Volume 5, Issue 10, October-2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Overview of Comparative Analysis of Mobile Ad-hoc Networking Routing Protocols

Pooja Kamboj*
Research Scholar, CSE Department
Guru Nanak Dev Engineering College,
Ludhiana, Punjab, India

Jasbir Singh Saini
Associate Professor, CSE Department
Guru Nanak Dev Engineering College,
Ludhiana, Punjab, India

Abstract*— In recent years mobile ad-hoc networks become very popular. It is a new paradigm of portable devices enabling different types of communications immediately and easily such as person-to-person, machine-to-person, and person-to-machine. Mobile ad-hoc network is a network containing mobile nodes as laptops, phones etc. To provide communication between the nodes or the network a routing protocol is required. This paper provides the characteristics, functionality of the different routing protocols according to their category of routing protocols.

***Keywords*— MANET, AODV, DSR, DSDV, CGSR, ZRP, TORA**.

I. INTRODUCTION

A Mobile ad-hoc network (MANET) is a self-configuring infrastructure less network of mobile devices. MANET is a kind of wireless ad-hoc networks. Some or all nodes of the network are mobile. So the network becomes flexible with infrastructure for the range of communication. Each device in MANET is free to move in any direction independently. Some MANETS are restricted to local areas such as a group of laptops while others may be connected to internet. Sharing of information within nodes of network is done by routing process [1]. Routing is a process of selecting paths in a network and routing protocols have been designed for ad-hoc networks. Routing protocols are required for the communication purpose of the network. Routing protocol enables the nodes to select routes from source to destination for the communication between them. Some specific characteristics of routing protocols include the manner in which routing protocol avoid routing loops, scalability etc [2]. Routing protocols basically are of three types: Reactive, Proactive and Hybrid Routing Protocols. There are many protocols present nowadays according to these types of Routing protocols such as AODV, ZRP and TORA etc.

II. ROUTING PROTOCOLS

A routing protocol is required to send a packet from source node to destination node via number of nodes. Several routing protocols have been designed for mobile ad-hoc networks [6]. Mainly, Routing protocols are classified into three types:

A. Reactive Protocols
B. Proactive Protocols
C. Hybrid Protocol

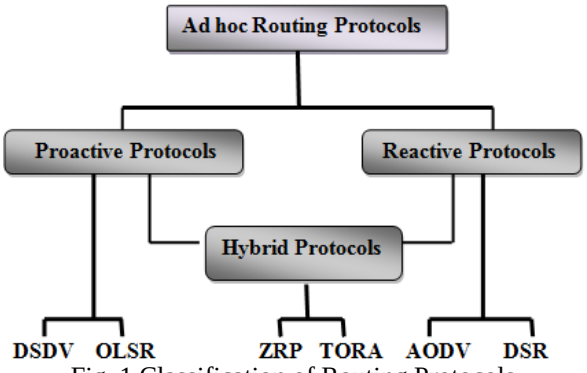

Fig. 1 Classification of Routing Protocols

A. Reactive or On-Demand Routing Protocols-

In reactive routing protocols, routes are not predefined for routing. Routes are generated by route discovery mechanism only, when it is required by source to transmit a packet to destination [6]. Reactive protocols have lesser routing overhead but higher latency because these protocols do not make the nodes to start a route discovery until a route is required [9]. Examples:

- AODV (Ad-hoc On-demand Distance Vector Routing Protocol).
- DSR (Dynamic Source Routing).

B. Proactive or Table Driven Protocols-

In proactive routing protocols, all routes are predefined in routing tables and source nodes uses that routes to forward a packet to destination. Each node needs to be update routing tables regularly. Proactive protocols have higher routing overhead due to periodic updates in routing tables and lower latency because routes are predefined [9],[10]. Examples:

- DSDV (Destination-Sequenced Distance-Vector Routing).
- OLSR (Optimized Link State Routing).

C. Hybrid Protocols-

Hybrid protocols includes the features of both reactive and proactive routing protocols [6].These protocols are suitable for large scale networks and overcome the drawback of both reactive and hybrid routing protocols. Examples:

- ZRP (Zone Routing Protocol).
- TORA (Temporally Ordered Routing Algorithm Protocol).

1) AODV (Ad-hoc On-Demand Distance Vector Routing) -

AODV is a Reactive Routing Protocol. AODV adopts a different mechanism to maintain routing information [1]. The basic operations of AODV are Route Discovery for creating route from source to destination and Route maintenance for dealing with topology changes [2]. RREQ (Route REQuest), RREP (Route REPly), RERR (Route ERRor) packets are used by AODV. It also uses routing tables to contain the information about the routes. AODV uses sequence numbers carried in routing packets to avoid routing loops. If node wants to send data to another node; firstly it checks the table entry; if there is no valid path available between them. Then node Discovery Process begins. HELLO messages are used to confirm the presence of the neighbor nodes.

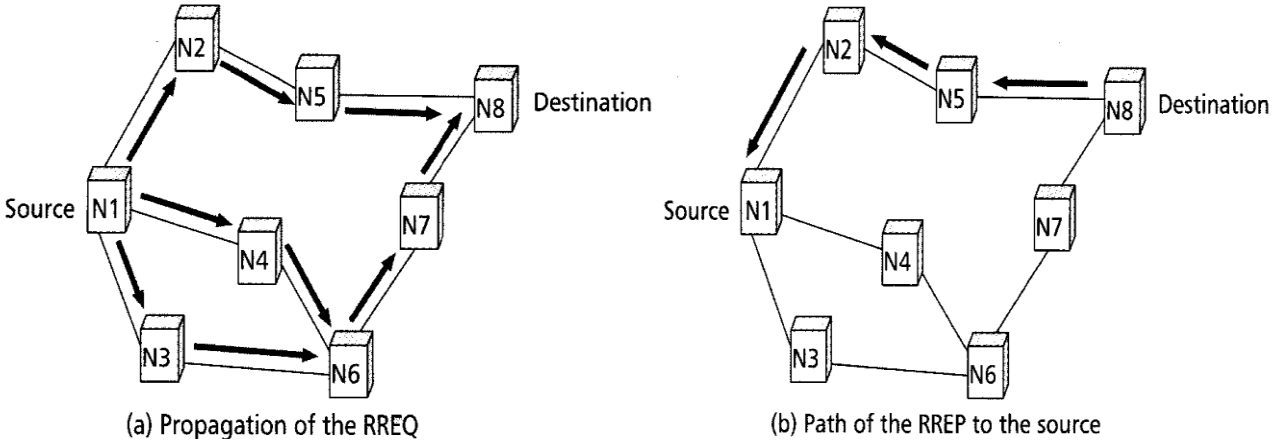

Fig. 2 AODV Route Discovery [2]

Source node broadcasts RREQ to all neighboring nodes till the destination node is found. RREQ contains information as source node address, destination node address, broadcast id, sequence number, TTL value. Sequence number defines the freshness of the packet and TTL value increments by 1 until the destination is not found. Each node contains its own cache to save the received RREQs. Highest sequence number packet is accepted, lowers are discarded. Intermediate nodes record the entries in the routing tables about the packet having the required information. RREP packet is generated according to RREQ of the source node using the information of the route from the routing table. RREP is in reversible direction to RREQ. Previous entry of routing table is expired if it is not used recently. If any link breaks then RERR packet is generated to inform the neighboring nodes then all routes are discarded that link. If source node moves and route to destination is still required then the Route Discovery process is reinitialized for the Route Maintenance operation.

2) DSR (Dynamic Source Routing) –

DSR is simple and reactive routing protocol. DSR protocol mechanisms are Route Discovery and Route Maintenance. DSR use the source routing which avoids keeping information in intermediate nodes and each node contains the hop-by-hop route. The routes are stored in Route Cache of node. If Source node wants to send data to another node then it uses the Route Cache information; if the valid route is not available then the Route Discovery process begins. As shown in Figure, Source node sends the data to destination node by broadcasting RREQ (Route REQuest) with the header contains the information as source address, destination address and sequence number. When intermediate node receives RREQ packet then it checks route cache; if it is not its destination node then RREQ packet is sent to next hop with adding address in its header as shown in Figure. So header contains route from source to destination. When the path is available in Route Cache then source node adds all the address to the header of the packet. As shown in Figure 4 the RREP packet is sent back from source to destination. If any link disconnected then RERR packet is generated and packet is sent to source node then again Route Discovery mechanism starts.

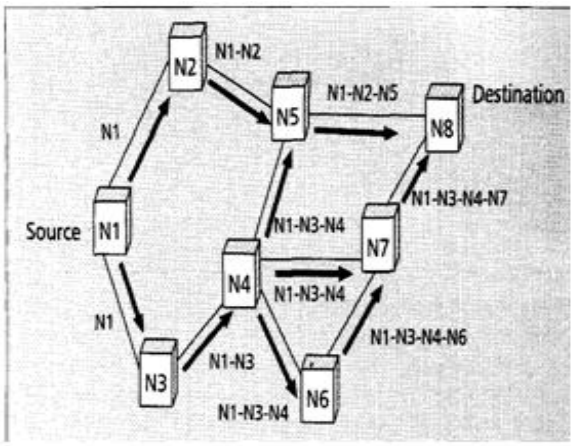

Fig. 3 Construction of Route Cache [2]

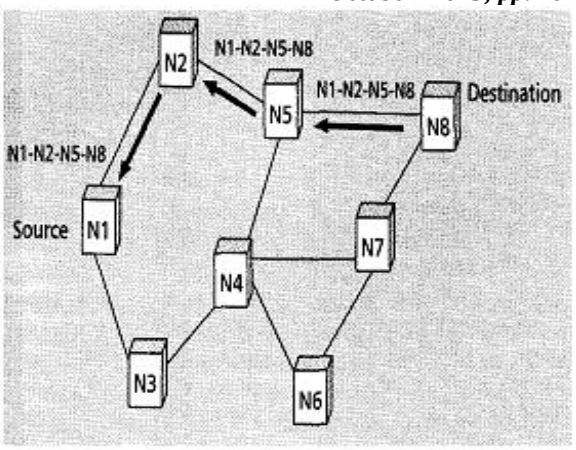

Fig. 2 Route Reply [2]

3) DSDV (Destination Sequenced Distance Vector Routing Protocol) -

Destination Sequenced Distance Vector (DSDV) routing protocol is type of proactive routing protocol and it is modification of Bellman-Ford routing algorithm, is based on the distance vector algorithm [3]. This protocol appends a new attribute, sequence number to each entry of route table at each node. In case, if a route is already exists in routing table before traffic arrives then transmission occurs without delay [4]. In case of route failure to the next hop, the node updates the sequence number immediately and forwards the information to its neighbors. After receiving the routing information the node checks in its routing table. In case, if the route entry already exists in routing table of node then it compares the sequence number of the received information with the entry of routing table and updates the information.

Example of DSDV operation:

DSDV operates by having each node maintain a table with information about the next node and information about distances on a route [5]:

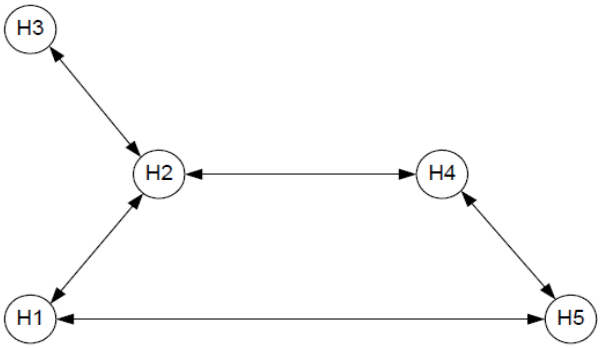

Fig. 5 A Simple Topology

Table: Routing table for H4 node in the DSDV protocol.

Dest	Next Hop	Metric	Seq. No	Install
H1	H2	2	S406_H1	T001_H5
H2	H2	1	S128_H2	T001_H5
H3	H2	2	S444_H3	T001_H5
H4	H4	1	S123_H4	T001_H5
H5	H5	1	S489_H5	T001_H5

Table illustrates the nodes only stores information about destination and next hop and not about the entire route. As seen the route from H4 to H3 goes through H2, which means that the metric is 2 (hops). The next node on the route from H4 to H3 is H2, and H4 will therefore forward packets for H3 to H2. Information concerning the next hop is stored in the Next Hop column.

4) CGSR (Cluster-head Gateway Switch Routing) –

CGSR Protocol is a clustered multi-hop wireless network with numerous heuristic routing schemes that uses a distributed algorithm. A distributed cluster-head (CH) selection algorithm is used to select a node as the cluster head. By aggregating nodes into cluster that controlled by cluster heads and a framework for developing additional features for bandwidth allocation, channel access and routing is created [6].

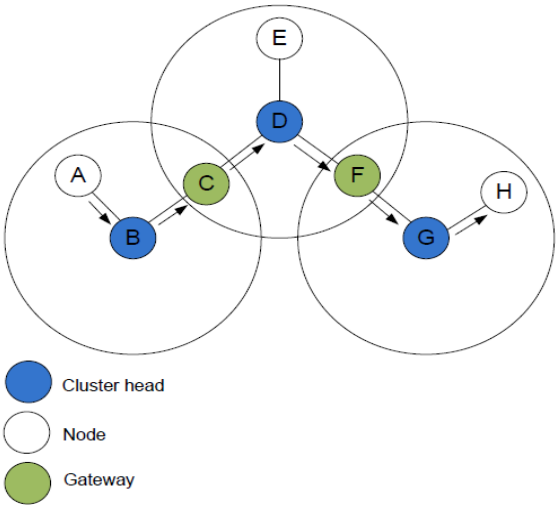

Fig 6: Cluster-head Gateway Switch Routing

Gateway nodes act as bridge nodes between two or more clusters. A packet transmit by a node is first routed to its CH and then is routed from the CH to gateway of another cluster and then to the CH and so on, until the destination cluster head is reached. Frequent changes in the CH may affect the performance of the routing protocol.

5) ZRP (Zone Routing Protocol) –

ZRP was the first hybrid routing protocol and combines the both reactive and proactive routing approach. ZRP is proposed to reduce the delay caused by route discovery in reactive protocols and control the routing overhead that occurs in proactive protocols due to periodic updates [7].ZRP partitions the complete networks into small routing zones consisting of its k-neighborhood. It consists of two sub routing protocols:

- IntrA-zone Routing Protocol (IARP).
- IntEr-zone Routing Protocol (IERP).

IARP is a proactive approach and used within routing zones to maintain up-to-date routing tables of zones. IERP is a reactive approach and used for area beyond the zones to discover a global routes [9].

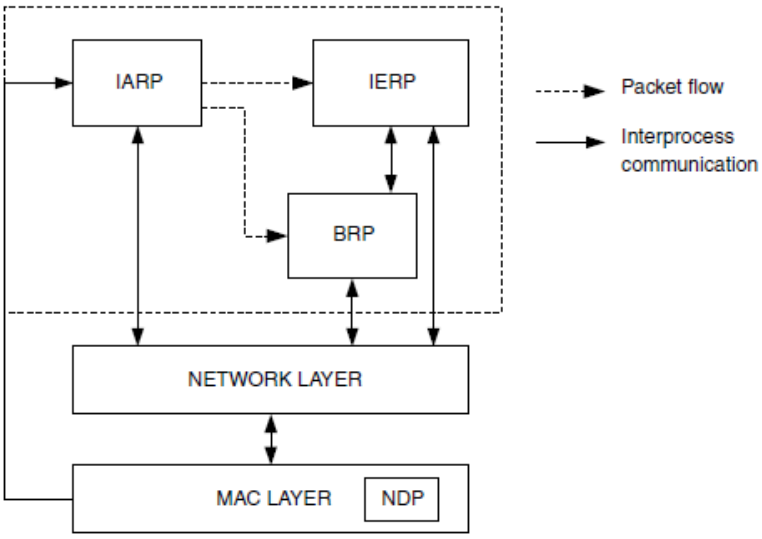

Fig 7: Design diagram of ZRP

If the source and destination is in the same zone then source uses a route from proactively cached routing table that is maintained by IARP. If the destination is outside of the zone then route is reactively discovered by IERP [7]. In route discovery, the source node broadcasts a route request packet to its peripheral nodes or border nodes, including its own address, destination address and a unique sequence number. Route request packets are sent to peripheral nodes by using the Bordercast Resolution Protocol (BRP). After receiving the request packet, peripheral nodes check their local zone. If the destination is outside the local zone, then peripheral node forwards packet to its peripheral nodes. If local zone containing a destination node then it send route reply back to source [8]. New neighbor nodes and link failures are discovered by Neighbor Discovery Protocol (NDP). In figure, the node S wants to broadcast a packet to node X and the zone radius is r=*2*. The nodes from A to J belong to the routing zone of S, but not other nodes. The nodes G to J are peripheral nodes.

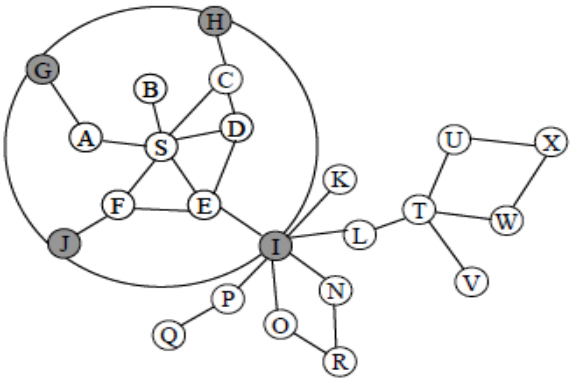

Fig 8: Routing Zone of S

6) TORA (Temporally Ordered Routing Algorithm) –

TORA is highly adaptive, loop free and proficient distributed hybrid routing algorithm [10]. It provides multiple routes to destination. The protocol performs three essential functions:

- Route Creation.
- Route Maintenance
- Route Erasure

Route creation in this protocol is done by using QUERY and UPDATE packets. To discover a route to destination, the node sends a QUERY packet to its neighbor nodes [11]. Initially height of destination is set to 0 and all other nodes to NULL. The source node transmits a QUERY packet by including ID of destination node in it.

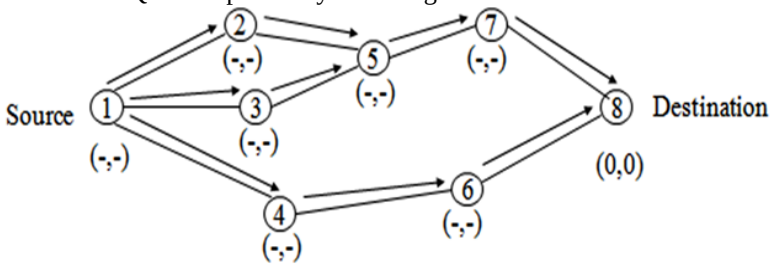

Fig 9: Propagation of the QUERY message

A node that has non NULL height sends a reply with UPDATE packet that list its height .A node that receives a UPDATE packet sets its height to one greater than the height of that node from which it was received the UPDATE packet [11]. Higher height node is considered upstream node and lower height is downstream. In route creation phase, nodes use a height metric to form Directed Acyclic Graph (DAG) that routed at the destination. Flow between nodes in DAG from higher to lower height node [12].

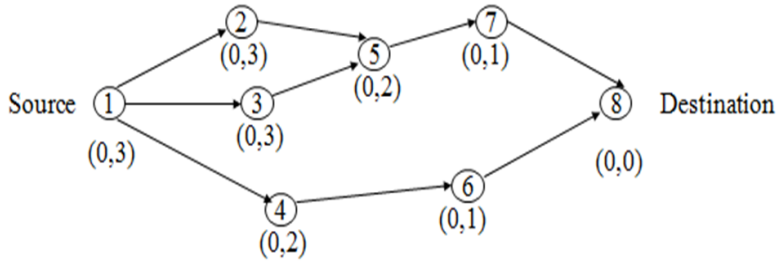

Fig10: Node's height is updated

When the nodes change its position then DAG is broken and route maintenance is required to form a DAG again for that particular Destination. Route erasure results in reset of all routes in network, when network partition is detected by node and then node will generate CLEAR packets and broadcast throughout the network. [11].

III. CONCLUSIONS

In this paper, we analysed reactive, proactive and hybrid routing protocols of mobile ad-hoc network. The two protocols from each category have been taken up for the further study. There are numerous routing protocols have been proposed. We conclude that each protocol works in a different way in ad-hoc networks and routing protocols plays a major role in network performance. It has been further concluded that proactive routing protocols are more efficient for ad-hoc network due to regular routing updates that helps in route identification and deals with dynamic topology. Moreover, hybrid routing protocols overcome the drawbacks of both reactive and proactive protocols and it is mainly used for large scale networks.

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