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Cross Layer Architecture for Maintaining QoS in Multimedia Applications

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Abstract

Background/Objectives: Multimedia Applications on Mobile Ad hoc Networks (MANETs) are gaining immense popularity recently due to their necessity in latest environments. Hence, multimedia applications like video streaming, video conferencing and environment monitoring must be made possible in real-time in Mobile Ad hoc Networks. Mobility of nodes, life of battery, changes in topology and protocols affect the performance of MANET. Hence providing good Quality of Service (QoS) for multimedia applications in MANET is a challenge. **Methods/Statistical Analysis:** The RED algorithm with video precedence called as SiViRED (Significant Video Information Random Early Detection) – AQM in the Network layer that provides service differentiation based on the pre-assigned service classes and video packet drop priority specified in packet header. This will reduce congestion and decrease delay and jitter when compared to conventional methods. **Findings**: Proposed a novel technique that uses a cross layer architecture in which information from application layer is used with UDPLite in Transport layer and Active Queue Management (AQM) with SiViRED in Network Layer with modified dynamic mapping in MAC layer that guarantees 14% increase in Peak Signal to Noise Ratio (PSR) and 40% decrease in delay compared to conventional methods. **Application/Improvements:** Developed a cross layer technique that improves the end-to-end performance of multimedia services over Mobile Ad hoc Networks.

Keywords: Delay, Jitter, Mobile Ad hoc Networks, PSNR, QoS

1. Introduction

Mobile Ad hoc Networks (MANETs) itself-configuring and infrastructure less network of mobile devices connected without wires. MANETs are complex in nature as each device is free to move and can link with other devices frequently hence wireless medium is used. All these attributes make MANET more intricate entity to deal with. Moreover transmitting multimedia applications over MANETs maintaining a QoS is a big challenge.

The challenge could be overcome by two methods: 1. Video Compression and 2. Application layer QoS control technique. Video compression techniques are used to reduce the amount of data size so that lesser amounts of data are transmitted in the bandwidth scarce Networks and the size of memory used is reduced. Application-Layer QoS control techniques are used to reduce the transmission delays and the packet loss that occur in the network. Rest of the article is organized as follows: 1. Related works, 2. Proposed system, 3. Simulation results and discussions and 4. Conclusion.

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2. Related Works

In MANETs, energy is lost when we retransmit a packet to compensate the packet losses that occur due to the varying topology constraints. In communication networks AQM is a solution for global synchronization.

In MANETs, Routers employ AQM methods, such RIO[1] where service differentiation is afforded to the traffic. In[2] Floyd et al, in adaptive RED or Active RED (ARED), depending upon the average queue length RED is made more or less aggressive. If the average queue length swings in the section of min threshold then early recognition is too hostile. On the contrary if the average queue length swings in the section of max threshold then early recognition is being too conventional. Therefore the ARED cannot restrict the congestion of video in MANETs accurately. NRED is an augmentation of the primitive RED scheme. In[3] presumed that every node goes on measuring the size of its proximity queues. One more presumption is when the queue size goes beyond an assertive threshold, total drop probability is evaluated by the algorithm of NRED and this total drop probability is transferred to all the nodes in the proximity. The proximity node initiates the dropping of packets. However in the MANETS, the nodes in the topography would not assist that much for the reason that the topology will vary most regularly. So assistance cannot be anticipated. Another reason is nodes will transmit proximity congestion warning Packets to the neighborhood nodes for a second time which is time consumption and those packets will be using the channel bandwidth during the congestion resulting in high delay. Thirdly no priority has been given to the packets so all the packets will be given equal preference while dropping the packets during congestion. So using NRED algorithm with AQM for video streaming in MANETs is not beneficial. In[4] proposed a cross-layer architecture where each data partition was mapped statically into MAC layer.

In[7], proposed a cross-layer mapping algorithm where the mapping is done according to the importance of the frame information.

In[8] Naveen Chilamkurti et al. proposed dynamic mapping algorithm in which video packets are adaptively mapped to the relevant Access Category.

In the above two approaches[7] and [8]inter-packet delay is very high. In proposed system, a cross layer architecture in which an Active Queue Management for diffServ in MANETs has been designed that uses the video significance information gathered from application layer and UDPLite in transport layer, SiViRED AQM ALGORITHM[9–14] in network layer to avoid congestion, Dynamic mapping in MAC layer to reduce delay and jitter and to improve the performance of streaming.

3. Proposed System

In proposed system, we combine the RED algorithm with video precedence called as SiViRED (Significant Video Information Random Early detection) – AQM in the Network layer that provides service differentiation based on the pre-assigned service classes and video packet drop priority specified in packet header. This will reduce congestion and decrease delay and jitter when compared to conventional methods.

SiViRED - AQM is implemented in Edge Router. Edge Router has 3 virtual queues for 3 video frames I – packet frame, P - packet frame, B – packet frame. I frame called as Intra frame is very necessary for more quality whereas P-frames and B-frames are called as delta frames. P-frame – contain only the data that have changed from preceding I – frame and B - frame contain data that have changed from both preceding and following frames. Thus I packet has high priority than P packet and P packet has more priority than B – packet frame. The marking of drop differentiation of video packets takes place at video source based on the type of MPEG frame.

The generated video information at the Application Layer is mapped to the Type of Service (ToS) of DS field in IP header. The ToS field contains the pre-marked video priority information. I-frames are assigned in low precedence drop probability and P-frames are assigned mid level precedence probability, B-frames are assigned very high precedence drop probability. According to the priority information and service differentiation defined by the, SiViRED AQM algorithm in edge routers the video traffic is handled.

When the queue gets accumulated in edge router with video packets and transcends the indicated threshold, SiViRED drops the packets according to the assigned drop probability. Significant Video Information based Random Early Detection (SiViRED), unites the capabilities of the RED algorithm with video Precedence (I packet>P packet>B packet). This combination affords preferential traffic handling for higher priority video packets and lower priority video packets than conventional traffic. It can discriminate and reject lower priority traffic when the queue begins to get overfilled. If the numbers of packets are more than the minimum threshold then the packets are stored in a queue if it is greater than maximum threshold then the lower priority packets are dropped, if the average queue size is between maximum and minimum then arriving packets are stored with a drop probability.

The maximum threshold (maxth) parameter value is assigned as 0.8* queue length and minimum threshold (minth) is assigned as 0.6* queue length and maximum dropping probability (Pmax_I) is assigned as 0.016 for I Packet. Maximum threshold parameter (maxth) for P packet is assigned as 0.6* queue length and minimum threshold (minth) is assigned as 0.4* queue length and maximum dropping probability (Pmax_B) is assigned as 0.02. For B packets and maximum threshold parameter (maxth) is assigned as 0.4* queue length and minimum threshold (minth) is assigned as 0.2* queue length and maximum dropping probability (Pmax_B) is assigned as 0.03 respectively. The weight of queue (w_q) is assumed as 0.002. Network layer packets are sent to MAC layer. In MAC layer the proposed modified dynamic mapping is used.

In modified dynamic mapping the MPEG 4 videos are mapped dynamically to the apt category (AC). Failed delivery of B-frame does not influence the video but failure delivery of I-frame causes the frames in GOP undecodable. Significant video frames are placed in appropriate category. The video frames are mapped in AC queues such as AC[0], AC[1], AC[2]. Other traffics are assigned to AC[3].

When the video data are imparted as traffic, according the static mapping algorithm suggested in[1], the I frame will often be aligned to AC[2], then the P frame is aligned to AC[1] and the B frame is assigned to AC[0]. Whenever AC[2] queue is unoccupied then the static mapping algorithm leads to unwanted communication delays. To evade the packet failure the planned mapping algorithm vibrantly assigns the video to the suitable AC in MAC layer depending upon the importance of video, network traffic. To assign prioritized video information into higher precedence AC queue as much as possible, new factor called Probability-TYPE is set up so that video frame which are of least significant types will be allocated higher probability. Probability-TYPE is termed for I, P, B video frames as Prob_I for I frame, Prob_P for P frame and Prob_B as Probability-TYPE for B frame depending upon the importance of the video frame. The frame that is aligned to a less priority queue, the transmission chances of that frame is more than that of significant video frames.

In addition, to maintain dynamic adaptation to the variations in the network traffic, MAC queue length is used to denote the ongoing network traffic load. Based upon the IEEE 802.11e requirement, when MPEG-4 video packets are sent an IEEE 802.11e, video packets have been assigned to AC2 with good probability to use channel other than less priority ACs. The constraint is, when there is an escalation of video streaming, the queue quickly jams and packets are dropped. On account of this reason, the planned mapping algorithm re-organizes the lately obtained packets into another existing less priority queues, when AC2 queue becomes full. The two threshold parameters, maxth and minth are adopted alternatively to overcome the forthcoming traffic jams by using queue management in prior. Probability-TYPE will be adapted based on the queue length resulting to a Probability-New. Probability-New is based on four parameters namely math, minth, current queue length and Probability-TYPE. When the Probability-New value is higher chances for the packet to get assigned into a priority queue which is low. The queue length is managed with the help of threshold parameters. The threshold parameters for IPB packets are configured to the percentages of the total number of packets which is assumed as 50 (queue length). The maximum threshold (maxth) parameter value is assigned as 40 and minimum threshold (minth) is assigned as 10. The integrated function in mapping approach using these parameters is given

$$\textit{Probability-New} = \frac{\textit{Probability–Type*queuelength (AC2)}}{\textit{Maxth – minth}}$$

In this function, when the length of AC2 is between maxth and minth, the packets are assigned to ACs depending on their Probability-Type, current queue length. The AC2 queue length is taken into account because it has good chance to access the link than supplementary lower priority ACs and if this queue gets filled the video packets will be dropped.

4. Simulation Results and Discussions

In the simulation, we proposed SiViRED method,

Table 1. Simulation Parameters for UDPLite AND SiViRED Algorithm and Modified Dynamic Mapping Algorithm

Parameter	Value
Area	500x500m
No. of Mobile Nodes	20 nodes
Mobility Model	random waypoint model
Speed	(0<5) m/s
Routing Protocol	DSR
Traffic type	VBR/UDPLite
Queuing schemes	SiViRED
Buffer size	50 packets
MAC protocol	802.11e
Video	Foreman YUV QCIF

Table 2. Comparison of PSNR, delay of proposed approach and other related approaches

Methods	Delay in msec	PSNR in dB
802.11e	0.74	32.93
Static Mapping	0.79	32.19
Dynamic Mapping	0.7	34
UDPLite with SiViRED algorithm and Modified dynamic mapping algorithm	0.5	39

Modified dynamic mapping algorithm in MAC layer. The video sequence Foreman", is at QCIF format with 400 frames.

The above table shows that the proposed approach supercedes all the other related approaches in terms of delay and PSNR.

5. Conclusion

A cross layer technique has been developed that can improve the end-to-end performance of multimedia services over Mobile Ad hoc Networks. We have extended the use of MDC scheme along with UDPLite and Multipath routing for improving the efficiency. Developed a novel Active Queue Management scheme at network layer to avoid congestion and to reduce the delay and jitter and to improve the performance of streaming and developed a modified dynamic mapping algorithm in MAC layer associated with the mechanics of IEEE 802.11e that improves the quality of video under varying network conditions.

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