CHAPTER 1

INTRODUCTION

1.1 WIRELESS NETWORK

Wireless communication has gained popular usage and spread significantly because of the flexibility, convenience of use and less installation cost. It uses radio waves for communication, and hence the devices are free to move and are not tied to a fixed location as in hard wired network. A Wireless Local Area Network or WLAN is a local area network (LAN) in which a user using mobile device can get connected through a wireless radio connection for communication and access applications and information without wire connection. The technologies for wireless LANS are specified by IEEE 802.11 group standards. In already established offices, WLAN can easily provide a way for creating a network without disturbing the buildings, which otherwise needs facilities for laying wires to form network.

There are two types of WLAN networks that can be formed: infrastructure networks and ad hoc networks. Office areas and hotspots mainly use infrastructure network for their service. The wireless network is split up into a number of cells of Basic Service Set (BSS), each controlled and serviced by a base station or Access Point (AP). A distribution system connects several BSSs via the AP to form a single network called Extended Service Set (ESS), and it has its own identifier, the ESSID. The wireless coverage area is thus extended by the distribution system. Each Access Point may have a range of between 30 and 300 metres dependent upon the environment and the location of the Access Point.
The other type of WLAN network used is termed as an ad hoc network. They may be needed when several people join to form a network and need to share some data or if they need to access any resource or service without the use of wire connections. In this situation, the communication between users is wirelessly established, and they directly communicate with each other without the help of any access points. Wireless devices within the range of each other can discover and communicate directly without involving central access points. Ad hoc networks are thus built between stations, forming one or more Independent Basic Service Set (IBSS).

1.2 MOBILE AD HOC NETWORK (MANET)

Mobile Ad Hoc Networks (MANETs) are an emerging type of wireless networking, in which mobile nodes associate with each other on an ad hoc or extemporaneous basis. The wireless communication nodes within the range of each other, join in an infrastructureless environment to form a network as shown in Figure 1.1.

![Figure 1.1 Mobile Ad Hoc Network](image)

The nodes are mobile in nature and free to move independently in any direction. Since the nodes are mobile, their links to other devices change frequently. MANET is formed instantaneously to manage the situations where computation infrastructures are non-existent. Each mobile node that is part of
the MANET acts as a router and establishes communication between them. To communicate with the node outside its communication range, a sequence of intermediate nodes in ad hoc networks is required to relay messages on behalf of this node, resulting in multi-hop wireless network. The nodes have the ability to self-organize themselves to formulate a network. They have only limited resources such as transmission power and battery life.

1.2.1 Applications of MANET

With their self-forming nature and their ability to cope with rapid changes of the topology, ad hoc networks are attractive to a variety of applications. Military applications, emergency situations such as in disaster zones, battlefield communications, vehicular networks, collaborative file sharing, business and commercial applications, personal area communication utilizing mesh network, etc. are some example applications which use MANET for communication. These applications need a network to be formed instantly without any infrastructure. Disaster areas might lack communication infrastructure support, and hence, MANET plays a crucial role in such areas for the rescue operations.

1.2.2 Routing in MANET

Communication between devices in MANET is possible by the routing protocol used in the network. In order to establish an ad hoc network and provide communication between devices, an efficient routing protocol is needed. The purpose of the routing protocol is to discover speedy changes of the topology in such a way that intermediate nodes can act as routers to forward packets between the communicating pair. The routing protocols are classified as proactive, reactive and hybrid (Royer et al. 1999). Proactive routing maintains routing state. Reactive routing reduces the impact of frequent
topological changes by obtaining the routes on demand basis. Hybrid routing combines the nature of proactive routing and reactive routing.

1.2.2.1 Proactive Routing

In proactive routing protocols or table-driven routing protocols, each node maintains the network topology information representing the route to reach every other node in the network in one or more tables. This routing information in tables is updated periodically by every node so as to maintain a consistent and up-to-date view of the network. When the network topology changes, update messages are propagated throughout the network in order to reflect the current topology of the network. The number of necessary routing-related tables and the method adopted for the distribution of the topology change information across the network differentiate these proactive routing protocols. WRP (Murthy et al. 1996), DSDV (Perkins et al. 1994), GSR (Chen et al. 1998) are some examples for table-driven routing protocols.

1.2.2.2 Reactive Routing

In reactive routing protocols or on-demand routing protocols, the tables containing all up-to-date routes are not maintained at every node. The routes are created as and when needed. Hence these protocols do not exchange routing information periodically. When a source wants to send data to a destination, it invokes the connection establishment mechanism, also called route discovery mechanism, to find the path to the destination only at that instant. The route remains valid till the destination is reachable or until the route is no longer needed. AODV (Perkins et al. 2003), DSR (Johnson 2003), TORA (Park et al. 1997) are some examples for reactive routing protocol.
1.2.2.3 Hybrid Routing

Hybrid routing protocols use the proactive approach for setting up routes for the nearby nodes and reactive approach for the far away nodes. This is because of the fact that frequent communication involves nearby nodes much more than the far away nodes. ZRP (Beijar 2002) is one of the examples for hybrid routing protocols.

1.2.2.4 Group Communication and Multicasting

With the rapid development of group communication applications in today’s world, multicast routing has attracted more attention. The network needs fundamental changes to the conventional routing protocols in spite of its individual features. In multicasting, a path is set up connecting all the multicast group members, and packets are forwarded to every receiver from the source in a single transmission. Group communication application includes audio/video conferencing and also one-to-many data forwarding in critical conditions such as disaster recovery or battlefield surveillance.

The existing protocols can be classified into tree-based, mesh-based (Gujral et al. 2012) and hybrid (Mnaouer et al. 2007). Tree-based routing protocols build a single path between any two mobile nodes in the multicast group. They require only minimum number of copies of the packet to be sent through the branches on the tree. Hence these protocols are bandwidth-efficient. If the mobility increases, the link failures activate the retransmission in the entire tree. If there are many sources located on the network, then the network needs to maintain a shared tree or maintain multiple trees. But, it results in heavy storage and control overheads. Some of the examples of tree-based routing are Ad hoc Multicast Routing (AMRoute) protocol (Xie et al. 2002) and Multicast Ad hoc On-demand Distance Vector routing protocol (MAODV) (Baolin et al. 2005).
Mesh-based routing protocols find stable multicast paths from source to destinations. They are more resistant to mobility as well as to link failures. The main drawback in mesh-based protocol is that they introduce more redundancy of data packets since multiple copies of similar data packets are distributed through the mesh. It results in poor packet delivery and higher control overhead in high node mobility circumstances. Some of the examples are Dynamic Core-based Multicast Protocol (DCMP) (Rajeswari et al. 2015), On-Demand Multicast Routing Protocol (ODMRP) (Nayak et al. 2015), Core Assisted Mesh Protocol (CAMP) (Garcia-Luna-Aceves et al. 1999), Forwarding Group Multicast Protocol (FGMP) (Chiang et al. 1998) and Neighbor Supporting ad hoc Multicast routing Protocol (NSMP) (Lee et al. 2000) and location-based multicast routing protocol (Ko et al. 2000).

Hybrid routing protocol combines the benefits of both the approaches. Here, a node proactively manages only the link information of the nodes within the variable sized local neighborhood referred to as the routing zone. It reactively sends out the route request to destinations through broadcast algorithms. Example of hybrid routing protocols are Zone Routing Protocol (ZRP) (Basurra et al. 2015) and Hybrid Energy Efficient Routing Distributed Clustering approach (HEED) (Younis et al. 2004).

When the ad hoc network is established and working, users will obviously want to utilize several services. The nodes in MANET offer a variety of services. A service is a facility that is useful for the other nodes in a network. The nodes in MANET are usually with limited resources and so they have difficulties in accomplishing the tasks that cannot be finished alone. Hence it becomes essential to utilize the resources and services available in the other devices to complete the tasks efficiently. For example, a mobile device without a printing support will require a printer to do the printing task. Thus, getting the benefit of resources available in an ad hoc network requires knowledge of
services provided by the other devices. The way for the interaction with these services is also one of the important issues in MANET. The process of interaction with a service is mostly achieved with the help of routing in a network. Most of the existing service discovery protocols use broadcasting or multicasting to achieve service discovery. A group of devices may request a certain service, and hence multicasting-based group communication is considered as a better base for establishing service discovery in MANET.

1.3 SERVICE

A service is viewed as an application or software component running in a mobile node. Any node that is in need of a service may send request to any other node in the network. The nodes which provide the services are called service providers. Each service provider can provide more than one service. The service requestors can make use of the available services after getting reply from the service providers. A service is also viewed as a facility that is useful for the other nodes in a network. Example services are printer service, fax, etc.

1.4 SERVICE DISCOVERY IN MANET

Service discovery allows the nodes to advertise their services and to use the needed services available in the other nodes (Artail et al. 2008). The service discovery protocols suggested for one type of network are not suitable for another type of network because each network has different characteristics.

The most important characteristics of MANET are the mobility and the rate of joining and leaving of devices from the network. Fixed network devices do not have mobility. The nodes do not join or leave the network or a few nodes may join and leave the network. In ad hoc network with very restricted mobility and low rate of join or leave, there are few nodes that are
fixed. But in mobile ad hoc network (MANET), the devices are assumed to have unrestricted mobility, and they can join or leave the network at any rate. There may be even no fixed node. From these characteristics of different types of network it is inferred that the problem of service discovery is very challenging in MANET compared to the other type of networks.

The usual service discovery protocols used in wired networks are not suitable for mobile ad hoc networks. Hence a modified service discovery is thus needed to simplify the task of building the network using mobile devices, maintaining and introducing new devices and services to a mobile ad hoc network.

1.4.1 Service Discovery Architecture

Service Discovery protocols depend on the underlying service discovery architecture. Service discovery architecture can be classified into directory-based architecture, directoryless architecture and hybrid architecture (Kozat et al. 2004). In directory-based architecture, the services are registered with a directory, and the service requestors are informed about the services through the directories only. Directories are implemented either centralized or distributed. Directoryless architecture does not rely on service directory. The service providers and service requestors accomplish their task by either multicasting or broadcasting the necessary information. Hybrid architecture combines both the approaches. The service requestors, if they are aware of service directory in their vicinity, make use of directory; otherwise broadcasting is used to achieve service discovery. Service descriptors are represented in MANET nodes mostly by using Web Ontology Language OWL (Kopena et al. 2005), XML (Helal et al. 2003), UUID (Obaid et al. 2007), Bloom Filters (Bloom 1970).
1.4.2 Service Discovery Modes

Service discovery modes are classified into proactive, reactive and hybrid. In proactive approach, service providers advertise their services in periodic time intervals. The initial service discovery delay is very less in this approach. Reactive mode makes use of on-demand queries from the service requestors to service providers or service directories to find the required service. The queries are sent by multicasting or broadcasting. Hybrid mode allows the usage of both proactive and reactive service discovery modes. The main aim of this thesis focuses on handling the request and response operations for the services.

1.4.3 Service Lookup Methods

Service lookup is the process of finding or looking for a required service. There are generally two methods to look for a service. The first is the ‘query’ method which is also called active or pull method. In ‘query’ method, clients solicit for one or more services. Service providers, in turn, respond to the client requests. The drawback to this method is that several clients may ask separately for the same service. The second method of service lookup is the ‘announcement’ method also called as passive or push method. Here, services send periodic announcements to all clients. However in this method, clients must handle all service announcements whether they are interested or not. Moreover, the interval between service announcements is the deciding factor for the client to wait for before it can learn about the available services. If the interval is too high, then most of the service requests will face failure.

1.4.4 Cross Layer Service Discovery

Communication between the nodes facilitates the usage of services available in the other nodes. Cross layer service discovery makes use of the communication that is established by the underlying network layer routing
Some existing solutions rely on the routing protocol to achieve both data forwarding and service discovery. Cross layer protocols eliminate redundancies and provide optimized performance. However, it needs changes to the routing protocols to achieve the same. Cross layer service discovery method provides the means for efficient service discovery and selection, reduces traffic, interference over the network and increases overall network throughput.

The effect of topology changes in the network is easily incorporated in the service selection. The routing protocol reflects the topology changes, and hence, the best nearby service can be found out by combining the routing protocol with service discovery methodology. The communication between the devices is localized in the presence of topology changes, and higher network throughput is achieved than a typical application-layer solution (Varshavsky et al. 2005).

1.4.5 Routing issues in MANET that impact Service

The following are some of the main issues in routing to be considered when deploying service discovery in MANETs:

1. Unpredictability of Environment
2. Unreliability of Wireless Medium
3. Resource-Constrained Nodes
4. Dynamic Topology
5. Transmission Errors
6. Node Failures
7. Link Failures
8. Route Breakages
9. Congested Nodes or Links
1.5 MOTIVATION

Service provisioning and service discovery in MANET are essential due to the enormous use of mobile devices and the need for service access at anytime and anywhere. The service discovery protocols used in traditional networks cannot be applied in MANET because of the wireless medium interferences and the mobile nature of the nodes. As both the service process and the routing processes generate and receive messages, it is possible to exploit the routing layer for efficient dissemination of service control messages. But at any given time, the status of the communication links used in routing between the nodes depends on various factors.

Mobility of nodes in MANET causes frequent disconnections and topology changes. Furthermore, the success of communication between the nodes depends on the received strength of the signal between the nodes. As the nodes move away from each other, the signal strength weakens, and hence results in unsuccessful data delivery. The energy constraints of the nodes also add to the problem. Moreover, the mobility nature of nodes and the topological changes result in high overheads, and this disturbs the throughput value in terms of packet delivery ratio (Li et al. 2014).

Hence service discovery should rely on a highly stable and reliable routing protocol. Multicasting protocol can be modified to be used as the protocol model for implementing cross layer service discovery. But multicasting protocols used for achieving service discovery suffers scalability when used in a large network. The tree-based multicast protocol, when modified, can act as a robust protocol that performs background processing to automate trivial tasks and let the user concentrate on his/her main objective of service discovery. Therefore, stability, energy and efficient multicasting architecture are needed to achieve better service discovery in MANET.
1.6 OBJECTIVES

1. To achieve service discovery in MANET using a Stable and Energy aware Service Discovery (SESD) for MANET.
2. To develop a signal strength and stability model for neighbor node selection. The stability model is formulated based on received signal strength.
3. To use stable and energy aware multicast group communication concept for establishing the communication path.
4. To use the zone-based hierarchical structure for efficient service lookup operation.
5. To analyze and reveal the performance of SESD based upon various performance criteria such as packet delivery ratio, control overhead, end-to-end delay, service success ratio, energy utilized, etc.

The scope of the thesis is restricted to service discovery based on service id and does not deal with the design of the service name and context.

1.7 CONTRIBUTION

This research focuses on the service discovery in MANET. First a multicasting protocol (M-EEMC) is formulated as the base for implementing service discovery. Here, multicasting is achieved using an active tree surrounded by passive mesh. Transmission range is dynamically varied for each node based on neighbour density and mobility. Residual energy of nodes is used for tree formation and maintenance to achieve better performance.

Next, a stability model is formulated based on received signal strength. Stable and energy aware forwarding node selection is suggested and used in zone structure to achieve efficient multicasting. Subgroups are formed.
inside the zone for analysing the efficiency of hierarchical routing and group communication.

Finally, a stable and energy aware service discovery protocol is recommended based on the performance improvement gained by the stability model and zone-based multicasting. The work uses zone management and directory maintenance with a view to distributing the load among the nodes, and thus reducing the energy consumption of the nodes. Group communication concept is twined with the service requestor concept to simplify the service lookup operation. Cross layer service discovery is proposed and implemented based on the signal strength and stability, energy awareness and group communication in a zone-based structure which reduces control overhead of MANET to a great extent.

SESD is suggested and the performance analysis shows that it achieves better performance mainly in terms of service success ratio and also assures lesser control overhead and energy consumption. The performance analysis of all the works are carried out in network simulator NS2 using the simulated data reflecting the real scenarios.

1.8 ORGANISATION OF THE THRESIS

The thesis is organized as follows.

Chapter 2 presents an exhaustive literature review in the area of multicasting, link stability-based multicasting, zone-based routing and service discovery in MANET. The observations from the existing work and challenges are also presented in this chapter.
In Chapter 3, a Mobility based Energy Efficient Multicast protocol (M-EEMC) for MANET is presented. The performance of M-EEMC is analysed based on the success of packet delivery and energy efficiency.

Chapter 4 formulates the signal strength-based stability calculation and suggests stable and energy aware forwarding node selection. Based on the stability model, a zone-based multicasting protocol named SEMC is formed and analysed. Hierarchical management of nodes using subgroups is also suggested. The results of SEMC are compared and analysed with the existing methods.

In Chapter 5, service discovery in MANET (SESD) is formulated on the basis of stable and energy aware zone-based multicasting. Service descriptor storage and zone management are suggested. The results are analysed and summarized.

Finally, Chapter 6 ends this thesis with conclusion and recommendations for future work.

1.9 SUMMARY

This chapter provides a brief introduction to Mobile Ad Hoc Network and the routing in MANET. The details of services and service discovery architectures, modes and lookup services are also discussed. The research motivations and research objectives are also briefly explained in this chapter. The contributions of this thesis are discussed, and the organization of the thesis is also presented in this chapter.