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Multicast Routing Protocols in Mobile Ad Hoc Networks

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Abstract*: *A Mobile Ad-hoc network (MANET) is a network which forms a kind of self organized network without any pre-established infrastructure over radio links. Mobile Ad Hoc Networks (MANETs) are more effective in node –to- node communication. In current era of technology where most of the things are based on networks, MANETs are more suitable for wireless communication and data transfer medium due to the advent of 3G, 4G & 5G technologies. The primary objective of such an ad-hoc network routing protocol is to create appropriate and efficient route between a pair of nodes so that messages can be transmitted in a timely fashion. The dynamic design of this network makes routing protocols a prominent part in creating efficient routes between pairs of nodes The design of routes should be achieved with minimal overhead and bandwidth usage In last two decades many multicast routing protocols are designed and implemented. This paper focuses on some of the MANETs protocols and their characteristics along with their advantages and disadvantages.

Keywords*: *adhoc networks, bandwidth, infrastructureless, symmetric, topology.

I. INTRODUCTION

Wireless network means a system of wireless nodes that can communicate freely with the help of infrastructureless base stations. These stations are then connected to wired or wireless techniques. There were some areas where these networks are very difficult to implement like military applications, research community, disaster relief operations, etc. Wired network means a system of wire d nodes that allow two or more entities of a communication system to transmit information via physical medium. Multicasting is basically routing of data packets to multiple nodes which shares one common address. It is also called group oriented computing as there can be more than one sender. There are protocols in wired networks which can multicast but as MANET has some unique characteristics so separate protocols for multicast are provided [1]. Adhoc means for the purpose", self-organizing network architecture.

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Base station is not required in these networks. Adhoc networks are categorized as Mobile Adhoc Networks (MANETs), Wireless Sensor Network (WSN), Vehicular Adhoc Networks (VANETs), Wireless Mesh Network (WMN).After the successful implementation of adhoc wireless networking technology, it offers a distinct set of challenges which is different from traditional wireless systems and wired networks.

Adhoc networks consists of peer to peer networks where the packets are traversed in a store and forward manner from source to destination through the intermediate nodes as shown in Figure 1.where all nodes should know the exact position of nodes when there is updation in the network topology. In the figure (Mobile Host) MH2 changes its position from MH3 to MH4.Now all the remaining nodes should know the change in topologies. There is one major issue in the figure is that of symmetric and asymmetric links.MH1 and MH3 both the nodes are symmetrically linked with each other i.e. both are in associative radio range of each other. MH4 and MH7 are asymmetric nodes and it is very difficult to route in asymmetric links. So there are number of issues that are considered while making the network topology of ad hoc networks due to changes in infrastructure [2].In this paper we focus on routing protocols for MANETs.

II. CHARACTERISTICS OF MANET

Following are some of the features of MANET

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- **Dynamic Topologies**: The topology of the network changes arbitrarily and at unequal times as the nodes are free to move haphazardly with changing speeds. Since no central authority is there to control them so these networks are self -configure and self maintain and therefore they do not require any static infrastructure. Since the networks with static infrastructure are hard to be deployed.
- **Peer-to-Peer nature**: As the nodes are free to move so the communication between nodes is peer to peer. The protocols designed for these nodes need to be robust to handle distributed topologies. To efficiently perform network functions at the lower most layers these different characteristics of wireless adhoc networks would need different techniques.
- **Limited computing and energy resources**: Due to the limited battery capacity, the computing power, memory, and disk size, as well as device size, weight, and cost are limited. As the nodes are free to move and are very small in size so the energy conservation is the important criteria to keep in mind.

- **Limited service coverage**: As the distance between devices is not fixed and the limitations of network conditions, implementation of service for wireless devices is more challenging in comparison to wired networks so there are more constraints in implementing MANETs.
- **Higher interference results in lower reliability**: In MANETs as the devices communicate with each other without wire so there are many interferences of signals like infrared signals from sunlight, radio signals with electrical devices and due to multipath self interference also occurs.
- **Highly flexible network conditions**: Movement of users causes frequent disconnection in the networks so there is more data losses due to interference and channel also changes frequently which results in reduction in power.
- **Limited Bandwidth**: The bandwidth is relatively very less as compared to wired networks due to free movement of nodes. The communication in adhoc networks becomes very challenging because of recurrent changes in the links and limited bandwidth.

III. EVOLUTION OF MANET

During 1970s Norman Abramson developed the ALOHA net system for wireless computer communication .The Defense Advanced Research Projects Agency (DARPA) initiated both theoretical and experimental research on the viability of utilizing packet-switched radio communications to provide consistent computer communications. They introduced packet radio network during the years 1973-1987 and this network was considered to be a reliable, operational and robust network. The DARPA PRNET project consists of network devices, routing protocols and mechanized distributed network management protocols. But PRNET was used to solve the problem of multi-hop communications between mobile vehicles without a central station [2]

During the years 1980 to 1993 a project called Survivable adaptive radio networks (SURAN) was funded by DARPA to create a set of mobile ad hoc network (MANET) radio-routers, known as "packet radios". It was developed to provide small, low cost radio, algorithms for thousands of nodes, etc. [3] in infrastructureless environments. There was scalability in the algorithms designed and resilience to electronic attacks.

A project called GloMo (Global Mobile Information Systems) was developed to provide connectivity and access to services to mobile users. This project consists of self organizing networks and includes satellite communication networks, heterogeneous networking with IP overlays .This project was basically used in Wide area information systems, systems for rapid development of armed forces.

Despite growing interest in ad hoc networks, there were numerous other great advances in the 1990s. In this era the adhoc networks came with various communication equipment's like laptops and notebooks. In several research papers and conferences the notion of mobile nodes came into existence. IETF set up a MANET working group in the mid-1990s to standardize various routing protocols for adhoc networks. The IEEE Committee 802.11 defined a medium access protocol based on collision avoidance to establish mobile adhoc networks.

There are actually two types of wireless mobile networks: infrastructured networks with fixed and wired gateways. Example of this network is WLAN (Wireless local area network[15].

Second one is Infrastructureless network. Example is MANET which is a self organizing and self healing network. Till now many MANET routing protocols have been proposed which have their own advantages and disadvantages to adapt different networking environments.

Refer Figure 1: Structure of MANET

IV. MULTICAST ROUTING PROTOCOLS FOR ADHOC NETWORKS

As ad hoc networks are infrastructureless so the packet is transmitted to a number of nodes so many protocols are needed to route the traffic of these networks. These protocols helps the packet to find the best path so that the packet reaches to the correct destination. Many researchers found many protocols and have been a focus on area of research for many years [4].

Refer Figure 2: Types of Manet's Routing Protocols

A. Table driven routing protocols

These protocols keeps all the routing information of each and every node that are connected to the network. All nodes have a simple and consistent view of all topology of the network, as topology is periodically modified. So all the nodes can forward the packets by taking immediate decisions.

i) OLSR (Optimized Link State Routing Protocol)

The main concept of this protocol is multipoint relays (MPRs).During the flooding process MPRs are selected which forward broadcast messages. In this protocol individual nodes uses topology information to determine next hop destinations for all nodes in the network using the shortest hop forwarding paths. This technique greatly decreases the message overhead compared to the classic flooding method, in which each node transmits each message when it receives its first copy. The nodes which are selected as MPRs can generate the link state information.

Advantages:

- It is used for applications which needs minimum delay as it has less average end to end delay
- Most suitable for adhoc networks due to its frequent changes in source and destinations pairs

Disadvantages

- Routing table has to be maintained for all possible routes.
- The overhead increases when the number of nodes increases in the network topology.

ii) The Fisheye State Routing (FSR) protocol [5]

This protocol was developed in large networks to reduce routing update overheads. Information about the link state is shared with neighbor's at a frequency that depends on distance to destination. These entries help the nodes build up the network topology map and determine the optimal routes [6].

The central node preserves the updated information about the network's inner nodes such that the more distant node gets less knowledge and information's reliability and accuracy decreases.. This protocol increases the scalability of the routing protocol by gathering data of topology which is to be required in future.

Advantages

- It is suitable for larger networks which controls the overhead.
- It is very easy and straightforward as it maintains the updates shortest routes.

Disadvantages

- It decreases the scalability of the routing protocol
- It increases the processing overhead and storage complexity.

iii) DSDV

The Destination-Sequenced Distance Vector (DSDV) Protocol is a table-driven routing protocol that is a modified variant of the classical routing algorithm Bellman-Ford. It is based on the Routing Information Protocol (RIP) in which a node keeps a routing table containing the network's viable destinations and the number of hops to each destination. The protocol's routing table is very simple, in which each table entry has a new entry named sequence number that is incremented each time a node sends an updated message. And the consistency across the network is maintained. -- DSDV maintains two routing tables for packet forwarding and one for advertising incremental routing. The entries in the table are new sequence, destination address, number of hops to the destination node and the sequence number of the destination.[11]

Advantages

- As paths to all network destinations are always open, there is less delay in setting up the path phase.
- There is an incremental modification approach with sequence number labels that tags current wired network protocols that can be adapted to Ad-hoc Wireless networks. Therefore all current wired network protocol can be useful with less change to ad hoc wireless networks

Disadvantages

- DSDV, which uses battery power and a limited amount of bandwidth, requires a regular change in the routing table.
- Every when the network topology shifts, a new sequence number is needed before the network converges again. DSDV therefore does not fit for highly complex or large-scale networks.

iv) Protocol Independent Multicast (PIM)

This protocol uses the information form unicast routing protocols to build its topology.
PIM is available in two modes:
PIM-Dense Mode (PIM-DM)
PIM-Sparse Mode (PIM-SM)

PIM-Dense Mode (PIM-DM)

PIM-DM only uses source-based trees. It is suitable for those receivers who are interested in multicast data and those who are not interested can send prune messages to get them removed from the tree.

PIM-Sparse Mode (PIM-SM)

PIM-SM by default uses shared trees.in this protocol the recipients are distributed sparsely throughout the network. Routers use PIM Join and Prune messages to enter and exit multicast distribution trees.

Advantages

PIM is flexible and scalable which is suitable for large heterogeneous networks.

B. On Demand (Reactive protocols)

As the name suggests these protocols create the routes on request rather than maintaining up to date information of the network topology. Some of the protocols have been discussed here.

i) TORA

TORA is a an effective, highly adaptive, loop-free and scalable routing protocol which is based on link reversal algorithm. The main feature of this protocol is limiting the transmission of information in the adhoc environment. It also localize the control packets over a smaller region near the incidence of the changing topology .Hence every node contains only information about its adjacent nodes.

Advantages

- It has routing capabilities on multipaths.
- It functions well in dense networks.

Disadvantages

- It is not flexible.
  To any source-destination pair, it provides multiple routes. To this end, teach node must preserve routing knowledge about their neighbors in one-hop.

ii) AODV (Ad Hoc On-Demand Distance-Vector Routing Protocol)

AODV is capable of both kinds of casting namely unicast and multicast. This protocol does not hold the routes from each node to another node, but discovers the path as and when necessary for as long as possible.
Discovery of the path is achieved using the control messages Route Request (RREQ) and Route Reply (RREP). The RREQ packets are flooded in the network which traverses the network and the traversed mobile nodes stores the information regarding the source, destination and the node which received the RREQ packet[22].

Advantages

- It follows the least congested route as compared the shortest route
- It does not uses source routing so additional overhead of data is ignored.

Disadvantages

- It is not suitable for growing networks because with the increase in network the performance metrics tend to decrease.
- As this protocol assumes that all nodes must cooperate with each other so it is more vulnerable to attacks. And new routes would not be established.

iii) DSR

This protocol is designed for multihop wireless adhoc networks of mobile nodes. In this the network is self organized and self configured and there's no need of any existing network infrastructure. The main principle behind this protocol is Route discovery" and "Route maintenance". They are working together to discover and maintain routes to arbitrary destinations within adhoc networks. There are multiple routes for the destination and the sender is allowed to select and control the routes which are used in routing of the packets[21].

Advantages

- No need to keep the routing table, as the entire path is in the packet header.
- Can work in networks with unidirectional links.

Disadvantages

- With the increase in mobility there is decrease in performance.
- If there is a break in the link then it cannot repair it locally.

iv) CBRP

The nodes are partitioned into clusters in this protocol. Each cluster has a cluster head and these heads function within their cluster as temporary base station and interact with their peers. Each node has an undecided state. After starting of the timer a hello packet will be broadcasted by the node and if it receives a reply then it will become the cluster member otherwise it will make itself cluster head. And this is possible if it has bidirectional links with one or more neighboring nodes[7].

Advantages

- Reduces the overhead of routing and route discovery traffic.
- Uses "local repair" mechanism to reduce delay and new route discovery traffic.
- Increases the packet delivery ratio.

Disadvantages

- There is an increase in overhead of packet then the cluster size increases.
- The communication between different cluster heads is complex.

There is a comparison table consisting of some of the protocols based on few parameters

Refer Table 1: Comparison of various protocols based on few parameters

V. RESULTS AND DISCUSSIONS

The main contribution of the author in the paper is that the author tries to cover some of the aspects of reactive and proactive protocols. After discussing about the characteristics, advantages and disadvantages, the author has made a summary of some of the protocols on different parameters. Based on these parameters, one can choose any protocol depending upon the suitability and requirement of the network topology. Till date lots of improvement made in this field but many studies [8],[10],[13] shows that still some improvements are required. Hence keeping some issues in mind author tried to overcome from these problems by representing a comparative table 1 based on various parameters.

VI. CONCLUSION

In this paper author tries to give an overview of MANET routing protocols, their characteristics, advantages and disadvantages and also a brief summary chart of proactive and reactive protocols. The main idea of a routing protocol is to send information between two nodes. These protocols are used in many networks such as Local Area Networks (LAN), Mobile Ad hoc Networks (MANETs) or Wireless Mesh Networks (WMN). Ad-hoc mobile networks reflect the future of wireless networks. Nodes in these networks can produce traffic for both users and applications and perform various network functions. Over the past few years, numerous multicast routing protocols have been developed but no such protocol yet developed which can solve all the ad-hoc problems. So it has always a point of research for the researchers in the coming future.

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Dr. Nupur Soni is currently working as an Associate Professor in School of Computer Applications in Babu Banarsi Das University. She has over 12 years of experience in the field of teaching. She also has published over 12 research papers in the field of mobile networks, sensor networks, wireless networks.

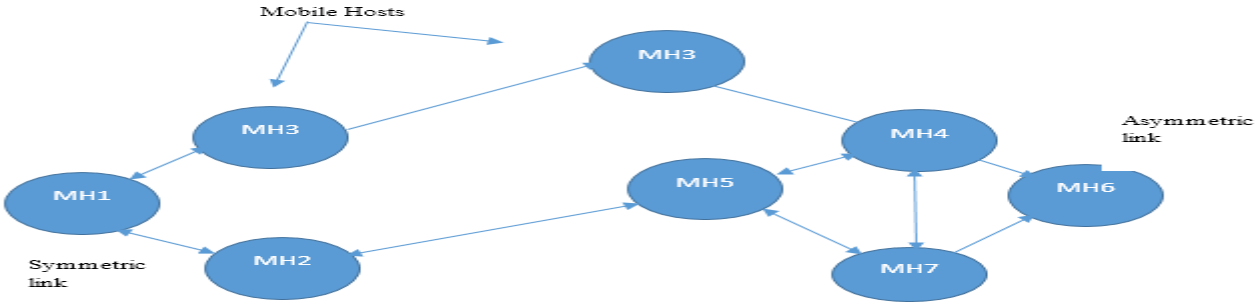

Fig 1. Structure of Manet

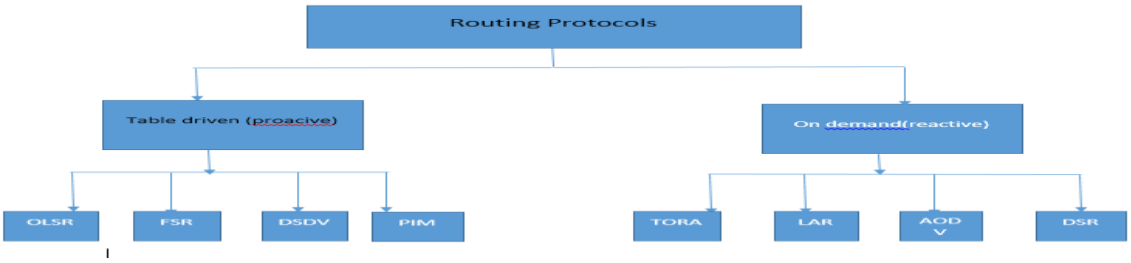

Fig. 2. Types of Manet's Routing Protocols

Table- I: Comparison of various protocols based on few parameters

protocol	Type of protocol	Routing overhead	Mobility support	Utilization of bandwidth	Technique	Source routing
OLSR	PROACTIVE	less	Good performance in high mobility conditions	more	unicast	yes
FSR	PROACTIVE	less	Good performance in high mobility conditions	more	unicast	yes
DSDV	PROACTIVE	More than AODV	Good performance in high mobility conditions	less	unicast	yes
PIM	PROACTIVE	MORE	Good performance in high mobility conditions	less	multicast	yes
TORA	reactive	most	Good performance in high mobility	less	multicast	no
LAR	reactive	LESS	Low performance in high mobility	less	multicast	no
AODV	reactive	LESS	Good performance in high mobility conditions	more	Unicast and multicast	no
DSR	reactive	Less than AODV	Low performance in high mobility	more	Mainly unicast	yes