Mobile Ad-Hoc Network (MANET) for Disaster Management.

Mrs.S.S.Jadhav
Department Of E and TC Engineering
Pd. Dr. D.Y.Patil Institute of Engineering and Technology,
Pimpri, Pune, India.

Prof. Dr. A. V. Kulkarni
Department Of E and TC Engineering
Pd. Dr. D.Y.Patil Institute of Engineering and Technology,
Pimpri, Pune, India.

Prof. Dr. Radhika Menon
Department Of Mathematics
Pd. Dr. D.Y.Patil Institute of Engineering and Technology,
Pimpri, Pune, India.

***Abstract*—Information technology plays an important role in facilitating disaster management and allowing planners for a more efficient disaster handling. Climate change can reasonably be expected to increase countries' vulnerability to natural hazards in future. We are already witnesses of extreme meteorological phenomena, such as expanded fires and floods. This paper gives Mobile Ad-Hoc Network (MANET) along with Dynamic Source Routing protocol (DSR). Simulation results for performance measurement of DSR algorithm for normal condition are given first. Same parameters are measured after applying disaster condition on nodes is presented in next section. In last section simulation results of disaster prevention condition are given. It is observed that performance of the network after application of prevention condition is nearly same as the normal performance. The performance is evaluated in terms of Network Throughput, Packet Delivery Ratio, and Average end to end delay**

Keywords— ***MANET, DSR Algorithm, throughout, PDR, end to end delay***

I. INTRODUCTION

Everyone would admit that disaster early warning is more important than later treatment and damage repair. In June 2013, a multi-day cloudburst centered on the North Indian state of Uttarakhand caused devastating floods and landslides in the country's worst natural disaster since the 2004 tsunami. Though some parts of Himachal Pradesh, Haryana, Delhi and Uttar Pradesh in India, some regions of Western Nepal, and some parts of Western Tibet also experienced heavy rainfall, over 95% of the casualties occurred in Uttarakhand. As of 16 July 2013, according to figures provided by the Uttarakhand government, more than 5,700 people were "presumed dead."[1] This total included 934 local residents.[2]

In India about 60% of the landmass is prone to earthquake of various intensities; over 40 million hectares is prone to floods; about 8 % of total area is prone to cyclones and 68% of the areas is susceptible to drought. Apart from natural disasters, some cities in India are also vulnerable to chemical and industrial disasters and man-made disasters [3], [4].

The role of information and communication technology in disaster management has been evolving. Large quantities of disaster-related data are being generated. Behavior of critical infrastructures is being explored through simulation, response plans are being created by government agencies and individual organizations, sensory systems are providing potentially relevant information, and social media have been flooded with disaster information. Current data storage systems are disparate and provide few or no integration capabilities. To make the most of available information, a reliable and scalable storage system supported by information sharing, reuse, integration, and analysis is needed.

The occurrence of Flood in Uttrakhand left a devastating blow on the country. Complete prevention of natural disaster is beyond human capabilities but the involvement of the state-of-the-art technology and communication technology systems are panacea for implementing reliable disaster recovery measures.

In first section details of Mobile Ad-Hoc Network (MANET) are given. Dynamic Source Routing protocol (DSR) is presented in next section. Simulation results for performance measurement of DSR algorithm for normal condition, disaster condition and disaster prevention condition are given in last sections. The performance is evaluated in terms of Network Throughput, Packet Delivery Ratio, and Average end to end delay.

II. MOBILE AD-HOC NETWORK (MANET)

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. 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 self-configuring, decentralized network; 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. The routers, the participating nodes act as

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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. 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 place without the aid of any infrastructure. This property makes these networks highly robust [5].

Mobile ad hoc network nodes are furnished with wireless transmitters and receivers using antennas, which may be highly directional (point-to-point), Omni directional (broadcast), probably steerable, or some combination thereof. At a given point in time, depending on positions of nodes, their transmitter and receiver coverage patterns, communication power levels and co-channel interference levels, a wireless connectivity in the form of a random, multihop graph or "ad hoc" network exists among the nodes. The MANET allows a more flexible communication model than traditional wire line networks since the user is not limited to a fixed physical location. It is a new special network that does not have any fixed wired communication infrastructure or other network equipments.

A. Routing in MANET

The term routing refers to the process of selecting paths in a computer network along which to send data. This process is used to exchange information about topology and link weights, and a routing algorithm, that actually computes paths between nodes.

Mobile Ad-hoc networks are self-organizing and self-configuring multihop wireless networks where, the structure of the network changes dynamically. This is mainly due to the mobility of the nodes. Nodes in these networks utilize the same random access wireless channel, cooperating in a friendly manner to engaging themselves in multihop forwarding. The nodes in the network not only act as hosts but also as routers that route data to/from other nodes in network. In mobile ad-hoc networks where there is no infrastructure support as is the case with wireless networks, and since a destination node might be out of range of a source node transmitting packets; a routing procedure is always needed to find a path so as to forward the packets appropriately between the source and the destination.

Within a cell, a base station can reach all mobile nodes without routing via broadcast in common wireless networks. In the case of ad-hoc networks, each node must be able to forward data for other nodes. This creates additional problems along with the problems of dynamic topology which is unpredictable connectivity changes.

Routing is difficult since mobility causes frequent network topology changes and requires robust and flexible mechanism to search and maintain routes. Routing protocols must also deal with other constraints such as low bandwidth, limited energy consumption, and high error rates etc.

Some of the routing protocols are Ad-hoc On Demand Distance Vector routing (AODV), Dynamic Source Routing protocol (DSR), Destination Sequenced Distance Vector (DSDV), Temporary Ordered Routing Algorithm (TORA), Associatively Based routing protocol (ABR), Location Aided Routing Protocol (LAR), Signal stability based Adaptive Routing Protocol (SSA), Optimized Link State Routing (OLSR) etc. These conventional routing protocols have some features and drawbacks too. The shortcomings can be eliminated considering the bio-inspired approach to the routing in Ad-hoc network.

B. Table-Driven routing protocols (Proactive):

These protocols maintain the routing information even before it is needed. Each and every node in the network maintains routing information to every other node in the network. Routes information is generally kept in the routing tables and is periodically updated as the network topology changes. There exist some differences between the protocols that come under this category depending on the routing information being updated in each routing table. Furthermore, these routing protocols maintain different number of tables. The proactive protocols are not suitable for larger networks, as they need to maintain node entries for each and every node in the routing table of every node. This causes more overhead in the routing table leading to consumption of more bandwidth.

C. On Demand routing protocols (Reactive):

Reactive protocol is identified as On-demand protocols because it creates routes only when these routes are needed. The need is initiated by the source, as the name suggests. When a source node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. After that there is a route maintenance procedure to keep up the valid routes and to remove the invalid routes[13]. A reactive routing protocol comes here and which are working in following two parts:

1) Route discovery:

In the wired network source node broadcast the ARP packet request to all the nodes in the existing wired network before sending any information in the form of packet to any node. Using the ARP request packet, source gets the information about the nodes MAC addresses. Same mechanism used here for the route discovery except the thing that route discovery works over the IP layer. Route discovery looks almost the same, but it works in IP layer and also keep the information regarding to the nodes out of source range of transmission. Thus in the MANET, if the source does not find any route towards to the destination, then source node broadcast the route discovery packet among all the mobile nodes in the network in order to find out the route and reach destination. The intermediate nodes in the route forward the route discovery packet to next node in path [8].

2) Route maintenance:

After the route discovery over in which route between the source node and destination node has been find out, the next step is start working in order to maintain that route still the message delivery to the destination, such mechanism is called as route maintenance. Route maintenance check the validity of route because in the MANET nodes move freely not at fixed position. If the during the transmission links get failed due to some reason, source node again start the route discovery mechanism find out the new path towards the destination. DSR is most efficient protocols for the MANET from the reactive routing protocols which is presented below in detail [9], [10].

III. Dynamic Source Routing (DSR)

The first reactive protocol which was proposed is called as Dynamic source routing protocol which had goal of imposes the routing mechanism in MANET network which size up to the 200 mobile nodes, with the high mobility. As compare to other unicast routing protocols, dynamic source routing protocol does not use the concept on routing table. Rather than the routing tables, DSR uses the source routing option in the packet itself which is on transmit and the mechanism of route cache which stores the full list of IP addresses of the mobile nodes in the MANET network in order to recognize the route towards to destination node.

The key feature of this protocol is that it is a pure on demand protocol, i.e. it does not employ any periodic exchange of packets. DSR does even employ beacon packets like some other on demand protocols. Consequently, DSR applies on demand schemes for both route discovery and route maintenance. This makes the routing overhead traffic scales to the actual needed size automatically, which is considered as the main advantage of DSR.

On the hand, DSR employs source routing, so that each data packet contains the full path it should traverse to its destination. Source routing is some time considered as a disadvantage of DSR. For route discovery a node which wants to send packets to a specific destination floods the network with a route request packet, this packets is flooded by all intermediate nodes in the network until it arrives to the destination which in turn replies by a route reply packets.

Route discovery: Here the route request packet is used to find out the route towards the destination if the source node doesn't find any route in the route cache. Throughout the MANET such route request packet is broadcasted. While packet traversing from the source to destination using the intermediate mobile nodes, each intermediate nodes add its own IP address into that route request packet IP list. Thus when the destination node receives the packet, the request packet contains the all the route from source to the destination which is called as path accumulation also. After receiving the packet from the source node, destination node again start the route discovery mechanism in order to transfer the route reply packet back to the destination again. It can either use the source route which is recorded into the request packet in order to send the route reply packet in reverse order. Finally in this approach after the route discovery mechanism, both source node and destination node have the complete route from source to the destination.

Route maintenance: In the DSR protocol, there is no concept like HELLO messages which are periodically updated as like in proactive routing protocols as well as AODV protocol. Rather every mobile node in the network is responsible for the maintenance of the routing protocol in between the node and next hop in route from source to the destination. This route is detected by the MAC layer or software acknowledgement which is DSR specific. In the any link lost in between, then source route error packet is used to notify by the source node of particular route path and again initiate route discovery mechanism. In the DSR, route cache is mostly used for the same purpose [6].

While route discovery phase, if the intermediate node encounters the route from the source to destination or route towards the destination from the its own routing cache, then this node reply with the route reply packet and then send the route from the source to destination on same time.

DSR is based on the multi paths concept, thus if any link break and source receives the route error packet, then it can directly use the alternate route which is available in source route cache, this resulted into the reduced routing overhead.

The concept of packet salvaging, in which if the any intermediate route from the source to destination route detects next hop link breakage, then in such case if that intermediate route has another route available towards the destination in its route cache, it can directly used the same route to forward the packet towards the destination[11], [12].

IV. Simulation results:

The three conditions for Dynamic Source Routing protocols are simulated in NS2 environment. NS2 is stand for Network Simulator Version 2. NS2 is nothing but the discrete event simulator for the researches in the area of networking. NS2 provides the simulation and research supports for the wired networks, wireless networks by using TCP, and UDP, IP, and CBR patterns of the communications. NS2 is made of two parts basically such as NS means network simulator and other one is NAM means network animator [7]. The network conditions considered for simulation are tabulated below. The network size is changed by varying number of nodes to observe the effect of network size on the performance of protocol.

TABLE I. PARAMETERS FOR SIMULATION

Simulation Parameters	**Value/ description**
Number of nodes	10/20/30
Traffic pattern	Constant Bit rate (CBR)
Network Size	1000 X 1000
Simulation time	100s to 1000s
Routing protocol	DSR

A. Throughput

The network throughput is the ratio of packets generated at source to packets received at destination. For the set network conditions the Comparison result for throughput as shown below. From the figure 1 it is clear that, for normal routing condition and for disaster prevention condition throughput is nearly same. When disaster condition is applied on the network throughput gets decreased. The results obtained during simulation are tabulated and a graph is plotted for comparative analysis as shown below.

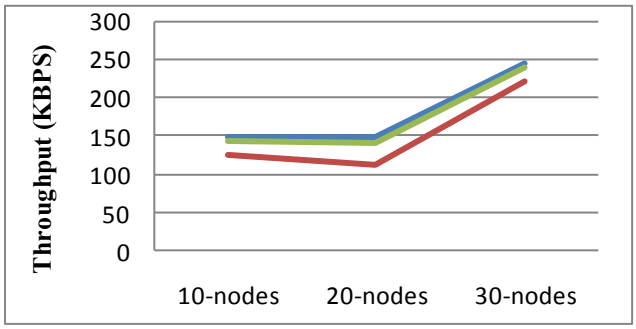

Fig.1 Average Throughput in KBPS

TABLE II. THROUGHPUT FOR 10/20/30 NODES

	10 Nodes	20 Nodes	30 Nodes
Normal Routing	146.98	125.29	141.98
Disaster condition	147.04	112.15	139.04
Preventing disaster	244.26	221.37	238.59

B. Packet Delivery Ratio

It is the calculation of the ratio of packet received by the destinations which are sent by the various sources of the CBR. Packet Delivery Ratio is defined as the ratio of the total number of data packets received by the destination node to the number of data packets sent by the source node. This measure tells us how many data packets are successfully delivered at their destinations. The PDR graphs for the protocols are show in figure 2.

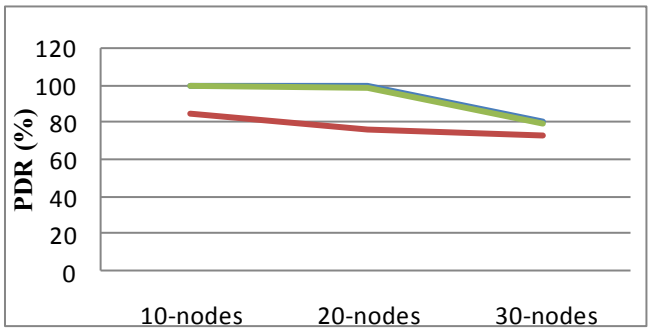

Fig.2. Packet Delivery ratio

TABLE III. PACKET DELIVERY RATIO FOR 10/20/30 NODES

	10 Nodes	20 Nodes	30 Nodes
Normal Routing	100	84.29	99.29
Disaster condition	99.48	75.62	98.077
Preventing disaster	80.45	73.04	79.54

C. Average end to end delay:

Average end to end delay for three conditions is shown in figure 3.

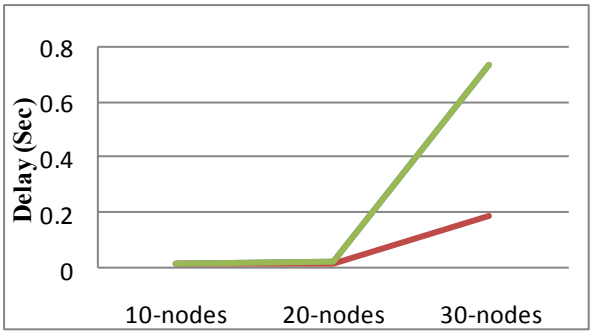

Fig.3. Average end to end delay

TABLE IV AVERAGE END TO END DELAY FOR 10/20/30 NODES

	10 Nodes	20 Nodes	30 Nodes
Normal Routing	0.0143	0.0189	0.0144
Disaster condition	0.0249	0.0185	0.02525
Preventing disaster	0.7391	0.19	0.74

V. CONCLUSION

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 self-configuring, decentralized network; where all network activity, including discovering the topology and delivering messages must be executed by the nodes themselves. Hence routing functionality is incorporated into the mobile nodes. This paper gives simulation results of DSR protocol for three different network conditions. The result shows comparison of the DSR protocol considering the performance metrics and network size. For normal routing condition and for disaster prevention condition performance parameters shows nearly same results. When disaster condition is applied on the network all performance parameters gets decreased.

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