CHAPTER 2

LITERATURE REVIEW

This chapter gives the literature review of various routing protocols and related research efforts made in wireless routing protocol for MANET.

2.1 INTRODUCTION

Wireless communication has shown its numerous advantages over wired communication fuelled by digital and Radio Frequency (RF) fabrication developments, portable mobile devices such as cellular phones, personal digital assistants and laptops. The above tools have brought great demands for wireless communication. Various wireless communication networks such as cellular networks (Rappaport 2004), Wireless Local Area Network (WLAN), bluetooth networks, Ultra Wideband (UWB) networks, MANETs and WiMAX. Among these, cellular networks, WLANs and bluetooth are the most widely used networks, requiring costly infrastructure and centralized administration. Bluetooth hosts can get connect to each other in an ad-hoc fashion, but this technology is targeted only at low power and short range wire replacement. Therefore, MANETs are characterized by a multihop network topology that can change frequently during mobility. In recent years, information transfer over ad-hoc networks has been increased.

A MANET is a distributed network that does not require centralized control, and can change frequently due to mobility. An efficient routing protocol is needed to established path between two communication
lines. Several routing protocols have already been proposed by various researchers.

2.2 CLASSIFICATION OF ROUTING PROTOCOLS

Routing protocols for MANETs are classified into three types based on the routing information mechanism (Royer & Toh 1999):

1. Proactive or table-driven routing protocols
2. Reactive or on-demand routing protocols
3. Hybrid routing protocol

Routing protocols for MANETs are broadly based on the decisions made to find a route for the destination node, determination of the structure of the wireless network and geographical information.

2.3 PROACTIVE OR TABLE-DRIVEN ROUTING PROTOCOL

Proactive protocol also called table driven is the expansion of wired routing protocol used mainly send data from the source node to destination node through multihop in ad hoc network. It maintains the information about global topology in the form of routing tables at each node. The updated messages are frequently added to the routing table. It is used mainly in disaster area (Krishna2006). In it, as noted by Royer (1999) there are six protocols: Destination Distance Vector Routing (DSDV), Wireless Routing Protocol (WRP), Source Tree adaptive Routing (STAR) protocol, Optimal Link State Routing(OLSR), Fisheye Routing (FSR), Hierarchically Segmented Routing (HSR) and Global State Routing (GSR).
2.3.1 **Destination Distance Vector Routing (DSDV)**

DSDV, the first table-driven routing protocol for MANET, is proposed by Perkins and Bhagwat (1994). It is the enhanced version of the distributed Bellman-Ford algorithm where in each node maintains a table that contains the shortest path and the first node and the shortest path to every node in the network. Routes are established based on traffic control and they are available all the time. Each node maintains one or more tables that contain routing information to the other node of the network. Nodes continuously update the tables to provide fresh view of the whole network. Updates are so frequent that the advertisement must be made regularly to make sure that every node can always find another node in the network. The data broadcast by the mobile node contains its new sequence number, destination address, number of hops needed to reach destination and sequence number of the information received from the destination (Carlos & Agrawal 2000).

Periodic transmissions of routing table update the topology information of the entire network (Park & Yoo 2010). If any change occurs in the routing information, it will be updated and transmitted immediately from that respective node. In broadcasting using DSDV, every mobile node DSDV protocol requires the own routing table that maintain information about the neighbor also. Routing information is updated automatically in two ways: one is “full dump” and another is “incremental”. In full dump, the complete routing information is sent to the neighbors, while incremental update requires only those entries which need to be sent.

DSDV is required to maintain a complete list of routing information and all the nodes create routes on demand basis. This approach considerably reduces the number of broadcast messages. When a source node desires to send data to a destination node, it checks if it already has a route to
the particular destination node. If the required number of valid route is present, DSDV initiates the route recovery process. The source node sends Route Request (RREQ) to its neighbors, which is forwarded to its neighbor until the destination node is reached or an intermediate node with a route to the destination node is found. The entire intermediate node receives the RREQ packet update or records in their routing tables the address of the neighbor from which the packet is received. Once the destination route is found or reached, a Route Reply Packet (RREP) is routed back to the source node along the reverse path. After receiving the RREP packet, the source node can start sending data using the newly found route (Charles & Pravin 1994).

DSDV is quite suitable for creating ad-hoc networks with small number of nodes. Since no formal specification of this protocol is not commercially implemented. The advantage of the DSDV algorithm is its loop free path. The disadvantage of DSDV is that it requires a regular update of routing table, which uses battery power and a small amount of bandwidth even when the network is idle. Whenever the topology of the network would be change, a new sequence number is necessary before the network recoverages. Hence, DSDV is not suitable for dynamic network route (Charles & Pravin 1994).

2.3.2 Wireless Routing Protocol (WRP)

WRP is an extended version of distance vector protocol. It is used to eliminate the count to infinity problem, and to decrease the convergence time. It requires a large memory space for processing. So, it is not suitable for large mobile networks. Each node in WRP maintains the following four tables.
1. Link Cost Table (LCT): Each node maintains the cost, link identifier and directly connected nodes.

2. Distance Table (DT): Each node in the DT contains the information about the hop not directly connected.

3. Routing Table (RT): RT maintains the path details of all the nodes, and the up-to-date information about the destination node.

4. Message Retransmission List (MRL): Each node in the wireless network sends a HELLO packet to its neighbor node, and after receiving the message packet, the destination node sends the Acknowledgement (ACK) to the source node. If it does not get ACK from the destination node within a certain period, the information is kept in MRL.

WRP uses the Bellman-Ford algorithm to calculate the shortest paths. The DT contains the visit of the neighbor nodes. It includes a matrix form, where each element or node maintains the information on the distance between the penultimate nodes reported by a neighbor for a particular destination node. The RT consists of the up-to-date information of the network view for all known destination nodes. Similarly LCT contains the cost, the number of nodes to reach the destination node, and relaying messages through each link. MRL is used to create an entry for every updating message and to maintain the counter which maintains and retransmits messages for each entry. For every retransmission, the counter would be decremented and the list of recent messages would be updated in the table for every entry. After transmitting the updated messages marked to RT and sent the acknowledgement to the source. When the counter reaches zero, all the entries check whether acknowledgement is received. It is not received, the updated message will be retransmitted and then the message will be
deleted. If the link is broken, the number of update periods is not entered in to the routing table (Park & Yoo 2010).

2.3.3 Source Tree Adaptive Routing (STAR) Protocol

STAR protocol is a variation of table-driven routing protocols, with the Least Overhead Routing Approach (LORA) as the key concept rather than the Optimum Routing Approach (ORA) that is employed by the existing table-driven routing protocols. In STAR protocol, every node broadcasts tree information to its source. The source tree consists of the wireless link node used by the preferred path to the destinations. Every node, using its adjacent link and the source tree broadcast by its neighbors, makes a partial graph of the topology. During the transmission, each node sends an updated message to its neighbor. Each node is required to initiate update messages about new destination, if any change occurs in routing loops and if the cost exceeds the given threshold. Hence each node has the path, which in most cases would be optimal to a destination node.

2.3.4 Optimal Link State Routing (OLSR)

OLSR is a pure linked state protocol for MANET. When a node wants to updates the topology, it retransmits the routing packets to its neighbor. It is also called multipoint relay of the node. The node that is not a multipoint relay, receives the updated packets from the source and updates topology information in the packet, but would not rebroadcast the message packets. OLSR reduces the size of control packets by hiring a node and sends only routing updates for nodes that have selected node as a multipoint relay. It is a hop-by-hop routing protocol and each hop employs the most recent information to route a packet. When a node is successfully delivered to the
packets it is faster and followed by a neighborhood node. The frequency of the message is traced to the nodal mobility.

2.3.5  **Fisheye Routing Protocol (FSR)**

FSR is a hierarchical routing protocol is applied to reduce the size of information used to represent a graphical data. The fisheye captures with high detail pixels near the focal point. When the focal point is increased in distance, the detail would be decreased. In ad-hoc network, the fisheye approach is used to maintain information related to the path quality and accurate distance of the immediate neighborhood node. In FSR, after receiving up-to-date information from the neighborhood, the details are stored in the link state table. FSR is similar to LSR protocol and used to maintain the topology map. The topology map is used to calculate the shortest path of the node and it would reduce the message control overhead. When the network size is bigger, the update message that would consume considerable amount of bandwidth depends upon the updated period. When the size of the updated message is reduced, it would not affect routing accuracy.

2.3.6  **Hierarchically Segmented Routing Protocol (HSR)**

HSR proposed by an Iwata in 1999, is a multilevel clustering and logical partitioning of mobile nodes. The mobile network is divided into clusters and a master node is chosen as that of any one of the cluster-based algorithm. In HSR, the master node organizes the overall network into cluster and so on. The mobile nodes of a cluster broadcast their link information to the other nodes. The master node maintains its cluster information and sends it to neighboring cluster heads through gateway. Master node is a higher level member of the cluster, and it exchanges the connection information and provides lower level information among the nodes. To avoid flooding, the
lower level information is used by any one the existing cluster algorithm that has run at that level. HSR is a very good routing protocol for MANET. It provides good scalability and many facilities for finding the best path for MANET. It is mostly used in vast network. In a large network, it gives low overhead facility and reduces the end-to-end delay; it is used to seamless connectivity and improves the quality of service.

2.3.7 Global State Routing Protocol (GSR)

GSR was proposed by Chen in 1998. It is similar to DSDV. It maintains the link state routing and avoids flooding of routing information. In it, every node maintains a neighborhood list, topology table, next hop table and DT. Neighborhood list maintains the list of its neighborhood. Topology table maintains the link state information and maintain the timestamp of the information. Next hop table maintains the information related to next hop to which packets for destination are forwarded. The DT maintains the details of the shortest distance to the destination node.

Link state protocols are used to generate the routing messages on a link. After receiving routing message, the topology table maintains the sequence number of messages and stores them in the table. After receiving the message, the mobile node would reconstructits RT and broadcast the link information to its neighborhood.

2.4 REACTIVE OR ON-DEMAND ROUTING PROTOCOLS

A table-driven routing is a source-initiated on-demand routing. It creates routes only when desired by a source node. When a node requires a route to a destination, it initiates a route discovery process with the network. The route discovery process is completed once a route is found or all possible route permutations have been examined. The reactive protocols are divided
into four types: Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), Flow state Dynamic Source (FSDS) routing and Power Aware DSR based routing protocol.

2.4.1 Ad Hoc On-demand Distance Vector (AODV)

AODV is a multicast routing protocol proposed by Perkins and Royer, in 1999. It is used to build a route between the nodes as long as needed by the desired source node. In this algorithm, a tree structure is formed to connect a multicast group member. The trees structure is utilized used to collect the group members and the nodes to connect the members. It contains the sequence numbers to guarantee the originality of routes. It is self-starting, loop-free and it maintains large numbers of wireless nodes (His & Abdullah 2009).

AODV constructs routes using REEQ and route reply cycle. When a source node decides a route to a destination node that does not have a route, it would broadcast an RREQ message packet across the wireless network. Then the nodes receiving the RREQ message packet update their routing message for the source node and set up a link between the source nodes in the RT. It maintains the IP address of the source node, broadcast ID, sequence number, and current destination sequence number of the particular source node. The source node receives an RREP that consists of the biggest sequence number or the same sequence number with the smallest hopcount; it updates routing information for that particular destination node and starts using the best route. After receiving the RREQ, destination sends a RREP to the corresponding source node. Once the source node receives the RREP message packet, it begins to forward message packets to the destination node. When the source node stops sending the message packets, the link would time out the node that can be deleted from the intermediate node in the RT. If a link is
broken when the route is active, it will propagate a Route Error (RERR) message to the particular source node and informs to the unreachable destination node. After receiving RERR packet, the source node selects the new route using the route discovery (Charles & Pravin 1994).

2.4.2 Dynamic Source Routing (DSR)

DSR protocol is an on-demand routing protocol designed to construct the bandwidth consumed by control packets in wireless ad-hoc networks by eliminating the periodic updation of the message table required in the table-driven approach. The major difference between DSR and the other on-demand routing protocols is that it is beacon-less. Hence it does not require periodic HELLO packet transmissions, and is used to inform its neighbor’s node. In this DSR, during the route construction, a route by flooding RREQ message packets in the wireless network is established. The destination node, on receiving a RREP message packet, responds by sending an RREP message packet back to the source node, which carries the route traversed by the RREQ message packet received.

In DSR, each source node determines the path to be used in transmitting its message packets to the selected destination node. It involves two components: one is called route discovery and another one is route maintenance. Route discovery ensures the optimal path for a transmission between a given source node and a destination node. Route maintenance determines that the transmission path is residue optimal and loop-free as wireless network, when subjected to change. It requires the change in route during the message transmission.
2.4.3 Flow State Dynamic Source Routing (FSDS)

FSDS is an extension of DSR that would provide the benefit of source routing protocol, without using the message packet overhead connected with source routing. FSDS works with many packets to be sent without using source route header, thereby significantly reducing the message overhead. The main disadvantage of DSR is that if the biggest message packet header is used, when time source route of packet would be longer, which is called implicit source routing. The main idea of FSDS isto introduce a so-called flow table for every network node and to make a powerful routing protocol. Every flow of node forwards the packets and every entry is recorded in the flow table.

2.4.4 Power-Aware DSR-based Routing Protocol

Power-aware routing protocols are used to reduce energy consumption in message packets transmission between a source node and a destination node. They are used mainly to avoid routing of message packets through multiple hops which reduce the amount of energy consumption. The power-aware routing protocols aimed at optimizing the flooding of routing information over the wireless network and avoiding interference and occurrence of collision. MANET is needed to make every protocol is an energy efficient. Every protocol has some benefits and shortcomings (Baiamonte & Chiasserini 2004). Protocols can be performing better in every condition. Power-aware depends upon the network parameter and selects the protocols to be used. Many protocols giving energy efficient routing have been proposed with slight modifications for use in wireless ad-hoc networks.
2.5 HYBRID ROUTING PROTOCOL

Hybrid routing protocol for MANET is suitable for both proactive and reactive routing protocols. The resulting hybrid routing protocol archives better performance than its components and able to adjust dynamically to different network conditions. This routing protocol combines the advantages of both the proactive and reactive protocols. Hybrid routing protocols are lightweight, simple and designed to avoid excessive control overhead. These protocols are classified into node-centric or cluster centric. A network is organized into clusters or groups in a cluster-centric network. The clustering optimizes the use of the resources and reduces the size of the routing tables. Cluster-centric protocols adopt different rules for inter-cluster-traffic.

Proactive protocols have less latency and large overhead while reactive protocols have more latency and less overhead. So hybrid protocol is used to overcome the shortcomings of both proactive and reactive routing protocols. It uses the mechanism of route discovery in reactive protocol of the table maintenance of proactive protocol. So, avoids overhead and latency problems in the ad-hoc networks Hybrid routing protocol is more suitable for large networks where in large numbers of nodes are present. Various hybrid routing protocols are available in MANET: Zone Routing Protocol (ZRP) and SHARP Zone Routing Protocol (ZRP).

2.5.1 Zone Routing Protocol (ZRP)

ZRP is suitable for a broad range of MANETs, and is used mainly for the networks with large distance and various mobility patterns. In ZRP protocol, every node maintains the local region routes, which is labelled as routing zone. Query-reply mechanism is used for creating a route. For producing different zones in the ad-hoc network, a mobile node first has to
know about who its neighbors are. A neighbor is described as a mobile node which establishes a direct communication within one hop transmission range of that mobile node. ZRP uses the mechanism of query control and reduces the route query traffic by directing query outward messages. During the query packet forwarding, a node would be identifying whether it is coming from its neighbor or not. If yes, the neighbor node is in the same zone. After receiving query packets, the destination node sends reply message packets to the particular source node via the reverse path mechanism.

2.5.2 Sharp Hybrid Adaptive Routing Protocol (SHARP)

SHARP describes the proactive zones about some nodes. The number of mobile nodes in a specific proactive zone is resolute by the zone radius. In zone radius all the nodes is a member of the particular proactive zone for that mobile node. If a given destination node is not present in a proactive zone, query-reply is used to establish the route to that node. Proactive zone involves proactive routing mechanism. In the proactive zone, the node would be maintaining the routes proactively to the centralized node. In this routing protocol, proactive zones are generated automatically if some destinations are frequently addressed within the network. Proactive zones act as a collector of packets, and are used to forward the packets efficiently to the destination node once the packets reach any node at the zone vicinity.

2.6 CLUSTER BASED ROUTING IN MANETS

Cluster Based Routing Protocol (CBRP) is a fully distributed operation. It is used to reduce flooding in route discovery process. It is a uni-directional links. If any node is broken the routes are repaired locally without using rediscovery process.
2.6.1 Location Based Clustering

Location based routing protocol is employed to identify the zonal information. This protocol is categorized into two types: one is request zone and another one is expected zone. Request zone is mentioned in the rectangular area that includes both the sender and receiver. Location based clustering protocol is used to reduce the routing overhead and broadcast storm.

Shih & Yen(2014) have proposed a new cluster based routing protocol, named as Core Location Aided Cluster based Routing protocol (CLACR). In this method the entire network is indicated in square area. In this technique, every cluster and the master node would be selected using master node election algorithm. All the routing nodes are responsible for routing and message transfer. In this method, the data transfer is considered in the decreasing manner. This method used to reduce the routing overhead and to increase the lifetime of routes.

2.6.2 Neighbor Based Clustering

Neighbor based clustering is used to perform route discovery and traffic load. In this clustering protocol, the 3-level hierarchical scheme is used. 0 nodes are called the first level of the cluster. The 1-cell is called the second level of the cluster. Each node of the cell is available on 1-hop away from the master node. The 2-server of the cluster is called a server leader. This protocol contains a set of cells. The cluster would be reconstructing the slave nodes updated at every turn. Hence the cluster would be reassembled and the cluster members would be also updated at each turn.
2.6.3 Power Based Clustering

Sheu & Wang (2006) have proposed an efficient clustering protocol called power based clustering was elected using election algorithm. Moreover, a clustering architecture is created by defining a bottleneck node to be a mobile node with power consumption lower than a predefined threshold value. Bottleneck master node is to the bottleneck mobile node that elects a master node.

2.6.4 Artificial Intelligence Based Clustering

Fuzzy relevance-based master node selection Algorithm, which is used to select the master node using fuzzy relevance for clustering based wireless MANET. The fuzzy relevance-based master node selection algorithm constructs efficient clusters and manages the sensors and status of the mobile node using fuzzy information. In the Fuzzy Relevance Degree (FRD), the fuzzy value is considered as $\mu$, which is used to perform and manage mobile clustering. In this artificial intelligence based clustering algorithm, some of the nodes act as coordinators of the clustering technique and chosen by FRD to perform the clustering process.

2.6.5 Mobility Based Clustering

Muthuramalingam et al (2010) have proposed a new algorithm that uses Weighted Clustering Algorithm (WCA) for the clustering information and cluster maintenance. In a wireless MANET, node management is done by clustering.

Cluster Information: In cluster information, RREQUEST information is sent by each mobile node to notify its neighbors. A RREQUEST message consists of the state of the mobile node. A neighbor list
is constructed by each mobile node based on the received RREQUEST messages. In the mobile nodes based on the weight value, the master node is elected based on the weight values of the mobile nodes. The lowest weight node is chosen as the master node. Cluster maintenance: It maintains battery power and threshold value, it considered to be the two distinct types of operations and the movement of mobile node to the outside of its cluster edge.

Mobility prediction: The weighted clustering algorithm is based on the use of mobility prediction in the cluster maintenance phase.

2.6.6 Weight Based Clustering

Pandi & Palanisamy (2011) have presented a flexible weight based clustering algorithm for MANET called 2-hop clustering algorithm. The performance of the proposed algorithm increases the transmission range, maximum displacement and number of nodes. The weight of each node is calculated by the weight function \( w(p) \). Depending upon the weight the master node would be elected with its neighbors in the 2-hop range. The node with the highest weight declares itself as the master node.

2.7 PROBLEM STATEMENT

Since MANET is a multi-hop, self configuring and infrastructure-less network, designing a new protocol is a biggest challenge. Many of routing algorithms are developed by researcher for MANET. Some of the algorithm is derived from old tailored for MANET, while some are especially invented for MANET. In the past few years, researchers have been used many routing protocols to find a best path in ad-hoc networking. Many of researcher efforts focus specifically on finding the new protocol to find the shortest path from source node to destination node like cluster based routing protocols, power-aware routing protocol and so on. Finding optimal path is the major
problem in MANET, because two or more routes are available in same source and destination pair. MANET requires to particular routing functionality and methodology used to found the route. In our thesis mainly concentrate on used to find the shortest path routing using various new algorithms and method such as FCESR, FCECR, PSFRT and FCEMRR.

2.8 OBJECTIVES OF THE RESEARCH

The main objectives of the present research are to identify and determine the concepts of the shortest path routing problem in MANET,

- To evaluate and implement of Fuzzy Clustering based Energy Saving Routing (FCESR) Protocol for MANET. In FCESR develop CAT and MAT is used to identify the effective path without unnecessary data forwarding.
- To develop another new algorithm named as Fuzzy Cost Enabled Cluster based Multipath Routing (FCECMR) Algorithm. FCECMR employed to overcome the problem of route discovery overhead and vector cost of node.
- To identify the another new method to find a new technique in Path Selection using Fuzzy and Rough Set Theory (PSFRT) in Wireless MANET. This approach used to select the best paths In this approach find a new solution to utilize the information gain and provides the IF-THEN decision rules to find a best routing path with minimum number of resources and total vector cost.
- To identify another approach named as Fuzzy Cost Enabled Multipath Routing with Rough Set (FCEMRR) Approach in MANET is used to evaluate the best path and develop a new model indiscernibility matrix and IF-THEN decision rules to select a optimal path.
2.9 SIGNIFICANCE OF THE RESEARCH

The present research is significant as it’s evolves new algorithms and methods to find out the effective path in MANET. It reduces the total vector cost, energy consumption, end-to-end delay and route discovery overhead. In addition to finding fuzzy and rough set theory to introduce a rule reduction method to applying IF-THEN decision rule and indiscernibility matrix. This method is very useful to find the optimal path with the minimal resources and total vector cost.