AN INTRINSIC ANALYTICAL STUDY ON ROUTING PROTOCOLS FOR MANET

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ABSTRACT

Mobile Ad hoc Network (MANET) is a collection of moving nodes acting as routers as well as hosts and connected with each other through wireless links. The topology of mobile Ad hoc network is dynamic in nature and there is no centralized fixed infrastructure. Such a network may operate in a stand-alone fashion or may be connected to the Internet. In order to transmit the data/control packets from one node to other node, there are requirements of routing protocols. Since the nodes are dynamic in nature and limited in resources such battery power, bandwidth and storage capacity, the connection between two nodes can break at any moment. Therefore, achieving efficient and robust routing is a critical task in MANET. In this paper, an attempt has been made to do the intrinsic analytical study on existing routing protocols for MANET in order to evaluate their performance by reviewing the literature available in the vicinity of MANET. The main objective is to get an idea to select the base protocols for further research work in the field of MANET.

Keywords*: Ad hoc, AODV, DSDV, DSR, MANET, Network, OLSR, Protocol, Routing, TORA, WRP, ZRP*

1. Introduction

Wireless network [1, 2] allows the devices to stay connected but not through cables of any kind. Generally radio waves are used for wireless data communication between two devices. It makes the devices to be connected to the network while roaming from one place to other place as shown in figure 1.

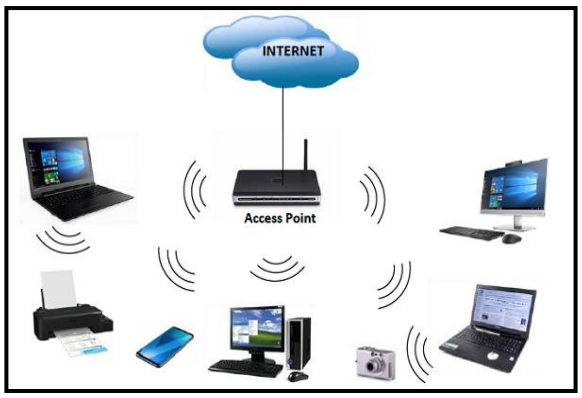

Figure 1: Wireless Networks

The wireless networks are further divided into two categories [9, 11]:-

a) Infrastructure wireless network
b) Ad hoc/Infrastructure-less wireless network

Infrastructure wireless network is the wireless networks that contains wireless router/access point and enables other devices connect to it wirelessly. This is the common deployment to build a home wireless network. In order to build up an infrastructure wireless network, the most common method is to set up and configure a wireless router which has built-in Infrastructure mode support and connect it to DSL, cable, 4G/5G or other broadband modem, so that to allow other computers, laptops, printers, TV, mobile phones, tablets or other electronic devices with built-in wireless adapter connect to it to form a local wireless network with Internet access. The other type of wireless network is Ad hoc/infrastructure-less wireless network that allows you to quickly set up wireless connectivity between laptops, computers or mobile devices to share files or information. Usually the infrastructure wireless network is for permanent setup at home or office, whereas the ad-hoc wireless network is more for ad-hoc or temporary connectivity between computing or mobile devices, however the only minor drawback for infrastructure wireless network is that you need additional hardware, such as wireless router or access point to set it up. In other words, base stations are fixed and devices are in movement in Infrastructure wireless networks. Since the devices are dynamic in nature, whenever one device is beyond the range of its own base station, it gets into the range of another base station. On the other hand, Ad hoc /infrastructure-less wireless network does not require any fixed base stations. In this category, all the devices are in movement and they behave as hosts/routers. The moving devices in the Ad hoc network dynamically setup routing among them to form their own network and this is known as Mobile Ad hoc

Network (MANET). Each device in MANET behaves as a host as well as a router depending upon the situation and the topology of network is dynamic. In nut shell, a temporary network is formed without any static infrastructure where all the devices are free to moving randomly. MANET is more vulnerable than wired network. Some of the key challenges for MANET are given below:-

- How to handle the limited bandwidth of wireless networks
- How to handle the dynamic network topology
- How to achieve the stable and efficient routing
- How to tackle the network overhead
- How to handle the issue of scalability
- How to achieve QoS parameters
- How to handle the security threats and implement secure routing
- How to handle the power/battery constraints and achieve energy efficient routing
- Lack of centralized management will impede trust management for nodes and how to handle the same.

2. Routing Protocols

Whenever a device (source) wants to send some information to some other device (destination), a routing protocol [1,4,5] is required. The information is transmitted to destination via number of devices/nodes by means of packets. Basically, routing protocol finds a path to be followed by data packets from a source node to a destination node. Routing protocols used a in traditional wired networks cannot be directly applied in Ad hoc wireless networks due to high dynamic topology and absence of centralized infrastructure. There are certain issued in designing a routing protocol for Ad hoc wireless networks as given below:-

a) Mobility of nodes
b) Bandwidth constraints
c) Resources constraints like battery life and processing power
d) Error-prone shared broadcast radio channel
e) Collisions of data and control packets during transmission
f) Hidden and exposed terminal problems

3. Classification of Routing Protocols

Routing protocols for Ad hoc wireless networks can be classified into different types on the basis of following criterion [1]:-

a) Based on routing information update mechanism
b) Based on the use of temporal information for routing
c) Based on topology information organization
d) Based on utilization of specific resources

Among these different classification criterions, the prominent one is the first one and efforts have been made in this paper to do the comparative study of routing protocols based on the routing information update mechanism. The Ad hoc wireless network routing protocols are further divided into three categories based on first criterion as shown in figure 2:-

- Proactive routing protocols
- Reactive routing protocols
- Hybrid routing protocols

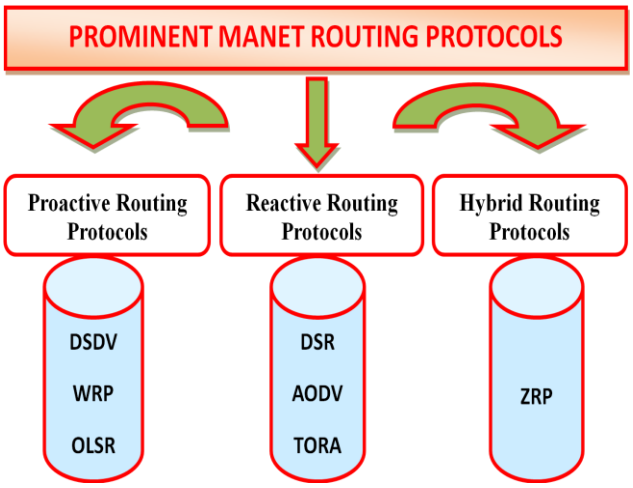

Figure 2: MANET Protocols

3.1 Proactive Routing Protocols

In proactive routing protocols [1, 4, 5, 6, 7] each node maintains routing/network topology information to every other node in the network in the form of routing tables by periodically exchanging the routing information. All nodes keep on updating these tables to maintain latest view of the network. These protocols are also known as table driven routing protocols. This type of routing protocols uses link-state routing algorithms which frequently floods link

information about its neighbors. These protocols store the routing information in tables and maintain the information up to date by exchanging the control packet from their neighbors. The examples of prominent proactive routing protocols are DSDV, OLSR, and WRP.

3.2 Reactive Routing Protocols

In reactive routing protocols [1, 4, 5, 6, 7], routes are created on need basis. Protocols falling under this category do not maintain the network topology information. The necessary path is created, as and when required, by using connection establishment procedure. When a transmission occurs from source to destination, it invokes the route discovery procedure. The route remains valid till destination is achieved or until the route is no longer needed. These protocols are also known as on-demand routing protocols. Reactive routing protocols reduce overheads that are present in proactive protocols. These protocols use distance-vector routing algorithm and establishes the route to a destination by initiating route discovery procedure on the request of a node. The examples of prominent reactive routing protocols are DSR, AODV and TORA.

3.3 Hybrid Routing Protocols

Hybrid routing protocol [1, 4, 5, 6, 7] is the mixture of proactive and reactive routing protocol. The protocols which come into this category combine the features of both proactive and reactive routing protocols. Nodes within a certain range/geographical location uses table-driven approach and nodes beyond the range use on-demand approach. The prominent hybrid routing protocol is ZRP.

4. DSDV

Destination Sequenced Distance Vector (DSDV) [10, 12] protocol is a pro-active table driven routing protocol for mobile ad-hoc networks. In DSDV, each node has to participate in broadcasting routing updates. Here, each node keeps record of routing table containing entries of destinations and number of hops required to reach the destination.

4.1 Benefits

Some of the key benefits of DSDV are given below:-

a) Appropriate for creating networks with less number of nodes.
b) Less delays in setting up the process of routing.
c) In DSDV, there is no formation of routing loops.

4.2 Limitations

Despite benefits, DSDV is not free from limitations as given below:-
a) Continuous updating of routing tables is required
b) More consumption of battery power
c) Bandwidth is used even when the network is inactive
d) Not suitable for dynamic networks

5. WRP

The Wireless routing protocol [13] is a proactive, table-driven unicast routing protocol for mobile ad hoc networks. Each node in WRP maintains a table of routes, distance table, link-cost table and message retransmission list table. In WRP, routing table maintains distance from any particular node to each destination node through its neighboring nodes. Link cost table maintains the cost of the link to the nodes successfully receiving a message from the neighbor. Message retransmission list i.e. MRL table keeps the track of pending nodes to be arrived, so that they can be retransmitted if required. If there is no change in routing table, 'hello' message is transmitted to ensure its connectivity. As and when update message is received, distance table is updated and a best route path is determined.

5.1 Benefits

Some of the key benefits of WRP are given below:-
a) In WRP, consistency check is carried out with the neighboring nodes to eliminate loops that speed up the convergence.
b) WRP fixes count-to-infinity problem.

5.2 Limitations

Despite benefits, WRP is not free from limitations as given below:-
a) Maintaining so many tables increases overhead and requires huge amount of memory and robust processing capabilities.
b) Updating table entries increases overhead

that makes WRP unsuitable for ad-hoc wireless network.
c) WRP is not suitable for highly dynamic and large ad-hoc environment as it has limited scalability.

6. OLSR

Optimized Link State Routing Protocol (OLSR) [14] is a proactive protocol used in mobile Ad hoc network. In this type of network, routes are maintained for the whole network. This protocol uses hello and topology control to find and then dissipate link state information over the mobile Ad hoc network. This information is further required to find next hop towards destination.

6.1 Benefits

Some of the key benefits of OLSR are given below:-
a) Minimal route discovery delays
b) Implementation is user-friendly with less overhead
c) Centralized system is not required to manage the routing process
d) Works well with expeditious changes in source and destination
e) Simple to blend the routing protocol into existing operating systems

6.2 Limitations

Despite benefits, OLSR is not free from limitations as given below:-
a) Maintains all routes even if not required
b) Continuous updating of routing tables
c) Estimating speed and cost for every path
d) Determining congestion free path
e) Consumption of power even when route is not in use
f) Consumption of power in searching for new paths and alternate paths as well
g) Overhead increases with increase in mobile hosts
h) Jamming creates a problem as path cannot be reconstructed

7. DSR

Dynamic Source Routing (DSR) [8, 10, 15] protocol is an on-demand protocol designed to restrict the bandwidth consumed by control packets in Ad hoc wireless networks. This is achieved by eliminating the periodic table-update messages which was required in the table-driven approach. This routing protocol is source-initiated rather than hop-by-hop. It is based on the concept of source-based routing rather than table-based routing. This protocol does not require any existing network infrastructure. It allows the wireless network to be completely self-organizing. Two essential phases of this protocol are route discovery and route maintenance. In this routing protocol, each node is maintaining a cache to store recently discovered paths.

7.1 Benefits

Some of the key benefits of DSR are given below:-
a) No need to keep a routing table within each node
b) Allows multiple routes to any destination
c) Loop-free routing and rapid recovery when routes in the network change
d) Minimizes the number of route requests propagated in the network
e) An intermediate node can use an alternate route from its own cache, when a data packet meets a failed link on its source route
f) Does not enforce any periodic update messages from the mobile hosts for maintenance of routes, thus avoiding wastage of bandwidth.

7.2 Limitations

Despite benefits, DSR is not free from limitations as given below:-
a) Not scalable to large networks
b) Requires significantly more processing resources than other protocols
c) Spend a lot of time to process any control data a node receives in order to obtain the routing information, even if it is not the intended recipient
d) Route maintenance process does not locally repair a broken link
e) Inconsistencies during route reconstruction phase because an intermediate node may send a Route Reply using a stale cached route
f) Connection setup delay is higher than table-driven protocols
g) Even though the protocol performs well in static and low-mobility environments, the performance degrades rapidly with increasing mobility.
h) Routing overhead is involved on account of

source-routing mechanism

8. AODV

Ad hoc On-Demand Distance Vector (AODV) [3, 10, 16] routing protocol is mainly based on DSDV &DSR protocols and it uses an on-demand approach for finding the routes. This protocol does not maintain routes from every node to every other node. Routes are discovered on need basis and maintained till they are needed. In this routing protocol, whenever a node wants to transmit a data packet to destination, the entries in route table are checked. It is ensured whether there is a current route to the destination or not. If route exists, data packet is forwarded to the next relevant node towards destination. If route do not exists, then route discovery process is executed. DSR uses source routing in which a data packet carries the complete path to be traversed. However, in AODV, the source node and the intermediate node stores the next hop information corresponding to each flow for data packet transmission. Three types of packets are used during transmission over AODV viz. Route Request, Route Reply and Route Error packets.

8.1 Benefits

Some of the key benefits of AODV are given below:-

a) Routes are established on-demand

b) Respond very quickly to the topological changes and hence adaptive to highly dynamic networks

c) Do not make use of source routing and hence no additional overheads on data packets

d) Supports both unicast and multicast packet transmissions

e) Very less time is required for connections and detection of the latest route to the destination

f) No central administration is needed to handle the routing process

g) Loop-free and scalable to a large number of mobile nodes

h) Reliable for Ad hoc wireless networks

8.2 Limitations

Despite benefits, AODV is not free from limitations as given below:-

a) Generation of large number of control packets on link breakage leads to increase in congestion over active route.

b) High processing demand and consumes high bandwidth.

c) Build the routing table requires significant time

d) Few performance metrics show downfall when the size of network grows

e) Shortest path may be lost due to traffic during the path discovery process

f) Do not utilize any congestion control or avoidance mechanism to balance traffic load

9. TORA

Temporally Ordered Routing Algorithm (TORA) [17, 18] is an on demand routing protocol for wireless ad hoc networks. TORA is source-initiated, loop-free, scalable, highly adaptive and efficient routing protocol. It is based on link reversal algorithm. It supports multipath routing capability by providing multiple routes to a destination node. In this protocol, each node maintains one-hop local topology information and also has the capability to detect partitions. TORA provides localization of control packets to a small region during the re-configuration process initiated by a path break. The distance metric used in TORA is height from the destination. It uses height parameter to determine the direction of a link between any two nodes for a given destination. The functioning of TORA is broadly divided into three segments: establishing/creating the route, maintaining the route and erasing the route on need basis.

9.1 Benefits

Some of the key benefits of TORA are given below:-

a) Operate fine in a highly dynamic environment

b) Incurs less control overhead on account of limiting the control packets to a small region during route re-configuration

9.2 Limitations

Despite benefits, TORA is not free from limitations as given below:-

a) Very old source sequence number leads to inconsistent routes by intermediate nodes

b) Not based on the strategy of finding shortest path

c) Local re-configuration of paths leads to non-optimal routes

d) Concurrent detection of partitions and subsequent erasing of routs leads to temporary oscillations and transient loops
e) Depends on synchronized clocks among nodes
f) DSR and AODV outperforms TORA

10. ZRP

Zone Routing Protocol (ZRP) [19] is a hybrid routing protocol combining the advantages of both proactive and reactive routing protocols. This protocol finds loop free routes to the destination. It divides the network into zones of variable size. The main philosophy used in this protocol is to make use of proactive routing strategy within a limited zone and to make use of reactive routing strategy beyond that zone. Two types of routing protocols are used within ZRP. An Intra-zone Routing Protocol (IARP) is used in the routing zone where proactive routing is employed whereas Inter-zone Routing Protocol (IERP) is used beyond the proactive routing zone i.e. within reactive routing zone.

10.1 Benefits

Some of the key benefits of ZRP are given below:-
a) Less control overhead as in a proactive protocol or reactive protocols
b) Single route request can lead to multiple replies of route

10.2 Limitations

Despite benefits, ZRP is not free from limitations as given below:-
a) Short latency for finding new routes
b) Large overlapping of nodes' routing zones in the absence of query control
c) Decision on the zone radius has a significant impact on the performance of the protocol

11. Conclusion and Future Scope

An intrinsic study on different routing protocols for MANET have been carried out in this paper along with their comparative analysis depicting the benefits and limitations of each routing protocol over the other. The analytical study depicts that DSR and AODV can be chosen as the base protocols for research in the vicinity of mobile Ad hoc networks. Efforts shall be made in future to carry out simulation modeling of DSR and AODV routing protocols over Network Simulator. The performance of both these protocols shall be analyzed using various performance evaluation metrics resulting to selection of more efficient protocol for further research in the field of MANET.

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