Implementation of Congestion Avoidance Technique in AODV

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Abstract: A mobile Ad-hoc network (MANET) is an interconnection of autonomous mobile nodes which are connected using wireless links and which forms a multi-hop network with dynamic topology. In such a network every node acts as a router and cooperatively helps in communication. The constant movement of the nodes leads to dynamic change in network topology, as a result the paths between the communication nodes breaks very often in MANET. In order to have a successful communication, the whole process of discovering new path needs to be carried out again and again. This leads to a delay in transmission and consume more network resources. In this paper, we propose an enhancement to an existing protocol namely AODV, to incorporate congestion along the path while discovering route between the source and the destination node. The proposed protocol CA-AODV is simulated using NS2 and the results are compared with the original protocol, namely AODV.

Keywords — MANET, Routing, AODV, CA-AODV, Congestion, CFT

I. INTRODUCTION

A mobile ad-hoc network (MANET) is a collection of self-organising dynamic wireless mobile nodes which communicate without any fixed infrastructure to form a temporary network. As the links in dynamic environment can break very often, maintaining route between the communicating nodes is difficult and challenging. When a link fails, all packets that have been already sent along the route are dropped which results in reduction of average packet delivery ratio. Also, the communication is halted, till a new path is found. This increases end-to-end delay [1]. An efficient routing protocol must quickly find the path between the source and destination node. Thus, existing protocols can be enhanced to consider congestion during route discovery phase.

II. LITERATURE REVIEW

Congestion in a network occurs if the demand on the network resources is greater than the available resources. Congestion will lead to high packet loss and long delays. Over the years and several techniques have been developed to control congestion in wireless networks. V. Thilagavathe et al. [2]. Proposed an algorithm based on additive increase and multiplicative decrease of congestion window. Here congestion window is increased by 1 MSS (Maximum segment size) until a loss is detected and when there is a congestion, the congestion window is multiplicatively decreased. When the received packet rate exceeds a predefined threshold, control is established in transport layer by decreasing packet sending rate at the source. Also, when the estimated received power at current time is beyond an exponential average power of received signal, congestion is assumed at the MAC layer and an alternative route is established. The proposed protocol was able to provide better packet delivery ratio and reduce the delay. A Mobile Agent Based Congestion Control using AODV routing protocol was proposed by Vishnu Kumar Sharma et al [3]. Here the mobile agent selects feebly loaded neighbour as the next hop and updates the routing table. The proposed technique attains high delivery ratio and reduces the delay. Detection and removal of packet dropper nodes in MANET was proposed by Reeta Bourasi et al. [4]. This algorithm uses reliability checking method during transmission of data packets to detect packet dropper nodes and eliminates the packet dropper nodes during the packet transfer. The proposed algorithm provides better performance with packets of varying sizes. Senthilkumaran et al. [5] proposed a dynamic congestion detection and control routing (DCDR) algorithm for ad hoc networks that is based on the estimation of the average queue length at the node level. Here a node can detect current congestion level using the average queue length and sends a warning message to its neighbours. On receiving warning message, neighbours attempt to find a congestion-free alternative path towards the destination. This mechanism ensures reliable communication within the MANET and simulations shows that DCDR has better performance than the EDOCR, EDCSCAODV, EDAODV and AODV routing protocols. Alhamali Masoud Alfrgani et al. [6] proposed a congestion control schemes for bandwidth estimation, and congestion window manipulation. They have provided a comprehensive comparison of these strategies in relation to bandwidth

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estimation, congestion window size manipulation and performance evaluation. Anju et al. [7] focuses on congestion detection and prevent the congestion in Ad hoc on demand routing protocol (AODV).

III. Ad hoc On-demand Distance Vector (AODV) Protocol

The Ad hoc On-demand Distance Vector (AODV) [8] routing protocol is a reactive protocol which is built on the Destination Sequenced Distance Vector (DSDV) protocol. It can provide both unicast and multicast communication between the mobile nodes [9]. In unicast communication, source node begins the route discovery process by broadcasting a Route Request Packet (RREQ) to all its neighboring nodes. The format of RREQ Message is shown in the figure 1. The validity of the route is established by comparing the sequence number. If the sequence number in the RREQ packet is larger than the sequence number stored in the routing table, then RREQ packet is considered to be valid. Sequence numbers also avoids the loops in the route and to ensure that only most recent requests are replied by the intermediate nodes.

Type	J	R	G	D	U	Reserved	Hop Count
RREQ ID							
Destination IP address							
Destination Sequence Number							
Originator IP Address							
Originator Sequence Number							

Figure 1: RREQ Message Format.

When an intermediate node receives RREQ, it checks it routing table for the reverse route towards the source. If it does not have the route entry towards the source or if its route is invalid, then a reverse route is setup towards the source and the sequence number of the source is stored in routing table. The intermediate node then checks for a valid route to the destination address. If there is no valid route, then it will increase the hop count value in the RREQ and re-broadcast RREQ to all its neighbours. Same procedure is followed at the subsequent intermediate nodes until it reaches destination or to a node having valid route. Since RREQ is broadcasted to all neighbours, there is a chance that same RREQ being received more than once by an intermediate node. In such a case, intermediate node will compare its sequence number for the same source in its routing table with the sequence number in RREQ. If the sequence number of RREQ is higher than its stored sequence number, then it will broadcast RREQ, otherwise it will discard the repeated RREQ. When the RREQ reaches the destination or an intermediate node having valid route, it will generate a Route Reply (RREP) message and unicasts it towards the source. RREP message format is shown in Figure 2.

Type	R	A	Reserved	Prefix Sz	Hop Count
Destination IP address					
Destination Sequence Number					
Originator IP Address					
Lifetime					

Figure 2: RREP message format.

When the RREP reaches the source, it starts data transmission along this route. Such a route along which the data packets are sent is called as an Active route. As the nodes in MANET are continuously moving, the active route between the source and the destination nodes may break at any time. When a node in the active route realizes that the link to its next node is broken, it invalidates all the routes passing through the broken link. It then creates a RERR message and sends it to all neighbours utilizing this link. This message travels in reverse direction towards the source node. All the nodes that received the RERR will also invalidates their affected routes. When the source receives the RERR, if it still has the data to be sent to the destination, it will reinitialize the route discovery process again.

IV. Congestion controlled AODV

The AODV protocol does not take into consideration, the congestion during route discovery. It always selects the route with lower hop count. If the lower hop count path is already congested, then it can lead to an increase in the end-to-end delay. For a given link in a node, occupied size of the buffer gives a measure of congestion. By measuring the occupied buffer size of all the nodes along the path from source node to destination, we can estimate the congestion along the path and use this as a means to select the alternate for communication [10]. Active load can be computed using equation (a)

$$\text{Active\_load} = Min\left[\frac{1}{n_p}\sum_{i=1}^{n_p} \text{buffer\_size}(i)\right] \text{-----(a)}$$

The buffer_size(i) indicates the occupied size of the buffer for the link i of the intermediate node which is participating in the route p and n_p is number of hops in the route p.

To measure the active load, we need to incorporate buffer size into RREP packet. The modified RREP packet structure is shown in Figure. 3. Whenever an intermediate node receives a RREP packet, it adds its active buffer size value to the *buffer_size* field and forwards the RREP packet to the next node. When the source node receives the RREP packet, it divides the *buffer_size* field value with *hopcount* to get the level of congestion in the path.

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destination address	destination sequence number	source address	hopcount	buffer_size

Figure 3: Modified AODV, RREP packet to accommodate Buffer Size

The algorithm for estimating congestion level is as follows

Step 1: IF Packet_Type = RREP THEN
Step 2: IF node address ≠ source address of the packet THEN
buffer_size = buffer_size + occupied size of the buffer of link connecting next node on the route
Step 3: ELSE IF node address = source address of the packet THEN
Congestion level for the given route = buffer_size/hopcount
Step 4: END IF for step 2
Step 5: END IF for step 1

When the source node receives the first RREP from the destination, it uses this path as its active route and waits for next three RREP from the destination. If no additional RREP is received, then same path is taken as the active route. However, if it receives any additional RREP, then it selects the path with lower congestion. The path selection process is as follows. Arrange the paths in ascending order of congestion level. If the paths have same *congestion level*, then a path with short length (less hops) is chosen. This way we can create a Congestion Aware AODV (CA-AODV).

V. SIMULATION AND RESULTS

The performance of AOMDV and CA-AODV routing protocols is compared using NS-2.34 simulation framework. Simulation is carried over a square area of 1000m x 1000m flat space. The mobility model used during simulation is Random way point model. Various parameters such as Average Delay, Buffer size, Traffic Overhead and Packet Delivery ration are measured by varying number of connections. Table 1 shows the detailed description of simulation environment.

Parameter	Value
Dimensions	1000X1000 sq. m.
Number of Nodes	30 - 70
Number of Connections	25
Source Type	CBR
Packet Size	512 bytes
Buffer Size	50 packets
Mac Layer	802.11 b
Simulation Model	Random Way Point
Routing Protocols	AOMDV, CA-AODV
Propagation Radio Model	Two Ray Ground
Physique layer	Band width as 2 Mb/s
Maximal Speed	20 m/s
Pause Time	10 s
Interval Time To send	2 packets /s
Simulation Time	100 s

Table 1: Experimental Setup

a) *Packet Delivery Ratio:* Packet delivery ratio (PDR) is the no of packets received by the destination divided by the no of packets originated. Higher the value of PDR, better is the routing protocol. As Shown in the figure 4, when the number of connections increases PDR of both protocols decreases steadily. However, CA-AODV shows higher value and hence out performs AOMDV.

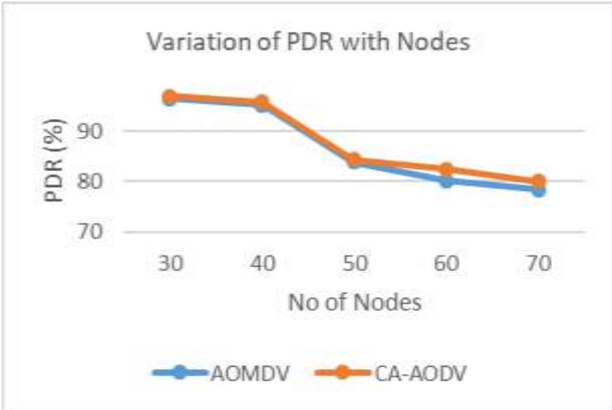

Figure 4: Variation of % of PDR with no of Nodes

b) *Routing Overhead*: Routing overhead refers to the number of control packets generated during communication. As shown in figure 5, routing overhead increases with number of Nodes. In case of CA-AODV the number of control packets required is less than AOMDV. Thus CA-AODV reduces the congestion in the network.

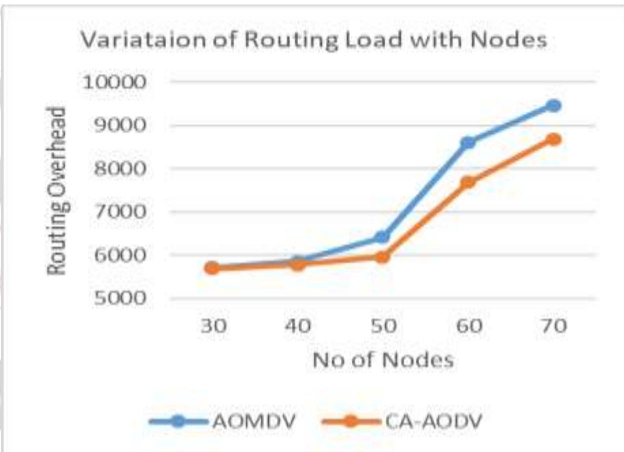

Figure 5: Variation of routing overhead with no of Nodes

c) *Throughput*: Throughput specifies the total number of bytes successfully received at the destination. It is measured in Kbps. It is observed that CA-AODV is able to provide a better throughput as compared to AODV. This is evident in the figure 6.

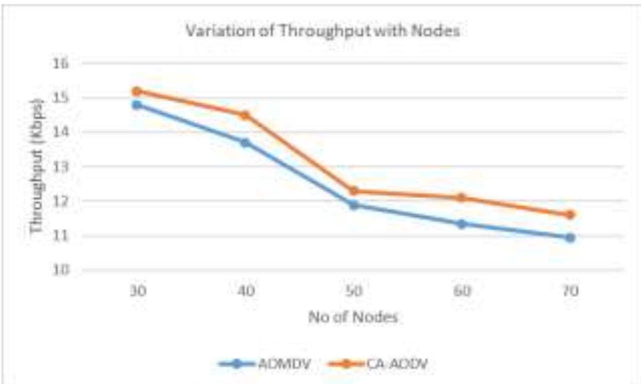

Figure 6: Variation of Throughput with no of Nodes

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VI. Conclusion

A mobile Ad-hoc network (MANET) is formed by the cooperative efforts of autonomous mobile nodes which communicate with each other using wireless links to form a multi-hop network with dynamic topology. When a link in an active path fails, all packets that have been already sent along the path are dropped. This reduces the average packet delivery ratio. Due to the broken link, communication is also halted until a new path is found. This increases end-to-end delay.

In this paper we have modified a reactive protocol namely, AODV to incorporate congestion level of path, during route selection phase. The modified process selects a path with less congestion. Simulation of both AODV and modified protocol, namely, CA-AODV were carried out using NS2. From the simulated results, it is observed that the modified protocol CA-AODV is able to provide a better throughput and packet delivery ratio, while reducing the routing load on the network. Thus we can conclude that, avoidance of congested paths, achieves better packet delivery ratio and reduces the routing load on the network. As the simulation was carried out in a medium sized network, it can also be concluded that, instead of using AODV in a medium sized network, the modified CA-AODV can be used to achieve better performances.

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