An Analysis based on Comparative Study of Routing Protocols in MANET

Kritika Lamba[1], Aprajita Rawat[2], Shelja Sharma[3], Dr. Prateek Jain[4]
Department of Computer Science & Engg.[1,2,3]
Manav Rachna International Institute of Research & Studies[1,2,3]
Accendere KMS Pvt. Ltd[4]

Abstract: **MANET which stands for Mobile Ad-hoc Network is a kind of wireless network or infrastructure-less network through which devices can communicate with each other with the help of nodes or without the help of base station. In this, all the nodes are free to move means any node can easily enter and leave the network. In MANET communication is easily possible through Routing Protocols. Routing Protocols which is a set of rules which governs the journey of message packet from source to destination. Routing protocol is used to facilitate communication in mobile ad-hoc network. It is used for efficiency in performance between nodes effortlessly. In this paper we have done a comparison analysis of various Routing protocol along with the working principal of AODV, DSDV and WRP. Lastly, in this paper we have also discussed about the various areas for using Mobile Ad-Hoc network.**

1. INTRODUCTION

A network is an inter-connection of nodes or devices to exchange information to each other. Since it is highly flexible it is now mainly used for communicating and resource sharing. A network is a collection of computer, servers, and network devices, peripheral or other devices which is used to share the data among all over the people in the world[1]. The most common example is Internet. When the network was introduced we had only one network that is infrastructure network.
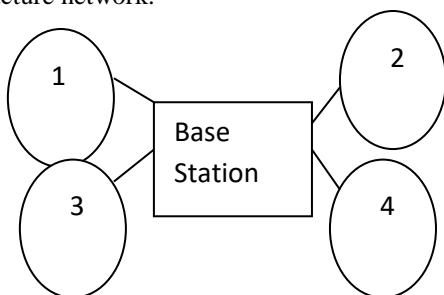

Figure 1. Infrastructure network

Infrastructure network is a network in which message packet is transfer from one device to another with the help of base station[1]. In this network devices are communicated with each other with the help of base station [2]. In this hard ware and software are used for connectivity of devices. Infrastructure network includes networking hardware's such as Router, Switches, and Cable etc. In Infrastructure network transfer data rate is about half as compare to ad-hoc network [3]. Infrastructure network are difficult to set and are

very expensive and difficult to manage as compare to ad-hoc network [1]. So, there are many disadvantages of infrastructure network that is they are very costly, difficult to maintain and required proper infrastructure [3]. So, to overcome these problems ad hoc network was introduced.
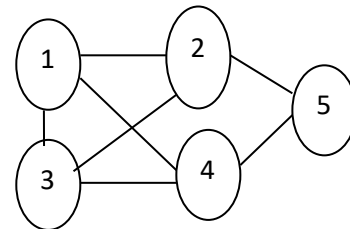

Figure 2. Ad-hoc network

Ad-hoc in Latin means "for this purpose only" with no fixed infrastructure. Ad-hoc Network which is a Local Area Network is a collection of wireless hosts (nodes) forming a temporary network without any centralized administration or authority that means each node act as a router [4]. To make an ad-hoc network functional, the nodes are assumed to follow self-organized protocols and the intermediate nodes are expected to communicate between two nodes [5]. Ad-hoc networks are built spontaneously because the nodes get connected directly and forwards packets to one another for communication. These packets coordinate with each other to send the message to the destination without any base-station. Ad-hoc networks were mainly used for military requirements and all for other security operations[6]. A large number of devices connected to each other in this network get complicated and hard to manage as there is no fixed infrastructure. Ad hoc network is used for sharing the information in many fields such as military fields, business meetings, schools, colleges, battlefields and for many other purposes `. Ad hoc network is very much cheaper as it reduces the infrastructure cost and also very flexible as the nodes automatically get connected with any base station [6]. Ad-hoc networking helps the devices to connect or disconnect from the network easily [7]. So, to make ad-hoc network more reliable and efficient mobile ad-hoc network is introduced.

MANET (Mobile Ad-hoc Network) is one of the advanced networks that have been used in today's world. Mobile Ad hoc Network is a collection of nodes sharing a wireless connection without any centralized authority. MANET is a wireless networks or infrastructure less network in which

devices communicate with each other with the help of nodes [8]. It is very difficult to imagine that how every node communicates with ever other node without any base [8]. MANET has become very popular due to its rapidly growing sensor-based application and effortless wireless links to connect devices. Mobile Ad-hoc Network (MANET) is a kind of local area network that forms an automatic connection to the nodes in the network [9]. In this device are communicating with each other without the help of base station [10]. As in MANET the communication take place with the help of nodes due to this wireless communication it is widely used in the military field, disaster relief and so on. MANET provides us various advantages over infrastructure network like reduce infrastructure cost, easy way to communication one device to another device in the network and it provides access to information and services without any base station; it is less expensive [3]. MANET has dynamic topology that is the nodes can easily enter and leave network as well as it can move freely in the network. In MANET it is essential that each individual node must act as a router and is responsible for transmission of packets in the network [10]. To maintain routing information MANET has to contain more nodes which require greater processing power, memory and bandwidth. In MANET, communication link breakage is very fast, as nodes are free to move to anywhere. MANET provides us various advantages like it provide access to information and services without any base station, it is less expensive. In MANET the network can be setup at any place at any time.

1.1 Routing Protocols

Routing protocol is used to facilitate communication in mobile ad-hoc network. It is used for efficiency in performance between nodes effortlessly. Routing protocols defines a set of rules which governs the journey of message packet from source to destination in a network [11]. Routing protocols provides routes to the message packet so that information can be transmitted between nodes without any loss of data [12]. A routing protocol first transfers the information to the nearest neighbor node after that the whole information must be transmitted to the whole network. Routing protocols help in discovering the path for the message packet and it also avoids self-looping and redundancy of information [13]. Routing protocols of MANET should have the following Properties

1. A routing protocol should be arranged in the way of increasing reliability.
2. A routing protocols must have unidirectional flow of data.
3. It is used in defense field to transfer messages during severe operation.
4. It is used in disaster effected or damaged areas.
5. It is used in Mine site where there is not any other source of communication.
6. It is also used in Business meetings areas where is less network available.

1.2 CLASSIFICATION OF ROUTING PROTOCOLS

In MANET there are different types of routing protocols each of them is applied according to the network circumstances.

PROACTIVE ROUTING PROTOCOL

It is also referred as Table-driven routing protocol. In this routing protocol, every node in the network has to maintain a routing table which contains information about network topology even when it is not required. More than one routing Table is maintaining by the nodes in the network that contain routing information and help in reducing the delay in communication. This protocol is not useful for the large network as each node in this network have to maintain routing Table. If any change occurs in the network topology then each node sends the message to the entire network. The maintaining cost of each node in this network is high.

TYPES OF PROACTIVE ROUTING PROTOCOLS
Destination sequenced distance vector (DSDV)
This type of protocol is said to be a Table-driven routing scheme protocol. In DSDV, a routing Table is created through each entry in Table which consists of a sequence number and the sequence number that is provided to the entry is usually even if there a link which is present otherwise another odd type number is recommended [13]. This number which is initiated by destination but the emitter requires redirecting another update along with its sequence number. The distribution of routing information between the source nodes and destination nodes with updated incremental additional information is more constantly in proceedings. A proper management is also available to update the routing Table which was formed when the message packets are transferred from source to destination but with a disadvantage of consuming more battery even in idle condition of network [14]. Also, DSDV is not considered appropriate in large scale networks because when there is change in topology of network, another new sequence number is required before the re-assemble of network [10].

Wireless Routing Protocol (WRP)
WRP is comparatively more advanced protocol because it consists of more enhanced features of DSDV. The nodes in this protocol have to maintain more than one Table so that it can contain more appropriate information about the routing in the network [14]. This protocol removes convergence time & count to infinity problem. In addition, the nodes in the network should contain greater processing & large memory space. This protocol is not appropriate for the wide range network [15]. In WRP the nodes in the network have to manage four routing Tables. These Tables contain the information about the routes which have been discovering at the time when the message packet is transfer from the source to destination. This Table also contains the information about the message packet which is being transferring from one node to another node. This protocol is comparatively a very better protocol in the network.

III. OPTIMIZED LINK STATE ROUTING (OLSR)

OLSR is just a Table-driven pro-active protocol and it uses link state scheme in an optimized manner. Its main purpose is to diffuse topology information. But in classic link state algorithm, link-state is flooded from network. OLSR uses this since the protocol is runs in wireless multi-hop scenarios this is known as multi point relaying. It mainly consists maintaining and updating info in a various Tables and data is based on the received control traffic. Control traffic used for retrieve information from Tables. Actually, OLSR is an IP routing protocol optimized for Ad- hoc networks and it's used on various wireless networks.

REACTIVE ROUTING PROTOCOLS

This protocol is also referred as on demand protocol as route is generated whenever it is required [15]. If there is no communication held between the nodes then these nodes does not contain any information about the routing in the network [16].

TYPES OF REACTIVE ROUTING PROTOCOLS
AD-HOC ON-DEMAND DISTANCE VECTOR (AODV)

This protocol makes inter-connections to communicate with destination source node by sending Route Request which contains sender address sequence, destination address, sequence number, broadcast id and sequence number [16]. Like DSR these protocols also uses route maintenance & route discovery. AODV contain large no of mobiles nodes in the network. This protocol is a distributed kind of approach which keeps the track of only the adjacent nodes but do not initiate the route path for the packets to be transferred to the receiver. In AODV the routes are discovered when necessary and are discarded when not in use. In addition, it allows various nodes to enter or leave the network. In this the route is only available till the message packet is delivered and after that the route is discarded [16].

TEMPORALLY ORDERED ROUTING PROTOCOL (TORA)

Highly energetic nature of the network is handling by these types of protocol. The routes are created, maintained and erased by TORA. Based on the link reversal algorithm TORA is a distributed routing protocol It is mainly made to find the routes on demand to give multiple routes to the destination. In this protocol it is not essential to maintain routes between every source to destination[2]. The steps taken by TORA can be explained in terms of water flowing down hills through a network of tubes towards the destination that model the routing state of the network. The link between the nodes in the network is represented by tubes. In this protocol the packets flowing towards the destination are represented by the water in the tubes. If the packet does not flow toward the destination then this protocol finds another path to pass the packet towards the destination

DYNAMIC SOURCE ROUTING (DSR)

The main aim of this protocol is to limit the bandwidth by avoiding long convergence time and the periodic Tables updates. The main fact of this protocol is to establish the route when it floods a route request message in the network

& two procedures are required: -Route maintenance & route discovery.

Route maintenance

On demand is routing protocol, so during transmission it looks up the routing of a packet. The transmission node at very first phase search its route cache to check whether the valid destination exist and if it is happening the route discovery process end here and the node start transmitting the message packet to the destination node. If there exist no destination address so to reach the destination the node broadcasts the route request [17]. It gives back the learned path back to the source node when the destination node gets this packet.

Route discovery

The method of broadcasting a message to inform the network or node facline network by a node to all other nodes. Early detection of node or link failure is provided since wireless network utilize hop to hop acknowledge

HYBRID ROUTING PROTOCOLS

Hybrid protocol attains best features advantages since it acquires the properties of both the protocol that are proactive and reactive protocol. As both the protocol lack somewhere to be perfectly routing therefore hybrid protocol were introduced to overcome the short coming. it is known that both proactive and reactive protocol having some imperfection or failing like proactive protocol have less latency and more overhead while the reactive protocol has vice versa but hybrid protocol balance features of both protocols and thus making itself more reliable and advanced. But within various advantages hybrid protocol also have disadvantages like high power consumption & also to maintain high level topologies. They acquire more memory. The architecture of hybrid protocol network is of hierarchical type which allow the nearest node to collaborate to work in cooperatively to form a backbone to reduce the route discovery and increase the scalability [17]

TYPES OF HYBRID ROUTING PROTOCOLS
ZONE ROUTING PROTOCOL (ZRP)

ZRP mainly used for reducing overhead and latency and it also divides network into zones. It is a protocol it uses when sending info over the network .it is used for reducing overhead of processing and it also used for speed up delivery. It reduces the overhead of proactive routing protocol and decrease the latency of reactive routing protocol. It's suitable with almost all networks with large span and diverse mobility patterns. Routing zones is defined separately. Routes are available but for only outside the zone [17]. Separate routing zone is defined for each node. Routing zone has a radius.

CLUSTER HEAD GATEWAY SWITCHED ROUTING (CGSR)

CGSR is basically a network topology which is in hierarchal structure. Their first level is cluster head and then passing through the packets to the destination. It is a Table-driven routing protocol in clustering system. Each number of nodes which must me predefined all are formed into a cluster and

for assigning purpose. Each node maintains two Tables: a cluster member table and a routing table. It uses a distributed clustering algorithm. There are so many reasons for which we have to replace the head[17]. Cluster member table records the cluster head for each destination node and another table contains the next hop.

ORDER ONE NETWORK PROTOCOL (OORP)
OORP is basically designed to do work with wireless mesh network and the most promising and prominent feature of this protocol is that it can handle hundreds of the nodes simultaneously[18].

1.3 BLOCK DIAGRAM ROUTING PROTOCOL
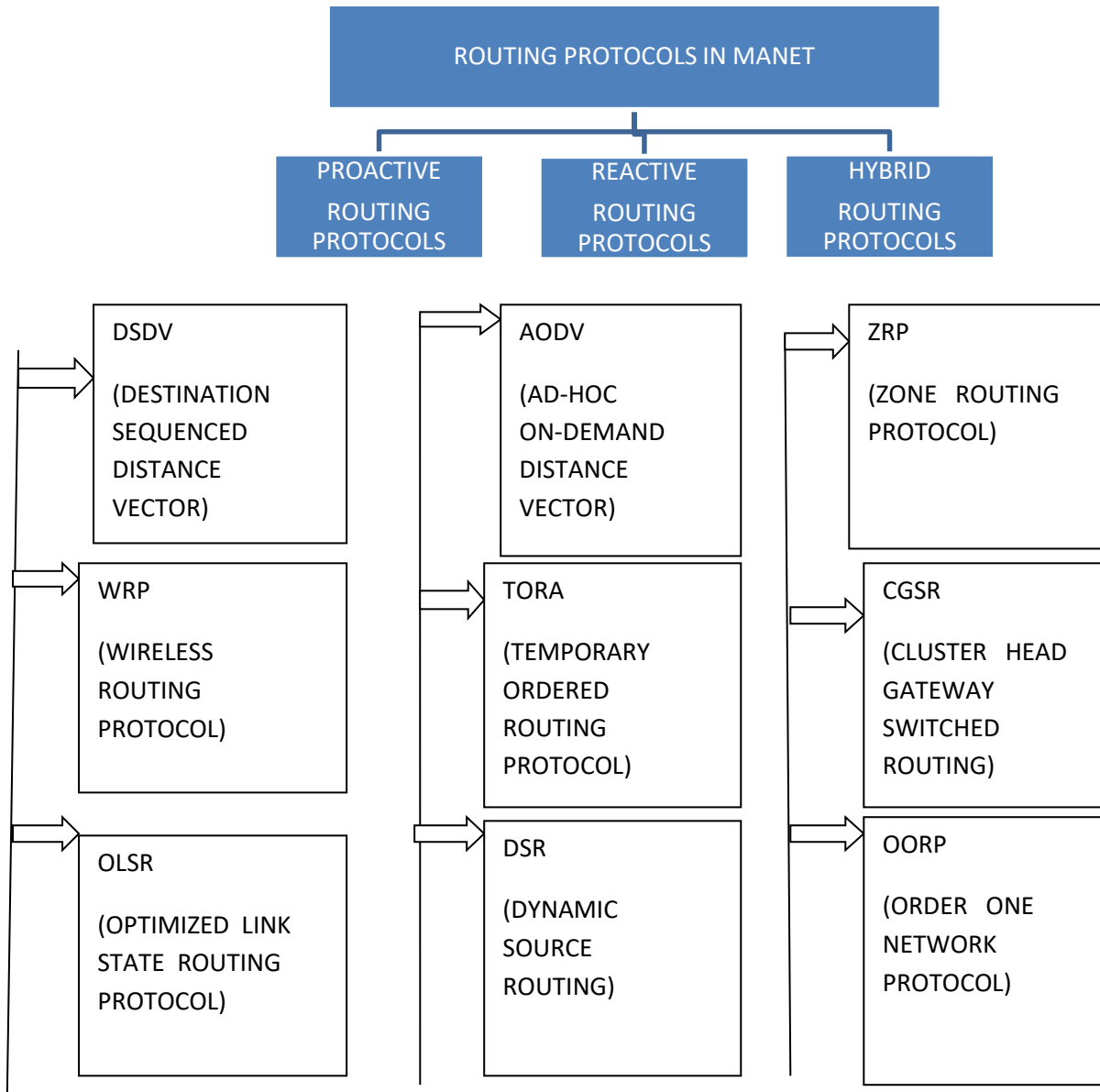The various types of the routing protocols in Mamet is being shown in Figure 3.

Figure 3. MANET routing protocols

1.4 Comparison of Routing Protocol

Table 1. Comparisons of Routing Protocols

PROACTIVE ROUTING PROTOCOLS	REACTIVE ROUTING PROTOCOLS	HYBRID ROUTING PROTOCOLS
They follow Table driven routing scheme.	They follow On-demand routing scheme.	They follow combination of both routing scheme.
Each and every node has to maintain one or more table to store routing information and thus also called table driven routing protocol.	They do not maintain routing info in-fact they send info in an on demand.	They divide set of nodes into zones into network topology.
They maintain up-to-date routing info and minimize the delay in communication.	Since this protocol search for on demand route there is delay in communication.	Since they combine both proactive and reactive protocols therefore they have advantages of both and thus balance the delay.
There is no flooding of info in-fact due to up-to-date table they quickly determine which node is present in the table.	The route searching in result in flooding of info in whole network.	Since they acquire properties of both therefore there is no flooding of information.
They need higher bandwidth requirement.	They need lower bandwidth requirement.	They need medium bandwidth requirement.
They have low latency that means the time taken by the packet of data to move from one destination to another is less.	They have high latency that means the time taken by the packet of data to move from one destination to another is more.	They have inside low and outside high latency this is because this protocol acquires properties of both proactive and reactive.
Routing Overhead which means sometimes routing packets and data packets use same bandwidth which results in route overhead, is high in proactive.	Routing Overhead which means sometimes routing packets and data packets use same bandwidth which results in route overhead, is low in reactive.	Routing Overhead which means sometimes routing packets and data packets use same bandwidth which results in route overhead, is medium in hybrid.

2. APPLICATIONS OF MANET

Due to rise in this easy to connect sensor-based technology which can be accessed effortlessly from anywhere due to its infrastructure-less network ad-hoc network is gaining immense supremacy with the growth in its advanced technology which has been proved boon in commercial, defence sector and private sectors [18]. In addition to this Mobile Ad-Hoc Networks also provides access to the users to transfer or receive information from anywhere to everywhere despite of any geographic region. In comparison to the infrastructure networks, nodes of wireless networks have dynamic topology [18]. Dissimilar to other mobile networks, MANETs do not need fixed framework network and does not contain any central authority which can control the flow data which is an advantage to the network because it makes the network easily adjustable and helps in powerfully withstand the problems in adverse conditions.

1. Military Area: (Jun-Zhao) This sensor-based technology has been proven to be a boon for defense sector as its advance features helps the military soldiers to transfer their crucial information in or around the military battlefield for safety purpose of soldiers, vehicles and headquarters. Nowadays it is very common a military equipment containing computer chips or some sort of sensor-based gadget that contains information or for communication purpose between soldiers and headquarters. Ad- hoc networking provides advantage of network technology of local places to the military so as to transfer or receive information and thus forms an information network between the soldiers, vehicles, and military information headquarters. The very first of introducing ad hoc network was for this field as it was mainly designed to facilitate the military and to be used by defence for safety purposes [19].

2. Commercial Sector: Ad hoc networks can be used in areas affected by huge crisis in natural calamity like landslide, flood and other destructive mishaps. Also, it can be used in war zones, emergencies like fire broke out and rescue operations from disaster. This is because the devices used for these may get damaged or crash or even get lost in the area which is too distant [19]. In order to safe people and to be able to communicate with other team member, rescuers use these wireless sensor-based network. In this device are connected automatically forming a network for the rescuers to be able to communicate during their rescue operations so that they can perform it without any big complications and securely. Not only this, other commercial sectors where it used to be ship-to-ship ad hoc mobile communication, law enforcement, etc [19].

3. Data Networks: This application of MANET allows it to perform easy computation everywhere. It provides the allowance to devices to communicate data with other devices in the network. The devices in the infrastructure-less network may be very far as compared to the devices connected in a fixed infrastructure in a network regardless to this network could be increased so that it can be easily available and spread over a large geographical area to be high in usage[20].

4. Personal Area Network: Personal Area Network (PAN) is a local network which is very short in range and is accessed by a private authority or say single authority. In this node have a fixed range and is certainly low in distance [11].

5. Bluetooth: Bluetooth is a wireless technology which allows user to communicate in a certain range which is generally shorter as compared to other advance technologies. It simply connects devices like laptops, mobile phones, computers for communication purposes between them [1]. And also, nowadays it range is getting better by the time and also it is getting advanced, like we can now use wireless headphones in mobiles or we can connect our car's stereo system with mobile phone.

6. Local Level: Ad-hoc network automatically connects immediate connection and temporary multimedia network using note book computer to spread and share

information among participants, for example, conference or classroom [20]. Appropriate low-level application might be in home networks where devices can communicate directly to exchange information. Similarly, in other civilian environments like taxi, cab, sports stadium, boat, small aircraft, etc.

7. Sensor Networks: This is the very basic operation of MANET that it is a sensor-based technology. It consists of enormous number of small sensors which easily detects, responds, indicates and records between devices. These sensors easily detect the other devices and automatically get connected to help in communication in a sensor fixed area. These sensors help to detect temperature, pressure, toxins, pollutions, etc [21]. Each and every sensor has a limited potentiality to communicate and also every sensor in the network rely on another sensor to carry the data or message packet forward in the on-going purpose of communication in order to reach the destination. Each sensor individually is limited in terms of its detecting, connecting and message forwarding abilities which in turn causes loss of data and is vulnerable to failure of transmission of data. Mobile ad-hoc networks could be used in security related issues in across the globe in the near future [21].

3. CHARACTERISTICS OF MANET

MANET is a wireless network through which devices communicate with each other with the help of node. Due to this wireless property it is more in demand in the market which is increasing day by day. There are various character sticks of MANET:

1. DYNAMIC TOPOLOGY: Nodes are easily entered and leave network as well as it can move freely in the network [13]. In this node change their position quickly. Dynamic topology membership may interrupt the connections between the nodes. If any of these nodes are identified as compromised the trust of connection between the nodes get broken.
2. BANDWIDTH: As we compared to infrastructure network the ad-hoc network or wireless network have less bandwidth. In Wireless network links have lower capacity than in wired networks [21]. In computation when the data pass through the wireless network they face many problems like multiple access, fading, noise, and interference conditions, etc.
3. LIMITED SECURITY: As in MANET the data is transfer from one node to another node and also there is no centralized authority which control the flow of data due to which data can accessed by any unauthorized member. Due to this limited security it is a big challenge in the wireless network. As mobile ad-hoc network is a distributed network therefore it is more prone to security attack [21]. Due to hike in this wireless sensor-based technology MANET is more vulnerable to monitor others important data and can also access it without any permission of the data owner.

4. Routing Overhead: As in mobile ad-hoc networks nodes change their position any time in the network due to which some routing table get established which is responsible for routing overhead [21].
5. Hidden terminal problem: That the hidden terminal problem refers to the collision of packets at a receiving node due to the simultaneous transmission of those nodes that are not within the direct transmission range of the sender but are within the transmission range of the receiver [21].
6. Packet losses due to transmission errors: Ad hoc wireless networks experience a much higher packet loss due to factors such as increased collisions due to the presence of hidden terminals, presence of interference, Uni-directional links, and frequent path breaks due to mobility of nodes [21].
7. Mobility-induced route changes: The network topology in an ad hoc wireless network is highly dynamic due to the movement of nodes; hence an on-going session suffers frequent path breaks [21] This situation often leads to frequent route changes.
8. Battery constraints: The systems in the networks have forbidden on the power source in order to conserve the size and weight of the system [21]

4. SECURITY GOALS OF MANET

Although MANET is a much-advanced technology with highly sensor-based communication skills but still due to its self connectivity features to transfer the message packets it also lacks in security features. The security in MANET needs to overcome various threatening attacks to one's personal data.

1. Availability: It means the access to the data and services is only allowed to an authoritative user [19]. In wireless network it is not save because the nodes are sensor based and are automatically get connected to each other. So, MANET should guarantee more tendencies of advance services of network in spite of service attack denial [22].
2. Confidentiality: MANET should ensure that the assets or personal data must be accessed by authoritative users only and not by uncertified user for illegal activities. In addition, MANET should protect the data from the prohibited users which intern may access one's personal data during transmission [10]. Also, the wireless network should shield users against any spying activities by malicious users so that they could not use their data for illegal purposes.
3. Integrity: The wireless networks should make sure that the data must be modified by an authoritative user only in well approved manner and also there should not be any corrupted message that is transferred [22]. Integrity is a guarantee that there is no modification in the information that is transferred to the destination after it is sent by its original source.
4. Authentication: It is an assurance that the users that are accessing the data are authenticated that means they are validated and are not deceivers [22]. In MANET, there is no central authorization for controlling the data access

and transfer so there is no guarantee that the user is authenticated. It should be verified in MANET that the resources in the network must be accessed by a certified node only. Authentication also means that only a well approved user has the right to access the resources [13]. And also, that the data received by the receiver is not delivered by an illegitimate source.

5. Authorization: It means that the data already stored in system must be accessed by the authoritative user only. This security feature of MANET must assure that the rights provided to the authorized users must not be violated by any other malicious user for illegal purposes [22].

6. Freshness: It must be assured in MANET that the spiteful nodes do not send the packet again which were already sent by it [22]. This feature will increase the efficiency in performance while transmission of information and also in addition it will decrease the overhead problems in communication.

7. Resilience to attacks: This feature will help to save the range of operations and transmissions for long term efficient transmission when any part of node is damaged or compromised. This will lead to less loss during transmission of data.

8. Non-repudiation- It is related to authentication service. This property features the helplessness of the user that he/she cannot disallow or deny any of the transactions in the network [22]. MANET should provide assurance shield to the user to protect its data from any other user. It must be authoritative user's wish whether the transaction should take place or not.

9. Access control- As the name suggests, this feature is related to control of assessment of data. It helps to safeguard the data and resources from unauthorized users in the network [22]. MANET should improve these features for protecting the data from hackers or other malicious users.

5. CHALLENGES IN MANET

There are various challenges that MANET needs to overcome. Some of them are the following:

1. Finite wireless transmission range: MANET have a very confined number of radio frequencies and thus it offers very minimal data rates in comparison to what an infrastructure network can provide [10]. Due to this the routing protocols in this sensor-based network uses the most favorable bandwidth flawlessly to keep the routing overhead problems as less as it can be achieved.

2. Routing Overhead: In infrastructure less, network nodes are able to move freely anywhere in the network and hence they can change their position. In MANET routing overhead is the result of clash between messages packets which often uses same bandwidth in the network. Some unwanted routes are created in network which is responsible for routing over head [22].

3. Battery constraints: As the devices in these networks have to manage their flexibility so that they can be easily carried anywhere. So, the batteries of these devices are very small in size due to which it is present in very limited amount. Due to these restricted battery services the nodes in the network are not able to use the network appropriately. In order to overcome this problem, the power of battery should be increased so that the nodes in the network could be able to use the resources effortlessly[21].

4. Asymmetric links: In infrastructure networks, in majority the network depends on the stable links which are the symmetric links. But in the case of ad-hoc networks there is dynamic topology due to which the nodes are able to move freely and thus can constantly change their positions in the network area [22]. Taking an example for this, consider a MANET (Mobile Ad-hoc Network) where source node A sends a signal to its destination node B but even though this doesn't tell anything regarding to the quality of the reverse direction connection.

5. Time-varying wireless link characteristics: In this network, the sensor-based channel can be influenced by a large variety of communication barriers like loss of path, declining, disturbance and obstacles during transmission process. Due to these factors there is resistance in the range, dependability and in rate of data in the process of transmission in the network [20]. In expansion to this, all these factors affect the transfer of message packets from source to destination which occur due to the defective condition of environmental and also due to its flexibility or ability to move between the sender and the receiver.

6. Packet losses due to transmission errors: Loss of packet during data transmission is the result of high bit error rate (BER) in this sensor-based network [21]. Ad hoc networks record an enormous quantity of packet loss, this is also due to clash between the packets due to various causes like interference, invisibility of terminals, one sided link, breakage of path due to portability and natural built -in properties of wireless network when they are transmitted from source to destination.

6. CONCLUSION

The conclusion of Mobile Ad hoc networking is very appealing but improvement in bandwidth and capacity is required which implies the need of a higher frequency. There are many challenges related to security expressed as it is designed for limited attack and vulnerabilities. MANET is the most promising network and importance of MANET cannot be denied as the world of computing is getting portable and compact. In his paper we are discussing about the routing protocols, there types and comparative analysis of Proactive, Reactive and Hybrid. In this paper we are discussing about the area in which the mobile ad-hoc network is widely used like in military field, local area, personal area, commercial sector etc. This paper will provide you the review study of MANET.

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