REVAMPING QUALITY OF SERVICE OF VIDEO STREAMING OVER WIRELESS LAN

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Abstract

Just like video streaming over a wired network, streaming can also be done over a wireless LAN. However, real-time streaming over wireless networks is a challenging proposition due to the highly variable nature of wireless links and the resource-poor nature of mobile devices. In such a context, transmission control schemes have to dynamically adapt both to the application requirements and the channel conditions. In this *paper, we put forward a short review of some recent innovations, which have been devised to thoroughly revamp the Quality of Service (QoS) of video streaming over WLANs. Depending on their applications, the solutions have focused mainly on the following three network layers: Media Access Control layer (MAC), Application layer (APP) and Physical layer (PHY). In this paper, we propose an adaptive cross-layer quality-of-service (QoS) scheme for wireless channel and streaming applications. For the sake of adaptive QoS, the cross-layer architecture assumes that layer information could be exchanged between application layer and lower layers. In addition, priority-based adaptive QoS scheduling for MPEG video streams is proposed here. It considers the frame type of the MPEG-4 video file so as to efficiently provide non-similar priorities to important packets of video. IEEE 802.11e protocol assigns top priority to video applications. It does this in order to reduce delay and packets losses, which could happen due to other competing traffic. Simulation results performed with the network simulator ns-2 will show that the cross-layer architecture allows a good performance under both, light and heavy loads, while minimizing the mean packet delay and frame jitter. We aim to minimize the dropping of frames and frame jitter while gracefully degrading video quality to enable the same.*

Keywords: *IEEE 802.11, Quality of Service (QoS), video streaming, WLAN, multimedia, cross-layer solutions.*

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1. INTRODUCTION

The nature and complexity of the software systems had changed significantly in the last 30 years. The previous applications run on single processor and produce fixed output .But with the advancement in the technology application are having the complex user interface and these applications run on the various systems simultaneous like applications which support client server architecture.

The multimedia content that is delivered by a provider to an end-user constantly is called as 'Streaming media'. Unlike the traditional 'wait till it is downloaded' constraint of viewing videos, client media players here have the provision to play the data (such as a television episode) simultaneously as the file is being downloaded (or 'buffered') at the client end. Also, the user can quit the download process at any moment and at that moment; the data used up will be automatically cleared.

Since IEEE802.11 WLANs usually possess a high transmission capacity and unrestricted connections, they usually provide an ideal platform for pervasive sharing of video content and communications. However, it remains a challenging task to attain a high performance for video streaming over IEEE 802.11 WLANs [1]. Main reasons for this are the inherent characteristics of dynamic channels and compressed video. In this paper, few recent innovations are described, which have been devised mainly to boost the Quality of Service (QoS) of video streaming over Wireless LANs.

The characteristics about wireless channel are it being dynamic as well as error-prone. Video streaming is not easy since the transmission of video data packets over wireless channel is quite difficult. The reason for it is that compressed video content is not only error sensitive but also time critical. The various algorithms used for video compression try to achieve bandwidth reduction. But they usually tend to create complex dependencies among video frames and blocks. During wireless streaming, errors or losses in video data packet cause problems to both, current and following video frames. Also, in case of a delay, video data packet streaming needs to be kept lower than the limit of latency threshold. The value for it is often determined according to the time for frame decoding at the receiver end, requesting for an on-time streaming and reception of packets from the immediately following frame when video is still on. It is essential for video streaming, because the video packets, which happen to exceed the delay threshold will be rendered useless, in spite of being efficiently transmitted to receiver ends, but after the deadline has passed. The above conflicting requirements in video streaming over WLANs, error reduction and delay constraints, have paved the way for inspiration required to develop an entirely new class of wireless streaming technologies, which could be able to attempt guarantying efficient as well as on-time transmission of video packets over WLANs.

Recent advances in video streaming over WLAN have been results of the enhancement of IEEE802.11 standards. The first standard for Wireless LAN was published in the year of 1997 with its data rate approximately in the range of 2 Mbps whereas a later standard, that is, IEEE802.11n amendment, was published in year 2009, which could attain a high speed of up to 600 Mbps, thanks to the new technology that it used for transmission at the physical layer. Upcoming amendments to previous standards are IEEE 802.11ac and 802.11ad. They are currently under development with an aim to manage to provide better throughputs in the 5 GHz and 60 GHz frequency bands. The primary aim of IEEE802.11ad at present is to achieve a theoretical peak throughput, as high as7 Gbps that can and will be utilized for streaming high-definition videos in wireless environments. The ever increasing values of throughput at the Physical layer (PHY) guarantee a bandwidth that would be high enough to support such high capacity transmission of video streams. Correspondingly, careful design innovative techniques will be required for MAC layer error recovery and channel access mechanisms to attain seamless video streaming over WLANs. Amendment standards, namely, IEEE802.11e and IEEE802.11aa have been devoted to boost the efficacy of transmission of video data at the Media Access Control (MAC) layer. IEEE802.11e explicitly specifies a collection of parameters for high priority channel access in video streaming, so as to minimize the overall delay in transmission. On the other hand, IEEE802.11aa specifies a set of new mechanisms for error recovery for video multicasting or broadcasting over Wireless LANs. Apart from those mechanisms specified in the standard for MAC and PHY layer, there exist some non-standard mechanisms that have been designed to upgrade the performance of video streaming over WLANs. For example, we have schemes for cross layer optimization, admission control, and so on. Among these strategies, the cross layer scheme is relatively more attractive than others, in the view of resolving most of known inherent problems of video streaming over wireless LANs. Lately, many researchers have been experimenting with a big range of cross-layer solutions and most of them have been able to make good progress in it.

2. LITERATURE REVIEW

2.1 Cross-Layer Solutions

Dearth of interaction made between the network layers result in the limitations to single-layer approaches. In spite of being well-defined, the network layers show relations since some of them are dependent other layers to achieve the highest potential. Cross-layer architecture is becoming the trend of networking since the past decade. Several cross-layer architectures have been proposed, which led to an eccentric design for network architecture. In this paper, we shall focus on some available cross-layer solutions [1]. Most of them rely upon off-the-shelf methods used in Wireless LANs. Though it is difficult to say as to how is it possible to adeptly utilize them in order to enhance the overall QoS of video streaming over WLANs. Various considerations have been tried out, so as to boost the QoS performance in video streaming over WLANs. For the scenario of real-time video streaming, the video transmission performance is mostly affected by three layers mentioned below. Researchers focusing on video streaming over WLANs, usually tend to neglect the impact of wired networks as the bottleneck in such hybrid networks lies in its corresponding wireless counterpart. Therefore, the cross layer solutions in this paper shall be limited in its focus to the following three intimately coupled layers: PHY layer, MAC layer and APP layer. The main aim of such cross-layer methods is to accurately design suitable interaction algorithms between these layers based on their characteristics and mutual dependence in order to optimize the resultant QoS performance of the video streaming. For APP layer, it is essential to understand how a video data format that the video coding algorithm generates, can be used by different network layers. For MAC layer, the way to utilize the characteristics of video coding algorithms will contribute to decipher the suitable access mechanism that shall be accepted. A few common transmission parameters in the MAC layer can also be accepted in cross-layer, including the MAC-FEC, the retry limit and the contention window size. At PHY layer, MIMO technology and rate adaptation technique are frequently deployed. According to the three network layers associated with the cross-layer design, cross-layer solutions can be categorized in the following four ways: the APP-PHY, the APP-MAC, the MAC-PHY and the PHY-MAC-APP.

2.1.1 APP-PHY

Essential characteristics of the PHY layer are MIMO and AMC technology. With apt designing, the MIMO technology can also be referred to as an extended adaptive modulation and coding technique. Thus, this category of solutions usually focuses at mapping the APP-layer video data characteristics with the PHY layer transmission rate adaptation (AMC). This methodology of matching the physical layer rate adaptation to the application layer video rate variation has been deployed by various schemes. One scheme allocates different PHY rate modes to different layers of SVC streams. Another utilizes the rate of video streaming waveform from the APP layer in order to guide the adaptation of the selection of wireless PHY layer rate. Also, it has been displayed that the error resilient video coding implemented in application layer can also be amalgamated with PHY layer rate adaptation to achieve improved performance in video streaming over WLANs. More specifically, the strategies of JSCC and error concealment together have been coupled with rate adaptation in PHY layer for a solution that would be end-to-end optimal. For the application of MIMO technology, a prolific cross-layer solution has been developed to match various layers of H.264/SVC encoded video bit streams with dissimilar virtual MIMO channels with the configuration settings of the spatial multiplexing MIMO. An efficacious and simple solution has been implemented by adaptive selection of channel, according to the partial channel information.

2.1.2 APP-MAC

The APP-MAC design can be explained by exploiting the interactions between the MAC layer characteristics and features of the video streams. In the case of contention-based channel, these focus on how to map the queuing priority of video frames into 802.11e EDCA priority queues. They follow the H.264 data partitioning technology in order to generate disparate video data packets priorities and relate them to the proper priority queues of the Enhanced Distributed Channel Access (EDCA). What is special about the novel QoE-aware multicast scheme is that the enhancement layer of the SVC streams of video data and the base layer will be inserted into the following access categories of Enhanced Distributed Channel Access: alternate and primary queues, respectively, as defined in 802.11aa: one of the lately developed WLAN standards. In the case of channel access mechanisms that are contention free, the cross-layer solutions deal with how we can utilize limited bandwidth to schedule as many units as possible. An adaptive algorithm has been put forward, which makes decisions about retransmission of video data as per their priorities.

2.1.3 MAC-PHY

This category of cross-layer solutions doesn't consider the video data characteristics during the design process. Just like some single-layer solutions that would work in either one of PHY or MAC layers, the aim is to achieve network maximized throughput. Among them, a combined adaptation of contention window size at MAC layer and MIMO configuration at PHY layer has been devised. A technique is applied at the physical layer assisted link differentiation-distributed queuing MAC layer protocol. Another is imposed by the link differentiation-multiple polling protocol physical layer at the MAC layer but assisted by the PHY layer. [1] They provide an enhanced throughput for video data traffic in WLAN, including the video traffic that desires high throughput due to high volume of video data.

2.1.4 PHY-MAC-APP

In theory, two or more network layers can be combined to further bolster the performance of video streaming over WLAN. A unique combination of MAC, APP and PHY layers is highly desirable and has been attempted in recent years. However, attempts to coagulate three or more network layers usually lead to sophisticated interactions between them. The key to success of such solutions is how to efficiently minimize the risk that is involved in it, based on terms of exponential increase in instantaneous values of state parameters relevant to such interactions. Once, a neural network based approach was proposed. It monitored the MAC layer back-off parameters online according to APP layer QoS requirements and PHY layer channel conditions.

2.2 Cross-Layer Scheme For Manets

This scheme proposes a cross-layer mechanism for video streaming over Mobile Ad-Hoc Networks (MANETs). It distinguishes two main areas in which traffic is prioritized depending on how important the streamed video packets are:

- At network layer, a scheduling policy is applied in which each incoming packet from the upper layers is given a specific priority depending on the type of video frame it is.
- At MAC layer, the access of the various applications is differentiated, based on QoS criteria.

The design (Fig. 2.1) is based on the attributes of voice and video streaming applications. Such applications are characterized by different tolerance in terms of end-to-end delay. A real time service, like video transmission, requires there to be much less delay than a file transfer application in order to ensure that it works smoothly and in a proper way. Specifying priority for traffic depending on traffic classes is a way to maximize the performance of a network.

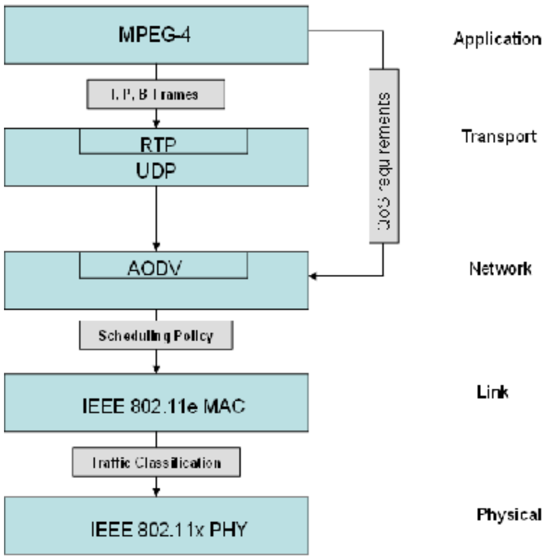

Fig 2.1 Cross-layer design

This means that a packet with higher priority and a packet with lower priority must be treated differently so that the packet with higher priority is delivered first. In highly loaded MANETs that usually consist of a large number of nodes, or in cases that the bandwidth is limited, it is possible that the transmitted packets are dropped from the queues in the mobile nodes.

Priority queues can be implemented using a popular method called Priority Scheduling. A queue is assigned to each traffic class. The packets are ordered in this queue. The way in which packets are served and removed from the queue is dependent on the ordering and directly affects it [2]. In a queue containing video packets, the information about frame type and the priority assigned to a packet are utilized to carry out the ordering.

In the transmission of video files encoded by an MPEG-4 video encoder three types of video frames are generated: I-frames, P-frames and B-frames [2]. I-frames are compressed to a very low extent and contain information generated by encoding a still image. P-frames are more compressed than I-frames. The encoding of P-frames is done from the previous I-frames or P-frames. B-frames utilize information from previous and forward frames. In the video sequence B-frames are considered to be the least important frames.

The above idea is expressed and described in the algorithm that follows. A first-in first-out (FIFO) queue is not used at the MAC layer. Instead the importance of the frame is taken into account to insert the packets into the queue. The top positions in the queue are occupied by the most important frames. The packets of other types with lower priority take their place in the tail. The rule used to process the packets is that the packet in the head of the queue has to be served first as it has higher priority. If the queue exceeds its size limit and a packet needs to be dropped, then it drops a packet in the tail every time.

Algorithm: Enque Function –

```
enque(packet) {
if( packet.isVideo() )
{
while( nextPacket.isVideo()
AND  nextPacket.priority < packet.priority)
{
position++ }
insertToQueue(packete, position);
}
else
{ insertToQueue(packete, tail) }
if( queue.size() > limit ) {
dropTail();
}}
```

The IP datagrams are also marked based on the type of application. In mesh networks this task is simpler than in a wired network with fixed infrastructure which may have different administrative domains in a path between the sender and receiver(s) of a video. In ad hoc networks every node acts as a router too, thus providing this flexibility. QoS support in the IEEE 802.11e protocol is provided by the Enhanced Distributed Coordination Function (EDCF). This function manages the wireless medium in the Contention Period (CP) and helps the Distributed Coordination Function (DCF) function of the legacy IEEE 802.11 protocol give a better performance. Therefore, four different Traffic Classes (TCs) are implemented and video traffic must be assigned the highest priority amongst all the applications operating in the wireless network.

2.3 History-Aware Robust Rate Adaptation

Even widely accepted rate adaptation algorithms like RRAA, fail to utilize the knowledge of the performance of a channel in a short-term time period. There are time intervals during transmission where the performance of a transmission rate can be highly dynamic. It can be followed by time intervals, which may go up to a time of longer than 10 seconds [3], where a rate's performance is stable as compared to the previous time interval. This peculiar behavior may be due to the dynamics of a channel, which can change according to the environment in which it exists.
A good rate adaptation algorithm would be one which responds well to rapid channel changes and which also limits transmissions at rates which have a high loss percentage.

As most rate adaptation algorithms do not keep any record of rates other than the current one, they keep transmitting at high loss rates [3]. They can also lead to selection of rates lower than the optimal as a result of some actions they take while adapting the rate.

History-Aware RRAA is an improved version of RRAA whose goal is to limit transmissions at rates with high loss, while also being able to adapt to intense channel dynamics.

2.3.1 Designing History-Aware RRAA

The first component proposed by HA-RRAA is an Adaptive Time Window mechanism, the goal of which is to limit trying to transmit at low goodput rates, while also adapting to rapid channel changes. Then, History-Aware RRAA, an improved version of RRAA is designed which utilizes the proposed adaptive time window mechanism. HA-RRAA utilizes fast adaptation to improve RRAA. HA-RRAA also uses fast adaptation to handle mobility and hidden terminals [3]. Another component of HA-RRAA is cost-effective adaptive RTS/CTS modules. This is useful in scenarios where there is mobility and it gradually reduces RTS/CTS overhead.

2.3.2 Adaptive Time Window

Adaptive time window (twnd) mechanism is based on the 802.11 binary exponential backoff algorithm. The time window maintains a timer. The window works according to the following cases: 1) exponentially increase a timer upon failure to transmit, 2) reset the timer when transmission succeeds, 3) bound the timer in the values [0, Tmax]. The scheme transmits at rates that offer lower goodput less frequently over time when there is an exponential increase of the time window upon repeated transmission failures. It thus prohibits transmission at these rates. This mechanism remains adaptive to fast channel dynamics as it bounds and resets the time window appropriately. Initially, the adaptive time window is set to a value:

$$TR = TC * 2^{exp};$$

exp – an exponent factor which represents the number of times that moving from a rate R to the next higher rate has failed, TC - the minimum estimation window (ewnd).

History-Aware RRAA makes use of the adaptive time window to limit transmitting at high loss rates adjacent to the current rate R. The adaptive time window mechanism also captures the magnitude of losses, by linearly increasing time window with loss. The revised adaptive time window can be expressed as:

$$TR = TC * 2^{exp} * \max(1, P/P0);$$

P - Short-term loss ratio of the rate R, P0 - loss normalization factor.

HA-RRAA also maintains a time window for the next higher rate RT adjacent to the current rate R. Every time that transmission at RT fails, HA-RRAA will move downward to rate R. It will also update time window based on the above expression, while the exponential 'exp' will be increased by one. The time window for a rate RT will be reset in two cases: 1) when transmissions at the rate RT are successful, meaning that HA-RRAA does not need to move to the lower rate R, 2) when channel deteriorates to such an extent that HA-RRAA moves transmission from R to the next lower rate.

The algorithm for the scheme is as follows:

```
ALGORITHM:
1: while (!false) do
2: rcv_tx_status(lastframe);
3: A - RTS();
4: if RTSPass then
5: HA_RRAA();
6: if RTSWnd> 3 then
7: fix_re_tx_rate();
8: end if
9: end if
10: end while
```

Algorithm for HA_RRAA():

```
HA_RRAA: Input (ACK Frame), Output (R)
1: R = highest_rate;
2: timer = ewnd(R); fastimer = min{10,ewnd(R)};
3: while (!false) do
4: rcv_tx_status(lastframe);
5: Q = update_loss_ratio();
6: if (timer == 0 || (fastimer<= 0 && Q >= QThresh)) then
7: if Q > QMTL || Q >= QThresh then
8: if R != RT then
9: reset (exp, TR);
10: end if
11: TR = update_twnd(Q,exp);
12: RT = R; exp++;
13: R = next_lower_rate(R);
14: else
15: if R == R_{T} then
16: reset (exp, TR);
17: end if
18: if Q < QORI and TR == 0 then
19: R = next_high_rate(R);
20: end if
21: end if
22: timer = ewnd(R); fastimer = min{ewnd(R),10};
23: end if
24: send (next_frame, R);
25: timer- -; fastimer- -; TR - - ;
26: end while
```

2.3.3 Handling Mobility and Hidden Terminals

Fast adaptation: HA-RRAA uses fast adaptation mechanism to boost RRAA's responsiveness to fast channel deterioration. A small window of frames is maintained (min {ewnd, 10} frames) and the loss ratio inside this window is computed. If the loss ratio P is greater than or equal to a threshold value PThresh, then HA-RRAA will move transmission rate downward to the next lower rate.

2.3.4 Cost-Effective Adaptive RTS Filter

HA-RRAA has an adaptive RTS mechanism to address hidden terminals at a low cost. A-RTS tries to reduce signaling overhead by selectively turning on RTS. But there can still be significant overhead in the cases where the actual time required to transmit a frame is less than the RTS/CTS transmission overhead. HA-RRAA implements a cost-effective adaptive RTS scheme. It is based on the general idea of A-RTS, but does not blindly turn on RTS, to further avoid overheads. HA-RRAA turns on RTS only when the overhead is significantly smaller as compared to the other components to be transmitted. First, HA-RRAA estimates the RTS/CTS overhead (TRCTS); the channel time required to transmit RTS/CTS messages. Then it computes the time required to transmit the frame as:

$$Tframe = FRAME/R + Toverhead \text{ where}$$

FRAME - MAC-layer frame size,
R - transmission rate,
Toverhead - various IEEE802.11 protocol overheads like SIFS, DIFS, ACK etc.

After these calculations, HA-RRAA will turn RTS on if and only if the following condition is true:

$$Tframe >= k * TRCTS; \text{ k stands for benefit/cost ratio.}$$

This condition is made necessary considering that with RTS/CTS off, the frame may need at least one retry to get through in case a collision occurs.

2.3.5 Combining Everything

Fig. 2.2 shows the complete architecture of HA-RRAA.
It waits for a MAC-layer feedback. Upon its reception the following steps are carried out: 1) loss ratio is estimated for selecting the next transmission rate, 2) the adaptive time window is set, 3) fast adaptation is applied to handle drastic channel changes in scenarios having mobility, 4) cost-effective adaptive RTS filter is updated.

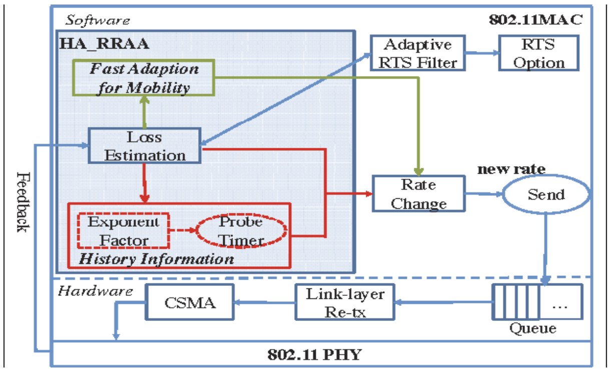

Fig 2.2 HA-RRAA Architecture

3. PROPOSED APPROACH

The approach proposed in this paper is based on the following six important steps:

3.1 Setting up a Video Stream

The first step is to set up a video stream over a wireless LAN. A stream server is set up which has the video to be streamed over the network. The stream server starts streaming the video. The receiver's (stream viewers) connect to the server to receive the stream. Then packets of the video being streamed are transmitted over the network using a protocol like UDP or RTP. For the purpose of this project, these steps will be done using a network simulator

3.2 Allocating Bandwidth

The total available bandwidth of the channel is divided between real time and non-real time traffic [6]. Real time traffic is allocated more bandwidth than non-real time traffic in order to support better video quality. According to the bandwidth allocation scheme [6], real time traffic will be allocated 80% of the bandwidth while non-real time traffic will be allocated the remaining 20% of the bandwidth.

3.3 Analyzing the Stream and Channel Conditions

The stream is initially started at a video quality and a rate that is found suitable. However, the selected parameters may not be optimal. Hence, the channel is tested and the stream is analyzed so that better QoS may be provided.

3.4 Calculating Losses

In this step the amount of packet loss, the number of frames dropped, delay etc. will be calculated at a receiver. Based on these values certain actions will be taken if necessary. All these values are sent to the stream server, i.e. the sender.

3.5 Optimizing the Video Stream

If the values calculated in the previous step exceed a certain threshold then the sender deduces that the current parameters are not optimal and hence must be changed in order to provide better QoS. The sender thus reduces its sending rate by a specific amount. But it does so at the cost of reduction in video quality. It uses a cross-layer mechanism for doing so. The physical, MAC and application layers are involved in this. At the application layer the video player need to use an adaptive codec for this purpose.

3.6 Maintaining an Optimal Stream

After bringing the video stream to an optimal level of QoS it is also important to ensure that it keeps providing a similar level of QoS. For this, the sender need to constantly analyze the various parameters like number of frames dropped, amount of packet loss, delay etc. and then adjust the stream accordingly. This way QoS will be enhanced and ensured for the video stream over the WLAN.

4. PROTOTYPE IMPLEMENTATION

For the prototype a stream was set up over a wired LAN between two computers. An MP4 video file was streamed using VLC Media Player. The H.264 codec was used for it. We used three protocols for streaming the same video file, namely, User Datagram Protocol (UDP) and Real Time Transfer Protocol (RTP).

In order to observe the variations in the video stream various specified bitrates were used for all three protocols. The bitrates that were used were 32 kbps, 64 kbps, 128kbps, 256 kbps and 512 kbps.

Each individual stream was tracked using the Wireshark tool. Input and Output (IO) graphs were also plotted for them.

Based on our tests we can draw the following conclusions:

- Video quality at lower bitrates is bad as the number of bits that will be sent is low.
- A lower bitrate, however, does not suffer from any buffering between frames or frame delay.
- As the bitrate is increased it is observed that the video quality also gets better.
- Higher bitrates above a certain value, though, introduce problems like frame delay and occasional buffering between frames.

The images in the pages that follow depict our observations.

4.1 UDP

4.1.1 32 kbps

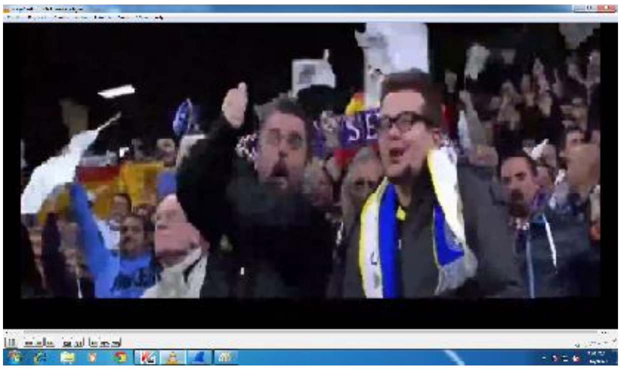

Fig 4.1.1 UDP 32 kbps video still

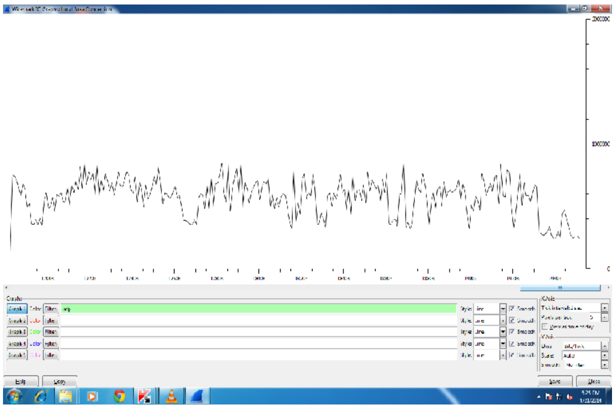

Fig 4.1.2 UDP 32 kbps receiver IO graph

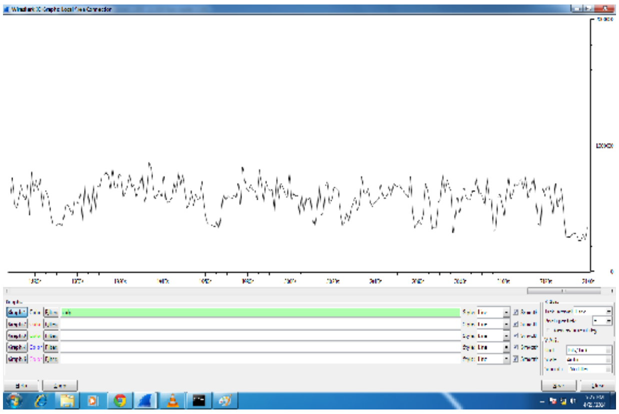

Fig 4.1.3 UDP 32 kbps sender IO graph

4.1.2 512 kbps

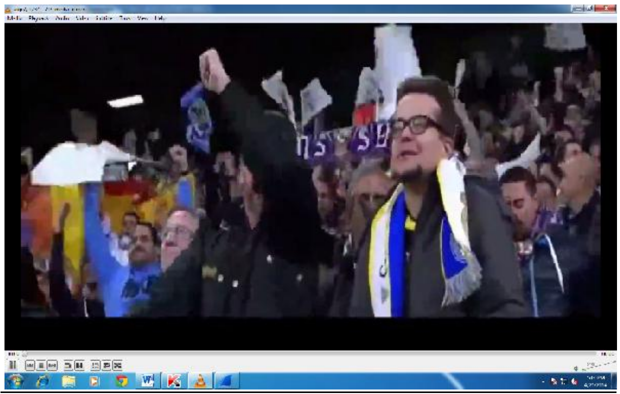

Fig 4.1.4 UDP 512 kbps video still

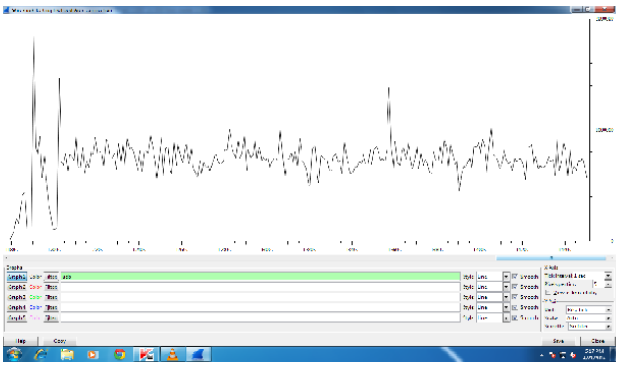

Fig 4.1.5 UDP 512 kbps receiver IO graph

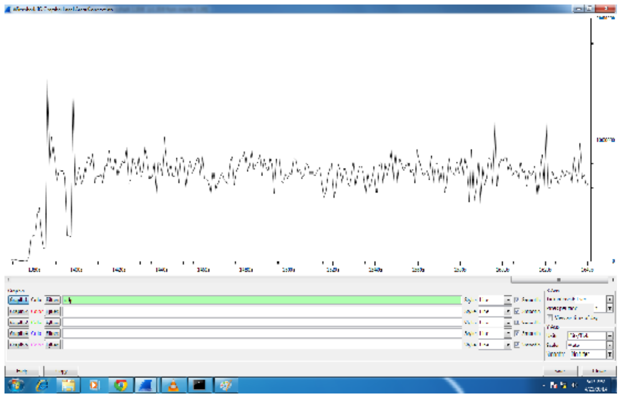

Fig 4.1.15 UDP 512 kbps sender IO graph

4.2 RTP

4.2.1 32 kbps

Fig 4.2.1 RTP 32 kbps video still

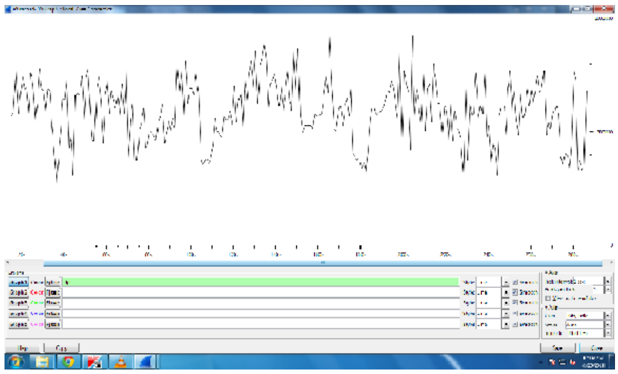

Fig 4.2.2 RTP 32 kbps receiver IO graph

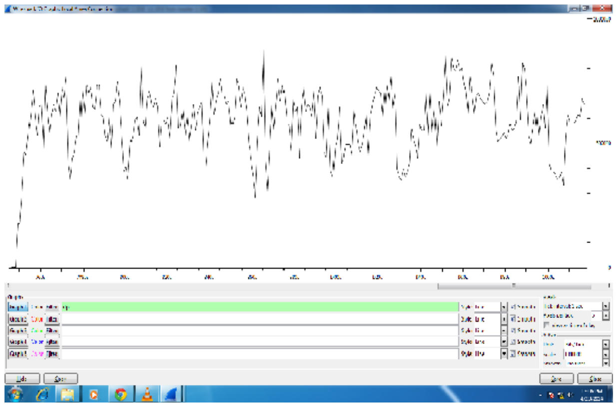

Fig 4.2.3 RTP 32 kbps sender IO graph

4.2.2 512 kbps

Fig 4.2.4 RTP 512 kbps video still

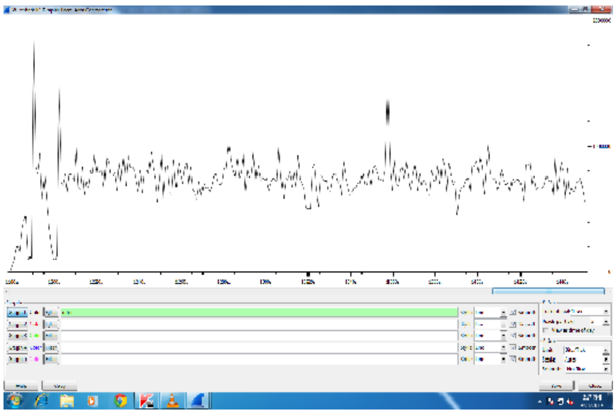

Fig 4.2.5 RTP 512 kbps receiver IO graph

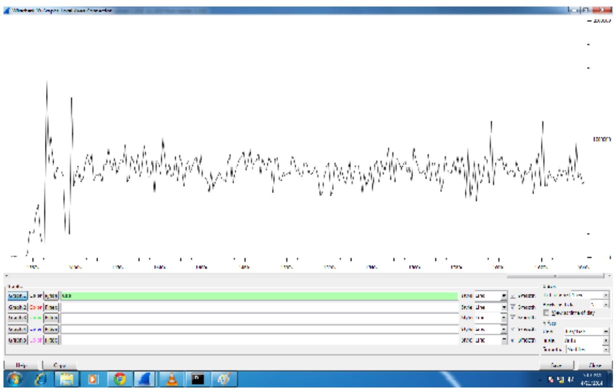

Fig 4.2.6 RTP 512 kbps sender IO graph

5. CONCLUSIONS AND FUTURE WORK

To conclude, the current scenario makes it difficult to simultaneously achieve a fast data transfer speed as well as a good image quality in video streaming. Thus, efforts have to be made so as to enable attaining high-performance in video streaming over IEEE802.11 Wireless LANs.

In our future work, our proposed scheme will enhance the Quality of Service performance for video streaming over WLANs. This will enable wireless LANs to support a better level of video streaming. This will be helpful in further developing the IEEE standards.

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