CHAPTER 1

INTRODUCTION

In today’s fast and rapidly thriving world of technologies, more and more businesses perceive the advantages of usage of computer networking. Depending on the firm’s size and availability of resources, it might be a trivial LAN containing only a few dozen computers; however, in large corporations the networks can grow to immense and complex mixture of clients and servers.

A computer network is a system for communication between computers. These networks may be fixed (cabled, permanent) or temporary (as via modems or null modems). Networks and the technologies needed to connect and communicate through and between them, continue to drive computer hardware, software, and peripherals industries. This enlargement is mirrored by growth in the numbers and types of users of networks from researchers and businesses to families and individuals in everyday use.

Since their evolution in the 1970s, wireless networks have become increasingly widespread in the computing industry. This is particularly true within the past decade which has seen wireless networks being adapted to enable mobility. There are currently two variations of mobile wireless networks.

The first is known as infrastructured networks, i.e., those networks with fixed and wired gateways. The bridges for these networks are known as base stations. A mobile unit within these networks connects to, and communicates with, the nearest base station that is within its communication range. As the mobile unit travels out of range of one base station and into the range of another, a “handoff” occurs from the old base station to the new, and the
mobile is able to continue communication seamlessly throughout the network. Typical applications of this type of network include wireless local area networks (WLANs).

The second type of mobile wireless network is the infrastructureless mobile network, commonly known as an ad hoc network. Infrastructureless networks have no fixed routers; all nodes are capable of movement and can be connected dynamically in an arbitrary manner. Nodes of these networks function as routers which discover and maintain routes to other nodes in the network. Examples of applications of ad hoc networks are its use in emergency search-and-rescue operations, meetings in which persons wish to quickly share information, and data acquisition operations in remote locations[1][5].

### 1.1 MOBILE AD HOC NETWORKS

A mobile ad hoc network (MANET) is a self-configuring network of mobile routers (and associated hosts) connected by wireless links - the union of which form a random topology. The routers are free to move randomly and organize themselves at random; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. Minimal configuration and quick deployment make mobile ad hoc networks suitable for emergency situations like natural or manmade disasters, military conflicts, emergency medical situations, etc.,.

#### 1.1.1 Need for Mobile Ad hoc Networks

Ad hoc networks form spontaneously without the need of an infrastructure or centralized controller. This type of peer-to-peer system concludes that each node, or user, in the network can act as a data endpoint or intermediate repeater. A repeater is a network device that is used to regenerate or replicate signals that are weakened or distorted by transmission
over long distances and through areas with high levels of electromagnetic interference. Thus, all users work together to improve the reliability of network communications. These types of networks are also popularly known as "mesh networks" because the topology of network communications resembles a mesh.

The redundant communication paths provided by ad hoc mesh networks greatly improve fault tolerance for the network. Additionally, the ability for data packets to "hop" from one user to another effectively extends the network coverage area and provides a solution to overcome non-line of sight (LOS) issues.

Mobile applications present additional challenges for mesh networks as changes to the network topology are swift and widespread. Such scenarios require the use of Mobile Ad hoc Networking (MANET) technology to ensure that communication routes are updated quickly and accurately as MANETs are self-forming, self-maintained, and self-healing, allowing for extreme network flexibility [15].

1.2 ROUTING ON MOBILE AD HOC NETWORKS

The routing in mobile ad hoc network can be performed in a number of ways based on the following constraints:

1.2.1 Shortest Path Routing

The objective of the shortest path routing is to find a path between the source and destination that has the smallest total cost, where the total cost of a path is the sum of the hop costs in that path. A network is represented as a graph, with its terminals as nodes and the links as edges. Lower the cost, the more suitable the link is. The cost is determined depending upon the criteria to be optimized.
Figure 1.1 Shortest Path Routing

Figure 1.1 shows the example scenario of shortest path routing where a number of routes are available from the source to reach the destination. Here the source node forwards the packet through the shortest route with a minimal cost.

1.2.2 Energy Based Routing

In this case of routing, the node selects the route according to the energy level of the intermediate nodes. Every node of mobile ad hoc network has limited energy and at each transmission-reception process, it loses some energy. Hence the intermediate node can become dead when the packet is in half way, and this creates a link failure. Owing to route failure, the intermediate node has to compute the new route and forward it once again. This increases the latency of the packet and also reduces the throughput of the network.

Figure 1.2 Energy Based Routing
Figure 1.2 shows the routing based on energy of the nodes. Here the node 2, along the forward path loses its energy and hence the link between 1-2 breaks. This requires a rediscovery of route and it increases the latency of the packet. Hence the energy based routing protocol, selects the route according to the energy level of the intermediate nodes of the route selected [20][37][64].

1.2.3 Latency Based Routing

In latency based approach, the latency of each route is computed and based on it the route with less latency value will be selected as target route to perform transmission. The latency can be computed according to the traffic and link delay present in the network. Link delay is computed based on the traffic at a single hop and the network traffic can be computed according to the overall traffic at all the nodes of the network.

1.2.4 Traffic Based Routing

In this approach, the target route will be selected based on the traffic present in the route. There may be a path which is the shortest to reach the destination, so that all the nodes will send the packet through the particular route. This increases the traffic on the particular route and increases the latency. The traffic based routing selects even a longer route which has less traffic and reduces the overall latency [12][65].

1.2.5 Link Status Routing

The link status routing is an efficient approach in routing packets in mobile ad hoc networks. In this approach, the nodes select a target route based on the link status of the intermediate nodes. The node identifies the set of nodes present in the route and verifies the
link status of the node. The problem in this approach is, verification of the link status that increases the latency of the network[55].

1.2.6 Network Density Based Routing

In this protocol, the route is selected according to the network density, for example when a node selects the route, it computes the number of nodes around each neighbour present in the route. Based on the network density, the node selects a route to forward the packet to the destination. This reduces the latency of the network and increases the throughput of the network also.

1.3 ROUTING PROTOCOLS FOR MANETS

In order to aid communication within the network, a routing protocol is used to discover routes between nodes. The main goal of such an ad hoc network routing protocol is to build correct and efficient route between a pair of nodes so that messages may be delivered in a timely manner. Route construction should be accomplished with a minimum of overhead and bandwidth consumption. An Ad hoc routing protocol is a standard that controls how nodes come to agree in the way to route packets, between computing devices in a MANET. In ad hoc networks, nodes do not have a prior knowledge of topology of network around them, they have to discover it. The basic idea is that a new node publishes its presence and listens to broadcast messages from its neighbours. The node learns about new near nodes and ways to reach them, and announces that it can also reach those nodes. As time goes on, each node knows about all other nodes and one or more paths to reach them.

Routing algorithms have to:

- keep routing table fairly small.
• choose the best route for the given destination (this can be the fastest, most reliable, highest throughput, or cheapest route).
• keep table up-to-date when nodes die, move or join.

Many protocols have been developed for mobile ad hoc networks which must deal with the typical limitations of these networks, which include high power consumption, low bandwidth, and high error rates. As shown in figure 1.3 below, these routing protocols may generally be categorized as: (a) table-driven (proactive) and (b) source-initiated on-demand driven (reactive) (c) hybrid [13][16][38].

![Figure 1.3 MANET Routing Protocols](image)

1.3.1 Table-Driven Routing Protocols

The table-driven routing protocols try to maintain consistent, up-to-date routing information from each node to every other node in the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating updates throughout the network in order to maintain a rational network view. The areas where they differ are the number of necessary routing-related tables and the methods by which changes in network structure are broadcast [35][39].
1.3.1.1 Destination-Sequenced Distance-Vector Routing (DSDV) Protocol

The Destination-Sequenced Distance-Vector Routing protocol (DSDV) is a table-driven algorithm based on the classical Bellman-Ford routing mechanism. The enhancements made to the Bellman-Ford algorithm include freedom from loops in routing tables [49].

Every mobile node in the network maintains a routing table in which all of the possible destinations within the network and the number of hops to each destination are stored. Each entry is marked with a sequence number assigned by the destination node. The sequence numbers enable the two mobile nodes to differentiate stale routes from new ones, thereby avoiding the formation of routing loops. Routing table updates are periodically transmitted throughout the network in order to maintain table consistency. To help ease the potentially large amount of network traffic that such updates can generate, route updates engage two possible types of packets. The first is known as a “full dump” which carries all available routing information and require multiple network protocol data units (NPDUs). During periods of occasional movement, these packets are transmitted occasionally. Smaller “incremental” packets are used to relay only that information which has changed since the last full dump. Each of these broadcasts should fit into a standard size NPDU, thereby reducing the amount of traffic generated. The mobile nodes maintain an extra table where they store the data sent in the incremental routing information packets [53].

New route broadcasts contain the address of the destination, the number of hops to reach the destination, the sequence number of the information received regarding the destination, as well as a new sequence number unique to the broadcast. The route labeled with the most recent sequence number is always used. In the occasion that two updates have the same sequence number, the route with the smaller metric is used in order to optimize the path. Mobile nodes also keep track of the settling time of routes, or the weighted average time that
routes take to reach a destination will vary before the route with the best metric is obtained. By postponing the broadcast of a routing update by the length of the settling time, mobiles can decrease network traffic and optimize routes by eliminating those broadcasts that would occur if a better route was discovered in the near future [32][34][46][48].

1.3.1.2 Cluster head Gateway Switch Routing (CGSR) Protocol

The Cluster head Gateway Switch Routing (CGSR) protocol differs from the DSDV protocol in the type of addressing and network organization scheme involved. Instead of a large network, CGSR is a clustered multihop mobile wireless network with several heuristic routing methods. By having a cluster head controlling a group of ad hoc nodes, a framework for code separation (among clusters), channel access, routing and bandwidth allocation can be accomplished. A cluster head selection algorithm is used to select a node as the cluster head, using a distributed algorithm within the cluster. The disadvantage of having a cluster head scheme is that frequent cluster head changes can severely affect routing protocol performance since nodes are busy in cluster head selection rather than packet relaying. Hence, instead of calling cluster head reselection every time the cluster membership changes, a Least Cluster Change (LCC) clustering algorithm is introduced. Using LCC, cluster heads only change when two cluster heads come into contact, or when a node moves out of contact of all other cluster heads [8].

CGSR uses DSDV as the underlying routing scheme, and hence has much of the same overhead as DSDV. However, it modifies DSDV by using a hierarchical cluster head-to-gateway routing approach to route traffic from source to destination. Gateway nodes are nodes that are within the communication range of two or more cluster heads. A packet sent by a node is first routed to its cluster head, and then it is routed from the cluster head to a gateway to another cluster head, and so on until the cluster head of the destination node is reached. The
packet is then transmitted to the destination. Using this method, each node maintains a “cluster member table” where it stores the destination cluster head for each mobile node in the network. These cluster member tables are broadcast by each node regularly using the DSDV algorithm. Nodes update their cluster member tables on the reception of such a table from a neighbour [17].

Additionally, each node must also maintain a routing table, which is used to determine the next hop in order to reach the destination. On receiving a packet, a node will ask its cluster member table and routing table to determine the nearest cluster head along the route to the destination. Next the node will check its routing table to determine the node in order to reach the selected cluster head. It then transmits the packet to this node.

1.3.1.3 Wireless Routing Protocol (WRP)

The Wireless Routing Protocol (WRP) is a table-based protocol which is developed with the aim of maintaining routing information among all nodes in the network. Each node in the network is responsible for maintaining four tables: (a) distance table, (b) routing table, (c) link-cost table, and (d) message retransmission list (MRL) table. Each entry of the MRL contains the sequence number of the update message, a retransmission counter, an acknowledgment-required flag vector with one entry per neighbour, and a list of updates sent in the update message. The MRL records which updates in an update message needs to be retransmitted and which neighbours should acknowledge the retransmission [25].

Mobile nodes inform each other of link changes through the use of update messages. An update message is sent only between neighbouring nodes and contains a list of updates (the destination, the distance to the destination, and the predecessor of the destination), as well as a list of responses indicating which mobiles should acknowledge (ACK) the update. Mobiles send update messages after processing updates from neighbours or finding a change in a link
to a neighbour. In the event of the loss of a link between two nodes, the nodes send updated messages to their neighbours. The neighbours then update their distance table entries and check for new possible paths through other nodes. Any new paths are sent back to the original nodes so that they can update their tables accordingly [56].

Nodes learn about the existence of their neighbours from the receipt of acknowledgments and other messages. If a node is not sending messages, it must send a hello message within a specified period to ensure link. Otherwise, the lack of messages from the node indicates the failure of that link; this may cause a false alarm. When a mobile receives a hello message from a new node, that new node is added to the mobile's routing table, and the mobile sends the new node a copy of its routing table information.

1.3.2 Source-Initiated On-Demand Routing

Source-initiated on-demand routing uses a different approach from table-driven routing. This type of routing establishes routes only when required by the source node. When a node requires a route to a destination, it starts a route discovery process within the network. This process is completed once a route is found or all possible routes have been examined. Once a route has been established, it is maintained by some form of route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired[7][21][22].

1.3.2.1 Ad hoc On-Demand Distance Vector Routing (AODV) Protocol

The Ad hoc On-Demand Distance Vector (AODV) routing protocol builds on the DSDV algorithm previously described. AODV is advancement on DSDV because it typically minimizes the number of required broadcasts by creating routes on an on-demand basis, as compared to maintaining a complete list of routes as in the DSDV algorithm. AODV is a pure
on-demand route acquisition system, as nodes that are not on a selected path do not maintain routing information or participate in routing table exchanges[24][27][28].

When a source node desires to send a message to some destination node and does not already have a valid route to that destination, it initiates a Path Discovery process to locate the other node. It broadcasts a route request (RREQ) packet to its neighbours, which then forward the request to their neighbours, and so on, until either the destination or an intermediate node with a new route to the destination is obtained. AODV utilizes destination sequence numbers to ensure all routes are loop-free and contain the most recent route information. Each node maintains its own sequence number, as well as a broadcast ID. The broadcast ID is incremented for every RREQ the node initiates, and together with the node's IP address, uniquely identifies a RREQ. Along with its own sequence number and the broadcast ID, the source node includes in the RREQ the most recent sequence number it has for the destination. Intermediate nodes can reply to the RREQ only if they have a route to the destination whose corresponding destination sequence number is greater than or equal to that contained in the RREQ.

During the process of forwarding the RREQ, intermediate nodes record in their route tables the address of the neighbour from which the first copy of the broadcast packet is received, thereby establishing a reverse path. If additional copies of the same RREQ are later received, these packets are rejected. Once the RREQ reaches the destination or an intermediate node with a new route, the destination or intermediate node responds by unicasting a route reply (RREP) packet back to the neighbour from which it first received the RREQ. As the RREP is routed back along the reverse path, nodes along this path set up forward route entries in their route tables which point to the node from which the RREP came. These forward route entries indicate the active forward route. Associated with each route entry is a route timer
which will cause the deletion of the entry if it is not used within the specified lifetime. As the RREP is sent along the path established by the RREQ, AODV only supports the use of symmetric links [29][30][33].

Routes are maintained as follows. If a source node moves, it is able to restart the route discovery protocol to find a new route to the destination. If a node along the route moves, its upstream neighbour notices the move and propagates a link failure notification message (a RREP with infinite metric) to each of its active upstream neighbours to inform them of the deletion of that part of the route. These nodes in turn propagate the link failure notification to their upstream neighbours, and so on until the source node is reached. The source node may then choose to reinitiate route discovery for that destination if a route is still desired[40][44][58].

1.3.2.2 Dynamic Source Routing (DSR) Protocol

The Dynamic Source Routing (DSR) protocol is an on-demand routing protocol that is based on the concept of source routing. Mobile nodes are required to maintain route caches that contain the source routes of which the mobile is aware. Entries in the route cache are continually updated as new routes are observed [17][53][59].

The protocol consists of two major phases: route discovery and route maintenance. When a mobile node has a packet to send to some destination, it first consults its route cache to determine if it already has a route to the destination. If it has an unexpired route to the destination, it will use this route to send the packet. On the other hand, if the node does not have such a route, it initiates route discovery by broadcasting a route request packet. This route request contains the address of the destination, along with the source node's address and a unique identification number. Each node receiving the packet checks whether it knows of a route to the destination. If it does not, it adds its own address to the route record of the packet
and then forwards the packet along its outgoing links. To restrict the number of route requests propagated on the outgoing links of a node, a mobile node only forwards the route request if the request has not yet been seen by the mobile node and if the mobile node's address does not already appear in the route record.

A route reply is generated when either the route request reaches the destination itself, or when it reaches an intermediate node which contains in its route caches an unexpired route to the destination. By the time the packet reaches either the destination or such an intermediate node, it contains a route record specifying the sequence of hops taken. If the node generating the route reply is the destination, it places the route record contained in the route request into the route reply. If the responding node is an intermediate node, it will append its cached route to the route record and then generate the route reply. To return the route reply, the responding node must have a route to the initiator. If it has a route to the initiator in its route cache, it may use that route. Otherwise, if symmetric links are supported, the node may reverse the route in the route record. If symmetric links are not supported, the node may initiate its own route discovery and piggyback the route reply on the new route request. Route maintenance is accomplished through the use of route error packets and acknowledgments. Route error packets are generated at a node when the data link layer encounters a fatal transmission problem. When a route error packet is received, the hop in error is removed from the node's route cache and all routes containing the hop are truncated at that point. In addition to route error messages, acknowledgments are used to verify the correct operation of the route links. Such acknowledgments include passive acknowledgments, where a mobile node is able to hear the next hop forwarding the packet along the route [31][36][43][46].
1.3.2.3 Temporally-Ordered Routing Algorithm (TORA)

TORA is a highly adaptive, loop-free, distributed routing algorithm based on the concept of link reversal. TORA is proposed to operate in a highly dynamic mobile networking environment. It is source-initiated and provides multiple routes for any desired source-destination pair. The key design concept of TORA is the localization of control messages to a very small set of nodes near the occurrence of a topological change. To achieve this, nodes need to maintain routing information about adjacent (1-hop) nodes. The protocol performs three basic functions: (a) route creation, (b) route maintenance, and (c) route deletion.

During the route creation and maintenance phases, nodes use a “height” metric to establish a directed acyclic graph (DAG) routed at the destination. Thereafter, links are assigned a direction (upstream or downstream) based on the relative height metric of neighbouring nodes.

This process of establishing a DAG is similar to the query/reply process proposed in LMR (Lightweight Mobile Routing). In times of node mobility, the DAG route is broken and route maintenance is necessary to re-establish a DAG routed at the same destination. Upon failure of the last downstream link, a node generates a new reference level which results in the propagation of that reference level by neighbouring nodes, effectively coordinating a structured reaction to the failure.

Links are reversed to reflect the change in adapting to the new reference level. This has the same effect as reversing the direction of one or more links when a node has no downstream links. Timing is an ideal factor for TORA because the “height” metric is dependent on the logical time of a link failure; TORA assumes that all nodes have synchronized clocks. TORA's metric comprises of five elements, namely: (a) logical time of a link failure, (b) the unique ID of the node that defined the new reference level, (c) a reflection
indicator bit, (d) a propagation ordering parameter, and (e) the unique ID of the node. The first three elements collectively represent the reference level. A new reference level is defined each time a node loses its last downstream link due to a link failure. TORA’s route deletion phase essentially involves flooding a broadcast “clear packet” (CLR) throughout the network to erase invalid routes [36][46][59].

1.3.2.4 Associativity-Based Routing (ABR) Protocol

The Associativity-Based Routing (ABR) protocol is devoid of loops, deadlock, and packet duplicates, and defines a new routing metric for ad hoc mobile networks. This metric is known as the degree of association stability. In ABR, a route is selected based on the degree of association stability of mobile nodes. Each node regularly generates a beacon to signify its existence. When received by neighbouring nodes, these beaconing causes their associativity tables to be updated. For each beacon received, the associativity ticks of the current node with respect to the beaconing node are incremented. Association stability is defined by the connection stability of one node with respect to another node over time and space. A high degree of association stability may indicate a low state of node mobility, while a low degree may indicate a high state of node mobility. Associativity ticks are reset when the neighbours of a node or the node itself moves out of proximity. A fundamental objective of ABR is to derive longer-lived routes for ad hoc mobile networks [9].

The three phases of ABR are: (a) route discovery, (b) route re-construction (RRC), and (c) route deletion. The route discovery phase is achieved by a broadcast query and awaitreply (BQ-REPLY) cycle. A node desiring a route, broadcasts a BQ message in search of mobiles that have a route to the destination. All nodes receiving the query (that are not the destination) append their addresses and their associativity ticks with their neighbours along with QoS information to the query packet. A successor node erases its upstream node
neighbours' associativity tick entries and retains only the entry concerned with itself and its upstream node. In this way, each resultant packet arriving at the destination will contain the associativity ticks of the nodes along the route to the destination. The destination is then able to select the best route by examining the associativity ticks along each of the routes. In the case where multiple routes have the same overall degree of association stability, the route with the minimum number of hops is selected. The destination then sends a REPLY packet back to the source along this route. Nodes propagating the REPLY mark their routes as valid. All other paths remain inactive and the possibility of duplicate packets arriving at the destination is avoided.

1.3.2.5 Signal Stability Routing (SSR)

SSR selects routes based on the signal strength between nodes and on a node's location stability. This route selection criterion has the effect of choosing routes that have stronger connectivities. SSR can be divided into two cooperative protocols: the Dynamic Routing Protocol (DRP) and the Static Routing Protocol (SRP).

The DRP is responsible for the maintenance of the Signal Stability Table (SST) and the Routing Table (RT). The SST stores the signal strength of neighbouring nodes, which is obtained by periodic beacons from the link layer of each neighbouring node. The signal strength may be recorded as either a strong or weak channel. All transmissions are received by, and processed in, the DRP. After updating all appropriate table entries, the DRP passes a received packet to the SRP.

The SRP processes packets by passing the packet up the stack if it is the intended receiver or looking up the destination in the RT and then forwarding the packet if it is not. If no entry is found in the RT for the destination, a route-search process is initiated to find a route. Route requests are propagated throughout the network but are only forwarded to the
next hop if they are received over strong channels and have not been previously processed (to prevent looping). The destination chooses the first arriving route-search packet to send back because it is most probable that the packet has arrived over the shortest and/or least congested path. The DRP then reverses the selected route and sends a route-reply message back to the initiator. The DRP of the nodes along the path updates their RTs accordingly. Route-search packets arriving at the destination have necessarily chosen the path of strongest signal stability, as the packets are dropped at a node if they have arrived over a weak channel. If there is no route-reply message received at the source within a specific timeout period, the source changes the PREF field in the header to indicate that weak channels are acceptable, as these may be the only links over which the packet can be propagated. When a failed link is detected within the network, the intermediate nodes send an error message to the source indicating which channel has failed. The source then initiates another route-search process to find a new path to the destination. The source also sends an erase message to notify all nodes of the broken link [26].

1.3.3 Hybrid Routing Protocols

Hybrid direction-finding protocols use both proactive and reactive behavior of the routing protocols. Such mechanisms are intended to diminish the overhead generated by exchanging control messages in both the mechanisms [51].

1.3.3.1 Zone Routing Protocol (ZRP)

The Zone Routing Protocol has a hybrid nature because it has the behavior of both proactive and reactive methods. It has three different components to route within a zone, route between different zones and to route in the borders of the network.
The whole network is grouped and separated into different zones based on geographic location where each zone represents a small element of the complex. Every node maintains its own routing table where it keeps routes to other nodes in the zone. A zone radius is maintained using which the coverage area to be reached with most number of hops. The routing process is performed using the route table based on the IARP procedure in a zone. A node be able to belong to additional than one zone.

To find out the border node in the network, the ZRP is used. If there is a path in the route table of border node, a reply will be sent directly to the source node. The request will be rebroadcast to the next level nodes. This procedure will be continued till it reaches the destination node and when it reaches, it creates an unicast message to the source node as a reply. If it receives more than one reply for the same request then it selects an efficient route based on the QoS metrics [31].

1.4 INTRODUCING NANO TECHNOLOGY FOR MANET ROUTING

Nano technology is very important in mobile ad hoc network, because of its direct communication between source to destination but WSN have one intermediator like base station or central station, so nano technology differs from WSN. Nanotechnology provides favourable development in miniaturization and fabrication of nanomachines with simple sensing, computation, communication, and action capabilities. A nanonetwork can be a network of communicating nanomachines. Moreover, mobile ad hoc nanonetwork consists of two kinds of mobile nanonodes, namely, nanomachines and infostations. Nanomachines can sense the environment and gather some environmental information to deliver infostations. Based on the collected information coming from nanomachines, infostations make decision for an appropriate action. Route discovery is the most energy consuming process in
nanomachine routing. To reduce energy depletion occurring in the neighbouring nodes, memory sharing schemes are used [2][3][4].

In mobile ad hoc network, the quality of service has to be maintained for a prolonged period of time. It not only depends on the power consumption but also on the latency, packet delivery rate and memory. In order to strengthen the QoS and the lifetime of the network, energy loss has to be reduced by reducing the frequency of route discovery process.

This research focuses on designing optimized approach which maximizes the lifetime of the network as well as improving the QoS of the network.

1.5 THESIS GOALS

There are various techniques for routing data packets efficiently. Among them, the standard Ad hoc On Demand Distance Vector (AODV) routing protocol is popular due to its accuracy and performance.

The main goal of this thesis is to incorporate nanotechnology with AODV to achieve better QoS.

The main goals of this research are to design and develop efficient routing protocols to:

- reduce the latency of the network.
- maximize throughput of the network.
- increase the packet delivery ratio.
- reduce the energy depletion ratio of all the nodes participating in the routing process.
- maximize the energy efficiency and increase the lifetime of the nodes.

1.6 THESIS OUTLINE

This thesis is organized as follows: Chapter 2 performs a deep survey of routing methods discussed earlier for the mobile ad hoc network. The thesis discusses various challenges faced during the implementation of above mentioned concepts.
The chapter 3 discusses an integrated approach of nanotechnology to the nodes of mobile ad hoc network to perform molecular communication in the AODV routing environment. This is followed by Chapter 4 with an optimized nano adapted AODV routing in MANET for performance development. Chapter 5 discusses the Enhanced Nano adapted AODV routing protocol using cluster tree for mobile ad hoc networks.

Chapter 6 describes the Lifetime Maximization Technique Using Light Weight Memory Sharing Scheme of Nanomachines for Data Transmission in MANET.

The chapter 7 summarizes the entire research work and future ideas to improve the routing.