A cross layer Design to Enhance Throughput for Multimedia Streaming over Mobile Ad hoc Networks

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Abstract

The main objective of this paper is to propose a novel method for enhancing the Quality of Service (QoS) of multimedia applications in wireless adhoc networks. The enhancement is achieved by implementing the Connectionless Light Weight Protocol (UDPLite) in transport layer that supports multimedia applications. In addition to implementing the transport layer protocol, parameters of MAC layer have also been considered to propose an approach that achieves a reduction in delay, jitter and increase in Peak Signal to Noise Ratio (PSNR). This Proposed method achieves 9% improvement in reduction of delay and 5% improvement in PSNR as compared to the conventional UDP Protocol.

Index Terms- Connectionless Light Weight Protocol, Enhanced Distributed Channel Access, MANETs, PSNR, QoS, RTP, UDP, UDPLite, Video Streaming.

1. Introduction

Recent advancements in computing techniques have become an integral part of wireless communication networks. Mobile Ad hoc Networks (MANETs) have emerged amid the unprecedented growth of Internet and are increasingly attracting attention because of its ability to connect across nodes without relying on pre-existing network infrastructure. New horizons for wireless connectivity along with inevitable wireless data transmission over IP, patches ad hoc networks with the Internet. The widespread emergence of real-time voice, audio and video applications, stimulates the successful development of viable technologies to provide these multimedia applications over mobile ad hoc networks. The performance of MANET is affected by various factors such as mobility of node, battery life and routing protocols, topology change etc... Hence protecting the multimedia applications from these changes is essential.

The notion of application-layer over transport-layer protection is not new and hence traditional real-time multimedia services have been realized on RTP over UDP. UDP is an unreliable protocol that is suitable for delay sensitive applications such as real-time media applications which are sensitive to network delays and do not benefit from retransmission in case of packet loss / error. UDPLite [1] is an extension to UDP that allows partial checksums on multimedia data by enabling the applications to specify, the sensitive and insensitive parts of the multimedia stream on a per-packet basis. Errors in the sensitive part cause a packet to be discarded whereas an error in the insensitive part allows it to be delivered. The check sum is carried out on the number of bytes of the packet that are sensitive. UDP has a strict checksum where corrupted packets will be discarded if they contain any transmission errors. Real time streaming may use audio and video codecs that are error resilient, which gives flexibility to receive data with bit errors within the packet payload.

Many wireless mobile adhoc networks adopt the widespread IEEE 802.11 Wireless LAN standard as the link layer communication protocol. Several studies focused on performance enhancement of multimedia communications over 802.11 wireless LANS [2,3,4]. For instance, layered coding coupled with Unequal Error Protection (UEP) obtained by using different retry limits at the link level has recently been shown to deliver interesting results. As both the Medium Access Control (MAC) layer and the Physical (PHY) layer of 802.11 [5] are designed for best effort data transmissions, the original 802.11 standard does not take QoS into account. Hence to provide QoS support IEEE 802.11 standard group has specified a new IEEE 802.11e standard. IEEE 802.11e that supports QoS by providing differentiated classes of service in the Medium Access Control (MAC) layer, it also enhances the physical layer so that it can deliver time sensitive multimedia traffic, in addition to traditional data packets.

The IEEE 802.11e standard introduces the Hybrid Coordination Function (HCF) as the medium access control scheme. While backward compatible with DCF and PCF, HCF provides stations with prioritized and parameterized QoS access to the wireless medium. HCF combines aspects of both the contention-based and the contention free access methods, where the contention-based channel access mechanism in HCF is known as the Enhanced Distributed Channel Access (EDCA) and its contention free counterpart is known as the HCF Controlled Channel Access (HCCA).The EDCA is an extension of conventional distributed coordination function. It provides prioritized QoS services which classifies all the traffics destined medium access control (MAC) layer to multiple access categories (ACs) and it differentiate the chance to get a transmission opportunity (TXOP) using unequal channel access parameters.

In this paper we argue that for 802.11e based ad hoc networks, a partial checksum approach at the transport layer along with enhanced distributed channel access (EDCA) can improve the performance of video transmission. In this paper an attempt has been made to get the benefits of Udplite along with EDCA. The rest of the paper is organized as follows .In section 2 we discuss the aspects of EDCA and Udplite. In Section 3 we discuss about the related work. In section 4 we discuss about proposed system. Section 5 establishes system simulation model and gives results to illustrate the performance while conclusion are drawn in section 6.

2. CLWP and EDCA

UDP is a connectionless unreliable best effort transport layer protocol. The UDPLite protocol allows the application to receive the corrupted packets instead of dropping them altogether. This is achieved by a partial checksum which only covers a fixed amount of sensitive data. Integrating UDPLite into existing UDP framework is simple. The length field in the UDP header is replaced by the coverage field, which signifies how many bytes of the packet are checksummed. With a checksum coverage value replacing the packet length, UDPLite packets are treated as classic UDP packets with the checksum enabled. To address security concerns and handle the multiplexing of other transport level flows, the packet header should always be checksummed. If corruption occurs in the Sensitive region or in the header, the packet is dropped at the receiver otherwise the packet is passed up to the application through a interface.

In EDCA, packets arriving from higher layers are tagged with four different user priorities and each priority is mapped to one of four Access Categories (ACs). The four different Access Categories (ACs) are Voice traffic, Video traffic, Best Effort traffic and Back Ground traffic that are represented as AC0, AC1, AC2 and AC3 respectively. Each AC maintains a local queue and an independent back off instance parameterized with a specific set of contention parameters. All ACs independently contend for access to the channel and internal collisions may occur, but are solved by allowing the AC with the highest priority to gain access to the channel. The Contention Window(CW) parameters are CW_{min} and CW_{max} and Arbitrary Interframe Space(AIFS) are used to differentiate between ACs. Instead of waiting the normal Differentiated Inter frame Space(DIFS) time, each AC waits a specific AIFS time. Higher priorities have lower values of the CW parameters and AIFS. This leads to a higher fraction of the capacity and lower delays since the channel access frequency is increased. An additional parameter is the transmission opportunity (TXOP) that specifies the length of time the channel is occupied by a station. Depending on this limit, one or several packets may be transmitted when an AC has acquired the channel. Priority differentiation used by EDCA ensures better service to high priority class while offering a minimum service for low priority classes.

3. Related Work

They [4] had improved EDCA by adjusting the parameter adaptively to channel state or congestion level. An example is the adaptive congestion window. In [5] they had implemented adaptive EDCA where the access point adopted the contention window based on the network congestions. They [6] had applied a two level protection and guarantee mechanism for voice and video traffic by distributed admission control. They have done a budget calculation in EDCA to protect existing video streams and they also investigated the issue of bandwidth allocation for video streams. In [7] error layer architecture was used which is based on the data partitioning and they have been associated to each

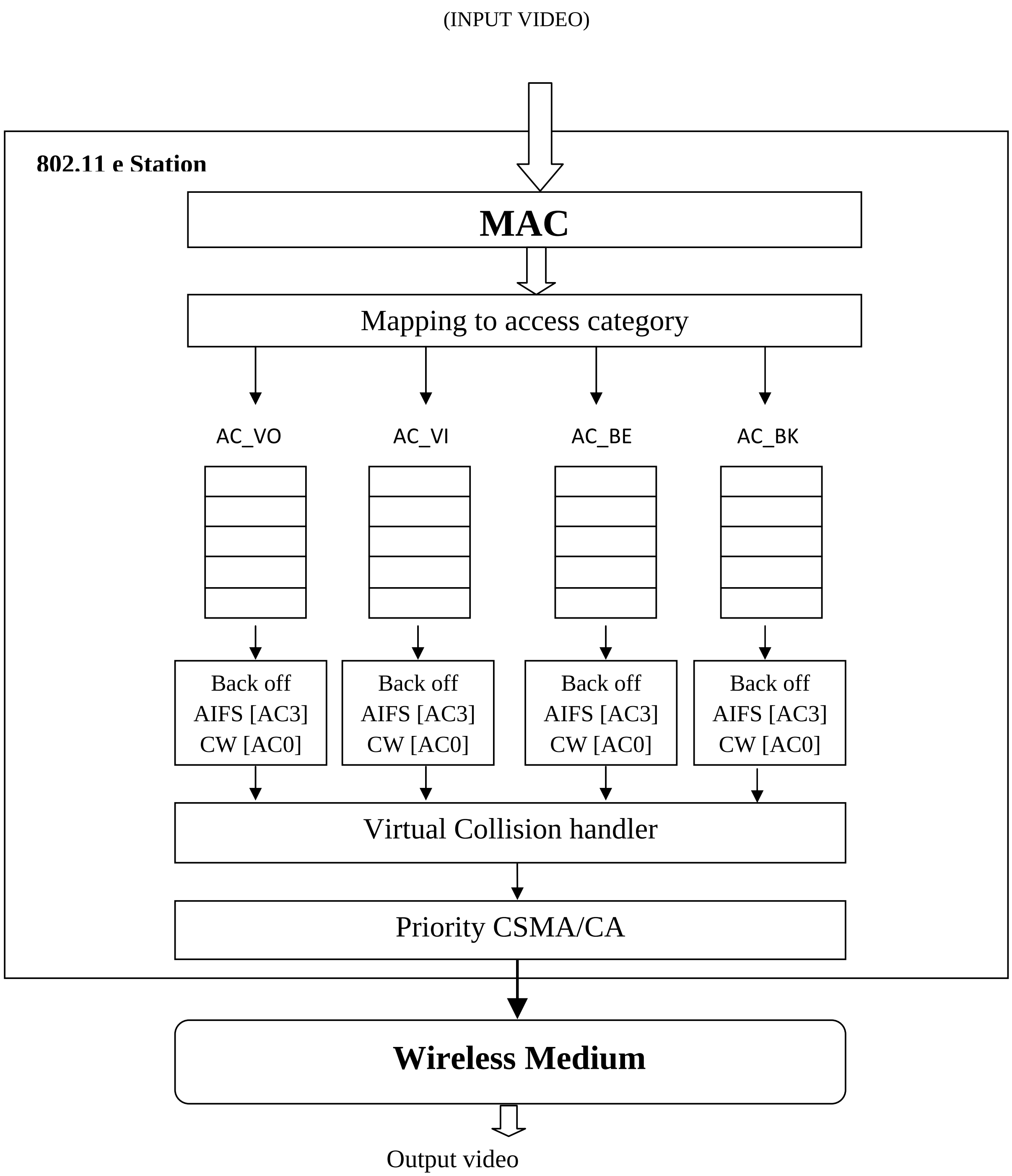

Figure 1: Four Access Categories in 802.11e

partition within the access layer categories of EDCA. In [8] macro and micro rate control schemes have been used at the application layer and network layer which uses bandwidth estimation and adaptive mapping of packets using video classifications. They [9] had built a wireless video system using the error resilient low bit rate video coder by implementing Udplite and PPP Lite in transport and link layer protocols for cellular video. They [10] had transmitted H.264 video over an ad hoc scenario using Udplite which has reduced retransmission using unequal error protection. They [11] had implemented a multimedia network asic design which had included the characteristics of H.264 with Udplite to reduce packet loss.

4. Proposed System

The figure 2 depicts the main components of the system architecture for wireless media streaming. The media source generates media streams that are initially sent to the encoder and from there to the application layer buffer. From application layer packets are sent to the transport layer where sensitive packets are checksummed and if an error occurs the packet is dropped otherwise the packet is transferred to the link layer buffer. In the receiving side the packet s are received from physical layer to link layer buffer. From there it is passed on to the the Udplite and to the application layer buffer. From application layer buffer it is sent to decoder and then to the client.

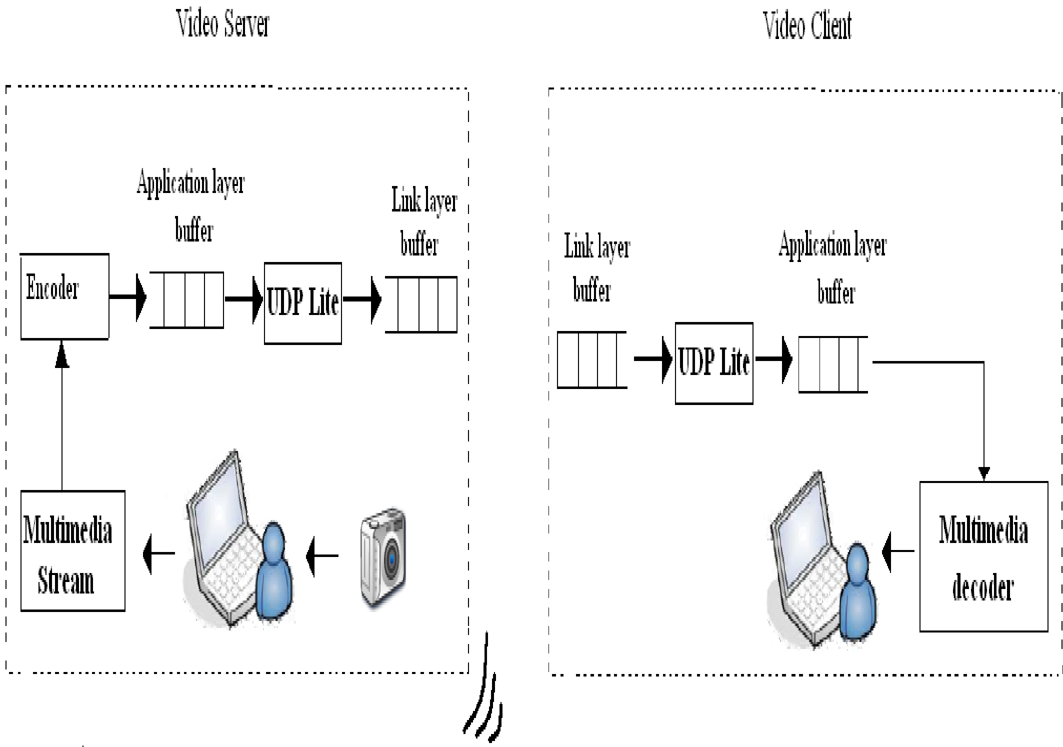

Figure 2: Multimedia Streaming System

5. Performance Evaluation

To evaluate the performance of IEEE 802.11e along with the MPEG4 CLWP with EDCA we have conducted simulations using a widely adopted network simulator NS2. We compare the video traffic in the following cases: MPEG4 UDP, MPEG4 CLWP, MPEG4 EDCA UDP and MPEG4 EDCA CLWP.

5.1 Simulation Topology

The simulation is performed with 3 types of video sources like YUV QCIF (176 x 144) Foreman, Claire, Akiyo. Each video frame was fragmented into packets before transmission and the maximum packet size over the simulator network is 1000 bytes. Figure 3 presents the simulation topology in the experiment. There are eight ad hoc wireless nodes where one is video server and another is video receiver. The data rate of wireless link is 1Mbps.

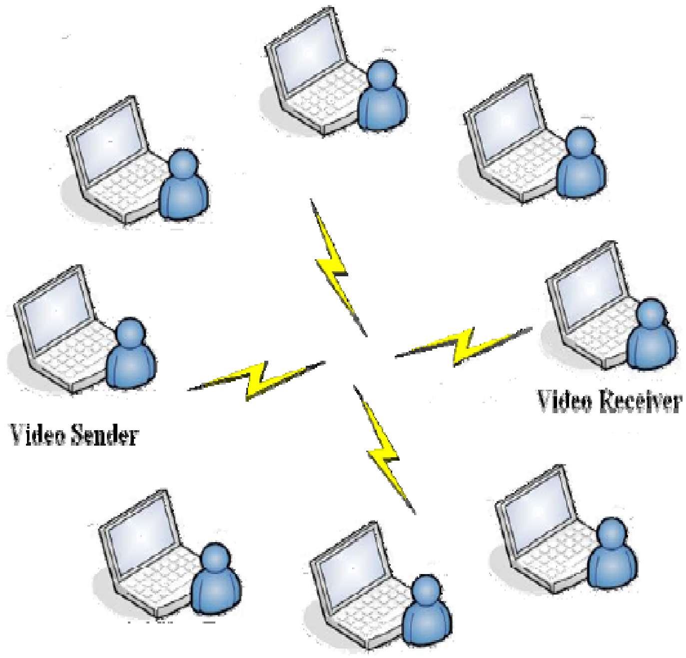

Figure 3: Network topology used in simulation.

Source Address			Pseudo-header
Destination Address			
Zero	Proto	UDP Length	
Source Port		Destination Port	UDP lite header
Coverage		Checksum	

Figure 4: The UDPLite Header

5.2 Experiments and Results

In all simulation experiments the delay, jitter and PSNR values are used to evaluate and compare the performance of 4 cases: MPEG4 UDP, MPEG4 CLWP, MPEG4 EDCA UDP and MPEG4 EDCA with CLWP while transmitting three different types of video sources.

5.2.1 Delay

Figure 5 represents the delay produced by MPEG4 UDP and MPEG4 CLWP and Figure 6 represents the delay produced by MPEG4 EDCA UDP and MPEG4 EDCA with CLWP while transmitting the Foreman of 400 frames as video source. The delay produced by MPEG4 UDP is 0.82 sec because no priority is given for the video packet. In the second case, the delay (0.79 sec) is comparatively less than MPEG4 CLWP since it provides partial checksum. While in the MPEG4 EDCA UDP the delay is 0.79 sec, since priority is given to video packets than other data packets during high contention. In the fourth case, the delay is reduced to a large extend of 0.72 sec because priority given to video packets are due to partial checksum.

Similarly Figure 7, Figure 8, Figure 9 and Figure 10 represents the delay evaluation for the four cases while transmitting the other two video sources namely Claire (500 frames) and Akiyo (300 frames) respectively.

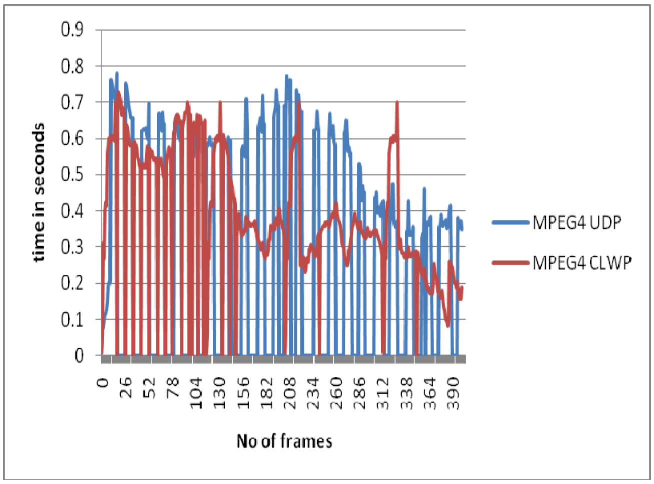

Figure 5: Delay produced by MPEG4 UDP and MPEG4 CLWP (Foreman).

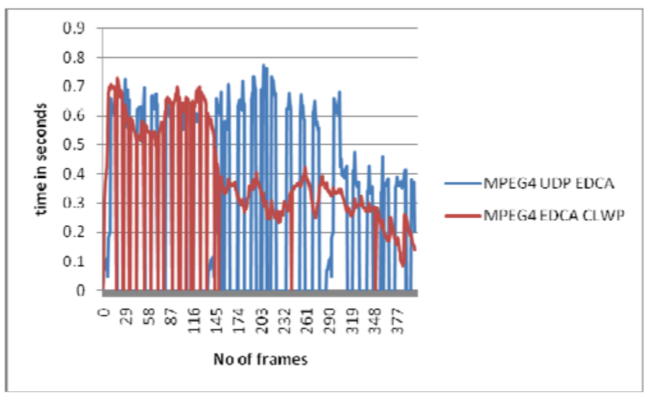

Figure 6: Delay produced by MPEG4 EDCA UDPand MPEG4 EDCA CLWP (Foreman).

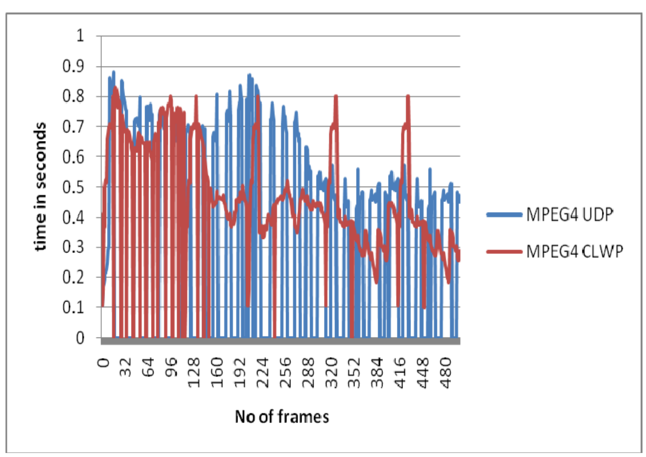

Figure 7: Delay produced by MPEG4 UDP and MPEG4 CLWP (Claire).

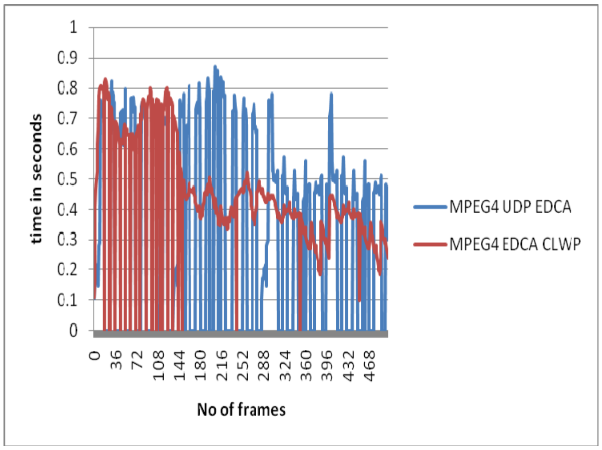

Figure 8: Delay produced by MPEG4 EDCA UDPand MPEG4 EDCA CLWP (Claire).

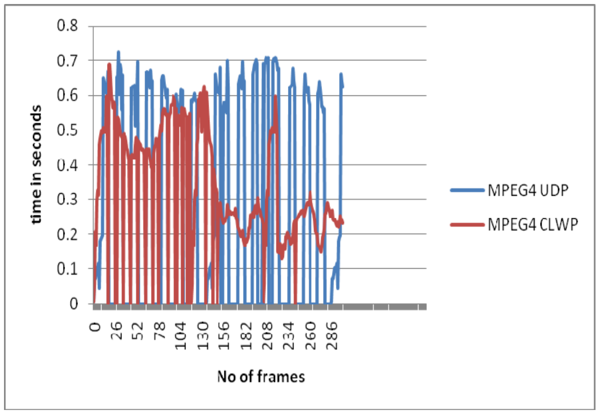

Figure 9: Delay produced by MPEG4 UDP and MPEG4 CLWP (Akiyo).

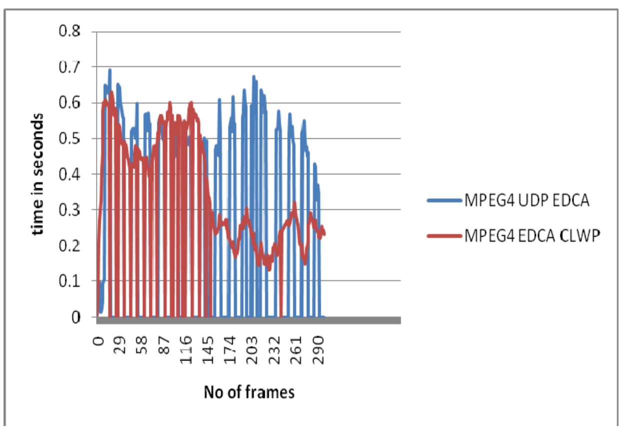

Figure 10: Delay produced by MPEG4 EDCA UDPand MPEG4 EDCA CLWP (Akiyo).

5.2.2 Peak Signal Noise Ratio

Similarly PSNR value is calculated for all four cases for three video sources. Figure 11 represents the PSNR produced by MPEG4 UDP and MPEG4 CLWP and Figure 12 represents the PSNR evaluated in the case of MPEG4 EDCA UDPand MPEG4 EDCA with CLWP while the video source transmitted is Foreman.

MPEG4 UDP gets a PSNR of 30db since the corrupted packets are dropped and also due to contention more packets will be lost. In the second case, PSNR is 33db because CLWP provides partial checksum which allows corrupted packets to be transmitted during the receiving application. In MPEG4 EDCA, the PSNR is 34db because more priority is given to video traffic. In MPEG4 with CLWP and EDCA PSNR is 37db which is considerably higher than the other cases.

Similarly Figure 13 and 14 represents the PSNR produced when transmitting Claire video and Figure 15and 16 represents the Akiyo evaluation.

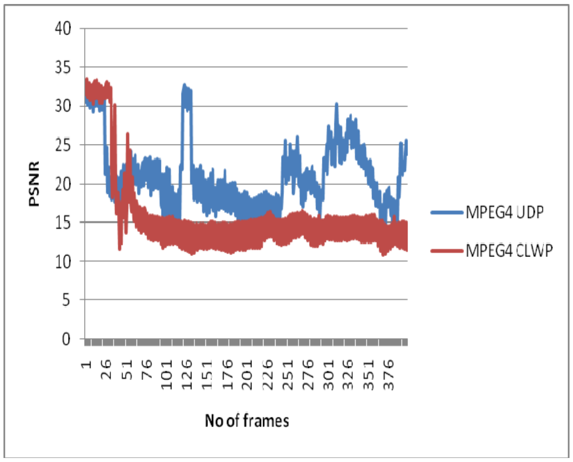

Figure 11: PSNR produced by MPEG4 UDP and MPEG4 CLWP (Foreman).

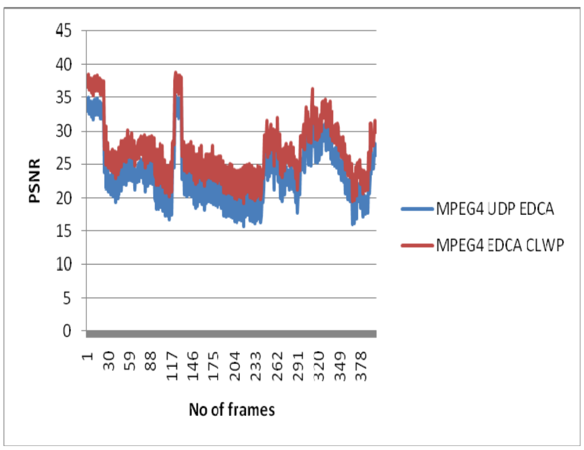

Figure 12: PSNR produced by MPEG4 EDCA UDP and MPEG4 EDCA CLWP (Foreman).

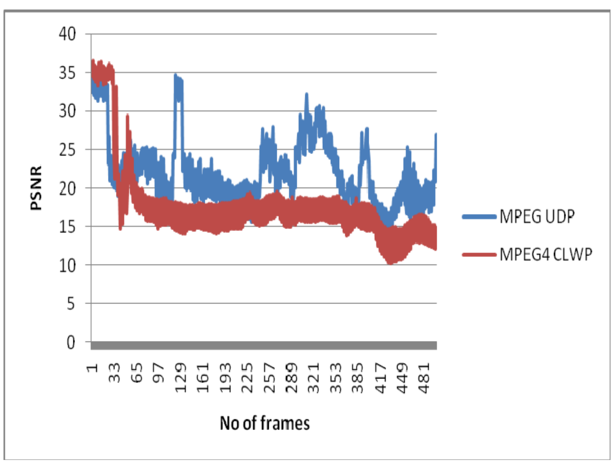

Figure 13: PSNR produced by MPEG4 UDP and MPEG4 CLWP (Claire).

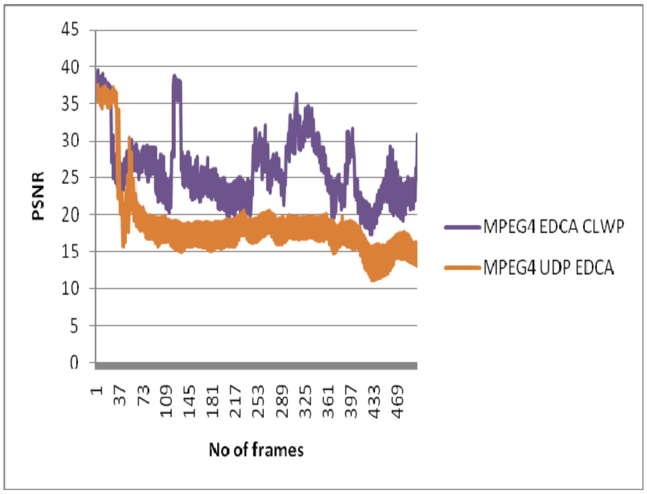

Figure 14: PSNR produced by MPEG4 EDCA UDPand MPEG4 EDCA CLWP (Claire).

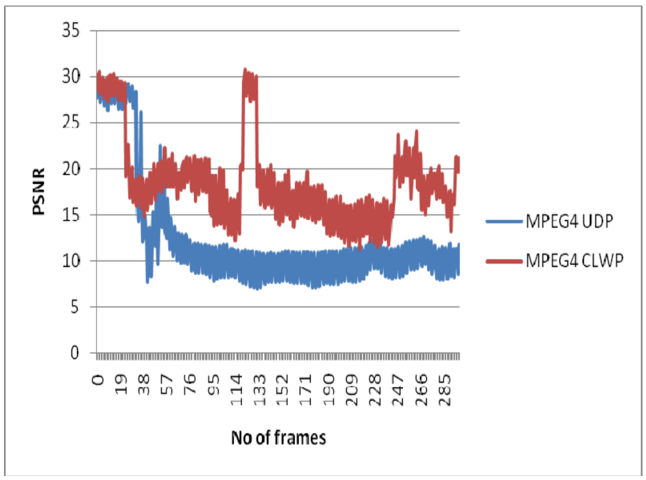

Figure 15: PSNR produced by MPEG4 UDP and MPEG4 CLWP (Akiyo).

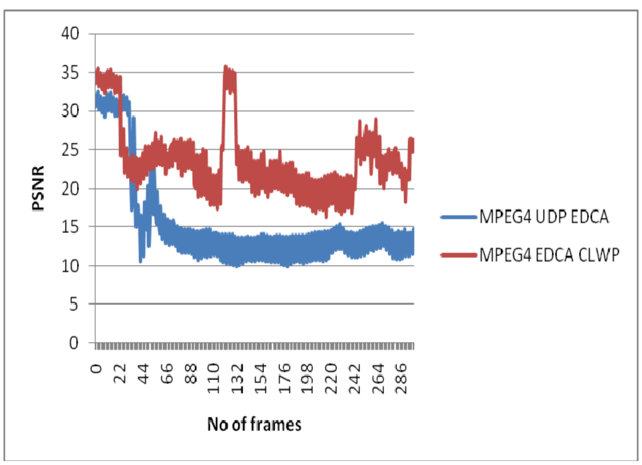

Figure 16: PSNR produced by MPEG4 EDCA UDP and MPEG4 EDCA CLWP (Akiyo).

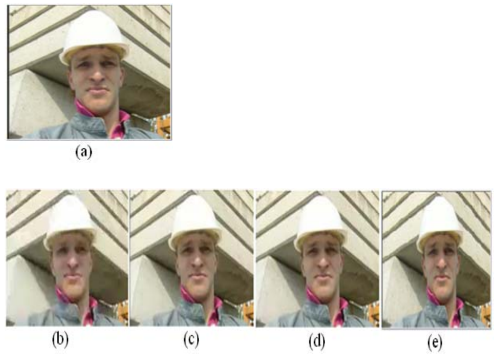

Figure 17: (a). Original video frame (Foreman), (b). PSNR of MPEG4 with UDP, (c). PSNR of MPEG4 with CLWP, (d). PSNR of MPEG4 with EDCA and (e). PSNR of MPEG4 with CLWP and EDCA.

Figure 18: (a). Original video frame (Claire), (b). PSNR of MPEG4 with UDP, (c). PSNR of MPEG4 with CLWP, (d). PSNR of MPEG4 with EDCA and (e). PSNR of MPEG4 with CLWP and EDCA.

Figure 19: (a). Original video frame (Akiyo), (b). PSNR of MPEG4 with UDP, (c). PSNR of MPEG4 with CLWP, (d). PSNR of MPEG4 with EDCA and (e). PSNR of MPEG4 with CLWP and EDCA.

5.2.3 Jitter

Figure 20 and 21 represents the Jitter obtained from the four cases while transmitting the Foreman video. Similarly the jitter value for Claire video and Akiyo video are represented through the Figure 22, 23, 24 and 25.

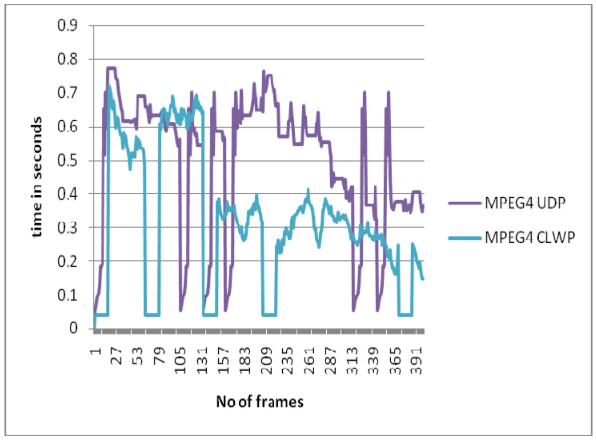

Figure 20: Jitter produced by MPEG4 UDP and MPEG4 CLWP (Foreman).

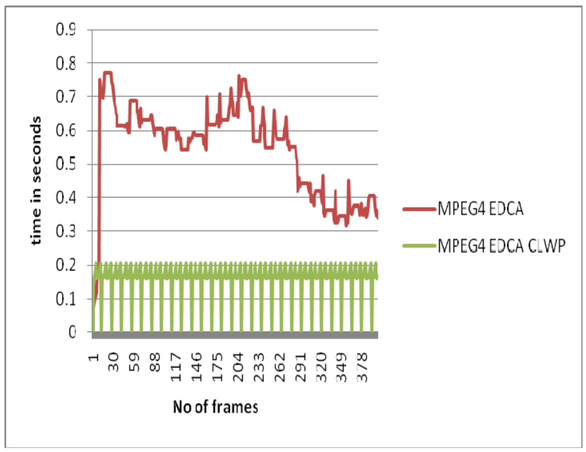

Figure 21: Jitter produced by MPEG4 EDCA UDP and MPEG4 EDCA CLWP (Foreman).

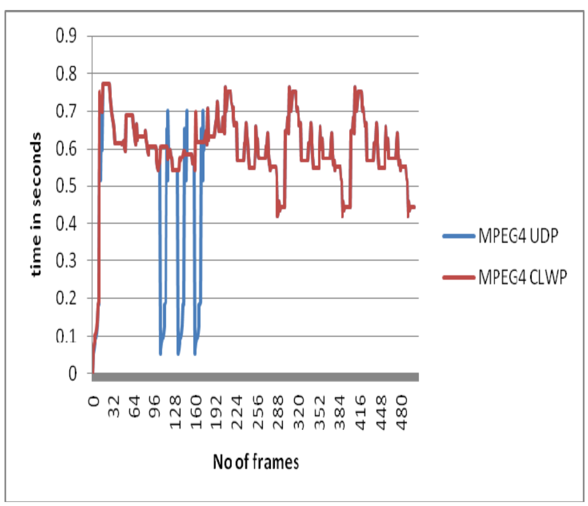

Figure 22: Jitter produced by MPEG4 UDP and MPEG4 CLWP (Claire).

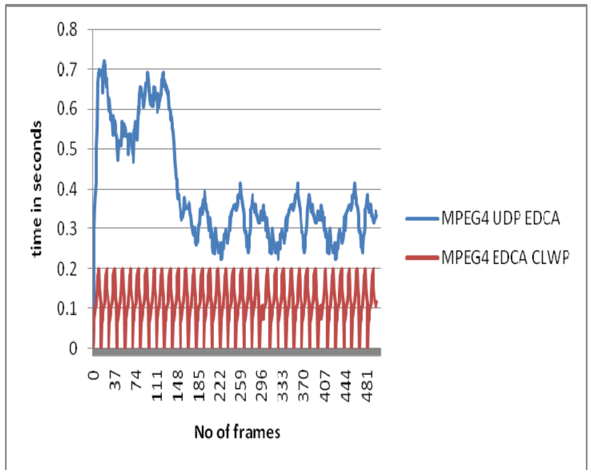

Figure 23: Jitter produced by MPEG4 EDCA UDPand MPEG4 EDCA CLWP (Claire).

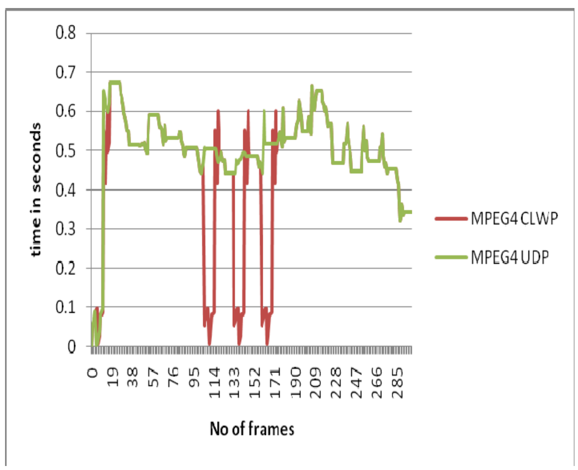

Figure 24: Jitter produced by MPEG4 UDP and MPEG4 CLWP (Akiyo).

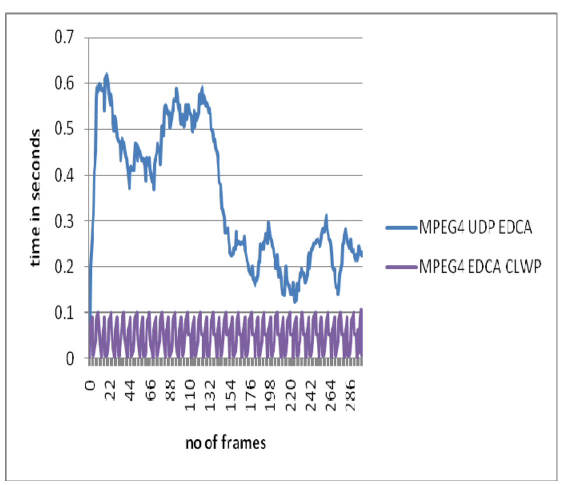

Figure 25: Jitter produced by MPEG4 EDCA UDP and MPEG4 EDCA CLWP (Akiyo).

6. Conclusion

Simulations are performed to investigate the performance of four cases while transmitting different types of video sources. The simulation results show that the implemented CLWP (udplite) protocol along with EDCA can increase the PSNR value and decrease the jitter and delay to a great extent than all the other cases.

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