Research Article

AN EXPERIMENTAL INVESTIGATION OF MULTIMEDIA STREAMING OVER IEEE 802.16e MOBILE WIMAX

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ABSTRACT
The advent of broadband wireless networks, such as WiMAX, is paving the way for the widespread deployment of high-bandwidth video streaming services for mobile users. The paper proposes an experimental setup for the simulation study to evaluate the user’s QoE parameters when video is streamed from a source to a Mobile Station (MS) via a WiMAX Base Station (BS). The WiMAX Forum’s ns-2 simulator can be used to carry out all the simulations.

KEYWORDS
Video Streaming, WiMAX

I. INTRODUCTION
As the wireless multimedia communication services have been booming, the demands for real-time video streaming increase sharply. Recent development in high speed wireless networks has made it possible to provide real-time video streaming. Among those wireless standards, Worldwide Interoperability for Microwave Access (WiMAX) is prominent on the aspects of high-data rate and long-range coverage. The standard for mobile WiMAX networks is IEEE 802.16e that has come out for MBWA (Mobile Broad Band Wireless Access) in 2005. The user’s Quality of Experience (QoE) in video streaming is more dependent on the underlying Quality of Service (QoS) characteristics of the communication network, significant ones among them being the reserved bit rate, packet loss rate, packet delay and delay variation (jitter). The effect of these network metrics on QoE also depends on other factors specific to the video sequence (e.g., duration of the video, its mean and peak bit-rates, burstiness, etc.), and the type of the video streaming application itself. The IEEE 802.16 standard supports different scheduling services that are suitable for service flows with different traffic types, such as constant bit rate (CBR) or variable bit rate (VBR) traffic, and real-time traffic. The WiMAX BS schedules packets over the wireless channel while ensuring the QoS guarantees of each service flow. However, the QoS parameters assigned to a service flow by the BS, e.g., the reserved traffic rate, maximum BS to MS latency, and tolerated jitter, may vary over the lifetime of the flow. This change in QoS may occur due to the variation in the load at the BS, such as when the number of users connected to the base station changes, or due to the variation in the received signal strength at the MS, such as when the user moves away from the base station.

This paper proposes a framework for video streaming over a WiMAX network. In order to evaluate the performance of the transmitted stream over mobile WiMAX, we propose a connection scenario with one BS (Base Station) and one MS (Mobile Station) as streaming client. The above scenario can be implemented by the WiMAX module supported by NS-2. After simulation, the received video stream can be reconstructed, and then compared with the original one, in order to evaluate the effects of the scenario. We propose simulating the transmission of video clips from a video source in the wired network (i.e., in the IP core) to a vehicular receiver who is moving at a constant speed.

The remainder of this document is organized as follows: in Section II, a brief introduction to WiMAX is provided, and in Section III, we will explain our proposed framework environment, the platform introduction and parameter settings. Finally, a brief conclusion will be drawn in Section IV.

II. WiMAX
WiMAX is a broadband wireless data transmission technology for fixed and mobile users [1]. It is based on the air interface protocol specified by the IEEE 802.16 standard, which details the Physical (PHY) and Media Access Control (MAC) layers for the wireless link between the BS and the MS. The standard for the fixed user scenario was given in IEEE 802.16d [5], which was later enhanced to support user mobility in IEEE 802.16e [6]. As the MAC layer can support multiple PHY specifications, we propose the use of Orthogonal Frequency Division Multiple Access (OFDMA) PHY in which the BS allocates transmission resources to multiple MSs and data transmission is done on a frame-by-frame basis. An OFDMA frame is a fixed-sized contiguous region, in both the time and frequency domains, which is divided into downlink and up-link sub-regions. Within an OFDMA frame, the BS scheduler allocates slots to
where a slot is the smallest transmission resource in a frame. In addition, we may use the Point-to-Multipoint (PMP) mode of IEEE 802.16e and the duplexing scheme to be employed is Time Division Duplex (TDD).

A service flow constitutes a flow of packets between the BS and MS with predefined QoS parameters. The resources allocated to a flow within an OFDMA frame is based on the QoS requirements of the service flow. The IEEE 802.16e standard supports five scheduling services to accommodate flows with diverse QoS requirements. Of these five services, the real-time Polling Service (rtPS) is designed for flows that transport variable bit rate (VBR) traffic, such as MPEG video streaming, while the Unsolicited Grant Service (UGS) is designed for flows that transport constant bit rate (CBR) traffic. We may use any of these depending on the scenario and the need for study. For example, if the primary goal is to investigate the impact that different reserved rates have on the perceived video quality, simulations can be performed using UGS and only its maximum sustained traffic rate QoS parameter can be considered.

The IEEE 802.16 supports multiple Modulation and forward error correction Coding Schemes (MCS). Based on the channel condition experienced by the MS, the BS can choose to employ different MCSs for different MSs, which can further change dynamically across frames for the same MS. Choosing a more robust MCS allows the transmission to tolerate poorer channel conditions, but results in lower data rate. The QoE for a streaming service depends on conventional network metrics such as bit rate, packet loss rate, packet delay and jitter, and various video sequence specific factors, such as its encoding scheme and the video streaming application. Two important QoE metrics in a video streaming service are the receiver starvation probability and the received video quality. The starvation probability is the long-run fraction of frames or packets that miss their playout deadline at the receiver. The received video quality can be measured using subjective or objective video quality metrics.

III. EXPERIMENTAL SETUP

The simulations can be performed on the WiMAX Forum ns-2 System Level Simulator on the simple topology shown in Figure 1(a), which consists of a source node (typically in an IP network) generating video traffic, a WiMAX Base Station (BS) and a Mobile Station (MS). The source node is connected to the BS via a 100 Mbps link and has a certain propagation delay. In each simulation run, the source node streams a short video clip to a vehicular mobile user. During a run of the simulation, the user moves at a constant distance along a circular path maintaining a fixed distance from the BS (we deliberately recommend this mobility pattern so that the path loss does not change significantly during a single simulation run). As can be seen from the figure, the streamed video is transmitted over the WiMAX downlink, i.e., from the BS to the MS. In line with other QoE studies, we also recommend use of short representative video clips and to employ the publicly available EvalVid video evaluation toolkit to measure the impact of various network parameters on the QoE.

III.A. EvalVid

EvalVid is a toolkit that provides an integrated framework to assess the quality of the video transmitted over a network. It has a modular structure, making it possible to exchange, at user’s discretion, both the underlying transmission system as well as the codecs. Figure 1(b) shows the structure of the EvalVid framework and its interfaces with ns-2. We may use the three agents, MyTrafficTrace, MyUDP and MyUDPSink, that are part of EvalVid that integrates it with ns-2. The evaluation process begins with the encoding of the raw YUV video, which then generates the respective MPEG frames (I, P and B) and the corresponding encoding times. The agent MyTrafficTrace is an extension of the ns-2 agent Application/Traffic/Trace, which extracts the frame type, frame size, and inter-packet times from an input video trace file. It then fragments the frames into segments depending on the MTU (maximum transmission unit) of the underlying network and passes them to the lower UDP transport layer at appropriate times. MyUDP is an extension of the ns-2 agent Agent/UDP, which receives packets from the upper layer and records, in a sender trace file, the time stamps, packet ID, and payload size of
each transmitted packet. Lastly, MyUDPSink receives the transmitted packets over the network and records, in a receiver trace file, the received time stamps, packet IDs, and payload size. After the simulation, based on these trace files and the original encoded video, EvalVid produces the corrupted MPEG-4 video, which is then decoded and error concealed into raw YUV format. Finally, this YUV video can be compared with the original YUV video to evaluate the end-to-end delivered video quality (i.e., the PSNR values of the video frames).

### III.B. Simulation Parameters
We may characterize the impact of the following parameters like delay, distance between the BS and the MS on the user’s viewing experience using PSNR (averaged over all the frames in the original video) as the metric.

### III.C. Simulation Results
For a given video, reserved rate, MCS, and distance, we can find out what will the minimum value of tolerable delay for which the PSNR of the received video is greater than or equal to some desired value. To this end, we can perform a simulation run with a given video and the above set of parameters to obtain the received packet trace, then, using $R_T$ and the EvalVid setup; we can compute the average PSNR of the received video.

### IV. CONCLUSION
In this paper, we have proposed a framework for investigating the Quality of Experience (QoE) of video streaming over a WiMAX network which can be simulated using the WiMAX Forum ns-2 simulator. The video quality is recommended to be measured using the average PSNR of the received video. This work can be extended to study the impact of specific techniques, such as scalable video coding and packet prioritization, on the user’s experience.

### VI. REFERENCES
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6. IEEE. 802.16-2005 Standard for local and metropolitan area networks part 16: Air interface