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Performance Enhancement of AODV Protocol for Dense MANETS

[1]Sharmila Sankar and [2]V. Sankaranarayanan
[1]Department of Computer Science and Engineering, BS Abdur Rahman Crescent Engineering College, Chennai, Tamil Nadu, India
[2]BS Abdur Rahman Crescent Engineering College, Chennai, Tamil Nadu, India

Corresponding Author: Sharmila Sankar, 22/34, Visagathottam Saidapet, Chennai, Tamil Nadu, India Tel:+919884821441

ABSTRACT

Although, *ad hoc* on-demand distance vector (AODV) can respond a route quickly, it involves all the nodes in the network for path finding and yields a long delay when a route is rebuilt in dense networks. This is because when a node receives RREQ packet, it will try to find a path to the destination if it do not have one. Therefore many redundant RREQ packets are generated in the network. And when a source receives RRER packet an alternative routes are built as a new path discovery to the destination. We introduced a new route discovery and maintenance strategy by utilizing received signal strength information. The algorithm works by selectively rebroadcasting the RREQ packets during path discovery, in order to reduce the control packets in the network and introducing a new bridge node or handing off to a new node along the active path to prevent the link from failure. From the simulation result, the proposed algorithm improved the performance of Dynamic Source Routing (DSR) in terms of routing overhead, latency and throughput.

Key words: Controlled flooding, probabilistic routing, multiple paths, link break prediction, RSSI

INTRODUCTION

Mobile *ad hoc* networks (MANETs) are networks without infrastructure and having mobile nodes communicating with each other through multi hop wireless links. In mobile *ad hoc* networks, devices are self-organizing which makes its communication setup and maintenance completely different from other networks. Each node in MANET's can act as both a router and a host. Hence mobile *ad hoc* network can be deployed easily with a high degree of freedom and low cost.

MANETs are considered to be resource limited, for example, low wireless bandwidth, limited battery capacity and computing power and dynamic in nature, for example topology changes and channel fading. Recent advances in wireless technologies have resulted in a large number of wireless devices participating in the *ad hoc* network. Some real time scenarios like military, civil applications and sensor networks may involve thousands of nodes. These applications may take advantages of self-organization of large-scale *ad hoc* networks. Scalability is a crucial property under such application environments. The conventional routing protocols for fixed networks are no longer appropriate for MANETs due to heavy routing overheads that consume too many resources such as bandwidth and energy and the convergence time of the protocols which is too long compared with dynamics of MANET.

Many routing protocols have been developed for *ad hoc* networks including Destination Sequenced Distance Vector routing protocol (DSDV) (Perkins and Bhagwat, 1994), Cluster head

Gateway Switch routing protocol (CGSR) (Chiang *et al.*, 1997), Wireless Routing Protocol (WRP), *ad hoc* on-demand distance vector (AODV) (Perkins and Royer, 1999), Dynamic Source Routing (DSR) (Broch *et al.*, 2001), density based routing protocols (Natsheh and Buragga, 2010), *ad hoc* routing schemes in general divided into two categories: table-driven routing which maintains tables as conventional fixed networks and on-demand routing which attempts to establish a route when a communication request occurs. On-demand routing algorithms are more suited to devices with less memory. While many studies on these protocols assume several dozen nodes as the size of the network, the number of nodes may actually exceeds hundreds of nodes in a place as most of the handheld devices used now-a-days comes with communication capability. The performance of routing protocols in highly populated *ad hoc* networks requires further study.

Many routing protocols were proposed for stable routing in wireless mesh and *ad hoc* networks. (Bitam and Batouche, 2008) propose a new system for the topology discovery which is inspired from a bees society. It is based on swarm intelligence emerged from the communication between bees and it is reactive system. The main idea is to allow each node discovers its own view of the whole network topology (global vision) from its particular knowledge (local vision) without any central control and in adaptation with the MANET features. Tingrui *et al.* (2011) propose an improved hierarchical AODV routing protocol based on cognitive radio (CIH-AODV) for cognitive wireless mesh network which exhibits better scalability and performance in the network and incurs less routing overhead for finding alternate routes when a route is lost. Furthermore, they present a novel technique for CIH-AODV termed fresh route detection which is designed to support cognitive radio. Meng *et al.* (2008) propose AODV routing protocol based on mobility prediction (MAODV) which can control node route by keeping and switching route through estimating the neighbor node’s distance and predicting the neighbor node`s mobility to fit fast changed network topology. This mechanism reduces the end-to-end delay effectively and enhances the real-time character which is important to the voice communication and the video communication. Congestion adaptive *ad hoc* on demand distance vector routing protocol (Sharma *et al.*, 2006) copes the problem of load sharing in case of congestion dynamically with the change in network and it is done by means of the changing status of the probability of the nodes around a node. It works in coordination with AODV rather than against it. In this protocol every node warns its preceding node about the occurrence of congestion using congestion status parameters. This is done based on the condition whether the number of packets being queued at the interface queue of a node is more than 80% of its buffer size. If this is the case than the preceding node uses a secondary non-overlapping route to direct the incoming packets. That route must be non-congested. Traffic will split probabilistically over these two routes, primary and secondary, thus reducing the chances of congestion. presents the detailed study of the performance of AODV protocol. High mobility of nodes results in active route failure and re-route discoveries. Such frequent route discoveries result in decreased network performance. Hussain *et al.* (2007) analyzed in detail the effect of different node mobility parameters on the performance of AODV (*ad hoc* on demand distance vector) routing protocol.

ISSUES IN ON-DEMAND ROUTING PROTOCOL IN DENSE NETWORKS

One of the challenging issues here is to reduce flooding in the path discovery and maintenance since wireless bandwidth is limited. On-demand routing protocol broadcast control packets to establish routes to destination nodes. In dense networks formed by many mobile nodes, a high number of broadcast packets are generated, thereby causing collision, contention and battery power wastage in mobile nodes. Moreover most of the routing protocols rediscover the path on link failures which adds on to the network congestion and contention. In dense environment many nodes participate in route discoveries and rediscoveries and hence a high number of control packets are generated which eventually causes contention that blocks the data transmission. Furthermore, intermediate nodes suffer from battery power depletion as it transmits the redundant control packets. When the density of the network is sufficiently high, most of them may not perform well. In this study we propose a new routing algorithm which overcomes the drawbacks associated with the existing protocols for MANETs. Simulations show that the proposed algorithm achieves better in most aspects than most of the notable protocols and with much less overhead.

THE PROPOSED NEW ROUTING ALGORITHM

We propose a new on-demand route establishment method for the dense network. Our proposed method is based on AODV and an extension of Probabilistic Routing Protocol (PRP) (Sankar and Sankaranarayanan, 2010). The proposed protocol solves the problems of general on-demand routing protocols that cause unnecessary flooding in dense environment. The proposed algorithm focuses on three metrics, namely the number of broadcast packets during active path construction and during path maintenance, packet delivery ratio and latency.

NETWORK INITIALIZATION

Every node maintains a neighbor table which keeps track of a nodes neighbor. When a node need to join the network it transmits “Hello” packet. The other nodes which hears the “Hello” packet makes an entry in their neighbor table. Nodes in the network transmit “Hello” packet periodically to maintain the freshness of the neighbor table.

ROUTE ESTABLISHMENT

A node that seeks communication with the other node in the network starts a path discovery unless the node has route entry of the destination node in its neighbor table. Path discovery process is initiated by generating a Route REQuest (RREQ) packet. In AODV protocol the RREQ packets are broadcasted by every node in the network until the destination is reached which creates channel contention and congestion problems thus by reducing the network performance. To overcome this problem, in our algorithm, the generated RREQs are not blindly flooded, instead they are selectively broadcasted as illustrated in Fig. 1. Of n neighbors a node, n/k farthest neighbors

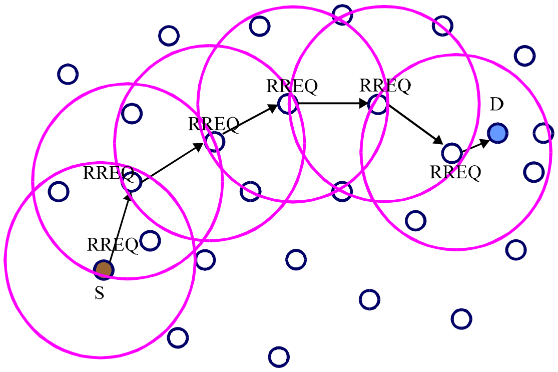

Fig. 1: Controlled flooding of RREQ

are chosen for rebroadcasting the RREQ packets, where k is the reachability parameter (Sankar and Sankaranarayanan, 2010). Since the node density in the network is considered to be high, the probability of reaching the destination through selective/border node retransmission is very high. This has been thoroughly studied by Sankar and Sankaranarayanan (2010). Alternate paths (if any) are constructed during the route reply phase and maintained by every node that handles the RREQ packet.

ROUTE MAINTENANCE

The routes are constructed in route discovery phase with farthest neighbor of each forwarding node. This method eventually reduces the number of hops but there is high chance of link breaks in case of high mobility conditions. We assume that the nodes are not Global Position System (GPS) enabled and moreover the GPS do not help us locating devices' exact positions in dense conditions. We use the Received Signal Strength (RSS) values to determine the proximity of the nodes. Received Signal Strength Indicator (RSSI) is a measurement of the power present in a received radio signal.

The proposed protocol also uses RSSI values to determine the mobility of the nodes, direction of the mobility and hence forecast the link breaks. When the link breaks can be forecasted, then weaker links along the active path can be substituted with a stronger one. The intermediate node that tends move may get closer to either predecessor or successor node or it may move away from both its neighbors along the active path.

Received radio: The danger of the link break due to the distance between nodes being farther than the communication range is detected based on the received radio. The received power Pr at the time of receiving packets as shown with the following equation depends on the distance d between nodes:

$$\mathrm{Pr} = \frac{\mathrm{Pt.Gt.Gr.ht^2.hr^2}}{\mathrm{d^4.L}}$$

where, Pt, Gt and ht are the transmitted power, the antenna gain and the height of the antenna on the transmitted side. Gr and hr are ones on the received side. L is the loss factor of the system. In advance, each intermediate node transmits information of the transmitting side to the next hop of the destination route. The threshold of the received power which corresponds to the distance between nodes detecting the danger of the link break is defined from the above information.

In our algorithm each intermediate node on an active route detects a danger of a link break based on the strength of the received radio. The received power Pr at the time of receiving packets is given by the MAC layer parameter (RSSI). When the received power at the time of receiving data packets is less than the threshold and has decreased as compared with the previous received power, the node initiates the local (self) recovery. Once a link is detected unsafe, the current active node will send a local help (HLP) packet to its neighbors along the path for finding a bridge node to the next hop (Sankar and Sankaranarayanan, 2011). Density is the key factor to find a bridge node for local self recovery. When the number of neighbor nodes around each intermediate node increases and the density rises, the probability of locating a bridge node is high. The node which is likely to cause link break, forecasts it, tries to fix up the problem to be created in near future by getting neighbor details of its upstream and downstream nodes. The motivation behind this method is that there may be a small local change in the network topology such that the link from A to B is broken but the overall network topology has not changed significantly. If the problems could not be fixed, then an error packet is generated and forwarded to the upstream node. In turn the upstream node after tried to fix up the problem by checking the backup route cache. If another new path could be picked from backup route cache, then a beacon signal is generated and forwarded along the path which checks whether the secondary path stored in the backup route cache is still alive. If a response to the beacon signal is received then the data transmission is continued in the identified alternate path.

PERFORMANCE EVALUATION

To evaluate the performance of proposed protocol, we used OMNet++ simulator (Varga, 2003). This simulator allows us to observe and measure the performance of proposed protocol under various conditions. In the simulation the random waypoint model is used as the mobility model. IEEE 802.11 distributed coordination function is used as the MAC protocol. The channel bandwidth is set to 2 Mbps. The data packet size is 512 bytes. The flow pattern is CBR. The following were the metrics measured in the simulation.

Packet delivery ratio (PDR): The number of packets received by all destinations over the number of packets sent by all sources.

Average end-to-end delay: The average interval from the time the unicasting of a source node is initiated to the time this node finishes its unicasting.

Routing overhead: The number of necessary control messages for all nodes in the network to maintain the routing table or a source node to establish and maintain a route to the destination node.

Routing overhead: The control message overhead incurred by AODV, AOMDV, probabilistic routing protocol with active route maintenance (PRP-ARM) (Sankar and Sankaranarayanan, 2011) and the proposed protocol is shown in Fig. 2. It is clear from Fig. 2 that the number of control messages used by AODV to discover and maintain the discovered path is increases heavily with the increase of number of nodes in the network. This increased routing overhead leads to congestion in the network and hence the degradation in the throughput. In contrast to AODV, the number of routing overheads generated by PRP-ARM and the proposed

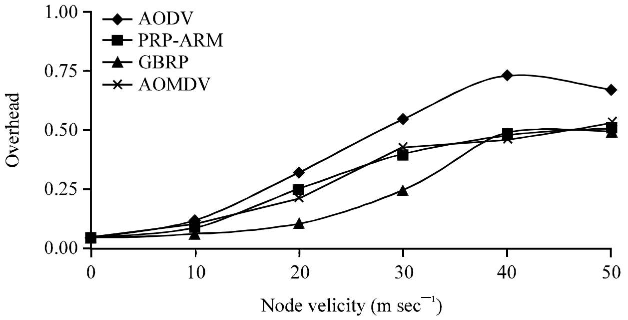

Fig. 2: Normalized routing overhead

routing algorithm is very less. Compared to AODV, AOMDV generates a reduced number of overheads, whereas our protocol generates route discovery and maintenance packets as that of AOMDV on the increased mobility speeds. On increased mobility, there is frequent change in the topology and hence the backup route information gathered at the time of route discovery becomes obsolete. Since the network is dense the number of neighbors of the nodes in the network is high and so there is high chance of finding a new neighbor to handoff even in the high mobility conditions. As the proposed protocol is the extension of PRP-ARM, it performs well in high mobility conditions.

Delivery ratio: Figure 3 illustrates the packet delivery ratio with varying node velocities. When the node density is less, performance of the all the three protocols are almost the same. As the node speed increases (Fig. 3), frequent link breaks occur which in turn initiates the route rediscovery. This route rediscovery session introduces contention and congestion in a high dense network which makes the PDR worse even more. Due to these reasons many of the transmitted data packets are lost and the packet delivery ratio of AODV and AOMDV decreases more quickly with the increased node velocities. The delivery ratio of PRP-ARM and proposed algorithm are maintained constant and there is no degradation in the performance. The packet drops in the proposed protocol very much reduced since the link breaks are forecasted and fixed up locally. If the link break could not be fixed locally and in case of unavailability of backup route, the source node reinitiates the route discovery process. In route discovery process the number of nodes that rebroadcasts the RREQ is minimized as only few of the neighbor nodes of source and other intermediate nodes are allowed to rebroadcast the RREQ (controlled flooding). In spite of minimizing the number of nodes that rebroadcast the RREQ, a communication path between source and destination could be established due to increased node availability in dense networks. This reduces the channel contention and congestion and thus the packet drops which leads to higher packet delivery ratio in dense conditions. In higher node velocities (lesser pause time) the backup routes constructed during route discovery phase is not stable and hence the new path is constructed with handoff procedure or new path discovery is initiated, for many source-destination pair.

End-to-end delay: Figure 4 presents the average end-to-end delay of each scheme. In general, delay of any scheme increases as node velocity increases. In lesser node velocities where the average speed of the nodes is 0-20, the latency of AODV is lesser and so the latency of PRP-ARM and the proposed algorithm. On the other hand, the delay of AODV increases rapidly as node velocity increases and soon exceeds the delay of the proposed algorithm and PRP-ARM. AODV

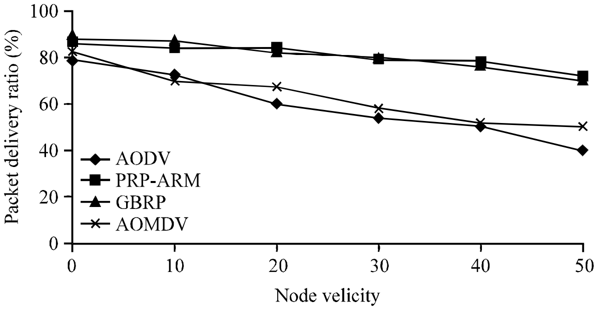

Fig. 3: Delivery ratio with varying node density

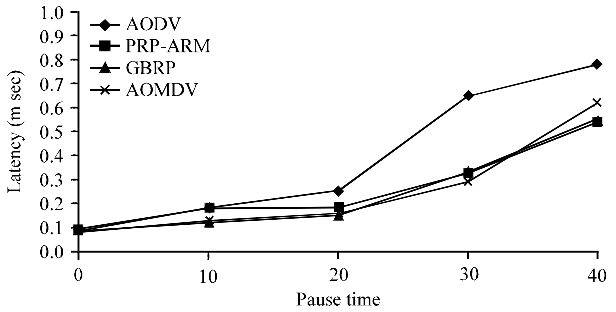

Fig. 4: Average end-to-end delay

initiates a new path discovery from the source end only after the link failure is detected, where as in the proposed protocol the link error likely to occur is detected and an early action is taken on fixing up the problem locally.

CONCLUSION

In this study, we have proposed a greedy new routing algorithm that makes use of the multiple paths available between source and destination pairs for route maintenance. An attempt has been made to control the flooding of control packets which degrades the network performance. Selective rebroadcast of RREQ packets is suggested exploiting the large number of neighbors of nodes in dense network. A proactive link maintenance based on signal strength is proposed which minimizes the number of packets being dropped due to link break and new route construction. Multiple possible paths to the destination nodes are maintained by every node which is used in case of link failure prediction, if not stale. We have studied the performance of proposed method using simulations under varying mobility and network densities. All these simulations demonstrates that our algorithm outperform AODV in terms of packet delivery ratio and end-to-end delay, while it reduce the routing overhead significantly and consume much less network bandwidth and energy. The backup routes are constructed at no extra cost for route maintenance.

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