Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 3, Issue. 2, February 2014, pg.432 – 437

REVIEW ARTICLE

Review on MANET: Characteristics, Challenges, Imperatives and Routing Protocols

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Abstract- Nowadays, with the rapid propagation of lightweight wireless devices such as laptops, wireless telephones, and wireless sensors, the potential and importance of nomadic computing particularly mobile ad hoc networking have become apparent. A mobile ad hoc network, or MANET, is an infrastructure less temporary network, formed by a set of wireless mobile hosts that has no central administration and establish their own network dynamically. Moreover, the network's environment has some features that add extra complications, such as the frequent changes in the topology caused by nodes mobility, as well as the unreliability, resource constraint and the bandwidth limitation of wireless channels. A number of protocols have been proposed in the literature for efficient routing in MANET. Due to the dynamic topology of Mobile Adhoc Network, this paper mainly concentrates on different routing techniques which are the most challenging issue in today's scenario. Different strategies have been proposed for efficient routing which claimed to provide improved performance. There are different routing protocols proposed for MANETs which makes it quite difficult to determine which protocol is suitable for different network conditions .This paper gives proposal of different strategies by provides an overview of different routing protocols proposed in literature.

Keywords: MANET, Routing Protocol, Dynamic Topology, Mobility, Performance

I. INTRODUCTION

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 conventional networks, but it is compatible with the conventional networks. In such an environment, it may be necessary for one mobile host to enlist the aid of other hosts in forwarding a packet to its destination, due to the limited range of each mobile host's wireless transmissions. Routing in Mobile Adhoc network is challenging due to the constraints existing on the transmission bandwidth battery power and CPU time and the requirement to cope with the frequent topological changes resulting from the mobility of the nodes. Nodes of a MANET cooperate in the task of routing packets to destination nodes since each node of the network is able to communicate only with those nodes located within its transmission radius R, while the source and destination nodes can be located at a distance much higher than R. All the nodes in a multi-hop wireless ad hoc network cooperate with each other to form a network without the presence of any infrastructure such as access point or base station as shown in Figure 1.1.In MANET, the mobile nodes require to forward packets for each other to enable communication among nodes outside the transmission range. The nodes in the network are free to move independently in any direction, leave and join the network arbitrarily. Thus a node experiences changes in its link states regularly with other devices. Eventually, the mobility in the ad hoc network, change of link states and other properties of

wireless transmission such as attenuation, multipath propagation, interference etc. create a challenge for routing protocols operating in MANET. The challenges are enhanced by the various types of devices of limited processing power and capabilities that may join in the network.

A. Characteristics of MANET [1]

Autonomous and infrastructure-less: MANET does not rely on any established infrastructure or centralized administration. Each node operates in distributed peer-to-peer mode, acts as an independent router and generates independent data. Network management has to be distributed across different nodes, which brings difficulty in fault detection and management.

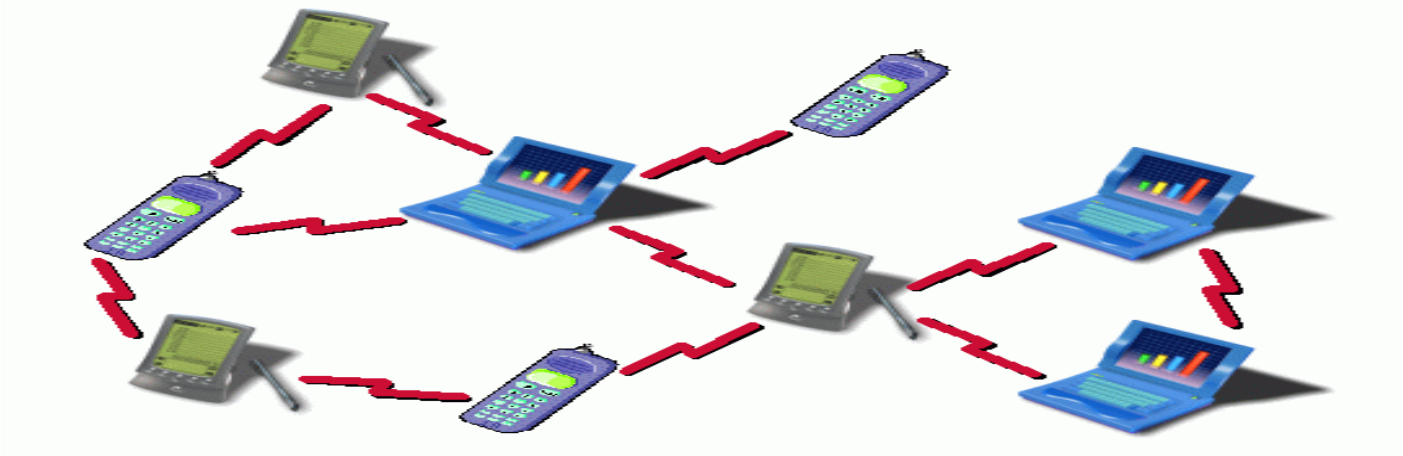

Figure 1.1: MANET

Multi-hop routing: No default router available, every node acts as a router and forwards each other's packets to enable information sharing between mobile hosts.
Dynamic topologies: In mobile ad hoc networks, because nodes can move arbitrarily, the network topology, which is typically multi-hop, can change frequently and unpredictably, resulting in route changes, frequent network partitions, and possibly packet losses.
Variation in link and node capabilities: Each node may be equipped with one or more radio interfaces that have varying transmission/receiving capabilities and operate across different frequency bands [7, 8]. This heterogeneity in node radio capabilities can result in possibly asymmetric links. In addition, each mobile node might have a different software/hardware configuration, resulting in variability in processing capabilities. Designing network protocols and algorithms for this heterogeneous network can be complex, requiring dynamic adaptation to the changing conditions (power and channel conditions, traffic load/distribution variations, congestion, etc.).Energy constrained operation. Because batteries carried by each mobile node have limited power supply, processing power is limited, which in turn limits services and applications that can be supported by each node. This becomes a bigger issue in mobile ad hoc networks because, as each node is acting as both an end system and a router at the same time, additional energy is required to forward packets from other nodes.

Network scalability: Currently, popular network management algorithms were mostly designed to work on fixed or relatively small wireless networks. Many mobile ad hoc network applications involve large networks with tens of thousands of nodes, as found for example, in sensor networks and tactical networks [9]. Scalability is critical to the successful deployment of these networks. The steps toward a large network consisting of nodes with limited resources are not straightforward, and present many challenges that are still to be solved in areas such as: addressing, routing, location management, configuration management, interoperability, security, high capacity wireless technologies, etc.

B. Advantages & Applications of MANET

The following are the advantages of MANET [2]:

- They provide access to information and services regardless of geographic position.
- These networks can be set up at any place and time.
- Independence from central network administration. Self-configuring network, nodes are also act as routers. Less expensive as compared to wired network.
- Scalable—accommodates the addition of more nodes.
- Improved flexibility.
- They are robust due to decentralize administration.

Some of the typical applications include:
Military battlefield: Ad-Hoc networking would allow the military to take advantage of commonplace network technology to maintain an information network between the soldiers, vehicles, and military information head quarter.

Collaborative work: For some business environments, the need for collaborative computing might be more important outside office environments than inside and where people do need to have outside meetings to cooperate and exchange information on a given project.

Local level: Ad-Hoc networks can autonomously link an instant and temporary multimedia network using notebook computers to spread and share information among participants e.g. conference or classroom. Another appropriate local level application might be in home networks where devices can communicate directly to exchange information.

Personal area network and Bluetooth: A personal area network is a short range, localized network where nodes are usually associated with a given person. Short-range MANET such as Bluetooth can simplify the inter communication between various mobile devices such as a laptop, and a mobile phone.

Commercial Sector: Ad hoc can be used in emergency/rescue operations for disaster relief efforts, e.g. in fire, flood, or earthquake. Emergency rescue operations must take place where non-existing or damaged communications infrastructure and rapid deployment of a communication network is needed.

C. Ad Hoc Networking Issues

In general, mobile ad hoc networks are formed dynamically by an autonomous system of mobile nodes that are connected via wireless links without using the existing network infrastructure or centralized administration. With the advantage of dynamic topology i.e. the nodes are free to move randomly and organize themselves arbitrarily; such flexibility and convenience do come at price.

Ad hoc wireless networks inherit the traditional problems of wireless communications and wireless networking [10]:

- the wireless medium has neither absolute, nor readily observable boundaries outside of which stations are known to be unable to receive network frames;
- the channel is unprotected from outside signals;
- the wireless medium is significantly less reliable than wired media;
- the channel has time-varying and asymmetric propagation properties;
- Hidden-terminal and exposed-terminal phenomena may occur.

II. CLASSIFICATION OF ROUTING PROTOCOL

Because of the highly dynamic nature of a mobile ad hoc network many frequent and unpredictable changes in network topology are observed which adds difficulty and complexity to routing among the mobile nodes. Thus, the importance of routing protocol in establishing communications among mobile nodes, make routing area the most active research area within the MANET domain. Numerous routing protocols and algorithms have been proposed, and their performance under various network environments and traffic conditions have been studied and compared.

Several surveys and comparative analysis of MANET routing protocols have been published [11, 12]. Ref. [14] provides a comprehensive overview of routing solutions for ad hoc network, while an updated and in depth analysis of routing protocols for mobile ad hoc network is presented in [14]. A preliminary classification of the routing protocols can be done via the type of cast property, i.e., whether they use a Unicast, Geo-cast, Multicast, or Broadcast forwarding [13].

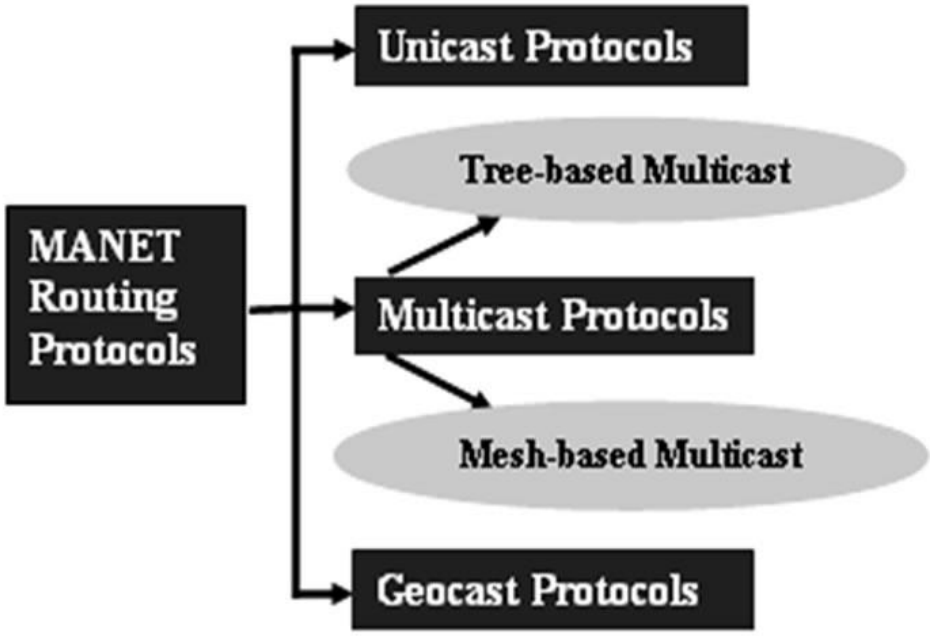

Figure 2.1: Classification of MANET Routing Protocols

Unicast forwarding means a one-to-one communication, i.e., one source transmits data packets to a single destination. This is the largest class of routing protocols found in ad hoc networks.
Multicast routing protocols come into play when a node needs to send the same message, or stream of data, to multiple destinations.
Geo-cast forwarding is a special case of multicast that is used to deliver data packets to a group of nodes situated inside a specified geographical area.
This section presents the various aspects of routing algorithms and the following section will provide brief description of various unicast routing protocols, respectively.

A. Unicast Routing

A primary goal of unicast routing Protocols is the correct and efficient route establishment and maintenance between a pair of nodes, so that messages may be delivered reliably and in a timely manner.
The below Figure 2.2 will show the classification of various unicast routing protocols.

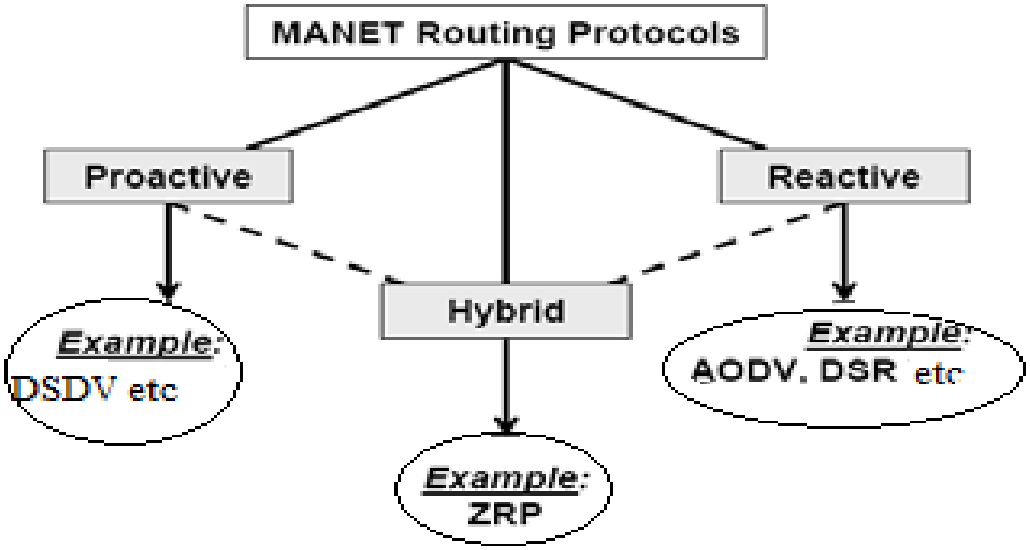

Figure 2.2: Classification of Unicast Routing Protocols

Providing routing protocols for MANETs has been, in the last 10 years, perhaps the most active research area for the ad hoc network community. A large number of routing protocols have been designed, either by modifying Internet routing protocols, or proposing new routing approaches. The number of proposed protocols is too large to be surveyed in this paper. Below, I therefore present a high-level classification of MANET routing protocols.
MANET routing protocols are typically subdivided into three main categories:

- Proactive routing protocols.
- Reactive on-demand routing protocols.
- Hybrid Protocols.

1) Proactive Routing Protocols: In these protocols, each node maintains a constant route to all other network nodes. They are also called table –driven routing protocols as each node has to maintain one or more table for storing routing information and any changes in network topology need to be reflected by propagating updates throughout the network in order to maintain a consistent network view. Example of such schemes is the conventional routing protocol is Destination sequenced distance vector (DSDV).
Destination-Sequenced Distance-Vector (DSDV) protocol [10] is a distance-vector protocol with extensions to make it suitable to MANET. Every mobile node maintains a routing table which lists all the available destinations, the metric and next hop to each destination and a sequence number generated by the destination node. Using such routing table stored in each mobile node, the packets are transmitted between the nodes of an ad hoc network. Each node of the ad hoc network updates the routing table with advertisement periodically or when significant new information is available to maintain the consistency of the routing table with the dynamically changing topology of the ad hoc network [16].

2) *Reactive Routing Protocols [5]:* In these types of protocols in order to reduce the overhead, the route between two nodes is discovered only when it is needed. Representative reactive routing protocols include: Dynamic Source Routing (DSR), Ad hoc On Demand Distance Vector (AODV) etc. Reactive routing is also known as on-demand routing protocol since they do not maintain routing information or routing activity at the network nodes if there is no communication. If a node wants to send a

packet to another node then this protocol searches for the route in an on-demand manner and establishes the connection in order to transmit and receive the packet. The route discovery occurs by flooding the route request packets throughout the network.
Examples of reactive routing protocols are the Ad-hoc On-demand Distance Vector routing (AODV) [17] and Dynamic Source Routing (DSR).

Dynamic Source Routing (DSR) [18] is the competent and simple routing protocol. It follows the source routing technique. In this the complete sequence of nodes is determines by the sender of the node through which the packet is forwarded. Then the route is listed in the packet header and each hop is identified by the address of the next node and the packet is transmitted to the destination host. DSR is completely self-organizing and self-configuring and requires no existing network infrastructure. The DSR protocol allows dynamically discovering of a source route across multiple network hosts to any destination in the network. Two mechanisms that make up the operations of DSR are Route Discovery and Route Maintenance. But before continuing some assumptions are made:

- All nodes should be willing to forward packets to other nodes in an ad-hoc network.
- The diameter of ad-hoc network is equal to the minimum number of hops travelled by a packet.
- The speed with which the nodes move is moderate with respect to the packet transmission latency.
- The hardware should deliver each and every packet to the network driver software without filtering based on link layer destination address.

Ad-hoc On-demand Distance Vector routing (AODV) is a reactive improvement of the DSDV protocol. AODV minimizes the number of route broadcasts by creating routes on-demand [19], instead of maintaining a complete list of routes as in the DSDV algorithm. Similar to DSR, it has on-demand process of discovering routes, the route request is then forward by the source to the neighbors, and so on, until either the destination or an intermediate node with a fresh route to the destination, are located.
Comparison between DSR and AODV: DSR has a potentially larger control overhead and memory requirements than AODV since each DSR packet must carry full routing path information, whereas in AODV packets only contain the destination address. On the other hand, DSR can utilize both asymmetric and symmetric links during routing, while AODV only works with symmetric links. In addition, nodes in DSR maintain in their cache multiple routes to a destination, a feature helpful during link failure. In general, both AODV and DSR work well in small to medium size networks with moderate mobility.

3) Hybrid Routing Protocols: These protocols combine the strategies of both proactive and reactive protocols. Example of hybrid routing protocols is Zone Routing Protocol ZRP.
Zone Routing Protocol is a hybrid routing protocol that divides the network into zones. ZRP provides a hierarchical architecture where each node has to maintain additional topological information requiring extra memory. A zone Zk(n) with radius k is define for each node n as the set of nodes at a distance at most k hopes from n. Zk (n) = {i: H (n, i) <= k}, where H (i, j) is the distance in number of hops between node i and node j. The node n is called the central node of the routing zone, while a node b such that H (n, b) =k is called a peripheral node of n. while the other nodes are called as the internal nodes.

B. Comparison Table

Table 1 summarizes the main charactertics of the most cited protocols discussed so far [3, 5]:

Routing Protocol	**Route Acquisition**	**Flood**	***Delay***	***Multipath capability***
DSDV	Computed a Priority	NO	*NO*	*NO*
DSR	On-Demand only when needed	YES, Aggressive use of caching reduces flood scope	*YES*	*Not Explicitly. The technique of salvaging may quickly restore a route*
AODV	On-Demand only when needed	YES, conservative to reduce flood scope	*YES*	*No although recent research indicates viability.*
ZRP	Hybrid	Only outside a source zone	*Only if the destination is outside the source zone*	*NO*

TABLE 2.1 Comparison between various Routing Protocols

III. FUTURE RESEARCH AREAS IN MANET

As already mentioned in this paper, the research in the area of mobile ad-hoc networks is far from being exhaustive. Much of the effort is spend on devising routing protocols to support the effective and efficient communication between nodes that are part of the network. However, there are many topics for research in this field like:

- Interoperation with the internet- How can ad-hoc network seamlessly and efficiently access the internet in order to provide advanced services.
- Quality of service (QoS) - Is it feasible for bandwidth/delay constraint applications to run well in a MANET?
- Security- How can the network secure itself from malicious or compromised hosts?

IV. CONCLUSION

We have seen a great development in the field of wireless networks (infrastructure based) and in the field of Mobile ad hoc network (infrastructure less network). In this paper, we discuss MANET and its characteristics, advantages, application, challenges, issues and various types of routing protocols for efficient and effective communication between the mobile nodes participating in a dynamically established network of nodes. The routing protocols are broadly classified into Broadcast, Unicast and Multicast routing Protocols. In this paper, a brief description on unicast routing protocols is provided and how they are better than other routing protocols is shown.

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