Periodical and On-Demand Topology Dissemination in routing protocols: A comprehensive Analysis based on Delay, Delivery Ratio and Throughput

Ramalingam. M, [#1], Dr.Thiagarasu.V [#2,] Narendran.P [#3]

[#1]*Assistant Professors in Computer Science,*

ramsgobi@gmail.com

[#2]*Associate Professors in Computer Science,*

[#3] *Head &Associate Professors in Computer Science,*

Gobi Arts & Science College, Gobichettipalayam, T.N, India

***Abstract*—MANET is a self-organized and self-configured network, in which each node changes its geographical position frequently and acts as a router to forward packets. The mobile node acts both as a host and a router for forwarding packets to other node(s). 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 five well known protocols namely DSDV, OLSR (proactive), DSR, AODV (reactive routing protocols) and ZRP (Hybrid) 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. In the packet delivery ratio, DSR performs well when the numbers of nodes are less and DSDV performs well when there is more number of nodes. AODV protocol has the lowest delay in the delay performances. DSR and AODV perform better in the throughput when compared to DSDV, OLSR and ZRP.**

***Keywords*—MANET, Routing Protocol, Performance Metrics, Packet Delivery Ratio**

I. INTRODUCTION

A Mobile Ad-hoc Wireless Network (MANET) is a collection of autonomous wireless nodes that communicate dynamically and establishes the network to exchange the information. Ad hoc Network can be created and used at anytime, anywhere without using any fixed topology or centralized administration. The ability of self-configuration of MANET can be used in conferences, meetings, natural disasters, crowd controls, battle fields and emergency situations.

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 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].

MANETs have several salient characteristics: i) Dynamic topologies ii) Bandwidth constrained, variable capacity links, iii) Energy-constrained operation and limited physical security etc. Therefore the routing protocols used in ordinary wired networks are not well suited for dynamic environment [3]. By embed the routing functionality in mobile node, the MANET offers effective communication and multi-hop relaying in wireless modern world. In such a network, mobile nodes can be moved and organized freely in an arbitrary way [2].Main function of the routing protocol is route selection and packet delivery to proper destination.

Routing is one of the most important challenges in ad-hoc networks because of the active topology and mobility of node. So, numerous algorithms have been proposed for Ad-hoc network and they can be classified into various categories such as 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. RELATED WORK

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 on demand reactive protocols of AODV and DSR are compare based on the throughput, delivery ratio, and end-to-end delay metrics. This has done using Ns2 simulator Vijaya et.al [13].

Two properties of Routing protocols are Qualitative and Quantitative. Distributed operation, loop freedom, demand

based routing & security comes under the category of Qualitative. End-to-end delay, throughput, route discovery time, memory byte requirement & network recovery time comes under the category of Quantitative. Mohammed Bouhorma et.al [14] reviewed quantitative properties of routing protocol. The MANET routing protocol has been analyzed and reviewed by number of researchers is listed out in table I.

TABLE I

RELATED WORK

Author Name Reference	Simulation Tool	Simulation time	Simulation Area	Performance metrics	Variable parameter
Parul sharma et al. [13]	MAT LAB	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

III. MANET ROUTING PROTOCOLS

A. 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. Some of the proactive Routing Protocols are AWDS, CGSR, OLSR, DFR, DBF, FSR, HSR, IARP, and TBRPF.

B. 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,

- 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.
- 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, ABR, AODV, SSA, DSR, CHAMP, CBRP, and LAR1.

C. 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. Some of the hybrid protocols are ZRP, HRPLS, ADV, HSLS, HWMP, and OORP. Summary of proactive, Reactive, Hybrid protocols are described in Table II.

D. Routing Protocols

1) AODV-Ad-hoc on-demand Distance Vector:

[4] AODV is a combination of DSR and DSDV algorithms, which consists 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].

2) DSR-Dynamic Source Routing Protocol:

First reactive routing protocol [7], it balances 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), and Route Cache [19].

3) Destination-Sequenced Distance-Vector Routing:

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.

4) ZRP -Zone Routing Protocol:

The first hybrid routing protocol (ZRP) was introduced by Hass in 1997. It consist the both proactive and reactive things. "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-neighbourhood [18]. Intra-zone Routing Protocol (IARP) and Inter-zone Routing Protocol (IERP) are used to inside routing zone and between routing zones. 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 [18].

5) OLSR -Optimized Link State Routing :

Optimized Link State Routing (OLSR) protocol is a proactive routing protocol where the routes are always immediately available when needed. OLSR is an optimization version of a pure link state protocol in which the topological changes cause the flooding of the topological information to all available hosts in the network. OLSR may optimize the reactivity to topological changes by reducing the maximum time interval for periodic control message transmission [19].

The uniqueness of OLSR is that it minimizes the size of control messages and rebroadcast by using the MRP (Multipoint Relaying). The basic concept of MPR is to reduce the loops of retransmissions of the packets. Only MPR nodes broadcast route packets. The nodes within the network maintain a list of MPR nodes. MPR nodes are selected within the environs of the source node. The selection of MPR is done by the neighbor nodes in the network, with the help of HELLO messages [20].

TABLEII
SUMMARY OF PRO-ACTIVE, REACTIVE, HYBRID 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 Overhead	High	Low	Medium

IV. PERFORMANCE METRICS

A. *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].

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

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.

B. *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).

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

C. *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].

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

V. PERFORMANCE COMPARISONS AND SIMULATION RESULTS

NS2 is an object oriented simulator used by the network research community and here, the ns2 is used for experiments. A simulation study is carried out to assess the presentation of MANET routing protocols. The Routing Protocols are DSDV, AODV, ZRP, OLSR & DSR and throughput, packet delivery ratio and average end-to-end delay metrics are used in this simulation.

A. *Packet Delivery Ratio (PDR)*

In positions of packet delivery ratio, DSR and AODV loss a considerable number of packets in the course of route detection phase. The OLSR has high delivery ratio in high mobility but medium at low mobility. The network traffic will be less when the number of node is less so DSR and ZRP effects well. Load will be high in the network when the number of node is so the DSR performance drops as well as ZRP also. Comparing AODV with DSR, the AODV has a faintly lower packet delivery performance because of its higher drop rates in the high traffic network. AODV dropping some packets in route expires so new route must be found. The PDR and AODV are worse in high rate of packet delivery ratio. The performance of DSDV and AODV are better with more number of nodes in the packet delivery ratio.

B. *Delay*

Route establishment of DSDV may not happen fast. The performance of DSDV is degrading due to rising in the number of nodes the load of interchange of routing tables becomes high and the rate of exchange also increases due to the mobility of nodes. This lead to lengthy delays waiting or new routes construction. Although the delay for DSDV is better than the DSR protocol. The delay is increased in ZRP, when the number of node increases. The delay of OLSR is low in high mobility and medium in low mobility. In the terms of route discovery phase, the DSR performance is better therefore shows better result in route establishment and packet delivery ratio. But in the high mobility environment its performance decline due to more congestion in the network. So the presentation of DSR is degrading in the high traffic network setting. In the result of end to end delay AODV protocol has the lowest delay.

C. *Throughput*

It is the ratio of the total amount of data that reaches a receiver from a sender to the time it takes for the receiver to get the last packet. The throughput of OLSR is low in high mobility and medium in low mobility. The reason of fixed zone radius, the ZRP has constant throughput. In AODV protocol the route discovery and packet delivery ratio is better in the simulation environment. Its throughput value high, when comparing with the other two protocols. DSDV shows better result but its throughput decries when the simulation time increase. Even though AODV is an on-demand routing protocol, its uphold throughput value when the time increase. DSR play better roll at lower pause time and grows as time increase. Hence, AODV shows well outcome in the throughput phase.

VI. CONCLUSION

In this research exposition, the MANET routing protocols have been studied and classified into proactive, reactive and hybrid. MANET routing protocols performance comparison is an important aspect. Hence the five well known routing protocols are analysed with three performance metrics namely number of packet delivery ratio, average end -to-end delay, and throughput. 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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