Hybrid Scenario Based Analysis of the Effect of Variable Node Speed on the Performance of DSDV and DSR

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Abstract. Routing in mobile ad hoc network is considered as a challenging task due to the drastic and unpredictable changes in the network topology resulting from the random and frequent movement of the nodes and due to the absence of any centralized control. Routing becomes even more complex in hybrid networking scenario where the MANET is combined with the fixed network for covering wider network area with less fixed infrastructure. Although, several routing protocols have been developed and tested under various network environments, but, the simulations of such routing protocols have not taken into account the hybrid networking environments. In this work we have carried out a systematic simulation based performance study of the two prominent routing protocols: Destination Sequenced Distance Vector Routing (DSDV) and Dynamic Source Routing (DSR) protocols in the hybrid networking environment under varying node speed. We have analyzed the performance differentials on the basis of three metrics – packet delivery fraction, average end-to-end delay and normalized routing load using NS2 based simulation.

Keywords: Mobile ad hoc network, hybrid network scenario, varying node speed, performance analysis, packet delivery fraction, average end-to-end delay, normalized routing load.

1 Introduction

A group of mobile devices can form a self-organized and self-controlled network called a mobile ad hoc network (MANET) [1-6]. The main advantage of these networks is that they do not rely on any established infrastructure or centralized server. These networks are autonomous where a number of mobile nodes equipped with wireless interfaces communicate with each other either directly or through other nodes. The communication is multi-hop and each node has to play the role of both the host as well as the router. But due to the limited transmission range of the MANET

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nodes, the total area of coverage is often limited. Also due to the lack of connectivity to the fixed network, the users in the MANET work as an isolated group. However, many applications require connection to the external network such as Internet or LAN to provide the users with external resources.

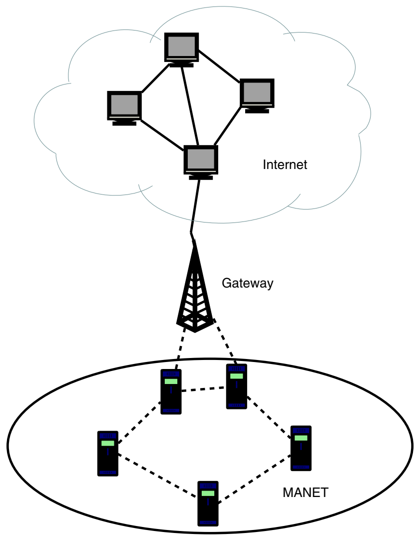

Fig. 1. Hybrid Network

Sometimes a hybrid network can be formed by combining the ad hoc network with the wired network. By using this combination we can cover a larger area with less fixed infrastructure, less number of fixed antennas and base station and can reduce the overall power consumption. Due to the hybrid nature of these networks, routing is considered a challenging task. Several routing protocols have been proposed and tested under various traffic conditions. However, the simulations of such routing protocols have not taken into account the hybrid network scenario. In this work we have carried out a systematic performance study of the two prominent routing protocols: Destination Sequenced Distance Vector Routing (DSDV) and Dynamic Source Routing (DSR) protocols in the hybrid networking environment under different node speed.

The rest of the paper is organized as follows. Section 2 describes the related work. Section 3 and section 4 details the simulation model and the key performance metrics respectively. The simulation results are presented and analyzed in section 5. Finally the conclusion has been summarized in the section 6. The last section gives the references.

2 Related Work

Several simulation based experiments have been made to compare the performance of the routing protocols for mobile ad hoc network.

Das et al. [7] made performance comparison of routing protocols for MANET based on the number of conversations per mobile node for a given traffic and mobility model. Small networks consisting of 30 nodes and medium networks consisting of 60 nodes were used. Simulation was done using the Maryland Routing Simulator (MARS).

Performance comparison results of two on demand routing protocols – AODV and DSR is presented in the work of Das, Perkins and Royer [8]. They used NS2 based simulation. CBR sources were used with packet size of 512 bytes. Two different simulation set ups were used. One with 50 nodes and 1500m x 300m simulation area and the other with 100 nodes and 2200m x 600m simulation area. The performance metrics studied were: packet delivery fraction, average end-to-end delay and normalized routing load.

Johansson, Larssson, Hedman and Mielczarek [9] in their work incorporated new mobility models. A new mobility metric was introduced to characterize these models. Using this metric, mobility was measured in terms of relative speeds of the nodes instead of absolute speeds and pause times. The network consisted of 50 nodes. There were 15 sources and the data packets transmitted were of 64 bytes. Performance analysis was made in terms of throughput, delay and routing load.

Park and Corson [10] made a performance comparison between TORA and an "idealized' link state routing protocol. Many simplifications were made in the simulation environment. For example, in the simulation scenario packets were transmitted at the rate of only 4, 1.5, or 0.6 packets per minute per node for avoiding congestion. Total duration of the simulation run was 2 hours. The network was connected in a "honeycomb" pattern. The node density was kept constant artificially. The notion of true node mobility was missing. Every node was connected to a fixed set of neighboring nodes through separate links. Each link switched between active and inactive states irrespective of other links. Immediate feedback was available when a link went up or down which is not the case in reality.

These works, however, do not take into consideration the influence of hybrid network scenario over the performance of the routing protocols. In this work we have studied the effect of varying node speed on the performance of two prominent routing protocols for mobile ad hoc network – Destination Sequenced Distance Vector Routing (DSDV) and Dynamic Source Routing (DSR) protocol in the hybrid networking environment.

3 Simulation Model

We have done our simulation based on ns-2.34 [11-14]. NS is a discrete event simulator. It was developed by the University of California at Berkeley and the

VINT project [11]. Our main goal was to measure the performance of the protocols under a range of varying network conditions. We have used the Distributed Coordination Function (DCF) of IEEE 802.11[15] for wireless LANs as the MAC layer protocol. Data packets were transmitted using an unslotted carrier sense multiple access (CSMA) technique with collision avoidance (CSMA/CA) [15].

The protocols have a send buffer of 64 packets. In order to prevent indefinite waiting for these data packets, the packets are dropped from the buffers when the waiting time exceeds 40 seconds. The interface queue has the capacity to hold 80 packets and it is maintained as a priority queue. We have generated the movement scenario files using the setdest program which comes with the NS-2 distribution. The total duration of our each simulation run is 900 seconds. We have varied our simulation with movement patterns for six different node speed: 5m/s, 10m/s, 15m/s, 20m/s, 25m/s, 30m/s. In our simulation environment the MANET nodes use constant bit rate (CBR) traffic sources when they send data to the wired domain. We have used two different communication patterns corresponding to 30 and 40 sources. The complete list of simulation parameters is shown in Table 1.

Table 1. Simulation Parameters

Parameter	Value
Protocols	DSDV, DSR
Number of mobile nodes	70
Number of fixed nodes	10
Number of sources	30,40
Transmission range	250 m
Simulation time	900 s
Topology size	900 m X 600 m
Source type	Constant bit rate
Packet rate	5 packets/sec
Packet size	512 bytes
Pause time	100 seconds
Node speed	5m/s, 10m/s, 15m/s, 20m/s, 25m/s, 30m/s
Mobility model	Random way point

3.1 Hybrid Scenario

We have used a rectangular simulation area of 900 m x 600 m. In our simulation we have used two ray ground propagation model. Our mixed scenario consists of a wireless and a wired domain. The simulation was performed with 70 wireless nodes and

10 wired nodes. For our hybrid networking environment we have a base station located at the centre (450,300) of the simulation area. The base station acts as a gateway between the wireless and wired domains. For our mixed simulation scenario we have turned on hierarchical routing in order to route packets between the wired and the wireless domains. The domains and clusters are defined by using the hierarchical topology structure. As the base station nodes act as gateways between the wired and wireless domains, they need to have their wired routing on. In the simulation setup we have done this by setting the node-config option–wiredRouting on. After the configuration of the base station, the wireless nodes are reconfigured by turning their wiredRouting off.

4 Performance Metrics

We have primarily selected the following three performance metrics in order to study the performance comparison of DSDV and DSR.

Packet delivery fraction: This is defined as the ratio between the number of delivered packets and those generated by the constant bit rate (CBR) traffic sources.

Average end-to-end delay: This is basically defined as the ratio between the summation of the time difference between the packet received time and the packet sent time and the summation of data packets received by all nodes.

Normalized routing load: This is defined as the number of routing packets transmitted per data packet delivered at the destination. Each hop-wise transmission of a routing packet is counted as one transmission.

5 Simulation Results and Analysis

In this section we have analyzed the effect of varying node speed on the performance of DSDV and DSR in the hybrid simulation scenario.

5.1 Packet Delivery Fraction (PDF) Comparison

From Fig. 2 we observe the difference in the packet delivery performances of DSDV and DSR from our simulation experiments. We have measured the packet delivery fraction of these two protocols by varying the node speed with respect to 30 and 40 numbers of sources. From the graphs we see that DSDV shows better packet delivery performance than DSR at lower node speed. This happens due to the fact that, at lower node speed, the network remains relatively stable and once a route is established, it continues to be available for a longer period of time. Due to the proactive nature of DSDV, routing information exchanges take place regularly between the nodes and each node maintains routing information to every destination all the time. Consequently, most of the packets can be delivered smoothly without having to wait for the path setup time. This results in better packet delivery performance of DSDV. On the contrary, DSR, being a source routing protocol, a significant time is required for initial path setup. During this time, no packets can be delivered to the destination due to unavailability of routes. This results in lower packet delivery fraction of DSR in comparison to DSDV.

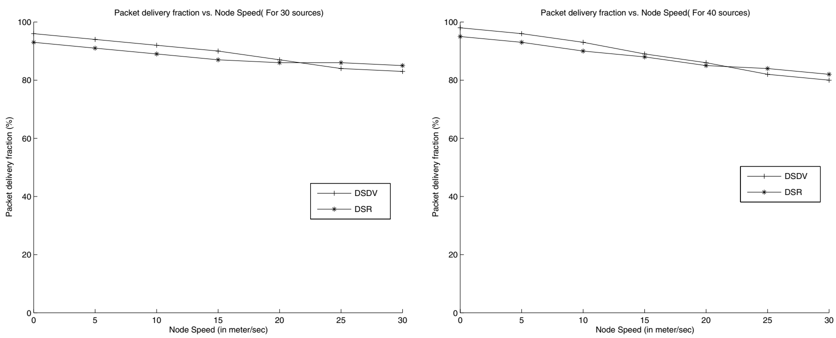

Fig. 2. Packet Delivery Fraction vs. Node Speed for 30 and 40 sources

With higher node speed, the network topology becomes highly dynamic and link breaks become more frequent. The unavailability of routes causes the nodes to show deterioration in the packet delivery performance for both DSDV and DSR. The periodic nature of operation of DSDV makes it less adaptive to these frequent changes. It requires greater number of full dumps to be exchanged between the nodes in order to maintain up-to-date routing information at the nodes. This huge volume of control traffic occupies a significant part of the channel bandwidth and lesser channel capacity remains available for the data traffic which results in reduced packet delivery fraction of DSDV at higher node speed.

DSR on the contrary, is more adaptive to the frequently changing scenario due to its on-demand nature of functioning. DSR maintains multiple routes in the cache. Thus, even if a link is broken due to higher node speed, alternative routes can be obtained from the cache. This reduces the number of dropped packets and results in better packet delivery performance of DSR.

5.2 Average End-to-End Delay Comparison

From Fig. 3 we can observe the fact that DSDV has less average end to end delay in comparison to DSR. DSDV is a proactive routing protocol. In DSDV, nodes periodically exchange routing tables between them in order to maintain up-to-date routing information to all destinations. Due to this regular route optimization, nodes have access to fresher and shorter routes to the destinations all the time. Hence, whenever a source node wants to send a packet to a destination node, with the already available routing information it can do so without wasting any time for path setup. This instant availability of fresher and shorter routes thus results in less average end-to-end delay in the delivery of data packets in case of DSDV.

DSR, on the contrary, is a reactive source routing protocol and routing information exchanges do not take place regularly. Instead, if a node in DSR wants to send a packet to a destination node, it has to first find the route to the destination in an on demand fashion. This route discovery latency is a part of the total delay. DSR being a source routing protocol, the initial path set up time is significantly higher as during the route discovery process, every intermediate node needs to extract the information before forwarding the data packet. Moreover in DSR, the source needs to wait for all the replies sent against every request reaching the destination. This increases the delay.

From the figures it is evident that the average end-to-end delay becomes more with higher node speed and greater number of sources for both the protocols. Frequent changes in the network topology due to increasing node speed results in greater number of link breaks. This together with the greater number of sources requires DSR to invoke the route discovery process more frequently in order to find new routes. The frequent invocation of the route discovery creates huge amount of control traffic. The data traffic to be delivered also becomes more with greater number of sources. This results in more collisions, further retransmissions and higher congestion in the network. Consequently, the route discovery latency increases due to the constrained channel. This in turn increases the average end-to-end delay. In addition to that, due to the higher priority of the control packets, the data packets need to spend more time in the queue waiting for the huge volume of control packets to be delivered. This also increases the end-to-end delay in delivering the data packets. In case of DSDV, due to higher speed of the nodes and frequent link breaks, routes become unavailable and nodes need to wait till the next routing information exchanges for new routes. Thus the delay increases depending upon the duration of the interval between the successive routing information exchanges.

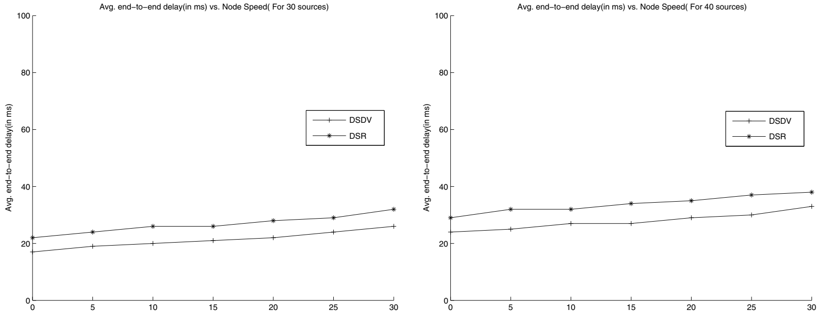

Fig. 3. Average End to End Delay vs. Node Speed for 30 and 40 Sources.

5.3 Normalized Routing Load Comparison

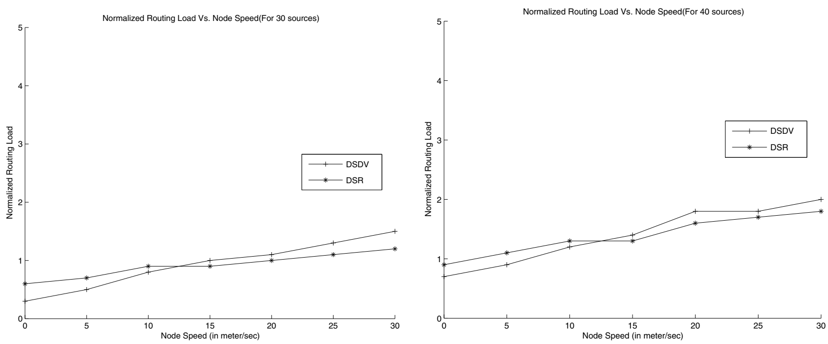

Fig. 4. Normalized Routing Load Vs. Node Speed for 30 and 40 Sources

From Fig. 4 we note that initially at lower node speed, DSR has greater normalized routing load. This is attributed to the fact that DSR being a source routing protocol, with every packet the entire routing information is embedded. In addition to that, in response to a route discovery, replies come from many intermediate nodes. This increases the total control traffic. In case of DSDV, initially, at lower node speed, the network topology remains relatively stable. Hence, nodes need to exchange only incremental dumps rather than full dumps. This results in lesser overhead of DSDV.

Both DSDV and DSR suffer from increased normalized routing load with higher node speed and greater number of sources. In case of DSR, with increasing node speed, the route discoveries need to be invoked more often due to increase in the number of broken links. Furthermore, as DSR does not use route optimization until the route is broken and continues using longer and older routes, the chances of link breaks also increase. This further adds to the number of route discoveries which ultimately results in huge control traffic and subsequently higher normalized routing load. Greater number of sources also causes frequent invocation of the route discovery which significantly increases the volume of control overhead. Higher volume of data and control traffic creates congestion in the network. This results in further collisions, more retransmissions and newer route discoveries and further adds up to the already increased control overhead which ultimately results in higher normalized routing load.

With higher node speed, the network topology experiences frequent and high volume of changes. DSDV, due to its proactive nature of operation, is less adaptive to this highly dynamic scenario. Therefore, nodes need to exchange full dumps in order to maintain up-to-date routing information. This causes greater routing overhead for DSDV. In comparison, DSR uses aggressive caching strategy and the hit ratio is quite high. As a consequence, in highly dynamic scenario, even if a link breaks, DSR can resort to an alternate link already available in the cache. Thus the route discovery process can be postponed until all the routes in the cache fail. This reduces the frequency of route discovery, which ultimately results in less routing overhead of DSR.

6 Conclusion

In this paper we have carried out a detailed ns2 based simulation to study and analyze the performance differentials of DSDV and DSR in the hybrid scenario under varying node speed with different number of sources. Our work is the first in an attempt to compare these protocols in hybrid networking environment. From the simulation results we see that at lower node speed, DSDV shows better packet delivery performance than DSR mainly due to the instant availability of fresher and newer routes all the time. On the other hand, with higher node speed, DSDV shows more deterioration in the packet delivery performance than DSR mainly due to its less adaptability to the highly dynamic network topology. DSR's better performance is attributed to its ability to maintain multiple routes per destination and its use of aggressive caching strategy. In terms of the average end-to-end delay, DSDV outperforms DSR. The poor performance of DSR in terms of average end-to-end delay is primarily due to its source routing nature and its inability to expire the stale routes. Both the approaches suffer form greater average end-to-end delay when we increase the speed of the nodes and the numbers of sources. At higher node speed we observe that DSR shows lower routing load in comparison to DSDV. DSR applies aggressive caching technique and maintains multiple routes to the same destination. Hence, in highly dynamic scenario, even if a link is unavailable due to link break, DSR can resort to an alternate link already available in the cache. This results in reduced frequency of route discovery which ultimately reduces the routing overhead of DSR. On the other hand, at lower node speed, the network topology remains relatively stable. Hence, in DSDV, nodes need to exchange only incremental dumps rather than full dumps. This results in lesser overhead of DSDV. Thus we can conclude that if routing delay is of little concern, then DSR shows better performance at higher mobility in terms of packet delivery fraction and normalized routing load in hybrid networking scenario. Under less stressful scenario, however, DSDV outperforms DSR in terms of all the three metrics.

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