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Study in Manet Routing Protocols: A Comprehensive Analysis Based On Delay, Delivery Ratio and Throughput

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ABSTRACT - A Mobile ad hoc Network (MANET) is a collection of autonomous wireless nodes forming temporary network to exchange information (packets) without using any fixed topology or centralized administration. In this dynamic network, each node changes its geographical position and act as a router for forwarding packets to the other node. Broadcast method is used to routing the information from one source point to all the nodes in the network. The mobile node acts as both a host and a router for forwarding packets to other node. Flat routing protocols are required for small network but the large network requires hierarchical or geographic protocols. In this paper, an attempt has been made to compare three well-known protocols DSDV (proactive), DSR and AODV (reactive routing protocols) by using the three performance metrics. The performance of these protocols is analyzed in terms of their average throughput, average delay and packet delivery on the basis of these comparisons the best routing protocol for MANET has been proposed.

Keyword: MANET, Routing protocol, performance Metric

I. INTRODUCTION

A Mobile Ad-hoc Network (MANET) is a temporary wireless network without having fixed infrastructure to interact and its aims to processing synchronized data transformation, and assured data transaction.

MANET can find its applications in the following areas [17]

- Military use
- Intelligent transportation in Vehicle-to-vehicle communication [5]
- Search and rescue
- Ad hoc networks in airports, meeting, natural disaster
- PAN (Personal Area Networks) connecting mobile phones, laptops systems, smart watches, and other computers

Traditional routing protocols used in hardwired networks, such as distance vector protocols and link state protocols cannot be applied in the MANET directly for the following reasons:

- There may be uni-directional links between nodes
- There is more than one eligible path between two nodes

Related Work

The Ad Hoc Networking is not a new one, in 1972 DARPA (Defense Advanced Research Projects Agency) and PRNET (Packet Radio Networking) projects were progressed into the Survivable Adaptive Radio Networks (SURAN) program. It was encouraged by the efficiency of the packet switching technology. Then microelectronics technology made possible to integrate all the nodes and network devices into a single unit Called Ad Hoc Nodes [12]. The performance of AODV and DSR (on demand reactive protocol) compares by using the throughput, delivery ratio, and end-to-end delay metrics. This has done using Ns2 simulator Vijaya et. al [13].

Mohammed Bouhorma et.al[14] Reviewed quantitative properties of routing protocol. Two properties of Routing protocols are Qualitative and Quantitative. Distributed operation, loop freedom, demand based routing & security are under the category of Qualitative. End-to-end delay, throughput, route discovery time, memory byte requirement & network recovery time are under the category of Quantitative. Mobile Ad hoc network working group was formed by Internet Engineering Task Force (IETF) in mid 1990s to standardized routing protocols for the newly adopted technology

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as well as by IEEE 802.11 for wireless networks. The main characteristics of MANETs are the mobility of nodes, i.e. nodes can move in any direction and at any speed which leads to arbitrary topology and frequent partitioning of the network.[2]. Routing is one of the most important challenges in ad-hoc networks because of the active topology and mobility of node. So numerous algorithms are proposed for Ad-hoc network and it can be classified into various categories are proactive, reactive and hybrid. Main divisions of the MANETs are unicast, multicast, and broadcast. The unicast can be additionally classified into topology based and geographical based protocols.

II. MANETS ROUTING PROTOCOLS:

Proactive Routing Protocol

Proactive protocols continuously broadcast complete picture of topology on every node and learn the global topology updated information among the network node in order to discover the path from source to endpoint. It is also called table-driven protocol, it maintain routing table to store the routing information and getting the information whenever needed. It is not fit for large network.

Table 1: summary of Related Work

Author Name Reference	Simulation Tool	Simulation time	Simulation Area	Performance metrics	Variable parameter
Parul sharma et al. [13]	MATLAB	500 sec	600 x 600 m	Average End to End Delay, Packet Delivery Fraction	Number of Nodes, Traffic type, Band width, Packet size, Mobility Model
P. Manickam et al.[14]	Network Simulator 2.29		500 x 500 m	PDR, Throughput, Average end to end delay	Radio model, Application- FTP, MAC- Mac/802_11, Max speed
Nazmus Saquib[15]	Visim tool	150 sec	500 x 400	Throughput, PDR, Routing load	Channel Type, MAC type, Radio-propagation model, Network interface type, Interface Queue Type, Antenna model- Omni Direction
Kavita Pandey et al.[16]	ns-allinone-2.34	150 sec	500 x 500	Throughput, PDR, Routing overhead, Dropped packets, Delay	Mobility Model, Platform -Linux, Fedora core 9, Antenna type, Number of node
Sunil Kumar Kaushik et al.[17]	Ns-NAM	300 sec	700 x 700	Throughput, PDR, Normalized Routing Load (NRL)	Speed, pause time, packet size , simulation time and Traffic Node

Some of the proactive Routing Protocols are:

- AWDS (Ad-hoc Wireless Distribution Service)
- CGSR (Cluster head Gateway Switch Routing Protocol)
- OLSR (Optimized Link State Routing Protocol)
- DFR (Direction Forward Routing)
- DBF (Distributed Bellman-Ford Routing Protocol)
- FSR (Fisheye State Routing Protocol)
- HSR (Hierarchical State Routing Protocol)
- IARP (Intra zone Routing Protocol)
- TBRPF (Topology Broadcast Based on Reverse-Path Forwarding Routing Protocol)

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III. REACTIVE ROUTING PROTOCOL:

Reactive protocols are using query-reply dialog mechanism. Frequently storing the topology broadcast information is waste of bandwidth. Instead of storing the updated data in routing table, this reactive protocol discovers the route only on the demand basis. The routing has two phases,

(i) Route discovery: It means, construction of route between the source and destination node. When the route is not obtainable to the endpoint, the source node broadcast a route discovery packet to all nodes in the network.

ii) Rout maintenance: [4] Once the route is established, it introduced to check the validity of the route. The link may be break because of shutdown or the node may move. The source node reinitiates the route discovery task immediately when the route disconnect form source to destination.

Some of the Reactive Routing Protocols are:

- ACOR (Admission Control Enabled On Demand Routing)
- ABR (Associativity Based Routing)
- AODV (Ad-hoc on-demand Distance Vector)
- SSA (Signal Stability based Adaptive Routing)
- DSR (Dynamic Source Routing)
- CHAMP (CacHing And MultiPath Routing)
- CBRP (Cluster Based Routing Protocol)
- LAR1 (Location Aided Routing – Scheme 1)

IV. HYBRID ROUTING PROTOCOLS

The hybrid protocol inherits assets of proactive as well as reactive routing protocols to making control of delay and packages. The mixed approach is used to establish the route and activate the nodes.

- ZRP (Zone Routing Protocol)
- HRPLS (Hybrid Routing Protocol for Large Scale Mobile Ad-hoc Networks with Mobile Backbone
- ADV (Adaptive Distance Vector Routing)
- HSLS (HAZY Sighted Link State Routing Protocol)
- HWMP (Hybrid Wireless Mesh Protocol)
- OORP (Order one Routing Protocol)

AODV (Ad-hoc on-demand Distance Vector)

[4] AODV is a combination of DSR and DSDV algorithms, which consist the following procedures:

Route discovery: The AODV broadcast the route request packet in the MANET when the route is not able to discover.
Then the destination or intermediate nodes answer with the route reply packet.

Route maintenance: Every node in the network broadcast the HELLO packet periodically to ensure its active participation. When the neighbor node not receive a Hello packet, that the particular node relation will be consider as cracked.

For packet transmission in AODV uses the next-hop information that is stored in the source and intermediate node It uses the characteristic of route discovery and maintenance of DSR and includes the hop by hop sequence of DSDV [5]. In AODV the source and intermediate node store the next-hop information for packet transmission and also uses the characteristic of route discovery and maintenance of DSR. It uses the hop by hop destination sequence number to find latest route [6].

DSR-Dynamic Source Routing Protocol

DSR is the first reactive routing protocol [7], it balance up to two hundred nodes. It is developed at Carnegie Mellon university Pittsburgh USA for use of multi-hop wireless mobile ad hoc networks [2]. Instead of maintain routing table it uses the Route Cache option is maintained by each node to discover and maintain the route. Unlike proactive routing protocols the DSR not broadcasting the periodic HELLO message. The header of the packet consists of intermediate node list for routing. Route establishment between the source and destination is only on-demand basis using request/reply mechanism.
Downside: Repair a broken link between the nodes is not possible in the route maintenance system of DSR. The connection establishment is taking higher time than the table-driven protocol.

Three parts of route establishment in DSR:
Route Request (RREQ)
Route Reply (RREP)
Route Cache

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Table 2: summary of Multicast Routing

Multicast Protocols	Multicast Topology	Initialization	Independent of Routing Protocol	Dependency on Specific Routing Protocol	Maintenance Approach	Loop Free	Flooding of Control Packets	Periodic Control Messaging
ABAM	Source-tree	Source	Yes	No	Hard state	Yes	Yes	No
BEMRP	Source-tree	Receiver	Yes	No	Hard state	Yes	Yes	No
DDM	Source-tree	Receiver	No	No	Soft state	Yes	Yes	Yes
MCEDAR	Source-tree over Mesh	Source or Receiver	No	Yes (CEDAR)	Hard state	Yes	Yes	No
MZRP	Source-tree	Source	Yes	No	Hard state	Yes	Yes	Yes
WBM	Source-tree	Receiver	Yes	No	Hard state	Yes	Yes	No
PLBM	Source-tree	Receiver	Yes	No	Hard state	Yes	No	Yes
MAODV	Shared-tree	Receiver	Yes	No	Hard state	Yes	Yes	Yes
Adaptive Shared	Combination of Shared-and Source-trees	Receiver	Yes	No	Soft state	Yes	Yes	Yes
AMRIS	Shared-tree	Source	Yes	No	Hard state	Yes	Yes	Yes
AMRoute	Shared-tree over Mesh	Source or Receiver	No	No	Hard state	No	Yes	Yes

DSDV

Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing structure and it is uses the Bellman-Ford algorithm. It was developed by C. Perkins and P.Bhagwat in 1994 [9]. The table-driven routing protocols attempts to maintain consistent, up-to-date routing information from each node to every other node in the network [8].The DSDV using one or more table to store routing information and also adds a new attribute, sequence number, to each route table. In every mobile station contain the list of available destination and the number of hop to reach the destination node. Its uses two method to update the routing table, one is "full dump" and the second one is even-driven incremental update. Full dump method sends the whole routing table but the incremental sends only updated entries of table.

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V. PERFORMANCE METRICS

Average Delay

Data packet takes the average amount of time to reach the destination. This metric is designed by subtracting "time at which first packet was conveyed by source" from "time at which first data packet reached to target node (Destination)". This comprises all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times [10][11].

Minimum Delay: The data packet takes the Minimum Time to reach the next node.
Maximum Delay: The data packet takes the Maximum Time to reach the next node.
Average End-to-End Delay: The data packet takes Time to reach the destination.
Simulation Time: Time between the simulation start and simulation ends.

$$\textbf{Average End-to-End Delay} = \frac{\sum (\text{Time received} - \text{Time sent})}{\text{Total data packets received}}$$

Throughput

Throughput means that in certain time the ratio of data packets reaches a destination from the source. The unit of throughput is measured in bytes or bits per sec (byte per sec or bit per sec or Kilobits per second (Kbps)).
Some of the following factors shake the throughput:

- Many topology changes,
- Unreliable communication between nodes,
- Limited bandwidth offered and limited energy.

Every network aims to obtain a high value throughput and it can be represented as mathematical equation [12].

Data Rate

Within a given time sum of packets are moving from one place to another place (speed of travel) [12].

$$\text{Throughput} = \frac{\text{Number of delivered packets} * \text{packet size} * 8}{\text{Total duration of simulation}}$$

Packet Delivery Ratio

Packet Delivery Ratio (PDR) is the ratio between the numbers of data packets sent by the source (CBR-Constant Bit source) that are received by the destination (CBR-receivers). The transport protocol measures the loss rate.

Packet Delivery Ratio = Σ CBR Packets received / Σ CBR Packets sent

It designates the ratio of packets, which reach the end node (Destination).

$$\text{Packet Delivery Ratio} = \frac{\text{Number of received packets}}{\text{Number sent packets}}$$

Table.3 Summary of proactive, reactive and hybrid routing protocols

	Proactive	Reactive	Hybrid
Network Organization	Flat / Hierarchical	Flat	Hierarchical
Topology Dissemination	Periodical	On-demand	Both
Route latency	Always available	Available when needed	Both
Mobility Handling	Periodical updates	Route maintenance	Both
Communication	High	Low	Medium

Overhead			

VI. CONCLUSION:

In this study, the MANET routing protocols have been studied and classified into proactive, reactive and hybrid. MANET routing protocols performance comparison is an important aspect. The routing table can be referred by the topology-based routing technique to obtain the routing information and geographical-based routing uses the neighbors' location table. Link state routing protocols are widely used in large networks due to their fast convergence and high reliability, so it is better than the distance vector routing. Hence the five well known routing protocols are analyzed with three performance metrics namely number of packet delivery ratio, average end -to-end delay, and throughput. Link-state routing or distance-vector routing is used by the topology based routing protocols to get the topology information at the same time the geographical-based routing protocols uses the location updates to get geographical data. The study suggests that each protocol has its own merits and drawbacks in different aspects. DSDV performs well in packet delivery ratio as well as DSR also but in the less number of nodes. AODV plays well in the delay performance scenario. In the throughput, AODV perform better than DSR.

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