Performance Variation of Routing Protocols with Mobility and Scalability in MANET

Manish Kumar, Chetan Sharma, Arzoo Dhiman and Ajay Kumar Rangra

Abstract The network in which nodes are mobile and these nodes communicate with each other by a wireless system not including any infrastructure is known as Mobile Ad HOC Network. Due to mobility of the nodes in MANET, routing a packet from source to destination becomes more difficult. So, many routing protocols have been purposed with reference to MANET but in a scenario of large nodes with high mobility no protocol is proved to be that efficient due to some particular limitation of that protocol. Therefore, mobility and scalability are alarming issue in mostly all protocols which support routing. The routing depends on the protocol; therefore, mobility and scalability of different routing protocols DSR, AODV and OLSR are evaluated in different network sizes with varying mobility rate. Firstly, the simulation environment is provided by varying some important parameters like pause time, speed and variation in number of nodes together. Then comparison between the three protocols is done to determine the best protocol in real-time scenario. Performance when measured on high scalability on a simulation of OLSR protocol as compared to that of AODV and DSR, the results deduced were far better.

Keywords MANET · Mobility · Scalability · AODV · DSR · OLSR

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1 Introduction

A Mobile Ad hoc Network is a network which does not need any infrastructure and configures itself by wireless link for communication of mobile nodes. As in a network which follows such type of strategy to communicate, nodes are free to move in any direction independently. So, wireless links keep on changing very frequently which help to complete the communication process. So, basic challenge faced in a MANET is to keep all the devices updated with the information further required for routing purpose. The position of the mobile nodes (which kept on changing in case of MANET) and their ability of transmission power play a major role in deciding the topology of network. Overall creation, organization and administration in a MANET are done by network itself [1, 2].

2 Categories of Routing Protocols

Some of the protocols which have been developed with context to MANET [3–6] can be classified into the following three categories [7] as shown in Fig. 1.

2.1 On-Demand Routing Protocols

In case of on-demand protocols, routes are searched only in case when some nodes need to communicate with each other. The process to discover the route terminates when it ends in finding a route or not at all any route. So, due to this feature of route maintenance this is also known as reactive protocol. Some popular routing protocol

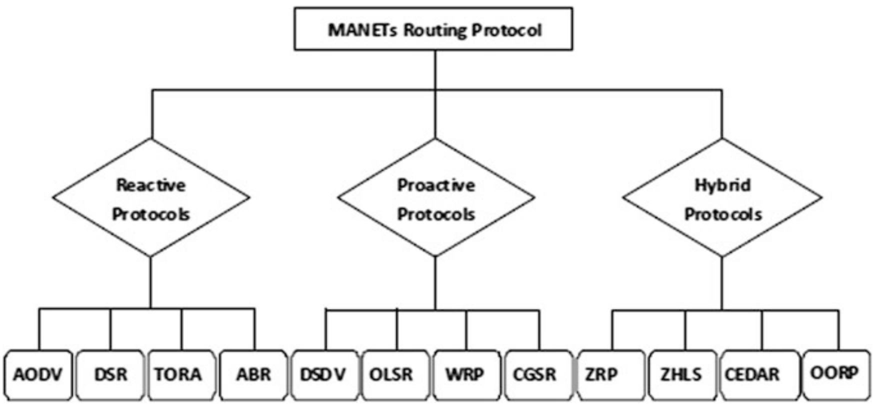


Fig. 1 Classification of routing protocols

which use this reactive technique for communication in MANET are dynamic source routing (DSR), ad hoc on-demand distance vector (AODV) routing protocol and temporally ordered routing algorithm (TORA).

2.1.1 Ad Hoc On-Demand Distance Vector (AODV)

In this protocol, the route reply packet is transmitted back to the origin node and target node gets the routing data packet. AODV protocol uses two steps for communication purpose that is discovery and maintenance of route. When any node wants to send the packet, the process of route discovery get initiated by sending route request packet to its adjacent nodes. If route exists to the target node from these adjacent nodes then a route reply packet will be returned back. In case when these adjacent nodes don't have any route to the target nodes, it will further send a route request packet to its own adjacent nodes excluding the origin node which started the communication process. If a node goes out of network then the corresponding routing table is updated by the process of route maintenance.

2.2 Table Driven Routing Protocols

The table driven routing protocol is also known as proactive protocol. These protocols keep their routing table information updated besides the need of data transfer. This feature of keeping updated routes help in finding the shortest path which leads to reduced delay.

2.2.1 Optimized Link State Routing (OLSR)

The OLSR determine and broadcast the link state information by using topological control message and "hello" interval. Every node uses this link state information to calculate the hop count so that shortest path to the destination is found. The advantage of OLSR is its ability to adapt the changes in network with no overhead of control message creation.

3 Analysis Factor in MANET

3.1 Mobility

Mobility means competence to sustain the network while nodes of the network keep changing their location.

There exist four popular models to support mobility i.e. random way point, random point group mobility, manhattan mobility model and freeway mobility model. We have selected Random Waypoint Model in our research work. In this model, there is a uniform distribution of velocity from zero to max (max is the highest velocity which can achieve by any node), which is randomly chosen by a node to reach any arbitrary location. The pause time parameter decides the duration of node to stop after reaching arbitrary location.

3.2 Scalability

A network has some limiting parameters like its size and traffic rate. But the ability of network to sustain its performance even with the increase of these parameters is known as scalability.

4 Performance Metrics

The following are some performance metrics which play a major role while deciding the efficiency of MANET routing protocols: average jitter, packet delivery ratio, normalized routing load, average throughput and average end-to-end delay. All these metrics must be calculated by varying some parameters related to the network like: network size, average connectivity, topological rate of change, mobility, link capacity. We have used the following two metrics for work which we found most important.

4.1 Average End-to-End Delay

The average time taken to reach from origin to target node by data packets including various delays is known as average end-to-end delay.

4.2 Average Throughput

The data packets fruitfully transferred per unit time is known as average throughput of the network.

5 Previous Work

In the previous research, most of the researcher focus was on analyzing scalability and mobility separately, but actually both these factors influence the network performance at the same time. So, I have decided to analyze the routing protocols considering scalability and mobility together.

6 Problem Statement

A collection of nodes which change their locations randomly and vigorously is denoted as Mobile Ad Hoc network. This random and vigorous movement leads to change in connections among them. Even though various routing protocols can be used to implement Mobile Ad Hoc network but there is no standard algorithm which perform efficiently with various issues like variation in network size, node mobility pattern and load of traffic. Therefore, choosing a protocol to implement MANET with above issues is an immense challenge. By variation in the number of nodes and their mobility, the performance of the network may decline. As the performance of MANET depends upon the protocols used for routing, so to determine which protocol gives better performance with change in mobility and scalability, we need to compare these protocols.

7 Objective

The primary objective of our research work is to study three routing protocols: dynamic source routing (DSR), ad hoc on-demand distance vector (AODV) and optimized link state routing (OLSR). We compared these protocols on two parameters which are scalability and mobility. The performance of these two parameters on the simulator. The simulator is provided with various number of nodes and the speed is managed by the simulator. Finally, find the best protocol for large number of nodes with varying speed.

8 Research Methodology

Statistical data for analysis produced in the current paper are results of experimentations and investigations performed using simulation. Research carried out using these process/experiments is called quantitative research.

9 Simulation Tool

The current research work has been carried out on Optimized Network Engineering Tool (OPNET) Modeller 14.5 which provides virtual network communication environment. The model is widely used and accepted across research fraternity as it is appropriate for the research studies, network modelling and engineering and performance analysis. Apart from being a leading environment for network modelling, this tool has been used in number of industry standards, networking protocols and devices [8].

10 Network Model Design

The OPNET modeller provides a blank scenario to run the configurations and simulations [9, 10]. The blank scenario is created using the set-up wizard provided in the modeller which generates a workspace. Now for simulation environment, drag and drop feature of the workspace is used wherein we get the application configuration, profile configuration along with mobility configuration and nodes. These configurations utility are picked from the object palette provided in the work space (Fig 2).

10.1 Application Configuration

Application configuration is an integral part of a network scenario. It is used to generate the required type of traffic in the network. Among the available choices of applications provided in the application configuration, namely FTP, email, HTTP, database and print, we have chosen HTTP Web application. The heavy browsing feature of the HTTP Web application is used as shown in Fig. 3.

10.2 Profile Configuration

To generate application traffic, user profiles need to be created. The user profiles can be created using the profile configuration utility provided in the simulator. Using the same, we can generate multiple profiles. As per our user design requirement, restrictions can be placed on the usage of nodes placed in the network environment. In this research, we have created only one profile named "Profile1" as shown in Fig. 4.

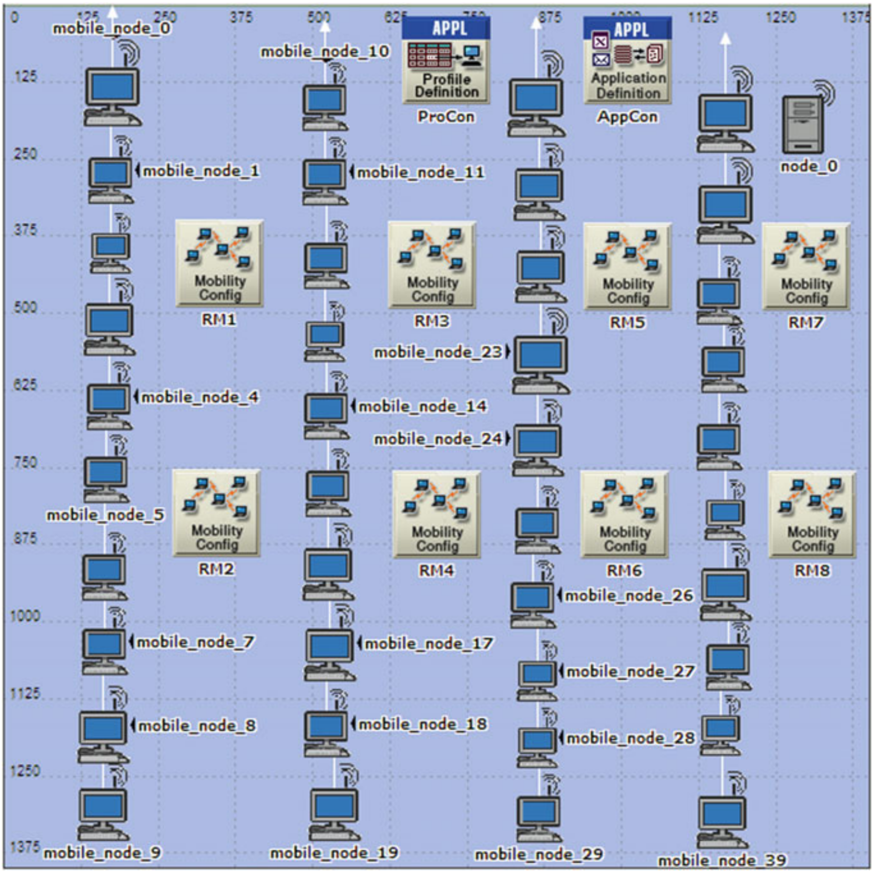
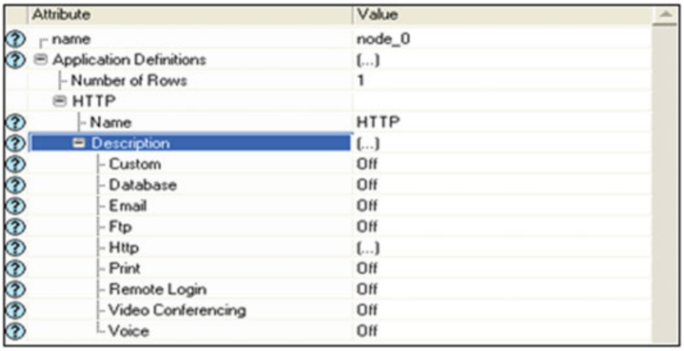


Fig. 2 An example of network model design of MANET using 40 nodes



Attribute	Value
name	node_0
Application Definitions	(...)
Number of Rows	1
HTTP	
Name	HTTP
Description	(...)
Custom	Off
Database	Off
Email	Off
Ftp	Off
Http	(...)
Print	Off
Remote Login	Off
Video Conferencing	Off
Voice	Off

Fig. 3 Application configuration attributes

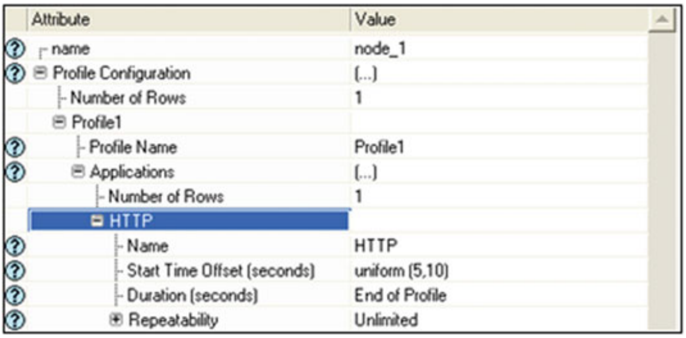


Fig. 4 Profile configuration attributes

10.3 Mobility Configuration

A control environment of mobility model is provided in the mobility configuration. The control on the nodes is managed by maintaining the parameters such as speed, start time and stop time of a given node. In this proposed work, I have varied speed and pause time of the nodes. The speed of the nodes is changed from 0 to 24 m/s. To ensure that the mobile nodes are configured with mobility, I have chosen random waypoint mobility model in this current work.

11 Scenarios and Parameters

In this research work, simulation mainly considers the performance of routing protocols with variation in the number of nodes and their speed. Here, we have taken 20, 40 and 60 number of nodes under nine different scenarios for simulation in context to AODV, DSR and OLSR. Application and profile configurations are used to generate the traffic for hyper text transfer protocol. Table 1 describes the values taken for different simulation parameters while observing three MANET protocols.

Parameters for individual protocols also varied from default setting except OLSR, because the OLSR gives best performance with these parameters. Table 2 show the parameters and their respective values.

Table 1 Simulation parameters

Attribute	Value	Attribute	Value
Maximum simulation time	600 s	Transmit power (W)	0.020
Interface type	Wireless (ad hoc)	Buffer size (bits)	1,024,000
Network area	1000 * 1000 m 1400 * 1400 m 1725 * 1725 m	No. of nodes	20, 40, 60
Mobility model	Random way point	Protocols	DSR, AODV, OLSR
Data rate (bps)	11 Mbps	Traffic generation application	HTTP (heavy browsing)

Table 2 DSR, AODV and OLSR parameters

DSR parameters		AODV parameters		OLSR parameters	
Route expiry time	300 s	Route request retry	5	Willingness	Willingness always
Max buffer size	Infinity	Route request rate limits (packets/sec)	10	Hello interval (seconds)	2.0
Expiry time	30 s	Gratuitous route reply flag	Enabled	TC interval (seconds)	5.0
		Active route timeout (seconds)	10	Neighbour hold time (seconds)	6.0
		Hello interval (seconds)	Uniform (1, 1.1)	Topology hold time (seconds)	15.0
		Allowed hello loss	10	Duplicate message hold time (seconds)	30.0
		Timeout buffer	2	Addressing mode	IPv4

11.1 DSR Parameters

See Table 2.

12 Performance Evaluation Metrics

Due consideration is given to important metrics for analyzing the performance of various routing protocols for mobility with the combination of scalability. The metrics chosen for this particular simulation are:

Average Throughput

The data packets fruitfully transferred per unit time are known as average throughput of the network. In our study, messages delivered per second are considered to evaluate throughput.

Average End-to-End Delay

The average time taken to reach from origin to target node by data packets including various delays is known as average end-to-end delay.

All the above metrics must be calculated by varying some parameters related to the network like:

- Network Size
- Average Connectivity (Average degree of node)
- Mobility
- Link Capacity (bits/sec)

In this research work, we have chosen speed of the nodes, pause time and network size as the varying parameter as we are evaluating the scalability and mobility of the MANET routing protocols.

13 Performance Comparison of Protocols

The following record analysis describes the performance comparison of protocols based on the mobility and scalability.

13.1 Network Delay

Figure 5 shows the delay for network packets transmission in AODV, DSR and OLSR for 20, 40 and 60 nodes, respectively. In the above analyzed scenarios,

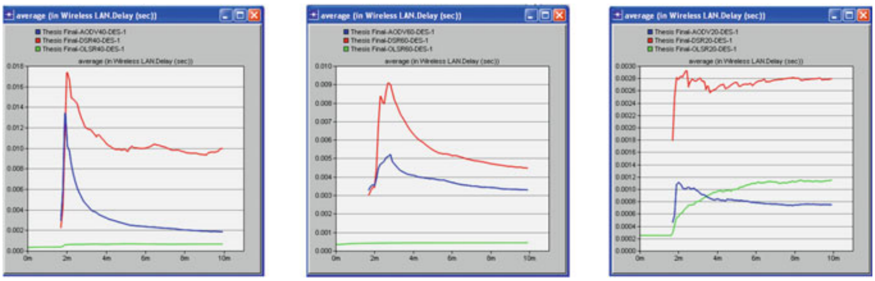


Fig. 5 Network delay for 20, 40 and 60 nodes (DSR, AODV and OLSR)

AODV and OLSR are showing very less network delay as compared to DSR. So, DSR is lacking in performance among these three protocols. The basic fact which leads to failure of DSR is use of caching hard line. Even when more than one choice is available DSR lacks in finding the fresh routes due to its inability to run out the decayed routes. We can observe that AODV delay is low in fewer numbers of nodes and mobility but increased as the number of nodes and mobility rate increases. This is due to the reason that there is less overhead for RREQ and RREP for fewer nodes but very higher as the number of nodes and mobility grow.

OLSR outperformed DSR and AODV in consideration of network delay in general. The table driven approach of OLSR is basic reason for these results. The delay in transmission is low because the extra work to discover the new route is not required in case of OLSR. Therefore, in terms of network delay OLSR and AODV are more scalable and mobile than DSR protocol.

13.2 Throughput

Figure 6 depicts the throughput of all three protocols for 20, 40 and 60 nodes, respectively. In our comparison study of three protocols, DSR is lacking in all the parameters chosen. DSR is far behind than OLSR and AODV in case of throughput. First reason is high cache of routes maintained by DSR. Secondly, the routes which are no longer in use do not deleted by DSR and it leads to problem in determining fresh routes.

If we change the number of nodes with variation in their speed, AODV protocol performs moderately in reference to throughput parameter. AODV keeps track of multiple routes from source to final node which leads to discovering an optimal route almost in each case. In determining new routes, AODV compromises with increased latency to manage the control of traffic. There is no doubt that AODV compromises with latency for controlling the network traffic.

The OLSR outperformed the AODV and DSR in our simulation in context to throughput also. Basic reason for this performance is use of proactive technique by

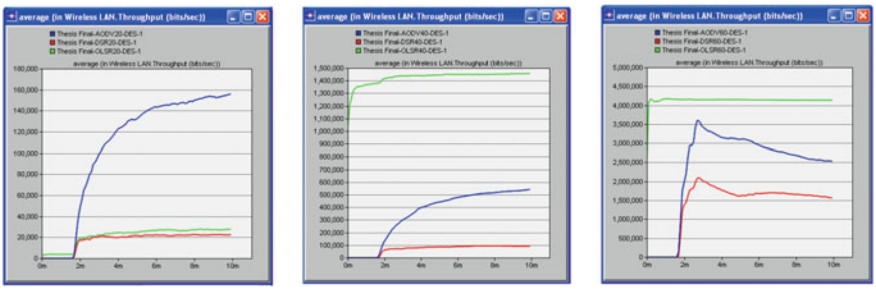


Fig. 6 Throughput for 20, 40 and 60 nodes (DSR, AODV and OLSR)

OLSR where MPR is used to update the various links which leads to control the overall overhead in network traffic. This does not affect the performance of OLSR when the network contains the small number of nodes but as the number of nodes increases with mobility it limits the performance of the protocol to some level. But, we can analyze that efficiency of the OLSR is great in case of network with high density of nodes.

14 Results and Conclusion

The simulation results conclude that the performance varies from protocol to protocol with mobility and scalability. The network's average end-to-end delay increased for all three routing protocols as and when the number and speed of the nodes increased. With the increase in number of nodes and their varying speeds, a delay has been observed in the network. Ultimately, under all the scenarios used OLSR performed far better than DSR and AODV has minimum network delay in high mobility and more number of nodes. In both the metrics, DSR's performance was not satisfactory even after using cache. But OLSR showed best results as compared to DSR and AODV in context to throughput. AODV is just behind the OLSR in case of performance in throughput but its reaction is very quick while operating as it maintains the overhead involve in routing better. All this analysis is based upon comparing the different routing protocols by varying their speed parallel with increase in number of nodes to determine the best possible protocol in real-time scenario so that cost involved can be minimized with best possible routing of network packets.

15 Future Work

For future consideration, other routing protocols apart from DSR, AODV and OLSR can be evaluated such as ZRP which belongs to hybrid routing category. Various parameters have been varied and tested during the work such as number of nodes, network area, mobility and pause time. Other parameters such as data rate and traffic applications are kept constant. It would be interesting to see the behaviour of the routing protocols by varying these parameters.

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