

Standardization Activities for Mobile WiMAX

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The WirelessMAN standard developed by the IEEE 802.16 Working Group (WG) on Broadband Wireless Access Standards for wireless metropolitan area networks is commonly referred to as the specification for the Mobile Worldwide Interoperability for Microwave Access (Mobile WiMAX) system, but this is not exactly true. The WirelessMAN standard developed by IEEE 802.16 WG includes detailed specifications and various optional functionalities so that it can cover various usage scenarios such as ones ranging from fixed access to mobile access and may extend system performance. The Technical Working Group of the WiMAX Forum selects suitable functionalities and parameters from IEEE 802.16 specifications for the Mobile WiMAX scenario. Discussion in IEEE 802.16 WG is carried out by individual experts, while that in the WiMAX Forum is carried by industrial delegates. Therefore, there are some differences in the standardization activities in IEEE 802.16 WG and WiMAX Forum. Technically sound contributions are more important for standardization in IEEE 802.16 WG, while much weight is put on industrial interest in the WiMAX Forum. This paper briefly reviews the relationship between these two standardization organizations and describes Fujitsu's activities concerning them.

1. Introduction

Mobile Worldwide Interoperability for Microwave Access (Mobile WiMAX) is one of the outstanding wireless system technologies that can provide higher data rates than existing 3G cellular phone systems and cover a wider area than a wireless local area network system. Responding to industry and market demands for broadband wireless access services for data communication, the IEEE 802.16 Working Group (WG) on Broadband Wireless Access Standards¹⁾ has started to develop a standard for a broadband wireless access air interface for metropolitan area networks (MANs) called IEEE 802.16 WirelessMAN. The development of the WirelessMAN standard first targeted point-to-point fixed line-of-sight wireless links and later extended to point-to-multipoint fixed non-line-of-sight links and then to mobile usage

scenarios. Today, IEEE 802.16 WG is developing two new standards 802.16j and 802.16m. The 802.16j will provide relay functionality and 802.16m will provide higher data rates and additional functionalities to meet the requirements for IMT-Advanced (IMT: International Mobile Telecommunications) defined by ITU-R.²⁾

Meanwhile, an industry-led, not-for-profit organization called the WiMAX Forum³⁾ is playing an important role in practical deployment and promoting the Mobile WiMAX system. The nine working groups of the WiMAX Forum (see **Figure 5** later) play individual roles that are either technical or non-technical. Among them, the Technical Working Group (TWG) handles technical issues and has developed the Mobile System Profile Specification,⁴⁾ which describes selected features and operating parameters to be used for Mobile WiMAX system deploy-

ment. Fujitsu has been working actively in both standardization bodies on detailed specifications and the profiling of the features for particular usage scenarios.

This paper describes standardization activities related to Mobile WiMAX. Section 2 briefly introduces the Mobile WiMAX system. Section 3 describes the development of the WirelessMAN standards in IEEE 802.16 WG and WiMAX Forum TWG. Section 4 describes two new standardization activities taking place in the IEEE 802.16 WG. Section 5 ends the paper with some concluding remarks.

2. Specifications defining Mobile WiMAX

Mobile WiMAX is a broadband wireless access technology based on the IEEE 802.16 WirelessMAN air interface standards. Among the family of IEEE 802.16 WirelessMAN standards, Mobile WiMAX in particular is based on the IEEE Std 802.16-2004⁵⁾ and IEEE Std 802.16e⁶⁾ specifications. On top of the IEEE specifications, the Mobile System Profile Specification,⁴⁾ which is being developed by the WiMAX Forum TWG, specifies selected features and operating parameters for the Mobile WiMAX system scenario. In fact, as its name implies, it should be said that Mobile WiMAX refers to the system defined by the WiMAX Forum's Mobile System Profile.

First, we look at the IEEE 802.16 WirelessMAN standard. This standard describes precise specifications for both fixed and mobile broadband wireless access systems and includes both mandatory and many optional functionalities in order to offer much flexibility and possible performance enhancement for various operating scenarios. The coverage of the IEEE 802.16 WirelessMAN standard is shown in **Figure 1**. The IEEE 802.16 WirelessMAN standard consists of three parts. The first is a convergence sublayer that interfaces higher-layer protocols such as IPv6 and IPv4 to the IEEE 802.16 media access control service data unit (MAC SDU). The second

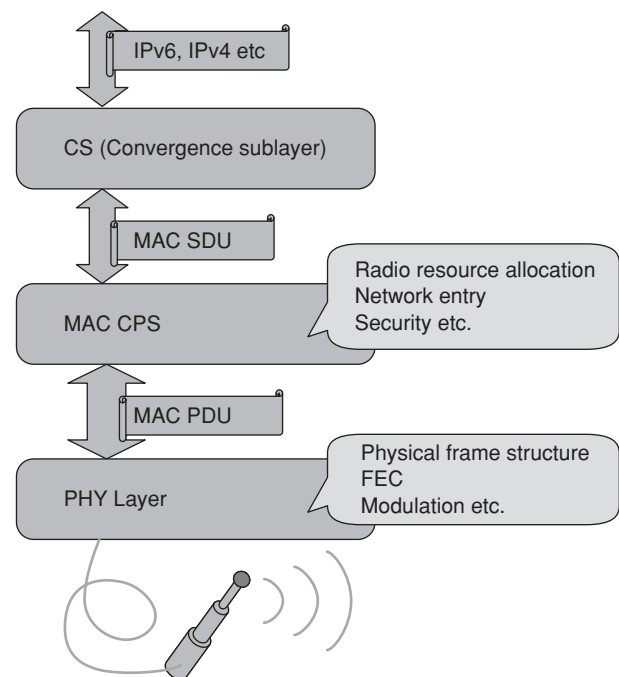


Figure 1
Coverage of IEEE 802.16 wirelessMAN standard.

is the MAC common part sublayer (CPS), which performs fragmentation or packing of the MAC SDUs to make them fit into MAC protocol data units (PDUs), which have a suitable format for handling by the physical layer. MAC CPS also performs various kinds of radio link control such as radio resource assignment, network entry procedure, and security functions. The final part is the physical layer, which defines the physical frame format, forward error correction, and modulation schemes.

On the other hand, unlike the IEEE WirelessMAN standard, the WiMAX Forum's Mobile WiMAX System Profile does not describe precise specifications, but lists functionalities and parameters that should be used for a Mobile WiMAX system. This list enables a Mobile WiMAX system composed of components from multiple vendors to share common functionalities and interoperability among products. **Figure 2** shows the relationship between the IEEE 802.16 WirelessMAN standard and the Mobile WiMAX System Profile, where it specifies mandatory

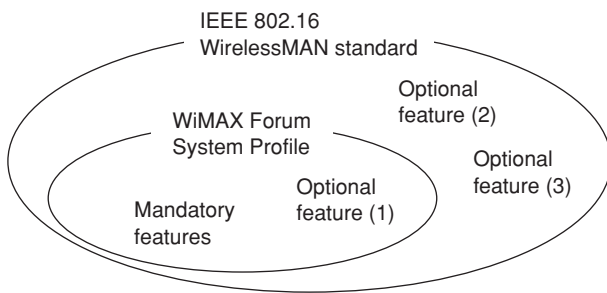


Figure 2
Relationship between IEEE 802.16 WirelessMAN standard and WiMAX Forum System Profile.

features and one of the optional features of the IEEE 802.16 WirelessMAN standard for use by a Mobile WiMAX system.

One typical example of differences occurs among the three different physical layer schemes defined in the IEEE 802.16 WirelessMAN standard, namely, single carrier (SC), orthogonal frequency division multiplexing (OFDM), and orthogonal frequency division multiple access (OFDMA).^{note)} The Mobile WiMAX System Profile specifies only the OFDMA physical layer to be used because it can provide suitable operation only for mobile usage through its scalable architecture and other control signal mechanism. Similarly, the Mobile WiMAX System Profile selects other appropriate functionalities from the IEEE 802.16 WirelessMAN standard together with common operating parameters for mobile usage scenarios.

3. Standardization activities in IEEE 802.16 and WiMAX Forum

3.1 IEEE 802.16 WG

IEEE 802.16 WG was established in 1999. The first standard that it produced was IEEE 802.16-2001. This was for point-to-point line-of-sight wireless access [Figure 3 (a)] using a carrier frequency of 10 to 66 GHz. Later, in IEEE 802.16-2004,⁵⁾ it was expanded to include

note) There used to be an SCa physical layer specification, but it will be removed through the IEEE 802.16Rev2 process.

point-to-multipoint non-line-of-sight wireless access [Figure 3 (b)], which uses a carrier frequency of less than 11 GHz. However, these standards consider only fixed operation, so some functionalities needed for mobile operation, such as handover, are not defined and the modulation scheme may not offer the best performance in the mobile environment where channel conditions change very quickly.

In 2003, IEEE 802.16 WG started to develop 802.16e in response to industry and market demand for broadband mobile wireless access [Figure 3 (c)]. It was completed in 2005 as IEEE 802.16e-2005.⁶⁾ IEEE 802.16e-2005 also contains the outcomes of 802.16-2004/Cor1, which describes corrections for errors in IEEE 802.16-2004. Since IEEE 802.16e-2005 is written as an amendment of IEEE 802.16-2004, we need to refer to both IEEE 802.16-2004 and IEEE 802.16e-2005 and regard them together as one complete standard. There is currently a project called P802.16Rev2 in IEEE 802.16 WG that aims to combine them into one single document and incorporate further error corrections, which were formerly handled by the P802.16-2004/Cor2 project. We should note that these corrections include many important ones for Mobile WiMAX systems. The latest P802.16Rev2 draft (the current one) is D3.⁷⁾ It is expected to be completed in 2008 and will presumably be called IEEE 802.16-2008.

IEEE 802.16 WG is also undertaking several other projects, such as 802.16f/i MIB (MIB: management information base), 802.16h for WirelessMAN in the license-exempt band, and 802.16g for the network management plane. The 802.16f/i has been already been merged into the 802.16Rev2 draft and will be part of the main standard document. P802.16j and P802.16m are ongoing projects for new air interface specifications intended to add relay functionality and to comply with the requirements of ITU-R's IMT-Advanced, respectively. The family of standards that has been developed or is under

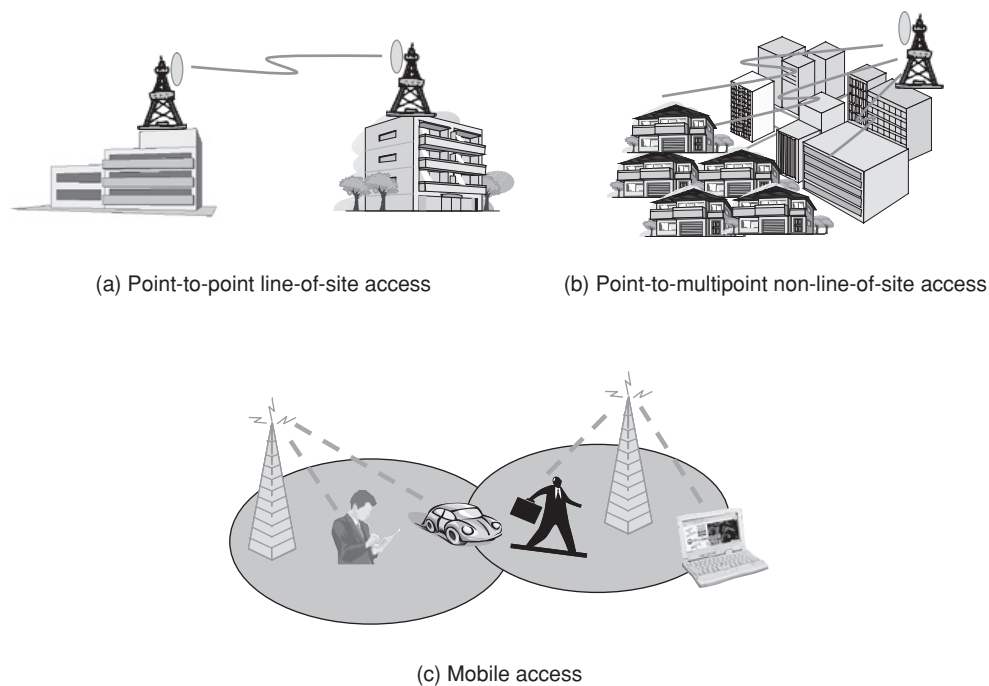


Figure 3
Scenarios for IEEE 802.16 WirelessMAN standards.

development in IEEE 802.16 WG is summarized in **Figure 4**.

Participation in IEEE 802.16 WG is undertaken on a personal basis and voting rights for WG discussions and decisions are given to individual persons who attended the last several meetings. Fujitsu sends ten or more engineers to each IEEE 802.16 meeting from its subsidiaries in Japan, the UK, the USA, Canada, and China. It currently owns fourteen voting rights and will be adding three more at the March 2008 meeting. In IEEE 802.16 WG discussions, much weight is put on engineering viewpoints. Therefore, in order to obtain a good consensus from the WG members and to get submitted technical contributions adopted in a new standard or an amendment of the existing standard, it is more important to submit well-investigated and technically sound contributions with well-written text. Otherwise, it is difficult to get one's technology pass through to the standard. Since the Fujitsu team controls several votes, we are playing

an important role in consensus-making in the WG discussions and in some situations, Fujitsu votes have a strong influence on decisions when decision-making votes take place.

3.2 WiMAX Forum

As stated in the introduction, the WiMAX Forum is an industry-led, not-for-profit organization. It was established in June 2001 by nine companies, including Fujitsu, and one organization. Since broadband wireless access captured public interest in around 2004, the WiMAX Forum has been adding approximately 100 member companies each year. Today, there are more than 520 member companies. Fujitsu is still playing an important role in the WiMAX Forum as one of 15 board members.

Among nine WGs within the WiMAX Forum organization shown in **Figure 5**, the TWG handles technical specifications. The TWG first completed the Mobile WiMAX System Profile release 1.0⁴⁾ and specifications for its certifica-

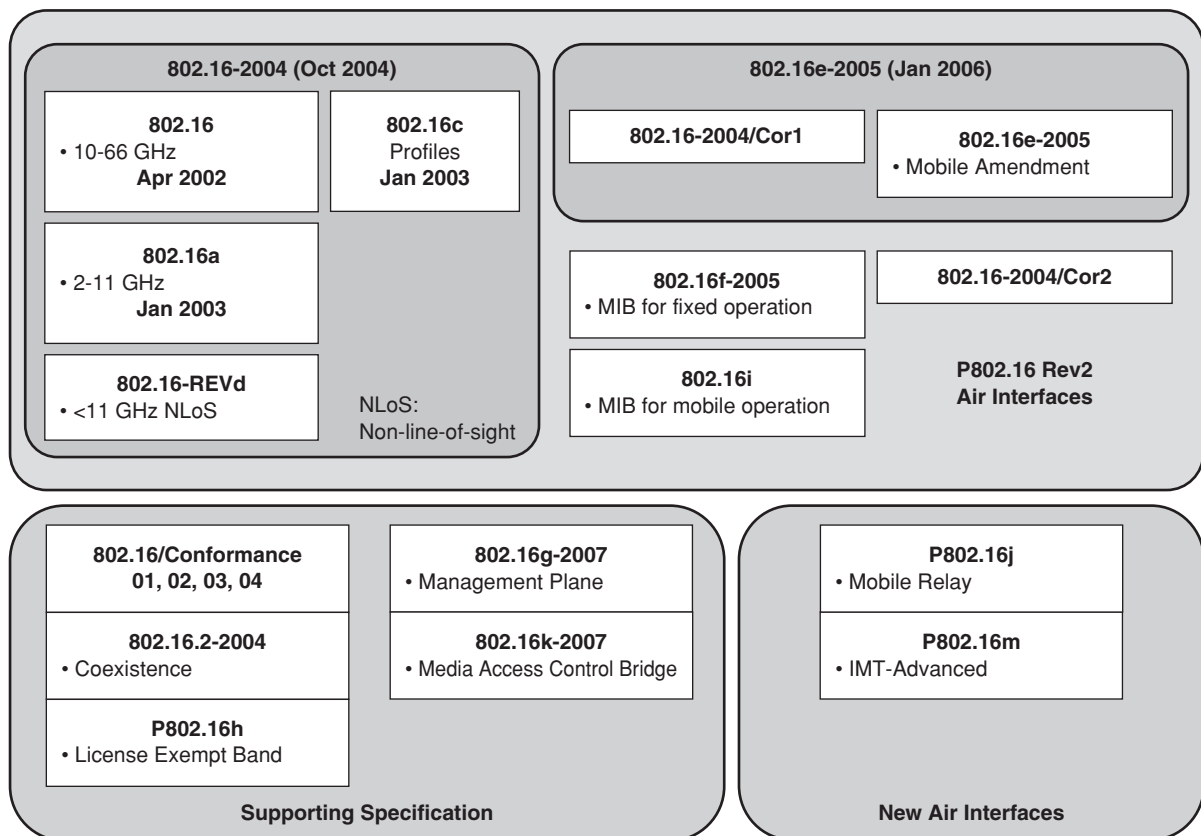


Figure 4
IEEE 802.16 standards family.

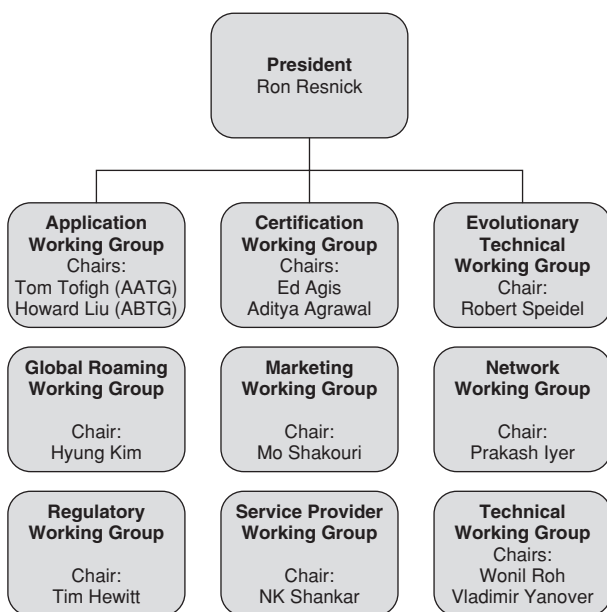


Figure 5
WiMAX Forum organization.

tion in early 2007. Currently, the main themes of TWG discussions are the maintenance of those documents, Recommended Practice Documents (RDPs), and Mobile WiMAX System Profile release 1.x. An RPD is a document that describes clarifications and common understandings among WiMAX Forum member companies about ambiguous items in the 802.16 specification in order to ensure interoperability among WiMAX products. As one of the WiMAX product suppliers, Fujitsu has been heavily involved in those TWG activities because it is considered to be crucial for the success of the WiMAX industry. Unlike IEEE 802.16 WG, participation in WiMAX Forum meetings is undertaken on a company basis, and voting rights are granted to the member companies with recorded attendance in a few of the last meetings. In the TWG, there are 45 companies who were granted voting rights

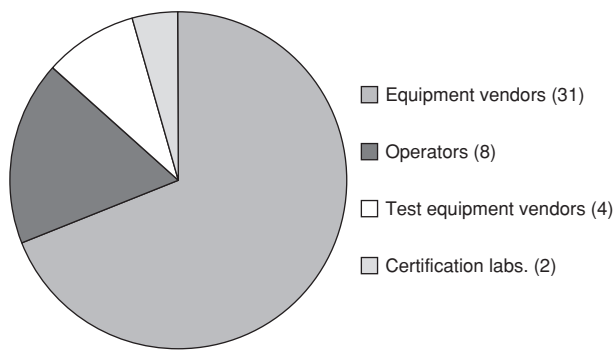


Figure 6
Breakdown of companies having voting rights in TWG.

at the December 2007 meeting. A breakdown of these companies is given in **Figure 6**. The main drivers of the TWG are equipment vendors (including chip vendors). When the TWG makes decisions on which features should be included in the system profile, it is important whether most of the member companies want to implement and use them. Therefore, minor contributions (i.e., ones supported by only one or a few companies) tend to be voted down. Contributions that prove the effectiveness of a technology and have less impact on hardware or software are more likely to result in that technology being included in the system profile.

4. New IEEE 802.16 air interface projects P802.16j and P802.16m

Currently, two new task groups in IEEE 802.16 WG are developing additional air interface standards. One is P802.16j⁸⁾ and the other is P802.16m. The 802.16j will add relay functionality without any modifications to the specifications of mobile stations. 802.16m will be a new air interface that offers higher spectrum efficiency and throughput to meet the requirements for IMT-Advanced systems.

The 802.16j development started in July 2006 and the latest draft specification is P802.16j/D3.⁸⁾ In the latest draft standard, various functionalities have been described so

that it can support various modes of operation (e.g., relay topology and centralized/distributed control). Recently, in the WiMAX Forum, a new work item for developing system requirements has been approved in the Service Provider Working Group (SPWG). When SPWG completes this task, the TWG is expected to start defining the system profile for relay. Since Fujitsu has been quite heavily involved in the development of the 802.16j standard and thoroughly investigated which mode of operation would be more suitable for particular usage scenarios,⁹⁾ we believe that Fujitsu is ready to participate in TWG discussions on relay profiling and to develop relay products at the earliest market opportunity.

The development of 802.16m started in March 2007. Definition of the System Requirements Document and Evaluation Methodology has just been completed and definition of the System Description Document (SDD) has just started. The SDD will describe the high-level functional architecture of the standard. Fujitsu has already made several contributions regarding the relay function in 802.16m. We are proposing that the relay architecture in 802.16m should inherit much of that of 802.16j in order to minimize the development effort needed for 802.16m as well as to provide backward compatibility. The detailed text of the standard will be drawn up after the SDD has been completed. The WiMAX Forum plans to start defining release 2 of the System Profile when the 802.16m draft is in good shape. This is expected to happen in about 2009 or 2010.

5. Conclusion

In this paper, we described standardization activities in IEEE 802.16 WG and the WiMAX Forum. We focused on MAC and physical layer specification aspects, which are handled by IEEE 802.16 WG and the WiMAX Forum TWG. Detailed technical specifications with various functionalities and a wide range of parameters to accommodate various usage and deployment

scenarios are being developed in IEEE 802.16 WG, while WiMAX Forum TWG defines a list of selected features and parameters for the Mobile WiMAX scenario, which is called the System Profile. For standardization in IEEE 802.16 WG, technically sound contributions are important, while for adoption in the Mobile WiMAX system, contributions of industrial interest are more important. Fujitsu is actively working in both standardization bodies to ensure the success of the whole WiMAX industry.

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