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Appendix I

List of publications

List of publications

- [1] **A. Srivastava**, D. Kumar and S.C Gupta, "Mobile Ad-Hoc Network Performance in a Disaster Management Scenario," African Journal of Computing & ICT- IEEE journal Vol. 7, No. 1 - March, 2014, PP 1-10.
- [2] **A. Srivastava**, D. Kumar and S.C Gupta, "MANET BASED COMPARISON OF NETWORK SIMULATORS: NS2 & QUALNET," Pensee Journal France (SCI journal) Vol. 76, No. 2- Feb 2014, pp 2-12.
- [3] **Ashutosh Srivastava**, Deepak Kumar, Suresh C. Gupta, "Geographic and Reactive Routing Protocols for MANET," In proc. of the 7th European Modelling Symposium (EMS-2013), Manchester U.K., 20-22 November 2013, PP 590 – 594.
- [4] **A. Srivastava**, D. Kumar and S.C Gupta, "Modelling mobility in emergency scenario for MANET applications," In proc. of the International conference on Recent advances in engineering and computational sciences Chandigarh, Panjab. 6-8 October 2014, pp 1-6.
- [5] Deepak Kumar, **Ashutosh Srivastava**, Suresh C. Gupta, "Routing in Ad Hoc Networks under Reference Point Group Mobility," In proc. of the 7th European Modelling Symposium(EMS-2013), Manchester U.K., 20-22 November 2013, PP 595 – 598.
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[8] **Ashutosh Srivastava**, Deepak Kumar, Suresh C. Gupta, "DSSAM- Digitally Signed Secure Acknowledgement Method for MANETs," International Journal of Wireless Information Networks, Springer. -- **Under review**.

[9] **Ashutosh Srivastava**, Suresh C. Gupta, "SROA: Shortest route with obstacle avoidance in Manet," International Journal of Wireless Information Networks, Springer -- **Under review**.

Appendix II

Reprints of published research papers

Mobile Ad-Hoc Network Performance in a Disaster Management Scenario

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ABSTRACT

A post disaster situation demands an efficient communication and coordination among rescue teams. Exchange of real time information among responders and emergency management centers is crucial for saving lives. In such scenario, MANETs are suitable for providing communication mechanism, as they are easy to deploy and do not require elaborate infrastructure. In this paper, we have considered that the relief and rescue operations in a post disaster situation are managed at three stages, viz: Disaster core location (incident-location), first aid treatment area and hospital area, with a relief ambulance as a link between them. The communication between the stages is considered to be provided by a MANET based network setup. Mobility of MANET nodes between the three stages has been modeled with Reference point group mobility (RPGM) based on attraction level. Performance of ad hoc network is analyzed for reactive (AODV [1, 2]), proactive (OLSR [3]) and hybrid (ZRP [4]) protocols. Our simulation studies conducted on Qualnet indicates that both the mobility model and routing protocols affect the communication between the stages.

Keywords: Post disaster mitigation, MANET, Mobility model, AODV, OLSR, ZRP, RPGM..

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1. INTRODUCTION

Disaster situations have been seen to be transitive and the mitigation process constitutes an important phase. Mitigation involves handling of casualties that arise from disaster. In post disaster mitigation management, relief teams cannot rely on existing infrastructure because there is high probability of bursting of whole communication backbone. With the advent of MANETs, a rapid deployment of infrastructure is possible. A mobile ad hoc network (MANET) consists of wireless mobile nodes that are mobile and self-organized.

Performance of a MANET system depends on mobility modeling [5, 6, 7]. In the past post disaster management scenarios have been analyzed under different framework and mobility models. In most of these works random waypoint mobility model has been used to analyze MANET performance. In this paper, we have proposed a three layered framework to model post disaster management scenario. A better depiction of nodes movement can be obtained through RPGM, which has been used in our simulation.

The organization of the paper is as follows. In the next section we describe the current scenario and background of the topic. In the subsequent section we propose a three layered framework for disaster mitigation scenario to figure out architectural and performance characteristics.

These performance characteristics are measured and modeled for catastrophic situations like disaster. The next section describes the features of the proposed framework, followed by logical setup of framework in the next section. In the subsequent section performance evaluation of the routing protocols and mobility models is provided. The proposed mobility-model pattern by rescue teams is also evaluated. We also examine the performances delivered by proposed framework to comply with the use of standard routing protocols on our defined set of metrics with predefined cases. Finally we conclude the work with future prospect.

2. CURRENT SCENARIO

In general, a disaster can be classified into two major types - natural disasters, such as an earthquakes, tsunamis, and floods, and Anthropogenic (Human-Induced Disasters) such as war and terrorism. Effects of these disasters could be extremely damaging to the infrastructures, causing environmental degradation, disease, hunger and death. Here, we mainly focus on impulsive natural disasters, such as an earthquake. In post disaster situations, our intention is to provide quick disaster response and recovery. It's a complex process requiring a wide range of resources to ensure the safety of the population and the recovery of the affected area. Many disasters took place in recent past.

The Gujarat Earthquake in India caused 20,000 casualties and 166,000 thousand injuries (according to NIDM, India). The disaster response and recovery effort required approximately 2 thousands Crore rupees in disaster response and recovery funds. Over 25,000 emergency personnel were deployed throughout the region (according to PIB, Govt. Of India) [8]. The Tsunami of 2004 was triggered by an earthquake on the ocean floor. It badly affected Indonesia, Sri Lanka, India, Thailand, Maldives, Somalia, Myanmar and Malaysia. The number of casualties exceeded 162,500 with major brunt taken by Indonesia (CRS Report for Congress) [9]. It required approximately 6,000 military support personnel, 10000 contractors and 6000 volunteers for the relief operations.

The magnitude of these disasters in terms of government resources and lives affected, demonstrates the need for fast, efficient response and recovery.

2.1 State of the art

A concise inspection of past few years' works on emergency Ad-hoc network covers mobility, performance metrics and routing. A considerable amount of work has been done on the area of emergency mobility framework. The researchers have chosen random way point mobility model [10] and analyzed the general performance characteristics.

Meissner et.al [11] developed requirements and technology for integrated disaster management communication and information system. In particular they addressed network configuration, scheduling and data management issues during the response and recovery phases. The design issues and architectural concepts for an integrated disaster management system are identified. An infrastructure is provided that allows for horizontal and vertical information flow from the officer or fireman on the scene up to the central operations staff by means of a multi-level wireless voice and data communication infrastructure. The network hardware includes terrestrial trunked radio or satellite technology for wide area communication, wireless LAN ad hoc networks for disaster site hot spots, and personal or body area networks for frontline personnel, allowing them to act as data sources and sinks by means of smart connected devices, e.g. robust mobile terminals and sensors.

A Graph based approach was used by Stepanov et.al [12]. The instantiation of the Graph Walk Mobility Model is similar to the Random waypoint mobility model but the model uses a graph representing the spatial environment in the Spatial Model. The model relies on the Spatial Model to reflect spatial constraints of user movement imposed by the environment. The Model provides a map of the area containing its topological elements. To offer a standard interface for data access and to reuse existing data sources, the spatial model is built on top of existing standards for describing environments in digital form.

A pixel oriented approach for mobility modeling was used by Kraaier et.al [13]. In this model mobility parameters namely transition probabilities is calculated to reach the predefined stationary user distribution. The simulation area is divided into small parts and performance is evaluated. Kim et.al [14] uses a trace based approach. Here a foundation is provided for real user movements by exploring mobility characteristics in traces of mobile users. A method is presented to estimate the physical location of users from a large trace of mobile devices associating with access points in a wireless network. Based on the extracted mobility characteristics, a mobility model is developed, focusing on movements among popular regions.

In 2006 an innovative software infrastructure (software, models, services etc.) was built and developed by Mecella et.al [15] for supporting collaborative work of human operators in emergency/disaster scenarios. Here the whole team is considered to carry on a macro process and the different teams (of the different organizations) collaborate through the interleaving of all the different processes. The idea is to investigate a 2-level framework for such scenarios: a back-end peer-to-peer community, providing advanced services requiring high computational power, data-knowledge-content integration, and a set of front-end peer-to-peer communities, that provide services to human workers, mainly by adaptively enacting processes on mobile ad-hoc networks.

A work pad architecture consisting of two layers (front and back end) was developed by Catarci et.al [16] in 2008. The back end is a P2P network that lets front end teams collaborate through information exchange and coordination. Work pad employs user-centered techniques from human-computer interaction paradigms. User centered design relies on continuous interaction with end users to understand how organizations are arranged during disasters, what information is critical, and how teams exchange this information among themselves and with their operational centers

The causes that paralyzed the entire communication systems in Taiwan earthquake was analyzed by Jang et.al [17]. In this paper a MANET based communication platform was proposed. It included a Rescue Information System for Earthquake Disasters to support a large number of rescue volunteers under catastrophic natural disasters. The platform is designed and implemented using MANET. Rescue people, voluntary or mission-specific professional could use their own notebook PCs to construct a multi-hop ad-hoc network to form a basic wireless intranet first. On top of this MANET based emergency network platform, a Rescue Information System for Earthquake Disasters (RISED) is implemented to support rescue operations for catastrophic earthquake disasters. The system consists of Disaster Assessment Subsystem, Fastest Rescue Route Generation Subsystem, Health Care and Relief Resources Integration Subsystem, and Wounded Victim Arrangement Subsystem.

Mobility patterns play an important role for performance evaluations of mobile networks. To simulate user movement, existing simulation tools provide only a few simple mobility models (e.g., random movement) suitable for particular scenarios. There is no environmental heterogeneity available in any form in these models. In reality these models do not fit for disaster areas due to their mobility specific assumptions. Our proposed post disaster mitigation model framework features attraction point group mobility [16] (group movement based upon the attraction point). The group of nodes movement orientation is basically through group leader with the same attraction features. Nodes are only allowed to move along the predefined paths. Each node searches for the possible attraction points to visit. Each attraction point has its own attractivity value. Attractivity value is a uniform random number between 0 and 1. We have designed three cases to test out the mobility framework performance in terms of packet transfer under the standard Ad-hoc routing protocols namely AODV, OLSR and ZRP.

3. PROPOSED LAYERED FRAME WORK

In post disaster situations, effective management depends upon communication amongst affected public, protection forces, rescue teams including some out-sided teams (NGO's) and fire brigades. In such situation teams cannot move around random fashion. There is one head or a group of best trained personnel (tactical operational command). They are responsible for where and how to move because moves are determined by well-defined strategy. These strategies are mostly based on the layered framework or architecture which we have designed in figure 2.

It is a three layer architecture which includes DCL (disaster core location) as layer-1, FTL (first treatment location) as layer-2, HL (hospital location) as layer-3. Disaster effective area and its neighborhood are divided into special areas as disaster core location, first treatment location, hospital location etc. The second layer has some sub layers like transport units & TOC (Tactical operational command) unit. Layer 1 is the core disaster area location which also has some out-side teams (Govt. /NGO teams). Layer 2 is the first treatment location/casualties handling, here teams provide first-aid treatment for injured & sufferer and layer3 is the hospital location. In figure 2 bi-directional bold arrows shows the path of the vehicle or transport units which carry affected and injured people & bring them to the second layer. The second layer area has two places: waiting for treatment area and the casualties handling, where first aid treatment is provided. Finally they are moved to hospital location. In the case of layer1 & layer2 most of the support is provided by push to talk & push to speedy move by common pedestrians who are present in above layers after the disaster. There can be delay in transports units to handle everyone on time. This delay is significant and meaningful for saving life at the time of disaster. In general terms teams take up sufferer and transport them on direct way to 3rd layer (hospital location). Here we have taken ad-hoc network supportable entities

(nodes). Mobility of nodes shall be in group. In our framework we explore this model and routing of nodes based on attraction point and level of severity, layer to layer. We have taken transport nodes (ambulance) to each and every layer because at the time of emergency there might be the possibility of availability of ambulance near to the incident core location. At the time of moving, there is the possibility of ad-hoc communication sink, due to obstacles. Due to the complexity of the framework, we have left it for future work.

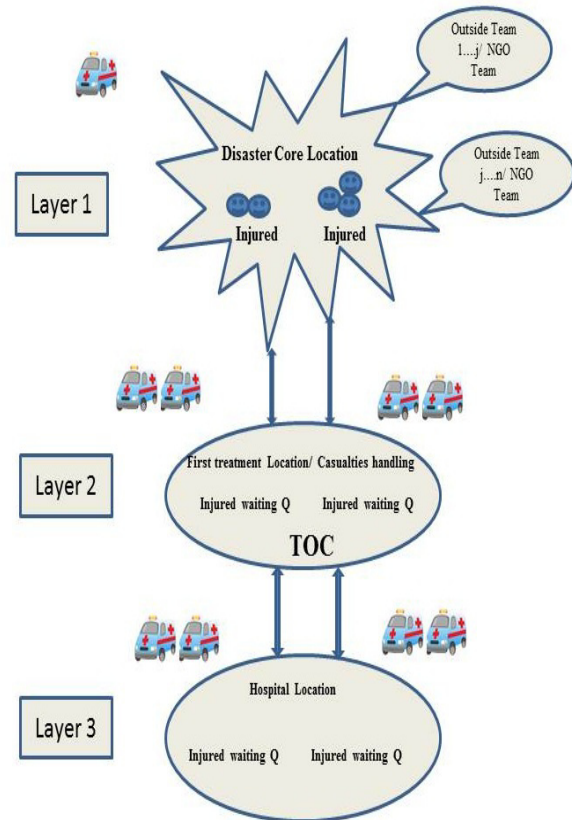


Figure: 2 post disaster mitigation layered rescue model

4. FEATURES OF FRAMEWORK

The desired features or characteristics for post Disaster mitigation scenario includes:

- (i) Group/Team mobility
- (ii) Heterogeneity
- (iii) Routing algorithms for entities and their performance.

4.1 Group mobility

In disaster scenario, the rescue task is always performed as integration of various teams or groups. Group mobility model stands for the team or group movement in the real scenario, where either a function creates group behavior or the nodes are somehow arranged with a group leader [16]. In our framework, we have considered attraction/ reference point group mobility model [18, 19].

ATTRACTION/REFERENCE POINT GROUP MOBILITY MODEL: It is spatial dependent [20, 21] and the movement of a node is influenced by the node around it. In disaster mitigation operation, team collaboration has to exist and the users are likely to follow the team leader. Therefore, the mobility of mobile node can be influenced by other neighboring nodes too. Since the velocities of different nodes are correlated in space, thus we call this characteristic as the Spatial Dependency of velocity. In this, each group has a center, which is a logical center or a group leader node. The movement of the group leader determines the mobility behavior of the entire group. The logical function of group leaders and group members are described below:

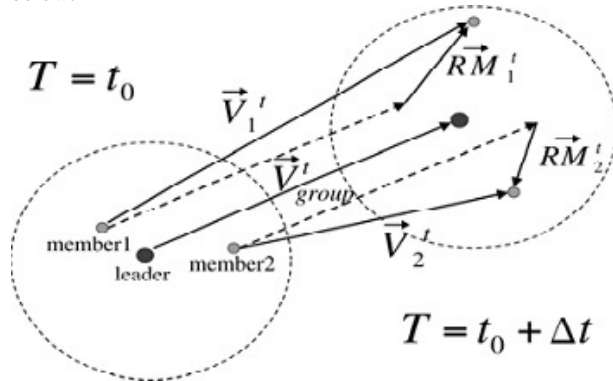


Figure: 3 Movement in A-RPGM, providing two snapshots at time $T=t_0$ (left circle) and time $T=t_0+\Delta t$ (right circle)

- A. *The Group Leader* [18]: Its movement at time t can be represented by motion vector \mathbf{V}_{group}^t . It does not only define the motion of group leader itself, but it also provides the general motion trend of the whole group. Each member of this group deviates from this general motion vector \mathbf{V}_{group}^t by some degree. The motion vector \mathbf{V}_{group}^t can be carefully designed, based on certain predefined paths and attractivity factor [19].
- B. *The Group Members*: The movement of a group member is affected by the movement of its group leader. For each node, the movement (i.e. mobility) is assigned with a reference point that follows the group movement.

In Figure 3 \mathbf{V}_{group}^t is the motion vector for the group leader and the whole group. \mathbf{RM}_i^t is the random deviation vector for group member i , and the final motion vector of group member i is represented by vector \mathbf{V}_i^t . With appropriate selection of predefined paths for group leader and other parameters, the RPGM model is able to emulate a variety of mobility behaviors, according to mobility scenario [16].

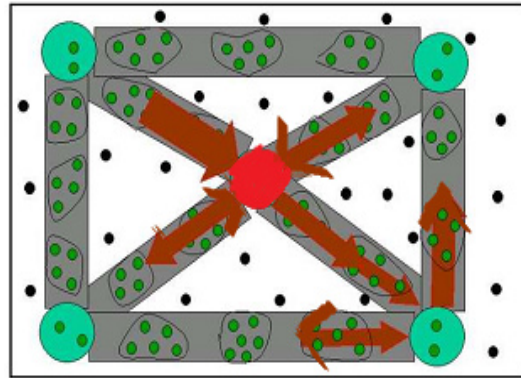


Figure: 4 group mobility view

All nodes belonging to the same group tend to have same movement tracks. However, inside the group, members also have relative mobility. This mobility makes two vectors

1. Group mobility vector, which is shared by all members of the same group.
2. Internal mobility vector, which represents the relative mobility of a node inside the group.

The vector sum of the two mobility vectors decides the mobility of the node. In figure 4 we have presented the 180° view for movement of groups in disaster scenario. Four green corners show the safe zone, as layer2 of our mobility model. Red center point shows disaster core location as layer1 of our mobility model. Small covered area on the path which includes 4-5 nodes show groups/teams and the simple black point show normal pedestrians movement to and from disaster core location.

4.2 Heterogeneity

In this paper we consider heterogeneity in terms of 3 environment values.

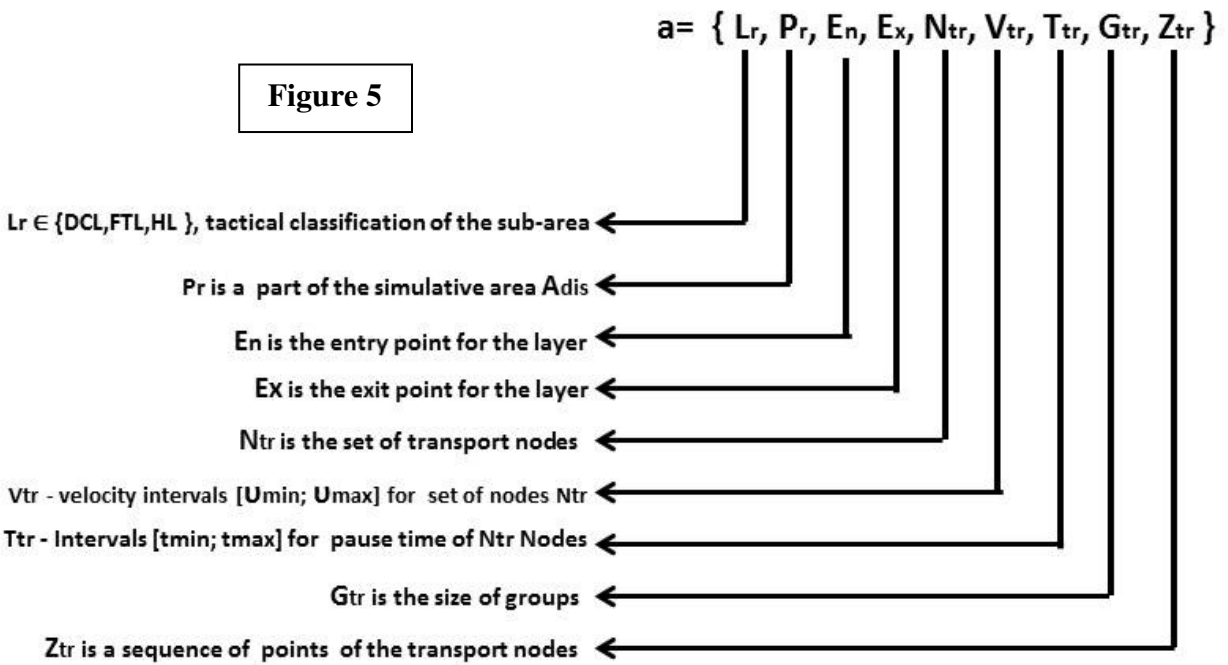
1. Movement of nodes: Normally we consider movement on a plane, but in hilly areas it will be more suitable to consider the movements in height also.
2. Path followed/Routing: There can be situations when the link which was followed recently, is not available now.
3. Density of nodes. The number of peoples at the disaster location may also vary depending on the geographical location of the site.

4.3 Routing procedure

The protocol selection for routing is based on the scenario support. Here we have taken few assumptions like entities or group of entities tend to move towards a specific destination area (inter or intra layer movement) & follow a defined path used for movement and pause time of the nodes is taken as a monotonic function. To test the mobility frameworks performance we have considered AODV, OLSR and ZRP. This selection has been done choosing one from each group: Proactive Routing Protocol, Reactive Routing Protocol and Hybrid Routing Protocol.

5. LOGICAL SETUP OF FRAMEWORK

In section 3 we proposed a three layer architecture which includes DCL (disaster core location) as layer- one, FTL (first treatment location) as layer 2, HL (hospital location) as layer 3. It means whole simulative area is sub divided into three sub layers. Logically simulative area **Adis** has three sub layer areas “a”, each of which is represented as a tuple mentioned in the figure 5.



Each tactical area “a” has dual entry-point **En** and an exit-point **Ex**. Transport nodes move from one layer to another layer following cycle path **Ztr** choosing one velocity of the interval **Vtr** for the whole cycle. The cycle depends on the layer the node is assigned. For example in **figure 6** the cycle for the transport nodes of first and second layer area is: $Z_{tr} = \text{rand-Ex, rand-En, FTL, rand-Ex, rand-En}$. For rand and FTL the node waits for a uniformly distributed pause time chosen from **Ttr**. This models the first aid and the handing over of a patient. Here rand represent the randomly selection of any one path for movement from layer to layer.

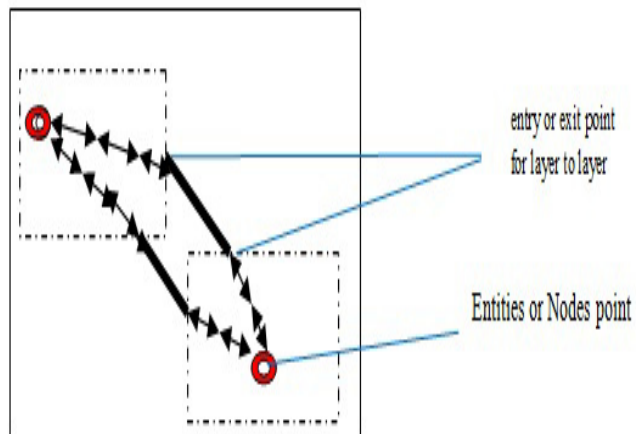


Figure: 6 Layer to layer movements

6. PERFORMANCE EVALUATION OF PROPOSED FRAMEWORK

The Post disaster mitigation mobility scenario may consist of high speed, low speed nodes or a mix of both. Speed for slow nodes (pedestrians) ranges between 1-1.5 m/s and fast nodes (vehicles/transport) ranges between 5-15 m/s. In the proposed model there are two important aspects: Attraction points for nodes from layer to layer and grouping behavior [22] (people influence each other's mobility, clustering in groups, avoid colliding with each other). Due to the complexity of the collision-avoidance parameter, it is not considered in the simulation model. It can be taken up as a future work.

6.1 Simulator

Various N/W- simulators such as NS2 [23], Qualnet[24] and OPNET [25] are surveyed and Qualnet 5.0 is chosen due to the fact that it allows simulation of complex networks and includes all advanced wireless model library with other supportive Ad-hoc networks library. Qualnet supports the random waypoint, reference point group mobility model along with user defined trajectories.

6.2 Simulation Model

In this paper we have considered a model based on attraction which is built on the concept of reference point. Two cases have been studied viz: nodes taken as a single group and nodes taken as multiple groups. The first case is the normal motion of nodes, considering the whole network as a single group. Here a common motion policy applies to whole group. The second case is considered by dividing the whole network in groups of average size 4. It is based on group mobility. Here, we have considered groups of mixed pedestrians and vehicles based on speed. The parameter "MIX" indicates a mixture of 25% vehicles group (5-15 m/s) and 75% pedestrians group (1-1.5 m/s). For these models, we set group parameter (specified by velocity-matching, and expressed in the fraction of nodes that exhibit the specified group behavior) [26] indicating that every node acts in confirmation to group behavior.

For both these cases 3 sub case has been considered based on attraction. The attraction/reference points of the model provide proper predefined reference paths to the nodes or group of nodes for moving from one layer to another. In order to take the advantages of Reference point group mobility (RPGM) [13, 14] in our framework, we have included it in our simulation. The target of this simulation is to point out the ways in which attraction points change routing algorithm behavior. Here node speed has been chosen to be uniform between 1 and 15m/sec. The three sub cases are as follows:

Case a: It represents the movement of nodes to a fix flagged single attraction point, and back to their original position. It is a cyclic movement which mainly covers vehicle node movement from incident location to hospital location for carrying sufferer and then moving back to original position for remaining sufferers.

Case b: It represents the movement of nodes, by arbitrarily opting one, among the three attraction points and back to their original position.

Case c: It represents the movement of nodes, by arbitrarily opting one among three attraction points and then move to another randomly chosen attraction point. It is a transitive movement.

For these two models we have evaluated the influence of framework on the performance of MANET routing protocols. The simulation model includes 50 mobile nodes movement in an area of 1500m x 1500m. The whole setup is divided into three layered areas. In the initial position the nodes are distributed as 20 for DCL, 12 for FTL and 8 for HL (among these 4-5 nodes behave as an ambulance or speedy vehicle in each layer). Remaining nodes are treated as external input for the DCL with pedestrian speed. We have used two ray ground propagation models. Each node in the simulation has a radio transmission range of 180m with MAC protocol as IEEE 802.11b Wireless LAN (10 MBit per second). The data traffic with transport protocol UDP has been considered. The parameters for traffic pattern and framework scenario are given in Table 1.

Table 1: Parameters for Traffic Pattern & Framework Scenario

Traffic pattern	
Packet Size	512 Bytes
Packet Rate	4 pkts/sec
Data traffic	CBR
Parameters for the framework scenario	
Dimensions	1500m x 1500m
No. of nodes	50
Min. speed	1m/s
Max. speed	15m/s
Average number of nodes in a group	4
radio transmission range	180m
pause times	10 to 300 sec.
Simulation time	1200s
Antenna Model	Omni-direction
propagation model	Two ray

6.3 Performance metrics

Here we evaluate two parameters for performance evaluation of the proposed framework namely packet delivery fraction (PDF) and normalized packet delivery fraction (N-PDF). PDF gives an estimate of efficiency of communication network in terms of Packets sent and received. Since in our model, we have considered group movement for disaster core location, first aid treatment area and hospital area hence it is important to study the group behavior in terms of packet delivery fraction. The parameters evaluated are

- **Packet Delivery Fraction (PDF):** PDF is the ratio of the number of packets originated by the application layer sources and the number of packets received by the destinations. It describes the loss rate.

Packet delivery fraction = Data packets received / Data packets sent

- **Normalized Packet Delivery Fraction (N-PDF):** packet delivery ratio normalized to the non-group variant of each scenario.

Normalized packet delivery fraction = PDF for group movement / PDF for non-group movement.

7. RESULTS

7.1 Effect of nodes considered as a single group.

The attraction/reference points of the model provide proper predefined reference paths to the nodes or group of nodes for moving layer to layer. In order to take the advantages of Reference point group mobility (RPGM) [18, 19] in our framework, we have included the same. The target of this simulation is to point out the ways in which attraction points change routing algorithm behavior. Here node speed has been chosen to be uniform between 1 and 15m/sec.

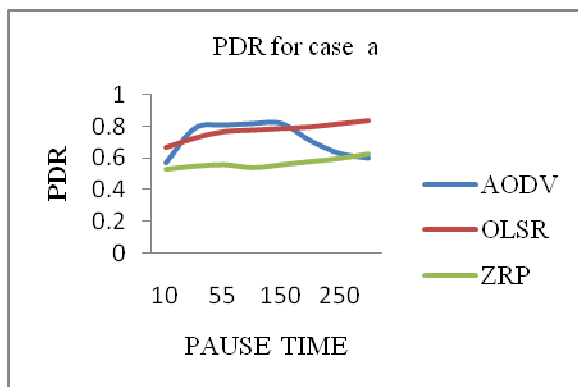


Figure: 7-a

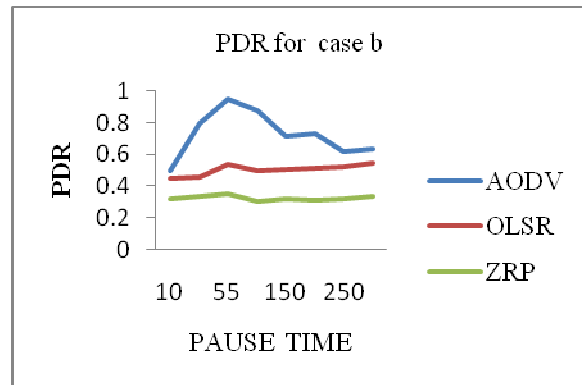


Figure: 7-b

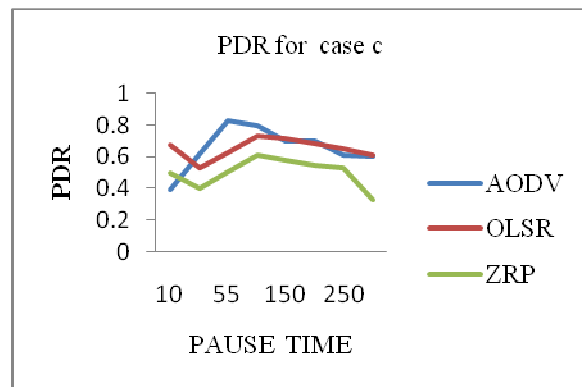


Figure: 7-c

Figure: [7-a, 7-b, 7-c] shows the packet delivery ratios for AODV, OLSR & ZRP for the defined cases.

7.2 Effect of nodes considered as multiple groups.

For the mobility cases discussed above, results have been plotted in figure 8. We have plotted the PDR (packet delivery ratio), normalized to the non-group variant of each scenario. The normalization is done with respect to the previous scenarios with nodes having maximum speed 15m/s. Here "Case 'x'MIX_GM" stands group mobility variants of mixed **pedestrians / vehicle** scenarios for particular case 'X'. We observe that group settings have impact on routing protocols, particularly for AODV.

"Case a MIX_GM", corresponds to group mobility for case 'a'. "Case b MIX_GM", corresponds to group mobility for case 'b'. "Case c MIX_GM", corresponds to group mobility for case 'c'.

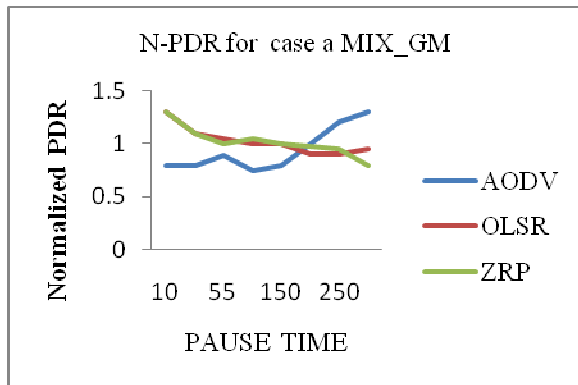


Figure: 8-a

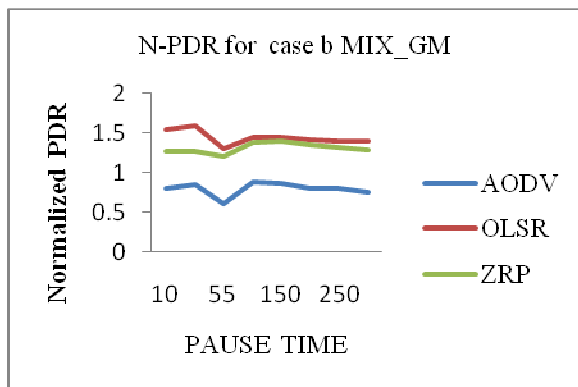


Figure: 8-b

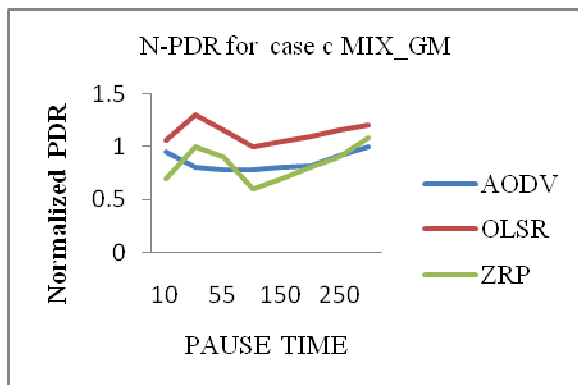


Figure: 8-c

Figure: [8-a, 8-b, 8-c] shows the normalized packet delivery ratios for AODV, OLSR & ZRP for group mobility.

7.3 Analysis of results

AODV: When pause time varies, the packet delivery fraction increases but this increase is up to the certain pause time. This is due to the fact that as pause time increases, the relative mobility of the nodes decreases, and hence the congestion also decreases in the network. The end-to-end delay also decreases as the pause time is increased.

This is due to the fact that as the pause time increases, the network topology becomes relatively stable and hence the number of stale routes in the routing tables decreases. Thus route discovery and maintenance takes less time. In the case of group movement the performance increases. Hence it can be said that AODV supports RPGM in defined ways.

OLSR: It works proactively (i.e. the routes are established before packet transmission). The group motion does have a profound effect on OLSR, as can be observed through results. With the increase in pause time the mobility of the nodes decreases resulting in decreased congestion, and hence PDR decreases. Since some of the cases are highly dynamic, the performance of OLSR degrades in these cases. In general its performance is better than AODV. The performance is average in almost all the cases but the Packet delivery ratio is higher than AODV and ZRP for group motion.

ZRP: ZRP being a hybrid protocol behaves differently. It works proactively in the starting but gradually changes to reactive mode, and the effect of this shift can be observed in the results. With group mobility the performance increases showing that it supports group motion. In certain cases (e.g. case c), performance is not good because the nodes are highly dynamic in this case.

8. CONCLUSION & FUTURE WORK S

This paper demonstrates and evaluates the framework for post disaster mitigation mobility at rescue operation by rescue teams. We have simulated framework of mobility with three MANET routing algorithms ZRP, AODV and OLSR. Here we have used the concept of attraction points for the model. Using these points the mobility scenarios are designed. We have taken reference or attraction point's concept to make the advantage of reference point group mobility inside our post disaster mitigation mobility model.

Our simulation shows that Manet routing algorithms behaves significantly different under the mobility scenarios designed on the same platform. For analyzing the performance of routing protocols in practice, such a scenario-based approach is vital. In future works, the level of severity of the disaster can be increased by addition of real temptation effect (e.g. obstacle avoidance in mobility and layer to layer movement through shortest path) on mobility in post disaster scenario as well as trying to add environmental effect like temperature and pressure with the use of sensors network.

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Nomenclature

1. **RPGM**: Reference Point Group Mobility model.
2. **DCL**: It is the Disaster Core Location i.e. the site at which disaster has occurred.
3. **FTL**: It is the First Treatment Location i.e. the place where the victims are given first aid.
4. **HL**: It is the Hospital Location for providing health services to the victims.
5. **TOC**: Tactical Operational Command.
6. $\mathbf{V}^t_{\text{group}}$: It is the motion vector for the group leader and the whole group.
7. \mathbf{RM}^t_i : It is the random deviation vector for group member i .
8. \mathbf{V}^t_i : It is the final motion vector of group member i .
9. **Adis**: It is the logically simulative area.
10. **a**: It is the sub layer of logically simulative area Adis and there is three such sub layers.
11. $\mathbf{Lr} \in \{\text{DCL, FTL, HL}\}$: It is the tactical classification of the sub-area **a**.
12. **Pr**: It is a part of the simulative area Adis.
13. **En**: it is the entry point for the layer.
14. **Ex**: It is the exit point for the layer.
15. **Ntr**: It is the set of transport nodes.
16. **Vtr**: It is the velocity interval $\{\mathbf{Vmin}; \mathbf{Vmax}\}$ for the set of nodes **Ntr**.
17. **Ttr**: It is the time interval $\{\mathbf{tmin}; \mathbf{tmax}\}$ for pause time of **Ntr** nodes.
18. **Gtr**: It is the size of groups.
19. **Ztr**: It is a sequence of points of the transport nodes.

Authors' Briefs



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Modelling mobility in emergency scenario for MANET applications

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ABSTRACT

In a post disaster situation, movement of rescue teams should be modelled effectively to ensure proper communication and co-ordination amongst different teams. For this it is necessary that movement is modelled effectively. In this paper we propose an emergency scenario movement modelling by managing the co-ordination task by a four way directional movement. The communication between the stages is considered to be provided by a MANET based network setup, since they are easy to deploy and do not require elaborate infrastructure. Mobility of MANET nodes between the stages has been modeled with random waypoint mobility model (RWM). Performance of the scenario is analyzed for three routing protocols viz. LAR [1], DYMO [2] and AODV [3]. Packet delivery ratio, end to end delay, normalized routing load and data packets forwarded is estimated for these protocols. From the results it is observed that for such situations, performance of geographic routing protocols is better than other reactive protocols.

Keywords: MANET; Geographic routing protocols; LAR; DYMO; AODV.

I. INTRODUCTION

In post disaster management, relief teams cannot solely rely on existing infrastructure because there is high probability of bursting of whole communication backbone. With the advent of MANETs, a rapid deployment of infrastructure is possible. In case of a disaster management system, MANETs have been found to be suitable for providing communication infrastructure.

A Mobile Ad hoc NETWORK (MANET) consists of wireless mobile nodes that are mobile and self-organized. Performance of a MANET system depends on mobility model used. The rescue operation constitutes an important phase in disaster management. The importance of improving the rescue techniques can't be ignored. Few techniques exist for e.g. using their mobile phones; the

emergency response team can locate survivors [4]. The main focus of this paper is to understand the movement in the post disaster mitigation scenario. Simulations have been carried out to compare the routing protocols for packet delivery ratio, end to end delay, normalized routing load and data packets forwarded.

Earlier works in the area of disaster management paid attention to develop an emergency mobility framework. Random waypoint model [5] is the preferred model to define the mobility scenario.

A pixel oriented approach for mobility modeling was used by Kraaier et.al [6]. The authors have used transitional probabilities to reach the stationary distribution which is predefined for users. The simulation area is divided into small parts and performance is evaluated. An algorithm GAF [7] turns off the unnecessary nodes thereby reducing the energy consumption. Authors in [8] analyze the performance of routing protocols using CBR traffic for fixed number of nodes based on scenario. We introduce a four-way movement design, which reflects the possible motion of users in post disaster scenario and study the performance of LAR, DYMO and AODV routing protocols.

The organization of rest of the paper is as follows. In the next section we describe the proposed scenario for disaster management. In the subsequent section we briefly describe the routing protocols namely AODV, LAR and DYMO followed by a description of the scenarios considered for simulation. Then we describe the simulation setup, analysis of results. Finally we conclude the paper.

II. PROPOSED SCENARIO

Under four-way movement design, we have taken five nodes that are placed on the four directional-way with one node in center made stationery.

Except this stationary node other four nodes are moving on the four directional-way with 30 m/s for in & out direction, nodes are communicating to center stationary node and also with the nodes in the adjacent confine areas. Under randomize movement vehicular nodes are moving randomly with 30m/s.

The whole area has four sub areas of equal size 500x500m² at each corner, as shown in Figure 1. The nodes in the corner areas 1-4, represent the group of people working together in their confine area. These nodes (confine area nodes) have an average speed of 1.5m/s. These nodes communicate with each other using CBR links. They move randomly within the confine area. One another set of fixed nodes move with a speed of 30m/s. These nodes symbolize vehicles used at the emergency rescue operation. These nodes communicate with each other using VBR links for locating positions of each and to inform one another the location of the disaster. In our design, we have taken four-way movements and fully randomize way movement of vehicular nodes. We have taken terrain region of 1500x1500m² for the simulation study.

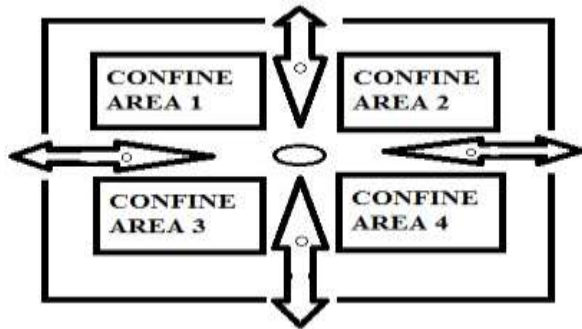


Figure 1: Simulation design model

III. ROUTING PROTOCOLS

Under this section we give a precise description of the routing protocols studied in our work.

1. AODV

AODV stands for “Ad hoc On-Demand Distance Vector” algorithm. It is a reactive protocol. It is dynamic, self-starting and multi-hop protocol. The routes to destinations which are not active, is not

maintained here. It allows mobile nodes to obtain routes for new destinations. Source broadcasts a RRQP (route request packet) to find a route to the destination. This message propagates in the network until an intermediate node is reached which has most recent route information or until it reaches the destination. The intermediate nodes also forwards RRQP and updates its local table providing information on origin of RRQP. This information is further used in forming the reply path for the route reply packet. It happens because AODV uses only those links that are symmetric. In AODV the intermediate nodes maintain the routing information as and when the RRP (route reply packet) traverses back to the source. The mobile nodes respond to link breakages and network topology change in sync with other nodes. In case of a link breakage, the nodes which are affected should be notified in order to enable them to invalidate the routes. This is done using link-lost technique.

2. LAR

A Location-Aided Routing (LAR) protocol is geographic routing protocol or position-based routing protocol.

This protocol assumes that source node sends data to destination node using the information of co-ordinate geographic location of the destination. The network address becomes unusable in this case but the performance is seen to improve. The overhead which is generated by route discovery packets accounts for decreased traffic overhead. Global Positioning System (GPS) can be used in calculating the location of a node.

The unique characteristics of location based protocols are:

- i. Each node determines its own location.
- ii. Source knows the location of destination.

Due to this property, packets can be successfully routed to destination, removing the necessity of knowledge of network topology. LAR belongs to category of reactive protocol and is built on DSR (Dynamic Source Routing protocol).

In DSR protocol the entire network is flooded by RREQ packet, when route to a specific node is not found. This flooding is minimized in LAR by using the location information. The packets are flooded in a forwarding zone called the Request Zone, which in

itself is based on location information. Two techniques were proposed by Young-Bae-Ko to determine whether a particular node is a candidate of the request zone. These techniques are LAR Box and LAR Step Protocol.

LAR Box Protocol

Here, the candidature of a node is determined by using the location information of the node and expected zone for the node which initiates the flooding.

The Expected Zone is determined by following information:

- Most recent location of the node.
- Time at which this location is calculated.
- Average velocity of the node.
- Current time.

If a node is found to be in the request zone, it forwards the route request packet using the same technique of finding the zone flooding the packet.

LAR Step Protocol

Here, the candidature of a node is determined by finding the distance between the node and destination. If this distance is smaller than the previously calculated distance for the node which wants to flood data then its candidature is approved. For e.g. let us suppose that distance between node A (the node which sends the RREQ packet) and node B is D_x , and the distance between node C (the node which received the RREQ packet) and node B is D_y . Now, the node C will forward the RREQ packet if $D_y \leq D_x$.

2 DYMO

Dynamic Manet On-demand (DYMO) routing protocol is a fast and reactive routing protocol. DYMO has less routing overhead due to the use of path accumulation function. Only those routing information, which is important for all active source and destination is maintained. Hence less information is maintained and due to this facility DYMO is considered to be memory efficient.

There are two protocol operations:

- Route Discovery

In this operation a RREQ broadcast message is initiated by source. Some extra information like

source address, destination address, sequence number, hop limit etc. are provided to in range immediate neighbors. When the RREQ is received by an intermediate node, it performs path accumulation (a path to source is created and address of this intermediate node is appended to RREQ packet), and then this message is broadcasted to neighborhood of the intermediate node. The path accumulation is done to reduce the number of RREQ packets in future. This process continues till the RREQ reaches destination. When the destination receives the message, it initiates a RREP (Route Reply) packet as an acknowledgement. The RREP is sent back to the source using the reverse path. In order to avoid loops and obtain current information about routes, sequence numbers are utilized. Finally when source node receives RREP packet, a route is established.

- Route Maintenance.

This operation has two gears:

- When a packet is successfully delivered, the route lifetime is extended for further use.
- Link failure: The information regarding the broken link is sent using RERR (Route Error) packet. When a node, upon receiving a routing packet is unable to find a route, initiates creation of a RERR packet. This packet contains a list of nodes which are unreachable and the sequence number. A RERR gives information that the current route no longer exists; hence an alternate route should be searched.

IV. SCENARIO

Eight scenarios have been created with varying number of nodes. Each scenario consists of five-nodes set, among 4 nodes set to represent four-way movements to the center and one node behave as stationery at center point. Confine Area at each corner are $500 \times 500 \text{m}^2$. In each confine region the number of nodes varies from 5, 7, 9, 11, 13, 15, 17 and 19, which means that the total nodes would vary from 25, 33, 41, 49, 57, 65, 73 and 81. The whole network include miscellaneous mobility (one node as stationery, four nodes for four way directional

movement with speed of 30 m/s and rest nodes for confine areas with speed of 1.5 m/s). All the three protocols are applied on all the discussed scenarios and their performance is evaluated.

Scenarios	Nodes in confine region	Total No. of nodes	VBR +CBR flows
Scce.1	5	25	15
Scce.2	7	33	20
Scce.3	9	41	25
Scce.4	11	49	30
Scce.5	13	57	34
Scce.6	15	65	45
Scce.7	17	73	60
Scce.8	19	81	65

Table I: Number of nodes and CBR flows

V. SIMULATION SETUP

Various network simulators such as NS2, Qualnet and OPNET are surveyed and finally Qualnet is chosen for our simulation as Qualnet allows simulation of complex networks with standard GUI features and it includes all advanced wireless model library with other supportive Ad-hoc networks library. Qualnet supports the mobility models: random waypoint, reference point group mobility as well as self-defined designed trajectories.

1. SCENARIO PARAMETERS

The simulation parameters are shown in table 1. The journey of a node originates from a random location. This journey ends on a random location. The speed of the node in journey is also random. When the node reaches its destination, the next destination is calculated and the node starts its journey after a pause. In this scenario the nodes in the four regions are continuously moving without pause and the vehicle nodes are moving with speed of 30m/s (randomly in one scenario and in specified directions in another scenario) with pause time of 2s. Identical mobility and traffic scenarios are used across all the protocols.

Traffic pattern	
Packet Size	512 Bytes
Packet Rate	5 pkts/sec
Data traffic	CBR, VBR
Parameters for the framework scenario	
Dimensions	1500m X 1500m ²
Confine Area at each corner	500 X500m ²
Node Placement (restricted to confine area)	Random
Node Placement (Vehicular nodes)	Four-way movements design /Random
Total No. of nodes	25,33,41,49,57,65,73 and 81
Min. speed	1.5m/s
Max. speed	30m/s
Routing Protocols	AODV, LAR(box),DYMO
Radio trans. range	180m
Pause times	2s
Simulation time	400s
Antenna Model	Omni-direction
Propagation model	Two ray

Table II: Simulation setup

2. PERFORMANCE METRICS

We have evaluated two parameters for our scenarios as discussed below.

Packet Delivery Fraction (PDF): PDF is defined as the ratio of the number of packets that are sent by the source(s) and the number of packets received by the destination(s). It depicts the loss rate.

Packet delivery fraction = Data packets received / Data packets sent

Average End to End delay: It is the time taken by a packet to reach destination node from a source node. The route discovery wait time is included, which a node may experience in case a route is not available. The average delay is computed as: $D_{avg} = \sum (t_r - t_s) / Pr$, where t_s is the packet send time and t_r is the packet receive time for the same packet at destination.

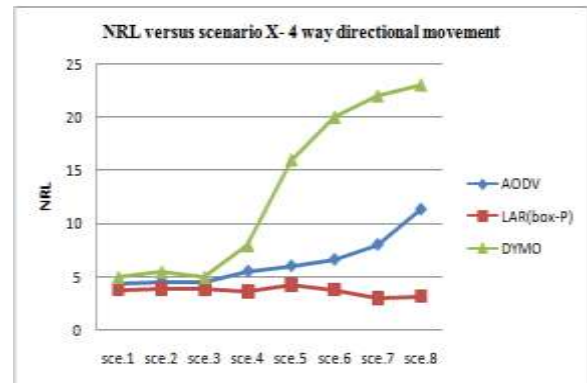
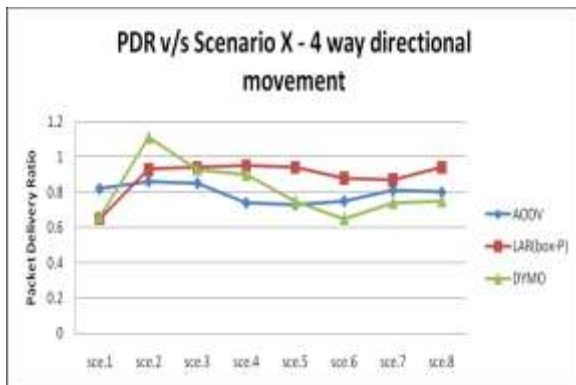
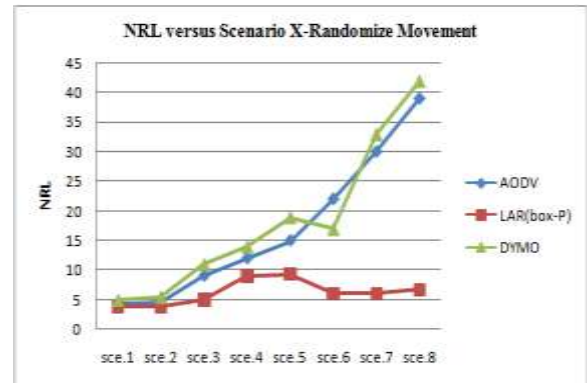
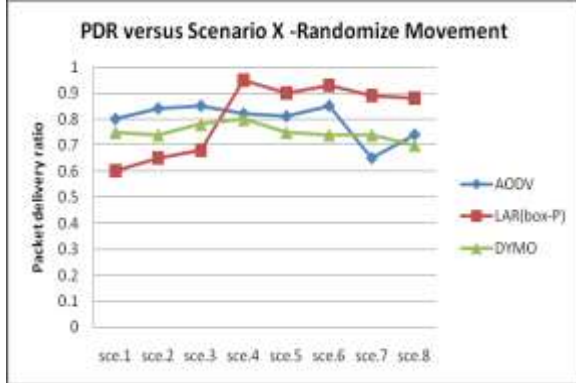
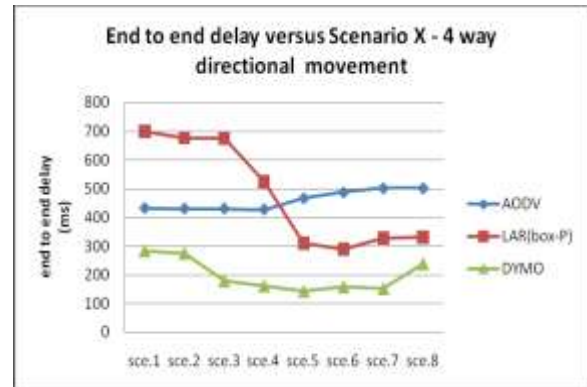
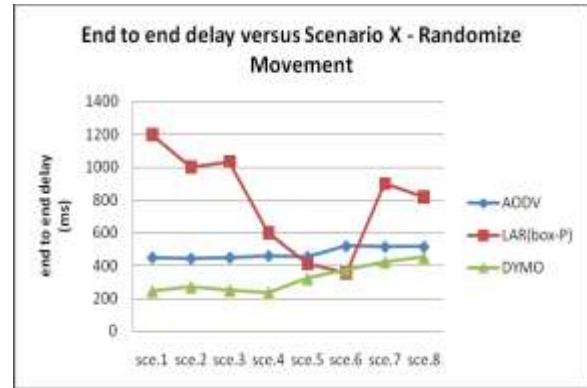
Normalized routing load (NRL): It is defined as the ratio of control packets to data packets in the network. It gives a gauge of the routing overhead; i.e. the number of control packets required (for route discovery/maintenance) to successfully send data packets to their destinations. It characterizes the

protocol routing performance under congestion. NRL is determined as: P_c/P_d , where P_c is the total control packets sent and P_d is the total data packets sent.

Data packets forwarded (DPF): It is the number of data packets forwarded in a particular time interval.

VI. RESULTS & EVALUATION

For 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 randomize motion and pre-defined four way directional motion of the vehicular nodes, with varying number of traffic sources and CBR+VBR flows as shown in Table 1. It is also observed from the results that all the three protocols : DYMO (fast reactive), AODV (reactive) and LAR-BOX (geographic routing protocol-reactive with GPS) perform well.



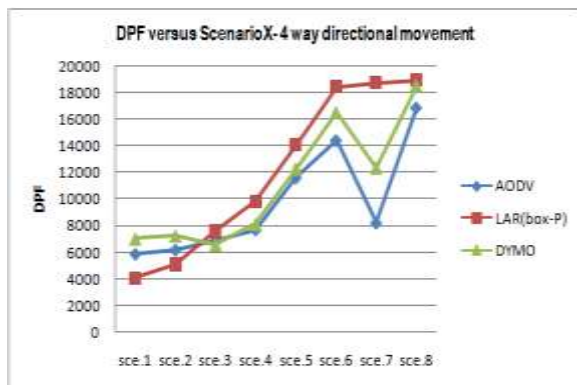
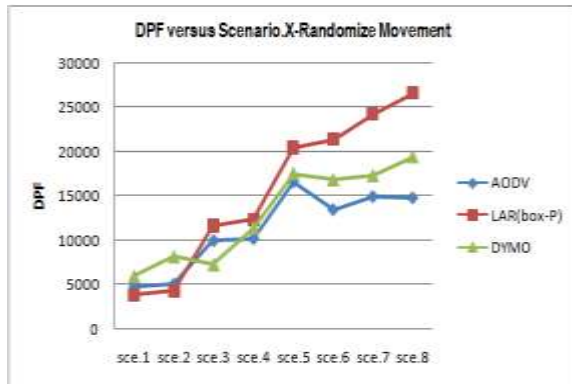


Figure 2: performance metrics (a-h)

The PDR and End to end delay is better for LAR at peak load, when the movement of the vehicular nodes is along the direction indicated as compared to their random movement for the above said metrics. However Performance of AODV and DYMO is better than LAR for low load randomize movement for all the considered scenarios. On the other hand we observe that average end-to-end delay is lowest in DYMO as compared to both LAR and AODV. This is due to the fact that DYMO is fast, it has less routing overhead by the use of path accumulation function. The End-to-end delay in LAR gradually increases after attaining lowest point in mid load for randomizes movement in comparison to four way directional motion. In the same way we have considered normalized routing load and data packets forwarded, the LAR (box p) has given approximate better performance than other two routing protocols.

VII. CONCLUSION

This paper evaluates the modeling of emergency scenario through the impact of reactive & geographic routing protocols. The performance metrics are compared for randomized mobility. Here we have observed that by organizing the terrain region into four equal sized symmetrically placed sub-regions give optimum results in the terms of PDF, end-to-end delay, normalized routing load and data packets forwarded

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MANET BASED COMPARISON OF NETWORK SIMULATORS: NS2 & QUALNET

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Abstract

Choice of a suitable simulation tool is vital for MANET studies. NS2 & Qualnet are used for this purpose. They provide various features for preparing, analyzing and evaluating parameters of a network scenario. In this paper we compare characteristic features of these two & few other popular network simulators. Manet simulations has been carried out to observe Good put, Computation time and memory usage for NS2 & Qualnet.

Keywords: Network Simulator, NS2, Qualnet, Good put, Computation Runtime, Memory usage

1. Introduction

A network simulator is used to analyze the features and performance of wired and wireless Networks like packet loss, delay, throughput, Quality of service etc., for various networking scenarios. After executing the scenario on a simulator, the results are analyzed in various dimensions which include customization mechanisms, speed of execution (parallel execution), usability, level of scalability, model diversity. Graphical User Interface helps a lot to understand the Usability feature to start creating a scenario-simulation [Lessmann, 08] [Sasson, 02]. There are many network simulators that exist with specific features. Some of the network simulators are NS2, NetSim, OMNeT++, REAL and Qualnet. In this paper we work on the Ns2 and Qualnet simulator with defined cases.

NS-2 is widely used in academic research. Many enhancements modules (i.e., multi-rate schemes, IEEE 802.11a/g/e and energy consumption models) have been incorporated. Although it's advanced version NS3 has been developed in 2008 but NS2 still continues to be used widely because of its simplicity and usefulness. Qualnet is developed from the GloMoSim simulator [Zeng, 98]. Qualnet incorporates some extra features such as weather factor and high speed mobility. Simulator studies have been made with these simulators in an attempt to compare them. In the past Kargl and Schoch [Kargl, 07] compared network simulators JiST/SWANS and NS2 for wired

networks. Lucio et al. [Lucio, 03] proposed a comparison study for Ns2 and OPNET on the test bed for wired networks. In [Hogie, 05] authors endeavored to map characteristics that MANETs Simulation tools should reflect and support with description of GlomoSim, J-Sim, NS-2, OMNet++, OPNET Modeler. In [Ivanov, 07] authors compared nature of traffic flow in simulations with test bed experiments. However, analysis is limited to fixed network and is evaluated on NS-2 only. In contrast, our comparisons are extended to wireless networks with parameters like memory usage, computation time, area impact etc.

In this work we have calculated the effect of minimum distance on good put, network size on computation time and memory usage with effect of area. The simulations has been carried out on both NS2 & Qualnet keeping all the parameters same.

A brief description of available Network Simulators is given below:

1.1 NS2 (Network Simulator version2) provides a support for simulation of multicast protocols, TCP, routing and overall networks (wired and wireless). It is open source software [ISI, 95]. A review on MANET simulations shows that NS2 holds 43.8% usage (from a review on wire-less network research papers from ACM symposium based on 250 articles from a five-year-period).

1.2 OMNET++ (Optical Micro-Networks++) is an open-source simulation tool. It originates from a student project at the Technical University of Budapest in 1992. Its model consists of several (hierarchically nested) modules, starting with the system module. Modules at the lowest level are termed simple modules. They are programmed in C++ and encapsulate the actual behavior of a system. In the higher level, modules consisting of one or more modules which are known as compound modules.

1.3 REAL (Realistic and Large) network simulator is mainly used for packet-switched data networks. It analyzes the dynamic behavior of flow and congestion control schemes.

1.4 NETSIM (Network Based Environment for Modelling and Simulation): was developed by Tetcos in 1997, in association with IISc Bangalore. It has an object-oriented system modelling and simulation environment to support simulation and analysis of voice and data communication scenarios, for High Frequency Global Communication Systems. It helps to simulate Cisco Systems networking hardware and software. It is basically designed to aid the user in learning the Cisco Input Output System command structure.

1.5 QUALNET [Scalable, 02] is intended to be used for large, homogeneous networks, heterogeneous networks and the distributed applications. It is an advanced version of GloMoSim used by Scalable Network Technologies for their defence projects. It consists of high-fidelity network simulation software. It supports network and networking device performance. Qualnet supports several application layer protocols such as variable bit rate, Constant bit rate (CBR), File Transfer Protocol (FTP), or VoIP. It enables its users to create and design new protocol models, optimize existing and new models, analyse the performance of networks and perform 'what-if' analysis to optimize them etc. Its architecture consists of three layers: the simulation kernel (a discrete event scheduler) as basic layer, the model libraries as second layer and the top layer, which is defined by the developer graphical user interface.

2. NS2 and Qualnet – Component diagram & Comparative study

2.1 NS2

NS2 was built in C++ and provides a simulation interface through OTcl, an object-oriented dialect of Tcl. The user describes a network topology by coding OTcl scripts, and then the main NS2 program simulates that topology with specified dimensions or parameters. The NS2 is designed on the basis and believe of flat earth model in which it assumes that the environment is flat without any elevations or depressions. However the real world does have geographical features like urban area and mountains. NS2 fails to provide these real modelling environments.

2.1.1 Otcl

OTcl runs slower but can be programmed easily, making it suitable for simulation configuration. The component diagram of Ns2 is given in Figure 3. Ns2 has proper data and control separation. OTCL in the Front End includes Control part of Ns2, Topology (Simulation scenario), configurations, Event driven, Periodic or Triggered action. C++ in the Back End includes Core of Ns2, data part of Ns2, Packet processing and execution.

2.2 Qualnet

It utilizes VC++ for implementing new protocol. It has the capability of parallel simulation for complex scenario. Hence we can run it for distributed functions as well. The architecture is shown in figure 2.

Model libraries: It contains Developer, Wireless, and Multimedia. Enterprise Model Libraries are additional libraries for modelling e.g. Wireless, network security and sensor networks. Qualnet supports scenario based simulation.

For creating scenario there is a specified process which includes nine stages in block flow diagram given in Figure 3.

2.3 Comparative study: We consider important behavioral and structural feature of simulators. Based on few selected parameters, we tabulate characteristic features of some popular network simulators in table 1. These features have been inferred through the catalogues and relevant literature of the simulators. Brief definitions of parameters which have been considered, are listed below.

- **Applicability:** If a system makes full use of resources for both network and system application, it is said to be Applicative.
- **Parallelism:** It supports large structures (generally more than 1500 node topology) and the simulation runs in parallel module execution.
- **Mobility:** It allows simulating mobile nodes and real time environment.
- **Scalability:** It supports maximum scenarios, for any terrain and any size of network.
- **Interface:** It considers the simulators languages and supports platform implementing language.

- Available modules: These are the modules which are supported by the simulator.
- Emulation: It supports simulation and emulation of real time scenarios.
- Graphical support: It allows and visualizes all scenarios in graphical view to provide a good understanding of the topology.

3. Simulators Usability

The simulators usability in application analysis is given in figure 4. This usability is defined as the percentages of simulators which are used in network applications. This usability is calculated by accessing previous cited papers in reputed network journals, since last five years.

4. Simulation scenario and evaluation

This section is divided into 2 parts, one includes designed case study with reference to simulators and second includes comparison of both simulators on the basis of designed cases which were taken up in first part. We are taking two simulators Ns2 & Qualnet, with two cases of different scenario to get the comparative result of both the simulator.

4.1 CASE - 1: For large networks the parallel simulators perform better than others. But for smaller networks most of the features are supported by many simulators. Hence it is difficult to choose one. The main problem is how to choose the simulator depending upon prevailing conditions. For our simulation, we fixed the minimum distance between a pair of nodes with the simulation area of $500 \times 500 \text{m}^2$ and $250 \times 250 \text{m}^2$. For performance analysis (figure 11-12) we worked with minimum fixed distance for a pair of nodes in 10 iterations. Similarly the good put is calculated based on the average result for the simulation study. Good put is defined as the ratio of total data packets successfully sent and total packets transmitted in the network.

4.1.1 Setup & performance comparison:

The topology consists of seven nodes arranged in an arbitrary fashion with a minimum side length between pair of nodes is 5 meters for first iteration. Similarly 10 meters for 2nd iteration. In this way assessment for up to 55 meters in 11th iteration. The simulation setup is shown in table 2.

Nodes are running in 802.11b ad-hoc network at 2.4 GHz. The topology is shown in figure 5. Through VBR+ application, data packets send from node1 to node7 over UDP and the good put is measured. Concurrently through another VBR application data send from node4 to node6. Links are used at full capacity.

In Qualnet the good put fluctuates at larger distances and also at all distances. Although the fluctuation is quite more, it is considered more realistic. The simulated good put is slightly over 10 MB/s for distances smaller than 25 meters. The results are shown in figure 6 for 500×500 area and figure 7 for 250×250 area. After the initial alignment of the nodes they tend to move towards each other with the passage of time. This process continues repeatedly and if the area is larger it is less frequent else it is more frequent. This is due to the fact that in a bigger area the probability of

best orientation is lesser as compared to smaller area. This improves the throughput. Movement has a positive effect on throughput.

4.2 CASE - 2: For any application the running time and hardware (memory) usage are crucial factor to decide simulation tool. Here for comparing simulation tools we have taken simple network structure, without aiming the simulation of a real network, because its performance is mostly dependent on the code of the network models and their computational complexity.

4.2.1 Setup & performance comparison: We have taken a basic network structure, where the nodes are arranged in a square fashion connected with the CBR links in Figure 8. Here we made two nodes that must have communication between each other. In figure 8 those nodes are labelled with the name of sender and receiver. The receiver node "11" is located at the below corner and sender node "1" is located at the top left corner; instead of it we have chosen different pair in each iteration for the same wireless environment.

We have taken this scenario for its simplicity. Same nodes setup pattern has been used for 50,100,150,200 and 250 nodes. All simulation runs were conducted on a processor dual core-2.6Ghz with 2GB of RAM, running Ubuntu Linux 9.0 desktop edition. Our measurements were taken using ns-2 version 2.33 and Qualnet version 5.0.

4.2.2 Computation-runtime: For bigger area movements can be longer and frequent, and this result in higher computation runtime. Figure 9, 10 shows the measured simulations runtime at different network sizes for the compared network simulators. It is not applicable to large-scale network simulations: For a network size of 250 nodes, it needs 30 seconds on an average to complete the simulation run, actually it is a very small network and system is so much powerful and so it computes very quickly. Ns2 takes more computation time by network sizes 200 & 250 nodes in compare to Qualnet.

4.2.3 Memory usage: As similar setup of simulation for computation run-time, we measured the maximum memory usage of the individual simulators. The outcome shows in figure 11, 12. Ns2 and Qualnet for area 500x500 setup takes up more memory than the Ns2 and Qualnet for area 250x250 setup scenario. The difference in memory usage between Qualnet and the Ns2 tools increases with larger network sizes.

The memory usage performances of ns-2 and Qualnet share a dissimilar linear growth of memory usage but Qualnet is the better simulation tool out of the two. It is because of the fact that with increasing network size and area-size node moment will get large number of coordinates, analyzing all movement would be possible with relatively high degree of space & time complexity. Also in NS2 as the topology grows, more trace files are generated and it consumes memory.

4.2.4 Area impact: For same setup environment, we measured computation-runtime of the individual simulator with change in simulation Area for fixed network size 200 nodes. Figure 13 shows impact of area on computation time with fixed network size. It depicts that Ns2 is taking more computation time than Qualnet for the area A3 & A4. This happens in Ns2 because with increase in area the trace files increase exponentially and it leads to more memory consumption, hence computation time is more as compare to Qualnet.

5. Conclusion

In this paper, we have compared basic features of Network simulators including NS2 & Qualnet. The simulators studied included NS2, OMNET++, OPNET, NETSIM, REAL and Qualnet etc. Simulators architecture and Component diagram have been studied for NS2 & Qualnet. We investigated their performance and the scalability of the tools. Our result shows that while both Ns2 and Qualnet are efficient for carrying out small-scale network simulations: however for a moderate scaled network Qualnet has been found to be better in terms of network speed, memory consumption and for larger areas.

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<u>Salient Features</u>	<u>NS2</u>	<u>GloMoSim</u>	<u>J-Sim/NetSim</u>	<u>OMNet++</u>	<u>OPNet</u>	<u>QualNet</u>
Document and user support	Poor	Poor	Poor	Good	Good	Excellent
Applicability	Net./Sys	Net./Sys	Network	Net./Sys	Net./Sys	Net./Sys
Available Modules	Tcp-ip/Wire/Wireless/Ad-hoc/WSNA	T/W	Tcp-ip/Wire/Wireless/Ad-hoc/WSNA	Tcp-ip/Wire/Wireless/Ad-hoc	Tcp-ip/Wire/Wireless/Ad-hoc/WSNA	Tcp-ip/Wire/Wireless/Ad-hoc/WSNA
Interface	C++/OTcl	Parsec (C-Based)	Jacl	C++/NED	C or C++	Parsec (C/VC++Based)
Parallelism	No	SMP/Beowulf	RMI-based	MPI/PVM	Yes	Yes
Mobility	Support	Support	Support	No	Support	Support
Graphical Support	No or very limited visual	Limited Visual	visualization and debug facility	Good visualization and excellent facility for debug	Good visualization and excellent facility for debug	Excellent graphical support, Excellent facility for Debug.
Scalability	Small	Large	Small	Large	Medium	Very Large
Extendibility	Good	Good	Good	Good	Excellent	Excellent
Emulation	Limited	Not Direct	Yes	Limited	Not Direct	Yes

Table-1: Simulators and corresponding salient features

Table 1 shows the salient features for various simulators and their comparison.

Packet Size	512 Bytes
Packet Rate	4 packets/sec
Data traffic	VBR+
Dimensions(Area)	500m x 500m & 250m x250m
No. of nodes	10
Min. speed	1m/s
Max. speed	15m/s
Routing algorithm	AODV
radio transmission range	60m
Position Granularity (meters)	1.0
pause times	5s
Simulation time	200s
Antenna Model	Omni-direction
Mobility Model	Random way point
propagation model	Two ray

Table-2: Parameters for simulation setup case1

Table 2 shows parameters chosen for simulation and their respective values

Packet Size	512 Bytes
Packet Rate	4 packets/sec
Data traffic	CBR
Dimensions(Area)	250m x250m & 500m x 500m
No. of nodes	50,100,150,200 and 250
Min. speed	1m/s
Max. speed	15m/s
Routing algorithm	AODV
radio transmission range	60m
Position Granularity (meters)	1.0
pause times	5s
Simulation time	200s max
Antenna Model	Omni-direction
Mobility Model	Random way point
propagation model	Two ray

Table-3: Parameters for simulation setup case2

Table 2 shows parameters chosen for simulation and their respective values

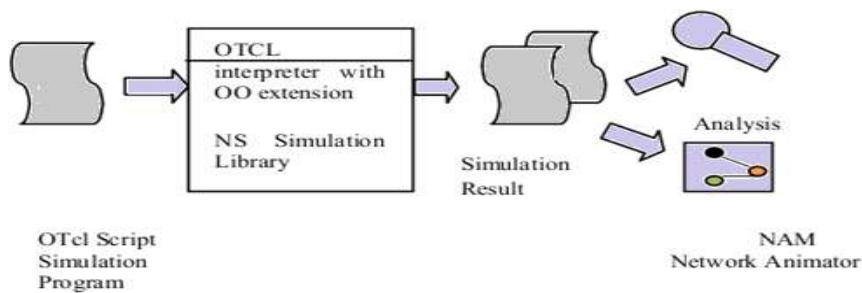


Figure-1: Architecture

Figure 1 shows the component diagram of Ns2 i.e. the architecture of NS2.

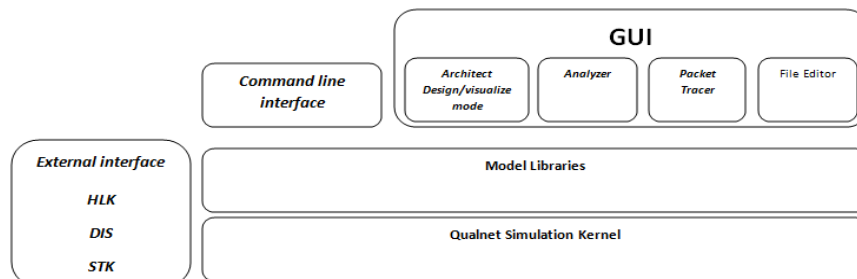


Figure-2: Qualnet Architecture

Figure 2 shows the component diagram of Qualnet simulator i.e. the architecture of NS2.

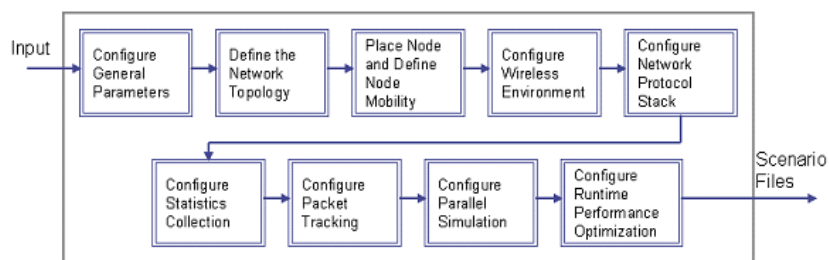


Figure-3: Creating scenario

Figure 3 shows the process of creating a scenario in Qualnet simulator.

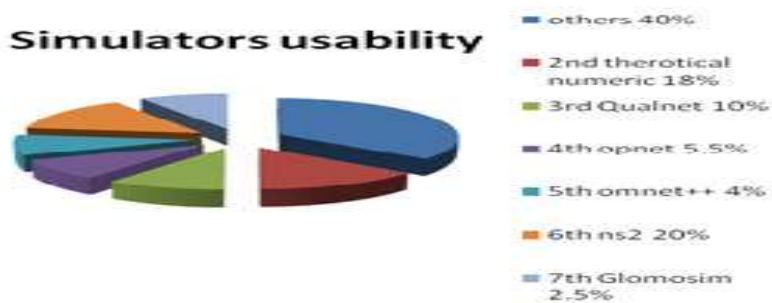


Figure-4: Simulators usability

Figure 4 shows the usability of various simulators in the market and research areas.

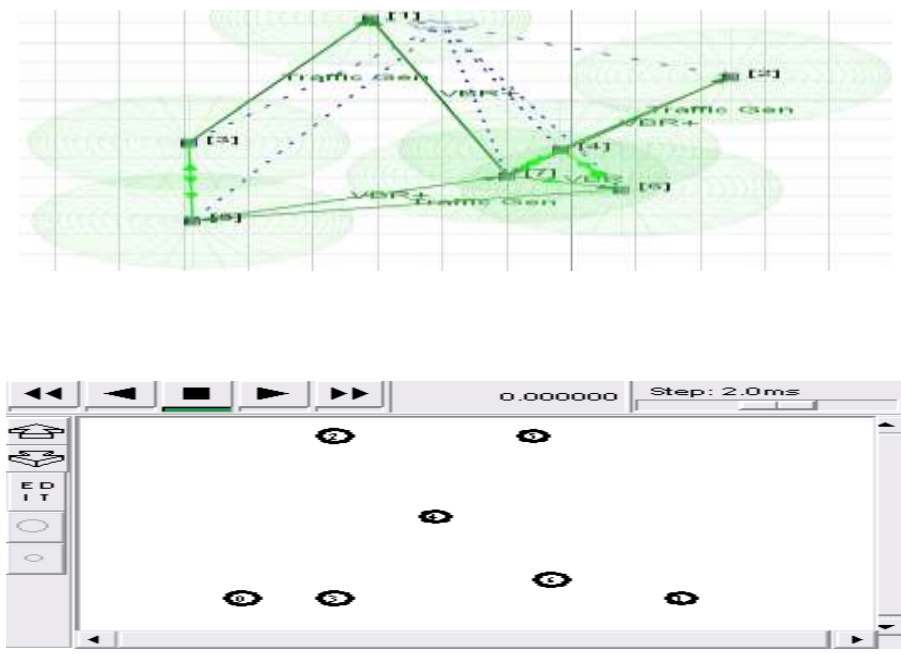


Figure 5: simulation running shot (Qualnet & Ns2)

Figure 5 shows the topology of the simulation in Qualnet for case 1.

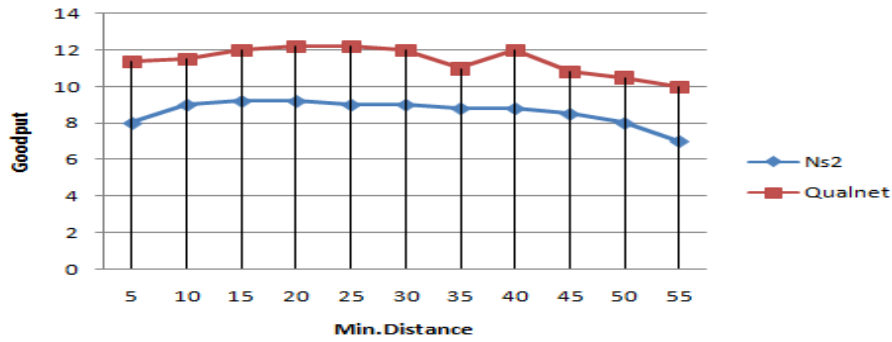


Figure 6: Good put performance with minimum side length between pair of nodes & fixed simulation area 500x500.

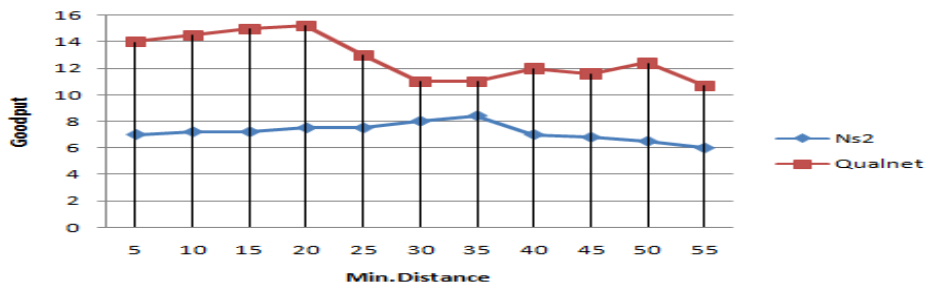


Figure 7: Good put performance with minimum side length between pair of nodes & fixed simulation area 250x250.

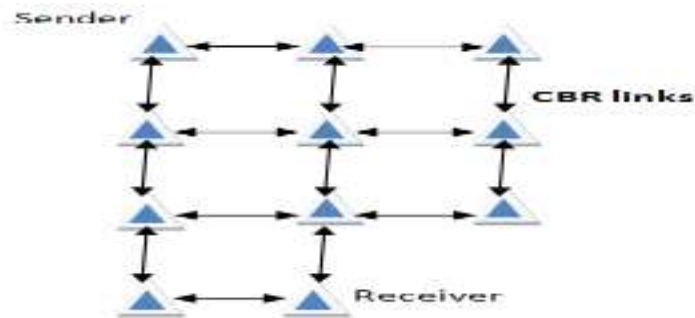


Figure 8: network structure

Figure 8 shows the topology of the simulation in Qualnet for case 2.

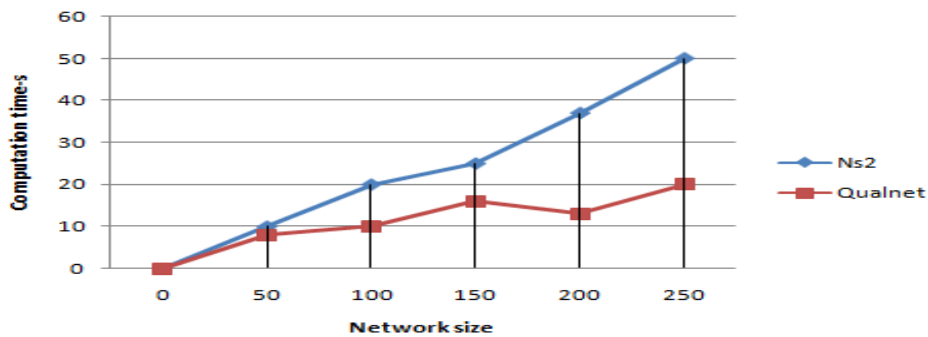


Figure 9: computation time performance with network-size & simulation area 500x500.

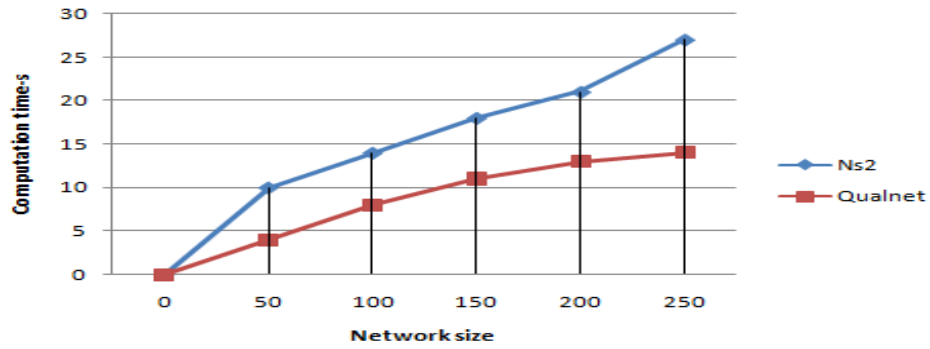


Figure 10: computation time performance with network-size & simulation area 250x250

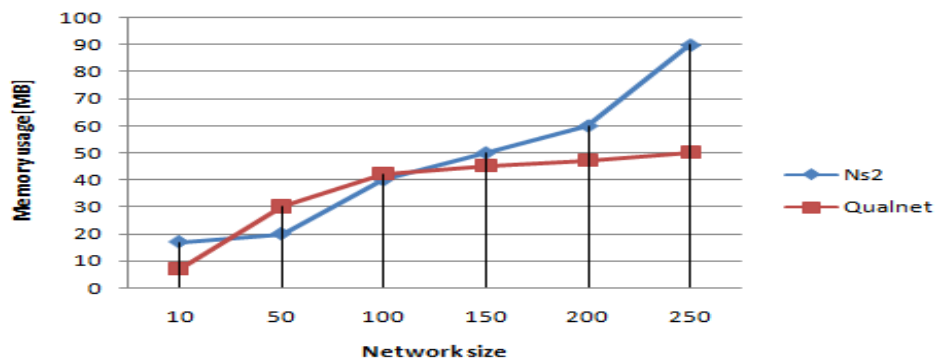


Figure 11: Memory usage performance with nodes increment & simulation area 500x500

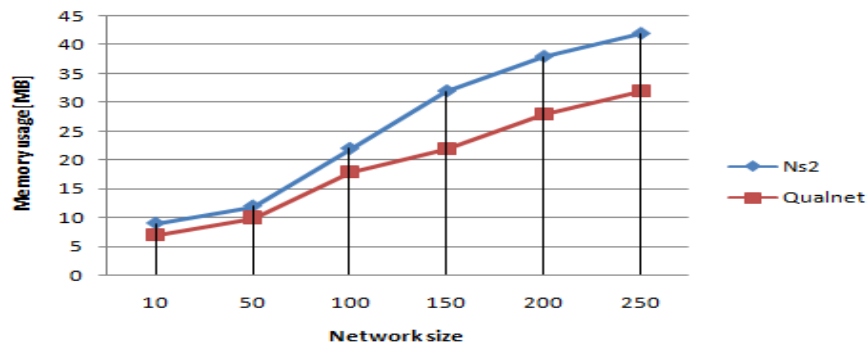


Figure 12: Memory usage performance with nodes increment & simulation area 250x250

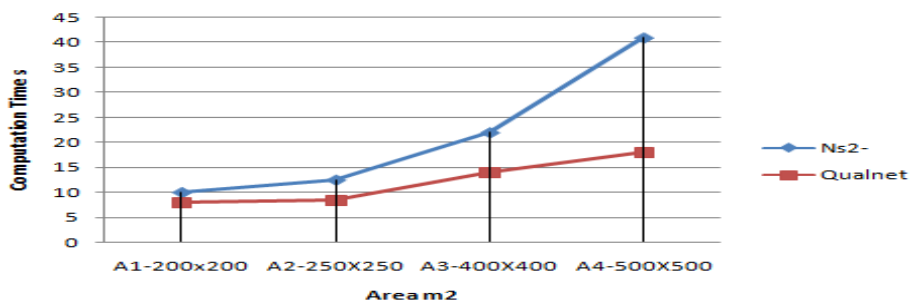


Figure 13: computation time performance with change in simulation Area for fixed network size 200 nodes

Geographic and Reactive Routing Protocols for MANET

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Abstract - Mobile Ad-hoc NETWORK (MANET) is a readily deployable wireless network suitable as a communication backbone during emergency response operations. These networks are infrastructure less. The goal of this paper is to simulate the scenarios for emergency situations. Various routing protocols have been proposed for MANETs like AODV, DSDV, LAR, DYMO, TORA etc. They are classified as proactive (table driven), reactive (on demand), geographic (based on GPS) etc. We have chosen three reactive routing protocols viz. LAR [1], DYMO [2], AODV [3] for performance evaluation. The mobility scenario is generated with random waypoint mobility model. Packet delivery fraction and end to end delay is estimated for these protocols. From the results it is observed that for such situations, performance of geographic routing protocols is better than other reactive protocols.

Keywords: MANET, Geographic routing protocols, LAR, DYMO, AODV.

I. INTRODUCTION

A mobile ad hoc network (MANET) is a group of wireless nodes that are mobile and self-organized. Performance of a MANET system depends on mobility model used. In case of a disaster management system, MANETs have been found to be suitable for providing communication infrastructure. The rescue operation constitutes an important phase in disaster management. The importance of improving the rescue techniques can't be ignored. Few techniques are already available, such as the Emergency Response Team trying to locate survivors through signals from their mobile phones [4]. The main focus of this paper is to understand the movement in the post disaster mitigation scenario. Simulations have been carried out to compare the routing protocols for packet delivery fraction and end to end delay.

II. PREVIOUS WORK

Earlier works in the area of Disaster management paid attention to energy efficient routing. A number of works has been done to develop an emergency mobility framework. Random waypoint model [5] is the preferred model to define the mobility scenario. A pixel oriented approach [6], the simulation area is divided into small parts and performance is evaluated and averaged. An

algorithm GAF [7] is designed to reduce energy consumption in the network by turning off unnecessary nodes. Scenario based performance analysis of routing protocols using CBR traffic for fixed number of nodes is proposed by [8].

III. ROUTING PROTOCOLS

Under this section we give a precise description of the routing protocols studied in our work.

A. AODV

AODV stands for "Ad hoc On-Demand Distance Vector" algorithm. It is a reactive protocol. It is dynamic, self-starting and multi-hop protocol. AODV does not require, maintaining routes to destinations that are not in active status. It allows mobile nodes to obtain routes for new destinations. Source broadcasts a RRQP (route request packet) to find a route to the destination. This broadcast message propagates until it reaches an intermediate node that has recent route information about the destination or until it reaches the destination. When an intermediate node forwards the RRQP, it updates its own table about the origin of route request. This information is used to form the reply path for the route reply packet as AODV uses only symmetric links. As the RRP (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 any link breaks; affected pair of nodes must be notified, so that they are able to invalidate the routes using the link-lost.

B. LAR

A Location-Aided Routing (LAR) protocol is geographic routing protocol or position-based routing protocol. It is based on the idea that the source node sends packet to the coordinative geographic location of the destination node instead of using the network address. It also has an edge on to improve performance of ad hoc routing protocols such as LAR protocol. This protocol decreases traffic overhead generated by route discovery

packets. According to the norm Global Positioning System (GPS) is helpful to getting the node location information. Position-based routing protocol has two main features that each node determines its own location and the source has knowledge of destination location. Hence, without knowledge of the network topology all packets can be routed to the destination. LAR is a reactive source routing protocol also, that is build up on the DSR (Dynamic Source Routing protocol). In DSR protocol if the neighbors of node S do not have a route to node D, S floods the entire ad hoc network with a route request packet for D. LAR protocol uses location information mobile nodes to flood a route request packet for D in a forwarding zone called the Request Zone instead of the entire ad hoc network. This Request Zone is determined by location information. Young-Bae-Ko proposed two concepts for this purpose, namely LAR Box and LAR Step Protocols to determine whether a node is member of the Request Zone or not.

LAR Box Protocol: Here a neighbor of mobile node S determines if it is within the Request Zone by using the location of S and the Expected Zone for mobile node D. The Expected Zone is determined by the most recent location information on D (XD, YD), the time of this location information t_0 , the average velocity of D V_{avg} , and the current time t_1 . This information creates a expected circle area with radius $R = V_{avg} * (t_1 - t_0)$ centered on (XD, YD). The Request Zone is a rectangle area (Figure 1) with Source S in one corner (Xs, Ys), and the Expected Zone containing D in the other corner. If a neighbor of S determines it is within the Request Zone, it forwards the route request packet further. A wireless mobile node that is not a neighbor of S knows that it is within the Request Zone by using the location of the neighbor that has sent the route request packet and the Expected Zone for D based on the most recent available information.

LAR Step Protocol: Here intermediary mobile node determines that it is within the Request Zone if the mobile node is closer to destination node D than the neighbor that has sent the route request packet. in particular, if the distance of the neighbor S that has sent the route request packet to D is $DIST_s$, and the distance of the mobile node I that has received the route request packet to D is $DIST_i$, then the mobile node I will forward the route request packet if $DIST_i \leq DIST_s$. Fig. 2 illustrates the LAR Step Protocol. Both LAR Box and LAR Step include a two stage route finding method. In the first stage, the route request packet is forwarded according to either LAR Box or LAR Step. If a route reply packet is not received within the route request timeout period, then a second route request Packet is flooded through the entire ad hoc network. If a route reply packet is again not received within the route request timeout period, then D is considered unreachable. If D remains unreachable for 25 seconds, packets for D are dropped.

C. DYMO

Dynamic Manet On-demand (DYMO) routing protocol is a fast and reactive routing protocol. DYMO has less routing overhead due to the use of path accumulation function. DYMO is also memory efficient since it maintains little routing information. In DYMO, only routing information that are significant to all active sources and destinations is maintained where as other protocols require entire routing information of all nodes with in a network. There are mainly two protocol operations: Route Discovery and Route Maintenance.

In route discovery, source node initiates the broadcasting of a RREQ (route request) message. This message contains source address, destination address, sequence number, hop limit and more optional field to its immediate neighbors in range. After receiving the RREQ, an intermediate node establishes a backward path to the source node appends its own address (i.e. path accumulation) to RREQ message and rebroadcast it to neighboring nodes. The aim of path accumulation is to reduce the number of RREQ message transmission in further path discovery. In this way, network is flooded with RREQ messages until the request reaches its destination node. When destination node receives a RREQ message, it creates a route reply (RREP) message as a response to RREQ and the RREP message is sent back along the reverse path. Sequence numbers are used to avoid routing loops and to obtain fresh information about routes. An intermediate node that receives RREP, process RREP as similar to RREQ. When source node receives the RREP, the route is established.

In route maintenance, this scheme has two components; (1) extension of route lifetime in case of successful delivery of packets & (2) link failures: broken link information is sent through the RERR message. If a node receives a packet for routing, unable to find a link to the destination, create a RERR message containing a list of unreachable node addresses, sequence numbers and sent it back to the source node. An RERR informs the source node that the current route is no longer available.

IV. SIMULATION SETUP

The whole area has four sub areas of equal size 500x500m² at each corner, as shown in Figure 3. The nodes in the corner areas 1-4, represent the group of people working together in their confine area. These nodes (confine area nodes) have an average speed of 1.5m/s. These nodes communicate with each other using CBR links. They move randomly within the confine area. One another set of fixed nodes move with a speed of 30m/s. These nodes symbolize vehicles used at the emergency rescue operation. These nodes communicate with each other using VBR links for locating positions of each and to inform one another the location of the

disaster. In our design, we have taken four-way movements and fully randomize way movement of vehicular nodes. We have taken terrain region of 1500x1500m² for the simulation study.

A. Four-Way Movements & Randomize Movement

Under four-way movements design, we have taken five nodes that are placed on the four directional-way with one node in center made stationery. Except this stationery node other four nodes are moving on the four directional-way with 30 m/s for in & out direction, nodes are communicating to center stationery node and also with the nodes in the adjacent confine areas. Under randomize movement vehicular nodes are moving randomly with 30m/s. Figure 1 shows this setup.

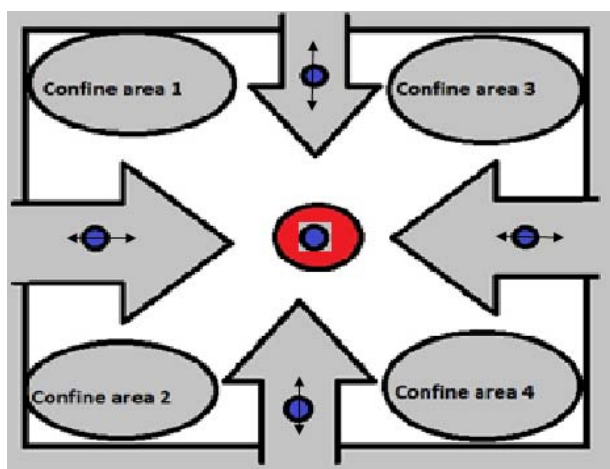


Figure 1. Four way movements

B. Scenario

Eight scenarios have been created with varying number of nodes. Each scenario consists of five-nodes set, among 4 nodes set to represent four-way movements to the center and one node behave as stationery at center point. Confine Area at each corner are 500x500m². In each confine region the number of nodes varies from 5, 7, 9, 11, 13, 15, 17 and 19, which means that the total nodes would vary from 25, 33, 41, 49, 57, 65, 73 and 81. The whole network include miscellaneous mobility (one node as stationery, four nodes for four way directional movement with speed of 30 m/s and rest nodes for confine areas with speed of 1.5 m/s). All the three protocols are applied on all the discussed scenarios and their performance is evaluated.

V. SIMULATOR

Various network simulators such as NS2, Qualnet and OPNET are surveyed and finally Qualnet is chosen for our simulation as Qualnet allows simulation of

complex networks with standard GUI features and it includes all advanced wireless model library with other supportive Ad-hoc networks library. Qualnet supports the mobility models: random waypoint, reference point group mobility as well as self-defined designed trajectories.

VI. SCENARIO PARAMETERS

The simulation parameters are shown in table 1. Here, each node starts its journey from a random location to a random destination with a randomly chosen speed.

TABLE 1: NUMBER OF NODES AND CBR FLOWS

Scenarios	Nodes in confine region	Total No. of nodes	VBR flows	+CBR
Scce.1	5	25		15
Scce.2	7	33		20
Scce.3	9	41		25
Scce.4	11	49		30
Scce.5	13	57		34
Scce.6	15	65		45
Scce.7	17	73		60
Scce.8	19	81		65

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 pause and the vehicle nodes are moving with speed of 30m/s (randomly in one scenario and in specified directions in another scenario) with pause time of 2s. Identical mobility and traffic scenarios are used across all the protocols.

A. Performance Metrics

We have evaluated two parameters for our scenarios as discussed below.

Packet Delivery Fraction (PDF): PDF is the ratio of the number of packets originated by the application layer sources and the number of packets received by the destinations. It will describe the loss rate that will be seen by the transport protocol.

Packet delivery fraction = Data packets received / Data packets sent

Average End to End delay: It indicates the time taken for a packet to travel from the source node to application layer of the destination node. It also includes the route discovery wait time that may be experienced by a node when a route is initially not available. The average delay is computed as: $D_{avg} = \frac{\sum (t_r - t_s)}{Pr}$, where t_s is the packet send time and t_r is the packet receive time for the same packet at destination.

TABLE 2: SIMULATION SETUP

Parameters for the framework scenario	
Packet Size	512 Bytes
Packet Rate	5 pkts/sec
Data traffic	CBR, VBR
Dimensions	1500m X 1500m ²
Confine Area at each corner	500 X 500m ²
Node Placement (restricted to confine area)	Random
Node Placement (Vehicular nodes)	Four-way movements design /Random
Total No. of nodes	25,33,41,49,57,65,73 and 81
Min. speed	1.5m/s
Max. speed	30m/s
Routing Protocols	AODV, LAR(box),DYMO
Radio trans. range	180m
Pause times	2s
Simulation time	400s
Antenna Model	Omni-direction
Propagation model	Two ray

VII. RESULTS & DISCUSSION

Simulations were carried out for both random motion and predefined four way directional motions of the nodes, with varying number of traffic sources. Both constant bit rate and variable bit rate traffic were used. In general all the three considered protocols viz. DYMO (fast reactive), AODV (reactive) and LAR-BOX (geographic routing protocol-reactive with GPS) perform well.

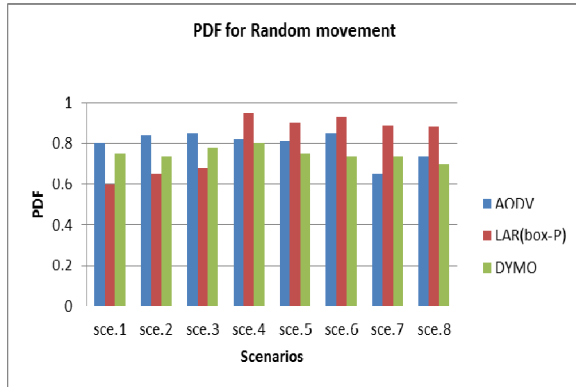


Figure 2. PDF for Random movement for scenarios given in Table 1.

The PDF and end to end delay is better for LAR at peak load (scenario no. 4-8), when the movement of the vehicular nodes is along the direction indicated as compared to their random movement for the above said metrics. However Performance of AODV and DYMO is better than LAR for low load randomize

movement for all the considered scenarios for PDF. On the other hand we observe that average end to end delay is lowest in DYMO as compared to both LAR and AODV. This is due to the fact that DYMO is fast, it has less routing overhead by the use of path accumulation function. The End-to-end delay in LAR gradually increases after attaining lowest point in mid load for randomizes movement in comparison to four way directional motion.

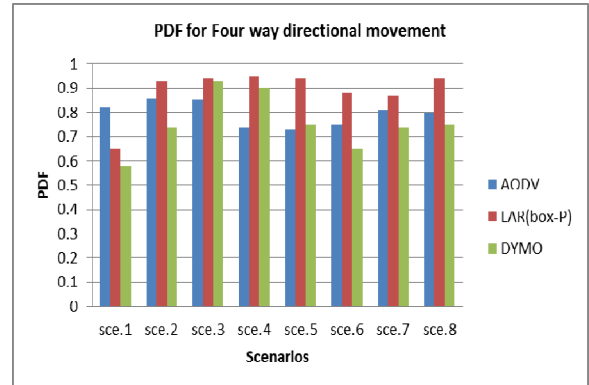


Figure 3. PDF for four way directional movement for scenarios given in Table 1.

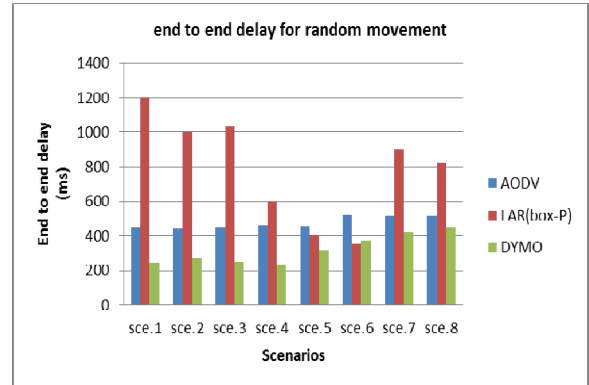


Figure 4. end-to-end delay for random movement for scenarios given in Table 1.

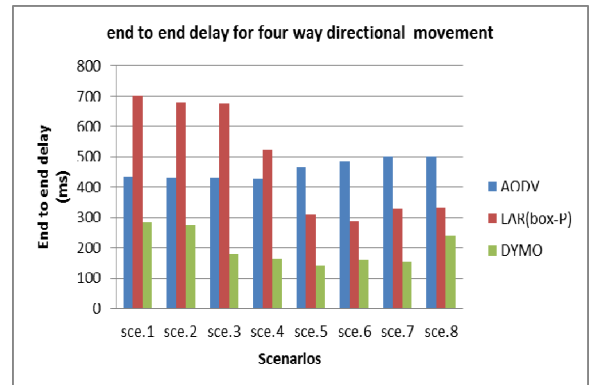


Figure 5. end-to-end delay for four way directional movement for scenarios given in Table 1.

VIII. CONCLUSION

This paper evaluates the modelling of emergency scenario through the impact of reactive & geographic routing protocols. The performance metrics are compared for randomized mobility. Here we have observed that by organizing the terrain region into four equal sized symmetrically placed sub-regions give optimum results in the terms of PDF and end-to-end delay.

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Performance Comparison of DSDV and AODV Routing Protocols in MANETS

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Abstract—This paper aims to compare performance of some routing protocols for Mobile Ad-Hoc networks (MANETs). A Mobile Ad-Hoc Network (MANET) is a collection of wireless mobile nodes forming a temporary network without using any centralized access point, infrastructure, or centralized administration. Data transmission between two nodes in MANETs requires multiple hops as nodes transmission range is limited. Mobility of the different nodes makes the situation even more complicated. Multiple routing protocols [1] especially for these conditions have been developed during the last years, to find optimized routes from a source to some destination. This paper presents performance evaluation of two different routing protocols (AODV and DSDV). We have used Network Simulator II to perform the simulations. Performance evaluation of AODV and DSDV is evaluated based on Average end to end delay.

Keywords-MANET, AODV, DSDV, DELAY. Reactive Protocols, NS2, Delay, Throughput, Packet Size, Time interval, Routing Overhead.

I. INTRODUCTION

In the last few years, the use of Mobile networks has grown fast. In particular, a very large number of recent studies focused on Mobile Ad Hoc Networks (MANETs) [2]. A MANET is a network without the aid of any fixed infrastructure, in which nodes belonging to the MANET can either act as end-points or routers. This kind of network, which is self-organizing, is very useful when the fixed infrastructure is not economically practical or physically possible such as battlefield scenarios, natural disasters etc.

It has potential application in the locations where setting of infra-structured networks is not possible and also in emergency disaster relief operations after natural hazards like earthquake. It is essential to restore communication networks in large-scale disasters by repairing the infrastructure as quickly as possible and taking appropriate measures to control congestion. Communication and sharing of information in emergencies are also possible via ad hoc networks, which take full advantage of the features of wireless communication [3] including fast and temporary setup and terminal portability and mobility. Ad-Hoc networks can enable communication among temporarily

assembled user terminals without relying on the conventional communication infrastructure.

A routing protocol is a protocol that specifies how routers communicate with each other, disseminating information that enables them to select routes between any two nodes on a computer network. Each router has a priori knowledge only of networks attached to it directly. A routing protocol shares this information first among immediate neighbors, and then throughout the network. This way, routers gain knowledge of the topology of the network. 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 network. Various routing protocols available for Ad- hoc networks are AODV, CGSR, DSDV, DSR, OLSR, WRP, ZRP etc. In this paper we are using AODV and DSDV.

Our goal is to carry out a systematic performance study of DSDV [4] & AODV [5]. A brief review of Routing in MANET is presented below. Organization of the rest of paper is as below. In the section I, routing protocols of MANETs [6, 7, 8, and 9] is briefly reviewed. Section II, describes the simulation environment. Section III presents the simulation and results followed by their interpretations and conclusion in section IV.

II. ROUTING IN MANETS

A. Routing protocols: Introduction

These protocols are basically concerned with two processes. Determining optimal Routing Paths & transferring the information groups (packets) through an inter network. The later concept is called as packet switching which is straight forward and the path determination could be very complex. Performance of MANETs depends on the routing protocol scheme employed. Traditional routing protocols do not work efficiently in MANETs due to its dynamic nature. Hence, designing an efficient and reliable routing protocol is very challenging to the changing network conditions such as network size, traffic density, and other network conditions. Routing protocols use several metrics to calculate the best path for routing the packets to its destination. These metrics are a standard measurement that could be number of hops, which is used by the routing algorithm to determine the optimal path for the packet to its destination. The process of path determination

is that, routing algorithms initialize and maintain routing tables, which contain the route information for the packet. This route information varies from one algorithm to another. Routing tables are filled with a variety of information which is generated by the routing algorithms. Developing efficient routing protocols for MANETs has been an extensive research area during the past few years, and various proactive and reactive routing protocols have been proposed. This paper aims to compare some of the routing protocols through simulation.

B. AODV

Ad hoc On-demand Distance Vector Routing (AODV) protocol is an on demand routing protocol as it determines a route to the destination only when a node wants to send data to that destination. The source broadcasts a route request (RREQ) packet when it wants to find path to the destination. The neighbors in turn broadcast the packet to their neighbors until it reaches an intermediate node that has recent route information about the destination or until it reaches the destination. An already received route request packet is discarded by the nodes. The route request packet uses sequence numbers to ensure that the routes are loop free and that the intermediate node replies to route requests are the most recent. A node records the node from which request packet received first to construct the reverse path for route reply to source node. As the route reply packet traverses back to the source, the nodes along the path enter the forward route into their tables. Due to the mobile nature of nodes, route maintenance is required. If the source moves then it can reinitiate route discovery to the destination. If one of the intermediate nodes move then the moved nodes neighbor realizes the link failure and sends a link failure notification to its upstream neighbors and so on until it reaches the source upon which the source can reinitiate route discovery if needed. AODV has greatly reduced the number of routing messages in the network. AODV only supports one route for each destination. This causes a node to reinitiate a route request query when it's only route breaks. But if mobility increases route requests also increases.

C. DSDV

The Destination-Sequenced Distance-Vector (DSDV) protocol is a proactive routing algorithm based on the idea of the classical Bellman-Ford routing algorithm with certain improvements. Each node maintains the routing table with all possible destinations within the network and the number of required hops to reach the destination is also maintained in the table. Each destination assigns a sequence number in order to find out stale routes and prevent routing loops. For table consistency routing information are propagated to update routing table periodically. In order to decrease network traffic for updating routing table two sequential steps are followed. In the first step, a full dump is maintained. Such packets contain all available routing information. Then incremental packets are transmitted which carry only the changed routing information since the last full dump process. Therefore a node exchanges routing tables (fully or partially) with its neighbors, periodically or whenever a change in topology is detected.

III. ROUTING PERFORMANCE COMPARISONS

In this section we present our simulation efforts to evaluate and compare the performance of the protocols that we described previously in Section II.

A. Simulation scenario

We implemented our programs based on the NS2 (Network Simulator 2). Recently NS2 has been the predominant simulator in wireless communication researches. In order to evaluate the performance of the protocols as the networks size scales up, each experiment was carried out on the 500m × 500m square simulation fields of three different scales of mobile nodes. 120 nodes were chosen to represent ad hoc network. Nodes were generated randomly at random position. Nodes were generated at random time as if few nodes were entering into the topology. Nodes were moving at constant random speed. Radio propagation model used was two-Ray Ground. Antenna model used was Omni Antenna. Movement was linear and node speed was constant for a simulation.

B. Performance Metrics:

The following performance metrics are evaluated:

1) *Packet delivery ratio: The ratio of the data packets delivered to the destinations to those generated by the CBR sources. 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.*

$$\text{Packet delivery ratio} = \frac{\text{Packets received by the destination node}}{\text{Packets received} + \text{Packets dropped}}$$

2) *Average end-to-end delay: This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.*

3) Node Characteristics

METHOD	VALUE
Channel Type	Channel/Wireless
Radio Propagation Model	Propagation/two ray Ground
Network Interface Type	Phy. /wireless
MAC Type	Mac/802.11
Interface Queue Type	Queue/Drop tail
Antenna	Antenna/Omni Antenna
Maximum Packet in if	50
Area(m, m)	500, 500
Number of Mobile Nodes	120
Source Type	UDP
Simulation Time	500 sec
Routing Protocol	DSDV, AODV
Speed	5m/s,10m/s,40m/s

IV. SIMULATION RESULTS

A. Packet Delivery Ratio

The average Packet Delivery ratio of the DSDV & AODV protocols in the scale of network is plotted in Fig. (1, 2), in which y-axis represents the packet delivered. Observing the throughput comparison in different routing protocols we found that, the On-demand protocol AODV performed particularly well, delivering over 85% of the data packets regardless of mobility rate. While DSDV could not achieve good packet delivery ratio when moves more frequently. This result is valid for each of the cases with different simulation -time and number of nodes. Ad hoc On-demand Distance Vector Routing (AODV) is an improvement on the DSDV Destination-Sequenced (Distance Vector Routing (DSDV) is a table-driven routing protocol– DSDV). The performance of DSDV is better with more number of nodes in comparison with the performance of AODV, which is consistently uniform. In terms of dropped packets, DSDV’s performance is the worst. The performance degrades with the increase in the number of nodes. AODV performs consistently well with increase in the number of nodes.

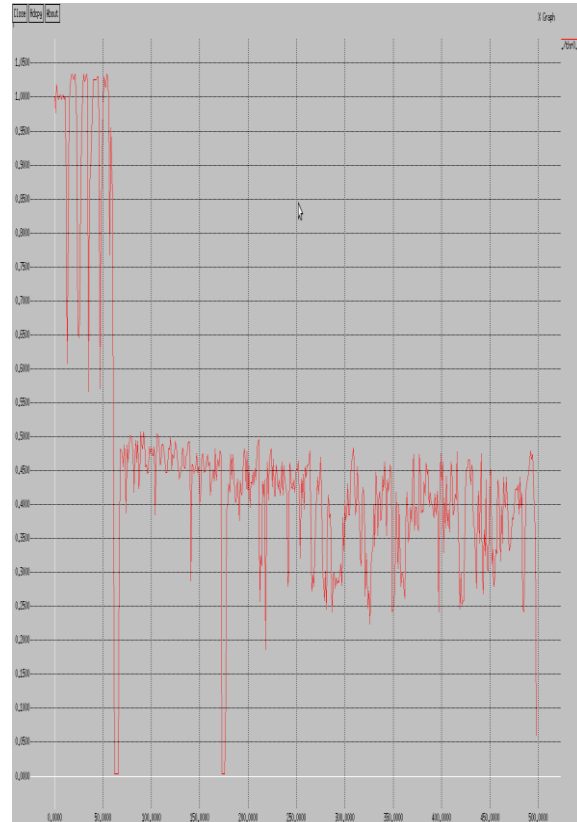


Figure 1. (DSDV 120 Nodes, 5 m/sec)

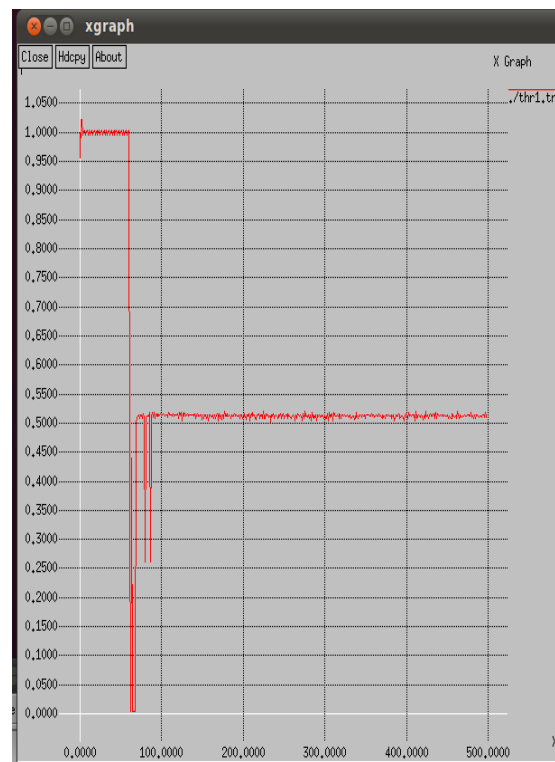


Figure 2. (AODV 120 Nodes, 5 m/sec)

B. Delay comparison

For average end-to-end delay, the performance of DSDV (fig. 3) is degrading because due to increase in the number of nodes the load of exchange of routing tables becomes high and the frequency of exchange also increases due to the mobility of nodes. This comparison was based on increase in number of nodes. Since DSDV pro-actively keeps the routes to all destinations in its table it does not have to initiate the route request process as frequently as in AODV (fig. 4). Hence on average DSDV clearly has less delay. DSDV performed pretty stable. The reason is that it is a table-driven protocol, so a node does not need to find a route before transmitting packets. So the delay is quite stable.

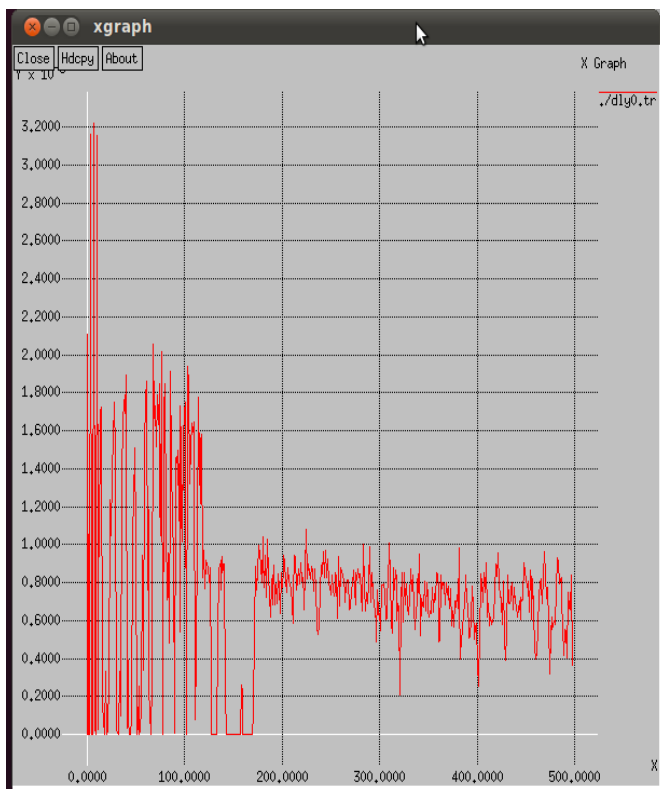


Figure 3. Delay DSDV (120 Nodes, 10 m/sec)

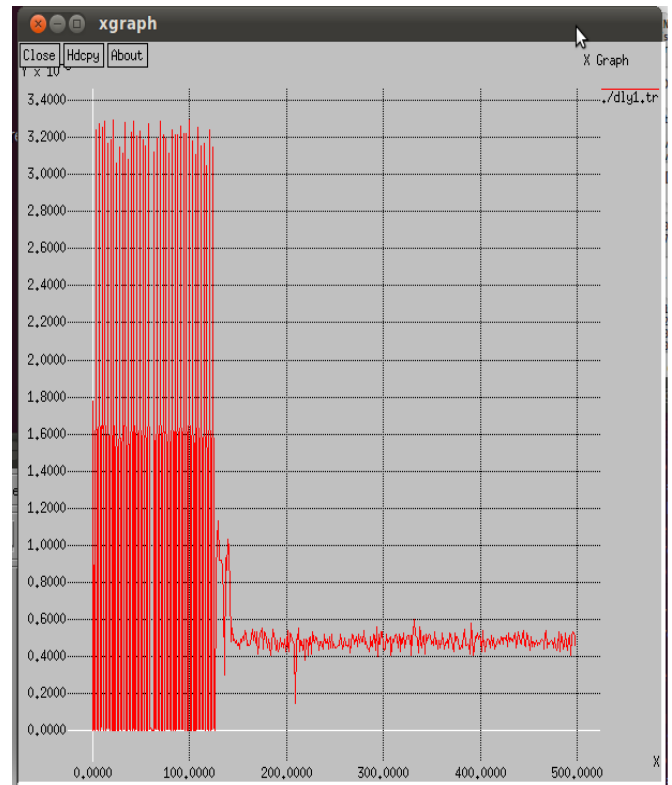


Figure 4. Delay AODV (120 Nodes, 10 m/sec)

V. CONCLUSIONS

We have presented a performance comparison of important routing protocols for mobile ad hoc wireless networks. The two protocols have some kind of route maintenance mechanisms, which store the routing information until sources do not need it anymore or until routes becomes invalid; that is, some intermediate nodes become unreachable.

Using NS-2 we simulated wireless ad hoc networks of 50 nodes, employing AODV and DSDV as the routing protocols. AODV managed to handle the increased load, even though more packets are dropped and more routing packets are generated. The results of the simulations yield some interesting conclusions: AODV suffers in terms of packet delivery fraction (PDF) but scales very well in terms of end-to-end delay. DSDV on the other hand scales well in terms of packet delivery fraction (PDF) but suffers an important increase of end-to-end delay. From the results obtained one can come to the conclusion that both major routing protocols, AODV and DSDV, have important drawbacks when it comes to scalability. Therefore this work can motivate further research on improving the current protocols and/or create new ones to meet the challenges of large-scale wireless networks.

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Performance Comparison of Pro-active and Reactive Routing Protocols for MANET

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Abstract— Efficient routing protocols can provide significant benefits to MANETs for both performance & reliability. Many routing protocols [1] for such networks have been reported. Amongst the most popular ones are Dynamic Source Routing (DSR), Ad-Hoc on demand distance vector (AODV) & Temporary ordered routing algorithm (TORA). In this paper we compare MANET Protocols DSDV & AODV individually using Network Simulator NS2. The performance matrix includes Delay and Throughput. We are comparing the performance of routing protocols on changing the parameters packet size, time interval between packet sending.

Keywords- AODV, DSR, Reactive Protocols, MANET, NS2, Delay, Throughput, Packet Size, Time interval, Routing Overhead.

I. INTRODUCTION

MOBILE Ad-Hoc network is a wireless network & self configuring network of moving nodes or routers. The term “Ad-Hoc” implies “can take different forms” and can be “standalone, mobile or networked”. The nodes are free to move randomly & organize themselves arbitrarily, thus, the network’s wireless topology may change rapidly and unpredictably. Mobile Ad-Hoc network [2] is infra-structure less network due to mobile routers. Due to these properties MANET has wide application in industrial and commercial field involving cooperative mobile data exchange, inexpensive alternates to cellular based mobile network infrastructures.

It has potential application in the locations where setting of infra-structured networks is not possible and also in emergency disaster relief operations after natural hazards like earthquake. It is essential to restore communication networks in large-scale disasters by repairing the infrastructure as quickly as possible and taking appropriate measures to control congestion. Communication and sharing of information in emergencies are also possible via ad hoc networks, which take full advantage of the features of wireless communication [3] including fast and temporary setup and terminal portability and mobility. Ad-Hoc networks can enable communication among temporarily assembled user terminals without relying on the conventional communication infrastructure.

Our goal is to carry out a systematic performance study of DSDV [4] & DSR [5]. A brief review of Routing in MANET is presented below. Organization of the rest of paper is as below. In the section II, routing protocols of MANETs [6, 7, 8, and 9] is briefly reviewed. Section III, describes the

simulation environment. Section IV presents the simulation and results followed by their interpretations and conclusion in section V.

II. ROUTING IN MANETS

A. Routing protocols: Introduction

These protocols are basically concerned with two processes. Determining optimal Routing Paths & transferring the information groups (packets) through an inter network. The later concept is called as packet switching which is straight forward and the path determination could be very complex. Performance of MANETs depends on the routing protocol scheme employed. Traditional routing protocols do not work efficiently in MANETs due to its dynamic nature. Hence, designing an efficient and reliable routing protocol is very challenging to the changing network conditions such as network size, traffic density, and other network conditions.

Routing protocols use several metrics to calculate the best path for routing the packets to its destination. These metrics are a standard measurement that could be number of hops, which is used by the routing algorithm to determine the optimal path for the packet to its destination. The process of path determination is that, routing algorithms initialize and maintain routing tables, which contain the route information for the packet. This route information varies from one algorithm to another. Routing tables are filled with a variety of information which is generated by the routing algorithms.

Developing efficient routing protocols for MANETs has been an extensive research area during the past few years, and various proactive and reactive routing protocols have been proposed. This paper aims to compare some of the routing protocols through simulation.

B. Destination-Sequenced Distance Vector

DSDV is one of the most well known table-driven routing algorithms for MANETs. DSDV routing protocol maintains a routing table that lists 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. So, the update is both time-driven and event-driven. The routing table update can be sent in two ways: - a "full dump" or an incremental update. A full dump sends the full routing table to the neighbors and could span

many packets whereas in an incremental update only those entries from the routing table are sent that has a metric change since the last update and it must fit in a packet. If there is space in the incremental update packet then those entries may be included whose sequence number has changed. When the network is relatively stable, incremental update 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.

C. AODV

The Ad hoc on-demand Distance Vector routing protocol does not maintain global routing information for the whole network. Nodes that do not belong to a route do not need to maintain information about that route. Such nodes do not send or receive topology-update packets; hence they have information only for their active routes. A node considers a route as active, if it sends, receives or forwards packets for that route and if there is at least one data packet transmitted through this route within a fixed time interval. Hence in AODV, route discovery packets are initiated and broad-casted only when a source desires to contact an intended destination for which it does not have a valid route. Furthermore, changes in network topology must be sent only to those nodes that will need this information. Thus, AODV dynamically establishes route table entries. Every node maintains an increasing counter in order to replace unused or broken routes. A disadvantage of AODV is that it does not support asymmetric links. That is, AODV is capable of supporting only symmetric links between nodes, both of which are able to send packets to each other.

III. ROUTING PERFORMANCE COMPARISONS

In this section we present our simulation efforts to evaluate and compare the performance of the protocols that we described previously in Section II.

A. Simulation scenario

We implemented our programs based on the NS2 (Network Simulator 2). Recently NS2 has been the predominant simulator in wireless communication researches. In order to evaluate the performance of the protocols as the networks size scales up, each experiment was carried out on the 500m × 500m square simulation fields of three different scales of mobile nodes. 50 nodes were chosen to represent ad hoc network. Nodes were generated randomly at random position. Nodes were generated at random time as if few nodes were entering into the topology. Nodes were moving at constant random speed. Radio propagation model used was two-Ray Ground. Antenna model used was Omni Antenna. Movement was linear and node speed was constant for a simulation.

B. Node Characteristics:

1. Link Layer Type: Logical Link type(LL)
2. MAC type: 802_11
3. Queue type: Drop-Tail
4. Network Interface type: wireless
5. Channel type: wireless

C. Performance Metrics:

The following performance metrics are evaluated:

1. Packet delivery ratio: The ratio of the data packets delivered to the destinations to those generated by the CBR sources. 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.

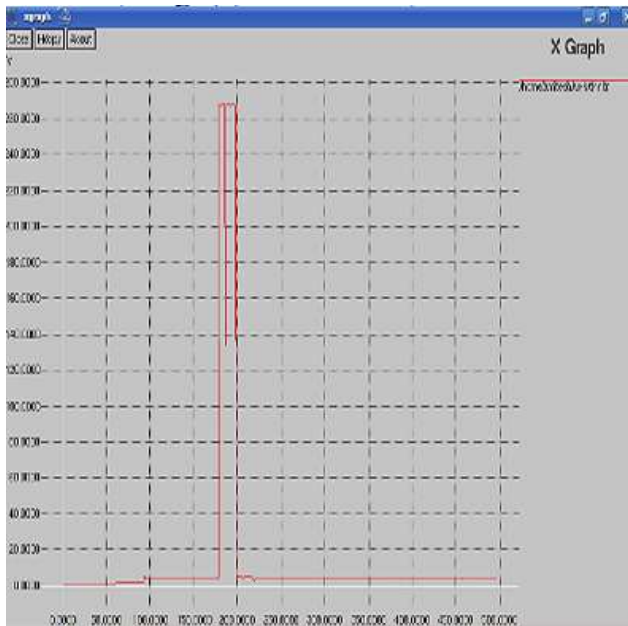
$$\text{Packet delivery ratio} = \frac{\text{Packets received by the destination node}}{\text{(Packets received + Packets dropped)}}$$

2. Average end-to-end delay: This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.

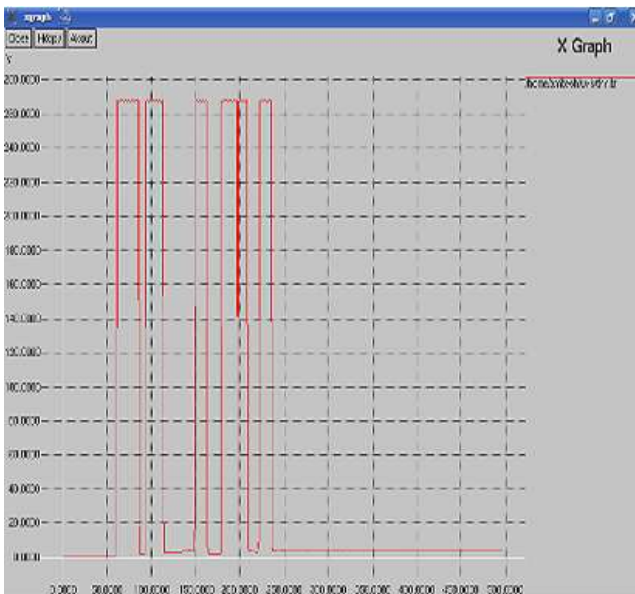
IV. SIMULATION RESULTS

A. Packet Delivery Ratio

The average Packet Delivery ratio of the DSDV & AODV protocols in the scale of network is plotted in Fig. (a, b), in which y-axis represents the packet delivered. Observing the throughput comparison in different routing protocols we found that, the On-demand protocol AODV performed particularly well, delivering over 85% of the data packets regardless of mobility rate. While DSDV could not achieve good packet delivery ratio when moving more frequently. This result is valid for each of the cases with different simulation -time and number of nodes. Ad hoc On-demand Distance Vector Routing (AODV) is an improvement on the DSDV Destination-Sequenced (Distance Vector Routing (DSDV) is a table-driven routing protocol– DSDV). The performance of DSDV is better with more number of nodes in comparison with the performance of AODV, which is consistently uniform. In terms of dropped packets, DSDV’s performance is the worst. The performance degrades with the increase in the number of nodes. AODV performs consistently well with increase in the number of nodes.



- AODV 50 nodes (Packet Delivery Ratio)

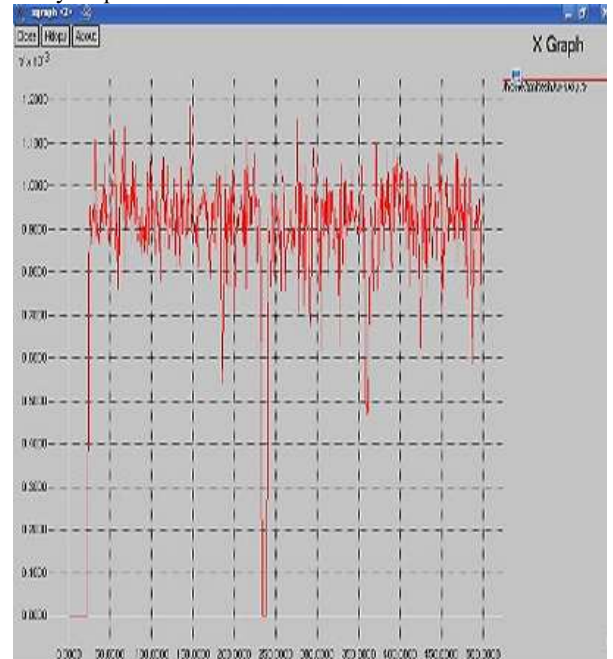


- DSDV 50 nodes (Packet Delivery Ratio)

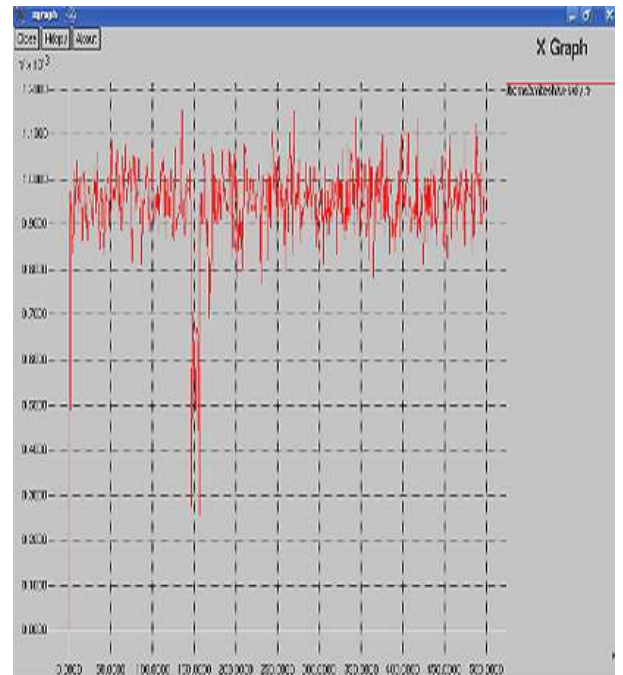
B. Delay comparison

- For average end-to-end delay, the performance of DSDV (fig. c) is degrading because due to increase in the number of nodes the load of exchange of routing tables becomes high and the frequency of exchange also increases due to the mobility of nodes. This comparison was based on increase in number of nodes. Since DSDV pro-actively keeps the routes to all destinations in its table it does not have to initiate the route request process as frequently as in AODV (fig. d). Hence on average DSDV clearly has less delay. DSDV performed pretty stable .The reason is

that it is a table-driven protocol, so a node does not need to find a route before transmitting packets. So the delay is quite stable.



- DSDV 50 nodes (Delay)



- AODV 50 nodes (Delay)

V. CONCLUSIONS

We have presented a performance comparison of important routing protocols for mobile ad hoc wireless networks. The two protocols have some kind of route maintenance mechanisms, which store the routing information until sources

do not need it anymore or until routes becomes invalid; that is, some intermediate nodes become unreachable.

Using NS-2 we simulated wireless ad hoc networks of 50 nodes, employing AODV and DSDV as the routing protocols. AODV managed to handle the increased load, even though more packets are dropped and more routing packets are generated. The results of the simulations yield some interesting conclusions: AODV suffers in terms of packet delivery fraction (PDF) but scales very well in terms of end-to-end delay. DSDV on the other hand scales well in terms of packet delivery fraction (PDF) but suffers an important increase of end-to-end delay. From the results obtained one can come to the conclusion that both major routing protocols, AODV and DSDV, have important drawbacks when it comes to scalability. Therefore this work can motivate further research on improving the current protocols and/or create new ones to meet the challenges of large-scale wireless networks.

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