CHAPTER 3

EFFECTIVE ROUTING PROTOCOLS FOR MANET

Mobile Ad-hoc Network (MANET) is a collection of wireless mobile nodes. In MANET nodes are self-motivated topologies can arbitrarily change their geographic locations. MANET consists of wireless links with considerable bandwidth. These MANETs routing protocols are categorized into Proactive Routing Protocols (PRP), Reactive Routing Protocols (RRP) and Hybrid Routing Protocols (HRP).

3.1 INTRODUCTION

Mobile Ad-hoc Network (MANET) is a group of nodes that are in nature of changing their location frequently. Such kind of nodes is arranged to form a network. Each of the devices used by information producers and consumers can be considered a node in mobile Ad-hoc network. In a typical MANET, mobile nodes come together for a period of time to exchange information. While exchanging information, the nodes may continue to move, and so the network must be prepared to adapt continually. In the applications we are interested in, networking infrastructure such as repeaters or base stations will frequently be either undesirable or not directly reachable, so the nodes must be prepared to organize themselves into a network and establish routes among themselves without any outside support. The mobile nodes in the network dynamically establish routing among themselves to form their own network “on the fly.” In the simplest scenarios, nodes may be able to communicate directly with each other, for example, when they are within
wireless transmission range of each other. However, ad hoc networks must also support communication between nodes that are only indirectly connected by a series of wireless hops through other nodes. The presence of wireless communication and mobility make an ad hoc network unlike a traditional wired network and requires that the routing protocols used in an ad hoc network be based on new and different principles. Routing protocols for traditional wired networks are designed to support tremendous numbers of nodes, but they assume that the relative position of the nodes will generally remain unchanged.

In a mobile ad hoc network, however, there may be fewer nodes among which to route, but the network topology changes can be drastic and frequent as the individual mobile nodes move. Efficient routing in an ad hoc network requires that the routing protocol operates in an on-demand fashion, and requires that the routing protocol limits the number of nodes that must be informed of topology changes. Ad hoc networks running such a protocol can be designed and implemented, and they perform well enough to support useful applications. Table-driven routing protocols provide fast response to topology changes by continuously monitoring the link network changes with the help of updating the table frequently. However, the price paid for this rapid response to topology changes is the increase in signaling overhead, and this can lead to smaller packet delivery ratios and longer delays when topology changes increase. On-demand routing protocols operate on a need to have a basis, and can, in principle, reduce the signaling overhead. However, the long setup time in route discovery and slow response to route changes can offset the benefits derived from on-demand signaling and lead to inferior performance.

Given that proactive and reactive routing schemes for MANETs have relative advantages and disadvantages, comparing the two are important.
The both table driven and on-demand protocols exhibit advantageous and inferior performance to the other one depending on different network configurations, particularly with respect to different node mobility, node density, and traffic load. Significant work (Elizabeth et al. 1999, Tanenbaum 2000 & Hubaux et al. 2001) has been conducted to evaluate and compare these protocols under network profiles of various mobility and traffic configurations. Such performance comparisons have been mostly conducted via discrete-event simulations. Simulation-based studies of routing schemes are a powerful tool to gain insight on their performance for specific choices of network parameters. It is important to note that this work captures the essential behavior and scalability limits in the network size of both protocols by quantifying their performance. The simulation results are not intended to provide an exact match with our analysis; they are provided only as a supporting evidence for the conclusions regarding protocol behaviors observed in the literature. With the aid of simulations, we show that the analytic results agree with the simulation findings.

The chapter is organized as follows; section 3.2 presents related work in the modeling of routing protocols. Section 3.3 presents Ad-hoc routing protocols, implementation of AABR in section 3.4, performance evaluation in 3.5. Section 3.6 presents experimental study and discussion. Finally we present the conclusion of this chapter in section 3.7.

3.2 RELATED WORKS

A routing protocol is required to establish routes between participating nodes for enabling the communication. In MANET the following metrics are essential that are multiple network hops, limited transmission range may be needed to provide data communication between two nodes in the network. Since MANET has the node which can operate without base stations not only as a host but also as a router, forwarding
packets for other mobile nodes in the network (Das et al. 2001 and Lee et al. 1999). Conventional routing protocols based on distance vector or link state algorithms cannot be applied here since the amount of routing related traffic would waste a large portion of the wireless bandwidth, and such discovered routes would soon become obsolete due to the mobility of nodes (Viennot et al. 2004). There are frequent unpredictable topological changes in these networks, which makes the task of finding and maintaining routes as difficult. Meanwhile, many previous studies concentrate on the statistical analysis of link availability in ad hoc networks (Tsirigos & Haas 2004). Based on the experimental results obtained through simulation, it is shown that the link duration has a multi-model distribution when the node’s speed is slow, and the path duration can be approximated by an exponential distribution at moderate and high velocities. However, since the solutions provided by these studies are valid only for some specific circumstance, they could not be fully extended to universal ad hoc networks and practical MANETs applications. Link availability is considered as a fundamental parameter when evaluating mobility in MANETs. However, analytical studies for analyzing description of this variable have been limited. An analytical framework (Lebedev 2005) is created and analytic expressions characterizing the statistics for link lifetime, new link inter-arrival time, link breakage interarrival time and link change inter-arrival time were derived based on constant velocity model, which simply assumes that two mobile nodes move in a straight direction before the link breaks up. Obviously, this assumption is too idealistic. A prediction-based link availability estimation algorithm was developed and investigated with random walk mobility model. The algorithm tries to predict the probability that an active link between two nodes will be continuously available for a certain period Tp, which is obtained based on the current node’s movement.
The several routing protocols compared with their behaviors have been limited to simulation-based approaches (Perkins et al. 1999 and Jacquet et al. 2001) under various configurations. The performance evaluation metrics used in these simulations or experimental based approaches include time delay, throughput and packet delivery ratio. Network configurations vary on traffic pattern, mobility, and network density. The parametric models for proactive and reactive protocols to evaluate the individual routing control overhead. Certain analytical study on routing overhead has been carried out. Their work took mobility and topology changes into considerations. It is shown that an analytical tool for both proactive and reactive protocols then proposed a model to study the operation of classic reactive (AODV) and proactive (Optimized Link State Routing) protocols in the presence of faulty links. However, this work does not cover other aspects of network parameters on the performance of routing protocols.

3.3 AD-HOC ROUTING PROTOCOLS

This section gives a detailed explanation of the several types of present and familiar routing protocols.

3.3.1 Network Traffic Model

We consider a new traffic flow or simply a new session as one that is associated with the arrival of a new application-level session request at a node i with some destination j, j≠i, in the network. Traffic flows are randomly generated with uniformly distributed sources and destinations. Long-lived traffic flows are assumed in order to investigate protocol performance under the steady state of nodes mobility and traffic distributions. Short-lived traffic flows, reflecting transient behaviors, are beyond the scope of this chapter. Furthermore, well-connected networks are assumed, i.e., if an existing path
for any traffic session is broken, there is always an alternative path (with high probability) available to support continuing operations of the traffic flow.

3.3.2 Neighbor Node Sensing

Neighbor sensing protocols, such as periodic broadcasts of HELLO messages, are effective approaches used in routing protocols (both proactive and reactive) to detect the availability of links between neighbor nodes. New links are detected when HELLO messages are received from nodes not included in the neighbor list. Existing links are declared as failed if none of the HELLO messages from the neighbor node is received during a certain amount of time window.

3.3.3 Routing Protocols Model

The router determines the path between sender and receiver by its Internet Protocol (IP) address. In MANET, there is no static IP address due to the mobility nature of the nodes. Here we provide descriptions of proactive and reactive routing protocols, which incorporate the basic characteristics of many existing routing protocols. The generic protocols below do not consider any protocol specific techniques, such as local repairs, multi-point relay, and route caching mechanisms.

3.3.3.1 Proactive routing protocol

In proactive routing protocols, every node in a routing table maintains information about routes to every other node. These tables are updated periodically. This also named as table driven protocol. When a packet arrives, the node checks its routing table and forwards the packet accordingly. Every node monitors network links and every change has been updated in the table. The packets have been flooded over the entire network. Other nodes
update their routing tables accordingly upon receiving the update packet. In a well-connected network, the same topology broadcast packet could reach nodes multiple times and therefore enjoy a good packet reception probability. We assume that every node reliably receives topology packets from other nodes.

### 3.3.3.2 Reactive routing protocol

In reactive routing protocols, nodes maintain their routing tables on a needed basis. In this, the nodes do not maintain up-to-date routes for different destinations from the same source. When a node does not have knowledge about any route to a specific destination, it uses the flooding technique to identify the route. The process of path setup is called route discovery. Complementarily, another process called route maintenance is necessary to find an alternative path if a former path was broken. This was designed to reduce overheads in proactive protocols.

Route Discovery is a mechanism initiated by a node depends on the arrival of next packet in order to discover a new path to reach the destination. Source floods the whole network with route request (RREQ) packets. Upon receiving the RREQ packet, the destination sends out a route reply packet (RREP) along the reverse path to the source. As a result, sender node gets the shortest path to the destination.

Route Maintenance is a mechanism by which source is notified that a link along an active path has broken, such that it can no longer reach the destination through that route. Upon reception of a notification of route failure, the sender can initiate a route discovery again to find a new route for the remaining packets to the receiver. In reactive routing protocols, each node does not maintain routing tables before a routing task is triggered. They only find a route on demand by flooding the network with RREQs, i.e., before
sending data packets sender broadcasts router request and initiates a route discovery process. If a link breakage is detected during packet delivery, a new RREQ is generated.

### 3.3.4 Destination-Sequenced Distance-Vector

In DSDV, each mobile node of an Ad-hoc network maintains a routing table, which lists all available destinations, the metric and next hop to each destination and a sequence number generated by the destination node. Using such routing table stored in each mobile node, the packets are transmitted between the nodes of an ad hoc network. Each node of the ad hoc network updates the routing table with advertisement periodically or when significant new information is available to maintain the consistency of the routing table with the dynamically changing topology of the ad hoc network. Periodically or immediately when network topology changes are detected, each mobile node advertises routing information using broadcasting or multicasting a routing table update packet. The update packet starts out with a metric of one to direct connected nodes.

This indicates that each receiving neighbor is one metric (hop) away from the node. The update data is also kept for a while to wait for the arrival of the best route for each particular destination node in each node before updating its routing table and retransmitting the update packet. It is different from that of the conventional routing algorithms. After receiving the update packet, the neighbors update their routing table with incrementing the metric by one and retransmit the update packet to the corresponding neighbors of each of them. The process will be repeated until all the nodes in the ad hoc network have received a copy of the update packet with a corresponding metric. If the update packets have the same sequence number with the same node, the update packet with the smallest metric will be used and the existing route will be discarded or stored as a less preferable route. If
a node receives multiple update packets for the same destination during the waiting time period, the routes with more recent sequence numbers are always preferred as the basis for packet forwarding decisions, but the routing information is not necessarily advertised immediately, if only the sequence numbers have been changed. In this case, the update packet will be propagated with the sequence number to all mobile nodes in the ad hoc network. The advertisements of routes that are about to change may be delayed until the best routes have been found.

Delaying the advertisement of the possibly unstable route can dump the fluctuations of the routing table and reduce the number of rebroadcasts of possible route entries that arrive with the same sequence number. The elements in the routing table of each mobile node change dynamically to keep consistency with the dynamically changing topology of an ad hoc network. To reach this consistency, the routing information advertisement must be frequent or quick enough to ensure that each mobile node can almost always locate all the other mobile nodes in the dynamic ad hoc network. Upon the updated routing information, each node has to relay the data packet to other nodes upon request in the dynamically created ad hoc network.

### 3.3.5 Ad-hoc On-demand Distance Vector

The Ad-hoc On-demand Distance Vector (AODV) routing algorithm is a routing protocol designed for ad hoc mobile networks. AODV is capable of both unicast and multicast routing. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members.

The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers to ensure the
freshness of routes. It is loop-free, self-starting, and scales to large numbers of mobile nodes. The AODV protocol uses route request (RREQ) messages flooded through the network in order to discover the paths required by a source node. An intermediate node that receives RREQ replies to it using a route reply message only if it has a route to the destination whose corresponding destination sequence number is greater or equal to the one contained in the RREQ. The RREQ also contains the most recent sequence number for the destination of which the source node is aware.

A node receiving the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with the corresponding sequence number greater than or equal to that contained in the RREQ. If this is the case, it unicasts RREP back to the source. Otherwise, it rebroadcasts the RREQ. Nodes keep track of the RREQ’s source IP address and broadcast ID. If they receive RREQ which they have already processed, they discard the RREQ and do not forward it. As the RREP propagates back to the source nodes set up forward pointers to the destination. Once the source node receives the RREP, it may begin to forward data packets to the destination. If the source later receives RREP containing a greater sequence number or contains the same sequence number with a smaller hop count, it may update its routing information for that destination and begin using the better route.

As long as the route remains active, it will continue to be maintained. A route is considered active as long as there are data packets periodically traveling from the source to the destination along that path. Once the source stops sending data packets, the links will time out and eventually be deleted from the intermediate node routing tables. If a link break occurs while the route is active, the node upstream of the break propagates a route
error (RERR) message to the source node to inform it of the now unreachable
destination(s).

3.3.6 Basic Ant Routing

In Ant System (Shaar et al. 2006) positive feedback, distributed computation, and constructive greediness are the properties of highly dynamic nodes and asymmetric links in wireless networks, the basic ant routing did not perform well. We then developed three improved versions of ant routing based on the message initiated constraint-based routing framework (Scott & Bambos 1994).

3.3.7 Sensor-Driven and Cost-Aware Ant Routing

One of the problems of the basic ant-routing algorithm is that the forward ants normally take a long time to find the destination, i.e., no repeating nodes if possible. That happens because ants initially have no idea where the destination is. Only after one ant finds the destination and traverses back along the links will the link probabilities of those links change. That is not an unrealistic assumption for Ad-hoc networks since feature-based routing dominates address-based routing in that space. Some features, such as geographic location, have a natural potential field. If the destination does not have a clear hint, pre-building the feature potential is sometimes still efficient. Cost awareness generalizes the objective of shortest path length so that ants can apply other routing metrics as well, e.g., energy-aware routing.

3.3.8 Flooded Forward ant Routing

Flooded forward ant routing exploits the broadcast channel in wireless networks. When a forward ant starts at the source, it tells all its neighbors to look for the food, and neighbors tell neighbors and so on until
the destination is found. Ants then traverse backward to the source and leave pheromone trails on those links. To control the flooding, only those ants who are "closer" to the food will join the food searching process.

3.3.9 Flooded Piggybacked Ant Routing

Forward ants and ABR were combined for flooding the packet to route and to discover good paths at the same time. Single-path routing tends to have high loss rates, due to dynamic and asymmetric properties. But in Manet networks, Multi-path routing such as flooding is very robust and has high success rate.

3.3.10 Energy-Efficient Ant-Based Routing Algorithm

Whenever a WSN protocol is designed, it is important to consider the energy efficiency of the underlying algorithm, since this type of networks has strict power requirements. In this section, we describe a new energy-constrained protocol, the EEABR protocol, which is based on the Ant Colony Optimization heuristic and is focused on the main WSN constraints. On such networks deployed in the real environment, it is important to point out that sensor nodes may not have energy replenishment capabilities. This assumption forces the use of energy-efficient algorithms in order to maximize the network’s lifetime. In contrast, in timely delivery packet networks, a routing algorithm attempts to find the shortest path between two distinct devices (source and receiver), which can be easily done by choosing the path with fewer communication hops. In WSNs, such requirements are relegated to the second plane, since the quality of service and service awareness are not as important as in normal MANETs, where running protocols required low communication delays. The remainder of this section summarizes the idea behind EEABR. First, the basic ant-based routing algorithm is explained.
Next, an improvement on the basic algorithm is presented. Finally, the proposed EEABR algorithm is described.

### 3.3.11 Basic Ant Based Routing for WSN

It has been applied with success to many combinatorial optimization problems (Sugikawa et al. 1995). Its optimization procedure can be easily adapted to implement an ant-based routing algorithm for WSN. A basic implementation of the Ant Net algorithm can be informally described as follows.

i. In a network execution, the path for the generic node indicates the basic steps from the starting energy. The important elements and its links have been explained by the use of functional design. The network self-organization is composed of startup functions, route discovery, route maintenance, topology, network access, information about nodes, routine, command interchange, position determination, sub-network merging, traffic determination, routing, network TDMA scheduling, network time distribution and dynamic circuit establishment / disestablishment.

ii. Power-up node initialization. Upon power-up, a node will execute a number of initialization routines, such as internal node self-test and health status determination, and built-in calibration. It will also launch any procedures that have been preprogrammed to reflect specific mission requirements and expectations (e.g., begin sampling a particular sensor).

iii. Network discovery. The node then determines whether it can hear an already-operational microsensor network, by listening
for invitations to join and possibly “overhearing” other ongoing communications. Normal network operations will provide radio broadcasts of such invitations to discover the network within a bounded time (preprogrammed for this mission), so that if a new node does not hear anything within a prescribed time, it knows the network does not yet exist.

Note that the ability to hear these “discovery” messages may require the acquisition of a spread spectrum code. If the node does not hear anything within the network discovery time-out, it will assume that it is the first node, and begin to issue invitations for other nodes to join it. The network boot up latency specification determines the frequency of invitations, which in turn bounds the discovery time-out.

3.3.12 Associativity Based Routing Protocol

EABR- Enhanced Associativity Based Routing Protocol consists of two phases, namely route discovery and phase and route reconstruction phase. The improvement done to the original ABR was in the route reconstruction phases. The route reconstruction RRC phase will be invoked in three situations; namely during source (SRC), destination (DEST) or the intermediate node (IN) movements. EABR will try to locate an alternate valid route without the need to rebroadcast a query unless and until it is definitely needed. In the original ABR, the DEST role is passive in terms of DEST node movement. However, in EABR, the DEST node has an active role in route reconstruction. Moreover, ABR route invalidation is always performed toward the DEST in the case of IN movement, while an optimization is achieved in EABR to invalidate the shortest partial route from the IN toward either the DEST or the SRC.
3.4 IMPLEMENTATION OF ANT IN ABR

AABR- Ant Associativity Based concept is utilized during multicast tree discovery, selection, and reconfiguration. This allows routes that are long-lived to be selected, thereby reducing the frequency of route reconstructions. AABR employs a localized route reconstruction strategy in response to migrations by source, receiver, and tree nodes. It can repair an affected subtree via a single route reconstruction operation. AABR is also capable of handling multicast group dynamics when mobile hosts decide to join and leave. The performance of AABR is simulated and compared with Associativity Based Routing protocol ABR and ANT routing protocols. The objective of AABR is to optimize some bandwidth utilization used by routing agents and to minimize the overhead. In AABR updates, all the other nodes’ position information by learning from the position information included in the message passed through this node. The flooding mechanism in wireless networks is very robust and works extremely well when the network is highly dynamic. The same strategy to control the flooded forward ants as in FF is used to control the flooded data ants. In this case, the data ants not only pass the data to the destination but also remember the paths which can be used by the backward ants to reinforce the probability on these links. The probability distribution constrains the flooding towards the destination for future data ants. This method has a very high success rate with relatively high energy consumption.

We studied the basic AABR to solve the routing problem in mobile Ad-hoc networks. A basic AABR routing algorithm was proposed, and several improvements, inspired by the features of wireless sensor networks (low energy levels, low processing, and memory capabilities), were considered and implemented. The resulting Ant ABR based routing protocol, called Ant & Associativity Based Routing (AABR), uses lightweight ants to
find routing paths between the mobile nodes and the sink nodes, which are optimized in terms of distance and energy levels.

### 3.4.1 Network Model

In this AABR the different area parameters were taken i.e., different area and nodes levels were maintained. The study incorporate with the ns-2 simulator. The radio propagation model determines the strength of a transmitted signal at a particular point of the space for all transmitters in the system. Based on this information the signal reception conditions for the receivers can be evaluated and collisions can be detected.

### 3.4.2 Performance Metrics

Various performance metrics are used for comparing different routing strategies in ad-hoc networks. Some properties of AABR (Table 3.1) has considered for our simulation process. Different levels of scenario have considered.

1. **Latency**: The time delay of a packet from the source to the destination.

2. **Success rate**: The ratio between total numbers of packet received at the destinations versus actual number of packets sent from the source (Table 3.2 and Table 3.3).

3. **Energy consumption**: Assuming each transmission consumes an energy unit, the total energy consumption is equivalent to the total number of packets sent (Figures 3.1 and 3.4).

4. **Energy efficiency**: The fraction of the number of packets received at the destination versus the energy consumption in the network; some of these metrics are correlated and some
conflict with each other. For different applications, different metrics may be relevant.

**Table 3.1  Properties of AABR in MANET**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Description</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of nodes in the network</td>
<td>N</td>
</tr>
<tr>
<td>2</td>
<td>Network diameter</td>
<td>D</td>
</tr>
<tr>
<td>3</td>
<td>Number of nodes affected by topological changes</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Diameter of the affected network segment</td>
<td>L</td>
</tr>
<tr>
<td>5</td>
<td>Total number of nodes forming the route from SRC to DEST</td>
<td>Y</td>
</tr>
<tr>
<td>6</td>
<td>Diameter of Y; the directed path where the REPLYs packets transits</td>
<td>Z</td>
</tr>
<tr>
<td>7</td>
<td>Total number of nodes forming the newly constructed route from SRC to DEST; W&lt;= Y</td>
<td>W</td>
</tr>
<tr>
<td>8</td>
<td>Diameter of W</td>
<td>P</td>
</tr>
</tbody>
</table>

**Table 3.2  Permissible nodes with in 60 x 60 sq. m range**

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Energy Level</th>
<th>Latency</th>
<th>Success Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABR</td>
<td>Y(N/D)</td>
<td>68%</td>
<td>78%</td>
</tr>
<tr>
<td>Ant</td>
<td>Y(N/D)-Z</td>
<td>70%</td>
<td>72%</td>
</tr>
<tr>
<td>AABR (Observed)</td>
<td>W(N/D)-Z</td>
<td>55%</td>
<td>85%</td>
</tr>
</tbody>
</table>

**Table 3.3  Permissible nodes with in 100 x 100 sq. m range**

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Energy Level</th>
<th>Latency</th>
<th>Success Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABR</td>
<td>Y(N/D) - L</td>
<td>53%</td>
<td>60%</td>
</tr>
<tr>
<td>Ant</td>
<td>Y(N/D)-(Z+L)</td>
<td>65%</td>
<td>55%</td>
</tr>
<tr>
<td>AABR (Observed)</td>
<td>W(N/D)-(Z+L+X)</td>
<td>45%</td>
<td>75%</td>
</tr>
</tbody>
</table>
Figure 3.1  Energy Vs transmission rate

Figure 3.2  Time Delay Vs transmission rate
Figure 3.3 Throughput Vs transmission rate

Figure 3.4 Energy consumption
3.5 PERFORMANCE EVALUATION

3.5.1 Packet Delivery Fraction

It is the ratio of the data packets delivered to the destinations to those generated by the sources (Table 3.4). Packet Delivery Fraction (PDF) = Total Packets Delivered to destination / Total Packets Generated.

Mathematically, it can be expressed as:

\[ P = \frac{1}{C} \sum_{j=1}^{n} \frac{R_f}{N_f} \]  \hspace{1cm} (3.1)

where, \( P \) is the fraction of successfully delivered packets, \( C \) is the total number of flow or connections, \( f \) is the unique flow id serving as index, \( R_f \) is the count of packets received from flow \( f \) and \( N_f \) is the count of packets transmitted to \( f \). The PDF values obtained for the simulation parameters. The graph shown in figure 3.5 indicates the PDF comparison of routing protocols, DSDV and AODV (modified).

Table 3.4 Packet delivery fraction for DSDV and AODV (modified)

<table>
<thead>
<tr>
<th>Nodes (observed)</th>
<th>Routing Protocol</th>
<th>Total Packets Sent</th>
<th>Total Packets Received</th>
<th>Packet Loss</th>
<th>Packet Delivery Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>DSDV</td>
<td>8091</td>
<td>7665</td>
<td>426</td>
<td>0.9473</td>
</tr>
<tr>
<td></td>
<td>AODV</td>
<td>8195</td>
<td>8097</td>
<td>98</td>
<td>0.9880</td>
</tr>
<tr>
<td>50</td>
<td>DSDV</td>
<td>8287</td>
<td>7355</td>
<td>932</td>
<td>0.8875</td>
</tr>
<tr>
<td></td>
<td>AODV</td>
<td>8787</td>
<td>8685</td>
<td>102</td>
<td>0.9883</td>
</tr>
<tr>
<td>75</td>
<td>DSDV</td>
<td>8680</td>
<td>7502</td>
<td>1178</td>
<td>0.8642</td>
</tr>
<tr>
<td></td>
<td>AODV</td>
<td>8584</td>
<td>8386</td>
<td>198</td>
<td>0.9769</td>
</tr>
<tr>
<td>100</td>
<td>DSDV</td>
<td>8388</td>
<td>7656</td>
<td>732</td>
<td>0.9127</td>
</tr>
<tr>
<td></td>
<td>AODV</td>
<td>8985</td>
<td>8784</td>
<td>201</td>
<td>0.9776</td>
</tr>
</tbody>
</table>
Table 3.5 Throughput for DSDV and AODV (modified)

<table>
<thead>
<tr>
<th>Nodes</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSDV</td>
<td>1740.45Kbps</td>
<td>1725.36Kbps</td>
<td>1825.25Kbps</td>
<td>1922.36Kbps</td>
</tr>
<tr>
<td>AODV (modified)</td>
<td>7055.54Kbps</td>
<td>7935.25Kbps</td>
<td>8155.36Kbps</td>
<td>8005.26Kbps</td>
</tr>
</tbody>
</table>

3.5.2 Throughput

The throughput of the routing protocol is that in the certain time the total size of useful packets that received at all the destination nodes. The unit of throughput is MB/s, however, we have taken Kilobits per second (Kb/s). The throughput values obtained for the simulation parameters of Table 3.5. The graph is shown in Figure 3.6 indicates the throughput comparison of routing protocols, DSDV, and AODV (modified).

![Figure 3.5 Number of nodes Vs packet delivery fraction](image)
3.5.3 **End To End Delay**

The delay experienced by a packet from the time it was sent by a source till the time it was received at the destination. Figure 3.7 shows the End-to-End Delay for these protocols as a function of the number of nodes. The performance of AODV (modified) is better than DSDV for varying number of nodes especially between 20 and 100 nodes.
3.6 STUDY AND DISCUSSION

In the performance simulation, the source is changing from node to node, following the movement of the evader, and the destination is mobile. The source rate is about one packet per second. For the basic ant routing, the ratio between data ants and ABR is set to be two initially. The AABR interval is changing according to the quality of the discovered path, but the data rate is fixed. The Figure 3.2 shows the time delay comparison. There is an initialization phase of 3 seconds for establishing the connectivity of the network. In the AABR, hello packets are sent out from each node used to establish the potential field and the initial probability distribution of links. Both initializations use about the same amount of energy, i.e., 3N, where N is the number of nodes in the network. A total of 200 seconds is simulated for the AABR algorithms, with 10 random runs for each. Performances are compared among the AABR, ABR and ANT algorithms for MANET application. The Figure 3.3 shows the AABR routing has extremely high success rates than the other two. Similarly the DSDV is performing poorly than the AODV (modified). The End-to-End delay and throughput graphs had shown the evidence of our implementation.

3.7 CONCLUSION

This AABR and AODV (modified) algorithm were incorporated along with this work that helps for improving the routing methods. The AABR was used for load balancing in routing and AODV (modified) has been considered for on demand purpose. This combined work gave an effective and improved routing algorithm for MANET. This technique is being used in further implementation of secure multicast and CHS and PLGP-M works. The next chapter has shown the details about secure multicasting.