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Performance analysis of Broadcast Neighbors Discovery Protocol for Mobile Ad hoc Networks based on node mobility

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ABSTRACT: In ad hoc networks, wireless devices, simply called nodes, have limited transmission range. Therefore, each node can directly communicate with only those within its transmission range (i.e., its neighbors) and requires other nodes to act as routers in order to communicate with out-of-range destinations. Broadcasting of control packets throughout the entire network is essential for the route discovery, route maintenance and forwarding data packets to every pair of source and destination. Flood routing is a very simple routing strategy that a packet received from a node is copied and transmitted on all outgoing links of that node except for the link that the packet arrived from. After the first transmission, all the routers within one hop receive the packet. After the second transmission, all the routers within two hops receive the packet, and so on. Unless a mechanism stops the transmission, the process continues; as a result, the volume of traffic increases with time cause a serious waste of resources creates broadcast storm problem. In this paper, a new broadcast neighbor discovery routing is implemented to reduce the overhead associated with flooding. A node selects a group of its neighbors for forwarding the packet being broadcast to additional nodes. The performance metrics are analyzed using NS-2 for varying number of data senders (multicast group size) and data sending rate (offered traffic to the network) over QoS aware group communication. Simulation results show that our scheme performs well in most cases and provides robust performance even with high traffic environments. The simulation experiments show that new method can reduce the overhead for different node mobility speed, as compared with the conventional AODV and DSDV routing protocols.

KEYWORDS: MANET, AODV, Rebroadcasting, Flooding, Route Discovery, Routing overhead.

1 INTRODUCTION

In ad hoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner and can act as transceiver also as a router at the same time without relying on any infrastructure or central management i.e. is operating without any assumptions of pre-planning, notably without any a priori designation of which devices are to be acting as routers in order for connectivity in the network to be assured. The advantages of ad hoc networks lie in their low costs (because no infrastructure is required) and high flexibility. The drawbacks include reduced efficiency, smaller communication range, and restrictions on the number of devices that can be included in a network. Broadcasting in a challenging issue in MANETs than wired networks due to node mobility and limited network resources. There is no single optimal approach for all situations because of the random node movement patterns. Reliable Broadcasting in Ad-hoc networks poses more challenges than the one in wired networks for the following reasons: node mobility, temporary network partition and scarce system resources. The wireless medium has variable and unpredictable characteristics of the signal strength and the propagation fluctuate with respect to time and environment resulting in disconnection of the network at any time . The strength of the received signal depends on the power of the transmitted signal, the antenna gain at the sender and receiver, the distance between mobile nodes, the obstacles between them, and the number of different paths the signals travel due to reflection. Since MANETs have limited channel bandwidth availability and low battery power, their algorithms and protocols must conserve both bandwidth and energy [7]. Further node mobility also creates a continuously changing communication topology in which existing routing paths break and new ones form dynamically. This approach is based on selecting a group of one hop neighbor act as forwarding node to carry out a broadcasting process and minimize the redundant rebroadcast.

1.1 EFFECT OF HELLO MESSAGE

Mobility metrics focus on a node and changes in its neighborhood. A node simply depends on exchanging "Hello" messages to sense the neighbors and depend on message exchange to sense the neighbor changes. Hello protocol is the basic technique for neighborhood discovery in wireless ad hoc networks. It requires nodes to claim their existence/ aliveness by periodic 'hello' messages. Central to a hello protocol is the determination of 'hello' message transmission rate. Undesired disruptions in wireless communication, transmission power changes, or loss of synchronization between neighboring nodes due to node mobility. The main difference between neighbor discovery in infrastructure wireless networks and MANET's are that neighbor discovery in the former is performed only by the central node, for which energy consumption is not a issue. In addition, the hidden nodes are assumed to be able to hear the HELLO messages broadcast by the central node. In contrast, neighbor discovery in MANET's is performed by every node, and hidden nodes cannot hear the HELLO messages when they sleep. This is because any new node, or a node that has lost connectivity to its neighbors, can hear its neighbors simply by listening to the channel for a short time. So a special neighbor discovery scheme should be used.

The usefulness of a hello protocol highly depends on the transmission rate of 'hello' message [3]. If the rate is too high with respect to node mobility, precious communication bandwidth and energy will be wasted for unnecessarily frequent transmissions. On the other hand, if it is too low, neighbor tables will quickly become out-of-date, leading to failure in other network operations and thus bandwidth waste and energy loss in those other operations. An optimal hello protocol maintains accurate neighborhood information at minimal 'hello' transmission rate. Unfortunately, no constant rate can always remain optimal in dynamic MANET. The rate should evolve together with the network along time for the best performance. But the impact of hello protocol on the network performance has not been studied until recently in [11, 14]. Existing hello protocols all have noticeable limitations and weaknesses. The neighbor discovery process usually entails the exchange of identities (e.g., MAC addresses) between two adjacent nodes.

1.2 DETECTING NEIGHBOURHOOD CHANGE

If a node does not transmit 'hello' message, its neighbors will consider their location estimates for that node are correct. They are not able to distinguish this situation from node failure, where the node is malfunctioning and will never transmit 'hello' message. If a new neighbor arrives without sending 'hello' message (it is possible when the current set of neighbors of that node all have acceptable location estimates), the node will not be able to know it or update its neighborhood. Additional mechanism is needed for detecting neighborhood change and improving the algorithm performance. A straightforward method is to use constant low frequency 'hello' message, regardless of node mobility. While 'hello' message loss implies node departure, forced 'hello' transmission increases the chance of new neighbor discovery.

1.3 REVIEW OF BROADCASTING PROTOCOLS

Broadcasting is the backbone of most network layer protocols, providing important network management control and route establishment functionality. Broadcasting is a fundamental operation in MANETs whereby a source node sends the same packet to all the nodes in the network. In multi-hop MANETs where all the nodes may not be within the transmission range of the source, intermediate nodes may need to assist in the broadcast operation by retransmitting the packet to other remote nodes in the network. In traditional broadcast settings, the dissemination of packets often uses up valuable network resources such as node power and bandwidth. Hence, it is important to carefully choose the intermediate nodes so as to avoid redundancy in the dissemination process. Several broadcast approaches have been suggested in the literature including simple flooding, probability based, location based method and neighbor knowledge based approaches [7] [8]. In simple flooding, source node first broadcasting a packet to all neighbors. It is forwarded by every neighbor in the network exactly once until all reachable network nodes have received that packet. Though simple flooding ensures the entire coverage, it has the largest forward node set and may cause broadcast storm problem in the network. Probability and location based methods are proposed to solve the broadcast storm problem [9] a node rebroadcasts the received packets according to a certain probability and exploiting the geographic information respectively. In these schemes, each node will estimate its potential contribution to the overall broadcasting before forwarding a broadcast packet. If the estimated contribution is lower than a given threshold, it will not forward the packet. However, the estimation methods are some time inaccurate and cannot ensure the full network coverage.

In neighbor-knowledge-based approaches, periodic exchange of neighborhood information among nodes via "Hello" packets, which is used in the decision to rebroadcast. A small set of forward nodes is selected to avoid flooding in the whole coverage.

2 Related Work

The following are the qualitative and quantitative analysis of broadcasting methods of MANET by means of different performance metrics. An efficient broadcast protocol for ad hoc networks using directional antennas IN [7]. This protocol, called directional self-pruning (DSP), is a non-trivial generalization of an existing localized deterministic broadcast protocol using Omni directional antennas. Compared with its Omni directional predecessor, DSP achieves much lower broadcast redundancy and conserves bandwidth and energy consumption. The broadcast algorithms based on the dynamic approach typically have small maintenance cost and are expected to be robust against node failures and network topology changes. Many local broadcast algorithms in this category use local neighbor information to reduce the total number of transmissions and to guarantee full delivery. Many algorithms such as probability-based and counter-based [6], do not rely on neighbor information. These algorithms typically cannot guarantee full delivery but eliminate the overhead imposed by broadcasting "Hello" messages or exchanging neighbor information. Many of the existing neighbor-information-based broadcast algorithms in this category can be further classified as neighbor-designating and self-pruning algorithms. In neighbor designating algorithms [9]–[11], each forwarding node selects some of its local neighbors to forward the message. Only the selected nodes are then required to forward the message in the next step. For example, a forwarding node u may select a subset of its 1-hop neighbors such that any 2-hop neighbor of u is a neighbor of at least one of the selected nodes [9]. In self pruning algorithms [3], [12], [13], on the other hand, each node decides by itself whether or not to forward a message. The decision is made based on a self-pruning condition. For example, a simple self-pruning condition employed in [12] is whether all neighbors have been covered by previous transmissions. In other words, a node can avoid forwarding/rebroadcasting a message if all of its neighbors have received the message by previous transmissions. ,Neighbor discovery is an important aspect of many algorithms in mobile wireless ad hoc networks [9], [8], [1]. Neighborhoods knowledge is assumed in many routing protocols used in wireless sensor networks. For example in [9] the authors assume that nodes know the location of one- and two-hop neighbors. This information is used to implement a coordinate based routing algorithm. In [8] nodes are assumed to maintain information about their one-hop neighbors in order to perform routing in multi-hop wireless networks. Flooding refers to the process whereby a node rebroadcasts a packet when it receives it for the first time. Although flooding is simple and can achieve delivery to a large percentage of nodes in the network, it has been shown to be expensive and wasteful; it consumes much of the communication bandwidth, wastes network resources and causes serious redundancy, contention and collision, which are collectively referred to as the broadcast storm problem.

Probabilistic flooding achieves good results compared with simple flooding. It reduces transmission redundancy, while being able to reach a large percentage of nodes. However, this approach uses the same probability without taking the density of the node's neighborhood area into consideration. For example, if the node is in a dense area (i.e., has many neighbors), the packet can reach the same set of nodes many times, resulting in broadcast redundancy. A dynamic probabilistic approach, where the broadcast probability, P, is dynamically adjusted based on network density[9]. To adjust the probability, short HELLO packets are used to count one-hop neighbors. If the number of neighbors is high, this indicates that the node is in a dense area. Thus, the chance of receiving numerous rebroadcasts of the same packet is high, and the probability P is set low to avoid redundancy. On the other hand, if the number of neighbors is small, P is set high to increase the chance of reaching the neighbors. Neighbor-knowledge-based schemes make rebroadcast decisions depending on information on neighboring nodes obtained by exchanging HELLO messages.

3 On demand distance vector routing

In On demand distance vector routing, routes are built up using RREQ and RREP (similar to DSR): when a source needs to send a packet to a destination for which it does not already have a route, it broadcasts a RREQ. Nodes that hear this request update their information for the source node and set up backward pointers to the source node in the route tables. If the node has a route to the destination, it replies to the source; otherwise, it broadcasts the information to further nodes. Dynamic Source Routing(DSR) can greatly reduce the overhead by performing on-demand routing. The routing procedure consists of two steps: an initial route discovery, followed by route maintenance that reacts to changes in the link states in the network. During the route discovery, the network is flooded with so-called RREQ packets. The route request contains the Identification (ID) of the intended information destination, a unique packet ID, as well as a list of nodes that have already been visited by the message. When a node receives a route request packet, it checks whether it is either the intended destination or has a path to the destination stored in its own routing table. If that is not the case, the node rebroadcasts the

RREQ, adding its own address to the list of visited nodes in the message. If the node is the destination (or has a path to the destination), then the node answers with a RREP, which tracks back along the identified path to the source, and finally informs the source about the sequence of nodes that have to be taken from source to destination. During route maintenance, the protocol observes whether links in the established route are broken. It then either uses an alternative stored route for the destination, or initiates another full route discovery process. A problem in DSR is the so-called reply storm, which occurs when a lot of neighbors know the route to the target, and try to simultaneously send the information. This wastes network resources. Route reply storms are prevented by making each node that wants to transmit wait by an amount of time that is inversely proportional to the quality of the route it can offer. In other words, a node that wants to suggest a good route is allowed to transmit sooner than a node that suggests an alternative, worse, route. Furthermore, nodes listen to route replies transmitted by other nodes, and do not transmit if another node has already transmitted a better route.

4 Broadcast based on demand Neighbour Discovery Scheme (BNDS)

BNDS is a neighbor discovery method based on neighbor information. This scheme is an on-demand, broadcast-based ad hoc route discovery protocol that is developed for MANETs. The aim of this scheme is to minimize effect of flooding by reducing redundant broadcasts and also reduces the routing overhead. Each node keeps knowledge of their neighbor's within a 1-hop and 2-hops radius that is achieved by periodic “Hello” messages. Each message contains the node address and list of known neighbors. When a node receives a “Hello” packet from all its neighbors, it has two-hop topology information i.e. only packets that would reach additional neighbors are re-broadcast and select particular set of node to forward the broadcast packet to their one hop neighbors. The sender choose group of one hop neighbors for forwarding the broadcast packet, includes their addresses in the packet header, and broadcasts the packet. Those particular set of nodes receive the broadcast packet is a forwarding node if its address is included in the packet header. Otherwise, it simply drops the received packet. Neighbor nodes repeat the same process carried by the sender. The selection of forwarding node is based on the largest number of neighbors among one hop neighbors with sender is called neighbor degree. If a intermediate node. When a RREQ packet reaches its destination node, the destination sends a reply to the source of the request, and it does not forward the packet. Information on neighbors that is used in the proposed schemes is obtained via HELLO messages that are exchanged periodically similar with conventional AODV.

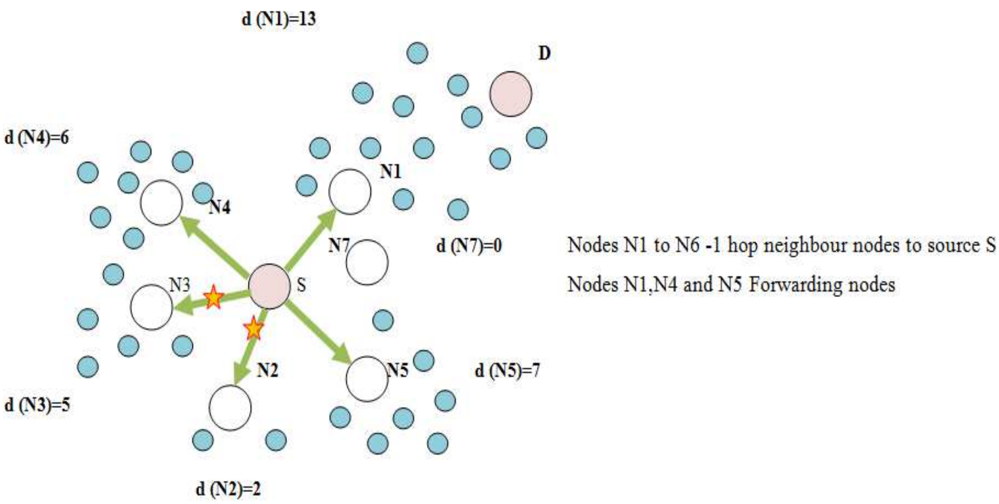

Fig. 1. Selection of forwarding nodes.

Each node follows a parameter called the node degree d, where the degree of node N, degree(N), is the number of one hop neighbors with this node. The degree of a node is equal to the size of that node’s neighbor table and this table contains an entry for each neighbor updated from within specified time intervals. The merit of the degree is considered as the largest number one hop neighbor in the network. Each node broadcasts a Hello message containing its address and degree and a node frequently updates its routing and neighbor tables contain the addresses of all N’s 1-hop neighbors and their degrees sorted in the decreasing order. If a source node S want to transmit the data packet to destination D, starts sending RREQ to its nearest one hop neighbors and need to choose first three or four forwarding nodes based on order of largest degree. In further need to optimize the number of forwarding nodes (F) depending on the density of the network. We have experimented with F as three. The source node appends their addresses to the RREQ message. Upon receiving the RREQ message, only those nodes whose addresses are among the F neighbors 'addresses will process the message and rebroadcast it further, as shown in Fig.1.The steps of BNDS execution is given in Fig. 2.

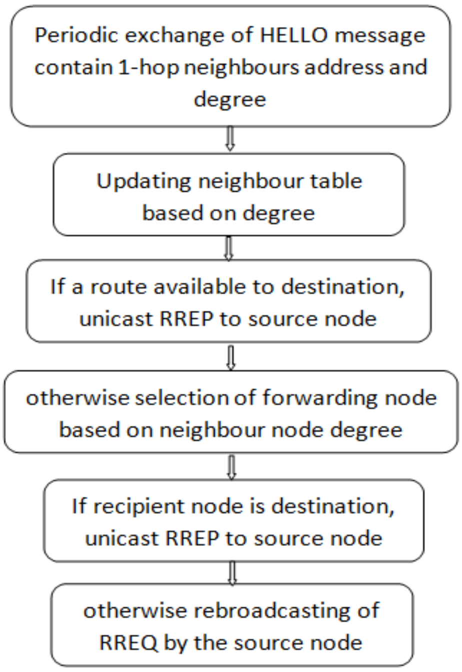

Fig. 2. BNDS Execution

Table 1. Simulation parameters

Parameter	**Value**
Simulator	Network simulator 2
Routing protocols	BNDS,AODV, DSDV
Number of nodes	50
Simulation area	1000 m X 1000 m
Mobility speed	10,20,30,40 m/s
Transmission range	250 m
Movement model	Random-waypoint
Traffic type	Constant Bit Rate
Packet rate	4 packets/s
Data payload	512 bytes/packet
Link bandwidth	2 Mbps
Simulation time	100 s

5 SIMULATION SETUP

The simulation is carried out with the Network Simulator (NS) 2.34 event driven open source software on a platform with and Ubuntu 9.10.The topological area of 1000 m×1000 m region is chosen with fixed node density as 50 deployed, random waypoint mobile model[14], network setup consists of 50 nodes are CBR data sources placed randomly and transmission range of 250 m moves at variable speed from 10 to 40m/s. The simulation is allowed to run for 100 seconds and runs are repeated ten times with different random seeds. The Distributed Coordination Function (DCF) of the IEEE 802.11 protocol is used as the MAC layer protocol and the network bandwidth is 2 Mbps. The additional simulation parameters adopted in this as shown in Table 1.

6 RESULTS AND DISCUSSIONS

This section presents the impact of node mobility on the performance of BNDS is compared with DSDV and AODV as the base routing protocol, where route discovery is based on flooding and neighbor knowledge . The main aim is to reduce the routing overhead in the route discovery, therefore minimizing collision and increasing the overall performance in the network. The performance of three protocols is evaluated using the following important Quos metrics. They are control overhead, packet delivery ratio, Average throughput and End-to-end delay.

6.1 ROUTING OVERHEAD

It represents the ratio of the number of control packets generated by the protocol to the number of data packets received by the destinations. It considers routing overhead and the MAC control overhead (ARP packets and control packets such as- RTS, CTS and ACK).The three route discovery algorithms impose vastly different amounts of overheads when the node mobility is increase. Fig. 3 demonstrates that BNDS can significantly mitigate the routing overhead incur during the route discovery process. The routing overhead is gradually increasing with mobility speed due to expense of control packets and overhead is moderate initially in BNDS when compared with the conventional AODV and DSDV. Finally, the mobility speed at 40m/s BNDS demonstrates superior performance over the conventional AODV and DSDV by further reducing the overhead as shown in Fig.3.Overall, the simulation results show that as the mobility speed increases from 10 to 40 m/s , the routing overhead increases for all the three protocols BNDS outperform AODV and DSDV significantly. When speed increases, the probability that packets collide becomes larger, leading to higher route discovery overhead.

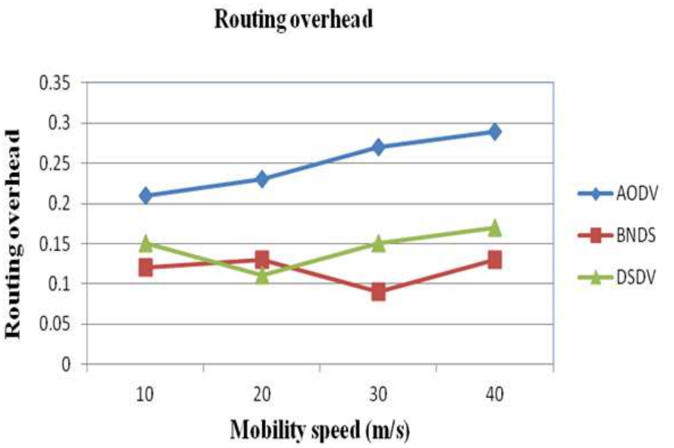

Fig. 3. Mobility speed Vs Routing overhead

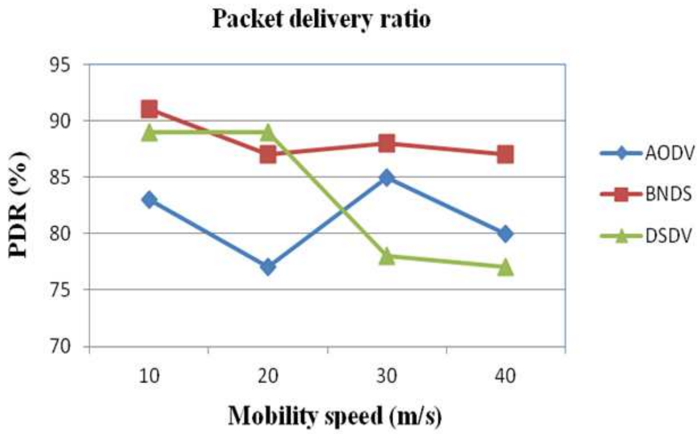

Fig. 4. Mobility speed Vs Packet delivery ratio

The results reveal encouraging benefits in overall routing control overhead but also show that network operating conditions have a critical impact on the optimality of the forwarding probabilities against node mobility.

6.2 Packet Delivery Ratio

It is the number of packets received by the destination to those generated by the CBR source (or) the ratio of the number of data packets received by destination nodes to those sent by the source nodes. Fig.4 shows that increasing mobility speed of the nodes the delivery ratio reduces for all protocols. Reasons for this reduction are packet collisions and dropped packets. It can be seen in Figure . that BNDS is achieved higher delivery ratios than AODV and DSDV for all maximum speed values.

6.3 Average Throughput

Average throughput is defined total number of data packets received (bytes) at destinations in one second. Fig. 5 shows average throughput with increasing node mobility. From the above results BNDS can significantly reduce the routing control overhead and increased PDR and average throughput also benefit when compared with the conventional AODV for increasing mobility speed. The effects of node mobility on the performance of the three protocols in terms of average throughput is gradually reduced. The throughputs achieved by all the protocols are nearly same when the mobility around 20 m/s.

6.4 Average End to End Delay

It represents the average delay experienced by each packet when travelling from to destination due to buffering during route discovery, queuing delay at the interface queue, retransmission delays at the MAC, propagation and transfer times. Fig. 6 measures the end-to-end delay of data packets that have been received at the destinations. When node mobility increases, more RREQ packets fail due to broken link to reach the destinations due to high probability of packet collisions and channel contention cause by excessive redundant retransmissions of route request packets. When mobility speed is 40 m/s all the three protocols demonstrates the effects of poor network connectivity on delivery latency. However, BNDS shows that it can achieve better delay under high mobility.

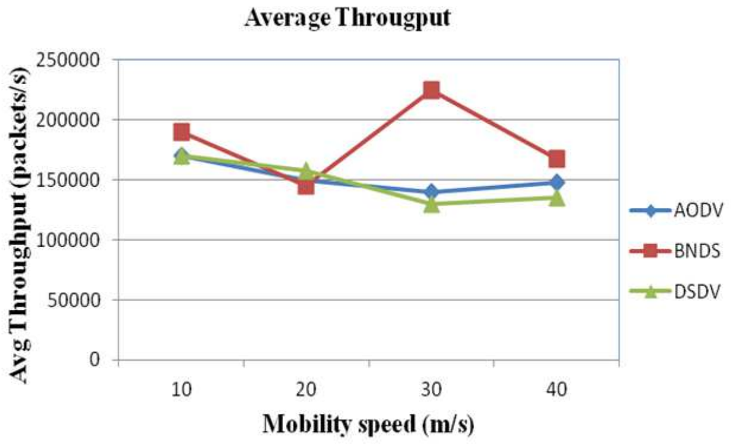

Fig. 5. Mobility speed Vs Average throughput

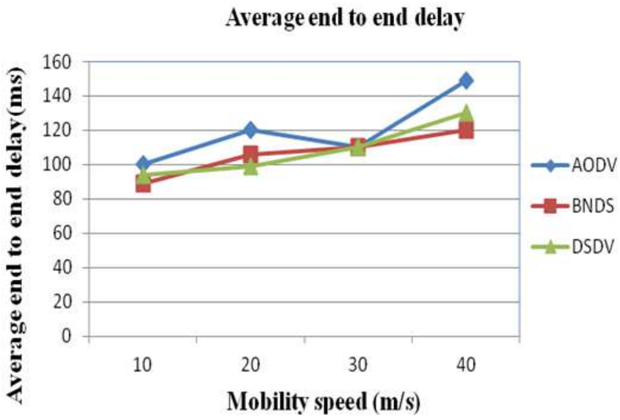

Fig. 6. Mobility speed Vs Average End to end delay

7 CONCLUSION

The major focus of this paper has been the analysis of new probabilistic route discovery algorithms based on locally collected information and the performance is compared with conventional reactive and proactive routing protocols, such as AODV and DSDV. The source node selects a group of its one-hop neighbors for forwarding the RREQ packet based on node degree and this process is repeated by every selected forwarding node, except the destination node. It can significantly reduce the routing overhead and minimize the packet collisions associated with the route discovery process while minimizing end-to-end delay increasing PDR and average throughput. The conventional AODV routing protocol implementation in ns-2 has been modified to obtain neighbor information. Extensive simulation experiments have been conducted base on impact of a node mobility and this approach can generate less rebroadcasts while keeping the reachability high. The results have revealed BNDS exhibit superior performance advantage in terms of routing overhead, average throughput, Packet delivery ratio and end to end delay compared with conventional AODV and DSDV. It would be an interesting prospect to examine the effects of probabilistic broadcast method and impact of mobility speed hybrid routing protocols.

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