Performance Metrics of MANET in Multi-Hop Wireless Ad-Hoc Network Routing Protocols

R.Devi, B.Sumathi, T.Gandhimathi, G.Alaiyarasi
1st year, M.Tech (Software Engineering),
Department of Information Technology,
Periyar Maniammai University, Vallam, Thanjavur, Tamilnadu, India.
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Abstract
MANET is a wireless network that transmits from computer to computer. Instead of using a central base station (access point) to which all computers must communicate, this peer-to-peer mode of operation can greatly extend the distance of the wireless network. To gain access to the Internet, one of the computers can be connected via wire or wireless.A routing protocol is a protocol that specifies how routers communicate with each other, disseminating information that enables them to select routes between any two nodes on a computer network, the choice of the route being done by routing algorithms. Each router has *a priori* knowledge only of networks attached to it directly. A routing protocol shares this information first among immediate neighbors, and then throughout the network Protocols are divided into three categories: Proactive, Reactive and Hybrid. A number of routing protocols have been proposed for this purpose like Ad Hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Destination- Sequenced Distance Vector (DSDV). In this paper, the simulation results were analyzed by graphical manner and trace file based on Quality of Service (QoS) metrics: such as throughput, drop, delay and jitter. Finally, the performance differentials based on Packet Delivery Ratio to evaluate and analyze the performance of various routing protocols. we study and compare the performance of the following three routing protocols AODV, DSR and DSDV.

Keywords: On-demand, Table driven, DSR, AODV, DSDV, Adhoc, MANET.

I. INTRODUCTION
MANET is a wireless network that transmits from computer to computer. Instead of using a central base station (access point) to which all computers must communicate, this peer-to-peer mode of operation can greatly extend the distance of the wireless network. To gain access to the Internet, one of the computers can be connected via wire or wireless.

A. MANET-Usage
Military scenarios, Sensor networks, Rescue operations,Students on campus, Free Internet connection sharing, Conferences.

B.Types of MANET
1. Vehicular ad-hoc network
2. Intelligent vehicular ad-hoc network
3 .Internet Based Mobile Ad hoc Networks

Ad-hoc network (VANETs) are used for communication among vehicles and between vehicles and roadside equipment. Intelligent vehicular ad-hoc networks (InVANETs) use WiFi IEEE (WAVE standard) and WiMAX IEEE 802.16 for easy and effective communication between vehicles with dynamic mobility.Internet Based Mobile Ad hoc Networks (iMANET) are ad hoc networks that link mobile nodes and fixed Internet-gateway nodes.

The Mobile Ad-Hoc Network is characterized by energy constrained nodes, bandwidth constrained links and dynamic topology. In real-time applications, such as audio, video, and real-time data, the ad hoc networks need for

Quality of Service (QoS) in terms of delay, bandwidth, and packet loss is becoming important. Providing QoS in ad-hoc networks is a challenging task because of dynamic nature of network topology and imprecise state information. Hence it is important to have a dynamic routing protocol with fast re-routing capability, which also provides stable route during the life-time of the flows. Generally there are two distinct approaches for enabling wireless mobile units to communicate with each other:

Ii. Limits of Pure General-Purpose Manet Research

A. USERS' PERSPECTIVE

Generally, MANET is justified by the possibility of building a network where no infrastructure exists, or to have a "free" network where users can communicate without cost, provided that the node density is sufficient. However, reports about MANET perception from the users' perspective are missing. The users' evaluation indicates the following major problems in pure general purpose MANET:

• Users' motivations for using large-scale MANET are not clear.

• Application scenarios able to attract user interest are missing.

• There is a lack of effective MANET implementations that can be used by non-expert users.

• Mesh network is a more pragmatic approach to build multihop ad hoc networks.

B. TECHNICAL PERSPECTIVE

Although MANET research has been going on for some time, there are relatively few experiences with real ad hoc networks. The lack of accuracy in most MANET simulation studies in one or more of the previous points drastically reduces the credibility of MANET research. Here are the most common issues in MANET simulation that may result in the lack of realism in simulation studies.

Simulation Modeling

Simulation Model Solution

Analysis of the Simulation Output

Iii .Characteristics Of Manet:

A. Dynamic topologies: the network topology--which is typically multi-hop may change randomly and rapidly at unpredictable times, and may consist of both bidirectional and unidirectional links.

1) *Bandwidth constrained links:* Wireless links have significantly lower capacity than their hardwired counterparts. They are also less reliable due to the nature of signal propagation.

2) Energy constrained operation: Devices in a mobile network may rely on batteries or other exhaustible means as their power source. For these nodes, the conservation and efficient use of energy may be the most important system design criteria.

B. MANET Challenges: Regardless of the attractive applications, the features of MANET introduce several challenges that must be studied carefully before a wide commercial deployment can be expected. These include

Routing: Routing is the main process used by Internet hosts to deliver packets. Internet uses a hop-by-hop routing model, which means that each host or router that handles a packet examines the Destination Address in the IP header, computes the *next hop* that will bring the packet one step closer to its destination, and delivers the packet to the next hop, where the process is repeated.

Security and Reliability: In addition to the common vulnerabilities of wireless connection, an ad hoc network has its particular security problems due to e.g. nasty neighbor relaying packets. The feature of distributed operation requires different schemes of authentication and key management. Further, wireless link characteristics introduce also reliability problems, because of the limited wireless transmission range, the broadcast nature of the wireless medium (e.g. hidden terminal problem), mobility-induced packet losses, and data transmission errors

C. Quality Of Service (QoS):

QoS (Quality of Service) refers to a broad collection of networking technologies and techniques. The goal of QoS is to provide guarantees on the ability of a network to deliver predictable results. Elements of network performance within the scope of QoS often Include availability (uptime), bandwidth (throughput), latency (delay), and error rate.

Inter-networking: In addition to the communication within an ad hoc network, inter-networking between MANET and fixed networks (mainly IP based) is often expected in many cases. The coexistence of routing protocols in such a mobile device is a challenge for the harmonious mobility management.

Iv. Performance Metrics of Manet

The following metrics are considered for simulating and analyzing the performance of routing protocols and characteristics of MANET

Jitter*:* Jitter describes standard deviation of packet delay between all nodes.

Throughput: The throughput metric measures how well the network can constantly provide data to the sink. Throughput is the number of packet arriving at the sink per milliseconds.

Power consumption*:* The total consumed energy divided by the number of delivered packet.

Packet Delivery Ratio (PDR)*:* PDR is the ratio of the number of packets successfully received by all destinations to the total number of packets injected into the network by all sources. The PDR is a number between 0 and1.

Average Packet Delay*:* It is sum of the times taken by the successful data packets to travel from their sources to destination divided by the total number of successful

Packet: The average packet delay is measured in seconds.

Average Hop Count*:* It is the sum of the number of hops taken by the successful data packets to travel from their sources to destination divided by the total number of successful packets. The average hop count is measured in number of hops.

V. Features of Manet

Some of the salient features that describe the MANET clearly are

Dynamic network topology*:* Since the nodes are mobile, the network topology may change rapidly and unpredictably and the connectivity among the terminals may vary with time

Autonomous terminal*:* In MANET, each mobile terminal is an autonomous node, which may function as both a host and a router (to perform switching functions).

Multi hop routing*:* When delivering data packets from a source to its destination (i.e., only when the nodes are not directly linked), the packets should be forwarded via one or more intermediate nodes.

Distributed operation*:* Since there is no background network, the control and management of the network is distributed among the terminals.

Light-weight terminals: In most cases, the MANET nodes are mobile devices with less CPU processing capability, small memory size, and low power storage. Such devices need optimized algorithms and mechanisms that implement the computing and communicating functions.

Vi. Routing Protocols In Manet

Routing Protocols:

A **routing protocol** is a protocol that specifies how routers communicate with each other, disseminating information that enables them to select routes between any two nodes on a computer network, the choice of the route being done by routing algorithms. Each router has *a priori* knowledge only of networks attached to it directly. A routing protocol shares this information first among immediate neighbors, and then throughout the network Protocols are divided into three categories: Proactive, Reactive and Hybrid

A. Proactive Protocols:

In this type of routing protocol, each node in a network maintains one or more routing tables which are updated regularly. Each node sends a broadcast message to the entire network if there is a change in the network topology. However, it incurs additional overhead cost due to maintaining up-to-date information and as a result; throughput of the network may be affected but it provides the actual information to the availability of the network. Distance vector (DV) protocol, Destination Sequenced Distance Vector (DSDV) protocol, Wireless Routing protocol Fisheye State Routing (FSR) protocol are the examples of Proactive protocols.

B. Reactive Protocols: In this type of routing protocol, each node in a network discovers or maintains a route based on-demand. It floods a control message by global broadcast during discovering a route and when route is discovered then bandwidth is used for data transmission. The main advantage is that this protocol needs less touting information but the disadvantages are that it produces huge control packets due to route discovery during topology changes which occurs frequently in MANETs and it incurs higher latency. The examples of this type of protocol are Dynamic Source Routing (DSR), Ad-hoc On Demand Routing (AODV) and Associativity Based Routing (ABR) protocols.

C. Hybrid Protocols: it is a combination of proactive and reactive protocols taking the best features from both worlds.

Distance Vector (DV) Protocol: it is a proactive protocol that works on the principles of distance vector where each node in a network maintains a distance table that contains the shortest distance and the address of the next hop router. Initially, each node knows only the distance with the nodes that are directly connected and a distance vector is initialized with that distance. Initially, distance to all others nodes that are not directly connected are initialized to infinity. When a change occurs in the network, each node updates its directly connected neighbors to the least cost distance vector. This process continues until convergence. The advantages of distant vector protocol are 1) No need for global broadcasting and 2) Short route acquisition delay since all information for each node are available in the routing table. The disadvantages are 1) Long convergence time which may cause counting to infinity problem for large networks, 2) Non-availability of alternative paths.

Dynamic Source Routing (DSR) Protocol: It is a reactive protocol that creates a route on demand using source routing protocol i.e. it requires a full series of paths to be established between source and destination nodes to transmit packets and each packet follows the same path. The major motivations of this protocol are to limit the bandwidth by avoiding the periodic table updates and long convergence time. The underline fact to this protocol is that it floods a route request message in the network to establish a route and it consists of two procedures: Route Discovery and Route Maintenance.

Ad-hoc On-demand Distance Vector (AODV) Protocol:

It is a classical routing protocol for MANETs that compromise the trade-off problems like large packet header in reactive source protocol and large messaging overhead due to periodic updates in proactive protocols. It uses a distributed approach i.e. it keeps track of the neighbor nodes only and it does not establish a series of paths to reach the destination. It also uses route discovery and route maintenance mechanism like DSR.

Performance Metric:

In this paper we have worked on Packet Delivery Ratio as the performance metric to evaluate and analyze the performance of various routing protocols.

• Packet Delivery Ratio:

Packet delivery ratio is defined as the ratio of data packets received by the destinations to those generated by the sources. This performance metric gives us an idea of how well the protocol is performing in terms of packet delivery at different speeds using different traffic models. Mathematically, we can define as

$$PDR(\%) = \frac{\sum_{i=1}^{m} \text{Sum of Data packets received by each destination}}{\text{Sum of data packets generated by each source}} \quad m$$

Where i, indicates the number of o/p file

m, indicates the total number of o/p file.

Performance Results of AODV, DSR:

DSDV: The graphs given here are the performance analysis of the routing protocol with respect to different metric considered above. The X- Axis shows the number of nodes and the y axis shows the Metric considered.

In terms of packet delivery ratio (Figure1), DSR performs well when the number of nodes is less as the load will be less. However its performance declines with increased number of nodes due to more traffic in the network. The performance of DSDV is better with more number of nodes than in comparison with the other two protocols. The performance of AODV is consistently uniform.

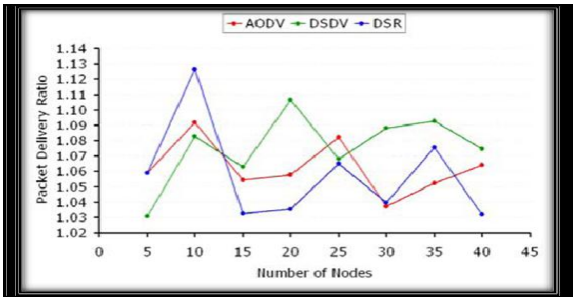

Fig 1. Packet delivery ratio for AODV, DSR, DV

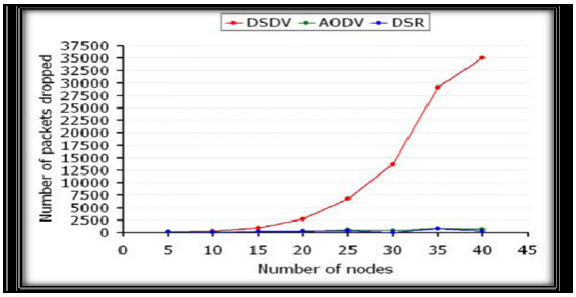

Fig 2. Dropped Packets for AODV, DSR, DV

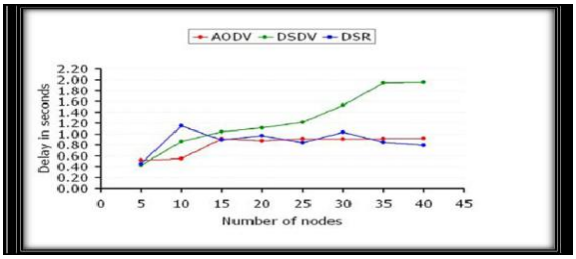

Fig 3. Average End-to-End delay for AODV, DSR, DV

In terms of dropped packets (Figure2), DSDV's performance is the worst. The performance degrades with the increase in the number of nodes. AODV and DSR performs consistently well with increase in the number of nodes. For average end-to-end delay (Figure3), the performance of DSR and AODV are almost uniform. However, the performance of DSDV is degrading due to increase in the number of nodes the load of exchange of routing tables becomes high and the frequency of exchange also increases due to the mobility of nodes.

Vii. Conclusion

It is difficult for the quantitative comparison of the most of the ad hoc routing protocols due to the fact that simulations have been done independent of one another using different metrics and using different simulators. In this paper, we have presented comparison studies about On-Demand (DSR and AODV) and Table-Driven (DV) routing protocols. Our comparison indicate that the performance of the two on demand protocols namely DSR and AODV is superior to the DSDV in conformance

with the work done by other researchers as mentioned in section 2. It is also observed that DSR outperforms AODV in less stressful situations, i.e smaller number of nodes.

AODV outperforms DSR in more stressful situations. The routing overhead is consistently low for DSR and AODV than in comparison with DSDV especially for large number of nodes. This is due to the fact that in DV the routing table exchanges would increase with larger number of nodes. Our comparison also indicate that as the number of nodes in the network increases DV would be better with regard to the packet delivery ratio, but it may have considerable routing overhead. As far as packet delay and dropped packets ratio are concerned, DSR/AODV performs better than DSDV with large number of nodes. Hence for real time traffic AODV is preferred over DSR and DSDV. For less number of nodes and less mobility, DV's performance is superior. A general observation is that protocol performance is linked closely to the type of MAC protocol used. In conclusion, the design of the routing protocol must take into consideration the features of the lower layer protocols.

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