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COMPARATIVE STUDY OF ROUTING PROTOCOLS FOR MANETS

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Abstract
Mobile Ad Hoc Network (MANET) is collection of multi-hop wireless mobile nodes that Communicate with each other without centralized control or established infrastructure. The wireless links in this network are highly error prone and can go down frequently due to mobility of nodes, interference and less infrastructure. Therefore, routing in MANET is a critical task due to highly dynamic environment. In recent years, several routing protocols have been proposed for mobile ad hoc networks and prominent among them are DSR, AODV and TORA. This research paper provides an overview of these protocols by presenting their advantages and disadvantages of the proactive, reactive and hybrid protocols and then makes their comparative analysis of their advantages and disadvantages. The objective is to make observations about how the advantages and disadvantages of these protocols can be improved.

***Keywords*: MANET, Proactive, Reactive and hybrid routing protocols, advantages and disadvantages**

I. INTRODUCTION
The absence of fixed infrastructure in a MANET poses several types of challenges. The biggest challenge among them is routing. Routing is the process of selecting paths in a network along which to send data packets. An ad hoc routing protocol is a convention, or standard, that controls how nodes decide which way to route packets between computing devices in a mobile ad-hoc network. In ad hoc networks, nodes do not start out familiar with the topology of their networks; instead, they have to discover it. The basic idea is that a new node may announce its presence and should listen for announcements broadcast by its neighbors. Each node learns about nearby nodes and how to reach them, and may announce that it can reach them too. The routing process usually directs forwarding on the basis of routing tables which maintain a record of the routes to various network destinations

.Mobile networks can be classified into infrastructure networks and mobile ad hoc networks [2] according to their dependence on fixed infrastructures. In an infrastructure mobile network, mobile nodes have wired access points (or base stations) within their transmission range. The access points compose the backbone for an infrastructure network.

In contrast, mobile ad hoc networks are autonomously self-organized networks without infrastructure support. In a mobile ad hoc network, nodes move arbitrarily, therefore the network may experiences rapid and unpredictable topology changes. Additionally, because nodes in a mobile ad hoc network normally have limited transmission ranges, some nodes cannot communicate directly with each other. Hence, paths in mobile ad hoc networks potentially contain multiple hops, and every node in mobile ad hoc networks has the responsibility to act as a router.

A. Characteristics of routing protocols

To compare and analyze mobile ad hoc network routing protocols, appropriate classification methods are important. Classification methods help researchers and designers to understand distinct characteristics of a routing protocol and find its relationship with others.

a) Proactive routing Protocols:

Every proactive routing protocol usually needs to maintain accurate information in their routing tables. It attempts to continuously evaluate all of the routes within a network. This means the protocol maintains fresh lists of destinations and their routes by periodically distributing routing tables throughout the network. So that when a packet needs to be forwarded, a route is already known and can be used immediately. Once the routing tables are setup, then data (packets) transmissions will be as fast and easy as in the tradition wired networks. Unfortunately, it is a big overhead to maintain routing tables in the mobile ad hoc network environment. Therefore, the proactive routing protocols have the following common

Disadvantages:

1. Respective amount of data for maintaining routing information.
2. Slow reaction on restructuring network and failures of individual nodes.

Proactive routing protocols became less popular after more and more reactive routing protocols were introduced. In this section, we introduce three popular proactive routing protocols – DSDV, WRP and OLSR. Besides the three popular protocols, there are many other proactive routing protocols for MNAET, such as CGSR, HSR, and MMRP and so on.

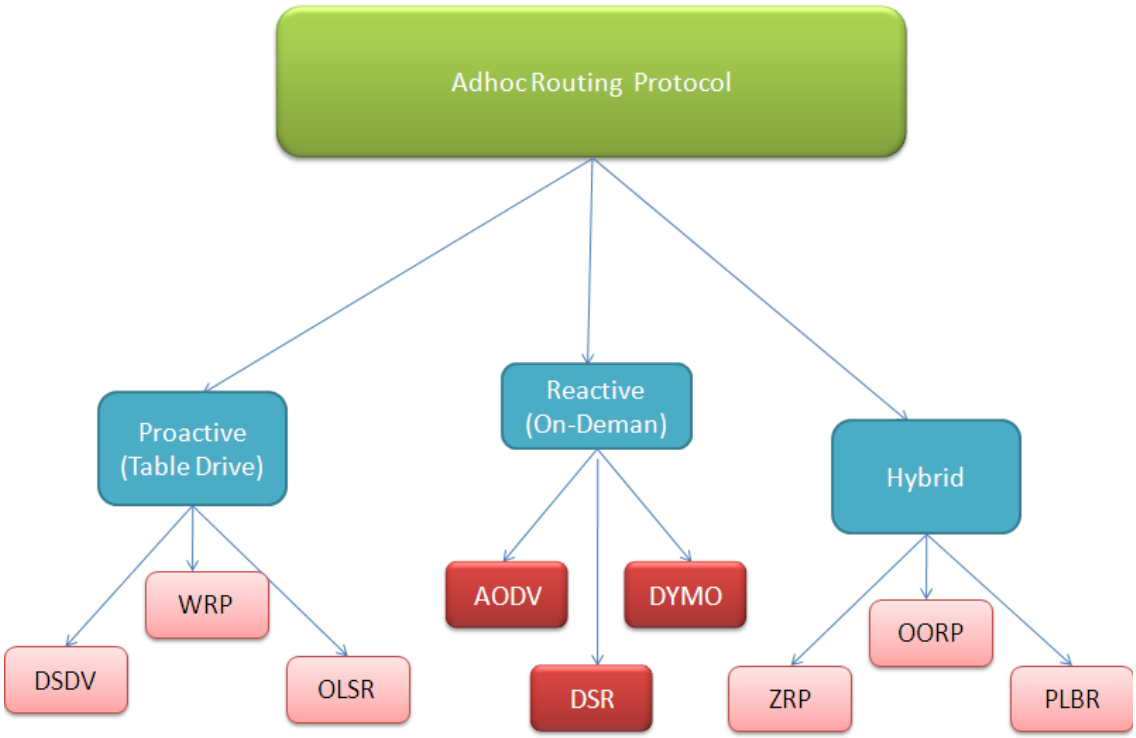
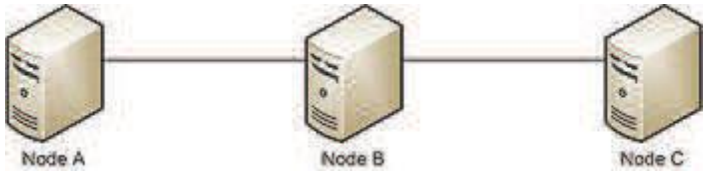


Figure 1: Ad Hoc Routing Protocol List

Destination-Sequenced Distance Vector (DSDV):

Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm. It was developed by C. Perkins and P. Bhagwat in 1994. The main contribution of the algorithm was to solve the routing loop problem. Each entry in the routing table contains a sequence number. If a link presents the sequence numbers are even generally, otherwise an odd number is used. The number is generated by the destination, and the emitter needs to send out the next update with this number. Routing information is distributed between nodes by sending *full dumps* infrequently and smaller incremental updates more frequently.



For example the routing table of Node A in the above network is

Destination	Next Hop	Number of Hops	Sequence Number	Install Time
A	**A**	**0**	**A46**	**001000**
B	**B**	**1**	**B36**	**001200**
C	**B**	**2**	**C28**	**001500**

Naturally the table contains description of all possible paths reachable by node A, along with the next hop, number of hops, sequence number and install time

Wireless Routing Protocol (WRP)

The Wireless Routing Protocol (WRP) is a proactive unicast routing protocol for MANETs. WRP uses an enhanced version of the distance-vector routing protocol, which uses the Bellman-Ford algorithm to calculate paths. Because of the mobile nature of the nodes within the MANET, the protocol introduces mechanisms which reduce route loops and ensure reliable message exchanges.

Optimized Link State Routing (OLSR)

The Optimized Link State Routing Protocol (OLSR) is an IP routing protocol optimized for mobile ad-hoc networks, which can also be used on other wireless ad-hoc networks. OLSR is a proactive link-state routing protocol, which uses Hello and Topology Control (TC) messages to discover and then disseminate link state information throughout the mobile adhoc network. Individual nodes use this topology information to compute next hop destinations for all nodes in the network using shortest hop forwarding paths.

PROTOCOLS	ADVANTAGES	DISADVANTAGES
Destination-Sequenced Distance Vector (DSDV)	▪ DSDV was one of the early algorithms available. ▪ creating ad hoc networks with small number of nodes.	▪ DSDV requires a regular update of its routing tables, which uses up battery power and a small amount of bandwidth even when the network is idle. ▪ Also, whenever the topology of the network changes, a new sequence number is necessary before the network re-converges; thus, DSDV is not suitable for highly dynamic networks
Wireless Routing Protocol (WRP)	▪ WRP has the same advantage as that of DSDV. ▪ In addition, it has faster convergence and involves fewer table updates.	▪ The complexity of maintenance of multiple tables demands a larger memory and greater processing power from nodes in the wireless ad hoc network. ▪ At high mobility, the

		control overhead involved in updating table entries is almost the same as that of DSDV and hence is not suitable for a highly dynamic and for a very large ad hoc wireless network as it suffers from limited scalability.
Optimized Link State Routing(OLSR)	▪ The routing overhead generated, while generally greater than that of a reactive protocol, does not increase with the number of routes being used. ▪ Default and network routes can be injected into the system by HNA (Host and Network Association) messages allowing for connection to the internet or other networks within the OLSR MANET cloud. ▪ Network routes using reactive protocols do not currently execute well. ▪ Timeout values and validity information is contained within the messages conveying information allowing for differing timer values to be used at differing nodes.	▪ The original definition of OLSR does not include any provisions for sensing of link quality; it simply assumes that a link is up if a number of hello packets have been received recently. ▪ Implementations such as the open source OLSRD (OLSR Daemon, commonly used on Linux-based mesh routers) have been extended (as of v. 0.4.8) with link quality sensing. ▪ Being a proactive protocol, OLSR uses power and network resources in order to propagate data about possibly unused routes. ▪ For small scale wired access points with low CPU power, the open source OLSRD project showed that large scale mesh networks can run with OLSRD on thousands of nodes with very little CPU power on 200 MHz embedded devices. ▪ Being a link-state protocol, OLSR requires a reasonably large amount of bandwidth and CPU power to compute optimal paths in the network.

b) Reactive Routing Protocols:

In bandwidth-starved and power-starved environments, it is interesting to keep the network silent when there is no traffic to be routed. Reactive routing protocols do not maintain routes, but build

them on demand. A reactive protocol finds a route on demand by flooding the network with Route Request packets. These protocols have the following advantages:

1. No big overhead for global routing table maintenance as in proactive protocols.
2. Quick reaction for network restructure and node failure.

Even reactive protocols have become the main stream for MANET routing, they still have the following main disadvantages:

1. High latency time in route finding.
2. Excessive flooding can lead to network clogging.

There are many reactive routing protocols for MANET.

We only introduce three popular (AODV, DSR and DYMO) and one new (ODCR) protocols in this section.

Ad hoc On-demand Distance Vector (AODV)

Ad hoc On-Demand Distance Vector (AODV) Routing is a routing protocol for mobile adhoc networks (MANETs) and other wireless ad-hoc networks. It is jointly developed in Nokia

Research Center, University of California, Santa Barbara and University of Cincinnati by C. Perkins, E. Belding-Royer and S. Das. AODV is capable of both unicast and multicast routing. It is a reactive routing protocol, meaning that it establishes a route to a destination only on demand. In contrast, the most common routing protocols of the Internet are proactive, meaning they find routing paths independently of the usage of the paths. AODV is, as the name indicates, a distance-vector routing protocol. AODV avoids the *counting-to infinity* problem of other distance-vector protocols by using sequence numbers on route updates, a technique pioneered by DSDV. In AODV, the network is silent until a connection is needed. At that point the network node that needs a connection broadcasts a request for connection. Other AODV nodes forward this message, and record the node that they heard it from, creating an explosion of temporary routes back to the needy node. When a node receives such a message and already has a route to the desired node, it sends a message backwards through a temporary route to the requesting node. The needy node then begins using the route that has the least number of hops through other nodes. Unused entries in the routing tables are recycled after a time. When a link fails, a routing error is passed back to a transmitting node, and the process repeats.

Dynamic Source Routing (DSR)

Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks. It is similar to AODV in that it forms a route on-demand when a transmitting computer requests one. However, it uses source routing instead of relying on the routing table at each intermediate device. Many successive refinements have been made to DSR, including DSRFLOW. Determining source routes requires accumulating the address of each device between the source and destination during route discovery. The accumulated path information is cached by nodes processing the route discovery packets. The learned paths are used to route packets. To accomplish source routing, the routed packets contain the address of each device the packet will traverse. This may result in high overhead for long paths or large addresses, like IPv6 (Internet Protocol version 6). To avoid using source routing, DSR optionally defines a flow id option that allows packets to be forwarded on a hop-by-hop basis.

Dynamic MANET On-Demand Routing (DYMO)

DYMO routing protocol has been proposed by Perkins & Chakeres [3] as advancement to the existing AODV protocol. It is also defined to as successor of AODV or ADOVv2 and keeps on updating till date. DYMO operates similar to its predecessor i.e. AODV and does not add any extra modifications to the existing functionality but operation is moreover quite simpler. DYMO is a purely reactive protocol in which routes are computed on demand i.e. as and when required. Unlike AODV, DYMO does not support unnecessary HELLO messages and operation is purely based on sequence numbers assigned to all the packets. It is a reactive routing protocol that computes unicast routes on demand or when required. It employs sequence numbers to ensure loop freedom. It enables on demand, multi-hop unicast routing among the nodes in a mobile adhoc network. The basic operations are route discovery and maintenance. Route discovery is performed at source node to a destination for which it does not have a valid path. And route maintenance is performed to avoid the existing obliterated routes from the routing table and also to reduce the packet dropping in case of any route break or node failure.

PROTOCOLS	ADVANTAGES	DISADVANTAGES
Ad hoc On-demand Distance Vector (AODV)	▪ The main advantage of this protocol is that routes are established on demand and destination sequence numbers are used to find the latest route to the destination. ▪ The connection setup delay is lower. It creates no extra traffic for communication along existing links. ▪ Also, distance vector routing is simple, and doesn't require much memory or calculation.	▪ AODV requires more time to establish a connection, and the initial communication to establish a route is heavier than some other approaches. ▪ Also, intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries. ▪ Also multiple Route Reply packets in response to a single Route Request packet can lead to heavy control overhead. ▪ Another disadvantage of AODV is that the periodic beaconing leads to unnecessary bandwidth consumption.
Dynamic Source Routing(DSR)	▪ This protocol uses a reactive approach which eliminates the need to periodically flood the network with table update messages which are required in a table-driven approach. In a reactive (on-demand) approach such as this, a route is established only when it is required and hence the need to find routes to all other nodes in the network as required by the table driven approach is eliminated. ▪ The intermediate nodes also utilize the route cache information efficiently to reduce the control overhead.	▪ The disadvantage of this protocol is that the route maintenance mechanism does not locally repair a broken link. ▪ Stale route cache information could also result in inconsistencies during the route reconstruction phase. ▪ The connection setup delay is higher than in table driven protocols. ▪ Even though the protocol performs well in static and low-mobility environments, the performance degrades rapidly with increasing mobility. ▪ Also, considerable routing overhead is involved due to the source-routing mechanism employed in DSR. ▪ This routing overhead is

		directly proportional to the path length.
Dynamic MANET On-Demand Routing (DYMO)	• The DYMO protocol presents a variety of new features over AODV. • The performance evaluation Shows that DYMO outperforms AODV as a MANET protocol. • The protocol is energy efficient when the network is large and shows a high mobility. • The routing table of DYMO is comparatively less memory consuming than AODV even with Path Accumulation feature. • The overhead for the protocol decreases with increased network sizes and high mobility.	• The DYMO protocol, however, does not perform well with low mobility. • The control message overhead for such scenarios is rather high and unnecessary. Another limitation lies in the applicability of the protocol as stated in the DYMO Draft which states that DYMO performs well when traffic is directed from one part of the network to another. • It shows a degraded performance when there is very low traffic random and routing overhead outruns the actual traffic.

c) Hybrid Routing Protocols:

This type of protocols combines the advantages of proactive and reactive routings. The routing is initially established with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding. The choice for one or the other method requires predetermination for typical cases. The main disadvantages of such algorithms are:

1. Advantage depends on amount of nodes activated.
2. Reaction to traffic demand depends on gradient of traffic volume.

Zone Routing Protocol (ZRP)

Zone Routing Protocol (ZRP) was the first hybrid routing protocol with both a proactive and a reactive routing component. ZRP was first introduced by Haas in 1997. ZRP is proposed to reduce the control overhead of proactive routing protocols and decrease the latency caused by routing discover in reactive routing protocols. ZRP defines a zone around each node consisting of its k-neighborhood (e.g. k=3). That is, in ZRP, all nodes within k-hop distance from node belong to the routing zone of node. ZRP is formed by two sub-protocols, a proactive routing protocol: Intra-zone Routing Protocol (IARP) is used inside routing zones and a reactive routing protocol: Inter-zone Routing Protocol (IERP), is used between routing zones, respectively. A route to a destination within the local zone can be established from the proactively cached routing table of the source by IARP. Therefore, if the source and destination is in the same zone, the packet can be delivered immediately. Most of the existing proactive routing algorithms can be used as the IARP for ZRP. For routes beyond the local zone route discovery happens reactively.

Order One Network Protocol (OORP)

The Order One MANET Routing Protocol (OORP) is an algorithm for computer communicating by digital radio in a mesh network to find each other, and send messages to each other along a reasonably efficient path. It was designed for, and promoted as working with wireless mesh networks. OORP can handle hundreds of nodes, where most other protocols handle less than a hundred. OORP uses hierarchical algorithms to minimize the total amount of transmissions needed for routing. Routing overhead is only about 1% to 5% of node to node bandwidth in any network and does not grow as the network size grows. The basic idea is that a network organizes itself into a tree.

Nodes meet at the root of the tree to establish an initial route. The route then moves away from the root by cutting corners, as ant-trails do. When there are no more corners to cut, a nearly optimum route exists.

Preferred Link-based Routing Protocol (PLBR)

Reactive routing protocols

Basic concept:

Each node maintains two tables: NT and NNT

Each node selects a subset called Preferred List(PL)

K: the size of the PL

Preferred List construction:

Neighbor Degree-based Preferred Link Algorithm based on neighbor nodes' degree divides its neighbor nodes to reachable and unreachable Weight-based Preferred Link algorithm based on the weight given to a node its weight is based on its neighbors' temporal and spatial stability

PROTOCOLS	ADVANTAGES	DISADVANTAGES
Zone Routing Protocol(ZRP)	• It reduces the control traffic produced by periodic flooding of routing information packets (proactive scheme). • It reduces the wastage of bandwidth and control overhead compared to reactive schemes.	• The large overlapping of routing zones.
Order One Network Protocol (OORP)	• The networks have enough memory to know of all nodes in the network, there is no practical limitation to network size. • The system can use nodes with small amounts of memory. • The network has a reliable, low-overhead way to establish that a node is not in the network. • OORP mixes the proactive and reactive methods.	• Central nodes have an extra burden because they need to have enough memory to store information about all nodes in the network. • OORP do not include security or authentication. Security and authentication may provided by the integrator of the protocol. • Typical security measures include encryption or signing the protocol packets and incrementing counters to prevent replay attacks
Preferred Link-based Routing Protocol(PLBR)	• The efficient flooding mechanism _ reduces the routing control overhead and provides better solutions than the other reactive protocols. • A flooding efficient protocol has higher scalability and decreases the network collisions.	• Both PLBR and WBPL are much more computationally complex than the other reactive protocols.

CONCLUSIONS AND FUTURE WORK

This research paper provides an overview of these protocols by presenting their advantages and disadvantages of the proactive, reactive and hybrid protocols and then makes their comparative analysis so to analyze their advantages and disadvantages. The objective is to make observations about how the advantages and disadvantages of these protocols can be improved. Each protocol introduced in this chapter has its own advantage and disadvantages in different MANET settings or environments. Therefore, it is hard to say which one is the best .In future in this paper we are including large number of protocols in MANETS.

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