An Integrated Cross Layer Approach for Multimedia Streaming using Multipath and Multiple Description Coding in Mobile Ad-Hoc Networks

N.GOMATHI[1], Dr.P.SEETHALAKSHMI[2], Dr.A.GOVARDHAN[3]
Research Scholar[1], Department of CSE[2], Principal[3],
JNTU, Hyderabad[1], Anna University of Tech, Triuchirappalli [2], JNTUH College of Engineering, Hyderabad [3]
gomathi1974@gmail.com

Abstract
The objective of this paper is to propose a novel method for enhancing the QoS of multimedia applications in mobile adhoc networks by using Multipath and Multi Description Coding. The enhancement is achieved by implementing the Multi Description Coding (MDC) at application layer along with Connectionless Light Weight Protocol (UDPLite) in transport layer and multipath at network layer. This approach achieves an increase of 12.75% in Peak Signal to Noise Ratio (PSNR) which is an improvement in PSNR as compared to the conventional methods.

KEYWORDS
MANETS, QoS, Multiple Description Coding (MDC), UDPLite, Multipath Transport, Video Streaming, PSNR.

1. Introduction

Video communication is desired over mobile ad-hoc networks because of its use in military, homeland defense and disaster recovery applications. In ad-hoc networks nodes can act as hosts or as routers to forward data from one node to another node that are not reachable in one hop. As the nodes can move freely over the network, video transmission in mobile ad-hoc network is challenging because of frequent link failures, limited bandwidth and route changes. Although one could switch over to an alternative route, it may take unacceptably a long period of time, causing a temporary disruption to the video session. Furthermore, more stable and reliable routes should be preferred instead of just the shortest one. To overcome both the limitations of link-level reliability, bandwidth and the time-varying nature of the network topology, multiple paths between the source and destination have been incorporated to enhance the route robustness while increasing the usable bandwidth for end-to-end connection.

Multi Path Transmission (MPT) has traditionally been considered for non-real-time data transmission, where the traffic is split on the bit level in a random manner. For transmission of compressed video streams obtained using temporal prediction and variable length coding, such random splitting can make the received information bits on one path useless, if any bits in the other path are lost. Therefore, one must jointly design source coding and traffic splitting strategies for Multipath transmission to be actually helpful. In this paper, a structure for MANET that includes the *Split Multipath Multimedia Dynamic Source Routing* (SMMDSR) protocol along with Multiple Description Coding has been designed to improve the quality of video. SMMDSR is a routing protocol that establishes multiple paths simultaneously between two nodes. It is similar to Dynamic Source Routing (DSR) protocol and it is used to construct maximally disjoint paths. Providing multiple routes helps minimizing route recovery process and control message overhead.

Two viable options for source coding are Multiple Description Coding (MDC) and Layered Coding (LC). Both the techniques produce multiple sub-streams that can be carried on separate paths. Multiple Description Coding (MDC) is an alternative to the Layered Coding for streaming video over unreliable channels [1].

With MDC, the sub-streams (each called a description) have equal importance in the sense that each received description alone can guarantee a basic level of reconstruction quality, and additional description can further improve the quality. As the loss of one description does not influence other descriptions, a lost packet in any path does not require any retransmission. On the other hand, with Layered Coding, the base-layer stream is more important and can provide a basic level of quality, whereas remaining enhancement-layer streams serve to refine the base-layer quality and the enhancement layers alone are not useful. The path carrying the base-layer packets should have a higher reliability, either naturally or through forward error correction (FEC) and any lost base-layer packets should ideally be retransmitted. Obviously, the choice of the coding strategy depends on the path conditions and the delay required of the underlying application. So to achieve low delay and good quality multimedia streaming, Multiple Description Coding (MDC) in Application Layer and UDPLite in the transport layer along with Multipath in Network layer has been implemented.
The rest of the paper is organized as follows. In section 2 the aspects of Multiple Description Coding, UDPlite and Multipath are discussed. In section 3 we discuss about the related works. Section 4 discusses about the proposed designs. Section 5 establishes system simulation model and give result to illustrate the significance of the work while conclusion are drawn in section 6.

2. Multi Path Routing, Multiple Description Coding , Udplite

In MANETs, nodes are mobile and may join or leave the network whenever necessary thus forming a dynamic topology. Nodes that are in the transmission range of each other are called neighbors and they can send data packets directly to each other. However, when a node needs to send data to another non-neighboring node, the data is routed through a sequence of multiple hops, with intermediate nodes acting as routers. Multiple paths provide load balancing, fault-tolerance, and higher aggregate bandwidth. When different sub-streams are carried along multiple routes the traffic is spread evenly ensuring load balancing, alleviating congestion in bottlenecks. From a fault tolerant perspective, multipath routing can provide route resilience. Multiple paths are used to route data simultaneously and the aggregate bandwidth of the paths may satisfy the bandwidth requirement of the Multimedia application. Since there is more bandwidth available, a smaller end-to-end delay may be achieved.

Route Discovery

Split Multimedia Multipath routing is an on-demand routing protocol which builds multiple routes using request/reply cycles. The Route Request (RREQ) messages are flooded to the entire network by the source in order to find the route to the destination since no route information is known. The several duplicates which are traversed through different routes reach the destination since the packets are flooded. The Destination sends the Route Reply Packets back to source via the chosen routes after selecting the multiple disjoint routes from the duplicate packets.

RREQ Propagation

The SMMDSR builds maximally disjoint multiple paths. Maximally disjoint routes are constructed to prevent certain nodes from congestion and to utilize the available network resources efficiently. When the source has data packets to send but does not have the route information to the destination, it transmits a RREQ packet. The RREQ packet contains the source ID and a sequence number that uniquely identify the packet. When a node other than the destination receives a RREQ that is not a duplicate, it appends its ID and re-broadcasts the packet. The intermediate nodes are not allowed to send the RREPs back to the source even when they have route information to the destination. The intermediate node should not drop every duplicate RREQs, it should forward the duplicate packets that traversed through a different incoming links than the link from which the first RREQ is received, and whose hop count is not larger than that of the RREQ to the destination.

Route Selection Method

When receiving the first RREQ, the destination records the entire path and sends a RREP to the source via the same route . The node IDs of the entire path is recorded in the RREP, and hence the intermediate nodes can forward this packet using this information. After this process, the destination waits for certain duration of time to receive more RREQs and learn all possible routes. The maximally disjoint routes can be selected because the destination knows the entire path information of the first route and all other candidate routes.

Route Maintenance

The mobility and congestion and packet collision causes disconnection in the route. The broken routes are immediately recovered to do effective routing. In SMMDSR when a node fails to deliver the data packet to the next hop of the route, it is said that the link is disconnected and sends a ROUTE ERROR (RERR) packet to the up stream direction of the route. The RERR packet is received by the source and it removes the every entry in route table that uses the broken link. When the source is informed of route disconnection and the session is still active it uses the following method in discovering routes: Initiates the route recovery process when any route of the session is broken or initiates the route recovery process only when all the routes of the session is broken

When the source receives RREP after flooding RREQ, the source has information about all routes to the destination and the source can send the sub streams through various routes to the destination. Among the descriptions even if atleast one description is received correctly at any point in time is beneficial. The improved reconstruction of video quality is provided by MDC as more descriptions are received. The MultipleDescriptionCoding video transmission evaluation framework is shown below [2].

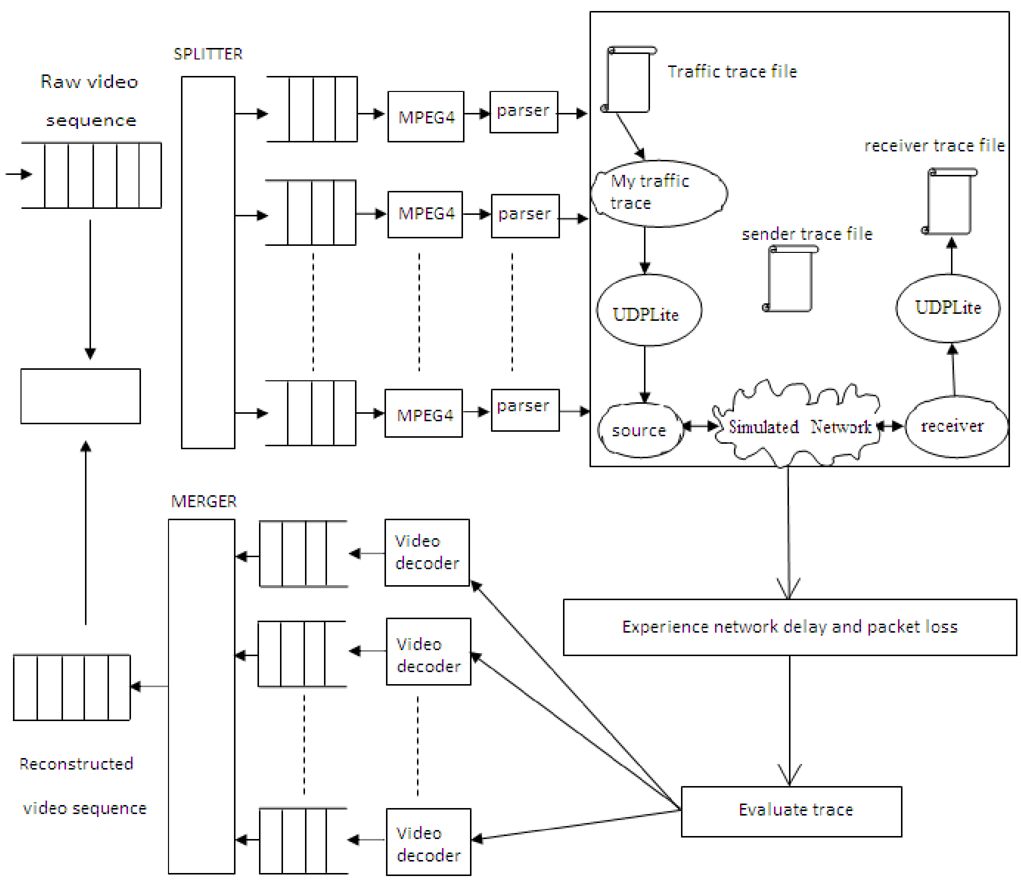

Figure 1: MDC video transmission evaluation framework

The main components of the evaluation framework are described as follows:

Raw Video Sequence: The video source is YUV QCIF (176 x 144)

Splitter: Multiple Descriptors have been splitted using frame based approach. The raw video sequence Foreman in qcif format which has 400 frames in YUV format is split into 4 Descriptions by the Splitter Program.

Video Encoder: Each Description is encoded using Xvid (MPEG4).

Parser: Each Compressed video Sub stream from the output of video encoder was read by parser program which generates a trace file that contains frame id, frame type, frame size, and designated sending time.

My Traffic Trace: The records in the traffic trace file are read by the application and the application generates the corresponding packets in NS2. The Packets are sent to the lower UDPLite layer by the application at the appropriate time specified according to the user setting specified.

UDPLite: Essentially, UDPLite is an extension of the UDP agent. This new agent allows users to specify the output file name of the sender trace file and it records the timestamp of each transmitted packet, the packet id, and the packet size.

UDPLite Sink: It is the receiving agent for the slice packets sent by UDPLite. This agent also records the timestamp, packet ID, and size of each received packet in the user specified file.

Evaluate Trace: The number of records in the sender trace file and the receiver trace file are calculated after the simulation. From this how many packets are sent and received are known and also, a distorted video file, which corresponds to the possibly corrupted video found at the receiver side, is produced. The generation of the possibly corrupted video can be regarded as a process of copying the original compressed video file packet by packet, omitting packets which are lost or corrupted during transmission.

Merger: After decoding each received reconstructed video file, the decoded distorted video sequences are fed into the merger program to generate the reconstructed raw video sequence. Because digital video quality assessment, e.g. PSNR, is performed frame by frame. Therefore, the total number of video frames in the reconstructed raw video sequence must be the same as that of the original video. If some sub-streams are lost, the merger program does very simple error concealment by copying the last successfully decoded frame to the lost frames until a correct decoded frame is found. For example, if the video is divided into 4 sub-streams and the third sub-stream is lost, the reconstructed video frame will be frame 1, 2, 2, 4, 5, 6, 6, 8…and so on.

In Multiple Description Coding while decoding the media stream, any description can be used; however, the quality improves with the number of descriptions received in parallel. Thus higher the number of descriptions received, higher will be the video quality. As long as all the descriptions are not lost simultaneously the quality of video can be assured. In order to reduce the likelihood of simultaneous loss of descriptions, different descriptions are transmitted through different paths. Thus MDC along with Multipath routing helps to reduce the possibility of simultaneous loss of different descriptions and enables load balancing in networks.

The use of Multiple Description Coding along with multi path routing in video streaming improves the quality of video. The quality of video can be further increased by enabling the application layer to specify about the importance of packets and those packets can be preserved by the UDPLite protocol in the transport layer along with Multiple Description Coding. The notion of application-layer over transport-layer protection is not new and hence traditional real-time multimedia services have been realized as Real-time Transport Protocol (RTP) over User Datagram Protocol (UDP). User Datagram Protocol (UDP) is an unreliable protocol that is suitable for delay sensitive applications such as real-time media applications that are sensitive to network delays and do not benefit from retransmission in case of packet loss / error. Amoolya Sing et.al, discussed that UDPLite [3] is an extension to UDP that needs damaged data to be delivered rather than discarded by networks, so it 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. The UDPLite protocol allows the application to receive the corrupted packets instead of dropping them. This is achieved by a partial checksum which covers only a fixed amount of sensitive data. The length field in the UDP header is replaced by the coverage field, which signifies how many bytes of the packet is check summed. In UDPLite the header portion of Multimedia data is sensitive and it is covered by the checksum and the payload is non sensitive and it is not covered by the checksum.

In UDPLite if the Coverage value is Zero, checksum covers the entire packet. If the coverage value is 8 then checksum covers the UDP header alone. If the value lies between 1 and 7, they are reserved because UDPLite checksum should cover the header. If the value is more than eight a portion of data is protected by the checksum. When the bit error occurs in the sensitive part (corruption of the port field makes the data to be delivered to the wrong application) the packet will be discarded. Even though the error occurs in the non sensitive part the packet will be transmitted to the application because a packet with an error in the application payload can cause a glitch in the video quality, while an undelivered packet can cause a noticeable break in the video stream.

3. Related Work

The performance analysis of Multipath Routing, UDPLite and Multiple Description coding has been carried out by many research scholars. Nitin Gogate, and Shivendra S. Panwahad combined Multiple Description Coding (MDC) and Multiple Path Transport (MPT) for video and image transmission in a multi hop mobile radio network. A comparison of the performance of the MDC–MPT scheme to a system using layered coding and asymmetrical paths for the base and enhancement layers have been made [4]. [4]They had concluded that MD coder was more effective in overall performance when compared to layer coding approach. Patricia Acelas, Pau Arce, and Juan C.Guerri implemented Multiple Description Coding (MDC) technique and Multi Path transmission for improving the video quality, and also the Quality of Experience of the final receiver was improved in high mobility scenario [5]. Mónica et al had designed a-MMDSR Adaptive-Multi Path Multimedia Dynamic Source Routing, a protocol able to self-configure dynamically depending on the state of the network. The path error probability was found using a straightforward analytical model. This model is used by the routing scheme to estimate the lifetime of the paths. The routing algorithm periodically updates a set of paths, classifies them according to a set of metrics and arranges a multipath forwarding scheme [6]. S. Mao et.al, proposed to combine multi stream coding with multipath transport to show that the path diversity provides an effective means to combat transmission error in ad hoc networks in [7]. B.A Heng et.al, had discussed about an adaptive Multi Description mode selection approach which adapts to the network conditions as well as to the video characteristics in [8]. Yiting Liao et.al, had proposed a routing aware multiple description video coding approach to support video transmission over mobile adhoc networks with multiple path transport in [9]. Ali C. Begen, Yucel Altunbasak, Ozlem Ergun, Mostafa H. Ammar developed models for Multi Description streaming over multiple paths and based on these models a multi-path selection method had been proposed [10]. [10]This method chooses a set of paths to maximize the overall quality at the client under various constraints. The result showed PSNR improvement, end-users experiencing a more continual, i.e., uninterrupted, streaming quality. Yen-Chi Lee et al compared the error-resilience capabilities of Layered Coding and Multiple Description Coding encoding techniques over a wide range of packet loss rates and they concluded that if no error protection is applied to both encoding techniques, Multi Description Coding has better performance than Layered Coding in error prone Networks[11]. Gomathi et al had implemented a cross layer design to improve the video quality by using UDPLite in transport layer along with Mac layer scheduling mechanisms [12].

In this paper a multipath routing protocol called Split Multipath Multimedia Dynamic Source Routing (SMMDSR) is implemented which construct maximum disjoint points. SMMDSR uses route messages like Route Request (RREQ) and Route Reply (RREP) that selects different paths suitable for the transmission of video descriptions. Also the proposed method does not require any additional control packets or an extra channel connection in the network. We only extract and utilize the information embedded in typical routing messages. More over the use of UDPLite along with MDC and SMMDSR further improves the quality of the video.

4. Proposed System

The architecture of the proposed system is shown in Fig.2. Video sequence is split using a splitter and then encoded into multiple descriptions at the sender the video of high quality can be obtained.

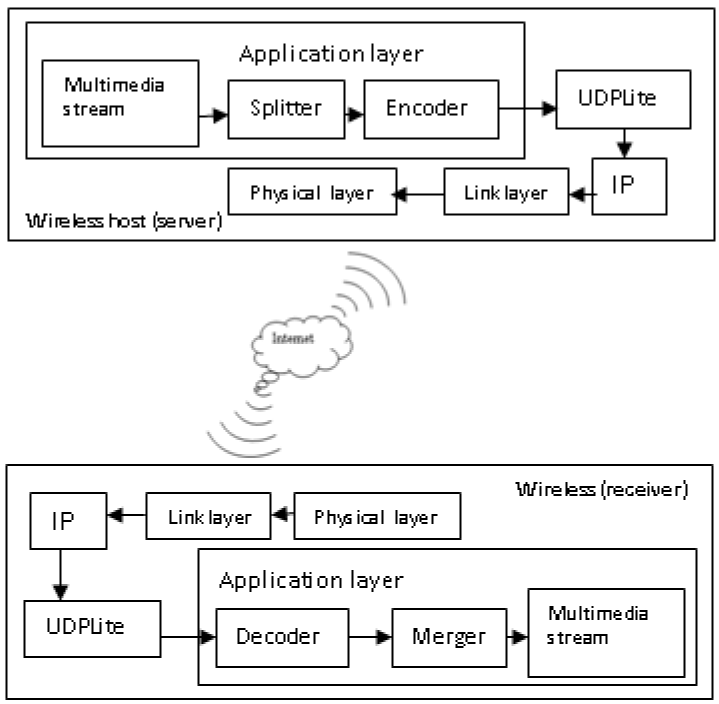

Figure 2: Architecture Diagram of Multi Description Coding

5. Simulation Results And Discussions

Implementation and simulation setup of MDC along with UDPLite and multipath Scheme

The MDC along with UDPLite and multipath system over an ad-hoc network have been simulated using MPEG-4 encoder and NS2 simulator. The performance of the received video at the receiver has been examined.

1) Network Settings

In the ad-hoc network twelve nodes are placed where one node act as a source and sends the descriptions to the receiver through various paths The topology that has been used for simulation is shown in figure 3. A video sender splits the video into four compressed descriptions(substreams) and transmits. Each description is transmitted to the receiver through Multiple Paths.

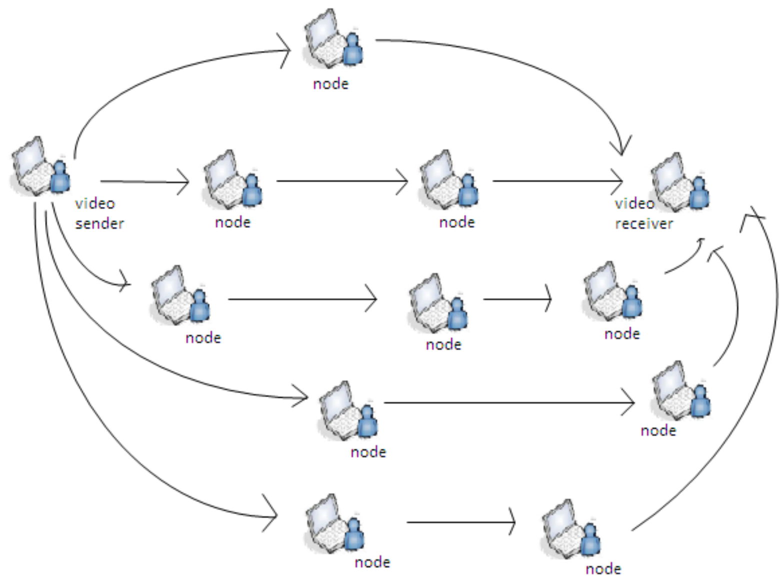

Fig 3: Simulation Topology

2) Video source and estimation metrics

Three video sequences namely “Foreman”, “Akiyo” and “Claire” in QCIF format have been considered for evaluating the proposed system. The video sequences are encoded into packets before transmission. The video description is transmitted in multiple paths in which the sender does not retransmit to recover loss packets. The data rate of the wireless link is 10 Mbps. We use PSNR of all descriptions to evaluate the objective video quality of the decoded video sequences.

A. Results and Discussions

Using the simulation setup of MDC along with UDPLite and multipath routing the performance of the received video quality (Peak Signal to Noise Ratio (PSNR)) has been compared in four cases which are MDC UDP without multipath, MDC UDPLite without multipath, MDC UDP with multipath and MDC UDPLite with multipath.

1) Overall Performance

To evaluate the performance of the Multiple Description Coding with UDPLite in an end to end network, a simulation has been conducted using a widely adapted network simulator. The video quality is compared in following cases. Multiple Description Coding UDP without multipath, Multiple Description Coding UDPLite without multipath, Multiple Description Coding UDP with multipath, Multiple Description Coding UDPLite with multipath.

Figure 5 represents the PSNR produced by Multiple Description Coding UDP without multipath and Multiple Description Coding UDPlite without multipath, Figure 6 represents the PSNR produced by Multiple Description Coding UDP with multipath and Multiple Description Coding UDPlite with multipath routing while transmitting Foreman of 400 frames as video source. Similarly Figure 7 and Figure 8 represent PSNR evaluation for the four cases while transmitting Claire (500 frames). Figure 9 and Figure 10 represents the PSNR evaluation for the four cases while transmitting the video source Akiyo (300 frames) respectively.

The PSNR was found to be extremely good in MDC UDPLite with multipath combination when compared with other cases

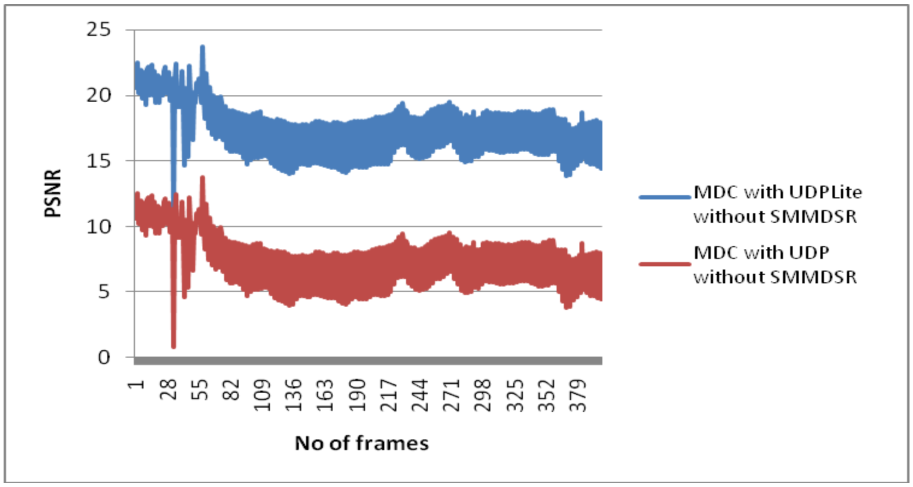

Figure 4: PSNR value of MDC UDP without SMMDSR, MDC UDP lite without SMMDSR (Foreman).

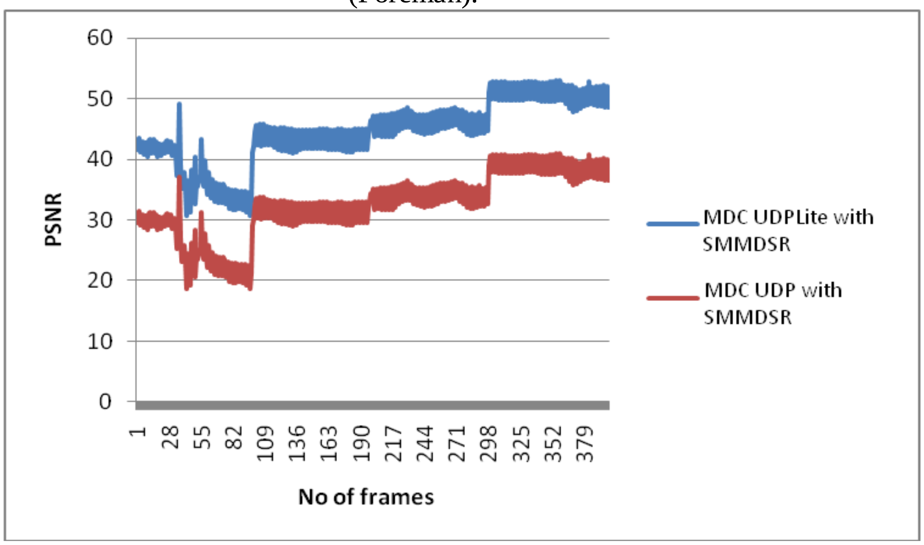

Figure 5: PSNR value of MDC UDP with SMMDSR, MDC UDP lite with SMMDSR (Foreman).

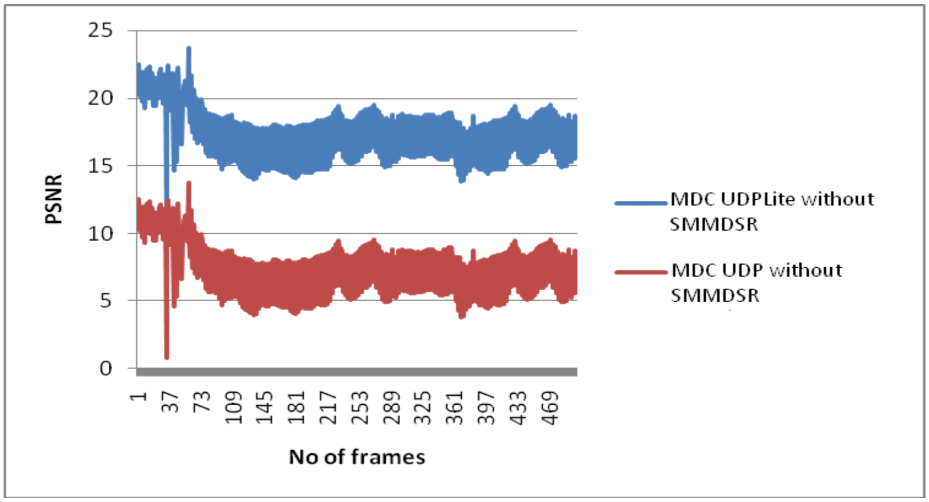

Figure 6: PSNR value of MDC UDP without SMMDSR, MDC UDP lite without SMMDSR (Claire).

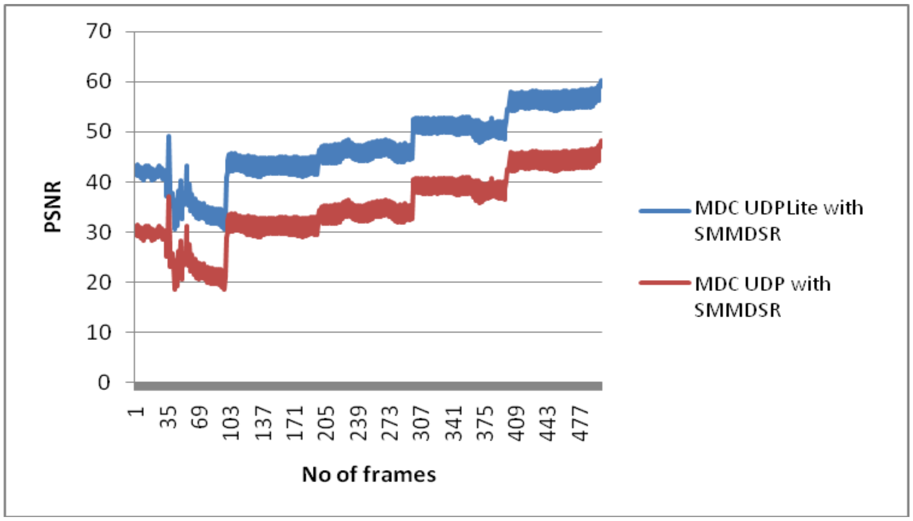

Figure 7: PSNR value of MDC UDP with SMMDSR, MDC UDP lite with SMMDSR (Claire).

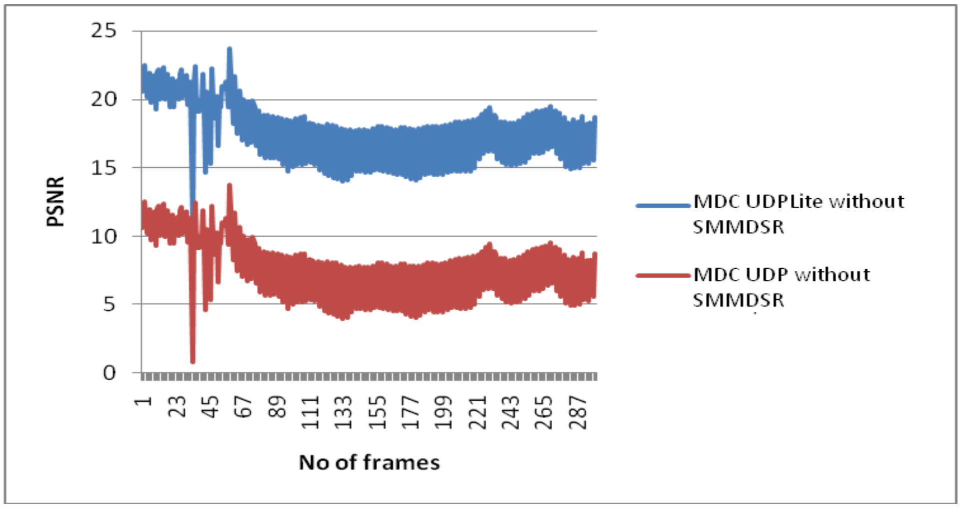

Figure 8: PSNR value of MDC UDP without SMMDSR, MDC UDP lite without SMMDSR (Akiyo).

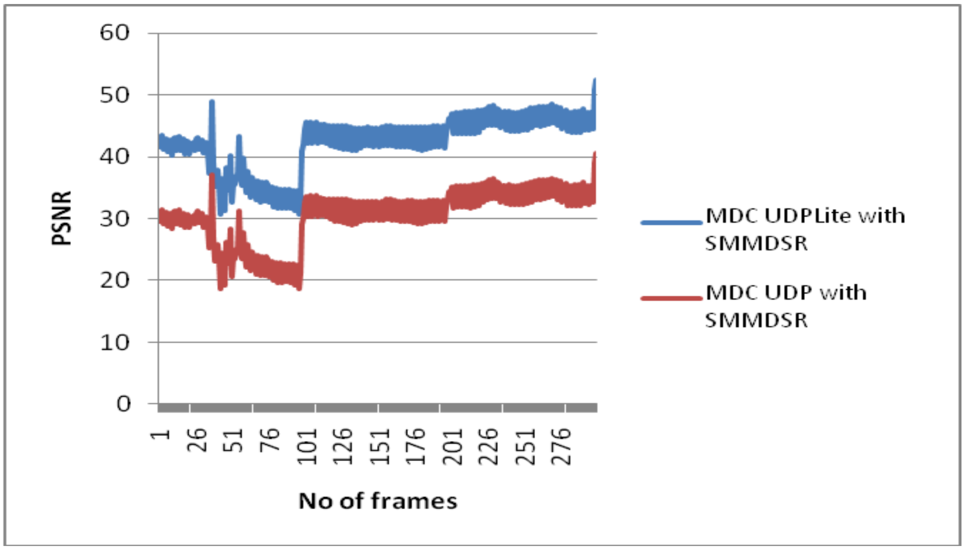

Figure 9: PSNR value of MDC UDP with SMMDSR, MDC UDP lite with SMMDSR (Akiyo).

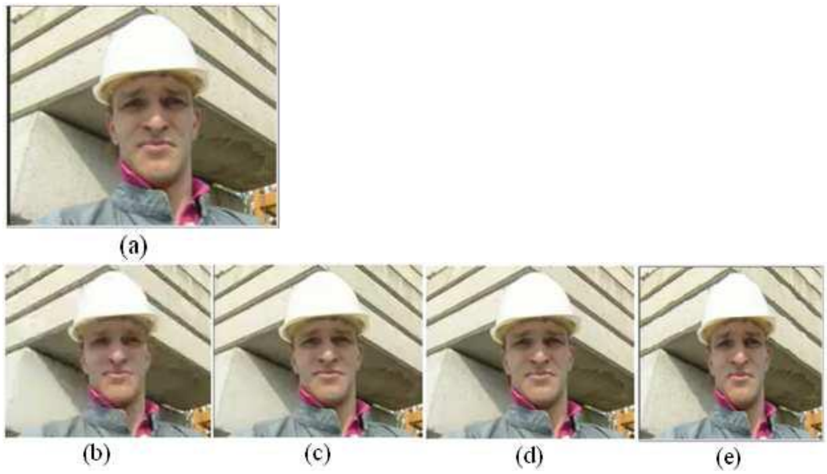

Figure 10: Original video frame (Foreman), (b). PSNR of MDC UDP without SMMDSR, (c). PSNR of MDC UDPLite without SMMDSR, (d). PSNR of PSNR of MDC UDP with SMMDSR and (e). PSNR of MDC UDPLite with SMMDSR.

Figure 11: Original video frame (Claire), (b). PSNR of MDC UDP without SMMDSR, (c). PSNR of MDC UDPLite without SMMDSR, (d). PSNR of PSNR of MDC UDP with SMMDSR and (e). PSNR of MDC UDPLite SMMDSR with .

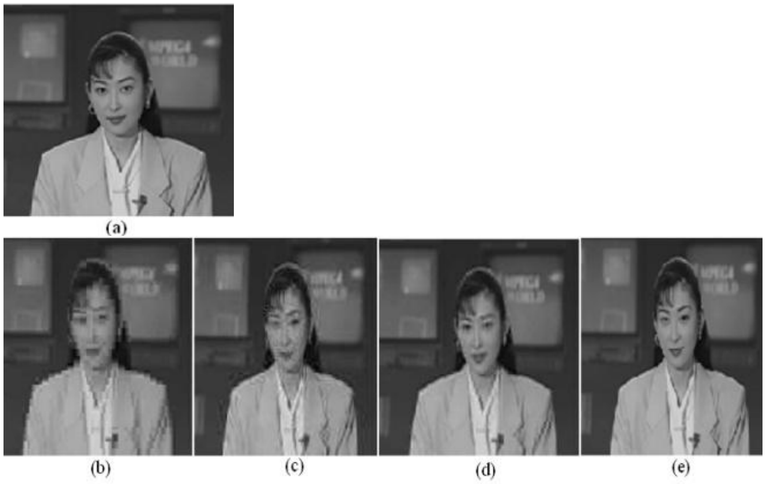

Figure 12: Original video frame (Akiyo), (b). PSNR of MDC UDP without SMMDSR, (c). PSNR of MDC UDPLite without SMMDSR, (d). PSNR of PSNR of MDC UDP with SMMDSR and (e). PSNR of MDC UDPLite with SMMDSR.

6. Conclusion

Multi Description Coding along with UDPLite and multipath transport has been proposed to enhance the quality of video transmission over wireless ad-hoc networks. The proposed approach has been examined using ns2 simulator. The simulation results show that our method achieves upto 12.75 % improvement in PSNR for different video sequences.

7. References

[1] Wang Y, Orchard MT, Vaishampayan V, Reibman AR, "Multiple description coding using pair wise correlating transforms," IEEE Trans Image Process., pp. 351-66, 2001.

[2]140.116.72.80/~smallko/ns2/MDC.

[3]Amoolya Sing Almudena Konrad Anthony D. Joseph "Performance Evaluation of UDP Lite for Cellular Video," in Proc. NOSSDAV '01, 2001.

[4] Nitin Gogate, Doo-Man Chung, Shivendra S. Panwar, Yao Wang, "Supporting Image and Video Applications in a Multihop Radio Environment Using Path Diversity and Multiple Description Coding", Ieee Transactions On Circuits And Systems For Video Technology Vol. 12, no. 9, September 2002.

[5] Patricia Acelas, Pau Arce, and Juan C. Guerri,"Effect of the Multiple Description Coding over a Hybrid Fixed-AdHoc Video Distribution Network", Springer-Verlag Berlin Heidelberg, pp. 176–187, 2009.

[6] Mónica Aguilar Igartua, Víctor Carrascal Frías, "Self-configured multipath routing using path lifetime for video-streaming services over Ad Hoc", Computer Communications 33 (2010) 1879–1891.

[7] S. Mao, S. Lin ,S.S. Panwar. Y. Wang, and E. Celebi, "Video transport over ad-hoc networks: Multistream coding with multipath transport", IEEE Selected Area in Communication, vol. 21, Issue 10, Object

Identifier: 10.1109/JSAC.2003.815965, 2003 , Page(s): 1721 – 1737.

[8] B.A Heng, J.G. Apostolopoulos, and J. S. Lim, "End-to-End rate-distortion optimized MD mode selection for multiple description video coding", EURASIP J. Appl. Signal Process., 2006.

[9] Yiting Liao; Gibson, J.D., "Routing-Aware Multiple Description Video Coding Over Mobile Ad-Hoc Networks", IEEE Transactions on Multimedia, Publication Year: Feb 2011 Vol 13,Issue1 , Page(s): 131 – 142.

[10] Ali C. Begen, Yucel Altunbasak, Ozlem Ergun, Mostafa H. Ammar , "Multi-path selection for multiple description video streaming over overlay networks", Signal Processing: Image Communication Volume 20, Issue 1, January 2005, Pages 39-60.

[11] Yen-Chi Lee, Joohee Kim, Yucel Altunbasak, Russell M. Mersereau, "Layered coded vs. multiple description coded video over error-prone networks" Signal Processing: Image Communication 18, pp.337–356, 2003.

[12] N.Gomathi, Dr.P.Seethalakshmi, and Dr.A.Govardhan, "A cross layer Design to Enhance Throughput for Multimedia Streaming over Mobile Ad hoc Networks " International Journal on Computer Science and Engineering Vol. 3 No. 1 Jan 2011, pp.114-126

Mrs.N.Gomathi has received her B.E. degree in Electronics and Communication Engineering in 1996 from Madras University and M.E. degree in Computer Science and Engineering in 2001 from Anna University, India. She has 13 years of teaching experience and currently she is working as Professor in the Department of computer Science and Engineering, Veltech Multitech Engineering College, Anna University, India. Her area of research includes Multimedia Streaming, and Wireless Networks.

Dr. P. Seethalakshmi has received her B.E. degree in Electronics and Communication Engineering in 1991 and M.E. degree in Applied Electronics in 1995 from Bharathiar University, India. She obtained her doctoral degree from Anna University Chennai, India in the year 2004. She has 15 years of teaching experience and currently she is working in the Department of computer Science and Engineering, Anna University, Trichy, India. Her area of research includes Multimedia Streaming, Distributed Computing, Wireless Networks, Network Processors and Web Services.

Dr.A.Govardhan did his B.E in computer science and engineering from Osmania University College of Engineering, Hyderabad, India in 1992, M.Tech from Jawaharlal Nehru University (JNU). Delhi in 1994 and he earned his Ph.D from Jawaharlal Nehru Technological University, Hyderabad (JNTUH) in 2003. He joined Jawaharlal Nehru Technological University in year 1994 as an Asst.Prof, became Associate Professor in 1999 and professor in 2006.He is a member of Standing Committee for Academic Senate, JNT University Hyderabad and Academic Advisory Committee (AAC), UGC-Academic Staff College, JNT Hyderabad. He is presently a Professor of CSE and Principal, JNTUH college of engineering Nachupally (Kondagattu), Karimnagar Dt., India.