Chapter 4

MANET Performance in a Disaster Management Scenario

Introduction

A post-disaster situation demands an ef icient 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. The performance of a MANET system depends on mobility modeling [63, 64, 65]. 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 investigate MANET performance.

In this chapter, we have proposed and model the framework of a post-disaster management system using Mobile Ad-Hoc network (MANET), for this we have proposed a three layered framework to model post-disaster management scenario. A better depiction of nodes movement is obtained through RPGM, which is used in our simulation. 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), irst 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. The co-ordination task is managed by a four-way movement. [35] The mobility of MANET nodes between the three stages has been modelled with Reference point group Mobility (RPGM) based on attraction level. The proposed mobility model pattern by rescue teams is evaluated. We also examine the performances delivered by proposed framework to comply with the use of standard routing protocols on our de ined set of metrics with prede ined cases. The performance of ad hoc network is analyzed for reactive (AODV [40, 66]), proactive (OLSR [67]) and hybrid (ZRP [43]) protocols. Our simulation studies conducted on Qualnet indicates that both the mobility model and routing protocols affect the communication between the stages.

Current Scenario

A disaster is classi ied into two major types:

a. Natural disasters such as earthquakes, tsunamis, and loods,
b. Human-induced disasters such as war and terrorism.

Effects of these disasters can cause environmental degradation, disease, hunger and death. Here, we mainly focus on impulsive natural disasters, such as an earthquake or tsunami. The recent disasters are listed below:

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 thousand Crore rupees in disaster response and recovery funds. Over 25,000 emergency personnel were deployed throughout the region (according to PIB, Govt. Of India) [68].

The Tsunami of 2004 was triggered by an earthquake on the ocean loor. It severely 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) [69]. It required approximately 6,000 military support personnel, 10000 contractors and 6000 volunteers for the relief operations.

On 11 March 2011, a 9.0 magnitude earthquake occurred east of the Japanese coast and Miyagi prefecture. This resulted in 30 meters high Tsunami, which was devastating. The number of casualties exceeded 16000 (Report by ICF Consulting services Private Ltd. under contract to European Commission) [70].

On 25 April and 12 May 2015, two earthquakes struck Nepal with the magnitude of 7.8 and 7.3 respectively on the Richter scale. The death toll rose over 8000 and number of injured persons crossed 18000 (Report by Regional Of ice for South East Asia of World Health Organization (WHO)) [71]. The vibrations spread to most parts of North India, taking more than 50 lives.

In June 2013, a multi-day cloudburst centred on the North Indian state of Uttarakhand caused devastating loods and landslides. The major brunt was taken by area in and around Shri Kedarnath Dham causing the death toll to go beyond 10,000 with more than 100,000 persons trapped in the valleys (Report by Wadia Institute of Human geology [72], and Wikipedia [73]).

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 in the area of urgency mobility framework. The researchers have chosen random waypoint mobility model [74] and analysed the general performance characteristics.

Meissner et al. [28] developed requirements and technology for integrated disaster management communication and information system. In particular, they addressed network con iguration, scheduling and data management issues during the response and recovery phases. The design problems and architectural concepts for an integrated disaster management system are identi ied. An infrastructure is provided that allows for horizontal and vertical information low from the of icer/ ireman on the scene up to the central operations staff using 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 using smart connected devices, e.g. robust mobile terminals and sensors.

A Graph-based Approach was employed by Stepanov et al. [29]. 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 re lect 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 modelling was used by Kramer et al. [30]. In this mobility model parameters namely transition probabilities are calculated to reach the prede ined stationary user distribution. The simulation area is divided into small parts and performance is evaluated.

Kim et al. [31] 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 an extensive evidence 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 traditional regions.

In 2006 an innovative software infrastructure (software, models, services, etc.) was built and designed by Mecella et al. [32] 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 various organisations) 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. [33] 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 organisations are arranged during disasters, what information is critical, and how teams exchange this information among themselves and with their operational centres

The causes that paralysed the entire communication systems in Taiwan earthquake was analysed by Jang et al. [34]. 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-speci ic professional could use their notebook PCs to construct a multi-hop ad-hoc network to form a primary wireless intranet irst. 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 a signi icant role in 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 it in disaster areas due to their mobility particular assumptions. Our proposed post-disaster mitigation model framework features attraction point group mobility [33] (group movement based upon the attraction point). The group of nodes low orientation is basically through group leader with the same charm features. Nodes are only allowed to move along the prede ined paths. Each node searches for the possible attraction points to visit. Each attraction point has its 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 regarding packet transfer under the standard Ad-hoc routing protocols namely AODV, OLSR and ZRP.

4.1 A Layered Framework for Mobility Modelling

In post-disaster situations, effective management depends upon communication amongst affected public, protection forces, rescue teams including some out-sided teams (NGO's) and ire 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 steps are determined by well-de ined strategy. These strategies are mostly based on the layered framework or architecture which we have designed in igure 4.1.

It is a three layer design which includes DCL (core disaster location) as layer-1, FTL (irst treatment area) as layer-2, HL (hospital location) as layer-3. Disaster active area and its neighbor-hood are divided into particular areas as core disaster location, irst 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 outside teams (Govt. /NGO groups). Layer2 is the irst treatment location/casualties handling; here teams provide irst-aid treatment for injured & sufferer and layer3 are the hospital area. In igure 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 irst aid treatment is provided. Finally, they are moved to hospital location. In the case of layer1& layer2, most of the supports are provided by the push to talk & force to speedy move by ordinary pedestrians who are present in above layers after the disaster. There can be a delay in transports units to handle everyone on time. This delay is signi icant and meaningful for saving a life on the date of the disaster. In general terms teams take up sufferer and transport them on the direct way to 3rd layer (hospital location).Here we have made ad-hoc network supportable entities (nodes).The mobility of nodes shall be in the 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 core incident location. At the date 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.

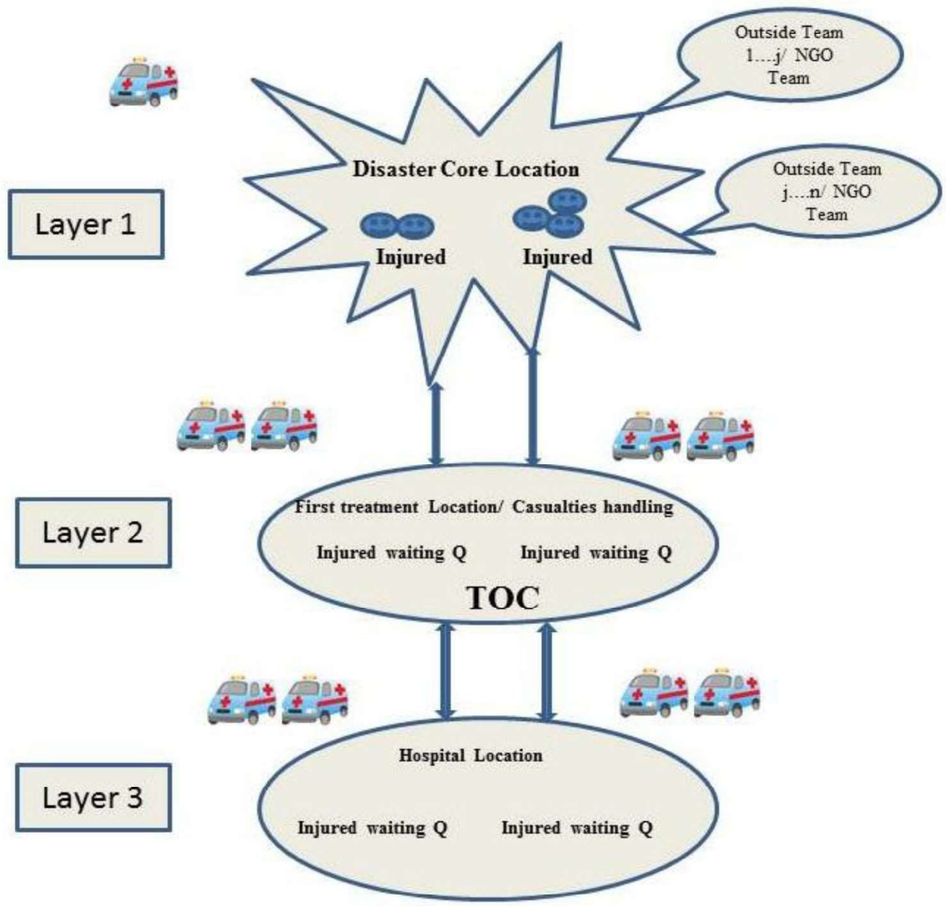


Figure: 4.1: post disaster mitigation layered rescue model

4.2 Features of layered 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.

I. Group mobility

In a 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 situation, where either a function creates group behavior or the nodes are somehow arranged with a group leader [33].In our framework, we have considered attraction/ reference point group mobility model [18, 75].

ATTRACTION/REFERENCE POINT GROUP MOBILITY MODEL: It is spatial dependent [50, 76] and the movement of a node is in luenced 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 in luenced 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 team leader determines the mobility behavior of the entire group. The logical function of group leaders and group members are described below:

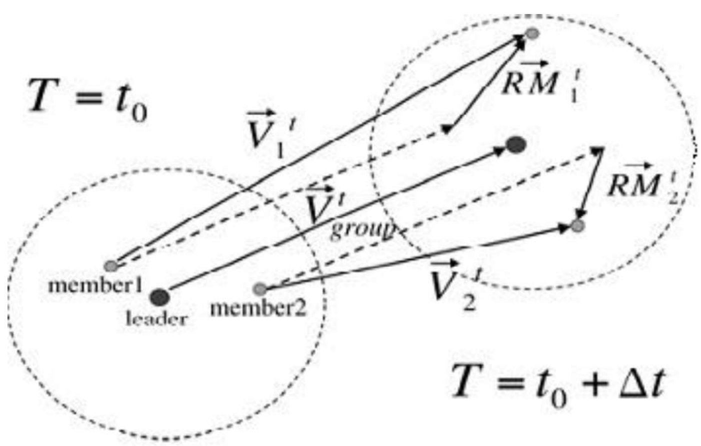


Figure 4.2: Movement in A-RPGM, providing two snapshots at time T=t0 (left circle) and time T=t0+Δt (right circle)

A. **The Group Leader [18]:** Its movement at time t can be represented by motion vector $\mathbf{V}^{t}_{\mathbf{group}}$. It does not only de ine 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 $\mathbf{V}^{t}_{\mathbf{group}}$by some degree. The motion vector $\mathbf{V}^{t}_{\mathbf{group}}$ can be carefully designed, based on certain prede ined paths and attractivity factor [75].

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 4.2 Vtgroup is the motion vector for the group leader and the whole group. $\mathbf{RM^t_i}$ is the random deviation vector for group member i, and the inal motion vector of group member i is represented by vector $\mathbf{V^t_i}$. With appropriate selection of prede ined paths for group leader and other parameters, the RPGM model is able to emulate a variety of mobility behaviours, according to mobility scenario [33].

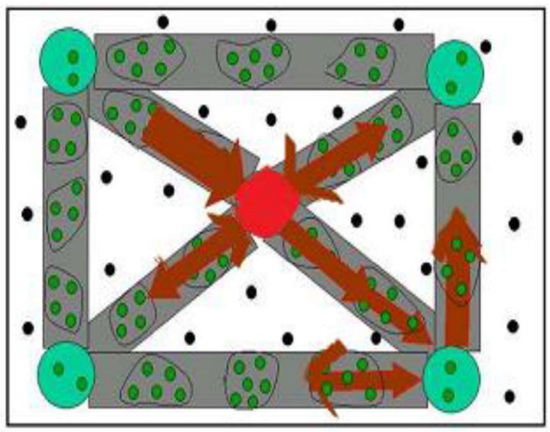


Figure 4.3: Group mobility view

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 igure 4.3 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 centre 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.

II. Heterogeneity

Here we consider heterogeneity in terms of three 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.

III. 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 speci ic destination area (inter or intra layer movement) & follow a de ined 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.

4.3 Logical Setup of Framework

We proposed a three layer architecture which includes DCL (disaster core location) as layer- one, FTL (irst 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 igure 4.4.

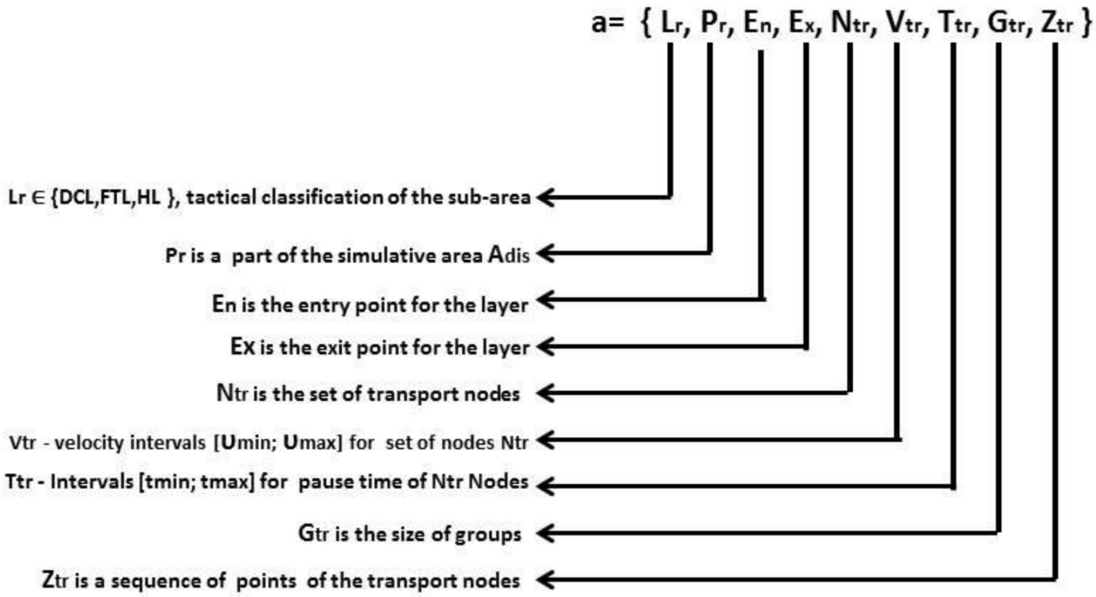


Figure 4.4: Logical Setup of Framework

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 igure 4.5 the cycle for the transport nodes of irst and second layer area is: Ztr = 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 irst aid and the handing over of a patient. Here rand represent the randomly selection of any one path for movement from layer to layer.

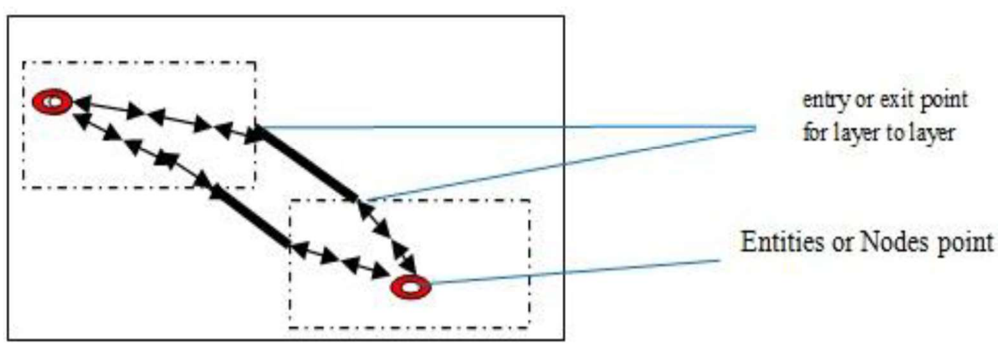


Figure 4.5: Layer to layer movements

4.4 Performance Evaluation of Proposed Layered 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/sand 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 [77] (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.

Simulator

Various N/W- simulators such as NS2 [52], Qualnet [53] and OPNET [78] 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 de ined trajectories.

Simulation Model

In this work 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 irst 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 (2.5-5 m/s) and 75% pedestrians group (1-1.5 m/s). For these models, we set group parameter (speci ied by velocity-matching, and expressed in the fraction of nodes that exhibit the speci ied group behavior) [79] indicating that every node acts in con irmation to group behavior.

For both these cases a three sub case has been considered based on attraction. The attraction / reference points of the model provide proper prede ined 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) [30, 31] 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 5m/sec. The three sub cases are as follows:

Case a: It represents the movement of nodes to a ix lagged 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 in luence 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 100m with MAC protocol as IEEE802.11b Wireless LAN (10MBit per second). The data traf ic with transport protocol UDP has been considered. The parameters for traf ic pattern and framework scenario are given in Table 4.1.

Traf ic pattern	
Packet Size	512 Bytes
Packet Rate	4 pkts/sec
Data traf ic	CBR
Parameters for the framework scenario	
Dimensions	1500m x 1500m
No. of nodes	50
Min. speed	1m/s
Max. speed	5m/s
Average number of nodes in a group	4
Radio transmission range	100m
pause times	10 to 300 msec.
Simulation time	300s
Antenna Model	Omni-direction
propagation model	Two ray

Table 4.1: Parameters for traf ic pattern & framework scenario

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 ef iciency of communication network in terms of Packets sent and received. Since in our model, we have considered group movement for disaster core location, irst 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):** it 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.

4.5 Results and discussion for Layered Framework Mobility Modelling

Effect of nodes considered as a single group

The attraction/reference points of the model provide proper prede ined 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, 75] 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 5m/s. here for case-a, case-b and case-c speed is taken as 1.5 m/s, 2.5 m/s and 5 m/s.

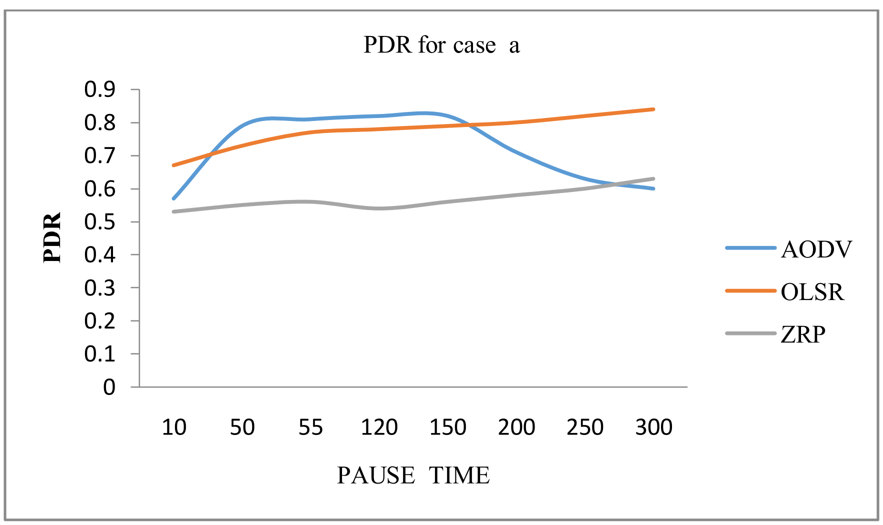
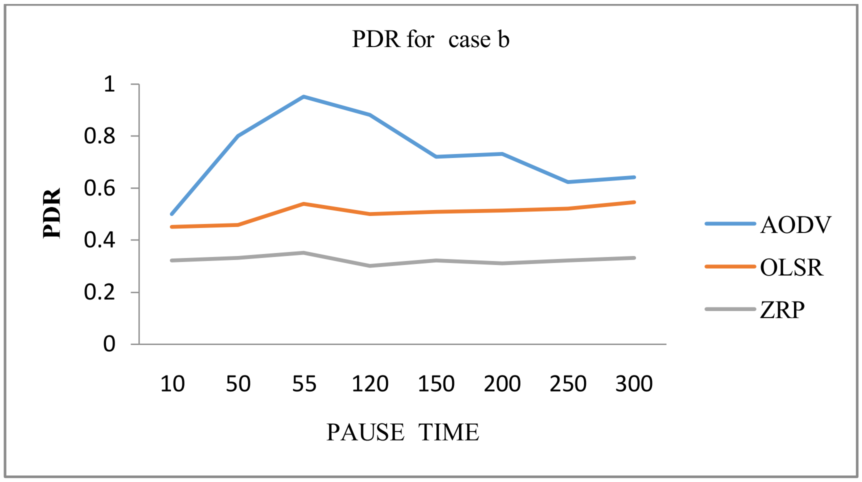


Figure: 4.6



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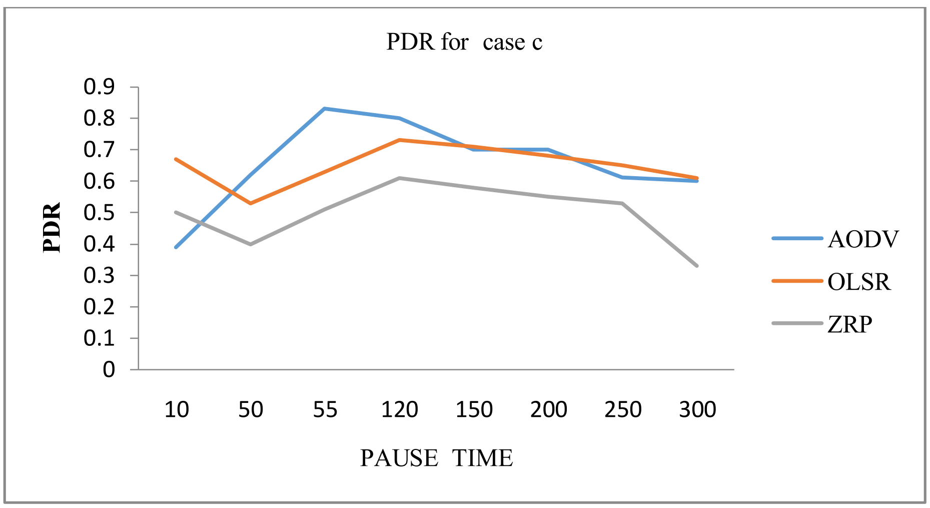


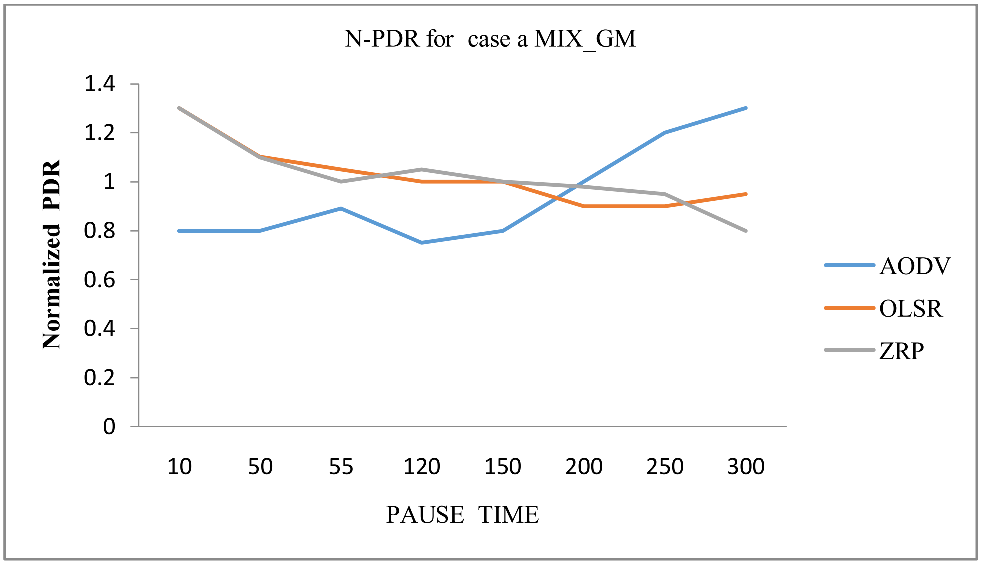
Figure: 4.8

Figure: [4.6, 4.7, 4.8] packet delivery ratios for AODV, OLSR and ZRP for the de ined cases.

Effect of nodes considered as multiple groups

For the mobility cases discussed above, results have been plotted. 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 5m/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'.



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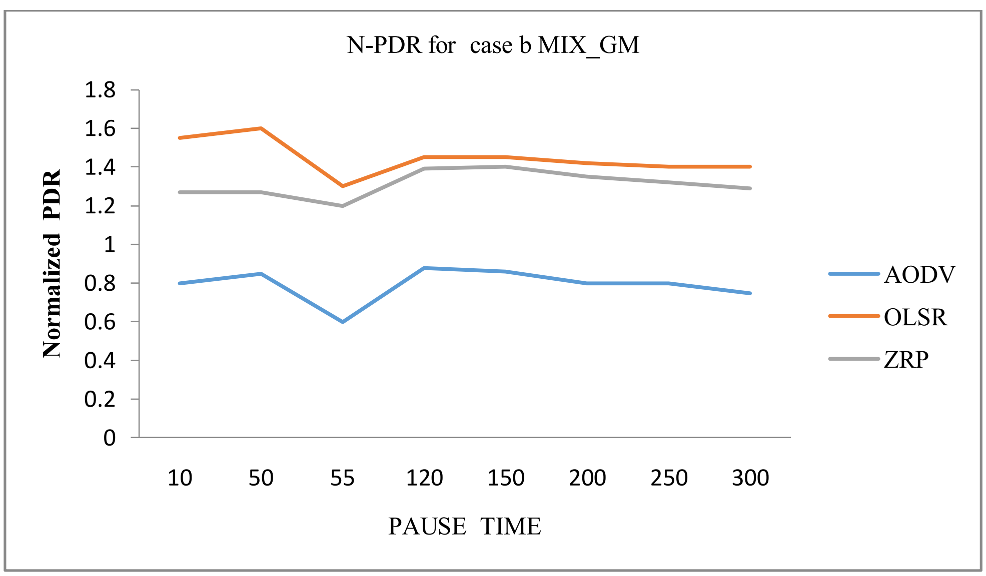

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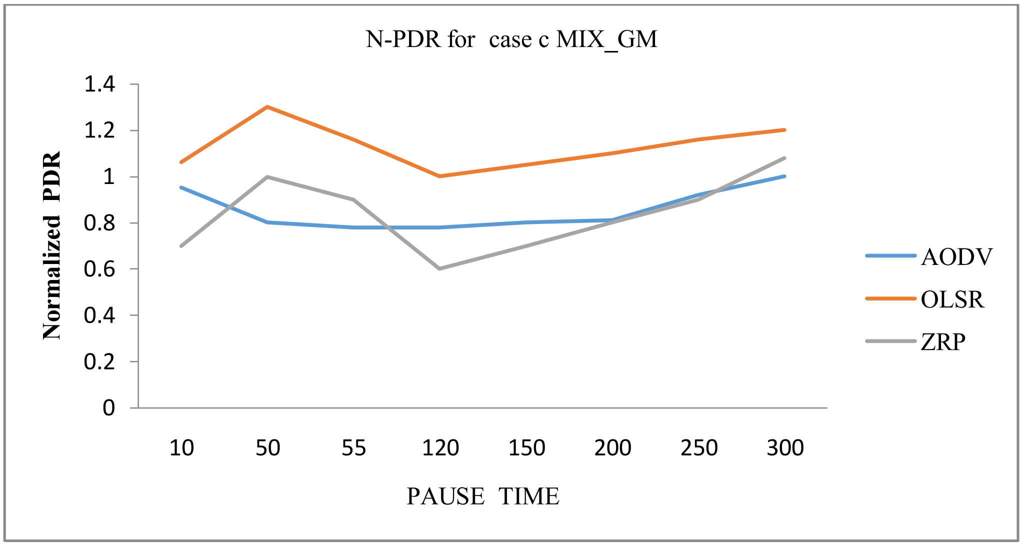


Figure: 4.11

Figure: [4.9, 4.10, 4.11] normalized packet delivery ratios for AODV, OLSR and ZRP for group mobility-de ined cases.

Analysis of results for Layered Framework Mobility

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 de ined 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.

4.6 Four way directional movement model

There are number of works have been done by many researchers for movement modelling of MANETs e.g. P. Johansson at.al. [80] etc.. We have designed four way directional movement design for rescue area for saving lives 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. Under four-way movement design, we have taken ive nodes that are placed on the four directional ways with one node in centre made stationery. Except this stationery node other four nodes are moving on the four directional-ways with 10 m/s for in & out direction, nodes are communicating to centre stationery node and also with the nodes in the adjacent con ine areas. Under randomize movement vehicular nodes are moving randomly with 10m/s. The whole area has four sub areas of equal size 500x500m2 at each corner, as shown in Figure 4.12. The nodes in the corner areas 1-4, represent the group of people working together in their con ine area. These nodes (con ine area nodes) have an average speed of 1.5m/s. These nodes communicate with each other using CBR links. They move randomly within the con ine area. One another set of ixed nodes move with a speed of 10m/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.

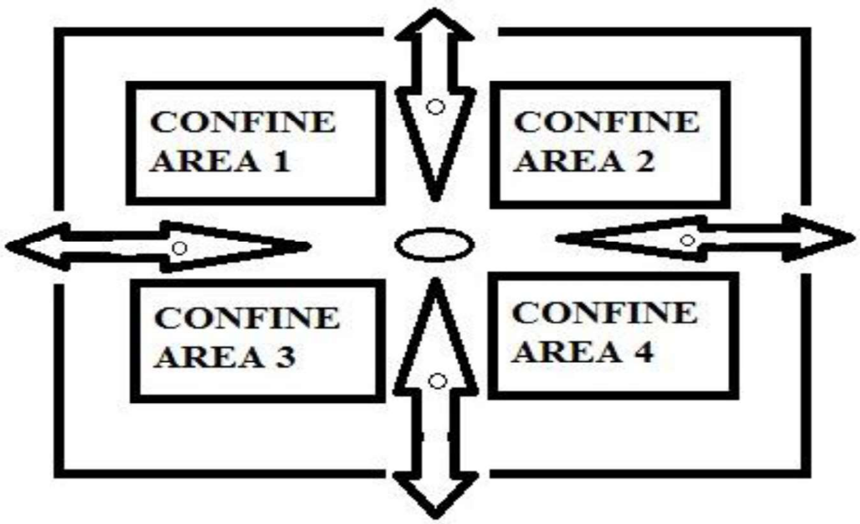


Figure 4.12: Simulation design model

Routing Protocols

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

AODV

AODV [40] 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 ind 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 noti ied, so that they are able to invalidate the routes using the link-lost.

LAR

A Location-Aided Routing (LAR) protocol [44] 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 traf ic 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 neighbours of node S do not have a route to node D, S loods the entire ad hoc network with a route request packet for D. LAR protocol uses location information mobile nodes to lood 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.

1. LAR Box Protocol

In LAR Box approach igure 4.13, a neighbour 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 t0, the average velocity of D Vavg, and the current time t1. This information creates an expected circle area with radius R = Vavg * (t1-t0) centered on (XD, YD). The Request Zone is a rectangle area with Source S in one comer (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 neighbour of S knows that it is within the Request Zone by using the location of the neighbour that has sent the route request packet and the Expected Zone for D based on the most recent available information.

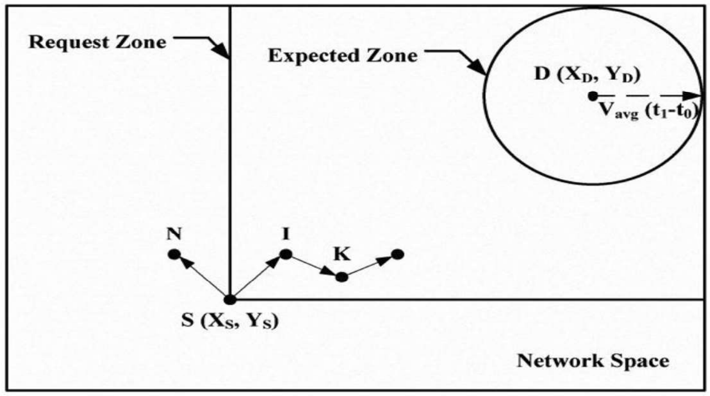


Figure 4.13: LAR BOX –P Protocol

2. LAR Step Protocol

In LAR Step protocol igure 4.14, intermediary mobile node determines that it is within the Request Zone if the mobile node is closer to destination node D than the neighbour that has sent the route request packet. In particular, if the distance of the neighbour S that has sent the route request packet to D is DISTs , and the distance of the mobile node I that has received the route request packet to D is DISTi , then the mobile node I will forward the route request packet if DIST i<= DISTs. Fig. 2 illustrates the LAR Step Protocol. Both LAR Box and LAR Step include a two stage route inding method. In the irst 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 looded 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.

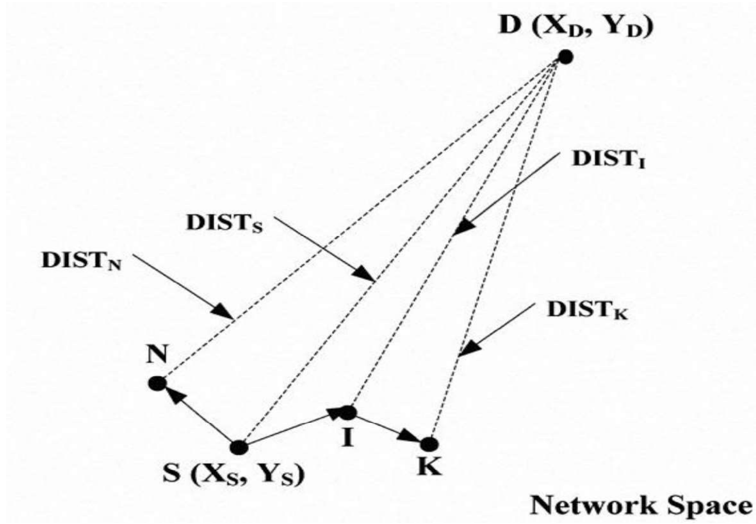


Figure 4.14: LAR Step Protocol

DYMO

Dynamic Manet On-demand (DYMO)[42] 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 ef icient since it maintains little routing information. In DYMO, only routing information that are signi icant 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 ield to its immediate neighbours 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 neighbouring nodes. The aim of path accumulation is to reduce the number of RREQ message transmission in further path discovery. In this way, network is looded 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 ind 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.

4.7 Designed Scenarios for Simulation.

Eight scenarios have been created with varying number of nodes. Each scenario consists of ive nodes set, among 4 nodes set to represent four-way movements to the centre and one node behave as stationery at centre point. Con ine Area at each corner are 500x500m2. In each con ine 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 10 m/s and rest nodes for con ine 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
Sce.1	5	25	15
Sce.2	7	33	20
Sce.3	9	41	25
Sce.4	11	49	30
Sce.5	13	57	34
Sce.6	15	65	45
Sce.7	17	73	60
Sce.8	19	81	65

Table 4.2: Scenarios parameters

Simulation Setup

Various network simulators such as NS2, Qualnet and OPNET are surveyed and inally 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-de ined designed trajectories.

Scenario Parameters

The scenarios parameter and simulation setup are shown in table 4.2 and table 4.3. Here, each node starts its journey from a random location to a random destination with a randomly chosen speed. Once the destination is reached, another random destination is targeted after a pause. In this scenario the nodes in the four regions are continuously moving without pause and the vehicle nodes are moving with speed of 10m/s (randomly in one scenario and in speci ied directions in another scenario) with pause time of 2s. Identical mobility and traf ic 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 1500m2
Confine Area at each corner	500 X500m2
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	10m/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 4.3: Simulation setup

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:

Davg = Σ (tr − ts) /Pr, where ts is the packet send time and tr is the packet receive time for the same packet at destination.

Normalized routing load: (NRL) is the ratio of control packets to data packets in the network. It gives a measure of the protocol routing overhead; i.e. how many control packets were required (for route discovery/maintenance) to successfully transport data packets to their destinations. It characterizes the protocol routing performance under congestion.

NRL is determined as: Pc/Pd, where Pc is the total control packets sent and Pd is the total data packets sent.

Data packets forwarded: (DPF) the number of data packets forwarded for a unique time interval.

4.8 Results & assessment of four way directional movement

For disaster management scenario, it is very important to deploy the nodes in such a manner that routing overheads, packet-loss and end-end delay are minimum. Simulations were carried out for both randomize motion and pre-de ined four way directional motion of the vehicular nodes, with varying number of traf ic sources and CBR+VBR lows as shown in Table 4.2. It is also observed from the results (igure 4.15-

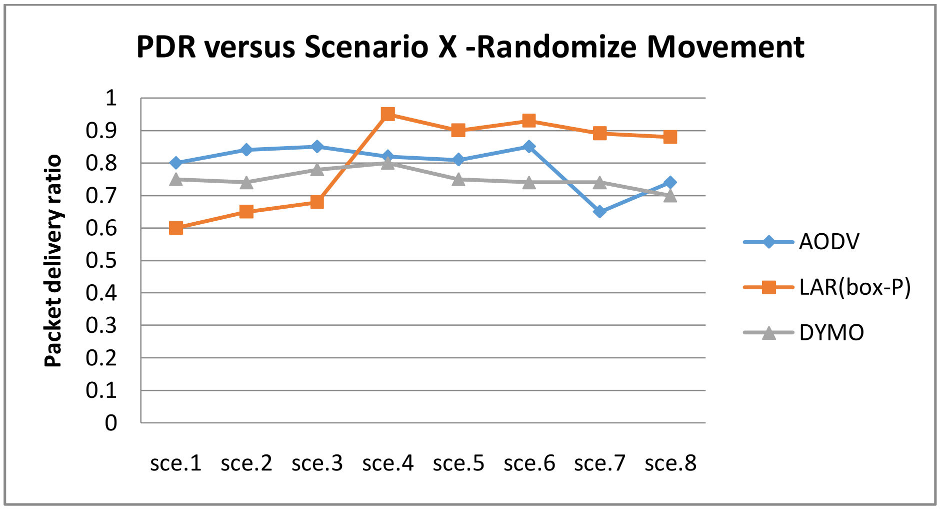


Figure 4.15

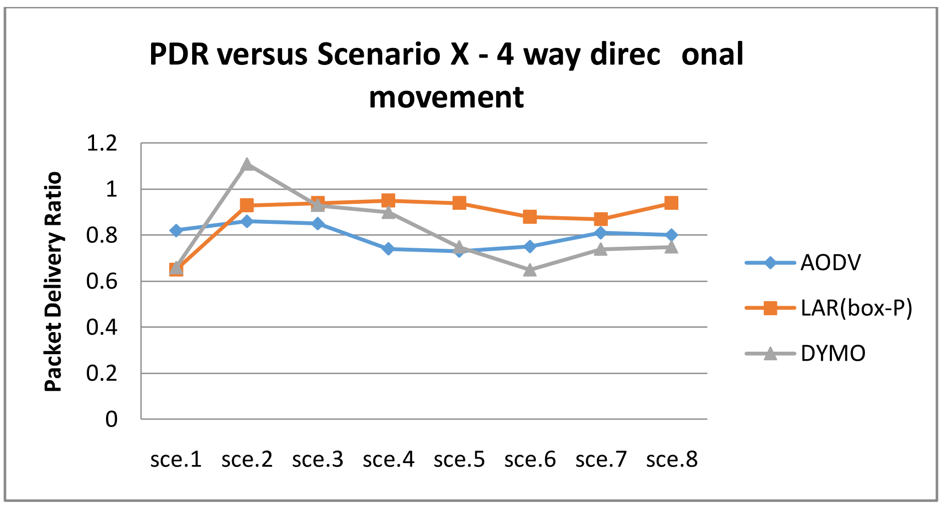
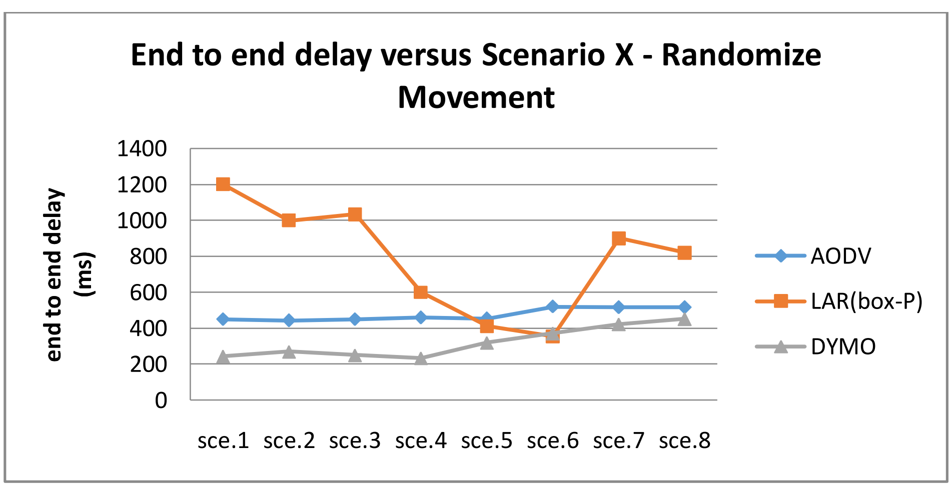


Figure 4.16



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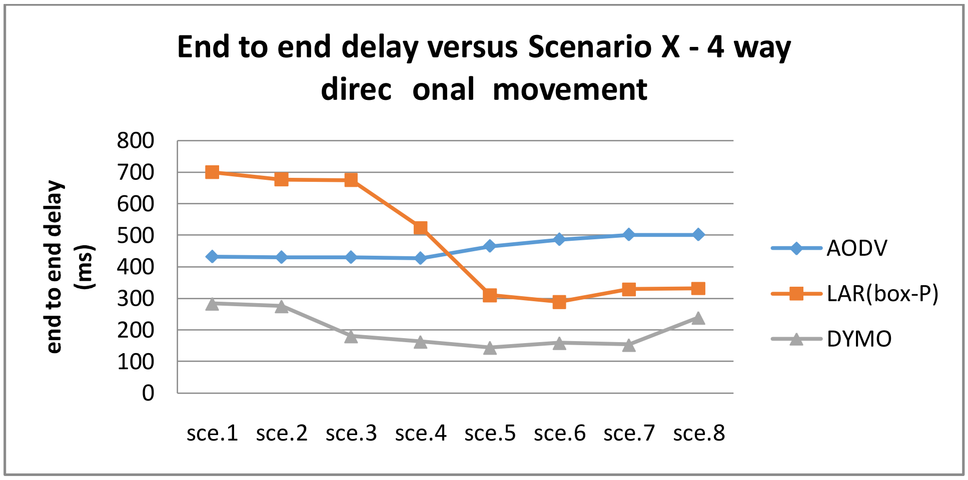
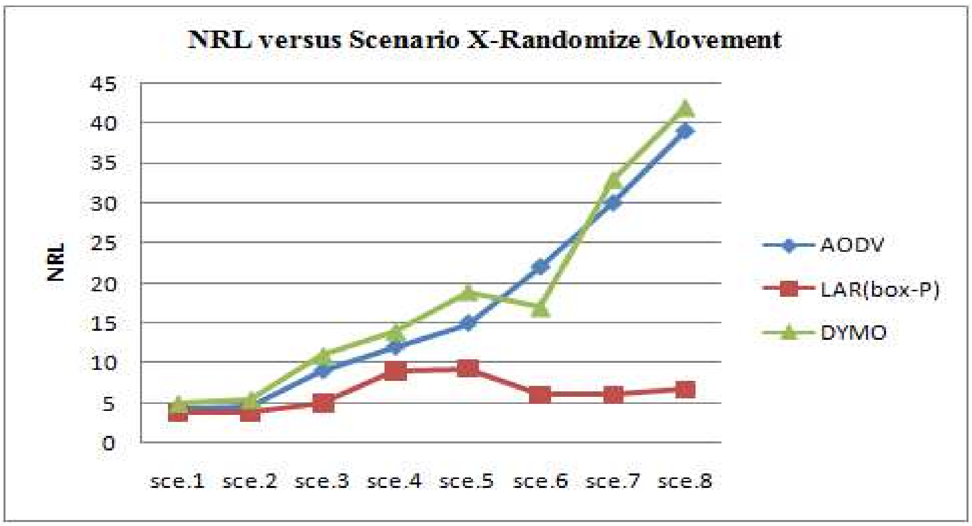


Figure 4.18



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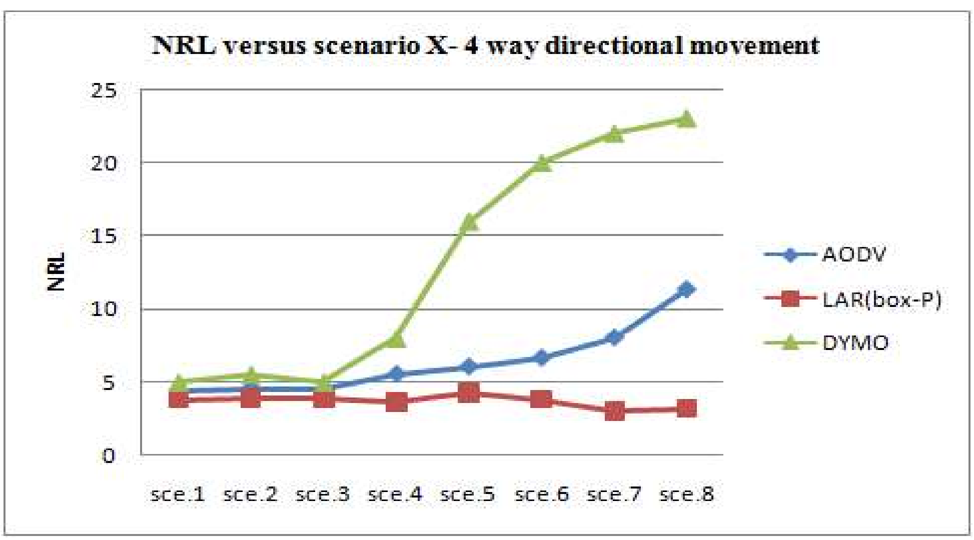

Figure 4.20

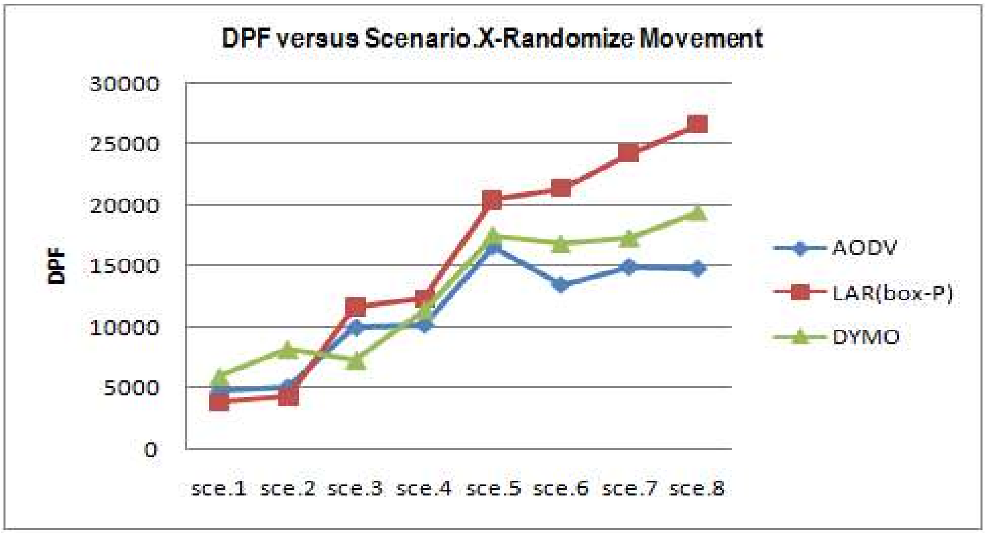

Figure 4.21

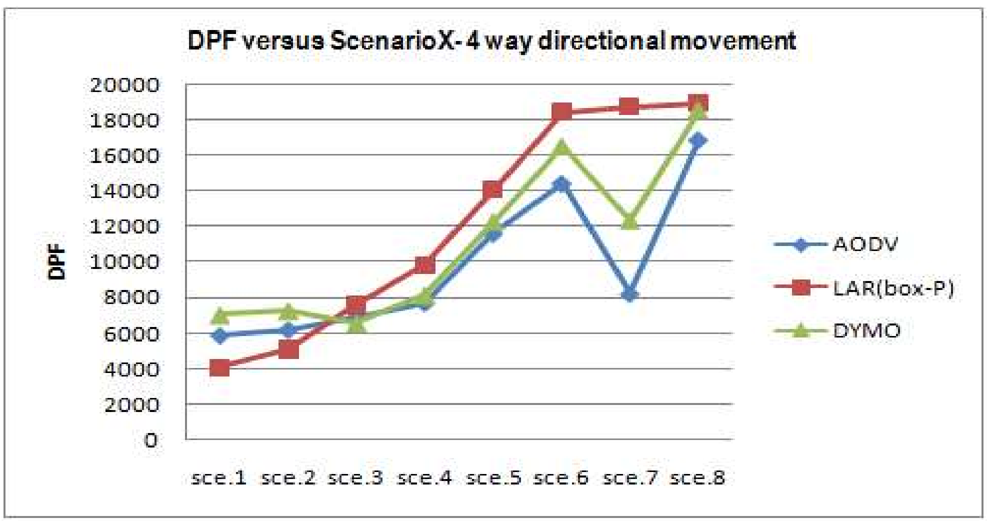

Figure 4.22

4.22) that all the three protocols: DYMO (fast reactive), AODV (reactive) and LAR BOX (geographic routing protocol-reactive with GPS) perform well according to the nodes motion.

When the movement of the vehicular nodes is along the direction as if compared to their random movement for the above said metrics, it have been observed that the PDR and End to end delay is better for LAR at peak load in both type movement but in low load 4-way directional movement is better. However Performance of AODV and DYMO is better than LAR for low load randomize movement. On the other hand we observed 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 for both movements.

4.9 Conclusion

This work 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 signi icantly 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. We conclude 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