Mobile WiMAX Features

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Abstract: - The Mobile WiMAX is a broadband wireless solution that enables convergence of mobile and fixed broadband networks through a common wide area broadband radio access technology and flexible network architecture. The broad industry participation will ensure economies of scale that will help drive down the costs of subscription and enable the deployment of mobile internet services globally, including emerging countries. This paper provides a comprehensive overview of the main features of this technology.

Key-Words: - Mobile WiMAX features, Quality of Service, Mobile WiMAX applications.

1 Introduction

The WiMAX technology is based on the IEEE 802.16-2004 Air Interface Standard. In Cecember 2005 the IEEE ratified the 802.16e amendment to the 802.16 standard; this ammedment adds the features and attributes to the standard necessary to support mobility [1]. Mobile WiMAX provides high data throughput and enables efficient data multiplexing and low data latency; these very important attributes enable broadband data services including data, streaming video and VoIP with high quality of service (QoS). Mobile WiMAX is a broadband wireless solution that enables convergence of mobile and fixed broadband networks through a common wide area broadband radio access technology and flexible network architecture [2].

2. Architectural Guidelines

The Mobile WiMAX End-to-End Network Architecture is based on an All-IP platform, all packet technology with no legacy circuit telephony. It offers the advantage of reduced total cost of ownership during the lifecycle of a WiMAX network deployment. The use of All-IP means that a common network core can be used, without the need to maintain both packet and circuit core networks, with all the overhead that goes with it. Another important benefit of All-IP is that it places the network on the performance growth curve of general purpose processors and computing devices'; computer processing advances occur much faster than advances in telecommunications equipment because general purpose hardware is not limited to telecommunications equipment cycles, which tend to be long and cumbersome. The end result is a network that continually performs at ever higher capital and operational efficiency, and takes advantage of 3rd party developments from the Internet community. This results in lower cost, high scalability, and rapid deployment since the networking functionality is all primarily software-based services.The guidelines that drove the development of the WiMAX architecture are the following [3]:

1. The architecture is based on a packet-switched framework, including native procedures based on the IEEE 802.16 standard and its amendments, appropriate IETF RFCs and Ethernet standards.
2. The architecture permits decoupling of access architecture (and supported topologies) from connectivity IP service. Network elements of the connectivity system are agnostic to the IEEE 802.16 radio specifics.
3. The architecture allows modularity and flexibility to accommodate a broad range of deployment options such as:
    - Small-scale to large-scale (sparse to dense radio coverage and capacity).
    - WiMAX networks.
    - Urban, suburban, and rural radio propagation environments.
    - Licensed and/or licensed-exempt frequency bands.
    - Hierarchical, flat, or mesh topologies, and their variants.
    - Co-existence of fixed, nomadic, portable and mobile usage models.

3. Mobile WiMAX Main Features

Unlike the CDMA-based 3G systems, which have evolved from voice-centric systems, WiMAX was designed to meet the requirements necessary for the delivery of broadband data services as well as voice. The Mobile WiMAX physical layer is based on Scalable OFDMA technology. The new technologies employed for Mobile WiMAX result in network and provide Mobile WiMAX Systems with many other advantages over CDMAbased 3G systems including [4]:

- Tolerance to Multipath and Self-Interference
- Scalable Channel Bandwidth
- Orthogonal Uplink Multiple Access
- Support for Spectrally-Efficient TDD
- Frequency-Selective Scheduling
- Fractional Frequency Reuse
- Fine Quality of Service (QoS)
- Advanced Antenna Technology

The scalable architecture, high data throughput and low cost deployment make Mobile WiMAX a leading solution for wireless broadband services. Hundreds of companies have contributed to the development of the technology and many companies have announced product plans for this technology. Mobile WiMAX systems offer scalability in both radio access technology and network Architecture. Some of the main features supported by Mobile WiMAX are [3]:

1. **High Data Rates:** Mobile WiMAX technology supports peak DL data rates up to 63 Mbps per sector and peak UL data rates up to 28 Mbps per sector in a 10 MHz channel [3].
2. **Quality of Service (QoS):** Quality of Service (QoS) determines if a wireless technology can successfully deliver high value services such as voice and video. The main issues in QoS are latency, jitter and packet loss. Table 1 shows that Mobile WiMAX supports a wide range of applications and data services with varied QoS requirements [3].

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

Table 1. Mobile WiMAX QoS

3. **Scalability:** Mobile WiMAX technology is designed to be able to scale to work in different channelizations from 1.25 to 20 MHz to comply with varied worldwide requirements as efforts proceed to achieve spectrum harmonization in the longer term. This allows diverse economies to realize the multi-faceted benefits of the Mobile WiMAX technology for their specific geographic needs such as providing affordable internet access in rural settings versus enhancing the capacity of mobile broadband access in metro and suburban areas [3,4].

4. **Security:** Mobile WiMAX adopts the best technologies available today. Support exists for mutual device/user authentication, flexible key management protocol, strong traffic encryption, control and management plane message protection and security protocol optimizations for fast handovers. The usage aspects of the security features are [3,4]:

   - **Key Management Protocol:** Privacy and Key Management Protocol Version 2 (PKMv2) is the basis of Mobile WiMAX security as defined in 802.16e. This protocol manages the MAC security using PKM-REQ/RSP messages. PKM EAP authentication, Traffic Encryption Control, Handover Key Exchange and Multicast/Broadcast security messages all are based on this protocol [3,4].
   - **Device/User Authentication:** Mobile WiMAX supports Device and User Authentication using IETF EAP protocol by providing support for credentials that are SIM-based, USIM-based or Digital Certificate or UserName/Password-based. Corresponding EAP-SIM, EAP-AKA, EAP-TLS or EAP-MSCHAPv2 authentication methods are supported through the EAP protocol. Key deriving methods are the only EAP methods supported [5].
   - **Traffic Encryption:** AES-CCM is the cipher used for protecting all the user data over the Mobile WiMAX MAC interface. The keys used for driving the cipher are generated from the EAP authentication. A Traffic Encryption State machine that has a periodic key (TEK) refresh mechanism enables sustained transition of keys to further improve protection [5].
   - **Control Message Protection:** Control data is protected using AES based CMAC, or MD5-based HMAC schemes [3,4].
   - **Fast Handover Support:** A 3-way Handshake scheme is supported by Mobile WiMAX to optimize the re-authentication mechanisms for supporting fast handovers. This mechanism is also useful to prevent any man-in-the-middle-attacks [3].

5. **Mobility:** Mobile WiMAX supports optimized handover schemes with latencies less than 50 milliseconds to ensure real-time applications such as VoIP perform without service degradation. Flexible key management schemes assure that security is maintained during handover. Battery life and handoff are two critical issues for mobile applications. Mobile WiMAX supports Sleep Mode and Idle Mode to enable power-efficient MS operation. Mobile WiMAX also supports seamless handoff to enable the MS to switch from one base station to another at vehicular speeds without interrupting the connection [2].
   - **Power Management:** Mobile WiMAX supports two modes for power efficient operation – Sleep Mode and Idle Mode. ***Sleep Mode*** is a state in which the MS conducts pre-negotiated periods of absence from the Serving Base Station air interface. These periods are characterized by the unavailability of the MS, as observed from the Serving Base Station, to DL or UL traffic. Sleep Mode is intended to minimize MS power usage and minimize the usage of the Serving Base Station air interface resources. **Idle Mode** provides a mechanism for the MS to become periodically available for DL broadcast traffic messaging without registration at a specific base station as the MS traverses an air link environment populated by multiple base stations. Idle Mode benefits the MS by removing the requirement for handoff and other normal operations and benefits the network and base station by eliminating air interface and network handoff traffic from essentially inactive MSs while still providing a simple and timely method (paging) for alerting the MS about pending DL traffic [6].
   - **Handoff:** For implementing a mobile network, a handoff mechanism must be defined to maintain uninterrupted user communication session during his/her movement from one location to another. Handoff mechanism handles subscriber station (SS) switching from one Base Station (BS) to another. Different handoff techniques have been developed. In general, they can be divided into soft handoff and hard handoff. ***Soft handoff*** is used in voice-centric cellular networks such as GSM or CDMA. It uses a make-before-break approach whereas a connection to the next BS is established before a SS leaves an ongoing connection to a BS. This technique is suitable to handle voice and other latency-sensitive services such as Internet multiplayer game and video conference. When used for delivering data traffic (such

as web browsing and e-mail), soft handoff will result in lower spectral efficiency because this type of traffic is bursty and does not require continues handover from one BS to another (figure 1) [7].

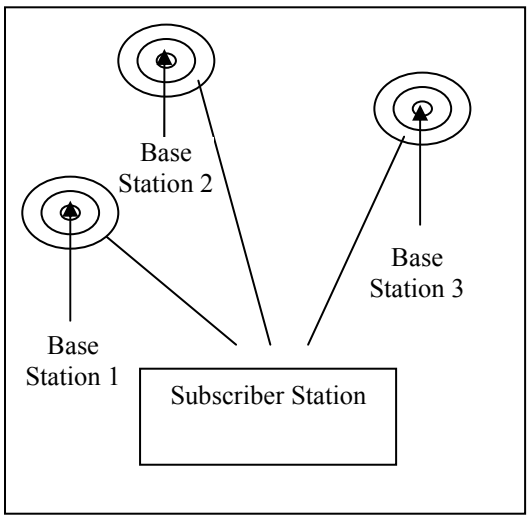

Figure 1. Soft Handoff.
SS maintains multiple connections.
Delay is very minimal.

Mobile WiMAX has been designed from the outset as a broadband technology capable of delivering triple play services (voice, data, video). However, a typical Mobile WiMAX network is supposedly dominated by delay-tolerant data traffic. Voice in Mobile WiMAX is packetized (what is called VoIP) and treated as other types of IP packets except it is prioritized. Hard handoff (HHO) is therefore used in Mobile WiMAX. In ***hard handoff***, a connection with a BS is ended first before a SS switches to another BS. This is known as a break-before-make approach. Hard handoff is more bandwidth-efficient than soft handoff, but it causes longer delay. A network-optimized hard handoff mechanism was developed for Mobile WiMAX to keep a handoff delay under 50 ms [7].

6. **Smart Antenna Technologies:** Mobile WiMAX supports a full range of smart antenna technologies to enhance system performance. The smart antenna technologies supported include [3]:
   - **Beamforming:** Beamforming uses multiple antennas to send a focused beam to an end user, creating a high-capacity link that can be steered throughout the cell area [3].
   - **Space-Time Code (STC):** Transmit diversity such as Alamouti code [8.9] is supported to provide spatial diversity and reduce fade margin.
   - **Spatial Multiplexing (SM):** Spatial multiplexing [10,11] is supported to take advantage of higher peak rates and increased throughput. With spatial multiplexing, multiple streams are transmitted over multiple antennas. If the receiver also has multiple antennas, it can separate the different streams to achieve higher throughput compared to single antenna systems.

7. **Fractional Frequency Reuse:** With Mobile WiMAX, users operate on subchannels, which only occupy a small fraction of the whole channel bandwidth; the cell edge interference problem can be easily addressed by appropriately configuring subchannel usage without resorting to traditional frequency planning. In Mobile WiMAX, the flexible sub-channel reuse is facilitated by sub-channel segmentation and permutation zone. A segment is a subdivision of the available OFDMA sub-channels (one segment may include all sub-channels). One segment is used for deploying a single instance of MAC [2,3,4].

8. **Multicast and Broadcast Service (MBS)**:
   Multicast and Broadcast Service (MBS) supported by Mobile WiMAX combines the best features of DVB-H, MediaFLO and 3GPP E-UTRA and satisfies the following requirements [3, 4]:
   - High data rate and coverage using a Single Frequency Network (SFN).
   - Flexible allocation of radio resources.
   - Low MS power consumption.
   - Support of data-casting in addition to audio and video streams.
   - Low channel switching time.

   The Multicast and Broadcast service (MBS) is supported in two ways [3,4]:
   - Embedded MBS: a separate MBS zone is defined in the DL frame along with the unicast service
   - Whole MBS: the whole frame can be dedicated to MBS (DL only) for standalone broadcast service.

   The MBS zone supports multiple Base Stations working in MBS mode using Single

Frequency Network (SFN) operation. It may be noted that multiple MBS zones are also feasible. When working in MBS mode, all the BS participating the same MBS transmit the same data, use the same permutation, subchanellization etc. The equivalent channel reception is the sum of the individual channels from all the BS in the MBS. The delay in the signal that comes from a distant BS translates to a delayed impulse response, which increase the delay spread of the equivalent/consolidated channel, generating therefore ISI in the SFN area (figure 2)

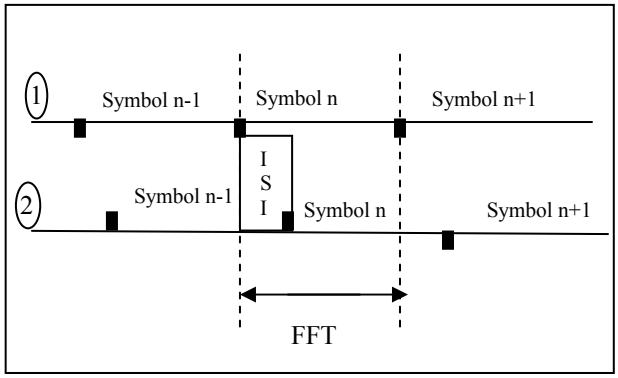

Figure 2. Multicast and Broadcast Service.

4. Mobile WiMAX Applications

The ultimate success of any technology, in many cases, is dependent on having an open standard with guaranteed equipment interoperability. This helps to drive up volume and minimize equipment variations and as a result, lowers manufacturing costs - cost savings that can ultimately be passed on to network operators and consumers. Additionally, guaranteed interoperability provides an added incentive for consumers to purchase their own user-terminals with confidence the terminals will interoperate with another operator's network. The WiMAX Forum, a non-profit trade organization comprised of more than 350 member companies, is well-positioned to promote worldwide adoption and harmonization of a standards-based broadband wireless solution based on the IEEE 802.16 air interface standard with guaranteed interoperability. To achieve this goal the forum defines system performance and certification profiles standard with designated mandatory and optional features along with a suite of conformance and interoperability tests that equipment must pass to ensure multivendor interoperability. It is expected that with widespread participation of ecosystem members and partners, and increased worldwide demand for 802.16e-based products, the cost per subscriber will decline significantly over the next 2-3 years. The WiMAX Forum has identified several applications [12] for 802.16e-based systems and is developing traffic and usage models for them. These applications can be broken down into five major classes. These application classes are summarized in table 2 together with guidelines for latency and jitter to assure a quality user experience.

Class	Application	Bandwidth Guideline	
1	Multiplayer Interactive Gaming	Low	50 kbps
2	VoIP & Video Conference	Low	32 to 64 kbps
3	Streaming Media	Low to High	5 kbps to 2 Mbps
4	Web Browsing & Instant Messaging	Mod erate	10 kbps to 2 Mbps
5	Media Content Downloads	High	> 2 Mbps

Class	Lantency Guideline		Jitter Guideline	
1	Low	< 25 msec	N/A	
2	Low	< 160 msec	Low	<50 msec
3	N/A		Low	<100 msec
4	N/A		N/A	
5	N/A		N/A	

Table 2. Mobile WiMAX Appication Categories with Bandwidth, Lantency, and Jitter.

A certification test lab for Fixed WiMAX systems was implemented at Cetecom Labs in Malaga, Spain in July of 2005 and WiMAX-compliant products for fixed services are now available and being deployed in the licensed 3.5 GHz band and license-exempt 5.8 GHz band. A second certification lab, TTA has being established in Korea. The WiMAX Forum regularly considers additional Mobile WiMAX

performance profiles based on market opportunities. These would address alternative frequency bands, channel bandwidths and may include Full or Half-Duplex FDD variations to comply with local regulatory requirements in selected markets. Figure 19 provides a view of the roadmap for WiMAX-compliant products.

5. Conclusion

Mobile WiMAX is based on open standard interfaces and a flexible network architectute and provides high performance, low cost broadband wireless services. Hundrends of companies have contributed to the development of the technology and many companies have announced product plans. The WiMax forum is developing mobile WiMAX system profiles that define the mandatory and optional features necessary to build a mobile WiMAX compliant air interface which can be certified by the WiMAX Forum.

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