Chapter 7

A Disaster Management System

7.1 Introduction

In this chapter, we propose and model a post disaster management system using Mobile Ad-hoc network (MANET). In a post disaster scenario, it is very important to model the movement of rescue teams for proper communication and co-ordination. This is crucial to save lives after a disaster. In a post disaster situation, the existing infrastructure may fail partially or completely. Hence, the communication cannot solely rely on it. With the advent of infrastructure less wireless networks i.e. MANETs; it is possible to be used as communication backbone as they are decentralized and easily deployable. Our proposed model consists of three stages namely disaster location, assign tasks and relief base with two interfaces, one between first and second layer and other between first and third layer. The links are provided by relief ambulance. The co-ordination task is managed by a four way movement. For group movement, we have used reference point group mobility model (RPGM). Simulations have been carried out to compare the routing protocols for packet delivery ratio and end to end delay.

In the past, post disaster management scenarios have been analyzed under various framework and mobility models. They are discussed in next section. In most of these works random waypoint mobility model has been used to analyze MANET performance. In this paper, we propose a three layer model for post disaster management scenario.

The organization of rest of the chapter is as follows. In the next section we describe the current scenario followed by state of the art in section 7.3. In section 7.4 the proposed model is discussed. Next, in section 7.5 simulation setup is provided followed by results and conclusion in next sections.

7.2 Current Scenario

A disaster can be classified into two major types:

a. Natural disasters such as an earthquakes, tsunamis, and floods,

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 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) [86].

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) [87]. 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 caused an up to 30 metres high Tsunami, which was devastating. The number of casualties exceeded 16000 (Report by ICF consulting services private ltd. under contract to European Commission) [88].

On 25 April and 12 May 2015, two earthquakes struck Nepal with 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 office for South East Asia of World Health Organization (WHO)) [89]. The vibrations spread to most parts of north India, taking more than 50 lives.

In June 2013, a multi-day cloudburst centered on the north Indian state of Uttarakhand caused devastating floods 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 [90], and Wikipedia [91]).

7.3 State of the Art

Here, we concisely inspect past works on disaster management using ad-hoc networks. The study includes mobility, performance metrics and routing. We observe that a considerable amount of work has been done on the area of disaster management. The preferred mobility model by researchers is the random way point mobility model [77], although other models have also been considered in some studies.

The requirements and technology was developed by Meissner et.al [58] integrated disaster management communication and information system. They addressed network configuration, scheduling and data management issues during the response and recovery phases and identified the design issues and architectural concepts for an integrated disaster management system. The infrastructure consists of 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. Terrestrial trunked radio or satellite technology were used 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.

Stepanov et.al [59] proposed a graph based approach by using Graph Walk Mobility Model which is similar to the random waypoint mobility model but uses a graph representing the spatial environment in the Spatial Model. To reflect spatial constraints of user movement imposed by the environment, the model relies on the Spatial Model. A map of the area containing its topological elements is provided. The spatial model is built on top of existing standards for describing environments in digital form to offer a standard interface for data access and to reuse existing data sources,

A pixel oriented approach was used by Kraaier et.al [60] for mobility modeling. Here, transition probability is calculated to reach the predefined stationary user distribution. The simulation area is divided into small parts and performance is evaluated.

Kim et.al [61] proposed a trace based approach. To model the real user movements, a foundation is provided 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 was proposed and developed by Mecella et.al [62] to support collaborative work of human operators in emergency/disaster scenarios. The whole team is considered to carry on a macro process and the teams from 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 [63] in 2008. It uses 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 [64]. 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.

From the inspection of past works, we observe that mobility patterns play an important role for performance evaluations of mobile networks. A few simple mobility models e.g. random waypoint model is considered to simulate user movement. This is suitable only for particular purpose. In these simple models the environmental heterogeneity is not considered, while this is an important factor in designing disaster management system. Our proposed post disaster mitigation model framework features random point group mobility. The group of nodes moves in sync with the leader. Nodes are only allowed to move along the predefined paths.

7.4 Proposed Model

The proposed architecture is shown in figure 7.1

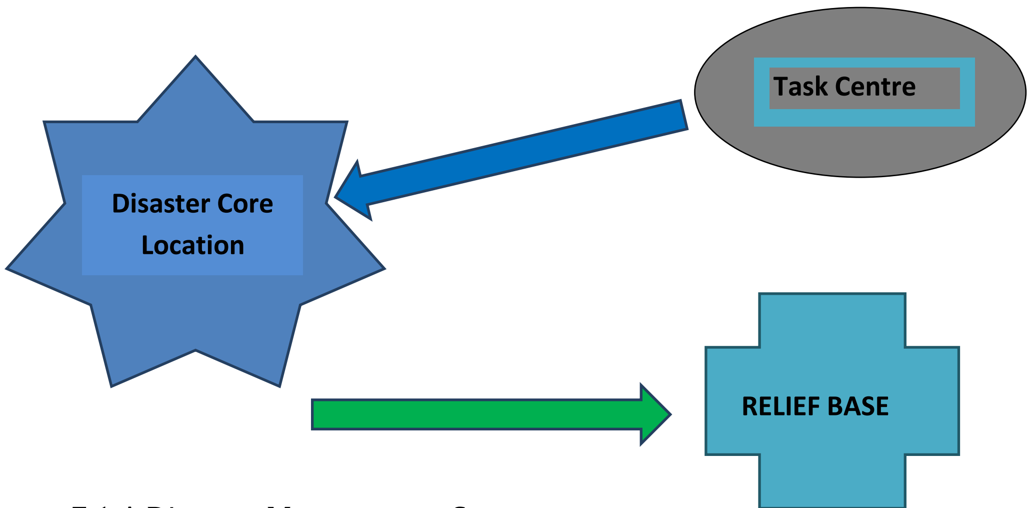


Figure 7.1 A Disaster Management System

We have considered 3 layers namely disaster location, assign tasks and relief base. Layer 1 is the core disaster location consisting of relief teams and the sufferers. Layer 2 is the location where jobs are assigned to various teams. Layer3 is the relief base, generally a hospital location. The movement between these layers is four way movement i.e. left, right, back and front. The nodes (people) move randomly within the layer and communicate with each other using CBR links. The nodes (vehicle) move randomly with a speed of 30m/s using VBR links. The communication between layers is shown in figure 7.2.

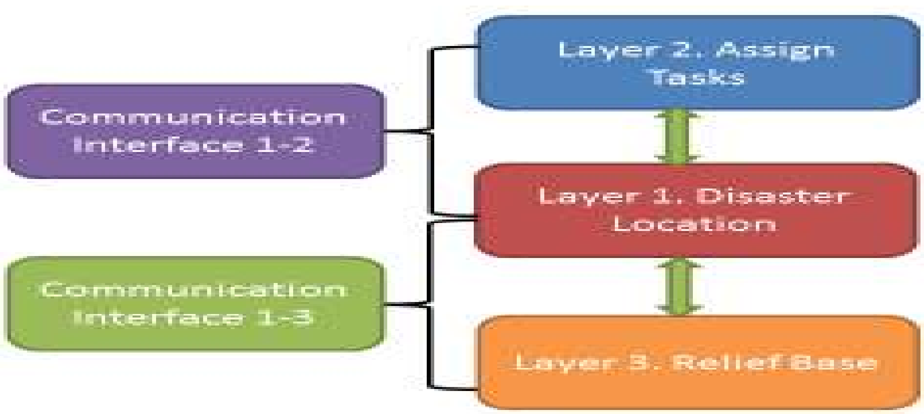


Figure 7.2: Communication between layers.

In post disaster situations, the teams cannot move around in random fashion. There is one leader in each group and the whole team follows the movement of the leader. Communication interface 1-2 shows the path of the vehicle or team(s) which move towards disaster location. Communication interface 1-3 shows the path of the vehicle or team which carry affected and injured people & bring them to the relief base. The third layer area has two places: waiting area for treatment and the casualties handling, where first aid treatment is provided. 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.

We have considered MANET supportable nodes following group mobility. In our framework we explore this model and routing of nodes based on attraction point and level of severity, layer to layer. The whole simulation area is sub divided into three sub layers. Simulation area L has three sub layer areas “Li”, each of which is represented as a tuple mentioned in the figure 5. Each tactical area “Li” has an entry-point En and an exit point Ex. Number of nodes at layer I is defined by Ni. Nodes move from one layer to another layer with a minimum and maximum velocity of Vimin and Vimax respectively. The size of the group at layer i is defined by Gi. The tuple definition is shown is figure 7.3.

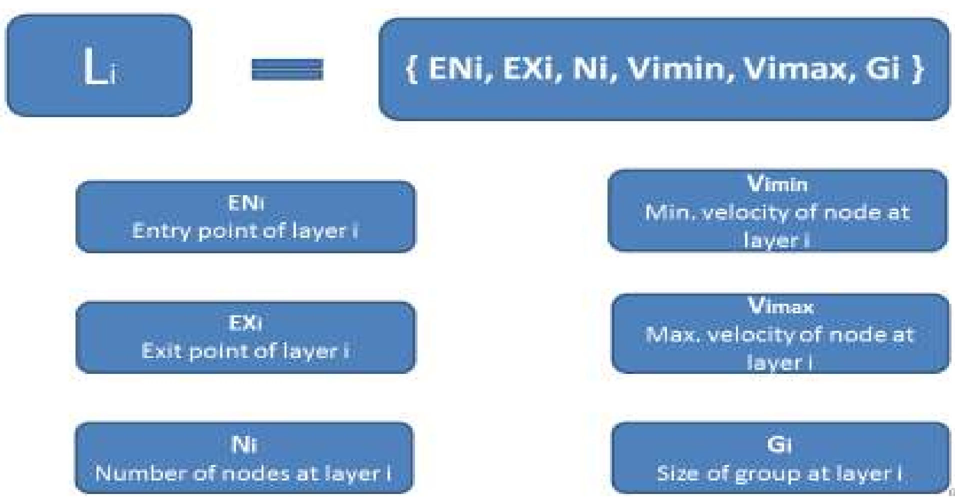


Figure 7.3: Definition of layer i.

7.5 Simulation Setup

We have used the concept of group mobility with an average group size of 8. 50 % of the number of groups is assumed to be vehicle group, with a speed of 5-10 m/s, to provide relief operations. Remaining 50% is assumed to be pedestrians group, with a speed of 0.5-1.5 m/s. Qualnet is chosen for our simulation as it 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. Simulation parameters are listed in table 7.1.

Parameter	Value
No. of Nodes	25, 50, 75, 100
Min. Speed	0.5 m/s
Max Speed	5 m/s
Group Size	8
Packet Size	512 Bytes
Mobility Model	Reference Point Group Mobility
Area	1000m x 1000m
Routing Protocols	AODV, OLSR

Table 7.1: Simulation Parameters

We have evaluated Packet Delivery Percentage (PDP) for our scenarios as discussed below. It 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 percentage = (Data packets received / Data packets sent) x 100

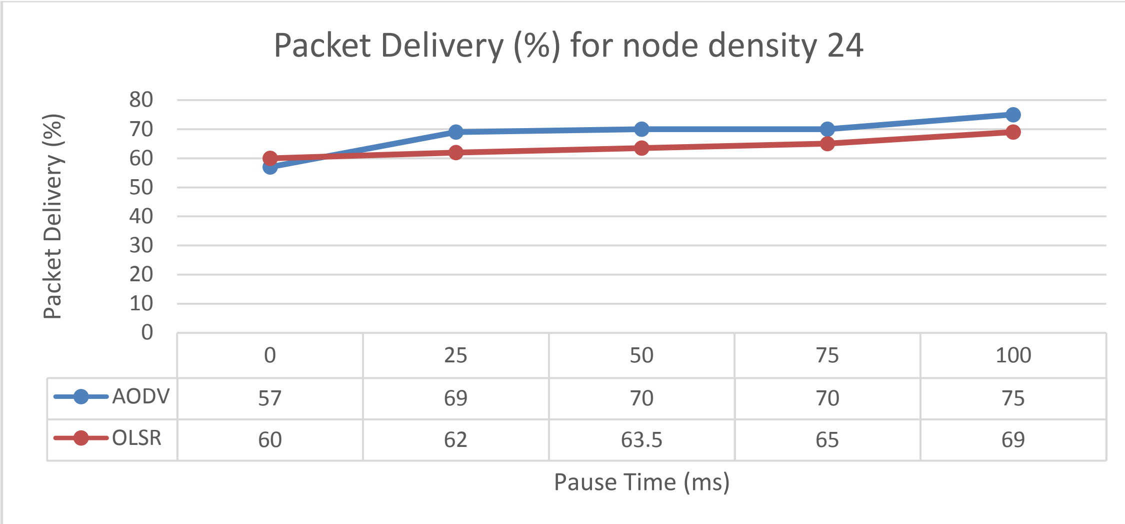
7.6 Results

Figure 7.4 to 7.7 shows the packet delivery percentage for node density 24, 48, 72 and 96 respectively.

AODV: When pause time varies, the packet delivery percentage increases. 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. As the pause time increases, the network topology becomes relatively stable, thereby decreasing the number of stale routes in the routing tables. Hence, route discovery and maintenance takes less time.

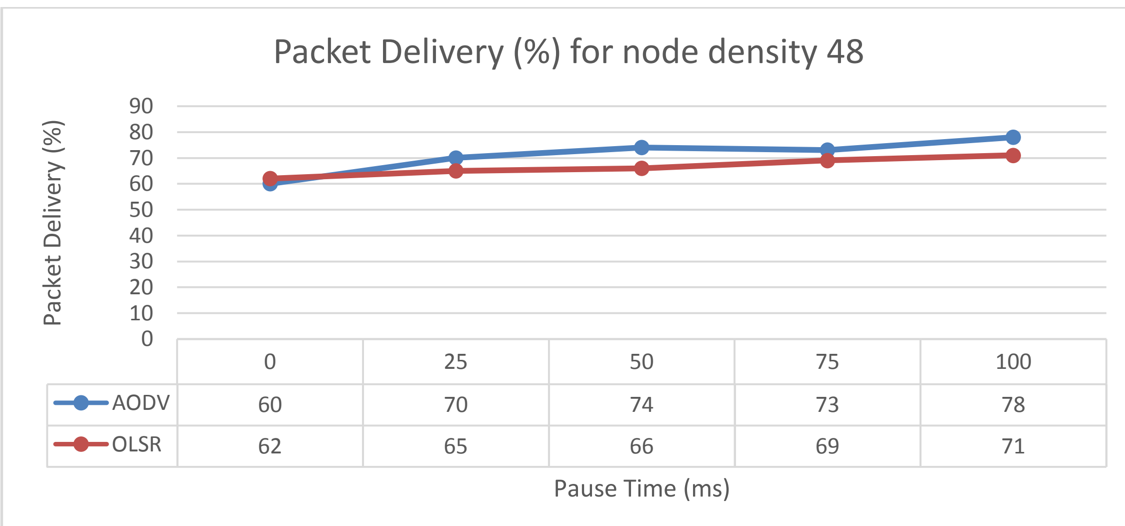
OLSR: It works proactively (i.e. the routes are established before packet transmission). The group motion does have some effect on OLSR, as can be observed through results. With the increase in pause time the mobility of the nodes decreases resulting in decreased congestion, and hence PDR decreases.

From the results, we observe that AODV (reactive protocol) performs better than OLSR (proactive) for designed scenario.



	0	25	50	75	100
AODV	57	69	70	70	75
OLSR	60	62	63.5	65	69

Figure 7.4: Packet Delivery Percentage for node density 24



	0	25	50	75	100
AODV	60	70	74	73	78
OLSR	62	65	66	69	71

Figure 7.5: Packet Delivery Percentage for node density 48

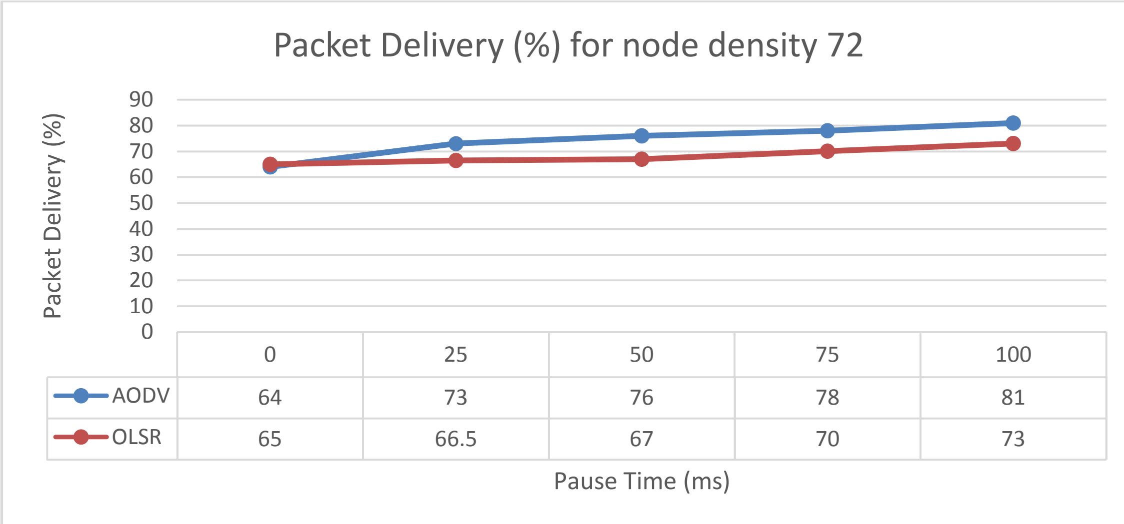


Figure 7.6: Packet Delivery Percentage for node density 72

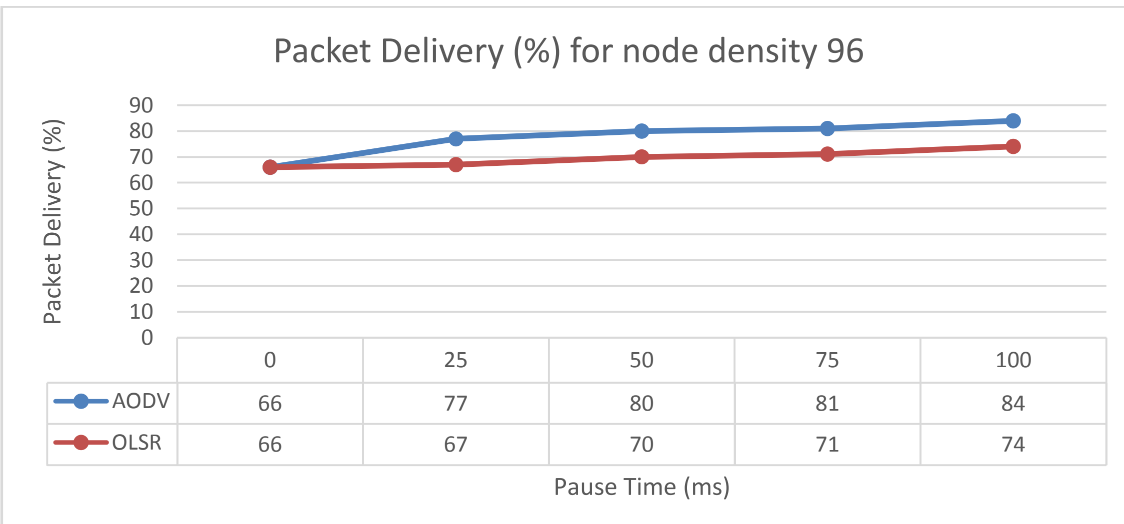


Figure 7.7: Packet Delivery Percentage for node density 96

7.7 CONCLUSION

This paper proposes and evaluates a model for post disaster situation. We have simulated framework of mobility with two routing protocols AODV and OLSR. We have used reference point group mobility model. Our simulations shows that routing protocols behaves significantly different under the scenarios designed on the same platform like variation in pause time, node density etc. For analyzing the performance of routing protocols in practice, such a scenario-based approach is vital.