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Comparative Study on MANET Routing Protocols

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Abstract: The MANETs are made up of a number of nodes that are capable of communicating with each other without using a fixed base station. The limitation in transmission range and the highly dynamic nature of these networks makes data transmission between the source and the destination travel over multiple hops which can vary over time. Reactive and proactive MANET routing protocols, namely AODV, DSR, TORA and OLSR are commonly used. This study focuses on performance investigation of reactive MANET routing protocol, namely AODV. Designing routing strategies for MANETs began by optimizing the routing protocols designed for wired networks. Position-based Selective Flooding (PSF) algorithm is used in the route discovery for AODV and investigated its performance evaluated using NS-2. Simulation results show that our position based flooding algorithm produce fewer routing overheads than the pure flooding, expanding ring search (used in AODV).

Key words: MANETs, routing, simulation, AODV, DSR, OLSR

INTRODUCTION

Mobility of the node is the main challenge of MANET routing. Compared to a typical wired LAN, ad-hoc network routing has not fixed route in transmission because nodes may disappear and re-appear due to mobility of the nodes in the routing. AODV routing protocol goal is to find the optimal path by taking into consideration communication overhead, latency and power by using most of the available hosts to reach the destination in order to reduce failure in transmission. AODV is the most effective on-demand protocol within their environment (Das *et al*., 2000). As Compared to other routing protocols such as OLSR, DSR and AODV with self similar traffic like CBR, Pareto and exponential the DSR performance was better for packet delivery ratio and OLSR performance degraded in high mobility situations. The AODV (Maashri and Khaoua, 2006) provides the most average performance amongst all. The research focused on routing performance with lower network congestion and with fixed number of nodes. The OLSR is the most favorite proactive protocol and AODV is the most effective on-demand protocol (Qasim *et al*., 2009; Das *et al*., 2000) within their environment. Similarly, evaluated DSDV, DSR and AODV with varying number of nodes and looked into scalability of the protocols. However, the result obtained here is more detailed and have similarities to the research done by Maashri and Khaoua (2006). Kaosar *et al*. (2005) were investigated the performance of OLSR and AODV under high constant bit Rate traffic. In addition, here results have been compared to the other protocols.

The route discovery in AODV, DSR and TORA protocols were proactive in nature which means that each protocol periodically exchanged routing information with other nodes in the network, in order to build their routing tables. This approach is scalable the routing lacks when the size of the network grows. On-demand routing protocols were designed to reduce the route discovery overheads by allowing each node to determine routes when they are required rather than maintaining a route to every destination.

Routing strategy mechanism: This section is having the discussion about DSR, AODV and OLSR routing algorithms and its performance during the reply and request aspects. A node which requires a route to a particular destination starts a route discovery phase where a Route Request (RREQ) packet is propagated through the network until the destination or an intermediate node to the destination is found or the packet expires. When a route is found, a Route Reply

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(RREP) is sent back to the destination using link reversal if the RREQ has travelled over bidirectional links or by flooding if unidirectional links are used. The route maintenance phase is initiated by an intermediate node which experiences a link failure while a route is still active. In this phase, the route can be repaired locally at the point of failure by using a localized route maintenance (Das *et al*., 2000) strategy or the node which detected the link failure notifies the source via a Route Error (RERR) message and the source will either use another route or initiate another route discovery.

Routing in on-demand protocols can be classified into two groups: source routing and point-to-point (also called hop-by-hop) routing. In source routing protocols such as DSR, each data packet carries the complete source to destination address, whereas in point-to-point routing (Das *et al*., 2000; Aboelela, 2011) data packets only carry the destination address and the address of the next hop which leads to the destination. This means that each intermediate node in an active route can make routing decisions, thereby allowing active routes to be adaptable to topology changes, whereas in source routing all the routing decisions are made at the source. This means that link failure in an active route may result in initiation of additional route discoveries at the source or at the point of failure. Furthermore, in source routing, an increase in the number of hops in the active route will result in an increase in the amount of overhead carried by each packet. In contrary, in point-to-point routing the size of each packet is not affected by multihoping. Therefore, point-to-point routing has more potential to scale better as the size of the network increases. In this, we investigated the AODV protocol with other protocols is used to reduce route discovery overheads, given that each source node possesses location information about the required destination. We proposed a number of different mechanisms to minimize the effects of link failure on the active route and increase the stability of each route. In this study, we compared the different routing protocol to identify which one is having the reduced route discovery overhead while maintaining high levels of throughput when the source has no location information about the destination. We investigated that, AODV route discovery strategy is having better performance compared with DSR, OLSR. Our results show that AODV has higher levels of scalability as the size (i.e. boundary), node density and traffic in the network grows.

MATERIALS AND METHODS

Proposed strategy mechanism: In this study, we propose Position-based Selective Flooding (PSF). In pure flooding or in ERS, all the neighboring nodes usually rebroadcast

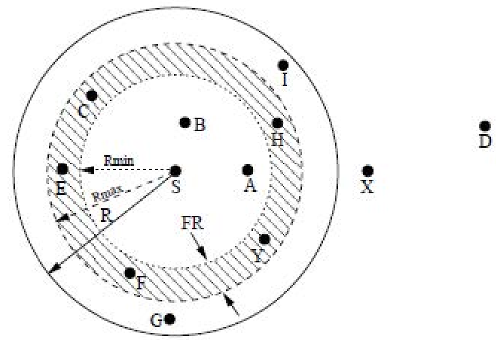

Fig. 1: Illustration of the forwarding region

the RREQ message, unless the TTL has expired. In a dense network, routing overhead can be significantly reduced by strategically selecting the retransmitting nodes to cover the entire network (or a selected area). In PSF, only a number of different nodes forward the RREQ packet, based on a selection criteria described below. We have also proposed a number of variations and improvements to make PSF more efficient. This PSF algorithm is used in the AODV Routing Protocol for the better performance in MANETs. The Overview and Definition of PSF and some observations are listed below.

Overview and definition: This proposed strategy (PSF algorithm) reduces the number of re-broadcasts during route discovery by allowing nodes which are positioned in a determined region, to re-broadcast the routing packets. To illustrate how this strategy works, suppose node S (Fig. 1), wants to determine a route to node D. Node S will initiate its route discovery and a RREQ is broadcasted which stores the source nodes location information. The receiving nodes then determine their relative distance to node S and rebroadcast the RREQ if they map into the Forwarding Region (FR). Note that the idea behind choosing FR comes as a result of the following observations: nodes that are located near the boundary of the transmission range, R, will create unstable (or short lived) links if they are selected as intermediate nodes in an active route. Selection of intermediate nodes which are close together will increase the number of hops in each route. This means that end-to-end delay will increase during data transmission. Furthermore, probability of route failure may increase. Since, the number of intermediate nodes in an active route increases, then the probability of a link failure causing the route failure will increase.

In a dense network, flooding over neighbours which are very close to each other may not significantly increase the probability of a successful route discovery or searching the entire network. In this case, routing overhead can be significantly reduced by strategically selecting the rebroadcasting nodes.

Each node which receives a rebroadcasted RREQ packet, will also calculate their own FR. If their location coordinates map within the FR and they are further away from the source than the previous hop, they will rebroadcast the RREQ packet. This is done by (Fig. 1) multiplying Rmax by the hop count and setting Rmin = Rmax*K. Therefore, the RREQ packet will continue to propagate away from the source at each hop. Note that K is a variable which determines the width of FR. In our simulation, we used a constant value for K. The advantage of PSF is that RREQ packets do not need to carry a forwarding list 2 to limit the number of rebroadcasts as compared to the neighbour aware strategies such as MPR. This means that the size of each RREQ packet will be smaller. Furthermore, nodes do not need to maintain 2-hop topology information.

Simulation environment and parameters: The research is carried out using network simulator-2 version 2.34 (NS2- 2.34). It is one of the most widely used commercial simulators based on Linux platform. The simulation focused on the performance of routing protocols with increased in scalability and mobility. Therefore, two simulation scenarios consisting of 30 nodes initially and doubling amount nodes, i.e., to 60 is considered. The nodes were randomly placed within certain gap from each other in 800×800 m and 1500×1500 m campus environment for 30 and 60 nodes, respectively.

Every node in the network was configured to execute AODV, DSR and OLSR, respectively. The simulation time was set to 600s and used Karn's algorithm to calculate the Transmission Control Protocol (TCP) parameters in the network. In addition to that all the nodes were configured with defined path trajectories for mobility in space within certain time interval. The simulation parameter configured in this research work is influenced from the related work produced on the same field by different references (1, 4, 5, 6, 9, 11 and 12).

The following section is given the discussion for wireless parameters like buffer size, traffic flow parameters configuration like application and profile and other related parameters for routing and refresh time.

RESULTS AND DISCUSSION

Wireless parameters: The wireless LAN parameters were common to all of the four routing protocols as shown in Table 1. In addition, one more wireless LAN scenario was created with RTS set to 256 as configured in the manual provided by Aboelela (2011) in order to minimize the chances of collision in the topology assigning RTS/CTS. This was also used to overcome the hidden node problem

Table 1: Wireless LAN parameters

Wireless LAN MAC address	Auto assigned
BSS Identifier	Auto assigned
Physical characteristics	Direct sequence
Data Rate (bps)	11 Mbps
Channel setting	Auto assigned
Transmit power	0.030
RTS threshold	None
Packet-Reception threshold	-95
Short Retry Limit	7
Long retry limit	4
AP beacon interval (sec)	0.02
Max received lifetime (sec)	0.
Buffer size (bits)	102400000
Large packet processing	Fragment
HCF	Promoted

Table 2: The FTP application parameters

FTP Application Parameters

Attribute	Value
Command mix (get/total)	0%
Inter-request time (seconds)	Constant (3600)
File size (bytes)	Constant (15000000)
Symbolic server name	FTP server
Type of service	Best effort (0)
RSVP parameters	None
Back-end custom application	Not used

(Aboelela, 2011) and provide an efficient operation of MANETs. The same wireless LAN parameters were configured with change in RTS threshold value from none to 256 for second scenario in both 30 and 60 nodes topology. The wireless LAN parameters configured matches to research work of (Qasim *et al*., 2009), except the buffer size was set to 102400000 bits as heavier flow of application was generated. In addition, the channel settings were set to "auto assigned" in order to avoid manual error. Also the transmission power was changed from 0.005-0.030 watt.

Traffic flow parameters: Traffic was generated in the network explicitly by configuring user defined application and profile definition.

Application configuration: A heavier application traffic flow in the topology was generated which each node will be processing from the respective application server in the network. The application traffic generated was as FTP_Application (Table 2): high load and video conferencing: high resolution video. The traffic generation parameter used for FTP_Application are the same as in the manual provided by Aboelela (2011) also in addition to that to allow more traffic flow in the network video application was also configured with default values available in OPNET for higher resolution video.

Profile configuration: The profile configuration for each application was defined as operation mode: serial

Table 3: The AODV parameters

Parameters	Values
Route request retry	5
Route request rate limits (pkts/sec)	10
Gratuitous route reply flag	Enabled
Active route timeout (sec)	30
Hello Interval (sec)	Uniform (10, 10.1)
Allowed hello loss	10
Timeout buffer	2

Table 4: The DSR parameters

Parameters	Values
Time between retransmitted request	500 msec
Size of source route header carrying n address	4n+4 bytes
Timeout for non-propagating search	30 ms
Time to hold packets awaiting routes	30s
Maximum rate for request sending replies for a route	1/sex

Table 5: The OLSR parameters

Willingness	Willingness always
Hello interval (sec)	2.0
TC interval (sec)	5.0
Neighbour hold time (sec)	6.0
Topology hold time (sec)	15.0
Duplicate message hold time (sec)	30.0
Addressing mode	IPv4

(Ordered) and start time: 55 sec. In addition, the FTP application start time was set to constant 5 sec of time period as similar to those configured in the manual provided by Aboelela (2011) and the video application start time was set at constant 75 sec. The constant mode of application traffic was selected so as to generate Constant Bit Rate (CBR) traffic flow in the network.

Routing protocol parameters: The gratuitous reply was enabled for AODV as it helps in reducing the time for route discovery. Also, the "hello" interval time was increased in AODV parameter from the default value to decrease the congestion in the topology (Qasim *et al*., 2009). The configuration parameter used for DSR was similar to resaerch done by Larsson and Hedman.

In Table 3, the AODV parameters that I have set were similar to those in work produced by Qasim *et al.* (2009). The parameter of willingness is changed to 'always' from the default value so as to decrease the MPR's in the network because MPR nodes generate periodic Topological Control (TC) message in the network and the increase in MPR nodes means generation of the more number of TC message in the network. In Table 4, maximum rate for request sending replies for a route has been taken for the primal criteria for DSR. In addition, the OLSR parameters were taken for our comparison. That was shown in Table 5.

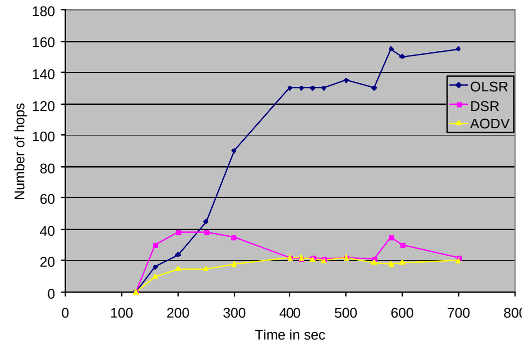

Fig. 2: Average end to end delay (30 nodes)

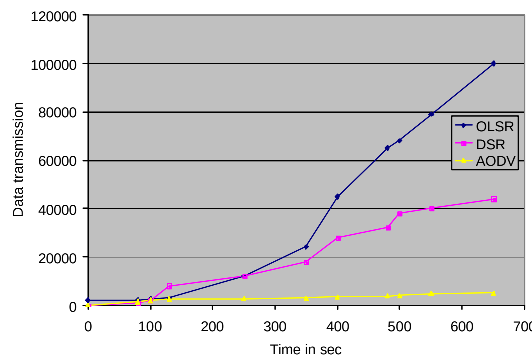

Fig. 3: Network load (30 nodes)

RX configuration parameter: All the RX configuration in the network was set to default except for the node refresh time was set to every 10 sec periodic interval.

Trajectory configuration: All nodes were configured to move in a path defined in the 'trajectory1_AS' parameter. The detail of the 'trajectory1_AS' is shown in the figure below. The trajectory configuration was similar to those in the manual provided by Aboelela (2011).

The trajectory basically defines the path for nodes to move in space in given periodic interval of time. In my simulation the mobile nodes wait until 120 sec and start moving in the path direction as defined in the trajectory parameter.

In this simulation study, two constant values for every node to calculate the Rmax and Rmin in the AODV algorithm. This was done to illustrate the benefits which AODV could have in a medium to large network. Figure 2-4 shown that average time taken for end to end delay in AODV has the better time delay compared with OLSR and DSR where the number of hops increased with respect to 30 and 60 nodes, respectively. The data transmission has been considered for the comparison and it states that the other two protocols parameters were not well suited for network load. This was shown for 30 and

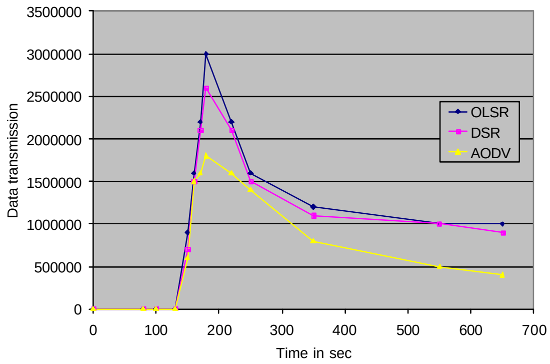

Fig. 4: Average end to end delay (60 nodes)

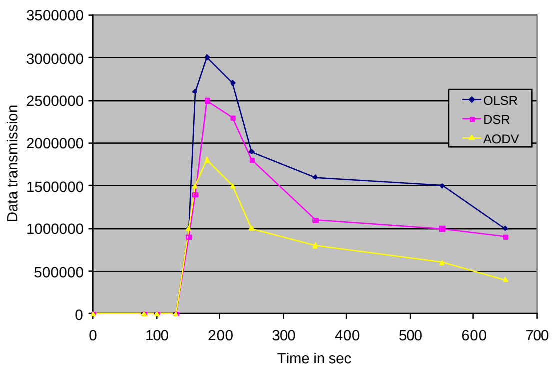

Fig. 5: Network Load (60 nodes)

60 nodes in Fig. 3 and 5, respectively. However, selecting constant values may not be beneficial for every network size or topology. For example, chosen values for a large network may not produce good results in a small network and vice-versa. Furthermore, we want every node to be able to calculate different FR's according to the node density of their neighboring topology. Thus, being able to successfully forward the RREQ message to different parts of the network while minimizing the number of retransmitting nodes. This section presents a number of different strategies to dynamically select FR's at each node.

CONCLUSION

This study presented a routing discovery strategy for mobile ad hoc networks. In this strategy, only a number of selected nodes take part in route discovery. In this, performance of AODV, OLSR and DSR was analyzed using NS2. The protocols were tested using the same parameters with high CBR traffic flow and random mobility. Performance of protocols with respect to scalability has also analyzed. Results showed that, AODV and OLSR experienced higher packet delay and network load compared to DSR. This was due to the localization mechanism employed in DSR. On the other hand, when segment delay is considered both OLSR and AODV performed very reliably and established quick connection between nodes without any further delay. However, DSR showed high end-to-end delay due to formation of temporary loops within the network. Finally, when overall performance is compared, Throughput was considered as the main factor because it is the actual rate of data received successfully by nodes in comparison to the claimed bandwidth. OLSR is performed worst among the three analyzed protocols, delivering much lower throughput than AODV and OLSR. It was argued that, this was due to table driven approaches having more complicated routing procedure. With regards to overall performance, AODV and OLSR performed pretty well showing average performance throughout the simulation which is equivalent to result generated by other researchers. However, AODV showed better efficiency to deal with high congestion and it scaled better by successfully delivering packets over heavily trafficked network compared to OLSR and DSR.

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