

A Survey: On Unicast Routing Protocols for Mobile Ad Hoc Network

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Abstract— A Mobile Ad-hoc Network (MANET) is form over wireless media by the various mobile nodes. In other word we can say if various mobile nodes from a network without any infrastructure, such kind of network is known as Mobile Ad-hoc Network. In MANET communication between two mobile devices are performed by routing protocol. In MANET each mobile node can directly communicate with other mobile node if both mobile nodes are within transmission range. Otherwise the nodes present in between have to forward the packets for them on network. In such condition each mobile node acts as a router to forward the packets for others. Forwarding packet in MANET with limited resources (like bandwidth constraints, hidden terminal and limited battery power) is a very challenging task. Till data may routing protocols were proposed are an improvement over a number of different strategies considered in the literature for a given network. So it is quite difficult to find out which protocol may perform better under different network conditions of MANET. In this survey paper we proved an overview of various routing protocols proposed by various researchers. We will also provide comparative study of all routing protocol to find out the performance of protocol for large MANET.

Keywords—Mobile Ad-hoc Network, Routing Protocol, Broadcast, Multicast, Security, Hybrid.

I. INTRODUCTION

A Mobile Ad-hoc Network is defined as the group of mobile device without any infrastructure, who tend to share their information collectively for their business purpose. Ad-hoc networks are wireless networks where each mobile node communicates with each other using multi-hop radio links. In MANET there is no stationary infrastructure or base station for communication. Each node itself in MANET acts as a router for forwarding and receiving packets to/from other nodes. Routing in ad-networks has been a challenging task ever since the wireless networks came into existence. The major reason for routing is the regular change in network topology, location because of high degree of node mobility. A number of protocols have been developed for achieve this task. Some of them are discussed in this paper. The node which is leaving / joins the network has routing ability, and allowed them to make multi hop paths which are not within the radio range. The nodes which are in-between the sender / receiver node will act as router and will forward the message to next node which is coming from sender [1].

In MANET routing will become more challenge task because of no fixed Network Infrastructure, Dynamic Network Configuration, Mobility of Nodes, frequent node Failure and low battery power etc [2]. MANET has its uses in the following areas:

- Creating Personal Area Network with the help of cell phones, laptops, smart watches and other wireless equipments.
- Provides with access to real-time information to the mobile user, even when they are away from their home or office.
- MANET can be extended to places which cannot be wired.
- MANET can form a temporary network for office, meeting room, or at any place where required without any infrastructure.
- MANET can use in Military (e.g. to create a network at battle fields), Searching and Reusing of resources.
- To make intelligent transportation system, Vehicle may use MANET. (where Vehicle will act as mobile node moving from one location to other location) [3, 22].

Routing is the process to moving information / packet from a source node to a destination node in a mobile ad-hoc network. During routing process, at least one intermediate node within the network is encountered. This concept is not new to computer science since routing was used in the networks in early 1970's. But this concept has achieved popularity from the mid-1980. The major reason for this is because the earlier networks were very simple and homogeneous environments; but, now high end and large scale internetworking has become popular with the latest advancements in the networks and telecommunication technology [4].

Routing protocol in Mobile ad-hoc network is divided into following types:

- 1) Unicast Routing Protocol
- 2) Multicast Routing Protocol
- 3) Broadcast Routing Protocol.

There are many kinds of routing protocol for Unicast, multicast and broadcast routing protocol in the MANET. All routing protocol cannot fit in all different scenarios and traffic patterns so they are further classified into other category.

For examples, reactive routing protocols are good for a large scale, narrow band mobile ad-hoc network [5] while on other hand proactive routing algorithms works for small scale, broad band mobile ad-hoc network [6]. In this survey paper we will discuss only Unicast routing protocols.

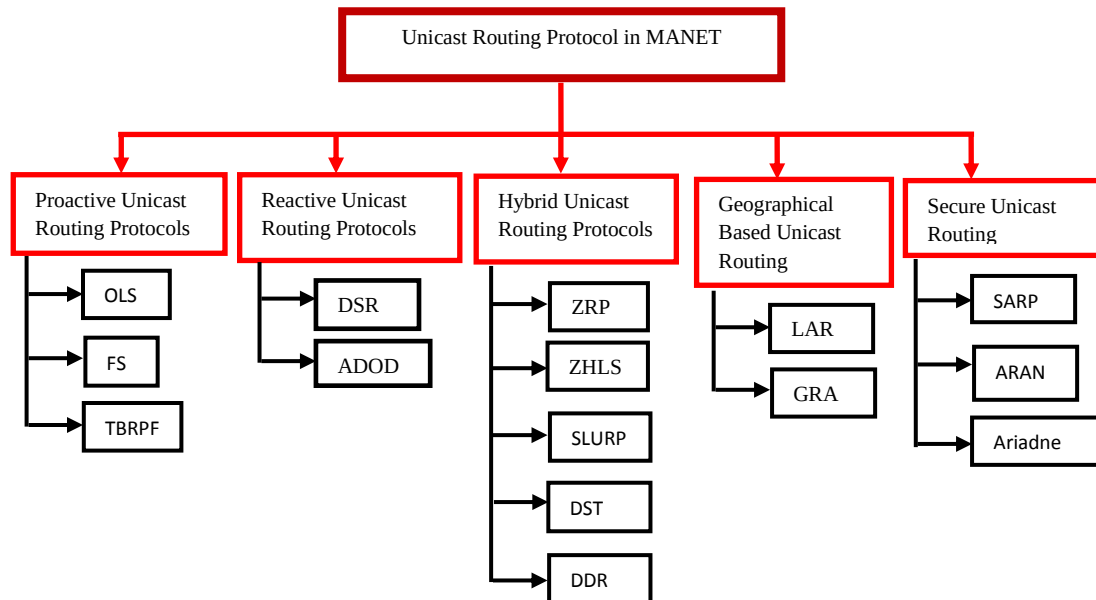


Figure1. Classification of various unicast routing protocol in MANET

II. UNICAST ROUTING PROTOCOL

Unicast Routing Protocol: in MANET most of applications are base on Unicast communication. In Unicast source mobile node transmit data packet to destination. While forwarding data packet dispatch node use the destination address in the data packet to look it up in routing table. If the destination address found in routing table the data packet will send to the corresponding next hop. But in such condition every node maintains the routing table in network. So the problem is that how the routing table is created and maintained in MANET. Unicast routing protocols are further divided into two categories:

Proactive Unicast Routing Protocol: In Proactive Unicast routing protocol each node in MANET maintains routing information to every other node in network to compute shortest path from the source to every destination node, which consumes lots of bandwidth. Such routing information is kept in many different types of tables. Such tables are time to time updates if network topology changes or a node moves from network.

Proactive unicast routing protocol are Divided as Optimized Link State Routing Protocol (OLSR), Fishey State Routing Protocol (FSR) and Topology Broadcast Based on Reverse Path Forwarding Routing Protocol (TBRPF).

Optimized Link State Routing Protocol: OLSR's [17] main aim is for large and dense Mobile Ad-Hoc Network. OLSR works on Multipoint Relaying flooding techniques to reduced topology broadcast packets. OLSR works according to the following points.

- Every mobile node broadcast **“hello”** message periodically to its neighbor. With this hello message every mobile node can obtain topological information for every node in MANET.
- Now based on topological Information, A node will select a subset of its neighbor to act as multipoint relaying nodes.
- Every node contains its global topological information and update, shortest path from source node to every other node can computed with dijkstra's Algorithm.

Fishey State Routing Protocol: FSR was proposed in [18] for aim at large scale and wit high mobility MANET. Name of this protocol comes from property of eye's fish. Fishey State Routing Algorithm works on following method.

- Based on distances the network is divided into different scopes. For example if the nodes are in 3 hops distance, they will come in same scope. Other node will come outer scope.
- The nodes which are in different scope, Routing entries corresponding to these nodes are sent at different frequencies and routing entries for inner nodes are sent at highest frequency and other entries are sent at lower frequency. Because of this reason the nearby node will receive more up to date link state updates compare to the node far away node.

Topology Broadcast Based on Reverse Path Forwarding Routing Protocol: TBRPF was proposed for several hundred of mobile nodes or high mobility in MANET [19]. In TBRPF each mobile node in network keeps incomplete global topological information. To reduce routing overhead TBRPF adopts following optimization steps:

- "hello" messages are exchanged among neighboring nodes periodic and differential. Only the changes of neighbor status are included in "hello" message.
- A part of spanning tree is broadcast to its neighbors if mobile node 'A' finds itself is on the path from its neighbor 'B' to a destination 'C' in the 'A' rooted spanning tree, it will put node 'C' and its adjacent links in the reportable topology sent to neighbors.
- Whenever required like network topology updated, mobile node mobility etc, it will update with "hello" message.

TABLE I
COMPARISON BETWEEN OLSR, FSR & TBRPE

Protocol	RS	CT	MO	CO
OLSR	F	O(D.I)	$O(N^2)$	$O(N^2)$
FSR	F	O(D.I)	$O(N^2)$	$O(N)$
TBRPE	F	O(D) or D+2 for link failure	$O(N^2)+$ $O(N)+$ $O(N+V)$	$O(N^2)$

RS=> Route Structure, CT=> Convergence time, MO=>Memory overhead, CO=> Control Overhead, V=>Number of neighboring nodes, D=>Diameter of the network, N=> Number of nodes in the network

III. REACTIVE UNICAST ROUTING PROTOCOL

Reactive Unicast Routing Protocol: Reactive protocols are also known as On demand routing protocol. Such protocol were reduced the overheads of proactive protocol by maintaining route information for active routes. Its mean the routing information is required and maintained only when one node wants to send data packet to destination. The concept of Reactive protocol was proposed to keep the waste of bandwidth as little as possible. In reactive routing protocol the overall routing process is divided into following steps.

- Route Discovery Process:** In route discovery process of MANET, if source node does not have route information in its routing table, source node broadcast a route discovery packet to the MANET to find out route between source and destination.
- Routing Maintenance:** once the route between source and destination has been setup. Route maintenance takes place, because mobile nodes move regularly or dead because of battery drain in a network. In such situation link failure were found along with path, source will reinitiate to find new path.

Reactive unicast routing protocol are Divided as Dynamic Source Routing Protocol (DSR) and Ad-hoc On-Demand Distance Vector Routing Protocol (AODV).

Dynamic Source Routing Protocol: In DSR [20] each packet required to carry the full address from source to destination. This property of DSR shows that it is not very effective protocol for large MANET because of the overhead carried out by packet will increase as network size increase. This is the only reason that DSR consume high bandwidth. DSR performed better for small network size.

Ad-hoc On-Demand Distance Vector Routing Protocol: AODV [21] is based on DSR and DSDV routing protocol. It use periodic sequence numbering procedure of DSDV and route discovery as DSR. In AODV the source data packet contains destination address to reduced routing overhead. AODV adaptable to highly dynamic networks.

TABLE II
COMPARISON BETWEEN DSR & AODV

Protocol	RS	MR	TC(RD)	TC(RM)	CC(RD)	CC(RM)
DSR	F	Yes	O(2D)	O(2D)	O(2N)	O(2N)
AODV	F	No	O(2D)	O(2D)	O(2N)	O(2N)

RS=> Route Structure, MH=> Multiple Routing, RD=> Route Discovery, RM=> Route Maintenance, RD=> Route Distance, CC=> Communication complexity, D=>Diameter of the network, N=> Number of nodes in the network

IV. HYBRID UNICAST ROUTING PROTOCOL

Hybrid protocols are the protocol which combines the nature of both proactive routing protocol and reactive routing protocol. Hybrid protocols are known as new generation protocols. Hybrid protocol reduced route discovery overheads by allowing nodes with closeness to work together to form some sort of a backbone. Hybrid protocols are proposed based on zone (region). It means a network is divided into number of zone by each mobile node. ZRP is hybrid unicast routing protocol.

Zone Routing Protocol: in ZRP [7] each node maintains network connectivity periodically in a given range (hops). This helps mobile nodes which are in the range of related zone to available immediately routes. The nodes which are outside the range of zone, for such nodes routes are determined on demand (reactive nature). And such nodes can use any on demand routing algorithms to find out routes. ZRP is flat in routing structure, and it works for single hops routing process, it uses shortest path routing metric method to find shortest path, it maintains intrazone and interzone tables for routing and routes are reconfiguration on point of failure or source notification which ever applicable. Time complexity for route discovery is O(I) for intra zone and O(2D) for Inter zone, where I is periodic update interval, route maintenance time complexity is O(I) intra zone and O(2D) for Inter zone, where I is periodic update interval and D is distance of zone, communication complexity for route discovery is O(Zn) intra zone And O(N+V) for Inter zone and , communication complexity for route maintenance is O(Zn) intra zone And O(N+V) for Inter zone. The main advantage of ZRP is it reduces retransmission but it overlaps different zones.

Zone-Based Hierarchical Link State: In ZHLS [8] routing protocols are divided into hierarchical structures.

The complete network is divided into non-overlapping zones. Such non-overlapping zones have unique zone ID and each node in such zone has unique node ID which is calculated by GPS. The hierarchical structure of network (topology) is formed in two levels on the basis of node level topology and zone level topology. In ZHLS no cluster head is required for data transmission. This reduces extra processing overhead while data transmission. When a node wants to send data packet to the node which is located in other zone, in such conditions source node broadcasts a zone level location request to all other zones, which required significantly low overhead if compared to flooding approach in reactive protocols. ZHLS is Hierarchical in routing structure and can have multiple routes if more than one virtual link exists in between mobile nodes. Routing maintenance is required for both interzone and intrazone. Time complexity for route discovery is O(I) for intra zone and O(D) for Inter zone, where I is periodic update interval, route maintenance time complexity is O(I) intra zone and O(D) for Inter zone, where I is periodic update interval and D is distance of zone, communication complexity for route discovery is O(Z/M) intra zone And O(N+V) for Inter zone where N is number of nodes in network, and M is number of zones or clusters in the network and , communication complexity for route maintenance is O(Z/M)^a intra zone And O(N+V) for Inter zone.

Scalable Location Update Routing Protocol: In SLURP [6] mobile nodes are arranged into number of non-overlapping zones. SLURP reduced cost of maintaining routing information by eliminating a global route discovery. In SLURP each node will assign regionID by static mapping using static mapping function $f(NodeID) \rightarrow regionID$. The routing structure of SLURP is hierarchical. Time complexity for route discovery is O(2Z_D) for intra zone and O(2D)^b for Inter zone, where Z_D is diameter of a zone, route maintenance time complexity is O(2Z_D) intra zone and O(2D) for Inter zone, where I is periodic update interval and D is distance of zone, communication complexity for route discovery is O(2N/M) intra zone And O(2Y) for Inter zone where N is number of nodes in network, and M is number of zones or clusters in the network and Y is number of nodes in the path to the home region , communication complexity for route maintenance is O(2N/M) intra zone And O(2Y) for Inter zone.

Distributed Spanning Trees Based Routing Protocol: In DST [9] each node is grouped into number of trees in a network. Every tree has two types of nodes route node, internal node. The root node controls the structure of tree in a network and rest of nodes are regular nodes in tree.

Root nodes responsible for merging a tree with other tree into network. Each node has its three different stage; router, merge and configure depending on that node wants to perform. In DST route determine into two stages; in hybrid tree flooding control packets are sent to all the neighbors and adjoining bridges in the spanning tree and the sent packet will hold for some time, such time is known as holding time. Holding time provides increases connectivity and stable network. In DST the control packet rebroadcasted along the tree edges. When control packet reaches down to a leaf node it is sent up the tree until it reaches a certain height referred to as shuttling level. Time complexity for route discovery is $O(Z_D)$ for intra zone and $O(D)$ for Inter zone, where Z_D is diameter of a zone, route maintenance time complexity is $O(Z_D)$ intra zone and $O(D)$ for Inter zone, where I is periodic update interval and D is distance of zone, communication complexity for route discovery is $O(Z_N)$ intra zone and $O(N)$ for Inter zone where N is number of node in network, communication complexity for route maintenance $O(Z_N)$ intra zone and $O(N)$ for Inter zone.

Distributed Dynamic Routing: In DDR [10] tree do not required root node. In DDR tree is created by sending periodic messages by neighbors. All tree in a network make a forest, which are connected by gateway. Each tree in the forest make a zone and assigned zoneID by running zone naming algorithm. DDR algorithm work in six phases such as performed neighbor election, forest construction, intra tree clustering, inter-tree clustering, zone naming and zone partitioning. Time complexity for route discovery is $O(I)$ for intra zone and $O(2D)$ for Inter zone, where I is periodic update interval, route maintenance time complexity is $O(I)$ intra zone and $O(2D)$ for Inter zone, where I is periodic update interval and D is distance of zone, communication complexity for route discovery is $O(Z_N)$ intra zone and $O(N+V)$ for Inter zone and , communication complexity for route maintenance is $O(Z_N)$ intra zone and $O(N+V)$ for Inter zone.

V. GEOGRAPHICAL BASED UNICAST ROUTING PROTOCOL

Such routing algorithms are working on the geographical location of mobile nodes. Graphical location for a mobile node is identified by GPS. LAR and GAR are the protocol which came into the category of geographical based unicast routing protocol in MANETs.

Location Aided Routing Protocol: LAR [11] tries to reduce the routing overheads which is present in traditional flooding algorithm by using Location Information.

In LAR it is already assumed that each mobile nodes known its location in network through GPS. LAR works according to the following steps.

- The source mobile node puts the location information of self and destination node in the routing request packet.
- Routing requested packet broadcast within the required zone.
- On receipt of route request packet, the destination mobile node sends reply with its current location to source.
- If because of some error, LAR fails to find out route to the destination, routing protocol resorts to flooding of routing message throughout the MANET.

Geographical Routing Algorithms: In GRA [12] every node in MANET knows the position of itself, the destination and all its neighbors which is store in the routing table at each node as entries (P_i, S_i) , where P_i is the geographic position of a node and S_i is neighbors. When a source A want to send data packet to destination B, source A puts the geographical information of itself, destination B, into data packets and search its routing table to find out nearest neighbor to destination B, and forwarded data packet to the neighbor of destination B and so on till data packet not reached to destination node B.

VI. SECURITY AWARE ROUTING PROTOCOL

Security is very important constraint in MANET, because every data packet sent from source mobile node to destination should be kept secure during the routing process so that attackers cannot read the data packet before delivered to the destination. Some secure routing protocols were proposed to be valid and survivable against the various attacks.

In SAR [13, 15] each mobile node has security level, when source node broadcast route discovery packet RREQ in MANET. Only the nodes having higher or equivalent security level can forward RREQ and RREP packets. Others mobiles node will drop the routing packets. Such path is secure enough to send information in MANET. But the path which is selected by SAR cannot consider as shortest path because of different security level for mobile nodes.

Authenticated Routing for Ad hoc Networks: ARN [14] use authentication scheme for securing information in MANET. ARN works as follows:

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- As mobile node received RREQ /RREP packets, first of all it identified the source with source's corresponding public key and then signed the message with its own private key.

Ariadne: It [16] can authenticate routing messages using one of three schemes: shared secrets between each pair of nodes, shared secrets between communicating nodes combined with broadcast authentication, or digital signature. Ariadne uses the following notation to describe security process in MANET:

- A, B are assumed as sender and receiver node, (as communicating nodes).
- K_{AB} and K_{BA} denote the secret MAC keys shared between A and B (one key for each direction of communication).
- MACKAB (M) denotes the computation of the message authentication code (MAC) of message M with the MAC key K_{AB} .

We assume that every pair of communicating nodes A, B share the secret MAC keys K_{AB} , K_{BA} . We also assume that every node has a TESLA one-way key chain, and that all nodes know an authentic public TESLA key of each other node in the network.

VII. CONCLUSION

In this survey paper we have study various kinds of Unicast routing protocols were review and we come to the conclusion that all Unicast protocol can not perform better, in all network conditions. Every protocol performed better in some specific condition according its characters. In compare to proactive Unicast and reactive Unicast routing protocol, hybrid Unicast routing protocol performed better. Some routing protocols are require security mechanism, which are vulnerable to IP Spoofing and other kinds of attacks. Secure routing protocols detects the attacks at the cost of long latency, power and energy concussion and other overhead.

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