CHAPTER 1

INTRODUCTION

Nowadays, the ad hoc network is based on low power circuit networks, and has become a mandatory resource for many applications. In an ad hoc network, nodes are communicated in co-operative and distributed approach for routing the data packets in the network.

1.1 PREAMBLE

The wireless network is an emerging and essential technology because of the rapid growth in wireless devices. The mobile devices with wireless network interface are becoming popular for future computing environment which contains infrastructure and infrastructure-less networks. In earlier infrastructure-based communication, terminals communicated and sustained through a fixed central controller, for instance Wireless Local Area Networks (WLANs). In the advanced version, infrastructure-less wireless networks are grouped in an ad hoc method, where terminals establish the communication over multi-hop wireless links. A set of mobile terminals forms the network independently without any fixed infrastructure. Such a network is known as a Mobile Ad hoc NETwork (MANET). The MANET is an auto-configurable system of the
wireless nodes, which moves randomly and communicates through wireless multi-hop links (Jeoren Hoebeke et al. 2004). In MANET, nodes are acting as a router in order to forward the data packets to the other nodes in the network (Saleh Ali and Putra Sumari 2010). The nodes are supplied with the antenna that permits them to transfer and receive the signals from the other nodes. The node can send and receive the data packets within a certain radius, which is known as transmission range. The radius is defined by the level of transmission power. When the node broadcasts the data packet to another node, the transmission may be overheard by all the nodes which are placed within the transmission range, and these nodes are called intermediate nodes or neighboring nodes.

The MANET can be formed rapidly whenever the node wants to exchange the information with a signal node (unicast transmission) or with more than one node (multicast transmission). The communication between the pair of nodes can be single-hop or multi-hop. In single-hop transmission, nodes are communicated directly within the transmission range. In multi-hop transmission, nodes are acting as relay points, and the node can transmit the data packets to another node positioned outside its transmission range (Youssef et al. 2013). In MANET, nodes are moving spontaneously, and the topology of such a network keeps on changing automatically, which makes the routing more difficult during the route discovery phase. The ubiquitous features of MANETs are rapid deployment, flexibility, robustness and support for mobility. Figure 1.1 explains the typical MANET architecture.
1.2 CHARACTERISTICS OF MANET

The MANET contains a collection of wireless nodes, which can be set up dynamically anywhere at any time without any pre-defined infrastructure. According to Corson and Marker (1999) the characteristics of MANET are described below:

- **Autonomous:** The node in MANET does not depend on any fixed infrastructure. Every node operates in a distributed manner and acts as an independent router in order to forward the data packets.

- **Dynamic Topology:** In MANET, nodes move randomly with various speeds, therefore the network architecture may change arbitrarily at unpredictable time. The rapid mobility of the node leads to the development of new network topology. The topology of such a network is
dynamic because of the constant movement of nodes (Ramachandra et al. 2004).

- **Multi-hop Routing**: In MANET, no fixed routers are available between the nodes. Each node acts as a router and transmits the data packets to the other nodes when they are out of their transmission range (Dow et al. 2005).

- **Energy Constrained Operation**: In MANET, nodes depend on exhaustible battery power. So, the most important design criteria are based on minimizing the energy conservation. Nodes should be more energy-efficient and operate with restricted memory resources (Ghosekar et al. 2010).

- **Limited Physical Security**: The wireless network is more susceptible to security issues. The mobility infers the higher security issues such as spoofing, eavesdropping and Denial-of-Service (DoS) attacks.

- **Ad hoc Addressing**: Routing, addressing and location identification are tough to implement because of limited resource availability.

- **Bandwidth Constrained and Variable Capacity of Links**: In MANET, the bandwidth is limited because of lack of infrastructure which is tough to hold the higher bandwidth in the network traffic. Thus, the MANET
operates with limited bandwidth and variable link capacity. This leads to high bit errors, unstable and asymmetric links, noise, interference, congestion and fading (Mohammad Ilyas 2002).

1.3 ADVANTAGES OF MANET

The advantages of MANET are described below:

- **Accessibility:** The MANET offers access to the information and services irrespective of the geographic position.

- **Infrastructure-less:** The MANET can be set up anywhere at any time without any fixed central administration.

- **Dynamic:** The nodes are free to move dynamically in the self-organization temporary network.

- **Decentralized and Robust:** The MANET is robust. When the node leaves from the network, connectivity to the other nodes is recognized through the active nodes in the network. Such a node uses the multi-hop communication between the source and the destination nodes.
1.4 APPLICATIONS OF MANET

The MANET offers numerous benefits and versatility in various applications due to its dynamic infrastructure. The application of MANET in different fields is mentioned below:

- **Emergency Services**: The MANETs are very useful in emergency operations such as search and rescue, disaster recovery and commando operation (Al-Omari and Sumari 2012).

- **Tactical Network**: The MANET can be used to establish communication between a group of soldiers for tactical operations such as military communication and automated battlefield (Mohit and Rashmi 2012).

- **Commercial and Civilian Environments**: The MANET can be used in E-Commerce processes such as E-Payment from anywhere at any time and business applications.

- **Vehicular Services**: The ad hoc network is used to transmit the weather and road condition, inter-vehicle network and taxi cab network (Tsung-Chuan Huang et al. 2010).

- **Education Services**: The ad hoc communication is used in lectures or meetings and conferences.

- **Entertainment**: Wireless point-to-point networking, outdoor internet communication, multi-user games, theme
parks, smart sensor and consumer applications are embedded with ad hoc communication.

1.5 ROUTING PROTOCOL IN MANET

The routing protocol is used to establish the connection between the pair of nodes in the network. Routing is the procedure of interchanging the information from one node to another node in the network in order to forward the data packets. In MANET, routing protocol increases the complexity because of its different characteristics like dynamic topology, limited resources and time varying QoS requirements (Frodigh et al. 2000). Generally, routing involves two procedures, like selecting the optimal route and transferring the data packets in the network. The routing protocol can be categorized as Proactive Routing Protocol, Reactive Routing Protocol and Hybrid Routing Protocol.

In proactive routing protocol, every node maintains the routing table which contains the routing information about the neighboring nodes (Kumar 2013). Every node updates the routing table periodically with the latest routing information. Example: Destination Sequenced Distance Vector Routing (DSDV) (He Guoyou 2002) and Optimized Link State Routing Protocol (OLSR) (Clausen 2003).

In reactive routing protocol, routes are established on demand basis for routing the data packets (Gurleen Kaur Walia 2013). The route discovery process is invoked whenever the transmission happens between the source and the destination nodes. Example:
Ad Hoc On-Demand Distance Vector Routing (AODV) protocol (Perkins 2003) and Dynamic Source Routing (DSR) protocol (Johnson and Hu 2007).

The hybrid routing protocol, incorporates the properties of both proactive and reactive routing protocols (Haseeb Zafar 2011). The dynamic shift between proactive routing protocol and reactive routing protocol is based on the network condition. For instance, proactive routing protocols are used for network communication, and reactive routing protocols are used to communicate within the network. Example: Zone Routing Protocol (ZRP) (Zygmunt 2002).

## 1.6 NEED FOR ENERGY OPTIMIZATION IN MANET

In MANET, nodes are operated with limited battery power, and the energy-efficient routing is an inspiring task (Floriano De Rango et al. 2012). In MANET, the entire routing mechanism is incorporated with all the nodes in the network which may consume more battery power. So, computation and communication of each node are constrained. A few reasons for energy-efficient routing in MANETs are

- limited battery power of the nodes
- difficulties in exchanging battery
- selection of optimal transmission power
- frequently updating the network topology when the nodes move out of range
- routing the packets through intermediate nodes
- lack of central organization
- lack of efficient utilization of the channel

In MANET, nodes also act as a router, and they route the packets to other nodes (Scott et al. 2004). Since each node spends energy continuously, minimizing the power consumption becomes a challenging task. The power reduction of battery beyond the permissible limit may lead to the division of the network. The efficiency of the energy is measured by a period of time over which the network can accomplish a certain performance level, and it is known as network lifetime. Power failure of a node not only disturbs the node itself but also degrades the performance of the entire network. The energy level of the node has a direct impact on the network operation such as packet delivery ratio, delay, throughput, etc. For this reason, it is necessary to design an energy-efficient routing protocol for MANET.

1.7 PROBLEM STATEMENT

The emergence of numerous nodes in MANET demands to create and develop a novel intelligent routing protocol. Developing and establishing an energy-efficient route is a major design issue because node lifetime is the most critical limiting factor in MANET. Dynamic nature and limited battery power of nodes in MANET do not guarantee the route availability for any real-time communication. And
also, MANET has inherited the traditional issues of wireless communications such as link failure, retransmission, routing overhead and connectivity overhead. In larger networks, more nodes are used to forward the data packets and more energy is consumed during the route discovery process. Due to limited energy, the network performance degrades, and therefore finding the energy-efficient route in MANET is a major problem.

In order to develop an energy-efficient route, the routing algorithm should choose the path which minimizes the power consumption and maximizes the network lifetime. Therefore, there is a necessity to propose a novel energy-efficient routing protocol for MANET.

1.8 RESEARCH MOTIVATION

Energy consumption is one of the major factors that define the life of the network, and mobile nodes which are mostly operated by batteries. In MANET, a significant amount of energy is consumed not only during the communication but also when the node overhearing the data packets sent from the other nodes. This requires energy optimization in the mobile nodes to enhance the lifetime of the network. This can be attained by integrating energy awareness in every aspect of design and operation that can be made to acclimate to work effectively in diverse environments. This research work focuses on energy optimization in MANET.
1.9 OBJECTIVES

The objective of the research work is summarized as follows:

- To design fuzzy logic-based routing protocol in order to improve the network performance by maximizing the usage of network resources in MANET
- To design fuzzy logic-based clustering scheme in order to effectively manage the node’s position and energy in MANET
- To design cross-layer approach-based bee routing algorithm in order to achieve the reliable energy-efficient routing protocol for MANET

1.10 THESIS CONTRIBUTIONS

The contributions of the research work can be structured as follows:

- In this thesis, a fuzzy logic approach is proposed in order to develop energy-efficient routing methods that achieve the minimum energy consumption of packets at routing layers in MANET.
- The proposed fuzzy logic-based clustering is used to avoid the stale routing at routing layers.
• The proposed cross-layer approach-based bee optimization is used to develop an energy-efficient routing protocol for MANET. This contains cross-layer interaction between the physical layer, network layer and MAC layer.

![Diagram of the proposed method](image)

**Figure 1.2 Overview of Proposed Energy-Efficient Routing Method**

The overview of the proposed method is shown in Figure 1.2. Initially the mobile nodes are placed randomly in the network...
terrain area. The first phase forms fuzzy based energy-efficient routing in order to minimize the energy consumption of mobile nodes. The second methodology forms a fuzzy-based clustering model, which decreases the network overhead during routing. The third method examines the optimal path for routing the data packets. All the three mechanisms are combined to design an energy-efficient routing protocol for MANET.

1.11 ORGANIZATION OF THE THESIS

The chapters of the thesis are structured as follows:

**Chapter 1** presents the introduction to MANET and its application, characteristics, the problems and also objective of the research work.

**Chapter 2** presents the review of literature which provides the necessary background for a general understanding of challenges faced while routing in MANET and also explains the overview of the latest literature.

**Chapter 3** deals with the fuzzy logic system for routing. It also discusses the proposed algorithm in detail with its advantages over the existing fuzzy logic system.
Chapter 4 gives detailed ideas about the selection of cluster head based on the node’s energy and also explains the fuzzy-based clustering scheme to resolve the harms found in ad hoc networks.

Chapter 5 discusses a novel bio-inspired routing algorithm for MANET in order to increase the network lifespan.

Chapter 6 summarizes the outcome of the research work and outlines the possible directions for future research.