

# An Overview of Next-Generation Mobile WiMAX Technology

Sassan Ahmadi, Intel Corporation

## ABSTRACT

The growing demand for mobile Internet and wireless multimedia applications has motivated the development of broadband wireless-access technologies in recent years. Mobile WiMAX has enabled convergence of mobile and fixed broadband networks through a common wide-area radio-access technology and flexible network architecture. Since January 2007, the IEEE 802.16 Working Group has been developing a new amendment of the IEEE 802.16 standard (i.e., IEEE 802.16m) as an advanced air interface to meet the requirements of ITU-R/IMT-advanced for 4G systems, as well as for the next-generation mobile network operators.

Depending on the available bandwidth and multi-antenna mode, the next-generation mobile WiMAX will be capable of over-the-air data-transfer rates in excess of 1 Gb/s and of supporting a wide range of high-quality and high-capacity IP-based services and applications while maintaining full backward compatibility with the existing mobile WiMAX systems to preserve investments and continuing to support first-generation products. This tutorial describes the prominent technical features of IEEE 802.16m and the potential for successful deployment of the next generation of mobile WiMAX in 2011+.

## INTRODUCTION

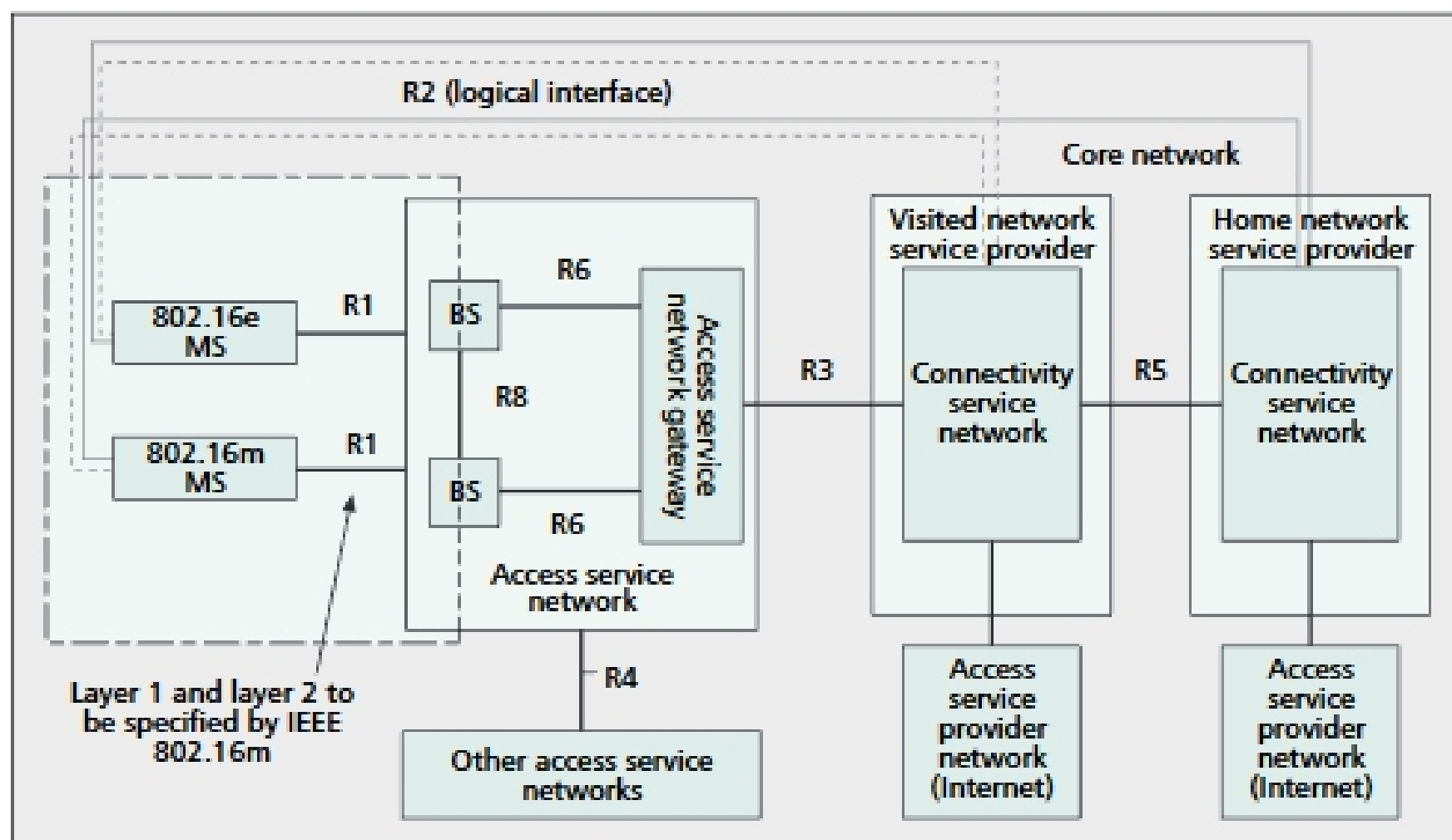
The growing demand for mobile Internet and wireless multimedia applications has motivated the development of broadband wireless-access technologies in recent years. Mobile WiMAX was the first mobile broadband wireless-access solution based on the IEEE 802.16e-2005 standard [1] that enabled convergence of mobile and fixed broadband networks through a common wide-area radio-access technology and flexible network architecture. The mobile WiMAX air interface utilizes orthogonal frequency division multiple access (OFDMA) as the preferred multiple-access method in the downlink (DL) and uplink (UL) for improved multipath performance and bandwidth scalability. Since January 2007, the IEEE 802.16 Working Group has

embarked on the development of a new amendment of the IEEE 802.16 standard (i.e., IEEE 802.16m) as an advanced air interface to meet the requirements of the International Telecommunication Union — Radiocommunication/International Mobile Telecommunications (ITU-R/IMT)-advanced for fourth-generation (4G) systems, as well as the next-generation mobile network operators.

Depending on the available bandwidth and multi-antenna mode, the next-generation mobile WiMAX will be capable of over-the-air data-transfer rates in excess of 1 Gb/s and support a wide range of high-quality and high-capacity IP-based services and applications while maintaining full backward compatibility with the existing mobile WiMAX systems to preserve investments and continuing to support first-generation products. There are distinctive features and advantages such as flexibility and the extensibility of its physical and medium-access-layer protocols that make mobile WiMAX and its evolution more attractive and more suitable for the realization of ubiquitous mobile Internet access.

The next-generation mobile WiMAX will build on the success of the existing WiMAX technology and its time-to-market advantage over other mobile broadband wireless access technologies. In fact, all OFDM-based, mobile broadband access technologies that have been developed lately exploit, enhance, and expand fundamental concepts that were originally utilized in mobile WiMAX.

The IEEE 802.16m will be suitable for both green-field and mixed deployments with legacy mobile stations (MSs) and base stations (BSs). The backward compatibility feature will allow smooth upgrades and an evolution path for the existing deployments. It will enable roaming and seamless connectivity across IMT-advanced and IMT-2000 systems through the use of appropriate interworking functions. In addition, the IEEE 802.16m system utilizes multi-hop relay architectures for improved coverage and performance. This article briefly describes the salient technical features of IEEE 802.16m and the potential for successful deployment of the next generation of mobile WiMAX in 2011+.



■ Figure 1. Mobile WiMAX network reference model [9].

The evaluation scenarios and associated parameters specified in IEEE 802.16m evaluation methodology document are based mainly on those that were used for the evaluation of the reference system to benchmark the relative improvements.

## IEEE 802.16M SYSTEM REQUIREMENTS AND EVALUATION METHODOLOGY

Full backward compatibility and interoperability with the reference system is required for IEEE 802.16m systems, although the network operator can disable legacy support in green-field deployments. The reference system is defined as a system that is compliant with a subset of the IEEE 802.16e-2005 [1] features as specified by the WiMAX Forum mobile system profile, Release 1.0 [2]. The backward compatibility feature ensures a smooth migration from legacy to new systems without any significant impact on the performance of the legacy systems, as long as they exist. Furthermore, the requirements for IEEE 802.16m were selected to ensure competitiveness with the emerging 4G radio-access technologies while improving and extending existing functionalities of the reference system.

The IMT-advanced requirements defined and approved by ITU-R/Working Party 5D and published as Report ITU-R M.2134 [3] are referred to as target requirements in the IEEE 802.16m system requirement document and will be evaluated based on the methodology and guidelines specified by Report ITU-R M.2135 [4]. The baseline performance requirements will be evaluated according to the IEEE 802.16m evaluation methodology document [5]. A careful examination of the IMT-advanced requirements reveals that they are a subset of, and less stringent than, the IEEE 802.16m system requirements; therefore, the IEEE 802.16m standard can qualify as an IMT-advanced technology. Table 1 summarizes the IEEE 802.16m baseline system requirements and the corresponding requirements specified by Report ITU-R M.2134 [3]. In the next sections, we briefly discuss how these requirements can be met or exceeded through the extension and enhancements of the legacy-system functional features.

The IEEE 802.16m systems are expected to meet all service requirements for IMT-advanced systems as specified by Report ITU-R M.1822 [7], where compliance is verified through inspection [4].

The IEEE 802.16m evaluation methodology document [5] provides simulation parameters and guidelines for evaluation of the candidate proposals against the IEEE 802.16m system requirements [6]. The evaluation scenarios and associated parameters specified in IEEE 802.16m evaluation methodology document are based mainly on those that were used for the evaluation of the reference system [8] to benchmark the relative improvements. There are similarities and differences between the evaluation guidelines, test scenarios, and configuration parameters specified by Report ITU-R M.2135 [4] and the IEEE 802.16m evaluation methodology document [5]. Compliance with Report ITU-R M.2134 requirements in at least three test environments is required.

## NETWORK REFERENCE MODEL AND IEEE 802.16M PROTOCOL STRUCTURE

The WiMAX Network Architecture Release 1.0 [9] specifies a non-hierarchical, end-to-end network reference model (Fig. 1) for mobile WiMAX that can be expanded to further include optional relay entities for coverage and performance enhancement in future releases.

The IEEE 802.16 standard [1] describes medium-access-control (MAC) and physical-layer (PHY) protocols for fixed and mobile broadband wireless-access systems. The MAC and PHY functions can be classified into three categories, namely, data plane, control plane, and management plane. The data plane comprises functions in the data processing path such as header compression, as well as MAC

Requirements	IMT-Advanced [3]	IEEE 802.16m [6]
Peak data rate (b/s/Hz)	DL: 15 (4 × 4) UL: 6.75 (2 × 4)	DL: 8.0/15.0 (2 × 2/4 × 4) UL: 2.8/6.75 (1 × 2/2 × 4)
Cell spectral efficiency (b/s/Hz/sector)	DL (4 × 2) = 2.2 UL (2 × 4) = 1.4 (base coverage urban)	DL (2 × 2) = 2.6 UL (1 × 2) = 1.3 (mixed mobility)
Cell-edge user spectral efficiency (b/s/Hz)	DL (4 × 2) = 0.06 UL (2 × 4) = 0.03 (base coverage urban)	DL (2 × 2) = 0.09 UL (1 × 2) = 0.05 (mixed mobility)
Latency	C-plane: 100 ms (idle to active) U-plane: 10 ms	C-plane: 100 ms (idle to active) U-plane: 10 ms
Mobility (b/s/Hz at km/h)	0.55 at 120 km/h 0.25 at 350 km/h (link-level)	Optimal performance up to 10 km/h Graceful degradation up to 120 km/h Connectivity up to 350 km/h Up to 500 km/h depending on operating frequency
Handover interruption time (ms)	Intrafrequency: 27.5 Interfrequency: 40 (in a frequency band) 60 (between frequency bands)	Intrafrequency: 27.5 Interfrequency: 40 (in a frequency band) 60 (between frequency bands)
VoIP capacity (Active users/sector/MHz)	40 (4 × 2 and 2 × 4) (Base coverage urban)	60 (DL 2 × 2 and UL 1 × 2)
Antenna configuration	Not specified	DL: 2 × 2 (baseline), 2 × 4, 4 × 2, 4 × 4, 8 × 8 UL: 1 × 2 (baseline), 1 × 4, 2 × 4, 4 × 4
Cell range and coverage	Not specified	Up to 100 km Optimal performance up to 5 km
Multicast and broadcast service (MBS)	Not specified	4 b/s/Hz for ISD 0.5 km 2 b/s/Hz for ISD 1.5 km
MBS channel reselection interruption time	Not specified	1.0 s (intrafrequency) 1.5 s (interfrequency)
Location-based services (LBS)	Not specified	Location determination latency < 30 s MS-based position determination accuracy < 50 m Network-based position determination accuracy < 100 m
Operating bandwidth	Up to 40 MHz (with band aggregation)	5 to 20 MHz (up to 100 MHz through band aggregation)
Duplex scheme	Not specified	TDD, FDD (support for H-FDD terminals)
Operating frequencies (MHz)	IMT bands 450–470 698–960 1710–2025 2110–2200 2300–2400 2500–2690 3400–3600	IMT bands 450–470 698–960 1710–2025 2110–2200 2300–2400 2500–2690 3400–3600

■ **Table 1.** IEEE 802.16m and IMT-Advanced system requirements.

and PHY data packet-processing functions. A set of layer-2 (L2) control functions is required to support various radio resource configuration, coordination, signaling, and management. This set of functions is collectively referred to as the control-plane functions. A management plane also is defined for external management and

system configuration. Therefore, all management entities fall into the management-plane category.

The IEEE 802.16 MAC layer is composed of two sublayers: the convergence sublayer (CS) and the MAC common-part sublayer (MAC CPS) [1]. For convenience, we logically classify