International Journal of Computer Applications (0975 – 8887)
National Symposium on "Modern Information & Communication Technologies for Digital India (MICTDI)

Impact of IFQ and EDCA on H.264/SVC over Mobile Ad Hoc Networks

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ABSTRACT

Digital India is the new vision to improve the quality of life by putting the technology into a new face. The smart city leads to digitization of cities, making services more transparent, efficient and easily accessible. The rapid increase in the use of multimedia services on wireless devices has increased the demand of streaming videos sharply. The use of H.264/SVC video standard over H.264/AVC standard has gained large popularity recently because of its non-rigid nature. H.264/SVC supports temporal, spatial and SNR scalability. This paper demonstrate the theoretical concept of these three types of scalability followed by impact of interface queue length (IFQ) and channel access mechanism on streaming videos transmission over Mobile Ad Hoc Network (MANETs). These network parameters are evaluated using network simulator 2 (NS-2) software integrated with scalable video streaming evaluation framework (SVEF).

Keywords

Mobile ad hoc network, Digital India, Smart city, Streaming videos, SVEF, NS2, IFQ, EDCA.

1. INTRODUCTION

The rapid increase in the use of multimedia services on wireless devices has increased the demand of streaming videos sharply. The advanced video coding (H.264/AVC) [1-2] standard has gain huge popularity but its static nature makes the quality of transmission difficult under limited bandwidth scenario [3]. While transmitting the streaming videos, the traffic and the devices at other end are unknown. Streaming of media refers to continuous reception of data by the end user while it is still transmitted by the provider [4-5]. The devices at other end also vary from mobile phone with low resolution requirement to high quality picture requirement of high definition (HD) display. The use of SVC overcomes the problem of uncertainty in network by providing one base layer and one or more than one enhancement layers [6]. The base layer provides the basic video quality whereas enhancement layer provides smoothness to the picture for high definition displays.

The MANETs [7-9] are basically decentralized networks in which each node (device) is independent from one another. These devices are driven by protocols mainly proactive and reactive. The IFQ [10] and channel access mechanism like distributed coordination function (DCF) and Enhanced distributed channel access (EDCA) play important role in the performance of the network. For providing better video quality, performance evaluation of the streaming video over MANETs is to be done under the influence of these network parameters using integrated framework. This integrated framework is simulation software comprised of NS-2 [11] with SVEF [12].

The rest of the paper is organised as follows: Section two, give introduction to the concept of H.264/SVC video standard with theoretical understanding of temporal, spatial and quality (SNR) scalability. Section three and four gives briefing about interface queue length and channel access mechanism respectively, Section five describes simulation environment, and Section six provides results and finally Section seven concludes the work

2. SCALABLE VIDEO CODING (H.264/SVC)

The SVC is basically developed by Joint video team (JVT) comprised of moving picture expert group (MPEG) [13] and Joint Scalable Video Model (JSVM) [14-15]. Streaming videos or H.264/SVC [16] standard is the extension of H.264/AVC or MPEG 4 part 10, which is commonly known as advance video coding. These video standards are basically used to compress the video. The streaming video has broad application in live streaming, conferencing, surveillance, broadcast and storage etc. The limitations to scalability restrict AVC to meet the needs of user connected at other end of network connection. The three types of scalabilities are discussed below:

2.1 Temporal Scalability

The video is basically comprised of moving frames one after the other.The temporal scalability allows the adjustment to the frame rate. This scalability permits the user to remove the redundant frames or to reduce the interval in next frames for smooth flow of video [17]. The structure of GOP is shown in Fig. 1.

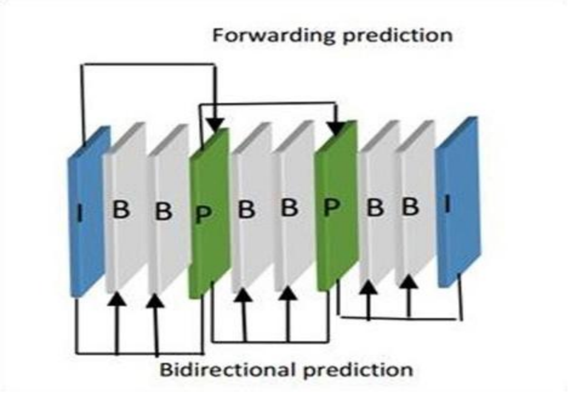


Fig 1: Structure of GOP

The video is made of group of pictures (GOP) consisting of I Intra-coded or independent frame, P Predictive-coded frame and B Bi-directionally predictive-coded frame [18].

2.2 Spatial Scalability

The spatial scalability gives adaptation to resolution of the video. The SVC is encoded with several resolution layers [19]. The base layer is the important and lowest layer. This provides the basic video quality. The upper layers are the enhancement layers which are responsible for providing quality to the video [20]. Without base layer, the enhancement layer is of no use. The spatial scalability uses information from different layer to reduce overall size using interlayer dependency.

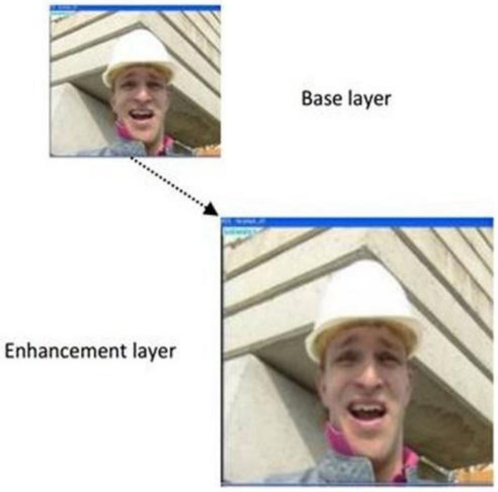


Fig 2: Spatial scalability

Fig. 2 shows the interlayer dependency of spatial scalability. In simple words, spatial scalability is tendency to have two or more resolution of same video sequence. The overall size of the video is addition of individual stream.

2.3 SNR (Quality) scalability

The SNR [21] scalability is known to provide quality to the video. In this video is coded with different quality levels [22]. In high peak traffic, the data of lower quality can be used to predicted data for higher quality. The base is layer is coded with low video quality and the enhancement layers are coded with higher video quality using quantization parameter.

3. INTERFERENCE QUEUE LENGTH (IFQ)

The IFQ is the interface queue length. The queue length of the network or the link is a deterministic factor in managing queue and handling buffer [23]. The parameter works in connection with the active queue management schemes. In wired scenario a queue is installed in each of simple link objects but in a wireless network, a queue is installed in each of the wireless physical interface. That is the reason NS2 calls a queue in a wireless network an interface queue. The most widely used queue type in wireless network is prioritized queues. NS2 implements prioritized queue in C++ class PriQueue [24]. This class derives from class Droptail and is bounded to the OTcl class. This behaves fairly similar to Droptail in which each packet is treated identically. With Droptail, when the queue is filled to its maximum capacity, the newly arriving packets are dropped until the queue has enough room to accept incoming traffic. But interface queue separates high priority and low priority packets at the head and at the end of the queue respectively.

4. CHANNEL ACCESS MECHANISM

The channel access mechanism is basically a technique to share a common channel by multiple users [25].

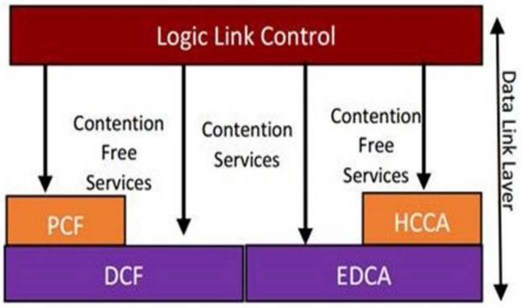


Fig 3: MAC layer with IEEE 802.11e amendment

In IEEE 802.11 [26], the channel access mechanism is defined in MAC sublayer. Fig. 3 shows the MAC layer with IEEE 802.11e [27-28] amendment. The point coordination function (PCF) and hybrid coordination function controlled channel access (HCCA) are contention free services. Distributed coordination function (DCF) is contention services based on carrier sense multiple accesses with collision avoidance (CSMA/CA). Whereas enhanced distributed channel access (EDCA) mechanism provides quality of services (QoS). In this mechanism, packets are differentiated according to the priority. The four traffic categories are: video, voice, best effort, and background. Stations with high priority packets are given access to the channel first than the stations with low priority packets.

5. SIMULATION ENVINOMENT

"MyEvalSVC" [20] is the toolkit used to evaluate the performance of streaming video over MANETs.

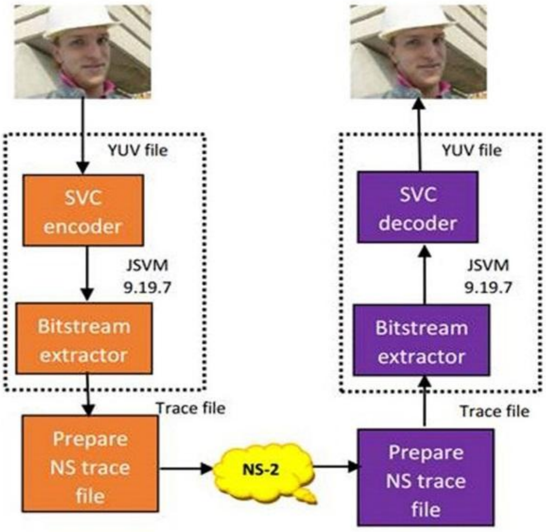


Fig 4: Simulation environment

These toolkits have integration of NS-2 software with SVEF [29-30]. The simulation consists of H.264/SVC video transmission over an Adhoc network of 500m × 400m terrain. There are three nodes, i.e., N0, N1, and N2. N0 transmits H.264/SVC video CBR with 0.2 Mbps to N1, and CBR with 0.3 Mbps and FTP to N2, respectively. The simulation environment is described in Fig. 4. Simulation and video parameters are shown in Table 1 and Table 2 respectively.

Table 1. Simulation parameters

Simulation parameters	
Channel type	Wireless channel
Radio propagation	Two ray ground
Network interface type	Wireless/Phy.
Interface queue type	Queue/Droptail
MAC type	MAC 802.11/802.11e
Link layer type	LL
Antenna model	Omni antenna
Max packet in IFQ	25/50/75/100
Number of mobile nodes	3
Routing protocols	AODV/DSDV
Fragment size	500
X dimension of routing	400 m
Y dimension of routing	500 m
Node speed	20 m/s
Time of simulation	59 sec

Table 2. Video Parameters

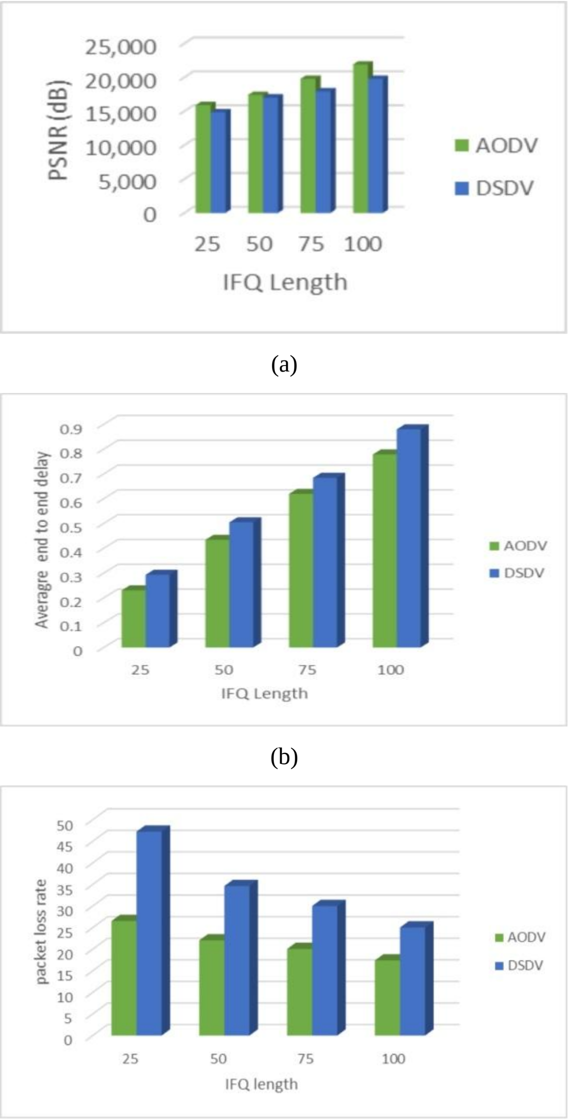
Video Parameters	
Video standard	H.264/SVC
Frame rate	30.0
Frames to be encoded	300
GOP	4
Base layer mode	2
Frame rate in	30
Frame rate out	30
Source width	352
Source height	288
Number of layers	2

The raw YUV (Y- luminance, U and V chrominance) video (in this paper Foreman video is used) is converted into H.264/SVC format using SVC encoder and bitstream extractor provided by Joint Scalable Video Model (JSVM 9.19.7). Further, FN stamping provided by SVEF is done to generate the trace file needed to simulate the video through NS-2. At the receiving side another trace file is generated. This file contains the information about packet number, sending time and receiving time. From this information the packet end to end delay and packet loss rate can be calculated. The received packets are passed through network abstraction layer (NALU) filter. Packets which are too late to arrive or cannot be decoded are discarded. Finally the video is decoded using JSVM decoder to calculate the peak signal to noise ratio (PSNR).

6. SIMULATION ENVINOMENT

6.1 Impact of Interface Queue (IFQ)

Firstly, the performance of streaming videos is evaluated using different IFQ length.



(a)

(b)

(c)

Fig 5: Results for (a) PSNR (b) average end to end delay and (c) Packet loss rate at varying IFQ length.

The results for PSNR, average end to end delay and packet loss rate are shown in Fig. 5.The Gnu plot for these results are shown in Fig. 6, 7, 8 and 9 individually for AODV and DSDV protocols. The results indicate that both AODV and DSDV protocols show high level of improvement in PSNR and packet loss rate with increase in the IFQ length specifically at value of 100 while average end to end delay is high for higher IFQ length. The queue size (i.e. IFQ length) at the MAC layer drastically impacts the PSNR. The best PSNR is achieved when the IFQ has value of 100 packets. If a packet is received at LL (link layer) and the queue is occupied with other received packet and waits for a network coding opportunity until the timer expires.

This increase the time require for the packet to travel from one to other. Longer the size of the queue more will be end to end delay. As the IFQ length increases the packet loss rate decreases. The reason behind the high packet loss rate at smaller IFQ length is due to smaller queue length as the queue is full and all subsequent received packets will be dropped resulting into packet loss. Comparatively, reactive protocol

AODV show dominating performance as compare to proactive protocol DSDV.

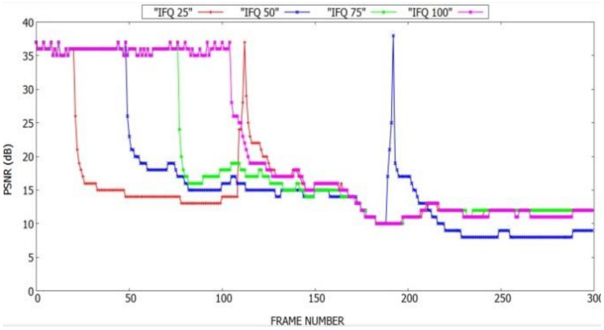


Fig 6: PSNR comparison for AODV protocol at varying IFQ length.

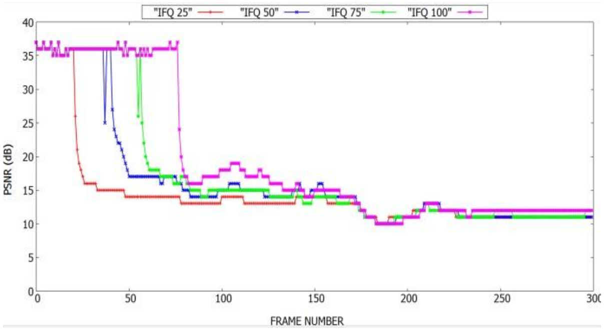


Fig 7: PSNR comparison for DSDV protocol at varying IFQ length.

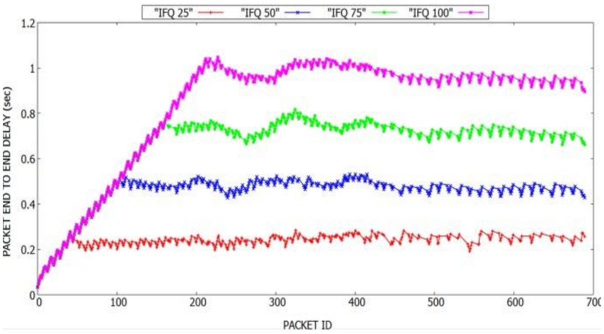


Fig 8: Packet end to end delay comparison for AODV protocol at varying IFQ length.

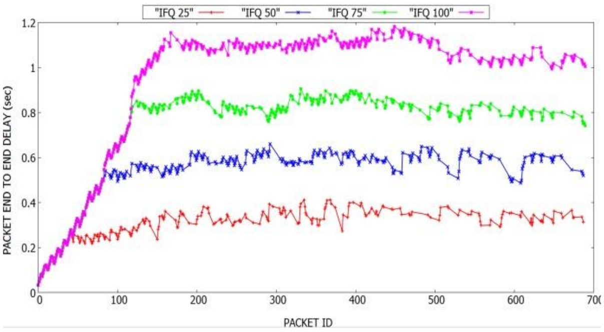
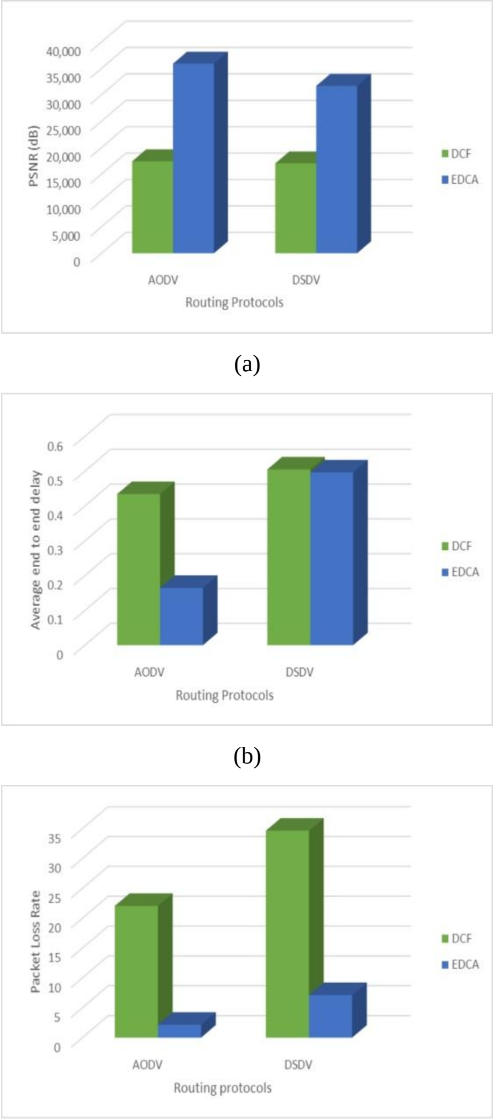


Fig 9: Packet end to end delay comparison for DSDV protocol at varying IFQ length.

6.2 Impact of Channel Access Mechanism

The results for PSNR, average end to end delay and packet loss rate are shown in Fig. 10.



(a)

(b)

(c)

Fig 10: Results for (a) PSNR (b) average end to end delay and (c) Packet loss rate at different channel access mechanism

Gnuplot for PSNR and average end to end delay comparison are shown in Fig. 11 and 12 respectively. Results for PSNR and packet loss rate completely show the superior performance of new improved EDCA mechanism over DCF for both the routing protocols.In EDCA, each packet received from the upper layer is assigned to the priority. Depending upon the user priority the packet is mapped on to the access categories. The frames with the higher priority are assigned the access categories with smaller contention window min, contention window max, and arbitration inter-frame space (AIFS) to influence the successful transmission probability in favour of high-priority data.

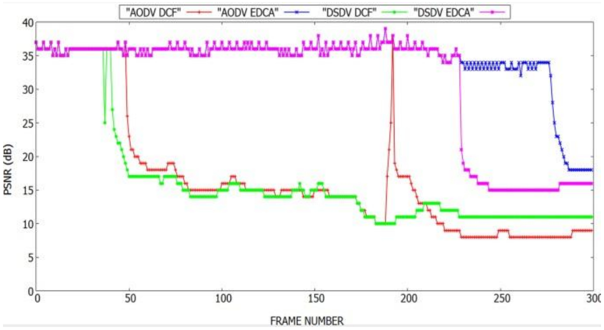


Fig 11: PSNR comparison at different channel access mechanism

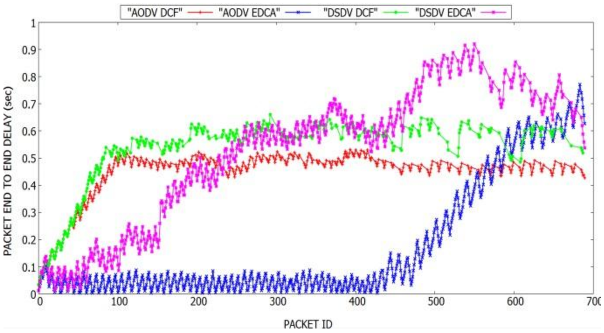


Fig 12: Packet end to end delay comparison at different channel access mechanism

The average end-to-end delay is very low for the reactive protocols under EDCA, i.e., there is no waiting time for the packets, which leads to the average end-to-end delay of a packet becoming almost equal to its transmission time plus its processing time. In case of AODV protocol more than half the packets have end to end delay remains under 0.1. The DSDV protocol does not show any noticeable results for average end to end delay under EDCA mechanism.

Protocols in the simulation for EDCA mechanism perform superior to the DCF mechanism. Specifically, AODV shows better performance with only 2% of packet loss rate. When all the packets are transmitted over DCF the packet loss rate is high. This is because all the packets go into the same output interface queue and the queue size is limited. When the queue is full, it starts to drop the packets while in EDCA the packets do not fall in one single queue. They are characterized individually according to priority assigned leading to drop in packet loss rate.

7. CONCLUTIONS

In this paper, an effort is made to give theoretical idea about scalable video coding and its different scalable modes. The simulation of streaming videos over MANETs using two routing protocols under the impact of IFQ and channel access mechanism is also done. Firstly, the outcome of the work recommends use of high value of IFQ length to get best value of PSNR and packet loss rate. Secondly, result for channel access mechanism recommends use of EDCA for enhanced performance as each packet are specifically queued according to the priority. This technique leads to very efficient way to transfer the data over MANETs as compare to traditional technique of using DCF. In future streaming videos can be tested using different node density, changing speeds of nodes. On the other hand, parameters of streaming like GOP, frame rate and bit rate can also be tested for better picture quality with constrained data.

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