Performance of Wimax for Telemedicine Applications

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Abstract—This paper investigates the suitability of WiMAX/IEEE-802.16 – based broadband wireless access (BWA) technologies for telemedicine services. Beginning with a brief review of Wireless communication technologies for health and comparison of the basic features of Wi-Fi and WiMAX broadband access technologies, performance of WiMAX physical layer has been evaluated for medical image transmission in terms of bit error rate (BER), peak-signal-to-noise ratio (PSNR) in MATLAB simulation environment.

Keywords- WiMAX, Telemedicine , CT scan image, BER, PSNR

I. INTRODUCTION

This article examines IEEE802.16 / WiMAX-based BWA technology for providing effective and efficient healthcare service in rural areas consisting of towns, smaller remote communities as well as widely scattered users. Traditional wireless telemedicine services use WLANs, 2G, 2.5G, and 3G wireless networks such as WiFi, GSM, GPRS, and cdma2000 or UMTS for patient monitoring (local and remote) and diagnostic purposes [1]-[6]. In telemedicine applications, large amount of radiological images and clinical data are transmitted from patient’s site to doctor’s end. Data may be required to be transmitted in real-time, particularly in trauma cases. This requires broadband data communication technologies. Broadband wireless access advantage of WiMAX and Wi-Fi technologies make them obvious and feasible choice for telemedicine applications. The IEEE 802.16 standard, which incorporates several advanced radio transmission technologies such as orthogonal frequency division multiplexing (OFDM), adaptive modulation and coding (AMC), and adaptive forward error correction (FEC), are designed to provide broadband wireless capability using a well defined quality of service (QoS) framework in wireless metropolitan area networks (Wireless MAN) [7,8]. Therefore, this is a promising technology to provide high data rate wireless transmission of medical records under strict QoS conditions over large areas to a large number of users. The paper is organized as follows: Section II briefly reviews the emerging wireless communication technologies for health. A detailed comparison has been made between WiMAX and Wi-Fi technologies for telemedicine applications in section III. Details of WIMAX simulation model are given in section IV. Section V presents the performance evaluation of WiMAX physical layer for medical CT scan image transmission in terms of BER of the channel and PSNR of the received medical image while section VI provides conclusions.

II. WIRELESS COMMUNICATION TECHNOLOGIES FOR HEALTH

With emerging wireless technologies, patients can access healthcare services not only from hospitals, but also from rural healthcare centers, ambulances, ships, trains, airplanes, or their homes. Three types of wireless systems i.e. satellite communications systems, cellular networks, and wireless LANs are used for telemedicine services for large, medium, and small coverage areas respectively. In terms of mobility, satellite communications systems provide the highest flexibility [9]. However, the cost of system operation is high, and the size/weight of the networking equipment is large/heavy. For local telemedicine services (e.g., inside a hospital or healthcare center), WLAN-based systems would be the most suitable [6]. However, WLANs have limitations in terms of mobility and coverage area. Cellular networks are suitable to provide pre-hospital treatment in a mobile scenario (e.g., in an ambulance). Even though cellular networks (i.e. 3G networks) offer a reasonable compromise between the mobility requirement and the cost of the system, transmission speed may not be high enough for high-quality diagnostic video and still images [4]. IEEE 802.16/WiMAX-based BWA technology is a feasible choice for providing telemedicine services in both fixed and mobile environments as it provides features as wide bandwidth, integrated services, QOS support and security, which are crucial for wireless telemedicine services.

III. WiMAX Vs Wi-Fi

WiMAX is designed to coexist with Wi-Fi and not to clash with it. WiMAX coverage is measured in square kilometers, while that of Wi-Fi is measured in square meters. One can certainly say that WiMAX serves as a backhaul for Wi-Fi hot spots. As compared with Wi-Fi, WiMAX specifications provide higher bandwidth and higher data security by the use of enhanced encryption schemes. Important differences in physical and MAC layers of WiMAX and Wi-Fi are highlighted below.

A. Physical Layer.

At the physical layer, there are enormous differences. The IEEE 802.11 wireless LAN standards operate on four radio link interfaces that operate in the 2.4 GHz or 5 GHz unlicensed radio bands [3]. The physical layer of the IEEE 802.16 air interface operates at either the 10-66 GHz or 2-11 GHz band. Both Wi-Fi and WiMAX make use of adaptive modulation and varying levels of forward error correction to optimize transmission rate and error...
performance. In WiMAX, the combination of modulation and coding schemes yields bandwidth efficiency up to 5bps /Hz, which is higher than the maximum bandwidth efficiency (2.7bps/Hz) achieved in Wi-Fi system.

B. MAC Layer

The WiMAX standards describe a sophisticated media access control (MAC) protocol that can share the radio channel among hundreds of users while providing reasonable or good quality of service (QoS) [8]. IEEE-802.11 wireless LANs use a media access control protocol called Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) which is not an efficient protocol similar to CSMA/CD in Ethernet. Unlike the contention-based MAC protocol used in 802.11 wireless LANs, WiMAX uses a Request /Grant access mechanism similar to cable modem systems.

C. Security

Security has been one of the major deficiencies in Wi-Fi, though better encryption systems are now becoming available but these techniques cannot protect vital medical information crucial for telemedicine services. The MAC layer security feature in the IEEE 802.16/WiMAX standard can provide access control and encryption functionalities for wireless telemedicine services.

IV. WiMAX SIMULATION MODEL

Figure 1 shows the block diagram of WiMAX physical layer in which the basic modules of an IEEE 802.16 transmitter and receiver are outlined [10]. The input data is randomized for the sake of spreading the sequences of ones and zeros in order to obtain easier decoding and time synchronization at the receiver end. To achieve this, randomizer adds a pseudo-random binary sequence to the bit stream. The Forward error correction (FEC) encoder consists of the concatenation of Reed-Solomon (RS) and convolutional codes (CC). The use of concatenated code improves the system performance. Interleaving is used to protect the signal against burst errors. The interleaver is composed of block and bit interleavers. The block interleaver maps adjacent coded bits onto non-adjacent sub carriers to overcome burst errors. The IEEE 802.16-2004 standard defines seven combinations of modulation and coding rates that can be used to achieve trade-off between data rate and robustness depending on channel and interference conditions [11]. The WiMAX system employs the phase and quadrature amplitude modulation schemes namely, BPSK (Binary Phase-Shift Keying), QPSK (Quadrature Phase-Shift Keying), 16-QAM (Quadrature Amplitude Modulation) and 64-QAM. If the radio medium is of good quality, a higher grade modulation scheme can be used that enables achieving higher data rate. If the quality of radio medium decreases (due to increased noise and interference), the WiMAX system can switch over to a lower-grade modulation schemes such that improved quality of communication can be assured. Our physical layer model uses QPSK modulation scheme with overall code rate of ¾.

In OFDM-based transmission, input bit streams are divided into several parallel bit streams of lower data rates and then they are used to modulate several densely spaced orthogonal sub-carriers.

V. PERFORMANCE ANALYSIS

Experiment was carried out by considering a CT scan image of size 256x256 with 8-bit grey levels available in reference [12]. This digital image is then transmitted over OFDM based physical layer of WiMAX system in Matlab simulation environment. The AWGN channel was assumed for transmission for the digital image. Performance of WiMAX channel is evaluated by calculating the BER for different values of received signal-to-noise ratio (E_b/N_0) of the received image. Figure 2 shows the variation in BER vs E_b/N_0 for various modulation schemes.

It is observed that the BER level decreases with the increase in E_b/N_0. Figure 3 shows the variation in PSNR of the recovered image with varying SNR (E_b/N_0). Figure 4 shows the CT scan images recovered at the receiver end at various E_b/N_0 values for 4-QAM/QPSK modulation scheme. It can be observed from Figure 3 that PSNR increases with SNR value. This is in conformity with the decrease in BER level with increase in SNR value (Fig. 2). Also, SNR requirement for a given PSNR increases with the level of modulation scheme used.
QPSK modulation scheme recovered CT scan image has PSNR= 35 dB for \( E_b/N_0 = 13.2 \) dB and at this level of \( E_b/N_0 \) BER is found to be 0.00012. Figure 4 closely demonstrates the act that PSNR value > 35 dB is required for obtaining imperceptible quality of recovered CT scan image.

VI. CONCLUSIONS

This paper presented an insight of WiMAX/ IEEE-802.16 BWA technology for telemedicine services. Simulation results demonstrated the performance of WiMAX physical layer for teleradiology applications. WiMAX offers great promise for its exploitation in telemedicine applications.

REFERENCES


