ENHANCED MULTIPATH ROUTING WITH CONGESTION AVOIDANCE FOR 802.11E BASED MOBILE ADHOC NETWORKS

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ABSTRACT

IEEE 802.11e Medium Access Control(MAC) proposes Enhanced Distributed Channel Access(EDCA) mechanism to provide Quality of Service to multimedia applications. EDCA gives differentiated treatment to high priority traffic . Despite this, due to the distributed nature of EDCA , network performance degrades when additional real-time flows are injected into the network. Towards this , our work proposes a routing mechanism that can take advantage of the service differentiation offered by EDCA MAC and at the same time overcome its limitation under heavy load conditions thereby facilitating transport of real-time data. Our work measures the available bandwith of the high priority access categories, energy level and contention level experienced at the intermediate nodes to determine robust paths and divert the audio-video stream along such less congested paths , to ensure better end-to-end delay and throughput. Simulation studies show that our protocol is able to protect delay constrained traffic under heavy traffic conditions.

KEYWORDS

MANET, Load balancing, Multimedia Transmission, QoS Routing.

1. INTRODUCTION

With the recent advances in wireless technology , use of Mobile ad hoc networks (MANET) for providing content -rich services is gaining popularity. So it has become very essential for MANET's to have a reliable, efficient Quality of Service mechanisms(QoS) to support diverse real-time multimedia applications. Ad hoc networks are wireless mobile networks without any infrastructure, wherein mobile nodes cooperate with each other to find routes and relay packets. Such networks can be deployed instantly in situations where infrastructure is unavailable or difficult to install, and are evolving rapidly to provide ubiquitous untethered communication. The ease with which MANET's can be formed has catalyzed its widespread deployment . Ensuring QoS guarantees for audio and video transport over these networks introduces new challenges due to the frequent link failures introduced arising out of mobility of nodes and time varying channel conditions. This necessitates optimizations at

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MAC , routing, transport layer and application layer. To reduce distortion at the receiver, mechanisms like Multiple Description Coding and Layered Coding schemes are devised at the application layer. These schemes decompose multimedia data into base and enhancement information resulting in large number of packets offered to the network. This calls for efficient routing mechanisms that can handle increased amount of traffic .Additional MAC layer mechanisms are also necessary that can reserve resources like bandwith, for delay sensitive traffic. One such optimization done at the MAC layer is the Enhanced Distributed Co-ordination Function (EDCF) of IEEE 802.11e ,which is an enhancement of IEEE 802.11 DCF medium access protocol . Based on the QoS requirements , different levels of proirity can be assigned to different types of traffic. In EDCF, traffic of different priorities is assigned to one of four transmit queues[1] ,which respectively correspond to four Access Categories(AC).Each AC transmits packets with an independent channel access function ,which implements the prioritized channel contention algorithm. Priority in gaining channel access to realtime data is given by assigning smaller contention window, which would mean lesser waiting time for them.

The 802.11e was initially proposed for wireless LANs which function in the presence of Access Points (AP). As MANET's are multi -hop networks and do not use AP's , supporting 802.11e MAC for ad hoc networks need additional modifications. Moreover IEEE 802.11e 's performance degrades when additional real-time traffic flows into the network .Due to the distributed nature of EDCF , level of contention among the flows that belong to the same traffic class increases resulting in collisions. At this juncture, MAC layer will have no option but to drop such frames resulting in the performance degradation. Adopting a routing layer solution can be used that detects such overloaded nodes that are busy forwarding high priority packets. The solution we propose here, estimates the load based on the medium utilization and level of channel activity around a node and selects paths that are lightly loaded and can possibly offer routing paths that can sustain delay sensitive traffic.

In the recent past suitability of multipath routing protocols have been discussed in [2][3] for transporting real-time applications over MANET. In wireless ad hoc networks for continuous real-time data transfer , routing protocols have to ensure lesser frequency of route failures for which multipath routing technique is a viable alternative. From a fault tolerant perspective , multipath routing can be achieved by using multiple paths simultaneously, for data transmission .But simultaneous transmission introduces interference among multiple paths resulting in lesser throughput and introduction of jitter which is unacceptable. Hence we use pre-computed primary path for transmission and switch to alternate path, when primary path fails.

The rest of the paper is organized as follows: Section 2 discuses the literature and related works .Section 3 gives a brief introduction to 802.11e. Section 4 introduces our proposed protocol. Performance evaluation of the proposed protocol is taken up in section 5.Conclusion is presented in section 6.

2. Review of Literature

IEEE 802.11 Distributed Coordination Function (DCF) lacked built -in mechanisms for supporting real -time services which demand strict QOS guarantees. With this aim, IEEE 802.11e[4] was initially proposed for supporting multimedia applications over wireless LANs.

Though IEEE 802.11 e EDCA can improve the throughput efficiency of delay sensitive traffic , simulation studies[5][6] show declined throughput compared to that of DCF under heavy traffic loads because of the increase in retransmissions and the way contention window is reset statically without considering changing network load conditions. Aiming at reducing collisions at high load conditions, a MAC layer solution PEDCA[7] is proposed by dynamically varying the transmission probability of each Access Category depending on the network load. This measure can protect high priority AC at heavy loads. [8] conducted performance study on the suitability IEEE 802.11e protocol on multi-hop ad hoc networks . Results show that voice and video traffic is able to maintain a steady throughput, independently of lower priority traffic up to a certain limit. [9] points out that IEEE 802.11e cannot guarantee strict QoS requirements needed by real-time services without proper network control mechanisms. They propose a call admission control and rate control scheme for real-time data along with letting best effort traffic use residual bandwidth. [10] proposes a routing mechanism with distributed call admission control algorithms which calculates available bandwidth according to local channel state and the information of the neighbour nodes.

TSLA[11] is a routing layer solution based on EDCA proposed for alleviating congestion and diverting incoming traffic over less congested paths. It uses MAC layer buffer size of the Access Categories ,to indicate congestion. Although using queue size of the Access Categories may reflect the amount of internal collision ,this is insufficient as this does not consider traffic activity of neighbouring nodes. So TSLA cannot assure throughput guarantees. Energy of the nodes while routing is also ignored here , which is one of the factors that determine the lifetime of a routing path.

In the recent past , load balancing solutions suggested involved finding paths with minimum traffic and routing data over such minimum traffic paths. Minimum traffic path comprised of nodes with least queue size. CSLAR[12] makes route selection based on channel contention information ,number of packets in its queue and number of hops along the route. Busy and idle portion of the channel around a mobile node is estimated using NAV obtained from MAC layer. LBAR[13] defines a new metric for load balanced routing known as the degree of nodal activity to represent the load on a mobile node.[14] discusses MRP-LB which spreads traffic at packet level granularity equally in to multiple paths. It distributes the load such that total number of congested packets on each route is equal. [15] defines a cost criterion that combines load information at a node with the energy expended in transmitting the RREQ packet from the previous node to the current node.
None of the above load balancing solutions distribute load without differentiating the type of data forwarded by the relaying nodes for alleviating congestion .

In the above literature QoS and load balancing solutions are either offered independently as MAC enhancements or as routing extensions without using 802.11e. So our objective is to devise a routing mechanism that establishes less congested multiple routing paths that are long lived to facilitate multimedia transmissions.

3. INTRODUCTION TO 802.11E

IEEE 802.11e MAC standard was proposed as an enhancement to the legacy IEEE 802.11 DCF in order to support quality of service in WLAN. It introduces two new access methods Hybrid Coordination channel access (HCCA) and the Enhanced Distributed Coordination Function (EDCF), renamed in latest 802.11e draft to EDCA (Enhanced Distributed Channel Access). The IEEE 802.11e EDCA mechanism provides differentiated, distributed access to the wireless medium .Original IEEE 802.11 treats all packets as equals and not differentiating time sensitive traffic. EDCA classifies the packets into four different classes voice(VO), video (VI), best effort (BE) and background (BK) and assigns each of these traffic types to four Access Categories. EDCA defines four access categories (ACs) namely AC_VO for voice, AC_VI for video , AC_BE for best effort and AC_BK for background classes of traffic to provide priority among different traffic types. EDCA provides differentiated and distributed access to the wireless medium.Each AC achieves differentiated channel access by varying the amount of time, a node would sense the channel to be idle and the length of the contention window during a backoff. Each frame from the higher layer carries its user priority(UP).Eight User Priorities(UP) identical to IEEE 802.11D priority tags are defined which can be mapped to any four Access Categories.The mappings from UPs to ACs is shown below.

Table 1 Access Category Mapping

User Priority(UP)	Access Category(AC)	Designation
1	AC_BK	Background
2	AC_BK	Background
0	AC_BE	Best effort
3	AC_BE	Best effort
4	AC-VI	Video
5	AC_VI	Video
6	AC_VO	Voice
7	AC_VO	Voice

After receiving a frame ,the MAC layer maps it into one of the four ACs, as shown in Table 1. Each AC is associated with one backoff entity and some AC specific parameters called the EDCA parameter set composed of Arbitrary Inter-Frame Space Number (AIFSN[AC]), minimum contention window (CWmin[AC]), and maximum contention window (CWmax[AC]). Channel must be idle for a contention period (CP) before a node can transmit data[5] . If the channel is idle for the whole CP, the station can transmit immediately after the CP. So with multiple stations contending for one radio channel, the shorter the CP, the higher the chance is to access the wireless medium. The CP consists of Arbitration Inter-frame Space (AIFS) and a random backoff time. The AIFS is a distinct value for each AC. After the idle duration of AIFS, the contention entity generates a random backoff period for an additional deferral time before transmitting. Basically, the smaller AIFSN[AC], CWmin[AC], and max[AC], the shorter the channel access delay for the corresponding priority. However, the probability of collisions increases when operating with smaller CWmin[AC].

4. PROPOSED CONGESTION AWARE MULTIPATH ROUTING PROTOCOL

Load balancing is very crucial in distributing network load uniformly over all parts of the network and extend the lifetime of the network .So routing protocols need to take routing decisions by taking into account experienced channel load, in addition to shortest hop metric. Even though preferential treatment to real-time data is given by EDCA at the MAC layer ,network performance degrades when additional real-time flows are injected into the network, resulting in the loss of delay sensitive audio and video packets. This is because with increasing real- time traffic ,high priority queues build up. Increasing traffic in the network leads to increasing level of contention among nodes while performing channel access resulting in more number of collisions and deterioration of end to end delay . IEEE 802.11e ,nodes here experience two types of collisions namely internal and external collisions. External collision occurs when neighbouring nodes simultaneously perform channel access. When more than one Access Category count their back-off counters to zero at the same time within a node, an internal or virtual collision is said to happen leading to packet drops. So with the increasing network load it is necessary to protect the delay constraints of real-time data. Our approach proposes Congestion Aware Multipath Routing mechanism, (CAMR) for improving the throughput of real-time data . Our solution , adopts a measurement based approach to assess the available bandwith between two nodes. Once bandwith is measured ,existing load status of Access Categories that carry audio and video traffic is measured. Remaining energy of the nodes is also measured. Route Discovery process is accordingly modified to consider current network load conditions.

4.1. Bandwidth Calculation

Accurate Bandwidth estimation is difficult in wireless networks as the channel is shared among the neighboring nodes. Therefore computing effective available bandwidth must not only take in to account transmission rate of a node , but also the transmissions of all neighboring nodes. We adopt bandwidth measurement technique based on the channel usage as in [15]. Every node counts the number of consecutive idle slots observed by the node over a period of time interval *Tmeas.* Channel usage refers to time taken by the MAC layer in transmitting data and control frames. This reflects the available bandwidth. From a set of sample values , a probability density function *idle(x)* of number of consecutive idle slots *x* could be derived. Later, average number of idle slots *Av-idle-slots* in the measurement interval can be computed as

$$Av\text{-}Idle\text{-}slots = \sum_{x=0}^{\infty} x.\,idle(x) \qquad (1)$$

Then the available bandwidth can be computed as

$$Available\text{-}Bw = \frac{Av-idle-slots}{Tmeas} \qquad (2)$$

In multi-hop wireless ad hoc networks ,buffer capacity of the nodes increase signifying the occurrence of congestion. Once available bandwidth is measured , another measure that is taken into account, is the kind of traffic that is being processed by the node. If the node is already relaying voice or video packets, then including such a node in a routing path may effect the quality of service. Hence we take into account the existing number of packets queued up at the AC for audio and video.

4.2. Algorithm

If (intermediate node has enough energy) and
(queue-utilization of AC[audio] < thresh)
and (queue-utilization of AC[video] < thresh)
if (*Available-BW* < *BW* in RREQ packet)
BW=Available-BW
else ignore RREQ packet

4.3. Route Discovery and Path Selection

CAMR is implemented over AOMDV [17] that computes link disjoint paths. Here at the intermediate nodes , duplicate copies of RREQ are not immediately discarded. Source node initiates Route discovery when routes are not available in the cache. Route discovery begins with the flooding of RREQ packets to all neighboring nodes. RREQ packets are modified to record the available bandwidth ie, *Available-BW* . RREQ is propagated only if the intermediate node has enough energy (thresh-energy) to sustain the transmission duration . Next a RREQ packet is ignored by the intermediate node , if queue size of voice and video AC is beyond a threshold. Source node initializes bandwidth to BW which is the maximum value of the bandwidth in the RREQ packet. While RREQ is propagated ,each intermediate node checks its available bandwidth with the value stored in RREQ packet . If the *Available-BW* of the intermediate node is found to be lower than the value in RREQ header ,then it is updated with the lower one. Thus the destination will come to know about a congested node. Destination after waiting for certain time interval gathers multiple routes ,which is restricted to three paths and selects two routing paths with highest *Available-BW* value in RREQ packet. Data transmission is initiated along the primary path by the source node. Transmission over secondary path is initiated by the source when a RERR is received over the primary path.

5. PERFORMANCE EVALUATION

In this section, benefits of CAMR is shown by comparing the simulation results with AOMDV .

5.1 Simulation Scenario

This protocol is simulated on OMNET++ [18] using 802.11e patch[19] to INETMANET. It is a simulator that is freely available and supports complete physical, data link and MAC layer models for simulating wireless ad hoc networks . We simulated a network of mobile nodes placed randomly in an area of 1500 x 600 square meters, with 60 mobile nodes. A source and a destination pair is selected randomly. Free space propagation model is assumed as the channel model. Each node is assumed to have a constant transmission range of 250 meters . Medium access control protocol used is IEEE 802.11e Enhanced Distributed Coordination Function (EDCF). CBR traffic is generated by the traffic sources. Audio traffic is generated by the CBR sources at the rate of 60 kbps .Similarly video traffic is generated by the CBR sources at a rate of 120 kbps and the rate of best effort traffic is kept at 200kbps. Packet size is 512 bytes. Source destination pairs are spread randomly over the network. Mobility pattern of the mobile nodes is generated using Random Waypoint model wherein a mobile node randomly selects another node as destination in the network and constantly moves towards it at a given velocity. Once it reaches there, it waits for some pause time and selects another node and again starts moving. Speed of a mobile node is assigned a value between 0 to 20meters/sec. To evaluate the performance of CAMR ,it is necessary to study its response under various traffic conditions. Hence we have considered two scenarios .In the first scenario video traffic was constantly increased stepwise every 20 seconds, keeping audio and best effort traffic constant. In the second scenario audio traffic was gradually increased every 20 seconds ,keeping video and best effort traffic constant.

5.2. Results

Working of CAMR protocol is compared with multipath AODV (AOMDV) routing protocol. Performance metrics analysed are packet delivery ratio, end to end delay and average energy consumed simulation time. Packet delivery ratio is the ratio of total number of packets that have successfully reached the destination to the total number of packets generated by all CBR sources. Figure 1 shows , how CAMR reacts to increasing video traffic. As can be seen in the figure , packet delivery ratio of real-time data is better than AOMDV .

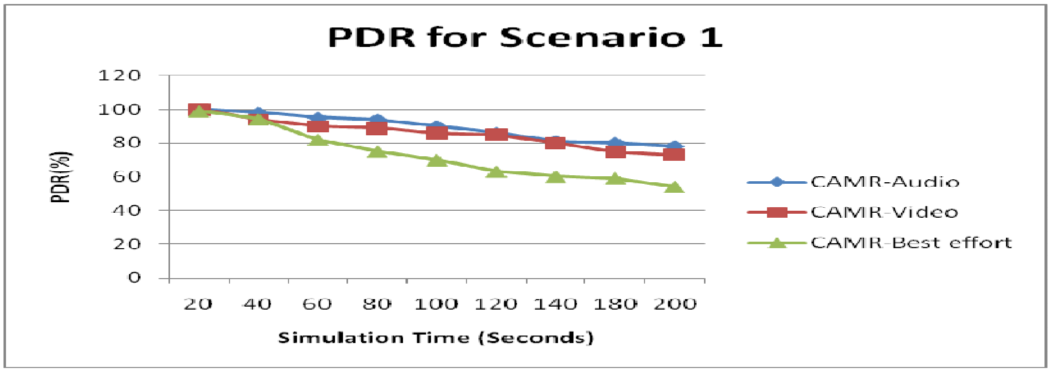

Figure 1. Variation in the PDR under increasing number of video flows

Increasing video sources results in the increase in the number of video packets being generated thereby building up of queue size of Access Category queue for video. CAMR avoids such nodes ,and selects nodes which has enough bandwidth and whose queue size of AC_VI is less than a threshold. Similarly PDR of video packets is more in CAMR than AOMDV. In both cases Packet Delivery Ratio(PDR) worsens when the traffic in the network increases. This can be attributed to the fact that increasing traffic increases the level of contention among the nodes thereby bringing down the packet delivery ratio. But CAMR manages to outperform AOMDV because CAMR selects routing paths which are not congested resulting in lesser number of packet drops. Figure 2 shows how AOMDV reacts to increasing video traffic. As can be seen from the graph AOMDV's average PDR of audio traffic comes down to 79 % whereas it is up to 90% in case of CAMR. Similarly PDR of video is higher in CAMR than AOMDV.

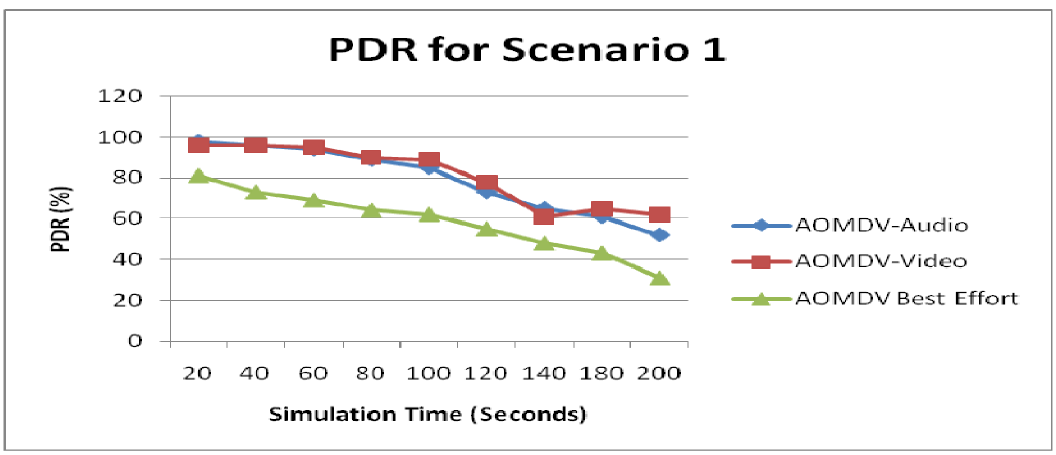

Figure 2. Variation in the PDR under increasing number of video connections

Performance of audio and video traffic and best effort is again studied for the second scenario. Because the number of audio flows increase in the second scenario as the simulation time progresses, CAMR manages to keep the audio PDR better than PDR of Audio packets for AOMDV by over 20%. Figure 3 shows this.

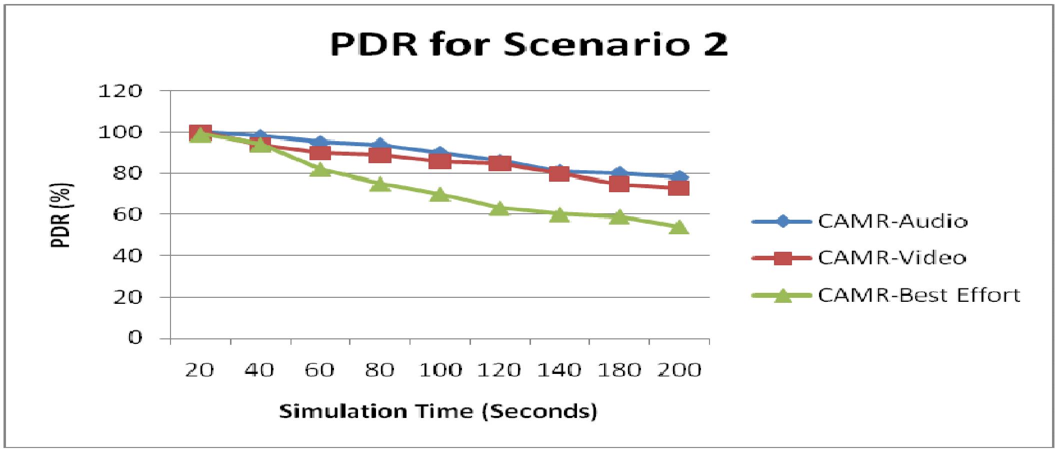

Figure 3. Variation in the PDR for increasing audio traffic

AOMDV's PDR of real-time data for scenario 2 is shown in figure 4. Again CAMR's PDR is higher by over 22%. Another thing to be noted about PDR achieved in the second scenario is that ,that it is comparatively less when compared to the first case. This is because the number of high priority audio traffic packets generated increase in the network thereby reducing the chances of finding congestion free nodes. Average end to end delay is another parameter studied by varying the number of audio and video source destination pairs. Channel access delay , queueing delay, transmission delay and number of hops contribute to end to end delay or the latency.

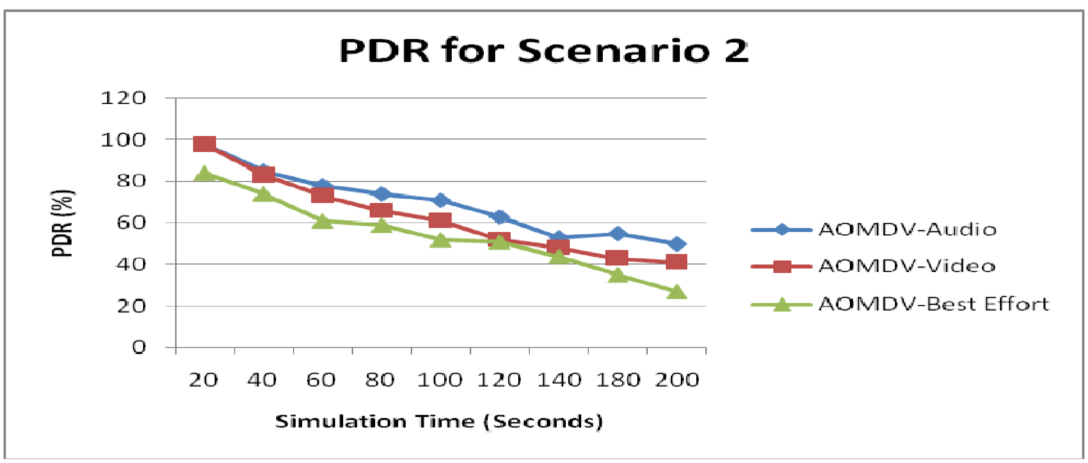

Figure 4. Variation in the PDR for increasing audio traffic

Latency is calculated as the difference in the time when the packet reaches the destination and the time when the packet is dispatched at the source. Latency experienced by the packets is again studied for both scenarios against simulation time. AOMDV suffers more delay when compared to CAMR.

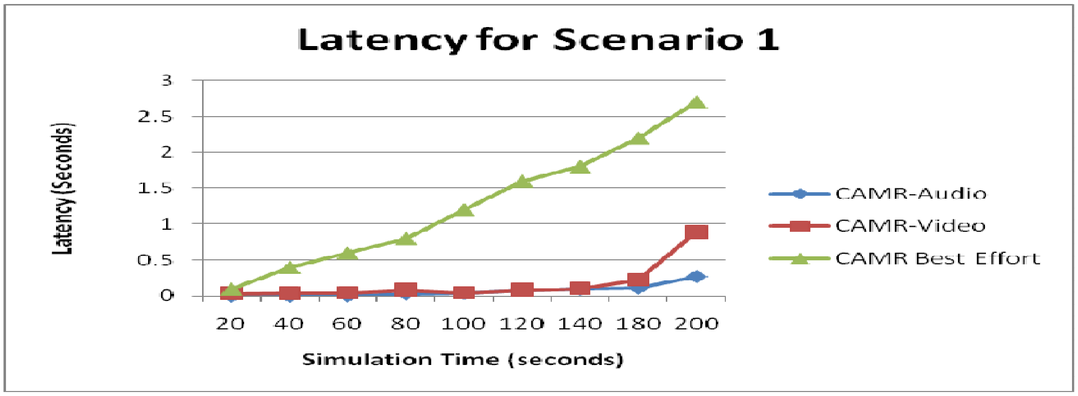

Figure 5. Latency suffered under increasing video traffic

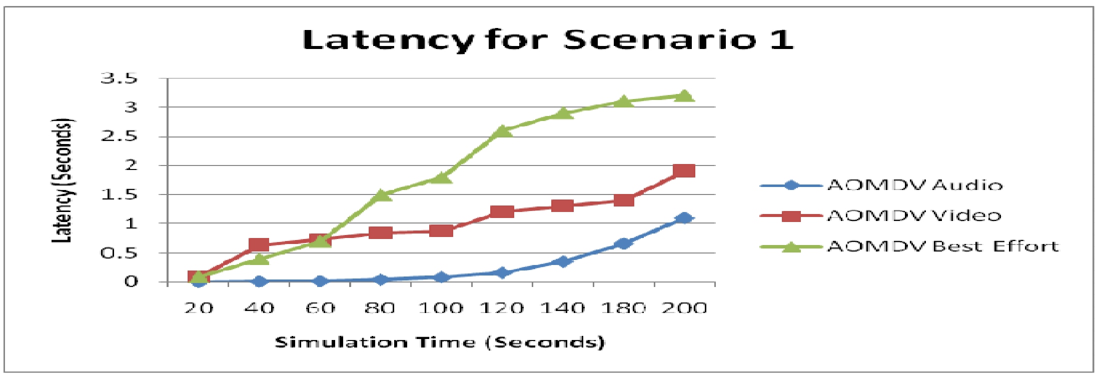

Figure 6. Latency suffered under increasing video traffic

AOMDV adopts ,only the shortest hop criterion without considering channel access contentions and queue size of the access categories while selecting routing paths. Hence ,the increased latency. Figure 5 and 6 shows this. CAMR manages to keep low ,the latency of video packets but not lower than delay for audio packets .As routing paths selected by AOMDV are congested ,there will be more amount of packet drops and retransmissions causing deterioration in the end-to-end delay. Figure 7 shows the latency experienced under scenario 2 wherein audio traffic is increased. As simulation time progresses , CAMR manages to keep the delay of audio traffic lower that of video traffic which is also what is desired.

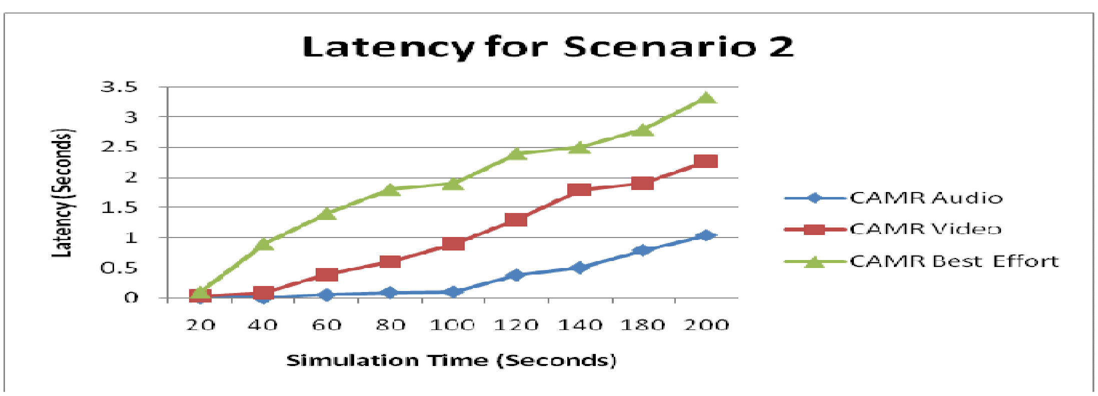

Figure 7. Variation in the latency under increasing number of audio flows

End to end delay suffered by best effort traffic is very much higher compared to that of audio and video traffic. There is not much distinguishable difference in delay observed by audio and video packets. This because of the fact that lower priority video packets flood the network , consuming the major share of the network bandwidth and at the same time, not depriving high priority audio packets its share of the required bandwidth. Figure 8 shows the latencies suffered.

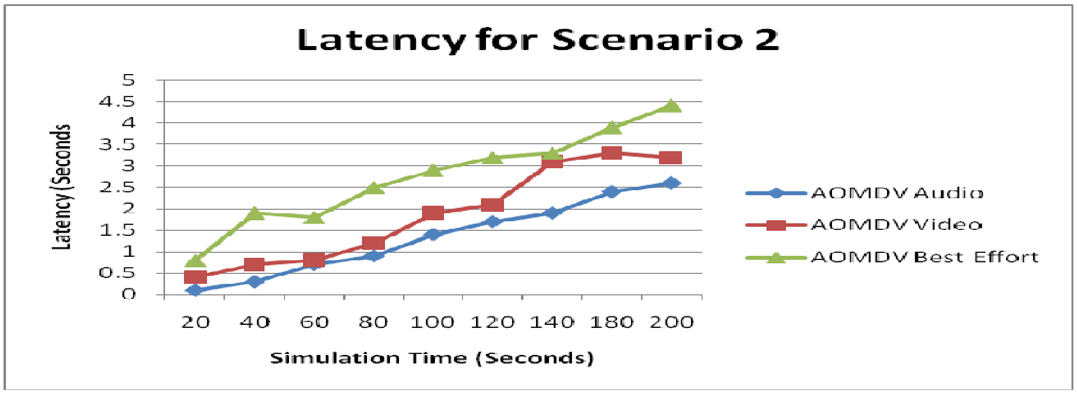

Figure 8. Variation in the latency for increasing audio flows

Average energy consumption is defined as the ratio of the sum of energy spent by all nodes to the number of nodes at the end of simulation .This metric is useful as it reflects on the energy usage of the nodes .When the traffic in the network increases queue size starts building up. This increases the level of contention among nodes resulting in collisions and packet drops. Packet drops further , cause retransmissions. All these attribute to increased energy consumption by the nodes resulting in network partitions. Average energy consumed by the nodes for CAMR is lesser than that of AOMDV asserting the fact that ,AOMDV does not adapt to increasing load .CAMR is successful in detouring paths with congested nodes thereby reducing the energy consumption. Figure 9 shows the average energy consumed by both CAMR and AOMDV against simulation time.

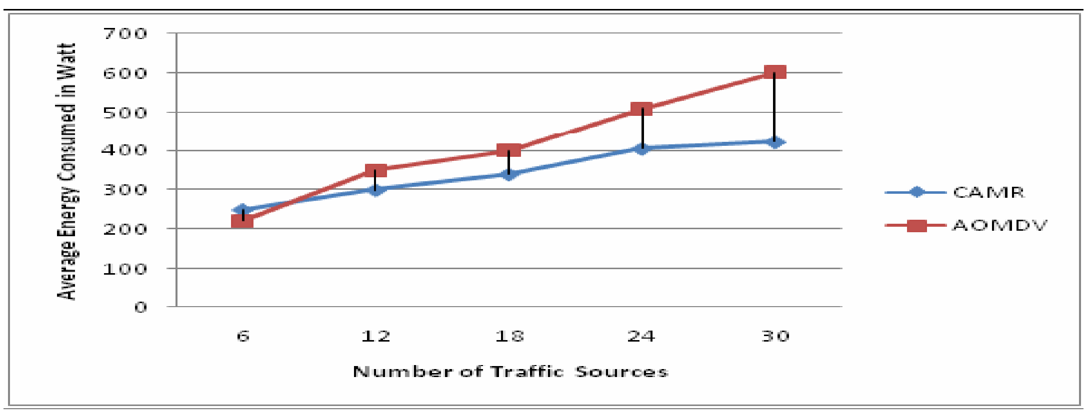

Figure 9. Average Energy consumed

6. CONCLUSIONS

Routing layer support is needed for providing QoS assurances to multimedia applications to work over 802.11e based mobile ad hoc networks. This paper addresses the issue of controlling congestion when the real-time traffic increases. We have devised a mechanism to estimate the available bandwidth at a node .This enables the routing protocol to find routing paths based on the load processed by nodes ,remaining energy available at the nodes and also according to the type of traffic processed. We then introduced a method, to modify the route discovery process and accumulate multiple paths that can process the multimedia traffic. We considered the effect of internal collisions that reflects channel contentions among flows belonging to equal priority and external collisions that reflects channel contention among the neighbouring nodes while establishing routing paths to achieve load balancing. Results show that CAMR can overcome the network performance degradation under increasing inflow of real -time traffic.

REFERENCES

[1] G. Bianchi, Understanding 802.11e contention-based prioritization mechanisms and their coexistence with legacy 802.11 stations," in *IEEE Network*, July 2005.

[2] Yihan Li, ShiwenMao, Shivendra S. Panwar, "The Case for Multi path Multimedia Transport over Wireless Ad Hoc Networks", Proceedings of the First International Conference on Broadband Networks (BROADNETS'04),IEEE 2004.

[3] N. Gogate et al., "Supporting Image/Video Applications in a Multihop Radio Environment using Route Diversity and Multiple Description coding", IEEE Trans. Circuits and Sys.for Video Tech. vol. 12, no. 9, Sept. 2002, pp. 777 –92.

[4] IEEE Std 802.11e/D8.0, Draft Supplement to Standard for Telecommunications and Information Exchange Between Systems Systems – AN/MAN Specific Requirements - Pan 11: Wireless Medium Access Control (MAC) and physical layer (PHY) specifications: Medium Access Control (MAC) Enhancements for Quality of Service (QoS), 2004.

[5] Weihua Helen Xi et al, "Effectiveness of QoS provided by IEEE 802.11e for different traffic types" IEEE 2005.

[6] Joe Naoum-Sawaya,et al "Adaptive Approach fo QoS Support in IEEE 802.11e wireless LAN ", IEEE 2005.

[7] Yanhong Cheng , Zhishu Li ,Baolin Li "Adaptive transmission Probability for IEEE 802.11e for MAC Enhancements" IEEE 2007.

[8] Carlos T. Calafate, Peitro Manzoni, and Manuel P . Malumbres "Assessing the effectiveness of IEEE 802.11e in multi -hop mobile Networks environments in 12th IEEE International Symposium on Modelling, analysis and Simulation of Computer and Telecommunication Systems (MASCOTS' 04) ,October 2004.

[9] Xiang Chen, Hongqiang Zhai and Yuguang Fang " Enhancing the IEEE 802.11e in QoS Support :Analysis and Mechanisms ", Proceedings of 2 nd International Conf. on Quality of Service in Heterogenous Wired/Wireless Networks(Qshine'05) IEEE 2005.

[10] Zhen Yan et al, " A Novel Call Admission Control Routing Mechanism for 802.11e based Multi-hop MANET ", IEEE 2008.

[11] Consolee Mbarushimana and Ali Shahrabi " Congestion Avoidance Routing Protocol for QoS-Aware MANETs" ,IEEE 2008.

[12] Yang Li, Hong Man "Three Load Metrics for Routing in Ad Hoc Networks "Proc of Vehicular Technology Conference September 2004,IEEE.

[13] H. Hassanein and A. Zhou, "Routing with Load Balancing in Wireless Ad Hoc networks in Proceedings", ACM MSWIM, Rome, Italy, July (2001).

[14] Pham, P. and Perreau, S., "Multi -Path Routing Protocol with Load Balancing policy in Mobile Ad Hoc Routing", IEEE pp. 48-52 (2002).

[15] Lijuan Cao Teresa Dahlberg, "Path Cost Metrics for Multi –Hop Network Routing" IEEE pp. 15-21(2006).

[16] Cheikh Sarr, Claude Chaudet Guillaume Chelius, Isabelle Gu´erin Lassous, " A node based available bandwidth evaluation in IEEE 802.11 ad hoc networks" ,Iinternational Journal of Parallel Emergent and Distributed Systems, July 2005.

[17] Marina, M.K., Das, S.R.: "On -demand Multipath Distance Vector Routing in Ad Hoc Networks", proceedings of the International Conference for Network Protocols,2001.

[18] http://www.omnetpp.org

[19] http://www.hluze.cz/2008/11/omnet-80211e-patch-for-inetmanet-20080920-ver-10/