Enhancing Quality of Video over Wireless IP Network

Dharm Singh* Chih-heng Ke Poonam Dhaka*****

Abstract

The IEEE 802.11 standard cannot provide QoS support for multimedia applications. Thus, considerable research efforts have been carried out to enhance QoS support for 802.11. Among them, 802.11e is the QoS enhanced standard proposed by the IEEE working group. We investigate the performance of video transmission over 802.11e wireless network through computer simulations. In this paper the MPEG-4 video transmission over the 802.11e, the highest priority for video was set, for FTP flow priority set to best effort (priority was set to second highest), and for background Exponential Traffic priority was set to lowest. The results show that the proposed wireless network mechanism is a simple system to improve the quality of MPEG video transmission over wireless network.

Keywords — Wireless networks, QoS, 802.11

1. Introduction

With the great advances in digital data compression (coding) technologies and the rapid growth in the use of IP-based Internet, along with the quick deployment of last-mile wireline and wireless broadband access, networked multimedia applications have created a tremendous impact on computing and network infrastructures. Wireless IPNetworks have become increasingly popular over the last number of years. During this time, user requirements have evolved, resulting in a more diverse mix of services being carried over the radio interface. In particular, delay sensitive real-time applications such as streaming multimedia and voice over wireless IP are growing in importance. These qualities of service (QoS) parameters are not currently taken into consideration in IEEE's widely deployed widely accepted 802.11b/g standard [11]. With the development of two high-speed physical (PHY) layers, IEEE 802.11g (54 Mb/s) [7] and IEEE 802.11n (100 Mb/s) [8], there is a growing need for multimedia services over WLANs (e.g. download-and-play, video conferencing, video streaming, video broadcasting, etc). However, 802.11 WLANs can only provide best-effort service, which would restrict the Quality-of-Service (QoS) for multimedia services. Therefore, a new standard, socalled IEEE 802.11e [9], defines the MAC procedure to support different kinds of traffics (voice, video, best-effortand background) over WLANs. The IEEE 802.11e

**Department of CSE, Maharana Pratap University of Agri. and Technology, Udaipur, India*

standard introduces the Hybrid Coordination Function (HCF) and specifies two access schemes: the Enhanced Distributed Channel Access (EDCA) and the HCF Controlled Channel Access (HCCA).

The number of adhoc routing protocols have been proposed and implemented, which include dynamic source routing (DSR), Destination sequenced Distance Vector (DSDV), ad hoc on-demand distance vector (AODV) routing. In the study [1] illustrated the performance of the Average End-to-End delay of routing protocol. The results using ns2 shows that DSR is best in case of both average end-to-end delay and packet delivery fraction over DSDV and AODV [1].Due to the limited transmission range of wireless network interfaces, multiple networks "hops" may be needed for one node to exchange data with another across the network. A user (node) can move anytime in an ad hoc scenario and, as a result, such a network needs to have routing protocols which can adopt dynamically changing topology. However, since there is no stationary infrastructure, such as base stations, mobile hosts need to operate as routers in order to maintain the information and the network connectivity [2].

1.1 Dynamic Source Routing (DSR)

DSR is based on the concept of source routing. For this protocol, mobile nodes are required to maintain route caches that contain the source routes of which the mobile node is aware. Entries in the route cache are continually updated as new routes are learned. There are 2 major phases of the protocol - route discovery and route maintenance Route discovery uses route request and route reply packets. Route maintenance uses route error packets and acknowledgements.

This paper explores the multimedia data transmission over 802.11b (DCF) and 802.11e (EDCA) mechanisms of operation, and compare the results and suggest the system to improved the multimedia over wireless network.

1.2 MPEG -4 Video Coding Standard

Video compression is undergoing constant changes as new coding/decoding (codec) systems are being developed and introduced to the market. MPEG (Moving Pictures Experts Group) an ISO/ITU standard for compressing digital video. Pronounced "em-peg," it is the universal standard for digital terrestrial, cable and satellite TV, DVDs and digital video recorders (DVRs). MPEG uses lossy compression within each frame which means pixels from the original images are permanently discarded.

MPEG-4 is an extremely comprehensive system for multimedia representation and distribution and most suitable for wired and wireless links. MPEG-4 (ISO 14496) is an ISO/IEC standard developed by MPEG, and it becomes an international standard at the beginning of 1999. MPEG-4 addresses the need for distributing rich interactive media over a variety of networks. MPEG-4 is widely used for high-quality video over IP networks, including streaming media over the Internet using PC, PDA, and 3G mobile phones. It is targeted for low bit rates. Its object-based coding functionalities allow for user interaction with audio-visual objects. MPEG-4 encoded video is expected to account for large portions of the traffic in future wired and wireless networks. Most researches currently use the MPEG-2 encodings. MPEG-4 provide very efficient video coding covering the range from the very low bit rates of wired and wireless communication to bit rates and quality levels beyond high definition television (HDTV). In contrast to the "*frame-based*" video coding of MPEG-1, MPEG-4 is *object based*. Each scene is composed of video object (VOs) that are coded individually. The main features of importance are MPEG-4's scalable coding techniques and error-resilient tools. These enhance network utilization and enable MPEG-4 senders to be more responsive to changes in network conditions. Designed as an adaptive representation scheme that also accommodates very low.

2. IEEE 802.11 Wireless Networks

IEEE 802.11 technology is mostly deployed for WLAN application. The original version of the standard IEEE 802.11 was released in 1997 and clarified in 1999, but is today obsolete. It specified two net bit rates of 1 or 2 megabits per second (Mbit/s), plus forward error correction code. It specifed three alternative physical layer technologies: diffuse infrared operating at 1 Mbit/s; frequency-hopping spread spectrum operating at 1 Mbit/s or 2 Mbit/s; and direct-sequence spread spectrum operating at 1 Mbit/s or 2 Mbit/s. The latter two radio technologies used microwave transmission over the Industrial Scientific Medical frequency band at 2.4 GHz. Previous WLAN technologies used lower frequencies, such as the U.S. 900 MHz ISM band. The IEEE 802.11 wireless LAN, also known as WiFi [6], has been classified into several standards including 802.11b, 802.11a, and 802.11g. The 802.11b and 802.11g are working in the 2.4 GHz Industrial-Scientitic-Medical (ISM) band. The 802.11a operates at 5 GHz Unlicensed National Information Infrastructure UNII/ISM bands in the US, and license-free 5 GHz bands elsewhere. Unlicensed frequency band of 2.4 - 2.485 GHz is an increasingly jumbled zone with interferences from microwave ovens, cordless phones, wireless cameras, Bluetooth and other RF solutions.

802.11e is a specification, approved by the IEEE in late 2005, to define QoS mechanisms for wireless gear that gives support to bandwidth-sensitive applications such as voice and video. The original 802.11 media access control protocol was designed with two modes of communication for wireless stations. The first, Distributed Coordination Function (DCF), is based on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), sometimes referred to as "listen before talk." A station waits for a quiet period on the network and begins to transmit data and detect collisions. DCF provides coordination, but it doesn't support any type of priority access of the wireless medium. An optional second mode, Point Coordination Function (PCF), supports time-sensitive traffic flows. Wireless access points periodically send beacon frames to communicate network identification and management parameters specific to the wireless network. Between the sending of beacon frames, PCF splits the time into a contention-free period and a contention period. With PCF enabled, a station can transmit data during contention-free polling periods. However, PCF hasn't been implemented widely because the technology's transmission times are unpredictable. Because DCF and PCF do not differentiate between traffic types or sources, the IEEE developed enhancements in 802.11e to both coordination modes to facilitate QoS. These changes would let critical service requirements be fulfilled while maintaining backward-compatibility with current 802.11 standards. The enhancement to DCF - Enhanced Distribution Coordination Function (EDCF) - introduces the concept of traffic categories. Each station has eight traffic categories, or priority levels. Using EDCF, stations try to send data after detecting the medium is idle and after waiting a period of time defined by the corresponding traffic category called the Arbitration Interframe Space (AIFS). A higher-priority traffic category will have a shorter AIFS than a lower-priority traffic category. Thus stations with lower-priority traffic must wait longer than those with high-priority traffic before trying to access the medium. To avoid collisions within a traffic category, the station counts down an additional random number of time slots, known as a contention window, before attempting to transmit data. If another station transmits before the countdown has ended, the station waits for the next idle period, after which it continues the countdown where it left off. No guarantees of service are provided, but EDCF establishes a probabilistic priority mechanism to allocate bandwidth based on traffic categories. Another way 802.11e aims to extend the polling mechanism of PCF is with the Hybrid Coordination Function (HCF). A hybrid controller polls stations during a contention-free period. The polling grants a station a specific start time and a maximum transmit duration.

2.1 IEEE 802.11e MAC protocol

Because the demands of multimedia applications over IEEE 802.11 based WLANs increase tremendously in recent years, task group E of IEEE 802.11 proposed a QoS extension of the IEEE 802.11 standard in 2005, called 802.11e. EDCA is designed to provide prioritized QoS by enhancing the contention-based DCF. Before entering the MAC layer, each packet received from the higher layer is assigned a specific user priority value and the priority value is tagged for each packet later. At MAC layer, EDCA introduces four different first-in first-out queues, called access categories (ACs). Each packet from the higher layer along with a specified user priority value should be mapped into a corresponding AC according to the type of traffic (e.g., background, best effort, video and voice). Each AC is also referred to as a backoff entity, which has its own contention parameters. Different contention parameters let different queues have different priorities and high priority queues can get more transmissions than low priority queues.

3. Performance Matrices

In this paper Investigators have considered several metrics in analyzing the performance of routing protocols.

- **Average delay :** Total number of delivered data packets divided by total number of data packets transmitted by all nodes.
- **Average End-to-End delay (seconds/packet) :** Total delay that each received packet has experienced to reach the destination divided by the total number of received data packets. We analyze the average end-to-end delay of the protocol in terms of seconds per packet received.
- **PSNR : Evaluation Metric :** The PSNR (peak signal to noise ratio) is a way to measure image quality in an objective way, pixel by pixel and provides the objective way to measure the video quality, investigator used PSNR in this study as a comparison metric. PSNR measures distortion between the original and the processed (impaired) versions of a video sequence. Let's say that we have two sequences: S (original) and S′ (impaired). S(x, y, k) is the luminance of a pixel at position x, y in frame k from the original sequence and S′(x,y,k) is the luminance of a pixel at the corresponding position in the impaired version. The sequences are K frames long, the frame size is M*N pixels, and each pixel luminance is represented with 8 bits. The Mean Square Error is first obtained with the formula below :

$$MSE = \frac{1}{KMN} \sum_{k=1}^{K} \sum_{y=1}^{M} \sum_{x=1}^{N} [S(x,y,k) - \bar{S}(x,y,k)]^2$$

The MSE is the cumulative squared error between the original and the impaired images. A lower MSE means a smaller error. The PSNR is then computed with the following expression:

$$PSNR_{dB} = 20 \log_{10} \frac{255}{\sqrt{MSE}}$$

The value 255 is the maximum possible luminance value that can be represented with 8 bits. The result of the PSNR is a decibel value.

4. Simulation Setup

The purpose of this experimental study was to measure the quality of the multimedia transmission over 802.11b (DCF) and 802.11e (EDCA) for successfully delivering multimedia data packets to their destinations. In order to get realistic performance, the results are averaged for a number of scenarios. Investigators were attempting to measure the protocols performance on a particular workload taken from real life. The simulation study of multimedia transmission over wireless network researcher's use three wireless network nodes n_0, n_1, n_2.Wireless Node n_0 is used to transmission of video data to wireless node n_1, n_1 will send a FTP flow to n_2, n2 will be sent to a Exponential Traffic to n_0, When the video transmission over the 802.11e researchers will be set the highest priority for video (priority will be set to 1), for FTP flow priority will be set to best effort (priority will be set to 2), and for background Exponential Traffic will be set to lowest priority (priority will be set to 3). Investigators use network simulator ns-2 to simulate wireless networks with various wireless routing protocols. NS-2 is a packet- level, discrete event simulator, widely adopted in the network research community. It evolved from the VINT (virtual internet testbed) project, a collaborative project among Lawrence Berkeley National Laboratory, University of California, Berkeley, University of South California, and Xerox PARC [3]. It is intended to provide a common reference.

5. Results and Analysis

The phrase peak signal-to-noise ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. PSNR is employed as an objective video quality metric of our experiments. The table I presents the simulation results and analysis for different wireless networks (802.11b and 802.11e) and start with a glimpse at the overall statistics, followed by a graphical analysis. In the end we present a comparison of 802.11b and 802.11e taken into consideration. The experimental data are shown in Table I and Figure 1.

The average values of PSNR of Multimedia video transmission over wireless network are shown in table-I. If comparisons are made between 802.11b and 802.11e, whose values are 33.991658, and 34.887196 respectively, the results show improving of PSNR value of PSNR of 802.11e if compared with 802.11e. The average delay with 802.11b and 802.11e are depicted in Figure 1. The average delays in seconds are 0.881965 and 0.081828 simultaneously.

Table I : Performance Parametres

WLAN	Average PSNR Value (dB)	Average Delay (sec.)	The Maximum Delay (sec.)
802.11b	33.991658	0.881965	1.257069
802.11e	34.887196	0.081828	0.495100

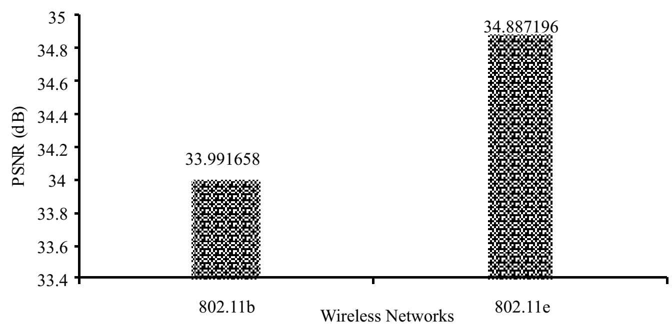

Figure 1a. Performance parameters (PSNR)

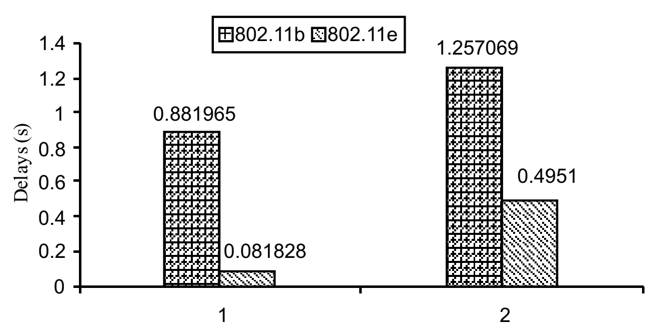

Figure 1b. Performance parameters (Delays)

Minimum average delay of experimental video is achieved by 802.11e. The simulated results of video transmission over wireless network for maximum delay are shown in table-I. By implementing 802.11b and 802, the values of maximum delay are 1.257069 and 0.495100 respectively. Minimum value of "maximum delay" of experimental video is achieved by 802.11e.

6. Conclusion

Researchers have implemented the multimedia transmission over 802.11 and 802.11e wireless networks and QoS supporting features of 802.11e compared to the 802.11b in Wireless IP Networks is presented. The performance of those schemes is discussed via simulation results. In this study the MPEG-4 video transmission over the 802.11e, the highest priority for video was set, for FTP flow priority set to best effort (priority was set to second highest), and for background Exponential Traffic priority was set to lowest.The simulation results show that MPEG video transmission over 802.11e provides better video quality than the 802.11b.

7. Reference

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