ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

A Study on Challenges and Issues on MANET

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ABSTRACT: MANET (Mobile Ad hoc Network) is an ad hoc network that can be formed on demand and allow nodes to communicate without any infrastructure. On demand set up of MANET makes it very popular as compared to the traditional wireless network. In traditional wireless network fixed point/central point is required for overall function of the network, whereas MANET is self organized and infrastructure free network which may be considered as a good approach for some specific applications such as battlefield survivability, communication in the natural or manmade disaster areas, emergency/rescue operations, Vehicular ad hoc network for communicating between vehicles to provide traffic information and warnings. However, at the same time this new network has different challenges and issues such as routing, security, cooperation, power management, multicasting, IP addressing, quality of service etc. which need to be addressed carefully before its real time application. In the present work, a comprehensive review of MANET including its characteristics, advantages, challenges and issues is presented which will be of great use for the researchers who would like to start their career in this field.

KEYWORDS: Mobile Ad hoc Network (MANET), Node characteristics, MANET characteristics, routing, multicasting, challenges in MANET.

I. INTRODUCTION

Traditional wireless network and cellular networks are limited by their need of infrastructure. These networks cover limited geographical area where infrastructure exists only. But sometime we need quick network set up without any infrastructure or any access point such as in the case of battlefield survivability, communication in disaster areas, communication between vehicles to provide traffic information etc. MANET is the only solution for these type of situations. MANET provides multi hop communications by wireless links. It is self organized network without any central point. All nodes in MANET may act as router and host simultaneously [1, 2] and are mobile in nature which leads to dynamic topology of the network. Nodes are free to join and leave the network at any time. Various characteristics of the nodes [1, 5-7] participating in the ad hoc network along with the advantages of MANET [2, 5] are given in Table 1.

Table 1: Node Characteristics and Advantages of MANET

	Characteristics of Nodes [1, 5-7]	**Advantages of MANET** [2,5]
1	Small in Size.	On demand setup
2	Light in weight	Provide unrestricted connectivity
3	Less CPU capability	Easily scalable
4	Less battery power	Robustness
5	Less memory backup	Fault tolerance
6	Can be easily theft or damage	Ease in deployment
7	Heterogeneous	Low cost.

II. CHARACTERISTICS OF MANET

MANET has following characteristics [1, 3-6]:

i. **Random and Dynamic Topology:** Due to mobility of nodes in MANET, topology of network changes very frequently and is very difficult to predict.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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Vol. 4, Issue 9, September 2015

ii. **Distributed Operational Environment:** MANET performs distributed operation because of two main reasons: first, nodes that are participating in the network are heterogeneous; second, due to lack of central authority in the network, the complete task of network management is divide among various nodes that are participating in the network.

iii. **Autonomous Nature of Nodes**: Due to lack infrastructure, it is the nodes of the network that are responsible for various functions like routing, forwarding and transmission. To perform such network functions, nodes may act like router and host both at a time.

iv. **Shared Broadcast Radio Channel**: All nodes in MANET shared radio interface for receiving and transmission.

v. **Bandwidth Constraints**: Nodes of the MANET use wireless links to communicate. These links are with low bandwidth compare to wired networks.

vi. **Lossy Links:** The nodes of the MANET are Mobile in nature, that way any node can go out of range of the network at any time. This causes frequently loss links between the nodes.

vii. **Network Scalability:** Nodes in the MANET can enter to the network at any time. In other words, network can grow up to any extent.

viii. **Self Organized:** MANET can be deployed without any central point or access point. Nodes in the MANET are intelligent to handle all the network functions including their own data transmission and hence are self organized.

ix. **Device Heterogeneous:** Devices or nodes in MANET are heterogeneous in nature. Mobile nodes can be phones, laptops or it can be tablets etc. with different configurations.

III. MAJOR ISSUES AND CHALLENGES IN MANET

1. Routing: Routing protocols are used to find the optimal path from source to destination node. Routing protocols are used to exchange the routing information. These are very important in MANET where topology changes very frequently due to mobility of nodes. Mobility, Bandwidth constraints, Hidden and exposed terminal problems and Resource constraints [7] of the nodes are some of the challenges which need to be addressed while designing routing protocols for MANET.

Number of routing protocols has been proposed in literature. Broadly, these protocols are divided into following three categories:

i. Proactive or table driven protocols
ii. On demand or reactive protocols
iii. Hybrid protocols

Proactive or table driven protocols: In these protocol every node maintains routing information in table that is periodically updated. Destination Sequenced Distance Vector [10] and Wireless Routing Protocol [11] are some of the protocols which fall under this category.
On demand or Reactive protocols: These protocols find path for nodes when it is necessary. In these routing information is not stored in tables. This reduces the overhead of the table driven protocols. Routing protocols under this category do not exchange information periodically [62]. Dynamic Source Routing Protocol [12] and Ad Hoc On-Demand Distance Vector Routing Protocol [13] are the protocols that fall under this category.
Hybrid protocols: These protocols are combinations of best features of protocols lying in proactive and reactive category. These protocols obtain path within the zone using table driven method and out of zone using on demand method [62]. Protocol comes under this category is Core Extraction Distributed Ad Hoc Routing Protocol (CEDAR) [14].

2. Multicasting: Multicasting is defined as communication with certain group members in a group. It is a kind of one-to-many communication. Due to characteristics of MANET, the traditional wireless network`s protocols are not suitable for multicasting and hence different protocols are needed that can meet the following challenges for multicasting [7]:

i. Robustness

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

ii. Efficiency
iii. Control overhead
iv. Scalability of group
v. Efficient group management

Multicast protocols are divided into following two broad categories: *Application dependent* and *Application Independent. A*pplication dependent are those multicast protocols that are designed for specific application. Protocols come under this category are Role Based Multicast (RBM) [15], Content Based Multicast(CBM) [16]. Application Independent protocols are those that are designed for general or conventional use [63]. Protocols of this category are divided as *Tree based and Mesh based multicast protocols.* In Tree based protocols there is a single path from source to destination. These protocols do not perform efficiently with high mobility, high load and large multicast group [63]. Common protocols that come under tree based multicast category are MAODV [17] and MCEDAR [18]. On the other hand, Mesh based protocols have multiple path between source and receiver; however, they suffer from excessive control message on the network [19, 20]. ODMRP [64] and DCMP [65] are the examples of mesh based protocols.

3. Medium Access Schemes: It includes optimum utilization of spectrum among all nodes of the network. Spectrum should be shared fairly in all nodes of the network. These protocols are very important for coordinating the access from active nodes. Following are the major issues which must be considered while designing MAC (medium access control) protocols [7]:

i. Bandwidth efficiency
ii. Quality of service
iii. Synchronization
iv. Hidden node/exposed node problem
v. Error prone shared media

Many MAC protocols have been proposed in the literature, which are broadly categorized into three types. First is *contention based protocols without reservation.* In these protocols no reservation for BW (bandwidth) is made in advance. Medium Access Protocol for Wireless LANs MACAW [21] and Floor Acquisition Multiple Access (FAMA) for Packet Radio Networks [22] are the protocols which come under this category. Second type is *contention based protocols with reservations* in which BW (bandwidth) reservation for transmission is made in advance. Protocols that fall under this category are: D-PRMA [23], CATA [24]. Third protocol is Contention based protocol with Scheduling. In this protocol distributed scheduling between the nodes is used. DPS [25] and DWOP [26] are the protocols which fall under third category. Other MAC protocols such as MMAC [27] and MCSMA [28] are also reported in the literature.

4. Transport Control Protocol (TCP): The main function of the TCP is to provide reliable end-to-end delivery of data packets, flow control and congestion control. Traditional wired protocols for TCP are not suitable for MANET. TCP protocols designed for MANET must address the following issues [66]:

1. Induced traffic
2. Induced throughput unfairness
3. Separation of congestion control, reliability and flow control.
4. Power and bandwidth constraints
5. Misinterpretation of congestion
6. Dynamic topology

Some of the protocols that are used for Transport Control in MANET are Split-TCP [29], TCP-ELFN [30] and TCP-F [31].

5. Quality of Service: QoS refers to the capability of a network to provide better service to selected network traffic over various technologies. Main goal of QoS is to provide better services of the network by properly utilizing the network resources. QoS is collection of requirements that a user need to fulfill his tasks. These requirements are like response time, bandwidth, signal to noise ratio and loss etc. [32].

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

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Vol. 4, Issue 9, September 2015

Different users have different requirements based on their need. So, QoS varies from user to user depending upon the application. QoS in MANET is very challenging task due to the unique characteristic of the network. Following are the challenges [32, 33] to be taken into consideration while designing QoS services to MANET:

i. Dynamically varies topology
ii. Imprecise state information
iii. Lack of central authority
iv. Error prone shared media
v. Hidden terminal problem
vi. Limited resource availability
vii. Insecure medium

6. Security: MANETs are highly vulnerable to security attacks, due to its characteristic like dynamic topology of the network due to mobility of nodes, insecure operational environment etc. Due to existing characteristics of MANET, it is very easy for intruders to damage or disturb the network and hence it is very hard to achieve security goals such as confidentiality, authentication, integrity, non repudiation and availability [67]. One must keep in mind the following issues/challenges while designing security solutions for MANET [7]:

i. Shared broadcast radio
ii. Insecure operational environment
iii. Lack of central authority
iv. Lack of association
v. Limited resources
vi. Physical vulnerability

Network attacks are divided into two types i) Active attacks and, ii) Passive attacks. In an active attack, the attacker intentionally tries to break secured systems. For this, attacker uses viruses, worms, or Trojan horses etc. to steal the information. These attacks are mounted against a network backbone, exploit information in transit, electronically penetrate an enclave, or attack an authorized remote user during an attempt to connect to an enclave. Active attacks result in the disclosure or dissemination of data files and/or modification of data [61]. In MANET every layer of TCP/IP models has some active attacks such as Jamming in data link layer; Wormhole, Blackhole, Byzantine etc. in network layer; Repudiation in application layer [66] ii) Passive attacks: A passive attack is a network attack in which a system is monitored and sometimes scanned to gain information about the target and no data is changed in passive attacks [59]. The types of passive attacks in MANET are eavesdropping, traffic analysis and snooping [60].

7. Energy/Power Management: Battery power of node is important resource and hence must be managed efficiently to avoid termination of node. The energy efficiency of a node is defined as the ratio of the amount of data delivered by the node to the total energy expended [34]. Energy management is very important in MANET because of the following major issues [34]:

i. Limited energy resource
ii. Difficulties in helping the batteries
iii. Lack of central coordination
iv. Constraints on the battery source
v. Selection of optimal Tx power
vi. Channel utilization

Energy Management schemes are classified into three categories namely: *Battery management schemes, Transmission Power management schemes and system power management schemes*. Energy management schemes should be applied layer wise. Battery scheduling [35] and Lazy packet [36] are the schemes used in battery management. Distributed Topology Control [37] is used in transmission power management schemes. Scheme that comes under system power management is low-power design for hardware [38].

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

8. Location Service: In MANET node uses GPS for finding the location of another node near to the destination node, than itself. Location services are used in forwarding. It does not required route establishment and maintenance. These protocols are quickly adaptive to route changes and more scalable than unicast protocols like DSR, AODV etc.
Protocols for Location Services are divided into three categories: *Greedy Forwarding, Directed Flooding and Hierarchical Routing.* Greedy forwarding and Directed flooding algorithms forward the packet to one or more neighbors, respectively [1]. Most Forward within Radius MFR [39] and DREAM [40] are the main protocols used in Greedy forwarding and in Directed flooding. Hierarchical routing is a combination of position based and non position based protocols. Terminode routing protocol is an example of Hierarchical routing [41].

9. Clustering: Cluster in MANET is division of network into virtual groups, based on the rules, in order to discriminate the nodes allocated to different sub networks [1]. Cluster based routing in MANET is important due to the heterogeneous nature of node. The main goal of clustering is to achieve scalability in the presence of large network and high mobility. In a cluster, nodes may act as *i) Cluster head*: local coordinator of the cluster *ii) Cluster Member:* ordinary node *iii) Cluster Gateway*: nodes with inter cluster links, forward information between clusters *iv) Cluster-Guests*: a node associate to a cluster [42]. Clustering algorithms are classified [42] as: *i) Identifier-based clustering ii) Connectivity-based clustering iii) Mobility-aware clustering iv) Low cost of maintenance clustering v) Power-aware clustering vi) Combined-weight based clustering.*

10. Cooperation: Due to unique characteristics of MANET, each node relies on its neighboring node to forward the packet to the destination and accordingly issue of node cooperation becomes very important as it is a basic requirement for the operation of MANET. However, a user may misbehave due to several advantages resulting from non-cooperation, the most obvious being power saving. Cooperation is harder to enforce in MANET than in infrastructure based network due to many reasons [43]. First, nodes can arbitrarily join and leave the network. Second, detection of misbehaving nodes is in distributed manner due to lack of central authority. Finally, user specific requirements and attitude is ignored. Nodes are broadly classified into four categories:

i. Cooperative nodes: are active in route discovery and packet forwarding with positive attitude.
ii. Malicious nodes: are active in both route discovery and launching attacks. These nodes intentionally try to damage the network.
iii. Selfish nodes: are active in route discovery, but not in packet forwarding. These nodes try to gain help from the network without willing to pay back the help received.
iv. Hacker node [44] might try to intercept the information exchanged between the nodes. Such violation is materialized through e.g. impersonation. Both selfish and malicious nodes are considered as misbehaving nodes.

Following are some of the major challenges for cooperation in MANET [50]

i) Lack of association
ii) Congestion in network
iii) Link failure
iv) Limited battery power
v) Privacy and security
vi. Node behavior

Cooperation enforcement schemes can broadly be classified into following three classes: i) Reputation or motivation based scheme ii) Virtual currency/credit/incentive based scheme iii) Game theory based schemes. CONFIDANT (Cooperation of nodes- Fairness in dynamic ad hoc network) [45] and CORE (Collaborative Reputation) [46] are the examples of the Protocols fall under Reputation or motivation based schemes. Express [47], SPRITE (A Simple, Cheat Proof, Credit-based System) [48] are the examples of protocols falling under the category of Virtual/currency/credit/incentive based schemes. CAP-SV (Contribution rewArd routing Protocol with Shapley Value) [49] is an example of protocol which falls under the category of Game theory.

11. IP Addressing: Node in MANET requires a globally unique address for communication on the network. In wired or traditional wireless networks, central authority is present in the network to assign IP address to the nodes without

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 9, September 2015

any duplicity [7], however, in the case of MANET; because of the absence of central authority, configuration of address should required some automatic mechanism that can assign address to nodes without duplicity [7,51]. Following are some of the major challenges for auto -configuration system:

i. Highly dynamic topology.
ii. Frequent partition and merging of networks.
iii. Lack of central authority
iv. Link failures

The auto-configuration protocols may broadly be classified into three categories i) *Stateful Protocols:* In this the nodes keep IP addresses of other nodes in a table. Thus, a node has information of network state. MANETConf [52] , Dynamic Address Allocation Protocol (DAAP) [53] The Moshin and Prakash proactive scheme [54] are examples of Stateful Protocols ii) *Stateless Protocols*: The IP address of a node is managed by node itself. The Nodes create a random address and perform a process to detect duplicate address to verify their uniqueness. Examples of stateless protocols are: *Agent based Passive Auto-configuration* (APAC) [55], *Address auto-configuration with address Reservation and Optimistic duplicated address Detection* (AROD) **[**56] iii) *Hybrid Protocols*: It uses the combinations of stateful and stateless protocols to improve the scalability and reliability of the auto-configuration. *Hybrid Centralized Query-based Auto configuration* (HCQA) [57], *Passive Auto configuration for Mobile* ad hoc *Networks* (PACMAN) [58] are the examples of hybrid protocols.

IV. CONCLUSIONS

A comprehensive review of MANET including its characteristics, advantages, challenges and issues has been discussed in this article. From the review presented above, it is concluded that in spite of many advantages of MANET, the real time implementation of MANET is a very challenging task. Because of the characteristics of MANET, it is very hard to achieve confidentially, authentication and other security goals. Further, because of the characteristic of nodes it is very difficult to address co-operation in MANET. Finally, it is concluded that the issues & challenges of MANET discussed in this article must be addressed very carefully which designing various protocols before its real time application.

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