4G wireless technology developments

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Overview

Definition of 4G

The 4G will be a fully IP-based integrated system of systems and network of networks achieved after the convergence of wired and wireless networks as well as computer, consumer electronics, communication technology, and several other convergences that will be capable of providing 100 Mbit/s and 1 Gbit/s, respectively, in outdoor and indoor environments with end-to-end QoS and high security, offering any kind of services anytime, anywhere, at affordable cost and one billing.

According to the 4G working groups, the infrastructure and the terminals will have almost all the standards from 2G to 3G implemented. The infrastructure will however only be packet based, all-IP. The system will also serve as an open platform where the new innovations can go with it.

4G standards

- WiMAX
- WiBro
- 3GPP Long Term Evolution
- HSOPA
- 3GPP2 Ultra Mobile Broadband

Services where 4G is used

- Wireless broadband access
- Multimedia Messaging Service
- Video chat
- Mobile TV
- High definition TV content,
- DVB
- Minimal service like voice and data

4G objectives

- A spectrally efficient system (in bits/s/Hz and bit/s/Hz/site)
- High network capacity

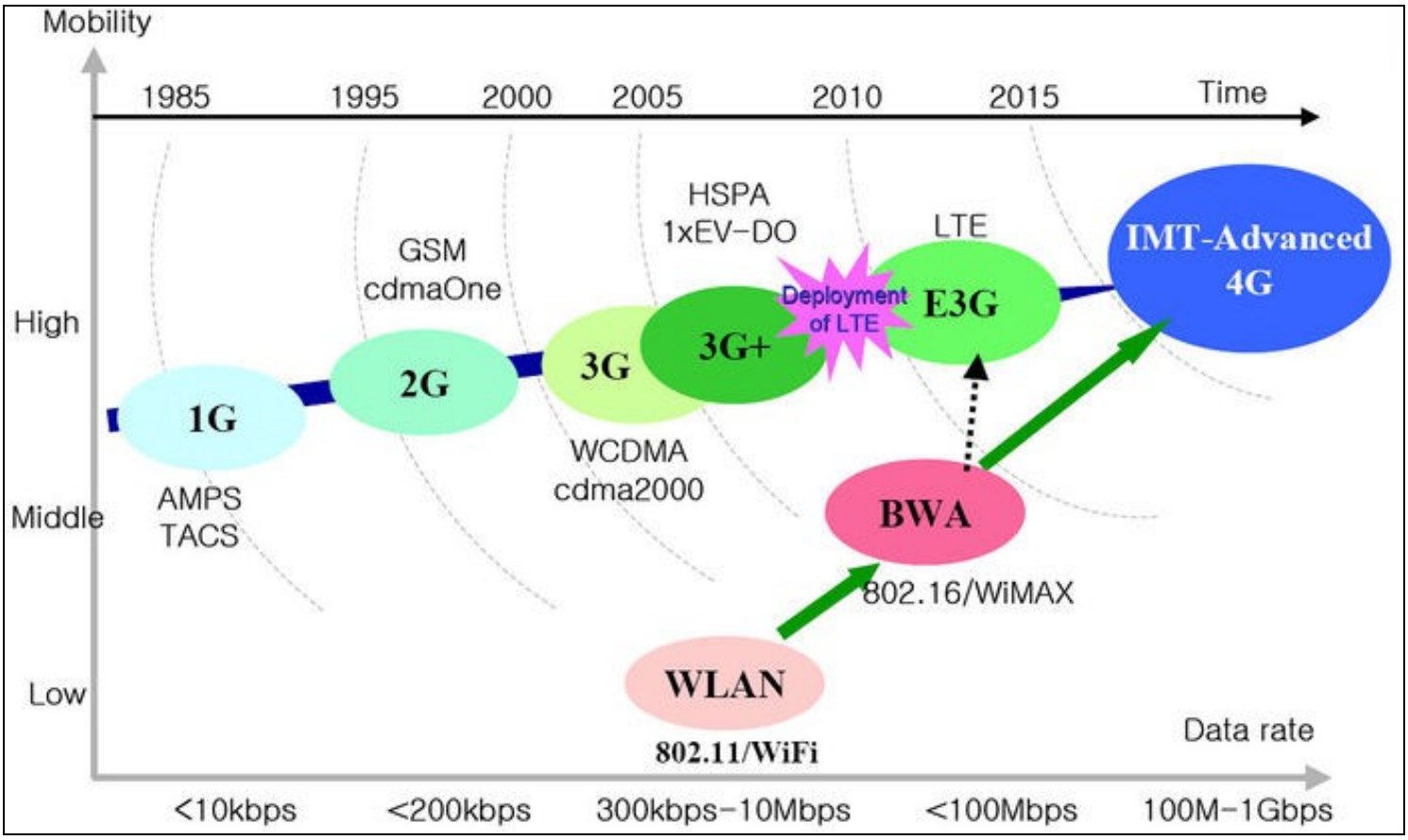
- A nominal data rate of 100 Mbit/s at high speeds and 1 Gbit/s at stationary conditions as defined by the ITU-R
- A data rate of at least 100 Mbit/s between any two points in the world
- Smooth handoff across heterogeneous network
- Seamless connectivity and global roaming across multiple networks
- High quality of service for next generation multimedia support (real time audio, high speed data, HDTV video content, mobile TV, etc)
- Interoperability with the existing wireless standards
- An all IP, packet switched network

Technology overview

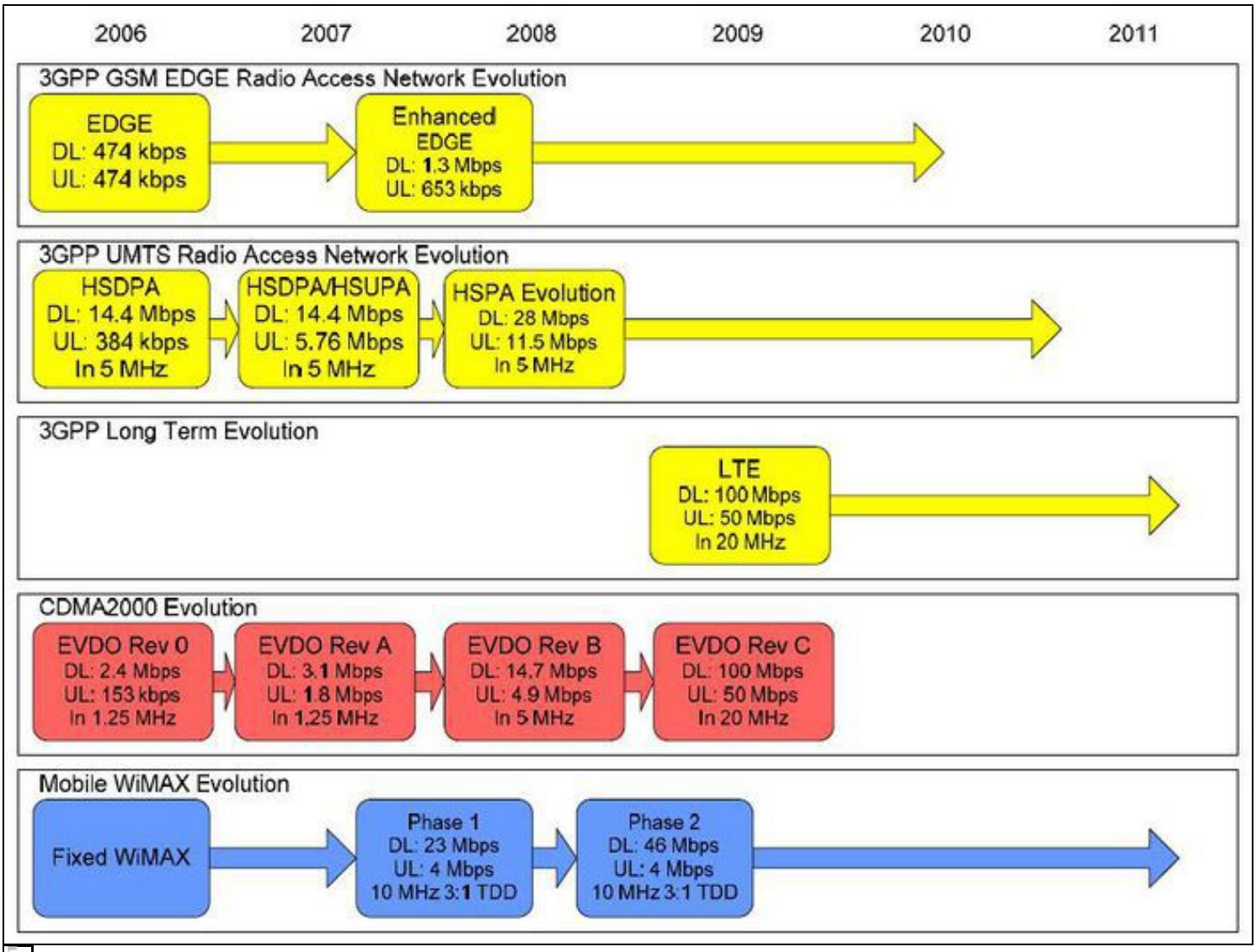
Mindmap below shows the overview of emerging technologies in 4G

Parameter	4G				
	WiMAX	WiBro	3GPP LTE	HSOPA	3GPP2 UMB
Logo					
Access scheme	OFDMA	OFDMA	SC-FDMA Uplink OFDMA Downlink	SC-FDMA Uplink OFDMA Downlink	OFDMA
Duplex system	TDD/FDD	TDD	TDD/FDD	FDD	FDD
Channel Bandwidth	3.5, 5, 7, 8.75, 10, 15, 20MHz	8.75MHz	1.25, 1.6, 2.5, 5, 10, 15 and 20 MHz	1.25 MHz to 20 MHz	1.25 - 20 MHz
FFT size	128, 256, 512, 1024, 2048	1024	128, 256, 512, 1024, 1536, 2048	128, 256, 512, 1024, 1536, 2049	N/A
Data rate	70 Mbps	30 - 50 Mbps	100 Mbps Downlink 50 Mbps Uplink	14.4 Mbps	275 Mbps Downlink 75 Mbps Uplink
Antenna System	MIMO-AAS smart antenna subsystems. (6 - antenna array)	MIMO-AAS smart antenna subsystems. (6 - antenna array)	MIMO-AAS smart antenna subsystems. (4 - antenna array)	MIMO-AAS smart antenna subsystems.	MIMO-AAS smart antenna subsystems.
FEC scheme	Convolution Code Convolution Turbo Code	Convolution Code Convolution Turbo Code	Convolution Code Turbo Code	N/A	N/A
Modulation	BPSK, QPSK, 16QAM, 64QAM	QPSK, 16QAM, 64QAM	QPSK, 8PSK 16 QAM	16 QAM	BPSK, 8PSK, QPSK, 16QAM, 64QAM
Frequency band	2.3GHz ~ 2.4GHz	2.3GHz ~ 2.4GHz	2010MHz ~ 2025MHz	N/A	450 MHz to 3.6GHz
Cell coverage	10 KM	1 KM	5 - 100 KM	N/A	N/A

Mobile technology roadmap

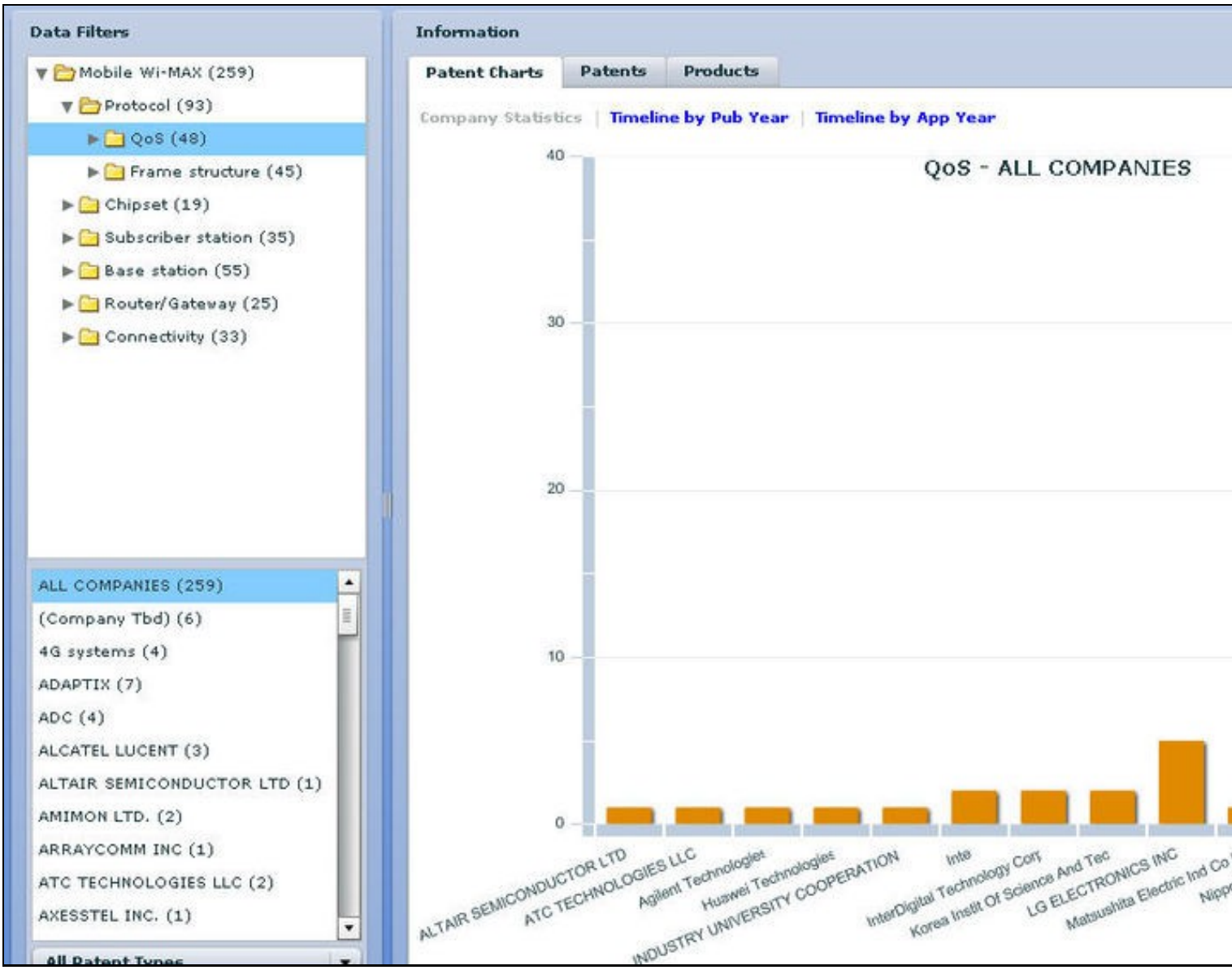

Mobility
1985
1995
2000
2005
2010
2015
Time
HSPA
1xEV-DO
LTE
GSM
cdmaOne
IMT-Advanced
4G
High
Deployment
of LTE
E3G
3G+
2G
3G
1G
WCDMA
cdma2000
AMPS
TACS
Middle
BWA
802.16/WiMAX
WLAN
Low
802.11/WiFi
Data rate
<10kbps
<200kbps
300kbps-10Mbps
<100Mbps
100M-1Gbps

Roadmap

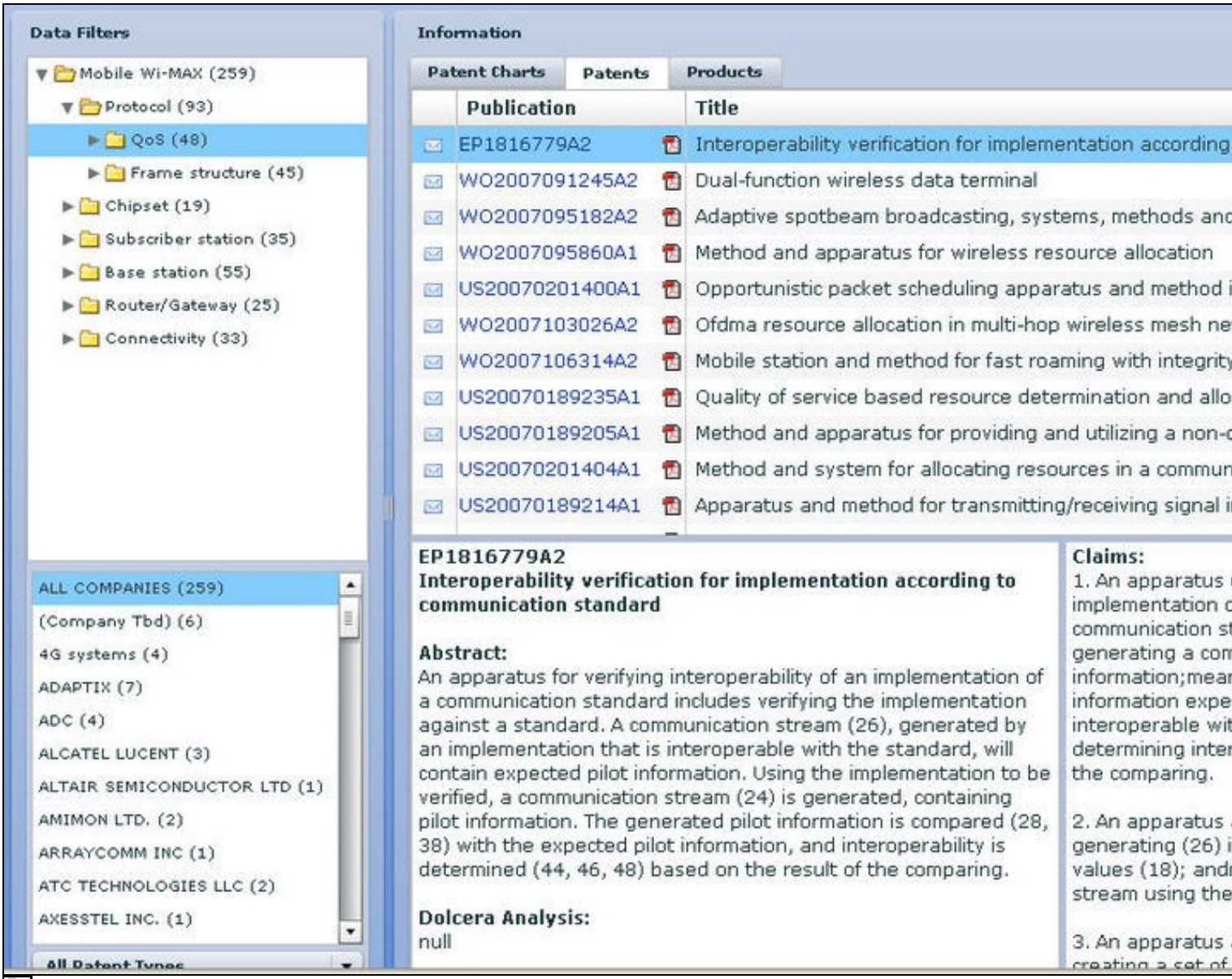


Roadmap

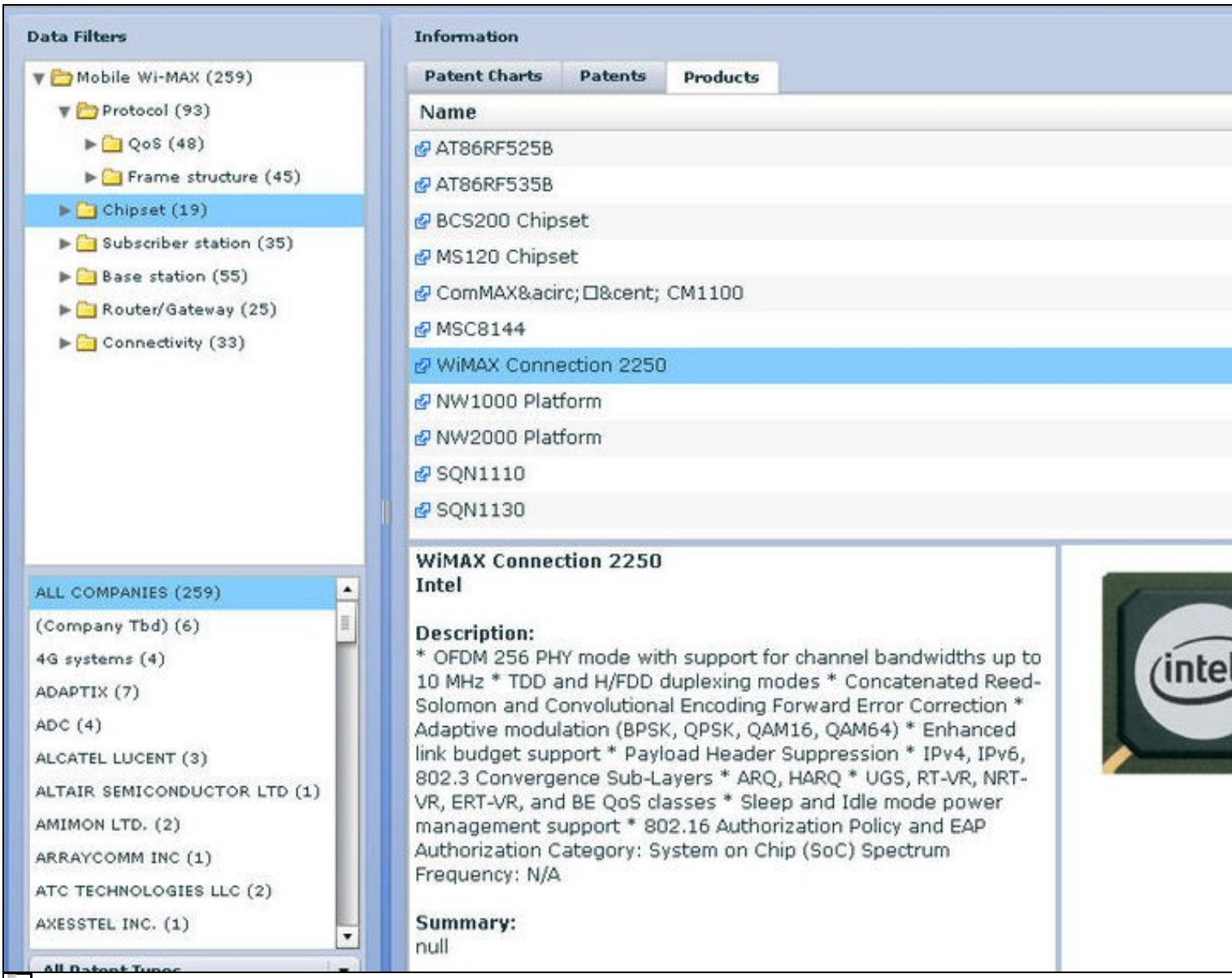
Dashboard Preview



Preview of company statistics per protocol



Preview of patents per protocol



Preview of the products for particular company

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WiMAX

WiMAX Dashboard

- WiMAX is defined as "Worldwide Interoperability for Microwave Access" by the WiMAX Forum, formed in June 2001 to promote conformance and interoperability of the IEEE 802.16 standard, officially known as WirelessMAN. WiMAX aims to provide wireless data over long distances, in a variety of different ways, from point to point links to full mobile cellular type access. In practical terms this enables a user, for example, to browse the Internet on a laptop computer without physically connecting the laptop to a wall jack.

Background Information

Spectrum coverage by geography Image below shows the spectrum for WiMAX users World wide.

FREQUENCY	USES
2-11 GHZ	What the IEEE 802.16-2004 specifies as the operating range for point to multi-point operations
1.7 and 2.1 GHz	Advanced Wireless Services in US; potentially a spectrum of choice for AWS spectrum holders (legacy service providers)
2.3 GHz	Wireless Communications Services in US; expect incumbent service providers who already hold this spectrum to use it for WiMAX services
2.4 – 2.483 GHz	ISM and FCC Part 15, largely unlicensed, used for Wi-Fi; to be avoided by WiMAX operators on concerns of interference from Wi-Fi
2.5 GHz	BRS/EBS in US; - Projected as being a popular licensed WiMAX spectrum choice in US and for those who could not get 3.5 GHz in other nations, probably the second most popular spectrum vendors will build product for
3.5 GHz	Unlicensed in many nations outside the US. Many nations have allocated it as the WiMAX spectrum. Almost all vendors offer WiMAX product for this frequency. Not useable commercially in the US, as it is spectrum held by the military.
3.65 GHz	FCC issued an announcement in 2004 promoting opening spectrum here for quasi-unlicensed use. Has yet to be finalized. Many products made for 3.5 GHz may work well in 3.65 GHz US application
4.9 GHz	aka "Public Safety", in the US, intended for use by First Responders (police, fire, ambulance and other emergency services)
5.4 and 5.8 GHz	US unlicensed; many vendors will offer this as their US unlicensed spectrum offering



Spectrum for WiMAX users World wide
Market research data:

- Worldwide WiMAX equipment revenues are forecast to reach $3.26 billion in 2009
- Worldwide outdoor wireless mesh access node sales are forecast to reach $1.17 billion in 2009
- Samsung leads overall WiMAX equipment revenue share in 3Q06, ahead of Alvarion, Airspan, and Aperto Networks
- Strix Systems leads overall outdoor mesh revenue market share in 3Q06, just ahead of Tropos Networks and BelAir Networks
- 35% of WiMAX equipment sales come from Asia Pacific, 30% from EMEA, 20% from North America, and 14% from CALA
- 49% of wireless mesh access node sales come from North America, 25% from EMEA, 18% from Asia Pacific, and 8% from CALA
- 802.16 standards The first 802.16 standard was approved in December 2001. It delivered a standard for point to multipoint Broadband Wireless transmission in the 10-66 GHz band, with only a Line of Sight (LOS) capability. It uses a single carrier (SC) physical (PHY) standard. Source

Standards

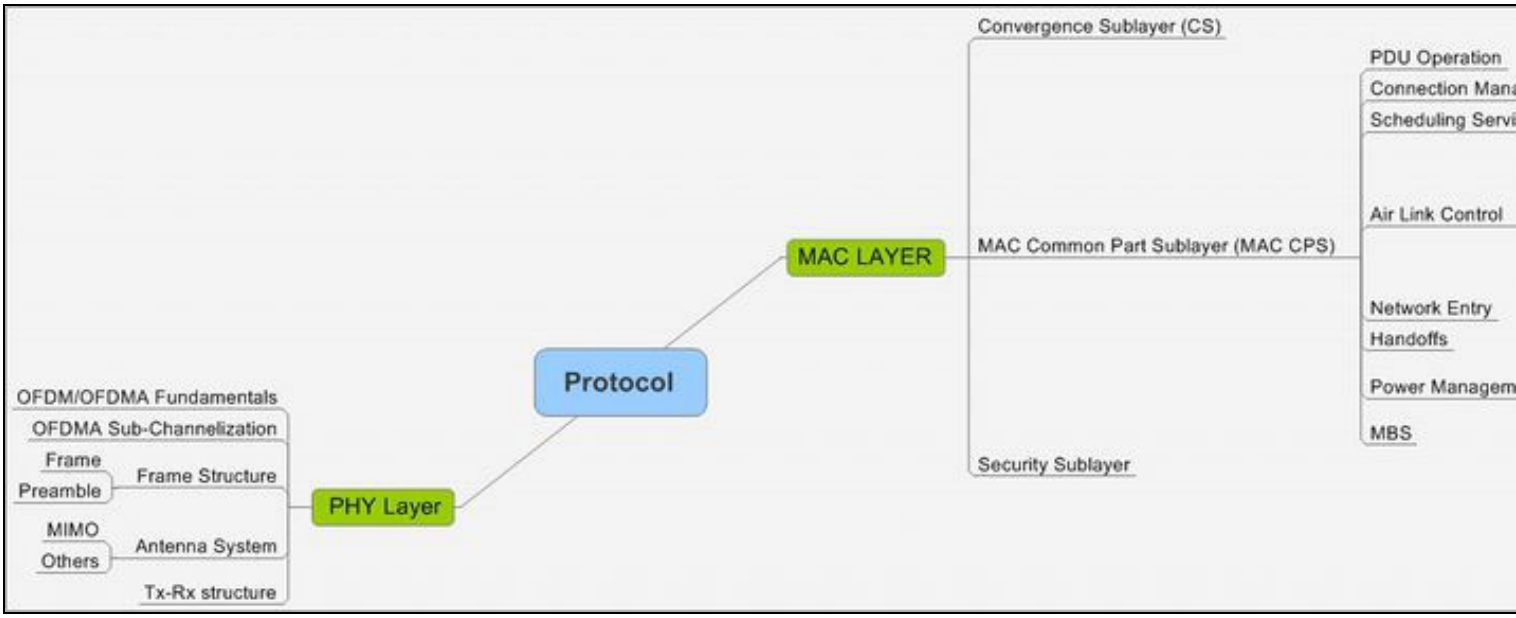
1. IEEE 802.16-2004 (802.16d) addresses only fixed systems
2. IEEE Std 802.16e-2005, also called mobile WiMAX
    - 802.16e also bring Multiple Antenna Support through Multiple-input multiple-output communications. This brings potential benefits in terms of coverage, self installation, power consumption, frequency re-use and bandwidth efficiency. 802.16e also adds a capability for full mobility support.
3. WiMAX II, 802.16m will be proposed for IMT-Advanced 4G (future development)
    - 3GPP LTE and WiMAX-m are concentrating much effort on MIMO-AAS, mobile multi-hop relay networking and related developments needed to deliver 10X and higher Co-Channel reuse multiples.

IEEE 802.16e-2005 improves upon IEEE 802.16-2004 by:

- Scaling of the Fast Fourier Transform (FFT) to the channel bandwidth in order to keep the carrier spacing constant across different channel bandwidths (1.25-20 MHz). Constant carrier spacing results in a higher spectrum efficiency in wide channels, and a cost reduction in narrow channels. Also known as Scalable OFDMA (SOFDMA).
- Improving NLOS coverage by utilizing advanced antenna diversity schemes, and hybrid-Automatic Retransmission Request (hARQ)
- Improving coverage by introducing Adaptive Antenna Systems (AAS) and Multiple Input Multiple Output (MIMO) technology
- Increasing system gain by use of denser sub-channelization, thereby improving indoor penetration
- Introducing high-performance coding techniques such as Turbo Coding and Low-Density Parity Check (LDPC), enhancing security and NLOS performance
- Introducing downlink sub-channelization, allowing administrators to trade coverage for capacity or vice versa

- Enhanced Fast Fourier Transform algorithm can tolerate larger delay spreads, increasing resistance to multipath interference
- Adding an extra QoS class (enhanced real-time Polling Service) more appropriate for VoIP applications.
- Adding support for mobility (soft and hard handover between base stations). This is seen as one of the most important aspects of 802.16e-2005, and is the very basis of 'Mobile WiMAX'. Source

Technology mapping parameters



IEEE 802.16e Protocol Stack

Content delivery

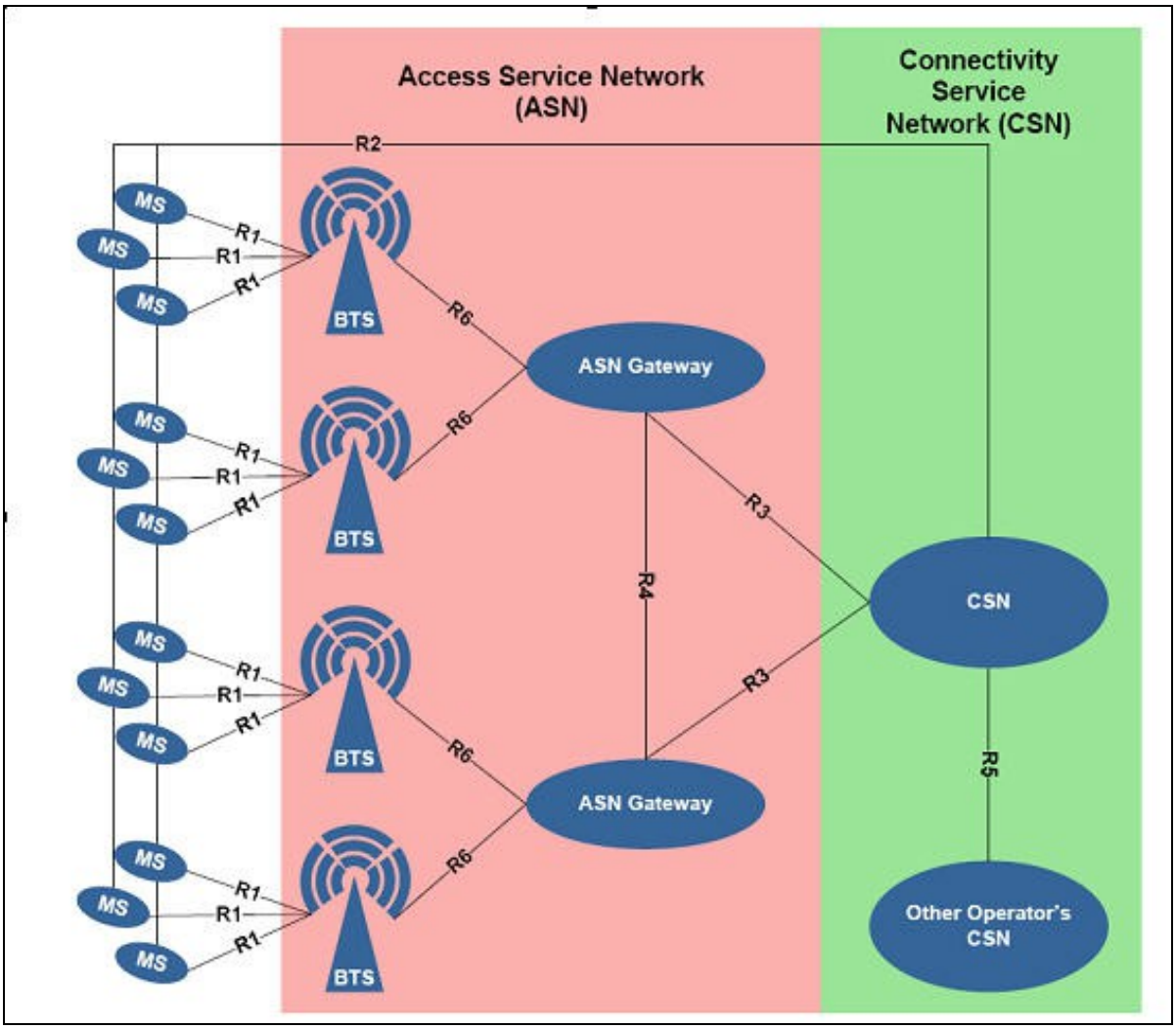
QoS service for WiMAX Content Delivery as per standard

	UGS	RT-VR	NRT-VR	BE	ERT-VR
Service	**Unsolicited Grant Service**	**Real-Time Variable Rate Service**	**Non-Real-Time Variable Rate service**	**Best Efforts Service**	**Extended Real-Time Variable Rate Service.**
	Real time service (e.g.VoIP) generating fixed data rate. Data can be provided as either fixed or variable length PDU.	Real-time service (e.g.MPEG) applications with variable bit rates. Require guaranteed data rate and delay.	Non Real time service (FTP) for guaranted data rate.This service is insensetive to delays.It is desirable in certain cases to limit the data rate of these services to some maximum rate.	The intent of the BE service grant scheduling type is to provide efficient service for best effort traffic in the uplink.	This service is to support real-time applications with variable data-rates, which require guaranteed data and delay, for example VoIP with silence suppression.
Parameters	1) Minimum reserved traffic rate 2) Maximum Latency 3)Request/Transmission Policy 4) Unsolicited Grant Interval	1) Maximum Latency 2) Minimum Reserved Traffic Rate 3) Maximum Sustained Traffic Rate 4) Traffic priority 5)Request/Transmission policy 6) Unsolicited Polling Interval	1) Minimum Reserved Traffic Rate 2) Maximum Sustained Traffic Rate 3) Traffic priority 4)Request/Transmission policy	1) Maximum Sustained Traffic Rate 2) Traffic priority 3)Request/Transmission policy	1) Maximum Latency Tolerated Jitter 2) Minimum Reserved Traffic Rate 3) Maximum Sustained Traffic Rate 4) Traffic Priority 5)Request/Transmission Policy 6) Unsolicited Grant Interval

WiMAX Network Reference Model

Access Service network(ASN): The ASN coordinates traffic across multiple Base Transceiver Stations (BTS) and supports security, handoffs and Quality of Service (QoS).

- The ASN interfaces the BTS and the all-IP core network?the CSN. Typically the ASN includes numerous BTSs with one or more ASN gateways.
- The ASN manages radio resources, MS access, mobility, security and QoS. It acts as a relay for the CSN for IP address allocation and AAA functions.



WiMAX Network Reference Model

Interface	Description	Functionality
R1	Interface between the MS and the ASN	Air interface
R2	Interface between the MS and the CSN	AAA (Authentication, Authorization, & Accounting), IP host configuration, mobility management
R3	Interface between the ASN and the CSN	AAA, policy enforcement, mobility management
R4	Interface between the ASNs	Mobility management
R5	Interface between the CSNs	Internetworking,roaming
R6	Interface between BTS and ASN gateways	IP tunnel management to establish and release MS connection
R8	Interface between the BTSs	Handoffs

ASN Gateway functions

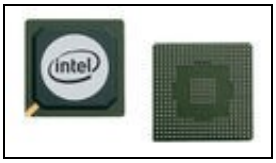
- Service Flow Authorization
- Authentication and key distribution
- Session/Context maintenance
- Handover co-ordination & Mobility management
- Paging control
- Accounting client
- DHCP proxy/relay
- MIP client/FA
- Data-path management and (re)-anchoring
- Policy Enforcement
- Multiple BS, ASN, CSN configurations

Companies

- List of companies

Products

Table below shows some of the products using WiMAX technology.

Company	Product		Image
	Main category	Sub category	
Intel	System on Chip (SoC)	WiMAX Connection 2250	
Redline Communication	Subscriber station	RedMAX? Indoor Subscriber Unit (SU-I)	
Airspan	Base station	HiperMAX	
Samsung	WiMAX mobile phone	Samsung SPH-P9000 Cellphone	
Navini networks	Antenna system	Ripwave? MX 2.3GHz	

Sample analysis

- Mobile WiMAX spreadsheet

Conferences

- WiMAX world conference - 2008 in USA.
- Big-name vendors lined up to offer WiMAX laptops
- Mobile WiMAX: The Attack Plan
- WiMAX Strategies 2007
- GSM>3G ME - The Leading Middle Eastern Communications Event - Dubai, UAE
- WiMAX 2007
- ISPCON fall - 2007
- IPTV world forum - 2007 Middle East & Africa
- Mobile Internet World conference - 2007
- Strategies for digital living markets - 2007 (Connections - Europe)
- IPTV Asia - 2007
- IPTV World Forum Latin America 08
- WCA International Symposium & Business Expo
- IPTV World Forum 08
- WiMAX Forum Congress Asia - 2008
- WiMAX Forum Global Congress - 2008
- WiMAX Forum Congress Americas - 2008
- WCA - 2008 Capitalizing on the 4G/WiMAX Eco-System
- The Professionals Meridian Conferences
- 'Broadband & Beyond' conference highlights WiMAX technology
- Amsterdam conference addresses WiMAX trends and issues
- WiMAX ? Financial, Services, Technology Trends for Service Providers
- 2007 WiMAX Forum Taipei Conference
- 4th MOBILE WiMAX Forum PlugFest 4th MOBILE WiMAX Forum PlugFest
- The 1st South Asia Broadband Communications Congress & Expo
- India ? Hub for Telecom Manufacturing & Exports
- ASSOCHAM Frost & Sullivan International Conference on Broadband 2007
- CommunicAsia 2007
- WiMAX World Europe 2007
- 3rd Mobile WiMAX Forum PlugFest
- 15th Convergence India 2007
- 2nd Mobile WiMAX Forum PlugFest
- India Telecom 2007
- WiMAX Focus

WiMAX deals

- Intel wins Nokia mobile WiMAX deal
- Samsung, Sprint in WiMAX deal for NYC
- Clearwire, Sprint Near WiMAX Deal -- WSJ
- CTIA: Moto wins ninth WiMAX deal; launches new BTS
- UK's picoChip wins WiMAX deal with China's ICT
- Motorola has secured two contracts to build WiMAX networks in Taipei, Taiwan.
- Intel mum on WiMAX deal in central China
- Nortel, Toshiba in WiMAX deal

- Sprint, Nokia Ink WiMAX Deal
- Airspan, Umniah WiMAX deal
- ZyXEL and Sprint sign deal for WiMAX customer premise equipment
- Intel Makes Largest Investment Ever in WiMAX Deal with Clearwire and Motorola
- Pipex pens WiMAX deal with Nokia Siemens Networks
- Nortel Scores WiMAX Deal in U.S.
- DoCoMo, Acca ready WiMAX deal
- AOL and Clearwire Seal WiMAX Deal
- Nera wins Africa WiMAX deal.

WiBro

WiBro is an acronym for wireless broadband and is actually a term that is in the process of being phased out in favor of the more collaborative and generic Mobile WiMAX.

- Korean standards makers early on adopted the term to describe their initiatives towards adopting a version of the 802.16e standard.
- Basically, the Korean standard chose to accept a specific mobile WiMAX iteration of 802.16e, rather than any future version that included backwards compatibility to fixed wireless 802.16 systems.
- Korea enjoys probably the most extensive 3G deployments in the world already, and its fixed broadband access per capita is the highest in the world. What it needed was an improved mobile broadband. In fact, the Korean government issued the first three deployment licenses for WiBro/Mobile WiMAX in January of 2005.
- WiBro/Mobile WiMAX in many respects is driving the mobile side of WiMAX at least from the point of view of vendors eager to provide products to these early deployments. This decision however, results in a backwards compatibility problem with Fixed WiMAX standards or 802.16-2004.
- The smooth interoperability of previous WiBro gear from Samsung with other vendors such as Motorola should be cemented this year as these two companies along with Intel have been chosen as the primary vendor for Sprint Nextel?s WiMAX deployment. The two companies clearly have a powerful incentive for their products to work seamlessly.

Standards

- WiBro is an integral part of IEEE 802.16e

Companies

- List of companies supporting WiBro technology

Industry news:

- South Korean telco SK Telecom and Wavesat, a Canadian developer of a WiMAX chipset, software and development platform have signed an agreement to cooperate in the development of WiBro/OFDMA technology for next generation mobile devices.
- Wavesat will work with SK Telecom (SKT) to develop WiBro/OFDMA systems-on-chips (SoCs), system tools and a development kit based on the WiBro 802.16e S-OFDMA profile. The U-mobile product portfolio from Wavesat will allow WiMAX wireless system providers (OEMs/ODMs) worldwide to develop and deploy fully mobile WiMAX and WiBro solutions.Source

Products Overview

Company	Product		Image
	Main category	Sub category	
Samsung	Mobile Station	M8000 WiBro handset	

		Super WiBro Phone	
		WiBro-enabled notebook pc	
	Access control Router	Access control Router	
Kisan Telecom	Base station	WiBro Repeater	
i-River	Mobile Station	G10 games console	

Korea Telekom	USB modem	iPlug Premium	

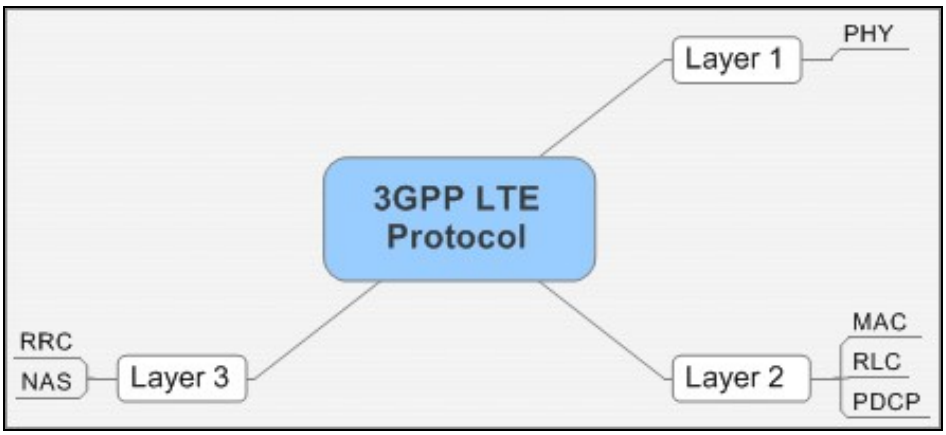
3GPP Long Term Evolution

3GPP LTE (Long Term Evolution) is the name given to a project within the Third Generation Partnership Project to improve the UMTS mobile phone standard to cope with future requirements.

- LTE focus is on Enhancement of the Universal Terrestrial Radio Access (UTRA) and Optimisation of the UTRAN architecture.
- Downlink based on OFDMA (OFDMA offers improved spectral efficiency, capacity, etc)
- Uplink based on SC-FDMA (single carrier) (SC-FDMA is technically similar to OFDMA but is better suited for uplink from hand-held devices- more considerations on battery power)

Standards

- Download rates of 100 Mbit/s, and upload rates of 50 Mbit/s for every 20 MHz of spectrum
- At least 200 active users in every 5 MHz cell. (ie 200 active phone calls)
- Sub-5ms latency for small IP packets
- Increased spectrum flexibility, with spectrum slices as small as 1.25 MHz (and as large as 20 MHz) supported (W-CDMA requires 5 MHz slices, leading to some problems with roll-outs of the technology in countries where 5 MHz is a commonly allocated amount of spectrum, and is frequently already in use with legacy standards such as 2G GSM and cdmaOne.) Limiting sizes to 5 MHz also limited the amount of bandwidth per handset
- Optimal cell size of 5 km, 30 km sizes with reasonable performance, and up to 100 km cell sizes supported with acceptable performance
- Co-existence with legacy standards (users can transparently start a call or transfer of data in an area using an LTE standard, and, should coverage be unavailable, continue the operation without any action on their part using GSM/GPRS or W-CDMA-based UMTS)



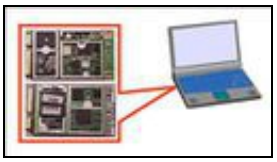
3GPP LTE protocol stack

Companies

- List of companies supporting 3GPP technology

Products

Company	Products		Image
	Main category	Sub category	
Rohde & Schwarz	Signal Analyzer	FSQ Signal Analyzer	

Pourseyed_UBC_IEEE_PDF.pdf Sierra Wireless	PC cards	PC card	
Anritsu Company	Test Systems	MX785201A test systems	
Anritsu Company		MD8480C signaling tester	
Picochip	Bse station	Base station damo	

HSOPA

High Speed OFDM Packet Access (HSOPA) is a proposed part of 3GPP's Long Term Evolution (LTE) upgrade path for UMTS systems. HSOPA is also often referred to as Super 3G. If adopted, HSOPA succeeds HSDPA and HSUPA technologies specified in 3GPP releases 5 and 6. Unlike HSDPA or HSUPA, HSOPA is an entirely new air interface system, unrelated to and incompatible with W-CDMA. Features of HSOPA

Standards

- Flexible bandwidth usage with 1.25 MHz to 20 MHz bandwidths. By comparison, W-CDMA uses fixed size 5 MHz chunks of spectrum.
- Increased spectral efficiency at 2-4 times more than in 3GPP release 6, peak transfer rates of 100 Mbit/s for downlink and 50 Mbit/s for uplink.
- Latency times of around 20 ms for round trip time from user terminal to RAN, approximately the same as a combined HSDPA/HSUPA system, but much better than "classic" W-CDMA.

Design

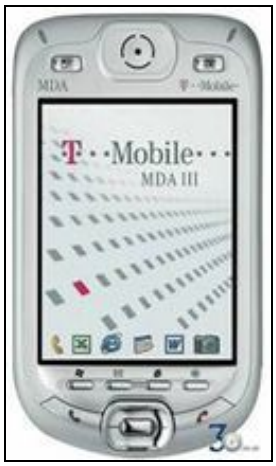
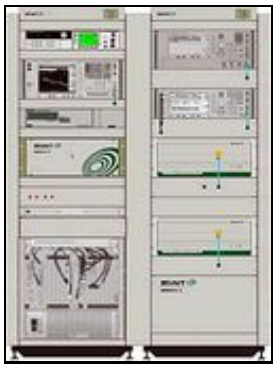
HSOPA uses Orthogonal Frequency Division Multiplexing (OFDM) and multiple-input multiple-output (MIMO) antenna technology to support up to 10 times as many users as W-CDMA based systems, with lower processing power required on each handset.[1]. Still in development, experimental performance is 37 Mbit/s in the downlink over a 5 MHz channel, close to the theoretical maximum of 40 Mbit/s.

Companies

- List of companies supporting HSOPA technology

Products

Company	Products		Image
	Main category	Sub category	
Orange	PC crad	PC card	

			
Samsung	Mobile	SGH-Z620	
T - mobile		MDA Vario III	
Sarian	Router	HR4110 HSDPA router	
Centro technologies	RF HSDPA Test Cases	MINT T1152-HSDPA	

3GPP2 Ultra Mobile Broadband

UMB (Ultra Mobile Broadband) is the brand name for the project within 3GPP2 to improve the CDMA2000 mobile phone standard for next generation applications and requirements.The system employs OFDMA technology along with advanced antenna techniques to provide peak rates of up to 280 Mbit/s.

Goals for UMB:

- Improving system capacity
- Greatly increasing user data rates throughout the cell
- Lowering costs
- Enhancing existing services
- Making possible new applications, and
- Making use of new spectrum opportunities.

The technology will provide users with concurrent IP-based services in a full mobility environment. The UMB standardization is expected to be completed in mid 2007, with commercialization taking place around mid-2009.

Standards

- OFDMA-based air interface
- Frequency Division Duplex
- Scalable bandwidth between 1.25-20 MHz (OFDMA systems are especially well suited for wider bandwidths larger than 5 MHz)
- Supports mixed cell sizes, e.g., macro-cellular, micro-cellular & pico-cellular.
- IP network architecture
- Supports flat, centralized and mixed topologies
- Data speeds over 275 Mbit/s downstream and over 75 Mbit/s upstream Source

More infromation

Key features

- Multiple radio and advanced antenna techniques
    1. Sophisticated control and signaling mechanisms (minimized) combine the best aspects of CDMA, TDM, OFDM, and OFDMA into a single air interface
    2. Multiple Input Multiple Output (MIMO) and Space Division Multiple Access (SDMA)
    3. Improved interference management techniques
- Ultra-high mobile broadband peak data rates
    1. Up to 280Mbps peak data rate on forward link
    2. Up to 68Mbps peak data rate on reverse link
- Ultra-low network latency
    1. An average of 16.8 msec (32-byte, RTT) end-to-end network latency
- Enhanced VoIP capacity and user experience
    1. Up to 500 simultaneous VoIP users (10 MHz FDD allocations)
- Scalable IP-based flat or hierarchical architecture
    1. Greater service deployment flexibility, improved performance, and lower cost of ownership
- Flexible spectrum allocations
    1. Scalable, non-contiguous and dynamic channel (bandwidth) allocations
    2. Support for bandwidth allocations of 1.25 MHz, 5 MHz, 10 MHz and 20 MHz
- Less power consumption
    1. Improved battery life

Source

Companies

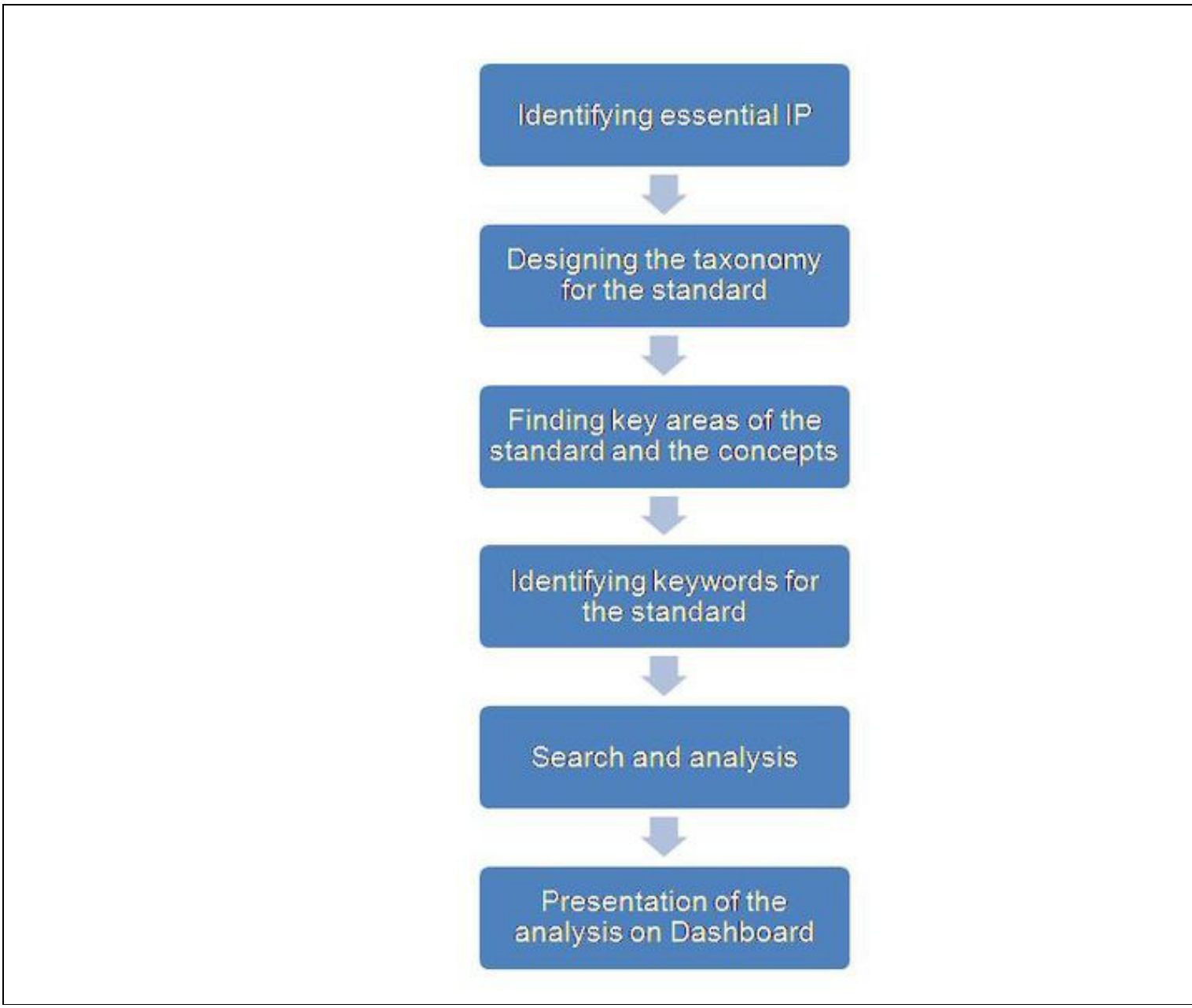
- List of companies supporting 3GPP2 UMB technology

Products

Company	Products		Image
	Main category	Sub category	
OQO Inc	Ultra mobile PC	OQO Model 2 ultra mobile	
3 Mobile	Broad band USB	Mobile Broadband USB modem	

Sprint	Mobile Broadband Card	EV-DO card	
Qualcomm	Base station	Base station	N/A

Process Chart



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