Mobile WiMAX in the Evolving Wireless Broadband Landscape
Introduction
Even with the surprising variety of wireless broadband technologies available today, Mobile WiMAX (IEEE 802.16e) has established clear advantages in several application areas. In many cases, Mobile WiMAX works alongside other wireless technologies to complete key parts of the data communications infrastructure. Understanding the role of Mobile WiMAX relative to other wireless technologies is critical in making the best choices for delivering the broadband products and services that customers want.

Fujitsu offers extensive Mobile WiMAX hardware and software resources for developers targeting this market. These resources include the MB86K21 Mobile WiMAX SoC; an evaluation and development system with software tools; a PC Card reference design; a complete software stack; and one of the smallest Mobile WiMAX radio modules in the industry.

Roaming the Wireless Landscape
Many different wireless broadband technologies are cooperating and competing in today’s wireless landscape. These wireless technologies fall into several categories: cellular communications, local area networks (LANs), personal area networks (PANs) such as Bluetooth, Ultra Wide Band (UWB) and metropolitan area networks (MANs). Table 1 lists a few distinguishing features of the standard wireless broadband technologies operating today.

The most widely deployed technologies for high mobility cellular communications are GSM and the 3G Wideband Code Division Multiple Access (WCDMA). These technologies support both packet- and circuit-switched data transfers and offer data rates far less than 1 Mbps. The General Packet Radio Service (GPRS) provides packet-oriented data services to GSM systems. The Universal Mobile Telecommunications System (UMTS) standard uses WCDMA as an underlying air interface and offers similar capabilities. UMTS is incompatible with GSM, but dual-mode UMTS/GSM data cards enable most mobile devices to be backward-compatible with regular GSM networks.

High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA) are parts of the High Speed Packet Access (HSPA) cellular communication standard, which provides much higher performance than earlier cellular standards. HSPA achieves this performance gain by using better modulation schemes and more refined protocols by which handsets and base stations communicate in a packet-switched scheme. These improvements lead to a better utilization of the existing radio bandwidth provided by UMTS. Still, the maximum single-user packet-download rate is about 14 Mbps—far lower than Mobile WiMAX.

Unlicensed Mobile Access (UMA) is a telecommunication system that enables seamless roaming and handover between local area networks and wide area networks using a dual-mode mobile phone. The local network may be based on private unlicensed spectrum technologies such as Bluetooth or 802.11, while the wide network is based on either GSM/GPRS or UMTS mobile services.

<table>
<thead>
<tr>
<th>Features</th>
<th>Mobile WiMAX</th>
<th>GSM</th>
<th>WCDMA</th>
<th>UMTS</th>
<th>HSPA</th>
<th>Bluetooth</th>
<th>802.11</th>
</tr>
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<tbody>
<tr>
<td>Peak Single User Data Rate</td>
<td>Up to 75 Mbps using EDGE</td>
<td>473.6 Kbps</td>
<td>384 Kbps</td>
<td>384 Kbps</td>
<td>13.96 Mbps</td>
<td>5.76 Mbps</td>
<td>2 – 3 Mbps</td>
</tr>
<tr>
<td>Channel Bandwidth</td>
<td>5, 7, 8, 75, 10 MHz</td>
<td>200 kHz</td>
<td>5 MHz</td>
<td>5 MHz</td>
<td>5 MHz</td>
<td>5 MHz</td>
<td>1 MHz</td>
</tr>
<tr>
<td>Access Technology</td>
<td>FDD, TDD OFDMA</td>
<td>TDMA</td>
<td>FDD, CDMA</td>
<td>FDD, CDMA</td>
<td>TDMA, CDMA</td>
<td>TDMA, CDMA</td>
<td>TDMA</td>
</tr>
<tr>
<td>Frequency Range</td>
<td>2 – 11 GHz</td>
<td>380 – 1900 MHz</td>
<td>885 – 1920 MHz</td>
<td>1885 – 2025 MHz (Uplink)</td>
<td>2110 – 2200 MHz (Downlink)</td>
<td>1880 – 2620 MHz</td>
<td>1880 – 2620 MHz</td>
</tr>
</tbody>
</table>

Table 1 – Popular Broadband Communication Standards in Wireless Industry
Mobile WiMAX

Mobile WiMAX is based on IEEE 802.16e, a packet-switched standard developed by the IEEE for MAN implementations. The standard supports high-speed data transfers via long-range radio communication. As mentioned earlier, Mobile WiMAX competes as well as coexists with other popular wireless communication standards.

Several factors are fueling wide-scale acceptance of Mobile WiMAX: low cost of deployment, high data rates, long range and the interoperability of Mobile WiMAX base stations and customer premises equipment (CPE). Mobile WiMAX systems can serve as a last-mile broadband wireless link in areas with no existing copper or fiber optic lines. High data throughput and long radio range also make Mobile WiMAX ideal for data backhauling for other wireless and wired networks such as WiFi, Bluetooth, LANs and the public switched telephone network (PSTN). Operating in both licensed and unlicensed frequency bands, Mobile WiMAX allows service providers to minimize deployment costs associated with spectrum usage.

Another Mobile WiMAX advantage is its high-quality standards-based data encryption, which enables secure, interoperable wireless data communications with no additional cost. Other wireless technologies, such as WiFi, GPRS and WCDMA networks, use standards-based encryption methods, but these methods are either less secure or more costly to implement.

For example, WiFi security protocols use encryption keys with 40 bits to 128 bits, compared to the 128 bits to 256 bits of the AES and DES protocols used in WiMAX. The lower security of WiFi's encryption keys has prompted some users to implement more expensive Secure-Sockets-Layer-based systems with added user-authentication procedures. Similarly, GSM needs additional authentication and security protocols that may not be part of the actual standard (depending on the GSM version) and can result in higher costs.

Further, Mobile WiMAX provides built-in quality of service (QoS) profiles. The standard offers better QoS control and utilization of network bandwidth for broadband data services such as video streaming and VoIP.

Rolling Out Mobile WiMAX

Mobile WiMAX offers high throughput coupled with security and QoS advantages, yet implementing the technology in real-world products costs relatively little. Highly integrated SoC solutions help maximize performance while minimizing both cost and power consumption.

Fujitsu provides such a solution, with a single SoC that integrates the MAC, PHY, radio control and all the necessary analog circuits for implementing the IEEE 802.16e Wave 2 standard. This MB86K21 SoC also includes dual processors to support a modular system software architecture for scaleable, cost-effective products suitable for a variety of applications. System integrators can implement an effective network management system by using the SoC’s detailed application programming interface (API) to display MAC management messages, network statistics and radio properties in real time.

SoC features such as multiple-in/multiple-out (MIMO) antenna diversity, automatic transmit control and beam forming help maximize range and sensitivity in any geographic environment. These features also minimize bit error rate, improve receive-signal-strength indicator (RSSI) and carrier-to-interference-and-noise ratio (CINR) for the channel, reduce delay in round-trip data, enable the use of fewer base stations in the network, and promote better propagation in challenging field conditions.

The SoC implementation of the 802.16e handover feature enables users to move from one sector, base station or network to another without losing connection or dropping packets at high speeds. To facilitate such handovers, a base station broadcasts information about neighboring base stations. Using this information, the mobile station scans for the neighboring base station, synchronizes with its downlink, performs ranging, and then terminates the connection with the previous base station. This approach enables seamless roaming for Mobile WiMAX.

System Resources

To support the rapid development of products based on the MB86K21 Mobile WiMAX SoC, Fujitsu provides a system development kit (SDK), reference design, software and development tools.

Fujitsu has also developed one of the smallest radio-frequency (RF) modules in the industry for WiMAX applications — 15 x 15 x 1.5 mm. This module is fully integrated, including the transmit-and-receive antenna switch, RF front end, transceiver chip and voltage-controlled clock crystal oscillator (VCTCXO). The module operates over the 2.496 GHz to 2.69 GHz range and supports the 5 MHz and 10 MHz bandwidth with low noise and high linearity.
Figure 1 shows the key blocks of the SDK for designing and verifying Mobile WiMAX CPE hardware. The SDK also provides resources for developing the system software stack.

The main components in the SDK that connect to the Mobile WiMAX SoC include flash memory, SDRAM, and a 2.5 GHz radio card. The latter supports 5 MHz and 10 MHz channels, and connects to the SDK via a standard PC Card type II interface. This format enables developers to substitute other radio cards if desired for system characterization.

In addition to the SoC and other hardware components, the SDK includes several development tools:

- Flash maintenance/update tool
- System parameter storage/update tool
- SoC maintenance/evaluation tool
- System control/management tool

The flash maintenance/update tool is used to write the initial firmware file to the flash memory of the SDK and reference design kit (more on this RDK later) and upgrade the firmware as needed. Similarly, the system parameter storage/update tool is used to save or upgrade the system parameter file on EEPROM. This file contains the network entry parameters including values for bandwidth request and management; radio channel selection; and RF transmit power.

Developers can use the SoC maintenance/evaluation tool to evaluate the SoC’s lower-MAC (LMAC), upper-MAC (UMAC), physical layer (PHY) and RF control units. The tool’s measurement and configuration modes enable users to set SoC parameters such as transmit power, automatic gain control (AGC) and automatic frequency control (AFC). The tool also displays or measures parameters such as MAC management messages, bit error rate (BER), packet error rate (PER), RSSI and CINR.

Finally, the system control/management tool provides base-station/mobile-station connection management and status monitoring. The tool also includes service flow management, classification rule management, handover control, sleep- and idle-mode controls, and automatic recovery of service.

Figure 1 – Fujitsu’s Mobile WiMAX System Design Kit (SDK) with SoC Shown in the Purple Box.
Product Form Factors and Reference Designs

Viable form factors for Mobile WiMAX CPE devices include PCMCIA cards, PCI Express boards, mini SD cards, indoor USB modems and USB flash dongles. To provide a head start, Fujitsu offers a complete PC Card reference design kit based on PCMCIA Type II PC Card specifications. (In addition to the PC card reference design kit, Fujitsu will also provide other Mobile WiMAX reference designs for a desktop modem with USB connectivity and USB flash dongle.)

The PC Card reference design is built around Fujitsu’s MB86K21 Mobile WiMAX SoC and a third-party RF transceiver (Figure 2). The PC Card has one transmit and two receive antenna ports to maximize transmit and receive efficiency with a power consumption of 3 Watts typical.

The design includes a complete software stack for the MAC and application layers. The modular software architecture of Fujitsu’s solution enables the easy reuse of key system software blocks. This architecture thus adapts readily to different applications, reducing time to market as well as the overall cost.

Fujitsu has performed extensive interoperability testing with base stations from leading vendors to ensure the stability and standardization of the system software. This assured interoperability with the most popular base stations offers a solid foundation on which service providers can launch a variety of applications, handle varying numbers of subscribers, and manage the total system cost.

During the interoperability trials, the design achieved data throughput close to the theoretical maximum limits for the 5 MHz and 10 MHz channels used. While exact throughput values depend on the many variables involved in test scenarios and conditions, typically the design realizes 25 Mbps at 5 MHz and 50 Mbps at 10 MHz (uplink plus downlink)—far higher than other mobile data services.

The reference design uses Card bus/PCI and USB 2.0 as the control and data interfaces to communicate with a host PC. A serial peripheral interface (SPI) is used for RF control, and an I²C bus is used for setting system parameters. A UART interface connects the design to a Subscriber Identity Module (SIM) card via a SIM controller. This connection enables use of the PC card for wireless modems in an Internet protocol (IP) set-top box or wireless handheld personal communication device.

Mobile WiMAX Moves Forward

The Mobile WiMAX standard opens the door to low-cost VoIP, real-time interactive gaming and video streaming across a wide spectrum of applications. Devices ranging from cellular phones and PDAs to personal computers can take advantage of these services. Fujitsu’s MB86K21 Mobile WiMAX SoC provides the necessary functionality, and Fujitsu reference designs and software suites simplify the application development.
Fujitsu has comprehensive plans to introduce additional small, highly integrated, low-power baseband SoC and RF solutions to this market in the near future, with system support and industry-standard interfaces for external host processors. The company has key capabilities in place to enable further advances in integration, including advanced process technologies and packaging options such as system in package (SIP) and printed circuit board (PCB) in package. Combined with Fujitsu's optimized software architecture, these capabilities make it practical to offer complete Mobile WiMAX system solutions for multiple frequency bands and channels by integrating the baseband processor, required memory, RF transceivers and other supporting functions into a single device.

For More Information
For more information on the Fujitsu MB86K21 Mobile WiMAX SoC, please visit the company website at http://us.fujitsu.com/micro/wimax or send e-mail to inquiry@bwa.fujitsu.com.