Theoretical and Simulation Study of Wireless Ad-Hoc Network Routing Protocols and Their Performance Evaluation

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Abstract: In the recent years the number of vehicles on road increases at high speed. A lot of road accidents and traffic congestion emerges. So to control it vehicular ad-hoc network came in picture. In the last few years many protocols were proposed to route the packets efficiently and correctly. But no one was capable of routing the packets in case of cross links. So, a protocol named GEOCROSS was proposed. The introduction of MANETs, VANETs, their routing protocols, protocol structure of VANET, how broadcasting takes place in VANET, how information is disseminated in VANET and VANET communication & routing protocols like vehicular collision warning communication (VCWC), vehicle heading based routing protocol (VHRP) and GEOCROSS routing protocol will discussed in this paper.

Keywords: *MANET, VANET, routing protocols.*

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I. INTRODUCTION

MANET (Mobile Ad-hoc Network) is a temporary self organizing system formed by a collection of nodes, which are connected with wireless links. In the network, nodes may be disappeared or new nodes may be appeared over the time due to node mobility. In the recent years, many researchers are contributing to the improvement of the performance of routing protocols in MANET. IETF (The Internet Engineering Task Force) created a working group in 1996 to deal with the MANET research [1]. MANET working group (WG) proposed two classes of protocols, which include reactive and proactive protocols. The three protocols that are using in this research are reactive which generate route discovery schemes when needed and thus they need smaller route discovery overheads.

1.1. Objectives and Goals

The objective of this master thesis is to evaluate the performance of wireless Ad-hoc network routing protocols specially AODV, DSR and DSDV through a theoretical and simulation study. After completing the thesis, the achievements should be,

- General understanding of different ad-hoc networks
- Generate and analyze a simulation environment for different performance metrics.
- A strong theoretical background for MANET routing protocols.
- Drawing a conclusion for the best performance routing protocols using somespecific network scenarios.

Network Simulator NS-2.35 is used to simulate the performance of protocols. This simulator provides a graphical user interface to build models in an object oriented approach.

II. BASIC CONCEPTS

Ad-hoc networks are self-organized, wireless and decentralized systems that form temporary networks. Wireless technology is becoming the dominant one because of mobility, accessibility and flexibility in information dissemination. Cellular phones, wireless internet like Wi-Fi, satellite televisions etc. are well known applications of wireless technologies. It is a well growing area for research. The two main reasons of rapid growth of mobile computing are lower prices and higher data rates.

MANET (Mobile Ad-hoc Network) is an infra-structure less IP based network of mobile and wireless machine nodes connected with radio. In operation, the nodes of a MANET do not have a centralized administration mechanism. It is known for its routable network properties where each node act as a “router” to forward the traffic to other specified node in the network. MANET (Mobile Ad-hoc Network) is a temporary self-organizing system formed by a collection of nodes, which are connected with wireless links. In the network, nodes may be disappeared or new nodes may be appeared over the time due to node mobility.

2.1. Ad-hoc Networks

An Ad-hoc network is a collection of wireless mobile hosts forming a temporary network without the aid of any stand-

alone infrastructure or centralized administration. Mobile Ad-hoc networks are self-organizing and self-configuring multihop wireless networks where, the structure of the network changes dynamically [2]. This is mainly due to the mobility of the nodes. Nodes in these networks utilize the same random access wireless channel, cooperating in a friendly manner to engaging themselves in multihop forwarding. The node in the network not only acts as hosts but also as routers that route data to/from other nodes in network.

Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. Each must forward traffic unrelated to its own use, and therefore be a router. Routing i n ad-networks has been a challenging task ever since the wire- less networks came into existence. The major reason for this is the constant change in network topology because of high degree of node mobility. A number of protocols have been developed for accomplish this task.

Routing is the process of selecting paths in a network along which to send network traffic. In packet switching networks, routing directs packet forwarding, the transit of logically addressed packets from their source toward their ultimate destination through intermediate nodes. An ad-hoc routing protocol is a convention, or standard, that controls how nodes decide which way to route packets between computing devices in a mobile ad-hoc network. Wireless ad-hoc networks have gained a lot of importance in wireless communications. Wireless communication is established by nodes acting as routers and transferring packets from one to another in ad-hoc networks. Routing in these networks is highly complex due to moving nodes and hence many protocols have been developed. In this paper we have selected three main and highly proffered routing protocols for analysis of their performance. Figure1 below represents the scenario of MANET.

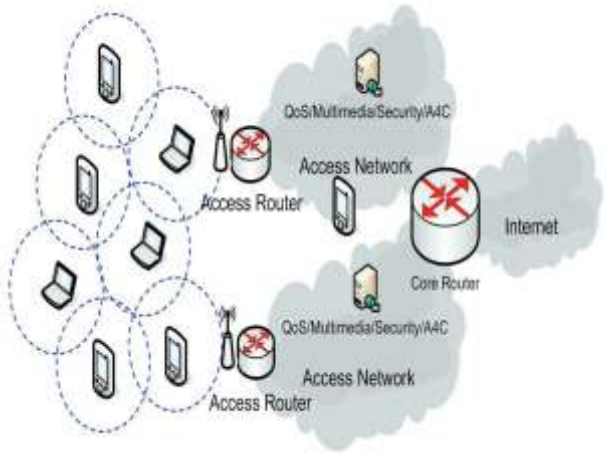

Figure 1: Ad-hoc network architecture [2]

III. ROUTING PROTOCOLS

3.1. Routing

Routing is the act of moving information from a source to a destination in an internet work. At least one intermediate node within the internet work is encountered during the transfer of information. Basically two activities are involved in this concept: determining optimal routing paths and transferring the packets through an internet work. The transferring of packets through an internet work is called as packet switching which is straight forward, and the path determination could be very complex.

Routing protocols use several metrics as a standard measurement to calculate the best path for routing the packets to its destination that could be number of hops, which are used by the routing algorithm to determine the optimal path for the packet to its destination. The process of path determination is that, routing algorithms find out and maintain routing tables, which contain the total route information for the packet.

The information of route varies from one routing algorithm to another. The routing tables are filled with entries in the routing table are ip-address prefix and the next hop. Destination/next hop associations of routing table tell the router that a particular destination can be reached optimally by sending the packet to a router representing the next hop on its way to the final destination and ip-address prefix specifies a set of destinations for which the routing entry is valid.

Routing is mainly classified into static routing and dynamic routing. Static routing refers to the routing strategy being stated manually or statically, in the router. Static routing maintains a routing table usually written by a networks administrator. The routing table doesn‘t depend on the state of the network status, i.e., whether the destination is active or not [6]. Dynamic routing refers to the routing strategy that is being learnt by an interior or exterior routing protocol. This routing primarily depends on the state of the network i.e., the routing table is affected by the activeness of the destination.

3.2. Routing in Mobile Ad-hoc Networks

Mobile Ad-hoc Networks are self-organizing and self-configuring multihop wireless networks, where the structure of the network changes dynamically. This is mainly due to the mobility of the nodes. [6] Nodes in these networks utilize the same random access wireless channel, cooperating in an intimate manner to engaging themselves in multihop forwarding. The node in the network not only acts as hosts but also as routers that route data to & from other nodes in network [7]. In mobile ad-hoc networks there is no infrastructure support as is the case with wireless networks, and since a destination node might be out of range of a source node transferring packets; so there is need of a

routing procedure. This is always ready to find a path so as to forward the packets appropriately between the source and the destination. Within a cell, a base station can reach all mobile nodes without routing via broadcast in common wireless networks. In the case of ad-hoc networks, each node must be able to forward data for other nodes. This creates additional problems along with the problems of dynamic topology which is unpredictable connectivity changes.

3.3. Classification of Routing Protocols

Classification of routing protocols in mobileAd-hoc network can be done in many ways, but most of these are done depending on routing strategy and network structure[9-10]. The routing protocols can be categorized as flat routing, hierarchical routing and geographic position assisted routing while depending on the network structure. According to the routing strategy routing protocols can be classified as Table-driven and source initiated. The classification of routing protocols is shown in the Figure 2.

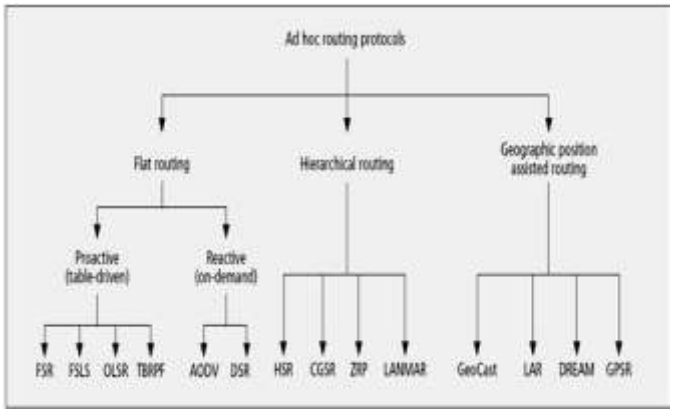

Figure 3.1: Classification of Routing Protocols in Mobile Ad-hoc Networks [2]

3.3.1. Pro-Active / Table Driven routing Protocols

Proactive MANET protocols are also called as table-driven protocols and will actively determine the layout of the network. Through a regular exchange of network topology packets between the nodes of the network, at every single node an absolute picture of the network is maintained. There is hence minimal delay in determining the route to be taken. This is especially important for time-critical traffic.

When the routing information becomes worthless quickly, there are many short-lived routes that are being determined and not used before they turn invalid. Therefore, another drawback resulting from the increased mobility is the amount of traffic overhead generated when evaluating these unnecessary routes. This is especially altered when the network size increases. The portion of the total control traffic that consists of actual practical data is further decreased. Lastly, if the nodes transmit infrequently, most of the routing information is considered redundant.

The nodes, however, continue to expend energy by continually updating these unused entries in their routing tables as mentioned, energy conservation is very important in a MANET system design. Therefore, this excessive expenditure of energy is not desired. Thus, proactive MANET protocols work best in networks that have low node mobility or where the nodes transmit data frequently. Examples of Proactive MANET Protocols include:

- Optimized Link State Routing (OLSR)
- Fish-eye State Routing (FSR)
- Destination-Sequenced Distance Vector (DSDV)
- Cluster-head Gateway Switch Routing Protocol (CGSR)

3.3.2. Comparison of Proactive and Reactive routing protocols

The following Table 1 briefly compares the Proactive (Table –Driven) routing protocol with Reactive (On-Demand) routing protocols.

Table 1: Comparison of Proactive and Reactive routing protocols

Proactive Protocols	Reactive protocols
Attempt to maintain consistent, up-to-date routing information from each node to every other node in the network.	A route is built only when required.
Constant propagation of routing information periodically even when topology change does not occur.	No periodic updates. Control information is not propagated unless there is a change in the topology
Incurs substantial traffic and power consumption, which is generally scarce in mobile computers	Does not incur substantial traffic and power consumption compared to Table Driven routing protocols
First packet latency is less when compared with on-demand protocols	First-packet latency is more when compared with table-driven protocols because a route need to be build
A route to every other node in ad-hoc network is always available	Not available

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IV. RESULTS AND DISCUSSIONS

4.1. Simulation

As already outlined we have taken three On-demand (Reactive) routing protocols, namely AODV, DSDV and DSR. The mobility model used is Random waypoint mobility model because it models the random movement of the mobile nodes.

4.2. AODV

In this scenario some parameters with a specific value are considered. Those are as shown in table 2.

Table 2: Scenario 1 for implementation of AODV

Parameter	Value
Number of Nodes	15,30,45, 60,75,90,
Simulation Time	200 sec
Pause Time	10
Environment Size	1000 x1000
Traffic Type	CBR
Packet Size	512 Bytes
Packet Rate	4 packets/sec
Maximum Speed	20 m/s
Simulator	NS-2.35
Antenna Type	Omnidirectional

4.3. DSDV

In this scenario some parameters with a specific value are considered. Those are as shown in table 3.

Table 3: Scenario 2 for implementation of DSDV

Parameters	Value
Number of Nodes	15,30,45,60,75,90
Simulation Time	200 sec
Pause Time	10
Environment Size	1000x1000
Traffic Type	CBR
Packet Size	512 bytes
Packet Rate	4 packets/s
Simulator	NS-2.35
Antenna Type	Omnidirectional

4.4. DSR

In this scenario some parameters with a specific value are considered. Those are as shown in table 4.

Table 4: Scenario 3 for implementation of DSR

Parameters	Value
Simulation Time	200 sec
No. of Nodes	15,30,45,60,75,90
Pause Time	10
Environment Size	1000x1000
Traffic Size	CBR
Packet Size	512 bytes
Packet Rate	4 packets/s
Maximum Speed	20 m/s
Simulator	NS-2.35
Antenna Type	Omnidirectional

4.5. Comparison of Performance Metrics

The comparison of various performance metrics for AOD, DSR and DSDV can be shown as below.

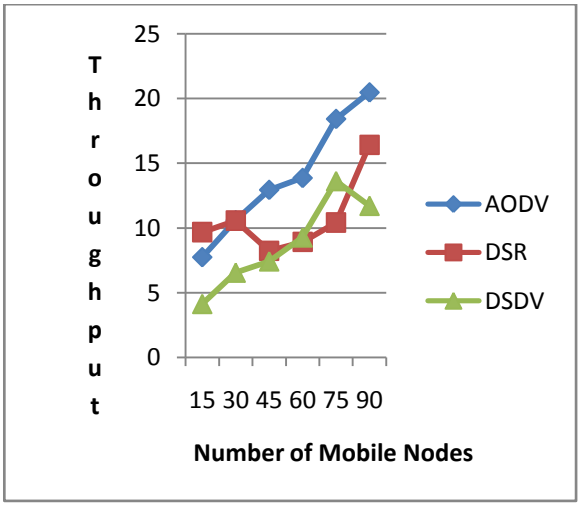

Figure 3: Network Throughput vs No. of Mobile Nodes for AODV, DSR and DSDV

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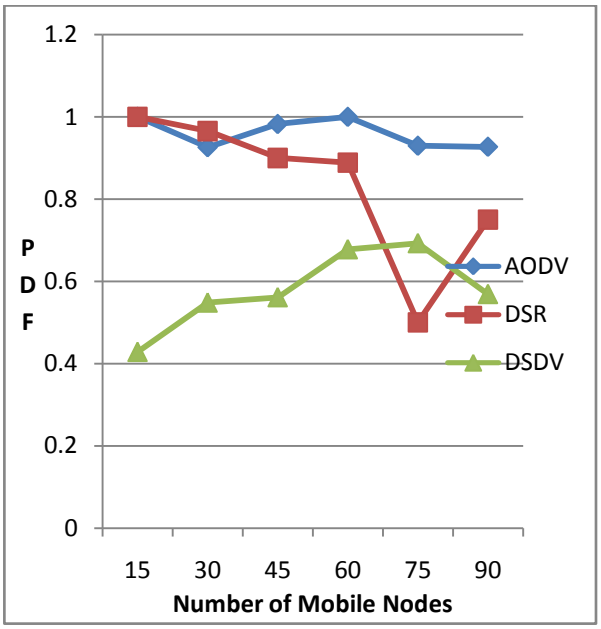

Figure 4: PDF versus No. of Mobile Nodes for AODV, DSR and DSDV

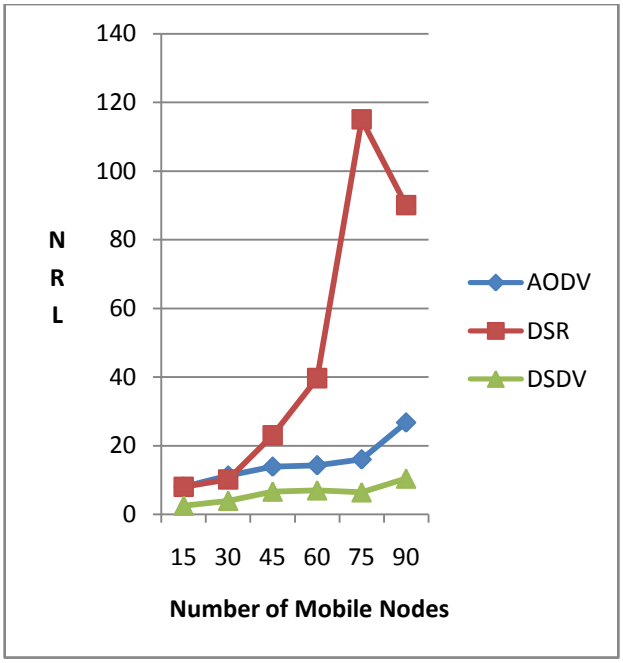

Figure 5: Normalized Routing Load vs No. of Mobile Nodes forAODV, DSR and DSDV

V. CONCLUSION

In the present research work three routing protocols, namely, Ad-hoc On-Demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR) and Destination –Sequenced Distance Vector Routing (DSDV) has been simulated and compared for different number of nodes. The simulation of these protocols has been carried out using NS-2 simulator. Different simulation scenarios are generated and the analysis of ad-hoc routing protocol is done in the mentioned traffic pattern on different number of nodes. Other network parameters are kept constant during the simulation.

The network throughput and normalized routing load of AODV increases as the number of nodes increase. AODV has very good packet receiving ratio as per simulation results. It is observed that the packet loss is very less in case of AODV as compared to DSR and DSDV.

The network throughput of DSR is less initially but it increases with the increased number of nodes whereas the packet delivery rate decreased substantially. The normalized routing load is also found increased with the increasing nodes. DSR has good packet receiving ratio and network throughput as compared to that of DSDV. Here, the normalized routing load is also found very high.The analysis of DSDV results in less network throughput and packet delivery rate as compared to AODV and DSR. The three protocols AODV, DSR and DSDV have been compared using simulation, it would be interesting to note that the behavior of these protocols on a real life test is bed.In this work other network parameters such as pause time, traffic type-CBR, simulation area etc. are kept constant. It would be interesting to observe the behavior of these three protocols by varying these network parameters.

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