Abstract—Mobile Ad hoc NETwork (MANET) is formed by a group of autonomous mobile nodes connected by wireless links, in which there is no backbone infrastructure. Routing in Mobile Ad-hoc Network has been a subject of extensive research over the past several years. Out of the various research issues, this work focuses on performance of routing protocols, which is an important design issue in mobile ad hoc networks. The Efficient routing protocols can provide significant benefits to mobile ad hoc networks, in terms of both performance and reliability. Many routing protocols with competing features have been developed for wireless ad hoc networks. Amongst the most popular ones are Ad hoc on-demand Distance Vector (AODV), Destination-Sequenced Distance-Vector Routing protocol (DSDV), Dynamic Source Routing Protocol (DSR), and Optimum Link State Routing (OLSR). The work in this paper focuses on observations regarding the performance comparison of the DSR, DSDV and AODV protocols for Constant Bit Rate (CBR) in mobile ad hoc networks (MANETs) by performing extensive simulations using NS-2 simulator.

Keywords—Cloud Computing; Mobile Ad-hoc Networks; Mobile Nodes; Multilingual; Routing Protocols.

Abbreviations—Ad hoc On-demand Distance Vector (AODV); Destination-Sequenced Distance-Vector (DSDV); Dynamic Source Routing (DSR); Mobile Ad hoc NETwork (MANET); Optimum Link State Routing (OLSR).

I. INTRODUCTION

Technological innovations of engineers have drastically changed the day-to-day lifestyle of people. The prominent among these is the telecommunications networking, the most complex and that owns the largest market size, has enabled us to change our lifestyle by entering into the era of information technology. During the last several decades, the world has seen phenomenal changes in the telecommunication industry. Wireless communications between mobile users is becoming more popular than ever before. This is due to technological advances in laptop computers and wireless communication devices, such as wireless modems and wireless LANs. This has led to lower prices and higher data rates. Wireless networks are becoming popular because of their “3 Anys”—any person, any where, any time [Xukai Zou et al., 2002]. People can get on-line, be reached, and interact anywhere and anytime.

II. MOBILE AD-HOC NETWORK

A Mobile Ad hoc NETwork (MANET) is formed by a group of autonomous mobile nodes connected by wireless links, in which there is no backbone infrastructure. The system may operate in isolation or may have gateways to interface with a fixed network. Ad hoc networks have no fixed routers. All nodes are capable of movement and can be connected dynamically in an arbitrary manner.

Usually, these nodes act as both end systems and routers at the same time. Nodes of these networks, which function as routers, discover and maintain routes to other nodes in the network. The topology of the ad hoc network depends on the transmission power of the nodes and the location of the MNs, which may change with time. The nodes (a router with multiple hosts and wireless communications devices) are free to move about and organize themselves randomly. These nodes may be located in or on airplanes, ships, trucks, cars, or on very small devices, and there may be multiple hosts per router. As a result, the network wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion.
III. ROUTING

Routing in Mobile Ad-hoc Network has been a subject of extensive research over the past several years. Because of the fact that it may be necessary to pass several hops (multi-hop) before a packet reaches the destination, a routing protocol is needed. Routing protocol has two functions:
1. Selection of routes for various source-destination pairs
2. Delivery of messages to their correct destination

The second function is conceptually straightforward using a variety of protocols and data structures (routing tables). Mobile ad-hoc networks, also known as short-lived networks, are autonomous systems of mobile nodes forming network in the absence of any centralized support. This is a new form of network and might be able to provide services at places where it is not possible otherwise. Absence of fixed infrastructure poses several types of challenges for this type of networking [Gavrilovska & Atanasovski, 2005]. One of these challenges is routing.

IV. CLASSIFICATION OF ROUTING PROTOCOLS

Ad-hoc routing protocols can be classified based on different criteria. The different classes of protocols are not mutually exclusive. Depending upon the routing mechanism employed by a given protocol, it may fall under more than one class. Routing protocols for Ad-hoc networking can be classified into four categories viz. (i) Based on routing information update routing mechanism (proactive or table-driven, reactive or on-demand and hybrid protocols), (ii) Based on the use of Temporal information (Past Temporal and Future Temporal) for routing, (iii) Based on routing topology (Flat Topology, Hierarchical Topology), (iv) Based on the Utilization of Specific Resources (Power Aware Routing and Geographical Information Assisted Routing) [Murthy & Manoj, 2007]. Following figure shows the classification of the routing protocols:

4.1. Dynamic Source Routing Protocol (DSR)

The Dynamic Source Routing (DSR) protocol is an on-demand routing protocol based on source routing [Broch et al., 1999; Perkins et al., 2001; Johnson et al., 2001; Royer & Toh, 2001]. DSR protocol is composed by two “on-demand” mechanisms, which are requested only when two nodes want to communicate with each other. Route Discovery and Route Maintenance are built to behave according to changes in the routes in use, adjusting themselves when needed. Along with those mechanisms, DSR allows multiple routes to any destination, thus can lead easily to load balancing or increase robustness.

4.2. Adhoc On-Demand Distance Vector (AODV)

AODV is a purely reactive routing protocol [Perkins & Royer, 1999; Perkins, 2000; Perkins et al., 2001; Royer & Toh, 2001; Du et al., 2003]. In this protocol, each terminal does not need to keep a view of the whole network or a route to every other terminal. Nor does it need to periodically exchange route information with the neighbor terminals. Furthermore, only when a mobile terminal has packets to send to a destination does it need to discover and maintain a route to that destination terminal. In AODV, each terminal contains a route table for a destination. A route table stores the following information: destination address and its sequence number, active neighbors for the route, hop count to the destination, and expiration time for the table. The expiration time is updated each time the route is used. If this route has not been used for a specified period of time, it is discarded.
4.3. Destination-Sequence Distance-Vector Routing (DSDV)

The Destination Sequenced Distance Vector Protocol (DSDV) is a proactive, distance vector protocol which uses the Bellman-Ford algorithm [Perkins & Bhagwat, 1994; Royer & Toh, 2001]. The design goals of DSDV were to keep the simplicity of the distributed Bellman-Ford and to avoid the looping problem in routing tables using the concept of sequence number. DSDV is a hop-by-hop distance vector routing protocol, wherein each node maintains a routing table listing the “next hop” and “number of hops” for each reachable destination. This protocol requires each mobile station to advertise, to each of its current neighbors, its own routing table (for instance, by broadcasting its entries).

V. METHODOLOGY

5.1. Simulation Environment

The simulator is used to simulate the ad hoc network routing protocols is the network simulator 2 (ns-2,2.29 version) from Berkeley. The trace file generated is in new format. Nodes in the simulation move according to “random way mobility model”. The movement scenario files used in simulation are characterized by change in pause time, speed and no. of nodes. To be able to make comparisons of routing protocols, the traffic source chosen is a Constant Bit Rate (CBR) source.

5.2. NS2

NS-2 (Network Simulator), a VINT (Virtual Inter-Network Testbed) project from U.C. Berkeley/LBL/Xerox PARC, is a discrete event simulator targeted at network research, which provides substantial support for simulation of TCP, routing and multicast protocols [Breslau et al., 2000; Fall & Varadhan, 2003; Floyd, 2010; Wikipedia]. The simulator is using a Tcl/Otcl (Tool Command Language/Object Oriented Tcl) as a command and configuration interface. There are four types of files related to NS-2 simulator. Model is described in files .tcl or .ns which have common subset of commands but not exactly compatible between each other’s. While simulator runs a model defined in .tcl/.ns file, simulation trace file (.tr) and animation file (.nam) are created during the session. Network Animator (.nam) files are used to visualize the behaviour of the network protocols and traffic of the model. Once created, users can play with the .nam file just like a media player and check the behaviour repeatedly. NS-2 facilitates the three broad themes of network research simulations:

1. Selecting a mechanism from several options
2. Exploring complex behaviour
3. Investigating unforeseen multiple-protocol interaction

It supports: TCP family, UDP, CBR, FTP, HTTP, Pareto, Exponential protocols, wires, wireless, unicast, multicast. Languages: both C++ and OTcl languages. Outputs: dynamic output. An overview on how simulation is to be done is shown in figure below.

VI. PERFORMANCE METRICS

Mobile ad hoc networks have several inherent characteristics. Design and performance analysis of routing protocols used for MANET is currently an active area of research. To judge the merit of a routing protocol, one needs metrics—both qualitative and quantitative—with which to measure its suitability and performance. These metrics should be independent of any given routing protocol. Specifically, this paper evaluates the performance comparison of AODV, DSR and DSDV routing protocols on the following performance metrics: Average routing overhead, Normalized routing load, Packet delivery ratio and end-to-end delay.

6.1. Average Routing Overhead

Average routing overhead is the total number of routing packets divided by total number of delivered data packets. This metric provides an indication of the extra bandwidth consumed by overhead to deliver data traffic. It is crucial as the size of routing packets may vary. The routing overhead describes how many routing packets for route discovery and route maintenance need to be sent in order to propagate the CBR packets. It is an important measure for the scalability of a protocol. It for instance determines, if a protocol will function in congested or low-bandwidth situations, or how much node battery power it consumes. If a protocol requires sending many routing packets, it will most likely cause congestion, collision and data delay in larger networks.

6.2. Packet Delivery Ratio

Packet delivery ratio is calculated by dividing the number of packets received by the destination through the number of packets originated by the application layer of the source (i.e. Constant Bit Rate (CBR)). It specifies the packet loss rate, which limits the maximum throughput of the network. The better the delivery ratio, the more complete and correct is the routing protocol.
6.3. Average End-to-End Delay

Average End-to-End delay (seconds) is the average time it takes a data packet to reach the destination. This metric is calculated by subtracting “time at which first packet was transmitted by source” from “time at which first data packet arrived to destination”. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times. This metric is significant in understanding the delay introduced by path discovery.

6.4. Normalized Routing Load

The number of routing packets transmitted per data packet delivered at the destination. Each hop-wise transmission of a routing packet is counted as one transmission.

VII. SIMULATION

In this paper, there I have taken three different scenarios. In the first scenario four different pause times have been taken i.e. 0, 5, 10 and 15 seconds. In the second scenario speed has been varied i.e. 10, 20, 30 and 40 m/s and last but not the least, in third scenario, no. of nodes have been varied and performance comparisons has been made between AODV, DSR and DSDV protocols. Identical mobility and traffic scenarios are used across protocols to gather fair results.

7.1. Test Scenario

There have chosen the simulation of 100 nodes in 1000X1000 square meter area. In the case of random waypoint model, a mobile node is assigned a destination. The mobile node then moves to the destination at given speed. Once the destination is reached, the mobile node stops for a given pause time. The mobile node then chooses another random destination for mobile node’s next movement. There have used CBR sources that started at different times because to get a general view of how routing protocol behaves, rather than TCP sources which use flow control and retransmission feature. The communication pattern is randomly created by the setdest tool defined in ns2 simulator. This tool contains the following arguments to generate a traffic movement file.

1. Number of nodes
2. Pause Time
3. Maximum Speed
4. Simulation Time
5. Maximum X co-ordinate value
6. Maximum Y co-ordinate value
7. Path of Output file in which movement pattern is created.

In the same way traffic pattern i.e. CBR or TCP is created. Cbrgen.tcl script is used to create CBR connections respectively. To create CBR connections following arguments are taken:

1. Number of nodes
2. Seed value
3. Number of connections
4. Rate at which the packets are to be transferred.

The parameters that are specified when randomizing the communication pattern are the traffic sources, packet size, the rate at which they are sending information and simulation time. Parameters of this scenario are summarized in below table. In this, only pause time is uniformly varied and rest of the parameters has been kept constant. A pause time of 0 seconds correspond to continuous motion i.e. nodes are always in mobility and pause time of 20 corresponds to no motion.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of nodes</td>
<td>100</td>
</tr>
<tr>
<td>Maximum Speed</td>
<td>20 m/s</td>
</tr>
<tr>
<td>Simulation time</td>
<td>200 sec</td>
</tr>
<tr>
<td>Pause Time</td>
<td>0,5,10, 15 sec</td>
</tr>
<tr>
<td>Environment Size</td>
<td>1000x1000</td>
</tr>
<tr>
<td>Packet Size</td>
<td>512 bytes</td>
</tr>
<tr>
<td>Traffic Type</td>
<td>Constant Bit Rate</td>
</tr>
<tr>
<td>Packet Rate</td>
<td>2 packet/sec (1 kbps)</td>
</tr>
</tbody>
</table>

VIII. PERFORMANCE ANALYSIS

8.1. Impact on Packet Delivery Ratio

Based on the scenarios mentioned above, different “Scene files” as well as “Traffic files” were generated and comparisons were made. The performance graphs figure 4, 5 and 6 illustrates the Packet delivery ratio for AODV, DSR and DSDV protocols.
Figure 6: Packet Delivery Ratio with Varying # of Nodes

It can be seen that the AODV has Packet delivery ratio independent of change in pause time or # of nodes. However, it declines a bit for higher speed. It is the highest and most stable among all 3 protocols. AODV achieves a packet delivery ratio between 85 to 100% for all 3 test scenarios. DSDV also has a stable packet delivery ratio for change in pause time and # of nodes but it is the lowest among all three protocols. It declines for higher speed. DSDV achieves a packet delivery ratio between 40 to 76%. Change in # of nodes has no effect on DSR’s Packet Delivery ratio. But for change in pause time and speed it declines rapidly but later gets stable. DSR also achieves a packet delivery ratio between 85 to 100% for change in no. of nodes. When change in pause time and speed is applied, packet delivery ratio falls between 45 to 80%.

8.2. Impact on Average Routing Overhead

Figure 7, 8 and 9 illustrates the performance graphs for average routing overhead required by all three protocols when subjected to varying scenarios. This metric gives an idea of the extra bandwidth that is required to deliver the data packets.

It can be seen that the DSR exhibits the highest average routing overhead because of its route cache property. It generates the highest no. of routing packets but its loss of packets is also more. DSR’s routing load increases in all 3 test scenarios. However, it decreases rapidly for higher speed. AODV’s routing overhead gradually increases in case change in speed or no. of nodes is applied. However, it starts declining as pause time is increased. DSDV is independent of change in pause time, speed and no. of nodes. Routing overhead is lowest and constant in all 3 test cases because of its table-driven nature. However, it gradually increases a bit for change in # of nodes.

8.3. Impact on End-to-End Delay

Figure 10, 11 and 12 describes the average end-to-end delay of DSR, AODV and DSDV protocols. Average end-to-end delay is the average time it takes a data packet to reach from source to destination. As route failure occurs, it takes longer for a data packet to reach its desired destination resulting in higher end-to-end delay.
Performance graphs illustrate that the End-to-end delay in AODV is not affected by change in pause time or speed. It is affected when # of nodes is changed; however, it gets stable as the no. of nodes is increased. Its performance is at par with DSDV. DSDV performs better than DSR and AODV as far as average end-to-end delay is concerned. End-to-end delay in DSDV is independent of any change in pause time, speed or # of nodes. It is lowest and most stable in all 3 test scenarios. DSR is the most affected. Its end-to-end delay is highest.

8.4. Impact on Normalized Routing Load
Figure 13, 14 and 15 illustrates the performance graphs for normalized routing load for all 3 protocols for the varying scenarios. Normalized routing load is the number of routing packets transmitted per data packet delivered at the destination. Each hop-wise transmission of a routing packet is counted as one transmission.

From the performance graphs it is evident that the Routing load in AODV is affected the most when change in nodes is applied. For change in pause time and speed, it is lower. DSDV has the lowest and stable Normalized Routing Load for change in pause time and speed due to its table-driven nature. However, it gradually increases for change in # of nodes. DSR’s routing load increases in all 3 test scenarios due to its route cache property. However, it decreases rapidly for higher speed.

IX. RESULTS

Table 2: Average Routing Overhead when Varying Pause Time

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Pause Time</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>AODV</td>
<td></td>
<td>29344</td>
<td>41371</td>
<td>44283</td>
<td>32839</td>
</tr>
<tr>
<td>DSR</td>
<td></td>
<td>23225</td>
<td>39031</td>
<td>65717</td>
<td>65472</td>
</tr>
<tr>
<td>DSDV</td>
<td></td>
<td>8153</td>
<td>8365</td>
<td>7902</td>
<td>8372</td>
</tr>
</tbody>
</table>

Table 3: Normalized Routing Load when Varying Pause Time

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Pause Time</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>AODV</td>
<td></td>
<td>5.914</td>
<td>8.685</td>
<td>9.38398</td>
<td>6.6448</td>
</tr>
<tr>
<td>DSR</td>
<td></td>
<td>5.128</td>
<td>11.54</td>
<td>29.1557</td>
<td>26.346</td>
</tr>
<tr>
<td>DSDV</td>
<td></td>
<td>2.89</td>
<td>3.225</td>
<td>3.1519</td>
<td>3.26393</td>
</tr>
</tbody>
</table>

Table 4: Packet Delivery Ratio when Varying Pause Time

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Pause Time</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>AODV</td>
<td></td>
<td>94.7298</td>
<td>90.8796</td>
<td>90.73255</td>
<td>94.58373</td>
</tr>
<tr>
<td>DSR</td>
<td></td>
<td>86.3489</td>
<td>64.68338</td>
<td>42.949696</td>
<td>47.63274</td>
</tr>
<tr>
<td>DSDV</td>
<td></td>
<td>53.7256</td>
<td>49.46855</td>
<td>47.98086</td>
<td>48.79209</td>
</tr>
</tbody>
</table>

Table 5: Average End-to-End Delay when Varying Pause Time

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Pause Time</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>AODV</td>
<td></td>
<td>0.06201</td>
<td>0.1497527</td>
<td>0.1528593</td>
<td>0.09282</td>
</tr>
<tr>
<td>DSR</td>
<td></td>
<td>0.66499</td>
<td>2.068005</td>
<td>2.4321835</td>
<td>3.83079</td>
</tr>
<tr>
<td>DSDV</td>
<td></td>
<td>0.15162</td>
<td>0.1381267</td>
<td>0.2180186</td>
<td>0.29878</td>
</tr>
</tbody>
</table>

X. CONCLUSIONS AND FUTURE SCOPE

This study was conducted to evaluate the performance three MANET protocols i.e. DSR, AODV and DSDV. These routing protocols were compared in terms of Packet delivery ratio, Average routing overhead, Average end-to-end delay
and Normalized routing load when subjected to change in pause time, speed and varying no. of nodes. Simulation results show that AODV performs better in terms of packet delivery ratio. DSR has the 2nd highest packet delivery ratio among the 3 protocols. DSDV performs the poorest in terms of packet delivery ratio. In terms of average routing overhead and normalized routing load, DSDV performs better than AODV and DSR. AODV follows DSDV closely for average routing overhead and normalized routing load. For average end-to-end delay metric, the performance of DSDV and AODV is quite similar to each other. DSR performs poorly for this metric. From the comparison and analysis, it can be concluded that the overall performance of AODV protocol is better among all three. DSR performs averagely for change in pause time, speed and # of nodes. DSDV performs worst for the variation of all test scenarios. Mobile Adhoc network is an upcoming area that is taking shapes slowly but steadily. During present work, impact of VBR traffic was also tried and studied for all three protocols using NS2 but it didn’t worked out as NS2 does not support VBR traffic. It was observed that VBR traffic can be studied using another simulator GloMoSim which supports this type of traffic.

REFERENCES


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