A State-of-The-Art of Routing Protocols for Mobile Ad-Hoc Networks (MANET)

Abdalftah Kaid Said Ali
Research Scholar, S.G.G.S. Institute of Engg. & Tech
S.R.T.M. University, Nanded, Mahrarashtra, India

U.V. Kulkarni, PhD
Associate Prof, Dept. of Computer Sci & Engg
S.G.G.S. Institute of Engg & Tech, Vishnupuri
S.R.T.M. University, Nanded, Mahrarashtra, India

ABSTRACT
Mobile Ad Hoc network (MANET) is a collection of two or more devices, nodes or terminals with wireless communication and networking ability that can communicate with each other without the assistance of any centralized administrator, centralized control or established infrastructure. It's called infrastructureless. A network can be formed dynamically by the wireless nodes to exchange information without using any fixed existing network infrastructure. Each node plays a role of router in the MANET as it must forward the traffic to other nodes. In this paper, discuss in details the main characteristics, applications, advantages, disadvantages and challenges of Mobile Ad Hoc Networks. Several routing protocols have recently been proposed for Mobile Ad Hoc Networks, In order to facilitate communication within the network, a routing protocol is used to discover route between nodes. On other hand, also this paper provides a survey of the type of routing protocols. These protocols can be classified into three main categories: proactive(Table-Driven), Reactive (On-Demand),and Hybrid Routing Protocols.

Keywords
Ad-hoc network (MANET), Proactive, Reactive, Hybrid, Routing Protocols.

1. INTRODUCTION
Mobile Ad Hoc Network (MANET) is an entirely wireless connectivity through the nodes that are formed by the actions of the network that usually has a restricted bandwidth, a dynamic shape and other characteristics. Network members may be inside the laptop, mobile phones, MP3 players, digital cameras and so on. Thus, Ad Hoc Network, with the advantage of mobility, is fully wireless and can be any mobile network infrastructure. Initially, the use of the Mobile Packet Radio Network in military is considered to be the introductory predecessor of MANET. With the rapid advancement in the personal communication systems in the last few years, the use of mobile phones is popularlized to communicate with others anytime, anywhere. It has became part and parcel of life. An ad hoc network is a collection of mobile nodes forming an instant network without fixed topology. In such a network, each node acts as both router and host simultaneously, and can move out or join in the network freely. The instantly created network does not have any base infrastructures as used in the traditional networks. However, it is compatible with the conventional networks. Wireless network has become very popular in the computing industry. Wireless network are adapted to enable mobility [1]. There are two types of mobile network: Infrastructure network and ad-hoc network. Infrastructure network are the network with fixed and wired gateways. Infrastructure mode wireless networking connects a wireless network to a wired Ethernet network. Infrastructure mode wireless also supports central connection points for WLAN clients. An ad hoc network typically refers to any group of networks where all devices have equal status on a network and are free to connect with any other ad hoc network devices in link range [2]. Many routing protocols are proposed for MANET. The protocols can be majorly classified into three categories: Proactive, Reactive and Hybrid. Proactive routing protocols try to maintain consistent, up-to-date routing information from each node to every other node in the network, whereas Reactive routing protocols create just routes when desired by the source node. Once a route has been set up, it is maintained by a route maintenance procedure. Hybrid routing protocols are proposed to combine the advantages of both proactive and reactive routing protocols and overcome their drawbacks[3].

This paper goes further than others, which aims to discuss in details the main characteristics, applications, advantages, disadvantages and challenges of Mobile Ad Hoc Networks. On the other hand, achieves a short description of the three main classes of protocols which is namely as : proactive, reactive and hybrid.

2. WIRELESS NETWORKS
Wireless networks gives flexible connection between users who are in different places. In addition, the network can be expanded anywhere or building without a wired connection. Wireless networks are divided into two types: Infrastructure networks and Ad Hoc networks [4], as can be seen in Figure 1.

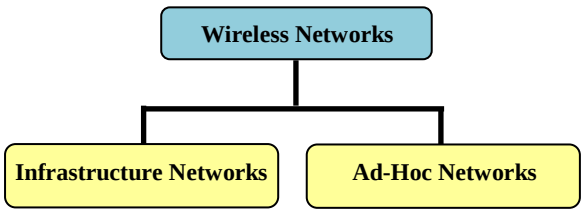

Figure 1 : Wireless Networks Categories

2.1 Infrastructure networks
This type of infrastructure wireless network relies on the third fixed party and in this architecture which allows the wireless station to make communication between each other as seen in Figure 2. When a source node wants to make a communication with a destination node, the source node tells the base station about that. An Access Point (AP) represents a central coordinator for all nodes. Any node can join the network through AP. In addition, AP organizes the connection between the Basic Set Services (BSSs) in order to make the route ready when it is needed. In spite of that, one

shortcoming of using an infrastructure network is the large overhead of maintaining the routing tables [4].

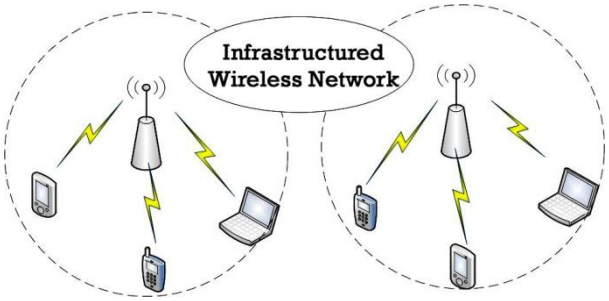

Figure 2: Infrastructure networks

2.2 Infrastructureless Networks or Ad Hoc networks

This type of network is well known as Mobile Ad Hoc Network (MANET) which can make communication with each other without the help of any centralized administrator. That is the wireless ad hoc network is a decentralized type of wireless network. In other words, the network is ad hoc because it does not rely on a preexisting infrastructure, such as routers in wired networks or access points in managed (infrastructure) wireless networks. Ad Hoc networks do not possess a fixed topology or a central coordination point. Thus, the source node and the destination node can communicate with each other by sending and receiving packets which is more complicated than infrastructure networks[4], as can be seen in Figure 3.

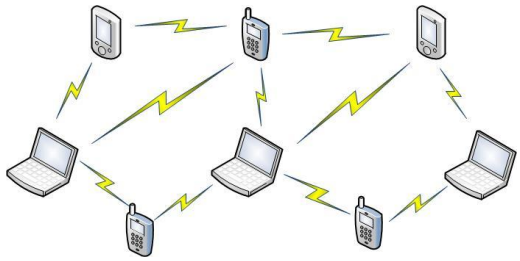

Figure 3: Ad Hoc Networks

3. MOBILE AD HOC NETWORKS (MANET)

MANET can be defined as a set of independent network mobile devices which are connected by various wireless links. These days, with the huge advancement in wireless network applications like laptop, PDAs and cell phones, researchers hope to improve the network services and performance. One of the defying design issues in wireless Ad Hoc networks is supporting mobility in Mobile Ad Hoc Networks (MANETs). The mobility of nodes in MANETs rises the sophistication of the routing protocols and the degree of connection's flexibility. In spite of that, the flexibility of allowing nodes to join, leave, and transfer data to the network rises security challenges [5].

A MANET is a collection of mobile nodes which share a wireless channel without any centralized control or established communication backbone. MANET has dynamic topology and each mobile node has restricted resources such as battery, processing power and on-board memory [5]. This type of infrastructureless network is of very usefulness in situation in which ordinary wired networks is not possible like battlefields, natural disasters etc. The nodes can directly communicate with each other where they are in the transmission range. If they are not located within the transmission range, then communication is done through intermediate nodes which want to forward packet. Thus, these networks are also called as multi-hop networks [4].

3.1 Characteristics of Mobile Ad Hoc Networks (MANET)

Mobile ad hoc network nodes have wireless transmitters and receivers by using antennas. This may be highly directional (point-to-point), omnidirectional (broadcast), probably steerable, or all these together. This ad hoc topology may change with time as the nodes move or adjust their transmission and reception parameters [6]. The characteristics of these networks can be summed up as follows [7]:

- Mobility.
- Multihopping.
- Self-organization.
- Energy conservation.
- Scalability.
- Security.
- Unmanned, autonomous vehicles.
- Connection to the Internet.

3.2 Application of Mobile Ad Hoc Networks (MANET)

The domain of wireless networking arises from several areas such as the integration of personal computing, cellular technology, and the Internet. This advancement rakes place because of the increasing interactions between communication and computing, that are altering information access from "anytime anywhere" into "all the time, everywhere." There recently has come into existence a large variety of networks, ranging from the well-known infrastructure of cellular networks to infrastructureless wireless ad hoc networks [5].

Ad Hoc Network has various applications which are summarized as follows:

- Community network
- Enterprise network
- Home network
- Emergency response network
- Vehicle network

3.3 Challenges (Issues) of Mobile Ad Hoc Networks (MANET)

In MANET [8], each node acts both as a router and as a host and even the topology of network may also change rapidly. MANET faces some main challenges which are mention bellow:

- Efficient and Stable routing
- Dynamic topology
- Network Scalability
- Network overhead
- Quality of Service

- Power Management
- Security

3.4 Advantages of MANET

MANET enjoys some advantages the most important of which are mentioned bellow [9]:

- MANET can easily execute this structure anywhere.
- MANET gives scalable result with more nodes.

3.5 Disadvantages of MANET

Although MANET has its own advantages, it is not free from some disadvantages the most significant of which are mentioned bellow [9]:

- Some security protocol in the network is not working properly in the ad-hoc
- If any malicious nodes with in entire network it is hard to find the malicious
- There is some good protocol in the wired network but it is tough to implement in the wireless node

4. MOBILE AD HOC ROUTING PROTOCOLS

Routing is considered the most important research issue in ad hoc networking. It controls routing packets between computing devices in a mobile ad hoc network. The nodes do not posses a prior knowledge of topology of network around them, so that they have to find out it. There is a fundamental idea about its location which is that a new node (optionally) makes known its presence and listens to broadcast announcements from its neighbors. The node knows about new nearby nodes and ways to reach them. Then, they may announce that it can also reach those nodes. Each node, in the course of time, knows about all other nodes and how to reach them in one or more ways. Routing Protocols can be classified into three categories on the basis of routing information update mechanism[10]. They are as follows:

- Proactive Routing or table driven Protocols.
- Reactive Routing or On-demand routing Protocols.
- Hybrid (Pro-active/Reactive).

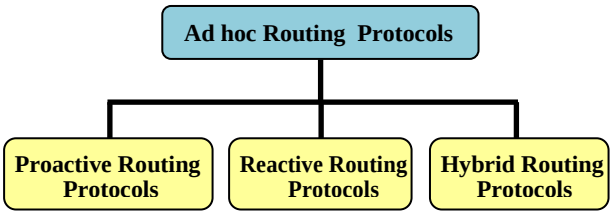

Figure 4: Classification of Ad hoc Routing Protocols

4.1 Proactive or Table Driven Routing protocols

Proactive protocols [11] continuously maintain routes to all nodes in routing table. This maintaining process includes nodes to which no packets are sent. When the network topology becomes different, it becomes necessary that routing tables are update as per the changes that occurs. Packets are transferred over the predefined route in the notified routing table. It is noted that the packet delivering is done faster, but the routing overhead is greater because all the routes have to be declared before sending the packets. They have lower latency because all the routes are continuously maintained at every times.

Examples:

- DSDV (Destination-Sequenced Distance- Vector Routing Protocol).
- OLSR (Optimized Link State Routing Protocol).

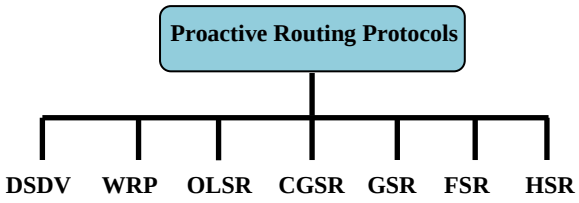

Figure5: Proactive Routing Protocols

4.1.1 Destination-Sequenced Distance-Vector Routing Protocol (DSDV)

The Destination Sequence Distance Vector (DSDV) is a proactive mobile and ad hoc routing protocol. The proactive DSDV protocol was proposed by Perkin and Bhagwat and is based upon the traditional Bellman-Ford algorithm. It is proposed in order to calculate the shortest number of hops to the destination. Each DSDV node maintains a routing table which stores such destinations as next hop addresses and number of hops as well as sequence numbers. Routing table updates are sent periodically as incremental dumps restricted to a size of 1 packet that only contains new information. DSDV compensates for mobility by using sequence numbers and routing table updates. If a route update with a higher sequence number is received it will replace the existing route and consequently decreasing the chance of routing loops. When a main topology change is discovered, an entire routing table dump will be executed. This can add important overhead to the network in dynamic scenarios [12].

4.1.2 Wireless Routing Protocol (WRP)

The Wireless Routing Protocol (WRP) is proposed by Murthy and Garcia- Luna-Aceves. Like DSDV, WRP is A table-based protocol that follows the Bellman-Ford Algorithm. Every node in the network employs a group of four tables in order to get more accurate information. These four tables are as follows:

- Distance table (DT)
- Routing table (RT)
- Link-cost table (LCT)
- Message retransmission list (MRL)

WRP has the main goat which lies in maintaining routing information between all nodes in the network concerning the shortest distance to every destination. Wireless routing protocols is a path-finding algorithm but it avoids the count-to-infinity problem. It is a loop free routing protocols. If the link between two nodes failed, update messages are sent by the nodes to their neighbors. When a link failure happens, the looping situation are illuminated and the route convergence is faster. [12].

4.1.3 Cluster Gateway Switch Routing Protocol (CGSR)

This protocol executes a distributed processing mechanism in the network. This protocol modifies DSDV by using a hierarchical cluster-head-to-gateway routing approach to route traffic from source to destination. Gateway nodes are known as nodes that are within the communication ranges of two or more cluster heads. A packet that is sent by a node is first sent to its cluster head. Then, the packet is sent from the cluster head to a gateway to another cluster head, and so on until the cluster head of the destination node is reached. The packet is then transmitted to the destination from its own cluster head. This protocol fulfils a distributed processing mechanism in the network by forming several clusters. However, CGSR has a demerit which is that frequent change or selection of cluster heads might be resource hungry and it might impact the routing performance [13].

4.1.4 Global State Routing (GSR)

GSR protocol points out that nodes exchange vectors of link states between their neighbors during routing information exchange. Nodes attains a global information of the network topology and optimize their routing decisions on the local area on the basis of the link state victors. Functionally, this protocol is like DSDV, but it develops DSDV. This means that it avoids flooding of routing messages [13].

4.1.5 Fisheye State Routing (FSR)

This FSR is considered as an development of GSR. This protocol uses the fisheye technique proposed by Kleinrock and Stevens in which the size of the information required is decreased to represent graphical data. It is an enhancement of GSR. The eye of a fish catches with high detail the pixels adjacent to the focal point. The detail reduces as the distance from the focal point rises. FSR maintains a topology map at each node. A link state table is maintained on the basis of the up to date information received from adjacent nodes. It will exchange information about the adjacent nodes. These tables are exchanged periodically only with their local neighbors. The update messages which are sent between the nodes could consume a lot of bandwidth, when the size of the network gets bigger. The sizes of these messages are decreased by using routing scopes in order to solve this problem. Scope is a group of nodes that can reach each other in given number of hops as can be seen in Figure 6. FSR significantly reduces the consumed bandwidth, because there is no flooding. [14]

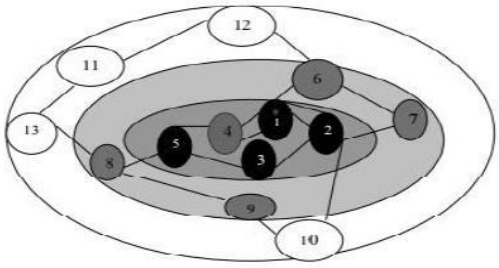

Figure.6: Fisheye State Routing

4.1.6 Hierarchical State Routing (HSR)

HSR is considered a multi-level cluster hierarchical routing protocol. HSR connects together dynamic, distributed multilevel hierarchical clustering technique with an efficient location management scheme. The hierarchical address is assigned to every node. This protocol divides the network into various clusters where each elected cluster head at the lower level in the hierarchy gets member of the next higher level. The fundamental idea of HSR is that each cluster head sums up its own cluster information and moves it to the neighboring cluster heads using gateways. After running the algorithm at any level, any node can flood the gained information to its lower level nodes. The hierarchical structure used in this protocol is able enough to deliver data with success to any part of the network [15].

4.1.7 Optimized Link State Routing (OLSR)

The OLSR is considered a point-to-point proactive protocol that employs an efficient link state packet forwarding mechanism called multipoint relaying. It optimizes the entire link state routing protocol. Optimizations are made in two ways: by decreasing the size of the control packets and by decreasing the number of links used for forwarding the link state packets. Here each node gains the topology information about the network by periodically exchanging link-state messages among the other nodes. OLSR is based on three mechanisms as follows: neighbor sensing, efficient flooding and computation of an optimal route using the shortest-path algorithm. Neighbor sensing is the discovery of changes in the neighborhood of node. Each node specifies an optimal route to every known destination using this topology information and stores this information in a routing table. The shortest path algorithm is then applied for purpose of computing the optimal path. Routes to every destination are constantly available when data transmission starts and remain valid for a specific period of time till the information is expired [12].

4.2 Reactive or On-Demand Routing Protocols

Reactive routing protocol is also called on demand routing protocol. Reactive protocols [11] are based on demand for data transmission. These protocols set up routes when demanded. They do not begin route discovery by themselves, until they are requested. Routes are only discovered whenever they are actually needed to forward packets from source to destination. They can decrease routing overhead when the traffic is low and do not need to find and maintain routes when there is no traffic and no need to update route information regularly. There are two main components in the on-demand routing protocols.

Examples:

- AODV (Ad-hoc On-demand Distance Vector Routing Protocol).
- DSR (Dynamic Source Routing Protocol).

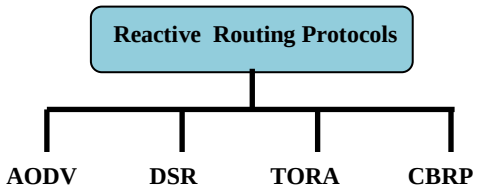

Figure7 : Reactive Routing Protocols

4.2.1 Ad Hoc On-Demand Distance Vector Protocol (AODV)

AODV is basically a development of DSDV. However, AODV is a reactive routing protocol instead of proactive. It creates routing based on demand in order to minimize the number of broadcasts, and it is not the case for DSDV. It broadcasts a route request (RREQ) packet, when any source node likes to send a packet to a destination. Then, the neighboring nodes in turn broadcast the packet to their

neighbors and the process carries on until the packet arrives the destination. Intermediate nodes record the address of the neighbor from which the first copy of the broadcast packet is received during the process of forwarding the route request. This record helps for establishing a reverse path when it is stored in their route tables. These packets are discarded, if additional copies of the same RREQ are later received. The reply is sent using the contradictory path. Concerning route maintenance, it can reinitiate a route discovery process, when a source node moves. If any intermediate node moves within a specific route, the neighbor of the drifted node can discover the link failure and sends a link failure notification to its upstream neighbor. This process continues until the failure notification reaches the source node. The source might decide to re-initiate the route discovery phase on the basis of the received information. [16].

4.2.2 Dynamic Source Routing Protocol (DSR)

Dynamic Source Routing (DSR) is a reactive protocol which based on the source route approach . In Dynamic Source Routing (DSR), shown in Figure.8, the protocol is based on the link state algorithm in which source initiates route detection on demand basis. The sender specifies the route from source to destination and it contains the address of intermediate nodes to the route record in the packet. DSR was designed for multi hop networks for small Diameters. It is known as a beaconless protocol in which no HELLO messages are exchanged between nodes for their notification of their neighbors in the network [16].

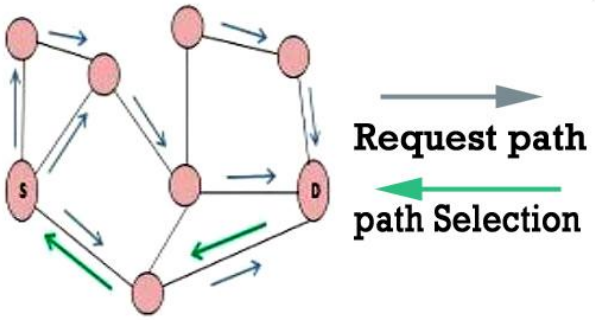

Figure 8: Dynamic Source Routing (DSR)

4.2.3 Temporarily-Ordered Routing Algorithm (TORA)

TORA is considered as a scalable, highly adaptive distributed routing algorithm designed for operating in a highly dynamic mobile networking environment. TORA is formed on the basis of the concept of "link reversal". The protocol is specifically designed to localize algorithmic reactions to topology changes by maintaining multiple routes to the destination. Shortest hop paths are given secondary importance and longer routes are often used to decrease the overhead of detecting newer routes. Therefore, TORA is suitable under the stability category. Moreover, TORA provides support to multicasting but it should be used in association with lightweight adaptive multicast algorithm (LAM) to support multicasting. The demerit of this protocol is producing temporary invalid routes like the LMR [15].

4.2.4 Cluster-Based Routing Protocol (CBRP).

Unlike the routing protocols described so far in CBRP, the nodes are organized in a hierarchy. The protocol divides the nodes of the ad-hoc network into a number of overlapping or disjoint clusters. Each cluster possess a cluster-head and member nodes. These cluster heads coordinate the whole routing process and are also linked to cluster heads of other clusters through gateway nodes. The protocol efficiently minimizes the flooding traffic during route discovery by clustering nodes into groups and accelerates this process as well. Moreover, the protocol pays special attention to the existence of unidirectional links and uses these links for both intra-cluster and inter-cluster routing [11]. This protocol has an attribute of scalability. However, in hierarchical routing protocols, the overheads associated with cluster formation and cluster maintenance is a shortcoming [17].

4.3 Hybrid Routing Protocols

Hybrid Routing Protocols enjoys that it contains both the advantages of reactive and proactive protocols. It can be derived from the two previous ones. The hybrid routing protocols faces the difficulty that is in what way to organize the network as per the network parameters. Even though it incorporates the advantages of the previous protocols, it is not free from some disadvantages the common of which is that the nodes that have high level topological information maintains more rout information. This, in turn, results in more memory and power consumption. The routing is initially recognized with some proactively prospected routes. Then, it serves the demand from additionally activated nodes through reactive flooding. The choice of one or the other method requires predetermination for typical cases. Reaction to traffic demand depends on gradient of traffic volume [18]. Examples of hybrid algorithms are:

- ZRP (Zone Routing Protocol).
- ZHLS (Zone-based Hierarchal Link state routing protocol).

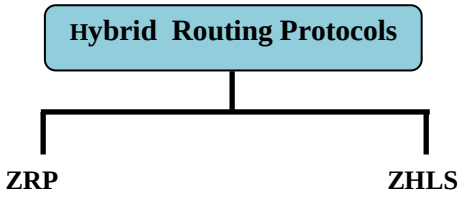

Figure 9: hybrid Routing Protocols

4.3.1 Zone Routing Protocol (ZRP)

Zone routing protocols was proposed by Haas and Pearlman. It is considered as a hybrid routing protocol which effectively incorporates the best features of proactive and reactive routing protocol. It also localizes the nodes into sub-networks. A zone around itself is defined by each node and the zone radius is the number of hops to the perimeter of the zone. The network is classified into routing zones as per distances between nodes. The reactive global search is obtained efficiently by querying only a chosen group of nodes in the network. The number of nodes queried is in the order of [r zone / r network]^2 of the number of nodes queried using a network-wide flooding process. Each node periodically must update the routing information inside the zone. Moreover, some local rout optimization is executed at every node. This performance contains the action as follows:

- Detecting of link failures
- Removal of redundant routes
- Shortening of routes.

Unless the zone radius is carefully chosen, a node can be in multiple zones and zones overlap [15].

4.3.2 Zone-Based Hierarchical Link State (ZHLS)

In ZHLS protocol, the network is divided into non overlapping zones as in cellular networks. It is based on hierarchical structure. Each node is familiar with the node connectivity within its own zone and the zone connectivity information of the full network. The link state routing is performed by employing two levels: node level and global zone level. The node level contains the node IDs of its neighbors in the same zone. The zone level topological information is distributed to all nodes. The routing information is already present in case the destination is available in its zone. Because only zone ID and node ID of a destination are required for routing, the route from a source to a destination is adaptable to changing topology. The zone ID of the destination is found by sending one location [15].

5. CONCLUSION

The current paper is composed of four main sections. Following the abstract and the introduction, it discusses the wireless networks which consists of two categories: Infrastructure networks and the Infrastructureless networks. The Infrastructure network has access point, while the Infrastructureless network has not access point. Then the second part of the paper is dedicated to present the Infrastructureless mobile ad hoc network (MANET). This section includes the characteristics, applications, challenges, advantages and disadvantages of mobile ad hoc network. After that, the researcher moves to deal with the ad hoc routing protocols which control routing packets among computing devices. The ad hoc routing protocols comprises proactive, reactive and hybrid (pro-active/ reactive) routing protocols. Each one of these routing protocols contains a group of protocols. Each one is discussed in some details. Eventually, the paper is concluded with the current conclusion.

6. REFERENCES

[1] Saleh Ali K.AL-Omar,Putra Sumari, "An Overview Ad hoc Networks For The Exiting Protocols and Applications", Journal on Application of Grph theory in Wireless Ad Hoc Networks (JGRAPH-HOC) Vol.2,no.1, March 2010.

[2] Hemagowri J, Baranikumari C, Brindha B, " A Study on Proactive Routing Protocol in Ad-hoc network", International Journal of Modern Engineering Research (IJMER), 2013.

[3] Hrituparna Paul, Dr. Prodipto Das, "Performance Evaluation of MANET Routing Protocols", IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 4, No 2, July 2012.

[4] Dr.S.S.Dhenakaran, Dr.S.S.Dhenakaran, "An Overview of Routing Protocols in Mobile Ad-Hoc Network", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 2, February 2013.

[5] Ammar Odeh, Eman AbdelFattah and Muneer Alshowkan, "Performance Evaluation Of AODV And DSR Routing Protocols In Manet Networks", International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.4, July 2012.

[6] G.Vijaya Kumar , Y.Vasudeva Reddyr , Dr. M. Nagendra , "Current Research Work on Routing Protocols for MANET: A Literature Survey", International Journal on Computer Science and Engineering Vol. 02, No. 03, 2010.

[7] Prasant Mohapatra , Davis Srikanth V. Krishnamurthy, "AD HOC ETWORKS, Technologies and Protocols", Springer Science , 2005.

[8] Amandeep Makkar, Bharat Bhushan, Shelja, and Sunil Taneja, "Behavioral Study of MANET Routing Protocols", International Journal of Innovation, Management and Technology, Vol. 2, No. 3, June 2011.

[9] V. Saravanan Asst, D.Vijayakumar, "Performance Of Reactive And Proactive MANET Routing Protocols With Trajectories", International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 8, October – 2012.

[10] N. Arora, "Performance Analysis of AODV, DSR and ZRP in MANETs using QualNet Simulator", Journal of Engineering Science and Technology Review 6 (1) (2013).

[11] Er. Pooja Kamboj,Er. Jasbir Singh Saini, "Formal Measure of the Effect of MANET size over the Performance of Various Routing Protocols", International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 10, October – 2013.

[12] Parvinder, Dr. V.K. Suman, "A REVIEW ON ROUTING PROTOCOL IN MANET", International Journal of Advanced Research in Engineering and Technology (IJARET), Volume 4, Issue 5, July – August (2013).

[13] Hrituparna Paul, Dr. Prodipto Das, "Performance Evaluation of MANET Routing Protocols", IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 4, No 2, July 2012.

[14] E. Edwin Lawrence, Dr.R.Latha, "A Comparative Study of Routing Protocols for Mobile Ad-Hoc Networks", International Journal of Computer Science and Mobile Computing, Vol. 3, Issue. 11, November 2014,

[15] Hrituparna Paul ,Dr. Prodipto Das, "Performance Evaluation of MANET Routing Protocols", IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 4, No 2, July 2012.

[16] Dr.S.S.Dhenakaran1, A.Parvathavarthini, " An Overview of Routing Protocols in Mobile Ad-Hoc Network", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 2, February 2013.

[17] Shailja R.Nayak, Rahul R.Balwaik, DR. Nisha Sarwade, "Comparative Review Study Of MANET Routing Protocols", The International Journal of Computer Science & Applications (TIJCSA), Volume 2, No. 01, March 2013.

[18] Swati Puri , Vishal Arora, "Performance of MANET: A Review", International Journal of Engineering Trends and Technology (IJETT) – Volume 9 Number 11 - Mar 2014.