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Comparative Analysis of Reactive, Proactive and Hybrid Routing Protocols in MANET

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Abstract- **The performance of routing protocols in Mobile Ad hoc network (MANET) always attracts many attentions. As many previous works have shown, routing performance is greatly dependent to the availability and stability of wireless links. Although there are some studies reported to evaluate the performance of routing protocols in MANET, little work is done for the system overall performance, which is generally referred to as the network throughput, delay and network load. MANET is a self organized and self configurable network where the mobile nodes move arbitrarily. Routing is a critical issue in MANET and hence the focus of this paper along with the performance analysis of routing protocols. We compared three routing protocols i.e. AODV, OLSR and GRP. Our simulation tool will be OPNET modeler. The performance of these routing protocols is analyzed by three metrics: delay, network load and throughput. All the three routing protocols are explained in a deep way with metrics. The comparison analysis will be carrying out about these protocols and in the last the conclusion will be presented, that which routing protocol is the best one for mobile ad hoc networks. The final evaluation is presented at the end of this paper.**

***Keywords— MANET, AODV, OLSR,GRP, OPNET,* Routing Protocols.**

1. INTRODUCTION

A MANET [1] is a collection of mobile nodes that can communicate with each other without the use of predefined infrastructure or centralized administration.Since no fixed infrastructure or centralized administration is available, these networks are self-organized and end-to-end communication may require routing information via several intermediate nodes. Nodes can connect each other randomly and forming arbitrary topologies. Each node in MANET acts both as a host and as a router to forward messages for other nodes that are not within the same radio range. The primary challenge in building a Mobile Ad hoc Network is equipping each device to continuously maintain the information required to route traffic.

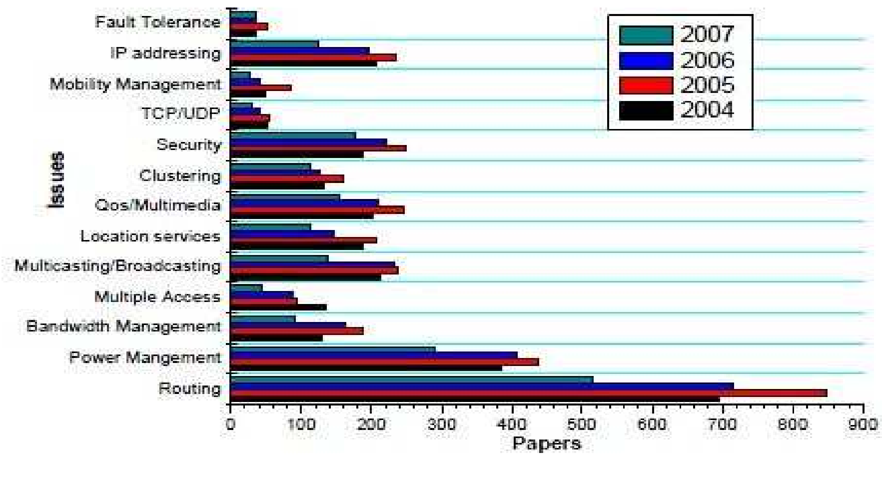

Figure 1. Trends of the MANET research from 2004 to 2007

Routing protocols then provide stable connections even if nodes are moving around. The trends of the papers published in IEEE Xplore [2] and ACM lib between 2004 and 2007 are illustrated in Fig. 1 And it shows that routing algorithms in this area are the hottest topics in the past years due to the fact that existing internet routing protocols were designed to support fixed infrastructure and they are unsuitable for MANETs. More than 4953 papers from 2004 to 2007 were searched using the keyword "ad -hoc networks". The research trends before 2004 can be found in [3].

During these years, there have been many discussions about which type protocols perform better. However, the protocol performance is different based on scenarios and little work is done for the routing strategy overall performance, which is generally referred to as the network throughput, delay and network load.The up to date standardized protocols are classified into three categories: Proactive routing protocols, Reactive routing protocols, Hybrid routing protocols.

In this paper, Proactive routing protocols, Reactive routing protocols, Hybrid routing protocols. Proactive protocols, such as Optimized Link State Routing (OLSR) [4] [5] attempt to monitor the topology of the network in order to have route information between any source and destination available at all time. Proactive Routing Protocols are also called table driven routing protocols as all the routing information is usually kept in tables. Reactive routing protocols such as Ad hoc On Demand Distance Vector (AODV) [6][7], find the route only when there is data to be transmitted and as a result, generate low control traffic and routing overhead. Hybrid protocols such as Gathering-based routing protocol (GRP) [8] could be derived from the two previous ones, containing the advantages of both the protocols, using some quality of one type and enhancing it with the participation of the other one. In this paper we evaluate the performance of a Proactive Routing Protocol (OLSR), a Reactive routing protocol (AODV) and a Hybrid protocol (GRP).

This paper is organized as follows: Section 2 presents overview of Routing protocols in MANETs. Section 3 describes the Simulation Environment studied. Section 4 analyzes results and discussion. Section 5 concludes this paper.

2. ROUTING PROTOCOLS IN MANETS

Routing protocols in MANET [9] [10] are divided into four categories: proactive, reactive and hybrid routing protocols. The most popular ones are AODV, DSR (reactive), OLSR (proactive) and GRP (hybrid).

This section describes the main features of three protocols AODV (Ad Hoc On-Demand Distance Vector Protocol), OLSR (Optimized Link State Routing) and GRP (Gathering-based Routing Protocol) deeply studied using OPNET 14.5. An ad-hoc routing protocol is a convention, or standard, that it improves the scalability of wireless networks compared to infrastructure based wireless networks because of its decentralized nature. Ad-hoc networks are best suited due to minimal configuration and quick operation.

2.1 Ad Hoc On-Demand Distance Vector Protocol (AODV)

AODV [11] is a reactive routing protocol that minimizes the number of broadcasts by creating routes on demand. The AODV algorithm is an improvement of DSDV [12] protocol. It reduces number of broadcast by creating routes on demand basis, as against DSDV that maintains mutes to each known destination. The main advantage of AODV protocol is that routes are established on demand and destination sequence numbers are used to find the latest route to the destination. The source broadcasts a route request (RREQ) packet when it wants to find path to the destination. The neighbors in turn broadcast the packet to their neighbors until it reaches an intermediate node that has recent route information about the destination or until it reaches the destination. When a node forwards a RREQ to its neighbors, it also records in its tables the node from which the first copy of the request came. This information is used to construct the reverse path for the route reply packet (RREP). AODV uses only symmetric links because the RREP follows the reverse path of the RREQ. An important feature of AODV is the maintenance of timer based states in each node, regarding utilization of individual routing table entries. A routing table entry is expired if not used recently. Another distinguishing feature of AODV is the ability to provide unicast, multicast and broadcast communication.

2.2 Optimized Link State Routing (OLSR)

OLSR [13] is a modular proactive hop by hop routing protocol. It is an optimization of pure link state algorithm in ad hoc network. The routes are always immediately available when needed due to its proactive nature. The key concept of the protocol is the use of "multipoint relays" (MPR). Each node selects a set of its neighbor nodes as MPR [8]. Only nodes, selected as such MPRs are responsible for generating and forwarding topology information, intended for diffusion into the entire network. The MPR nodes can be selected in the neighbor of source node. Each node in the network keeps a list of MPR nodes. This MPR selector is obtained from HELLO packets sending between in neighbor nodes. These routes are built before any source node intends to send a message to a specified destination In order to exchange the topological information; the Topology Control (TC) message is broadcasted throughout the network. Each node maintains the routing table in which routes for all available destination nodes are kept. Control traffic in OLSR is exchanged through two different types of messages: "HELLO" and "TC" messages. HELLO messages are exchanged periodically among neighbor nodes, in order to detect links to neighbors, to detect the identity of neighbors and to signal MPR selection. TC messages are periodically flooded to the entire network, in order to signal link-state information to all nodes. The best working environment for OLSR protocol is a dense network, where the most communication is concentrated between a large numbers of nodes.

2.3 Gathering-based Routing Protocol (GRP)

Gathering-based Routing Protocol [14] [15] combines the advantages of Proactive Routing Protocol (PRP) and of Reactive Routing protocol (RRP). PRP are suitable for supporting the delay sensitive data such as voice and video but it consumes a great portion of the network capacity. While RRP is not suitable for real-time communication, the advantage of this approach is it can dramatically reduce routing overhead when a network is relatively static and the active traffic is light. However, the source node has to wait until a route to the destination can be discovered, increasing the response time. The function of Gathering-based Routing Protocol (GRP) for mobile ad hoc network is to gather network information rapidly at a source node without spending a large amount of overheads. It offers an efficient framework that can simultaneously draw on the strengths of Proactive routing protocol (PRP) and reactive routing protocol (RRP) [16] collects network information at a source node at an expense of a small amount of control overheads. The source node can equip promising routes on the basis of the collected information, thereby continuously transmitting data packets even if the current route is disconnected, its results in achieving fast (packet) transfer delay without unduly compromising on (control) overhead performance.

3. Simulation Environment

The simulation mainly focuses on the performance of the routing strategies to react on the different scenarios in MANET [17]. Because the three protocols (AODV, OLSR and GRP) cover different routing strategies mentioned above, we will discuss these routing strategies based on the simulation results of the three protocols. In this paper, we evaluate the performance in terms of network throughput, delay and load.We carried out simulations on Opnet simulator [18] [19].
The simulation parameters are summarized in table 1. Modeler is commercial network simulation environment for network modelling and simulation. It allows the users to design and study communication networks, devices, protocols, and applications with flexibility and scalability.

Table 1: NETWORK PARAMETERS

Statistic	Value
Simulator	OPNET 14.5
Routing Protocols	AODV,OLSR and GRP
802.11 data rate	11 Mbps
Node	75
Scenario Size	3.5*3.5 km
Simulation Time	1800 second

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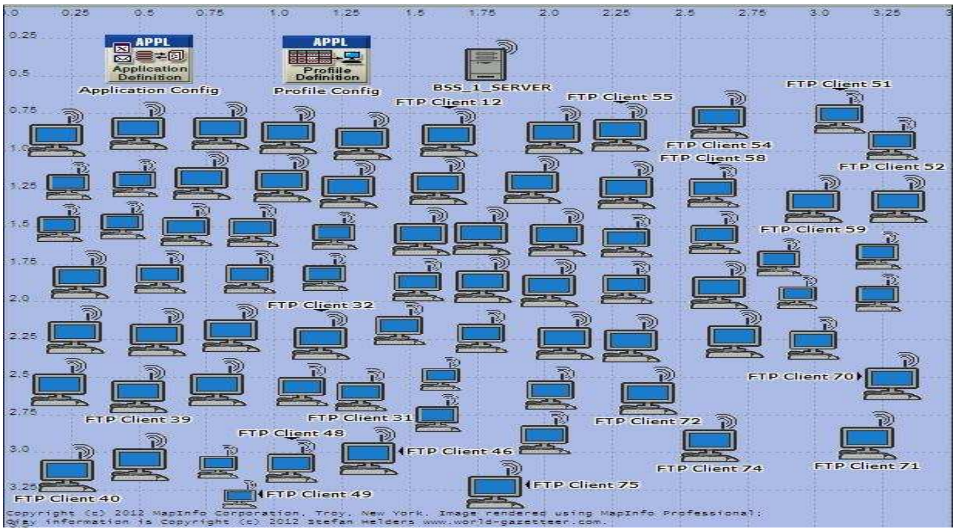

Figure 2: Network Topology Used

Figure 2. Shows a sample network created with 75 Nodes, one static FTP server, application configuration and profile configuration for the network in which FTP has been chosen as an application. Figure 2 depicts a network with 75 fixed nodes whose behaviour has to be analyzed nodes in the network with respect to time to determine the effecting features of each protocol. OPNET modeler 14.5 is used to investigate the performance of routing protocols AODV, OLSR and GRP with varying network sizes, data rates, and network load. We evaluate three parameters in our study on overall network performance. These different types of parameter show the different nature of these Protocols, the parameters are throughput, delay and network load.

3.1 Parameters used in the network

There are different kinds of parameters for the performance evaluation of the routing protocols. These have different behaviours of the overall network performance. We will evaluate three parameters for the comparison of our study on the overall network performance. These parameters are delay, network load, and throughput for protocols evaluation. These parameters are important in the consideration of evaluation of the routing protocols in a communication network. These protocols need to be checked against certain parameters for their performance. To check protocol effectiveness in finding a route towards destination, we will look to the source that how much control messages it sends. It gives the routing protocol internal algorithm's efficiency. If the routing protocol gives much end to end delay so probably this routing protocol is not efficient as compare to the protocol which gives low end to end delay. Similarly a routing protocol offering low network load is called efficient routing protocol. The same is the case with the throughput as it represents the successful deliveries of packets in time. If a protocol shows high throughput so it is the efficient and best protocol than the routing protocol which have low throughput. These parameters have great influence in the selection of an efficient routing protocol in any communication network.

3.1.1 Delay: The packet end-to-end delay is the time of generation of a packet by the source up to the destination reception. So this is the time that a packet takes to go across the network. This time is expressed in sec. Hence all the delays in the network are called packet end-to-end delay, like buffer queues and transmission time. Sometimes this delay can be called as latency; it has the same meaning as delay. Some applications are sensitive to packet delay such as voice is a delay sensitive application. So the voice requires a low average delay in the network. The FTP is tolerant to a certain level of delays. There are different kinds of activities because of which network delay is increased. Packet end-to-end delay is a measure of how sound a routing protocol adapts to the various constraints in the network to give reliability in the routing protocol. We have several kinds of delays which are processing delay (PD), queuing delay (QD), transmission delay (TD) and propagation delay (PD). The queuing delay (QD) is not included, as the network delay has no concern with it. Mathematically it can be shown as equation (1).

$$d_{end-end} = N[d_{trans} + d_{prop} + d_{proc}] \quad (1)$$

Where

dend-end= End to end delay
dtrans = Transmission delay
dprop = Propagating delay
dproc = Processing delay

Suppose if there are n number of nodes, then the total delay can be calculated by taking the average of all the packets, source destination pairs and network configuration.

3.1.2 Network Load: Network load represents the total load in bit/sec submitted to wireless LAN layers by all higher layers in all WLAN nodes of the network. When there is more traffic coming on the network, and it is difficult for the network to handle all this traffic so it is called the network load. The efficient network can easily cope with large traffic coming in, and to make a best network, many techniques have been introduced.

3.1.3 Throughput: Throughput is defined as; the ratio of the total data reaches a receiver from the sender. The time it takes by the receiver to receive the last message is called as throughput. Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec). Some factors affect the throughput as; if there are many topology changes in the network, unreliable communication between nodes, limited bandwidth available and limited energy. A high throughput is absolute choice in every network. Throughput can be represented mathematically as in equation (2);

$$\text{Throughput} = \frac{\text{Number of delivered packet} * \text{Packet size} * 8}{\text{Total duration of simulation}} \qquad (2)$$

4. RESULT ANALYSIS AND DISCUSSION

We carried out simulations on Opnet simulator 14.5. The results show differences in performance between considered routing protocols, which are the consequence of various mechanisms on which protocols are based. We carried out our simulations with 75 nodes. Figures 3,4 and 5 depicts the throughput, delay and network load of this network with respect to total simulation time which is taken as 30 minutes for which the simulation was run.

In this simulation, the network is set to 75 nodes, the traffic is FPT mode, the data transmission rate is 11 Mbps and the simulation time is 30 minutes.

4.1 Delay

The maximum network delay variation for 75 nodes a scenario is shown in respectively figure 3.The network delay of AODV is higher than GRP and OLSR. The delay of OLSR is well enough but AODV also has good delay especially when the number of nodes is more than 300.

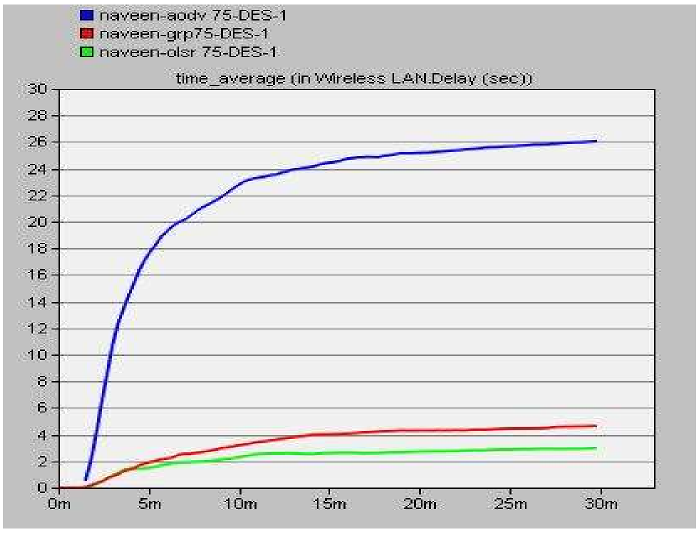

Figure 3: Delay comparison in routing protocols with 75 nodes

We found that OLSR has poor End-to-End delay. So delay of OLSR is less than GRP and AODV .It is because the head of each data packet will carry the routing information which will increase the length of packet and the time delay for Processing and queuing. Therefore, the entire network delay of AODV is significantly longer than OLSR and GRP. GRP has the least End-to-end and MAC delay (for most of the time), but its performance for packet delivery ratio decreases more than other protocols with increasing the number of nodes because of more traffic and congestion.

4.2 Network Load

The maximum network load variation for 75 nodes a scenario is shown in respectively figure 4.The network load of AODV is vary from 0 to 1,150,000 (bits/sec).

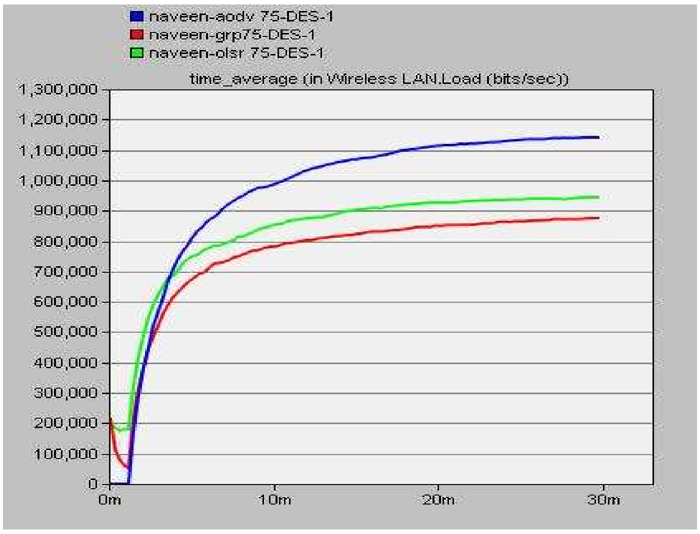

Figure 4: Network Load comparison in routing protocols with 75 nodes

In Fig. 4, we can see that under the GRP, the value of network load start with peak value equal to 200,000 bit/sec and start to decrease for some duration of simulation period and after that start to increase along the simulation period to reach the peak value 870,000 bit/ sec. Under the OLSR, the load begins with its smallest value to 19,000 bit/ sec until the 30 sec of simulation period than start to increase to reach its peak value which is equal to 950,000 bit/sec. The reason is that the routing mechanisms of the three protocols are different in which OLSR is based on purpose-driven, AODV is on-demand and GRP is based on Hybrid source routing.

4.3 Throughput

It is clearly observed from the figure 5 depicts the throughput of the network with 75 nodes. The network throughput for OLSR is better as compared to AODV and GRP.

Throughput is defined as the ratio of the total data reaches a receiver from the sender. The network throughput for various routing protocols i.e. AODV, OLSR and GRP in successful operation of the network without any node failure is shown in Fig. 5. The network throughput as evaluated is maximum for OLSR and least for GRP and throughput of AODV lies between the two.

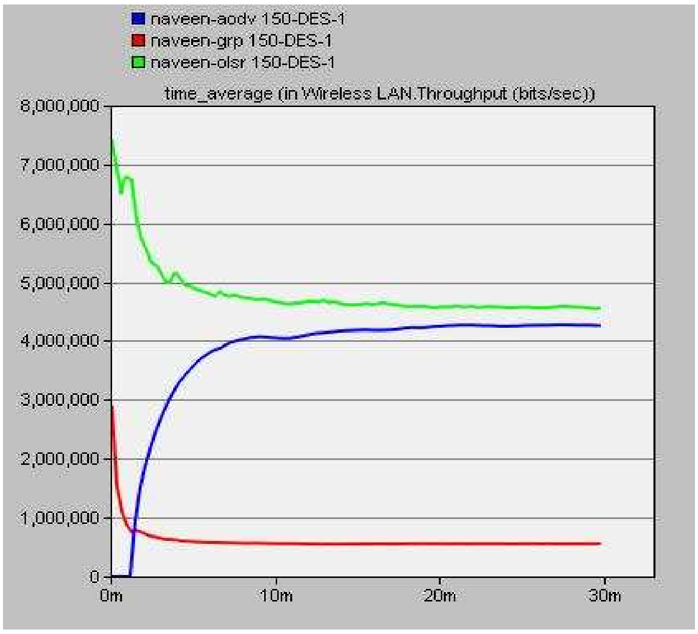

Figure 5: Throughput comparison in routing protocols with 75 nodes

5. CONCLUSIONS

In this paper, we discussed in the three routing protocols (AODV, OLSR and GRP), based on OPNET simulations. Our motive was to check the performance of these three routing protocols in MANET in the above mentioned parameters. The selection of efficient and reliable protocol is a critical issue. In this simulation work we get kinds of results. The study of these routing protocols shows that the OLSR is better in MANET according to our simulation results but it is not necessary that OLSR [20] perform always better in all the networks, its performance may vary by varying the network. At the end we came to the point from our simulation and analytical study that the performance of routing protocols vary with network and selection of accurate routing protocols according to the network, ultimately influence the efficiency of that network in magnificent way.

So proactive protocol OLSR outperforms in terms of throughput and gets the same low delay as OLSR. In future, we will focus on how to get stable and acceptable performance in dynamic ad hoc networks by constructing virtual bone networks using local broadcasting strategy in OLSR.

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