Global Journal of Computer Science and Technology: E
Network, Web & Security
Volume 15 Issue 4 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

A Cross Layer Model to Support Qos for Multimedia Applications on Wireless Networks

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GJCST-E Classification : *C.2.1*

Strictly as per the compliance and regulations of:

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I. Introduction

The increasing demand by of users to access infotainment solutions on wireless networks aid development of novel models to support applications [1] [2]. To support such multimedia application delivery on wireless networks high bandwidth [3], quality of service (QoS) [4], stringent delay requirements have to be accounted for. Wireless networks are characterized by limited bandwidth, hop based routing and error prone nature. This nature tends to induce transmission loss, delayed delivery and high jitter in supporting video streaming applications [5] [6]. The $ISO/IEC\ MPEG$ [7] group and the $ITU-T\ VCEG$ [8] groups have standardized the Scalable Video Coding (SVC) extension to the existing $H.264$video compression standard which can be adopted to support multimedia applications on wireless networks [9]. The SVC compression technique enables video encoding taking into account the varied quality, spatial and temporal parameters, thus providing adaptability. Considering wireless networks based on the network conditions, network configuration, application demands and QoS parameters the SVC video encoding can be adopted to support multimedia transmissions.

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Adoption of the SVC for multimedia data delivery on wireless networks cannot be considered as a holistic solution. . Video transmissions are delay bound and delivery of the data packets within the delay deadlines is of most importance [1] [5] [11] [14]. The multimedia data delivery is achieved through hop based mechanisms in wireless networks. The distortion and the available channel capacity vary during data delivery which needs to be accounted for. The end to end delay varies based on the physical layer condition and the buffering mechanism at the medium access. The transmission errors induced cause packet retransmission overheads. Based on the physical layer conditions the next hop routing mechanism also requires constant updation. In short it can be stated that, delivery of delay sensitive data on wireless networks put forth variations in the physical layer, medium access control layer (MAC) and the routing layer. Apart from these variations observed it is also critical to establish a balance between the data delivery and the QoS provided. Providing QoS at the cost of delayed data delivery is ineffective in the case of multimedia data [1] [14]. To address these issues researchers have proposed a cross layer architectures to account for the dynamics observed at the physical, MAC and routing layer for multimedia data [3] [12] [13] [14]. Combining cross layer optimization and SVC encoding for multimedia data delivery has been considered in [11], [15] and the results obtained prove the efficiency and assure QoS provisioning.

The existing models fail to address the tradeoff relation that exist between the QoS of the SVC encoded data transmission and end to delay i.e. if the QoS to be provisioned is high the end to end delays are high proved in [14]. To address this issue this paper introduces the QoS improvement scheme in video transmission ($QIVST$) model adopting a cross layer optimization approach. The $QIVST$ model considers the SVC encoded video streams for transmissions. Based on the physical layer conditions of the wireless network, the quality adaptation specifier (S_{s1}) and the physical layer knowledge specifier$(S_{s2})$are identified. A novel encoding scheme of the SVC video utilizing the S_{s1}andS_{s2} is considered at the MAC layer. The packets constructed at the MAC layer are routed through the next hop node based on the S_{s1}, S_{s2} and pending packets in that node. A similar approach is adopted at every intermediate hop node. The $QIVST$ model proposed is designed to address the tradeoff between QoS provisioning and delivery of the delay bound multimedia data. The cross layer optimization adopted in the $QIVST$ model provides adaptability to achieve better QoS in wireless networks and ensures the essential delay bound multimedia data delivery.

The remaining manuscript is organized as follows. A brief of the literature review discussing the state of the art mechanisms that currently exist is discussed in section 2. The proposed $QIVST$ model is presented in Section 3 of this paper. The simulation study with performance comparisons is discussed in the penultimate section of this paper. The conclusions and future work is discussed in the Section 5.

II. Literature Review

Numerous work considering multimedia data delivery on wireless networks has been proposed by researchers. A brief of the literature studied during the course of the research presented here is discussed in this section.

An ant colony optimization algorithm to support video streaming services on wireless mobile networks is proposed in [3]. A dual layer architecture constituting of the mini-community network layer and the community member layer is considered in [3]. The mini-community layer enables robust video data delivery and access methodologies. The resource and member management is achieved by the community member layer. The results presented prove the efficiency of the biologically inspired ant colony optimization.

A cross layer optimization technique to support video transmissions on wireless networks has been proposed by Yuanzhang Xiao et al [12]. The importance of resource allocation to support video transmissions is discussed. The cross layer architecture proposed by Yuanzhang Xiao et al enables dynamic scheduling and resource allocations among the wireless user nodes based on the physical channel conditions and the dynamics of video transmissions.

The cross layer fairness driven stream control transmission protocol based concurrent multipath transfer solution ($CMT-CL/FD$) is proposed in [13]. The efficiency of utilizing multipaths for video content delivery is highlighted. Optimizations were adopted at the physical, data link and transport layer in the $CMT-CL/FD$ to support video applications on heterogeneous wireless networks. In $CMT-CL/FD$ the cross layer optimization is adopted only at the transmitter.

Hypertext Transfer Protocol ($HTTP$) based Dynamic Adaptive Streaming ($DASH$) of SVC video in wireless networks is discussed in [11]. A cross layer optimization based on the Lagrangian method is adopted in $DASH$ to support streaming of SVC video. A novel resource allocation and packet scheduling algorithm is considered in $DASH$. Th e tradeoff that exists between data delivery and QoS of video transmissions is discussed. The tradeoff issue is addressed by Mincheng Zhao et al through a proxy based bitrate stabilization algorithm introduced in $DASH$.

Transmission of SVC video data in multi input multi output ($MIMO$) wireless systems is proposed by Xiang Chen et al [15]. A cross layer approach adopting optimizations based on the physical and application layer is proposed by Xiang Chen et al. To reduce transmission errors and reduce the number of retransmissions FEC mechanisms are also employed by the authors in [15]. An adaptive channel power allocation scheme is used in [15] to improve the QoS of video transmissions. The work proposed by Xiang Chen et al bears the closest similarity to the work proposed here and is further used for performance comparisons with our proposed $QIVST$ model. The major drawback of the cross layer approach proposed in [15] is that the tradeoff that exists between QoS provisioning and video data delivery is not addressed.

III. QoS Improvement Scheme in Video Transmission $QISVT$

a) *Wireless Network Modelling*

Let us consider a wireless network $\mathcal{N}$ deployed over an area of $\mathcal{A}$ sq.meters. The network N consists of a set of I nodes sharing the multimedia content D with J receiver nodes. The channel matrix of the b^{th} node is represented as $C[b]$ where $b \in I \parallel J$. The wireless channel Bandwidth considered is R_c and the channel error rate is represented by R_e. The channel noise is represented as N . The SVC video data [1] is considered as the multimedia content. Video transmissions are bulky and require efficient transmission mechanisms to meet the desired QoS. In the $QISVT$ model introduced in this paper the video content is initially encoded using the MPEG video coder. The $MPEG$ video coder considered adopts the Group of Pictures (GOP) structure described in [2] [14]. The GOP structure is shown in Fig.1. of this paper.

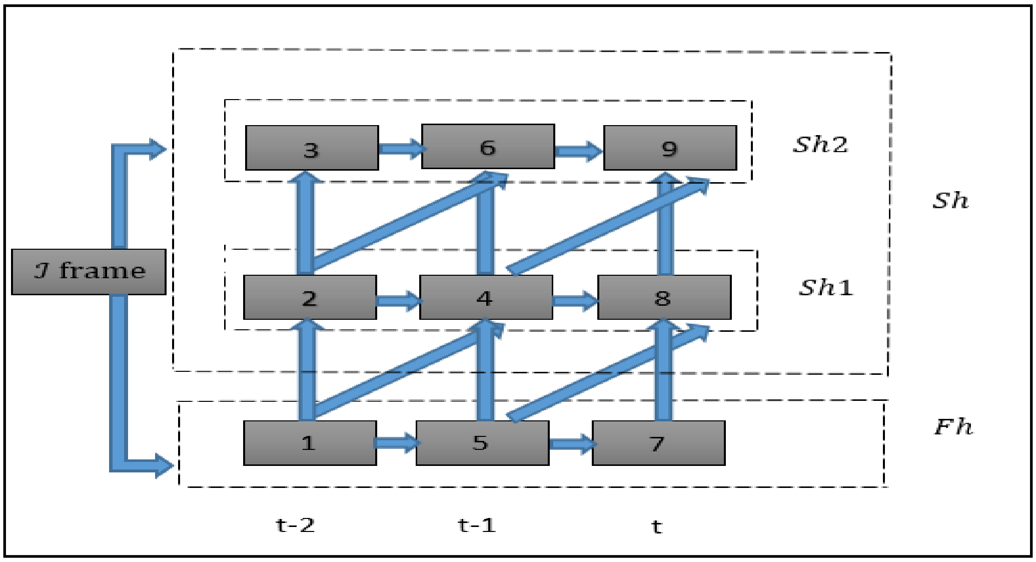


Figure 1 : Packet loss compensation by error correction in video transmission using QISVT scheme

The encoded frames are indexed by $g = 1,2,3 \dots\dots$. In the $QISVT$ model introduced the initial frame/reference frame $\mathcal{I}$ is transmitted first. The base layer B frame is donated as Fh and the enhancement/quality layer P frame is represented as Sh. In the existing mechanisms discussed earlier a loss of the FH and SH frame results in a retransmission enhancing end to end delays and reducing the wireless transmission QoS. To improve the QoS in multimedia content delivery over the network $\mathcal{N}$ the $QISVT$ model introduces a novel cross layer adaption technique[3]. By acquiring the prevailing physical layer properties of the node, the MAC layer packetization techniques and the routing to the neighboring nodes are accordingly adapted to achieve a cross layer design discussed in the proceeding sub-section of the paper.

b) Cross-Layer Design Of The $QISVT$ model

A discrete time based model to describe the cross layer architecture of the $QISVT$ model is considered. Let us consider a node $i \in I$ transmitting content D to its neighbor $j \in J$. At time $t-2$ the I frame is transmitted. The X_{t-1} frame consisting of $X_{t-1}^{F_h}$ and $X_{t-1}^{S_h}$ is transmitted at the $(t-1)^{th}$ time instance. In the $QISVT$ model the Sh frame is assumed to consist of two sub-frames namely $Sh1$ and $Sh2$ i.e. $Sh = Sh1 + Sh2$. The sub frame construction is considered to encode the previous Fh frame into the $Sh1$ and transmit it wirelessly to the node j at time t . The adoption of the sub-framing technique enables reconstruction of the Fh in case of transmission errors. The encoded frame $X1_t^{S_h,e}$ is defined as

$$X1_t^{S_h,e} = \left((1-S_{s1})X_{t-1}^{F_h}\right) + \left(S_{s1} \times X_{t-1}^{S_h}\right) \qquad (1)$$

Where S_{s1} is the Quality layer adaptation specifier introduced in the $QISVT$ model. Based on the physical layer parameters, the node bandwidth supported, the pending packets in the MAC queue and channel noise thevalue of S_{s1} is established on runtime. The quality adaptation specifier is constrained by the set $S_{s1} \in \{0, 0.1, 0.2 \dots 1\}$. The S_{s1} specifier enables in controlling the quality of the video transmission between the nodes i and j . Considering $S_{s1} = 1$ the best QoS can be achieved. When $S_{s1} = 0$ only the Fh is transmitted resulting in lower quality.

To account for the physical layer conditions in the MAC encoder the Physical Layer Knowledge Specifier S_{s2} parameter is introduced and is defined as

$$S_{s2} = Val : Val = \{0, \dots 1\} \qquad (2)$$

By introducing the S_{s2} parameter the composition of the $Sh1$ and $Sh2$ sub frames is achieved accounting for the physical layer parameters. If $S_{s2} = 0$ then $Sh1 = Fh$ and $Sh2 = \emptyset$ i.e. the physical layer exhibits high distortion and the transmission of the Fh layer is only considered. If $S_{s2} = 1$ then $Sh1 = Sh$ and $Sh2 = \emptyset$ is considered as an ideal condition when the physical channel exhibits no signal distortion hence the entire Sh layer is considered for transmission. The S_{s2} and S_{s1} parameters are derived based on the physical layer measurements carried out at Δt intervals. The channel noise, packet delay and the error rate observed in transmitting the frame $\mathcal{I}$ enables in initialization. The proposed MAC layer encoding can be now defined as

$$X1_t^{S_h,e,S_{s2}} = \left((1-S_{s1})X_{t-1}^{F_h}\right) + \left(S_{s1} \times X_{t-1.}^{S_h,S_{s2}}\right) \qquad (3)$$

Where ${X_1}_t^{S_h,e,S_{s2}}$ represents the MAC encoded data derived from the previous $X_{t-1}^{F_h}$ and $X_{t-1}^{S_h,S_{s2}}$ frame to be transmitted.

The MAC encoding is presented in Fig.2. of this paper.

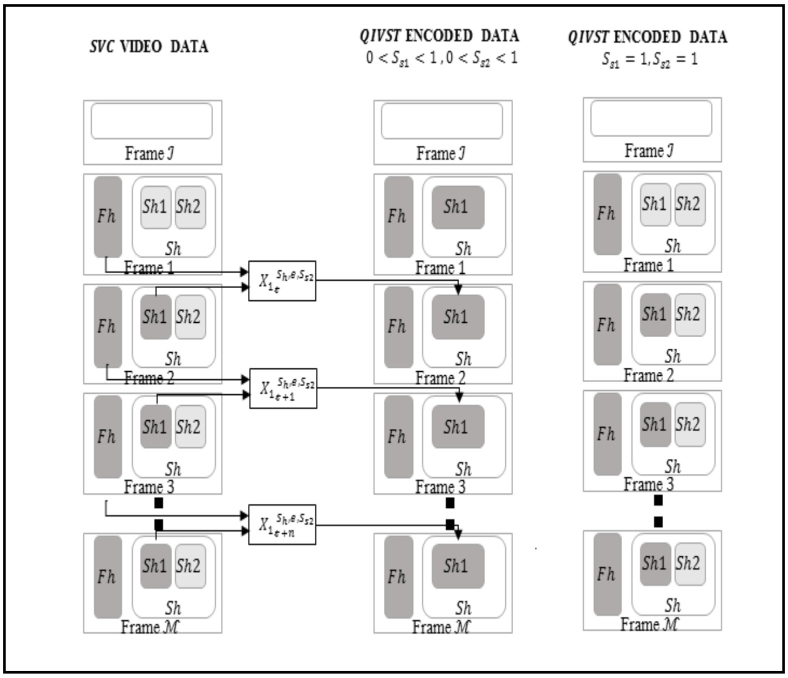


Figure 2 : Adaptive MAC encoding based on the QISVT model

Based on the MAC queues pending, S_{s1} and the S_{s2} parameter the routing layer is optimized to select the next hop neighbor node to achieve QoS.

The $QISVT$ model can be summarized as follows:

Step 1: Initialize Encoded Multimedia Data D

Step 2: Initialize Transmitting Node i and Receiving Node j

Step 2: Extract the frame $\mathfrak{J}$ and transmit from Node $i \rightarrow j$

Step 3: Measure Error Rate, Delay.

Step 4: Based on the measurements initialize S_{s2} and S_{s1}

Step 5: Based on D the Fh and Sh frame Data is derived.

Step 6: Based on S_{s2} and S_{s1} derive $Sh1$ and $Sh2$ and perform MAC encoding using Equation 3.

Step 7: Based on the MAC packet Queues Pending, S_{s2} and S_{s1} perform routing optimization to select hop node.

i. *Video Distortion in the $QIVST$ model*

Transmission over wireless channels induces errors in transmission. The transmission errors result in a huge number of video packet errors and losses. On packet error or loss occurrences, packet retransmission request and response messages are propagated. This phenomena induces huge amounts of overheads and the video packet delivery time increases effecting QoS. To improve QoS the cross layer $QIVST$ model to reduce packet delivery delays is introduced in this paper. The distortion observed at the receiver is proportional to the channel noise. When the channel noise observed is large, the $QIVST$ adapts to enable successful transmissions compromising QoS as video data delivery is delay bound. Packets delivered beyond the delay bound possess no significance and are generally dropped. The $QIVST$ model proposed provides a delicate tradeoff between timely delivery of data packets and QoS .The encoding at the MAC layer ${X_1}_t^{S_h,e,S_{s2}}$ enables recovery of the Fh from the encoded enhancement layer packet in case the base layer packet is lost. The encoding enables to achieve optimal QoS in noisy environments. In this section the modelling of the packet error probabilities, video frame transmissions, frame reconstruction, frame decoding, frame errors and the distortions observed is discussed.

Let the data D to be transmitted using the $QISVT$ model form $\mathcal{M}^{total}$ encoded packets. Each packet consists of b symbols. The symbols b need to be transmitted on the wireless Radio Layer Switching mode of $T_{(b)}$ through a channel which has an allocated bandwidth based channel rate of $R_{c(b)}$.The additive white gaussian noise present in the wireless channels induces transmission errors. The error rate experienced by the symbol b is given by $R_{e(b)}\left(R_{c(b)}, T_{(b)}\right)$.

Let us assume that there are $\mathcal{M}^{total}$ number of video packets formed from the video to be transmitted.In error free enviromets the complete $\mathcal{M}^{total}$ packets when transmitted will be received, decoding which would form the data D.In practical enviromets or actual conditions transmission errors occour due to the noise present in the wireless transmission medium. If out of $\mathcal{M}^{total}$ Packets only $\mathcal{M}$ packets are transmitted successfully and remaining $(\mathcal{M}^{total} - \mathcal{M})$ packets are lost during transmission such that error occurs at the $(\mathcal{M}+1)th$ packet, the probability of such an occurrence if $\mathcal{M} = 0$ is

$$Occ(\mathcal{M}|\mathcal{M}^{total}) = R_{e(b)}(R_{c(b)}, T_{(b)}) \quad (4)$$

The probability of occurrence during the transmission being active i.e. $0 < \mathcal{M} < \mathcal{M}^{total}$ is given by

$$Occ(\mathcal{M}|\mathcal{M}^{total}) = \prod_{d=1}^{\mathcal{M}} \left(1 - R_{e(d)}(R_{c(d)}, T_{(d)})\right) \times \left(R_{e(p+1)}(R_{c(p+1)}, T_{(p+1)})\right) \quad (5)$$

Considering $\mathcal{M} = \mathcal{M}^{total}$ the error probablity occurance is defined as

$$Occ(\mathcal{M}|\mathcal{M}^{total}) = \prod_{d=1}^{\mathcal{M}^{total}} \left(1 - R_{e(d)}(R_{c(d)}, T_{(d)})\right) \quad (6)$$

Let us consider at the t^{th}time the receiver node receives $\mathcal{M}$ video packets successfully out of the $\mathcal{M}^{total}$ packets. If $A_d$represents the number of symbols in the d^{th} packet, then the cumulative video data available at the receiver i.e. R^{rx}can be computed using

$$R^{rx} = \sum_{d=1}^{\mathcal{M}} (R_{c(d)} \times A_d) \quad (7)$$

The $QIVST$ model priorities the delivery of the Fh ensuring the delay constraints are attained. If the Fh encoded packet at thet^{th}time instance i.e. $X_t^{F_h}$ is lost then its recovery is possible from the $X_{1\,t+1}^{S_h,e,S_{s2}}$ encoded packet. Let the function $Dt(R^{rx}, S_{s1}, S_{s2})$ represent the distortion observed per frame at the receiver post decoding considering all the symbols of the Fh layer, the quality layer adaptation specifier S_{s1} , the physical layer knowledge specifier S_{s2} and $R^{rx}$is the total symbols of the Sh layer. Based on the error probabilities and the distortions of the individual frames the average distortion $Dt_{avg}[(S_{s1}, S_{s2})]$can be computed using

$$Dt_{avg}[(S_{s1}, S_{s2})] = Dt(0, S_{s1}, S_{s2})Occ(0 \mid \mathcal{M}^{total}) + \sum_{\mathcal{M}=1}^{\mathcal{M}^{total}} \{Dt(R^{rx}, S_{s1}, S_{s2})Occ(\mathcal{M} \mid \mathcal{M}^{total})\} \quad (8)$$

where $Dt(0, S_{s1}, S_{s2})$ represents the distortion observed with respect to the reference frame $\mathcal{J}$

The parameter S_{s2} controls the composition of the Sh data. In the case when channel noise is present and the channel bandwidth cannot support the transmission of the entire Sh layer i.e. $0 < S_{s1} < 1$ and$0 < S_{s2} < 1$, a part of theSh_2 is not considered for encoding and transmission and is defined as

$$V_t^{S_h} = X_t - (X_t^{F_h} - X_{t-1}^{F_h}) - X_{1\,t}^{S_h,e,S_{s2}} \quad (9)$$

Where $X_t$is the original frame considered at the t^{th}time instance.

To achieve optimum QoS the Fh layer is transmitted and the $Sh1$ is encoded at the MAC layer and transmitted. Let $V_t^{S_h1}$ represent the MAC encoded data of $Sh1$ and $V_t^{S_h2}$denote the decoded $Sh1$ data at the receiver. In the $QIVST$ model the packet loss probability of the Fh is assumed to be 0. The frame reconstructed at the decoder at the t^{th}time instance is defined as

$$X_{2\,t} = V_t^{S_h2} + (X_t^{F_h} - X_{t-1}^{F_h}) + X_{2\,t}^{S_h,d,S_{s2}} \quad (10)$$

where $X_{2\,t}^{S_h,d,S_{s2}}$represents the data at the receiver on performing the MAC layer decoding on the encoded data$X_{1\,t}^{S_h,e,S_{s2}}$.

The decoded version of $X_{1\,t}^{S_h,e,S_{s2}}$at the receiver on the basis of the partially decoded data of the Sh data i.e. $X_{2\,t-1.}^{S_h,S_{s2}}$is defined as

$$X_{2\,t}^{S_h,d,S_{s2}} = \left((1 - S_{s1})X_{t-1}^{F_h}\right) + \left(S_{s1} \times X_{2\,t-1.}^{S_h,S_{s2}}\right) \quad (11)$$

Utilizing the above definition in Equation 10 we obtain

$$X_{2\,t} = V_t^{S_h2} + \left(S_{s1} \times (X_{2\,t-1.}^{S_h,S_{s2}} - X_{t-1}^{F_h})\right) + X_t^{F_h} \quad (12)$$

where $X_{2\,t-1.}^{S_h,S_{s2}}$ is the partially decoded data of the Sh layer at the $(t-1)^{th}$time instance and is defined as

$$X_{2\,t-1.}^{S_h,S_{s2}} = V_{t-1}^{S_h2,S_{s2}} + (X_{t-1}^{F_h} - X_{t-2}^{F_h}) + X_{2\,t-1}^{S_h,d,S_{s2}} \quad (13)$$

The partially encoded data of the Sh layer i.e. $Sh1$ at the $(t-1)^{th}$ time instance is defined as

$$X_{t-1.}^{S_h,S_{s2}} = V_{t-1}^{S_h,S_{s2}} + \left(X_{t-1}^{F_h} - X_{t-2}^{F_h}\right) + X_{1_{t-1}}^{S_h,e,S_{s2}} \quad (14)$$

To compute the transmission error the difference between the encoded video frame at the transmitter X_t and the decoded video frame at the receiver X_{2_t} is considered and is defined as

$$T_e = X_t - X_{2_t} = V_t^{S_h} - V_t^{S_h 2} + X_{1_t}^{S_h,e,S_{s2}} - X_{2_t}^{S_h,d,S_{s2}} \quad (15)$$

Using Equation 8 and Equation 12 the error can be simplified as

$$T_e = V_t^{S_h} - V_t^{S_h 2} + \left(S_{s1} \times \left(X_{t-1.}^{S_h,S_{s2}} - X_{2_{t-1}}^{S_h,S_{s2}}\right)\right) \quad (16)$$

Using Equations 13 and equation 14 $\left(X_{t-1.}^{S_h,S_{s2}} - X_{2_{t-1}}^{S_h,S_{s2}}\right)$ cab be represented as

$$\left(X_{t-1.}^{S_h,S_{s2}} - X_{2_{t-1}}^{S_h,S_{s2}}\right) = V_{t-1}^{S_h,S_{s2}} - V_{t-1}^{S_h 2,S_{s2}} + \left(S_{s1} \times \left(X_{t-2}^{S_h,S_{s2}} - X_{2_{t-2}}^{S_h,S_{s2}}\right)\right) \quad (17)$$

The distortion of the m^{th} frame at the receiver post decoding at the at the t^{th} time instance is computed using

$$Dt_m(\mathcal{T}M, S_{s1}, S_{s2}) = Avg[(T_e)^2] \quad (18)$$

where $\mathcal{T}M$ is the throughputs observed as the receiver post decoding considering all the frames from the reference frame $\mathcal{I}$ to the m^{th} frame

From equation 18 it can be observed that the transmission errors effect the throughput observed and also induce distortion in video reconstruction at the receiver. The $QIVST$ model adapts based on the physical layer conditions to minimize the transmission errors by adopting adaptive MAC encoding and route optimization.

IV. Experimental Study

In this section the experimental study conducted to evaluate the performance of the proposed $QIVST$ model is discussed. The experimental study was conducted using Matlab. The performance of the $QIVST$ model is compared with the state of art $Bisection\ Algorithm - A1$ proposed by Xiang Chen et al [15]. Video clips 'City' and 'Stefan' of Common Interchange Format are considered for the experimental study. The video clips 'City' and 'Stefan' are encoded by the reference SVC codec JSVM (Joint Scalable Video Model). The 'City' video consists of 300 frames and the 'Stefan' video of 90 frames. The frame rate considered for both the videos is 30 frames per second. The SVC codec considers the GOP structure.

A wireless network consisting of 15 nodes is considered. The simulation study considers 4 transmitter nodes and 4 receiver nodes. Experiments considering the 'City' and 'Stefan' video were independently conducted. The M-QAM modulation and demodulation schemes were considered in the experimental study. An additive white Gaussian wireless noise channel is considered and the signal to noise ratio 0, 10, 20 and 30 dB is considered. The video transmissions carried out are monitored and the video is reconstructed at the receiver. An average of the monitored values considering 4 transmitters and 4 receivers is presented.

In the prevision section it has been stated that the distortion observed Dt is directly proportional to the transmission errors T_e i.e. $Dt \propto T_e$. The transmission errors observed per frame is represented in terms of the bit error rates (BER) observed for the duration of the simulation. The BER observed considering the 90 frames of the "Stefan" video transmitted is shown in Figure 3, 4 and 5. From the figures it is clear that as the channel noise i.e. SNR increased the distortion increases considering the QIVST model and the $Bisection\ Algorithm - A1$. At a $SNR = 30\ dB$ (in Figure 3) it is observed that the average BER considering the $Bisection\ Algorithm - A1$ is 0.21 and for the $QIVST$ model is 0.17. When the channel noise induced in the simulation environment is $20\ dB$ (in Figure 4) and $10\ dB$ (in Figure 5) the proposed $QIVST$ model based video transmissions achieves a BER reduction of 45.7% and 36.99% when compared to the $Bisection\ Algorithm - A1$. Based on the BER results it is evident that the proposed QIVST model is adaptive and performs better than the existing the $Bisection\ Algorithm - A1$ under varying channel noise conditions. Lower $BER's$ observed tend to enhance the QoS provided to multimedia data delivery over wireless networks.

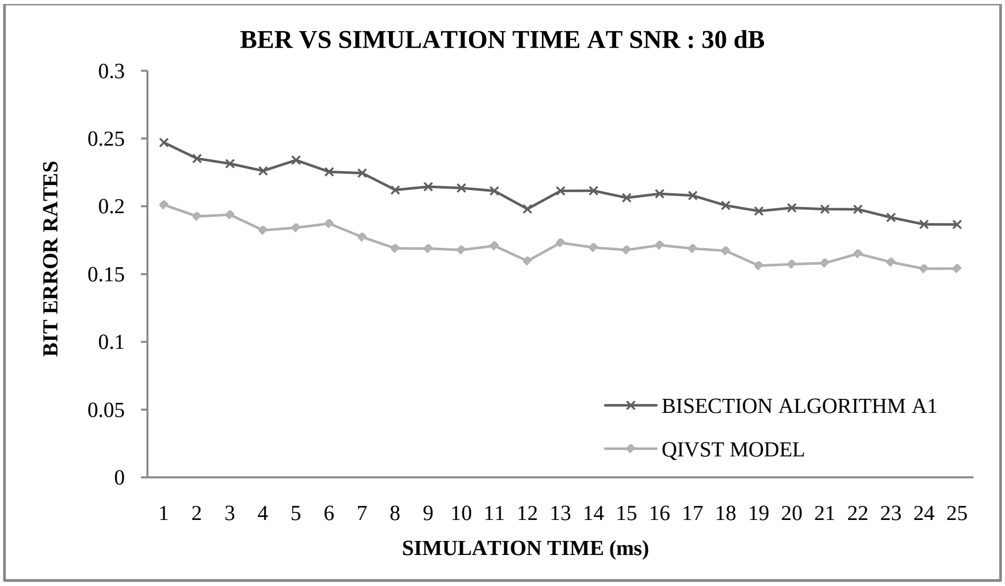


Figure 3 : Distorting Observed in terms of BER at SNR= 30dB vs Simulation Time

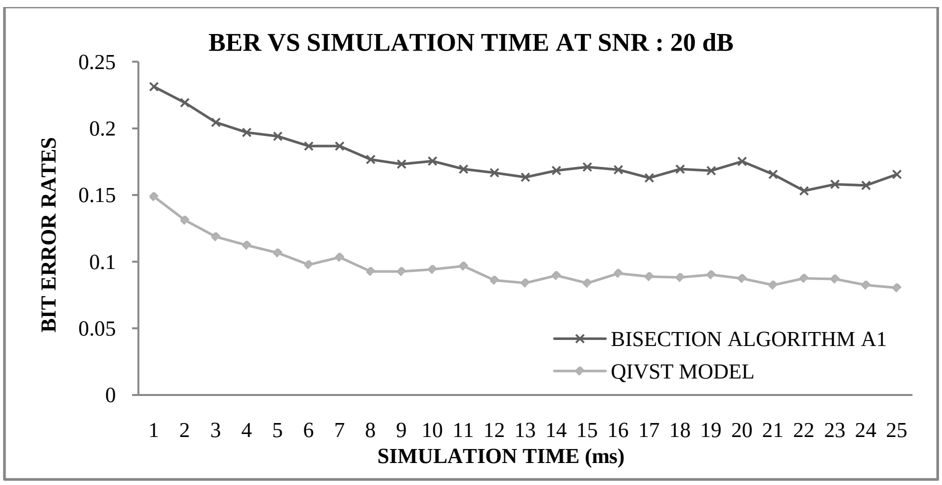


Figure 4 : Distorting Observed in terms of BER at SNR= 20dB vs Simulation Time

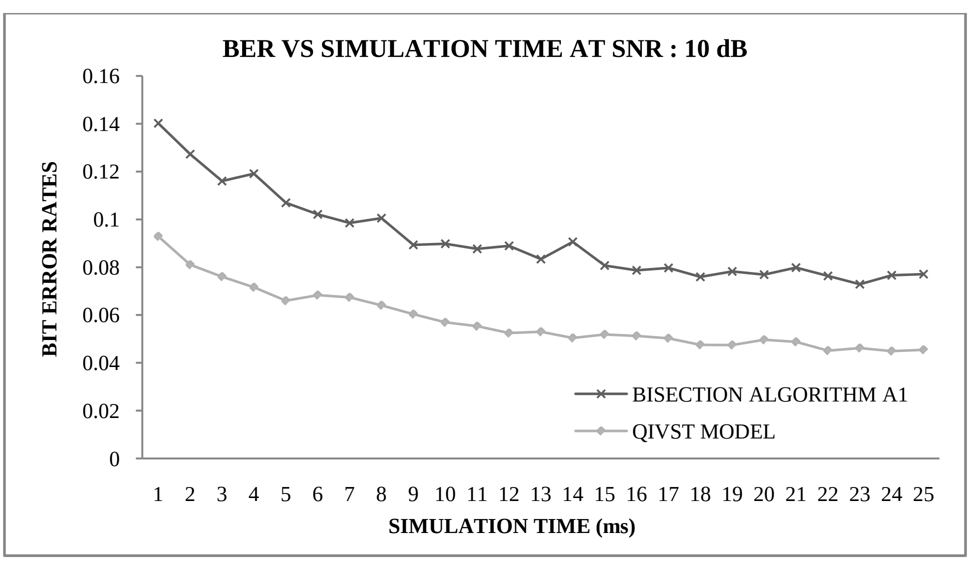


Figure 5 : Distorting Observed in terms of BER at SNR= 10dB vs Simulation Time

From equation 18 it can be observed that the transmission errors effect the throughput observed and also induce distortion in video reconstruction at the receiver. The $QIVST$ model adapts based on the physical layer conditions to minimize the transmission errors by adopting adaptive MAC encoding and route optimization.

In [15] the authors have introduced the "System utility" parameter for performance evaluation. Considering the GOP of video "Stefan" the system utility computed using the $QIVST$ model and the $Bisection\ Algorithm - A1$. The results obtained are graphically shown in Figure 6 of this paper. The system utility increases as the channel noise increases due to transmission errors. The increase in transmission errors induce an additional network overhead by introducing retransmission messages. From the figure it is evident that the proposed $QIVST$ model exhibits a higher system utility when compared to the the $Bisection\ Algorithm - A1$. The adaptive encoding and the cross layer architecture of the QIVST model also contribute to the increased system utility observations.

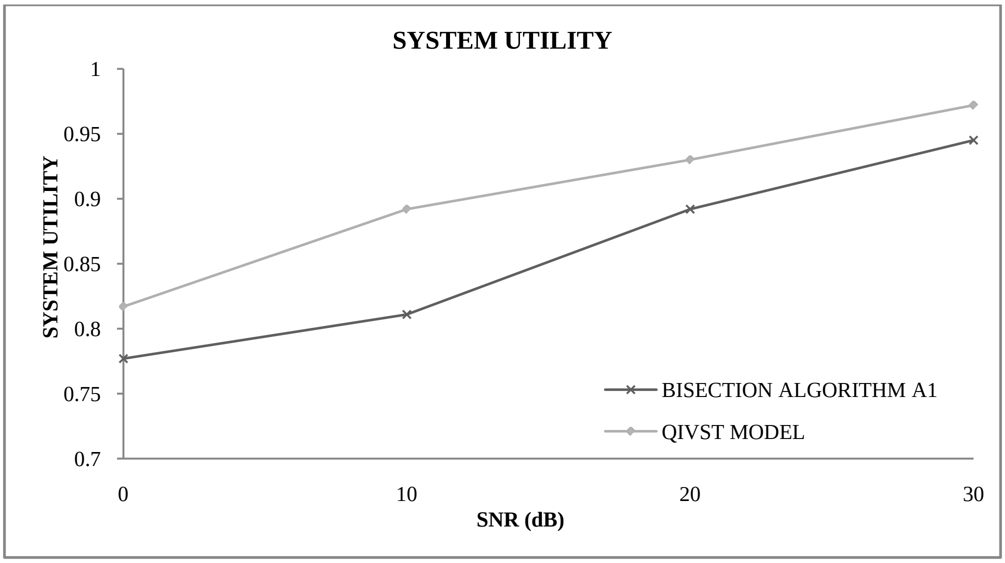
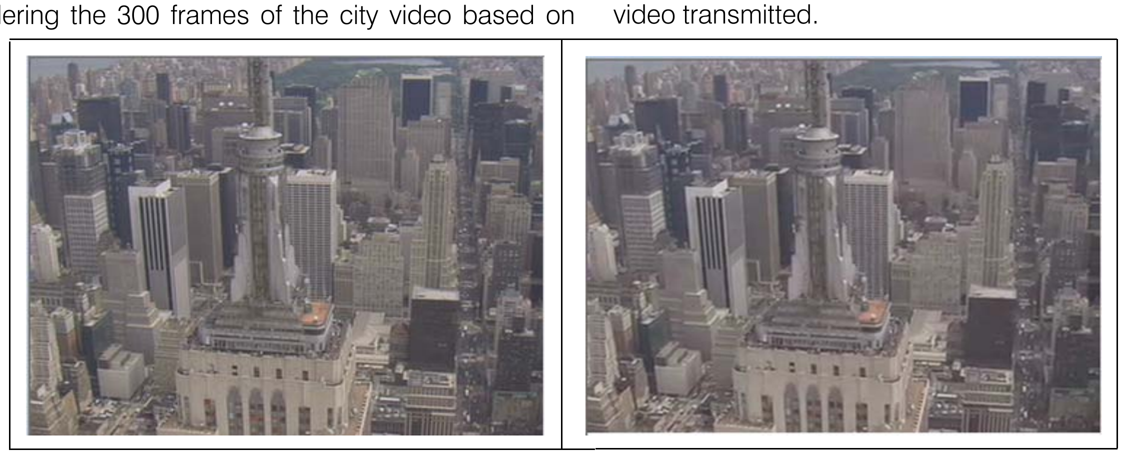


Figure 6 : System Utility

To evaluate the performance of the video delivery on the wireless network the 'City' video and the 'Stefan' video are transmitted. The reconstruction quality is observed in terms of the SNR per frame. For the City video a sample frame reconstructed at the receiver is shown in Figure 7 a considering the $QIVST$ model and Figure 7 b considering the $Bisection\ Algorithm - A1$. The reconstruction quality observed at the receiver considering the 300 frames of the city video based on the proposed QIVST model is shown in Figure 8. The reconstruction quality considering the $Bisection\ Algorithm - A1$ is shown in Figure 9. The reconstruction quality is computed per frame reconstructed at the receiver and is expressed in terms of the $PSNR$ observed. From Figure 8 and 9 it is evident that the $QIVST$ model outperforms the $Bisection\ Algorithm - A1$ in terms of the quality of video transmitted.



a b

Figure 7 : A sample reconstructed frame at the receiver for the "City" video considering the a. QIVST model proposed and b. Bisection Algorithm – A1

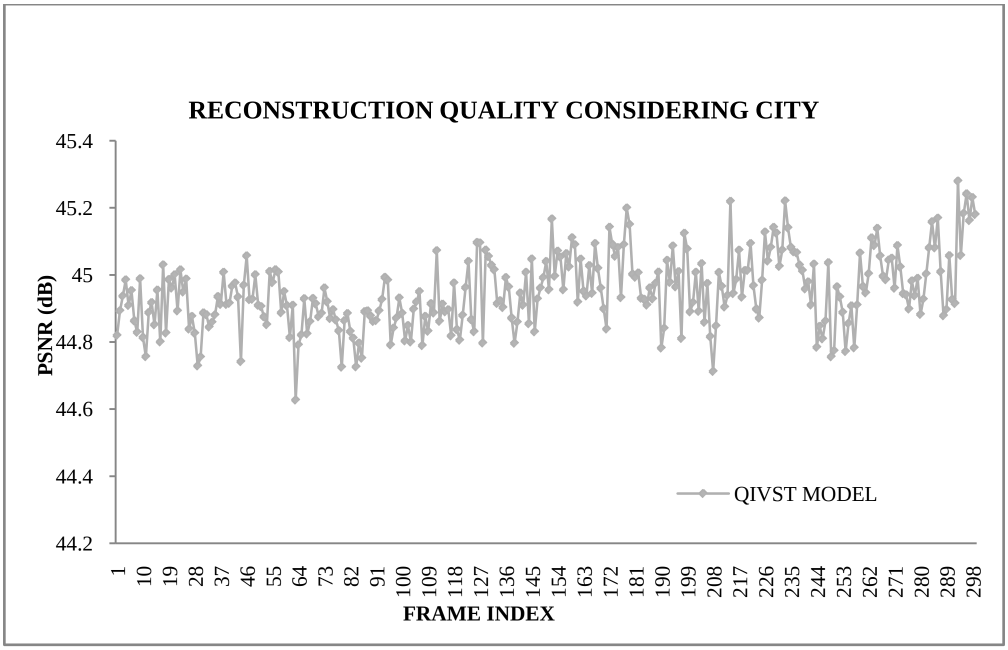


Figure 8 : Reconstruction quality per frame in terms of PSNR for the City video based on the QIVST model

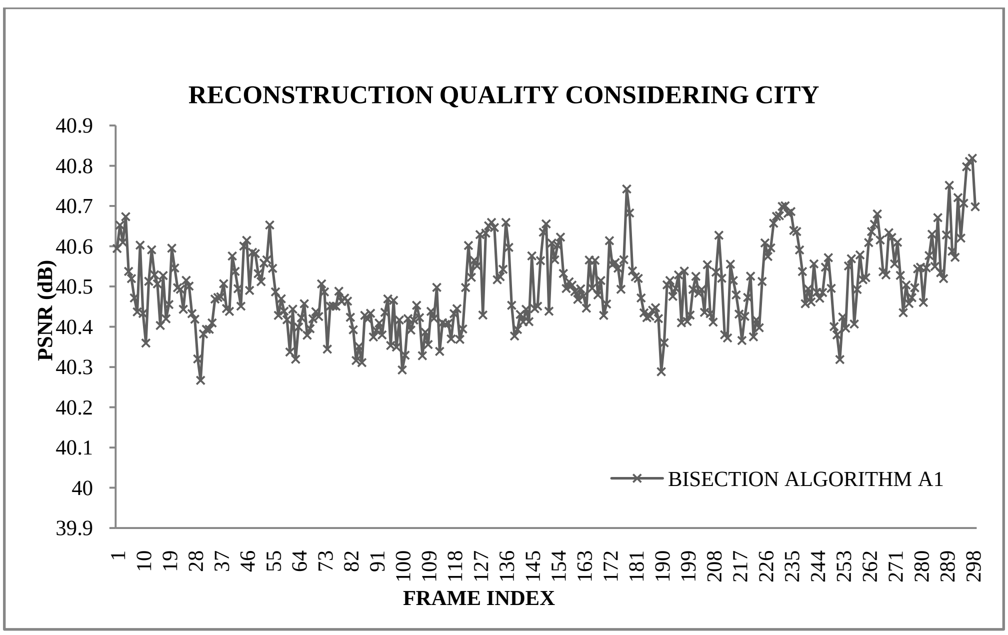
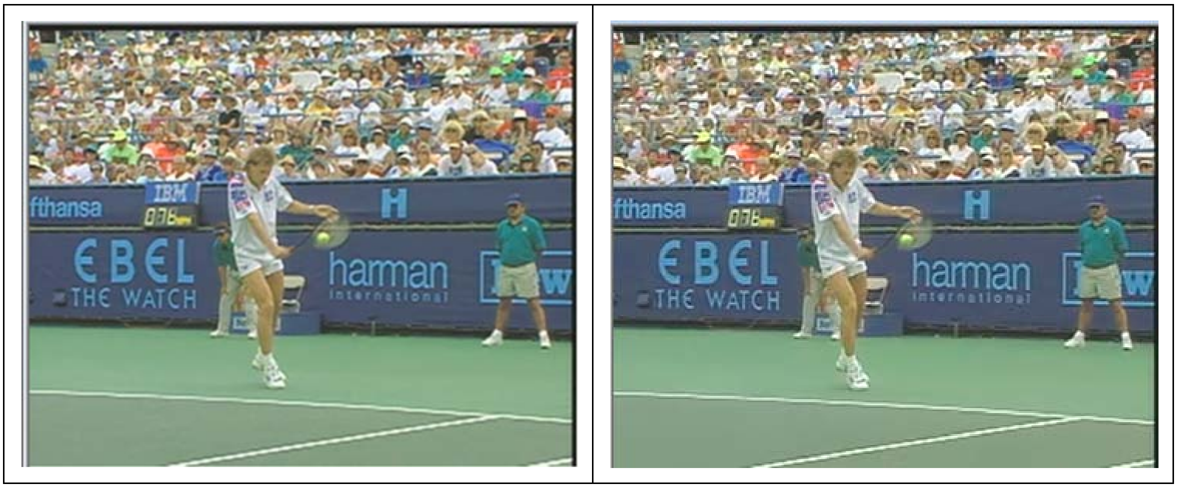


Figure 9 : Reconstruction quality per frame in terms of PSNR for the City video based on the Bisection Algorithm – A1

Considering the "Stefan" video a sample frame reconstructed using the $QIVST$ model and the $Bisection Algorithm - A1$ is shown in figure 10 of this paper. The per frame $PSNR$ computed depicting the quality of reconstruction is shown in Figure 11 and 12. From the reconstruction results considering the "Stefan" video shown in this paper it is clear that the $QIVST$ model provides better quality in video delivery over wireless networks when compared to the $Bisection\ Algorithm - A1$.



b b

Figure 10 : A sample reconstructed frame at the receiver for the "Stefan" video considering the **a.** QIVST model proposed and **b.**Bisection Algorithm – A1

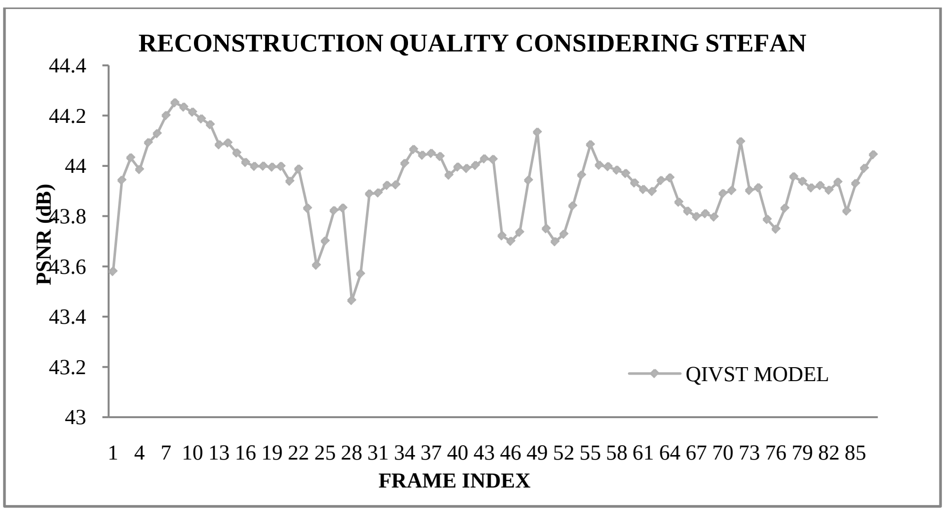


Figure 11 : Reconstruction quality per frame in terms of PSNR for the Stefan video based on the QIVST model

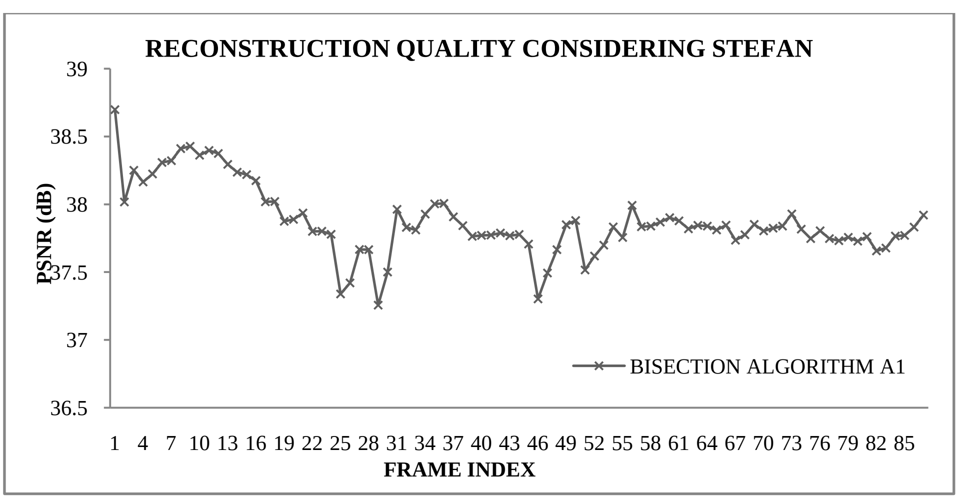


Figure 12 : Reconstruction quality per frame in terms of PSNR for the Stefan video based on the Bisection Algorithm – A1

The experimental study presented in this paper prove that the cross layer design based $QIVST$ model proposed is robust and adaptable proved in terms of lower $BER's$ observed. The $QIVST$ model induces an additional overhead due to the novel encoding scheme (proved by higher system utility observations) and improves the quality of video transmissions in wireless networks. The results also prove the proposed model superiority when compared to the state of art video delivery algorithm the $Bisection\ Algorithm - A1$.

V. Conclusion

High bandwidth requirements, delay sensitive nature and QoS measures of multimedia data delivery on wireless networks put forth numerous challenges. The use of SVC encoded streams on cross layer architectures have been proposed by researchers. The existing mechanisms fail to address the tradeoff between QoS and data delivery delays that exists. In this paper the QIVST model is introduced that adopts a cross layer design. The SVC video data considered in the QIVST model is further encoded at the MAC layer based on the physical layer conditions and the QoS achievable, to address the tradeoff issue highlighted. The distortion observed based on the QIVST model is presented. Based on the pending packet queues observed optimization of the routing layer is considered in the QIVST to minimize the end to end delay. The extensive results presented in the experimental study considering SVC video traces prove the robustness and efficiency of the proposed QIVST model when compared to the state of art existing system.

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