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Node Density based Performance Analysis of Two Reactive Routing Protocols in Mobile Ad-hoc Networks

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***Abstract*— Mobile ad-hoc network (MANET) is a collection of wireless mobile hosts forming a temporary network without the aid of any stand-alone infrastructure or centralized administration. MANET has the attributes such as wireless connection, continuously changing topology, distributed operation and ease of deployment. In this paper, the performance of two reactive MANET routing protocols, AODV and DSR, is compared. Both share similar On-Demand behavior, but the protocol's internal mechanism leads to significant performance difference. A detailed simulation has been carried out using OPNET 14.5. The metrics used for performance analysis are Average end-to-end Delay, Retransmission Attempts, Route Discovery Time and Number of Hops per Route.**

***Keywords*— MANET, Routing Protocols, Simulation, AODV, DSR.**

I. INTRODUCTION

Mobile ad-hoc wireless networks hold the promise of the future, with the capability to establish networks at anytime, anywhere. MANETs are collections of mobile nodes, dynamically forming a temporary network without pre-existing network infrastructure or centralized administration. Nowadays a lot of research efforts focus on MANET.

Routing protocol plays an important role if two hosts wish to exchange packets which may not be able to communicate directly. All nodes are mobile and can be connected dynamically in an arbitrary manner. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to other nodes in the network. This situation becomes more complicated if more nodes are added within the network. An Ad-hoc routing protocol must be able to decide the best path between the nodes, minimize the bandwidth overhead to enable proper routing, minimize the time required to converge after the topology changes.

II. RELATED WORK

Several researchers have done the qualitative and quantitative analysis of Ad-hoc Routing Protocols by means of different performance metrics. They have used different simulators for this purpose.

Broch et al. [8], conducted experiments with DSDV, TORA, DSR and AODV. They used a constant network size of 50 nodes, 10 to 30 traffic sources, seven different pause times and various movement patterns. Packet delivery fraction (PDF), number of routing packets and distribution of path lengths were used as performance metrics. They extended *ns-2* discrete event simulator [9], developed by the University of California at Berkeley and the VINT project [10], to correctly model the MAC and physical-layer behavior of the IEEE 802.11 wireless LAN standard.

Juan-Carlos Cano and Pietro Manzoni [11] concentrated on the energy consumption issues of routing protocols. They presented a performance comparison of the DSR, AODV, TORA and DSDV routing protocols with respect to energy consumption.

Ehsan and Uzmi [12], presented the performance comparison of DSDV, AODV, DSR and TORA based on simulations performed using network simulator-2. Three metrics: normalized routing overhead, packet delivery fraction and average end to end delay, were used to measure performance.

Karthikeyan et al. [13] studied the Reactive protocols, DSR and AODV as well as a Proactive Protocol, DSDV and their characteristics with respect to different mobility were analyzed based on packet delivery fraction, routing load, end-to-end delay, number of packets dropped, throughput and jitter using Network Simulator (ns-2).

III. CLASSIFICATION OF ROUTING PROTOCOLS

There are many ways to classify the MANET routing protocols. Depending upon how the protocols handle the packet to deliver from source to destination, most of the protocols are classified into three types.

A. Proactive or Table Driven Protocol

In the routing, the route is predefined. Packets are transferred to that predefined route. In this scheme, packet forwarding is faster but routing overhead is greater because one has to define all of the routes before transferring the packets. Proactive protocols [3] have lower latency because all routes are maintained at all the times.

Example of proactive is DSDV (Destination Sequenced Distance Vector).

B. Reactive or On Demand Routing Protocol

In the routing, the routes are not predefined [3]. A node calls for route discovery to find out a new route when needed. This route discovery mechanism is based on *flooding* algorithm which employs on the technique, a node just broadcasts the packet to all of its neighbors and intermediate nodes just forward the packet to their neighbors. This is a repetitive technique until reaches to destination; *reactive* techniques have smaller routing *overheads* but higher *latency* because a route from node A to node B will be found only when A wants to send to B.

Examples of Reactive are DSR, AODV.

C. Hybrid Routing

Hybrid protocols [3] are the combinations of reactive and proactive protocols. It takes advantages of these two protocols and as a result, routes are found very fast in the routing zone.

IV. Problems in Routing with MANET

The major problems [5] for routing in mobile ad-hoc networks are as follows:

A. Asymmetric links

Most of the wired networks rely on the symmetric links which are always fixed. But this is not a case with ad-hoc networks as the nodes are mobile and constantly changing their position within network.

B. Routing Overhead

In wireless ad hoc networks, nodes often change their location within network. So, some stale routes are generated in the routing table which leads to unnecessary routing overhead.

C. Interference

This is the major problem with mobile ad-hoc networks as links come and go depending on the transmission characteristics, one transmission might interfere with another one and node might overhear transmissions of other nodes and can corrupt the total transmission.

D. Dynamic Topology

Since the topology is not constant; so the mobile node might move or medium characteristics might change. In ad-hoc networks, routing tables must somehow reflect these changes in topology and routing algorithms have to be adapted. For example in a fixed network routing table updating takes place for every 30sec. This updating frequency might be very low for ad-hoc networks.

The purpose of this paper is to study, understand, analyze and compare, two mobile ad-hoc routing protocols DSR and AODV. Both are reactive protocols, they find a route to a destination on demand, whenever communication is needed. The routing mechanism in DSR uses source routing, while AODV uses a table driven routing framework (hop by hop) or destination routing and destination sequence numbers. The effectiveness of our work is illustrated by means of extensive simulations using OPNET 14.5.

V. Reactive Routing Protocols

A. Ad-hoc On-demand Distance Vector Routing (AODV)

AODV [2], [4] is an on-demand version of the table-driven Dynamic Destination Sequenced Distance-Vector (DSDV) protocol. It is another variant of classical distance vector routing algorithm, a confluence of both DSDV and DSR. It shares DSR's on-demand characteristics hence discovers routes whenever it is needed via a similar route discovery process. However, AODV adopts traditional routing tables; one entry per destination which is in contrast to DSR that maintains multiple route cache entries for each destination.

The initial design of AODV is undertaken after the experience with DSDV routing algorithm. Like DSDV, AODV provides loop free routes while repairing link breakages but unlike DSDV, it doesn't require global periodic routing advertisements. AODV also has other significant features. Whenever a route is available from source to destination, it does not add any overhead to the packets. However, route discovery process is only initiated when routes are not used and/or they expired and consequently discarded. This strategy reduces the effects of stale routes as well as the need for route maintenance for unused routes. Another distinguishing feature of AODV is the ability to provide unicast, multicast and broadcast communication. AODV uses a broadcast route discovery algorithm and then the unicast route reply massage.

B. Dynamic Source Routing (DSR)

The Dynamic Source Routing (DSR) [1], [2] is one of the purest examples of an on-demand routing protocol that is based on the concept of source routing. It is designed especially for use in multihop ad hoc networks of mobile nodes. It allows the network to be completely self organizing and self-configuring and does not need any existing network infrastructure or administration. DSR uses no periodic routing messages like AODV, thereby reduces network bandwidth overhead, conserves battery power and avoids large routing updates. Instead DSR needs support from the MAC layer to identify link failure. DSR is composed of the two mechanisms of Route Discovery and Route Maintenance, which work together to allow nodes to discover and maintain source routes to arbitrary destinations in the network. DSR has a unique advantage by virtue of source routing. As the route is part of the packet itself, routing loops, either short – lived or long – lived, cannot be formed as they can be immediately detected and eliminated. This property opens up the protocol to a variety of useful optimizations. Neither AODV nor DSR guarantees shortest path. If the destination alone can respond to route requests and the source node is always the initiator of the route request, the initial route may the shortest.

VI. OPNET Modeler

OPNET Modeler is commercial network simulation environment for network modeling and simulation. It allows the users to design and study communication networks, devices, protocols, and applications with flexibility and scalability. It simulates the network graphically and gives the graphical structure of actual networks and network components. The users can design the network model visually.

The modeler uses object-oriented modeling approach. The nodes and protocols are modeled as classes with inheritance and specialization. The development language is C. It provides a variety of toolboxes to design, simulate and analyze a network topology, routing protocols on the basis of various network parameters. MANET toolbox has been used in this work to simulate the network. Components used for designing of the network are MANET_Station (mobile), application configuration which decides the type of application running in the network, profile configuration for configuring the type of profile on the network. In profile configuration start time and stop time of the application can be set and pause time between the nodes is set. Mobility configuration will decide the mobility model of every node which is selected as random waypoint for this simulation. Attributes of workstation will set the routing protocol used for the simulation.

VII. Simulation Environment

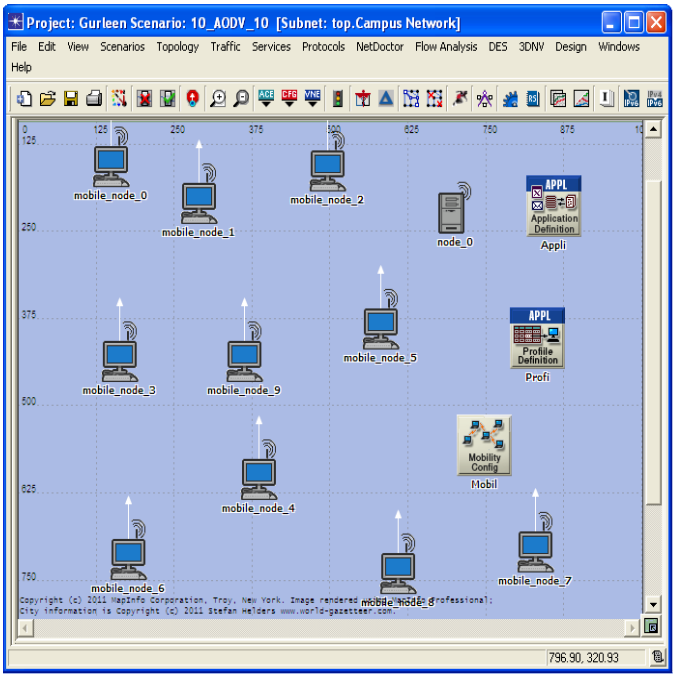

Fig. 1 MANET Scenario with 10 nodes

All scenarios have been modeled and evaluated using OPNET 14.5. Fig. 1 shows a sample network created with 10 nodes, one static FTP server, application configuration for the network in which FTP (File Transfer Protocol has been chosen) as an application. Fig. 1 depicts a network with 10 mobile nodes whose behavior has to be analyzed when nodes move in the network with respect to time to determine the effecting features of each protocol. In order to evaluate the performance of a generic scenario in ad-hoc networking, when analyzing mobile networks, modeling the movement of the set of nodes forming a MANET is essential. Random waypoint model of mobility has been studied. The Random Waypoint model has been selected to be used in all simulations presented in this document. Using Random Waypoint model, nodes go moving until they arrive at a random destination calculated by the algorithm. Once there, they get still for a period of time, called the pause interval. Once passed the pause interval, a new movement is calculated by the algorithm, with a random direction and speed.

VIII. Simulation Model

Main characteristics of the scenarios maintained are depicted in the Table I.

TABLE I
Main Characteristics of Scenario

Statistic	Value
Simulator	OPNET 14.5
Protocols Studied	AODV, DSR
Scenario Size	1000m x 1000m
Number of Nodes	10, 100
Node mobility (m/s)	10
Traffic Type	FTP
Node Movement Model	Random Waypoint Model
Transmit Power(W)	0.005
Simulation time	10 minutes

A. Traffic Modeling

Our simulation environment consist of 10 and 100 wireless nodes forming an ad-hoc network, moving in the proximity over about 1000m x 1000m flat space for about 10 minutes of simulated time.

B. Performance Metrics

The performance metrics selected to make the performance differences are:

1. Average end to end delay
2. Retransmission Attempts
3. Route Discovery Time
4. Number of Hops per Route

IX. Simulation Results and Analysis

The simulation results are shown in the following section and comparison between the two protocols are performed by varying numbers of nodes on the basis of the above mentioned metrics.

A. Average end to end delay

Fig. 2 and Fig. 3 show the overall delay in the network for 10 and 100 nodes. DSR experiences higher average delay compared to AODV. This is because DSR maintains a large cache (route information table) to store data transmission data. This results in higher delay in updating periodically with frequent changes occurring due to high mobility. In addition, the chance of using outdated or stale route information in forwarding packets is increased.

B. Retransmission Attempts

Fig. 4 shows the results of retransmission attempts for 10 nodes. DSR has the lowest value varying from 0.065 to 0.02

and AODV varies from 0.105 to 0.01. After 2 minutes of simulation, values of AODV start decreasing as compared to DSR.

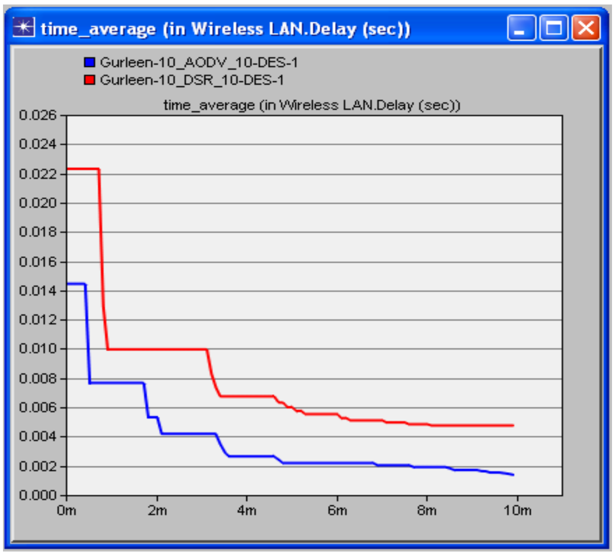

Fig. 2 Average End to end delay for 10 nodes

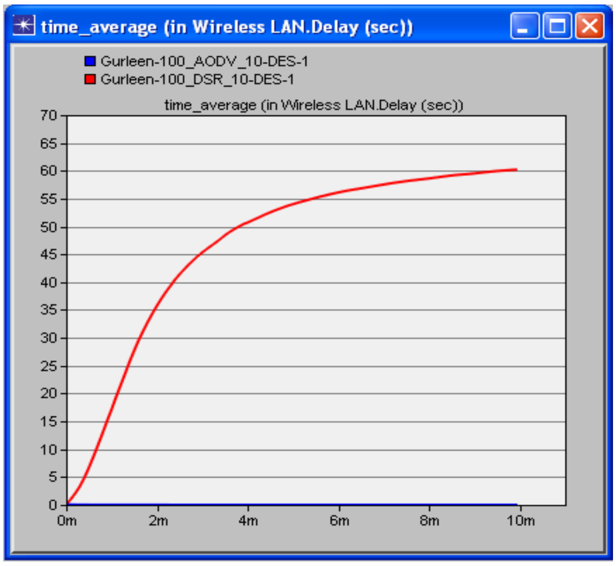

Fig. 3 Average End to end delay for 100 nodes

With the increase in number of nodes, there are significant changes as shown in Fig. 5. There is comparable increase in the values of both the protocols. However the graph of AODV is decreasing one and of DSR is vice versa. The value of AODV varies from 0.7 to 0.3 and becomes almost stable. But DSR graph shows an exponential increase with values varying from 1.0 to 1.5 and hence AODV is a better candidate.

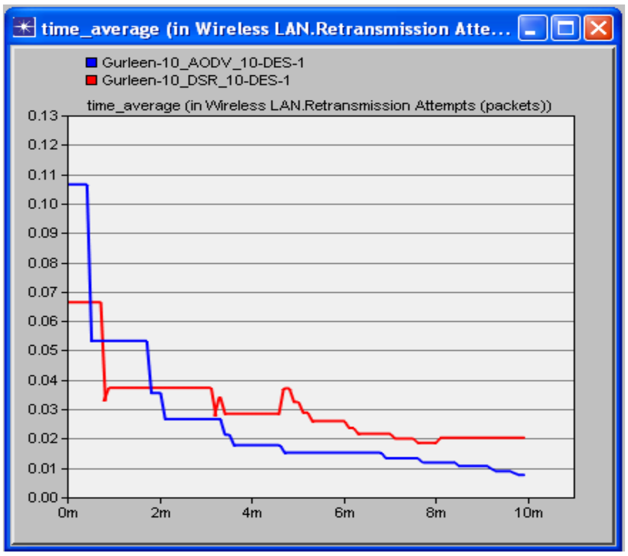

Fig. 4 Retransmission Attempts for 10 nodes

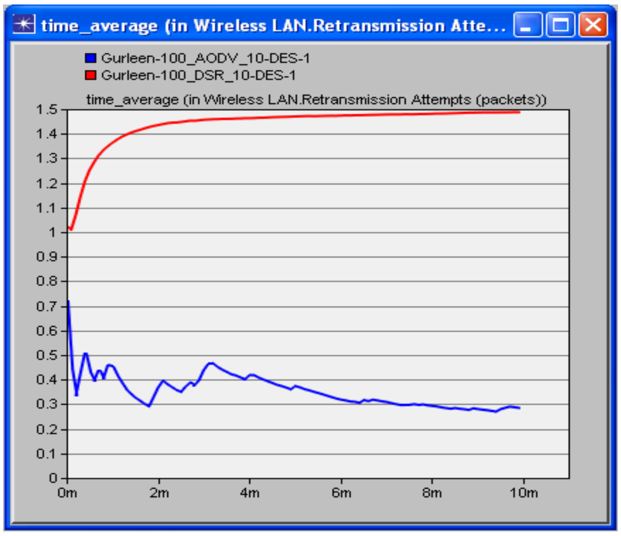

Fig. 5 Retransmission Attempts for 100 nodes

C. Route Discovery Time

Based on number of hops required and route discovery time between AODV and DSR, the following figures, Fig. 6, Fig. 7, Fig. 8 and Fig. 9, show that for any number of nodes, AODV performs better than DSR. For 100 nodes, route discovery time ranges from 1 second to 3.5 seconds for DSR throughout the simulation and that's why DSR needs more hops than AODV in every route. AODV has an excellent performance, taking less route discovery time and less number of hops per route.

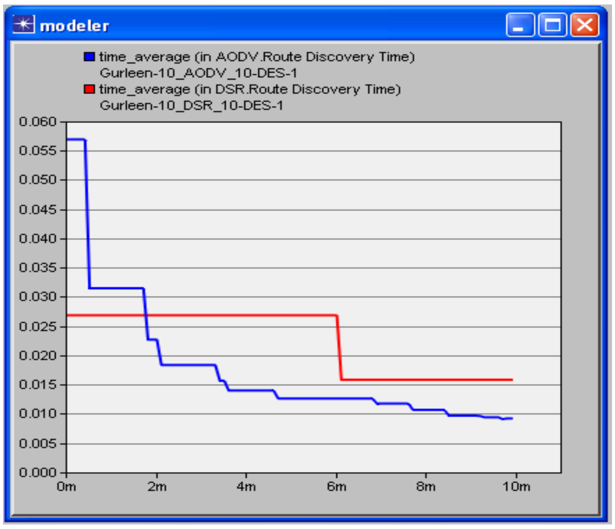

Fig. 6 Route Discovery Time for 10 nodes

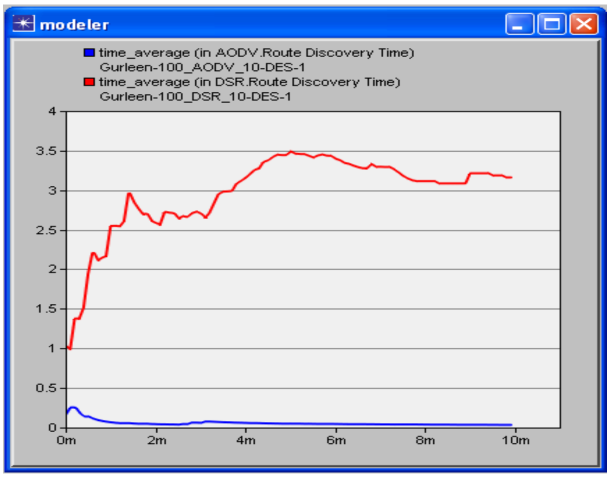

Fig. 7 Route Discovery Time for 100 nodes

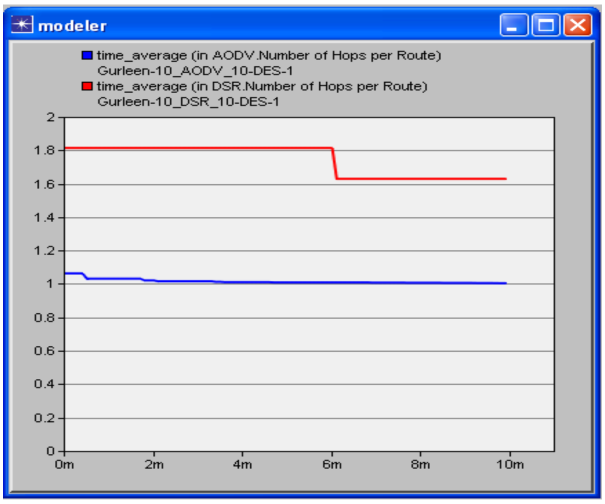

Fig. 8 Number of Hops for 10 nodes

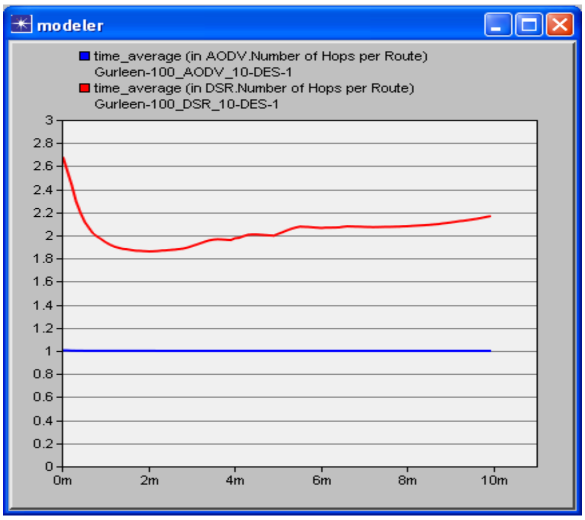

Fig. 9 Number of Hops for 100 nodes

X. CONCLUSIONS

The simulation study of our work consisted of two routing protocols AODV and DSR deployed over MANET using FTP traffic analyzing their behavior. In the paper, the performance difference is made between the two protocols for different number of nodes. In the paper, detailed analysis of the behavior of protocols based on some important metrics such as average end to end delay, retransmission attempts, route discovery time and number of hops per route is performed. Motive of doing this simulation was to check the performance of these two routing protocols in MANET in the above mentioned parameters using OPNET 14.5. The selection of efficient and reliable protocol is a critical issue.

The poor delay performance of DSR is mainly attributed to aggressive use of caching, and lack of any mechanism to expire stale route or to determine the freshness of routes when multiple choices are available.

In particular, DSR uses source routing and route caches and does not depend on any periodic or timer-based activities. DSR exploits caching aggressively and maintains multiple routes per destination. AODV, on the other hand, uses routing table, one route per destination, and destination sequence numbers, a mechanism to prevent loops and determine freshness of routes.

The general observation from the simulation is that AODV outperforms DSR in every respect.

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