ENHANCEMENT IN MOBILITY BASED ESTIMATION OF NODE STABILITY TECHNIQUE USING CLUSTERING SCHEME IN MANET

A Dissertation Submitted

By

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(15812)

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DISSERTATION TOPIC APPROVAL PERFORMA

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3. Image Processing

Signature of Supervisor 8/12

PAC Remarks: Student will focus on Issues like Power consumption, Mobility Issues as well as try to improve the performance of network with security feature. I am Expecting to Publish the Research Pa... our thesis ta...

APPROVAL OF PAC CHAIRPERSON: Signature: 1/10/11 Date: 1/10/14

* Supervisor should finally encircle one topic out of three proposed topics and put up for approval before Project Approval Committee (PAC)
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ABSTRACT

A mobile ad hoc network (MANET) is a network that is self-configuring in nature, consisting of several mobile nodes that can be created without any previously established infrastructure or any kind of centralized administration. In MANET, each node is free to move in any random direction independently which makes the network extremely flexible. To properly route the traffic, each node in MANET maintains the information required. Since, the nodes are mobile; they can even change the links to the other nodes frequently. MANET is a very useful concept in the world of wireless technologies. These are very advantageous as they are easy and quick to deploy whenever needed. They can be deployed in emergency scenarios where there is no possibility of deploying an infrastructure for the communication to be held out of the affected area. In this proposed work, an enhancement has been tried in the stability based technique to reduce end-to-end delay, packet loss and increase throughput in the network. To do so, the enhancement has been proposed which is based on the clustering of the mobile nodes. Location-based clustering is done in which the nodes are divided into smaller areas which hence, reduces the overhead and bandwidth of the communication. The selection of the cluster head is based upon the weighted values of the serving time of the node and the stability factor of the node. Serving time is the time for which the node can serve as the cluster head without its energy getting deprived. Stability factor is based upon movement of the node with respect to its transmission range. Hence, the node with the maximum value is selected as the cluster head. The simulation has been done in ns2 and the results of the present and the existing technique has been compared on the basis of the end-to-end delay, packet loss and the throughput. It has been observed that the results of the proposed technique are better than the existing work.

CERTIFICATE

This is to certify that, Ruchi Chaudhary has completed M.Tech dissertation proposal titled, 'Enhancement in Mobility Based Estimation of Node Stability Technique Using Clustering Scheme in MANET', under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of the dissertation proposal has ever been submitted for any other degree or diploma.

The dissertation proposal is fit for the submission and the partial fulfillment of the conditions of the award of M.Tech Information Technology.

Date:

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15812

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I would also like to thank the non-teaching staff for their help and support. Finally, yet importantly, I would like to express our heartfelt thanks to my beloved parents for their blessings, my friends for their wishes for the successful completion of dissertation proposal.

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DECLARATION

I hereby declare that the Dissertation proposal entitled, Enhancement in Mobility Based Estimation of Node Stability Technique Using Clustering Scheme in MANET, submitted for the M.Tech degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

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INTRODUCTION

1.1 Introduction to Wireless Networks

Traditionally the wireless networks were used which were single-hop infrastructure based having the access points to handle the communication among the nodes [3]. But it was not very feasible for the scenarios where the network for communication was urgently required for example in cases of some natural calamity or at some geographical places where deployment of the infrastructure is not possible. Hence, the Wireless Networks were introduced. The wireless networks technologies work without any physical connections that allow communication of wireless devices to and among each other without any requirement of an infrastructure network. These technologies use radio frequency transmissions to transmit data, whereas in wired technologies, cables are used. There is a vast variety of wireless technology ranging from systems, like mobile phones and Wireless Local Area Networks to devices like microphones, wireless headphones and many more devices which do not store or process the information. These also contain the infrared devices like wireless computer keyboards, remote controls, and wireless mouse, where all of them need a line of sight directly among the receiver and the transmitter to connect to each other. A brief elaboration about the wireless networks, standards and devices is discussed in this chapter.

1.1.1 Wireless Networks

A wireless network is a transport mechanism between and among devices. The wireless network provides a wide range of benefits as compared to the wired networks such as:

1. Deployment of a wireless system is very quick and easy and it also removes the necessity to deploy the cables through ceilings and walls.
2. Wireless networks can also be deployed at geographical places where wires cannot be deployed, for example in mountainous areas or deserted places.
3. Wireless networks are flexible and can be configured easily.

Figure 1.1 shows the scenario of a wireless network in which the three wireless devices are connected to the internet without any infrastructure. The wireless devices can be laptop,

mobile phone, personal digital assistants, satellite televisions, etc. the wireless devices can even connect to each other like in Bluetooth connection.

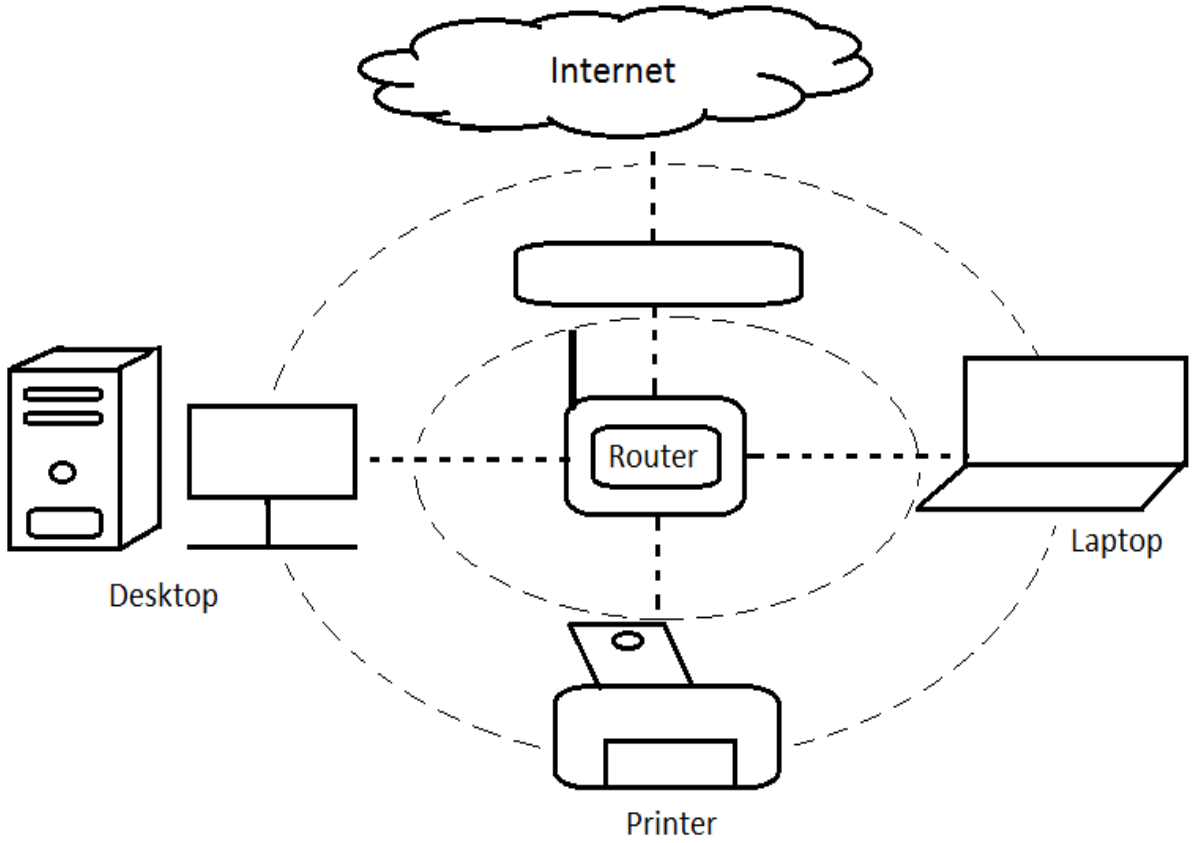

Figure 1.1 A Wireless Network

Wireless networks can be categorized in two parts:

1. Infrastructure-based wireless networks
2. Ad-hoc networks

Infrastructure-based wireless networks: the communication in Infrastructure-based wireless networks, takes place only among the wireless nodes present and the access points (AP). There is no direct communication between the wireless nodes. The AP controls the medium access as well as it behaves like a bridge to different networks, either wireless or wired. A number of wireless networks collectively can create a logical wireless network, so that together the access points along with the in-between fixed network can connect with many other wireless networks to collectively create a bigger network that will be beyond the range of the actual radio coverage.

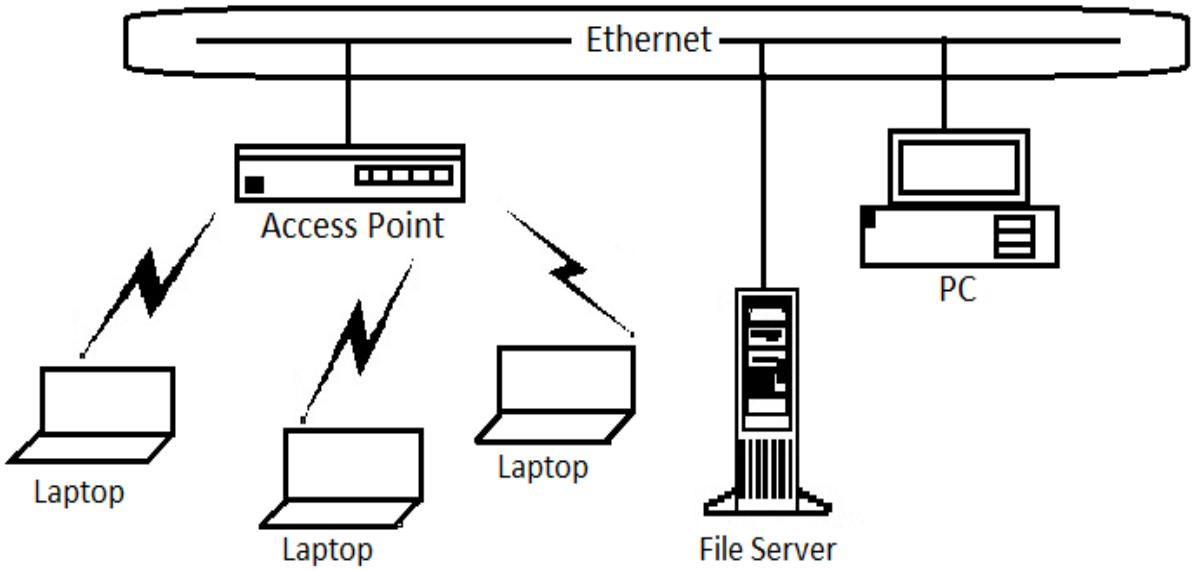

Figure 1.2 Infrastructure Based Wireless network

Figure 1.2 shows the infrastructure-based wireless network. The design of these networks is simpler as much of the required network functionality lies within the AP. In Infrastructure-based networks some of the flexibility is lost that the wireless networks can further offer, e.g., they cannot be deployed in any disaster scenario in cases when, due to destruction, no infrastructure is left.

One example for infrastructure-based networks is the typical Cellular Phone Network. The satellite-based cell phones also have an infrastructure, i.e. the satellites.

Ad-Hoc Networks: The term 'ad-hoc' is used for these networks because of their shifting network topologies. These networks do not require any infrastructure to work. No AP controlling medium is necessary and each node in the network can communicate directly with other nodes. The network is self-organizing and adapts to the change in topology which are generally due to link outrages or mobility of node in the network [1]. Nodes can only communicate within an ad-hoc network if they can approach each other physically, i.e., if the nodes are present within the radio transmission range of each other's or some nodes are present in-between that can forward the data to the nodes. Hence, nodes from the two different networks that are not in the same radio transmission range cannot communicate with each other. Figure 1.3 shows a scenario of ad hoc networks.

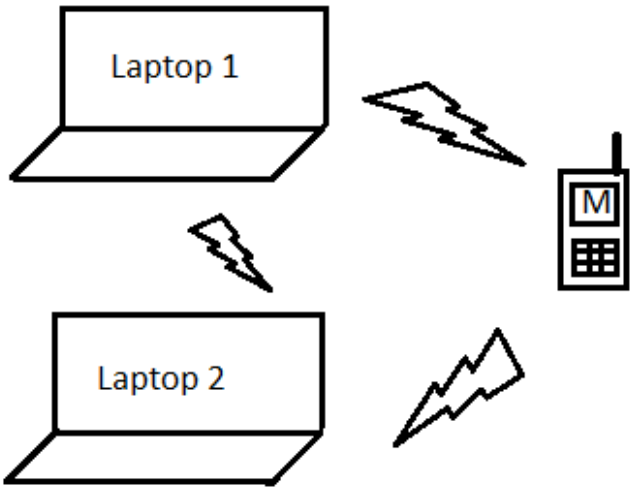

Figure 1.3 Ad hoc Network

The complexity of every node in an ad hoc network is very high, the reason for which is that every node has to deploy a medium access mechanism, to overcome the hidden and exposed terminal issue, and priority mechanisms to facilitate the required quality of service. This is a quick replacement of communication scenarios that are far away from any infrastructure, hence, exhibiting great flexibility whenever needed unexpectedly.

A good example of an ad-hoc network is Bluetooth. Master-slave configuration is done making a piconet. The master controls the flow of data being transmitted among the source and destination. As the devices in the network move in unpredictable manner, these networks have to be reconfigured instantly without much delay to cope up to the dynamic topology changes.

1.1.2 Wireless Networks Standards

The wireless technologies rely on various standards. These standards encourage mass production of devices and facilitate multi-vendor products to interoperate. The two standards that can be described in accordance to the wireless technologies are: IEEE 802.11 and Bluetooth. The wireless local area network follows the IEEE 802.11 standards. Ad hoc networks follow the proprietary techniques or they follow the Bluetooth standard. The standards have been described below.

IEEE 802.11: Wireless local area networks are based on this standard. This was designed to provide higher data rate and medium-range applications and to support portable and mobile stations. The major goal of the standard was to specify a simpler and durable WLAN which offers asynchronous and time-bounded services.

Bluetooth: Bluetooth is managed by Bluetooth Special Interest Group (SIG). This is a technology standard used to exchange data over short distances. It uses the master-slave structure for the communication. A piconet is formed in which a master communicates with the maximum of seven devices called the slaves synchronized to the same hopping sequence. The master controls the communication that is being done in the piconet and the hopping pattern is determined in the piconet, according to which the slaves synchronize themselves. Every piconet follows a hopping pattern that is unique. If any device has to participate in the piconet, it will have to synchronize to that pattern of the piconet. When groups of piconets are formed for the communication to be continued, scatternets are formed.

1.2 Mobile Ad hoc Network

A mobile ad hoc network (MANET) is an autonomous network that is self-configuring in nature and comprise of several mobile nodes that can be created whenever required without the need of any pre-established infrastructure. In MANET, each node can move freely in any random direction independently which makes the network extremely flexible. To properly route the traffic, each node in MANET maintains the information required. Since the nodes are mobile, they can even change the links to the other nodes frequently. The nodes also behave as routers called intermediate nodes to transmit data from a source node to a destination node. One big challenge that occurs in the deployment of a MANET is enabling each node to maintain the required information time to time to route the traffic. Such kinds of networks mainly operate according to themselves. The nodes are battery powered and hence, the issue of battery has always been there. Since, the links change frequently due to mobile nature, the problem of link failure generally, occurs. The mobile nodes form a cooperative kind of infrastructure acting both as end systems as well as intermediate systems.

Hence, as the network topology in MANET keeps on changing and also there is no pre-established network, there comes the requirement of an algorithm that is self-organizing so as to manage the network effectively [23].

Since, the growth of handheld devices likes laptops and mobile phones along with 802.11/Wi-Fi wireless networking; it has made MANET an evolving topic for research. Taking in assumption the mobility of the nodes inside the ad hoc network, many academic papers have evaluated protocols along with their proficiency with all nodes within a few hops. Evaluation of the protocols is based on metrics like end-to-end packet delays, the packet drop rate, overhead that is present inside of the routing protocol, network throughput, etc. This is a quick replacement of data transmission scenarios which are away from any kind of infrastructure to be deployed, hence, exhibiting great flexibility whenever needed unexpectedly. Figure 1.4 shows the scenario of a MANET.

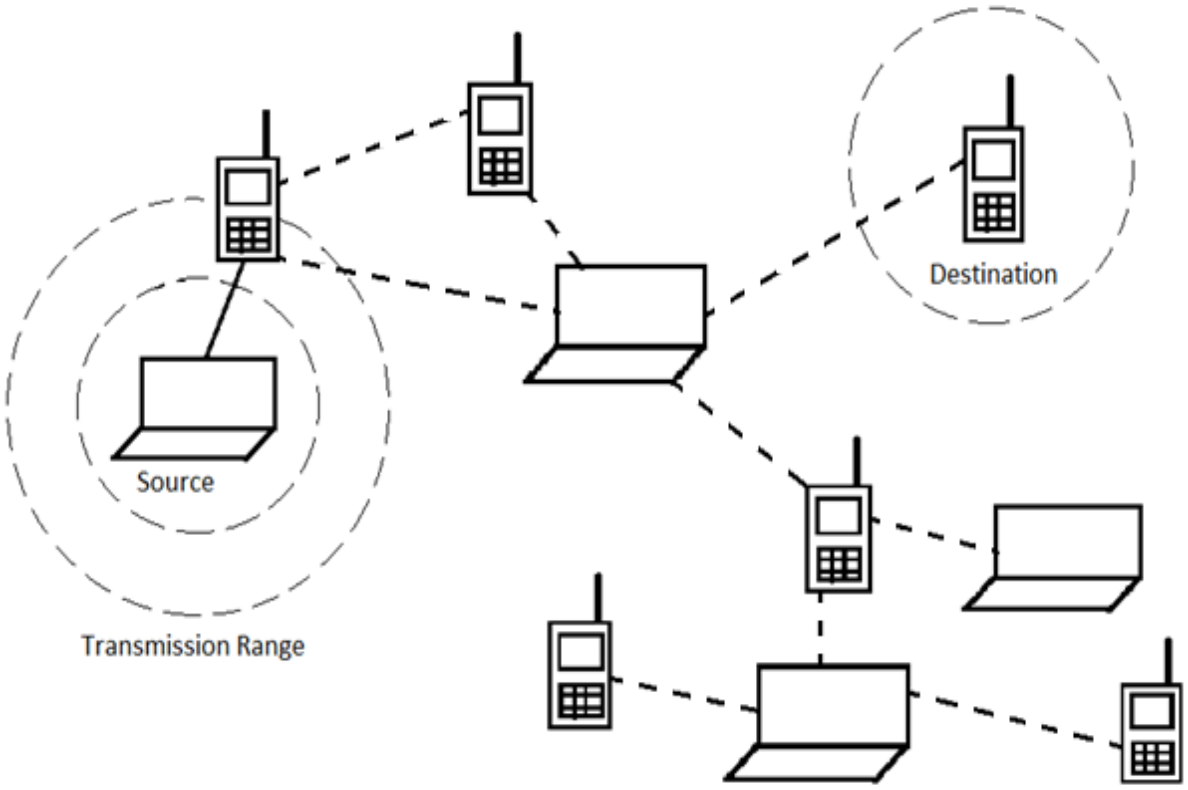

Figure 1.4 Mobile Ad-hoc Network

1.2.1 Types of MANET

MANET can be classified into three categories:

1. **Vehicular Ad hoc Network** (VANET): VANET is used for routing between and among the roadside equipment and vehicles.
2. **Intelligent Vehicular ad hoc network** (In VANET): This uses artificial intelligence that directs vehicles to act as an intelligent device in case of any accidents, drunk driving, vehicle-to-vehicle collisions, etc.
3. **Internet based Mobile ad hoc network** (iMANET): These networks are used for the linkage of the mobile nodes to the internet-gateway nodes. The basic routing algorithms do not apply directly in such types of ad hoc networks.

1.2.2 Applications of MANET

There are various applications of MANET. Some of the applications have been mentioned below.

1. **Emergency services**: MANET can be applied for emergency services such as search and rescue operations, crowd control, and disaster recovery operations. This can be a replacement for a fixed infrastructure in chances of any natural calamity like a tsunami.
2. **Tactical networks**: MANET can be used as tactical networks such as in automated battlefields, military communication and operations, etc.
3. **Sensor network**: MANET can also be applied as a sensor network which is a group of many embedded sensor nodes that are used to automate day-to-day functions by collecting the real time data. For example, remote sensors for earth shaking activities, weather, etc.
4. **Commercial environments**: E-commerce, described as electronic payment from any place. Vehicular services like reporting road conditions, news transmission, weather reports, and local ad hoc network with nearby vehicles to avoid accidents.
5. **Educational applications**: Setting up of conference rooms or virtual classrooms.
6. **Entertainment**: Multiuser games, robotic pets, etc.
7. **Location-aware services**: Services like transmission of actual workspace to current location, automatic call forwarding.

1.2.3 Challenges faced by the Mobile Ad hoc Networks

The following is the types of inefficiencies and limitations that have to be overcome in a MANET environment:

1. **Battery Constraints:** In mobile ad hoc networks, the mobile devices are mostly operated by batteries. Battery technology is still lagging behind microprocessor technology. There is a need for power conservation of the mobile devices as they perform the role of both end-to-end systems as well as an intermediate system and the forwarding of the packets on behalf of the others will consume power and hence, the good amount of battery power is required by the nodes to do the task.
2. **Broadcast nature of the wireless medium:** In a radio channel, the transmission made by a node is received by all the other nodes in the network that are within the transmission range of the node. Whenever there is a node receiving data, then apart from the sender node, there should be no other node in its neighborhood that should be transmitting any data to the receiving node. A node should get access to the shared medium only when its transmissions do not affect any ongoing session. Since multiple nodes may contend for the channel simultaneously, the possibility of packet collisions is quite high in wireless networks.
3. **Routing:** Since the presence of mobility among the nodes, the make and break of links is quite often and not deterministic. When considering the classical bellman-ford routing algorithm which is used to maintain and update the routing information in a packet radio network, since the nodes are fixed in nature or very less mobile. But in case of mobile ad hoc networks, there is a need of new routing protocols apart from the traditional ones so as to cope up with the frequent changes in the topology with frequent link changes.
4. **Media Access:** There is no centralized control and global synchronization in ad hoc wireless networks. Therefore TDMA and CDMA schemes are not suitable for such kind of networks. The presence of hidden terminals, exposed nodes and mobility must be accounted when designing MAC protocols for ad hoc wireless networks.
5. **Packet loss due to transmission errors:** There can packet loss in mobile ad hoc networks due to high bit error rate, hidden terminal problem which causes collision, unidirectional links, and frequent path breaks due to mobile nature of the nodes.

6. **Security and Privacy:** since the ad hoc networks are intranets unless there is some connectivity to the internet. Such kind of confined communication already has isolated attackers which are not local in the area. Since multiple nodes are involved in the communication, the packets that are to be relayed have to be authenticated by recognizing the packet originator.

1.3 Routing Protocols

Wireless networks, to offer last hop wireless connectivity, operate on top of a pre-constructed backbone infrastructure, e.g., cellular phone networks. It will be very advantageous for a wireless user to communicate without support of any fixed infrastructure to communicate with other users. Although, communication of such nodes will require the intermediate nodes to relay data when they are not in direct ranges of communication of their intended destinations. This kind of communication mechanism that is cooperative endows ad hoc networks with features like quicker deployment, higher mobility, distributed operation, and failure resilience. Such kind of features make MANET suitable for many operations such as rescue operations, battlefield communications, vehicular communication in urban areas, or network formed in any community areas, etc. Though, facilitating multi-hop communication in a dynamically changing network topology is far difficult than stated among the mobile nodes. Many factors like the wireless channel behavior, autonomous nature of mobile devices, limited battery and processing powers, etc. make it difficult. The route that is going to be followed can have multiple hops in between the source and the destination, hence, making the routing more complex than single hop communication [18]. Hence, any single routing protocol is not well suited for all application scenarios of MANET. Many routing protocols have been proposed for ad hoc networks in the past years. Some focus on minimal route establishment and quicker response to link failures, some focus on minimum control traffic and network scalability. Some try to optimize the network performance by considering factors like location information, or by distributing network into different zones or hierarchies. Hence, we can say that selection of a suitable routing protocol is crucial for any network's performance.

There are three types of protocols in MANET which can be classified as follows:

1. **Proactive Protocols**: These are also called Table-driven routing protocols. Each node present in the network maintains one or more routing tables that represent the entire topology of the network. The nodes regularly update these tables to maintain updated routing information from one node to all other nodes of the network. The topology information has to be exchanged on a regular basis among the nodes.

   Example of such kind of protocol can be Destination-Sequenced Distance Vector (DSDV) routing protocol. Disadvantage of a proactive routing protocol is that since the nodes have to regularly update their routing table, hence, battery power consumption is more and less bandwidth is present even in the idle state of the network. This type of routing protocols is not well suited for highly dynamic or large scale networks.
2. **Reactive Protocols**: These are also called On-demand routing protocols. These types of protocols are used for routing that creates routes only when required by the source node (SN) to transmit data to the destination node. Whenever the source node has a requirement of a route to the destination, it initiates a route discovery protocol process in the network. Once the route has been found, the process is completed. Some procedure of route maintenance is used to maintain the route once it has been established until either the destination becomes inaccessible along every path from the source or the route present is no longer desired.

   Example of such kind of protocols is Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR) protocols.
3. **Hybrid Protocols:** These protocols use the properties of both proactive and reactive routing protocols, i.e. frequent destinations routes and close neighborhood and are maintained proactively, and other destinations are searched on-demand.

   Example of such kind of protocols is Zone Routing Protocol (ZRP).

The figure 1.5 shows the various routing protocols that are used for the routing of the data in a mobile ad hoc network. Based on the topology and the area of the network, the specific routing protocols are used for the process of communication between the source and the destination.

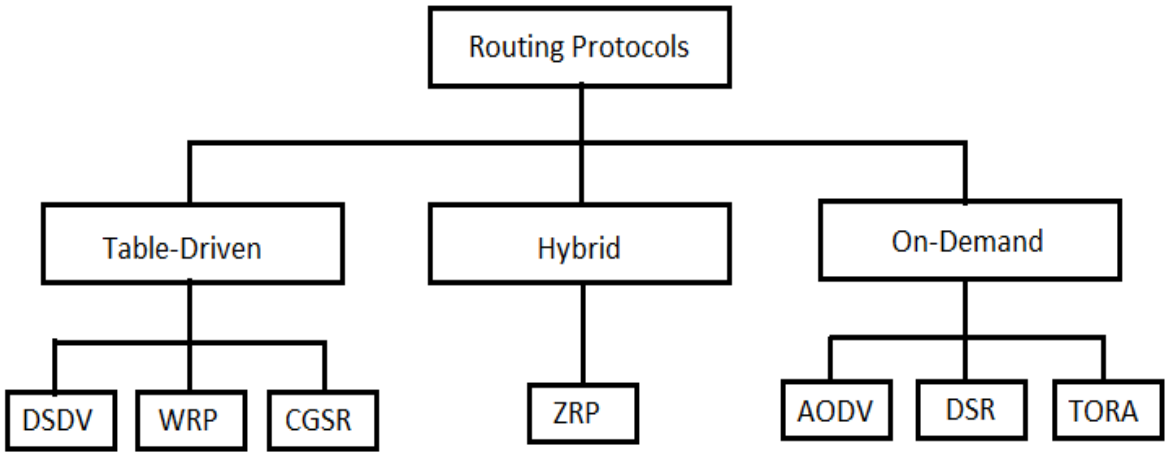

Figure 1.5 Routing Protocols in MANET

(a) Ad-hoc On-demand Distance Vector Routing (AODV)

AODV uses an on-demand Route Discovery and Route Maintenance mechanism for its working. For the data packet transmission in AODV, the source node (SN) and the intermediate nodes stores next-hop information which is corresponded to each flow for data transmission. The source node broadcast the RouteRequest (RREQ) packet inside the network when there is no route available to the destination. The AODV uses a DestinationSequenceNumber (DSN) to determine an updated path to the destination node (DN). If the DSN received for the current packet by the node is greater than or equal to the last DSN stored with the node having smaller hop count, and then the node updates its path information.

A RREQ carries the Source Identifier (SrcID), the Destination Identifier (DestID), the Source Sequence Number (SrcSeqNum), the Destination Sequence Number (DesSeqNum), the Broadcast Identifier (BcastID), and the Time to Live (TTL) field. The DesSeqNum that is accepted by the source describes the freshness of the route. When the RREQ is received by an intermediate node, the node either forwards the request or prepares a RouteReply (RREP) is any valid route to the destination is present with the node. By comparing the sequence number in the RREQ packet with the sequence number at the intermediate node, the validity of the route can be determined. If any RREQ has been received multiple times by a node, which can be indicated by the BcastID-SrcID pair, the duplicated copies get discarded. RREP

is transmitted by the destination node to the source node itself or via the intermediate nodes having the valid routes to the destination. While forwarding a RREQ, each intermediate node embeds the address of the previous node and it's BcastID. A timer is used to delete this entry in any case if a RREP is not received and the timer has expired. Hence, at the intermediate node an active path is stored. When the RREP packet has been received by the node, the information about the previous node which has transmitted the packet is also stored so as to forward the data to this intermediate node as a next hop towards the destination.

(b) Dynamic Source Routing (DSR)

Dynamic Source Routing is based on source routing instead of relying on the routing table at every intermediate node. A route cache has to be maintained by the mobile nodes that contain the source routes about which the mobile node is aware. All the routing information is maintained at the mobile node. The protocol consists of two steps, i.e. Route Discovery phase and Route Maintenance phase. When the source node has to send data to the destination node, it initially checks if it is having a route in the cache. If a route is present in the cache, it checks if the route is unexpired and if so, it uses that route to transmit the data. If there is no route found in the route cache, the RREQ packet is broadcasted to every ode present in the network. The packet contains Destination Address (DA), Source Address (SA), and Unique Identification Number (UIN). Each node that receives the RREQ checks if there is a path to the destination in their route cache. If not, the node adds up its own address in the Route Record of the data packet and further forwards the RREQ. A Route Reply (RREP) gets generated when either the RREQ has reached the destination or there is an intermediate node present which has a route towards the destination node in its route cache. At the end, the Route Record contains the sequence of hops taken. If the RREP is present at the destination node, it embeds the Route Record in the RREQ into the RREP. Else, if the RREP is at the intermediate node, then it embeds the cached route inside the route record and route reply. For the Route Maintenance, the Route Error (RERR) packets are used. RERR packets will be generated at the node when the Data Link Layer recognizes a transmission problem. The source node is always interrupted whenever a route is terminated. When the RERR packet gets received, the hop with error is removed away from the route cache of the node and all routes having the hop are removed at that instant.

(c) Destination Sequence Distance Vector Routing (DSDV)

Destination sequence distance vector routing protocol is a table-driven routing protocol which is based on the classic Bellman-Ford routing algorithm. In the algorithm, the improvement made is the avoidance of the routing loops in the mobile network of routers. A routing table is maintained by each node in the network which consists of all possible destinations within the non-partitioned network and the number of the routing hops is recorded to each destination. Hence, regardless of whether a source node requires a route or not, the routing information is readily available always. To differentiate between the stale routes from the new ones, a sequence number is used. Periodically, routing table updates are sent throughout the network so as to maintain table consistency. DSDV uses two types route update packets: Full Dump Packets and Incremental Packets. The former packet carries all available routing information and can require multiple network protocol data units (NPDUs). Whenever there is some occasional movement, these packets are transmitted less frequently. The latter ones are used to relay only the information that has changed since the last full dump. The address of the destination node, the number of hops to reach the destination, the sequence number of the information received regarding the destination, and the new sequence number unique to the broadcast are broadcasted in the new route.

1.4 Link Failure

The data packets are transmitted from the source node to the destination node through various intermediate nodes and if the there is a break in the link then the data packets might be dropped or lost. This is called link failure. This degrades the performance of the network and affects the important communication being held such as in a military area or a natural calamity. Hence, in route error messages are sent back to the source node so as to let them know that a link breakage has occurred and a new route will have to be defined. The link breakage can be due to low battery power, mobile nature of the node, or any bandwidth constraints. Figure 1.6 shows the occurrence of link failure between the two communicating nodes in which node 1 sends data to node 2 but node 2 is unable to forward it to node 3 since the link has broken in between the two nodes.

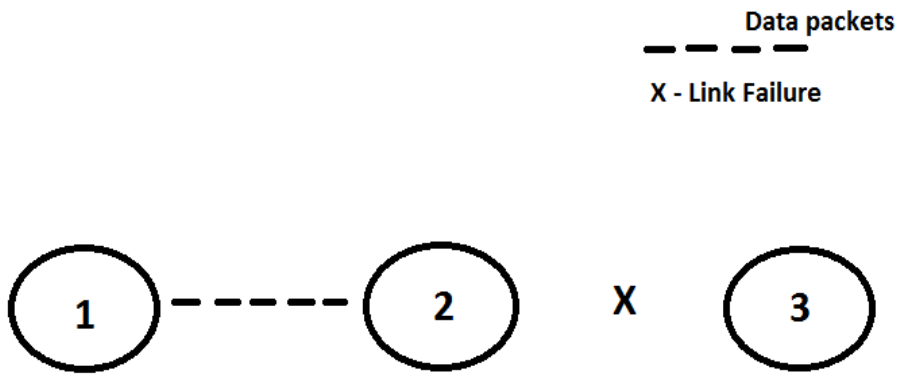

Figure 1.6 Link Failure

When successful communication is done various measures are checked out about that communication, some of which can be the throughput, packet loss, and delay.

1. **Throughput**: Throughput can be defined as the rate at which a successful message delivery is achieved over a communication channel. It is used to measure the performance of the network and the network connections.
2. **Packet Loss**: when in an wireless ad hoc network, since the nodes are not fixed to their positions, hence there can be packet loss which can be due to various factors such as movement of a node, no power in a node, etc. This degrades the network throughput since; retransmissions have to be done for the packets lost.
3. **Delay**: delay is called the latency which can be defined as how long it takes for an entire message to completely arrive at the destination since the first bit was sent out from the sender into the network. Delay is composed of:
    - Transmission time (T_{Trans}): The amount of time taken by the source to push the packet bits onto the link.
    - Queuing time (T_{Queue}): The amount of time spent by a packet in the routing queue.
    - Processing time (T_{Proc}): The amount of time taken to process the packet header.
    - Propagation time (T_{Prop}): The time taken for a packet to reach its destination.
    - Number of links (Q): The total number of hops through which the packet has travelled from the source to the destination.

$$Delay = (T_{Trans} + T_{Queue} + T_{Proc} + T_{Prop}) \times Q$$

1.5 Clustering Techniques in MANETs

Clustering in mobile ad hoc networks is a way of reconfiguring all the nodes in the network by dividing them into small groups which are virtually present. A hierarchical structure is created in the network. The division is done in accordance to the regional vicinity of the nodes and one of the nodes is selected as the cluster head. All the members of the cluster provide their information to their respective cluster heads and the routing in the network is done via the cluster heads. For every clustering technique, first the cluster formation is done and second, the cluster heads are selected. The cluster heads manage all the activities of the cluster such as, discovering the routes, updating of routing tables, and managing the processes of the clusters. Figure 1.7 gives a general view of clustering. The nodes with black color are the cluster heads while the gray color depicts the gateway nodes

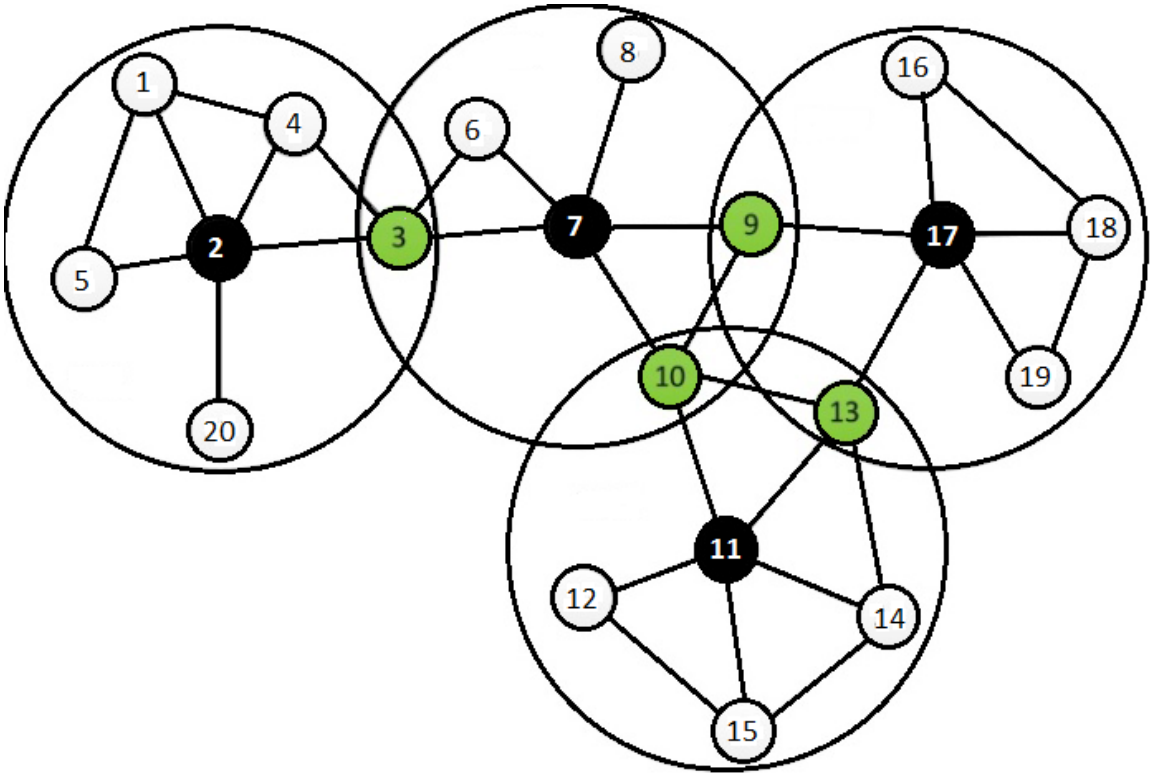

Figure 1.7 An example of Clustering Architecture

The nodes present in the clusters other than the cluster heads are called Ordinary Nodes. The nodes which are present at the edges of two different clusters are called the Gateway Nodes.

The cluster heads and the gateway nodes are responsible for the communication in inter-cluster routing. The scalability and the overhead problems are significantly reduced. When a node becomes unfit to continue further as a cluster head, re-affiliation techniques are used for the election of the new cluster heads. The current cluster structure in the network should be tried to be preserved as much as possible so that the excessive computation in the cluster maintenance is avoided.

1.5.1 Types of Clustering Techniques

There are various types of clustering techniques used in the division of the mobile ad hoc network. Following are some of the techniques discussed:

1. **Location Based Clustering**: In this, the information of the location of the mobile nodes is used so as to make the space of routing into smaller range. This reduces the overhead caused due to routing and also the broadcast storm is reduced.
2. **Mobility Based Clustering**: The nodes that are of the similar movement patters are confined in the same clusters.
3. **Power Based Clustering**: In this technique, the node with the maximum power is elected to be the cluster heads. Sometimes, even the node with the maximum serving time is selected as a cluster head.
4. **Weight Based Clustering**: In weight based clustering, various parameters are taken into consideration which are some weights and the node with the maximum value are elected as the cluster head. The parameters can be battery power, mobility, transmission power, degree of nodes, etc.
5. **Artificial Intelligence Based Clustering**: the cluster heads for the clusters in the network are selected based on the fuzzy logics estimated.

1.5.2 Advantages of Clustering

Clustering has many advantages in the mobile ad hoc networks when compared with the traditional networks. Some of them are mentioned as follows:

1. It helps in the reduction of the size of the routing tables used for routing and hence, improved routing.
2. The transmission overhead is reduced with the updating of the routing tables when there is a change in the topology of the network.

3. The communication bandwidth and the energy are saved in the ad hoc networks.
4. A better performance is achieved for the Media Access Control (MAC) layer, since the improvement in the power consumption, throughput, scalability and the spatial reuse in the network.
5. The information of the topology can be aggregated, since as compared to the nodes in the complete network, the nodes are smaller in the cluster.

Chapter 2

REVIEW OF LITERATURE

This chapter describes the study of the various research works that has been done in the previous years. There have been many researches that have been based upon the stability of the node and the route that has to be followed for the transmission of the data packets in a network. A brief description of the research work is described in the following paragraphs.

(Matthias R. Brust, Carlos H.C. Ribeiro, and Steffen Rothkugel, 2008) explain "Heuristics on Link Stability in Ad Hoc Networks". They have described about delay tolerant networks, the ad hoc networks, sensor networks, vehicular networks, etc. As these networks observe unplanned link failure, due to mobile nodes or some connection problems occurring inside the wireless medium. Ideally, the important processes and tasks are assigned to the nodes that observe less dynamic nature. The authors have reported on heuristics so as to classify nodes having links more stable than others. These heuristics that are described rely basically on local topological information present and are distributed fully. The authors have shown the occurrence of nodes with different levels of stability. The approaches that are applied to the heuristics are with different classification quality and are localized. The work is comprised of (1) introduction of a series of local heuristics, (2) developing an eligible methodology and metrics to check the quality of the heuristics, and (3) the results of the simulation. The results appear to be important in the areas of clustering algorithms. These algorithms might also take advantage of a prolonged stability of certain nodes topologically.

(SudipMisra, Sanjay K. Dhurandher, and Mohammad S. Obaidat, 2008) describe about "Node Stability-Based Location Updating in Mobile Ad-Hoc Networks". The authors have considered the location updating issue in mobile ad-hoc network. A location updating approach based on node has been proposed. They have simulated the proposed algorithm and compared to the traditional location updating algorithm taking in consideration different performance measures like the count of collisions occurring over the carrier, the energy consumed, and count of acknowledgements received. The simulation conducted show that the algorithm proposed outperforms the traditional location updating algorithm as have been used in previous routing protocols existing. It can be inferred from results that have been

obtained that the proposed algorithm is working more efficiently. It is able to effectively decrease the amount of energy consumed, the count of Hello packet acknowledgements that are routed and the count of collisions that occur in the network.

(Sahar Adabi, Sam Jabbehdari, Amirmasoud Rahmani and Sepideh Adabi, 2008) have proposed their work titled "A Novel Distributed Clustering Algorithm for Mobile Ad-hoc Networks". In this work they have proposed a new algorithm named distributed score based clustering algorithm for mobile ad hoc networks. They have considered the remaining battery, the number of neighbor nodes, and number of members, and the stability to calculate the node's score using a linear algorithm. When each node calculates the score, it should notify each of its neighbors about this. The nodes with the highest score become the cluster head of the cluster. A proposed work has been compared with the weighted clustering algorithm and distributed weighted algorithm in parameters as number of packets, number of re-affiliations, the lifetime of the system and end-to-end throughput and overhead in the network.

(Giovanna Carofiglio and Michele Garetto, 2009) have explained "Route Stability in MANETs under the Random Direction Mobility Model", the basic issue that arises in MANET is selecting of an optimal path present in-between any two nodes. The authors have advocated the method to improve efficient routing by selecting the most stable path to lessen the overhead and the latency occurring due to reconstruction of route. The study of both the probability of duration and the availability of the routing path are conducted. The focus is upon the case in which the nodes in the network move in accordance to the Random Direction model. The issue of selecting an optimum route in regards of availability of path is studied and an approach has been proposed so as to improve the efficiency of reactive routing protocols.

(SenthilVelmurugan Mangai and Angamuthu Tamilarasi, 2011) mentioned the work titled "A new approach to geographic routing for location aided cluster based MANETs". In the work, improved location aided cluster based routing protocol has been evaluated for the, MANETs that are enabled with the GPS for performance metrics such as the control head, packet delivery ration and end-to-end delay. When the cluster based routing and the exact location information of the nodes is used, the protocol reduces the control overhead that

results in high packet delivery ratio. Using the GPS, the end-to-end delay is reduced even when high mobility is present in the network. The performance of the proposed scheme is found to be better than the GPS free and GPS scarce MANETs since, the scheme forms stable clusters which contain members that remain within their associated clusters for longer period of time even when the targeted system has nodes speed that exceed the normal MANETs scenario.

(Javad Akbari Torkestani and Mohammad Reza Meybodi, 2011) proposed their work titled "A mobility-based cluster formation algorithm for wireless mobile ad-hoc networks". In their work they have described a proposal for a weighted cluster formation algorithm called MCFA which is based on learning automata. In this, random variables with unknown distributions have been assumed for the mobility parameters for the hosts. For each node, the expected relative mobility of each host is estimated with respect to the neighbors present which are done by sampling the parameters of mobility in different epochs. MCFA is an algorithm that is fully distributed where every mobile can choose its cluster head independently. This work is based on the local information that is received form the neighbors of the node and there is no need to synchronization of the host. When evaluated, the MCFA prove to be a better algorithm over the existing works for the clustering of the network which can be according to different parameters such as, control message overhead, cluster lifetime, number of clusters and the re-affiliation time. The weight that has been defined for each host is based on the relative mobility. The distribution parameters are unknown about the weights as random variables have been assumed. Whichever host has the maximum weight; it is assumed to be the cluster head. Host stability is ensured.

(Geetha Nair and Dr.N.J.R.Muniraj, 2012) presented "Prediction based Link Stability Scheme for Mobile Ad Hoc Networks". In this work, a prediction link stability scheme has been proposed to make form a balance with path stability, link, the neighbor node, and all the mobile nodes that extent the network. The purpose of the work is to provide better stability and reduce the packet loss. The scheme is comprised of four phases which are, checking for neighbor node stability, link, path, and total mobile nodes and, predicting the network lifetime in total. A better achievement has been performed in parameters of packet delivery

ratio, delay, overhead, network lifetime, and the energy consumption when compared to the existing method.

(Neha Gupta, Manish Shrivastava, and Angad Singh, 2012) have presented "Survey of Routing Scheme in MANET with Clustering Techniques". In this paper, an overview of various protocols is given in terms of their characteristics, functionality, benefits and limitations. A comparative analysis has been done to analyze the performance of these protocols, along with the comparison of existing works on clustering in mobile ad hoc networks. The work has been categorized as location based, artificial intelligence based, mobility based, weight based, and power based. The various advantages and the disadvantages of the techniques have also been presented. A comparative study and performance analysis of the different reactive routing protocols has been conducted. After the study, it has been observed that the performance for all the protocols was near-about stable in a low mobility and low traffic scenario. When in a sparse medium with low traffic, the performance was still almost stable. TORA is found to be giving a better packet delivery ratio. The AODV protocol improves as the medium becomes denser and the speed gets fast. Mostly a weight based approach for the clustering technique is used with various parameters such as, node degree, transmission power, mobility, distance, power, etc.

(Sunil Taneja and Ashwani Kush, 2012) stated the paper titled "Energy Efficient, Secure and Stable Routing Protocol for MANET". The factors such as, power, security, and stable routing have been combined and the new protocol is called Energy efficient secure and stable routing protocol. The random way point mobility model has been used. In the network, the results are for varying number of mobile nodes. For the evaluation, the performance metrics are taken as packet loss, normalized routing load, packet delivery ratio, throughput, and the average end-to-end delay. The proposed work of the protocol provides its purpose.

(Ibukunola. A. Modupe, Oludayo. O. Olugbara, and Abiodun. Modupe, 2013) have worked upon "Minimizing Energy Consumption in Wireless Ad hoc Networks with Meta heuristics". An energy function model has been described based on geographic adaptive fidelity (GAF), which is used to save energy consumption and is best known in mobile ad hoc network. Genetic algorithm (GA) and Simulated annealing (SA) met heuristics have

been compared in the work to decrease the battery consumption in the network. Both the techniques have been found to be optimal for the minimization of the energy consumption in the ad hoc network. The best fitness function value is determined by determining an appropriate size of the population and using it with the selected GA operators. As the results are compared, the GAF/GA model generated energy is not very much different from the one generated by the GAF/SA model. Hence, it can be assumed that the optimization based Meta heuristics are useful and effective for the minimization of the energy consumption in the mobile ad hoc network.

(Mohamed Aissa, Abdelfettah Belghith and Khalil Drira, 2013) explain their work titled "New strategies and extensions in weighted clustering algorithms for mobile Ad Hoc networks". A new strategy for the clustering of the wireless ad hoc network has been formed with improvements in the weighted clustering algorithm. Mathematically, a stability model and cluster size bound has been derived to replace sigma in the algorithm. There efficiencies have been proved. The work has outperformed the WCA compared in terms of the stability and the cluster formation. On demand, the non-periodic procedure is invoked for cluster head election. This reduces the computation and the communication costs. The framework has been constructed for dynamic organizing mobile nodes in a cluster where providing robustness in topological changes caused due to node failure, motion and insertion/removal is necessary.

(P. I. Basarkod, S. S. Manvi, D.S.Albur, 2013) have described in "Mobility based estimation of node stability in MANET" the stability factor of each node is described by analyzing the self and neighbor based mobility of the node. Providing an efficient, robust and low overhead unicast path from source node to destination node in MANET is a critical issue due to frequent changes in the mobility in the nodes and network topology (which cause frequent break down in radio links). Hence, checking the node stability with respect to the node mobility during path establishment is necessary. A method to find the stability factor of the node by considering self and neighbor nodes mobility has been proposed. The steps in finding the stability factor of a node are as follows. (1) All the nodes in MANET find the self-stability, i.e. when the node is moving to a new position with respect to its previous position. (2) Find neighbors stability of all the nodes in MANET by considering the

neighbor's self-stability, and (3) each node in the MANET will compute the stability factor based on self-stability and neighbors stability. The stability factor of a node may be used to establish a path from the source to the destination. The stable nodes in the path will provide higher packet delivery ratio and lower latency. Hence to check the node stability with respect to itself and its stability when surrounded by neighbors, we proposed two measurable quantities in our scheme that are node's own stability and neighbor node stability. Simulation results show clearly that node's stability will be affected under the influence of nodes movement and in the presence of varying number of nodes. Stability will be decreased when nodes are moving with higher speeds and connectivity of nodes will be stronger when more number of nodes is present.

(Mallikarjun B. Channappagoudar and PallapaVenkataram, 2013) have researched the work in which two systems are defined in the architecture: 1) Central monitoring system: A static agent (SA) is defined in this system which creates/destroys and deploys the mobile agent. 2) Central monitoring system: A static agent (SA) is defined in this system which creates/destroys and deploys the mobile agent. Mobile monitoring system: A Mobile agent (MA) is created by the SA migrates to all the zones defined to collect the information and interpret it and send it to the SA. The status monitoring segment collect information provided by the MA and interprets it and informs back to the MA if any kind of abnormality is found. The work is described as a distributed and a lightweight scheme.

As described by **(Ayesha Haider Ali, FariaKanwal, and KomalBashirthe, 2013)** main concept of the work is the selection of a Lead Node that will manage the level of energy of the nodes present in the network centrally using an Energy Table (ET). The selected route is based on per node and not per flow so as to avoid any drainage of any particular network path or node. A node will be selected as a lead node (LN) that will centrally manage the energy levels of other nodes by managing the energy tables. Work has been divided into 2 stages: a) selection of a lead node b) selection of energy aware route. In consideration that efficient management of energy is an important concept to increase the performance of MANET and network lifetime, the authors have developed an energy oriented power aware approach to optimize the energy consumed per node so that the nodes do not get exhausted in the path. The proposed mechanism is controlled centrally and managed by the lead node so

as to prevent any involvement of nodes in the selection of network routes based on energy levels. Hence, throughput of the system gets increased along with network performance bottle neck that is reduced.

(Abedalmotaleb Zadin and Thomas Fevens, 2013) address their research "Maintaining Path Stability with Node Failure in Mobile Ad Hoc Networks" which focuses on protection of the route of wireless mobile communications when node failure is present so as to improve the use of the nodes in MANET applications by discovering channels with efficient stable communication having increased number of packets delivered and longer lifetimes. A protocol based on node protection, which allows establishment of stable connections that experiences node failure occasionally. The proposed node protection protocol can be used as an improvement in the stability in communication in MANET having increasing realistic conditions that consist of occasional failure and node movement.

(Vibhor Kumar Goal, RishabhShrivastava and Vivek Malik, 2013) have explained "An Algorithm for Improvement of Link Failure in Mobile Ad-Hoc Network". An efficient routing algorithm is proposed that improves the efficiency of link failure in terms of power as well as bandwidth which improves the quality of services. In this routing protocol, there are some parameters used like TTL, Available Power List and Available Bandwidth List for communication. The routing protocol determines the minimum available power between sources to destination. Then source node decided the path which has maximum available power between source nodes to destination node.

(Stuart MacLean, Suprakash Datta, 2013) have described their research titled "Energy Constrained Positioning in Mobile Wireless Ad hoc and Sensor Networks". In the work, the problem to manage the tradeoff between the positional error and energy usage has been considered for the positioning algorithms. The positional error is improved as greater energy consumption cost. To govern the node's GPS unit, the strategies proposed were: error, random, and fixed. Different node speed and GPS activation level were experimented to compare the performance with respect to the positional error for activation strategies. The strategy for the error activation depends upon the positional error that has been estimated. It is superior to both the fix activation strategies and the random activation. When using the same energy in all comparisons, there is a significant reduction in the positional error

achieved by the random strategy achieved by the energy strategy. The node speed is depended upon for the decision of activating the GPS unit of the node. After a certain level, the GPS activation gives no result, and the mean positional error decreases.

(GaoXun, 2013) has proposed a clustering algorithm which employs Learning Automata (LA) in a distributed way which takes up the parameters of nodes distance and the mobility of the nodes which will be used to produce stable clusters. When using LA, the nodes can take decisions that are intelligent enough and adaptive in nature which will be based the information which is collected locally in earlier time. In the proposed algorithm, the node i first updates itself when it receives the Hello messages from its neighbors. The node then calculates the probability of the other nodes for them to be in the same cluster which has to be greater than 0.5. The node then declares the cluster head and maintains the cluster. The node that has the biggest number among its all neighbors is declared as the cluster head. All the clusters head's one hop neighbors are the cluster members (CM). In a cluster, the nodes with the same mobility pattern can be the member of the cluster. The cluster that is forms by the proposed technique are more stable making the algorithm a beneficial one for a network having mobility feature in group.

(V.Ramesh and Dr.P.Subbaiah, 2013) have stated their work titled "Energy Management Scheme with Load Balancing for Preemptive Dynamic Source Routing Protocol for MANET". For the new on-demand new on-demand routing protocol, the authors have proposed a load-balancing method. In this method, on the basis of the minimum energy availability, at any time, the PDSR selects a route of the nodes and the energy consumed per packet for that route in the given time. The PDSR increases the end-to-end delay and packet delivery ratio. Around 40% of the energy is saved at each node. According to the authors, the mechanism described can also be applied to reactive protocols, when some minor changes are done.

(Moazam Bidaki and Mohammad Masdari, 2013) have presented the work titled "Reputation-Based Clustering Algorithms in Mobile Ad Hoc Networks". In their work, it has been illustrated about the reputations integrated in the trust-based clustering techniques. Various parameters have been taken to compare the two schemes. The state of the trust-based clustering schemes have been analyzed which are aimed for the detection and the isolation of

the misbehaving and the malicious nodes which have low processing overheads and low communications. Hence, whenever selecting security mechanisms, their overheads should always be considered along with the environmental security requirements. There is a lack for the solution for operating the mobile ad hoc networks in a secure as well as hostile environment.

(M. M. El-Gazzar and Ben Bella S. Tawfik, 2013) discuss "Power Saving Management in Ad-Hoc Wireless Network". A sequence of procedures is used for the power savings that are done. The function for the power saving method describe the important steps to turn off the transmitter and receiver for a station in power saving method which informs about the other stations, to retrieve information about pending packets, and to transmit or receive traffic. For both the ad hoc networks and the infrastructure networks, the power saving function is different. For the ad hoc network, the power saving function uses a distributed manner to operate upon. By setting the power bit in the frame header, the station willing to enter the power saving mode, will have to complete an exchange of frame with another station successfully. The information regarding the estimation of the power-saving status is based upon frame exchange of the last data or the information locally.

(May Cho Aye and Aye Moe Aung, 2014) presented "Energy Efficient Routing for MANETs using On-demand Multipath Routing Protocol". They have proposed an energy efficient routing protocol that is based on the transmission power and residual energy of nodes for selecting an energy efficient path. The energy efficient routing algorithm is used to reduce the energy consumption in order so that the lifetime of the network increases. The proposed routing algorithm EER-AOMDV has been compared with standard AOMDV routing protocol for average energy consumption. The simulation results analyzed show that the new protocol maximizes the network lifetime by less energy consumption.

(R.Aiyshwariya Devi, and M.Buvana, 2014) stated "Energy Efficient Cluster Head Selection Scheme Based on FMPDM for MANETs". A fuzzy multiple criteria decision making approach is introduced that is based on hierarchical fuzzy integral and fuzzy parameter decision-making to select the cluster heads in an optimal manner to create a distributed energy-efficient algorithm for clustering. The cluster heads use three criteria that include the

residual energy of the nodes, the number of neighbors, the distance from the main node to the location. As the results are reviewed, the approach is quite effective to maximize the connectivity within each cluster and for localization of high intensity traffic within a cluster.

(HarpreetKaur, Gurbinder Singh Brar, Dr. Rahul Malhotra, 2014) proposed their work titled, "To propose a novel technique to reduce link failure problem in MANET". In this work, an enhanced AODV protocol is used. The techniques will follow only the path which has the highest signal strength. Header part is added in RREQ message which helps to find out the destination. Destination nodes check the vicinity of the adjacent nodes and those nodes further checks the vicinity of their adjacent nodes. After that source find out the average of the path. The path which has the maximum average value is selected as the final path. This work will help to reduce the problem of link failure and packet lost problem.

Chapter 3
PRESENT WORK

3.1 Problem Formulation

MANET is a very useful concept in the world of wireless technologies. These are very advantageous as they are easy and quick to deploy whenever needed. They can be deployed in emergency scenarios where there is no possibility of deploying an infrastructure for the communication to be held out of the affected area. Hence, it is important to keep a check on the network and make the best efforts so that there is no problem of any link failure due to energy or mobility in nodes present in the network. As, if such a situation occurs, this might affect the communication being held in the network.

In MANET, there are high chances of link failure due to many factors, some of which can be named as low battery power, highly random and dynamic topology of the network, moving of any node out of the transmission range of the node that is sending the data. Hence, an effective technique is required so that the chances of link failure due to mobile nature of the nodes can be reduced.

The stability factor of the nodes has been calculated, to create a link for the routing of the data packets from the source node to the destination node, in the previous research. For this, each node in the network calculates its self-stability based on its transmission range which can be described as the node's movement with respect to its current position. If the node moves away from its current position, the transmission range and the distance of the movement decide the stability. The node is said to be stable if its movement oscillates within a given fraction of the transmission range. The mobility and the speed in the given fraction of the transmission range are as desired by the administrator and hence will not affect the node stability. After the stability of the node has been calculated, the stability of the neighbor node is calculated. It can be descried as how well a node is being connected to its neighbor in terms of their self-stability. The nodes exchange messages with each other nodes that are present within the transmission range via the Hello messages. Each node hence collect connectivity information and the signal stability of the one hop neighbors and maintains a

neighbor list which contain an identifier for each neighbor. Hence, the neighbor node stability of any node ‘n’ at a given time ‘t’ with respect to all other neighbor nodes can be given as the ratio of the sum of all the self-stability of neighbors to the degree of the node ‘n’. The degree of the node can be described as the number of neighbor nodes ‘i’ connected to it denoted as ND.

Hence, using the values of the self-stability and the neighbor-stability, a single weighted metric call stability factor is derived. The stability factor of only the stable nodes is calculated. Hence, high stable nodes are extracted and the network topology is restricted to stable nodes so as to reduce the probability of link failure due to mobility in nodes.

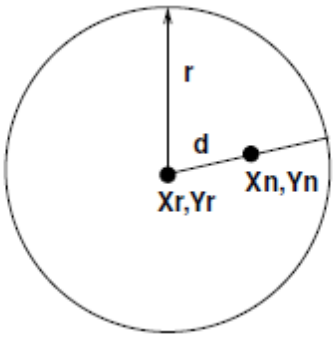

Figure 3.1 Node Movement

As we see, the transmission range of the nodes is considered for them to be stable enough to the data from the source to the destination and hence, making a stable route. But as observed, there is no consideration of what if the node that is considered to be stable enough to route a packet is deprived of the battery power and there is no enough battery power present in the node that is being used for the routing of a data. Hence an effective measure has to be taken for the node to be stable enough in terms of its transmission range as well as the battery power to be considered for its stability.

The figure 3.1 shows the movement of the node in the work for the mobility based stability of the node in which ‘r’ is the transmission range of the node and the movement of the node is shown from the (x_r,y_r) coordinates to the (x_n,y_n). It is said that the node will only be stable

if the movement of the node is less than the half of the transmission range of the node. This is called the self-stability of the node.

3.2 Objectives

A mobile ad hoc network (MANET) is an autonomous network that configures by itself comprised of several mobile nodes that can be deployed any time without the requirement of any pre-established infrastructure or centralized administration. The mobile nodes can move freely in any random direction independently hence, making the network extremely flexible. The communication is a multi-hop communication from the source node to the destination node. Each node acts as the source node, destination node, as well as a router to forward the data packets through it from the source node to the destination node. Being an ad-hoc network, the nodes in the network can move randomly in any direction, hence, creating a dynamic topology of the network which makes the communication infrastructure less. This is a major advantage of the MANET and hence, it can be used in emergency situations like any natural calamity, any war-like situations where there is no scope of deploying an infrastructure immediately for communication to be held.

There are various factors that can affect the communication taking place in a network which can be connection loss due to network topology change, low battery power, etc. The stability and minimum required energy of the node in a MANET is very important so that there is a continuous flow of information from the source node to the destination node without any interruption. If a node that is being used in the routing of the data is not a stable one, the communication might stop and there may be a link breakage which can lead to severe problems of data loss when the communication is done in any important scenario, e.g., a natural calamity. Hence the enhancement of the routing algorithm is an important part. This enhancement will overcome any problem of connection loss due to mobility in the network or due to less energy in the node during data transfer from the source node to the destination node. Whenever a data packet is to be transmitted from the source node to the destination node, the path which is most efficient is selected in order to achieve the best and optimum results. The problem occurs when the route is not stable enough. This can due to the property that the nodes in the network are mobile. The result is link failure. Due to breakage in the link the data packets get lost and hence, an efficient communication cannot be done.

Minimization of the link failure issues is a major concern so that the data packets can be sent from the source node to the destination node properly without any packet loss. Many researches have been done on the stability of the link. The work will enable us to lessen the chances of connection loss and packet loss problem. Hence, the performance degradation problem will improve.

In proposed work, certain measures are taken to enhance the communication between the source node, intermediate node, and the destination node.

The objectives of the study are as follows:

1. To propose enhancement in stability technique to overcome the problem of link failure occasions occurring due to mobility and low energy of the node.
2. The proposed enhancement will be based on clustering of mobile nodes in MANETs.
3. To implement the present and proposed enhanced techniques and thereby, analyze the results of both techniques in terms of throughput, delay, and packet loss.

Hence, by using the proposed scheme, we are trying to enhance the stability technique to overcome the issue of connection loss due to the mobile nature and low power of the nodes. We introduce the concept of clustering and the algorithm to select the cluster head in the network, and hence, reduction in the delay and packet loss in the network and increasing the throughput of the network.

3.3 Research Methodology

The mobile ad-hoc network is a self-configuring autonomous network in which the mobile nodes mobile and move freely in the area where it is deployed. Since, the mobile ad hoc network is of decentralized type, there rise issues in routing of data packets from source node to the destination nodes. Among all the issues arising, one is the issue of link failure due to the mobile nature and low battery power of the nodes in the network which tends to degrade the performance of the network. To reduce the chances of such a link failure due to the node mobility, stability value based technique had been proposed earlier in which the stability value of each mobile node has been calculated and on the basis of the stability of the node, routing of the data packets has been performed in the network.

As it has been observed in the previous work that there is no consideration of the battery power while considering a node to be stable or not; only the transmission range is considered to check the stability of the node; hence, there is a need to also consider the battery power of the node for it to be stable along with the transmission range.

Firstly, a link failure scenario is created in which the link gets failed due to a node movement while an ongoing communication between the source and the destination. In the proposed technique, an enhancement has been made in the work for calculation of the nodes to be stable enough by dividing the whole network into different clusters and by also considering the battery power of the node along with the stability factor of the node for it to be stable enough so that it can be considered to for routing of data from the source node to the destination node.

In the work, the network is divided into clusters. Location-based clustering is used to form the clusters in the network. In location-based clustering, the information of the mobile nodes is used to the routing space into a smaller range. This reduces overhead caused due to routing and broadcast storm. Once, the network is divided into the clusters, mechanism for the selection of the cluster head is followed. To select the cluster head, all the nodes in the clusters are checked for their current energy. The nodes which are having the current energy greater than the threshold energy are considered for the further election process of the cluster head. Now all the nodes are checked for their rate of consumption of their energy. This rate of consumption of the energy is used to calculate the serving time of the node for which the node can serve as a cluster head. Also, the stability factor of each node is calculated. A weighted parameter is assigned to both the serving time and the stability factor of the node and added together. The node with the greater value is elected to be the cluster head. And if any node moves from its position then the cluster re-election is done. Hence an enhanced work is done by also considering the energies of the node.

In the figure 3.2, the transfer from the source node to the destination node is shown using the AODV protocol. The source has to send the data to the destination. The route request is send till the destination from which the route reply is sent till the source and an optimal path is selected for the routing. Now, as the communication is being held, in between the communication an intermediate node moves from its position and due to this the intermediate node previous to this node is now unable to send the data any further till the destination. This

causes link failure and now, again a new route will have to be found by repeating the same process of source sending the route request till the destination and destination sending the route reply to the source for the path selection.

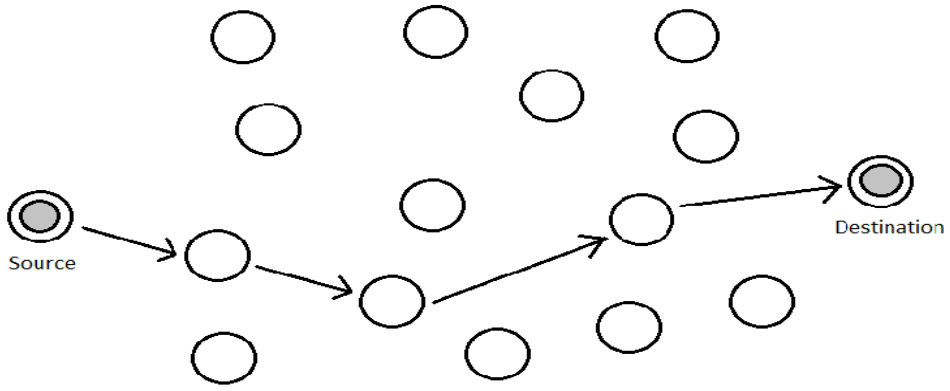

Figure 3.2 Data Transfer with AODV Protocol

In the figure 3.3, link failure is shown when a node has moved from its position during an ongoing communication and hence, the packets are dropped in between the communication which in turn degrades the performance of the network. Hence an effective technique is used in the proposed work so that there are less chances of link failure in the network and the throughput of the network is increased. Hence, the network is divided into clusters and the stable cluster heads are elected.

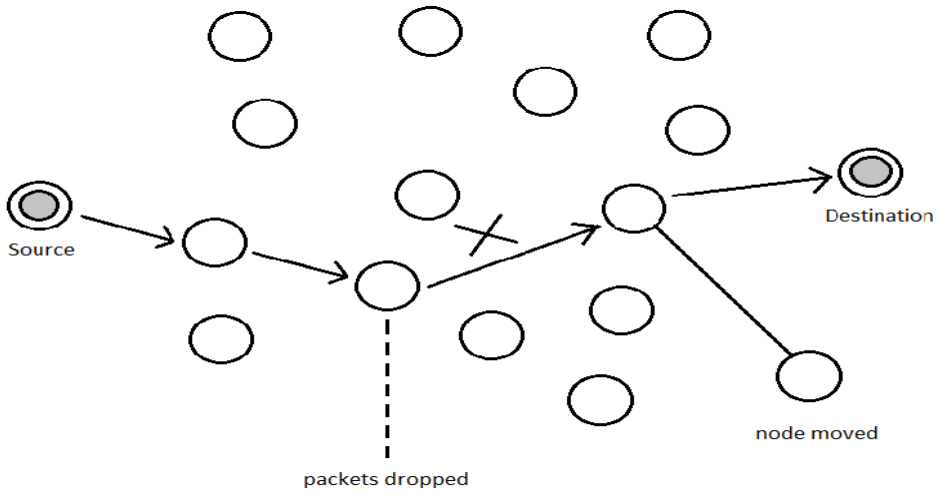

Figure 3.3 Link Failure in the Network due to Node Movement

The location based clustering is described in the figure 3.4 each cluster has a stable cluster head which has been calculated on the basis of the serving time of the node and the transmission range of the node.

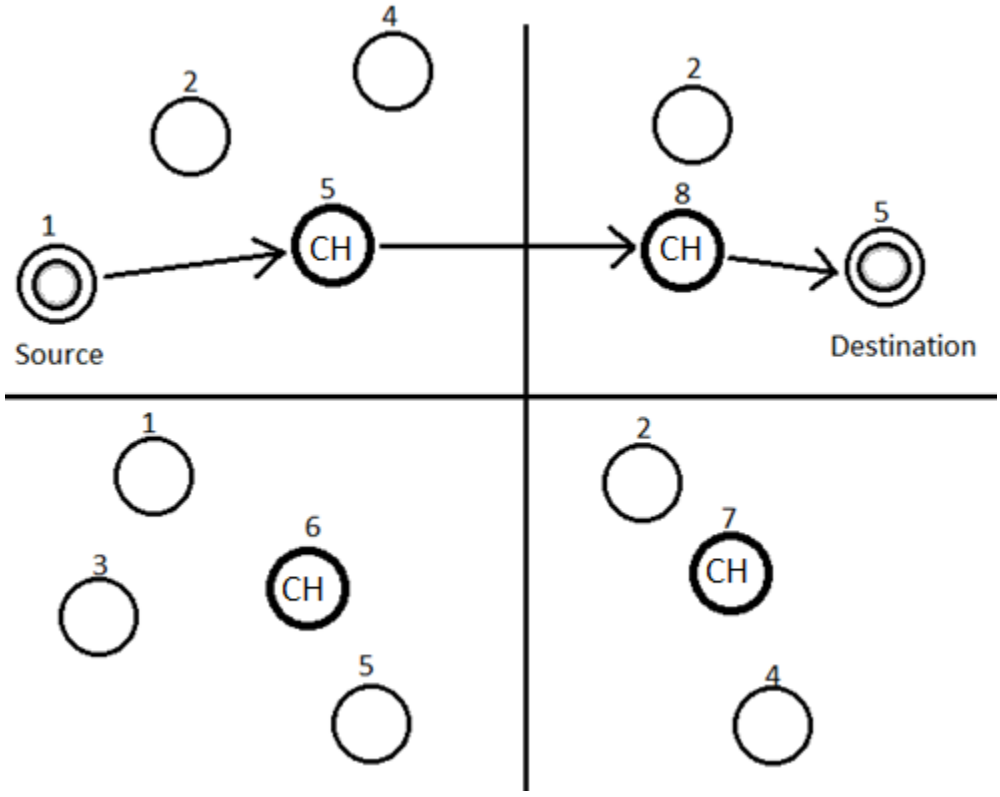

Figure 3.4 Network divided into Clusters

In the figure 3.4, a mobile ad hoc network is divided into clusters. When selecting a cluster head, the energy of each node is calculated. Now the nodes with energy greater than its threshold are considered for the further election process. The rate of consumption of the energy is checked from which the serving time of each node is calculated. Also, the stability factor of each node is also calculated. Now a weighted value is calculated by adding the both.

Value = w1 x serving time + w2 x stability factor

The node with the maximum value is considered to be elected as the cluster head for that cluster. Now, communication is shown from the source node to the destination node using AODV protocol and finally, the results are compared to with the previous work with respect to the packet loss in the network, the end-to-end delay and the throughput of the network.

Flow Chart for the Proposed Work

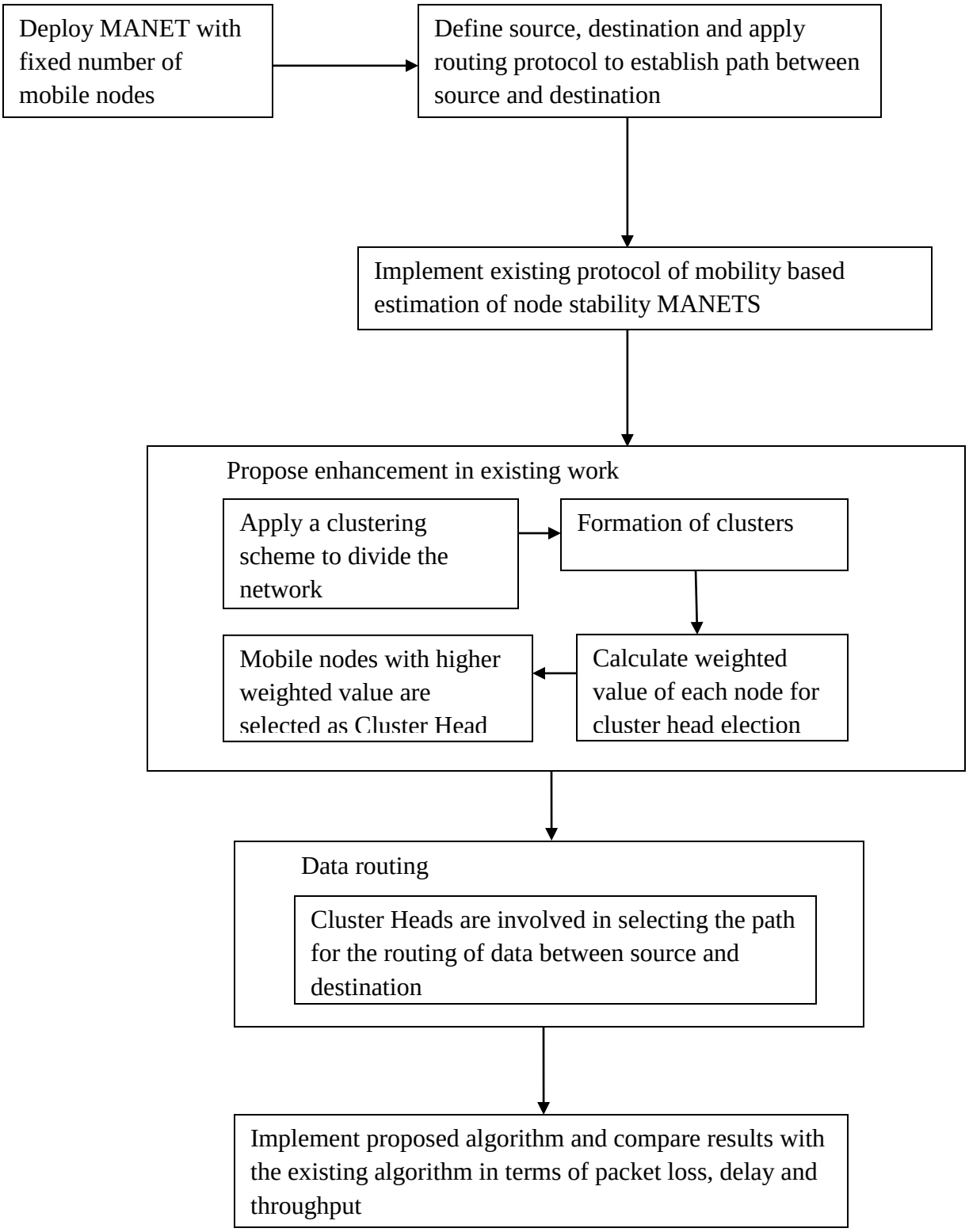

Figure 3.5 Flow Chart

Further, a flow chart has been shown which describes the various steps of methodology that is followed in the work done for the implementation of the proposed work. First we deploy a mobile ad-hoc network with a fixed number of mobile nodes. Source and destination will be defined and routing protocol will be established. Existing protocol implemented. The proposed work is to be implemented for the enhancement in the existing work.

The area will be divided using clustering technique. The algorithm for the selection of the cluster head will be implemented. The cluster head is selected on the basis of the weighted parameters that have been taken as the stability factor of the nodes in accordance to their transmission range and the serving time of the node for which it can serve as the cluster head. The node with the highest value is selected as the cluster head of the cluster. Now, when the data routing is done, the shortest path between the source and the destination will be selected. The routing is done via the cluster heads only from one cluster to another or when within a cluster. One hop cluster head is chosen for each cluster in the network. The results of the proposed work will be compared to the existing work.

Chapter 4

RESULTS AND DISCUSSION

The simulation has been done in ns2 simulator. In NS2, the executable command is ns that is used to take the input argument along with name of a .tcl simulation scripting file. A simulation trace file is created on the execution of the command and is used to plot graph and or create animation. It is an open source tool. It supports purpose of networking research for protocol design, traffic studies, protocol comparison, and designing of new architectures. NS2 supports two languages, C++ and Otcl. Otcl is used for the control of the simulation scenario configurations and manipulate the existing C++ objects. It assembles and configures the objects as well as schedule discrete events, i.e. the frontend. It is fast to write and change. C++ is used for data per packet processing as it defines the internal mechanism, i.e. the backend. It is the core of the ns. It is fast to run, detailed, and gives complete control.

C++ is fast to run but slower to code and change, whereas, Otcl is easy to code but it runs slow. NAM is the network animator which is used as visualization trace tool. Nam editor is a GUI interface to generate ns scripts.

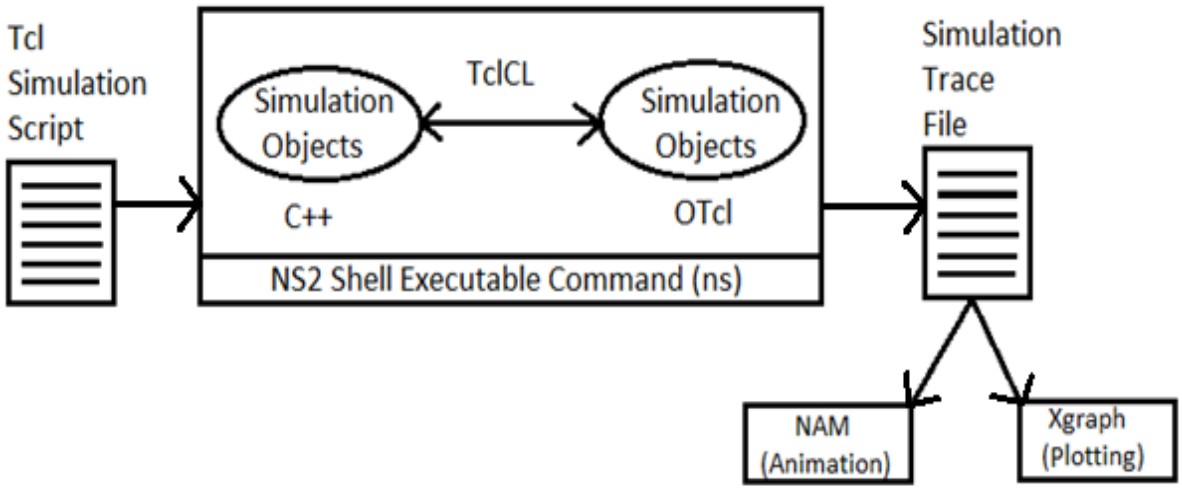

Figure 6.1 Basic Architecture of NS

6.1 Defining the existing work

In the proposed work a network system of 1000 X 1000 is considered where the type of propagation is wireless. The total numbers of packet that are sent from source to destination are 50.

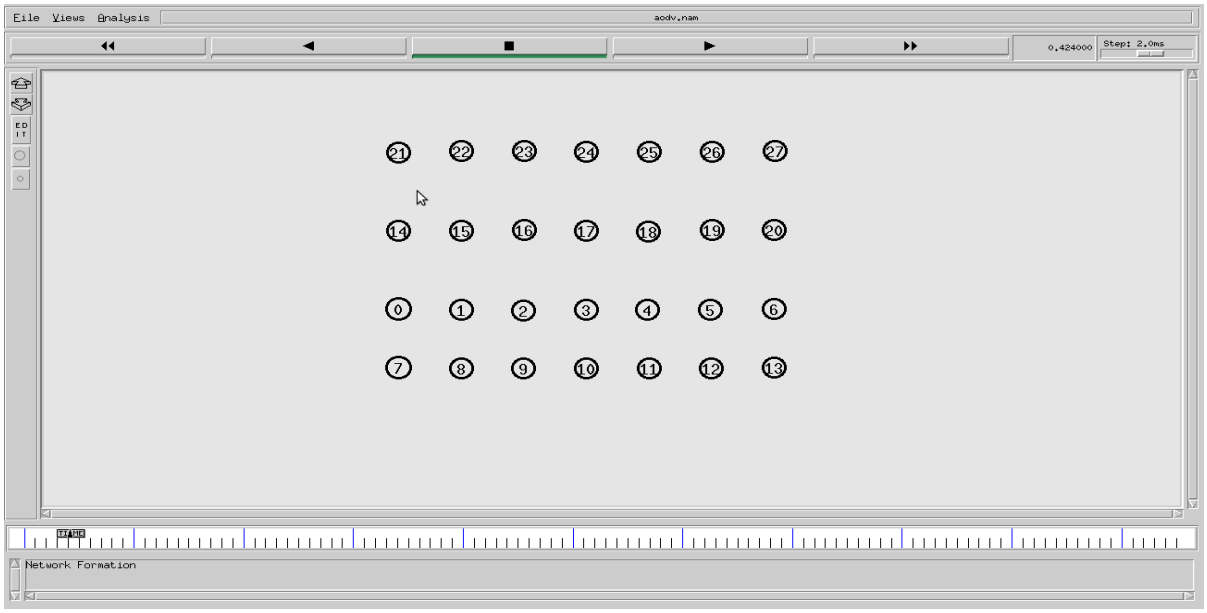

Figure 6.2 Deployment of the Nodes in the Network

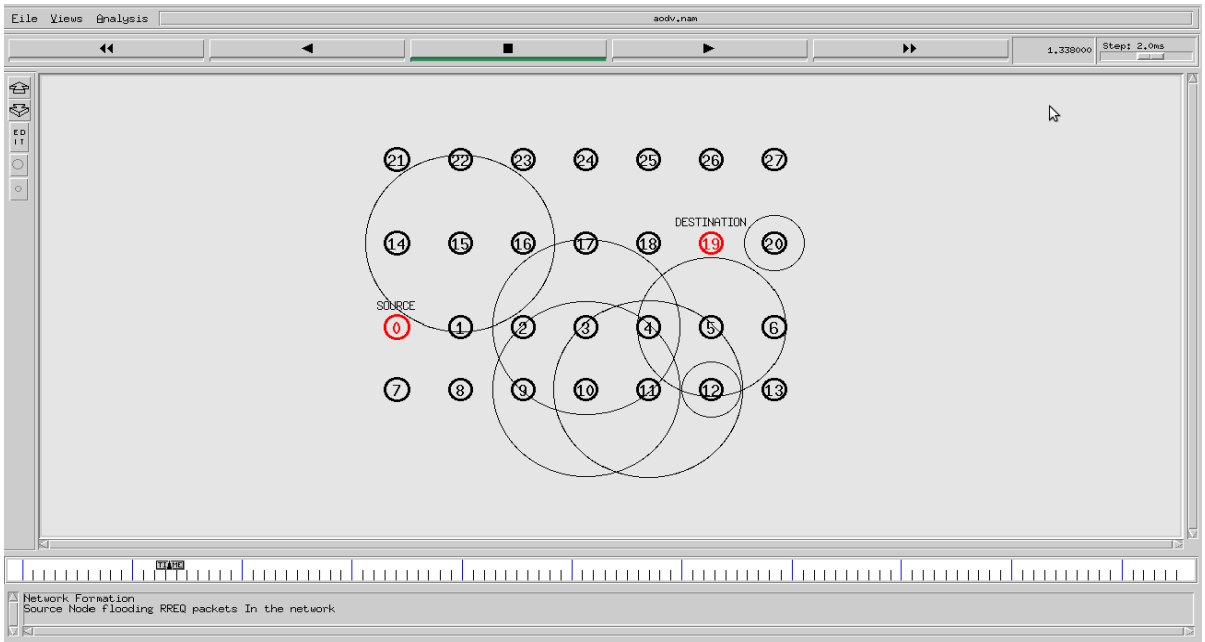

Figure 6.3 Source and Destination

The source and the destination are defined to make the communication between the two. The snapshot has been shown in figure 6.3. The source and the destination are defined with red color.

After the deployment of the network and defining the nodes, AODV algorithm is applied. The initial step in AODV algorithm is such that RREQ (Route Request) message is sent from the source node to their one hop node and this node forwards RREQ to next node present at another hop and this is done till the destination is reached. While this transmission is performed the broadcast id and the sequence number for each path is defined which keeps on increasing at every hop. On the basis of sequence number and hop count the best path is selected. Figure 6.4 shows the route request flooding.

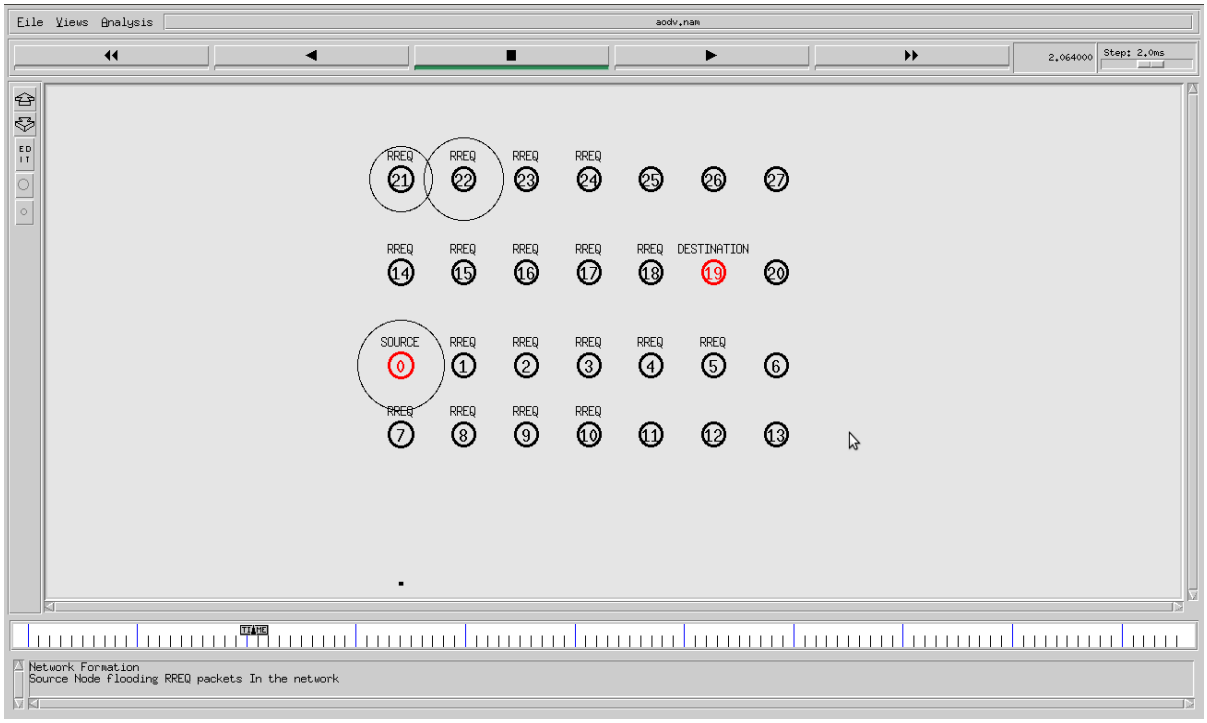

Figure 6.4 Route Request Flooding in the Network

Now, RREP (Route Reply) is sent from the destination node to the source node. The RREP message follows the same path followed by RREQ and the broadcast id and sequence number increases whenever fresh route availability is seen. The following snapshot shows how the scenario looks like, that is, how data packets are sent from destination node to source node. The RREP message is sent broadcasted to every path which was first accomplished by

RREQ. RREP follows the same path as that was followed by RREQ but the traversing is from the destination node to the source node. On establishment on AODV routing protocol, the sequence number keeps on increasing and at every hop sequence number of nodes are compared with the sequence number of the next hop node. Node with the higher sequence number replaces the node with less sequence number. Along with sequence number another parameter which is number of hops is taken in consideration on the basis that the path with least hops is selected as the best possible route. Figure 6.5 is the snapshot that shows the RREP sent in the network.

Figure 6.5 Route Reply

Now as the route request and the route reply has been received by all the nodes, the optimal path is finally defined that has to be followed by the source for the routing of the data packets in the network to the destination. The path that has been selected is now followed by the data packets that have been sent from the source node to the destination node. The intermediate nodes are present in the network that behaves as the routers for forwarding of the data. Figure 6.6 shows the path that has been established.

Figure 6.6 Path Establishment

Now, link failure has been shown in the network when a node moves from its position to a position that is out of the transmission range of its previous intermediary node. Hence, the communication stops and the data are no more forwarded to the destination. Hence, a stable path is not followed. Figure 6.7 is the snapshot that shows the link failure in the network.

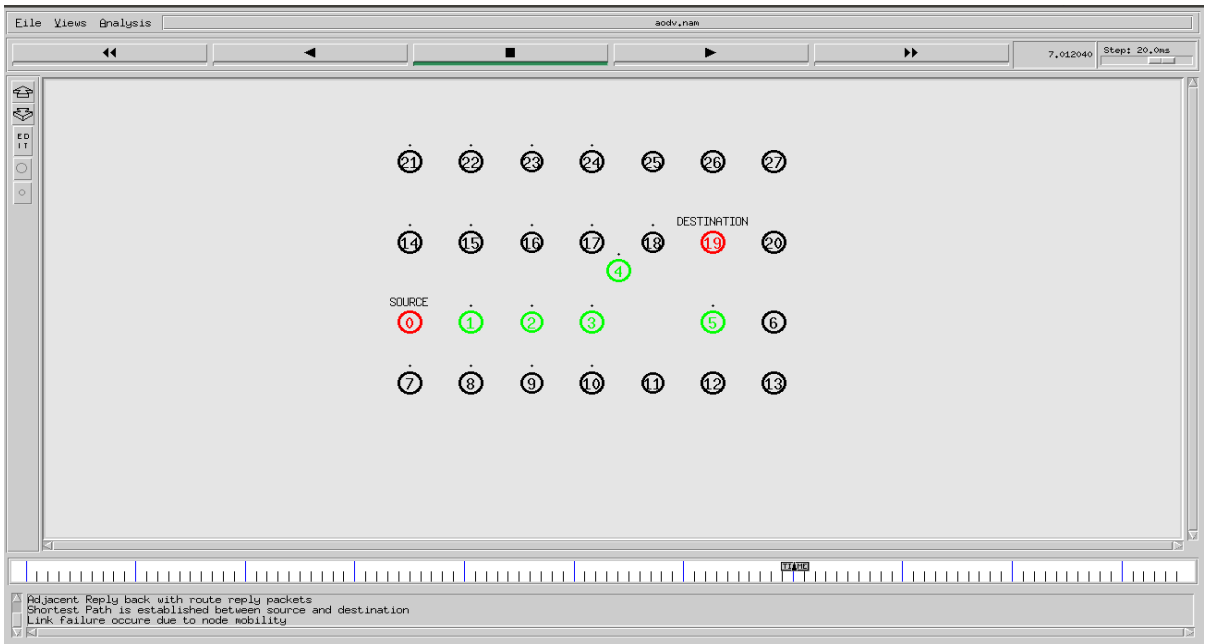

Figure 6.7 Node Movement

6.2 Deployment of the enhanced work

Another script is created for the implementation of the solution in which the clusters are formed in the network and the cluster heads are chosen based on the serving time and the stability factor each node that has energy greater than the threshold energy. The following figure shows the network deployment for the solution.

Figure 6.8 is taken that shows the nodes that have been deployed in the network. The same number of nodes is taken in the network as were taken in the deployment of the existing work.

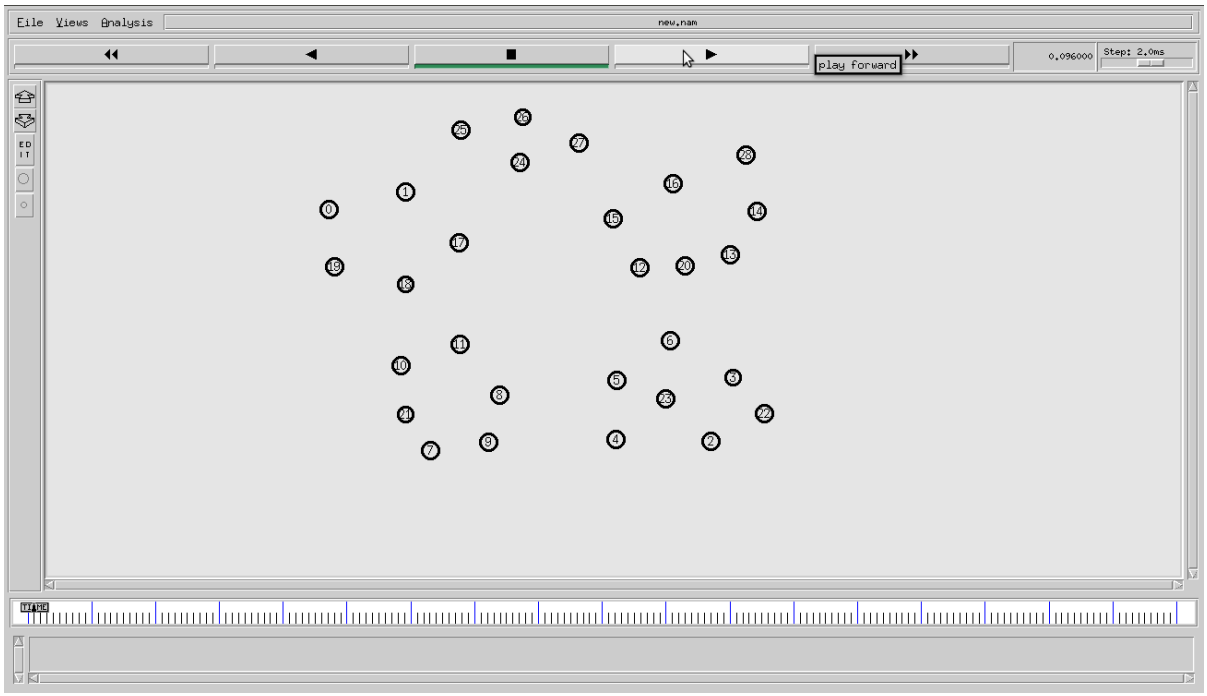

Figure 6.8 Deployment of the new Network

Now, the clusters are to be formed in the network, which is based on the location-based clustering mechanism. Each cluster is defined with different color to differentiate from each other. Figure 6.9 is the snapshot that shows the formation of the clusters in the network.

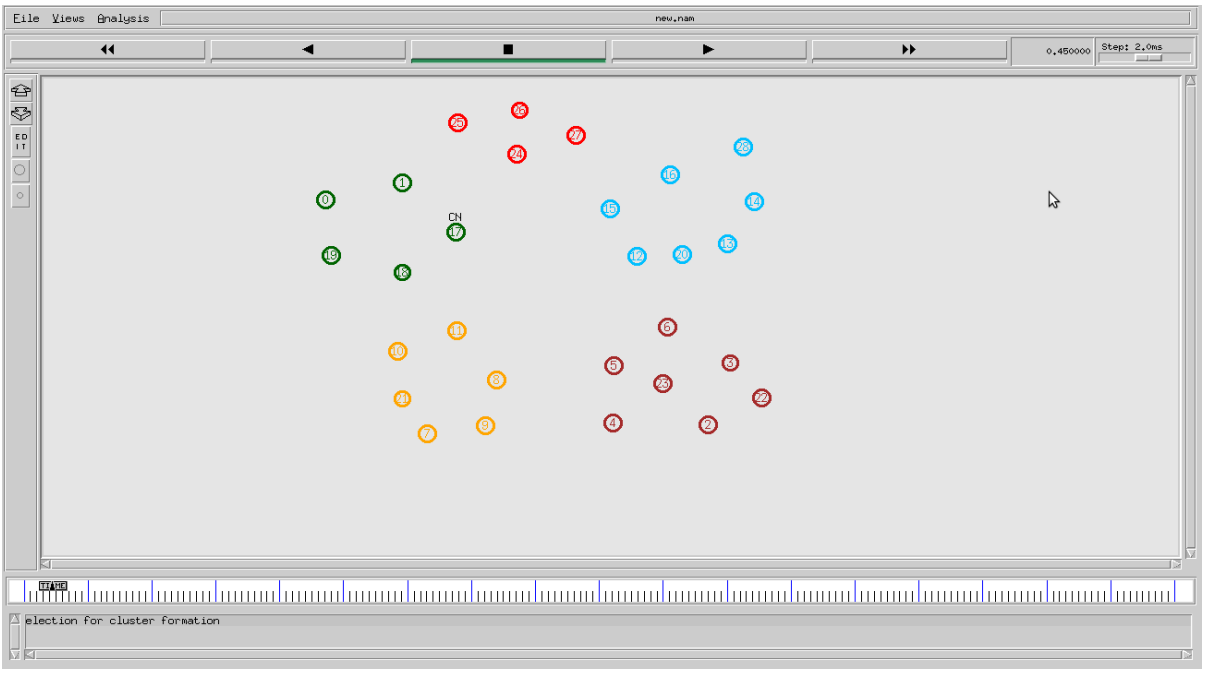

Figure 6.9 Formation of the Clusters in the Network

The election of the cluster head is to be done for each cluster. The cluster head is selected based on the weighted values of the serving time and the stability factor for each node that has energy greater than the threshold energy. The following snapshot shows the process for the selection of the cluster head for each cluster. Figure 6.11 shows the cluster heads formed.

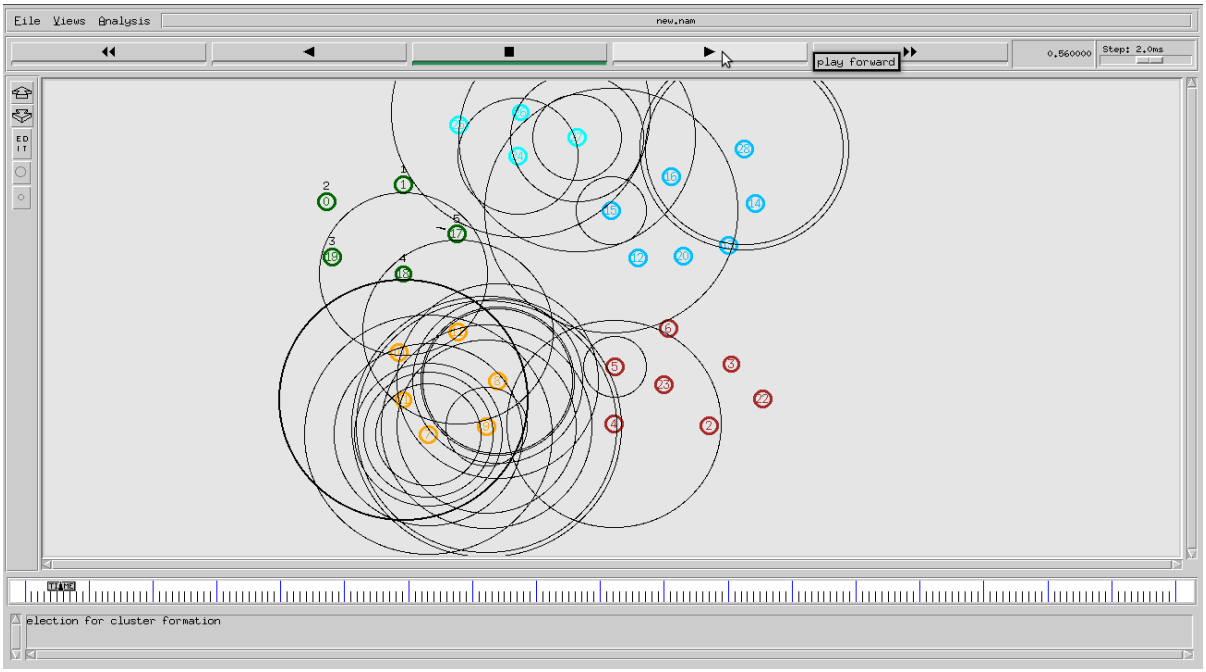

Figure 6.10 Process for the Election of Cluster Head

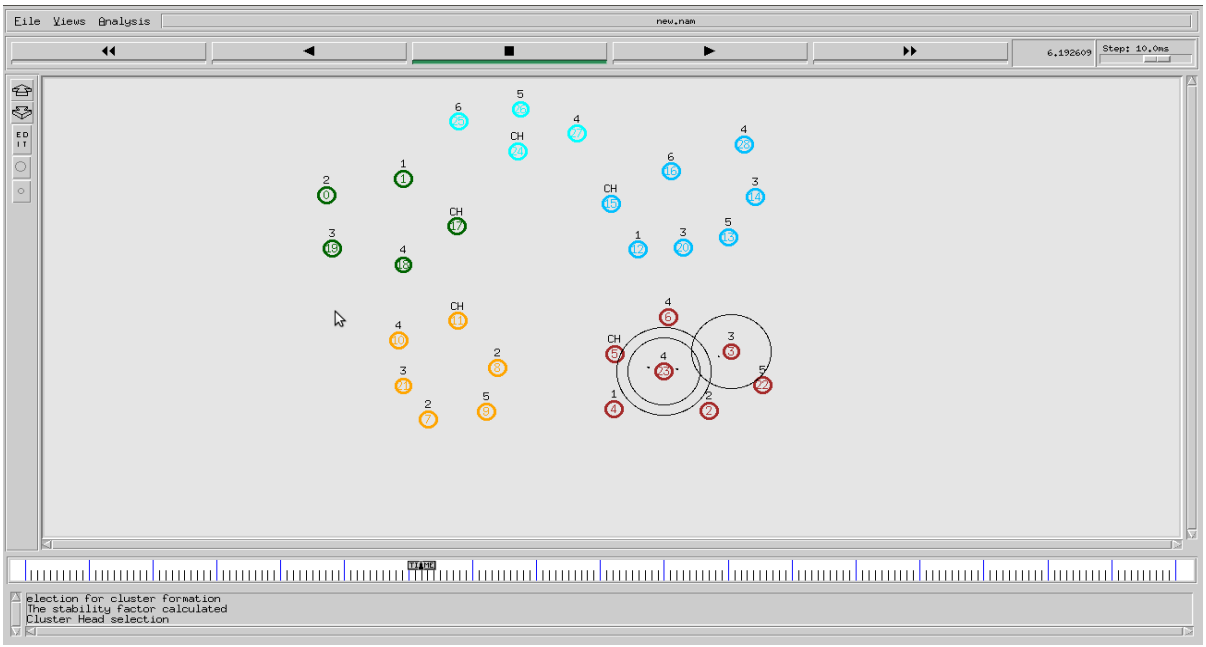

Figure 6.11 Cluster Heads selected

The cluster head consists of the one hop nodes in the cluster which in turn reduces the overhead in the cluster.Now, for the routing of the data packets, the source and the destination are defined in the network among which the communication has to be done. Figure 6.12 is the snapshot that shows defining of the source and the destination in the network.

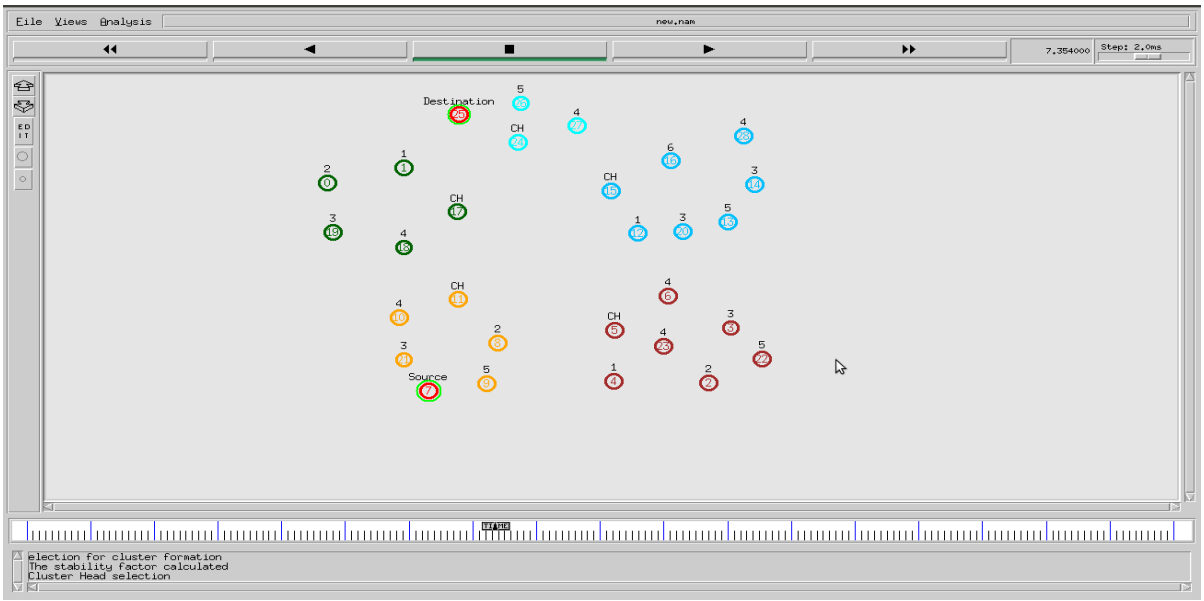

Figure 6.12 Defining the Source and Destination

Now, the communication between the source and the destination is done by finding an optimal path using the AODV protocol. Figure 6.13 is the snapshot for the communication. The communication is done based on the one-hop nodes of the cluster head. All the nodes give out their information to the cluster head and that cluster head further does the communication. Here, the source node initiates the communication and the information is sent out to the cluster head which further communicate to the cluster head of the destination node and then that cluster head communicate to the destination.

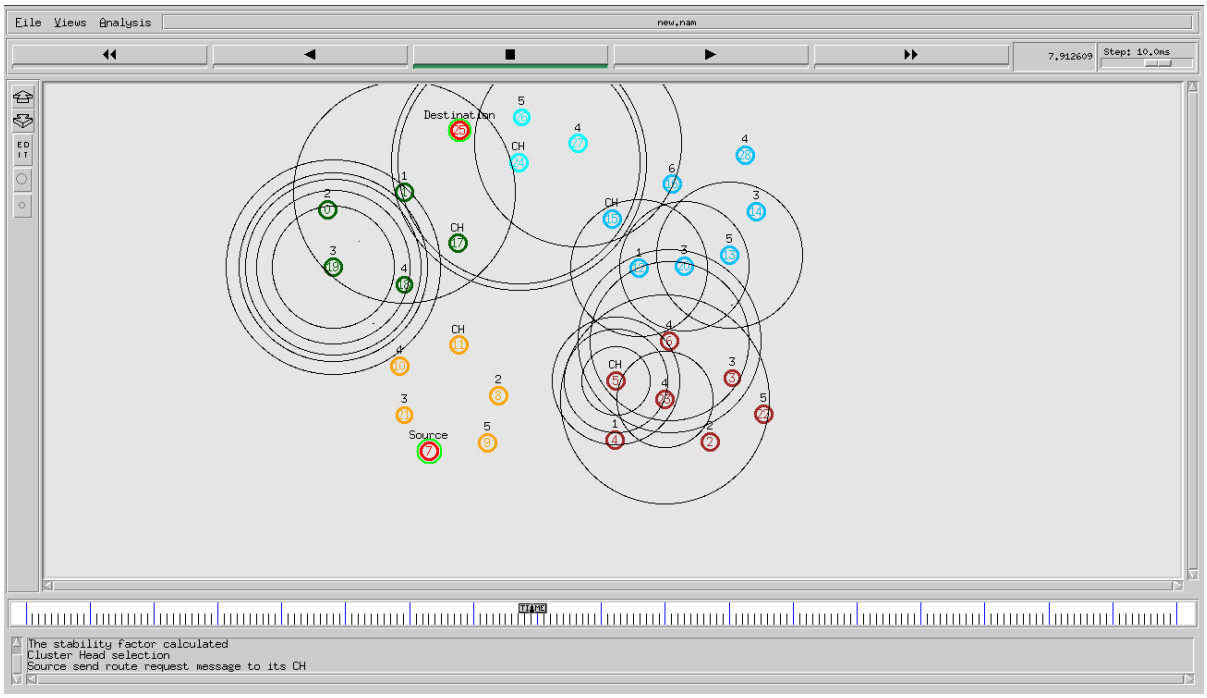

Figure 6.13 Communication between the Source and Destination

Now, when the communication is ongoing, one of the nodes in the network moves out of its cluster and joins another cluster in the network. Here, a cluster head re-election process has to be done for the selection of the new cluster head for that cluster. Figure 6.14 shows the movement of the node from its cluster and joining another cluster.

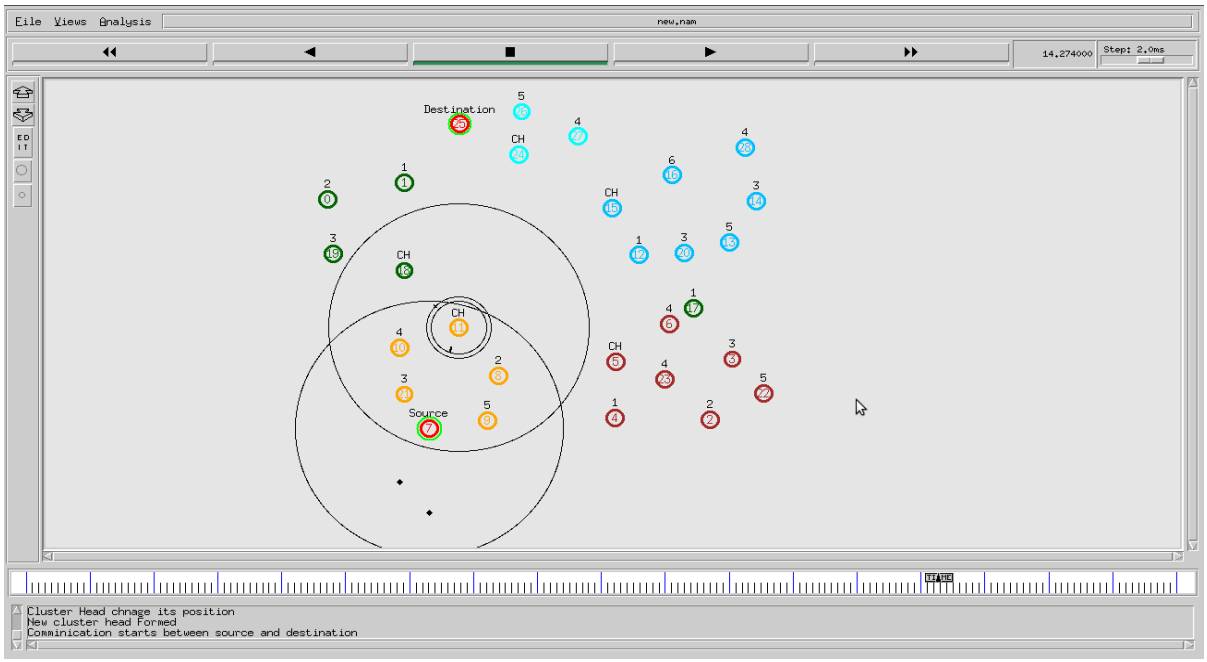

Figure 6.14 Node Movement from one Cluster to another

The Figure 6.15 shows the re-election process for the new cluster head of the cluster as the node has moved from its position and joined the another cluster.

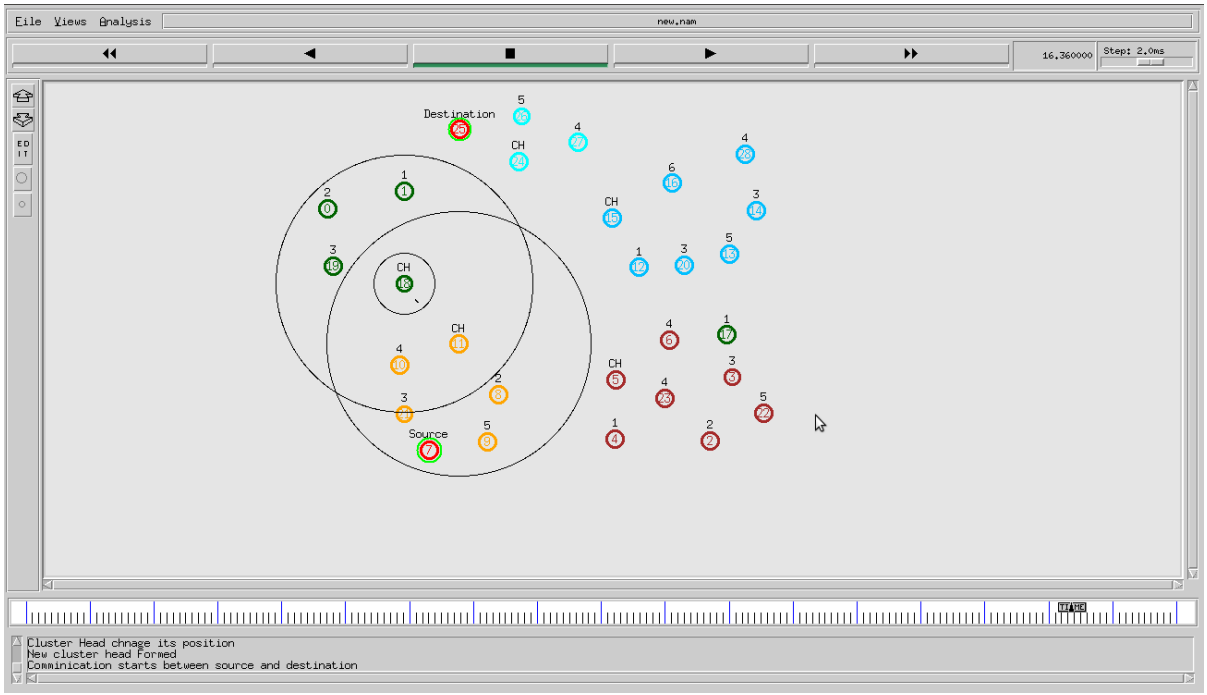

Figure 6.15 Cluster Head Re-Election

After the complete simulation is conducted, the communication performance is evaluated for both the works that are based on the parameters end-to-end delay, packet loss and throughput. Following are the graphs that show the performance evaluation. The green color is used for the plotting of graph of the old work and red color is used for the plotting of the graph of the new work.

In the graphs, it has been evaluated that the performance of the proposed work is better than the present work. There is less end-to-end delay in the process of the communication. The packet loss occurring in the network in the proposed technique is less as compared to the present work. The throughput that has been evaluated is higher for the proposed work than the present work. Hence, evaluated overall, the proposed technique proves to be a better concept for the communication in the network.

1. **End-to-End Delay**: the end-to-end delay of the communication has been plotted.

   Delay is defined as the total time taken by the packets to reach the destination form the start of the session.

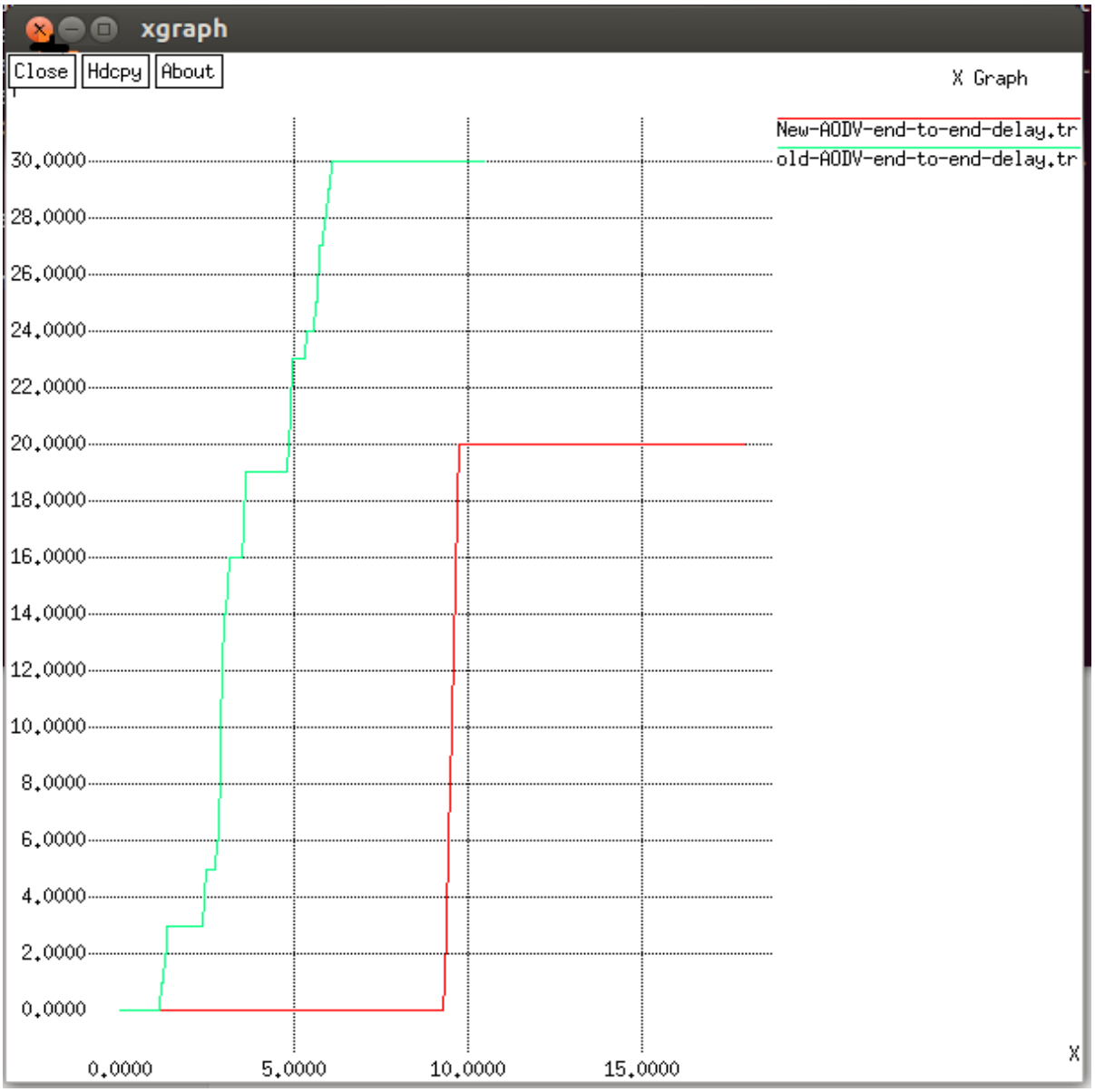

Figure 6.16 End-to-End Delay

2. **Packet Loss**: The following graph shows the packet loss happening during the ongoing communication in the previous and the present work.

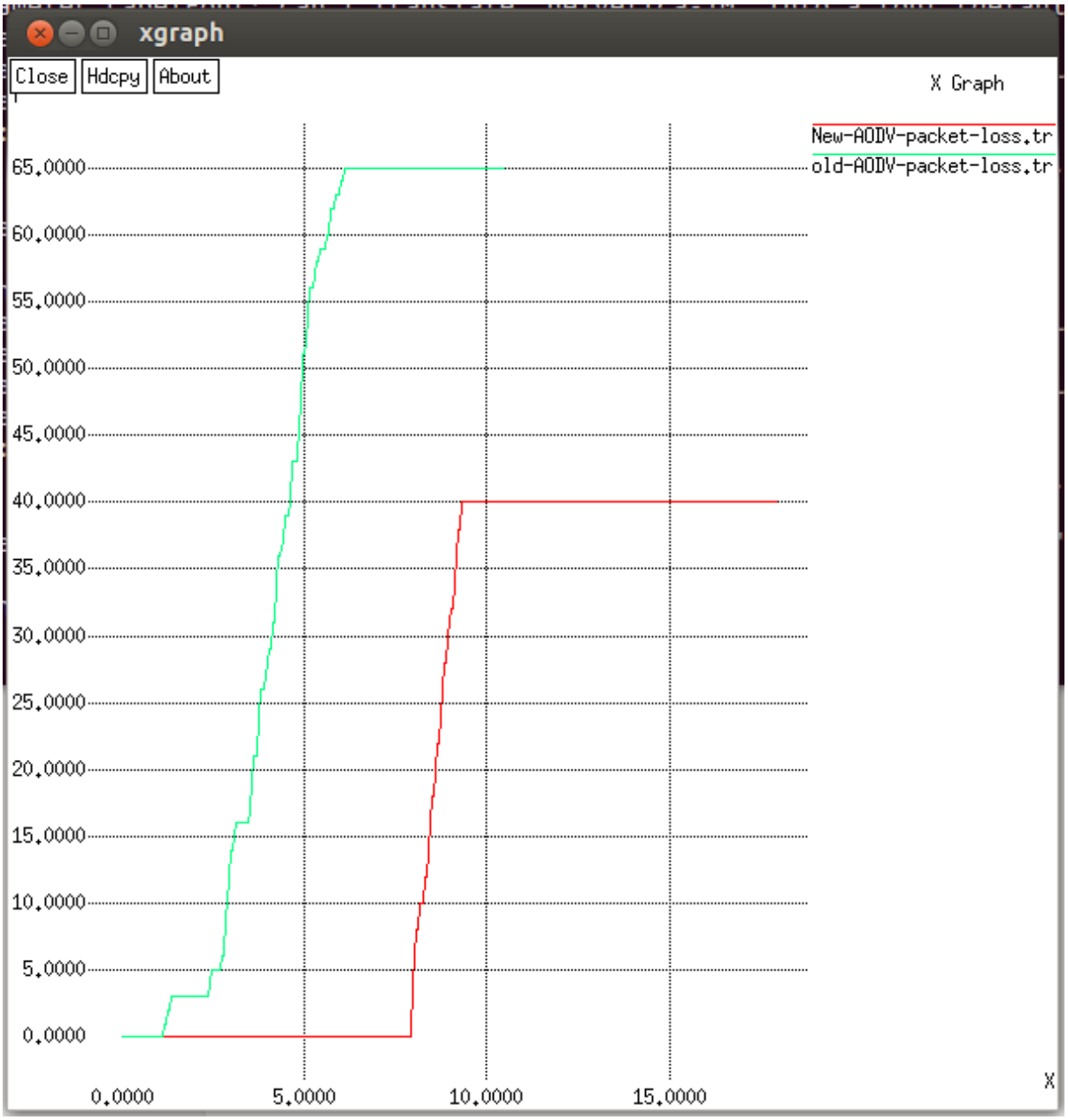

Figure 6.17 Packet Loss

3. **Throughput**: Throughput is described as the transmission of number of successful packets from the source to the destination in a given time period. The following graph shows the throughput obtained from the previous and the present work.

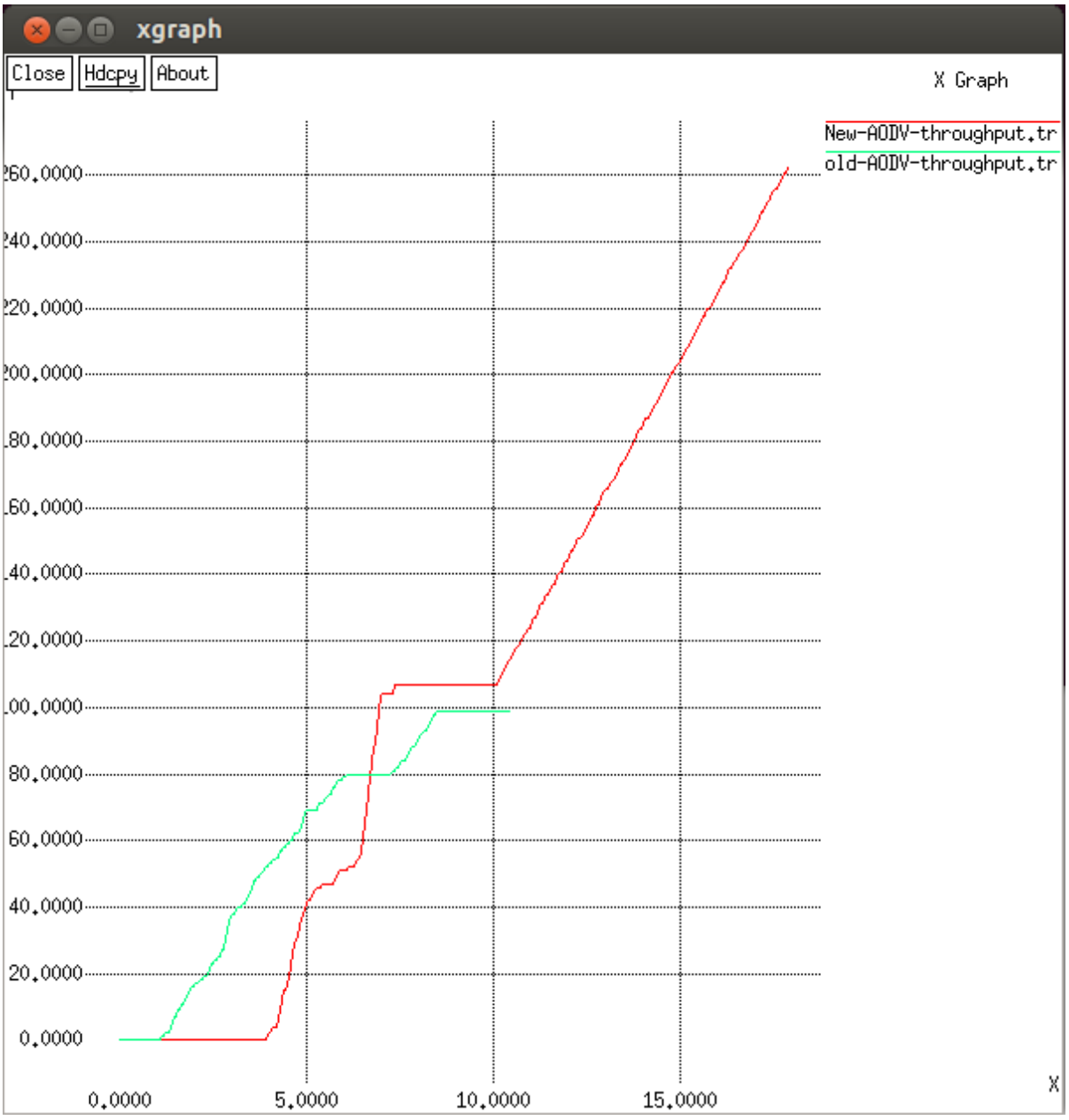

Figure 6.18 Throughput

Chapter 5

CONCLUSION AND FUTURE SCOPE

Mobile ad hoc network (MANET) being a kind of network that is autonomous in nature and self-configuring comprise of several mobile nodes which can be deployed quickly and easily without the need of any previously established infrastructure or any centralized administration. In MANET, each node can is free to move in any random direction independently which makes the network extremely flexible. To properly route the traffic, each node in MANET maintains the information required. Since, the nodes are mobile; they can even change the links to the other nodes frequently. The nodes also behave as routers called intermediate nodes to transmit data from a source node to a destination node. One big challenge to build a MANET is making each mobile device to maintain the required information time to time so as to route the traffic. Such kinds of networks mainly operate by themselves. Among all the issues arising, one is the issue of link breakage due to mobility which tends to reduce the performance of the network, and hence degrading the network.

An enhancement has been done in the stability based technique to the delay, packet loss and to increase the throughput of the network. To do so, the network has been divided into clusters based on the location-based clustering technique. The cluster heads are selected by first calculation the energy of each node in the cluster and the nodes with energy greater than the threshold energy are selected for further election process of the cluster head. Now, each node calculates its weighted value for the serving time of the node and the stability factor. The node with the highest value is selected as the cluster head. If, any node moves out of the cluster and joins another, then the re-election process for the cluster head is done.

Since, in the existing work, the nodes were not stable enough as only the stability factor of the nodes was considered that was based on the transmission range and the degree of the node. But, what if the node is stable enough but the node is having very low energy and can exhaust anytime. Hence, in the new work, the energy has also been considered for calculating the serving time of the node and weighted values of both, the serving time and the stability factor, have been considered. Now, the node can become more stable as it is already assured

that the node will not get deprived of the energy when a communication is already ongoing in the network.

For the future scope, the malicious node will be considered in the network and then an optimal technique will be found out for the communication of the nodes in the network without any data loss or theft.

Chapter 6

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Chapter 7

APPENDIX

AODV	Ad-hoc On-demand Distance Vector
AP	Access Point
BcastID	Broadcast Identifier
DA	Destination Address
DesSeqNum	Destination Sequence Number
DestId	Destination Identifier
DN	Destination Node
DSDV	Destination-Sequenced Distance Vector
DSN	Destination Sequence Number
DSR	Dynamic Source Routing
LAN	Local Area Network
M	Mobile
MANET	Mobile Ad-hoc Network
ND	Degree of Node
RERR	Route Error
RREP	Route Reply
RREQ	Route Request

SA	Source Address
SIG	Bluetooth Special Interest Group
SN	Source Node
SecSeqNum	Source Sequence Number
SrcID	Source Identifier
TTL	Time to Live
UIN	Unique Identification Number
VANET	Vehicular Ad-hoc Network
WLAN	Wireless Local Area Network
ZRP	Zone Routing Protocol