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RESPONSE TO ITU-R WP 8F QUESTIONNAIRE ON THE SERVICES AND MARKET FOR THE FUTURE DEVELOPMENT OF IMT-2000 AND SYSTEMS BEYOND IMT-2000

Introduction

This contribution was developed by IEEE Project 802, the local and metropolitan area network standards committee ("IEEE 802"), an international standards development committee organized under the IEEE and the IEEE Standards Association ("IEEE-SA").

The content herein was prepared by a group of technical and regulatory experts in IEEE 802 and was approved for submission by the IEEE 802.16 working group[1] on wireless metropolitan area networks and the IEEE 802 executive committee, in accordance with the IEEE 802 policies and procedures, and represents the view of IEEE 802.

IEEE 802.16 has developed a standard for broadband wireless access systems, which will enable deployments in various bands.

Response to Questionnaire[2]

It is our understanding that the Questionnaire's purpose is to gather information on analyses and forecasts of services and markets that will be used to estimate the spectrum requirements for the future development of IMT-2000 and systems beyond IMT-2000. Data wireless access traffic includes not only IMT-2000 traffic, but also other traffic from applications such as RLAN in hotspots and wireless metropolitan area networks (MAN). .

This response addresses Question 4 on "other radio systems", from the point of view of fixed and nomadic data traffic, with which IMT-2000 systems and beyond are envisaged to interwork. IEEE 802 systems are an integral part of broadband wireless services, delivered to fixed indoor and outdoor devices as well as nomadic devices and will thus contribute to the overall amount of data traffic.

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[2] ITU-R Administrative Circular CACE/326, "Questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000".

This response is focused only on services and applications provided by IEEE 802.16 systems and it is expected to lead to a more accurate spectrum estimation by WP 8F. More precise knowledge of future spectrum requirements for fixed, nomadic and mobile broadband wireless services will benefit administrations, spectrum license holders, and equipment manufacturers with vested interests in broadband wireless access throughout the world.

Note that IEEE expertise is not in developing market forecasts. However, in order to be responsive to the specific questions posed in the WP 8F questionnaire, we have extracted forecast data from available research reports.

Service and market forecast for IEEE 802.16 systems

IEEE 802.16 response to Question 4 of the above-mentioned Questionnaire is included in an appendix to this contribution.

It should be stated that service descriptions and market forecast contained in the appendix is based on industry market research data for IEEE 802.16 fixed and nomadic systems up to 2009 and does not include forecast for mobile systems. In this document, fixed and nomadic wireless access systems are as defined in Recommendation ITU-R F.1399.

Appendix

Response to questionnaire on the services and market for the future development of IMT-2000 and systems beyond IMT-2000

Q4. Service and market forecast for other radio systems

The future development of IMT-2000 and systems beyond IMT-2000 are envisaged to interwork with other radio systems such as wireless LAN and broadcasting systems. Please list any radio systems that might interwork with the future development of IMT-2000 and systems beyond IMT-2000, and forecast the future status of the parameters from Q3. Please indicate the percentage of users that subscribe to multiple systems/operators.

Fixed and Nomadic broadband access based on the IEEE Standard 802.16-2004[3] will be a significant part of future broadband wireless services delivered to a variety of user devices including fixed outdoor modems, indoor modems, laptops and other nomadic devices. Systems based on the IEEE Standard 802.16-2004 are considered for deployments in several countries. These deployments first start by serving medium and small businesses but will expand into the greater residential market. Lack of access to an affordable wired broadband solution around the world provides the potential for 802.16 to serve in the "last mile." Given the current and projected interest in 802.16-based broadband wireless access systems and their complementary nature to IMT-2000 systems, it is foreseeable that the interworking between the two systems will be achieved in the near future. Therefore, contribution of 802.16-based services to the overall demand for data services needs to be taken into account in the overall calculations for the spectrum requirements of future development of IMT-2000 systems, their enhancements, and systems beyond IMT-2000 because they may augment or diminish the spectrum requirements for IMT-2000 systems.

As requested in Q4, therefore, future status of the parameters in Q3 is being described below for 802.16 systems.

1 – Service issues

A wireless Metropolitan Area Network (MAN) based on the 802.16 air interface standard is configured in much the same way as a traditional cellular network with strategically located base stations using a point-to-multipoint architecture to deliver services over a radius up to several kilometers depending on frequency, transmit power and receiver sensitivity. The base stations are typically backhauled to the core network by means of fiber or point-to-point microwave links to available fiber nodes or via leased lines from an incumbent wire-line operator. The range and NLOS capability are two important parameters in deployments in a variety of environments. The technology was envisioned from the beginning as a means to provide wireless "last mile" broadband access with performance and services comparable to or better than traditional DSL, Cable or T1/E1 leased line services. The IEEE Standard 802.16-2004 supports fixed/nomadic applications, providing a variety of services to fixed outdoor as well as nomadic indoor users. Work is underway on a mobile extension (802.16e) supporting new capabilities needed for the mobile environment.

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[3] Doc. 9B/83 (Annex 6), "Preliminary Draft New Recommendation ITU-R F.[9B/BWA] "Radio interface standards for broadband wireless access (BWA) systems in the fixed service operating below 66 GHz".

The services that will be delivered by fixed and nomadic 802.16 deployments include[4]:

1. Residential and SOHO High Speed Internet Access: Today this market segment is primarily dependent on the availability of DSL or cable. In some areas the available DSL or cable services may not meet customer expectations for performance or reliability and/or are too expensive. In many rural areas residential customers are limited to low speed dial-up services. In developing countries there are many regions with no available means for internet access. 802.16-based technology will help operators address this market segment.

2. Small and Medium Business: This market segment is very often underserved in areas other than the highly competitive urban environments. The 802.16-based technology can potentially meet the requirements of small and medium size businesses in low density environments and can also provide an alternative in urban areas competing with DSL and leased line services.

3. Wi-Fi Hot Spot Backhaul: Wi-Fi hot spots are being installed worldwide at a rapid pace. One of the obstacles for continued hot spot growth, however, is the availability of high capacity, cost-effective backhaul solutions. This application can also be addressed with the 802.16-based technologies. Nomadicity would also allow 802.16 to fill in the coverage gaps between Wi-Fi hot spot coverage areas.

4. Cellular Backhaul: In the U.S. the majority of backhaul is done by leasing T1 services from incumbent wire-line operators. With 802.16, cellular operators will have the opportunity to lessen their independence on backhaul facilities leased from their competitors. Outside the US, the use of point-to-point microwave is more prevalent for mobile backhaul, but 802.16 can still play a role in enabling mobile operators to cost-effectively increase backhaul capacity using 802.16 as an overlay network. This overlay approach will enable mobile operators to add the capacity required to support the wide range of new mobile services they plan to offer without the risk of disrupting existing services. In many cases this application will be best addressed through the use of 802.16 based point-to-point links sharing the Point-to-Multipoint infrastructure.

5. Public Safety Services and Private Networks: Support for nomadic services and the ability to provide ubiquitous coverage in a metropolitan area provides a tool for law enforcement, fire protection and other public safety organizations enabling them to maintain critical communications under a variety of adverse conditions. Private networks for industrial complexes, universities and other campus type environments (e.g., large enterprise) also represent a potential application for 802.16 as do applications for vertical markets such as medicine, transportation, construction and real estate. Some examples of medical applications would include high resolution medical imaging for information sharing between hospitals and for remote diagnosis and physician collaboration.

6. Nomadic broadband access services: nomadic devices such as laptops enabled with 802.16 will enable users to connect to the Internet even when they are outside the range of a traditional Wireless LAN. This capability will open the door to many new services and usage models for users across many of the segments previously listed.

2 – Market issues

Demand for Internet services will continue to increase throughout the world at a fast pace. On the other hand, current and emerging applications such as the ones described above are leading to a growing demand for wireless broadband services and hence the number of 802.16 subscribers is expected to grow considerably by the year 2009 in all regions of the world.

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4 Business case models for fixed broadband wireless access based on WiMAX technology and the 802.16 standard, WiMAX Forum, 2004

It is important to note that the following tables containing subscriber forecasts do not include highly-mobile applications. These tables reflect the incremental growth in 802.16 fixed and nomadic services traffic some of which would interwork with IMT-2000 systems and beyond

Table 1 shows the growth forecast for 802.16 subscribers by region[5]. This table includes not only subscriber forecasts of systems based on the IEEE Standard 802.16-2004, but also subscriber forecasts for nomadic applications of systems based on the future 802.16 standard addressing new mobile capabilities.

Table 1: 802.16 Subscribers by Region (in millions)[6]

	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00879	0.09454	0.51842	1.53808	4.44115	374%
North America	0.00429	0.04476	0.27103	0.79567	1.99506	364%
Latin America	0.00199	0.01456	0.10119	0.27613	0.70602	334%
Europe	0.00437	0.05135	0.35957	1.10485	2.64515	396%
Rest of World	0.00150	0.01068	0.08358	0.24608	0.69671	365%
Total	0.02093	0.21588	1.33379	3.96081	10.48409	373%

This subscriber growth is not uniform among various environments or market segments. Residential/SOHO users are expected to grow at a much faster pace that other segments.

Tables 2 through 4 contain subscriber growth forecast information on various market segments for IEEE 802.16-2004.

Table 2: IEEE 802.16-2004 Residential/SOHO Subscribers by Region (in millions)

	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00242	0.02080	0.23235	0.64774	1.71812	416%
North America	0.00140	0.01258	0.15546	0.46941	0.99099	415%
Latin America	0.00129	0.00645	0.06394	0.16439	0.37658	313%
Europe	0.00187	0.02268	0.24657	0.75308	1.55050	437%
Rest of World	0.00092	0.00302	0.04330	0.11175	0.27765	317%
Total	0.00791	0.06552	0.74162	2.14637	4.91385	399%

[5] Tables 1-5 from *WiMAX/802.16: Opportunities for High Speed Wireless Data in Enterprise, SOHO, Residential and Portable (802.16e) Markets.* ABI Research. © 2004 All Rights Reserved. Used by permission granted to IEEE and ITU.

[6] The numbers reflected in Table 1 through Table 5 are based on aggressive forecasts. Moderate forecast data was not available for all tables.

Table 3: IEEE 802.16-2004 Small Medium Business (SMB) subscribers by region (in millions)

	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00587	0.04940	0.11235	0.22319	0.40459	188%
North America	0.00283	0.02127	0.04446	0.08259	0.15029	170%
Latin America	0.00064	0.00548	0.01654	0.03252	0.05414	203%
Europe	0.00239	0.01902	0.04147	0.07952	0.14353	178%
Rest of World	0.00048	0.00418	0.01287	0.02569	0.04437	210%
Total	0.01222	0.09935	0.22769	0.44351	0.79692	184%

Table 4: IEEE 802.16-2004 Enterprise Subscribers by Region (in millions)

	2005	2006	2007	2008	2009	CAGR (05-09)
Asia Pacific	0.00050	0.00270	0.00659	0.01259	0.02147	157%
North America	0.00005	0.00022	0.00044	0.00074	0.00130	126%
Latin America	0.00005	0.00030	0.00079	0.00159	0.00288	176%
Europe	0.00011	0.00055	0.00128	0.00233	0.00391	145%
Rest of World	0.00009	0.00068	0.00197	0.00419	0.00817	205%
Total	0.00080	0.00446	0.01107	0.02144	0.03773	162%

Table 5 contains subscriber growth forecast information across various market segments for nomadic applications of systems based on the future 802.16 standard addressing new mobile capabilities, referred to as 802.16e.

Table 5: 802.16e Subscribers by Region (in millions)

	2005	2006	2007	2008	2009	CAGR (06-09)
Asia Pacific	-	0.02	0.17	0.65	2.30	374%
North America	-	0.01	0.07	0.24	0.85	330%
Latin America	-	0.00	0.02	0.08	0.27	389%
Europe	-	0.01	0.07	0.27	0.95	371%
Rest of World	-	0.00	0.03	0.10	0.37	408%
Total	-	0.05	0.35	1.35	4.74	367%

In addition to the growth rate, subscriber penetration among various market segments is certainly not the same. Table 6 contains subscriber penetration data for residential/SOHO, business subscribers using a fixed CPE station, as well as stand-alone laptops with their own embedded station[7]. The following data is based on observations in the United States.

Table 6: Subscriber Penetration for 802.16 Services

Penetration	2006	2007	2008	2009
Residential/SOHO	3.94%	8.74%	14.13%	19.56%
SMB	0.75%	1.62%	2.56%	3.52%
Laptops	-	0.34%	0.78%	1.26%

3 – Preliminary traffic forecast

Tables 7 and 8 simply describe the capacity of an 802.16 base station for various channel bandwidths and coding/modulation schemes. By assuming a deployment scenario – e.g., available bandwidth and MHz per cell, distribution of various user types, and application breakdown -- it is then possible to calculate the total traffic volume of a base station.

It should be noted that the numbers reported in Table 7 and Table 8 are raw, theoretical data rates, assuming a cyclic prefix ratio of 1/32. Reporting raw data rates has the advantage of not making any deployment-specific assumptions. Actual data rates, namely the throughput provided by the base station throughout the cell and experienced by users, are a function of several factors including user distribution and propagation conditions and pilot distribution, will need to be taken into account according to agreed methodologies .

Table 7: Transmitter Raw Bit Rate of 802.16 OFDM[8] (in Mbit/s)*

Modulation / Code Rate	QPSK 1/2	QPSK 3/4	16 QAM 1/2	16 QAM 3/4	64 QAM 2/3	64 QAM ¾
1.75 MHz	1.45	2.18	2.91	4.36	5.94	6.55
3.5 MHz	2.91	4.37	5.82	8.73	11.88	13.09
7.0 MHz	5.82	8.73	11.64	17.45	23.75	26.18
10.0 MHz	8.38	12.57	16.76	25.13	33.51	37.70
20.0 MHz	16.76	25.14	33.52	50.26	67.02	75.40

* Note: This is the PHY raw bit rate only. MAC and frame (preamble, pilots, MAP, etc.) overhead are not included in calculation.

[7] *Executive Summary July 22, 2004* by LCC © 2004 All Rights Reserved. Used by permission granted to IEEE and ITU.

[8] FFT 256

Table 8: Transmitter Raw Bit Rate of 802.16 OFDMA (in Mbit/s)*

Modulation /Code Rate MHz	QPSK 1/2	QPSK ¾	16QAM 1/2	16QAM 3/4	64QAM 1/2	64 QAM 2/3	64 QAM ¾
1.25 MHz	1.14	1.71	2.28	3.42	3.42	4.55	5.13
1.75 MHz	1.59	2.39	3.18	4.78	4.77	6.37	7.17
3.5 MHz	3.17	4.77	6.34	9.54	9.51	12.74	14.31
5.0 MHz	4.55	6.82	9.10	13.64	13.65	18.20	20.46
7.0 MHz	6.35	9.56	12.70	19.12	19.05	25.48	28.68
10.0 MHz	9.10	13.65	18.20	27.30	27.30	36.39	40.95
20.0 MHz	18.20	27.30	36.40	54.60	54.60	72.79	81.89

* Note: This is the PHY raw bit rate only. MAC and frame (preamble, pilots, MAP etc.) overhead are not included in calculation. Mandatory subcarrier allocation modes are used for the numbers.