International Conference on Advances in Computing, Communication and Control (ICAC3'09)

Design of an Ad-hoc Network Model for Disaster Recovery Scenario Using Various Routing Protocols

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ABSTRACT

Ad-hoc networks are infrastructure less networks and can be established in any environment without pre-existing infrastructure with ease of deployment. The nodes in the network can communicate freely while being in motion. Several routing protocols such as DSR, AODV, and DSDV etc. have been developed for communication in these networks. Ad-hoc networks are especially deployable in situations like disaster management, as we need to act very fast in adverse conditions to save the lives of the victims or minimize losses.

In this paper we have analyzed the performance of these protocols for a disaster scenario. We have taken a fixed size terrain 1500x1000m^2, organizing it into equal sized symmetrically placed four sub-regions of 500x300m^2 , each(group of rescue teams) and a few fast moving nodes (communication system on transport vehicles) moving randomly. It is observed form the simulation results that for stable networks performance of proactive protocols is better than reactive protocols in the terms of e-e delay, But with increase in the mobility reactive protocols starts outperforming the proactive protocols. Performance of DSR and AODV is comparable for low mobility and low load scenarios but AODV always performs better than DSR for high load scenarios

Keywords

Adhoc networks, routing protocols, PDF, overheads, disaster scenario

1. INTRODUCTION

There are various usages of ad-hoc networks are: emergency search-and-rescue operations and data transfer in inhospitable terrain. The terrorist attacks and natural disasters have drawn ever increasing attention to improve rescue operations following a disaster in no time. One of the technologies that can be effectively used during disaster recovery is wireless ad-hoc networking [2].

The rescue teams can use a Mobile Ad-hoc Network in that situation without requiring a fixed infrastructure. This type of networks can be quickly deployed. Disasters are very dangerous and resulted in the loss of both lives and valuables. For example in August 2008, flood in Bihar affect more than million people. Terrorist Attack in September 2001 on the World Trade Center resulted in loss of millions of lives and millions of dollars business. Thus no one can ignore the importance of improving rescue techniques. Some techniques are already available [1]. For the rescue operation at the World Trade Centre site, the Wireless Emergency Response Team (WERT) tried to locate survivors through signals from their mobile phones [13].

2. RELATED WORK

Some of the previous work regarding networks in these applications focused on energy efficient routing [16] algorithms and also concentrate on performance comparison of existing routing protocols such as DSR, AODV,DSDV [5] with respect to energy consumption [13]. In addition an algorithm (GAF) is designed to reduce energy consumption in the network by turning off unnecessary nodes[14]. [10]have discussed scenario based performance analysis of routing protocols using CBR traffic by keeping the number of nodes fixed.

3. PROTOCOLS DESCRIPTION

This section gives short descriptions of the three ad-hoc routing protocols studied in this work.

3.1 DSDV

The Destination-Sequenced Distance-Vector (DSDV) Routing Algorithm is based on the idea of the classical Bellman-Ford Routing Algorithm with certain improvements. Every node maintains a routing table that contains all available destinations, the number of hops to reach the destination and the sequence number assigned by the destination node. The sequence number is used to distinguish stale routes from new ones and thus avoid the formation of loops. The mobile nodes periodically transmit their routing tables to their immediate neighbors. A node also transmits its routing table if a significant change has occurred in its table from the last update sent. So, the update is both time-driven and event-driven. When the network is relatively stable, incremental updates are sent to avoid extra traffic and full dump are relatively infrequent. In a fast-changing network, incremental packets can grow big so full dumps will be more frequent.

ICAC3'09, January 23–24, 2009, Mumbai, Maharashtra, India.

3.2 AODV

Ad Hoc On-Demand Distance Vector Routing (AODV): Ad hoc On-Demand Distance Vector (AODV) algorithm enables dynamic, self-starting, multihop routing between participating mobile nodes wishing to establish and maintain an ad hoc network. AODV allows mobile nodes to obtain routes quickly for new destinations, and does not require nodes to maintain routes to destinations that are not in active communication.

To find a route to the destination, the source broadcasts a route request packet. This broadcast message propagates through the network until it reaches an intermediate node that has recent route information about the destination or until it reaches the destination. When intermediate nodes forwards the route request packet it records in its own tables which node the route request came from. This information is used to form the reply path for the route reply packet as AODV uses only symmetric links. As the route reply packet traverses back to the source, the nodes along the reverse path enter the routing information into their tables

AODV allows mobile nodes to respond to link breakages and changes in network topology in a timely manner. When links break, AODV causes the affected set of nodes to be notified so that they are able to invalidate the routes using the lost link.

3.3 DSR

The key distinguishing feature of DSR is the use of source routing. That is, the sender knows the complete hop-by-hop route to the destination. These routes are stored in a route cache. The data packets carry the source route in the packet header. When a node in the ad hoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a route discovery process to dynamically determine such a route. Route discovery works by flooding the network with route request (RREQ) packets. Each node receiving an RREQ rebroadcasts it, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet that is routed back to the original source. RREQ and RREP packets are also source routed. The RREQ builds up the path traversed across the network. The RREP routes itself back to the source by traversing this path backward. the route carried back by the RREP packet is cached at the source for future use.

If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source if this route is still needed. DSR makes very aggressive use of source routing and route caching. No special mechanism to detect routing loops is needed. Also, any forwarding node caches the source route in a packet it forwards for possible future use.

4 SCENARIO DESCRIPTION

We have taken terrain region of $1500x1000m^2$ for the simulation study. This region is organized into four equal sized, symmetrically placed sub-regions of size $500x300m^2$ as shown in Figure 1. The nodes in the regions 1-4, represent members of the rescue teams having personal communication devices, with very low random speed of 1m/s. These nodes are continuously moving within the specified area and communicate with each other using CBR traffic. There is another set of nodes (fixed at 5) moving with the speed of 20m/s. These nodes represent the vehicles of the rescue operation. These nodes communicate with each other for locating positions of each and to inform one another the location of the disaster.

In the study we have taken both the directional movement and random movement of vehicular nodes as discussed below.

Directional Movement: The 5 nodes are placed on the diagonal with the node on the centre is fixed. The other four nodes are moving on the diagonal with 20m/s towards the centre node and again go back towards the corner. These four nodes are communicating with the centre node and also with the nodes in the adjacent regions.

Random Movement: In this scenario the vehicle nodes are moving randomly with 20m/s.

Eight scenarios have been created with varying number of nodes. Each scenario consists of five sets of nodes dispersed in the area of $1500x1000m^2$ as shown in Figure 1.The rectangular region of each region is $500x300m^2$ and the number of nodes in each region is varied from 5,8,10 and 15 for both the cases. With increase in the number of nodes, the network connectivity, number of traffic sources and number of CBR flows is also increased as shown in Table 1.

Table 1 : Number of nodes and CBR flows

Total nodes	Nodes in each region	CBR flows	sources
25	5	20	14
37	8	30	18
45	10	40	22
65	15	52	26

The network is designed in such a way so that the network include diverse mobility (95% of the nodes have low mobility and 5% very high). All the three protocols are applied on all the discussed scenarios and their performance is evaluated for these.

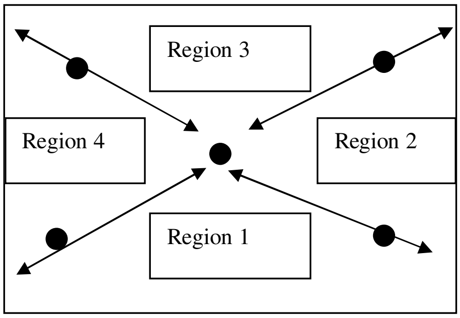

Figure 1: Disaster Scenario Simulation Area

5. SIMULATION SETUP

For simulation we have used NS-2[3] developed by Monarch research group in CMU [4]. It has the support for simulating multi hop wireless networks. The protocols maintain a send buffer of 64 packets. It contains all data packets waiting for a route, such as packets for which route discovery has started, but no reply has arrived yet. To prevent buffering of packets indefinitely, packets are dropped if they have to wait in the send buffer for more than 30s. All packets (both data and routing) sent by the routing layer are queued at the interface queue until the MAC layer can transmit them. The interface queue has a maximum size of 50 packets and is maintained as a priority queue with two priorities

each served in FIFO order. Routing packets get higher priority than data packets. Figure 2 shows the flow of packets within a node after being generated by application (upper layers).

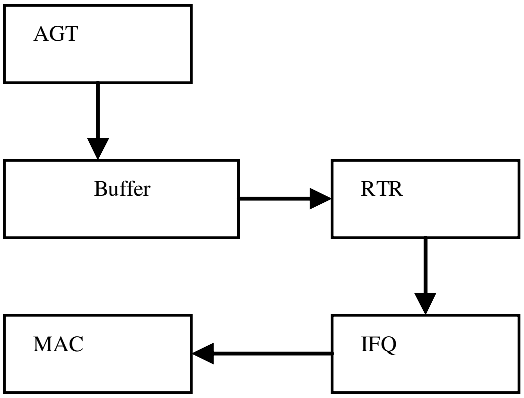

Figure 2: Flow of packets in a node

5.1 The Traffic and Mobility Model

We have done simulation of the scenario for 200 simulated seconds in a rectangular field of 1500x1000 with varying number of nodes.. The source-destination pairs are spread randomly over the network. The size of data packets is 512 bytes. Changing the number of sources and data-rate we can vary the load in the network. The mobility model uses the random waypoint model [12]. Here, each node starts its journey from a random location to a random destination with a randomly chosen speed. Once the destination is reached, another random destination is targeted after a pause. In this scenario the nodes in the four regions are continuously moving without pausing (0 pause time) and the vehicle nodes are moving with speed of 20m/s (randomly in one scenario and in specified directions in another scenario) with pause time of 5s. Identical mobility and traffic scenarios are used across all the protocols.

Table 2: Simulation Parameters

S. No.	Parameter	Value
1	Routing Protocols	DSR, AODV, DSDV
2	Packet rate	4p/s
3	Terrain Size	1500*1000m^2
4	Nodes	25,37,45,65
5	Node Placement (Vehicle nodes)	Random/diagonal
6	Node Placement (rescue team members)	Random
6	Mobility Model	Random Waypoint
7	Data Traffic	CBR
8	Simulation Time	200s
9	Speed	1m/s, 20m/s

6. SIMULATION RESULTS AND OBSERVATIONS

In a disaster management scenario, it is very important to deploy the nodes in such a manner that PDF, routing overheads, packet-loss and end-end delay are minimum. Simulations were carried out for both random motion and pre-defined directional motion of the vehicular nodes, with varying number of traffic sources and CBR flows as shown in Table 1. It is also observed from the Tables 3 and 4 that all the three protocols perform better, when the movement of the vehicular nodes is along the diagonals as compared to their random movement for the above said metrics. However Performance of AODV and DSR is better than DSDV for all the considered scenarios. On the other hand we observe that average end-to-end delay is lowest in DSDV as compared to both DSR and AODV (figure 4 & 7). This is due to the fact that packets are dropped, rather than queued if DSDV does not have a route. Simulation results also reveal that for PDF and throughput both DSR and AODV performs similar (figure 3 & 6). The End-to-end delay in DSR increases with the increase in the network load, but the packet loss in DSR is lowest (figure 5 & 8). DSR also has low overhead packets, but due to source route, byte overhead increases in DSR with increase in the number of hops in the path.

Random Movement

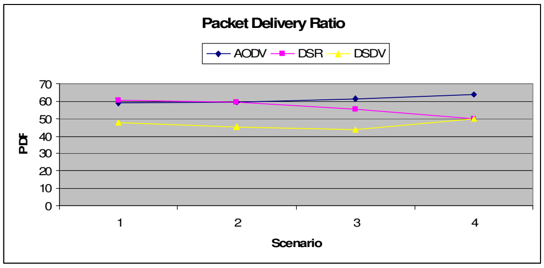

Figure 3: PDF in the four scenarios for various protocols

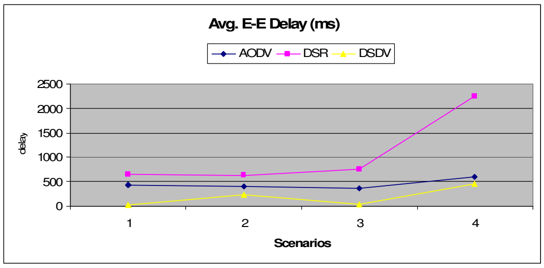

Figure 4: Avg E-E delay in the four scenarios (Delay is significantly increased for scenario 4 having large number of nodes 65)

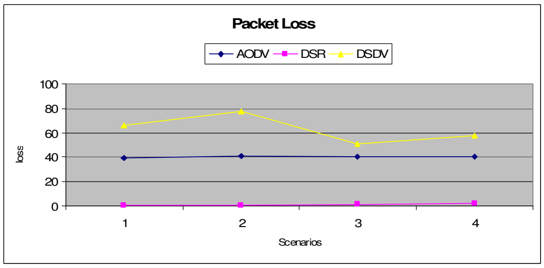

Figure 5: Packet-loss in the four scenarios. Packet-loss for DSR is negligible for first scenario and very low for the other three

Diagonal Movement

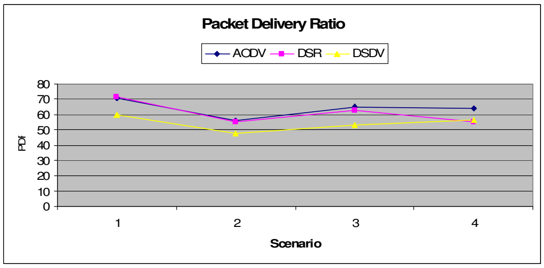

Figure 6: PDF in the four scenarios for various protocols

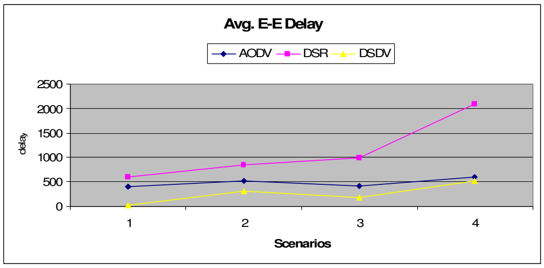

Figure 7: Avg E-E delay in the four scenarios (Delay is significantly increased for scenario 4 having large number of nodes 65)

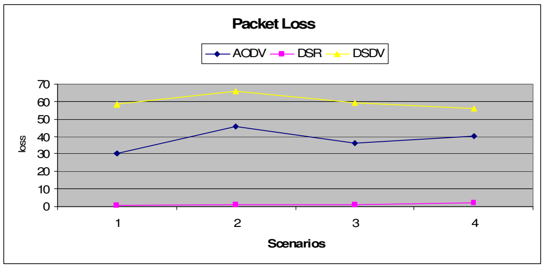

Figure 8: Packet-loss in the four scenarios. Packet-loss for DSR is negligible for first scenario and very low for the other three scenarios

Table3: Directional (Along The Diagonal) Movement Of Fast Moving Nodes

Number of Nodes	**25**			**37**			**45**			**65**		
Protocol	**AODV**	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**
Avg Throughput[kbps]	153.99	155.14	130.14	156.75	155.86	134.55	203.12	196.09	165.13	243.49	211.74	214.26
PDF	70.53	71.28	59.79	55.55	55.26	47.82	65.29	62.97	52.91	64.03	55.32	56.18
NRL	0.21	0.12	0	0.68	0.33	0	0.64	1.03	0	1.3	1.97	0
Routing Overhead	14.76	9.43	0	33.17	19.36	0	33.38	37.11	0	46.11	51.19	0
Avg e-e delay(ms)	400.47	598.2	18.45	527.1	847.85	297.75	412.7	990.2	184.03	599.72	2078.54	518.38
Packet Loss [%]	30.33	0.52	58.17	45.72	1.13	65.82	36.3	1.03	59.64	40.45	2.26	56.05
RTG PKTS	2160	1298	0	9186	4546	0	9629	15503	0	23893	36387	0
RTG packets forwarded	103	667	0	565	2403	0	473	11299	0	1334	26356	0
Data packets forwarded	4986	5214	2286	10616	12142	7091	9160	13281	4650	15665	23586	9448
dropped RTG packets	70	0	0	785	9	0	687	268	0	3089	361	0
dropped data packets	3192	3248	6626	6219	6756	9880	5443	6489	10196	7414	10112	12337

Table4: Random Movement Of Fast Moving Nodes

Number of Nodes	**25**			**37**			**45**			**65**		
Protocol	**AODV**	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**
Avg Throughput[kbps]	128.02	131.33	104.1	168.33	167.6	127.43	191.36	172.49	74.32	243.49	190.03	190.38
PDF	59.09	60.22	47.96	59.58	59.37	45.12	61.27	55.24	43.68	64.03	49.76	49.8
NRL	0.37	0.32	0	0.74	0.35	0	0.96	0.65	0	1.3	1.16	0
Routing Overhead	26.34	22.42	0	32.69	18.86	0	34.8	26.31	0	46.11	36.27	0
Avg e-e delay(ms)	436.27	649.81	13.1	402.4	633.6	232	363.53	754.79	31.13	599.72	2245.06	453.19
Packet Loss [%]	39.82	0.47	66.15	41.24	0.93	77.93	40.07	1.13	51.36	40.45	2.51	57.77
RTG PKTS	3859	3367	0	10021	4801	0	14519	9782	0	23893	21412	0
RTG packets forwarded	174	2182	0	623	2864	0	834	6337	0	1334	13436	0
Data packets forwarded	4413	5777	2691	12174	12614	6730	17264	20993	2360	15665	33667	15909
dropped RTG packets	64	2	0	700	17	0	566	49	0	3089	77	0
dropped data packets	4157	4439	7446	5616	6143	11613	6033	7692	2252	7414	11811	12727

7. CONCLUSIONS

From the simulations It is observed that by organizing the terrain region into four (say) equal sized symmetrically placed sub-regions provide optimum results in the terms of routing overheads, packet-loss and end-to-end delay. Further we find that overall disaster recovery operation monitored from centre of terrain with four fast moving (vehicle) nodes moving along the diagonal and communicating with the nodes in sub-regions(members of rescue teams) provide better results as compared to random motion of all the five fast moving nodes. It is interesting to note that the packet-loss is very low for the DSR protocol. The simulation results reveal that DSR should be considered for a scenario where paths are limited to few hops and there is a requirement of less number of control overheads.

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