WiMAX Subscriber Station Design Using the Fujitsu 802.16-2004 SoC Reference Kit
Introduction
The Fujitsu WiMAX reference kit offers a quick way to develop Time Division Duplex (TDD) or Half Duplex Frequency Division Duplex (HDX-FDD) subscriber stations for use in WiMAX networks. The kit consists of a development board and complete MAC-layer software. The board includes Fujitsu's MB87M3550 802.16-2004 WiMAX SoC and all the other hardware resources required for a typical subscriber station.

This technology backgrounder provides an overview of the steps involved in leveraging the reference kit to create self-configurable indoor or outdoor subscriber stations that operate in a licensed or license-exempt band from 2 to 11 GHz.

TDD or HDX-FDD Subscriber Station Reference Design
As shown in Figure 1, Fujitsu's WiMAX reference design board provides a radio module, a baseband daughter-board incorporating the Fujitsu WiMAX SoC, Ethernet and serial ports, power module and clock-generation circuitry. The SoC integrates MAC and PHY blocks that comply with the IEEE 802.16-2004 standard.

The PHY implements Orthogonal Frequency Division Modulation (OFDM) with 256 carriers. Under OFDM, the PHY supports various modulation schemes (including BPSK, QPSK, QAM16 and QAM64) in Time Division Duplex and Frequency Division Duplex modes using all the channel bandwidths specified by the WiMAX forum.

The reference kit's complete subscriber station MAC-layer software consists of upper and lower MAC parts (UMAC and LMAC, respectively). This software runs on the SoC's two embedded processors. The software can also run on external processors under multiple operating systems.

The upper MAC software implements the MAC management layer, service-specific convergence sub-layers, and multiple service classes to differentiate the service quality. The UMAC also provides common-part sub-layer, privacy, authentication and key-management services.

Running on another of the SoC's embedded processors, the lower MAC firmware implements time-critical lower-level 802.16 MAC functions, including PHY setup and control.

![Figure 1 - Subscriber Station Reference Design in TDD Mode](image-url)
Key blocks of this UMAC firmware include PHY Service Access Point (PSAP) management, PSAP scheduler, data control processor and OFDM PHY driver.

To assist in application development and customization of the upper MAC software, Fujitsu provides detailed documentation on the application program interfaces (APIs) to the upper and lower MAC software as well as the PSAP block.

**Application Design**

Application software for the host processor must manage and monitor wireless-centric network parameters, including:

- Channel selection
- Network association
- Data rate
- Number of Ethernet packets and PHY frames received/transmitted
- Receiver Sensitivity Signal Strength (RSSI)
- Bit Error Rate (BER)
- Site survey (local as well as remote to minimize maintenance costs)

The application module can use the API hooks of Fujitsu’s UMAC software to utilize the RTOS, TCP/IP stack and other hardware and software components of the CPE system. These resources can help implement a complete range of customer premises equipment (CPE) capabilities, including device configuration, network entry and other network operations. The host PC can communicate with the subscriber station via either a serial interface (RS-232) or Ethernet port for remote monitoring and management.

**VoIP**

Voice over IP (VoIP) applications can take advantage of the 10/100 Ethernet MAC interface provided by the Fujitsu WiMAX SoC. Most VOIP chipsets available today contain a three-port Ethernet switch with two ports (i.e., MII or PHY ports) external to the switch. An analog phone can use one of these ports via a subscriber-line interface controller (SLIC) chip, and a WiFi-enabled router can use the other, as shown in Figure 2. The third port, configured for LAN, connects to the Ethernet port of the WiMAX reference board. Developers can also use an analog codec to interface the subscriber station with an analog telephone.

Note that Fujitsu offers a Power PC board that provides a Time Division Multiplexing (TDM) interface to support T1/E1 interfaces for business-class CPE applications. Figure 3 shows this board with the WiMAX development board.

**Indoor and Outdoor CPE Configuration**

With the Fujitsu WiMAX SoC, an indoor subscriber station can use several different types of antennas, such as fixed broad-beam or fixed narrow-beam antennas. Additionally, the equipment can take advantage of multiple-input/multiple-output (MIMO), multiple-input/single-output (MISO) or single-input/single-output (SISO) antenna systems. These antenna systems can combine with techniques such as space/time...
coding (STC), Convolutional Turbo Code (CTC), and Automatic Repeat Request (ARQ) to improve the overall link budget for enhanced transmit and receive capability, while minimizing cost and power consumption.

Narrow-beam antennas send radiated power to one receiving location or receive power from one transmitting location. MIMO antenna systems are similar to adaptive antennas and consist of multiple-element antennas connected to an optimizing array processor. The attraction of MIMO antenna systems is the large gains in link transmission capacity that they can achieve within a given channel bandwidth. The antenna of an indoor CPE is usually fixed to the subscriber station and can be either a built-in block or an external unit of the system. Similarly, the power supply module of an indoor CPE can be either part of the station or an external unit.

In contrast to indoor subscriber stations, the antennas of outdoor stations are usually installed away from the station box and the power supply. Antennas may be mounted on roof tops, towers and hill tops depending on the type of terrain and desired coverage area. Software can adjust the antenna gain characteristics and the radiated transmit power to conform to local regulatory limits and reduce noise interference in large networks.

Self-Configurable Subscriber Stations
Self-configurable subscriber stations perform a variety of functions with minimal input from users, including system initialization and configuration, negotiating network-entry parameters and burst profiles with the base station. Application software negotiates and sets the required parameters, as well as quality-of-service (QoS) profiles for services such as VoIP, video and audio streaming, video surveillance and high-speed internet access.

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Summary
The Fujitsu WiMAX reference design board serves as an enabling platform for developing indoor and outdoor TDD or HDX-FDD subscriber stations. System software deliverables include the MAC-layer software and device drivers for various operating systems. Using these resources, OEMs can develop application software for configuration and control, network monitoring and management, and multiple QoS profiles for applications such as VoIP, video surveillance, and audio and video streaming.

More information on the IEEE 802.16 standard for broadband wireless access and the WiMAX Forum is available at www.wimaxforum.org and www.ieee802.org/16. For more information on Fujitsu’s broadband wireless SoC, please address e-mail to inquiry.bwa@fma.fujitsu.com. WiMAX Forum is a trademark of the WiMAX Forum.