Digital Postal Mobility Model

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(2008)

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Date: 02-04-2009

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This thesis is dedicated to my wonderful parents, who have raised me to be the person I am today and my loving friends who have supported me all the way since the beginning of my studies.

A dissertation Submitted To

Department of Computer Science,

Faculty of Basic and Applied Sciences,

International Islamic University, Islamabad

As a Partial Fulfillment of the Requirement for the Award of the

Degree of *MS in Computer Science*

Declaration

We hereby declare that this Thesis ***"Digital Postal Mobility Model"*** neither as a whole nor as a part has been copied out from any source. It is further declared that we have done this research with the accompanied report entirely on the basis of our personal efforts, under the proficient guidance of our teachers especially our supervisor *Dr. M.A.Ansari* If any part of the system is proved to be copied out from any source or found to be reproduction of any project from any of the training institute or educational institutions, we shall stand by the consequences.

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Acknowledgement

First of all we are obliged to Allah Almighty *the Merciful, the Beneficent and the source* of all Knowledge, for granting us the courage and knowledge to complete this Project.

I am thankful to my supervisor Dr. M.A Ansari (federal Urdu University) and my friend's Mr. fazl-e-Hadi (PhD, Bahria University) and Mr. Nadir Shah (PhD, China) who has helped in the project.

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Project In Brief

Project Title:	Digital Postal Mobility Model
Undertaken By:	Yasir Habib Khan 239-FAS/MSCS/F05
Supervised By:	Dr. M.A Ansari
Start Date:	February, 2008
Completion Date:	September, 2008
Tools Used:	Network Simulator NS-2
Documentation Tool:	Microsoft Word XP
Operating System:	Red Hat Enterprise Edition
System used:	Pentium IV

Abstract

The mobility models are one of the most important factors in the performance evaluations of a mobile ad hoc network (MANET). The Manhattan mobility model has been used to model the nodes mobility, where the movement pattern of mobile node on streets and roads defined by maps. However, DakNet ad hoc network that uses wireless technology to provide digital connectivity among village kiosks and private communication devices and between kiosks and a hub(for non-real time internet access) using low-cost WiFi radio transceivers. One typical mobility behavior is Geographical restriction movement. To investigate DakNet scenario an underlying realistic mobility model is desired. In this dissertation, we propose a "Digital Postal" based mobility model (DP model), which closely approximates the mobility patterns in DakNet scenario; it models the movement of nodes at pre-defined path and have a set of destinations and also visit all destination. We demonstrate our proposed mobility model by evaluating various MANET routing protocols, including DSR and DSDV, the performance of DP model is efficient than existing geographical restricted models and also simulation experiment shows that the choice of mobility model has significant impact on network performance.

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Chapter 1

INTRODUCTION

1.1 MANETS

Ad-hoc is a Latin word, which means improvised or the need of a moment for a specific purpose. In computer networking, we think of an *ad hoc network as* a wireless network without any infrastructure, e.g. wireless base stations.

We use ad hoc network because it has some potential benefits, which make it different from the other wireless Networks. Some of them are [2]:

- Ease of deployment
- Speed of deployment
- Decreased dependence on infrastructure

A mobile ad-hoc network (MANET) is a kind of wireless ad-hoc network, which is configuring network of mobile hops and also works as routers and associated hosts connected by wireless links The nodes are free to move randomly and organize themselves .Thus, the network's wireless topology changes priodically and unpredictably. These kind of networks work as standalone or may be connected to the larger Internet.

The incresed utility and use of laptops and 802.11/WiFi in 1990s, made MANETs a popular subject for research. Many of the research papers evaluate protocols assuming changeable degrees of mobility nodes within a bounded space, usually with all mobile nodes within a few hops of each other, and usually with nodes sending data at a constant rate[1]. Different protocols are then evaluated on the basis of packet drop rate, overhead, packet delivery ratio and other measures.

Recent advancements in communication like Bluetooth introduced a new type of wireless systems called mobile ad-hoc network or "short live" networks; they operate in the absence of fixed network infrastructure and offer quick and easy network deployment where, it is not possible. Mobile ad-hoc network is an autonomous system of mobile nodes connected by wireless links. On the network each node operates as router and end system for other nodes [1].

1.1.1 Application of Manets

Mobile ad-hoc networks can turn the dream of getting connected "anywhere and at any time" into reality [1]. Typical application examples include:

1. A group of peoples with laptops, in a business meeting at any place where no network services is present. They can easily network their machines by forming an ad-hoc network [3].
2. Military battle field: Ad-hoc networks were first used for military purposes, supported by Department of Defense (DoD) USA. Since then, they have become increasingly popular within the computing industry [3].
3. Disaster Recovery: A typical application for ad hoc network is a disaster area where pre-existing communication infrastructures have been damaged due to earthquake or a terrorist attack. Emergency personnel need to quickly establish communication to different rescue teams as well as to people in distress.
4. Sensor Network: Another application is sensor network, where the sensor node may move in a geographic region and pass the required information to the base station. This may be multi-hop communication because sensor nodes are becoming smaller, like smart dust, and power consumption is greater. Therefore these nodes use low radio range to reduce power consumption.
5. Personal Area Networking: Ad hoc networks can also play a role in civilian area such as the electronic classroom, convention centres and construction sites [4].Other applications include, e.g. Bluetooth and wireless home networking and some specials application (industrial control, taxis, boats etc).
6. DakNet

There are many examples where these networks may possibly be used, for example DTN etc [1].

Aspects:

There are various aspects of ad hoc networks discussed in literature as shown in the following figure [7].

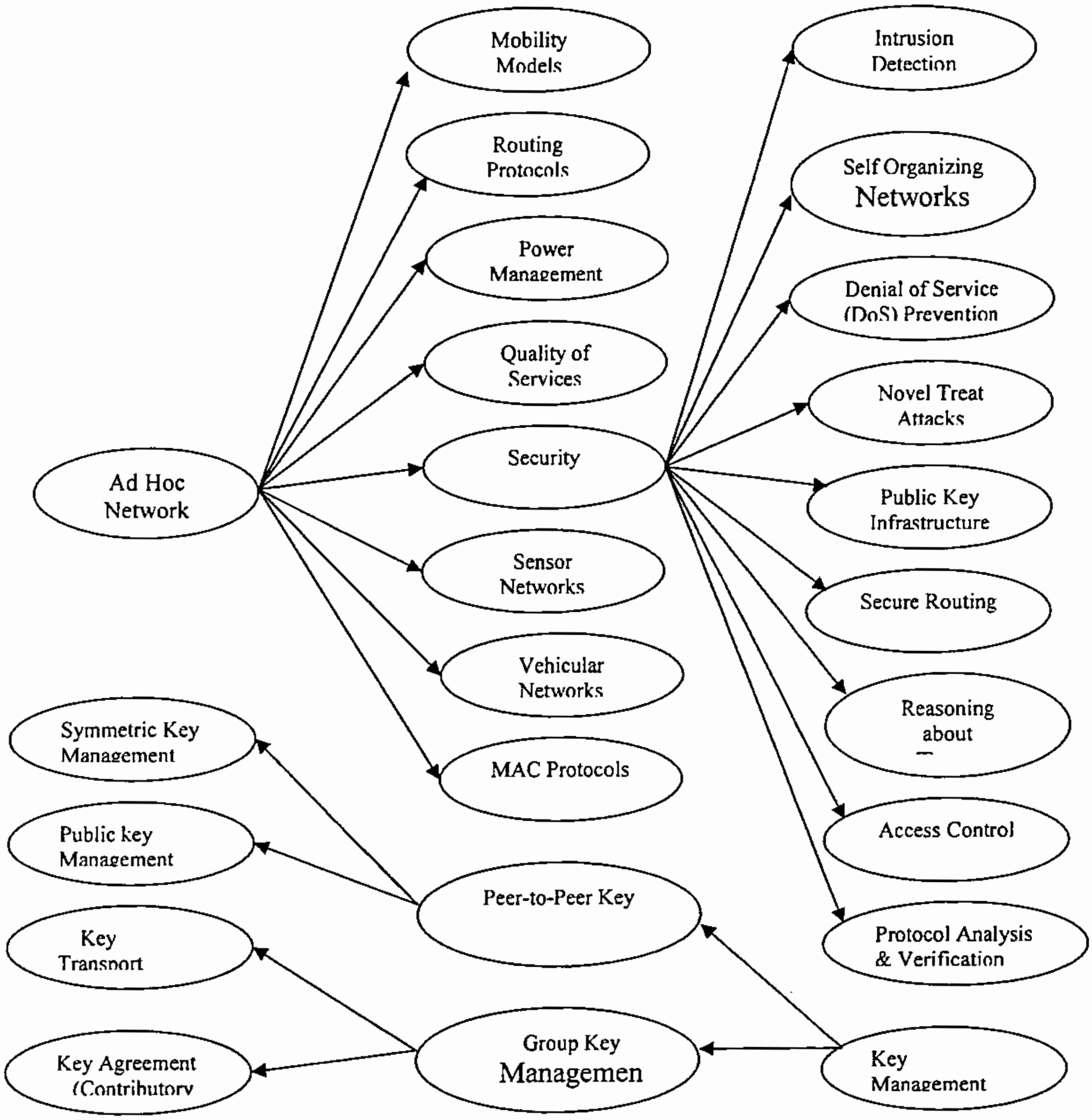

Figure 1.1 Main aspects of routing protocols

The main aspects of these networks are routing protocols and mobility models [7] and are discussed in the lines following diagram.

1.2 Routing In Ad Hoc Networks

Routing ad hoc networks is the process used for getting the packet from one mobile device and sending it through the network to another mobile device on a different network [2]. We can simply say that routing is the process of creating routing tables. The routing table is the table that is built up by the routing algorithm as a precursor to build a forward table (the forwarding table stores the routes to particular network destinations). It generally contains mapping from network number to next hop. For packet forwarding it use forwarding table and so must contain enough information to accomplish the forwarding function, we use routing protocols to create routing tables.

There are following three categories of routing protocols,

1.2.1 Pro-active Routing (Table-driven)

This type of protocols maintain fresh and the updated lists of destinations and their routes by periodically distributing routing tables throughout the network [6].

- Traditionally distribute shortest-path protocols
- Maintain routes between every host pair at all times
- These protocols are Based on periodic updates; High routing overhead
- Examples: DSDV (destination sequenced distance vector)[8], OLSR [5]

To ensure the freshness of the routing tables, these protocols adopt different sorts of mechanism.

"One of the adopted methods is broadcasting "hello," a special message containing address information, at fixed intervals of time. On receiving this message, each node updates its routing tables with fresh location and information's of other participating nodes [6]."

Destination Sequence Distance Vector routing protocol (DSDV), Wireless Routing Protocol (WRP) and Cluster-head Gateway Switch Routing (CGSR) are some of the popular table-driven protocols for mobile ad-hoc networks [6].

The main disadvantages of such algorithms are:

1. Non-availability of Respective amount of data for maintenance.
2. Slow reaction on restructuring and failures

1.2.2 Reactive Routing (On-demand)

In on-demand protocols, if a source node requires a route to the destination for which it have no routing information, it initiates a route discovery process its mean that info is only acquired when required, which goes from one node to the other until it reaches to the destination or an intermediate node has a route to the destination [6].

The main disadvantages of such algorithms are:

1. It takes high latency time in route finding.
2. The presence of Excessive flooding can lead to network clogging.

Examples are: AODV [20], DSR [19] and TORA

1.2.3 Hybrid (Pro-Active/Reactive)

This type of protocol combines the advantages of proactive and reactive routing.

> *"The proactive routing is established initiallty and then serve reactive flooding for additional activated nodes [6]."*

The choice for one or the other method requires predetermination for typical cases. The main disadvantages of such algorithms are

1. Its performance depends on amount of nodes activated.
2. Reaction to traffic demand depends on gradient of traffic volume.

Examples: ZRP

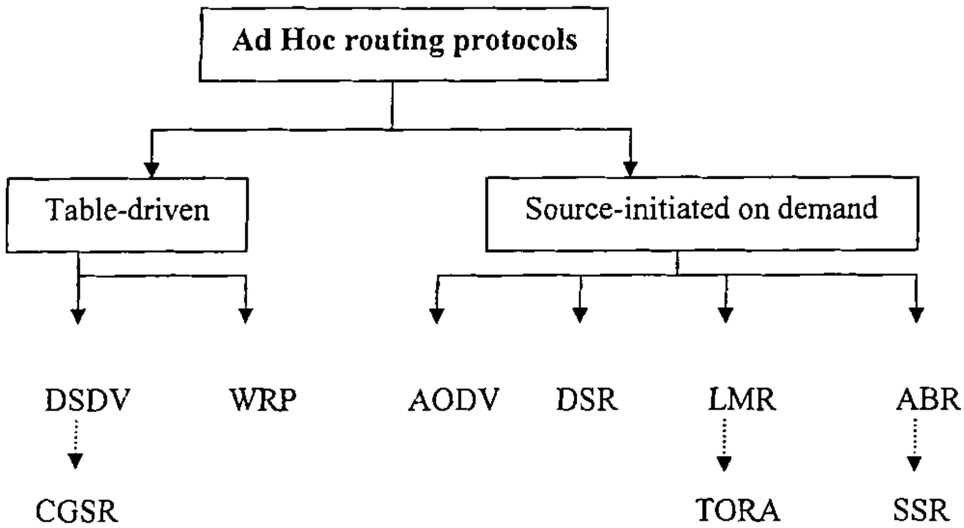

Figure 1.2 Types of routing protocol

1.3 DSR (Dynamic Source Routing) Protocol

DSR is reactive protocol which doesn't use periodic advertisements [10] [30]. It uses source routing. In source routing technique the sender of a packet determines the complete sequence of nodes through which the packet has passed and explicitly lists this route in the packet's header. It identifies each forwarding hop by the address of the next node to which the packets are transmitted further on the way to the destination host [31].

There are two significant stages in working of DSR: Route Discovery and Route Maintenance. A host initiating a route discovery broadcasts a Route Request (RR) packet and only those nodes will receive which are in its transmission range (wireless). The RR packet identifies the host or the target of the route discovery for which the route is requested. On successful initiation, the host receives a route reply packet which lists a sequence of network hops through which it will reach to the target. The request packet contains the address of the original initiator of the request, the target of the request and a route record sequence of hops taken by the route request packet when it is propagated through the network during the routing discovery.

Using any source route the host monitors the continued correct operate of that route. This monitoring is called route maintenance. When a problem is detected with a route in use route discovery discovers a new correct route to the destination [32].

To optimize route discovery process, DSR uses cache memory efficiently [7] [30]. When a host receives a route request packet not the target or nor already list in the route record in the packet or when the pair is not found in its list of recent request and if the host has a route cache entry for the target of the request then it may append this cached route to the accumulated route record in the packet or may return this route in a route replay packet to the initiator without propagating the route request by allowing data to be piggybacked on route request packet the delay of route discovery and the number of packet can be reduced.

"DSR uses no periodic routing advertisement messages, thereby reducing network bandwidth overhead, particularly during periods when little or no significant host movement is taking place. DSR has a unique advantage by virtue of source routing. As the route is part of the packet itself, routing loops, either short-lived or long-lived, cannot be formed as they can be immediately detected and eliminated [7]."

1.4 DSDV (Destination Sequenced Distance Vector)

Destination Sequenced Distance Vector (DSDV) is a Proactive routing protocol that solves the major problem associated with the Distance Vector routing of wired networks i.e., Count-to-infinity, by using Destination sequence numbers. Destination sequence number is the sequence number as originally stamped by the destination [7]. The DSDV protocol asks each mobile station to advertise, to each of its current neighbours, its own routing table. The entries in list may change dynamically with time, so the advertisement must be made often enough to ensure that every mobile computer can locate every other mobile computer. In addition, each mobile computer relays data packets to other computers upon request. Every time, the DSDV protocol guarantees loop-free paths to each destination.

Preference is given to Routes with more recent sequence numbers as the basis for making forwarding decisions, but not necessarily advertised. Where paths with the same sequence number are used, those with the smallest metric will be preferred.

"The routing updates are sent in two ways: a "full dump" or incremental update. A full dump sends the full routing table to the neighbours 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 [7]."

Incremental updates are sent when the network is relatively stable to avoid extra traffic. In a fast changing network full dump are frequent and incremental packets are infrequent as they can grow big.

The updates can be time triggered (periodic) or event triggered. When a mobile host receives any new or substantially modified route information it is retransmitted soon. When a different metric for some destination is showed by a stabilized rout its makes a significant change which need to be advertised after stabilization. If the metric remain the same and a new sequence number for a route is received, it considered as a sign cant change. The nodes then schedules newly recorded routes for immediate advertisement to the current Mobile Host's neighbours. Routes which show an improved metric are scheduled for advertisement at a time depends on the average settling time for routes to the particular destination.

"A broken link is described by a metric of infinity (i.e., any value greater than the maximum allowed metric). When a link to a next hop has broken, any route through that next hop is immediately assigned infinity metric and assigned an updated sequence number. Since this qualifies as a substantial route change, such modified routes are immediately disclosed in a broadcast routing information packet [7] [30]."

1.5 Mobility Models for Ad Hoc Networks

To study a new Mobile Ad hoc Network protocol, it is important to simulate this protocol and evaluate its protocol performance. Protocol simulation has several key parameters, including mobility model and communicating traffic pattern.

The mobility model is designed to describe the movement pattern of mobile users, like the change in their location, velocity and acceleration over time. Since mobility patterns may play a significant role in determining the protocol performance, it is desirable for them to emulate the movement pattern of targeted real life applications in a better way. One intuitive method to create realistic mobility patterns would be to construct trace-based mobility models, in which accurate information about the mobility traces of users could be provided. However, since MANETs have not been implemented and deployed on a wide scale, obtaining real mobility traces becomes a major challenge. Therefore, various researchers proposed different kinds of mobility models, attempting to capture various characteristics of mobility and represent mobility in a somewhat 'realistic' fashion. Much of the current research has focused on the so-called synthetic mobility models that are not trace-base driven.

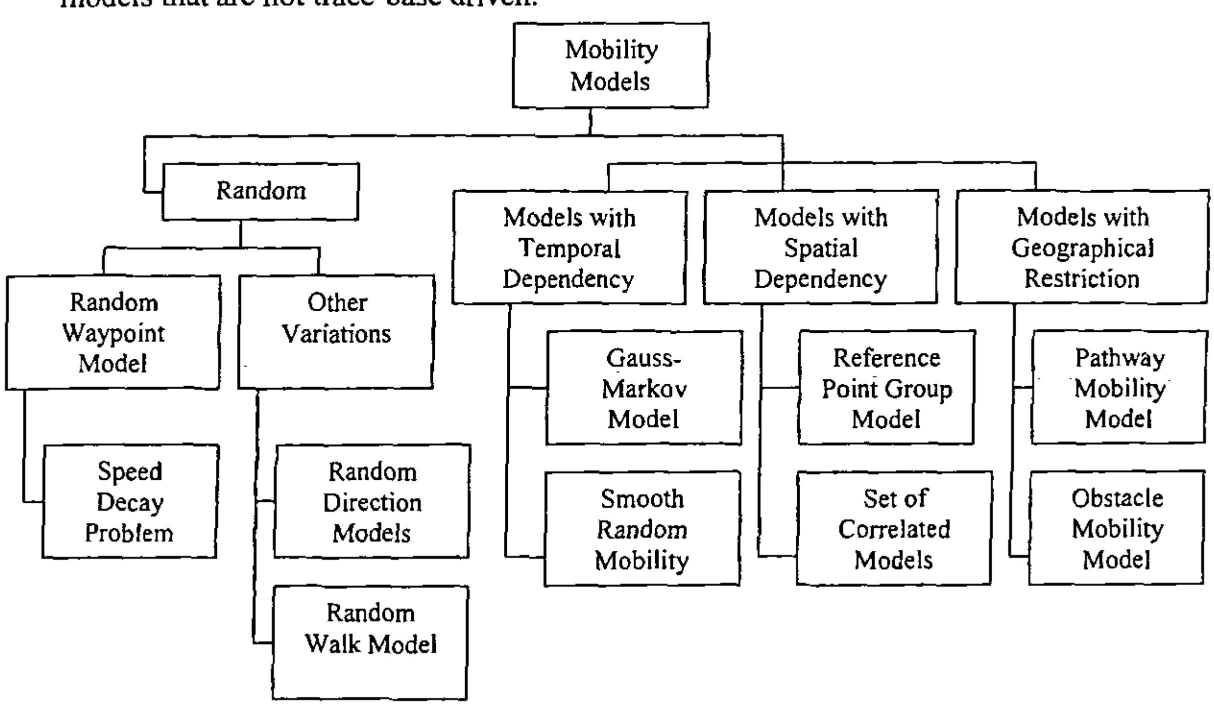

Figure 1.3 the categories of mobility models in Mobile Ad hoc Network [8]

We provide a categorization for various mobility models into several classes based on their specific mobility characteristics. For some mobility models, where the movement of a mobile node is likely to be affected by its movement history is called mobility model with temporal dependency. In some mobility scenarios, mobility models with spatial dependency where the mobile nodes tend to travel in a correlated manner. Another class is the mobility model with geographic restriction, where the movement of nodes is bounded by streets, freeways or obstacles [8].

There are several mobility models that represent mobile nodes whose movements are independent of each other (i.e., entity mobility models) and several mobility models that represent mobile nodes whose movements are dependent on each other (i.e., group mobility models) [9].

There are seven different synthetic entity mobility models, but we discuss two different synthetic entity mobility models for ad hoc networks because these are geographical restricted mobility model which have streets and roads and our proposed model have also streets and roads, the choose models are:

1. **City Section Mobility Model:** A simulation area that represents streets within a city [9].
2. **Manhattan Mobility Model:** A Manhattan model employs a probabilistic approach in the selection of nodes movement on pre define path [10].

1.5.1 Manhattan Mobility Model

The Manhattan model employs a probabilistic approach in the selection of nodes movements, since, at each intersection, a vehicle chooses to keep moving in the same direction with probability 1/2 and to turn left or right with probability 1/4 in each case [10].

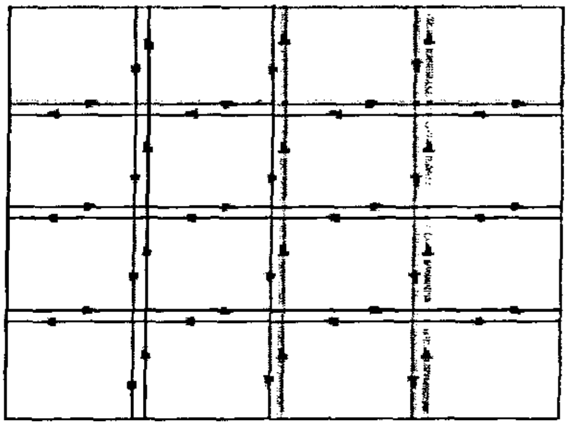

Figure 1.4 Manhattan model topology, each line representing a single-lane road. Vehicular movement occurs on the direction shown by the arrows [10].

1.5.2 City Section Mobility Model

In the City Section Mobility Model, the simulation area is a street network that represents a section of a city where the ad hoc network exists. The streets and speed limits on the streets are based on the type of city being simulated. Each Mobile Node (MN) begins the simulation at a defined point on some street. An MN then randomly chooses a destination, also represented by a point on some street.

> *"The movement algorithm from the current destination to the new destination locates a path corresponding to the shortest travel time between the two points. Upon reaching the destination, the MN pauses for a specified time and then randomly chooses another destination and repeats the process. The City Section Mobility Model provides realistic movements for a section of a city since it severely restricts the traveling behavior of MNs [9]."*

In other words, all MNs must follow predefined paths and behavior guidelines (e.g. traffic laws). In the real world, MNs do not have the ability to roam freely without regard to obstacles and traffic regulations. In addition, people typically tend to travel in similar patterns when driving across town or walking across campus [9].

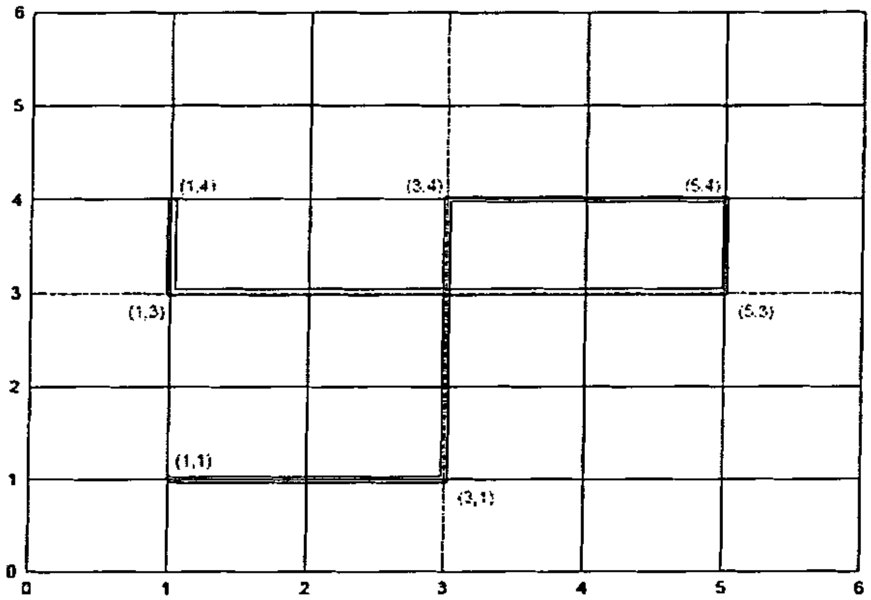

Figure 1.5 Traveling pattern of an MN using the City Section Mobility Model. [9].

The choice of a mobility model can have a significant effect on the performance investigation of an ad hoc network protocol. The results presented in every mobility models illustrate the importance of choosing an appropriate mobility model (or models) for the performance evaluation of a given ad hoc network protocol.

Chapter 2

Literature Survey

There is a rich literature on mobility models in the performance evaluation of protocols for ad hoc network. The goal to present a number of mobility models in order to offer researchers more informed choices when they are deciding upon a mobility model to use in their performance evaluations.

2.1 Mobility Models

The researcher illustrate that the choice of a mobility model can have a significant effect on the performance investigation of an ad hoc network protocol. The results presented illustrate the importance of choosing an appropriate mobility model for the performance evaluation of a given ad hoc network protocol.

Tracy Camp *et al.* [9] compare several mobility models using DSR protocols in paper. they use two types of mobility models that are entity base and group mobility models, and find their performance by using DSR protocol. They take different parameters, these are

- Data packet delivery ratio
- End-to-end delay
- Hop count
- Control packet overhead
- Control byte overhead

All these parameters are tested against speed of Mobile Node. In this paper she gives very detailed information about mobility models and describes several mobility models. The mobile nodes whose movements are independent of each other (i.e., entity mobility models) and several mobility models that represent mobile nodes whose movements are dependent on each other (i.e., group mobility models). The goal of this paper is to present a number of mobility models in order to offer researchers more informed choices when they are deciding upon a mobility model to use in their performance evaluations. They illustrate how the performance results of an ad hoc network protocol drastically change as a result of changing the mobility model simulated [9].

The paper also gives a good idea of choosing a mobility model, its importance and effects on the performance investigation of an ad hoc network protocol. They use NS-2 to compare the performance of different mobility models and compare four mobility models using DSR. The researchers should make an informed choice about the use of a mobility model, which means that since a single mobility model is unlikely to depict the behavior of the MNs in all scenarios, it may be best to evaluate an ad hoc network protocol with multiple mobility models. The similarities and differences between mobility models that randomly select directions and mobility models that randomly select specific locations should be analyzed [9].

In [9] the result of DSR presented is different from other papers because of the differences in there simulation environments, for example average speed, pause time, simulation time etc. but all the mobility models show different behavior because of node movement. The future of mobility models is to examine the movements of entities in the real world to produce accurate mobility models and also to develop new models that combine all the best attributes of some of the models [9].

Hemly *et al.* [8] performed and examined different mobility models proposed in the recent research literature. The authors also discuss various models that exhibit the characteristics of temporal dependency, spatial dependency and geographical constraints. They give an overview of the current research status of mobility modeling and analysis. They divide the models in four categories and their subcategories on the basis of specific mobility characteristics [8].

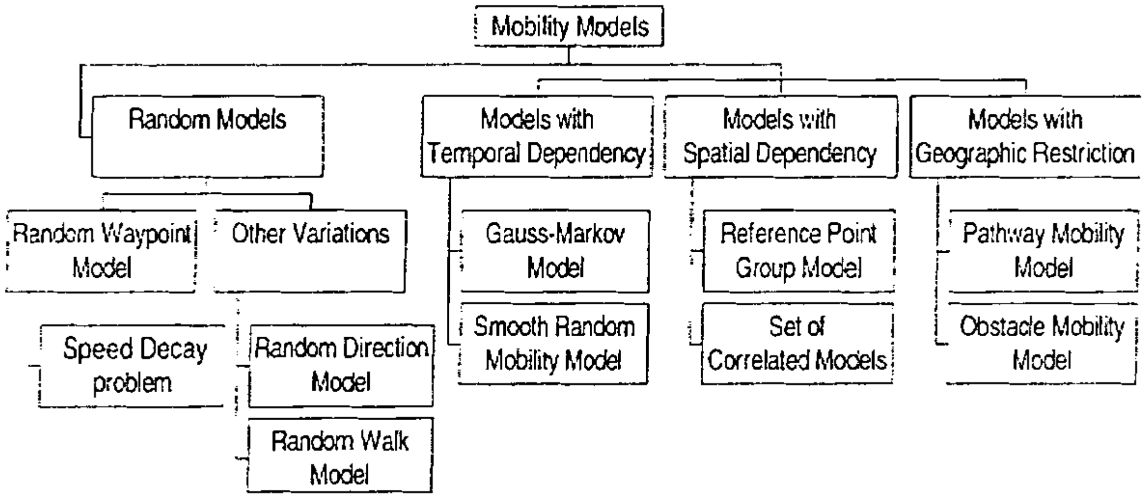

Figure 2.1 the categories of mobility models in Mobile Ad hoc Network [8].

In some mobility models, the movement of a mobile node is likely to be affected by its movement history. Authors refer to this type of mobility model as mobility model with temporal dependency. In some mobility scenarios, the mobile nodes tend to travel in a correlated manner. They refer to such models as mobility models with spatial dependency. Another class is the mobility model with geographic restriction, where the movement of nodes is bounded by streets, freeways or obstacles [8].

The authors discuss all the mobility models in detail, and give a mathematical equation, that is their stochastic properties and their limitation on other models. They also discuss the temporal dependency models where the guass markov model is dependent on the memory level parameter. So by adjusting parameters in temporal dependency, we can generate various mobility scenarios and the smooth random model where both speed and movement of nodes are decided by their pervious value.

The spatial dependency also generates various scenarios by adjusting parameters. Determining the motion behavior of mobile nodes is the important factor of geographical restriction models. For mobility models with geographic restrictions, those pathways are supposed to restrict and partly define the movement trajectories of nodes, even though certain level of randomness appears to exist. [8], every mobility model has its own characteristics and unique properties, so these mobility models behave differently, by evaluating ad hoc protocols performance it is important to use various mobility models instead of single model.

Zheng *et al.* [11], give the survey based paper on mobility models ad hoc network. The difference between ad hoc network and internet is that, that host in this network is resources constrained (limited energy, computing power and energy) and other is that the nodes are mobile, so it is continuously changing topology [11]. They give brief survey on mobility and also focus on statistical evaluation of mobile networks.

In [11] they classified the mobility models in three classes, while in [15], they classified them into two classes, and both based on their randomness. Their analysis consists of three parts and also shows the impact of mobility models on the performance of protocols.

They classified the mobility models into three categories [11]:

- Trace based models
- Constrained topology based models
- Statistical models

It then those are models trace based models where every things are deterministic, if there is only one partial randomness, these models are constrained topology based models, and when there is total randomness they call, statistical models.

The constrained topology based mobility models simulate real world's scenario. Some constrained topology based models, which are briefly describes in this paper are [11]:

- Reference point Group Mobility Model (RPGM)
- Mobility Vector Model
- Obstacle Mobility Model

The statistical models are basically idealistic rather than realistic, because in real world, the host will not move randomly with out destination, Examples of statistical models which is briefly describe in paper are [11]:

- Random Waypoint Model
- Random Direction Model

- Random Walk Model

The change in topology also affects the performance of routing protocols.

In this paper they only do the analysis of random waypoint model. The statistical properties of random waypoint model result on distribution of [11]:

- Transition length
- Transition time
- Host position (static, pausing, moving)

They classify mobility matrices in two categories [11]:

- Direct mobility matrices
- Derived mobility matrices

Host speed or relative speed is measurement with clear physical meaning is called direct mobility matrices. The derived mobility matrices like graph connectivity are measurement derived from physical observations, through mathematical modeling [14].

2.2 Scenarios Based Mobility Models

The mobility models are one of the important factors in performance evaluation, the scenario based mobility models are models in which different scenarios are applied on these models to propose new models but all these proposed models are based on the existing models and these scenarios are taken from our daily life. These scenarios are real world scenarios and like mobility models their characteristics are different (group motion or individual motion).

Helmy *et al.* [12] proposed new scenario base mobility model which called Weighted Way Point (WWP) mobility model. WWP model captures preferences in choosing destinations of pedestrian mobility patterns in a campus environment

It also incorporates location-dependent pause duration and weights for choosing next destination. They take a scenario for WWP model based on a mobility survey carried out on the campus of University of Southern California (USC). They further show that preferences in destination selection lead to significant discrepancy in ad hoc routing protocol performance. WWP model is also less mobile than RWP model with typical parameter settings. It is important to address the following issues [12]:

- The destination is NOT randomly chosen for pedestrians on campus.
- Given the environment setting of a campus, there are usually popular locations where people tend to visit more often than others. They investigate this issue in this work and propose a new model.

The major differences of WWP model and the popular Random Waypoint (RWP) model are [12]:

- Mobile nodes (MN) no longer randomly choose their respective destinations.
- The weights of choosing next destination location depend on both current location and time.
- The pause time distribution at each location is different.

They categorize buildings on campus into three different location types: classrooms, libraries, and cafeterias. The buildings and area that does not belong to these three categories are collectively referred to as other area. They also model the mobile nodes moving to off campus area with certain probabilities.

The author uses simulations to show the characteristics of WWP model, in comparison to RWP model and they further show the impact of WWP model on network performance. They compare the success rate of route discovery using DSR [4] under 2 different MN location relationships, MN pairs in the same location and MN pairs in different locations. Based on their simulation study, they came to the conclusion that preference in choosing destination in a mobility model has a non-negligible impact on wireless network performance [12].

From the survey they find the statistics about the pause time duration, transition probability and wireless network flow duration. The pause time distribution means pause time at each location that how much time student spends in class room, library and cafeteria. They just give the time. In the transition probability they give that in day time, in morning interval and in lunch time most of students are in cafeteria but most of the transition is between classroom and library that is more than 50% and the wireless network duration is the heavier trail for library because most of people work in library with their laptops connected to wireless network.

Gerla *et al.* [13] proposed a new scenario based model which is called Virtual Track mobility model (VT model) which closely approximates the mobility patterns in military MANET scenarios in this model they used the large scale military scenario whose behavior is group mobility. It models various types of node mobility such as group moving nodes, individually moving nodes as well as static nodes. The model dynamics of group mobility are group merge and split. In this model some nodes move in groups; while other move individually and independently. The group nodes must move following the constraint of the track. At switch station, groups can be split into much smaller groups and some are merged in to bigger groups. Nodes of same group move on same track and they also share the same group movement towards the next switch station [13].

The VT model is also capable to model randomly and individually by moving nodes as well as static nodes (such as sensors).

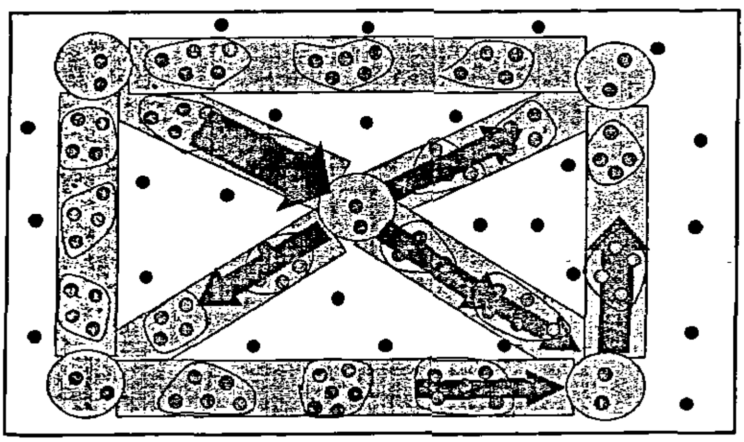

Figure 2.2 Virtual Track Model (VT model) [13]

In proposed virtual track based group mobility model, in figure there are 5 switch stations which are randomly placed in the field connected via 8 virtual tracks with equal width. Group moving nodes are moving towards switch stations along the tracks. They split and merge at switch stations as shown in the figure. The black nodes in Figure represent the individually moving nodes and static nodes. They are placed and move independent of tracks and switch stations. The nodes usually move following the predefined track [13].

The authors design the virtual track based mobility model by defining switch stations and virtual tracks, that user can specify the number of stations in the scenario. Then the VT model will randomly choose the positions for these stations in the field. Then tracks are defined to connect these switch stations. The user can also define the width of track and also randomly chosen. So after the tracks and switch stations are defined, it distributes nodes during initialization. The group nodes are initially distributed along the virtual tracks and the individual nodes are initially distributed in the whole field without considering the tracks. Movement of group mobility nodes are under the constraints of the tracks. After that the groups split or merge at the switch stations. In this each group is defined with a group stability threshold value. Last design is random and individual nodes.

In simulation, these models are implemented in the QualNet network simulator. They investigate the performance by using AODV routing protocol. They use the highway map for simulation, which has 11 intersection and they take these highways as the virtual tracks and intersections as the switch stations. In the first set of simulation they compare the performance of AODV routing protocol using their VT model versus the Random Waypoint (RWP), their parameters are Delivery Ratio, Throughput and End-to-End Delay. Their overall performance shows that group mobility (VT model) is worse than random mobility (RWP) because the connectivity within a group is strengthened but the connectivity across groups will be typically weaker than the average connectivity when all nodes are uniformly distributed and moving randomly in the space. RWP model, nodes reality moves in groups will give inaccurate optimistic results. Now they find the performance on same parameters but on the second set of the simulation experiment that is impact of individual random moving and static nodes. So, when the individual nodes are randomly distributed in the field, outside the "virtual track", the connectivity among multiple groups is increased. So this implies that the military scenario with dominant group mobility nodes will in general improve the network performance significantly [13].

In [13], authors give the new concept of "switch station" and "virtual track", and on virtual track they also apply some constraint. They use group movement and also individual movement of nodes and in performance evaluation they show by their simulation the individual node movement is better then group movement. They also give the concept of merging of nodes in the group and splitting of nodes from the groups. While simulating testing various network protocols, the selection of mobility model plays an important role.

2.3 Performance Evaluation

Performance evaluation is one of the most important part of mobility models. The researchers illustrate how the performance result of an ad hoc network protocol drastically changes as a result of changing the mobility model simulated. The performance test shows us how efficient and better it is from the existing models and how the performance of the protocol is affected by the mobility model.

Chandrasekhar *et al.* [7] give the performance analysis of different ad hoc routing protocols and the paper also gives a brief introduction to these protocols and about the performance parameters.

They performed the realistic comparison of four routing protocols DSDV, AODV, TORA and DSR. In [7], the authors provide a comprehensive analysis of the routing protocols using NS-2 simulator. These four protocols, all protocols are provided with identical traffic load and mobility patterns. They considered the TCP as transport protocol and FTP as traffic generator. The analysis is significant because they considered all the metrics as suggested by RFC 2501 and till to-date there are a few comparisons based on TCP [7]. The graphs are generated using X-graph. Simulation environment consists of 50 wireless nodes forming an ad hoc network, moving about over a 670 X 670 flat space for 200 seconds of simulated time. They pre-generated 45 different scenario files with varying movement patterns and traffic loads (FTP), and then ran all four routing protocols against each of these scenario files. Since each protocol was challenged in an identical fashion, they can directly compare the performance results of the four protocols [7].

Nodes in the simulation move according to a model that we call the "random waypoint" model. The movement scenario files we used for each simulation are characterized by a pause time. They ran the simulations with movement patterns generated for 9 different pause times: 0, 5, 10, 20, 30, 50, 100, 150, 200 seconds and 5 different speeds: 2, 5, 10, 15, and 20. A pause time of 0 seconds corresponds to continuous motion, and a pause time of 200 (the length of the simulation) corresponds to no motion. The matrices they selected were throughput, packet delivery ratio, routing overhead, path optimality, packet lost and average delay. All these parameters are finding against variation of mobility and variation in speed [7].

The variation of performance of all the protocols with speed is similar to the variation in performance with mobility as DSDV performs better than all the remaining protocols. The impact of speed on DSR is significant. Similar is the case with TORA. Results are only valid when they consider TCP traffic and TCP is not appropriate transport protocol for highly mobile multi hop networks and UDP is preferred [7].

Sarkar et al [14], give the performance analysis of various random mobility models [9] on the AODV [7] routing protocol. For that they consider three mobility scenarios:

- Random waypoint
- Random walk with reflections
- Random walk with wrapping

The performance of routing protocols varies across different parameters:

- Number of nodes
- Packet delivery
- End-to-end delay

In [14], gives a brief introduction of the mobility models that the random walk with wrapping mobility model, this model is similar to the random waypoint, but at a trip transition instant, a node picks direction, trip duration and numeric speed. The node moves in the given direction with the given numeric speed for the given numeric speed for the given trip duration. If on a trip, the node hits the boundary of the domain, it is wrapped around into the domain. The steady state version of this model is such that node position is uniformly distributed on the domain, the node speed has the same distribution as at a trip transition instant [14].

The other model that is random walk with reflection mobility model, and the main difference between this model and random walk with Wrapping is that whenever a node hits the boundary of the domain, it is not wrapped around, but reflected into the domain itself [14].

They implement the simulations in scenario generation tool and NS-2 simulator. They use scenario generating programs for computing mobility models. Their simulation runs are made with the number of nodes varying from 5 to 25 and in each scenario the nodes are in the center at the initial stages. Mobility scenario generator Scenario Generation tool produces the different mobility patterns following Random Waypoint, Random Walk-Reflections and Random Walk-Wrapping according to the format required by the NS-2. The movement was controlled as per the specifications of the respective models. If a node crosses the boundary of the area it is re-inserted at the beginning position in a randomly chosen lane [14].

The mobility models drastically affect protocol performance, they observe [14]:

- That random waypoint seems to produce the highest throughput.
- Random walk-reflection shows moderate packet delivery ratio.
- The delay on random waypoint is less as compared with two other models.
- The Random Walk with wrapping achieves the highest delay with node density as well as mobility.

- The effect on the routing overhead is very less with Random Walk model with wrapping then the others two models (number of nodes).
- The Random Walk with wrapping also achieves the lowest routing overhead with node density as well as mobility (pause time).

2.4 Basic Papers

The basic paper from which we get the idea of our project is DakNet, and the other which is related to our work is Message Ferries. Basically in DakNet they give the concept of message ferries. So first discuss the related paper to our project that is message ferries.

Zegura *et al.* [15], describe the message ferry MF approach to address the problem of efficient data delivery in sparse MANETS, MF is basically a set of special mobile node which provide communication services for nodes in the deployment area, the main idea is to introduce non-randomness in the movement of nodes and exploit such non-randomness to help deliver data. The MF designs exploit mobility to improve data delivery performance and reduce energy consumption in nodes.

The basic focus is on mobile networks where nodes are sparsely distributed, examples are [15]:

- Earthquake , which collapses buildings
- Traps peoples in the debris
- Damages utilities and roads
- Causes fire and explosions

The responsibility of MF is carrying data between nodes, that also carrying data among disconnected area because they consider the mobile nodes.

They basically developed two schemes of MF, these are [15]:

- Node-Initiated message ferry (NIMF)
- Ferry-initiated message ferry (FIMF)

In NIMF the ferries moved in deployment area according to know route and communicate with other node they meet [15] in this the node go closer for communication to ferries because ferries route is known.

In FIMF scheme, ferries move to meet nodes, so when nodes want to communicate it generate service request and the send the service request to chosen ferry using long rand radio, by receiving request the request the ferry adjust trajectory and using short range radio for exchanging data, the most communication involved short rang radio, only FIMF used long rang radio for controlling message.

Message ferries can be used effectively in the following categories of application [15]:

- Crisis driven
- Geography driven
- Cost driven
- Service driven

In [15], authors used limited resource for regular nodes then the ferries. The mobility of nodes and ferries can come in two varieties [15]:

- Task-oriented mobility
- Message-oriented mobility

In [15], authors focus on the single ferry, which have no buffer and no energy constraint. They discuss the two scheme of MF (NIMF, FIMF), that how these two schemes works there are different issues in both schemes and operations. They first discuss the node operation in NIFM, for communication they used the HELLO message from ferry, node reply's with an ECHO message. After identifying each other, the node and the ferry initiate a message exchange conversation. The node will transmit all its buffered messages to the ferry which will be responsible for delivery. Then discuss node trajectory control, the goal of *trajectory control* is to minimize message drops while reducing the negative impact of proactive movement. They propose a method for trajectory control that considers both impact on assigned task and message drop rate. They first consider message drops. Messages may be dropped in nodes because of message timeout or buffer overflow, and in the buffer-unlimited ferry because of timeout. In this paper, they use a simplified model based on *work time percentage* (WTP) to represent the impact. The messages may be dropped for either buffer overflow or message timeout, when buffered at a node waiting for interaction with the ferry [15].

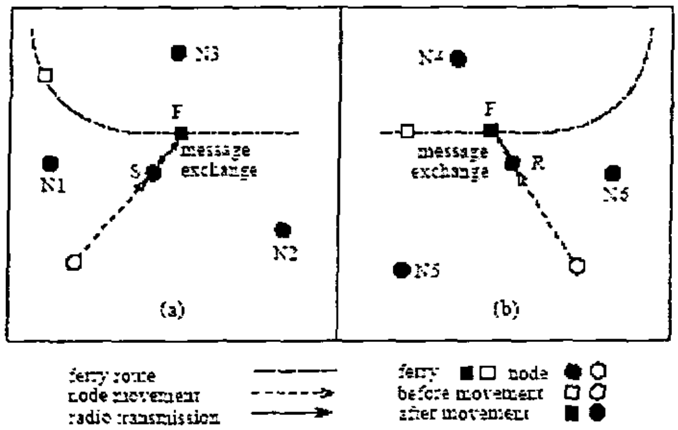

Figure 2.3, example of message delivery in the node-initiated MF scheme [15].

Then they discuss the second scheme that is NIFM, they assumed that ferry move fast then node and also assume that nodes are equipped with a long range radio which is used for transmitting control message.

The figure shows an example of FIMF operations [15]. The ferry operates in two modes: IDLE and WORKING. Initially the ferry is in the IDLE mode and follows a specific *default route*. It periodically broadcasts its location information to nodes via a long range radio. Upon the reception of a Service Request message from a node, the ferry switches to the WORKING mode. In the WORKING mode, the ferry maintains a set of nodes *H* that have requested service and tries to meet these nodes to relay messages [15].

To control the transmission of notification messages, we consider the following factors [15]:

- message drops,
- ferry location
- energy consumption

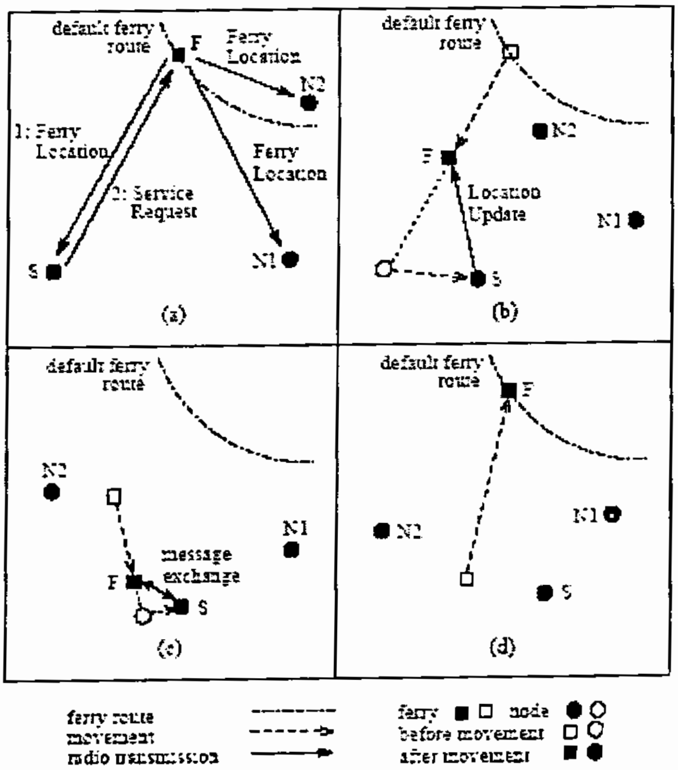

Figure 2.4 notification message rates [15]

They define *notification message rate* (NMR) as the average number of notification messages sent per second [15].

The authors study the following two heuristics. The first one is the nearest neighbor (NN) heuristic in which the ferry always visits the closest node after it finishes meeting with a node. The second heuristic is a traffic-aware (TA) heuristic which considers both location and message drop information [15].

For the performance evaluation of message ferry they use NS-2 simulation. They use the default energy model provided in NS. Author use both data delivery and energy metrics to evaluate the performance of the MF schemes. Message delivery rate and message delay are use to measure the data delivery and to measure energy efficiency, they use delivered messages per unit energy.

They first evaluate the impact of node buffer size on data delivery performance. They simulate the following schemes, NIMF, FIMF with the NN heuristic (FIMF-NN), FIMF with the TA heuristic (FIMF-TA) and Epidemic routing (ER) [15].

- As the node buffer size increases the message delivery rate for epidemic routing also increase but still lower than the MF schemes.
- Epidemic routing achieves much lower delay as compared to the MF schemes.
- The MF schemes achieve better energy efficiency, by 8 to 30 times, so using the same amount of energy; the MF schemes can deliver more than 8 times as many messages.

The authors also observe the impact of node mobility on the performance; both NIFM and FIMF are much less affected by node mobility. The data delivery greatly affected on mobility characteristics. Then they show the impact of WTP threshold on NIMF performance, impact of NMR threshold on FIMF performance and at last the impact of transmission range on FIMF performance. There simulation results show that the MF approach is very efficient in both data delivery and energy consumption [15].

In [15], gives a very detail concept of message ferry and also show the performance evaluation graph, but there are many ambiguities in this paper. For example when the sender gives the data to ferry then how the destination knows that this data is for me, they didn't give any procedure for that, second is that, that the ferry continuously sending HELLO message by using long range radio so this is the wastage of energy and also nodes are mobile so the LOCATION-UPDATE message will also be generated more then one time, and they also not define that how many times the ferry move to know route for sending and reviving data because there may be a limited buffer of ferry and that there will be buffer size. So there is some confusion in this paper.

Hassan *et al.* [16] proposed the concept of DakNet, that DakNet, an ad hoc network which is successfully deployed in the rural areas of India and Cambodia. The main goal of DakNet is provide "broadband connectivity for every one". DakNet, an ad hoc network that uses wireless technology to provide asynchronous digital connectivity, The DakNet wireless network takes advantage of the existing communications and transportation infrastructure to distribute digital connectivity to outlying villages lacking a digital communications infrastructure. DakNet, whose name derives from the Hindi word for "post" or "postal," combines a physical means of transportation with wireless data transfer to extend the Internet connectivity that a central uplink or hub, such as a cybercafé, VSAT system, or post office provides. DakNet transmits data over short point-to-point links between kiosks and portable storage devices, called mobile access points (MAPs). DakNet does not provide real-time data transport, physically transporting data from village to village by this means generally provides a higher data throughput than is typical with other low-bandwidth technologies such as a telephone modem [16].

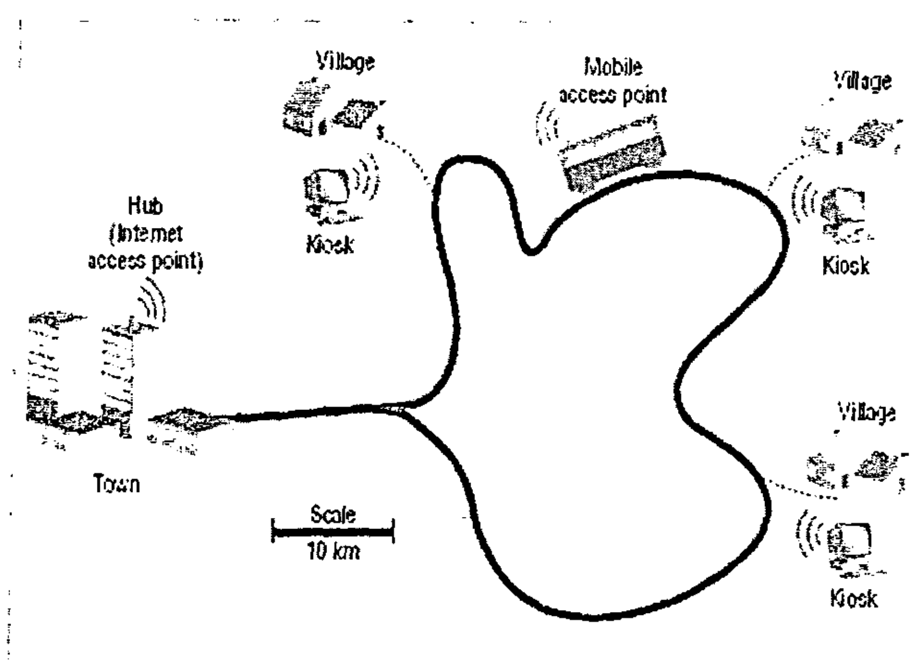

Figure 2.5 shows DakNet concepts. Physical transport, in this case a public bus, carries a mobile access point (MAP) between village kiosks and a hub with Internet access. Data automatically uploads and downloads when the bus is in range of a kiosk or the hub [16].

DakNet makes it practical for individual households and private users to get connected. Villages in India and northern Cambodia are actively using DakNet with good results. DakNet connections to make e-services like e-mail and voice mail available to residents in rural villages. A "session" occurs each time the bus comes within range of a kiosk and the MAP transfers data. The average length of a session is 2 minutes and 34 seconds, during which the MAP transfers an average of 20.9 Mbytes unidirectional (kiosk to MAP or MAP to kiosk) and up to twice that amount bidirectional (from kiosk to MAP and MAP to kiosk) [16]. The average "good put" (actual data throughput) for a session, during which the MAP and kiosk go in and out of connection because of mobility. Each bus can provide connectivity to approximately 10 villages. The results of the project, which we dubbed the Internet Village Motoman, were once again gratifying. For the first time, students in these Cambodian schools could send e-mail, request Web pages, and feel connected to the rest of the world [16].

Authors basically give the covering feature of DakNet, and give a detail analysis about DakNet, that how DakNet is implemented in rural areas and how it works. Basic aim of DakNet is to connect the rural areas with the rest of the world. DakNet gives the e-services like e-mail, voice mail, informative websites etc, but DakNet doesn't provide the real world data transfer. The main feature of DakNet is that the routes of node (bus, motorcycle, and oxcart) are moving on a pre-defined path for receiving and sending data from the villages. The destination of node is also pre-defined. DakNet is a successful project which is recently implemented in the rural areas of India and other third world countries where internet is not accessible.

Chapter 3

Problem identification

Manhattan mobility model [10] consists of street and roads. There are different maps which apply on Manhattan model. These maps are real world scenarios and there are many models which are based on constrained, means that restricted speed and randomness in destination. Such models are called constraints based mobility model. But the challenging task is to choose the mobility model for real world scenario.

Many mobility models which are proposed on scenarios based models take different scenarios from real world and apply on some existing models to propose new models.

DakNet [16] is a real world scenario, which is currently implemented and working in rural areas of India and Cambodia. Basically DakNet is the name of a project in which they provide internet services (e-service) to rural area but not the real time services. So choosing the mobility model for such scenario is very challenging.

So we chooses Manhattan mobility model for DakNet scenario because, in DakNet the node movement is in streets and roads with different speed and direction. In this model destination and path is predefine, so for the movement of node in the streets we need a model which consist of streets and roads and also speed limitation. The Manhattan model has such kind of characteristics and properties which are define above.

There is also a freeway model in which the nodes move in start direction with out intersection. So freeway model is not suitable for DakNet scenario. There are other models as well but there are some flaws, so Manhattan is the best one for DakNet like scenarios.

So the problem domain is defining below and proposed solution is also been given:

3.1 Problem Identifications

Different researchers use different approaches while doing research on ad hoc networks. The on going research intends to explore a specific application of mobile ad hoc network, called Message Ferries. The difference between the message ferries and normal node is that message ferries have advance/more capabilities like storage, processing and speed etc and also take responsibilities of carrying message among other nodes, while normal nodes are without such responsibilities.

Since mobility is the main feature of ah hoc networks and so there are different protocols that perform different behavior on different scenarios. There are different scenarios applied on mobility models to make them efficient. These all scenarios are taken from daily life. Henceforth, this research proposes to take the scenario of Digital Post System DakNet [16].

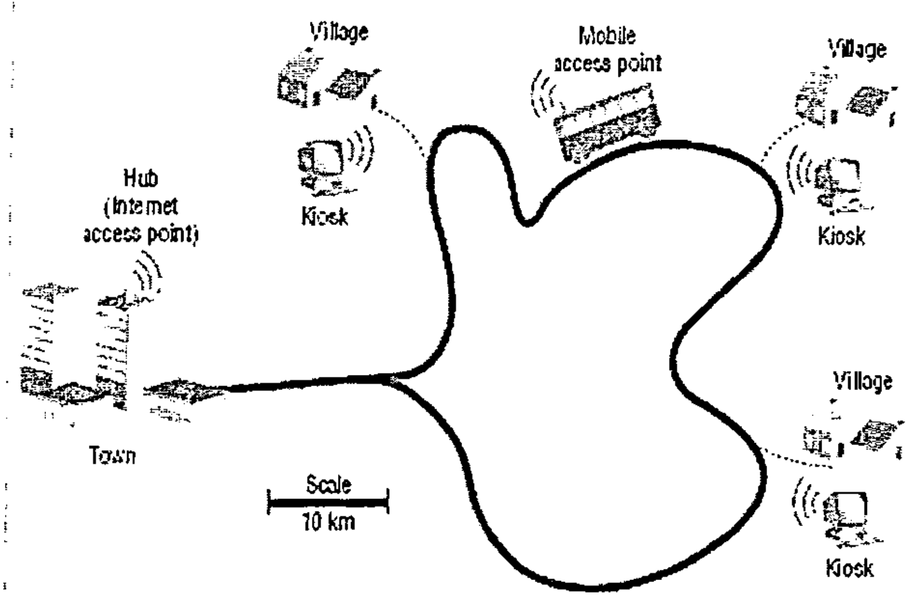

Figure shows DakNet concepts. Physical transport, in this case a public bus, carries a mobile access point (MAP) between village kiosks and a hub with Internet access. Data automatically uploads and downloads when the bus is in range of a kiosk or the hub [16].

The mobility characteristic of such system is that the Message Ferries move to a pre-defined path and destination and through DakNet the rural area people could also send e-mail, web pages and feel connected to the rest of world.

The mobility model that has been taken are city section mobility models [9] and Manhattan mobility model[10], both models are based on streets and highways but the main difference between them is that the city model scenario has the pre-defined path but not pre-defined destination. While Manhattan mobility model scenario uses the probability to decide the direction.

As the DakNet scenario has the predefined destination and paths so both the mobility models i.e. city section mobility model and Manhattan mobility model are not suitable for such scenarios due to the random selection of destination and probability based selection of the path.

3.2 Proposed Solution

A model suitable for digital post system will be proposed, where message ferries will move on predefined path and will pass to the predefined destinations, which will be more suitable for the DakNet like scenarios where the mobility pattern of the message ferries are known and it also have the complete knowledge of its destinations. The performance of the proposed mobility model will be tested against Manhattan Mobility model using Dynamic Source routing protocol (DSR) and Destination Sequence routing protocol (DSDV) using the following metrics

- Routing Overhead: It is the total number of control packets generated by routing protocol.
- Average End-to-end Delay: It is the average end-to-end delay data packets between source and destination.
- Delivery Ratio: It is the ratio of total packets send to the total packets received.

The proposed mobility model will give us better results than the previously proposed mobility models in such scenarios.

Chapter 4

System design

The Digital Postal Mobility Model (DPMM) is the mobility model which simulates the vehicular movement in a rural environment, in order to achieve this; existing models are not suitable for our scenario. In our DakNet scenario we have maps and roads and streets. So we want to choose that kind of map models which have the characteristics of maps, roads and streets. So we choose the Manhattan mobility model for this because manhattan have all the characteristics that we have required for our model, so we choose manhattan model for our base. The summarized diagrams are given below and feature diagram explanation is also shown in this chapter, this chapter gives a detail of our model design.

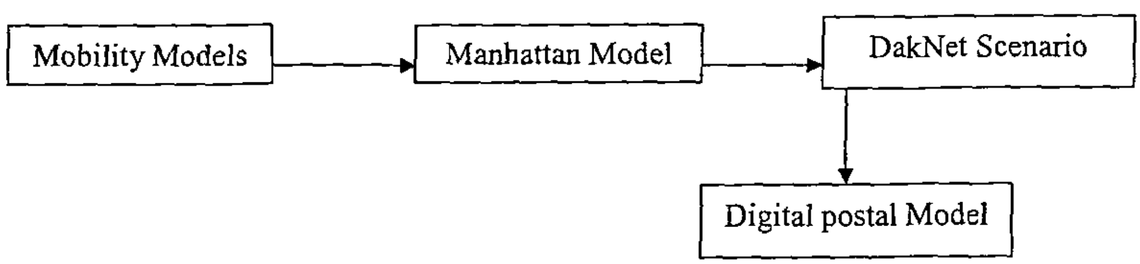

Figure 4.1 summary of proposed model

4.1 Mobility Models

The mobility model is designed to describe the movement pattern of mobile users, and how their location, velocity and acceleration change over time. Since mobility patterns may play a significant role in determining the protocol performance Research, the mobility model is performed in two directions. The first direction is to design new models in order to mimic the real world scenarios better. The second direction is to analyze these models. This includes finding the statistical properties of the mobility models, designing different mobility metrics and studying the influences of mobility models on routing protocols' performance [8].

4.1.1 Mobility Models Types

We classify various mobility models into three classes according to the degree of randomness. If models are built based on traces, then everything is deterministic and we call these models trace based models. If there is only partial randomness, the models are called constrained topology based models. Here hosts' movements are constrained by obstacles, pathways, etc., but speed and direction are still randomly chosen. Examples in this category include the Manhattan Mobility Model [10] which simulates vehicles moving along streets and roads where different streets and roads have different speed limits. If there is total randomness, we call these statistical models. Total randomness means that hosts can move anywhere in the area and the speed and direction are randomly chosen. Examples in this category include the Random Walk Model [9] and the Random Waypoint Model. [9]

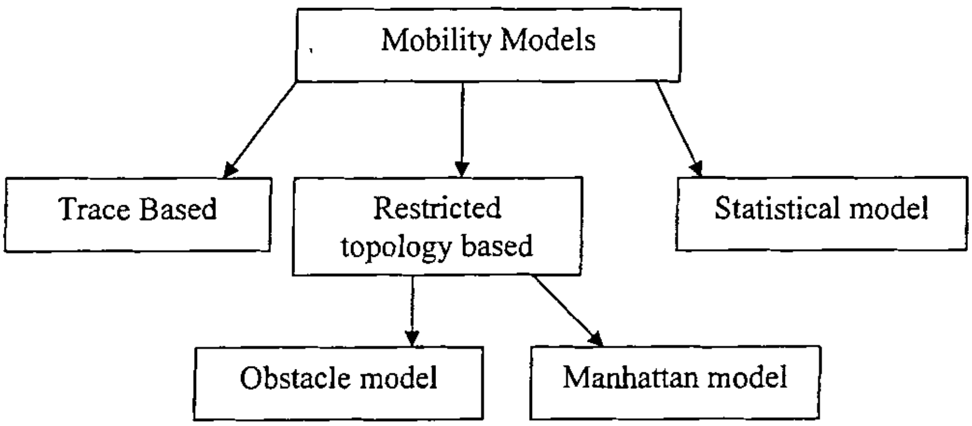

Figure 4.2 mobility models

4.2 Manhattan Mobility Model

We choose Manhattan model for our scenario because it contains streets and roads.

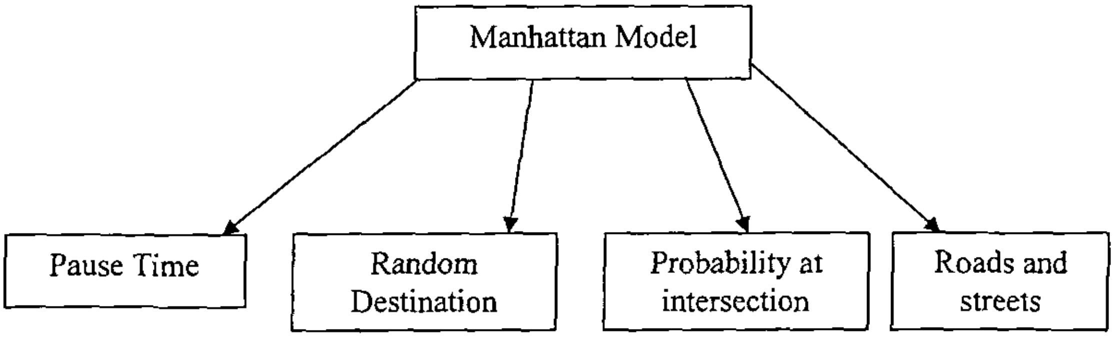

Figure 4.3 characteristics of manhattan mobility model

The characteristics of manhattan mobility model are pause time, random destination, probability at intersection and roads and streets. The main characteristic of Manhattan mobility model is probability at intersection.

Maps are used in this model too. However, the map is composed of a number of horizontal and vertical streets. The mobile node is allowed to move along the grid of horizontal and vertical streets on the map. At an intersection of a horizontal and a vertical street, the mobile node can turn left, right or go straight with certain probability. It also imposes geographic restrictions on node mobility.
However, it differs from the Freeway model in giving a node some freedom to change its direction [18].

4.3 DakNet Scenario

DakNet is a real world scenario which is currently implemented in rural areas of India and Cambodia; through this they connect the rural areas to the rest of world. DakNet is basically Hindi word which mean "post" DakNet provide the facilities of e-services.

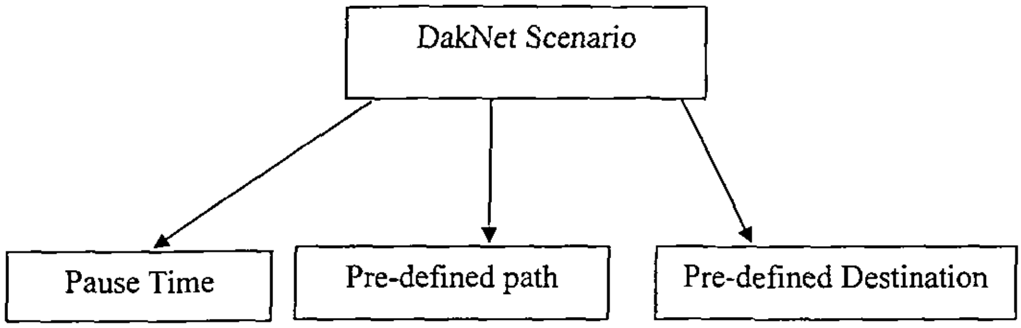

Figure 4.4 characteristics of DakNet scenario

The main characteristics of DakNet, that a node moves on a pre-defined path and also has pre-destination, so the node knows which destinations are to be visited first. It has a complete knowledge of its path and destination. Data automatically uploads and downloads when the node is in the range of nodes.

4.4 Digital Postal Mobility Model

The digital postal mobility models have same characteristics that DakNet scenarios have because we apply the DakNet scenario on manhattan model to propose the new model, the Digital Postal model is described in detail later.

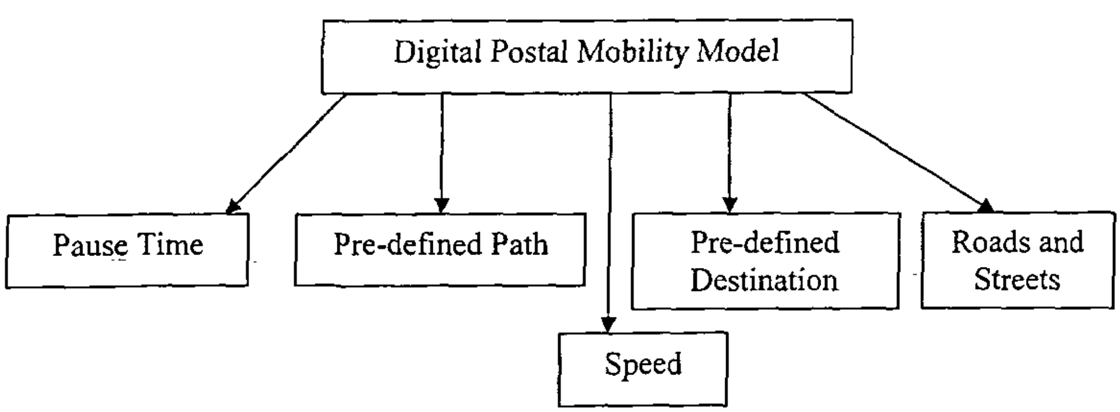

Figure 4.5 characteristics of Digital Postal Mobility Model

4.4.1 Pause Time

Pause time means, that when a node reaches to the destination it will stop at the destination and wait for some time. Different models have implemented different pause time. During pause time node will select the next destination. So in our proposed model pause time is the one of the characteristics.

4.4.2 Pre-defined path

In DPMM the path is pre-defined, it means that the node knows its path through which it moves. The main advantage of pre-defined path is that the node takes less time and energy to search destination. In trace based models [11] the path is deterministic, so pre-defined path is another characteristic of our proposed model.

4.4.3 Pre-defined Destination

In existing models the destinations are randomly selected, in our proposed model the destinations are pre-defined. These destinations are randomly located in the area. The source node knows which destination is to be visited first and on which path it will move to reach destinations, so this is one of the main characteristic of DPMM.

4.4.4 Roads and Streets

Manhattan mobility model is selected for our scenario based model because it has roads and streets. Other models also exist but they have only one main road like Freeway model [8]. So the proposed model consists of roads and streets for the movement of node. This is not important that the destinations are located on roads, it will be in streets as well and the DakNet scenario has also this characteristic.

4.4.5 Speed

The speed is main feature of every mobility model, but when we talk about roads and streets, it is important to define speed because on roads the speed of node is different than street.

These are the main feature and characteristics of proposed model, which is different from existing models.

4.5 DPMM Existing

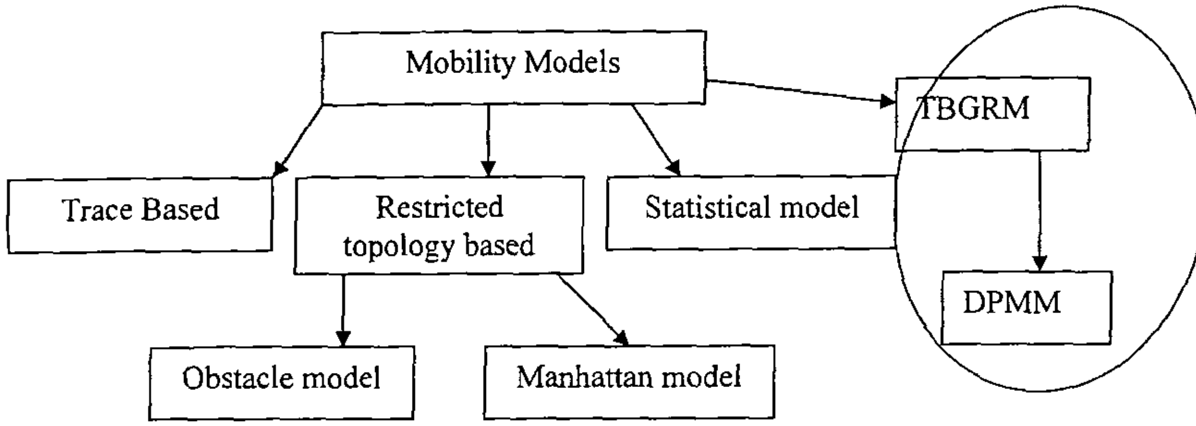

Figure 4.6 existing of proposed in mobility models

Digital postal mobility model lies in type which is called TBGRM (trace based geographical restriction model) because DPMM paths are predefined like the trace based models and also there are some geographical restriction because we used maps which are consists of streets and roads. There are some limitations on node about his speed as well. So we called this type of model trace based geographical restricted model.

Chapter 5

Implementation

5.1 NS-2 Simulator

NS (version 2) is an object-oriented, discrete event driven network simulator developed at UC Berkely written in C++ and OTcl. NS is primarily useful for simulating local and wide area networks. Although NS is fairly easy to use once you get to know the simulator, it is quite difficult for a first time user, because there are few user-friendly manuals. Even though there is a lot of documentation written by the developers which has in depth explanation of the simulator, it is written with the depth of a skilled NS user. The new user have some basic idea of how the simulator works, how to setup simulation networks, where to look for further information about network components in simulator codes, how to create new network components, etc [17] [25].

It implements network protocols such as TCP and UPD, traffic source behavior such as FTP, Telnet, Web, CBR and VBR, router queue management mechanism such as Drop Tail, RED and CBQ, routing algorithms such as Dijkstra, and more. NS also implements multicasting and some of the MAC layer protocols for LAN simulations [26]. The NS project is now a part of the VINT project (Virtual Inter Network Testbed), VINT is a DARPA-funded research project whose aim is to build a network simulator that will allow the study of scale and protocol interaction in the context of current and future network protocols. VINT is a collaborative project involving USC/ISI, Xerox PARC, LBNL, and UC Berkeley. [18] That develops tools for simulation results display, analysis and converters that convert network topologies generated by well-known generators to NS formats. Currently, NS (version 2) written in C++ and OTcl (Tcl script language with Object-oriented extensions developed at MIT) is available [17] [30].

5.1.1 Characteristics of NS-2

NS-2 implements the following features [17] [30]

1. Router queue Management Techniques DropTail, RED, CBQ,
2. Multicasting
3. Simulation of wireless networks
   - Developed by Sun Microsystems + UC Berkeley (Daedalus Project)
   - Terrestrial (cellular, adhoc, GPRS, WLAN, BLUETOOTH), satellite
   - IEEE 802.11 can be simulated, Mobile-IP, and adhoc protocols such as DSR [19], TORA [21], DSDV [7] and AODV [20].
4. Traffic Source Behavior- www, CBR, VBR
5. Transport Agents- UDP/TCP
6. Routing
7. Packet flow
8. Network Topology
9. Applications- Telnet, FTP, Ping
10. Tracing Packets on all links/specific links

5.1.2 Operating Systems for NS-2

Ns can be used on the following platforms [17] [30]:

- UNIX (Free BSD, SunOS, Solaris).
- Linux (RedHat 9, Enterprise Edition, FEDORA 4)
- Microsoft Windows

However for windows, Cygwing emulator is required for ns. The favorable operating system for ns is Linux/Unix operating system.

5.1.3 Limitations [17] [30]:

- NS-2 offers above mentioned exciting features but it is very difficult to work in NS-2 for new user.
- Ns–2 is memory extensive simulator, so there is lots of problem arises during simulated large network and as the number of nodes are increasing processing time also increasing.

- We have considerable confidence in ns, ns is not a polished and finished product, but the result of an ongoing effort of research and development.
- Bugs in the ns–2 software are still being discovered and corrected.
- Users of ns are responsible for verifying for themselves that their simulations are not invalidated by bugs.
- Patience to debug NS source code when needed.
- More complex simulations may need modification to NS source code.
- Debugging process are complicated so there is quite knowledge of c++ and OTcl required.

5.2 DPMM implementation

DPMM (Digital Postal Mobility Model) is implemented in NS-2. The following are the main part of implementation:

- Network topology
- Traffic pattern
- Node configuration
- Trace file

In network topology we define different configuration that are number of nodes, moving range, initial position and moving pattern (speed and direction). When we run the program, the numbers of nodes are asked on run time and also acceleration (speed) and other configuration are done by programming. The path is pre-defined and also the destinations.

In traffic pattern we define different patterns, and the number of connections, traffic of source/destination, connection type (TCP/UDP) and packet size. So in this model we use the UDP connection type.

After these we generates different scenes for different nodes and also make traffic file that is CBR file. So we set these files in TCL files and the configuration of TCL files is different for different nodes, The detail flow diagram is given below:

5.3 Implementation Details

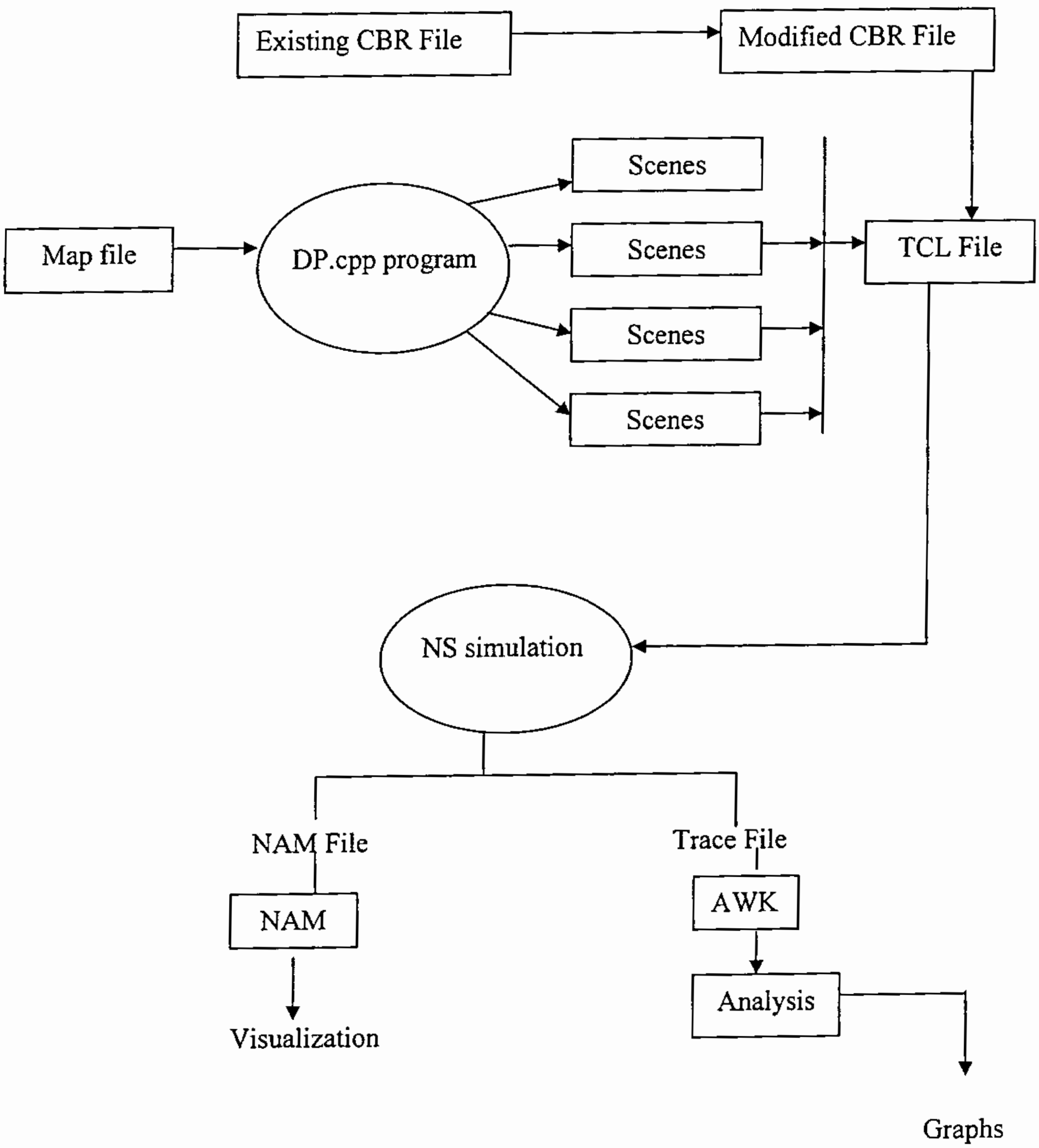

Figure 5.1 Implementation Flow Diagrams

5.3.1 Map File

In MH model, several horizontal and vertical streets co-exist in the simulation field and mobile nodes are moving on the lanes of the streets. For each street, it has several lanes in both directions. (Users can also define a street with only one direction). Please note, each lane should be separated from other lanes by some distance. That is to say, while designing the map file, the lanes are not supposed to overlap. However, the vertical and horizontal streets may cross with each other at the crosspoints. At the crosspoints, the mobile nodes are suppose to move ahead, turn left or turn right with certain probability. The map file is given below [18]:

MANHATTAN
HOR_STREET_NUM <num_of_horizontal_street>
VER_STREET_NUM <num_of_vertical_street>
LANE_NUM <overall_num_of_lanes>
LANE <street_id> <lane_id> <direction> <start_x0> <start_y0> <end_x0> <end_y0>
<total_number_of_crosspoints_in_this_lane> <vmin> <Vmax>
CROSSPOINT <crosspoint_id> <street_id> <lane_id> <direction> <position_x> <position_y>
CROSSPOINT <crosspoint_id> <street_id> <lane_id> <direction> <position_x> <position_y>

Similar to Map file of freeway model, the map file of Manhattan model starts with keyword 'MANHATTAN'.

Then, <num_of_horizontal_street> and <num_of_vertical_street> give the number of horizontal and vertical streets in the simulation field.

For each lane street, it starts with the keyword 'LANE', and the meaning of the parameters are described as follow:

<street_id> is the id of the street where this lane belongs,

<lane_id> is the unique id of this lane,

<direction> is the direction of this lane, for example, if lane is towards right and up, its

value is 1; otherwise, it is -1,

<start_x0> <start_y0> are the position of the starting point of this lane,

<end_x0> <end_y0> are the position of the ending point of this lane,

<total_number_of_crosspoints_in_this_lane> indicates how many crosspoints exist in this lane,

<vmin> <Vmax> defines the max and min allowed velocity of nodes on this lane. Please note, the values here should be consistent with the input parameters.

For each crosspoint, it starts with keyword 'CROSSPOINT', the parameters are described as:

<crosspoint_id> is the unique id of this crosspoint

<street_id> is the unique id of the street to which this crosspoint belongs

<lane_id> is the unique id of the lane to which this crosspoint belongs

<direction> is the direction of the street to which this crosspoint belongs

<position_x> <position_y> is the exact position of this crosspoint.

5.3.2 DP.cpp program

This is the main program, once the program is run; the users will be asked questions like:

(1) First, the overall number of mobile nodes in the simulation field is asked.

(2) Second, the Max and Min allowed velocity of mobile nodes are asked respectively. The users can input their desired values.

(3) Then, the users are also asked for the value of acceleration speed. By changing this parameter, the users are able to adjust the mobility behavior.

(4) In DP model, a map file is also needed for the Digital model to work appropriately. When the user is asked, the file name of this map file should be typed.

(5) Finally, the filename of output trace files are asked.

5.3.3 Scenes

When we run the program so, it generates scenes, which shows the nodes positions in the simulation area. We generate five different scenes for our simulation. The scenes are based on nodes and we generate scenes for different nodes. For example, in node-movement file scene, we see node-movement commands like

```
$ns_ at 1.00000 "$node_ (1) setdest 332.32999 399.32999 57.00000"
```

This, as described in earlier sub-section, means at time 1s, node1starts to move towards destination (332.3, 399.3) at a speed of 57m/s

5.3.4 TCL FILE

 # Define options

```
set val(chan)      Channel/WirelessChannel       ;# channel type

set val(prop)      Propagation/TwoRayGround      ;# radio-propagation model
set val(netif)     Phy/WirelessPhy               ;# network interface type
set val(mac)       Mac/802_11                    ;# MAC type
set val(ifq)       CMUPriQueue;#Queue/DropTail/PriQueue  ;# Interface queue type
set val(ll)        LL                            ;# Link layer type

set val(ant)       Antenna/OmniAntenna           ;# Antenna type

set val(x)         1000          ;# X dimension of the topography
set val(y)         1000          ;# Y dimension of the topography
set val(ifqlen)    50            ;# max packet in ifq
set val(seed)      0.0
set val(adhocRouting)  DSDV      ;# ad-hoc routing protocol
set val(nn)        51            ;# how many nodes are simulated
set val(cp)        "/root/yasir-project/traffic/traff1"   ;#/root/ns-allinone-2.29/ns-
                                              2.29/tcl/mobility/scene/cbr-3-test"
```

set val(sc) *"/root/yasir-project/scene-man-mod/man-mod50" ;*
set val(stop) *80.0* ;# simulation time

The following configuration has been done now we make five different TCL files for different scenes and in Tcl file we just change the number of node options and the set Val (sc) option in which we can put our scenes. So the scene option will also be changed five times because for every node change we make different scenes and in TCL file we also have a CBR file which defines our traffic file. We also upload this file in TCL file however; this file will remain same for every scene.

So when we simulate the TCL file, we get two kinds of out put file one is NAM file and other is Trace file.

5.3.5 NAM File

NAM [17] network animator is an animation tool for viewing network simulation traces and is used for visualization of network scenario. It provides visualization of;

- Packet flows, different packets can be colored.
- Node's native packets queue.
- Packets which are dropped.

For wireless network simulation, NAM plays an important role because it can help a node with in the range of another node. Nam is very important for the analysis of mobile node's movements during simulation.

5.3.6 Trace File

The format of trace file is given as [17]

r 100.381 _1_ AGT --- 82 tcp 1060 [13a 1 0 800] --------- [0:0 1:0 32 1] [32 0] 1 0

r: receive event;	100.381: time stamp;
_1_: node 1	AGT: trace generated by agent;
82: event (pkt) id ;	tcp: tcp packet;
1060: packet size;	

13a: expected duration of packet transmission;

1: sender mac id; 0: transmitter mac id;

800: pkt type; 0:0: sender address:port#;

1:0: receiver address: port#;

32: TTL; 1: next hop address; [32 0]: TCP sequence #, ack #;

So after getting the trace file we apply it on an AWK file to get our desire result which is

- Total delay
- Total packet sent
- Total packet receives
- overload

The out put of AWK file are these which is given above and after we get these data so we can make an analysis and draw a graphs.

Chapter 6

Performance Evaluation

6.1 Simulation Platform

Our protocol evaluations are based on the simulation using ns2 [14]. Nodes in the simulation move according to a model that we call the "Manhattan mobility" model. The movement scenario files we used for each simulation are characterized by a *pause time*, *pre-defined path* and *destination*. Upon reaching the destination, the node pauses again for *pause time, then* moves to another destination, and proceeds there. Each simulation ran for 80 seconds of simulated time. We ran our simulations with number of nodes, for 5 different nodes set: 40, 60, 80, 100, 120 nodes and When we run the program so, it generates scenes, which shows the nodes positions in the simulation area. We generate five different scenes for our simulation. The scenes are based on nodes that we generate scenes for different nodes

6.2 Metrics

In comparing the protocols, we chose to evaluate them according to the following metrics [6]:

Packet delivery ratio: the ratio between the number of packets received by the final destination and the number of packets originated by the sources. It is a measure of efficiency of the protocol

Routing overhead: The total number of routing packets transmitted during the simulation. For packets sent over multiple hops, *each* transmission of the packet (each hop) counts as one transmission. If control and data traffic share the same channel, and the channels capacity is limited, then excessive control traffic often impacts data routing performance.

Average Delay: It is a metric which is very significant with multimedia and real-time traffic. It is very important for any application where data is processed online.

6.3 Simulation Results and Comparison

We investigate the performance of Manhattan mobility model (MMM) and our proposed Digital Postal mobility model (DPMM) with two different routing protocols DSR [24] and DSDV [23]. In simulation results the Mod indicates our proposed model and Org indicates the Manhattan Mobility Model.

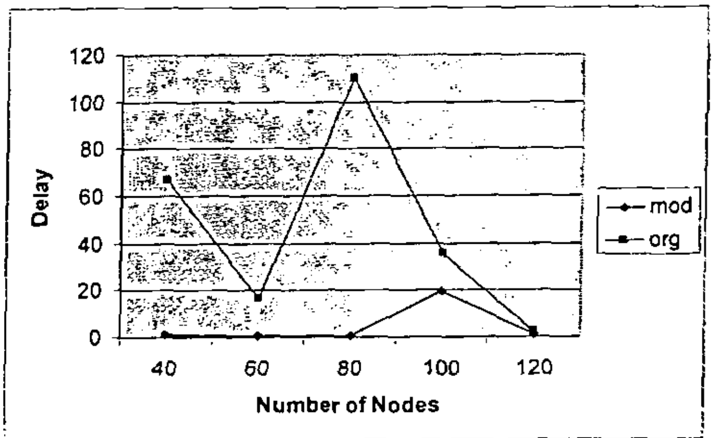

Figure 6.1 Delay experienced with varying number of nodes using DSR

The first simulation compares the effect on the delay using DSR routing protocol, which compare our proposed model DPMM with Manhattan model. Figure 6.1, shows the delay graph which conforms that our proposed model introduces low delay as compare to Manhattan model using DSR routing protocol. The delay is measured against the number of nodes increase. The delay is low in our proposed model because path and destination is pre-defined, so the complete route is in the cache of node and in our proposed model a node has a complete knowledge of his route and destination, while in Manhattan model the destination is chosen randomly which causes delay. So these are the factors which cause delay in movements of nodes and our proposed model is performing better than existing model.

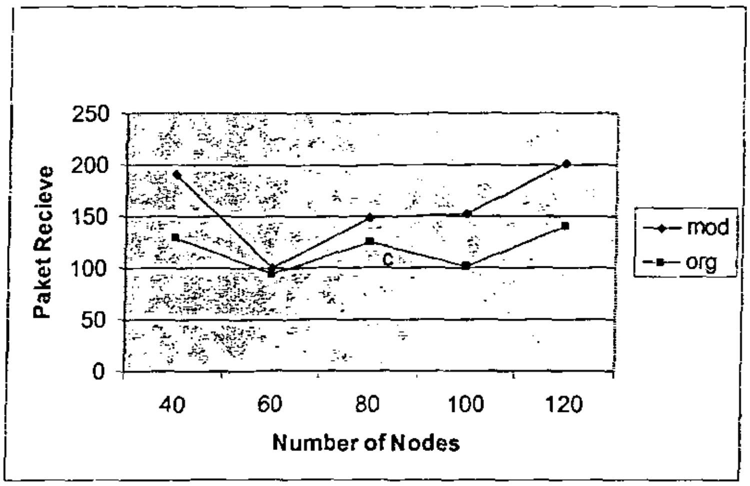

Figure 6.2 Packets Received with varying number of nodes using DSR

Total packet received graph is shown in Figure 6.2. The packets received under DPMM is high than the Manhattan model. So our proposed model is performing well in packet receiving test because every thing (route and destination) is pre-defined and the node has knowledge about its complete route and destinations. In DSR, route is computed before sending the packets and as figure shows when number of nodes increases the DPMM performs well and the graph line of DPMM goes up as compare to Manhattan mobility model.

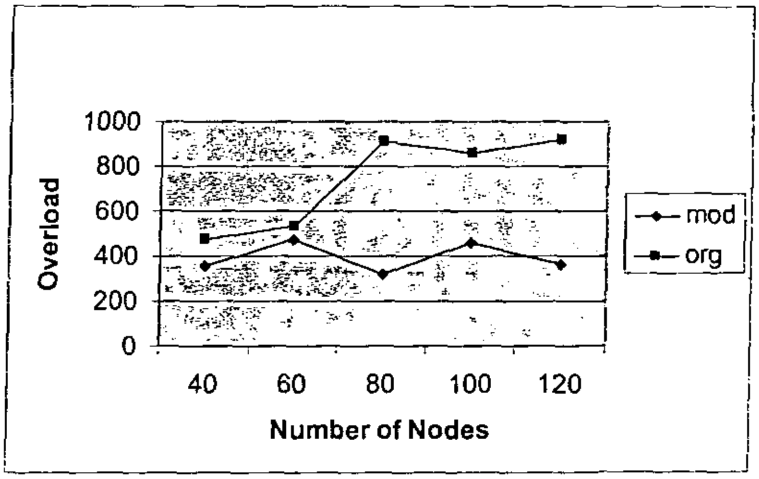

Figure 6.3 Overload experienced with varying number of nodes using DSR

The overload graph is shown in Figure 6.3, which graph shows that our proposed model is performing well and better then the Manhattan model because it will find the route once and save in his cache, so the node does not send RREQ for route finding and in DPMM the route and destinations are known before sending data so the overload graph line is low as shown in figure 6.3, which is better the original model.

We test our proposed model against existed Manhattan model using DSR routing protocol and figure 6.1, 6.2, 6.3 shows us the simulation results and we conclude that our proposed model DPMM is better than the Manhattan mobility model.

The first phase of the simulation is using DSR routing protocol which is shown above, so now in the second phase we study the same metrics using DSDV routing protocol

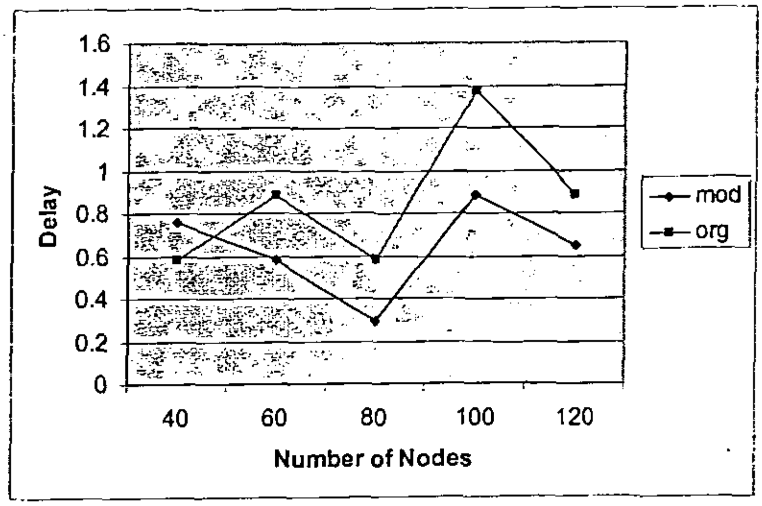

Figure 6.4 Delay experienced with the number of nodes using DSDV

Figure 6.4, shows the delay graph between DPMM and MMM, simulation shows that our propose model gives better results in delay graph while MMM achieve high delay with mobility.

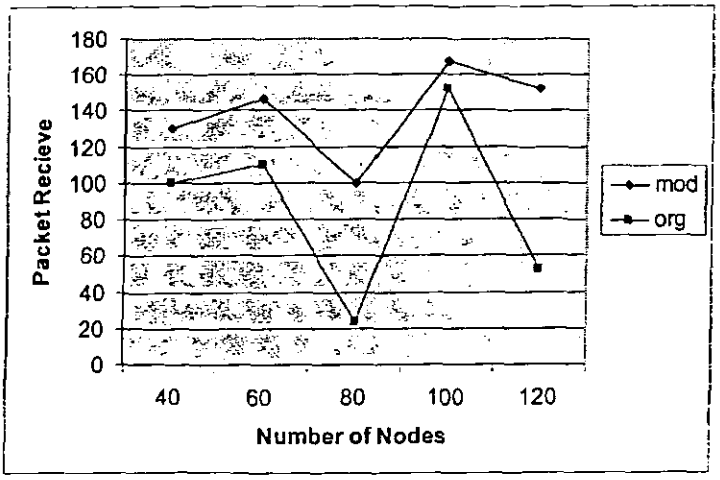

Figure 6.5 Packets Received with varying number of nodes using DSDV

Figure 6.5, shows the total packet received so we observed that the number of packet received is high under our proposed DPMM and the number of packets received in the graph of Manhattan model is low. So when the number of nodes is increased, our proposed model shows better and better than Manhattan model as shown in figure 6.5 clearly.

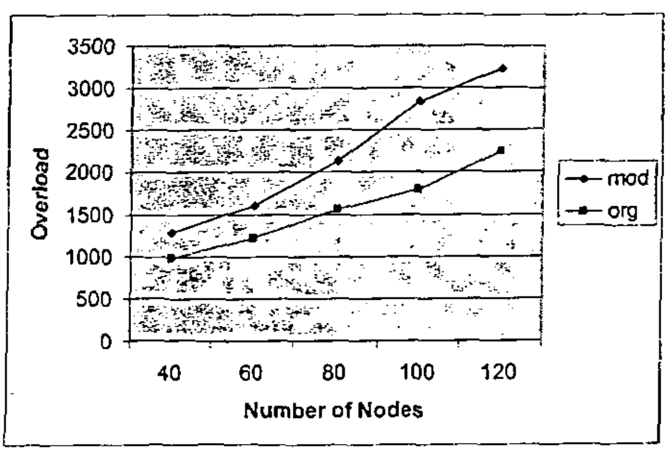

Figure 6.6 Overload experienced with varying number of nodes using DSDV

Figure 6.6, the overload graph between DPMM and MMM shows that our proposed model is not showing good results and the graph line is high than existing model. Our graph line is high because DSDV is a proactive routing protocol and in DSDV each node maintains a routing table. Each node periodically forwards the routing table to its neighbors and each node periodically floods status of its links, so the extra packets will be transmitted on network periodically which causes much traffic on networks and result a high overload.

In second phase of our simulation we studied the performance evaluation of DPMM and MMM using DSDV routing protocol. We observed that delay and packet received graphs behave well in DPMM but in overload graph shows poor results and the reasons of that is written above.

In the third and last phase of our simulations compared the routing protocols base on our model DPMM and in this phase of simulation we studied which routing protocol is performing well because every routing protocol is not suitable for every mobility model. Moreover every routing protocol has its own characteristics which are suitable for selected models so in this section we studied which one is better for our proposed model, DSR or DSDV.

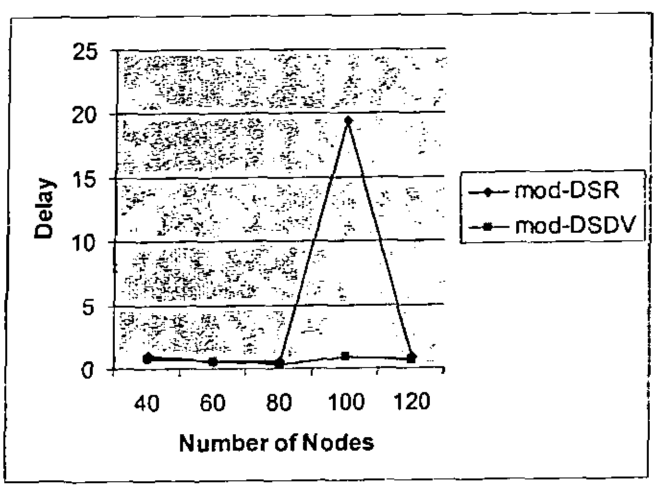

Figure 6.7 Delay experienced with varying number of nodes in DPMM

Figure 6.7, shows the delay graph between DSR and DSDV routing protocols based on our DPMM, the figure shows that comparatively DSR routing protocol is performing well the DSDV protocol while at single point when nodes are 100, the DSDV line is up but on other points DSR performs better then DSDV. So DSR performs well and better than DSDV.

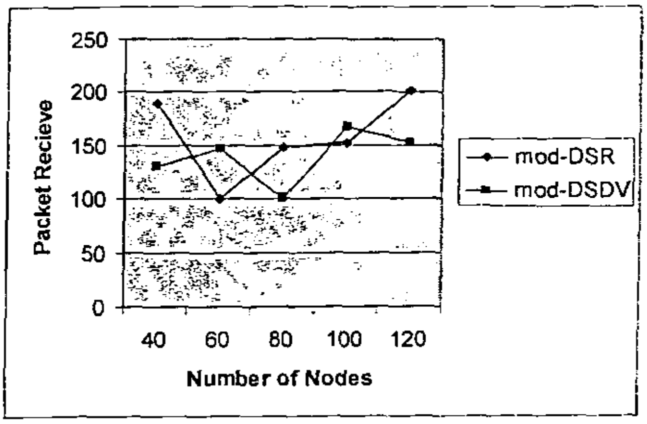

Figure 6.8 Packets Received with varying number of nodes in DPMM

Figure 6.8, shows that DSR is better on many points as compared to DSDV in total packets receiving graph.

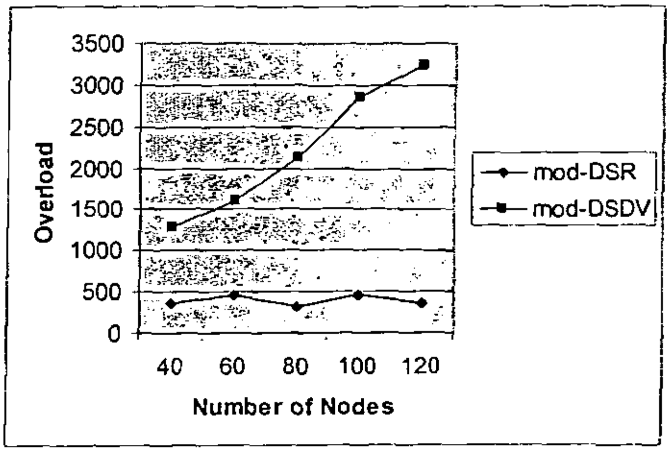

Figure 6.9 Overload experienced with varying number of nodes in DPMM

Figure 6.9 shows clearly that DSR is performing better and well then DSDV because DSR is reactive routing protocol and DSDV is proactive there fore there is no periodic update on nodes in case of DSR.

So when we compare both DSR and DSDV on our proposed model, we conclude that DSR is performing better then DSDV, we recommended that when using DPMM, use the DSR routing protocol at backbone.

Chapter 7

Conclusion

7.1 Introduction

The mobility models are one of the most important factors in the performance evaluations of a mobile ad hoc network (MANET). The Manhattan mobility model used to model the nodes mobility, where the movement patterns of mobile nodes on streets and roads are defined by maps. However, DakNet Ad hoc network uses wireless technology to provide digital connectivity between village kiosks and a hub with internet access. One typical mobility behavior is Geographical restriction movement. We investigate DakNet scenario an underlying realistic mobility model. We propose a "Digital Postal" mobility model (DP model), which closely approximates the mobility patterns in DakNet scenario and demonstrate our proposed mobility model by evaluating various MANET routing protocols, including DSR and DSDV, the performance of DP model is efficient than existing geographical restricted models and also simulation experiments to show that our proposed model is performing better than the existing Manhattan Mobility Model.

7.2 Achievements

We investigate the performance of Manhattan mobility model (MMM) and our proposed Digital Postal mobility model (DPMM) with two different routing protocols DSR [24] and DSDV [24].

Simulation has been perform in three different phases, First phase using DSR routing protocol on underline models are Digital postal Mobility Model and Manhattan Mobility Model, second phase using DSDV on same underline Mobility Models given above and third phase using both routing Protocol (DSR,DSDV) on underline our proposed model (DPM Model).

In first phase we find Delay, packets received and Overload. We test our proposed model against existing Manhattan model using DSR routing protocol and figure 6.1, 6.2, 6.3

shows us the simulation results and we conclude that our proposed model DPMM is better than the Manhattan mobility model because the destination and path is already defined and save in cache of node so no probability is performed.

In second phase we used same parameter by using DSDV routing Protocol. We studied the performance evaluation of DPMM and MMM using DSDV routing protocol. We observed that delay and packet received graphs behave well in DPMM but in overloading graph shows poor results because DSDV is a proactive routing protocol and each node maintains a routing table. Each node periodically forwards the routing table to its neighbors and each node periodically floods status of its links, so the extra packets will be transmitted on network periodically which causes much traffic on networks and result a high overload.

In the third and last phase of our simulations compared the routing protocols base on our model DPMM and in this phase of simulation we studied which routing protocol is performing well because every routing protocol is not suitable for every mobility model. Moreover every routing protocol has its own characteristics which are suitable for selected models so in that section we studied which one is better for our proposed model, DSR or DSDV and So when we compare both DSR and DSDV on our proposed model, we conclude that DSR is performing better then DSDV. We recommended that when using DPMM, use the DSR routing protocol at backbone.

So in all three phases we conclude that DSR is suitable for our proposed model.

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Acronyms and Abbreviations

AODV	Ad hoc on-demand Distance Vector
CBR	Constant Bit Rate
CGSR	Cluster-head Gate way Switch Routing
DOD	Department of Defense
DSDV	Destination Sequenced Distance Vector
DSR	Dynamic Source Routing
DPMM	Digital Postal Mobility Model
ER	Epidemic Routing
FTP	File Transfer Protocol
FIMF	Ferry-Initiated Message Ferry
MANET	Mobile Ad hoc Network
MN	Mobile Node
MF	Message Ferry
MAP	Mobile Access Point
MMM	Manhattan Mobility Model
NRM	Notification Message Rate
NN	Nearest Neighbor
NAM	Network Animator
NIMF	Node-Initiated Message Ferry
OLSR	Optimized Link State Routing
OTCL	Object oriented Toolkit Command Language
RPGM	Reference Point Group Model
RWP	Random Waypoint
RREQ	Route Request
TCP	Transmission Control Protocol
TA	Traffic Aware
TORA	Temporally Ordered Routing Algorithm
TBGRM	Trace Base Geographical Restriction Model

USC	University Southern California
UDP	User Datagram Protocol
VTM	Virtual Track Model
VINT	Virtual Inter Network Test bed
WRP	Wireless Routing Protocol
WTP	Work Time Percentage
WLAN	Wireless Local Area Network
WWP	Weighted Way point
ZRP	Zone Routing Protocol

Appendix

A User Manual

User manual provides the steps which enable a user to use the system. In the section we provide details required to run, simulation of, our Mobility Models in ns-2. All these are easy and simple.

A-1 Check out hardware

As far as hardware goes the minimum system requirements are recommended at the end of the performance testing and are as follows...
Minimum recommended system requirements:

- 500 MHz processor.
- 128 MB RAM.
- Monitor.
- Keyboard and Mouse.

A-2 Download and install NS-2

This part describes how to install NS2 on Red Hat Enterprise Edition (4 version). The NS2 version for this document is ns-2.29.

NS2 setup

1. Download NS-2 fromhttp://prdownloads.sourceforge.net/nsnam/ns-allinone-2.29.2.tar.gz?download.

2. Decompress the ns-allinone-2.29.rar.

3. Copy this folder under ~/root/

4. Change the path to ns-allinone-2.29/ns-2.29

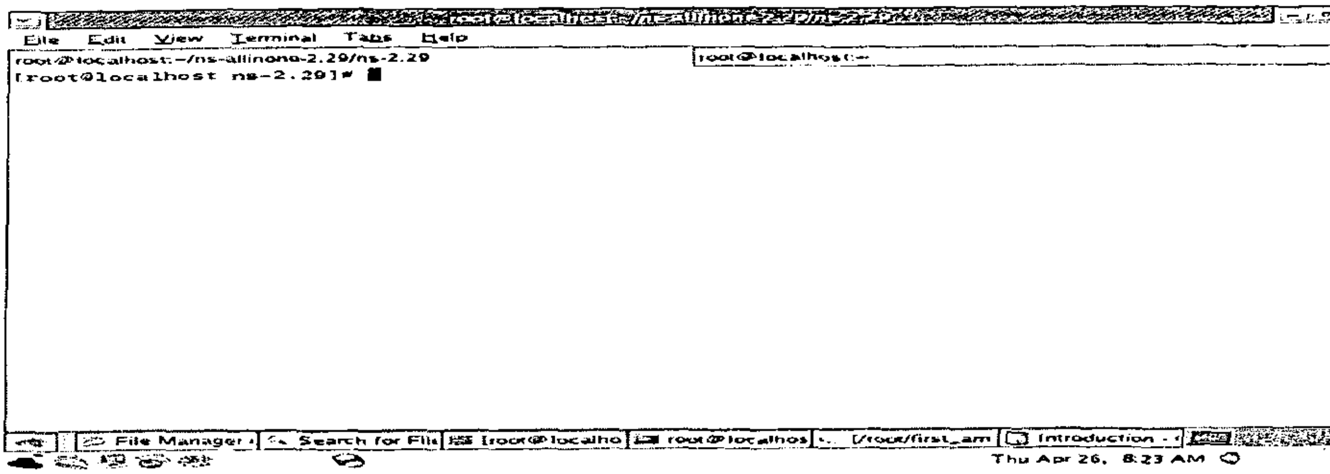

Figure A.1 Changing Path

5. Run the command "./configure"

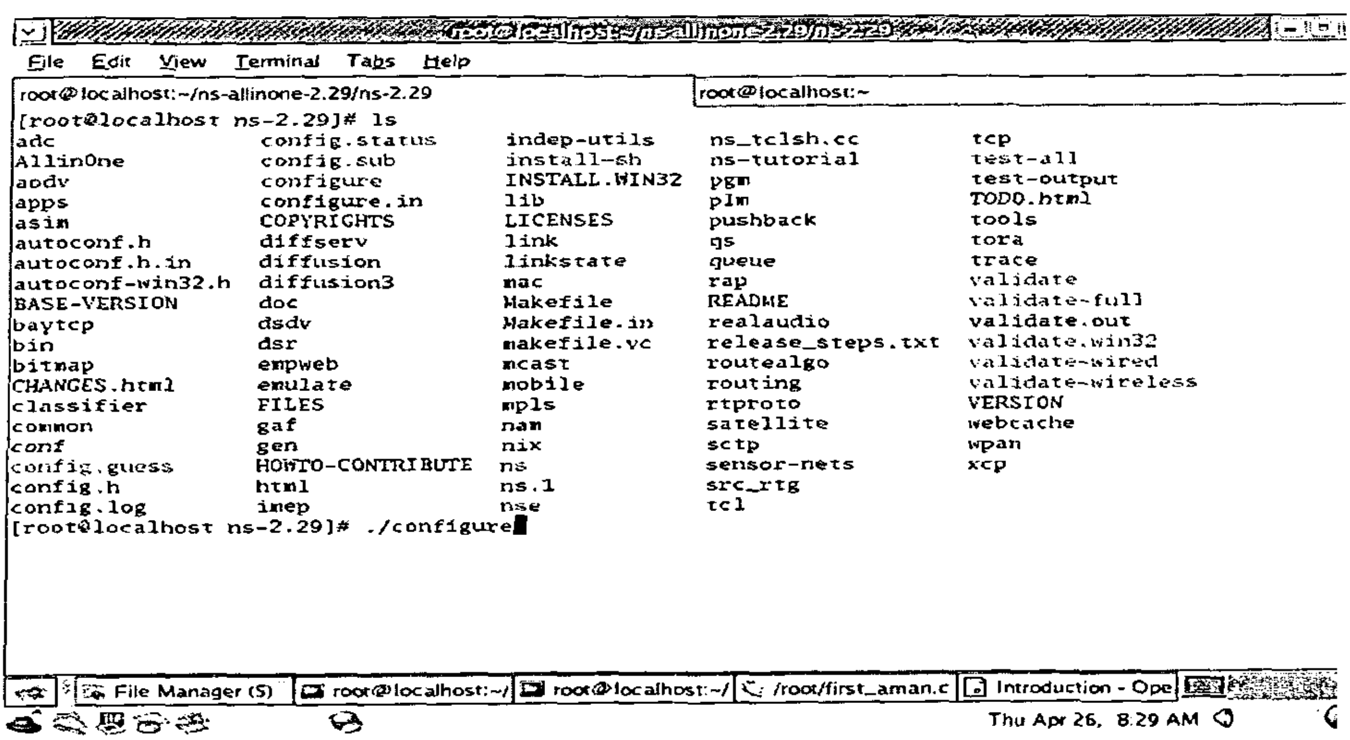

Figure A.2 Configure NS2

6. Now to compile ns-2 run make file

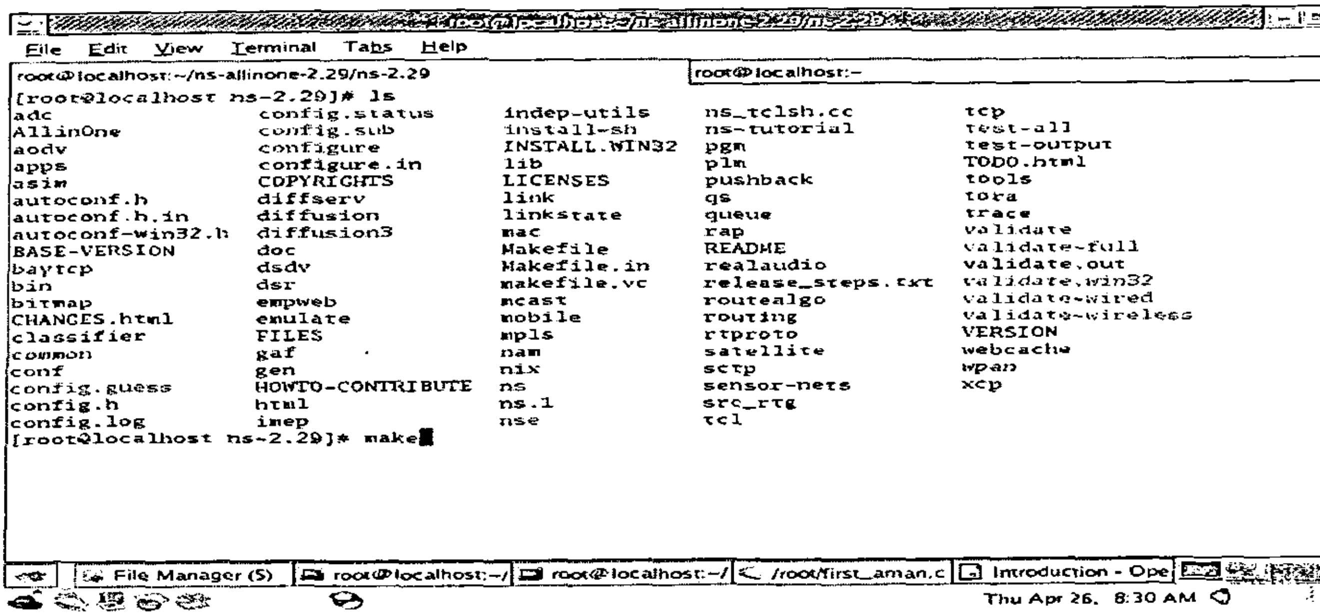

Fig3. Compile ns-2

7. Please be patient. It will take some time to finish the compilation.

8. When it is done, it should look like as follows.

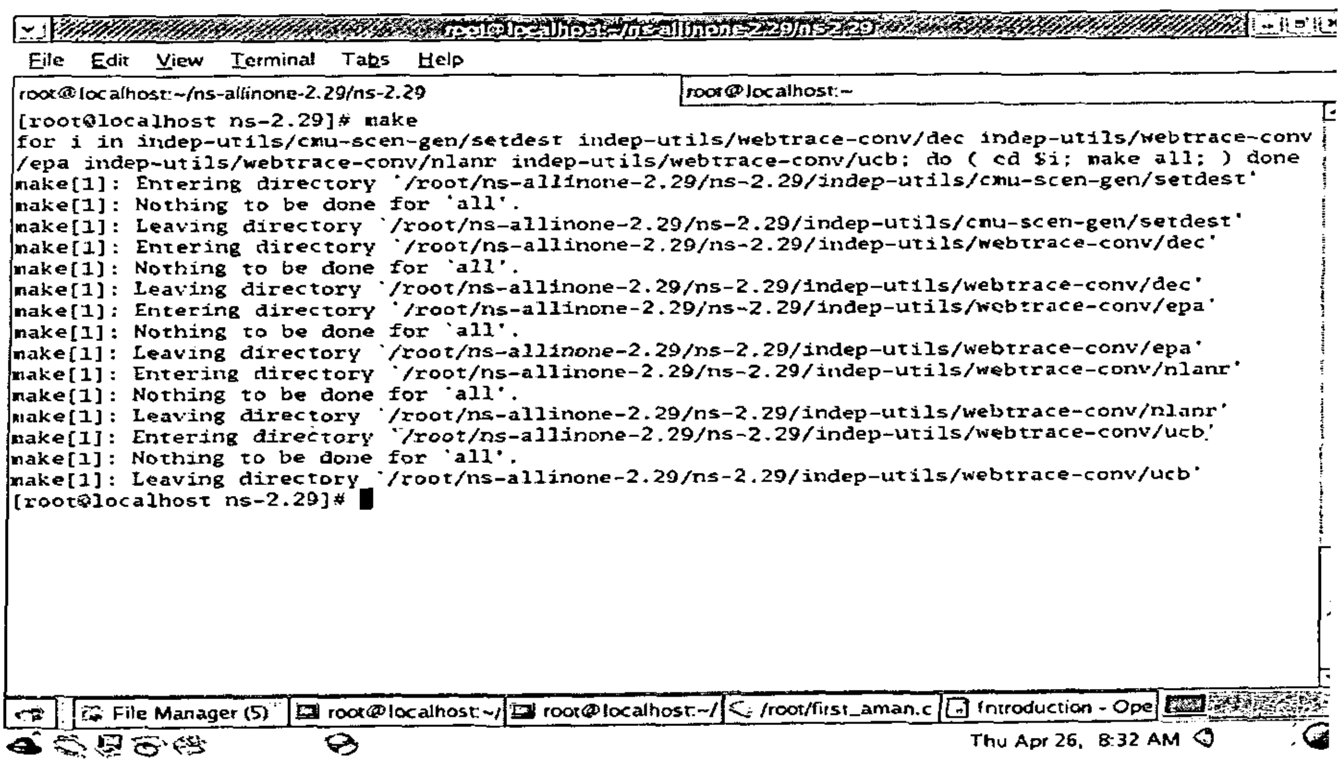

Figure A.4 Compilation Complete

9. Then set the variables path in ~/etc/profile of the variables PATH , LD_LIBRARY_PATH and TCL_LIBRARY

10. To make sure that you have successfully installed ns-2 and have set the paths correctly, run an example present ~/ns-2.29/ns-tutorial/examples/ by following command

$ ns example1a.tcl

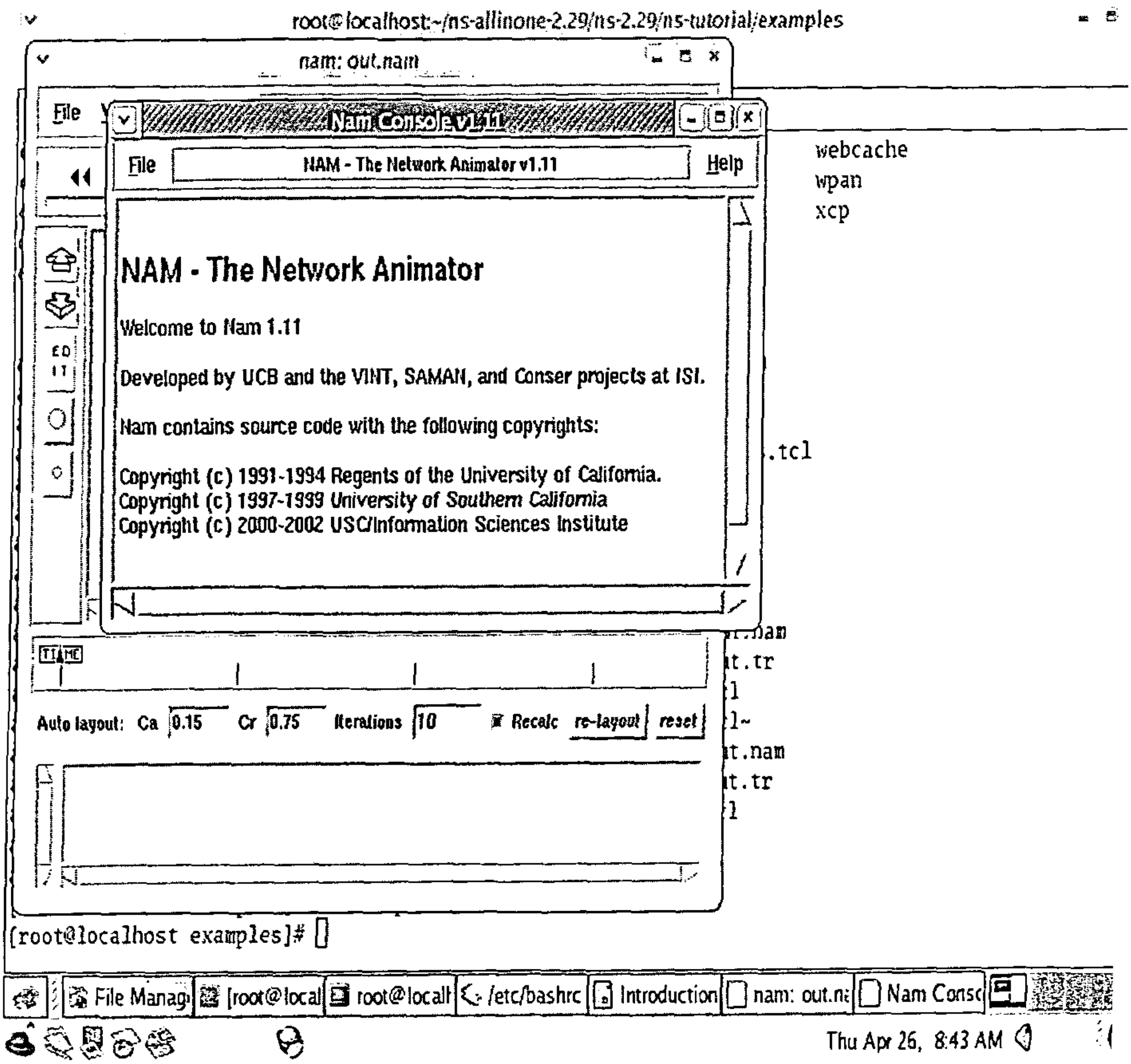

Figure A.5 Checking ns

11. If you see the error message like '§ns command not found'', no worry about this. Sometimes even you have setup the path, but it does not work. You can copy the ns.exe (nam.exe) to the same place as the simulation script.

To run our adaptive anycast protocol Simulation

1. Copy our Mobility Model and Manhattan Mobility Model and DSR and DSDV folder under ~/ns-2.29/.
2. Run the CP.cpp program
3. Set Map file.
4. Make five different scenes by changing the number of nodes.
5. TCL file will be made
6. Simulate these TCL files.
7. We get two kind of files NAM and Trace files, NAM is used for visualization of our project and in Trace file we have AWK file which is used for analysis.
8. After getting data we make graphs on the bases of this data.

Follow the same steps for generating DSDV analysis graph but only make changes in protocol option.

Our simulation for two protocols:

- DSR
- DSDV