

# Multi-Metric Routing Techniques for Video Quality Improvement Using Cross-layer Approach

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**ABSTRACT:** Video communication over wireless network hampers due to mobility of the nodes. Performance of the wireless networks depends upon multiple links, number of nodes and mobility of nodes. There might be possibility of link breakage during video transmission over the wireless network. This affects the quality of service of the video. While transmitting MPEG-4 video over Wireless Mesh Networks many parameters such as delay, latency needs to be considered. Cross layer approach is proposed to maximize the video quality for such time critical application. A Cross-layer approach allows interaction between the layers to enhance video quality. Parameters from different layers can be exchanged to improve quality of service. At the application layer MPEG-4 video is pre-processed to extract I,P,B frames. This information about the video frames can be shared with the network layer so that appropriate routing metrics can be chosen. Hop count is commonly used routing metrics to find out the path which can provide better QoS best route. Expected Transmission Count (ETX) metric is added along with hop count metric to select best QoS route. Performance metrics such as throughput, packet delivery ratio is improved.

**KEYWORDS:** Cross-Layer Approach, Expected transmission count, Hop Count, MPEG-4, Wireless Mesh Network.

## I. INTRODUCTION

Various parameters need to be considered while transmitting video over wireless mesh network. Cross-Layer approach is a mechanism to share information among layers. Cross-Layer design can be achieved by direct communication between layers, sharing database. Services provided by the Wireless technology are video traffic and data traffic. A wireless mesh network dynamically configures links between nodes but it is affected by density of traffic, network topology, transmission power and nodes [1]. Major challenge is to deliver video, multimedia traffic over the networks without degrading the network performance. While designing wireless networks different parameters such as number of nodes, mobility of nodes. The presence of wireless link inspires designer to use Cross-Layer approach that provides full freedom to exchange the parameter information among different layers. Multipath fading, changing channel characteristics, interference, and congestion in network degrade performance of network which indirectly hamper the video quality. Video quality can be improved by joint optimization of network parameters at different layers. Bandwidth availability is another issue with wireless network. Compression techniques are designed to overcome this problem. MPEG-2, MPEG-4, H.261, H.264 are the commonly used compression techniques. At the application layer MPEG-4 video is pre-processed to extract I,P,B frames. These frame type available at the application layer is exchanged with the lower layers. I frames are the key frames as these are obtained by compressing the information in single field. I frame is having highest priority as compared to P and B frames. Thus the information about the frames and the priority of the frames is passed to the lower layers to select correct network parameter. When multiple paths and multiple metrics are simultaneously used for forwarding the video packets, the assignment of the traffic for video stream must be considered.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

AODV and AOMDV protocol uses single routing metric to transmit the data. Performance of AOMDV is better than AODV as it caches multiple routes initially. Hence even if there is link breakage the AOMDV selects the alternate route which it has already cached. Thus AOMDV is modified so as to use multi routing metrics to ensure better service quality. In this paper discusses performance of the AODV, AOMDV and modified AOMDV protocol. The Modified AOMDV protocol uses cross-layer approach to direct video frames depending on the frame type and priority

## II. RELATED WORK

Quality of multimedia transmission over wireless network is affected by varying nature of wireless channel and disturbances like multipath fading, interference etc. Hence quality of video can be improved by dynamically adapting different payload lengths depending on the channel condition. Sayanthan Choudhury *et al.* proposed an Adaptive frame length transmission algorithm which can be used to select optimal payload size and data rate to maximize user throughput [2]. Simulation was done with different configuration. The First configuration represents a network with no packet collision and packet loss is entirely due to the channel loss. The second configuration represents a network with packet loss due to packet collision and channel loss. The effect of variable payload length and retransmission on throughput is considered. A proper selection of data rate along with payload size is essential to maximize spectral efficiency. In this paper authors have made important observation that the region of the optimal payload length is very narrow at low SNRs. Hence it is very crucial task to select payload length at low SNRs. In MAC layer if there is single bit error then entire payload needs to be discarded. Hence retransmission needs to be done. Though retransmission reduces packet loss rate, it also reduces throughput. In case of multimedia transmission, retransmission must be devised in such a way that it allows some packet loss instead of minimizing packet loss as multimedia traffic can tolerate loss. This helps in achieving higher throughput. If PHY and MAC layer parameters such as data rate, payload length and maximum number of retransmission are adapted then effective throughput can be achieved.

The problem of real time transmission of an individual video bit stream across a multihop 802.11a/e wireless network is investigated in [3]. In this paper it was assumed that mesh network topology is fixed over the duration of video session and before transmission, each application reserves a predetermined transmission opportunity interval. Video quality improvement can be obtained using integrated cross-layer solution. A novel multipath streaming framework over wireless ad hoc networks was proposed in [4]. A heuristic interference-aware multipath routing protocol was proposed which estimated concurrent packet drop probability of two paths by considering interference between links. Two node disjoint paths are chosen to achieve minimum concurrent packet drop probability. Hence robustness of video applications over wireless ad hoc networks can be achieved. Conflict graph is used to model effects of interference between wireless links. The conflict graph indicates which groups of links interfere with each other. This cannot be active simultaneously.

Interference-Minimized Multipath Routing (I2MR) protocol increases throughput by discovering zone-disjoint paths for load balancing [5]. Congestion control schemes are also proposed to increase throughput by loading the active paths at the highest possible rate that can be supported so as to minimize long-term path congestion. Real time transmission of an individual video bitstream across a multihop 802.11a/e wireless network is considered in [6]. The optimization algorithm adopts that each application reserves a predetermined transmission opportunity (TXOP) interval at each node.

## III. PROPOSED SYSTEM

In the proposed method, the video pre-processing is done at the application layer. It extracts the I, P, B information from the video. This information is passed to the network layer. The modified protocol implements multi routing metric which uses expected transmission count (ETX) and hop count. Expected transmission count is the count that defines number of transmission on the given link. If the link is not reliable, there can be number of retransmission on that link. Depending on the number of retransmission, expected transmission count can be identified. The link having lesser ETX is the reliable link. Hence the information that is having higher priority can be transmitted through that link. I and P frames can be transmitted through the routes which is having lesser ETX value. B frame is transmitted through the

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

route which is having ETX greater than the route which is used to transmit I frame. For transmitting voice hop count metric is used.

## Algorithm:

- 1) At the application layer video is pre-processed to extract I,P,B frames.
- 2) If the received frame is video frame the protocol switches to ETX Metric.
- 3) If the video frame is I or P frame the path which is having the lowest transmission count is assigned. This is the link having highest link quality.
- 4) If the video frame is B frame the second lowest transmission count is assigned.
- 5) Video traffic is routed to the path depending on the hop count metric.

## IV. INTEGRATION OF EVALVID TOOL WITH NS2

Experimentation of MPEG-4 video transmission is carried out using Evalvid tool. Evalvid tool is an Evaluation Framework for MPEG video transmission in NS2 environment. Following are the steps to integrate evalvid tool with NS2:

**Step 1:** packet.h needs to be modified to add frametype\_ and sendtime\_ field in common folder.

**Step 2:** Modify agent.h to add frame type for MPEG 4 transmission.

**Step 3:** mympeg folder is created under ns-2.35 and the files myudp.cc, myudp.h, myudpsink2.cc, myudpsink2.h, and mytraffictace2.cc are added to the folder.

The files are available on the site [7].

**Step 4:** Modify the file tcl/lib/ns-default.tcl to add default values.

**Step 5:** Makefile needs to be modified by adding mympeg/myudp.o, mympeg/myudpsink2.o and mympeg/mytraffictace2.o in the OBJ\_CC list.

**Step 6:** Recompile NS2 by using below commands

- ./configure
- make clean
- make
- make install

## V. VIDEO PROCESSING

Cygwin environment is used for video processing. Foreman Video is taken as sample for experimental purpose. The standard qcif (176 \* 144) Foreman video is in raw YUV format. Video is compressed using FFmpeg. Video processing is carried out in following steps [8 ]:

**Step 1:** Encode the raw yuv video with ffmpeg.

In this step raw foreman video is converted into m4v format by defining following parameters:

1. ffmpeg command is used for compression.
2. Value of group of picture (GOP) is set to 9.
3. Value of rate (r) is set to 30 frames/second.
4. Number of b frames between I and P frame is 2
5. Quantization value is set to 1.

## Command:

```
./ffmpeg.exe -s qcif -vcodec mpeg4 -r 30 -g 9 -bf 2 -qscale 1 -i foreman_qcif.yuv foreman_qcif.m4v
```

Fig 1 (a) shows the encoding of the the foreman video and (b) shows the encoded video in m4v format.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

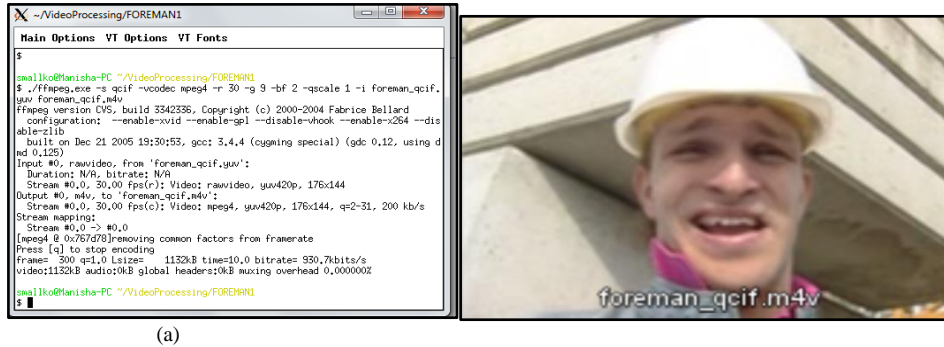


Fig. 1. Compression of video using FFMPEG (a) Encoding of Foreman video into mp4 (b) Result of conversion: m4v video [9]

## Step 2: MP4Box is used to Convert m4v to mp4 video.

Command:

```
./MP4Box.exe -hint -mtu 1024 -fps 30 -addforeman_qcif.m4v foreman_qcif.mp4
```

Fig 2 (a) shows the conversion of m4v to mp4 video and (b) shows the video in mp4 format.

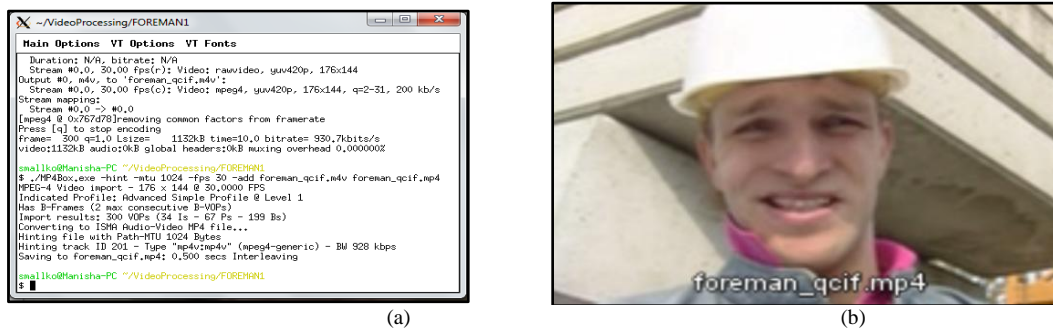


Fig. 2.MPEG-4 video conversion (a) Conversion of m4v to mp4 video(b) Result of conversion: mp4 video [ 9]

## Step 3: The mp4trace sends a mp4-file perRTP/UDP/IP to a specified destination host.

Command:

```
./mp4trace.exe -f -s 192.168.0.2 12346foreman_qcif.mp4 > foreman_qcif.st
```

Fig 3 (a) shows the extraction of I,P,B frames into text file and (b) shows the foreman\_st file format.

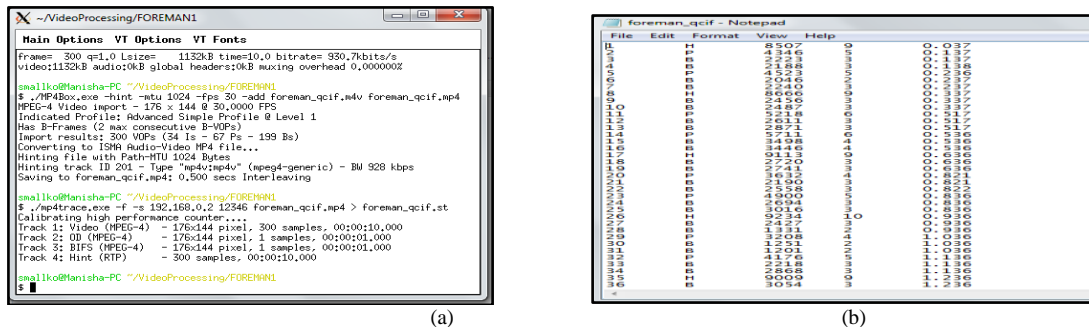


Fig. 3.Extraction of I,P,B frames from Foreman video. (a) Conversion of the video into trace file (b) Result of conversion: foreman\_st file [9]

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

## VI. EXPERIMENTAL RESULTS

Performance of the modified protocol is simulated using NS2.ns-2.35 is used and evalvid tool is integrated with it. Table I shows the simulation parameters configured.

Table I : Simulation Parameters

Parameters	Value
Network Interface Type	Wireless Physical
Radio Propagation Model	Two-Ray Ground
Antenna	Omni-directional Antenna
Link Layer	Link Layer (LL)
Interface Queue	Priority Queue
Routing Protocol	AODV,AOMDV

The performance parameters such as Packet delivery ratio, throughput, end-to-end delay and normalized routing overhead is calculated using awk files which processes the trace file to extract information.

### 1 Packet Delivery Ratio:

The packet delivery ratio (PDR) defined as a ratio of numbers of data packets reached to target over the network to number of packets generated.

$$PDR = \frac{\sum(\text{Number of Packet Receive})}{\sum(\text{Number of Packet Send})}$$

Fig 4 shows the graph of number of video streams vs packet delivery ratio. The Modified Protocol achieves higher PDR as compared to AODV and AOMDV protocol.

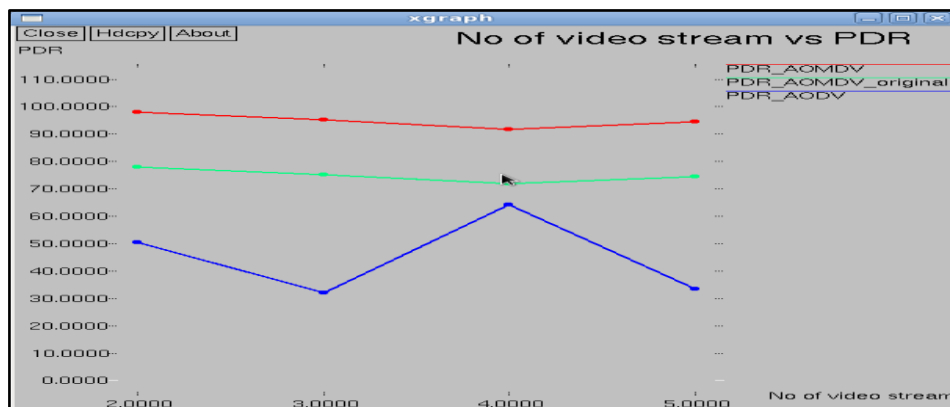


Fig 4: No of Video streams vs Packet Delivery Ratio

### 2 Throughput:

Throughput can be defined as the ratio of the total bytes in data packets received by sink nodes to time from first packets generated at a source to last packet received by sink nodes.

$$\text{Throughput} = \frac{\text{Total bytes in data packets received by sink node}}{\text{Time from first packet generated at source to last packet received by sink node}}$$

Fig 5 shows the graph of time vs throughput. The Modified Protocol achieves higher Throughput as compared to AODV and AOMDV protocol.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

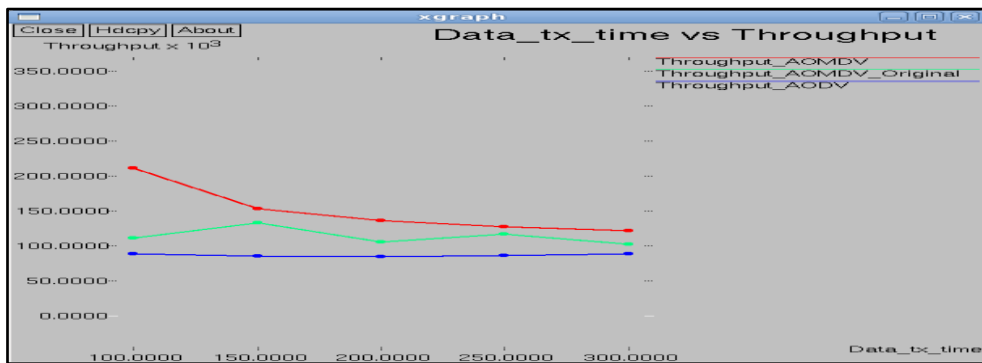


Fig 5: Time vs throughput

### 3 End to End Delay:

End-to-End Delay (E2ED) refers to time occupied by a data packet travel from a source to a destination in a network. Fig 6 shows the graph of number of nodes vs end-to-end delay. The Modified Protocol has less end to end delay as compared to compared to AODV and AOMDV protocol.

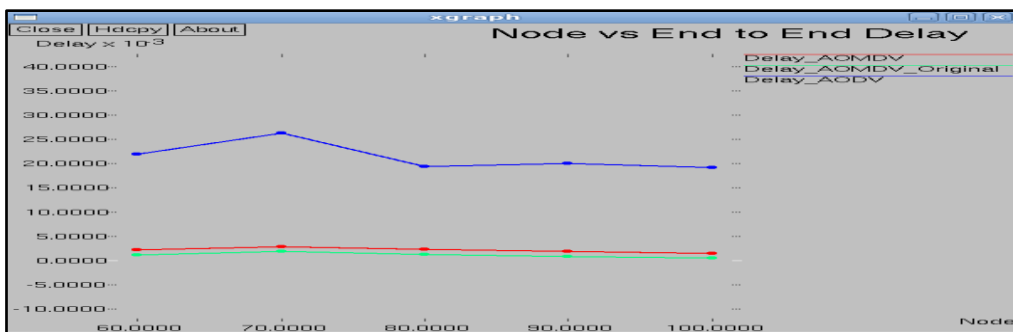


Fig 6: Node vs End to End Delay

### 4 Normalized Routing Overhead:

Routing overhead is defined as number of extra packets required for the network communication. Fig 7 shows the graph of number of video streams vs Normalized overhead. The Modified Protocol has less routing overhead as compared to AODV and AOMDV protocol.

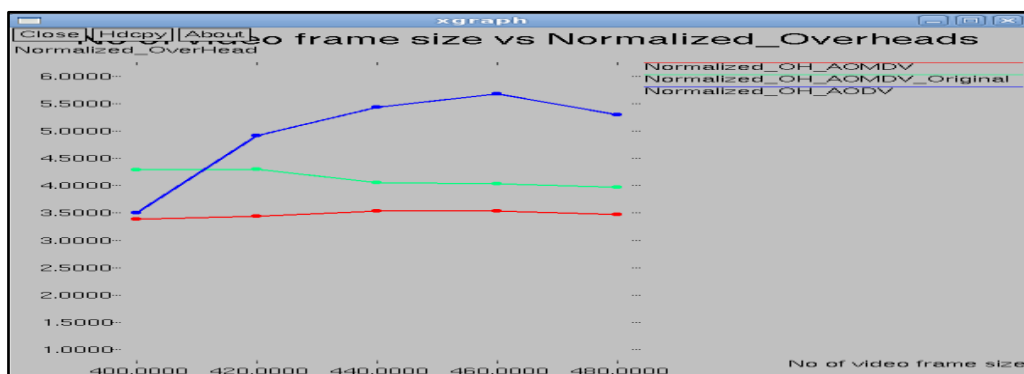


Fig.7: No of video frame vs Normalized routing overhead



# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

## VII. CONCLUSION

The proposed approach performs better in terms of packet delivery ratio, throughput, reducing routing overhead and end to end delay. The Proposed modified AOMDV routing protocol uses cross layer approach to improve video quality of MPEG 4 video transmission over wireless mesh network. It adds another Quality of Service Parameter ETX metric as a new routing metric to select the best Quality of Service.

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