WiMAX and Its Applications (4)

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Editor's Desk:
Worldwide Interoperability for Microwave Access (WiMAX), an emerging broadband radio access technology, has attracted much attention from the whole telecom industry in recent years. Its main features are high-speed transmission rate, large coverage, support for mobility, QoS guarantee and all-IP architecture. The technology fulfills the integration of packetized data, broadband access and mobilized terminal; therefore, it has a bright future for wide application. This lecture discusses WiMAX in four parts, and this part introduces QoS mechanism of the MAC layer and the WiMAX network architecture.

7 Application

Worldwide Interoperability for Microwave Access (WiMAX) Forum defines five application scenarios that are supported by WiMAX network architecture, namely fixed, nomadic, portable, simple mobiltiy and full mobility. Figure 9 illustrates a typical application scenario of WiMAX.

(1) Fixed Scenario

Fixed scenario is the basic business model of WiMAX network, mainly applied in Customer Premises Network (CPN) access, Local Area Network (LAN) connectivity and Base Station (BS) connectivity.

• CPN access: Any group (e.g. enterprise and school) or personal terminal can access its own CPN via a Subscriber Station (SS), and enjoy broadband Internet services through the air interface of WiMAX network. The CPN device that is connected to the SS via the standard Ethernet or E1 interface can be a network device (e.g., router, switch, or hub) or another wireless access point (e.g., Wireless Fidelity (Wi-Fi) hotspot). This access mode is similar to xDSL and other cable connections. As a result, it is an ideal solution for replacing existing cable connection methods.

• LAN connectivity: For a large enterprise which has several branches in a metropolitan area, the WiMAX fixed wireless broadband access system can be deployed to implement wireless connection between the headquarters and the LAN of each branch. This access mode avoids the trouble of laying private lines and allows access service to be delivered in a short time. In constructing private networks for customers, it is more advantageous than wired connection.

• BS connectivity: With E1 interface provided by WiMAX fixed broadband wireless access system, the mobile BSs of a GSM network or a 3G network can be interconnected. It can also serve as backhaul links to connect BSs back to the Mobile Switching Center (MSC).

(2) Nomadic Scenario

Nomadic access service is developed on the basis of fixed access service. In nomadic scenario, the terminals can access an operator's WiMAX network via different access points. But during each session, a user terminal can only access point-by-point, and it cannot be switched over different BSs. In the nomadic and later scenarios, user terminals are allowed to roam among different operator networks, and terminal's power management is achieved. For example, after a WiMAX wireless network card is installed, a notebook PC can access Internet in different places, but during a session, the

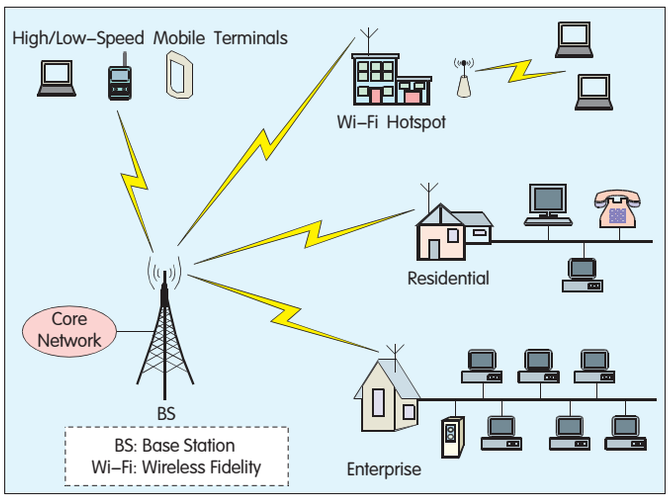


Figure 9. Typical application scenario of WiMAX.

▼Table 1. WiMAX service classes

Class Description	Real–Time Feature	Application Type	Transmission Rate
Interactive Gaming	Real–Time	Interactive Gaming	50–85 kb/s
VoIP, Video Conferencing	Real–Time	VoIP	4–64 kb/s
		Video Phone	32–384 kb/s
Streaming Media	Real–Time	Music/Speech	5–128 kb/s
		Video Clips	20–384 kb/s
		Movies Streaming	> 2 Mb/s
Information Technology	Non–Real–Time	Instant Messaging	< 250 B
		Web Browsing	> 500 kb/s
		Email	> 500 kb/s
Media Content Download	Non–Real–Time	Bulk Data, Movie Download	> 1 Mb/s
		P2P	> 500 kb/s

P2P: Peer–to–Peer VoIP: Voice over Internet Protocol

mobility of the PC is not supported.

(3) Portable Scenario

This scenario allows the terminals to switch over different BSs during a session. During a handoff, the user may experience service interruption, delay or reduced Quality of Service (QoS) for up to 2 seconds. The quality of handoff is "best effort" delivery. Upon completion of the handoff, TCP/IP application refreshes current IP address or rebuilds a new IP address. One example of this scenario is a laptop PC installed with a WiMAX wireless network card. In this case, the user can walk at a speed of about 1.5 km/h while maintaining his/her laptop's communication with the network.

(4) Simple Mobility Scenario

The simple mobile service is an extension of portable service. In this scenario, a user can deploy a WiMAX terminal to make high–speed wireless data communication when he/she is walking, driving or taking a bus. But once the travelling speed reaches 60–120 km/h, the data transmission rate may slightly decrease. This scenario can definitely control the quality of handoff: The delay in an inter–IP subnet handoff is less than 1 second, while the delay in an intra–IP subnet handoff is less than 150 ms; the data transmission interruption is no more than 150 ms. After the handoff, the QoS will rise up to its original class. This scenario requires the terminal to support sleep mode, idle mode and paging.

(5) Full Mobility Scenario

In this scenario, the user can move at a speed more than 120 km/h with broadband wireless access service not being interrupted. When there is not any network connected, the user terminal goes into low–power consumption mode. As for the quality of handoff, more rigorous requirements are imposed: The total handoff delay is less than 50 ms, and the data transmission interruption is no more than 5 ms. Like simple mobility scenario, the full mobility network requires the terminal to support sleep mode, idle mode, and paging.

The mobile data services are main applications of simple mobility and full mobility scenarios. They are also services occupying a considerable number of radio resources. Roughly, these services fall into five classes, that is, interactive gaming, VoIP and video conference, streaming media, information technology, and media content download (store and forward). The main features of each service class are listed in Table 1.

8 Hot Topics on WiMAX

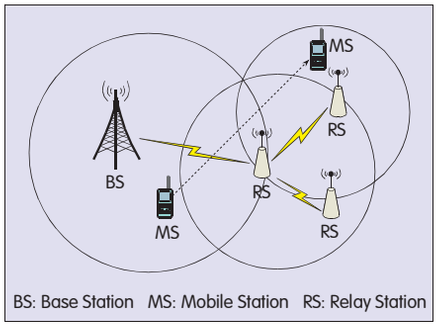
8.1 Spectrum Allocation

Currently, WiMAX networks have been successively put into commercial use. Up to 2007, more than 700 enterprises around the world have been granted to operate WiMAX networks. Among them, 275 operators are conducting WiMAX pilot tests. In 2004, Korea Telecom took the lead to introduce its mobile WiMAX system, i.e. WiBro. In 2007, American telecom operator Sprint announced that it would invest 5 billion US dollars to construct WiMAX broadband wireless network. In addition, the telecom operators in Pakistan, India, Russia and Australia are trying to make use of WiMAX networks for broadband network coverage of remote regions as well as broadband wireless service delivery in urban areas.

However, in recent years, the development of WiMAX technology suffers the spectrum allocation problem. IEEE 802.16 supports 10–66 GHz bands and the bands under 11 GHz. The transmission in 10–66 GHz bands relies on Line of Sight (LOS), so outdoor antennas are required. Consequently, these bands are applied in limited situations, mainly used for enterprises and to offer fixed wireless access. The bands under 11 GHz, which are Non–Line of Sight (NLOS) transmission bands, can realize indoor coverage, so outdoor antennas are unnecessary. Moreover, with the mobility function enhanced, mobile data services can be provided. Although WiMAX network can work in an unlicensed band, it can deliver carrier–class services only in licensed bands. Therefore, the WiMAX industry is trying to find frequencies within 2–6 GHz bands, especial frequencies lower than 3 GHz. At present, the available bands differ from one country to another. According to existing allocation mechanisms, the frequencies allocated to each WiMAX operator are far from meeting the requirements for large–scale cellular networking. WiMAX Forum expects a globally uniform frequency spectrum in 2.5 GHz or 3.5 GHz band to be allocated for WiMAX standard, but it is still unknown whether enough spectrums can be obtained.

8.2 WiMAX vs. 3G

In case of full mobility scenario, the WiMAX system performs almost the same as a next generation communication system. And compared with 3G networks, mobile WiMAX networks transmit data faster and cost less. As a result, since the very beginning of WiMAX, the issue whether WiMAX and 3G networks compete with each other has been discussed within the telecom industry. To get larger space for survival



▲Figure 10. Mobile multi–hop relay.

and development, WiMAX presents itself as a broadband wireless Metropolitan Area Network (MAN) technology, acting as a supplement rather than a substitute of 3G technologies. This has been generally agreed within the WiMAX society. However, the lack of a globally unified spectrum has greatly restricted the development of WiMAX. Therefore, at the beginning of 2007, supported by US government, WiMAX Forum changed its strategies and applied for joining 3G family in order to share the 3G spectrum resources allocated by the ITU. In October 2007, WiMAX, in the name of "OFDM WMN TDD", became the fourth 3G standard, following European Wideband Code Division Multiple Access (WCDMA), American CDMA 2000, and Chinese Time Division–Synchronous Code Division Multiple Access (TD–SCDMA).

Among the first three 3G standards, CDMA 2000 and WCDMA are Frequency Division Duplex (FDD)–based, while TD–SCDMA is based on Time Division Duplex (TDD) technology. ITU classifies WiMAX as TDD technology and does not permit it to use FDD bands. So far, no spectrum has been assigned to WiMAX. Apparently, WiMAX network is likely to share TDD bands with TD–SCDMA network. Except for China, most of the 3G TDD spectrums are still being not used. Therefore, WiMAX's joining into 3G family is very helpful for solving its bottleneck problem, i.e. spectrum problem. Meanwhile, Chinese 3G standard, i.e. TD–SCDMA, has to face a competitor. No doubt, these two standards will stand in competition with each other for both markets and spectrum resources.

Some traditional telecom operators do not regard WiMAX as a real mobile communication technology because it performs much poorer than 3G systems in terms of handoff and roaming. For instance, it does not support seamless handoff when the terminal travels. Besides, few chips, terminals and devices in the markets are compliant with WiMAX standard, and only WiMAX data network cards are available currently. The WiMAX handsets for commercial use will not be put into market until the end of 2008, let alone the timetable for terminals' consistency test. Hence, it is necessary to speed up WiMAX technical evolution and terminal development. Only doing so, WiMAX can survive the intensive competition with similar technologies and achieve worldwide application.

8.3 IEEE 802.16j and IEEE 802.16m

The technical evolution of WiMAX does not stop at IEEE 802.16e. To improve the network performance further and enable WiMAX to be a next generation mobile communications system, IEEE has started to make new standards for air interface technologies, i.e. IEEE 802.16j and IEEE 802.16m, which have attracted great attention and participation of many famous manufacturers in the world.

IEEE 802.16j can be regarded as an upgrade version of IEEE 802.16e. Its core concept is to reduce fading of shadow effect and to eliminate dead angles of transmission in radio transmission environment by ways of Mobile Multi–hop Relay (MMR) technology, thus enlarging network coverage, increasing system capacity and balancing the load. As shown in Figure 10, MMR introduces low–cost Relay Stations (RSs) between a BS and a SS for signal relaying. The proper arrangement of RSs can avoid bad transmission paths and reduce signal fading as well. Besides, the RS can adjust the power for forwarding signals based on actual situations, which can improve system capacity further. However, the introduction of RS brings a series of new problems. For example, complication of scheduling at Media Access Control (MAC) layer, guarantee of end–to–end QoS and selection of optimal hops. Besides, one principle made by IEEE 802.16j working group is not to change original SSs, which is no doubt a great challenge for standard makers. In August 2007, the first version of IEEE 802.16j standard was drafted out, which is now in the process of voting. It is expected to be finalized in the second half of 2008.

IEEE 802.16m is the next generation of IEEE 802.16e, aiming to be a standard for fourth generation mobile telecom system "International Mobile Telecommunications–Advanced" (IMT–Advanced). Its target transmission rate is 1 Gb/s in case of slow movement and 100 Mb/s in case of quick

movement. This standard will be downward compatible and will enhance the performance of broadcasting, multimedia, and VoIP services. It may adopt technologies quite different from those in IEEE802.16e, and develop new SSs. The working group of IEEE 802.16m was established in December 2006. At present, only technical requirements have been defined. The standard is expected to be released in 2009.

9 Conclusions

WiMAX system was first introduced as a broadband wireless system. In the physical layer, it uses such advanced technologies as Multiple–Input Multiple–Output (MIMO), Orthogonal Frequency Division Multiple Access (OFDMA) and adaptive modulation/encoding to improve its data transmission rate; in MAC layer, it enlarges its system capacity and delivers QoS–guaranteed data transmission services by means of adaptive resource scheduling strategies; in the network layer, it adopts all–IP network architecture to support mobility and roaming as well as to guarantee end–to–end QoS. After WiMAX joins 3G family, the WiMAX society continues to improve the core network technology of WiMAX system and tries to evolve it toward a next generation mobile communication system by making the standard IEEE 802.16m. Due to the unique technical advantages of the system and the continuously upheating participation of manufacturers in research and development, we believe WiMAX terminals and handsets will come into the market in near future and WiMAX will become a necessary technology for public telecom services.

(The end)

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Biographies

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Liu Danpu received her doctoral degree from Beijing University of Posts and Telecommunications (BUPT). She is a professor at BUPT. Her research interests include broadband wireless communications technologies, MIMO/OFDM, physical–layer and MAC technologies for ultra–wideband wireless communications systems. She has published more than 30 technical papers.

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Roundup

ZTE Achieves XOHM Certification for WiMAX Modem

ZTE USA, a subsidiary of ZTE Corporation, announced on October 8, 2008 that Sprint's XOHMTM WiMAX business unit had certified its TU25 USB modem after extensive evaluation in the XOHM Herndon, Va. lab environment. The USB modem is the first certified for use with XOHM's Mobile WiMAX service, the company's next generation broadband service commercially available in Baltimore and planned elsewhere.

ZTE's TU25 USB Modem provides XOHM's subscribers with reliable, high speed broadband wireless connection for laptops and desktop computers with a USB port.

The XOHM's certification signifies the product's interoperability with other elements of the WiMAX network including back–office provisioning and customer relationship management systems and infrastructure. Besides the XOHM certification, ZTE's modem has achieved Microsoft's WQHL certification, USB Forum certification and FCC certification, marking it ready for commercial usage.

"We know that part of our commercial success relies on our ability to offer our subscribers technologically advanced equipment that will enable them to seamlessly harness the power of our WiMAX service," said Bin Shen, VP, Product Management and Partnership Development for XOHM. "After putting ZTE's USB modem through rigorous testing, we are confident to offer our customers this product as part of their service equipment. We look forward to working with ZTE as we launch other cities later this year and next."