency band	~ 2 GHz 2,5 ÷ 2,7 GHz	2,3 GHz 2,5 ÷ 2,7 GHz 3,5 GHz	900, 1800 ? ~ 2 GHz
Channel bandwidth	5 MHz	1,75 MHz ÷ 28 MHz	1,25 MHz ÷ 20 MHz
Data rates	2 Mbit/s (Rel 4) 14,4 Mbit/s (Rel 5) 5,8 Mbit/s (Rel 6)	63 Mbit/s (↓) 28 Mbit/s (↑)	100 Mbit/s (↓) 50 Mbit/s (↑)
Modes	FDD (TDD)	TDD, (FDD)	FDD, TDD ?
Handover	Yes	Yes	Yes
Power control	Yes	Yes	Yes
Support of QoS	Yes	Yes	Yes
AAS	No	Yes (MIMO, Beamforming)	Yes (MIMO, Beamforming)

Conclusions

- 4G → BWA
- Objectives of 4G
  - 100 Mbit/s for mobility
  - 1 Gbit/s for fixed/portable
- Candidates
  - Ultra Mobile Broadband (UMB) …3GPP2
  - Long Term Evolution (LTE) …3GPPP
  - Mobile WiMAX (802.16m) …IEEE