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Performance Evaluation of Routing Protocols in Realistic Scenario for Mobile Ad Hoc Networks

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Abstract— **Mobile ad hoc networks (MANTs) are collections of autonomous mobile nodes with links that are made or broken in an arbitrary way. They have no fixed infrastructure and may have constrained resources. The next generation of IT applications is expected to rely heavily on such networks. However, before they can be successfully deployed, several routing problems must be addressed. These are mainly due to the ad hoc nature of these networks. This paper presents a comprehensive investigation on the performance of common MANET routing protocols in realistic network scenario. The routing protocols used in this research work include AODV, DSR and DSDV. This paper evaluates the performance of these protocols under simulation scenario based on a realistic mobility model. The evaluation is conducted using Network Simulator (ns-2) from Berkeley. As mobility is also an important metric for evaluating ad hoc networks, mobility of nodes is varied to examine the performance of these protocols under realistic scenarios. This simulation experiment shows the performance of each protocol under specific conditions both quantitatively and qualitatively.**

Keywords— **Mobile Ad Hoc Network**

I. Introduction

Mobile ad hoc networks are networks without a fixed infrastructure. Communications must be set up and maintained on the fly over mostly wireless links. Each node of an ad hoc network can both route and forward data. And also obviously mobile nodes within an ad hoc network move from location to location; however, finding ways to model these movements is not obvious. In order to simulate routing protocols for performance evaluation, it is necessary to develop and use mobility models that accurately represent movements of the mobile nodes that will eventually utilize the given protocol. Only in this type of scenario, it is possible to determine whether or not the proposed protocols will be useful when implemented. Therefore, it is imperative that accurate mobility models are chosen.

Therefore, a variety of mobility models and communication patterns have been developed in the simulators for performance evaluation of a design. It is important to use realistic mobility models so that the evaluation results will have a close correlation to the performance when actually deployed. However, the most commonly used mobility model is the Random Waypoint Mobility (RWM), which though being simple and easy to simulate is not very realistic. This kind of simulations also has some problems. First, it is hard to identify situations in which the protocols fail or have problems. Second, it has no connection to a real life situation and it may favour complex protocols, while in real life scenarios simpler protocols can find the routes almost as effectively.

In this paper, a new realistic mobility model was developed based on exiting real world map. Therefore, IMPORTANT mobility generator tools are used for generating the realistic movement pattern. A Manhattan mobility model was generated and a section of Mandalay Technological University was used as reference map. After generating the movement file and communicating file, the simulations had been started to run. In these realistic simulations, three set of simulations have been done with different node speed. The first set used the speed of 0.5 to 2 m/s that is speed of walking people. The second set used the speed of 2 to 10 m/s that means mobility is increased and third set used the speed of 10 to 30 m/s. And then the performance metrics of the three routing protocols were evaluated in terms of average throughput. The results show how the speed of nodes or mobility can affect the performance of routing protocols. This paper focuses on the performance evaluation of ad hoc routing protocols, including Destination Sequenced Distance Vector (DSDV), Ad Hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), through simulation. Simulation results are then provided to analyse the proposed ad hoc routing protocols for examining a robust routing protocol.

II. Routing Algorithms

Destination Sequenced Distance Vector (DSDV) is an entirely proactive protocol, i.e., DSDV does not attempt to find a route for a packet if none is available in the node's routing table when the packet arrives. The advantage of this approach is that a packet can be forwarded immediately if there is an entry for its destination in the routing table.

Dynamic Source Routing (DSR) also belongs to the class of reactive protocols and allows nodes to dynamically discover a route across multiple network hops to any destination. Source routing means that each packet in its header carries the complete ordered list of nodes through which the packet must pass.

The Ad Hoc On-Demand Distance Vector (AODV) routing protocol enables multi-hop routing between participating mobile nodes wishing to establish and maintain an ad hoc network. AODV is based upon the distance-vector (DV) algorithm. The difference is that AODV is reactive, as opposed to proactive protocols like DV, i.e. AODV only requests a route when needed and does not require nodes to maintain routes to destinations that are not actively used in communications.

III. Simulation Overview

A typical simulation with ns and the mobility extension is shown in Fig. 1. Basically it consists of generating the following input files to ns:

- A scenario file that describes the movement pattern of the nodes.
- A communication file that describes the traffic in the network.

These files can be generated by drawing with hand using the visualization tool Ad-hockey or by generating completely randomized movement and communication patterns with a script.

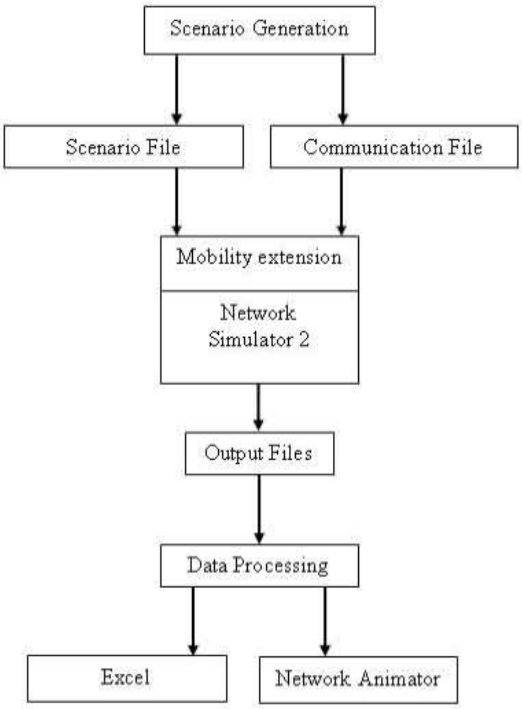

Fig. 1 Simulation Overview

These files are then used for the simulation and a trace file is outputted as a result. Prior to the simulation, the parameters that are going to be traced during the simulation must be selected. The trace file can then be scanned and analysed for the various parameters that wanted to measure. The graphs presented in this paper were generated by parsing through all these files with awk and perl scripts to collect statistics and then feeding Excel with the results. The trace file can also be used to visualize the simulation run with either Ad-hockey or Network animator (NAM).

IV. Simulation Methodology

Having previewed the simulation environment, in this section the simulation methodology will be put forwarded. It is kept variable parameters such as number of node, the amount of data traffic, size of the data packets and the link capacity constant through out the simulations. The network simulations carried out for realistic scenario are based in 1400m x 800m flat grid topography for all simulations. Number of Nodes is fixed to 100 in all simulations. More nodes would add extra complexity to the simulations and hence require more valuable time when simulating. Interface Queue Length (IFQ) specifies the number of packets that can fit in an interface queue, (a separate queue for each mobile node). If this queue fills up, packets will be dropped until there is space available in the queue. The IFQ was set to 50 packets for all simulation.

A. Traffic Type

One of the main advantages of ns is that its traffic descriptions and implementations are well implemented and documented. Ns being a simulator has one of the best TCP implementations,. This is of course very valuable when performing simulations. However in this case, TCP's flow control mechanisms such as slow start, congestion avoidance and fast retransmissions are not desired. They introduce overhead traffic and make it harder to calculate the amount of lost packets and evaluate the performance of routing protocols. This is why constant bit rate (CBR) traffic is used in all simulations.

The advantage of having a uniform traffic model for all the test case scenarios is that, with the total number of data packets sent out being constant, the total number of data packets successfully received at the destination will reflect a measure of the over all packet delivery ratio which in turn is a measure of how well the routing protocols had performed under various scenarios with different mobility patterns and different routing algorithms. The data packet size is very closely related to the variables that are sending rate and number of sending sources. Because the data packet size, sending rate and the number of sending sources together make up the total load fed into the network.

In all simulations the sending rate was fixed at 4 packets per second. The number of sending sources was fixed at 25, resulting in a total maximum constant bit rate (CBR) transfer rate of 128 kB/s.

B. Summarize the Simulation Variables

Simulations have therefore been done on a scenario believed to be realistic. The realistic scenario does not give a full picture of how the protocols behave generally. Instead they give some sense of weak points in the protocols. The environment size is 1400 x 800 meters for proposed realistic scenarios. This size is scaled according to the range of the transmitters. Three set of simulations have been done with different node speed: 0.5-2 m/s, 2-10 m/s and 10-30 m/s. All parameters used during the realistic simulations are shown in Table I.

TABLE I
SIMULATION PARAMETERS FOR REALISTIC SIMULATIONS

Parameter	
Transmitter range	250m
Interface queue length	50 packets
Simulation time	600.0 s
Number of nodes	100
Pause time	0.0s
Traffic type	Constant Bit Rate
Packet rate	4 packets/s
Packet size	512 bytes
Scenario size	1400x800m
Number of flow	25

V. PROTOCOL PERFORMANCE METRICS

The metric used to analyse protocol performance is mean throughput per node. While all of these were collected for each experiment set, only select graphs are presented here due to space limitations. Examining throughput, especially, when it is considered relative to different network scenarios, helps determine how well the routing protocols permit applications to optimize the use of the available bandwidth given the aforementioned limitations. Since the available bandwidth in a network is fairly well known, it is interesting to see what the actual throughput achieved in a simulation is. If a good estimation of this value can be extracted it would be possible to see how efficient the routing protocol is. The higher the average throughput is, the less routing overhead consuming the bandwidth.

VI. PROTOCOL COMPARISON

A. Average Throughput

The average throughput curves and traffic ratio for the different protocols with a packet size of 512 bytes are shown in Fig. 2, Fig. 3, Fig. 4 and Fig. 5. It must however be mentioned that the curves in this case are only interesting from relative view, as a comparison between the protocols. It have been tried to determined the relative difference in average throughput for different protocols with respect to the mobility or node speed and specific load that having used. The traffic ratio bar graph shows the ratio of sent and received packets during simulations.

The average throughput curves for all protocols are very similar to the packet delivery fraction curves. This is logical because large packet drops will of course mean lower throughput. Both DSR version and DSDV version show the poor result. AODV version has the highest throughput of three protocols even the mobility or node speed is high. DSR and DSDV have nearly identical throughput at $2m^{-1}s$ of maximum node velocity. But with high mobility, DSR has a very poor result and the lowest throughput because DSR protocol has some limitations when it comes to the size of the network and load of packets.

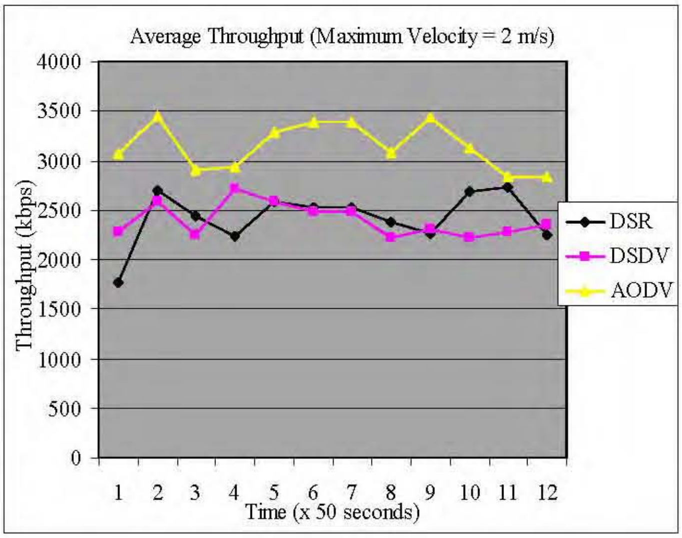

Fig. 2 Average Throughput (node speed = 0-2 m/s)

A larger network often means longer routes and longer routes mean that the source overhead in each packet grows. A large packet means longer transmission time and longer transmission time means that higher average delay.

DSDV protocol also does not scale well at high mobility. Its use of periodic broadcasts limits the protocol to small networks and the convergence time to a steady state would increase when routes go up and down. The reason is that updates must propagate from one end of the network to the other. The performance results show that AODV is the highest average throughput at all mobility.

It must however be noted that only the data packets are included in the calculations of throughput and no control packets are included in this definition. DSDV drops a large fraction of the packets already at maximum node speed of 10m/s and the throughput decreases more and more as the mobility increases. DSR have a much larger byte overhead than AODV at higher data rates.

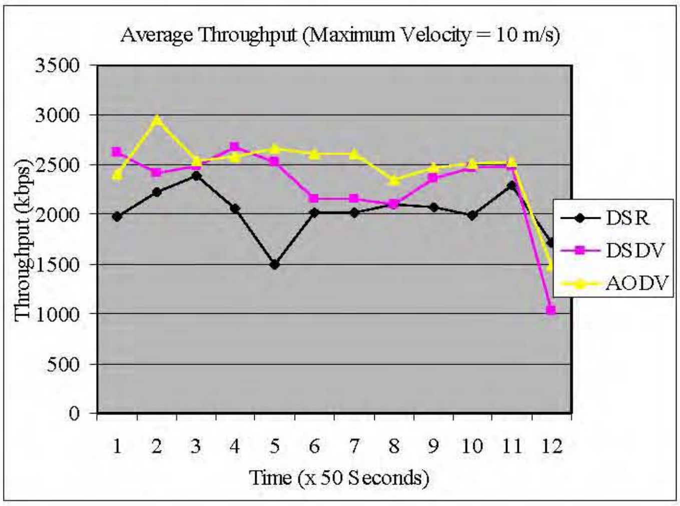

Fig. 3 Average Throughput (node speed = 2-10 m/s)

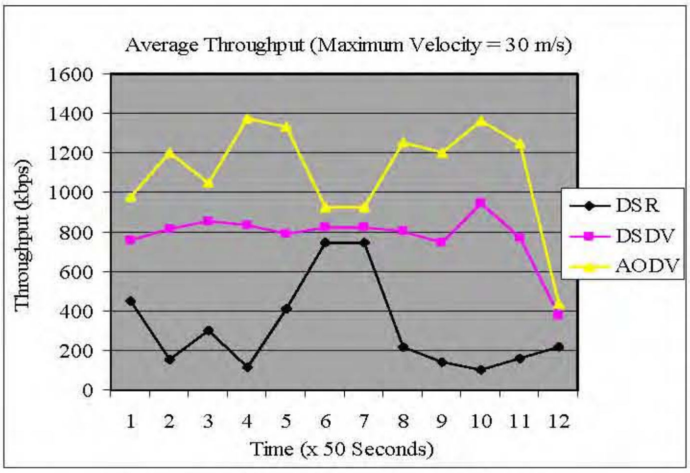

Fig. 4 Average Throughput (node speed = 10-30 m/s)

This also increases the load on the network and causes more packets to be dropped; thus AODV will have a better throughput at high data rate. At high CBR rates, the throughput will decrease when the mobility increases. This is however an effect from the large fraction of dropped packets.

VII. Conclusion

The simulations have shown that there certainly is a need for a special ad hoc routing protocol when the mobility increases. It is however necessary to have some sort of feedback from the link-layer protocol like IEEE MAC 802.11 when links go up and down or for neighbour discovery. Since DSDV is dependent of its periodic updates, its ability to deal with a dynamic topology is very poor. It has a poor ability to fast detect broken links and takes time to converge. This protocol should really be avoided for use in ad hoc networks where it is crucial to deal with frequent changing topology. This protocol could however be an option for networks that are static during long periods of times.

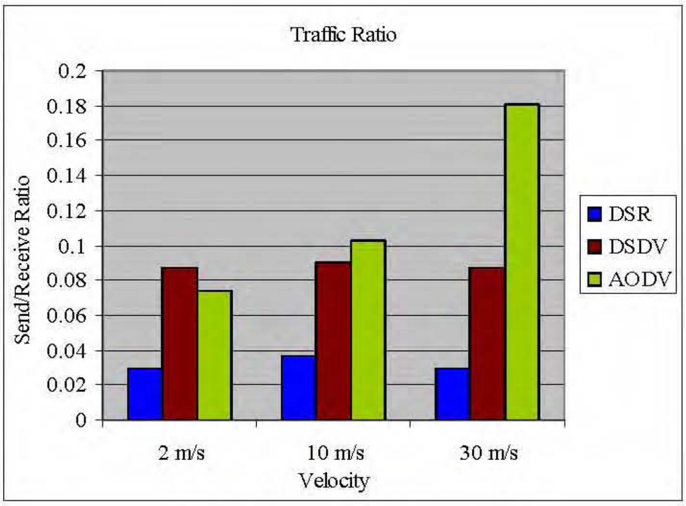

Fig. 5 Traffic Ratio (Throughputs)

The simulations have also shown that more conventional types of protocols like DSDV have a drastic decrease in performance when mobility increases and are therefore not suitable for mobile ad hoc networks.

DSR is however based on source routing, which means that the byte overhead in each packet can affect the total byte overhead in the network quite drastically when the offered load to the network and the size of the network increases. In these situations, a hop-by-hop based routing protocol like AODV is more desirable. One advantage with the source routing approach is however that in its route discovery operation it learns more routes. Source routing is however not desirable in ordinary forwarding of data packets because of the large byte overhead.

AODV has overall exhibited a good performance also when mobility is high. This protocol needs better link breakage detection. Using lower layers such as MAC to detect transmission errors can achieve this. A combination of AODV and DSR could therefore be a solution with even better performance than AODV and DSR. If combined protocol is used, the protocol actually shows a very good performance. Showing good results in the simulations and AODV, a highly optimized protocol, is a definite choice for highly mobile networks. Therefore, this protocol could definitely be used in highly mobile networks as well as static networks.

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