Network Path Discovery Mechanism for Failures in Mobile Ad hoc Networks

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Abstract- Mobile Ad-Hoc Networks (MANET) are form of wireless networks in which nodes can configure by themselves in free and dynamic manner to form temporary network topology. These networks do not have any fixed infrastructure and any centralized administration. Routing is the most challenging task in MANETs as the network topology keeps on changing due to mobility of nodes. Routing involves task of discovering route to destination node for a source to send data packets. In MANET, as there is no fixed infrastructure, nodes act as routers or packet forwarding devices. Ad-hoc On Demand Distance Vector (AODV) routing protocol used for routing in MANETs is considered most suited for such networks and is selected for introducing a new approach for path discovery. AODV looks for route only when any of the node is having data packets ready to be sent to some destination. But under node mobility and variable node density the performance of AODV reduced. In this paper a Network Path Discovery AODV protocol (NPDAODV) is proposed, which considers node speed, signal strength, distance between nodes and queue occupancy while discovering network path. Also the newly proposed protocol is compared with AMAODV, an earlier work. Network Simulator (NS2) is used to perform the comparative simulations to study the proposed work.

Keywords: MANET, AODV, NPDAODV, AMAODV, NS2, RREQ, RREP, RERR.

GJCST-E Classification : C.2.1

NETWORKPATHDISCOVERYMECHANISMFORFAILURESINMOBILEADHOCNETWORKS

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I. Introduction

In past many years wireless networks have attracted researchers, due to their wide scope applications ranging from mobile communication to wireless ad-hoc networks. Wireless technology have provided many standards for wireless networks, like 802.11 standards family. Many routing protocols have been developed, some for general and some for specific scenarios like vehicular ad-hoc networks (Mor, 2013). Still the majority of research work done in the field of networks concentrates wireless networks only.

Among all the wireless networks, Mobile Ad-Hoc Network (MANET) (Macker and Corson, 1997) is the one which has attracted majority of research people. In contrast to the infrastructure based networks nodes in are self- configuring, self-managing and self-organizing. Also due to absence of fixed infrastructure

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nodes are involved in receiving and sending packets which are not relevant or are of no use to them. Which means they act as routers or packet forwarding devices. Nodes are free to move in any direction, as the basic feature of wireless networks. Due to this free and random movement of wireless nodes many issues arise in any MANET scenario. It leads to frequent topology changes, higher consumption of energy, frequent and abrupt rise in control traffic to maintain the neighbor information (Daniel et al., 2012) . Due to topology changes the paths between any two nodes vary and future path may be of longer length, as shown in Figure. 1.
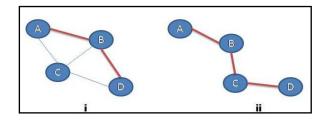

Figure 1 : MANET topology change due to mobility

Thus due to mobility of nodes the major challenge lies in the routing the packets from one node to another. At this point, the routing protocols comes into the picture. Routing protocols specifies the nodes that how to communicate with each other and provides information to select a path and send packets from source node to any destination node. It is the routing protocol using which nodes defines specific choice of path between any two nodes. In the past years many routing protocols have been suggested for wireless networks and for MANETs as well.

II. Routing Protocols

Here Based on their basic working mechanism these routing protocols can be classified in three categories (Moond and Singh, 2013). Proactive routing protocols uses tables to store the information of neighboring nodes as well as other nodes, managed by every node. If any source node have data ready to be sent, it consults these tables to follow the next hop towards the desired source. But in scenarios having high mobility these tables keeps on updating and they generally hold a path which may not be actually used.

Example of this type includes Destination Sequenced Distance Vector (DSDV) routing protocol.

Reactive routing protocols are considered best suited for MANETs (Moond and Singh, 2013). Unlike proactive routing protocols they do not maintain any information regarding current topology. They look for routes only when any node have data ready to be sent to some source node. At that time source node generates control packet which returns complete path or establishes a path between source and destination. Examples of this type includes Ad-hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) routing protocols.

Third type of protocols considers a mixture of good feature of both the above types and some advanced information like knowing the position of nodes prior to routing using Global Positioning System (GPS). These are called as hybrid routing protocols. Examples of these includes Zone routing protocol (ZRP).
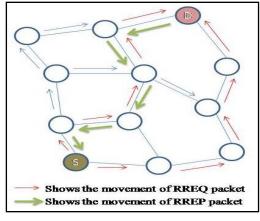
III. Working of Aodv

Ad-hoc On-Demand Distance Vector (AODV) (Perkins et al., 2003) is considered as most suited routing protocol for MANETs. As it do not maintain routes at all times between any two nodes in the network. Instead it only looks for routes between two nodes when the source node have data packets ready for forwarding. The initial time required by this protocol may be high, as data packets have to wait till the path is searched and setup. But this protocol saves the MANETs from routing load which may occur at times of high mobility ultimately saving the power, bandwidth and processing capability. The whole process of path establishing is in two phases.

a) Path Discovery Phase

In route discovery process, a node in the mobile ad hoc network dynamically discovers a fresh or stored route to other node in the network. The path so discovered may be in the direct radio transmission range of the node, or uses one or more nodes of topology as intermediate nodes. In AODV protocol, the source node having data packets ready to be sent, broadcasts a Route REQuest (RREQ) packet to all its neighbors. If any of the neighbors has a stored route to reach the destination, it sends a Route REPly (RREP) packet. If no route is found in their tables, the neighbors rebroadcast the RREQ packet after updating some of the fields in it. Following this process at each node, some of the RREQ packets reaches the destination. The destination node, on reception of a RREQ packet, sends back a RREP packet, which traverses back the path followed by the RREQ packet.

The Figure. 2. below explains the process of route discovery phase.

Figure 2 : Path discovery process

b) Path Maintenance Phase

AODV protocol also has some the mechanisms for situations when, a route is never discovered or RREP packet is lost on its way back to source node. In these circumstances the source node is obliged to start another route discovery process by sending new RREQ packet, after a time-out. AODV also uses a route maintenance process, which comes in effect to monitor the steadiness of a route currently in use and informs the sender node if any errors occurs. If any intermediate or destination node notices breakage in the route in use, it sends a Route ERRor (RERR) packet informing about the broken link. At this stage the sender node reinitiates the route discovery processes in search of a new route to the destination. The Figure. 3. below explains the process of route maintenance phase.
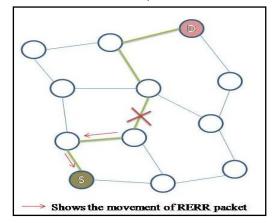

Figure 3 : Path maintenance process

Every routing protocol have its own features and some disadvantages also. Likewise AODV also have some challenges to face under some specific situations, like:

1. Routing overhead incurred by control packets.
2. Repeated route establishment under high mobility of nodes.
3. No alternate path availability in case of link break.
4. No provision of avoiding congested links.
5. No QoS provisions.

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IV. Proposed Work

The proposed work concentrates on path discovery process of AODV and thus a new routing protocol termed NPDAODV is proposed. In the proposed work firstly, the RREQ packet is added with four new fields viz. rreqdist, nodespeed, sigstr and node_que. The Figure. 4. below shows the new packet format of RREQ in NPDAODV.

Type	J	R	G	D	U	Reserved	Hop Count
RREQ ID							
Destination IP Address							
Destination Sequence Number							
Originator IP Address							
Originator Sequence Number							
rreqdist							
nodespeed							
sigstr							
node_que							

Figure 4 : New RREQ Packet Format for NPDAODV

At time when a node is looking for a path to destination node, it will broadcast a RREQ packet, initially having null values in new fields. As the neighboring nodes receive this packet they will update the fields including the new fields, before forwarding it. Thus as this packet travels its way towards the destination, every node this packet traverses will add the four values to the packet. When the destination will receive its first RREQ packet, the NPDAODV allows the destination to wait for another RREQ to arrive. Now the destination node compares the four values in both the packets to select the best and a RREP is sent using the selected RREQ packet. Thus, using NPDAODV a stable and long existing path is discovered and selected.

V. Simulation Environment

In this section the simulation environment for performing the simulations, are discussed in brief. Network Simulator (NS2) is used to perform simulations.

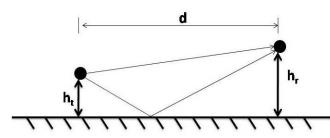### a) Random Waypoint Mobility Model

This model is used broadly in protocol development and performance assessment for MANET (Ahmad and Mata-ur-Rehman, 2010). In this model, the position of each node is selected randomly within user defined area and the node moves to a selected position in linear fashion with constant random speed, which is also user defined and is uniformly distributed between [0, Max Speed]. The node stops for a time called pause time before starting the next movement in next direction. Pause time is also user defined at the time of initialization.

The nodes in this model move in a linear direction, except when it has reached the boundary of specified area, where it reflects and changes its direction in sharp turn. This model leads to constant topology change, pause time and defined max speed have added effect on mobility of nodes. If the max speed is kept low and pause time is defined high, the topology remains relatively stable, whereas if max speed is high and pause time is small, the topology is highly dynamic. Problems with this model are that nodes take sharp turn and abruptly comes to halt due to pause time.

b) Two Ray Ground Propagation Model

The radio propagation models are used to predict the received signal power of each packet (Fall and Varadhan, 2011). A receiving threshold is defined for the physical layer of each node. When a packet is received. its signal power is determined and if it is below the receiving threshold, it is treated as error and is dropped by the MAC layer.

The best means of propagation between two nodes is the line of sight path. The two ray ground propagation model considers both the direct and ground reflection path as shown in Figure. 5. Previous simulations as shown that this model gives more accurate prediction at a long distance than free space model.

Figure 5 : Two Ray Ground Propagation Model with its Direct Ray and the Reflection

The received power at a distance is estimated by,

$$P_r(d) = \frac{P_t\,G_t\,G_r\,h_t^2\,h_r^2}{d^4 L}$$

where Pt is the transmitted signal power, Gt and Gr are antenna gains of transmitter and the receiver respectively. L is the system loss and ht and hr are the heights of the transmitter and receiver antennas respectively. The equation shows that the received power decreases fast as the distance increases.

c) Generating Traffic and Movement Patterns

For generating traffic patterns in simulations, a utility cbrgen.tcl is used. This utility is capable of generating CBR and TCP traffic. In this paper we have used CBR traffic.

For generating node movement in a fixed area NS2 provides a utility named, setdest. This is an inbuilt utility in NS2 and follows the random waypoint mobility model (Fall and Varadhan, 2011).

d) Simulation Parameters

The simulation parameters used for evaluating the performance of both the routing protocols are as listed in Table I. Two scenarios are used to evaluate the performance, which are, effect of increased node mobility and effect of increase in number of nodes

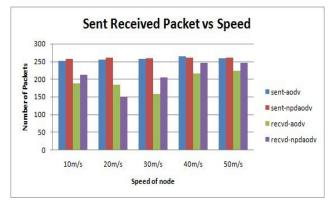Table 1 : List of Simulation Parameters

Parameters	Value
Simulation Time	100s
Topology Area	1000 X 1000m², 1500X1500 m²
Number of Nodes	10 to 100
Speed	10 to 50 m/s
Transmission Range	250m
Traffic Type	CBR
Packet Size	512 b
Pause time	0.0 and 1.0
Number of Connections	5

VI. Results and Discussion

In this section the proposed protocol, NPDAODV, is compared with the existing AODV routing protocol using the NS2 simulator (Fall and Varadhan 2011) and by selecting the scenarios having varying node mobility and number of nodes. Three scenarios are created, in first the node speed is changed from 10m/s to 50m/s, keeping the other parameters same and in second the number of nodes is varied from 20 to 100 keeping the other parameters same. In third scenario the proposed protocol is compared with AMAODV using packet delivery ratio.
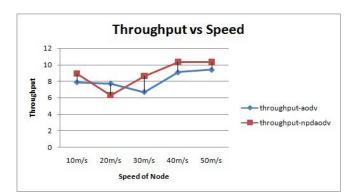
a) Scenario 1

As the speed of nodes changes from 10 m/s to 50m/s, the number of packets received decreases than number of packets sent due to frequent link failure caused by node mobility. But NPDAODV performs better than AODV as shown in Figure. 6.

Figure 6 : Number of Packets Sent-Received vs speed

As a result of more number of packets received by NPDAODV, the throughput and packet delivery fraction results are better than AODV, which can be clearly analyzed in Figure. 7.

Figure 7 : Throughput vs Speed plot

Also to verify the notion of long lived and stable path the routing load for both the protocols is compared, which shows that routing load in NPDAODV is decreased significantly compared to AODV, as shown in Figure. 8.
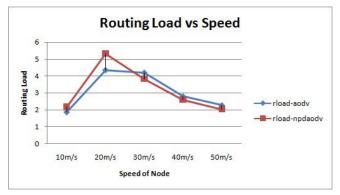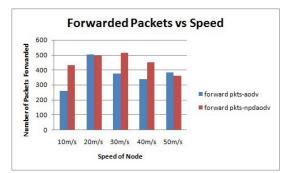

Figure 8 : Routing Load vs Speed plot

As the path discovered by NPDAODV is stable under variable node speed, as discussed above, the path selected may not be the shortest path, as in the case of AODV. This notion can be easily verified by the Figure. 9. showing the number of packets forwarded during the entire simulation. The forwarded packets are the packets which are forwarded by intermediate nodes to act as router or packet forwarding nodes.

Figure 9 : Forwarded Packet vs Node Speed.

b) Scenario 2

In this scenario the number of nodes is varied from 20 to 100. As the number of nodes increases under higher node mobility (Node Speed 30m/s) the two

routing protocols perform more similarly, whereas NPDAODV performing marginally better than AODV. The number of packets sent and received by both the protocols is shown in Figure. 10.
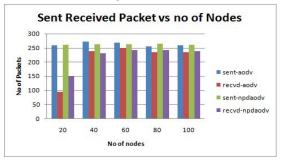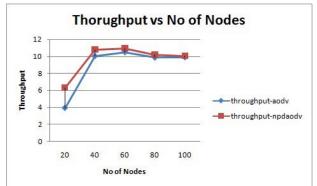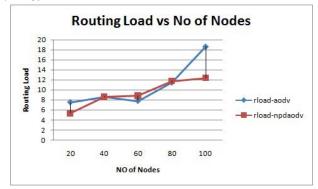

Figure 10 : Number of Packets Sent-Received

Again as a result of more number of packets received by NPDAODV, considering to number of packet sent, the throughput for NPDAODV is also better than AODV protocol. The plot in Figure. 11. clearly shows this.
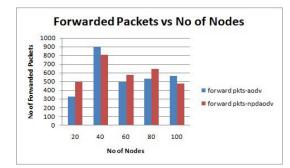

Figure 11 : Throughput vs Varying Number of Nodes plot.

The routing load for both the protocols under this scenario is also comparable, but again at times the NPDAODV routing protocol have lower routing load than AODV, which again justifies the notion of long lived path. This is shown in Figure. 12. The results are comparable due to the increased availability of nodes to discover path with the increase in number of nodes in the topology.

Figure 12 : Routing Load vs Varying Number of Nodes plot.

Also the results for number of forwarded packets are comparable due to same reason mentioned as above. But again at some time the number of forwarded packets for NPDAODV is higher, which reveals that the path discovered may not be shortest path, as shown in Figure. 13.
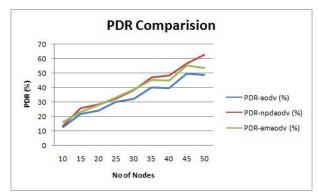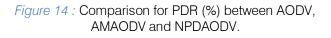

Figure 13 : Forwarded Packet vs Varying Number of Node.

c) Scenario 3

In this scenario we have compared our proposed work with an earlier work suggesting AMAODV (Ahmed et al., 2012) and with AODV. For this scenario some simulation parameters have been changed, like, number of nodes is kept between 10 to 50, maximum connections is kept 30, area of topology is 1500 X 1500 m2 and rate is kept 2.0.

Here in this scenario we have taken Packet Delivery Ratio (PDR) as one parameter and on that basis it is concluded that NPDAODV performs better than AMAODV and AODV, as shown in Figure. 14.

Figure 14 : Comparison for PDR (%) between AODV, AMAODV and NPDAODV.

VII. Conclusion

Ad-hoc On-Demand Distance Vector (AODV) is considered the most suitable routing protocol for Mobile Ad-hoc Networks (MANETs). Still using the notion of least hop count to select a path may not be suitable for MANETs having high mobility, which leads to varying distance between nodes and thus leading to frequent link failure in paths. This lead to the motivation for proposing NPDAODV, in which distance between nodes, signal strength, speed of node and queue size at node are taken in consideration during the path discovery phase.

The proposed protocol shows improved performance over AODV by receiving higher number of packets, by showing higher throughput, lesser routing load when speed of nodes is varied from 10 - 50 m/s. Higher throughput by incurring lesser routing load shows the discovery of long lived path for communication between nodes. Also similar results are obtained when number of nodes is varied from 20 to 100, by means of simulations using NS2. NPDAODV is also compared with AMAODV, in which it shows slightly better performance when packet delivery ratio is considered.

It can be concluded that NPDAODV shows better performance for failures in MANETs generated due to high mobility, thus leading to better performance of the network. In future, this protocol will also be tested for energy consumption in the network.

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