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MANET Review: Characteristics, Routing Protocols, Attacks and Performance Metrics

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Abstract: The term “mobile” is termed as moving and “ad hoc” is termed as a temporary network without any centralized administration or permanent infrastructure. Because of the dynamic MANET topology, this review is mainly concentrated on diverse routing techniques that are considered as the main challenges these days. A variety of strategies has been given for the effective routing for providing the enhanced performance. Different routing protocols have been presented for MANET that makes it’s hard to decide which protocol is appropriate for different network conditions. This paper gives an overview of MANET with its applications and characteristics, its routing protocols, attacks and its performance parameters.

Keywords: MANET, Routing Protocols, MANET Attacks, Performance Metrics.

I. INTRODUCTION

An ad hoc network is a compilation of mobile nodes producing an immediate network without fixed topology. In these networks, every node performs routers as well as host concurrently and could join or move out or in the network liberally [1]. This network does not have any base infrastructures as utilized in the standard networks, but it is suited to the conventional networks. Routing in MANET (Mobile AD HOC network) is difficult because of the constraints in CPU time, transmission bandwidth battery power and the need to manage the frequent topological variations resulting from the mobility of the nodes.

In MANET, the mobile nodes need to transfer the packets to each other for enabling the communication between nodes exterior the transmission range. The network nodes are free to move separately in some direction, leave and link the network randomly [2]. Therefore, a node experiences variations in its link state frequently with other devices. Ultimately, the Ad hoc network mobility modification of link states and another property of wireless transmission like multipath propagation, attenuation, and interference so on developing routing protocols operating challenge in MANET [3]. The challenges are improved by different types of devices of incomplete processing power and capability that might join in the network [4].

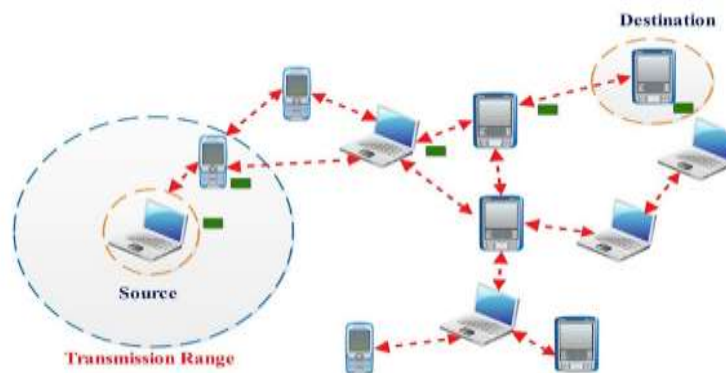


Figure 1: Mobile ad hoc Network

1.1 Characteristics of Mobile ad hoc Network

Mobile Ad hoc network consists of number of characteristics that are defined below in table 1 [5-6]

Table 1: MANET Characteristics

Characteristics	Description
Multi hop transmission	<ul style="list-style-type: none"> • While a source node with the destination node for a message is away from the transmission range than the MANETs are able of multi-hop transmission. • While transmitting the data packets from a source to its destination elsewhere from the direct wireless transmission range, the packets have to be transmitted via one or more intermediate nodes.
Autonomous behaviour	<ul style="list-style-type: none"> • Every node behaves as host as well as the router. That means a node has the capability of host and may also execute switching functions like a router, therefore, switches and endpoints are indistinguishable.
Dynamically changing topology	<ul style="list-style-type: none"> • Because of the mobile nodes, the variation in topology is common and dynamic in nature. • The connectivity between the nodes might change with time and dynamically begin routing between them as they move about.
Distributed nature of operation	<ul style="list-style-type: none"> • Because the centralized control is missing here, the operation and control of the network are dispersed between the nodes. • The nodes have to be collaborating for implementing different functions chiefly security and routing.
Inferior link capacity	<ul style="list-style-type: none"> • The scalability, reliability, efficiency, and capacity of wireless links are frequently inferior when the comparison with wired links takes place. • One end to end path could be collected by different sessions. • The terminals communicate via a channel which is subjected to fading, noise, interference and has low bandwidth as compared to the wired network. • This depicts the variable link bandwidth of wireless links.
Light weight features	<ul style="list-style-type: none"> • The nodes of MANET are mobile devices with low capability of CPU processing, less memory size and less power storage.
Infrastructure absence	<ul style="list-style-type: none"> • These networks should operate independently of any permanent infrastructure.

1.2 MANET Applications

Applications of MANET are defined in table 2 [7]:

Table 2: MANE T Applications

Applications	Description
Commercial sector	<ul style="list-style-type: none"> • It may be utilized in rescue/ emergency operations for the efforts of natural calamities relief, like a flood, in fire, or earthquake. • The rescue operations should take place where damaged communications infrastructure or non-existing and rapid deployment of a communication network is required. • The Information is transferred from one rescue team member to another.
Military battlefield	<ul style="list-style-type: none"> • The military equipment currently has several computer equipments. • During ad-hoc networking, the military can take the benefit of common place network technology for maintaining an information network between the soldiers, vehicles, and military headquarters. • Generally, the ad-hoc networks techniques came from this field.
Local Level	<ul style="list-style-type: none"> • The Ad hoc networks may autonomously connect temporary and an instant multimedia network by utilizing palmtop computers or notebook computers for spreading and sharing information between participants at a conference. • Other suitable local level application could be in home networks where devices may communicate for exchanging the information.
PAN (Personal Area Network)	<ul style="list-style-type: none"> • Short-range MANET can shorten the intercommunication among different mobile devices (like laptops, mobile phone, and wearable computers). • Conventionally wired cables are replaced by the wireless connections. • MANET may also extend for accessing the Internet or another network via mechanisms such as Wireless LAN.

II. CLASSIFICATION OF ROUTING PROTOCOLS IN MANET

Routing protocols are termed as a rule set that defines the journey of message packets from source to destination in the network [8]. MANET consists of a variety of routing protocols and is applied as per the network circumstances. Figure 2 defines the general classification of the MANET routing protocols [9].

2.1 Proactive Routing Protocols/Table Driven Protocols

In this protocol, every node preserves routing table with the information for the network topology even without its need [10]. The routing tables are efficient sometimes, when, the network topology varies. The proactive protocols are not suitable for huge networks as it requires for maintaining the node entries for every node in the routing table of every node. There are different proactive routing protocols. The examples of Proactive routing protocols are OLSR, DSDV, and WRP etc.

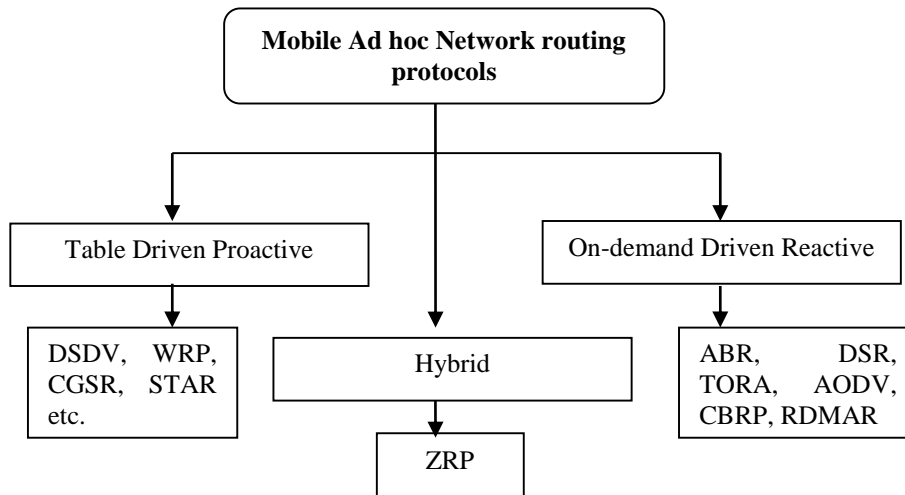


Figure 2: Routing Protocol Classification

2.2 Reactive Routing Protocols/On-Demand Routing Protocols

In this protocol, the route is established whenever it is required. The node starts the route discovery when it is commanded [11]. The route is taken by route discovery initiation procedure by the source node. Reactive Routing Protocols is consisted of below two components:

- i. **Route discovery:** In this phase, the source node starts the route discovery on demand basis. The source nodes consult the route cache for the accessible route from the source towards a destination or else if the route is not there it starts the route discovery. The source node packet has the destination node address as well intermediate nodes address towards the destination.
- ii. **Route maintenance-** Because of the network dynamic topology, the route cases failure among the nodes arises because of the link breakage etc, therefore, route maintenance is needed. The reactive protocols have the mechanism of acknowledgement because of which the route maintenance is possible.

The examples of Reactive protocols are AODV, DSR, TORA, and LMR.

2.3 Hybrid Routing Protocol

Hybrid Routing Protocol is a trade-off between proactive and reactive protocols. The proactive protocol has more overhead and less latency whereas the reactive protocols have less overhead and more latency [12]. Therefore, this protocol is required for overcoming the disadvantages proactive as well as reactive routing protocols. Combination of proactive and reactive routing protocol takes place in hybrid routing protocol [13]. It utilizes the On-demand mechanism of reactive protocol and the mechanism of table maintenance of proactive protocol for avoiding the problems of latency and overhead in the network. The hybrid protocol is suitable for big networks where large numbers of nodes are there. In this protocol, the large networks are categorized in zone set where routing inside the zone is executed by utilizing the proactive method and outside the zone, routing is executed by utilizing the reactive approach [14].

Table 3: Comparison of MANET Routing Protocols

Protocols	Advantages	Disadvantages
Proactive	<ul style="list-style-type: none"> • Less information available • Reduction of latency in the network 	<ul style="list-style-type: none"> • More overhead • Routing information is congested in the entire network
Reactive	<ul style="list-style-type: none"> • Availability of path when the required overheads is less and free from loops 	<ul style="list-style-type: none"> • Enhancement of latency in the network
Hybrid	<ul style="list-style-type: none"> • Appropriate for big networks and availability of advanced information 	<ul style="list-style-type: none"> • Enhancement of complexity

III. MANET ATTACKS

There is a number of attacks in MANET that are defined below [15-16]:

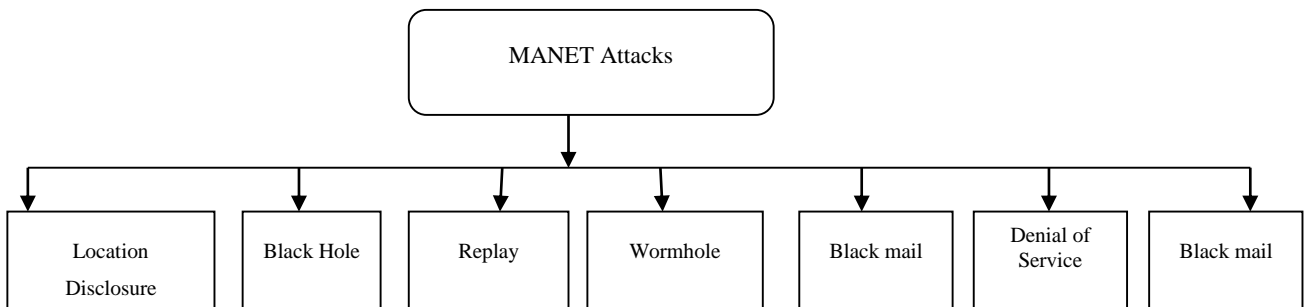


Figure 3: MANET Attack Types

There are various kinds of attacks on ad hoc network which are following:

1) Location Disclosure

It is an attack that targets the privacy needs of an ad hoc network. By utilizing the techniques of traffic analysis, simpler monitoring and probing approaches, an attacker can find the node location or the whole network structure.

2) Black Hole

In a black hole attack, the malicious node fits the false route replies towards the route requests, with the shortest path to a destination. The fake replies may be fabricated for diverting the network traffic by the malicious node for attracting the traffic towards it for performing a denial of service attack by removal of the received packets.

3) Replay

A replay attack is known as one of the attacks that reduce strictly the MANET performance. A replay attacker performs this attack by retransmission and interception of the suitable signed messages. The signed messages validation is verified by a timestamp discrepancy set by receiver and sender nodes. The replay attack generally attacks the route freshness.

4) Wormhole

It is one of the most influential attacks because it has the cooperation among two malicious nodes which participates in the network. Consider, node A, capturing the routing traffic at single network point network and tunnel them to another network point, to node B for sharing a private communication connection with A. The node B then injects the tunneled traffic back to the network. The connection among the nodes that have developed the routes for the wormhole link is totally under the two conspiring attacker's control. The packet control is the solution to this attack.

5) Blackmail

Its attack is applicable besides routing protocols that utilize the identification of malicious nodes mechanisms with the propagation of messages that attempt to blacklist the attacker. An attacker might build these reporting messages and attempts to separate the legitimate nodes from the network. The non-repudiation security criteria may be proved to be significant in a number of cases as it integrates a node to the messages it produced.

IV. RELATED WORK

Alex Hinds et al, focused on the range of available MANET routing protocols and discussed several features ranging from early protocols (e.g. DSDV) to higher level (e.g. MAODV). Protocol focused on Perkins' efforts to develop and improve MANET routing. A series of literature related to the MANET routing domain has been identified and reviewed, and the literature review identifies trends in research papers, such as the exclusive use of a stochastic waypoint movement model, not including key metrics from simulation results, rather than comparing protocol performance to available alternatives. **Arun Biradar**, focused on Mobile Ad Hoc Networks (MANETs) that consists of mobile platforms that are freely mobile. These are self-organizing and adaptive networks. These networks allow the spontaneous formation and deformation of mobile networks. The shortest path problem in MANETS requires that the path from the source node to the destination node be calculated, thereby, minimizing the sum of the total costs associated with the path. **Azzedine Boukerchea and Begumhan Turgut**, focused on Ad hoc wireless network to accomplish the difficult task of multi-hop communication in the absence of special infrastructure, the mobile node and change the topology network environment. It shows different limits for deployment as calorie restriction option, knowledge of the physical location of nodes, in

some cases, such as real-time or multicast traffic, as well as requirements. **Bow-Nan Cheng et al**, proposed a comparative analysis of various routing protocols in MANET. Various routing protocols has been analysed like AODV, OLSR and OSPF-MDR. Their performance has been evaluated in terms of routing overhead traffic, end-to-end message completion rate, and end-to-end delay, to examine performance vs. Trade-off. Disadvantage: Overall throughput is low. **Harjeet Kaur et al**, focused on Ad hoc network (MANETs) that consists of different types of mobile nodes. MANETs are mobile, so the authors connect to the network using a wireless connection. MANET can be deployed in a variety of applications at low cost. In MANET, different types of routing protocols have been recommended. These protocols can be divided into three main categories: reaction (on demand), active (table driven) and hybrid routing protocols, namely AODV, OLSR and ZRP. The research focuses on reactive, active and hybrid routing protocols such as AODV, OLSR and ZRP. **Fabrice Le Fessant et al**, has focused on sensor networks with environmental monitoring as the main application. The main objective is to limit the effect of separation caused by the malicious nodes in such networks. The authors has focused on routing protocols that depends on tree dependent topology in which the data is send through the sensor node to the sink via tree rooted at the sink. It has been assumed that the routing tree is developed by means of hop distance to sink. **Anjali et al**, showed the performance of AODV, OLSR, and GRP routing protocols for evaluation of FTP-based application traffic based on the IEEE 802.11, WLAN standard and 48 Mbps data rate. Through the use of OPNET simulator based on a variety of quantitative measurement - network load, throughput, retransmission attempts and media access delay, by changing the physical characteristics and the number of nodes are used to evaluate network performance. **Bow Nan et al**, proposed a comparative analysis of various routing protocols in MANET. Various routing protocols has been analysed like AODV, OLSR and OSPF-MDR. Their performance has been evaluated in terms of routing overhead traffic, end-to-end message completion rate, and end-to-end delay, to examine performance vs. trade off. **John et al**, proposed an algorithm for routing in MANET. In the proposed algorithm, some of the selfish nodes take place in route discovery. In this method, data that has to be send must be in encrypted form and contained the destination address in the message that has been sent.

V. PERFORMANCE METRICS IN MANET

The performance Metrics are considered as the measurements in MANET for analysing the routing protocols performance [17]. These are significant for evaluating the network performance. It elaborates how better the network is executing under a variety of parameters [18]. The performance metrics can be classified into below two types:

a) Quantitative Metrics

It is considered as the numerical measurement of the network performance. It can be described in numbers like Number of delays; Number of nodes, Number of bytes being transmitted and so on.

b) Qualitative Metrics

It is a quality measurement of the network performance. Quality can be calculated for Route Acquisition Time, Throughput and Packet out of delivery etc. Few performance metrics are:

i. Throughput

It is defined as the number of bits transferred for each unit time.

ii. Packet Delivery Ratio

It is defined as the total number of packet delivered for a total number of packet sent.

iii. End to End Delay

It is defined as the time taken by the packet for reaching the destination. The parameters that affect the performance are propagation delay, transmission delay, average delay, and processing delay.

iv. Jitter

Jitter is also termed as a delay. It occurs establishes because of improper setting of the network, network congestion and so on.

v. Packet Loss

It elaborates the number of bits lost because of the relay.

Table 4: MANET Performance Metrics

Metrics	Formula
Throughput	$\frac{\text{number of packets received}}{\text{number of per unit of time}}$
Packet delivery ratio	$\frac{\text{number of packets received}}{\text{number of packet sent}}$
End to End delay	$\text{Time of packet sent} - \text{Time the packet received}$
Jitter	$\frac{\{ (PA + 1) - 1(PS - 1) \} - \{ (PA) - (PS) \}}{N - 1}$ Where PA=Packet arrival, PS=Packet Start
Packet Loss	$\text{Number of packet sent} - \text{Number of packet received}$

VI. CONCLUSION

This paper has reviewed the MANET (Mobile ad hoc network) infrastructure. Initially, a brief introduction is discussed following the characteristics and applications for understanding more about MANET. MANET consists of a number of routing protocols that are analysed with its examples and types. The comparison of routing protocols with its advantages and disadvantages has been discussed. Later, the attacks undertaken in MANET are studied. The solutions related to these issues are significant to accomplish the wide commercial deployment requirements of MANET. We have examined the performance metrics utilized for the analysis of the network.

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