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Mobile streaming of H.264 video over Gilbert-Elliotts Channel

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Abstract**—**Mobile multimedia applications are becoming increasingly popular in recent years due to explosive growth in demand for such services in both wired and wireless network. Undoubtedly, future wireless communication systems will eventually integrated a broad range of multimedia services such as voice, video, and data. Video applications play an extremely important role in surveillance, entertainment and remote monitoring. It is very obvious that achieving more reliable and efficient multimedia communication over wireless channel is challenging due to unpredictable channel condition, fading and multipath. In this paper, we investigate the impact of the channel condition on packet loss and percieve video quality. The scenario has been simulated and analysed base on Gilbert channel model, and it is primarily due to the fact it gives more realistic representation of the bursty channel such as wireless medium.

Keywords—H.264/AVC, Packet Loss, Time Varying Channel, Average delay, channel model, probability error

I. INTRODUCTION

In recent years there has been an explosive growth in demand for multimedia application in both wired and wireless network. In wireless environment, it is very challenging to maintain video quality due to multi-path fading, co-channel interference, mobility, and shadowing, and interference from external radio sources and contention from other network nodes. Therefore, it is absolutely necessary to provide adequate quality of service (QoS) to support these applications in order to satisfy the increasing demand [1, 2]. With the recent technological advancement in video and wireless technology, there is dramatic need to integrate video applications into wireless environment and maintain its quality. The possibility of integrating multimedia application will depend greatly on high compression efficiency, increase available channel bandwidth and strategic plan. In wireless environment, the channel condition changes very rapidly due to multi-path fading, co-channel interference, mobility, and shadowing. Maintaining video quality in wireless environment is very challenging as a result of aforementioned reasons and interference from external radio sources and contention from other network nodes. The major problem with the deployment of such application in wireless LAN are high bit error, limited bandwidth, time varying channel condition, and dynamic network users. Therefore, it requires more strategic planning, and robust video coding which is adaptable to the network and constraints [3, 4].

Transporting video over wireless has been a major issue of concern in recent years due its significance in many application and networks. Perhaps video communication has been very much popular due its high bandwidth demand for a video data to be efficiently transported across wireless network. Its transmission over aforementioned network can eventually cause traffic and hence reduce the network performance. Therefore, it is really very challenging task, when considering the channel condition, limited bandwidth and other constraint. In order to efficiently address the problem, many factors have to be taken into consideration and a strategic plan is needed.

In order to maintain the required video quality and avoid interruption to the video play-out require adaptation of the video stream based on the channel conditions and multimedia content. This is primarily due the fact error correction mechanisms provided at the MAC and physical layer could not adequately prevent packet delays and decrease in bandwidth in the wireless medium. It is absolutely clear that the H.264/AVC CODEC provides rate adaptation ability on the coded video streams in order to effectively enhance the video quality, but unaware of the delivery deadline

The organization of this paper is as follows. Section II is primarily aimed at reviewing the video coding concept and channel delay analysis. Section III will focus mainly on the concept of system model. In section IV, much emphasis has been place on the methodology used. Results are discussed in section V. Finally, a summary and conclusion are provided in Section VI

II. OVERVIEW OF VIDEO CODEC & CHANNEL DELAY

A. H.264/AVC Standard

The video industry has witnessed a tremendous development in coding standards and their targeted applications in recent years. This has lead to the development of different coding standards, and it has become a major field of research with a key enabling technology required today in wide variety of applications. The new video coding standard recommendation H.264 of ITU-T also known as International Standard 14496-10 or MPEG-4 part 10 Advanced Video Coding (AVC) of ISO/IEC is the latest standard in a sequence of the video coding standards H.261 (1990), MPEG-1 Video (1993) , MPEG-2 Video (1994) , H.263 (1995, 1997) , MPEG-4 Visual or part 2 (1998) [6]. These previous standards reflect the technological progress in video compression and the adaptation of video coding to different applications and networks.

The technological advancement of H.264/AVC has had a profound impact on multimedia communication industry due to its performance and reliability in terms of supporting multimedia applications in various types of networks. The error resilience and bit rate adaptability features in H.264/AVC will play an integral role in a wireless network. The most important features of H.264/AVC required in a wireless transmission environment are data partitioning, slice structure, intra coding, flexible macroblock ordering (FMO), and switching pictures.

In recent years, most of the research work related to H.264/AVC mainly focus on performance analysis of the CODEC, video transmission and error resiliency. This has been mainly due to wide variety of applications where H.264 can be potentially applicable. Also, much effort and attention has been place on complexity analysis of the H.264/AVC for low bit rate application. More importantly, the amendment of FRExt has led to additional four High profiles namely: High (HP), High 10 (Hi10P), High 4:2:2 (Hi422P) and High 4:4:4 (Hi444P) [7]. As a result of such tremendous development, its compression efficiency is 10% more than that of main profile.

B. Channel Delay Analysis

Many factors contribute to delay in a video communication. In order to ensure more effective video transmission and reasonably maintain video quality, the delay has to be reduce significantly to minimum such that it will not have much effect on the perceive video quality. It is very important to ensure that the video transmission has been completed within a predetermine time interval. Generally, the delay can be categorically divided into 3 types [8] namely: transmitter, channel and receiver delay.

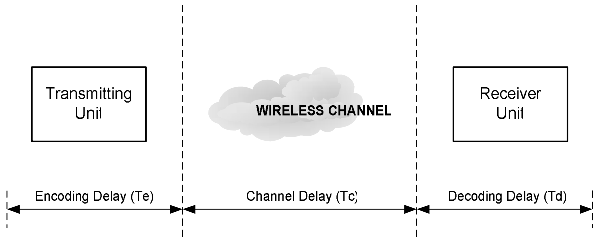

Figure 1: Wireless Channel Delay Analysis

The transmission channel delay is caused as a result of congestion and possible retransmission as the encoded video pass through the channel. It depends greatly on the condition and how successfully the data is delivered to the destination. Therefore, if the channel condition is worst, it will eventually increase the channel delay. Obviously, it is extremely important to keep track of the decoder buffer state in order to dynamically adjust with the bandwidth. At times the state of the decoder buffer has to be estimated through the available bandwidth. In a nutshell, different applications have different delay requirement.

III. SYSTEM MODEL

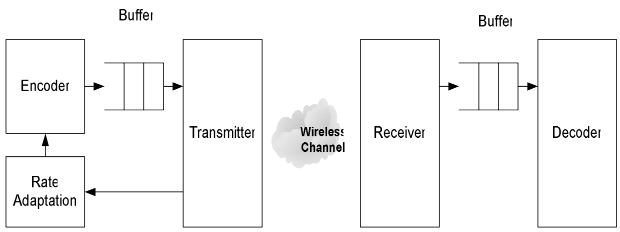

Figure 2: Video transmission system model

From figure 2 above, it can be seen that the system basically includes transmitter, channel and receiver. The source has been modeled as a sequence of compressed video frames. Each video frame is transported using multiple packets to the destination. The packets detail is tracked through its ID. This helps tremendously in analyzing the network performance in terms of delay, packet loss and video quality.

The burst nature of the wireless channel can be mimic more precisely using Gilbert channel model in order to critically analyse the video transmission over wireless medium. It is very obvious that markov chain has been used more extensively for modeling and analysis memory channels. The details about formulas used for evaluating the channel capacity of general markov channel can be found in [9].

Gilbert-Elliott is the special case of markov channel and it basically has two states.

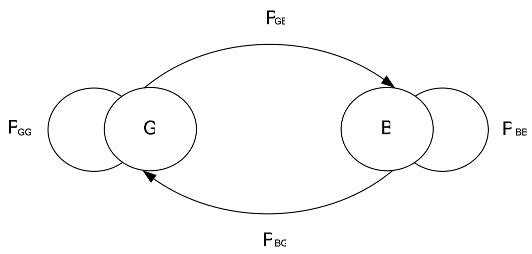

Figure 3: State diagram of the Gilbert Model

As can be seen in fig. 3, the model characterizes the packet loss process with two states that determines the loss behavior of the transmitted packets. It consists of one good state and one bad state with associated transition probabilities, and between the individual states and corresponding loss probabilities for the two states. Initially when the channel is in good or bad state, the system can end in good or bad state as well. P_{GB} is the probability that the channel changes from good to bad state while P_{BG} represent the probability of channel to change from bad to good state. Also, it is very important to note that the sum of overall average probability $\pi(G)$ in good state and average probability $\pi(B)$ in bad state is always unity.

It has been assumed that *φ(n, i)* is the probability that the sender transmits *n* packets over a Gilbert channel and the receiver correctly receives *i* packets. Also, it has been indicated in [10] that the probability can be expressed as

$$\varphi(n,i) = \pi(G)(\varphi G0Gi\,(n)+\varphi G0Bi\,(n))+ \pi(B)(\varphi B0Gi\,(n) +\varphi B0Bi\,(n)) \quad (1)$$

IV. SIMULATION RESULTS

A. Test Sequence

A sequence of IPPPP was considered for the experimentation. In the experiment, different probability error has been set to determine the effect of channel on the video quality. In order to simulate the above scenario, the channel has been assumed to be Gilbert channel. In the experimentation, the standard "Akiyo" and "foreman" QCIF (176X144) video files were encoded using H.264 encoder and the bit streams stored. The main focus is to mimic the video streaming scenario and frame rate was set to 30fps.

B. Simulation setup

NS-2 has been used to simulate the client and server scenario. IEEE 802.11 MAC have been used in DCF mode, retry limit of 16. NS-2 simulates the UDP and MAC protocol layers. Gilbert channel model was used to simulate the physical medium through which the video packets are transmitted. The channel condition was varied to determine the impact on the video quality. Apparently, it has been indicated that as probability error increases can eventually affects the quality of the video when transmitted over the wireless channel. Finally, the quality of the decoded video is compared with the original video.

C. Overview of Results

The simulation mainly involves comparison of different parameter setting on the video quality and packet loss. As can be seen in fig. 4, by increasing the data rate with a constant probability error will eventually improves the video quality over wireless network. Increasing the probability error (P = 0.03, 0.06, 0.09 & 0.12) will significantly affect the video quality at the destination and hence highly sophisticated means is required to provide adequate resiliency to these which causes detrimental effect to video quality in wireless environment. Also, the number of clients streaming the video has greater impact on the quality. This test has been conducted using the Akiyo (QCIF) sample. This clearly indicated that the video can be reasonably maintained by increasing the data rate. More precautionary measures have to be put in place to avoid further deterioration of video quality as the data rate increases.

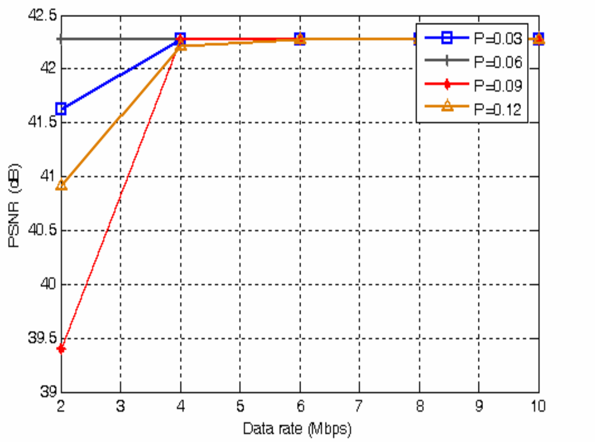

Figure 4: Effect of bit rate and probability error on transmitted video quality

In order to critically analyse the end-to-end delay, we keep track of the sending and receiving time for each of the packet transmitted. The data rate was varied between 2 - 10 mbps primarily to verify how the end-to-end delay varies as the data rate changes. As it can be seen from fig 5, the average delay decreases dramatically as the data rate increases. Also, it has been indicated that the rate at which the average delay reduces is affected by the probability error – higher probability error will culminate to higher delay as well. This is primarily due to the fact that the frames at P = 0.12 are more subjected to more transmission errors.

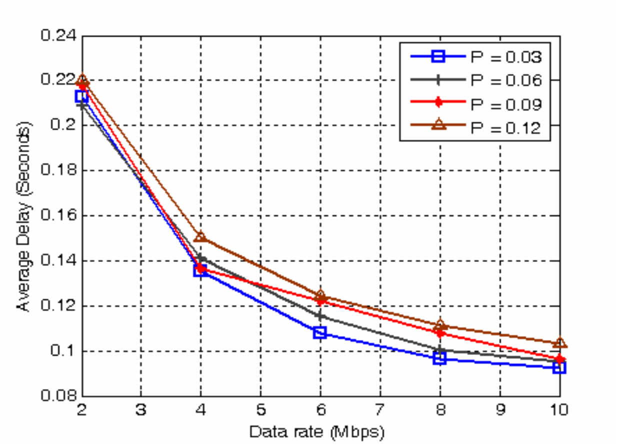

Figure 5: Average delay at different datarate and probablity error

It can be seen from fig 6 that the channel condition will have profound impact on the video quality unless more preventive measures have been put in place. In this case, the video file (foreman) was used to see how the video quality drastically reduced as the channel condition deteriorates.

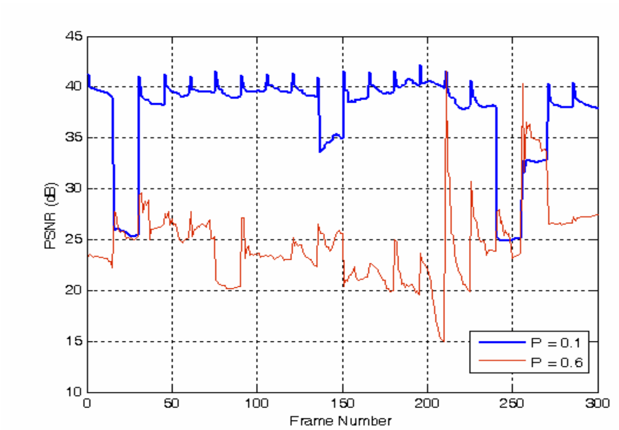

Figure 6: PNSR for the 300 frames of the foreman output sequence

V. CONCLUSIONS

In this paper, we demonstrated the profound impact of channel condition and other factors on video quality. The performance of the system has been examined using network simulator, utilizing Gilbert model to mimic the wireless channel. H.264/AVC has primarily been used to enhance video quality due to its brilliant features and capability. Our future work will primarily focus mainly on the development of cross layer solution strategy to dynamically adapt with the unpredictable channel condition in order to reasonably maintain video quality. This will eventually ensure more effective coordination and information transfer among the layers, and ultimately support effective video transmission over wireless channel.

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