Multisession Video Packet Scheduling

R. Arockia Xavier Annie, Murugesan Anitha, and P. Yogesh

Abstract. The main objective of this paper is to deliver quality video at the receiver end using the proposed scheduling schemes. The video is compressed for video streaming process, which may cause loss of packets (or) frames. Each video packet has different levels of contribution to improve the video quality at the receiver side. To overcome these problems the packet scheduling is being used. The packet scheduling is used to determine the priorities of each video packet (or) frame. The hybrid video encoder MPEG-4 is used for encoding and decoding. The importance level of video frame is based on frame types (I, P or B frames). The transmission errors are measured at finer scales for the Macro Blocks (MB) at packet-level. A simple packet scheduling by just assigning a higher and lower level priorities to the packets is tested for the video and the error scales are measured. The original input video is compared with the erroneous streamed video to determine the frame loss and packet loss. The frames which are not decoded are also considered as frame loss. With the outcome on high gain packet delivery, this scheduling scheme is better than other models.

Keywords: Video streaming, Priority Scheduling, Transmission distortion model.

1 Introduction

Video streaming is highly sensitive over mesh networks as the video packets are compressed and transmitted are erroneous with loss of packets (or) frames. A mesh network is a network that ensures that it has one of the two connection arrangements that is either, a full mesh topology or partial mesh topology.

R. Arokia Xavier Annie · Murugesan Anitha
DCSE, CEG, Anna University, Chennai – 600 025
e-mail: annie@annauniv.edu, anitha_kpm@yahoo.com

P. Yogesh
DIST, CEG, Anna University, Chennai – 600 025
e-mail: yogesh@annauniv.edu

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In a full mesh topology, each node is connected directly to each of the other nodes in the system, whereas in partial mesh topology the nodes are connected to only some of the nodes in the system. So, a mesh network utilises multisession video transmission that is more useful at the receiver side. The multisession video transmission can achieve better video quality without any delay in these network types.

In this paper, Packet Scheduling algorithm is used to schedule the packets by assigning 'higher and lower' priorities to the packets before transmission that engages in this multisession. The packets are scheduled even without setting any deadlines to packets or sometimes it may miss their deadlines which will result in loss of packets (or) frames. This erroneous video is considered as the transmission distortion model which compared with the original input video and evaluated. The evaluation is done by calculating the Peak Signal-to-Noise Ratio (PSNR) values for each frame.

Scheduling of packets involves choosing their sending order, or selecting the next packet to be sent. The basic criteria for deciding sending order is the deadline of Video Packets (VP). The sender sends the packet with Earliest Deadline First (EDF). In this case, the waiting time of packet in the receiver's buffer is minimized, and the minimum required buffer size at the receiver is obtained.

The remainder of this paper is structured as follows. In Section II, we summarize some of the important factors in the related literatures in multisession scheduling. Section III, we describe the system design under the action of two mesh network types. In Section IV we analyze the performance of the implemented scheme and analyse their results in Section V. Section VI concludes this paper.

2 Related Works

It is shown that the distortion-based utility gradients, is a simple but effective solution for downlink packet scheduling in wireless video streaming applications [1]. This provides optimal solution for the case, when the video packets are independently decodable and a simple error concealment scheme is used at the decoder.

Packet scheduling algorithms as proposed in [2], [9] for video streaming over channels by applying different deadline thresholds to the video packets with different importance. They have evaluated the performance in terms of PSNR, and observed improvements over the conventional earliest-deadline-first schemes in trace-driven simulations which are applied in our system.

X.Tong, Y.Andreopouls, and M.van der Schaar [3] has addressed the problem of robust video streaming in multi hop networks by relying on delay constrained and distortion-aware scheduling, path diversity, and retransmission of important video packets over multiple links. It is to maximize the received video quality at the destination node. And they have developed a linear model to estimate the transmission distortion of each MB. They have also observed that in wavelet based video encoders; the transmission distortion of video packets is approximately an exponential function of the packet index. Their theoretical derivations demonstrate that the path diversity is not beneficial when link failures are not expected in the multi hop infrastructure.

Vander Schaar et al [4] have shown that partitioning an embedded video stream into several priority classes can improve the overall received video quality. Based on this concept he has proposed a cross-layer approach using priority queuing [5]. The essential feature behind this approach is the priority queuing [10], based on which, the most important video packet is selected and transmitted, at each intermediate node, over the most reliable link, until the transmission success or the deadline expiration.

Ehsan Maani, Peshala V. Pahalawatta, Randall Berry, Thrasyvoulos N. Pappas, and Aggelos K. Katsaggelos [6] has introduced a content-aware multi-user resource allocation and packet scheduling scheme that can be used in wireless networks where imperfect channel state information is available at the scheduler.

Z.Miao and A.Ortega [7] has proposed a new delivery method, ERDBS(Expected run-time distortion based scheduling) for the framework to solve the packet scheduling problem. The proposed algorithm is designed for the sender driven transmission system can increase the receiver quality by selecting proper packets to be transmitted at any given time during the streaming session.

A.Dua and N.Bambos [8] has proposed a modelling framework is well suited to multimedia streaming applications with soft deadline constraints, where packets which miss their deadlines are not necessarily discarded.

3 System Design Overview

In this system we provide the major network design and the packet scheduling process for the transmission.

The system design is as shown in fig 1. The input video is compressed using video codec. The compressed video contains the video packets, frames, and macro blocks.

3.1 Buffer

The intermediate and destination nodes receive the video packets from ports and store them in the buffer. Buffer size is set initially (eg: 20). When the buffer level exceeds the buffer size, the packets with the least scheduling priorities in the buffer are dropped which is considered as error. The packet scheduler decides at each time slot which packet in the buffer to transmit or drop according to the scheduling assumed.

The cause for the transmission distortion is the packet loss due to buffer overflow and delay bound violation. Once a packet is lost, it will cause distortion in the decoded video frame.

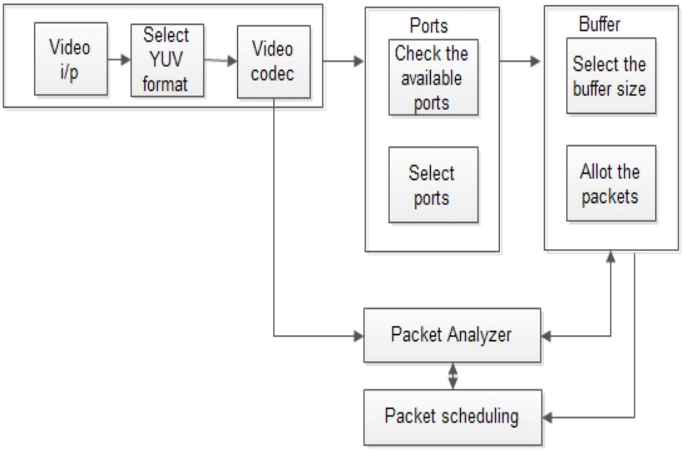

Fig. 1 Packet Priority Analysis Based Scheduling Method

3.2 Packet Scheduling Process

A frame is composed of several video packets (VP) separated by MPEG-4 codec. Considering the frame sequence {F0 F1 F2 …} to be displayed at frame rate of f frames per second. If the receiver starts to display the first frame F0 at time (t)= 0, then the n-th frame, Fn, is expected to be displayed at its deadline, i.e., at t = n/f. If a VP is not available at its expected display time at the receiver, it misses its deadline, and the receiver applies error concealment by copying corresponding macro blocks (MB) from the previous frame.

Scheduling of VPs involves determining their sending order, or selecting the next VP to be sent. One basic criterion for deciding sending order is the deadline of VPs. This means the sender sends the VP with Earliest Deadline First (EDF). In the case of EDF, the waiting time of VPs in the receiver's buffer is minimized, and as a result, minimum required buffer size at the receiver is achieved.

From the view of channel status, if the channel is in good condition without errors, then it is an advantage to use EDF criteria to send VPs in sequential order to obtain minimum average queue length in the receiver's buffer. But if the channel condition is poor with large error rates, then it is desirable to send more important VPs within GOPs first in order to achieve lower video distortion.

3.3 Packet Analyzer

The Fig-2 shows the analysis of the video packets. The erroneous video is compared with the original video in this analysis for evaluation.

3.3.1 Video Encoding

The input video is encoded using MPEG-4 codec. The video is of size 176x144. The codec basically divides this video into 400 frames. The encoded video will be stored, which is a compressed format of the video.

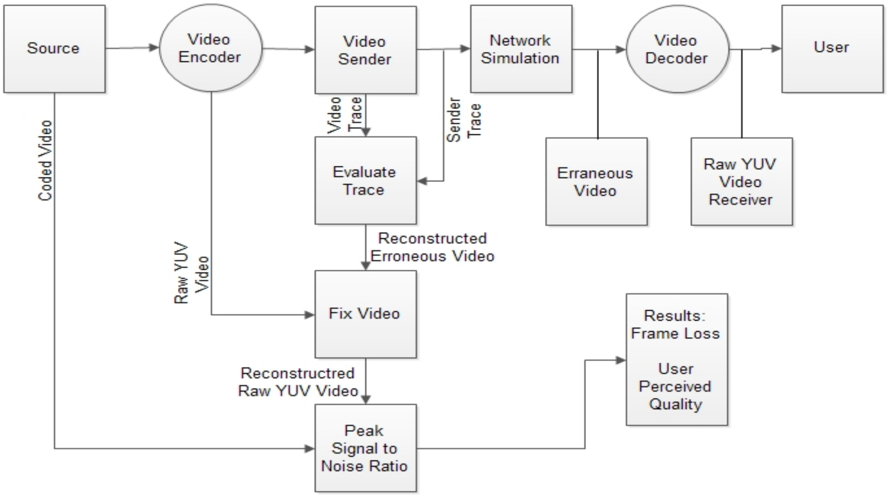

Fig. 2 Packet Analyzer

3.3.2 Video Sender

The video sender reads the compressed video file from the output of the video encoder. As shown in Fig 2, the video encoder fragments each large video into smaller segments via UDP packets over a simulated network. For each transmitted UDP packets, the framework records the timestamp, the packet-id and the packet payload-size in the sender-trace file. The video sender also generates video-trace file that contains information about every frame present in the original video file. The video-trace file and the sender-trace file will be later used for subsequent video quality evaluation.

3.3.3 System Simulation

The encoded video is simulated using NS2 simulator. Each frame will be fragmented into 1000 bytes for transmission. (Maximum packet length will be 1028 bytes, including IP header (20bytes) and UDP header (8bytes)).

3.3.4 Video Encoder

The compressed error video is decoded using MPEG-4 codec to find out the missing and the frames which are not decoded. The frames which are good and decoded correctly are also calculated.

4 Implementation

The network is designed in the Client-Server format. The Server nodes send the media streams to the client on request. The central node of the group acts as the classifier node. It has the property of ordering the packets to be sent to the client nodes and further more scheduling the packets. The group at the server side is formed by four nodes.

At the client side there is a group of four nodes, in which the central node is directly connected to the classifier node at the server side. The other three nodes are connected to the central node.

4.1 Packet Ordering and Queue Monitoring

The packets are ordered based on the flow-id (on which flow they are being transmitted), the size of the packet, the size of the queue using which they are to be transmitted. The packet-id is calculated using the flow-id in which they are present. Based on the arrival time of the packet and the id value, the packets are ordered in the queue. The total number of packets arriving in each flow is also counted and stored as separate text files in order to monitor the amount of traffic in each flow.

The queue is monitored throughout the network transmission process. Monitoring is done based on the following factors: (1) The queue which is currently transmitting the media packets, (2) the size of the queue, (3) the number of packets currently present in the queue and (4) the number of packets lost or dropped from the queue. This process of monitoring also helps in detecting the traffic and predicting the total amount of frame loss to occur.

4.2 Frame Classification

In order to classify each frame of the video file we use the trace files generated when the program starts execution. The trace files contain the following details: the frame number, the frame type, and the length of the frame. Based on the frame type the frames are classified as Type 1, Type 2, and Type 3. The “I” frames fall under the Type 1 category, “P” frames fall under Type 2, whereas “B” frames fall under Type 3. As each frame is classified the count of the frames is retrieved and stored. This procedure of classification is repeated for each and every trace file created for the video.

5 Result Analysis

ENCODING

- Total frames: 400 Frames.
- Total time taken for encoding: 55800 sec.
- Average time taken: 139.7 sec.

VIDEO SENDER

The following segment shows the packets sent and lost and the relevant frames lost. This is in consideration in the I-P-B Frames that were categorised in sent and lost section.

- Packet sent: p->nA: 549, p->nI: 173, p->nP: 109,p->nB: 266
- Packet lost: p->nA: 69, p->nI: 48, p->nP: 14,p->nB: 7
- Frame sent: f->nA: 401, f->nI: 45, f->nP: 89,f->nB: 266
- Frame lost: f->nA:43, f->nI: 23, f->nP: 13,f->nB: 266

Table 1 PSNR Calculation

Table .	PSNR VALUE
1	34.58
2	34.25
3	34.16
4	33.67
5	33.75
6	33.73
7	33.72
8	34.21
9	34.03
10	34.32
11	33.99
12	33.79
13	33.43
14	33.55
15	33.47
16	33.26
17	33.02
18	34.11
19	34.21
20	33.68
21	33.59
22	33.18
23	33.25
24	33.30
25	33.11

FRAME EVALUATION

- Good frames: 355
- Not decoded: 41
- Missing: 4

The table 3 contains the PSNR for sample of 25 frames. The system actually calculates the PSNR value for all the 400 frames. The mean and the standard deviation for those 400 frames are also calculated.

Mean of 400 frames: 24.36
Standard deviation of 400 frames: 8.92

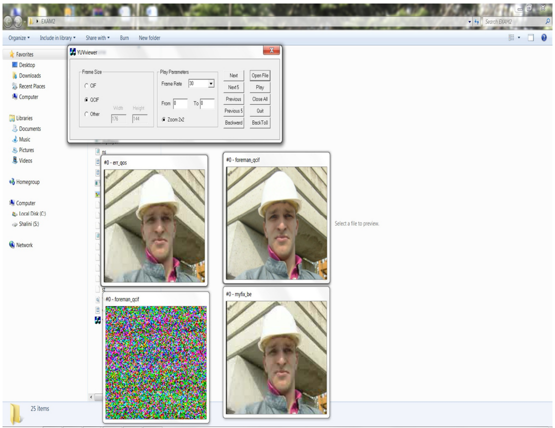

Fig. 3 Snapshot on the Frames Compared

This distortion captured is as shown in Fig. 4. The snapshot shows, the decoded video frame with normal and priority based scheduling. This graph shown in Fig 5 depicts the ratio of the number of frames to the PSNR value.

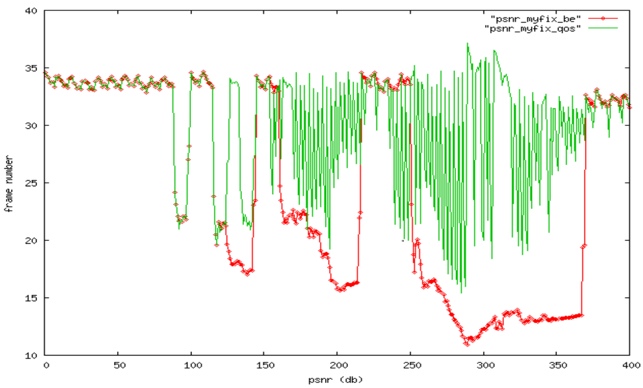

Fig. 4 Evaluated Video Frames Vs PSNR

6 Conclusion and Future Work

A fine-granularity transmission distortion model for the encoder to predict the quality degradation of the decoded videos caused by lost video packets has been developed. The frame loss and the packet loss are calculated by comparing the erroneous video and the original video. Packet loss and frame loss are being observed for all the frames (I, P and B). Packet scheduling algorithm used here, that schedules packets can be modified to use the performance evaluation of the system as a future work.

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