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Cross Layer Architecture for Maintaining QoS in Multimedia Applications

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Abstract: Multimedia applications requires certain QoS to meet certain functionality.QoS requirements include bandwidth guarantees and temporal guarantees. In this paper, we propose a novel method 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.

Key words: Transport layer · Mobile devices · Infrastructure less network · Video Compression

INTRODUCTION

Mobile Adhoc Networks (MANeTs) isself-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 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 Discussion.

Related Works: Especially in MANETs, packet loss results in increased overhead in terms of energy wasted to forward a packet which was dropped, additional energy required to retransmit this packet. Active Queue Management (AQM) has been a solution to the global synchronization problem in wired networks.

In MANETs, Routers implement active queue management schemes, such as RED with In and Out (RIO) [1] and provide service differentiation to the traffic according to pre-assigned service classes and drop priorities carried in the packet header.

In [2] Floyd *et al*, the adaptive RED or active RED (ARED) algorithminfers whether to make RED more or less aggressive based on the observation of the average queue length. If the average queue length oscillates around min threshold then early detection is too aggressive. On the other hand if the average queue length oscillates around max threshold then early detection is being too conservative. So the ARED active Queue management algorithm does not control the video traffic in MANETs properly.

NRED is an extension of the original RED scheme. K. Xu *et al* [3] assumed that each node keeps estimating the size of its neighborhood queue (distributed queue). Another assumption is once the queue size exceeds a certain threshold, an overall drop probability is computed by the algorithm of NRED and this overall drop probability is propagated to all the nodes in the neighborhood nodes. The neighborhood nodes starts dropping the packets. But in the MANETS the nodes in the topology would not cooperate that much because the topology will change very frequently. So cooperation cannot be expected. The second Point is nodes will send neighborhood congestion notification Packets to the neighborhood nodes again which is time consuming and

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those packets will be utilizing 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.

Sentini *et al*. [4] proposed a cross-layer architecture that relied on a Data Partitioning (DP) technique at the Application layer and an appropriate QoS mapping at the 802.11e-based MAC Layer. Each data partition was mapped statically into MAC layer [5, 6].

Zeadally *et al*. [7], proposed a cross-layer mapping algorithm to improve the quality of transmission of H.264 video stream over IEEE 802.11e based wireless networks. Cross-layer design involves the mapping of H.264 video slices (packets) to appropriate access categories of IEEE 802.11e rendering to significance of its information.

In [8] Naveen Chilamkurti *et al* proposed dynamic mapping algorithm in which video packets are dynamically mapped to the appropriate Access Category based on the factors namely the significance of the video data and the network traffic load. By exploiting the dynamic mapping approach, the transmissions of essential video data are prioritized thereby improving the queue space utilization.

In the above two approaches [7, 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.

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-frame packets are marked with the lowest drop probability and P-frame packets are marked with a medium drop probability, B-frame packets are marked with the highest drop probability. According to the priority information and service differentiation defined by the, SiVIREDAQM algorithm in edge routers the video traffic is handled.

When the queue gets accumulated in edge router with video packets and transcends a given threshold, the SiVIRED begins to drop packets following the specified drop probability parameters. 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 number 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. The packets from the Network layer are sent to the 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 appropriate category (AC). Loss of B- frame does not affect the video but loss of I- frame would cause all the frames in GOP(Group Of Pictures) to be undecodable. Based on the significance of the video the frame is placed in a appropriate category.The video frames are mapped in to Access Category (AC) queues such as AC [0], AC [1], AC [2] according to the video coding significance Other traffics are assigned to AC [3].

When the MPEG-4 video streams are transmitted as traffic, as per the static mapping algorithm proposed in [1], the I frame will always be mapped to AC[2], while the P frame will be mapped to AC [1] and the B frame will be mapped to AC[0]. If the AC [2] queue is empty (which means the video traffic load is light) such a static mapping algorithm will result in unnecessary transmission delays as well as high packet loss if AC [1] and AC [0] are almost full at the same time. To avoid the packet loss andto guarantee the quality of delivered video the proposed mapping algorithm dynamically allocates the video to the most appropriate AC at the MAC layer according to both the significance of video type and the network traffic load. To allocate important video data into higher priority AC queue in 802.11e MAC layer as far as possible, new parameter called Probability-TYPE is introduced so that less important video frame types will be assigned larger probability. Probability-TYPE have been defined for three video frames I,P,B as Prob_I for I frame, Prob_P for P frame and Prob_B as Probability-TYPE for B frame according to its coding significance. The frame which has been mapped to a lower priority queue, the transmission allocating probability of that frame is higher than that of important video frames. As a result, for the MPEG-4 codec the downward mapping probability relationship of these three video frame types is Prob_B > Prob_P > Prob_I.

Furthermore, to support dynamic adaptation to changes in network traffic loads, MAC queue length is used as an indication of the current network traffic load. According to the IEEE 802.11e specification, when MPEG-4 video packets are transmitted over an IEEE 802.11e wireless network, they are placed in AC2 category which has better opportunity to access the channel than lower priority ACs. The tradeoff is, when the video stream increases, this queue rapidly jams and dropping occur. For this reason, the proposed mapping algorithm re-arranges most recently received video packets into other available lower priority queues, while the AC2 queue is getting filled. The two threshold parameters, maxth and minth are adopted predicatively to avoid the upcoming congestion by performing queue management in advance.

Table 1: Simulation Parameters for Udplite and Sivired Algorithm and Modified Dynamic Mapping Algorithm

Parameter	Value
Area	500x500m
Number 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 and 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

Probability-TYPE will be adapted according to the current queue length and threshold values and the result is a new downward mapping probability, 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, the opportunity for the packet to be mapped into a lower priority queue is greater. 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 the Cross Layer mapping approach using these parameters is given

$$\text{Probability-New} = \frac{\text{Probability} - \text{Type*queuelength (AC2)}}{\text{maxth} - \text{minth}}$$

In this function, when the queue length of AC2 is between maxth and minth, the video packets are mapped to the ACs based on their Probability-Type and the current queue length. The AC2 queue length is taken into account because it has better opportunity to access the channel than other lower priority ACs and if this queue gets filled the video packets will be dropped.

RESULTS AND DISCUSSION

In the simulation, the proposed SiVIRED method and Modified dynamic mapping algorithm in MAC layer. The video sequenceForeman", is at QCIF format with 400 frames.

The above shows that the proposed approach outperforms all the other related approaches in terms of Delay.

CONCLUSION

The Multi Description Coding along with UDPLite and multipath transport and SiVIRED are proposed to enhance the quality of video transmission over Mobile adhoc Networks. The simulation results show that the proposed approach achieves an increase of 14% in Peak Signal to Noise Ratio (PSNR) which is an improvement in PSNR and 40% decrease in delay as compared to the conventional methods.

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