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Simulation Based Study to Present the Performance of Ad-hoc Routing Protocols

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ABSTRACT: Ad-hoc mobile/802.11 networks are fully considered as networks with no fixed physical line connections. Ad-hoc networks have no fixed topology due to the movement of the end nodes. All the nodes in ad-hoc networks are mobile. Each node taking part in this network can act as host and router which can send and receive data. In this type of situations some kind of routing protocols are needed for these mobile nodes to fully operate and function properly. Ad-hoc network has some common features, which need some routing protocol. The most significant one is the dynamic routing protocols, which quickly change the topology. Reactive routing protocols search a route to destination/remote device on needed basis. Proactive protocols maintain the whole routing table at each node. In order to show the performance, NS2 network simulator has been used. The purpose of this study is to show the performance of two widely known ad-hoc routing protocols, AODV and DSR, in terms of packet delivery ratio, average end-to-end delay and routing overhead by changing the mobility. The simulation has been carried out using NS2 2.29 as the simulation platform.

KEYWORDS: AODV, DSR, OLSR, Mobility, MPR, Traffic Pattern.

1 INTRODUCTION

Ad-hoc/802.11 networks are implemented with type of remote data transmission system that uses some form of waves as a media. Electromagnetic and radio waves are used as a carrier and this implementation normally takes place at the physical layer. In the last few years, the word networks have increasingly become a mobile. This is because the recent advancement in devices such as laptops and PDA (personal data assistant), which has brought these devices to the lower prices and increase the high data rates.

Ad-hoc networks can be characterized into two forms (i) Infrastructure network and (ii) ad-hoc network. In infrastructure mobile network, mobile devices have wired base stations in a specific range. The base station contains the central controller for an infrastructure network. In contrast, mobile ad-hoc networks are self-organized networks without infrastructure support. Devices move in a random manner, therefore the network may experience a quick and unknown topology changes. Furthermore, because devices in a mobile ad-hoc network normally have limited communication range, some devices will not send or receive data packets directly. Hence, routing paths in ad-hoc networks contain multiple hops. Every device in ad-hoc networks has the responsibility to act as a router to send and receive the data packets [1].

1.1 AD-HOC APPLICATIONS

Mobile ad-hoc network has different applications, which can be used in commercial and industrial site [2].

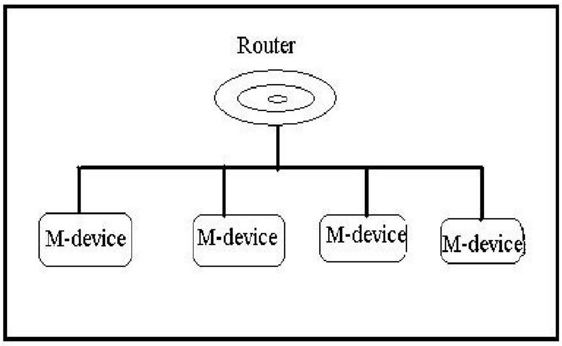

Fig. 1. Diagram of a mobile device

Important applications of ad-hoc applications are emergency services, commercial services, Education services, enterprise application, and Entertainment services.

1.2 ROUTING PROCESS

Routing is a process of taking data over the network from source to a defined destination. Routing operate at layer 3 of the OSI model. Routing is almost defined with switching. The main difference between routing and switching is that routing operates at layer 3 and switching operates at layer 2 of the OSI model. Using both switching and routing mechanism the whole process moves the data from source to destination. Routing process is however different than switching process.

When the source router sends the information to the neighbour router, the neighbour router checks the route of the destination router in the routing table. If the route is available in the routing table, it will send the information, if not then the router will discard the packet. If the router has more than one route available in the routing table the router will select the best available path to the destination and sends the information's [3].

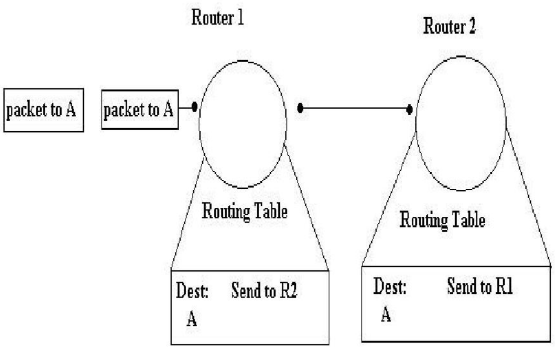

Fig. 2. The routing process from source to destination

The rest of the paper is organized as follows: the related work is presented in Section II. Section III contains the proposed work. Results are discussed in Section IV. We conclude the paper in Section V.

2 RELATED WORKS

In this section the followings routing protocols are discussed.

2.1 AD-HOC ON-DEMAND DISTANCE-VECTOR PROTOCOL (AODV)

AODV is a hop by hop routing protocol or in other words, AODV is an on demand distance vector routing protocol. AODV is combination of DSR and DSDV [4]. It has some features of DSDV protocol, for example using hop by hop routing, periodic notification messages and sequence numbers. By means of an updated DSDV, it reduces the amount of broadcasting messages and only creates routes on need basis [5], when a mobile device need to send some information/data, then AODV find out a route to a destination, and it keeps the routes in the routing table up to the time, when they are needed by the source. In AODV the sequence numbers guarantee the loop free and freshness of routes in the routing table. AODV is relatively the same as the bellman-ford distance vector algorithm, but it does work in mobile environment [5]. It can also be seen as an updated DSR protocol. Like DSR AODV use route discovery and route maintenance properties and it uses sequence number and periodic hello message properties of DSDV.

2.1.1 ROUTES TABLE IN AODV

Routing table [6] only adds all active routes, when source need to send data to the destination. Each entry has some information to the destination. Some of them are defined here, for example Number of total hops to the destination, sequence number, next hop, online neighbours for this route. Expiry time for this route is called life time. The life time reset itself every time, when the route has been used by any device to send the data. It has also another active time out which is the sum of expiry time and the current time. AODV only keeps information about the active links and hence offload the management of table. AODV deletes all the information about a link if it does not receive any information for RREQ message. AODV utilizes maximum of the bandwidth. This is because AODV does not broadcast periodic hello messages across the network. AODV always route packets on demand. Destination sequence number plays very important role in keeping the routing table fresh.

2.2 THE DYNAMIC SOURCE ROUTING PROTOCOL (DSR)

The Dynamic Source Routing Protocol (DSR) [7] is a reactive unicast routing protocol. DSR is popular for some of its important features, which are, it is simple, dedicated to ad-hoc networks and very efficient. DSR has two methods for communication, which are,

- Route discovery
- Route maintenance

2.2.1 ROUTE DISCOVERY MECHANISM

DSR is a reactive routing protocol and the route discovery mechanism is very simple. For a communication, DSR send a route discovery broadcast message to the whole network to find the feasible route to the destination. For example if a source device A wants to communicate with destination device Z, if device A has an active route in its routing table, then there is no need to send a discovery broadcast message, but if there is no active route in the routing table for device Z, then device A will send a broadcast the route discovery message. In the above example say, device A does not have an active route, so it will broadcast route discovery message to the network, each device between A and Z will receive this route discovery request message. All the intermediate devices will put their own information/address and will reply with route reply message to device A. when the device Z receive the route discovery request message, it reply back with route reply message to device A only. With this process all the intermediate devices save all active routes in the cache. This way the source can send and receive the packets.

2.3 DESTINATION SEQUENCED DISTANCE VECTOR PROTOCOL (DSDV)

DSDV [1], [8] is a proactive routing protocol in ad-hoc network, which uses bellman-ford algorithm. By using bellman-ford algorithm in ad-hoc network, it increment the sequence number of the new entry in the routing table for each device in the network. In order to operate correctly, DSDV end device has to send its full routing table to all neighbours periodically and vice versa to update its own routing table by getting the latest information from neighbour. All the end devices in the network have to update the routing table as soon as they get any update from neighbour. DSDV uses sequence number as its routing table attribute. The sequence number shows the updated information. A route with higher sequence number is favourable than lower sequence number. Higher sequence number shows most updated information. If the two routes have same sequence number then the route with lower hop count will be preferred [2]. The sequence number is incremented with each broadcast. If there is any broken link the sequence number is tagged as infinity.

2.3.1 DSDV ACTIVITIES

The DSDV protocol requires that every device in the network should send its own routing table periodically, as soon as they receive an updates from its neighbour. The entry in the routing table can change at any time, so the updated table should be sent to help locate the other devices in the network. This will ensure that if a device moves its actual location, then still it will be able to communicate with other destination devices, even if there is no direct link exists. When the devices move in the network, then they send the routing information by broadcasting the packets periodically. The information broadcasted by any device will have its own sequence number and further information.

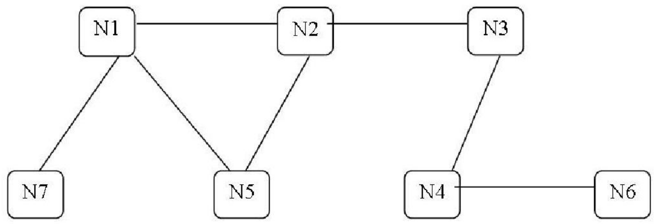

Fig. 3. Routing process mobile devices

2.4 OPTIMIZED LINK STATE ROUTING PROTOCOL

Optimized link state Protocol (OLSR) is a proactive routing protocol. OLSR is the updated version of link state routing protocol. This means that the active routing paths will always be available in the routing table, if any mobile device needs them for communication. As soon as the topology gets changed, then every device sends a full routing table to all other mobile devices in the network. This will create an over head and bottleneck on the actual link. In order to reduce the overhead created by a big pile of broadcast messages, there is a technique used to reduce these broadcast messages. A network protocol uses Multipoint Relays (MPR). The basic job of MPR is to reduce the broadcast messages in some areas in the network and also to provide the shortest path [7].

OLSR [15] is an independent routing protocol, which does not have a fixed central administration and perform flat routing. OLSR is proactive routing protocol which requires all nodes have full updated routing information in the network. On the other hand the limitation of OLSR can be that it sends the updated information across the network which use a lot of the link bandwidth. But it has still minimized the flooding by the selection of MPR, which are only allowed to advertise Hello message. By changing the time interval between the broadcast timing the protocol can be more suitable for ad-hoc network. OLSR is very easy to be integrated in the existing operating system without changing header of IP.

3 PROPOSED SOLUTION

In a general perspective about the reactive routing protocols, it is clear from the results below that both the protocols perform very well under high pause time i.e. low mobility but their performance tends to degrade at higher mobility. This is due to the fact that high mobility often results in route failures which mean often route discoveries will be made by these protocols due to their reactive nature. Performance wise the results showed that

- AODV performed better than DSR in terms of packet delivery ratio

The performance gap was high at low pause time (high mobility) but with high pause time (low mobility).

- DSR started performing better and the gap was significantly reduced.

In terms of average end-to-end delay,

- DSR performed well with lower delay than AODV with at high mobility.
- DSR outperforms the AODV at high mobility with a high performance gap.

This is because AODV uses more route requests than DSR. The reason is that these route requests propagate to all the mobile nodes in the network. The low overhead of DSR is due to the route cache feature and non-propagating route requests.

Both protocols have their advantages and disadvantages in terms of different metrics and scenarios. The prime reason for low performance of AODV relies on a single route and at high mobility this results is often route requests. This can be overcome with a route caching technique to maintain multiple routes to a destination. However, on the other hand the route caching technique has negative impact on the performance of DSR at high mobility. At high mobility, the probability of stale routes in cache is high which degrades the performance. If some sort of cache route expiry mechanism is implemented than it would eliminate the probability of stale routes and thus would improve the performance of DSR and AODV can also benefit from a similar caching technique.

4 SIMULATIONS AND RESULTS

NS-2 network simulation is the best method to present the performance of mobile routing protocols. Several simulation tools are available, like NS2, GLOMOsim, Mat-lab and OPNET. But I have selected to use NS2. There are two files which are input to the NS and these files give you output.

- File which shows the traffic.
- File which shows the movement pattern of the mobile nodes.

4.1 MOBILITY SEQUENCE

The mobility file is generated using NS2 set-dest script. This model used by set-dest is changing position in mobility model. The model imposes a randomly motion, which a node move towards a different destination with a speed varying between zero and high speed parameter, while at the same time generating the mobility file. After stopping at different destination for a specified ‘pause time’, the node continues this changing motion and stopping at a different destination until the simulation come to an end. The pause time parameter controls the motion of the node and is therefore a measure of mobility. For this reason, the pause time is varied to see its total effect. The selected pause times for this simulation are 10s, 15s, 20s, 30s, 50s, 100s and 110 sec. All parameters used to generate mobility file along with pause time is shown in the following table below,

Table 1. Simulation parameters of Mobility Sequence

No of nodes	30
Pause time	10, 15, 20, 30, 50, 100, 110
Maximum speed (m/s)	20
Simulation Time (s)	110
Area – X,Y	1500,300 (rectangular)

4.2 TRAFFIC PATTERN

Traffic files have been generated using cbrgen.tcl script which is part of NS2. Constant bit rate (CBR) traffic sources have been used. The parameters used for the traffic files are shown below in the table,

Table 2. Simulation parameters of Traffic Pattern

No of nodes	30
Seed	1
Maximum connections	10
Rate (Packet per second)	2.0

The three performance metrics have been counted and plotted against the pause time. The results of the simulation are shown in the following graphs along with a detailed discussion.

4.3 Performance Metrics

The followings performance metrics are used in the comparison of the protocols.

4.3.1 Packet delivery ratio

Packet delivery ratio is low for both AODV and DSR at lower pause time i.e. when the motion is too high. Higher mobility causes often route breaks which means more route discoveries are made in case of reactive protocols. With lower mobility the route breaks are not very often which results in few route discoveries and hence better performance for reactive protocols. Between AODV and DSR, it is clear that AODV outperforms DSR in packet delivery ratio in case of high motion/mobility. The fact is that AODV uses fresh routes each time in case of route failure while DSR has route caching feature which means multiple routes to a destination are maintained. After one route fails, the other routes are tried instead of trying to discover another one. In case of high mobility, link breaking often occurs, so chances for stale routes in DSR routing cache is high which is obvious from the results. DSR route caching has a positive effect at lower mobility as shown in the graph since they are not very often route failures. Figure shows the packet delivery ratio below,

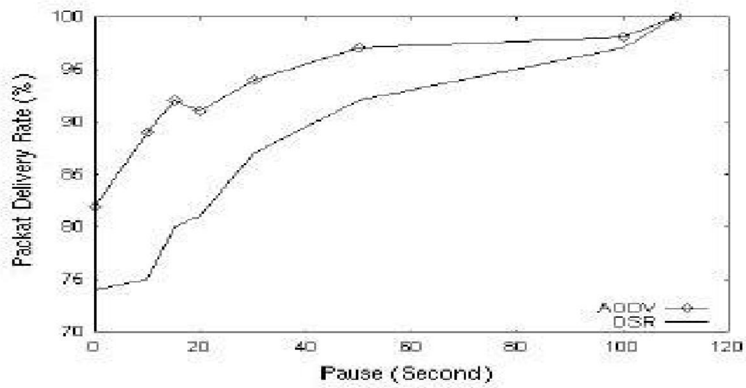

Fig. 4. Packet Delivery Rate vs. Pause Time

4.3.2 Average Delay

Average delay of AODV was higher than DSR at low pause time i.e. high mobility. This is because AODV generates more routing packet for discovering new routes in case of route failure which consumes bandwidth and therefore contributes to the delay in the network. On the other hand, DSR is utilizing route caching ability making less route discoveries in case of route failures thus using little bandwidth and therefore delay is low for DSR. But the difference between the two is not much even though DSR is using route caching. The reason for this is that when stale routes in DSR cache are chosen it adds to the delay as well as to the bandwidth utilization and delivery time is wasted. As the pause time is increased i.e. mobility is decreased, the average delay for both AODV and DSR starts decreasing. Both start performing better with low mobility with AODV matching DSR at pause time of 110. Figure shows the plotted graph below,

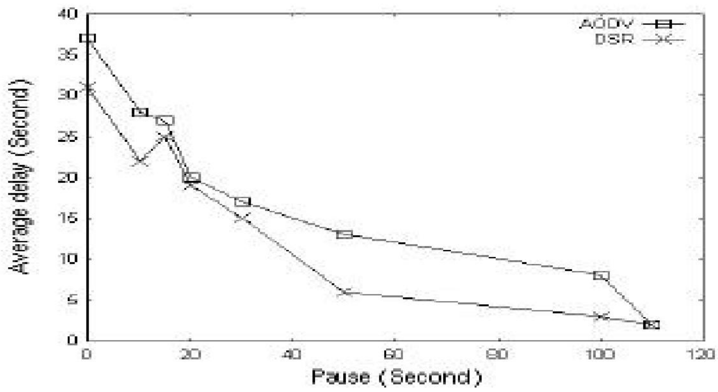

Fig. 5. Average Delay vs. Pause Time

4.3.3 AVERAGE ROUTING LOAD

Average routing load for AODV is higher than DSR. The difference is high at lower pause time i.e. high mobility/motion. The reason for high overhead of AODV is often route request packets for route discoveries which send this to every mobile node in the network. With high mobility this overhead is very high for AODV which relies upon fresh routes. DSR produces less overhead than AODV by utilizing route caching feature and using non-propagating route request packets for route discovery. With high pause time i.e with lower mobility. The difference reduces with the decreased mobility. Figure below shows the average routing load.

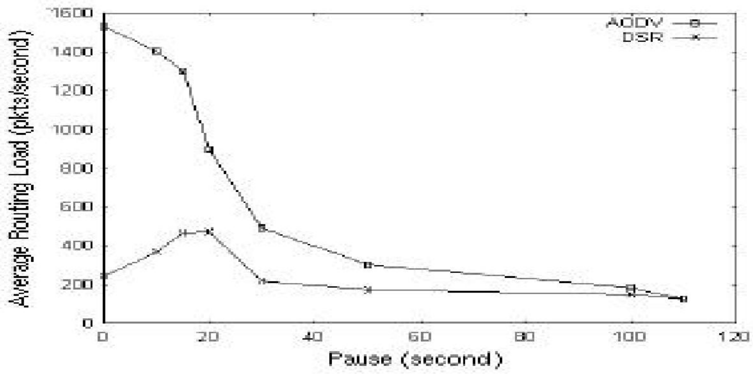

Fig. 6. Average Routing Load vs. Pause Time

5 CONCLUSIONS

Many routing protocols designed for mobile ad hoc networks are proactive, reactive or the combination of both (hybrid). The proactive derives their mechanism from traditional fixed line network to the ad hoc networks. These protocols maintain a table of all the routes in the network. These protocols have high routing overhead in maintaining and updating these tables and are therefore recommended in situation where bandwidth is not a problem. While typical mobile ad hoc networks have bandwidth constraint, reactive routing protocols were designed for mobile ad hoc networks to address the issues in proactive protocols and conserve the bandwidth and power. Being reactive in nature, these protocols adapt to topological changes better than proactive protocols and are therefore best suited for mobile ad hoc networks.

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