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Enhancement to Distortion-Resistant Routing Framework for Video Traffic in Wireless Multihop Networks

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***Abstract*– Routing protocols designed for wireless networks since a long time are application specific. Here, we are working to reduce distortion in video traffic flowing over a wireless network. Today's users demand high quality videos to be delivered seamlessly on their devices. In this paper, we discuss routing policies to reduce video distortion on an end to end basis. Conventional and popular link based routing metrics such as ETX cause high video distortion as they do not account for dependence across the links of a path. Hence, video traffic merges onto few paths causing distortion. To reduce the distortion in videos and report frame loss in videos, we build an analytical framework. A routing protocol for reducing distortion in videos is designed based on the framework's routing policy. Simulations are done to show the protocol designed is efficient in minimizing video distortion.**

***Keywords*– wireless network, video distortion, distortion minimization, routing protocol.**

I. INTRODUCTION

Broadband and wireless communication systems in today's world are more robust and ubiquitous than they used to be earlier [2]. In day to day life we observe wireless communications happening in cellular and wireless local area networks. This communication is observed only in the last two devices i.e. a base station and a wireless end system. Multihop wireless networks have one or many intermediate nodes which independently communicate among themselves along the route and send or receive packets using wireless links. Multihop networks can perform routing in a self-made manner, since they don't rely on any past framework base [1].

Internet applications such as IPTV (Internet Protocol Television) and VOIP (Voice over Internet Protocol) which have high bit – rate multimedia content and high QOS (Quality of Service) are being delivered to users due to increase in bandwidths of broadband year after year. Providing broadband access is still a challenge in rural and mountainous regions because of technical and/or economic reasons due to which people living in such regions cannot benefit from the advantages offered by broadband access [1]. 802.11 WLANs have limited coverage and one-hop wireless networks such as 3G and licensed WiMAX are costly and usually require licences for channel. Multihop broadband wireless networks is a solution which provides broadband access along with much needed QoS [1]. Multihop wireless networks have one or many intermediate nodes which independently communicate among themselves along the route and send or receive packets using wireless links. Multihop networks can perform routing in a self-made manner, since they don't rely on any past framework base.

Research interest has been increasing in wireless networks to deliver multimedia services as multimedia is expected to be a major traffic source over next – generation wireless networks [3]. Multimedia traffic is becoming very popular in wireless networks with the coming of smartphones. Transfer of video clips, pictures and voice data in areas of natural calamities, disaster recovery, drought hit areas, etc. to facilitate mission management by government agencies and NGO's has come as a hope to people in distress. Under such extreme scenarios maintaining a good quality of the video which is transferred is demanding from the user's prospect. The quality of video sent over wireless network is influenced by: 1) the use of compression techniques during which noise or distortion is added at the source and 2) both, errors entering in wireless channel and tampering also causes distortion in video [4].

Transmission losses can prevented by using different levels of encoding described in video encoding standards like MPEG-4 [7] or H.264/AVC [8]. I-type, P-type and B-type frames are groups of frame types which are defined in these encoding standards. In case of I-type frames data is encoded independently. In case of P-type and B-type frames encoding is performed based on the data encoded within other frames. Application-level performance of video transmissions can be derived using Group of Pictures (GoP) which allows for the matching of frame losses into a distortion metric [4].

Routing is the most often neglected critical functionality which affects the end-to-end video quality. There is a correlation between losses on the links that constitute routes from a source node to a destination node but most routing protocols which are designed for wireless multihop networks are application specific. Sometimes, few links can become heavily loaded with traffic which results in video distortion and while other links are less utilized as network traffic is independent. Network parameters and not application parameters are the only basis on which most of the routing protocols make their decisions to route the traffic [4].

II. Related Work – Existing Systems and their Limitations

Encoding and transmission of a video is handled in many ways and there are plenty of recommendations from different standardization bodies which govern the encoding and transmission of video. Original video clip can be fragmented into a number of substreams and transmitted over disjoint paths on a network. This technique to fragment an original video clip and then transmit is called Multiple Description Coding (MDC). Decoding process of the original video clip can be successful using the descriptions sent on the network and the quality of the video is improved with the number of decoded substreams. Layered Coding is another technique to send and improve the video quality. Multiple enhancement layers along with a base layer are used in this technique. Base layer is the most significant layer as enhancement layers are there only to refine the base layer quality and not useful by themselves. Therefore, in an encoded signal the base layer is the most critical layer. Layered Coding is adopted in this paper due to its popularity in applications and standards adopted [4], [5], [6].

Layered coding transmits video standards like MPEG-4 [7] and H.264/AVC [8] which provides guidelines on encoding and transmission of a video over a network. Different levels of encoding are to separate original video clip into an array of frames of different priorities with respect to quality. These are called I-, P- and B-frames. A structure named GOP (Group of Pictures) consists of group of such frames. I-frame is the initial frame in each GOP which is decoded independently from the same GOP without any other information. An array of P- and B-frames follows the I-frame which is used as a source to encode video clip. To decode other frames P-frames can also be used as a source [4].

The signal processing experimentation community is the pioneer in conducting research on frame – loss – resilient video [9]. Original video is divided into high and low priority frames and high priority frames are protected by FEC in [10]. Due to quantization and frames losses there is temporal and spatial error introduced in the video stream. To calculate the distortion introduced in the video an algorithm is proposed in [11] which is used for switching between inter and intracoding modes per macroblock. This results in higher Peak Signal to Noise Ratio (PSNR) [4]. Introduction of inter/intracoding with extra/redundant macroblocks is used to attain an enhancement to the transmission robustness of the coded bitstream [12]. Rate-distortion optimization scheme is used to determine the coding parameters. Simulations are conducted to evaluate these schemes. Simulations are done with a consistent frame-loss rate to observe the effect on network transmission. The characteristics of real world systems are not captured in such simulations [12].

To study the effects of wireless channel fading on video distortion a framework is designed in [13] which it is only credible for single-hop transmission. There is another credible amount of work performed on a single link in [14]. Experimentation is done to study the effects of frame loss and how much of distortion can be handled by the compressed video with respect to the length of error in a frame. A two dimensional Markov chain system is introduced after examining the achievement of video streaming over multihop 802.11 wireless network. End to end QoS is planned and deployed in video streaming model of two dimensional Markov chain along with performace evaluation. To reveal the average distortion transmitted along consecutive P-frames is formulated using a recursion model in [16]. Impact of routing on video distortion is not considered or done in any of the above researches.

Wireless 4G networks are also used to examine the performance of video transmissions since they have support high Quality of Service for video transmission. H.264/SVC encoding is examined over mobile WiMAX [17]. Quality of Service which is experienced by the end user is represented by metrics such as PSNR and MOS. Conclusion is that the performance is dependent on various encoding schemes used in protocols and reacts differently to the loss of frames in network. Again the impact of routing on video distortion is not considered or done in any of the above researches.

Routing algorithms for Quality of Service and cross layer optimization on wireless ad hoc and mesh networks is researched extensively [1], [2], [3], [18]. Based upon protocol evaluation metrics such as transport/application, network and MAC layer metrics, QoS can be divided in several ways. A survey of the same is done in [19]. Performance metrics specifically defined for video transmission is not taken into account in any of the routing schemes presented in the surveys. The applications need to indicate throughput and delay constraints even when a routing scheme with QoS is defined. In our approach, video distortion metric which is related to application performance metric is directly integrated into the route selection system.

To improve the Quality of Service multipath routing schemes are used in video transmission and routing is focussed on Multiple Description Coding [20], [21]. Disjoint paths are calculated using information collected at the destination node and this is an extension of Dynamic Source Routing which is used to support multipath video transmission. The routing scheme designed here is based totally on simulation without any analysis [20]. Disjoint paths in [21] are calculated by scheduling a given set of path lengths and there is no performance metric defined directly with video quality and instead delay constraints are used in the optimization. Minimization of overall video distortion is achieved by selecting routing paths properly. This is defined using a rate distortion model and used in an optimization problem. Wireless ad hoc networks use MDC for video multicasting. Selection of routes using optimization problem is a complex issue, hence a heuristic based algorithm is used to calculate the routes. [22], [23]. The models used in [22] and [23] use MDC to take into account the distortion of the video and we use LC approach along with differing on the way we model video distortion. 802.11 wireless mesh networks use multipath routing scheme for delivering video stream and it relies maximum on disjoint paths to gain good traffic engineering. The objective considered here is different as it aims to reduce the latency of video transmissions and does not consider distortion as a user based metric [24].

In [25] a hierarchical model is used to design a routing scheme for energy efficient video transmission with minimum QoS degradation for LC. Such hierarchical models depend on nodes which are combined in clusters and a periodic process of electing a cluster head takes place. This increases administrative frames on the network thereby increasing the processing and data communication. A model where all nodes of a network perform the same set of tasks and are equal without any hierarchy is proposed in our scheme.

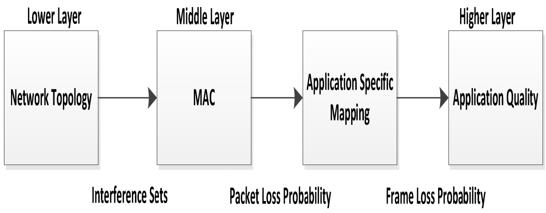

Figure 1 Multilayer Design

III. PROPOSED SYSTEM

In this paper, we discuss how video distortion experienced by the end user can be significantly reduced and the quality of video is improved by computing the application requirements. Certain number of packet losses per frame can be handled by different schemes used to encode a video clip. Any frame cannot be decoded if the lost packets in a frame exceed a certain threshold value. Distortion increases in a video stream with every loss of frame. At each hop along the path from source to destination the value of distortion depends on the positions of the unrecoverable video frames in the GOP. Multilayer design approach is used in our model as shown in Fig1. Evolution of frame losses in GOP are designed in an analytical model which used to outline the dynamic behaviour of the process instead of just focussing on a single network quality metric such as packet-loss probability. The probability of frame loss in GOP is matched with probability of packet loss on a link. Video distortion metric is then directly related to probability of frame loss. Routing can be posed as an optimization problem by using the above mapping from packet loss probability to video distortion where the objective is to minimize the end to end distortion by finding the path from source to destination [4].

In our conception, along the complete path total history of losses in GoP is taken into report specifically compared to traditional routing such as total expected transmission count (ETX) [26] which is in contrast to our routing protocol where the links are independently treated. Frame loss process is captured using dynamic programming approach. To minimize distortion, we have designed a routing protocol based in the above solution. I-type frames which are longer frames among the three frames are carried on the paths that have least congestion since the loss of these frames that carry fine grained information affects the distortion metric more. With minimum distortion our routing scheme is optimized for transmission of video clips on wireless networks and constraints relating to time like jitter are not taken into account directly in the design [4].

A. *Advantages of Proposed System*

1) *Impact of routing on video distortion is developed using a systematic approach:* A systematic approach that captures the impact of routing on the end to end quality of video in terms of distortion is the primary contribution. Minimum distortion is attained by computation of optimal routes in the framework. Impact of Physical layer and MAC layer is jointly considered in the model and the application semantics on the video quality [4].

2) *Distortion resistant video delivery system is designed using a practical routing protocol:* In accordance to the distortion and the position of a frame in the GoP, the source is used to collect distortion information on the links in the network designed in the protocol. Primarily wireless video is carried on the network using this routing protocol [4].

3) *Extensive experimentation done for evaluations:* End to end video distortion is kept to a minimum and proved by using the protocol which is tested by simulations and real-time experimentation using an 802.11a mulihop network. Peak Signal to Noise Ratio of video traffic is increased by 20% while using this protocol. This produces traffic with a MOS (Mean Opinion Score) that is 3 times higher when compared to traditional routing schemes. Quality of video received at the destination is improved significantly with gains in PSNR and MOS [10]. Different system parameters are also used to evaluate our protocol [4].

IV. SYSTEM DESIGN

Figure 2 and figure 3 shows an array of steps which are followed by each node in the network. Figure 2 shows the steps followed by the source node in a flowchart. Figure 3 shows the steps followed by the destination node and intermediate node in a flowchart.

Knowledge of the complete network which includes the nodes in the network and the quality of the links between these nodes is required to solve the issue of Minimum Distortion Routing (MDR). However, information about global state is not most of the times available to the nodes due to the dynamic nature and distributed operations of a network. The answer to MDR issue is obtained by the partial information gathered by the source node regarding the global state of the network. To gather the information regarding the state of the network the source node has to sample the network during a path discover process [4].

For every wireless link in the network estimation of ETX metric is included in the sampling process [26]. Quality of links is measured by the estimates obtained by above process. Probe messages are sent periodically to perform the estimation process by tracking the successful broadcasting of messages. During the Route Discovery Phase ETX estimates gathered from the neighbourhood nodes are appended in the Route Request messages. Route reply message is sent back to the source that contains the ETX estimates after the message is received by the destination [4].

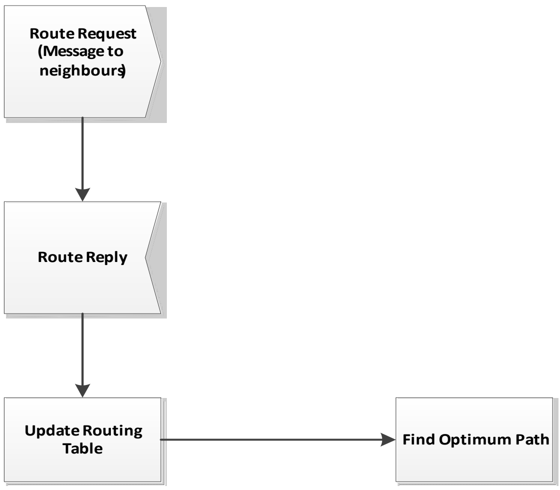

Figure 2 - Flowchart for application-aware routing (Source Node)

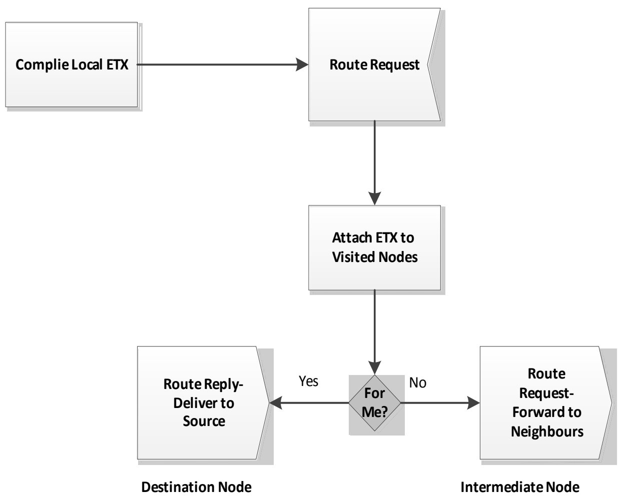

Figure 3 - Flowchart for application-aware routing (Destination & Intermediate Node)

V. Implementation

The proposed approach comprises the accompanying steps: Multihop routing networks, Video distortion model, Video distortion minimization and Video distortion dynamics.

A. Multi hops routing networks

Multi-jump cell system (MCN) is a design proposed for remote correspondence and MCNs join the advantages of having a settled base of base stations and the adaptability of specially appointed systems. They are equipped for accomplishing much higher throughput than current cell frameworks, which can be named single-jump cell systems (SCNs). This work focuses on MCNs and SCNs utilizing the IEEE 802.11 standard for remote LANs. We give a general outline of the engineering and the issues required in the configuration of MCNs, specifically the difficulties to be met in the configuration of a directing convention. We propose a steering convention for use in such systems. We lead broad test contemplates on the execution of MCNs and SCNs under different burden conditions (both TCP and UDP). At that point concentrates plainly demonstrate that MCNs with the proposed steering convention are a suitable option for SCNs, truth be told they give much higher throughput.

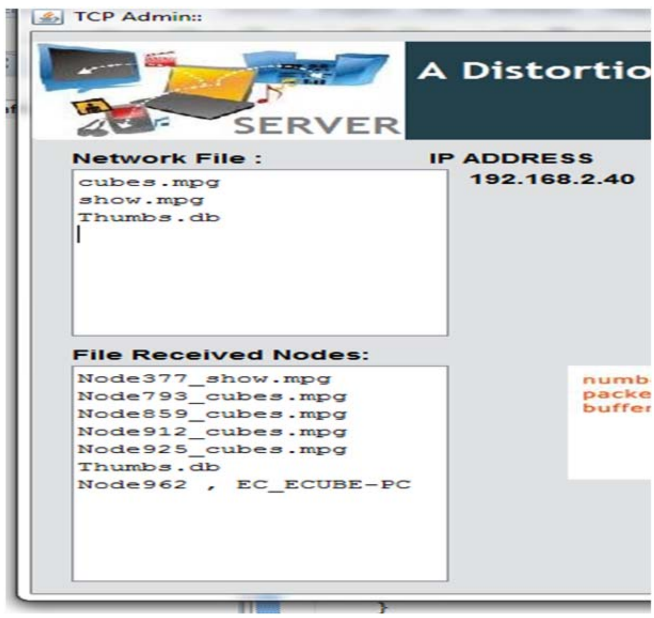

Figure 4 - Multihop Network Model

B. Video Distortion Model

Analytical model couples the functionality of the physical and MAC layers of the network. The application layer for a video clip is sent from a source to a destination node. The model for the lower layers computes the packet-loss probability by a set of equations. Packet-loss probability is then input to a second model to compute the frame-loss probability then corresponding distortion.

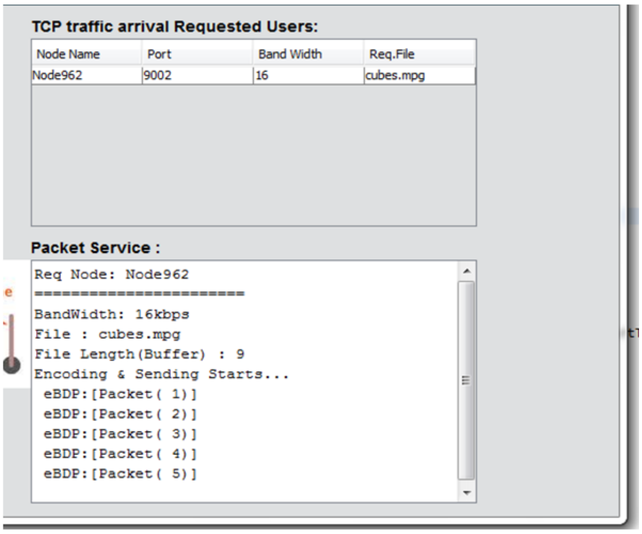

Figure 5 - Video Distortion Process

C. *Video Distortion Minimization*

Solution to the problem is based on a dynamic programming approach that effectively captures frame-loss process. A practical routing protocol is designed to minimise the distortion. The loss of the longer I-frames carry information affects the distortion metric more. The approach ensures that these frames are carried on the paths that experience the least congestion.

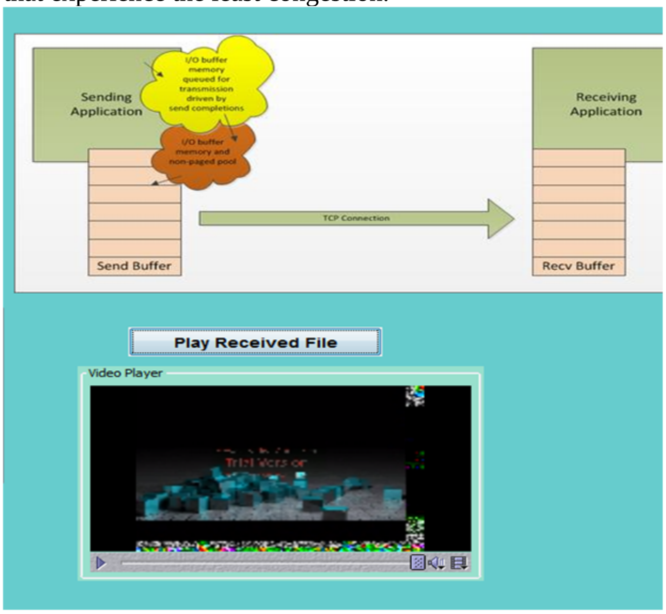

Figure 6 - Video Distortion Minimization

D. *Video Distortion Dynamics*

An analytical model is structured to characterize the dynamic behavior of the process that describes the evolution of frame losses in the GOP as video is delivered on an end-to-end path. The model captures how the choice of path for an end-to-end flow affects the performance of a flow in terms of video distortion.

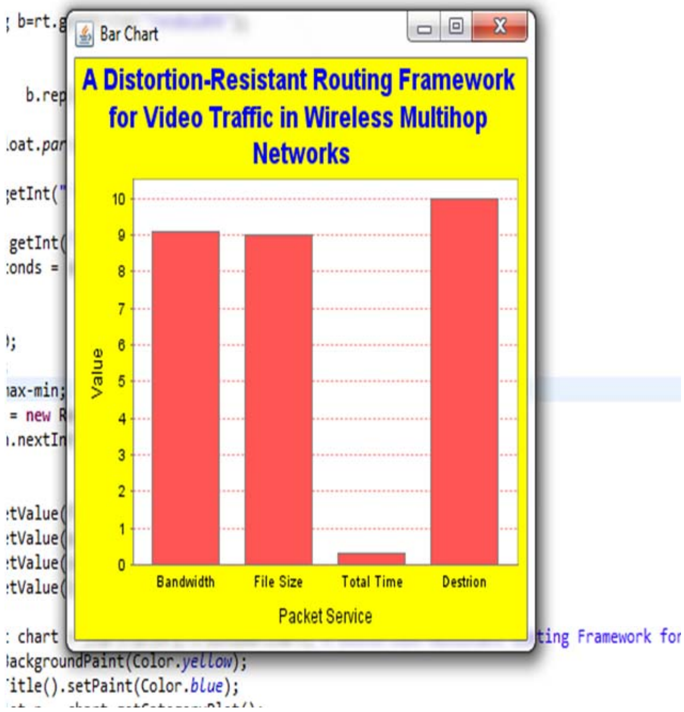

Figure 7 - Video Distortion Dynamics

VI. Simulation

A. *Step 1*

Client requests for video file from server.

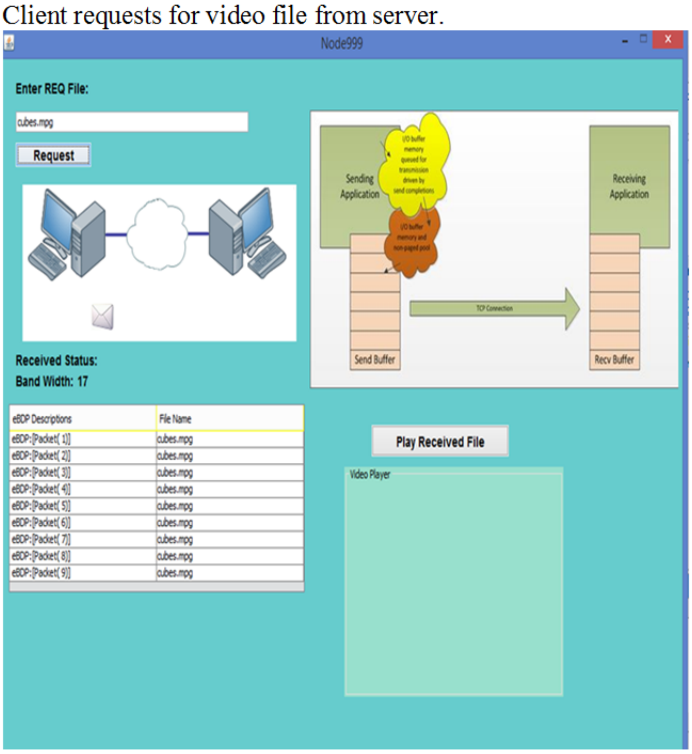

Figure 8 - Client Request

B. Step 2

Server checks for the file in its database and responds back to the client.

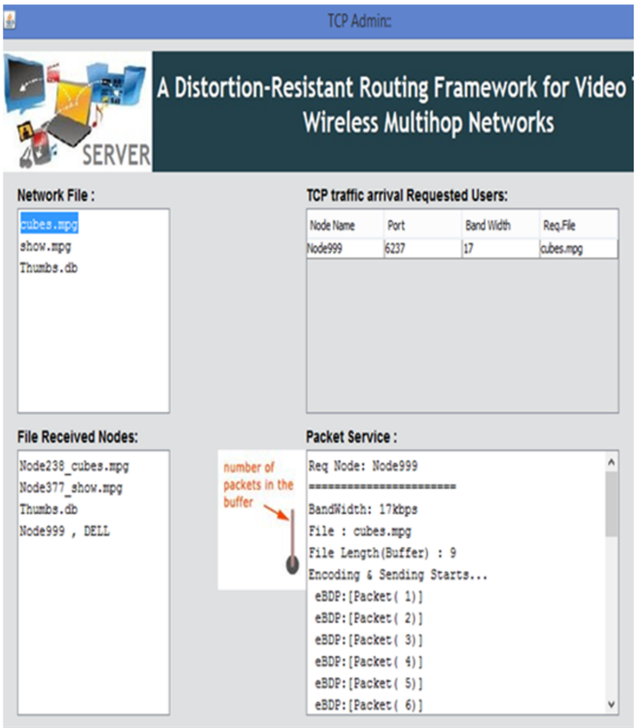

Figure 9 - Database Lookup by Server

C. Step 3

Client is receiving video one packet at a time while displaying the IP address and bandwidth used in the process.

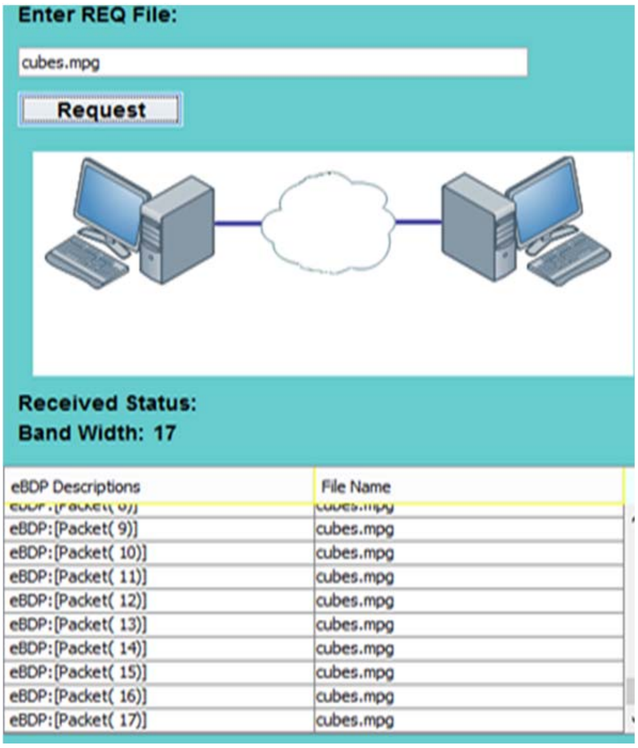

Figure 10 - Packets Received by Client

D. Step 4

Server displays the response results like file size, name of the file requested, number of packets sent, and bandwidth.

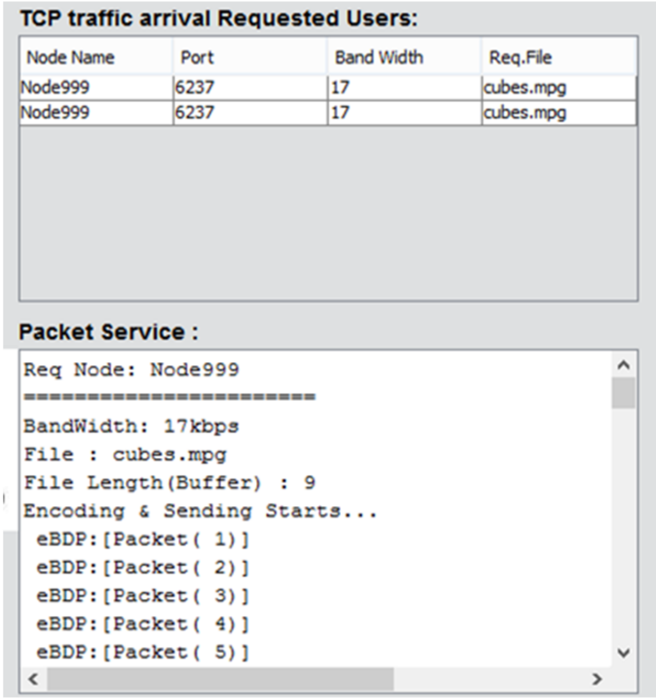

Figure 11 - Server Response

E. Step 5

Client receives the distortion-resistant video with better quality.

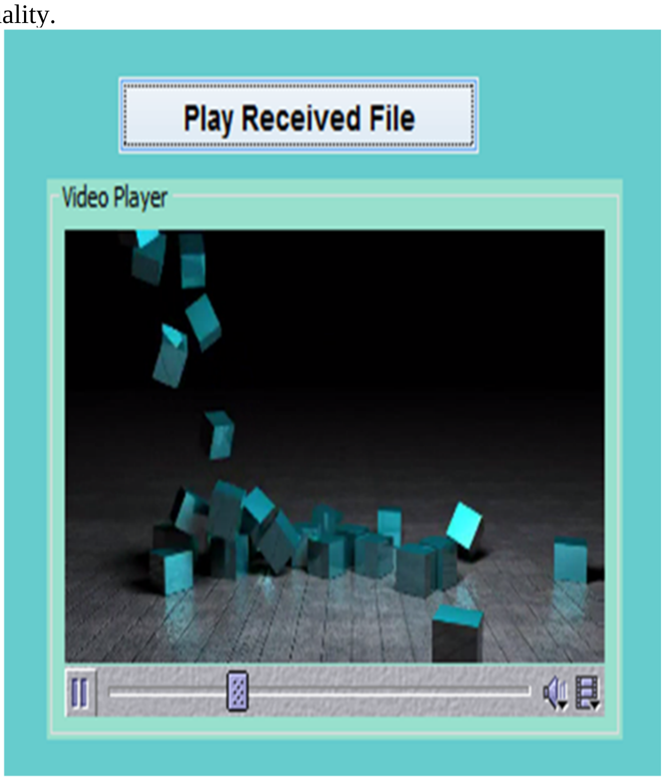

Figure 12 - Distortion Resistant Video at Destination

VII. RESULTS

A. *Comparative Analysis through Video Quality*

Figure 13 - Existing System

Figure 14 - Proposed Distortion Resistant Routing Algorithm

B. *Comparative Analysis through Bar Chart*

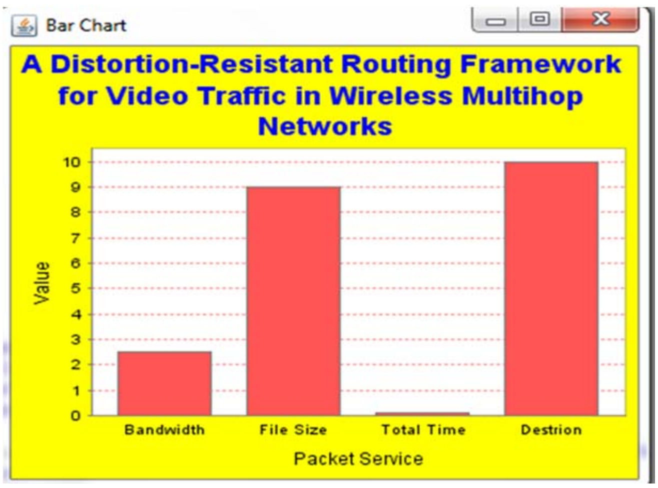

Figure 15 - Existing System

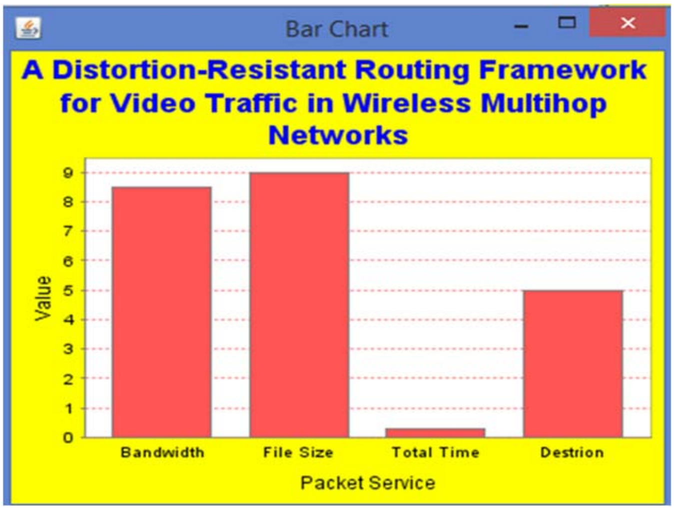

Figure 16 - Proposed Distortion Resistant Routing Algorithm

VIII. ENHANCEMENT TO THE PROPOSED SYSTEM

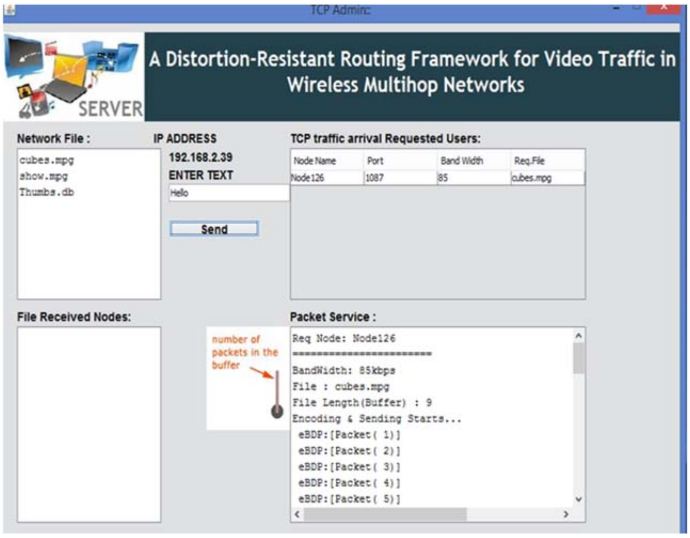

Figure 17 - Server Sends a Hello Text Message to Client along with the Video

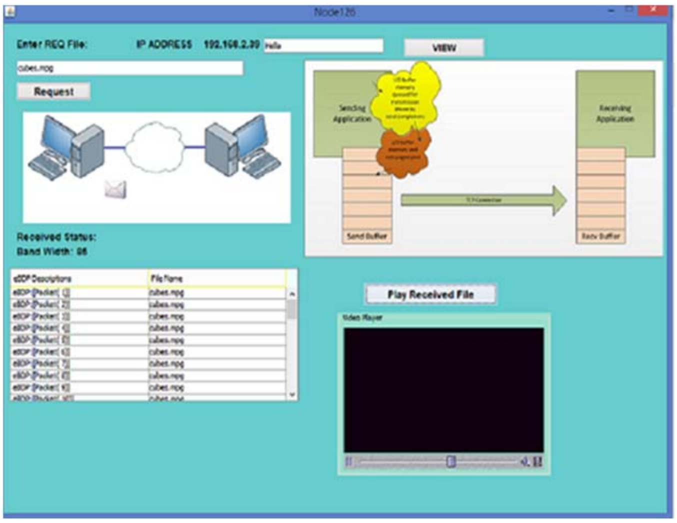

Figure 18 - Client Receives the Hello Text Message from Server along with the Video

IX. CONCLUSION

Due to the flaws and drawbacks of existing system in providing distortion free video an Analytical framework was developed using multihop wireless network to reduce the distortion while sending the video from source to destination. The Analytical framework uses the newly designed distortion resistance routing protocol for minimization of distortion in the video. The Proposed model improves the video quality by minimization of the distortion.

X. FUTURE SCOPE

Multiple videos can be sent to destination node at a time. The Text message sent along with video can be encrypted using cypher text methods.

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