CHAPTER 1

INTRODUCTION

1.1 GENERAL

Mobile Ad-Hoc Network (MANET) is a self-configuring and infrastructure less network. In it mobile devices are connected without using wires. In each mobile device are move freely and independently in any direction. MANET consists of several mobile nodes that dynamically exchange data among themselves. Due to this the transmission power that the mobile nodes required to exchange the information with any other node is limited. Several routing protocols are developed to accomplish this task. Multipath routing allows the establishment of multiple paths between a pair of source and destination nodes (Aarti & Tyagi 2013). Route discovery and maintenance is a challenging issue in MANET.

In a dynamic network, the application of MANET requires well-organized distributed algorithms to decide link scheduling, network organization and routing. However, determining possible routing paths and message in a decentralized situation, where network structure fluctuates, is not a precise problem. So designing a new protocol is a complex problem in MANET. Similarly in a static network, finding the shortest and optimal paths based on a given cost function from a source node to a destination node is not easier in MANETs (Anju 2012). The Factors such as wireless link quality, propagation path loss, fading, multiuser interference, power consumption and topological changes. MANET is only suitable to change the routing paths to improve any of the above effects.
MANET is applied in the following fields: Military environment, preservation of security, latency, reliability, intentional jamming and recovery from failure. Military networks are designed to keep and deduct a low probability of intercept. Mobile nodes prefer to emit as modest power as needed and transmit as rarely as possible, decreasing the probability of detection or interception. An error that occurs in any of these processes may corrupt the performance and reliability of the network (Ankur & Prabhakar 2013).

Some of the main features of MANET are given below:

a. It can be formed without any infrastructure
b. It follows dynamic topology where a node may join and leave the network at any time.
c. It has very limited security
d. Every node in it can assist in routing packets in the network.
e. It requires only limited power and bandwidth.

1.1.1 Fuzzy Logic

Fuzzy is a superset of conventional or Boolean logic that has been expanded (Baldwin et al 1981) to hold the model of partial truth values between "totally true" and "totally false". Fuzzy logic is expressed as a logical thinking which is approximate rather than exact. It is derived from the fact that most ways of human logical thinking and especially common sense reasoning are together in nature. In this method the variables are taken in binary sets, which range in degree between 0 and 1 and take a truth value where the variables take either true or false.
1.2 OVERVIEW OF WIRELESS NETWORKS

Wireless is a modern alternative of wired networking meaning that the devices are connected without using wires. Wireless network is a computer network used to exchange the data among various devices and to carry out some tasks without using cable. It means the exchange of data between computer and other devices in a network by radio signal frequency and electromagnetic waves. Wireless network is a telecommunication network which is an easiest and most common type of home network that does not require the use of cables or equipment for designing. Several application of wireless network technology has been used as

1. Wi-Fi
2. Bluetooth
3. Wireless home automation

1.2.1 Wi-Fi

Wi-Fi is a wireless networking used to communicate information from one computer to other devices: the information are transferred over a wireless signal. Wi-Fi networks use IEEE 802.11 standards to connect the devices in wireless networks. In modern wireless networks, the computer has a built-in Wi-Fi chip that allows users to discover and get connected to wireless routers. Nowadays, most of the mobile devices and video game systems support the Wi-Fi networks. Using routers, the devices are established with Wi-Fi connection and to communicate with the router and the other devices on the network. Using Digital Subscriber Line (DSL) or modem the routers can be connected to the internet to provide network connection to all the connected devices.
1.2.2 Bluetooth

Bluetooth is a wireless technology used to exchange data over short distances from fixed wireless mobile devices. Bluetooth technology was invented by Ericsson in 1994. It uses short-wavelength UHF radio waves and works as the ISM band from 2.4 to 2.485 GHz. It is mainly used in Personal Area Networks (PAN). It can connect several mobile devices, and overcome the synchronization problems. It involves wire-replacement protocol and is designed mainly for low-power consumption with a low-cost transceiver.

1.2.3 Wireless Home Automation

Home automation technology is utilized to execute routine tasks at home or office in a simple, safe and less expensive manner. It controls lights and dimmers, home theater and other entertainment systems, strengthens home security and automates door locks and increase efficiency (Seyed-Amin et al. 2011).

Its implementation takes place in the physical layer of the Open System Interconnectivity (OSI) reference model needed for a wireless router, which is to be connected to the modem, and a wireless receiver or connector on each device, which is to be networked and built in via adapter (Ankur & Prabhakar 2013).

1.3 MOBILE AD-HOC NETWORKS (MANETS)

MANET is a new paradigm of networks offering unrestricted mobility that does not require any centralized administration. Each node operates in the distributed peer to peer node, and every node works not only as a source and a sink but also as an independent router. Each device in MANET is free to move independently in any direction, and would therefore
change its links to other devices frequently. Each must forward traffic unrelated to the other devices frequently. Each must also forward traffic unrelated to its own use, and therefore be a router. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic (Aarti & Tyagi 2013). This network may operate on its own or may be connected to the larger internet.

1.3.1 Challenges in MANET

**Infrastructure less Network:** MANET does not depend on any centralized administration. Each node manages the operation in the peer-to-peer mode and acts as an independent router and generates the independent data.

**Dynamic topology:** In MANET, the mobile nodes are connected to each other in an arbitrary manner. The multihop can change frequently and link of the network varies slightly and is based on the proximity of one node to another node.

**Scalability:** Scalability is the major limitation of large scale deployment of MANETs. One way to solve this problem is using the existing infrastructure. The infrastructure is not available; an important research direction is the use of mobile backbone nodes. It is able to provide an accepted level of service even in the presence of a large number of nodes.

**Bandwidth Constraint:** Wireless links have considerably lower capacity than the wired links. Channel are shared by all the nodes in broadcast area, the bandwidth available for each wireless link depends upon the number of hops and handle the traffic. Thus, only a fraction of the total bandwidth is available for every node.
Security: Mobility implies higher security risk such as end-to-end network architecture or a shared wireless medium accessible to both the valid network users and the intruders. Eavesdropping, spoofing and denial of service attacks should be considered.

Power Consumption: In MANET, the power consumption of the nodes is an important issue. All the nodes in MANET get their energy from batteries, in limited resources. So, the power consumption is playing an important role in the wireless network (Ankur & Prabhakar 2013).

1.4 ROUTING PROTOCOLS

A routing protocol is a set of rules that specifies the way the routers communicate with each other disseminating information that enables them to select routers between any two nodes on a computer network. The choice of a route is being done by any one of the existing algorithms like DSDV, WRP and so on. Each router has a prior knowledge of the networks attached directly with it. The routing protocols share data among the nearest neighbors throughout the network. These protocols use any one of the routing protocols to determine network, data transfer and communicate path between the network nodes. They help to communicate the router and to understand the overall network structure.

1.4.1 Types of Routing Protocols

A routing protocol can be divided into two types:

1. Static routing
2. Dynamic routing
**Static routing:** Static routing maintains the routing table to particular routers to be set up by a network administrator. It does not use any specific routing protocols.

**Dynamic routing:** Dynamic routing uses any one of the routing protocols that dynamically discover the network destination. If any route is changed in the network, the dynamic routing is used to allow and to update the routing information in the routing table. Routers can continuously update the routing table whenever a change occurs in the network topology.

### 1.5 APPLICATIONS OF MANET

A MANET compromising mobile nodes and the structure of the network can change unexpectedly. Each mobile node acts as a hop as well as a router, and the network control is distributed among the nodes. Ad-hoc networking allows the mobile device to maintain the connection to the network and to add and remove the devices from the network easily. In recent days, MANET is applied in the following fields.

- Military field
- Commercial sector
- Virtual classrooms
- Monitoring of environmental changes
- Traffic networks

### 1.6 SECURITY GOALS IN MANET

A security protocol for ad-hoc wireless networks has to satisfy the requirements like confidentiality, integrity, authentication, non-reputation and scalability (Aarti & Tyagi 2013).
**Confidentiality:** Confidentiality is also called secrecy and privacy. It ensures that the information is accessed only by the authorized persons. It means that the confidential information can be operated only by the intended receiver. In case of ad-hoc networks, confidentiality is very important for protecting the transmission of sensitive information. This is quite vital because wireless links are easily susceptible to eavesdropping.

**Integrity:** Integrity confirms the information modified only by an authorized person during network transmission. The alteration can be due to either accidental factors like vagaries of the wireless links or malicious factors like the presence of an antagonist. An antagonist may operate data by inserting, deleting and substituting them. Integrity assures that a data being transferred is never corrupted.

**Authentication:** Authentication assures a node of the identity of the third party that is communicating with the ad-hoc network. They are two types of authentications are

**Entity authentication Data authentication:** Entity authentication is concerned with verifying the identity of the other communicating party. In systems that lack entity authentication mechanisms, an advisory can masquerade as an insider, thereby possibly gaining unauthorized access to network resources. Data authentication focuses on providing guarantees as to the origin of data, in addition to data integrity (Ankur & Prabhakar 2013).

**Non-repudiation:** Non-repudiation ensures that a party can neither wrongly deny action nor claim wrongly the other entities. For example, in the case of data transmission, the creator of a message cannot deny having sent a message after doing so. Further, the receiver cannot send the message when he or she claims to receive wrong message from an entity.
Scalability: Scalability is a major issue of security services in large MANET. If any problem occurs in a large network, scalability is used to solve any of the existing infrastructures like satellites, internet and so on. If the infrastructure is not available, the MANET will use the mobile backbone nodes.

1.7 TRANSMISSION MODE

Transmission is a process of sending and receiving information or signal over a two physical media: either wired or wireless. The different types of transmission techniques are given in the figure below.

![Diagram of transmission modes](image)

Figure 1.1 Types of transmission mode

In Figure 1.1 the transmission node is divided into three types such as simplex transmission, half duplex transmission and full duplex transmission.

Simplex transmission: Simplex connection is a communication network where in data flows in a single direction from the source to the destination. This type of communication is called unidirectional. Examples of this are TV broadcasting, door bells, fire alarm and security systems and so on.
Half duplex: Half duplex connection can transmit data in both the directions, but transmit data in one direction alone at a time. Time sharing technique is used for interactive data transmission. Both source and destination devices act as a sender and a receiver respectively, but do not transmit the message simultaneously as in the case of walkie-talkie, line printer and so on.

Full duplex: Full duplex connection can transmit messages in both the sides simultaneously. It is quite useful for serial communication connection. This type of transmission is shared by the channel capacity of the communication devices in both directions every time.

1.8 MULTIPATH ROUTING

Multipath routing is one of the routing techniques, mainly used to select the best path for multiple alternative paths through a particular network. It is also called alternative path routing. In multipath routing, source and destination nodes have a multipath or a set of paths between them. Several paths are available in source and destination pair, and the shortest path between them would be chosen. When the shortest paths are not available for a particular set of source and destination nodes, rather than blocking a connection, the alternative path between the two hops would be selected. Multiple routes from the source and destination are created to provide a backup route. When the primary route fails to deliver the packets, the backup is used. Multipath routing method has three basic steps.

- Multipath establishment and selection
- Routing maintenance
- Multipath transmission
1.8.1 Multipath Establishment and Selection

If any selected routing path is broken due to the message transmission; at this time, multipath selection helps the channel to transmit the data in another optimal path. When the data packets are transmitted through multipath, reliability in the number of paths available in the networks would be increased, but insignificant paths are forwarding data packets which would manipulate the other applications. If every hop chooses the next node within the lifetime, then it will be compared to the shortest path routing.

1.8.2 Routing Maintenance

A wireless link is easily breakable because topology can be dynamically changed in wireless network. If the link is broken in the wireless network as shown in Figure 1.2.

![Figure 1.2 Link Failures between the nodes](image)

The mobile node will neither receive any message from the adjacent node nor send any packet to the next hop. In the route maintenance, all the entries are made in the routing table. Moreover, the information or
entry about the broken node is deleted initiating a new route. This method is called route discovery (Park & Yoo 2010).

The following Figure 1.3 represents the selection of alternate path.

![Selection of an alternate path](image.png)

**Figure 1.3 Selection of an alternate path**

In Figure 1.2 and 1.3 the node 5 was broken. So the router would be choose the alternate routing path through the node 6 and deliver the message packet to the destination node.

### 1.8.3 Multipath Transmission

While transmitting data in multipath routing, every hop has a multiple path for a particular destination that is called multipath transmission. In multipath transmission, several paths are available to transmit packets from source to destination. Ensuring improvement in Quality of Service (QoS) in the multipath transmission requires the use of any one of the efficient routing protocols. In order to improve the QoS, during the multipath transmission the packet delivery ratio has also to be designed.
1.9 CLUSTERING

Clustering is a process of dividing nodes in MANET into different groups like master node, slave node and cluster gateway based on certain rules in order to improve the network scalability. A master node serves as a cluster to the member of the cluster node in a cluster communication. In other hand, cluster gateway is not a master node that coordinates the establishment of the connection between two hops. Slave node is responsible for sending and receiving packets with the help of the master node and cluster gateways as in Figure 1.4.

![Cluster structure diagram](image)

**Figure 1.4 Cluster structure**

A cluster structure facilitates the hierarchy of the communication network and enables the spatial reuse of resources to increase the system capacity. The advantage of the cluster structure is its provision for effective route discovery and maintenance. Even though it is important for network
scalability, clustering incurs its own computational and storage cost (Huiyao et al 1989).

In Figure 1.4 the neighbor nodes are grouped under one master node. The cluster gateway is used to communicate information from one cluster to another cluster. The master node keeps the details of all slave nodes neatly.

1.9.1 Cluster Structure

In the clustering network, all the nodes are classified into master node and slave nodes. The master node is one hop away from the slave node. It contains the IP address of the slave node, in addition to storing the IP address of the neighbor master node in that routing table (Huiyao et al 1989). Every slave node has one master node. It contains the IP address of the master node, which is stored into the routing table.

1.10 ENERGY AWARE ROUTING

Energy consumption is an important issue to be considered in designing a routing protocol in MANET protocol. For extending the lifetime of a network, each node needs some energy to participating node in a route path. In ad-hoc network, transmitting the information from the source and to destination takes place through multihop routing. If the energy gets exhausted, it will lead to instability in the network topology. Energy of a node decides the optimal power in the transmission path. Nodes in MANET have a limited battery and consume a lot of energy in every transmission and receive of data packet. In this situation, energy aware routing method is used. As this energy aware routing methods consider energy related information in a route cost metric, a single objective related to energy efficiency is optimized. When the topology has to be changed in the network, the energy of the participating
node is lost. To overcome this problem, an effective routing mechanism is required to forwarding data packets and to maintain QOS during communication between the nodes (Attarzadeh & Ow 2010).

1.11 CHARACTERSTICS OF FUZZY LOGIC

The fuzzy logic characteristics are as follows.

- It is viewed as an exact and approximate reasoning with limited values
- It holds the value of degree
- This system can be fuzzified
- It involves the interpretation of as a collection of variables and knowledge as a collection of equivalent or elastic
- It includes inference which is viewed as a process of contemporaries of elastic constraints

1.11.1 Fuzzy Set Theory (FST)

FST determines the set membership as a possibility distribution. The general form of fuzzy set theory is

\[ f: [0,1]^n \rightarrow [0,1] \]

where n is the Number of possibilities and f represents the single possible outcome.

FST expands set membership as it has varying definitions. It has been given various definitions by allowing both possibilities: number of possibilities and single possibility. A defined membership can be redefined and new logics based on the combination of sets and reason can be developed.
1.12 ROUGHSET THEORY (RST)

Rough set theory (RST) was proposed by Pawlak in 1982. It is disturbed with the analysis and classification of imprecise, incomplete or uncertain knowledge and information. Data analysis is one of the first non-statistical approaches. RST is a fundamental concept of the approximation of upper and lower space of sets. The subset generated by lower and upper approximations is characterized by objects that would possibly form part of a significant subset. RST becomes a valuable tool in the resolution of different types of problems such as knowledge analysis, demonstration of uncertain knowledge, evaluation of availability, quality of information with admiration to consistency, identification of date dependency and reasoning based on a deduct of uncertain information. RST is used in the following fields.

1. Medicine like analysis of data in dengue diagnosis
2. Analysis of database attributes and process control
3. Data mining
4. Mathematics

RST has been a methodology of knowledge discovery in relational databases or database mining (Hayri et al 1998). It is used as a mathematical tool to treat the imprecise and vague. It is similar to FST and is used to express a boundary region of a set by the uncertain and imprecision approach. It can be considered as interior and closure topological operations. FST is used mainly for membership function, but RST is an advanced mathematical concept that concentrates on topological operations (Skowron et al 2002).

1.13 ORGANIZATION OF THE THESIS

The thesis divided into 7 chapter’s chapter 1 has introduced general concept of wirelleses network and MANET. Chapter 2 presents the
review of various protocols of wireless ad-hoc networks reported by various researchers. It analyses various advantages and shortcomings of the algorithms.

Chapter 3 presents a Fuzzy Clustering based Energy Saving Routing (FCESR) protocol for MANET. It proposes a new algorithm named as wireless routing protocol used to find the effective path in MANET (Baiamonte & Chiasserini 2004). It involves to select the best path for multipath routing which reduces the inefficient use of battery power and network load using through the creation of a Master Awareness Table (MAT) and Cluster Agent Table (CAT).

Chapter 4 presents a Fuzzy Cost enabled Cluster based Multipath Routing (FCECMR) algorithm for MANET. The proposed algorithm is used in clustering to find the effective path for MANET.

Chapter 5 presents Path Selection Using Fuzzy and Rough Set Theory (PSFRT) in wireless MANET. In this, an IF-THEN decision rule is developed to provide an alternative for evaluating the selection of the best routing path with minimum number of resources and total vector cost.

Chapter 6 proposes Fuzzy Cost Enabled Multipath Routing with Rough Set (FCEMRR) approach in MANET. Fuzzy and Rough set theory are introduced and it’s proved that all the reductions can be obtained by using the method of indiscernibility matrix.

Chapter 7 concludes the thesis with the summary of the results and proposes possible further works on fuzzy based multipath routing.