ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 2, February 2018

Admission Control based Delay-Aware Routing Protocol for MANETs

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Abstract: **— Due to the recent developments in the hand-held devices and communication enhancements in wireless networks like mobile ad-hoc network (MANETs), these networks are targeted for providing real time services like video streaming, video conferencing, VOIP etc. Although, the basic design of MANETs is not fully capable to provide multimedia services, therefore some sort of quality-of-service is required in these networks. Providing requisite QoS guarantees in wireless multihop networks is much more challenging than in wired networks. In particular, it is important for routing protocols to provide QoS guarantees by incorporating metrics like achievable throughput, delay, jitter, packet loss ratio, etc. In this paper, we proposed an admission control based delay-aware routing protocol for reliable transmission of delay-sensitive multimedia applications over mobile ad-hoc wireless networks. To show the correctness and effectiveness of proposed scheme we perform simulations on various scenarios. The results obtained through simulation shows that our scheme is able to provide delay guarantees to an application whenever required.**

Index terms**: MANETs; Multimedia Streaming; Routing protocols; QoS; Topology; Node Mobility; Network Scalability;.**

I. INTRODUCTION

Mobile ad hoc networks (MANET) are collection of mobile hosts which can self-configure, self-organize and, self-maintain while communicating with each other through wireless channels in having no centralized control. The inherently infrastructure less, inexpensive and quick to deploy nature of MANETs is providing a promise for its use in diverse domains. Starting from late 1990s mobile ad hoc networks (MANETs) gained a huge popularity among people because of their infrastructure less, independent, inexpensive, live and on-the-fly nature. In MANETs one of the important open issues is routing i.e finding a suitable path from source to destination. Due of the rapid growth in use of applications like online gaming, audio/video streaming, VOIP and other multimedia streaming applications in MANETs, it is mandatory to provide some desired level of quality of service (QoS) for reliable delivery of data and/or quality. Providing required QoS guarantees in wireless multihop networks is much more challenging than in wireline ones mainly due to its dynamic topology, distributed nature, interference, multihop communication and contention for channel access. In particular it is important for routing protocols to provide some sort of QoS guarantees by incorporating few QoS metrics like achievable throughput, delay, jitter and packet loss ratio.

Despite the large number of routing solutions available in MANETs their practical implementation and use in real world is still limited. Multimedia and other delay or error sensitive applications that attract a mass number of users towards the use of MANETs realized that best effort routing protocols are not adequate for them. Because of the dynamic topology and physical characteristics of MANETs providing guaranteed QoS in terms of achievable throughput, delay, jitter and packet loss ratio is not practical. So, QoS-adaptation and soft-QoS is proposed instead. Soft-QoS means failure to meet QoS is allowed for certain cases, such as, when route break or the network becomes partitioned [1]. If nodes mobility is too high and topology changes very frequently providing even soft-QoS is not possible. So, for a routing protocol to function properly in a wireless network where mobility is high the rate of topology state information propagation must be higher than the rate of topology change. Otherwise the topology information will always be stale and inefficient routing will takes place or may be no routing at all. This applies equally to QoS state and QoS route messages. A network that satisfies the above condition is said to be combinatorial stable [2].

In this paper, we present the implementation details and discuss the results obtained through simulation process over various scenarios for the proposed Delay-Aware Routing Protocol (AC-DARP). This protocol is useful for transmission of traffic that is generated by applications which are critical and stringent requirements for end-to-end delay values. The applications such as online video streaming, TV on demand, Audio/Video conferencing, online gaming in n building etc have tight delay requirements which has to be satisfy by the network for their efficient and reliable communication. The traditional routing protocols used in MANETs such AODV, OLSR and DSR etc are not suitable for transmission of delay sensitive applications over wireless networks. So, we have to provide some QoS support to such applications in terms of some QoS metrics like delay, bandwidth, jitter etc. Our proposed method provides the QoS guarantees to the delay sensitive applications in terms of their delay requirements.

Our proposed delay aware routing protocol is based on a reactive routing protocol called Ad hoc On-demand Distance Vector (AODV). AODV is a reactive routing protocol build specially for routing in wireless networks. As, we know that the tradition MANETs routing protocols have no support provided to provisioning any type of QoS support for any applications. So, to provide the required delay guarantees we proposed this delay aware routing protocol. This paper is organized in the following manner. In Section II, we present the related work done in our area which includes the papers that are proposed the effective routing methods for delay-sensitive applications. This is followed by the proposed work for efficient routing for delay-sensitive applications in Section III. We also summarize the key features, basic operation, as well as major pros and cons of our proposed approach. In Section IV, We will conclude the paper with present state of the art and future work.

II. RELATED WORK

In this section, we discuss the past works done in MANET that includes the evolution of many new protocols to provide better performance. Ad hoc delay aware routing protocol is evolved to remove the problems of heavily loaded intermediate nodes that results in longer transmission delay and higher packet loss. Delay aware multipath source routing protocol (DMSR) send packets over multiple paths at a time and support QoS for real-time multimedia applications. DMSR is advantageous over DSR and i-DSR in the average end-to-end delay. It minimizes the route maintenance time and the frequency of route discovery [3, 4, 5, 6]. Power and Delay aware Temporally Ordered Routing Algorithm (PDTORA), is helpful where the nodes in the network do not satisfy QoS requirements of maximum delay and minimum power levels. PDTORA removes all these nodes from the network [7,8]. Delay Aware AODV-Multi-path (DAAM), records the delay of each route when set up multiple node disjoint paths during a single route discovery and shows remarkable improvements of end-to-end packet delay and delay variation compared to AODV, DSR, OLSR. [9,10]. Link Delay aware Routing protocol (LDAR), observes the link delays of various types present in the network. It periodically requests for the most recent link delays and passes this information to the rest of the network to compute shortest route to other nodes [11].

III. PROPOSED METHODOLOGY

In this section, we present the implementation and working details of our proposed Admission Control based Delay-Aware Routing Protocol (AC-DARP). The algorithm of our proposed method is presented and its working is explained using an example. The proposed AC-DARP uses a cross-layer technique to identify the delay requirements of a transmitting application. The cross-layer technique takes the delay values of each transmission requesting application from application layer and send it to network layer so that the network layer routing protocol (in this case AODV) can then find a route towards the destination that satisfy these delay requirements of the requesting application.

Furthermore, to maintain the delay constraints of already existing applications and newly requesting applications we have implemented an efficient call admission control (CAC) technique that stops the admission of techniques for which the network layer is unable to find the route that satisfies there delay requirements. This may be possible due to already existing applications in the network that take all the bandwidth in the network and not allow the route discovery process to find the delay aware routes. The CAC will reject the applications admission into the network if no delay-aware route is available at that time in the network.

A. Route Discovery phase of AC-DARP

When a source node got data packet from an application runs on application layer. It asks the application layer process to specify its delay requirements. After getting the delay requirements for the data packet it receives the source checks its routing table to find a suitable and active route towards destination, if such a route exists in the routing table the data packet is transmitted to next hop towards destination node. On the other hand, if the routing table has no route for the destination the source node starts a delay aware route discovery process with the delay values provided by the application.

ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

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For the route discovery process of AC-DARP we have added some extra fields in Route Request messages (RREQ) and node routing table of AODV. In RREQ message we added the following two fields: a) MAX_DELAY i.e. the maximum delay that a route can have to the destination for the application for which this packet belongs, the value of MAX_DELAY is set to equal to the delay value provided by the corresponding application. b) RREQ_START_TIME, this field is set to the time at which the RREQ to find the route for destination is initiated by the source.

In addition to this, the structure of the routing table of the source node is modified by added one extra field in it. This added field is used to store the delay of the route we discovered using over delay aware routing protocol. So, whenever a source node got a data packets it checks the routing table not for the existence of active route for the destination but also for the route that has delay less than the delay requirement of the application whose data packet is received by the source node.

When the source node initiates a RREQ to discover the delay aware route based on the delay value provided by the above application each intermediate node that receives this RREQ checks the delay that this RREQ is taken to reach at this intermediate node. This value we call PATH_OFFSET is calculated by taking the difference of the RREQ_START_TIME value in RREQ packet and the current simulation time. The intermediate node will only relay the RREQ packet if the calculated PATH_OFFSET value for that RREQ is less than the MAX_DELAY value given in the received RREQ. Otherwise, the intermediate node will discard the RREQ without rebroadcasting it further in this way we can decrease the RREQ packets in the network that increases the network capacity.

B. Pseudo Code for proposed Delay-Aware Routing Protocol

Variables Used:
S *= Source nodes*
D*= Destination nodes*
I *= Intermediate nodes*
DP ***= Data packet***
BEGIN ALGORITHM
IF*(S got a data packet)*
  Call the cross-layer process to get the delay requirements of the application
  Check routing table for routes
  IF *(S has route with specified delay for D)*
    Send the packet to next-hop towards destination
  ELSE
    Initiate route discovery process by broadcasting a RREQ
  ENDIF
ENDIF
IF*(S or I got a RREQ)*
  Check the received RREQ for duplicity
  IF *(duplicate)*
    Discard the RREQ
  ELSE
    Calculate the PATH_OFFSET value
  ENDIF
  IF *(PATH_OFFSET is greater than MAX_DELAY)*
    Rebroadcast the RREQ ELSE Discard the RREQ
  ENDIF
ENDIF
IF *(D got a RREQ && PATH_OFFSET is less than MAX_DELAY)*
  Initiates the RREP and ignore further RREQs with the same flooding ID
ELSE
  Discard the RREP and wait for another RREQ
  IF *(S didn't get a RREP for three consecutive RREQs)*
    S call the CAC process
    CAC reject the applications transmission request and give a timer to it (the application can retry to enter into network)
  ELSE
  Data session is admitted in the network
  ENDIF
ENDIF
END ALGORITHM

C. Working of AC-DARP with an Example

Figure 1 show how the proposed routing protocol finds routes that satisfy requesting applications delay requirements with the help of an example. Let us assume that S is the source node and D is the destination node. When node S got a data packet and don't have an active and delay aware route in its routing table it starts the route discovery phase by broadcasting the RREQ in the network. The RREQ broadcasted by S reached to its neighbors i.e. node A, E and H. The neighbors check the RREQ for duplicity and calculate the PATH_OFFSET. If the RREQ received is not a duplicate and satisfy the delay property these intermediate node (A,E,H,B,C,G etc) rebroadcast the RREQ like else the RREQ is discarded like node D did. When the first RREQ is received by D it also checks it for

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ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 2, February 2018

the duplicity and delay constraints and if satisfies it generates and unicast the RREP for the source node as shown in figure 1. The application session is admitted as soon as the RREP is received by the source node.

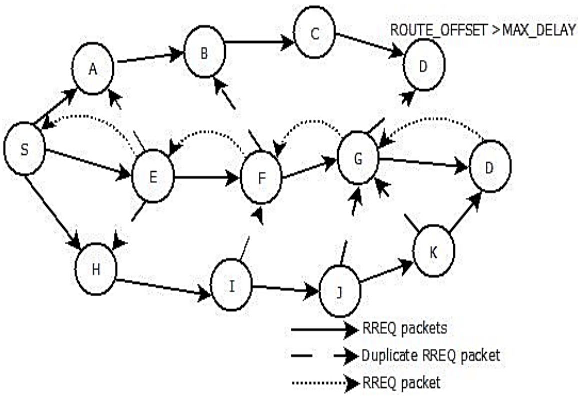

Fig. 1. AC-DARP Route Discovery Process

IV. SIMULATION RESULTS AND PERFORMANCE EVALUATION

In this section, we present the results obtained through simulations to show the correctness and effectiveness of our proposed method. All the simulations are done using the commercial simulator known as Qualnet. The Simulation parameters to build the scenarios are given in the Table 1. All the simulation results are calculated by taking the average of five different runs. In our simulation, all the scenarios are created using the parameters with values given in Table 1. All the source nodes are modeled with the traffic traces generated from real time video streams using the H.265/AVC encoder. The video trace file we used to model the source node's traffic contains two columns, in each row the first entry contains the inter-packet time between two consecutive video frames and the second entry contains the size of the video frame. The inter-packet time is kept constant but the size of video frames varies greatly. To introduce the background traffic in the network we use the constant bit rate (CBR) traffic sessions. In this way, we are able to build a virtual wireless network using simulation that represents a high fidelity to the real network while transmitting multimedia services over the network.

TABLE.I. Simulation Parameter Table

Simulator	Qualnet 5.0
Simulation time	1000 Sec
Application layer protocol	Traffic Trace
Transport layer Protocol	UDP
Routing protocols	AODV, AC-DARP
MAC layer protocol	802.11
Data rate	11 Mbps
Mobility model	Random way point
Video	Sony-Demo CIF (352x288)
Video Codec	H.264/SVC
Frame Size	22 to 37775 bytes
Inter packet time	33 ms
Mobility speed	0-20 m/s
Path-loss model	Two ray
Node pause time	30 Sec

A .Simulation Setup

In our simulation, all the scenarios are created using the parameters with values given in Table 1. All the source nodes are modeled with the traffic traces generated from real time video streams using the H.265/AVC encoder. The video trace file we used to model the source node's traffic contains two columns, in each row the first entry contains the inter-packet time between two consecutive video frames and the second entry contains the size of the video frame. The inter-packet time is kept constant but the size of video frames varies greatly. To introduce the background traffic in the network we use the constant bit rate (CBR) traffic sessions. In this way, we are able to build a virtual wireless network using simulation that represents a high fidelity to the real network while transmitting multimedia services over the network.

B. Performance evaluation

In this section, we present results obtained from different simulations on a variety of scenarios to prove the correctness and effectiveness of the proposed routing protocol i.e. AC-DARP. We compare the traditional AODV routing protocol to over proposed AC-DARP protocol in terms of packet delivery ratio (PDR), end-to-end delay (EED) and network throughput (NT) over wireless networks with increasing mobility and network load. The applications delay requirement is calculated by using the inter-packet time of the data session. We choose the delay requirements of the application as one third of its inter-packet time. In this way, we can take care of little fluctuations in received delay packets after a delay-aware route is established between the source and destination node caused by dynamic environment conditions of MANETs.

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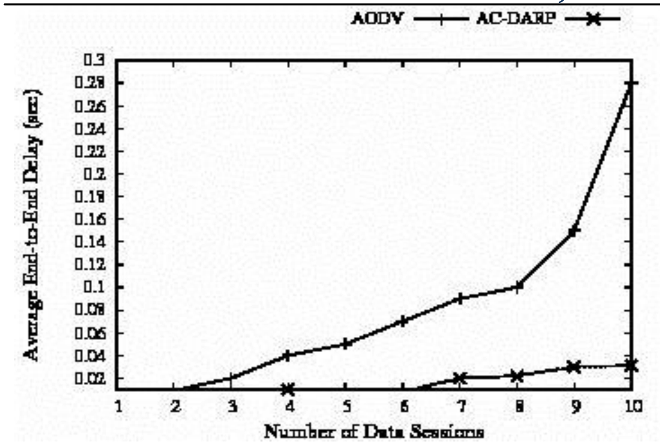

Fig.2. Effect of increase in video session on average EED

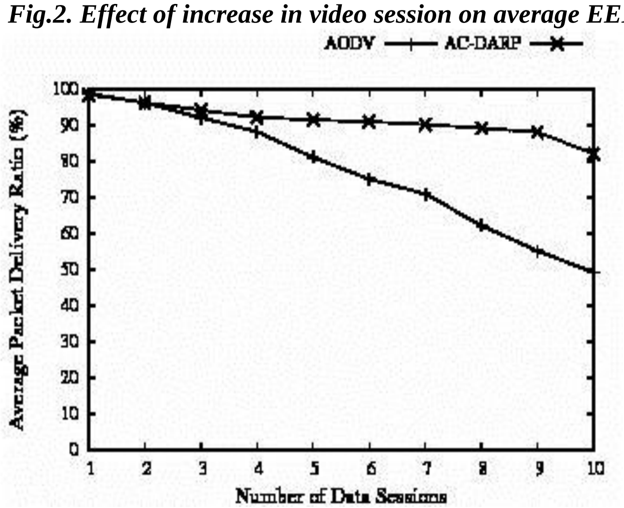

Fig.3. Effect of increase in video sessions on PDR

Figure 2 and Figure 3 shows the effect on EED and PDR with increases in number of video sessions in the network for both AC-DARP and AODV routing protocols. As we can observe from Figure 1 that the proposed AC-DARP outperforms the tradition AODV routing protocol by always providing the delay values which is less than the applications specified delay constraints. This is because our Call Admission Control (CAC) process will on admit those applications traffic for which our route discovery process is able to find suitable routes. On the other hand, in traditional AODV as soon as the numbers of video sessions are increased upto the numbers that consumes all the network bandwidth the delay of network starts increasing.

In Figure 3, it can be seen that the PDR of AC-DARP is more as compared to AODV because due to our admission control process only the limited number of sessions are running in the network at any time. But in AODV as the number of video sessions in the network increases the PDR starts dropping due to increases in

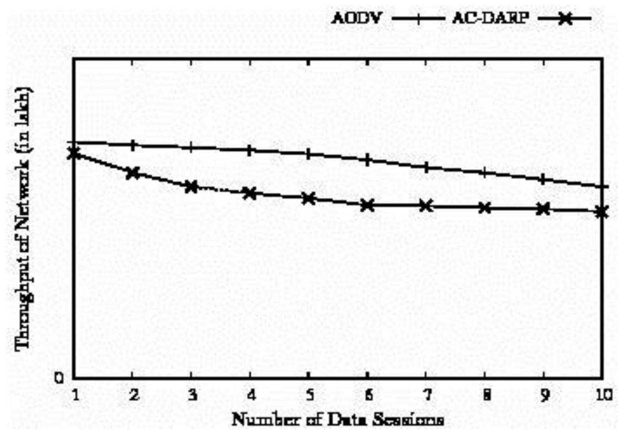

Fig. 4. Effect of increase in video sessions on network throughput

collisions due to channel contention. In Figure 4, we can see the effect on network throughput (NT) with the increase in number of video sessions in the network. The throughput of AODV is high as compare to AC-DARP because in AC-DARP a session is not admitted unless its delay requirements are satisfied by the underlying network. Due to this it may be possible that network have the resources but that are not enough to satisfy the current session delay constraints so the session is not admitted and network throughput decreases.

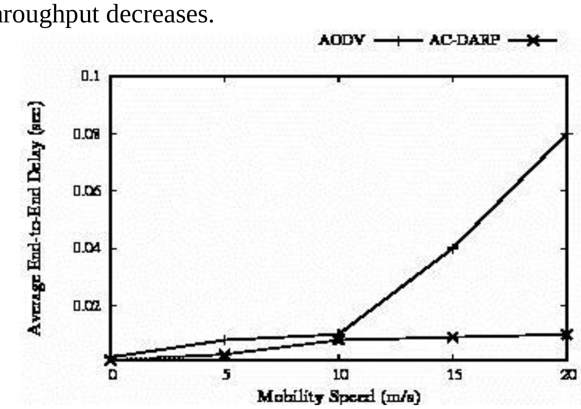

Fig. 5 Effect of increase in node's mobility on average EED

In Figure 5, we can see the results obtained for EED for AC-DARP and AODV routing protocols with increase in network mobility. As we can observe from Figure 5 that EED of both routing protocols is low when the mobility in network is very low. But as the network mobility increases the delay of both protocol increases

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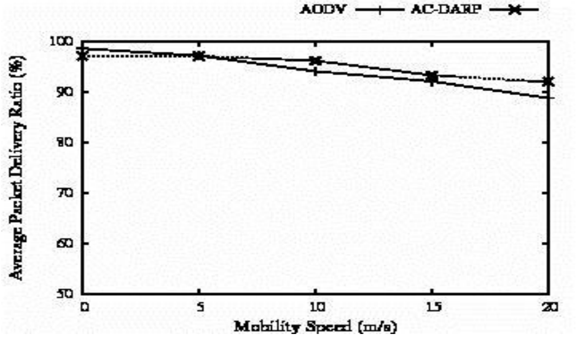

Fig. 6 Effect of increase in node's mobility on average PDR

but the increase in AC-DARP is low and smooth as compared AODV. This is because in AC-DARP the CAC process will only find the routes that satisfy the delay requirements of the requesting application after each route break due to high mobility in network.

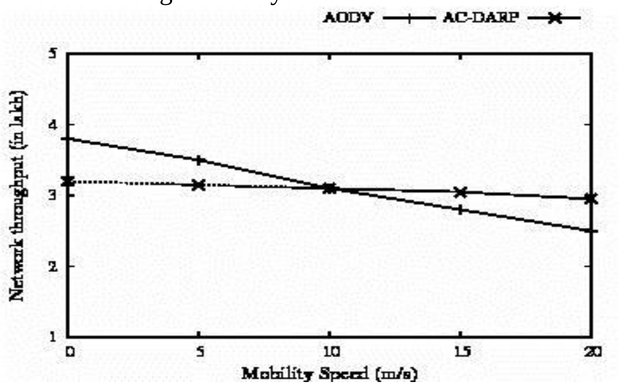

Fig. 7 Effect of increase in node's mobility on Network throughput

From Figure 6 and Figure 7, it can be seen that as the network mobility increases the PDR and NT of both routing protocols affected greatly. In Figure 6 we can see that with increase in network mobility both the routing protocols PDR decreases due to increase in number of route breaks caused by high mobility nodes in the network. As we have no support provided to handle the network mobility in our AC-DARP we can see that it will behave in the similar way the AODV behaves but due to our CAC process and route discovery process that increases the network capacity and also decreases the collisions in the network AC-DARP can sustain the effects of network mobility much better than the AODV.

V. CONCLUSION AND FUTURE WORK

In this chapter, we have presented the results and performance evolution to show the effectiveness and correctness of our proposed admission control based delay-aware routing protocol (AC-DARP) based on AODV routing protocol. This protocol is developed for reliable and efficient transmission of multimedia application over mobile ad hoc networks. The results show that AC-DARP is able to handle the video sessions and its decision to admit a session or reject a session that is based on network layer route discovery process is correct and efficient. We can say that AC-DARP is able to provide the delay guarantees of the applications once they are admitted in the network. In the future, we will use more than one QoS metric to find routes for the requesting applications so that more accurate admission control can be taken place. We will ask the delay as well as bandwidth constraints of the requesting applications and before admitted an application make sure that its multi constrained QoS requirements are fully satisfied by the underlying wireless network.

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