Comparison of Ad-hoc Reactive Routing Protocols using OPNET Modeler

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Abstract—**Ad hoc networks are infrastructure less self organizing networks. These networks are referred to as infrastructure less because there is no physical connection between the entities of ad-hoc networks. All the entities in ad-hoc networks communicate with other entities which lie in its radio frequency range. All the mobile nodes in the network dynamically set up paths among themselves to transmit packets temporarily. A Mobile Ad hoc Networking (MANET) is an autonomous system of mobile nodes. Nodes act as a router, client and server as well and its topology is dynamic as nodes join the network whenever there is need to transmit data and leave the network when transmission gets over. These networks do not have a Central Authority (CA) for the management of the network. In recent past, several routing protocols for MANET are being proposed. Some of the prominent and promising among them are Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), Temporally-Ordered Routing Algorithm (TORA) and Destination-Sequenced Distance Vector (DSDV).In this study, various reactive routing protocols such as Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Temporally Ordered Routing Algorithm (TORA), are compared on the basis of their throughput by increasing number of nodes in the network.**

Keywords: MANET; AODV; DSR; TORA; OPNET

I. INTRODUCTION

A Mobile Ad-hoc network (MANET) is a multi hop wireless network formed by a group of mobile node that have wireless capabilities. MANET is a collection of wireless nodes that dynamically create a wireless network among them without any infrastructure. Ad-hoc is a communication mode that allows computers to directly communication with each other without a router. In Latin, ad-hoc means "for this" meaning "for this special purpose". In ad hoc networks, nodes do not start out familiar with the topology of their networks; instead, they have to discover it. The basic idea is that a new node may announce its presence and should listen for announcements broadcast by its neighbors. Each node learns about nodes nearby and Static ad-hoc network the positions of a node may not change once it has become a part of the network. Ex- Rooftop networks. Mobile ad-hoc network is sometimes called a Mobile Mesh Network, is a self configuring N/W of mobile devices connected by wireless links. Each device in a MANET is free to move independently in any direction. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route the traffic. As the network topology is dynamic a routing protocol is needed to support the proper functionality of the network. This paper provides a comparative study through simulation of three routing protocols (DSR, AODV, and TORA) for mobile ad-hoc networks using OPNET modeler.

The main objective of this paper is to create a choice guide for a routing protocol for a given network scenario on the basis of throughput. The simulation is done for three different scenarios.

Paper is organized as follows: Section II briefly describes the routing protocols; section III describes the simulation tool used for this work, section IV talks about simulation environment followed by brief discussion on simulation model in section V and results in section VI with concluding remarks in section VII.

II. AD-HOC ROUTING PROTOCOLS

This section describes the main features of the three protocols AODV, DSR, TORA deeply studied using OPNET. An ad hoc routing protocol is a convention, or standard, that controls how nodes decide which way to route packets between computing devices in a mobile ad-hoc network.

A. On Demand / Reactive Routing Protocol

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 traveled 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, 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

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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. The advantage of this strategy is that routes are adaptable to the dynamically changing environment of MANETs, since each node can update its routing table when they receiver fresher topology information and hence forward the data packets over fresher and better routes. Under this category **D**ynamic Source Routing (DSR) protocol requires each packet to carry the full address (every hop in the route), from source to the destination. **A**d hoc On-demand Distance Vector (AODV) routing protocol is based on DSDV and DSR algorithm. It uses the periodic beaconing and sequence numbering procedure of DSDV and a similar route discovery procedure as in DSR. **T**emporally Ordered Routing Algorithm (TORA) routing protocol is based on the LMR protocol. It uses similar link reversal and route repair procedure as in LMR, and also the creation of a DAGs. Following section describes them briefly:

1) Ad-hoc on demand distance vector (AODV)

AODV [1] is an reactive (On-demand routing protocol) with small delay. Since it is an "On-demand" routing protocol, the routes are established only when needed to reduce traffic load. AODV supports the Unicast, Broadcast and Multicast scheme.The Count-To-Infinity and loop problem is solved with sequence numbers and the registration of the costs. In AODV every hop has the constant cost of one. The routes age very quickly in order to accommodate the movement of the mobile nodes. Link breakages can locally be repaired very efficiently. AODV is a modification of the DSDV algorithm. When a source node desires to establish communication session, it initiates a path-discovery process to locate the other node. 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 connection setup delay is less. The HELLO messages supporting the routes maintenance are range-limited, so they do not cause unnecessary overhead in the network.

2) Dynamic Source Routing (DSR)

The Dynamic Source Routing protocol (DSR) [2] is a simple and efficient routing protocol designed specifically for use in multi-hop wireless Ad- hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network. 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. 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.

3) Temporally Ordered Routing Algorithm (TORA)

A distributed routing protocol for mobile, multi hop, wireless networks is presented. This protocol is a type of "link reversal" algorithms which is highly adaptive, efficient and scalable and best suited for dense networks. This protocol uses a synchronized physical or logical clock and is called as Temporally Ordered Routing Algorithm (TORA). One of the advantages of TORA is its support for multiple routes another advantage of TORA is its support for its support for multiple routes. Although, unlike AODV, TORA does not incorporate multicast into its basic operation, it functions as the Lightweight Adaptive Multicast Algorithm (LAM), and together the two protocols provide multicast capability.
The Temporally-Ordered Routing Algorithm (TORA) is a reactive routing protocol that establishes route quickly. TORA possesses the following attributes:

* Loop-free routes
* Provide minimal routing functionality
* Minimize algorithm reaction
* Multipath routing

TORA creates a direct acyclic graph with the destination as the head of the graph. It requires IMEP (Internet MANET encapsulation protocol)-guarantees reliable in-order delivery of routing message. Each node keeps a reference value and the height of reference destination. Query packets are sent out until on reaches the destination or a node with a route to the destination. This node sends an updates to its neighbors listing its height for that destination. TORA is designed to minimize the communication overhead associated with adapting to network topological changes. The scope of TORA's control messaging is typically localized to a very small set of nodes near a topological change.

III. OPNET Modeler

OPNET Modeler is commercial network simulation environment for network modeling and simulation. It allows the users to design and study communication networks, devices, protocols, and applications with flexibility and scalability. It simulates the network graphically and gives the graphical structure of actual networks and network components. The users can design the network model visually. The modeler uses object-oriented modeling approach. The nodes and protocols are modeled as classes with inheritance and specialization. The development language is C. It provides a variety of toolboxes to design, simulate and analyze a network topology, routing protocols on the basis of various network parameters. MANET toolbox has been used in this work to simulate the network. Components used for designing of the network are MANET_Station (mobile), application configuration which decides the type of application running in the network, profile configuration for configuring the type of profile on the network. In profile configuration start time and stop time of the application can be set and pause time between the nodes is set. Mobility configuration will decide the mobility model of every node which is selected as random waypoint for this simulation. Attributes of workstation will set the routing protocol used for the simulation.

IV. Simulation Environment

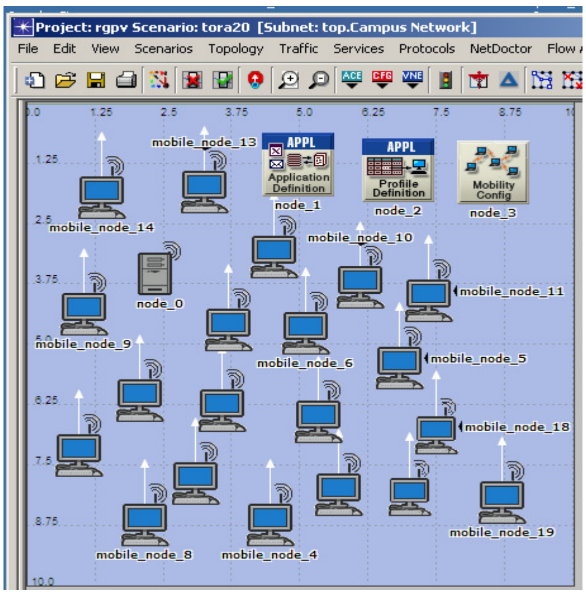

Figure. 1 MANET Scenario

All scenarios have been modeled and evaluated using OPNET [4][5] Figure 1. shows a sample network created with 20 nodes, one static FTP server, application configuration for the network in which FTP (File Transfer Protocol has been chosen) as an application.

Figure 1 depicts a network with 20 mobile nodes whose behavior has to be analyzed when nodes move in the network with respect to time to determine the effecting features of each protocol. In order to evaluate the performance of a generic scenario in ad-hoc networking, when analyzing mobile networks, modeling the movement of the set of nodes forming a MANET is essential. Random waypoint model [6] of mobility has been studied. The Random Waypoint model has been selected to be used in all simulations presented in this document. Using Random Waypoint model, nodes go moving until they arrive at a random destination calculated by the algorithm. Once there, they get still for a period of time, called the pause interval. Once passed the pause interval, a new movement is calculated by the algorithm, with a random direction and speed.

V. Simulation Model

Main characteristics of the scenarios maintained are depicted in the Table 1.

TABLE 1
MAIN CHARACTERISTIS OF SCENARIO

Statistic	**Value**
Scenario Size	**10kmx10km**
Simulation Time	**1 hour**
Nodes	**5,10,20**
802.11 data rate	**11mbps**

A. Traffic Modeling

Our simulation environment consist of 5, 10 and 20 wireless nodes in three different scenarios forming an ad-hoc network, moving in the proximity over about 10 x 10 Kilometer flat space for about 1 hour of simulated time.

B. Performance Matrices

The parameters on basis of which the protocols are evaluated are the default parameter of the protocols. There are number of metrics on the basis of which one can compare between these three protocols. In this work throughput has been used for simulation design and analysis purpose.

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 [7]. 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 [7]. A high throughput is absolute choice in every network. Throughput can be represented mathematically as in equation given below:

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

VI. Results

Figures 2,3 and 4 depicts the throughput of a network with respect to total simulation time which is taken as 1 hour for which the simulation was run. The number of nodes in the network are taken as 5,10 and 20 respectively. In the graphs, simulation time is taken on X-axis and number of packets in bits/sec are taken on Y-axis. The graphs are shown in the time average form.

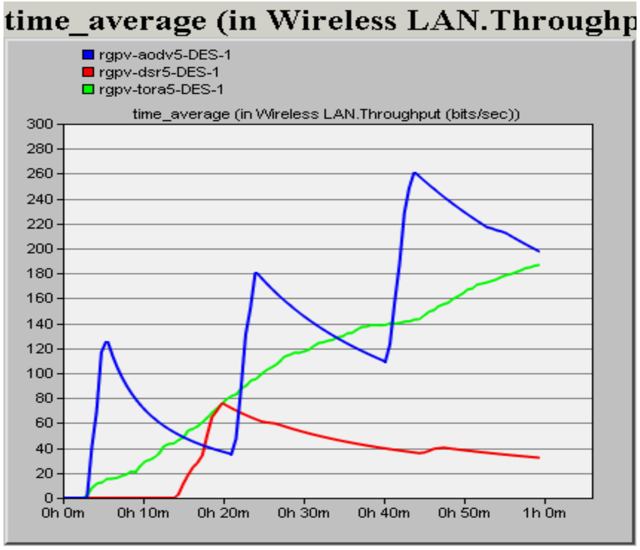

Figure .2 Simulation time v/s throughput (nodes=5)

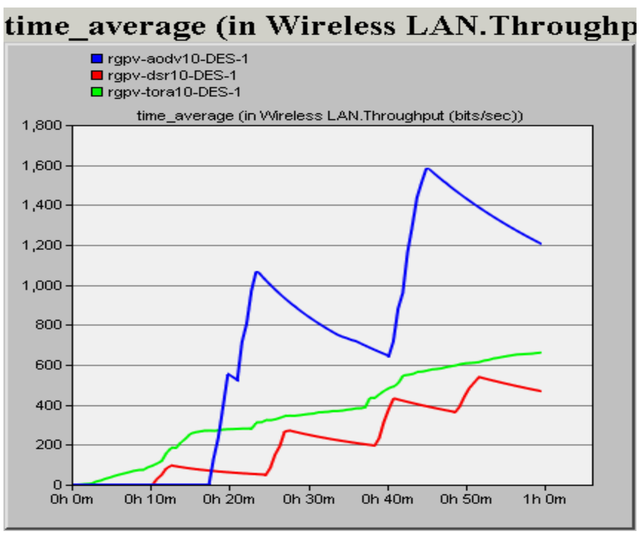

Figure .3 Simulation time v/s throughput (nodes=10)

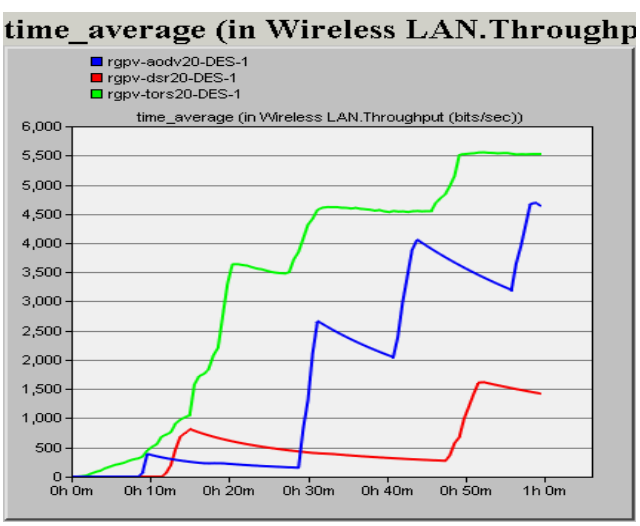

Figure .4 Simulation time v/s throughput (nodes=20)

VII. Conclusion

The simulation study of our work consisted of three routing protocols AODV, DSR and TORA deployed over MANET using FTP traffic analyzing their behavior with respect to throughput. Motive of doing this simulation was to check the performance of these three routing protocols in MANET in the above mentioned parameter. The selection of efficient and reliable protocol is a critical issue. From the above analysis of routing protocols, the AODV outperforms the two DSR and TORA protocols in terms of throughput in 5 mobile nodes. In 10 mobile nodes again the AODV perform well than DSR and TORA in throughput. In 20 mobile nodes TORA shows good results throughput than AODV and DSR respectively. By comparing AODV and DSR the results in the entire figures 2, 3, and 4, it can be seen that TORA and AODV perform well than DSR in throughput.

As seen in figure 2, 3, and 4 the throughput of AODV increases sharply up to a certain level and decreases abruptly for some time and then increases again showing spikes. This is because initially it takes a bit of time to discover the route and then start sending the packets. Since it does not have multiple entries in its routing table, AODV has to do the route discovery at regular intervals. As the numbers of nodes are increased the throughput of AODV also increases. In case of DSR, initially it takes much time as it has to make multiple entries of routes gathered after route discovery in its routing table. After route discovery its throughput increases uniformly but less then AODV and TORA. In case of TORA, the throughput increases continuously. TORA makes a Direct Allocation Graph (DAG) of all the nodes then start sending packets. TORA does not engage in the route discovery as it already has a DAG of all the nodes in the network. The throughput of TORA increases with increase in number of nodes. So according to the results, performance of TORA is better for dense networks. The AODV is better for moderately dense networks where as the DSR performs well in sparse networks.

The study of these routing protocols shows that the TORA performs better than AODV and DSR when the numbers of nodes are increased in a network according to our simulation results but it is not necessary that TORA 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.

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