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A QoS-based Measurement of DSR and TORA Reactive Routing Protocols in MANET

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Abstract— **An Ad hoc wireless network is an autonomous system of mobile nodes (associated hosts). For the last manifold, there has been a significant increase of interest in supporting quality of service (QoS) constraints in MANET (Mobile Ad hoc Network). Bestowing, QoS in MANET is a primarily complicated task due to lack of central administration, infrastructure less network, multicasting and variable capacity link effects. The maturity of wireless mobile wireless technologies and the evolution of different applications provide a reason for the introduction of QoS in mobile ad hoc network. The objective of this research is to extend and evaluate proposed routing protocols DSR and TORA in order to judge the QoS routing with respect to the attributes Throughput, Retransmission of Packets and End-to-end delay. In this paper, we make an attempt to compare the performance and efficiency of on-demand reactive routing protocols of MANET. These simulations are carried out using the Opnet 14.5 simulator.**

Index Terms— **DSR, MANET, OPNET, QoS, TORA**

I. Introduction

Mobile ad-hoc networks or "short live" networks control in the nonexistence of permanent infrastructure. Mobile ad hoc network offers quick and horizontal network deployment in conditions where it is not possible otherwise. Ad-hoc is a Latin word, which means "for this or for this only." Mobile ad hoc network is an autonomous system of mobile nodes connected by wireless links; each node operates as an end system and a router for all other nodes in the network. A wireless network is a growing new technology that will allow users to access services and information electronically, irrespective of their geographic position. Wireless networks can be classified in two types: - infrastructure network and infrastructure less (ad hoc) networks. Infrastructure network consists of a network with fixed and wired gateways. A mobile host interacts with a bridge in the network (called base station) within its communication radius [1]. The widely accepted definition of QoS is defined as "the collective effect of service performance which determines satisfaction degree of a service user." Achieving QoS in MANET corresponds to real need and is difficult as compared with traditional wired networks. QoS is essential element in routing which informs source node about successful availability of destination node. QoS guarantees in MANETs are difficulty because of the dynamic network topology, imprecise state information, hidden terminal problem and lack of central administration.

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II. Mobile Ad-hoc Network

A Mobile ad hoc network is a group of wireless mobile computers (or nodes); in which nodes collaborate by forwarding packets for each other to allow them to communicate outside range of direct wireless transmission. Ad-hoc networks require no centralized administration or fixed network infrastructure such as base stations or access points, and can be quickly and inexpensively set up as needed [1]. A MANET is an autonomous group of mobile users that communicate over reasonably slow wireless links. The network topology may vary rapidly and unpredictably over time, because the nodes are mobile. The network is decentralized, where all network activity, including discovering the topology and delivering messages must be executed by the nodes themselves. Hence routing functionality will have to be incorporated into the mobile nodes. MANET is a kind of wireless ad-hoc network and it is a self-configuring network of mobile routers (and associated hosts) connected by wireless links. The union of which forms an arbitrary topology. The routers, the participating nodes act as router, are free to move randomly and manage themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. Mobile ad hoc network is a collection of independent mobile nodes that can communicate to each other via radio waves. The mobile nodes can directly communicate to those nodes that are in radio range of each other, whereas others nodes need the help of intermediate nodes to route their packets. These networks are fully distributed, and can work at any. [2] Mobile ad-hoc networks can turn the dream of getting connected "anywhere and at any time" into reality. Typical application examples include a disaster recovery or a military operation. Not bound to specific situations, these networks may equally show better performance in other places. As an example, we can imagine a group of peoples with laptops, in a business meeting at a place where no network services is present. They can easily network their machines by forming an ad-hoc network. This is one of the many examples where these networks may possibly be used. The wireless users can be connected with the wireless system by the help of these access points, when they roam from one place to the other. The adaptability of wireless systems is limited by the presence of a fixed supporting coordinate. It means that the technology cannot work efficiently in that places where there is no permanent infrastructure.

III. ROUTING PROTOCOLS

Routing protocols for Mobile ad hoc networks can be broadly classified into three main categories:

- *Proactive or table-driven routing protocols*
- *Reactive or on-demand routing protocols.*
- *Hybrid routing protocols*.

A. Proactive or table-driven routing protocols

In proactive routing protocols, each node maintains routing information to every other node (or nodes located in a specific part) in the network. The routing information is usually kept in a number of different tables. These tables are periodically updated and/or if the network topology changes. The difference between these protocols exists in the way the routing information is updated, 1 detected and the type of information kept at each routing table [3]. Furthermore, each routing protocol may maintain different number of tables. Certain proactive routing protocols are Destination Sequenced Distance (DSDV), Wireless Routing Protocol (WRP), Global State Routing (GSR), Fisheye State Routing (FSR), Cluster-head Gateway Switch Routing (CGSR), and Optimized Link State Routing (OLSR).

B. Reactive or on-demand routing protocols

On-demand routing protocols were designed to reduce the overheads in proactive protocols by maintaining information for active routes only. This means that routes are determined and maintained for nodes that require sending data to a particular destination. Route discovery usually occurs by flooding a route request packets through the network. When a node with a route to the destination (or the destination itself) is reached a route reply is sent back to the source node using link reversal if the route request has travelled through bi-directional links or by piggy-backing the route in a route reply packet via flooding. Reactive protocols can be classified into two categories: source routing and hop-by-hop routing. In Source routed on-demand protocols [3], each data packets carry the complete source to destination address. Therefore, each intermediate node forwards these packets according to the information kept in the header of each packet. This means that the intermediate nodes do not need to maintain up-to-date routing information for each active route in order to forward the packet towards the destination. Furthermore, nodes do not need to maintain neighbor connectivity through periodic beaconing messages. The major drawback with source routing protocols is that in large networks they do not perform well. This is due to two main reasons; firstly as the number of intermediate nodes in each route grows, then so does the probability of route failure possible. Certain reactive routing protocols are Temporally Ordered Routing Algorithm (TORA), Light Weight Mobile Routing (LMR), and Associatively Based Routing (ABR).

C. Hybrid routing protocols

Hybrid routing protocols are a new generation of protocol, which are both proactive and reactive in nature. These protocols are designed to increase scalability by allowing nodes with close proximity to work together to form some sort of a backbone to reduce the route discovery overheads. This is mostly achieved by proactively maintaining routes to nearby nodes and determining routes to far away nodes using a route discovery strategy. Most hybrid protocols proposed to date are zone-based, which means that the network is partitioned or seen as a number of zones by each node. This section describes a number of different hybrid routing protocol proposed for MANETs [4].

IV. OVERVIEW OF DSR AND TORA

Every routing protocol has its own merits and demerits, none of them can be claimed as absolutely better than others. We have selected the three reactive routing protocols - DSR and TORA.

D. Dynamic Source Routing (DSR)

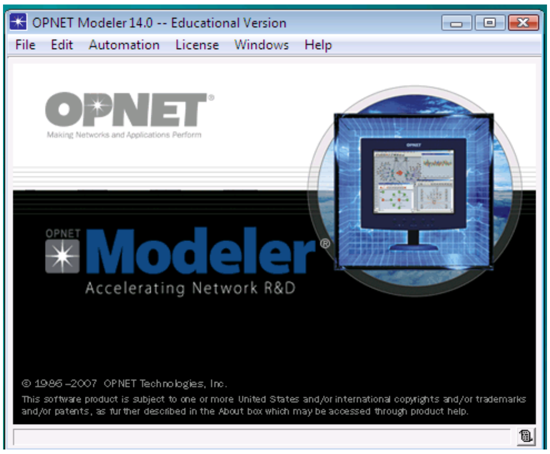
The dynamic source routing is based on the concept of source routing.[6] This means that the protocol will not be very effective in large networks, as the amount of overhead carried in the packet will continue to increase as the network diameter increases. Therefore in highly dynamic and large networks the overhead may consume most of the bandwidth. However, this protocol has a number of advantages over routing protocols such as AODV, LMR and TORA and in small to moderately size networks (perhaps up to a few hundred nodes), this protocol may perform better [7]. The protocol consists of two phases: Route Discovery and Route Maintenance. When a source node A wants to send a packet to a destination node, it first checks if it already has a route to destination node stored in its cache. If the route is not stored, a RREQ (Route Request) packet is broadcast with the address of source node in the route record. The RREQ contains the address of the destination, along with the source node's address and a unique ID number. When a destination node receives the RREQ packet, it then appends its address to the route record and sends back an RREP packet. If symmetric links are supported, the node may reverse the route in the route record. If symmetric links are not supported, the node may initiate its own route discovery and piggyback the RREP and the new RREQ. In the Rote Maintenance phase, if a transmitting node encounters a fatal error or does not receive acknowledgments of the transmitted packets, it generates a Route Error (RERR) packet. It also removes the routes that use this failed link from its cache. Furthermore, nodes between this node and the source remove the routes with the reported failed link from their caches upon receipt of the RERR packet. When the RERR packet makes its way to the source, a new route discovery process may be initiated. An advantage of DSR is that nodes can store multiple routes in their route cache, which means that the source node can check its route cache for a valid route before initiating route discovery, and if a valid route is found there is no need for route discovery. This is very beneficial in network with low mobility. Since they routes stored in the route cache will be valid longer. Another advantage of DSR is that it does not require any periodic beaconing (or hello message exchanges), therefore nodes can enter sleep node to conserve their power. This also saves a considerable amount of bandwidth in the network [8].

E. Temporally Ordered Routing Algorithm (TORA)

The Temporally Ordered Routing Algorithm (TORA) is a highly adaptive, efficient and scalable distributed routing algorithm based on the concept of link reversal [9]. TORA is proposed for highly dynamic mobile, multi-hop wireless networks. It is a source-initiated on-demand routing protocol. It finds multiple routes from a source node to a destination node. The main feature of TORA is that the control messages are localized to a very small set of nodes near the occurrence of a topological change. To achieve this, the nodes maintain routing information about adjacent nodes. The protocol has three basic functions: *Route creation*, *Route maintenance* and *Route erasure*. During the route creation and maintenance phases, nodes use a "height" metric to establish a directed acyclic graph rooted to the destination. Timing is an important factor for this protocol because the "height" metric is dependent on the logical time of a link failure; it assumes all nodes have synchronized clocks. TORA can suffer from unbounded worst-case convergence time for very stressful scenarios [10]. TORA has a unique feature of maintaining multiple routes to the destination so that topological changes do not require any reaction at all. The protocol reacts only when all routes to the destination are lost. In the event of network partitions the protocol is able to detect the partition and erase all invalid routes.

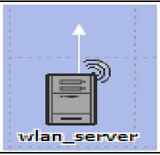
V. SIMULATION PARAMETERS

The Simulations were performed using Opnet 14.0 specifically familiar in the ad hoc networking community. It employs a Discrete Event Simulation approach that allows large numbers of closely-spaced events in a sizable network to be represented accurately and efficiently.



Each sender has constant bit rate/number of stations packet per second. The mobility model uses 'random waypoint model' in a campus network of size 1000m x 1000m with 20 nodes. During the simulation, each node starts its journey from random spot to a random chosen destination. Once the destination is reached, the node takes a rest period of time in second and another random destination is chosen after that pause time. This process repeats throughput the simulation, causing continuous changes in the topology of the underlying network [11]. Different network scenario for different number of nodes and pause times are generated.

Model Name	Application Configuration	Profile Configuration	Mobility Configuration
Quantity Used	1	1	1
Model Icon			

Model Name	Wlan_server(Fixed node)	Wlan_wkstn(Mobile node)
Quantity Used	1	20
Model Icon		

The model parameters that have been used in the following experiments are summarized in Table 2.

TABLE 2: SIMULATION PARAMETERS

PARAMETER	VALUE
Number of nodes	50
Simulation time	10 second
Campus network size	1000m*1000m
Application	Ftp
Start time offset (second)	Constant(0)
Duration	10 second
Mobility model	Random way point
Random way point Speed	30 meter/second
Pause time	300second
Start time	0 second
Simulator	Opnet modeler

VI. PERFORMANCE METRICS

This work focuses on two performance metrics which are quantitatively measured. The performance metrics are important to measure the performance and activities that are running on Opnet simulation. These metrics are:

Throughput- The ratio between the number of packets originated by the 'application layer' CBR sources and the number of packets received by the CBR sink at the final destination. This metric characterizes both the completeness and correctness of the routing protocol by giving its effectiveness.

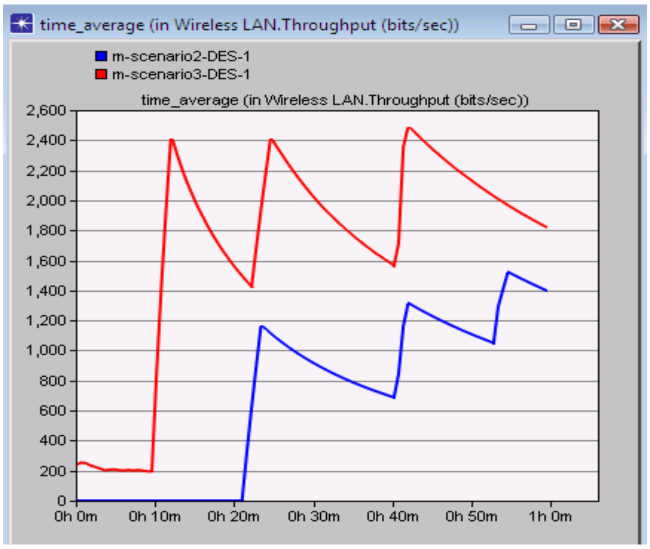
Average end-to-end delay- Average end-to-end delay is an average end-to-end delay of data packets. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance.

VII. Simulation Results

The simulation results are shown below in the form of graphs. Graphs show comparison between the three protocols by varying number of nodes and node speed (m/s)[11].

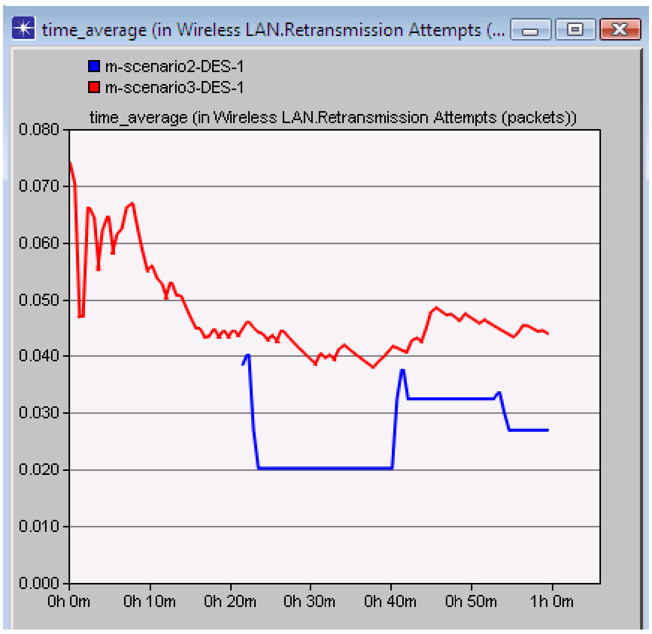
A. Throughput or Packet delivery Fraction (PDF)

Throughput explains the loss rate as seen by the transport layer. From these graphs it is clear that throughput decrease with increase in mobility. As the packet drop at such a high load traffic is much high. DSR drop a significant number of packets during the route discovery phase. As route acquisition takes time proportional to the distance between the source and destination [6].TORA performs better at high mobility but in other cases it shows to have a lower throughput. Buffering of data packets while route discovery in progress, has a great potential of improving DSR and TORA performances.



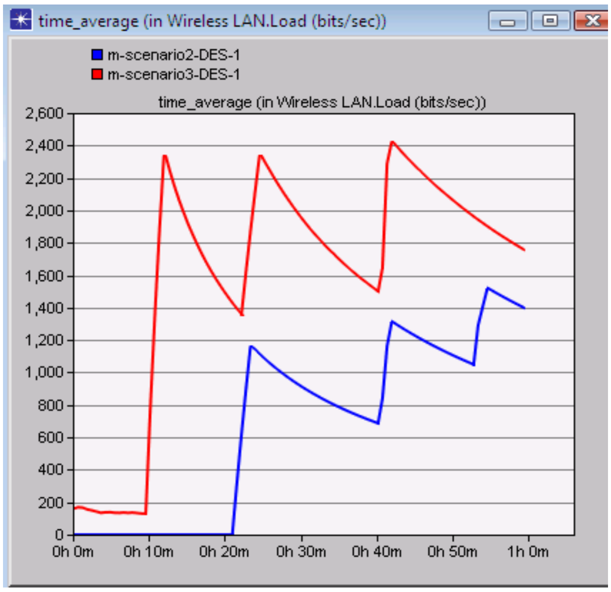
A. Retransmission of Packets

The total number of retransmission attempts by all WLAN MACs in the network until either packet is successfully transmitted or it is discarded as a result of reaching short or long retry limit.



B. End-to-End delay

The delay is affected by high rate of CBR packets as well. While source routing makes route discovery more profitable, it slows down the transmission of packets. DSR show poor delay characteristics as their routes are typically not the shortest. TORA has the worst delay characteristics because of the loss of distance information with progress. While DSR route discovery is fast, therefore shows a better delay performance than the other reactive routing protocols at low pause time.



C. Comparative Analysis

The aim of simulation performance evaluation is a comparison of a MANET between DSR and TORA routing protocols. In our simulation experiment, TORA performs better at high mobility and has a high throughput as compared to DSR. DSR is suitable for network in which mobiles move at moderate speed [12].

TABLE 3: COMPARISON OF THREE ROUTING PROTOCOLS

Metrics	DSR	TORA
Delay	Very good	Worst
Drop Packet	Very good	Good
Throughput	Very good	Worst
Scalability	Good	Best
Routing overhead	Best	Good

VIII. CONCLUSIONS

This paper does the realistic comparison of three routing protocols DSR and TORA. The considerable observation is, simulation results agree with expected results based on theoretical analysis. Mobile ad-hoc networks are wireless networks that use multi-hop instead of static networks infrastructure to provide network connectivity. From the experimental results we conclude that increase in the number of nodes will cause increase in the mean time for loop detection. When pause time increases, it leads to a decrease in the mean end-to-end delay and increase in the density of nodes yields to an increase in the mean end-to-end delay. Overall, DSR suits for networks with moderate mobility rate Whereas TORA is suitable for operation in large mobile networks.

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