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Mobile Ad Hoc Network: Features and Routing Protocols

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Abstract:

A Mobile Ad hoc Network is an open Ad hoc network in which a node can dynamically move in the network. These mobile nodes serve both as hosts as well as routers for directing data to and fro amongst various nodes in the network. Routing in MANET is the fundamental aspect to be considered while establishing any communication path in a network. Hence forth, design and selection of an efficient routing protocol is necessary to ensure a specific path amid source and destination with minimum routing overhead and bandwidth consumption. In this paper, various routing protocols along with their characteristics features are studied.

Keywords: MANET, Routing Protocols.

1. Introduction

MANET is an Ad hoc network which is entirely independent of any kind of pre-established or fixed infrastructure like wired network routers or wireless network access points. In MANET, mobile nodes lying within the transmission range may communicate directly whereas nodes beyond that range need to depend on certain other nodes to transmit messages.

MANET is configured as and when required, without help of any existing infrastructure [1] or fixed station. In MANET, the participatory node acts like a router [2] and is capable to move haphazardly.

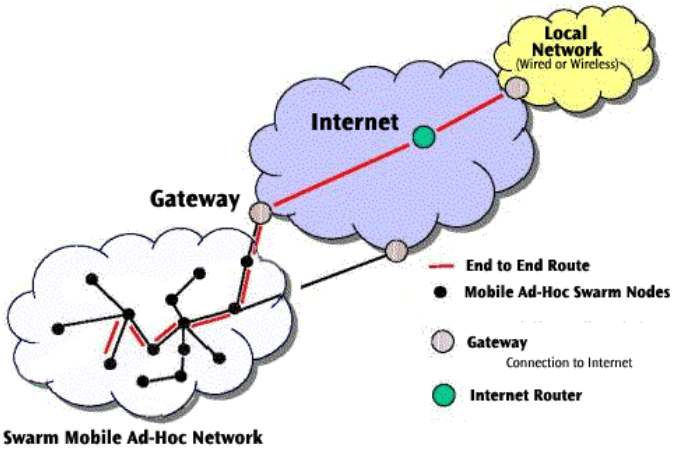

Fig.1: MANET Architecture

2. Differences between Cellular Networks and MANET

MANET differs from the cellular networks in the followings means:

- A Cellular network has fixed infrastructure whereas MANET is on-the-move network.

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- A Cellular network is employed in voice traffic but MANET is suitable for best-effort data traffic.
- A Cellular network follows Centralized Routing whereas MANET follows Distributed Routing.
- A Cellular network is Circuit-Switched network whereas MANET is Packet-Switched network.
- Due to fixed nature of a Cellular network, connectivity is seamless and there are no chances of call drops but in MANET frequent path breaks can be observed owing to mobile nature of nodes.
- Bandwidth reservation is easier to take up in infrastructure based cellular networks whereas in MANET, complex MAC protocols (medium access control protocols) are required for bandwidth reservation.

Fig.2a: Infrastructure network

Fig.2b: MANET

3. Characteristic Features of MANET

- **Dynamic Topologies:** As movement of mobile nodes is unpredictable in nature, so the network topology [3] goes on changing rapidly.
- **Bandwidth Limitations**: A MANET is inefficient towards low bandwidth networks because radio transmission got affected by interference, mobility etc.
- **Energy-constrained**: Because the mobile devices are battery-powered devices, the framework must therefore be designed for attaining longer life span.
- **Physical Security Limitations**: As nodes could even freely move into or out of the network due to unsecure bounds, and even with the knowledge of a particular network's radio range a node may join that particular network immediately if it falls into this particular range. Due to this variable characteristic, entire MANET network suffers from attacks which may be active or passive attacks [4], information leakage, false message response or change of data integrity or service denial etc.
- **Scalability:** A few predicted networks might be bulky having numerous nodes only in the specified routing area. As adaptability is not inherent to MANET; hence forth, it is difficult to attain scalability [5].

4. Routing Protocols

Various Routing protocols [12] in MANET are primarily categorized under three heads:

- Flat routing protocols
- Hierarchical routing protocols
- Geographic position assisted routing protocols[13]

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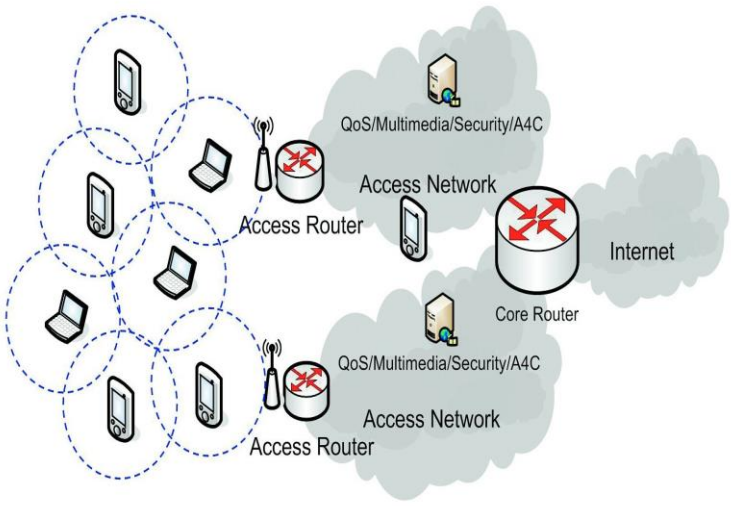

Fig.3: Routing in MANETs

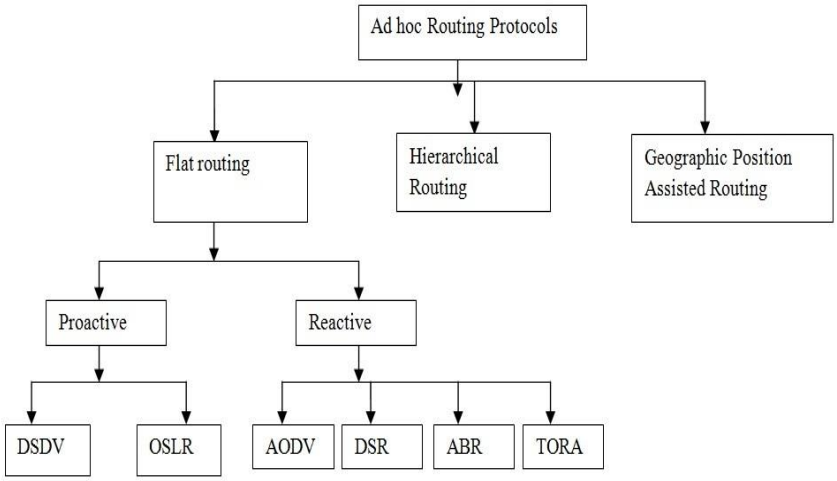

Fig.4: Routing Protocol Hierarchy in MANET

4.1 Proactive Protocols

- Table-driven Protocols [14]
- Used for updating information in network
- Route is created among the nodes in the entire network
- Periodic updation of route
- Large Routing Tables

4.1.1 DSDV (Destination-Sequence Distance-Vector Routing [11])

- Follows Bellman-Ford Algorithm
- Formation of routing table to the destination node in terms of hop-count
- Periodical Transmission of Routing table
- Destination node tags each entry with the sequence number
- Broadcasting of Distance Vector periodically
- Broadcast is limited to one hop only

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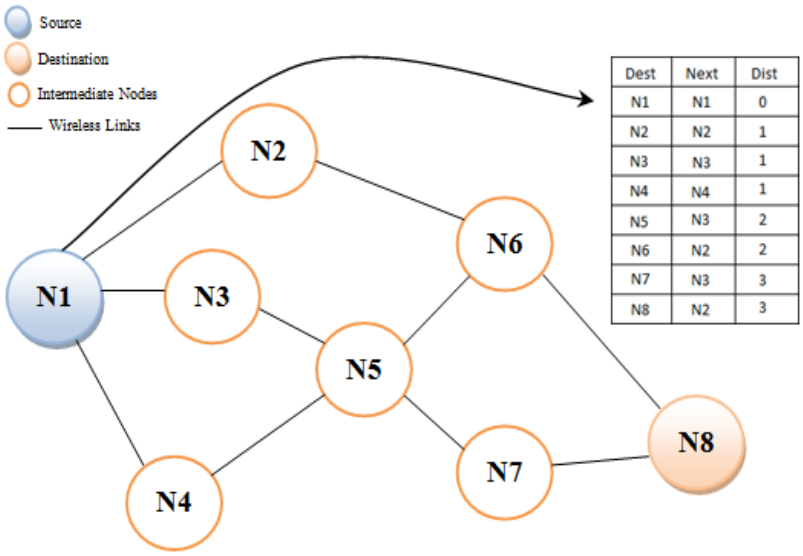

Fig.5: Routing in DSDV Protocol

4.1.2 OSLR (Optimized Link State Routing [10])

- Multi-point Relaying is being utilized
- Flooding of control messages in the whole network
- Suited for dense networks
- Not feasible to much extents in sparse networks

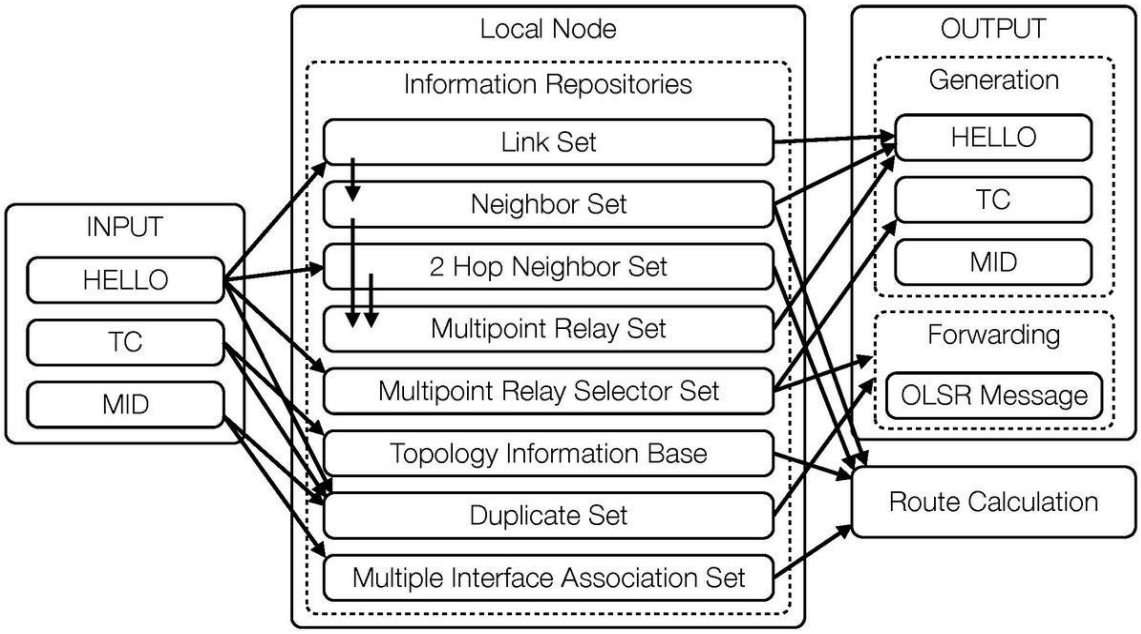

Fig.6: Routing in OSLR

4.2 Reactive Protocols

- On demand protocols
- Used for determining the structure of the network
- Routes from source to destination only
- Route is updated, only when it is necessary to be updated

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- Small routing tables or no routing tables

4.2.1 AODV (Ad hoc On-Demand Distance Vector [6]):

- Enhancement over DSDV [9]
- Decreases the count of broadcasts by creation of on-demand route.
- Path discovery procedure is being instigated by source node to locate intermediate nodes via broadcast of RREQ packet to its neighbor nodes.

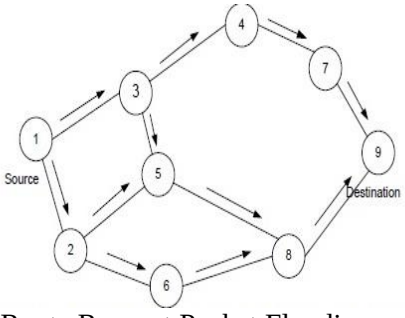

Fig.7a: Route Request Packet Flooding

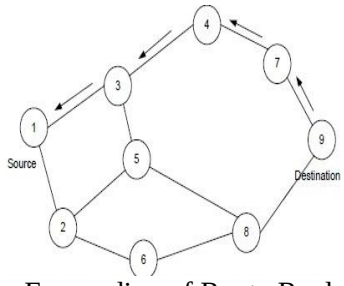

Fig.7b: Forwarding of Route Reply Packet

4.2.2 DSR (Dynamic Source Routing [7]):

- On-demand source routing
- A route cache, having information of all routes is maintained by each host
- Overall process is carried out in twofold phases: Route Discovery and Route Maintenance

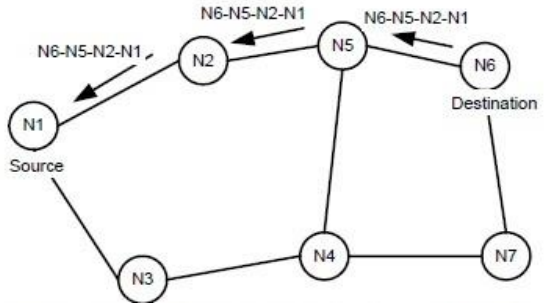

Fig.8: Route Reply with DSR

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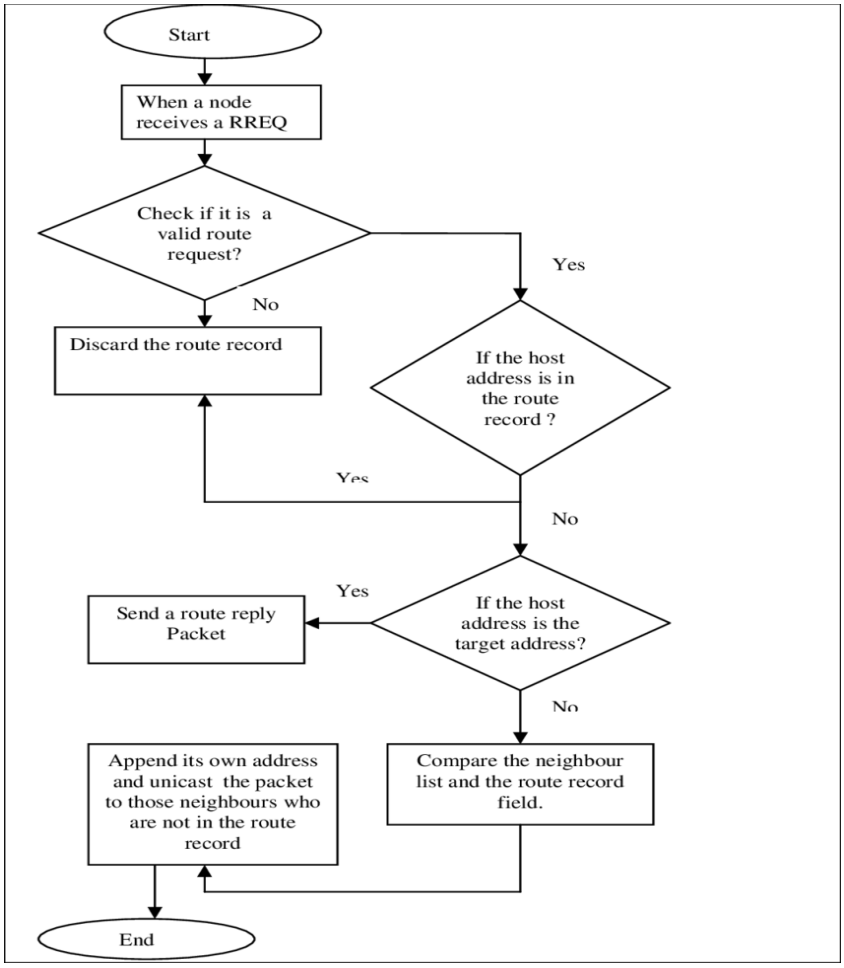

Fig.9: Working of DSR Protocol

4.2.3 ABR (Associativity Based Routing [8]):

- Route selection is done on the basis of degree of stability.
- Stability is determined by the connection stability of nodes identified over time and space with respect to each other.
- Associativity tables are designed and updated through Beacon entries.

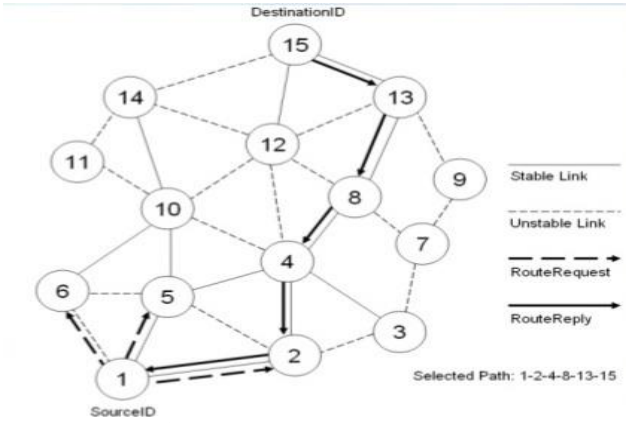

Fig.10: Routing in ABR

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4.2.4 TORA (Temporarily Ordered Routing Algorithm):

- Relies on concept of "Link-Reversal"
- Directed Acyclic Graph (DAG) is used as network topology

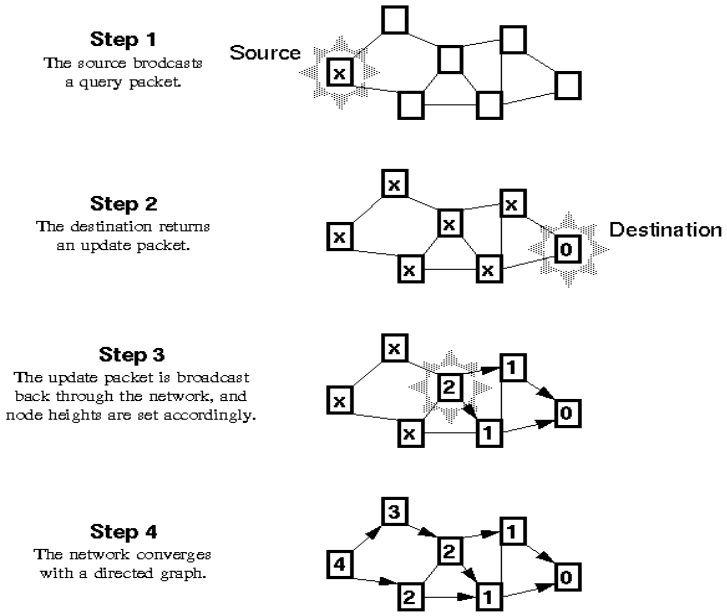

Fig.11: Route Creation in TORA

5. Performance Metrics for Routing Protocols

There are several metrics in MANET protocols which can be taken for gauging the performance are enlisted below:

- **Packet delivery ratio:** Data packets received from source nodes to destination/data packets. Fast delivery rate for packets means higher efficiency
- **End-to-end delay:** Time delay accrued among sender-sent data streams and their onset at destination/data packets received by destination. Output is best once the end-to-end delay in packets is small.
- **Throughput:** Bits delivered successfully between all active source nodes/ Bits successfully delivered to respective destinations. It should be high for a better performing network
- **Scalability:** Ability to scale with increasing network nodes is called scalability. A routing protocol should be scalable
- **Reliability:** Reliability is termed being capable of performing its necessary functionality under critical conditions for a specified time frame. High reliability ensures better performance of routing protocol
- **Control overhead:** Aggregation of time consumed, memory, no. of packets, bandwidth or various other resources required to reach to a particular destination node is called control overhead. An optimal value ensures higher performance
- **Routing loops:** Creation of a cycle during packet transfer is called routing loop. For better performance, routing protocol should be loop-free
- **Routing metric:** Absolute costs involved when selecting the optimal path to a destination node from source node. A routing protocol must possess minimal cost.
- **Storage complexity:** Metric that measures the storage used by the protocol to store the packets. Least storage requirements results into better performance of routing protocol.

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6. Comparative Analysis of Routing Protocols in MANET

Metrics / Protocol	Scalability	Reliability	Control overhead	Routing loops	Routing Type	Routing Method	Routing metric	Storage complexity
DSDV	No	Yes	High	Loop Free	Proactive	Broadcast	Shortest Path	O(n)
OSLR	No	No	High	Loop Exists	Proactive	Broadcast	Shortest Path	O(n)
AODV	No	Yes	Optimal	Loop Free	Reactive	Unicast/Multicast	Shortest Path	O(e)
DSR	No	Yes	Optimal	Loop Free	Reactive	Unicast/Multi-hop	Shortest Path	O(e)
ABR	No	Yes	Optimal	Loop Free	Reactive	Broadcast	Link Associativity & Shortest Path	O(N)
TORA	Yes	Yes	Reduced	Loop Free	Reactive	Multi-hop	Shortest Path	O(N)

7. Conclusion

In this article, brief review of different routing protocols has been done and their comparative analysis has been performed. The features of MANET and various performance metrics are studied. Based on this review, the AODV and DSR are having much better performance than other protocols. Considering the various protocol strategies, a better routing protocol can be chosen depending upon the requirement of the user and its associated network requirement. Our future work will be to implement these protocols in various simulation environments to enhance the performance of various networks.

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