RESEARCH PLAN PROPOSAL

Enhancement in features of Open Source Simulator for a Unified Analysis of Proactive, Reactive and Hybrid Routing Protocols of Mobile Ad Hoc Network

For registration to the degree of
Doctor of Philosophy

IN THE FACULTY OF SCIENCE

THE IIS UNIVERSITY, JAIPUR

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Enrollment No.:- ICG/2010/11476

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April 2011

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1. Introduction

Mobility, in the last two decades has experienced a transition towards mobility in the form of mobile devices, like cell phones initially, and hand-held computers and smart-phones later. These trends are going to increase in the following years, resulting in a huge mobile computing community. A **mobile ad hoc network** (**MANET**), sometimes called a mobile mesh network, is a self-configuring network of mobile devices connected by wireless links [Krag (2004)]. A tech term Computer dictionary gives definition for "Mobile Ad Hoc Network", *A MANET is a type of ad hoc network that can change locations and configure itself on the fly.* Because MANETS are mobile, they use wireless connections to connect to various networks. This can be a standard Wi-Fi connection, or another medium, such as a cellular or satellite transmission. Some MANETs are restricted to a local area of wireless devices (such as a group of laptop computers), while others may be connected to the Internet. For example, A VANET (Vehicular Ad Hoc Network), is a type of MANET that allows vehicles to communicate with roadside equipment. While the vehicles may not have a direct Internet connection, the wireless roadside equipment may be connected to the Internet, allowing data from the vehicles to be sent over the Internet. The vehicle data may be used to measure traffic conditions or keep track of trucking fleets. Mobile ad hoc network (MANET) is an autonomous system of mobile nodes connected by wireless links. Each node operates not only as an end system, but also as a router to forward packets. The nodes are free to move about and organize themselves into a network. These nodes change position frequently. MANET does not require any fixed infrastructure, such as a base station, therefore, it is an attractive option for connecting devices quickly and spontaneous. Mobile Ad Hoc Networks (MANETs) provide communication between all nodes in the network topology without the presence of a centralized authority; instead all nodes can function as routers. This gives the MANETs two of its most desirable characteristics; adaptable and quick to deploy. Routing protocols in MANETs are either based on the link-state (LS) routing algorithm or on the distance-vector (DV) routing-algorithm. Common for both of these algorithms is that they try to find the shortest path from the source node to the destination node. The main difference is that in LS based routing a global network topology is maintained in every node of the network. In DV based routing the nodes only maintain information of and exchange information with their adjacency nodes. Keeping track of many other nodes in a MANET may produce overhead, especially when the network is large. The IETF MANET Working Group has researched and developed a number of protocols for mobile ad-hoc networks, which have been described in [Perkins & Bhagwat (1994)], [Murthy et.al. (1995)], [Chiang et. Al. (1997)], [Zygmunt (1997)], [Broch et. Al. (1998)], [Perkins et. Al. (1999)],[Pei et.al. (2000)],[Gerla et. Al. (2001)],[Park & Corson (2001)],[Zygmunt et.al. (2002)] and [Bellur et. Al (2004)].

MANET routing protocols fall into two general categories**:** 1) Proactive routing protocols, 2) Reactive routing protocols. Proactive MANET protocols are table-driven and will actively determine the layout of the network. Through a regular exchange of network topology packets between the nodes of the network, a complete picture of the network is maintained at every single node. There is hence minimal delay in determining the route to be taken. Thus, proactive MANET protocols work best in networks that have low node mobility or where the nodes transmit data frequently. Examples of Proactive MANET Protocols include:

- Optimized Link State Routing, or OLSR
- Topology Broadcast based on Reverse Path Forwarding, or TBRPF [Bellur et.al. (2004)]
- Fish eye state routing or FSR[Pei et.al.(2000)]
- Destination –Sequenced Distance Vector or DSDV[Perkins & Bhagwat (1994)]

- Landmark Routing Protocols or LANMAR [Gerla et. Al. (2001)]
- Cluster head gateway Switch Routing Protocol or CGSR [Chiang et. Al. (1997)]

On-demand routing is a popular routing category for wireless ad hoc routing. It is a relatively new routing philosophy that provides a scalable solution to relatively large network topologies. The design follows the idea that each node tries to reduce routing overhead by only sending routing packets when communication is requested. Common for most on-demand routing protocols are the route discovery phase where packets are flooded into the network in search of an optimal path to the destination node in the network. There exist numerous on-demand routing protocols, but only two of them is significantly more important. These are Ad Hoc On-Demand Distance Vector Routing (AODV) [Perkins et.al.(1999)] and Dynamic Source Routing (DSR)[Broch et. Al.(1998)]. Examples of Reactive MANET Protocols include:-

- Ad Hoc On- Demand Distance Vector or AODV [Perkins et.al.(1999)]
- Dynamic Source Routing, or DSR [Broch et. Al.(1998)]
- Temporally Ordered Routing Algorithm, or TORA[Park & Corson (2001)]

Since proactive and Reactive protocols each work in different scenarios, so hybrid routing protocols develop, which use a mix of both proactive and reactive routing protocols. The basic idea behind hybrid routing protocols is to use proactive routing mechanism in small areas to reduce overheads and delays and reactive routing for the rest of the network. Example of Hybrid Routing Protocols include:-

- Cornell's Zone Routing Protocol (ZRP)[Zygmunt (1997)],[Zygmunt et. Al.(2002)]
- Wireless Ad Hoc Routing Protocol(WARP)[Murthy et.al.(1995)]

Mobile nodes in Wireless ad-hoc network need to operate as routers in order to maintain the information about network connectivity as there is no centralized infrastructure, therefore, Routing Protocols are required which could adapt dynamically to the changing topologies and works at low data rates. As a result, there arises a need for the comprehensive performance evaluation of the ad-hoc routing protocols in same framework to understand their comparative merits and suitability for deployment in different scenarios.

2. Review of Literature

Parameter zing and comparing the performance of routing protocols analytically is a very complex problem. Characterization and comparison of routing protocols have been limited to simulation based approaches, under various configurations. The performance evaluation metrics used in these simulations or experimental based approaches include packet delivery ratio, delay and throughput. Network configurations vary on traffic pattern, mobility and network density.

Certain analytical study on routing overhead has been carried out Jeya Kumar et.al. (2009) present evaluation of routing protocol on the basis of mobility model. The most widely used ad hoc routing protocols are Ad-hoc On-Demand Distance Vector Routing (AODV), Destination Sequenced Distance Vector (DSDV), Dynamic Source Routing (DSR) and Temporally – Ordered Routing Algorithm (TORA). Evaluation is based on mobility models such as random waypoint, random walk and random directions. The two different parameter constraints like packet-delivery fraction and end-to end packet delivery delay are compared with respect to mobility speed, traffic and network size. The simulation results shows that the AODV protocols in Random Waypoint mobility model performs better than DSDV, TORA and DSR in Random walk and random Direction mobility model.

Johansson Per et. al. (1999) presents an evaluation of three routing protocols Destination Sequenced Distance Vector (DSDV), Ad-hoc On-demand Distance Vector (AODV) and

Dynamic Source Routing (DSR) on the Random Scenario and Realistic Scenario. Extensive simulations are made on a scenario where nodes move randomly. They also simulate on the basis of delay and throughput to measure the traffic load. They created a three network scenarios i.e. Conference, Event Coverage and Disaster Areas and analysis them. They have made use of Network Simulator (ns2).

Al-Maashri et. al. (2006) present a number of measurement studies that demonstrated the network traffic which exhibit a self-similar nature, which has a considerable impact on queuing performance. This paper evaluates the performance of three well known routing protocols, DSR, AODV and OLSR, in the presence of the busty self-similar traffic. Different performance aspects are investigated including delivery ratio, routing overhead, throughput and end-to- end delay over CBR, pareto and exponential traffic mode.

Romdhani Lamia et. al. (2007), demonstrate the importance of considering energy saving in MANETs. Analysis are based on the comparison of two energy-based mechanisms called EAODV [Romdhani & Bonnet (2004)] an energy consumption rate-based routing protocol, and FAODV a cross-layer-based routing protocol[Romdhani & Bonnet (2006)]. They proposed a new approach that aims to in-corporate energy-related metrics in the decision of determining the optimal route between each pair of wireless devices. A new framework to compute a novel metric called energy-consumption rate which reflects how fast a node is consuming its remaining energy. F-AODV is a cross-layer forwarding strategy, which is based on the cooperation between MAC and routing protocol [Romdhani (2006)]. The proposal aims to minimize the number of Forwarding Nodes (FN) by hop, in the network. By this way, they decrease the contention amount and we improve the medium utilization. The objective of the simulations was to compare the performance of F-AODV and E-AODV, and the basic AODV protocol. Aim to evaluate the benefits of considering inter-layer cooperation and adaptation using several network scenarios. Simulation is measured on several significant metrics for MANETs: Packet Delivery Ratio (PDR), Routing Overhead (RO), Average Delay (AD), and Route Error Rate (RER).

Valentina T. et al.(2009) considers performance of mobile ad hoc network (MANET) routing protocols with respect to group and entity mobility models. The three widely used routing protocols have been investigated and compared: Destination Sequenced Distance Vector (DSDV), Ad-hoc On-demand Distance Vector (AODV) and Dynamic Source Routing (DSR). Entity Mobility models encompass: Random Waypoint (RW), Gauss-Markov (GM) and Manhattan Grid (MG) and Group Mobility Model encompass: Reference Point Group Mobility (RPGM). Simulations have been carried out using Network Simulator version 2 (NS2) and its associated tools for animation and analysis of results. Parameters of the investigation are Packet Delivery Fraction (pdf), Average end-to-end delay, Routing Protocol Overhead.

Kumar Mukesh et. al.(2010) focuses on the three popular routing algorithms Ad-Hoc on Demand Distance Vector (AODV), Dynamic Source Routing (DSR) both in reactive routing protocols and Cluster Based Routing Protocol (CBRP), a proactive routing protocol. The performance analysis is done with the help of packet delivery ratio (PDR), average end-to-end delay and routing overhead through simulation using GLOMOSIM simulator. CBR is the Traffic sources. Random waypoint model is one of the mobility models which are used for the scenario. To evaluate QoS parameters performance for IEEE 802.11 using different reactive routing.

Bertocchi et al. (2003) performed a comparison of link state, AODV and DSR protocols for two different traffic classes i.e., CBR and Poisson. For this they are used SAM (Simple Ad-hoc simulator). It is a modular cross platform event driven network simulator for ad-hoc network, written in C and developed by University of Ferrara. It simulate a channel with path loss, shadowing and fading with radio transmission having two Mac layers(CSMA and

IEEE802.11)with traffic CBR and Poisson. In order to compare routing protocols performance metrics are, Packet delivery fraction, throughput, average delay and energy per byte. In fixed node Ad hoc network, reactive protocol like AODV, DSR are better choice, if network load is moderate, they can save more energy compared to proactive protocol like link state. All protocol behaves in the same manner in delivery packet percentage, throughput and delays.

Das.R.samir et.al.(1998) evaluate several routing protocols for mobile wireless, ad hoc networks via packet level simulation. Protocol suite include routing protocols specifically designed for ad-hoc routing as well as traditional protocols such as link state and distance vector used for dynamic networks. These all are evaluated with respect to fraction of packet delivered, end-to-end delay and routing load for a traffic and mobility model. A discrete event, packet level routing simulator called MaRS(Maryland Routing Simulator) used for comparative performance evaluation.

Viennot et al.(2004) proposes a general parameterized model for analyzing protocol control overhead in mobile ad hoc networks. A probabilistic model for the network topology and the data traffic is proposed in order to estimate overhead due to control packet of routing protocols. Analytical model is validated by comparison with simulator ns-2. In this model, linearity of control overhead with regard to mobility. For this network parameters are number of nodes, numbers of edges, average degree of a node, link breakage rate and traffic parameters are route creation rate per node and number of active routes per nodes. A comparison between proactive and reactive routing protocols in control traffic overhead in fixed network and due to mobility. For these analyses we conclude among the reactive protocols, AODV generate more control traffic than DSR, high data traffic favor OLSR and for low data traffic DSR are better choice.

Zhouand Abouzeid et. al.(2003) proposes a mathematical and simulative frame work for quantifying the overhead of reactive routing protocols. Ns-2 simulator was used in which five networks of different sizes were considered. Here focus was on situation where topology changes because of node failure rather than node movements. They analyzed mathematically characterize the scalability properties of these protocols under different traffic patterns. For interdependence between traffic pattern and routing overhead by deriving quantitative measure. Manhattan grid model was used which has a discrete and regular topology with fixed degree per node. They designed two models regular and random. Regular grid is an abstraction of regular networks where we can control or assign the location and wireless coverage of nodes. Random topology is an abstraction of irregular and random network where we can not control and assign the location of the nodes.

Jacquet et. al. (1999) analyzed the performance of reactive and proactive routing protocols in random graph model. Reactive and proactive protocols needs to compare the overhead due to route discovery and route non-optimality with the overhead caused by periodic control traffic. Reactive protocol DSR is analyzed and checks the impact of route non-optimality and asymmetry in reactive protocols. Potential of flooding and optimization is analyzed in proactive protocols. Performance evaluation is completely based on a analytical methods (i.e. Generating function, asymptotic expansion) and does not rely on simulation software.

Broch et al. (1998) provide a realistic, quantitative analysis comparing the performance of a variety of multi-hop wireless ad hoc network routing protocols. Like DSDV, TORA DSR and AODV. They used ns-2 which includes node mobility, and realistic physical layer (including a radio propagation model supporting delay, capture effects and carrier sense) and radio network interfaces (include transmission power, antenna gain and receiver sensitivity) and IEEE802.11 medium access control protocol using DCF. These all protocols are analyzed on the basis of packet delivery ratio, routing overhead and path optimality. Each of the protocol performs well in some cases, yet has certain drawbacks in other. DSDV delivering virtually all data packets when node mobility rate and movement speed are low and failing to converge as node mobility increases. TORA although the worst performer in experiment in terms of routing packet overheads. DSR was very good at all mobility rates and movement speeds. Although its use of source routing increases the number of routing overhead bytes required by the protocols. AODV performs almost as well as DSR at all mobility rates and movement speeds and accomplishes it goal of eliminating source routing overhead, but it requires the transmission of many routing overhead packets at high rates of nodes mobility is actually more expensive than DSR.

3. Motivation / Justification and Relevance Proposed Area

A significant number of research efforts have been devoted to investigate Mobile Ad Hoc Networks (MANETs) over the past few years [Borch et.al.(1998)],[Das et. Al.(2001)],[Camp et.al. (2002)],[Lee et. Al.(2003)]. Interest in MANETs is due to their promising ubiquitous connectivity beyond that is currently being provided by the Internet.

- Firstly, MANETs are easily deployed allowing a plug-and-communicate method of networking.
- Secondly, MANETs need no infrastructure. Eliminating the need for an infrastructure reduces the cost for establishing the network. Moreover, such networks can be useful in disaster recovery where there is not enough time or resources to install and configure an infrastructure.
- Thirdly, MANETs also do not need central management. Hence, they are used in military operations where units are moving around the battle field and a central unit can not be used for synchronization. Nodes forming and Ad Hoc network are required to have the ability to double up as a client, a server, and a router simultaneously. Moreover, these nodes should also have the ability to connect to and automatically configure to start transmitting data over the network. It is impractical to expect a MANET to be fully connected, where a node can directly communicate with every other node in the network. Typically, nodes are obliged to use a multi-hop path for transmission, and a packet may pass through multiple nodes before being delivered to its intended destination.
- Networks using ad hoc configuration concepts can be used in many military applications, ranging from interconnected wireless access points to networks of wireless devices carried by individuals e.g. digital maps, sensors attached to the body, voice communication etc.

Different MANET applications have different needs and hence the various MANET routing protocols may be suitable in different areas. The size of the network and the frequency of the change in topology are factors that affect the choice of the protocols. There is no best protocol for all applications. There is still ongoing research on mobile ad hoc networks. Though many routing protocols have already been proposed and well-accepted in the research community because of their given promise and performance. These proactive and reactive routing schemes for MANETs have relative advantages and disadvantages, comparing the two are important. Significant work has been conducted to evaluate and compare these protocols under network profiles of various mobility and traffic configurations. Such performance comparisons have been mostly conducted via discrete-event simulations. (NS 3)Discrete-event network simulation is a powerful research tool for investigating protocol design, protocol interactions, and large-scale performance issues. While simulation is not the only tool used for data networking research, it is extremely useful because it often allows research questions and prototypes to be explored at many orders-ofmagnitude less cost and time than that required to experiment with real implementations and networks.

4. Objectives

Even though many protocols have been proposed, their comparative performance is not well understood. The main objectives of the proposed research are:-

- Upgrading the open source simulator for unified analysis of proactive, reactive and hybrid routing protocol,
- To acquire the detail understanding of ad-hoc routing protocols,
- To implement the mobility model i.e. random walk, random waypoint and random directions etc...or traffic model for simulation,
- To analyze the routing protocols behavior using varying node mobility and different parameters like packet delivery ratio, routing overhead, throughput, average end-to-end delay and path optimality by focusing on different scenario,
- To compare performance of different routing protocols and find out the most adaptive and efficient routing protocol for the highly dynamic topology in ad-hoc networks.

The main interest of the proposed plan is to test the ability of different routing protocols to react on network topology changes (for instance link breaks, node movement, and so on). Furthermore the focus was set on different network sizes, varying number of nodes and area sizes.

5. Plan of Work and Methodology

A plan of work describing the various aspects of the study in a logical sequence along with the methodologies to be employed, are the most important aspects of any research plan.

5.1 Experimental Techniques / Mobility Model or Process & Methods

Nodes in the simulation move according to the Mobility model or Traffic Model. Each node begins the simulation by remaining stationary for pause time seconds. It then selects a random destination in the rectangle space and moves to that destination at a speed distributed uniformly between 0 and some maximum speed. Upon reaching the destination, the node pauses again for Pause time seconds, selects another destination, and proceeds there as previously described, repeating this behavior for the duration of the simulation. Each simulation ran for N seconds of simulated time.

We proposed to run simulations with movement patterns generated for different pause times; a pause time of 0 seconds corresponds to continuous motion and pause time of N (the total time of the simulation) corresponds to no motion. If nodes are constantly moving, it putting stress on the routing protocols. The node chooses a direction, speed and distance of movement based on a pre defined distribution and then computes its next position and the time of reaching the destination.

5.2 Virtual Physical Characteristics of Simulation/ Simulation Characteristics / Data Analysis Tools

A simple workload model is used. Channel bandwidth of 2 Mbits/sec. Since no multiple-access contention or interference is modeled, each link essentially use the entire channel bandwidth while transmitting packets. In the simulation model, a packet can be uni-cast or broadcast. Broadcast transmissions are modeled as a sequence of uni-cast transmissions on all active links of a node, data packets are always uni-cast routing packets can be broadcast or uni-cast depending on the protocols requirement.

All nodes are assumed to have adequate buffer capacity for buffering packets awaiting forwarding. Data packets are processed (includes parsing the header, consulting the routing table or cache and adding the packet to the appropriate outgoing packet queue) in parallel. Data packets processing costs are fixed (1ms). Routing packets have higher priority over data packets in the node's outgoing packet queue. Routing packets are processed sequentially. Routing packet

Processing cost and routing packet sizes depend on the routing protocols being used.

Traffic source is to be CBR and packet sizes of 64 and 512 bytes. There is no acknowledgement or flow or congestion control in the workload model. Flow or congestion control mechanisms will be influenced by the routing dynamics and thus will change the load on the network. It is not clear how it will affect performance metrics. Workload traffic is always between a pair of source and sinks nodes.

5.3 Performance Metrics / Validation based on

In comparing the protocols, evaluation between them is done according to the following metrics:-

1) Packet delivery ratio: - the ratio between the number of packets delivered to the destination and the number of data packets sent by the sender. This will give us an idea of how well the protocol is performing in terms of packet delivery at different speeds using different traffic models.
2) Routing Overhead: - the total number of routing packets transmitted during the simulation. For packet sent over multiple hops, each transmission of packet (each hop0 counts as one transmission. It is important metric for comparing the protocols, as it measures the scalability of a protocol, the degree to which it will function in congested or low bandwidth environments, and its efficiency in terms of consuming node battery power.
3) Throughput (messages/second):- total number of delivered data packets divided by the total duration of simulation time. It analyzes the throughput of the protocol in terms of messages delivered per one second.
4) Average end-to-end delay (seconds):- the average time it takes a data packet to reach the destination. It is calculated by subtracting the time at which first packet was transmitted by source from the time at which first data packet arrived to the destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times.
5) Path Optimality: - the difference between the number of hops a packet took to reach its destination and the length of the shortest path that physically existed through the network when the packet was originated. It measures the ability of the routing protocol to efficiently use network resources by selecting the shortest path from a source to a destination.

5.4 Work Plan

Plan of work will be flow in this manner:-

1. Detail study of Proactive, Reactive and Hybrid Routing Protocols,
2. Network Simulator: - Study of its characteristics and coding schemes,
3. Comparison of Proactive, Reactive and Hybrid Routing protocols on simulator with different parameters,
4. Summarizing the result of comparison,
5. Drawing conclusion,
6. References, Bibliography.

6. Place of Work and Facilities Available

In order to complete the proposed research, simulations will be carried out on network simulator version 3.10 or 3. Hardware and operating system configuration for performing simulations is Processor Pentium 4, CPU 1.8 GHz, RAM 512 MB, Operating System Linux , Simulator ns3.10, in ICG college, THE IIS University, Jaipur, Rajasthan. If required other laboratories may also be used to strengthen and validate the research.

7. Challenges of the study

Simulation based studies of routing schemes are a powerful tool to gain insight on their performance for specific choices of network parameters. However, it is difficult to draw conclusions involving multidimensional parameter spaces, because running several simulation experiments for many combinations of network parameters is impractical. So all of these if not possible then comparison will go on with few of these parameters and with Network Simulator of different version as per the hardware requirement available.

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