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Report on WiMAX

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6 WiMAX

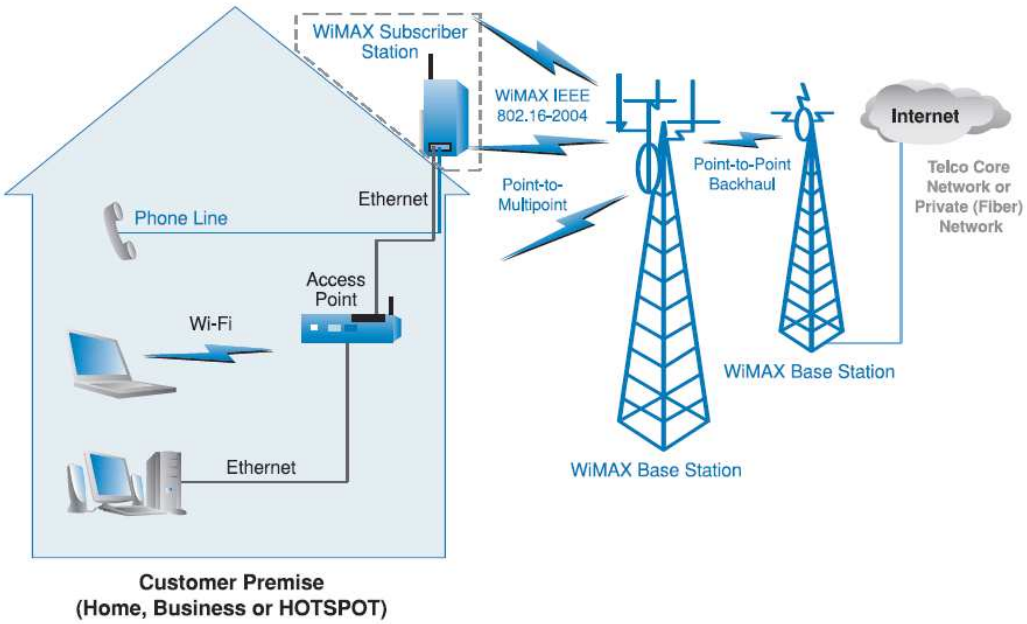
6.1 Background

Worldwide Interoperability for Microwave Access (WiMAX) is a wireless communication system that allows computers to remotely connect to high-speed data networks like the Internet.

The IEEE 802.16 standard defines the standards for Broadband Wireless Metropolitan Area Networks. [601]

WiMAX is the commercial name for this class of systems. The WiMAX Forum is an industry-led, not-for-profit organization formed to certify and promote the compatibility and interoperability of broadband wireless products based upon the harmonized IEEE 802.16/ETSI HiperMAN standard [602].

WiMAX systems are composed of subscriber stations, base stations, interconnecting switches, and databases. WiMAX provides an alternative solution to ADSL for the "Final Mile" broadband Access.



Source: Advanced Network Module, www.bournemouth.ac.uk

6.2 History

6.2.1 Fixed Access

The IEEE 802.16 Group was formed in 1998. Its original focus was on Line Of Sight (LOS). The Original IEEE 802.16 standard was completed in 2001. An amendment to the standard produced IEEE 802.16a to include Non-Line of Sight (NLOS)

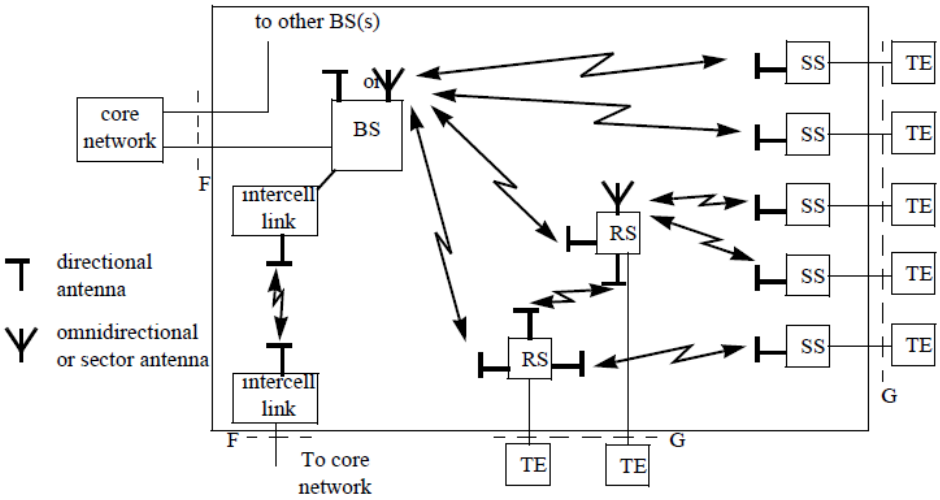
A revised standard, IEEE 802.16-2004 was produced for fixed subscribers.

6.2.2 Introduction of mobility

Subsequently in 2005, the IEEE 802.16e standard was produced to support mobile subscribers.

6.3 WiMAX

6.3.1 Fixed Broadband Wireless Access (FBWA)



Source [601] IEEE 802.16-2004 Reference diagram for FBWA systems

BS Base Station
RS Relay Station
SS Subscriber Station
TE Terminal Equipment (i.e. PC, Phone etc)

6.3.2 Spectrum

WiMAX can operate in the radio spectrum from 2GHz to 66GHz.

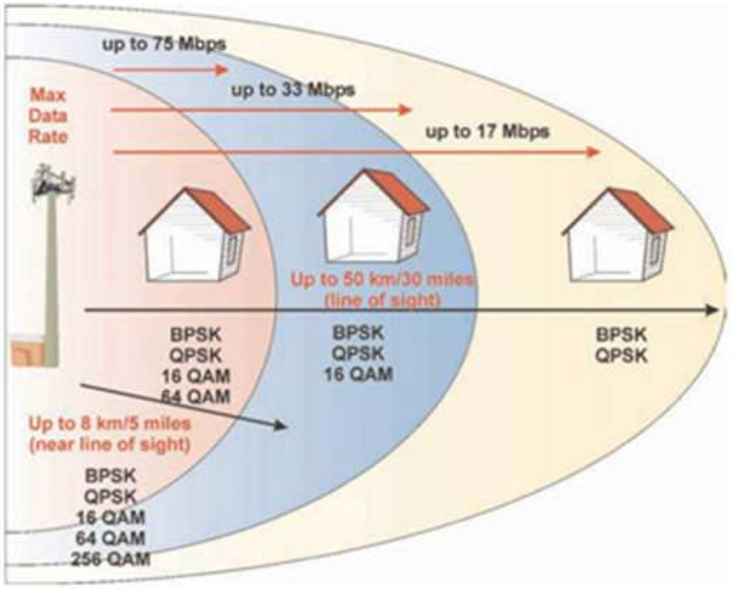
Though WiMAX can operate in the unlicensed spectrum, nearly all providers prefer to provide service in the licensed spectrum. The unlicensed spectrum can be unpredictable in terms of noise and interference and normally regulators insist that transmitters in this spectrum are very low power.

In the UK, Ofcom is the independent regulator and competition authority for the UK communications industries. Amongst its brief is the allocation/sale of radio spectrum. For example, Urban WiMAX which provides coverage in central London has 112MHz licence at 28.1925 and 29.2005MHz [604].

In America it is the Federal Communicate Commissions (FCC) that is responsible for allocating Spectrum.

6.3.3 Performance characteristics

Performance of WiMAX depends on the bandwidth allocated. For a typical 20MHz bandwidth, peak speeds of up to 75mbits^{-1} can be achieved.



Source [609] WiMAX Explained

6.3.4 Modulation in WiMAX

OFDMA

WiMAX uses Scalable Orthogonal Frequency Division Multiple Access (SOFDMA) for both the down and uplinks. WiMAX supports Frequency Division Duplex (FDD), Time Division Duplex (TDD) as well as adaptive Time Division Duplex. This means channel bandwidth can be divided in both the frequency and time domain and also between down links and uplinks.

Adaptive Modulation

On each of its sub-carriers, WiMAX uses adaptive modulation dynamically adjusting the modulation type of a communication channel based on specific criteria (e.g. signal quality – signal strength, interference and noise), dropping down from 256QAM near the base station down through BPSK at the edge of the cell.

Channel Bandwidth	Modulation	QPSK	QPSK	16 QAM	16 QAM	64 QAM	64 QAM
	FEC Coding	1/2	3/4	1/2	3/4	2/3	3/4
1.75 MHz		1.04	2.18	2.91	4.36	5.94	6.55
3.5 MHz		2.08	4.37	5.82	8.73	11.88	13.09
5 MHz		4.16	6.28	8.32	12.48	16.63	18.7
7 MHz		4.15	8.73	11.64	17.45	23.75	26.18
10 MHz		8.31	12.47	16.63	24.94	33.25	37.4
20 MHz		16.62	24.94	33.25	49.87	66.49	74.81

Source: "Wireless Broadband Spectrum Recommendation," A. N. Muragappan, June 2006

Source "Wireless Broadband Spectrum Recommendation," A. N. Muragappan, June 2006

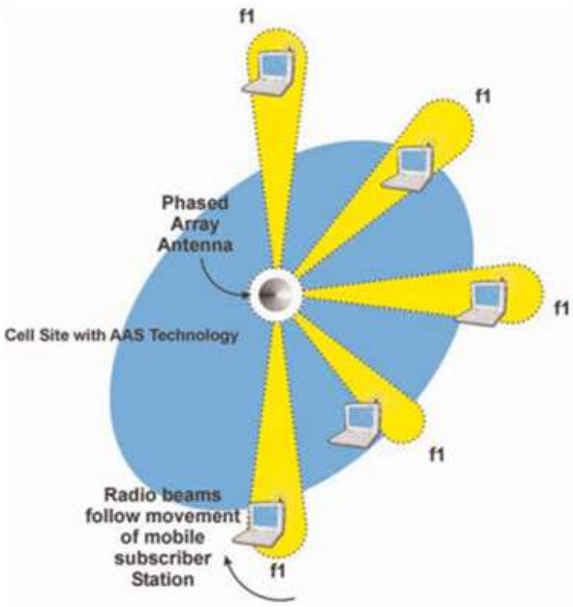
6.3.5 Sectoring, beam forming Diversity MIMO

Sectoring

WiMAX can re-use frequency within a cell by dividing the cell into sectors and positioning the base stations aerials in positions such that they form beams in particular directions. The frequency can be re-used between the individual beams.

Beam Forming

WiMAX can be built with Adaptive Antenna System (AAS). This is a form of sectoring where the beams follow the subscribers within a cell. Again, the frequencies can be re-used.



Source [609] Beam Forming, WiMax Explained

Diversity Transmissions

WiMAX uses diversity transmission (frequency, temporal and spatial) to improve the signal to noise ratio and extend the range of the base station. The subscriber station can combine the streams of information to build error free frames.

MIMO

WiMAX can use Multiple Input Multiple Output to either increase the throughput through spatial multiplexing or to improve signal to noise ration as stated above.

6.3.6 Network Topology

WiMAX networks can be point to point (this is normally used for backhaul network), Point to multipoint (i.e. Base Station to many Subscriber Stations) and mesh.

Mesh is where subscriber stations can be connected to multiple Base Stations and multiple base stations are connected to each other. This allows for redundancy, potentially better load balancing allowing packets to travel through many alternative routes.

6.3.7 Quality of Service (QoS)

WiMAX supports 5 classes of QoS in descending priority.

- Unsolicited Grant Services (UGS)
- real-time Polling Services (rtPS):
- extended real-time Polling Service (ertPS)
- non-real-time Polling Services (nrtPS):
- Best Effort Services (BES):

For example, Best Effort Service whereas Voice over Internet Protocol (VoIP) uses ertPS. (Use rtPS or UGS could be used but it would waste bandwidth as there are so many silences in speech)

QoS Category	Applications	QoS Specifications
UGS *Unsolicited Grant Service*	*VoIP*	• *Maximum Sustained Rate* • *Latency Tolerance* • *Jitter Tolerance* • *Grant Interval*
rtPS *Real-Time Polling Service*	*Streaming Audio or Video*	• *Minimum Reserved Rate* • *Maximum Sustained Rate* • *Latency Tolerance* • *Traffic Priority*
ertPS *Extended Real-Time Polling Service*	*VoIP with Voice Activity Detection/ Silence Suppression*	• *Minimum Reserved Rate* • *Maximum Sustained Rate* • *Latency Tolerance* • *Jitter Tolerance* • *Traffic Priority*
nrtPS *Non-Real-Time Polling Service*	*File Transfer Protocol (FTP)*	• *Minimum Reserved Rate* • *Maximum Sustained Rate* • *Traffic Priority*
BE *Best-Effort Service*	*Data Transfer, Web Browsing*	• *Maximum Sustained Rate* • *Traffic Priority*

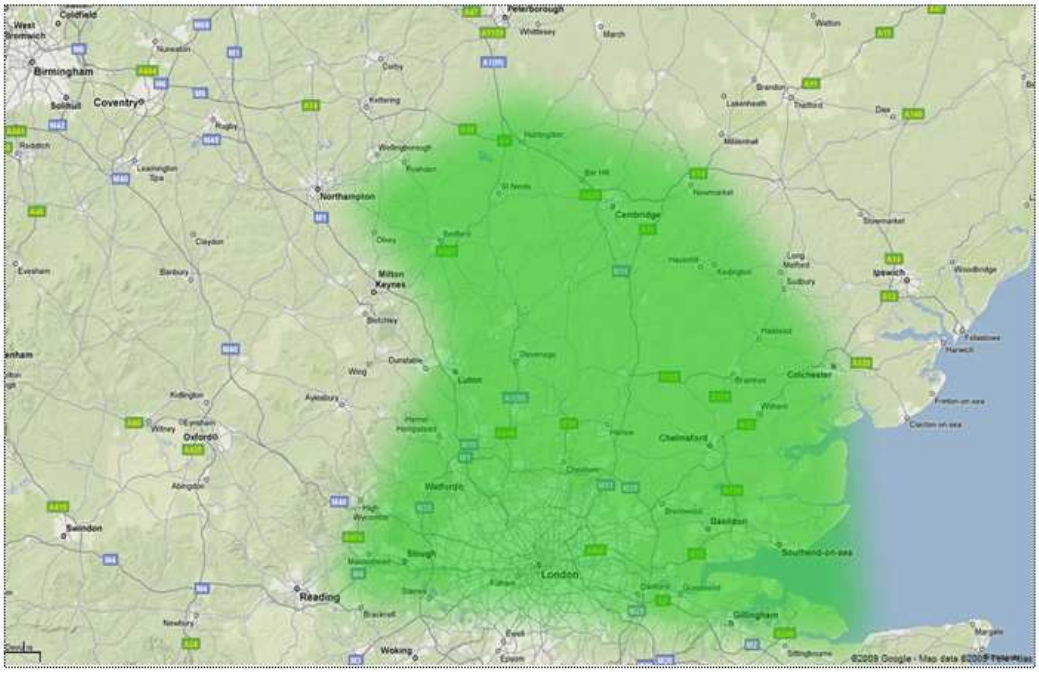
Source: "IP Design for Mobile Networks," Mark Grayson, Kevin Shatzkamer, Scott Wainner

Source [612]

6.3.8 WiMAX Coverage

In the UK, coverage of WiMAX is limited to 5 small service providers.

- Attend 2 Ltd, a WiMAX service that covers the South East of England.
- ConnectMK, Milton Keynes
- Digital Teesdale, Teesdale area in the North of England.
- LiveWave, Newcastle-upon-Tyne, Tynedale, Northumberland
- Urban WiMAX, Central London (travelcard Zone 1 and some of Zone 2).



Source [615] Attend 2 Ltd. Coverage

Rural UK Coverage

Digital Teesdale is backed by Durham County Council in conjunction with One North East. The Digital Teeside web site states that the WiMAX was a cost-effective method of providing broadband to rural locations. Speeds of up to $2Mbits^{-1}$ are now being offered. This contrasts with the project to cover Swindon with a 1,400 Wi-Fi-Mesh. This project has now been put on hold due to financial constraints.

Coverage in America is considerably more with Sprint and Clearwire leading the way.

WiMAX is also quite successful in developing countries where the roll out of fixed wire Broadband would very capital intensive.

6.4 Mobile WiMAX

IEEE 802.16e is the standard for mobile WiMAX. In practice, it is significantly different from Fixed WiMAX. Whereas the range from a Base station to a Subscriber unit could be up to 50Km, mobile subscriber units in a laptop or small mobile device are far less powerful and require Base stations every 3-5Km.[614]

It also requires greater technology in the Base Stations to allow for handover between cells. The modulation technique is also likely to be asymmetric with higher down link speeds than uplinks.

6.4.1 Costs of Mobile Coverage

Due to the number of base stations required and their added complexity, the cost of providing mobile WiMAX is much higher than providing fixed WiMAX.

Area covered by single sector base station with 90 degree antenna

WiMAX Solution		Range (Km)	Area (sq-Km)	Cost ($)	Cost/Area ($/sq-Km)	16e/16d
16d	pico BS	5	20	$1,850	$94	45
	pico BS	40	1257	$1,850	$1	2883
	Macro BS	5	20	$7,000	$357	12
	Macro BS	40	1257	$7,000	$6	762
16e	Macro BS	3	7	$30,000	$4,244	

$1,850 *Tranzeo TR-WMX-35-pBS
$7,000 *Aperto public pricing
$30,000 *Estimated Huawei 16e BS

Source [614]

UK Mobile WiMAX

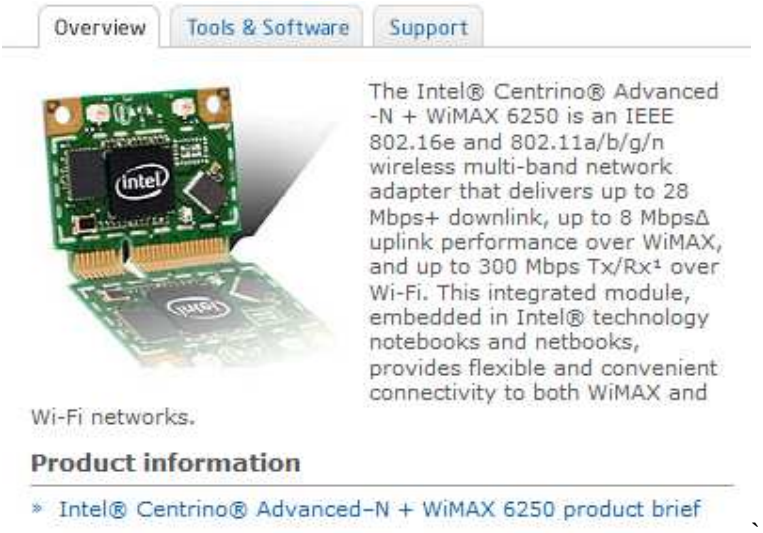
I could not find any evidence from any of UK WiMAX service providers of Mobile Coverage. – Though Nomadic coverage within a Cell was supported no true Mobile coverage was found.

6.4.2 Markets & Competition

Whereas Fixed WiMAX competes with DSL Broadband suppliers, Mobile WiMAX competes with 3G HSDPA in Mobile Telecommunications Market which has very large players (i.e. Vodafone, O2, T-Mobile).

6.4.3 Mobile Terminal Equipment

A brief survey in the UK market for Laptops with WiMAX built in showed very few devices available. Intel, a major backer of WiMAX has developed combined Wireless Wi-Fi-n and WiMAX cards (Note: WiMAX and Wi-Fi cannot be used simultaneously)



Source [604] Intel

The situation is different in the USA. The American Amazon web site advertises mobile WiMAX devices.

6.5 The Future WiMAX

6.5.1 Future Standards

The developing 802.16m standard offers new capabilities and efficiencies to meet the challenging International Mobile Telecommunications IMT-Advanced requirements.

Using 4x2MIMO in an urban microcell with a single 20MHZ channel the system will support 120Mbits^{-1} downlink and 60 Mbits^{-1} uplink.

The WiMAX Release 2 will incorporate improved latency, spectral efficiency and capabilities for VoIP. The WiMAX Forum hopes to see WiMAX release 2 commercially available within the 2011-2012 timeframe.

"As is evidenced here today, there is a broad ecosystem ready to deliver WiMAX as the first IMT-Advanced compliant technology to market," said Ron Resnick, president of the WiMAX Forum. "One of our top priorities is to bring WiMAX Forum Certified Release 2 networks and devices to market by the end of 2011. Even better, with double digit WiMAX deployment growth every month, the next release of WiMAX will have an even more substantial installed base upon which to build."[617]

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