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Probabilistic Broadcasting based on Neighbor Coverage for CBR and VBR Traffic in MANET

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Abstract:*Mobile Ad-hoc Networks are formed by nodes which can move dynamically without any controlling stations. These are communication networks in which every node can send and receive data within the network. After the deployment of network the next step is to find a path from source to destination. Routing protocols are used for the path discovery. Broadcasting of data is the primary way to establish a path in MANET. But it has problems like collision and contention. In order to reduce the overloading of the network the route discovery process has to be modified. This work proposes a new method to find the route in an ad-hoc network. The protocol selected for modification is Ad-hoc On-demand Distance Vector. In AODV the route is selected only when there is a requirement for a node to send data to another. In the proposed method route selection is done by the neighbor knowledge which is used to reduce the route overhead in the network. This method is based on a rebroadcast delay and rebroadcast probability. Simulation result shows that this approach can improve the average performance of broadcasting in various network scenarios. This method is simple and can be easily implemented in MANET.*

Keywords: Mobile Ad-hoc Network, Neighbor coverage, Probabilistic Broadcasting, Routing Overhead, Variable Bit Rate Traffic.

1. Introduction

Movements of nodes in a mobile ad hoc network cause the nodes to move in and out of range from one another. As the result, there is a continuous making and breaking of links in the network, making the network connectivity (topology) to vary dynamically with time. For any pair of source and destinations it imposes challenges for the network layer to determine the multi hop route which are used for sending data packets between them. Mobile ad hoc networks are using multi hop transmissions for communication. Usually shortest path and link state protocols are used for fixed networks. But due to the time varying nature of ad hoc mobile networks traditional routing techniques cannot be directly applied. The routing in Mobile ad hoc networks must be in such a way that they must dynamically adapt to variations in the network topology. For this reasons the routing protocols are designed in such a way that techniques are adapted to track the changes in the network topology. Another problem of ad hoc network is to find new routes when old routes are broken. Since ad hoc is having no controlling or base stations these operations must be done with the help of nodes which are to be worked together to perform these actions.

Since the MANETs are self-configuring the resources associated with it is very limited. So we have to select a routing protocol which is best and reduces the usage ofnetwork resources. A node is a network terminal which may be mobile having the capability to communicate with other nodes through wireless ports. Thus every node can send and receive data packets through the channel. So MANET is substantially different from other wireless networks. The sending of data in MANET depends upon the routing capability of intermediate nodes. So it requires a multi-hop transmission of data. The peculiarity of nodes is, they are small and battery powered making it mobile and portable. Resources are constrained and we have to make it more reliable. This can be done via the modification of protocol.

Mobile ad hoc networks are basically based on cellular concept, which is based on a controlling base station. The base stations in a cellular network are fixed and all the moving elements in the networks are connected to this base station for controlling and routing purposes. WLL, GSM, WLAN are the examples of this type. On the contrary Mobile Ad hoc Networks are formed in a distributed fashion. All the elements in this network topology that can move in any manner. Thus this type of network is not associated with pre-existing fixed infrastructure of networks. This is a very important peculiarity of MANET which enables the nodes to form rapid configuration without any delay of control from a central station.

2. Broadcasting Algorithms

The primary broadcasting mechanism used is flooding. In this each node blindly flood message to every other node in the network. Normally flooding is very simple and easy to implement. But in some cases it become very complex and it cause overloading of the network and lead to broadcast storm problem. The flooding protocol is analytically and experimentally studied and showed that a rebroadcast can provide only 61% additional coverage at most and only 41% additional coverage in average. Rebroadcasts are very costly and should be used with caution.

It classifies the broadcasting schemes into five classes to reduce redundancy, contention, and collision: probabilistic rebroadcast, counter-based scheme, distance-based scheme, location-based method and cluster-based method. In probabilistic scheme, a mobile host rebroadcasts packets according to a certain probability. In counter-based scheme, a node determines whether it rebroadcast a packet or not by counting how many identical packets it receives during a random delay. It is assumed in counter-based scheme that the expected additional coverage is so small that rebroadcast would be unimportant when the number of recipient broadcasting packets exceeds a threshold value. In distance-based scheme, they used the relative distance between a mobile node and previous sender to make the decision whether it rebroadcast a packet or not. In location-based scheme, additional coverage concept is used to decide whether to rebroadcast a packet or not. Additional coverage is acquired by the locations of broadcasting hosts using the geographical information of a MANET. In cluster-based scheme, MANET is divided into clusters, which is a set of mobile hosts. There are one cluster head and several gateways in a cluster. Cluster head is representative of a cluster and its rebroadcast can cover all hosts in that cluster. The gateways can only communicate with other clusters and have all the responsibilities of disseminating a message.

It classifies the broadcasting techniques into four groups and compared their performances: simple flooding, probability-based, area-based and neighbor knowledge scheme. In flooding scheme, every node in the network retransmits the message to its neighbors after receiving it. Probability-based scheme is a very simple way of reducing rebroadcasts. Each node rebroadcasts with a predefined probability p, where p =1 activates blind flooding. In area based scheme, a node determines whether it rebroadcast a packet or not by calculating its additional coverage area. Although area-based scheme works quite well, it doesn't know whether there is any node in the calculated coverage area. So, some nodes may not receive broadcasting packets. Neighbor knowledge scheme maintains neighbor node information to decide whether it or the neighboring nodes have to rebroadcast or not. By using periodic Hello packets the neighborhood method can exchange the information of neighbors to the whole network. The length of the period affects the performance of this scheme: If it is set too short then it could cause collision or contention while setting it too long would degrade its ability to cope with mobility. The main drawback of this method is that it introduces excessive contention and collision. It also increases the redundant rebroadcast and routing overhead.

3. Ad-hoc On-demand Distance Vector Routing Protocol

The protocol which is used for on demand routing in ad hoc network is Ad-hoc On-demand Distance Vector routing protocol. Each node should carry out therouting decisions because of no controlling stations. If a node knows the route to destinationthere is no need AODV and the packets are send on theroute. But there is no route to destination there should be aroute discovery process. In AODV the routes are found outby disseminating route request packets to the neighbouringnodes. It is notifications to the destination that a node iswant to send data. When a node receives RREQ, if it is thedestination it send a reply back to the source.If it is not the properdestination and it knows a route to the destination it alsoinitiates broadcasting of RREQ [6]. When an RREP packetis unicasted to the source there is the setting up of a reversepath to the source. Usually the routes are found out byflooding of Hello packets. In AODV the hello packets aredisabled. It is because the Hello packets induce increase inrouting overhead. RREQ is forwarded by flooding therequest as shown in Figure 1.

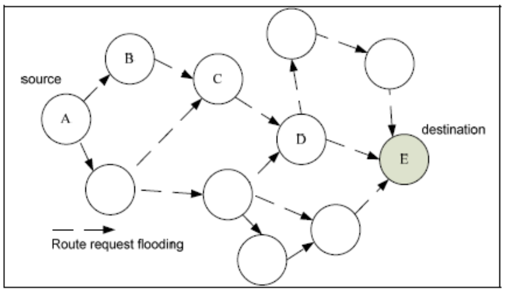

Figure 1: Flooding of RREQ in AODV.

The source and destination address, sequence numbers, broadcasting ID and other information regarding the routing in ad hoc networks are allocated in the RREQ packet. If a link is failed and the routing process cannot be completed, a RERR packet is send to the source. By receiving the RERR packet a node can understand the failure of the route. So RERR packet can initiates another route discovery process for finding another route to the destination in the network. When the RREP packet reach the source a reverse path is being built from destination to the source. The sending of data from source to destination is done through this path. The reverse path obtained via the propagation of RREP packet is as shown in Figure 2.

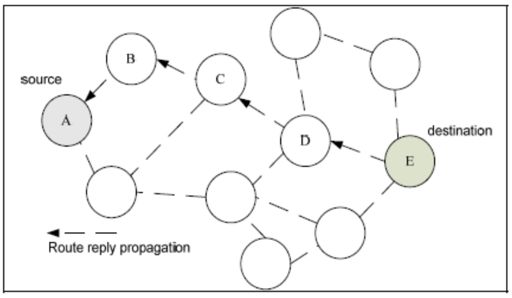

Figure 2:Reverse Propagation of RREP in AODV.

4. Probabilistic Broadcasting based on Neighbor Coverage towards Destination

Broadcasting of data is the primary way to establish a path in MANET. But it has problems like collision and contention. In order to reduce the overloading of the network the route discovery process has to be modified. This work proposes a new method to find the route in an ad-hoc network. The protocol selected for modification is Ad-hoc On-demand Distance Vector. In AODV the route is selected only when there is a requirement for a node to send data to another. In the proposed method route selection is done by the neighbour knowledge which is used to reduce the route overhead in the network.

This method is based on a rebroadcast delay and rebroadcast probability. The forwarding order is obtained from the rebroadcast delay. The node with lower delay has more common neighbours with previous node. If a node with lower delay broadcast the data the information can be easily spread in to the network. By additional coverage ratio and connectivity factor a rebroadcast probability is obtained. Based on this probability the forwarding is done

4.1 Architecture

The architecture of the proposed system is as shown in Fig. 3. In this the overall network is shown. The node s sends packets to node s. By finding uncovered nodes towards destination the packet can be broadcasted with less routing packets and can increase the performance of the routing.

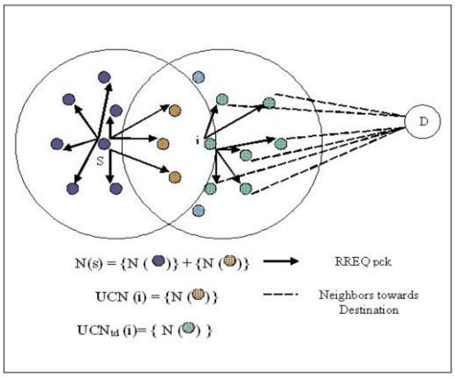

Figure 3: Architecture of the Proposed System.

Initially, each node in the network sends the beacon packets to each node in the communication range. A node which receives the beacon packet replies to the sender including its information. Thus, each node maintains the neighbor list frequently. A source node sends the RREQ packet to its neighbors, when it initiates the route discovery process. A node which receives the RREQ packet, it compares the neighbor list with its sender neighbor list. And, it determines the common neighbors. If node ni has more neighbors which are not covered by the RREQ broadcasting from s, if node ni rebroadcasts the RREQ packet, packet can reach more additional neighbor nodes in the network. In this work, the rebroadcasting based on nodes which are not able to receive the broadcast packet and known as Uncovered Neighbors set U(ni) of node ni as follows:

$$U(n_i) = N(n_i) - [N(n_i) \cap N(s)] - \{s\} (1)$$

$$T_p(n_i) = 1 - \frac{|N(s) \cap N(n_i)|}{|N(s)|} (2)$$

$$T_d(n_i) = MaxDelay \times T_p(n_i) (3)$$

The delay time is used to determine the node transmission order. It is used to exploit the neighbor coverage knowledge. The neighbor coverage knowledge should be disseminated as quickly as possible. RREQ packet send by the node s should reach all its neighbors of ni; i = 1; 2; . . . ; |N(s)|. All the neighbors should receive and process the RREQ packet. We assume that node ni has the largest number of common neighbors with the source node, and node nk has the lowest delay. When node nk rebroadcasts the RREQ packet, there are large numbers of nodes which are receiving the packet, because a node ni has the largest delay. Based on the rebroadcast delay, a node set the timer. When a node receives the duplicate RREQ packet before expires the timer, it adjusts the UCN list.

Additional coverage ratio is another factor, this metric indicates the ratio of the number of nodes that are additionally covered by this rebroadcast to the total number of neighbors of node ni in the network. The nodes that are additionally covered need to receive and process the RREQ packet. As Ra becomes bigger, more nodes will be covered by this rebroadcast, and more nodes need to receive and process the RREQ packet. Thus the rebroadcast probability should be set to be higher.

$$R_a(n_i) = \frac{|U(n_i)|}{|N(n_i)|} (4)$$

$$F_c(n_i) = \frac{N_c}{|N(n_i)|} (5)$$

Where Nc = 5:1774 log n, and n is the number of nodes in the network, It observes that when |N(ni)| is greater than Nc, the value of Fc(ni) is less than 1. So node ni is in the dense area of the network, then only part of neighbors of node ni forwarded the RREQ packet could keep the network connectivity. And when |N(ni)| is less than Nc, Fc(ni) is greater than 1. That means node ni is in the sparse area of the network, at that time node ni should forward the RREQ packet in order to approach network connectivity. Multiplying the additional coverage ratio and connectivity factor, we obtain the rebroadcast probability Pre(ni) of node ni:

$$P_{re}(n_i) = F_c(n_i) \times R_a(n_i) \qquad (6)$$

The node density and the connectivity factor are inversely proportional to each other. Fc increases the rebroadcast probability if the density of nodes in the network is low. Due to this the reliability of NCPR in the sparse area increases. The same procedure can be done for high dense node networks. In that case the increased node density decreases the parameter Fc and decreases the probability. This way it increases the efficiency of NCPR in the dense network area. Thus we can say that the factor Fc performs density adaptation with the probability.

In the proposed work, we include the scheme of destination towards neighbors' coverage. In that, sorts the UCN to UCN_{td} based on the destination direction. Thus, it reduces the routing overhead significantly.

5. Constant Bit Rate and Variable Bit Rate Traffic

The demand for services like high-definition television (HDTV), browsing of large video databases, video teleconferencing and the forthcoming video on demand (VOD) will rapidly increase in the coming years. The requirement of traffic changes as the user application need changes. The traffic required for audio, video and multimedia services are different since each of them having variations in bit rate of the traffic. Normally there are two different modes are used for encoding any video source namely constant bit rate (CBR) and variable bit rate (VBR). A CBR coding mode cannot guarantee constant video quality for all scenes because of the rate control mechanism. However, the users of videoapplications are interestedin invariable quality regardless of the complexity of thescenes.Therefore, they prefer a VBR coding mode, which maintainsconstant the picture quality, varying the output bit rate, toa CBR one.

For generating CBR traffic source, the main parameter is its interval. A constant interval is defined based on that traffic is generated. Optionally we can give random noise and packet size is also defined for this type of traffic. The inter-arrival time during burst is the interval that defined in the source code. The rate during on time is defined in bits per second. CBR can only be used for low speed applications with low quality.

The VBR traffic source is defined by rate, deviation of rate and time period. Burst, time period of burst and the number of changes during burst is also defined. The deviation in burst causes it to produce a variable bit rate traffic source. The transmission of packets is done rapidly in the ad hoc network topology. It can be used for very high rate application with high quality and with high delivery ratio.

6. Simulation Results

The simulation and analysis is done using a discrete event simulator known as Network Simulator version 2.35. The routing protocol AODV is modified by the neighbour coverage knowledge and probability.Channel selected for simulation is wireless channel with an area of 600x600m. The nodes are moving for a simulation time of 50sec with two ray propagation model. The simulation is done with CBR and VBR traffic with a packet size of 1024bytes. The queue used is drop tail queue with an IFQ length of 50.

After the simulation the performance is measured using various performance metrics. The MANET is simulated using the proposed NCPR routing protocol. For the first time the traffic selected is constant bit rate. Then the same MANET can be simulated using the variable bit rate traffic. The parameters for performance selected are Packet Delivery Ratio (PDR), Normalized Routing Overhead (NRO), and End to End Delay.

6.1 Packet Delivery Ratio

It defined as the ratio of the number of data packets successfully received by the CBR destinations to the number of data packets generated by the CBR sources. For the variable bit rate traffic the rate of traffic is changed. The performance comparison contains the CBR and VBR respectively. For each comparison the normal AODV routing protocol and the modified neighbor knowledge based probabilistic protocols are used.

The packet delivery ratio for CBR traffic in AODV and NCPR routing protocol is shown in Figure 4. The PDR increases when AODV is changed to NCPR. The green line represents the PDR of AODV routing protocol and the red line represents the PDR of NCPR routing protocol. The comparison is done by changing the nodes from 10 to 50. For 10 nodes the MANET is a less dense area and for 50 nodes it becomes a dense area. This graph represents the variation of PDR with low density to high density MANET topology.

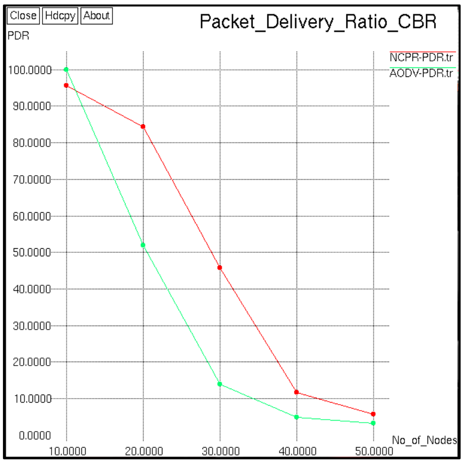

Figure 4: Packet Delivery Ratio in CBR Traffic.

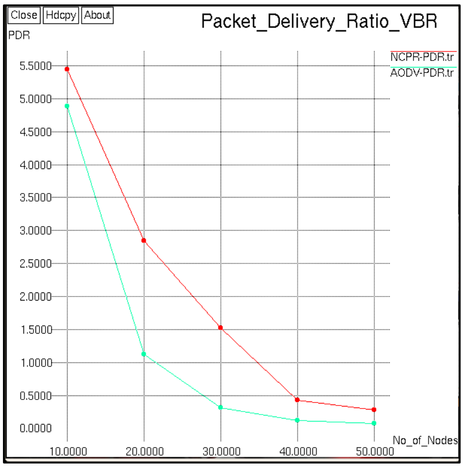

Figure 5: Packet Delivery Ratio in VBR Traffic.

4.1 Normalized Routing Overhead

The ratio of the totalpacket size of control packets (include RREQ, RREP,RERR, and Hello) to the total packet size of datapackets delivered to the destinations. The variation of NRO in variable bit rate is also checked by the modified protocol.

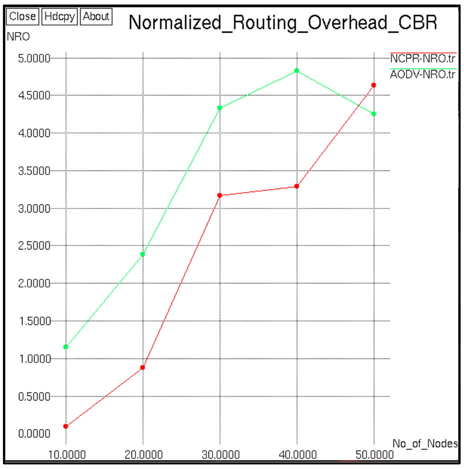

Figure 6: Normalized Routing Overhead in CBR Traffic.

Normalized routing overhead is the main parameter we want to reduce. It introduces extra control overhead than data traffic. NRO is checked for CBR and VBR traffic. We can see that for both traffic patterns NRO is very much reduced for NCPR routing protocol. The NRO is very less if we are using NCPR protocol in the variable bit rate scenario. In CBR traffic as the nodes increases the NRO is also increases. But if VBR is the traffic the NRO is reducing gradually for AODV and for NCPR.

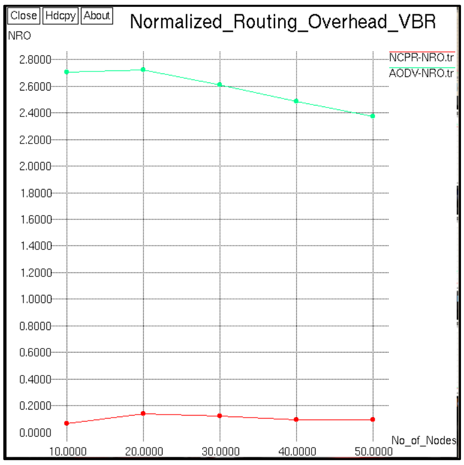

Figure 7: Normalized Routing Overhead in VBR Traffic.

6.2 End to End Delay

The average delay is defined as the successfully delivered CBR packets from source to destination node. It includes all possible delays from the CBR sources to destinations. For VBR it includes all possible delays from VBR sources to destinations. The following are the variation of end to end delay for CBR and VBR traffic in MANET. It is the total delay in transmitting the packet in the entire path. When the delay increases in the network certainapplications cannot hold it. But for applications which are not requiring the delay performance for the functioning.

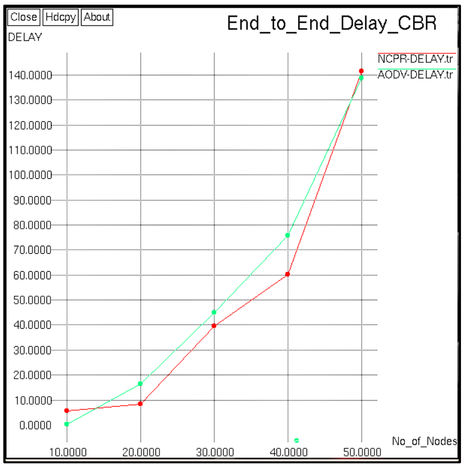

Figure 8: End to End Delay in CBR Traffic.

The comparison is done for end to end delay for MANET with two different protocols namely AODV and a modified version of AODV. For CBR traffic as the nodes moves the delay associated with the MANET increases. The high dense network is having large delay because of large number of nodes in between source and destination. In low dense network the area between source and destination is nearly free so that the packets can reach easily from source to destination. In the graph for CBR we can see that the delay associated with the network reduces when we are using NCPR as the networking protocol. For NCPR also the delay increases as the number of nodes increases gradually. But for VBR traffic the delay associated with MANET is higher than AODV. It is because of large bit rate for traffic generation. In future the protocol is to be modified for reducing end to end delay.

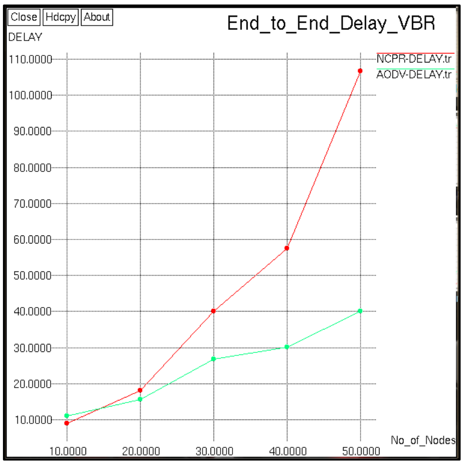

Figure 9: End to End Delay in VBR Traffic.

7. Conclusion

Broadcasting is an active research topic in MANETs. Animportant problem is how to minimize the number ofrebroadcast packets while good retransmission latency andpackets reachability are maintained. Even though the largenumber of rebroadcasts guarantees high reachability, it causeshigh network bandwidth wastage and so many packetscollisions. On the other hand, the small number of rebroadcastsresults in low reachability, because it cause rebroadcast chainbroken so that some hosts may not receive the broadcastpackets.In this paper, we proposed a probabilistic rebroadcastprotocol based on destination towards neighbor coverage to reduce the routingoverhead in MANETs. The new modified version of AODV routing protocol works well in CBR traffic environment and the generated VBR environment. Three parameters are used for performance analysis. The greater performance is obtained for the new scheme than AODV.

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