KDDI and WiMAX

CONVERGENCE IN
THE LAND OF THE RISING SUN

KDDI is moving towards the future with Ultra 3G, their convergent
fixed, wireless and mobile network vision
to build a ubiquitous network society

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1. Introduction

As fixed, wireless and mobile networks evolve towards a convergent IP future, service providers are investigating the various migration paths offered by both fixed and wireless technologies that provide a smooth transition from network-, user- and service-perspectives. Many operators envision a fully-converged all-IP network that will provide users a seamless and completely transparent experience optimized to their device, service requirements and location as they move across a wide range of fixed and wireless access technologies in a single session, whether using voice, data or multimedia applications.

WiMAX is a key element of this convergent IP future, and many operators – both fixed and mobile – are trialing WiMAX as part of their future network plans. The ability of mobile WiMAX (IEEE 802.16e-2005) to support and interface seamlessly with 2G and 3G networks also offers mobile operators a tested and proven all-IP complement to existing 2G and 3G mobile networks. Among other things, a WiMAX overlay can provide mobile operators with low cost additional capacity in spectrum and infrastructure limited regions, new real-time high speed data services, a proven and available path to an all-IP future and a seamless end user experience across services facilitated through an IMS/MMD core, which is fully supported by WiMAX.

Just as Wi-Fi has proven itself to be a complementary technology to mobile networks, the WiMAX Forum believes that mobile WiMAX services will also complement existing and future broadband technologies, both wired and wireless, to best assure the coverage and capacity requirements to meet consumer demand. As a result, many forward-looking operators around the world are currently acting on plans to integrate WiMAX into their existing and future networks to facilitate the move to an all-IP future. WiMAX's rapid and proven development, particularly its advanced OTA (Over the Air) interface and superior performance delivered by MIMO (Multiple Input Multiple Output antenna) and Beamforming (BF) capabilities, and roadmap positioning relative to other truly comparable alternatives such as Long Term Evolution (LTE), as shown in Figure 1, make WiMAX a leading technology choice to complement future mobile network developments.
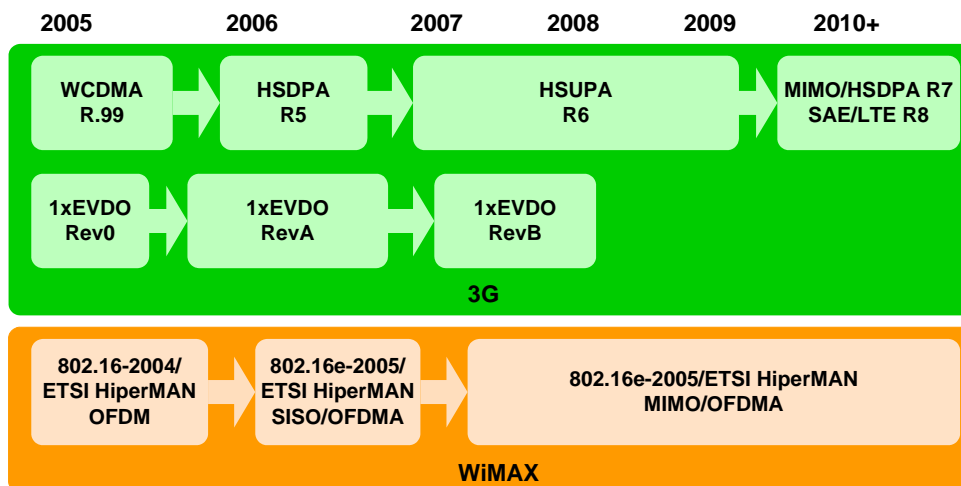
2005	2006	2007	2008	2009	2010+

WCDMA R.99	HSDPA R5	HSUPA R6		MIMO/HSDPA R7 SAE/LTE R8

1xEVDO Rev0 → 1xEVDO RevA → 1xEVDO RevB

3G

802.16-2004/ ETSI HiperMAN OFDM	802.16e-2005/ ETSI HiperMAN SISO/OFDMA	802.16e-2005/ETSI HiperMAN MIMO/OFDMA

WiMAX

Figure 1 Development roadmaps

KDDI, a primary full service Japanese operator, is the leading example to many operators around the world looking to mobile WiMAX technology as a key element of their all-IP convergent network futures. By actively pursuing and successfully trialing mobile WiMAX as part of its planned all-IP convergent network, referred to by KDDI as "Ultra 3G", KDDI is enhancing Japan's position as a leading international wireless society and early adopter and innovator of new technologies. KDDI's successful trialing of mobile WiMAX's interoperability with existing fixed, wireless and mobile networks shows that the convergent network KDDI calls Ultra 3G will successfully act as the foundation of what KDDI calls a Ubiquitous Network Society.

2. KDDI's "Ultra 3G" vision

KDDI currently provides both fixed and wireless services to customers throughout Japan via their existing DSL, FTTH and 2G/3G CDMA networks. KDDI provides extensive national coverage, with mobile coverage to over 99% of the Japanese population and a fixed network that reaches throughout Japan with just under 30,000km of terrestrial optical cable and over 10,000km of submarine cable around Japan, powering the Japan information highway. Through its leading technical R&D capabilities and vision, KDDI is empowering and embracing the development and integration of evolving technologies, with a view to realizing what KDDI defines as "a ubiquitous network society".

As part of the push towards realizing a ubiquitous network society, KDDI is actively pursuing a convergent wireless, fixed and mobile network that it has coined "Ultra 3G". Ultra 3G will provide users with a seamless experience across various complementary fixed, wireless and mobile access technologies on a packet-based core network for both voice and a full range of broadband data services. It is planned for services and applications to be provided to users seamlessly as they move between different access technologies and devices, with the access technology optimized to the user's location, device, service and application requirements, cost and throughput.

According to Tadashi Shinohara, Senior Manager at KDDI:

> "By bringing together fixed, wireless and mobile networks, we see Ultra 3G providing users with the most cost efficient and optimum bandwidth relevant to their location, user device and service or application being accessed, all in a completely dynamic and transparent fashion while on the move, say, from their office to the subway, driving in their car and then at home in their lounge room".

KDDI's vision of a single converged network is based on an IMS/MMD access-independent service platform that is powered by an all-IP based core network running IPv6 in parallel with IPv4. The network offers an evolutionary path that is immediately accessible, and will integrate wireless and fixed access by handing over transparently to the user between fixed and wireless access technologies:

- DSL

- FTTH (Fiber to the Home)

- Existing CDMA2000 variants (1xRTT, 1xEV-DO Rev 0)

- Future CDMA2000 variants (EV-DO Rev A and Rev B, Enhanced CDMA2000)

- Wi-Fi (IEEE802.11) variants (a, b, g, n)

- WiMAX (IEEE 802.16e-2005).

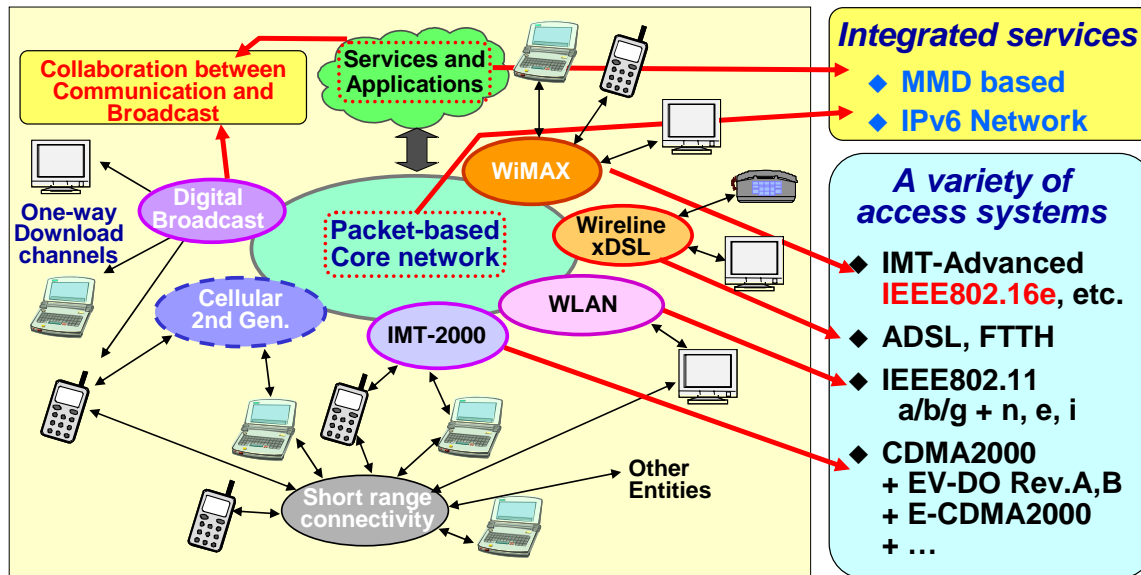The planned interactions of the various interfaces in KDDI's Ultra 3G network are shown in Figure 2.

Figure 2 Access Interfaces of KDDI's network

KDDI expects to harness the complementary capabilities and strengths of each access technology together to provide innovative MMD enabled services not capable on many existing networks. As a result of the reduced capex and opex requirements that an all-IP network enables, KDDI expects to bring these services and applications to users at reduced cost-per-bit or greater performance than those seen in existing standalone networks.

The use of WiMAX intended in KDDI's Ultra 3G network fits in the planned path to convergence of networks and services, and is appropriate for providing KDDI the opportunity to start its transition to the IP core and MMD environment ahead of other potential technologies. With the move to all-IP, KDDI expects four key network requirements to be achieved within a few years: mobility, broadband, always-on service and economic pricing of service. KDDI also expects to integrate broadcast (e.g. Digital Terrestrial Television) and communications services as part of the network as they move forward.

In moving towards this deployment plan KDDI has been undertaking mobile WiMAX trials in Osaka City to test the interaction of the wireless broadband elements of the Ultra 3G network.

3. KDDI mobile WiMAX trial

KDDI has been successfully trialing WiMAX throughout Osaka City since April 2005, running a system consisting of EV-DO base stations and three WiMAX base stations in an MMD environment alongside an IPv6 core network. The trial is being conducted in two phases, with Phase 1 completed in February 2006 and Phase 2, the advanced technology test, currently underway.
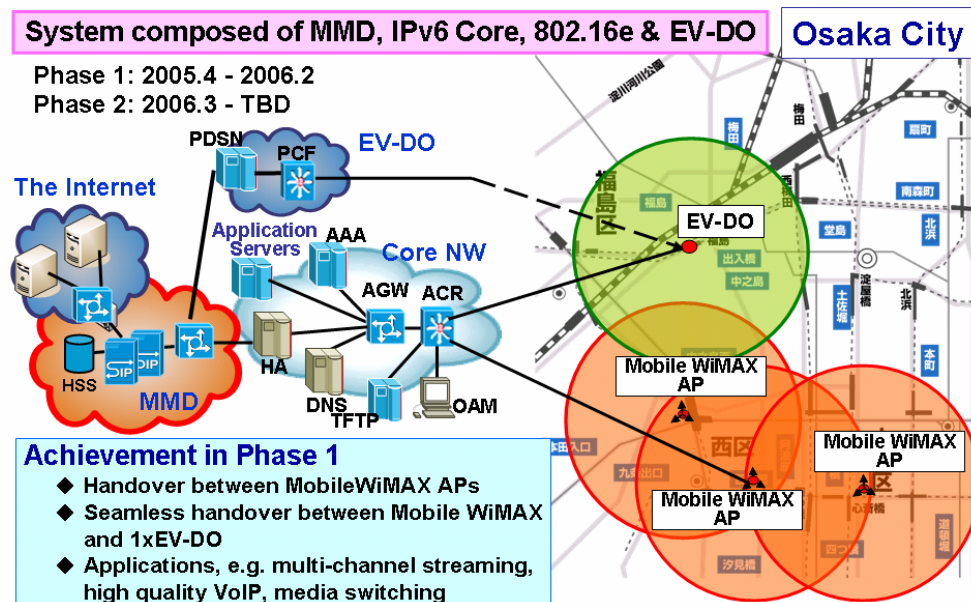
Figure 3 KDDI Field Trial

To date the trial has pointed towards the successful implementation of KDDI's vision for WiMAX and its role in Ultra 3G, with the demonstration of successful handovers within mobile WiMAX access points and between mobile WiMAX and EV-DO access points. The results were made even more impressive by the successful trialing of advanced data applications, such as multi-channel streaming, high quality VoIP and media switching. For example, KDDI successfully demonstrated a videophone service that transferred voice and video automatically and seamlessly. The trials also demonstrated the capability of the network to successfully maintain a mobile service session while moving between mobile and fixed network environments.

> "Our successful trial of mobile WiMAX and our world-first demonstration of the seamless handover between mobile WiMAX and our existing 3G EV-DO mobile network makes us extremely excited about the prospects of mobile WiMAX in Japan and the rest of the world. We are looking forward to facilitating a wide-spread roll-out of mobile WiMAX as part of our Ultra 3G plan throughout Japan" said Tadashi Shinohara, Senior Manager at KDDI.

The trial demonstrated the world's first successful handover between mobile WiMAX and EV-DO and the capability of WiMAX to be a key complement to 3G in future fixed-mobile convergent networks. The successful KDDI trial provides operators around the world with a real-world example of the capabilities of mobile WiMAX.

KDDI is building on these initial successes by further expanding the Osaka trial to test the performance of the mobile WiMAX network using MIMO technology with a 20MHz channel bandwidth profile. In addition, KDDI is also planning trials in Tokyo that will test the functionality and performance of mobile WiMAX utilizing Adaptive Antenna Systems (AAS) and Space Division Multiplexing (SDM).

4. KDDI geographic coverage and spectrum

The true complementary role WiMAX will play to 3G is highlighted by the fact that KDDI already has an extensive EV-DO network – which has coverage nationwide – along with an extremely high level of indoor coverage. KDDI sees WiMAX as a truly complementary technology to their existing and future 3G network.

Even though KDDI's 3G footprint is extensive, WiMAX will play a key role in plans to successfully rollout the Ultra 3G network with a dense coverage footprint nationwide. WiMAX will provide coverage in urban areas, extending the reach of local area Wi-Fi networks and complementing KDDI's EV-DO bandwidth in high-use, and spectrum- and capacity-limited urban environments. The overlay approach planned for Ultra 3G's coverage is shown in Figure 4.
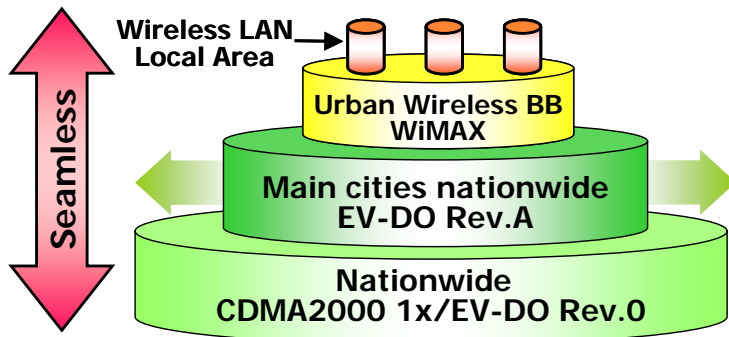

Figure 4 Ultra 3G coverage plan

KDDI's coverage and service plans hinge on obtaining a license in the 2.5GHz spectrum band during the Japanese spectrum allocation and standardization process, which is currently under consideration by MIC in conjunction with industry. KDDI is playing a leading role in the industry component of this process, with the BWA Subcommittee (responsible for standardization of Broadband Wireless Access (BWA) systems and liaison with international standardization bodies) chaired by a KDDI representative, Dr. Fumio Watanabe.

5. KDDI services and devices

Through WiMAX's ability to support IMS and MMD environments in the core, it will be possible to offer a full service set across all access technologies, ensuring the mobile service experience is not limited by the access technology or device being used. KDDI's service environment will allow for the simple addition of services and applications that can be supported throughout the network, as detailed in Figure 5. Users will experience both familiar and new applications and services through their various access devices transparently across the full range of access technologies on the Ultra 3G network.
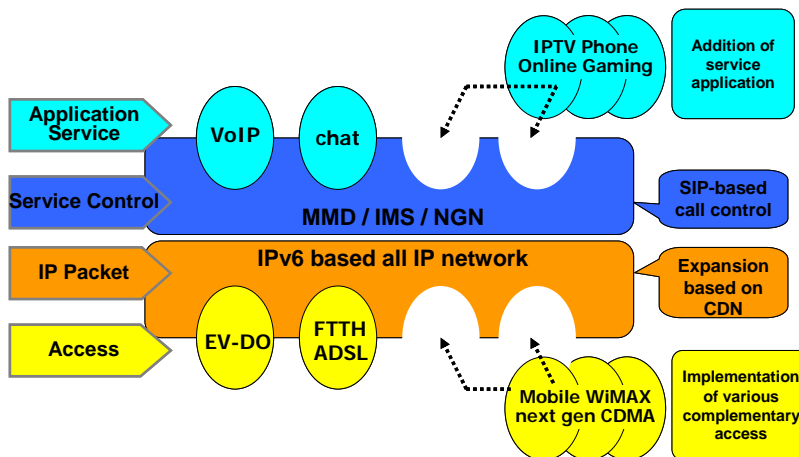
Figure 5 Ultra 3G service environment

The inherent high-throughput, low latency and QoS functionality in WiMAX will also enable KDDI to offer unique services, such as their planned real-time network storage services. This service will include the real-time uploading of time- and GPS location-stamped recorded audio, full quality digital video and high quality digital photographs for storage on a network database for retrieval at the user's discretion via a range of access devices. Other expected service offerings – across both the WiMAX network and full convergent network – will include mobile video and audio streaming, gaming, videoconferencing, multicasting and broadcasting and a range of vertical applications, such as surveillance, public safety, connectivity to remote devices, inventory tracking, fleet management and educational services. Although the broadband data capability of WiMAX is currently key to KDDI's future network plans, the VoIP service capability of WiMAX is also expected to provide complementary service to KDDI's mobile networks as the network and VoIP service capabilities evolve. The network will also provide an efficient way for KDDI to offload data-intensive applications from the CDMA network to free up the network for voice-centric applications.

Services and applications will not only move seamlessly across access technologies on a single device, but will also move between various user devices in the MMD environment. KDDI has successfully demonstrated an example similar to that seen in Figure 6, with a PDA device carrying an active videophone session over WiMAX detecting a TV, speaker, camera and microphone – all connected via various fixed access technologies in the home environment – and automatically transferring the active session to the newly discovered devices.

KDDI has a concept to offer service through intelligent multimode devices with built-in WiMAX capability that will dynamically choose the optimum network connection from the available access technologies.

Handheld devices are expected to be in the higher price range initially in comparison to that seen for similar form factors in the mobile world. It is also expected that a wide range of international vendors will manufacture devices, with equipment prices declining towards those seen in the mobile and computing world as user take-up increases and devices become mature. Additionally, with the integration of Wi-Fi and WiMAX into a single chipset, it is expected WiMAX will become standard on new issue laptops, just as Wi-Fi has already succeeded in doing.
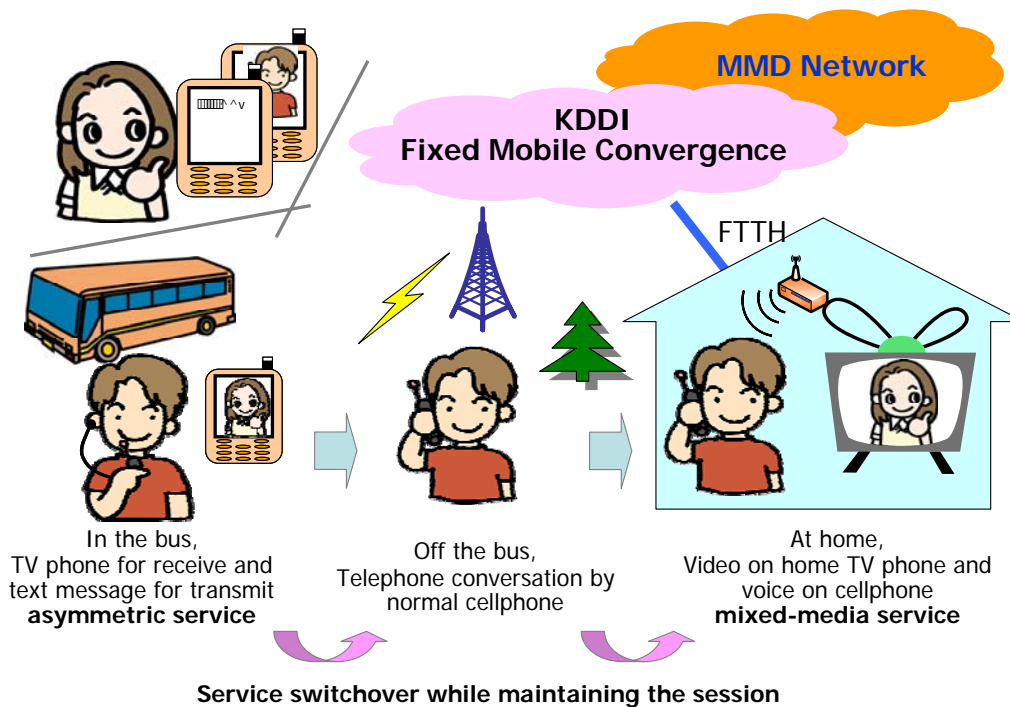
Figure 6 MMD service environment

6. Learning from the KDDI experience

As a leading mobile operator in one of the world's most advanced wireless and technological societies, KDDI is proving to other international operators the exciting possibilities mobile WiMAX provides to existing and future 3G mobile networks, along with the important role it can play in the convergent fixed, wireless and mobile all-IP network of the future. KDDI is showcasing in a real operating environment the advantages WiMAX offers to mobile operators and their subscribers:

WiMAX features	Benefits to KDDI and other mobile operators
High capacity	Supplementary coverage to 2G and 3G networks to offer significant high speed data capability
Low cost spectrum	Alternative low cost spectrum even in areas of strong coverage to ensure peak performance for key services and users
Low latency and high channel width	Services and applications that are cost- and performance-optimized for high speed real-time operation and essential for VoIP

Standards-based	Proven low risk technology with clear evolution path and widely available equipment and user devices including laptops and a variety of handheld devices
All-IP core	An already available avenue to rapidly move towards an all-IP IMS/MMD environment given other equivalent options such as LTE are still many years from implementation; lower operational cost base
Inherent IMS/MMD core	A transparent and fully integrated service and application set with existing 3G services
VoIP	An economical IP-based voice back-up to supplement existing and future mobile networks
Interoperability with fixed, mobile and wireless networks	Fully convergent network service with seamless transparent handovers and session continuation for users moving between 2G, 3G, DSL, FTTH, Wi-Fi and other fixed, wireless and mobile networks
Attractive IPR	Lower ongoing cost of operation, upgrade and user device royalties

KDDI's vision for WiMAX as an integral part of their Ultra 3G roadmap clearly shows the complementary role WiMAX provides to mobile 3G and next generation convergent networks. The successful ongoing trials also provide solid evidence of the seamless interoperability of WiMAX with a range of fixed, wireless and mobile access technologies.

KDDI is taking the lead and actively working to realize its ambitious vision of a fully converged network and they offer an inspiring model for other operators worldwide to follow.

7. Acronyms

1xEV-DO	Single Carrier (1x) Evolution Data Optimized
1xRTT	Single Carrier (1x) Radio Transmission Technology
2G	Second Generation
3G	Third Generation
4G	Fourth Generation
3GPP	Third Generation Partnership Project
3GPP2	Third Generation Partnership Project Two
AAA	Authentication Authorization Accounting
AAS	Adaptive Antenna System
ACR	Access Control Router

AGW	Access Gateway
AP	Access Point
BF	Beamforming
CCTV	Closed Circuit Television
CDMA	Code Division Multiple Access
CDN	Content Delivery Network
DNS	Domain Name System
DSL	Digital Subscriber Line
ETSI	European Telecommunications Standards Institute
EV-DO	EVolution Data Optimized
FDD	Frequency Division Duplex
FTTH	Fiber to the Home
GSM	Global System for Mobile communications
HA	Home Agent
HiperMAN	High Performance Radio Metropolitan Area Network
HSDPA	High Speed Downlink Packet Access
HSS	Home Subscriber Server
HSUPA	High Speed Uplink Packet Access
IEEE	Institute of Electrical and Electronics Engineers
IMS	IP Multimedia Subsystem
IMT	International Mobile Telecommunications
IP	Internet Protocol
IPR	Intellectual Property Rights
IPTV	Internet Protocol Television
ITU	International Telecommunication Union
LAN	Local Area Network
LTE	Long Term Evolution
MIMO	Multiple Input, Multiple Output
MMD	MultiMedia Domain
MP3	MPEG (Moving Pictures Experts Group) Layer 3
NGN	Next Generation Network
OAM	Operations Administration Maintenance
OFDM	Orthogonal Frequency Division Multiplexing

OFDMA   Orthogonal Frequency Division Multiple Access

PC   Personal Computer

PCF   Packet Control Function

PCMCIA   Personal Computer Memory Card International Association

PDA   Personal Digital Assistant

PDSN   Packet Data Serving Node

QoS   Quality of Service

SAE   System Architecture Evolution

SIP   Session Initiation Protocol

SISO   Single Input, Single Output

SDM   Space Division Multiplexing

STC   Space Time Coding

TFTP   Trivial File Transfer Protocol

UMTS   Universal Mobile Telecommunications System

WCDMA   Wideband Code Division Multiple Access

8. Further reading

[1]   WiMAX Forum (2005): Fixed, nomadic, portable ad mobile applications for 802.16-2004 and 802.16e WiMAX networks.
[2]   WiMAX Forum (2006): Mobile WiMAX – Part I: A Technical Overview and Performance Evaluation.
[3]   WiMAX Forum (2006): Mobile WiMAX – Part II: Competitive Analysis.
[4]   WiMAX Forum (2006): Mobile WiMAX Usage Scenarios.
[5]   WiMAX Forum (2006): Mobile WiMAX: The Best Personal Broadband Experience!

These documents are available at www.wimaxforum.org