JIMMA UNIVERSITY

JIMMA INISTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

SCHOOL OF COMPUTING

A Hybrid Adaptive Model for District Based Proactive-Geographic Steering Convention in MANET

By

Muleta Taye

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A Thesis Submitted to the School of Graduate Studies of Jimma University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Computer Networking

By

Muleta Taye

Declaration

I, the under signed, verify that this thesis study titled as A Hybrid Adaptive Model of District Based Proactive-Geographic steering convention in MANET is my original study, and has not been conferred by any other person for grant of a degree in current or any other university.

Advisor

Name: - Million Meshesha (PhD)

Signature:- ________________

Date:-____________________

Co-Advisor

Name: - Worku Brehane (MSc)

Signature: - _______________

Date:-____________________

Examiner

Name: - __________________

Signature: - _______________

Date:-____________________

Chairperson

Name: ___________________

Signature:- _______________

Date:-____________________

Dedicated

to

My Beloved Girl

LICHE TESFAYE

For Both Moments

“Thank you for Everything!!!”

Acknowledgements

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Acronyms

ABR	Associativity-based routing
AODV	Ad hoc on-demand distance vector
DB-PGSC	District Based proactive-Geographic steering conventions
DG	Directed Graph
DREAM	Distance routing effect algorithm for mobility
DSDV	Destination-Sequenced Distance Vector Routing
DSR	Dynamic source routing
FSR	Fisheye state routing
GG	Gabriel Graph
GLS	Grid Location Service
GPS	Global positioning system
GPSR	Greedy Perimeter Stateless Routing
GSR	Global state routing
IARP	InrA-zone routing protocol
Ie-DSC	Inter-sub-area Routing Protocol
IERP	IntEr-zone routing protocol
Is-DSC	In-sub-District Routing Protocol
LAR	Location Aided routing protocol
LDT	Localized Delaunay Triangulation
LMR	Light-weight mobile routing
MANET	Mobile Ad-Hoc Network
MFR	Most Forward within Radius
OLSR	Optimized link state routing
PRNAET	Packet Radio Network

QUDG	Quasi Unit Disk Graph
RNG	Relative Neighborhood Graph
SLURP	Salable location update routing protocol
SURAN	Survivable Adaptive Radio Networks
TORA	Temporally ordered routing algorithm
UD	Undirected Graph
UDG	Unit Disk Graph
Wi-Fi	Wireless Fidelity
WRP	Wireless routing protocol
ZHLS	Zone-based hierarchical link state
ZRP	Zone Routing Protocol

Abstract

From the time of its inception, wireless networks progressively being followed to enable mobility in mobile networks. In last few decades, a lot of Ad hoc network routing protocol were developed, specifically for Mobile Ad-Hoc Network. However no single routing strategy is well suited for different network scenario. This is due to the dynamic nature of MANET where nodes can move freely, the network size change as the nodes join and leave the network. Thus, the active directing conventions considered as robust for fast moving nodes may not be suitable for slow moving nodes and also protocols which perform well in large size network may not be suitable for small network size.

In this study, considering some of the basic issues arise in MANET, we proposed a methodology to solve two such major issues: routing and scalability. Broadly, the proposed methodology combines two families of routing protocols, proactive and position-based routing protocol. The designing framework considers a layering and unifying of distinct routing algorithms. On the top level the proposed technique divides a larger sized network into multiple small size networks, Districts. On the bottom of it, proactive and geographic routing convention are used at communication time by limiting the scope of proactive steering convention within a district only refereed as In-sub-District steering convention (Is-DSC). And a sequence of greedy, face followed by greedy algorithm is used to communicate a node outside of the respective region with the help of location information of nodes called IntEr-Sub-District Steering convention (Ie-DSC).

It is found that Hybridization is a good technique to have better result in different routing guidelines. In this study we developed Hybrid adaptive steering model which consists of architecture and algorithm of the proposed solution that can be applied in different network scenarios. Three different simulation scenario is utilized to understand the performance of the protocol, i.e small-size, large-size and the last scenario by changing the network size from 20 -100 nodes to understand how the steering convention behave as network density gradually grows. The main aim of MANET routing protocols is maximizing throughput, maximizing packet delivery ratio and minimizing the end-to-end delay, we employed the first two metrics to check how the proposed solution reacts for different network scenario. From the simulation result it is found that the proposed solution exhibit better performance in two metrics we selected, i.e throughput and packet delivery ratio, as the network size increased. The study suggests that the proposed solution shows better performance in both,. Small-scale and large-scale network scenario. Further the proposed solution should be implemented fully and simulation has to be done by changing different simulation parameter for different performance metrics in addition to the selected ones and needs to be compared with other active Hybrid routing Guidelines.

Keyword: Ad-hoc network, MANET, Scalability, Mobility, Routing

Chapter One
Introduction

1.1. Background

In the current accelerated and rapidly growing world of technologies, more and more businesses realize the benefit of using computer networking. Network is defined as a abstraction of people, antithetic or different system or perhaps organization who tends to share their valuable data for their business success [1]. When the term is traced to computer nomenclature, it is defined as a group of devices logically as well as physically connected for sharing information and services [1,3]. Computer network initially were used for sharing files and printers, but due to the development of applications, it has moved from specific job of the file and printer sharing to application mutuality. Nowadays wired and wireless types of networks are available, wired and Wireless networks. [1,2] Each of these network forms can be distinguished from one another based on the existence of physical connectivity.

Wired networks are remarkably more efficient, less expensive and much faster than wireless networks which allow equipment to be connected with the aid of wires and cables [1]. Once the connection is set the chance of getting disconnected is small in wired communication [1]. However, Wireless networks use some sort of radio frequencies in air to transmit and receive data instead of using physical cables. The most loving fact in wireless networks is the ability to eliminate the demand for laying out expensive cables and maintenance costs.[1,2] Such type of networks became popular in communication industry since 1970's, this is particularly true within the past decade which has seen wireless networks being adapted to enable mobility [2,3]. Wireless networks enable mobile users with Ubiquitous computing capability and information access irrespective of user's location based on the rule communication. The rule that guides the communication is known as protocol.

Currently, two kind of wireless networks. The first one id Infra-structured and infrastructure-less wireless network. Infra-structured wireless networks are equipped with fixed and wired gateway, so communication occurs via this gateway [2]. Cellular mobile, Radio and Television communication system are the main infrastructure type of network.

The second type of wireless network is the infrastructure-less mobile network, commonly titled as Ad-Hoc networks [2,4]. Such type of wireless network doesn't depend on whatever fixed Infrastructure unlike the infra-structured wireless networks, where all nodes has the quality to move and can be connected dynamically in an arbitrary manner [2,3,4].

Mobile Ad Hoc Network (MANET) are subtype of infrastructure-less Ad-Hoc network.[4,5,6] Nodes in such network can serve as routers which discover and keep path to other nodes in the network. The whole communication between nodes is controlled by routing guideline. A broad range of routing rules were formulated for both network types, but the basic goals of these protocols are the same[3], i.e. Maximizing throughput, Minimizing packet loss, Minimizing control overhead ,Minimizing energy usage and Minimizing end-to-end delay.

As noted by Rakhi and Nish [7] Steering convention in MANET can be categorized as Topology based and Position based steering guideline. Sometimes the second are identified as Geographical routing. Both families comply different routing philosophy. In Topology based routing protocol's one can consider the structure of the network for determining the routing line between nodes and utilize the path to forward the parcel, whereas position based routing protocol uses area data of the nodes directing process.

Since the inception of wireless technologies, the application area of Mobile Ad Hoc Networks is increasing. Battlefield communication, disaster relief management, conferences, electronic classrooms are some of the application areas. Nodes in MANET are equipped with limited resources and the mobile nature these nodes mainly change the structure of such network frequently. Moreover, without prior notice each node is free to join or leave the network whenever they want. Such behavior makes up link interruption in respective topology. The other major characteristics of MANET are the self-organizing and self-configuring, since it does not rely on fixed infrastructure and operate in shared wireless media. Last but not least, node in MANET is equipped with limited resources.

The above remarked characteristics of MANET, makes the routing procedure challenging task. To solve such routing challenges different routing algorithms were developed by unifying the active topology-based steering convention, called Hybrid routing protocols[ ]. Such routing guideline pretends to inherit the best parts of both reactive and proactive steering convention. However, the main idea of the hybrid routing protocols is limiting the set of forwarding nodes and using the proactive routing algorithm for nearly placed nodes which usually forward data to far placed nodes.

Of those, Zone Routing Protocol (ZRP) is the most interesting routing protocol. Zone Routing Protocol is not a very distinct protocol instead it provides a framework for other protocols [12]. It basically aims to address the difficulties in topology based routing specifically proactive and reactive routing protocol. It is topology- based hybrid steering guideline which incorporate the benefit of two different remarked routing approach, i.e proactive and reactive routing approaches. Such routing rule perform well in small networks.

Simulation result depict that the performance is almost negligible whenever the number of node exceeds 100 nodes [28]. The possible reason behind this is that a small change in the network topology causes frequent table update of every intermediate node for its zone through IARP. However, protocols which employ location information of nodes generally more applicable or scalable in case when the number of nodes are somehow large [7]. More often than not, this study entirely go around designing routing framework or architecture that integrate two different routing families for scalable and robust routing, i.e proactive and position-based routing rules, So as to make the proposed routing framework applicable for antithetic network scenario by limiting scope of their functionality.

1.2. Statement of problem

In MANET, factors like: high mobility, low bandwidth, growing size of network and limited computational capability of mobile nodes makes the choice of appropriate directing rule(protocol) with effective performance is difficult to adopt [8]. Due to the dynamic nature of network, which arises from the mobility of nodes in the network, makes selecting routing protocol in MANET a challenging task among researchers and scientists world-wide in recent decades [31]. To get a better from such challenges, several techniques and methods have been proposed, among these is the concern of this study Hybrid routing protocol, Because this directing guideline combines the best features of topology-based routing protocol specifically, proactive and reactive routing protocols. Such hybrid proactive/reactive routing protocols work well for networks of small-scale [9,10]. The other classes of routing protocols are position-based routing protocols, where nodes use area data or location information maintained locally/globally for further communication.

Most of the active hybrid proactive/reactive steering conventions are based on the concept of zone, one of such hybrid steering convention is Zone Routing Protocols (ZRP), whose topology is based on hybrid routing protocol, which defines the zone of routing in hops that each node is required to maintain the network connectivity [10].

From antithetic simulation results [26,27], it is observed that ZRP outperforms compared to individual proactive and reactive routing protocols. However, the performance of this protocol degrades due to some factors such as: mobility, number of nodes, traffic type or traffic load and zone radius [22, 24, 26, 28]. Zone Radius and node density are most importantly affect the performance of ZRP. Here, the most dominant parameter influencing on the efficiency of ZRP is the zone radius, since, it controls the number of nodes within the zone, the number of zone, and the number of overlapping zone in the network.

Despite its effectiveness, when compared to individual proactive and reactive protocols, [5] there are situations where the performance hybrid protocol degrades in relation to zone radius value. Thus as the value of zone radius becomes large, ZRP behaves like pure proactive and shows the performance of pure proactive routing protocol. And it acts like purely reactive as the zone radius becomes small with respect to its performance.

In addition to zone radius, number of nodes (density of node) is the other factor that affects the performance of ZRP [28]. It has been observed that the performance of ZRP decreases significantly in terms of some performance metrics. The reason of performance degradation is due to the fact that an increase in number of nodes in the network causes more number of control packets to flow in the network for establishing the route between a pair of source and destination thus affecting the performance metrics [28].

A number of routing protocol were developed in the past few decades [29] But, none of them is suitable for all network applications and contexts [30, 31]. Rules or protocols that are considered as robust for fast moving nodes may not be suitable for slow moving nodes and also protocols which perform well in large size network may not be suitable for small size network.

Hence, the main aim of this study is to explore the way to design adaptive model for hybridizing protocol in MANET that is suitable for any size, small and large network environment..

To this end, the current study attempt to investigate and answer the following research questions.

- What are the major issues that affect the scalability of MANET routing protocol?
- For which Network size does proactive routing protocol perform well?
- How proactive and geographic steering conventions can combine together into single for using in both small-scale and large-scale network scenario?

1.3. Objective of the Study

1.3.1 General objective

The Overall objective of this study is to propose A Hybrid adaptive model for District Based proactive-Geographic steering convention for Mobile Ad Hoc network (MANET) that performs well in any small-scale and large-scale network scenario.

1.3.2. Specific Objectives

The following are some of the specific objectives of the study:-

- To review works for understanding issues and approaches used in this area.
- To identify the optimal network size for which proactive routing shows good performance.
- To design a hybrid routing architecture.
- To develop Algorithm for activities involved in the proposed Hybrid architecture.
- To perform simulation for checking how the proposed model respond to distinct network size scenario.

1.4 Scope and Limitation

The scope of this study is delimited on infra-structure less wireless adhoc network specifically on MANET. The research is aimed to apply different routing principle or techniques so as to discover new hybrid adaptive routing approach to address the scalability and routing challenges of MANET..

The major limitation of the proposed model

- The top layer functionalities are not implemented due to the expense of time.
- Is-DSC is implemented only based on the principle of DSDV routing philosophy.
- Ie-DSC component utilize only the concept of area data assuming Source node knows physical location of destination node.

1.5. Significance of the Study

Advance in the development of wireless portable devices like, like laptops and phones, potentially, increased the usage of mobile ad hoc networks (MANET), as it supports wireless communication among multiple devices. It is due to the fact that MANET is a self-configuring network, which does not need any fixed or pre-existent infrastructure. This feature plays a vital role in minimizing or reducing the deployment cost and time.

Since the proposed routing guideline support small-scale and large-scale network , primarily, after the implementation, the study assist explicitly distinct area where MANET are applied in particular, small and dense number of user are available such as tactical network, in conferences, meeting rooms, commercial and civilian environments. Moreover, the study shows significance improvement in relation to the resource usage, particularly the amount of memory required to store information and latency in communication, it will improve the serving time of devices.

1.6 Methodology the Study

Methodology is a way to systematically solve the research problem using methods and techniques suitable for finding solution and answer the research questions. Since method and research design are important to attain the desired goal.

Research is defined as the systematic investigation into and study of materials and sources in order to establish facts and reach new conclusion. [76] Design Science Research is a research procedure for producing innovative construction intended to solve problems faced in the real world and, by that means, to make a contribution to the theory of the discipline in which it is applied. In line with this looked at it as a way that seeks to explore new solution alternatives to solve problems, to explain this exploratory process and to improve the Problem-solving process. [76] A design science is not concerned with action itself, but with knowledge to be used in designing solutions, to be followed by design based action.

Further it is characterized by its motivation of problem solving and distinguished from other by nature of the research program. Due to this research study has selected a Design Science Research as philosophical approach or methodology to propose a solution for the problem based on the characteristic of MANET routing approach, The process for research in design science we propose is shown in figure 1.1. the process is divided into three phase, problem identification, solution design and evaluation which interact with each other within the research process.

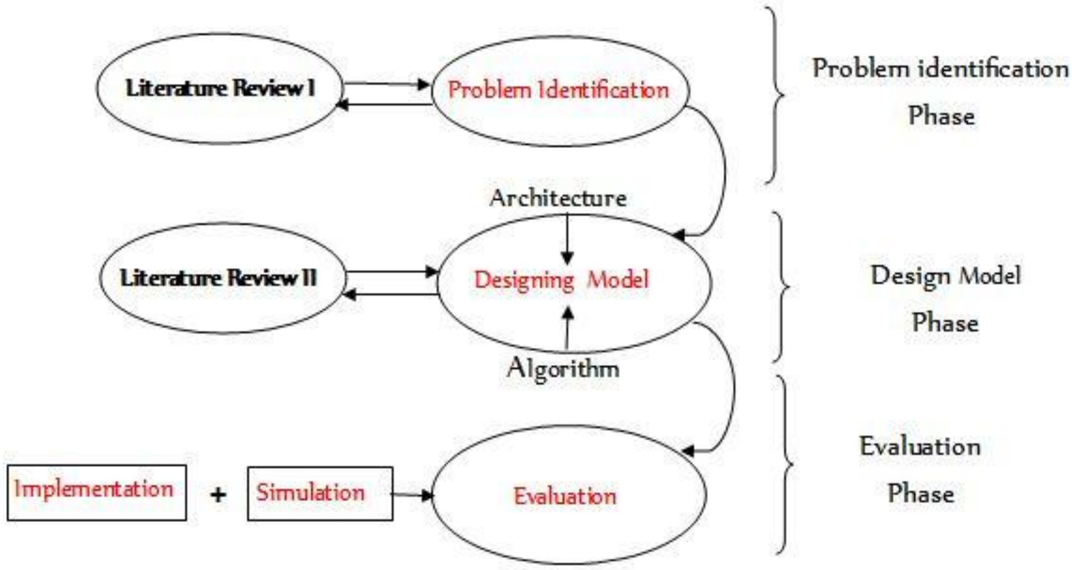


Figure 1.1 DSR process of the proposed solution [76].

Problem Identification phase

In the first phase of the research process, a area along with the problem is identified and ensured that the problem has practical relevance or might be of relevance once solved. To identify a problem, literature review can be used based on scientific publications as well as in practitioner reports. Inline with this, the research question arise from the current phase of the research.

Design model Phase

In the second phase, the model for the proposed solution is designed which include the architecture and developing its respective algorithms for the activities involved in the proposed solution. Like during the first phase, the existing knowledge base including state-of-the-art has to be taken into account to ensure research consistency. In contrast to literature research part I for problem identification, the focus of this step should be put on relevant scientific publications.

Evaluation Phase

Once the solution reaches a sufficient state, its evaluation can be started []. In this phase of the Design science Research process; implementation, simulation and evaluation is carried out by the means of a simulation scenario.1.4.3. Simulation tools

Network Simulator 2 (NS-2) is used as a simulation tool: because of its popularity and applicability in the antithetic research field especially in Mobile ad hoc networks and comes with fully equipped protocols, models, algorithms and accessory tools, and it is for free. Therefore, in terms of scientific acceptance, number of tools/modules and cost, NS-2 would be a sort of ideal choice.

1.4.4. Evaluation Metrics

It is greatly necessary to realize most important parameter while evaluating the performance of routing guidelines in mobile ad hoc network. In this study we selected two performance metrics to evaluate the performance of the proposed solution: throughput and packet delivery ratio.

Throughput: is the number of parcel that is passing through the line in a particular unit of time [28]. This performance metric shows the total number of packets that have been successfully delivered from source node to destination node per unit of time.

Packet Delivery Ratio:- is defined as the ratio of the number of data packet received by the destination node to those generated packets by the source node [67].

Chapter Two

Literature Review

2.1. History and Definition

Infrastructure-less wireless network, i.e. ad-hoc networks, could be categorized into the first, second, and the third time period ad-hoc networks systems. The instant or present ad hoc network are considered as the third generation ad-hoc network [11]. The first generation goes back to 1972. At that time, they were called PRNET (Packet Radio Networks). The second generation of ad-hoc networks emerged in 1980s, when the ad-hoc network systems were further improved and enforced as a part of the SURAN (Survivable Adaptive Radio Networks) program. This provided a packet-switched network to the mobile battlefield in a situation without infrastructure [11].

In the 1990s, the idea of commercial ad-hoc networks arrived with note-book computers and other viable communications equipment. At the same time, the idea of a collection of mobile nodes was projected at several research conferences. Since mid-1990s, a lot of work has been done on the ad hoc standards. Within the IETF, the MANET working group was born, and made effort to standardize routing protocols for ad hoc networks [11,2].

The earlier MANETs were titled packet radio networks, (PRNET) and were sponsored by DARPA in the early 1970s. BBN Technologies and SRI International designed, built, and experimented with these earliest network system [2]. The past of mobile ad-hoc networks can be dated back to the DoD1-sponsored Packet Radio Network (PRNET) research for military purpose in 1970s, which evolved into the Survivable Adaptive Radio Networks (SURAN) program in the early 1980s [11]. The popular IEEE 802.11 (Wi-Fi) wireless protocol incorporates an ad-hoc networking system when no wireless access points are present. The IEEE 802.11 system only handles traffic within a local ”cloud” of wireless devices. Each node transmits and receives data, but does not route anything between the network's systems. However, higher-level protocols can be used to aggregate various IEEE ad-hoc networks into MANETs [2].

Anti of based wireless networks, where each network user directly communicates with fixed access point or base station, a mobile ad hoc network, or MANET is a kind of wireless ad hoc network [12]. Which may complement infrastructure-based wireless networks and it is a special type of wireless mobile network which forms a temporary network without the aid of infrastructure or centralized administration. [2,12] Such type of network are identified by their self-forming, self-maintained, self-healing, self-organizing and self-configuring multi- hop network property, where the topology changes dynamically due to the mobile nature of the nodes allowing for extreme network flexibility. While MANETs can be completely self-contained as shown in figure 2.1

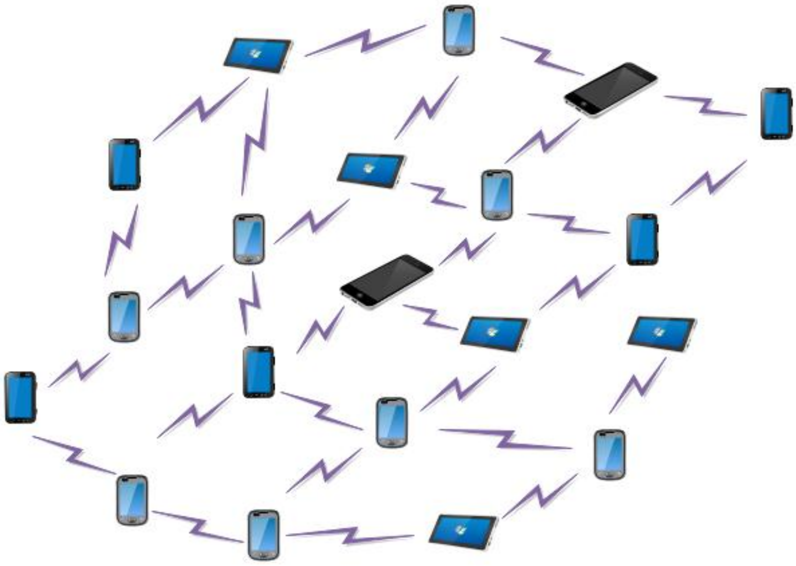


Figure.2.1: Mobile Ad Hoc Network

They can also be tied to an IP-based global or local network such as Internet or private networks as shown in figure2.2. These are referred to as Hybrid MANETs [2]. But this work entirely revolves around the serf-contained Mobile Ad Hoc Networks. The application of MANET ranges from civilian use to emergence rescue sites and in battlefield [13].Nodes in MANET use the same random access wireless channel, cooperating in a friendly manner to engaging themselves in multi-hop forwarding. The nodes in the network not only serve as hosts but also as routers used to deliver data to/from other nodes in network.

If the source node is incapable to deliver a message directly to goal nodes a result of the transmission range or scope, the source node use the halfway nodes to forward the message toward goal node.

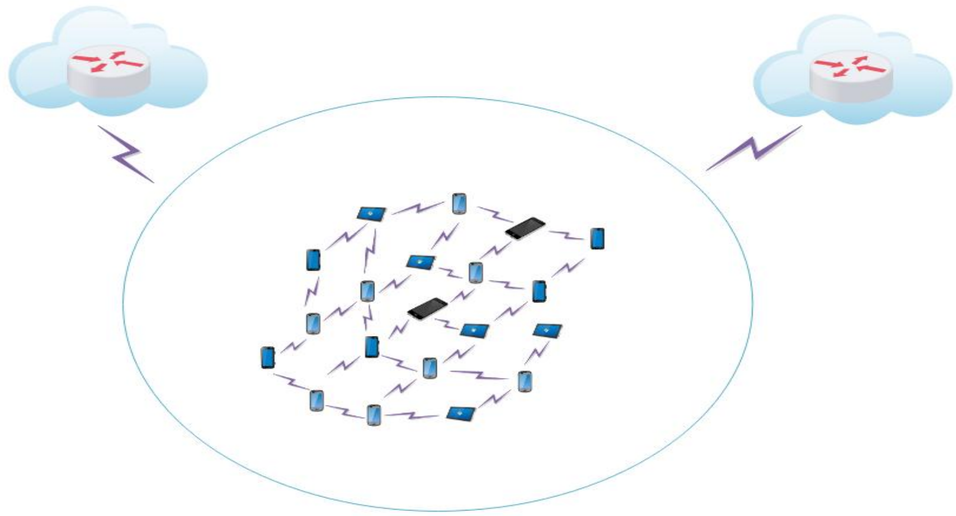


Figure.2.2:-Hybrid Mobile AdHoc Network

This means that, each node must be able to forward data for other nodes. This make over additional problems along with the problems of dynamic topology which is unpredictable connectivity changes [13]. Routing is very essential component in the study of MANETs.

2.2. Characteristics of MANET

Following are the main characteristics of Mobile Ad Hoc network [15]

- Dynamic Network Topologies: Nodes in MANETs can freely move independently in any direction inside the network as a result of their mobile nature. Consequently, MANET topology may change often and every which way, i.e randomly at unpredictable times and primarily consists of bidirectional links.
- Low Bandwidth: MANET'S nodes have small capacity and shorter transmission range than fixed infrastructure networks. The throughput of wireless communication is little than that of wired communication because of the effect of the multiple access, fading, noise, and interference conditions.
- Limited Battery Power: The nodes or hosts in MANET are operate on small batteries and other exhaustible means of energy. So, energy conservation is the most important design optimization criteria.
- Distributed operation: There is no background network for the central control of the network operations, the control of the network is distributed among the nodes. The nodes involved in a MANET should cooperate with each

other and communicate among themselves and each node acts as a relay as needed, to implement specific functions such as routing and security.

- Multi-hop routing: When a node tries to send information to other nodes which is out of its communication range, the packet should be forwarded via one or more intermediate nodes.
- Autonomous terminal: In MANET, each mobile node is an independent node, which could function as both a host and a router.
- Unreliable Communications: The shared-medium nature and unstable channel quality of wireless links may result in high packet-loss rate and re-routing instability, which is a common phenomenon that leads to throughput drops in multi-hop networks. This implies that the security solution in wireless adhoc networks cannot rely on reliable communication.
- Weak Physical Protection: MANETs are more prone to physical security threats than fixed-cable networks. Mobile nodes are usually compact, soft and hand-held in nature. Today, portable devices are getting smaller and smaller. They could get damaged or lost or stolen easily and misused by an adversary. The increased possibility of different types of attacks should be carefully considered.
- Scalability: Due to the limited memory and processing power on mobile devices, the scalability is a key problem when we consider a large network size. Networks of 10,000 or even 100,000 nodes are unreal, and scalability is one of the major design concerns.

2.3. Application and Challenges of MANET

The coming of ubiquitous computing and the creation of brand-new, powerful, efficient, portable or movable computing equipment have adjusted or focused to the importance of mobile and ad-hoc networking, is gaining value with the increasing number of widespread applications [11]. Ad-hoc networking can be applied anywhere where there is little or no communication infrastructure or the existing infrastructure is expensive or inconvenient to use [13]. Ad hoc networking allows the devices to maintain connections to the network as well as easily adding and removing devices to and from the network [14]. The set of applications for MANET is diverse, ranging from large-scale, mobile, highly dynamic networks, to small, static networks that are constrained by power sources. Some of the application of MANET can be described as follows.

2.3.1. Applications of MANET

Some of the application of MANET [16] are described below

- Military battlefield: Ad-Hoc networking would allow the military to take advantage of commonplace network technology to maintain an information network between the soldiers, vehicles, and military information head quarter.
- Collaborative work: For some business environments, the need for collaborative computing might be more important outside office environments than inside and where people do need to have outside meetings to cooperate and exchange information on a given project.
- Local level: Ad-Hoc networks can autonomously link an instant and temporary multimedia network using notebook computers to spread and share information among participants at a e.g. conference or classroom. Another appropriate local level application might be in home networks where devices can communicate directly to exchange information.
- Personal area network and Bluetooth: - A personal area network is a short range, localized network where nodes are usually associated with a given person. Short-range MANET such as Bluetooth can simplify the inter communication between various mobile devices such as a laptop, and a mobile phone.
- Commercial Sector: - Ad hoc can be used in emergency/rescue operations for disaster relief efforts, e.g. in- fire, flood, or earthquake. Emergency rescue operations must take place where non-existing or damaged communications infrastructure and rapid deployment of a communication network is needed.

2.3.2 Challenges in MANET

The peculiar characteristics of MANETs [13] remarked in section 2.2 enforce or impose many challenges to design of network directing guideline on all layers of the protocol.

- The physical layer must deal with rapid changes in link characteristics.
- The media access control (MAC) layer needs to allow fair channel access, minimize packet collisions and deal with hidden and exposed terminals.
- At the network layer, nodes need to cooperate to calculate paths.
- The transport layer must be capable of handling packet loss and delay

characteristics that are very different from wired networks.

- Applications should be able to handle possible disconnections and reconnection.

So that designing a steering convention which complete the above referenced element is very difficult.[4,13], Besides this, Routing, Scalability, Addressing and Internet connectivity, Multicasting, QoS, Power aware routing, Service and resource discovery, Security and node cooperation are some of the technological challenges in designing efficient routing protocol. Furthermore, following are challenge that impact the design of the routing rule[16]

- Limited bandwidth: Wireless link continue to have significantly lower capacity than infrastructured networks. In addition, the realized throughput of wireless communication after accounting for the effect of multiple access, fading, noise, and interference conditions, etc., is often much less than a radios maximum transmission rate.
- Dynamic topology: Dynamic topology membership may disturb the trust relation-ship among nodes. The trust may also be disturbed if some nodes are detected as compromised.
- Routing Overhead: In wireless ad hoc networks, nodes often change their location within network. So, some stale routes are generated in the routing table which leads to unnecessary routing overhead.
- Hidden terminal problem: The hidden terminal problem refers to the collision of packets at a receiving node due to the simultaneous transmission of those nodes that are not within the direct transmission range of the sender, but are within the transmission range of the receiver.
- Packet losses due to transmission errors: Ad hoc wireless networks experiences a much higher packet loss due to factors such as increased collisions due to the presence of hidden terminals, presence of interference, uni-directional links, frequent path breaks due to mobility of nodes.
- Mobility-induced route changes: The network topology in an ad hoc wireless network is highly dynamic due to the movement of nodes; hence an on-going session suffers frequent path breaks. This situation often leads to frequent route changes.
- Battery constraints: Devices used in these networks have restrictions on the

power source in order to maintain portability, size and weight of the device.

- Security threats: The wireless mobile ad hoc nature of MANETs brings new security challenges to the network design. As the wireless medium is vulnerable to eavesdrop- ping and ad hoc network functionality is established through node cooperation, mobile ad hoc networks are intrinsically exposed to numerous security attacks.

2.4. Routing protocol in Mobile Ad Hoc Network

Routing or steering conventions are very indispensable element for variety of network and defined as the act of tossing information from a source to a goal node in an internetwork to facilitate communication inside the network, a routing rule is used to discover line between nodes [1,2]. The primary goal of ad-hoc routing protocol is right and efficient route establishment between a pair of nodes so that messages may be delivered in a timely manner [2]. Routing a parcel from one node to other is crucial task. [9] Before, routing protocol was based on the topological information, which consist of two processes, i.e. path establishment and path maintenance utilizing link information that exists in the network for parcel forwarding. But now a days routing rules are designed to support position information to locate the exact locations of destination node as well as its neighbor node.

The Concept of Routing basically involves, two activities[1]: first, determining optimal routing paths and second, transferring the information groups (called packets) through an internetwork. The later concept is called as packet switching which is straight forward, and the path determination could be very complex[1,2]. As shown in the figure 2.3, routing protocols in MANET is classified in to two; topology-based and position-based routing.

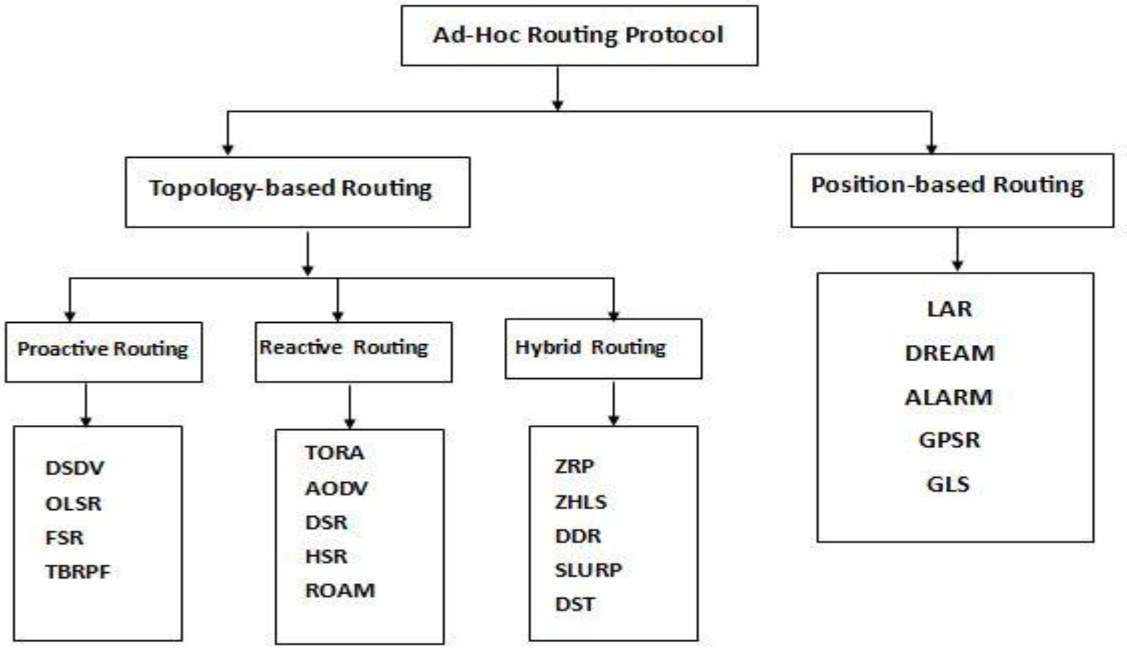


Figure.2.3: Classification of routing protocol adopted[7]

2.4.1. Topology based routing Protocols

Topology-based steering conventions consider the entire network topology to kick off the routing activity and also further classified into Reactive (On-demand), Proactive (Table- Driven) Routing and Hybrid routing. The first two classes are sometimes titled as Flat routing protocol and Hybrid as Hierarchical routing protocol as in figure 2.3.

Proactive routing protocol

Such directing rule are also titled as Table-driven routing protocols, since they keep the course data, ie routing information even before it is needed [5,6,10]. Each and every node in the network maintains course data to every other node in the network. Thus, nodes in the network continuously hunt routing information with in a network, so that when a path necessitates, it is easily acquired since already known [17]. Routes information is generally kept in the directing tables and is periodically updated as the network topology changes [5]. If node yearns to send any message to another node, so it will utilize the path in its table to deliver the information. Therefore, latency is low. However, when there is a lot of node movement then the cost of maintaining all topology information is very high. Furthermore, these directing rule maintain different number of tables. DSDV, WRP, OLSR, GSR, FSR are some of the remarkable proactive steering convention. Such steering rule are not appropriate or suitable for networks with many nodes, i.e bigger networks, as they need to maintain node entries for each and every node in the directing table of every node [5].

This causes more overhead in the routing table leading to consumption of more bandwidth. Such protocol will not scale in large network since a large portion of the network bandwidth is used in the updating procedures.

Destination-Sequenced Distance Vector Routing (DSDV)

The DSDV [5] algorithm is a modification of DBF, which guarantees loop free routes. It provides a single path to a destination, As the name indicates this protocol uses the concept of distance vector shortest path routing algorithm. In order to reduce the amount of overhead transmitted through the network, two types of update packets are used. These are referred to as a full dump and incremental packets.

Global state routing (GSR)

The GSR protocol [5] is based on the traditional Link State algorithm. However, GSR has improved the way information is disseminated in Link State algorithm by restricting the update messages between intermediate nodes only. In GSR, each node maintains a link state table based on the up-to-date information received from neighboring nodes, and periodically exchanges its link state information with neighboring nodes only. This has significantly reduced the number of control message transmitted through the network. However, the size of update messages is relatively large, and as the size of the network grows they will get even larger.

Fisheye state routing (FSR)

The FSR protocol [18] is the descendant of GSR. FSR reduces the size of the update messages in GSR by updating the network information for nearby nodes at a higher frequency than for the remote nodes, which lie outside the fisheye scope. This makes FSR more scalable to large networks than the protocols described so far in this section. However, scalability comes at the price of reduced accuracy. This is because as mobility increases the routes to remote destination become less accurate. This can be overcome by making the frequency at which updates are sent to remote destinations proportional to the level of mobility.

Optimized link state routing (OLSR)

OLSR [19] is a point-to-point routing protocol based on the traditional link-state algorithm. In this strategy, each node maintains topology information about the network by periodically exchanging link-state messages. The novelty of OLSR is that it minimizes the size of each control message and the number of rebroadcasting nodes during each route update by employing multipoint replaying (MPR) strategy. To do this, during each topology update, each node in the network selects a set of neighboring nodes to retransmit its packets.

Wireless routing protocol (WRP)

The WRP protocol [6] also guarantees loops freedom and it avoids temporary routing loops by using the predecessor information. However, WRP requires each node to maintain four routing tables. This introduces a significant amount of memory overhead at each node as the size of the network increases. Table 2.1 below describe the advantage and disadvantage of proactive routing protocols.

Advantage	Disadvantage
Routes are readily available.	It has to maintain complete network graph in Current state.
Quick response to application Program	Consumes lot of network resource in order to Maintain the network graph.

Table.2.1: Merit and Demerit of proactive routing protocol

Reactive routing protocol

These directing strategies are identified as On-demand routing protocols were planned to reduce the overheads in previous directing rules by maintaining information for active routes only [5]. This implies that routes are determined and maintained for nodes that require to deliver data to a particular Goal node. As the node yearns to deliver a parcel or message, first it set up a path or route to the Goal node, so the source node, initiates a route discovery process inside the network. [6] Once the process is completed and route is discovered or all possible route permutations have been examined the course information is maintained by some form of route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired. [5] The main drawback of this directing rule is that, in big or large networks they do not execute or perform well, due to two main reasons; firstly as the number of middle of the road nodes in each route grows, then so does the probability of route failure. Secondly, as the number of intermediate nodes in each route grows, then the amount of overhead carried in each header of each data packet will grow as well. Therefore, in large networks with significant levels of multihoping and high levels of mobility, these protocols may not scale well. [20] Route discovery usually occurs by flooding a route request packets through the network. When a node with a path to the destination, the destination will offer a route reply back to the source node using link reversal if the route request has traveled through bi-directional links or by piggy-backing the route in a route reply packet via flooding [5]. ABR, AODV, CEDAR, DSR, FORP, GEDIR, WAR are some reactive routing protocol.

Ad Hoc On-demand distance vector (AODV)

The AODV [21] routing protocol is based on DSDV and DSR algorithm. It uses the periodic beaconing and sequence numbering procedure of DSDV and a similar route discovery procedure as in DSR. However, there are two major differences between DSR and AODV. The most distinguishing difference is that in DSR each packet carries full routing information, whereas in AODV the packets carry the destination address. This means that AODV has potentially less routing overheads than DSR. [32] The other difference is that the route replies in DSR carry the address of every node along the route, whereas in AODV the route replies only carry the destination IP address and the sequence number. The advantage of AODV is that it is adaptable to highly dynamic networks. However, node may experience large delays during route construction, and link failure may initiate another route discovery, which introduces extra delays and consumes more bandwidth as the size of the network increases.

Dynamic source routing (DSR)

DSR protocol [32] requires each packet to carry the full address (every hop in the route), from source to the destination. This means that the protocol will not be very effective in large networks, as the amount of overhead carried in the packet will continue to increase as the network diameter increases. Therefore in highly dynamic and large networks the overhead may consume most of the bandwidth.

Associativity-based routing (ABR)

ABR [33] is another source initiated routing protocol, which also uses a query-reply technique to determine routes to the required destinations. However, in ABR route selection is primarily based on stability. To select stable route each node maintains an associativity tick with their neighbors, and the links with higher associativity tick are selected in preference to the once with lower associativity tick. However, although this may not lead to the shortest path to the destination, the routes tend to last longer. Therefore, fewer route reconstructions are needed, and more bandwidth will be available for data transmission.

Temporally ordered routing algorithm (TORA)

TORA [5] is on-demand routing protocol is based on the Light-weight mobile routing (LMR) protocol. It uses similar link reversal and route repair procedure as in LMR, and also the creation of a DAGs, which is similar to the	Disadvantage
• Routes are discovered on demand basis	• Very high response time, as route is needed on demand
• Bandwidth efficient protocols	
• Less network communication Overhead	

Table 2.2: Merit and Demerit of Reactive routing protocol

Hybrid Routing Protocols

Hybrid steering conventions are the other classes of topology-based routing protocol which utilize proactive and reactive properties, in cases which would increase the scalability of the network. Such type of routing protocol combines proactive and reactive routing protocol [10],in which nodes dwell inside a certain detachment from an anxious node are said to be in routing area and uses table driven routing protocol. [34] Communication between nodes in different areas will depends on the source initiated or on-demand routing strategies. Basically such steering conventions are designed to improve the scalability by permitting or allowing nodes with close proximity to work jointly to form some sort of a backbone to reduce the route discovery overheads

[5]. This is mostly achieved by proactively maintaining routes to nearby nodes and determining routes to far away nodes using a route discovery strategy. Most hybrid protocols proposed are zone-based, which means that the entire network is partitioned as a number of zones by each node. ZRP, ZHLS, SLUB, DDR are some of Hybrid routing protocol.

Zone Routing Protocol

ZRP [22,24,34] was the first hybrid routing protocol with both a proactive and a reactive routing component. ZRP is proposed to reduce the control overhead of proactive routing protocols and decrease the latency caused by routing discover in reactive routing protocols. ZRP defines a zone around each node consisting of its neighborhood. In ZRP, the distance and a node, all nodes within hop distance from node belong to the routing zone of node. As it is pointed out this routing protocol is formed by two protocols, a proactive routing protocol: Intra-zone Routing Protocol (IARP), is used inside routing zones and a reactive routing protocol: Inter-zone Routing Protocol (IERP), is used between routing zones, respectively. A route to a destination within the local zone can be established from the proactively cached routing table of the source by IARP therefore, if the source and destination is in the same zone, the packet can be delivered immediately. Most of the existing proactive routing algorithms can be used as the IARP for ZRP. For routes beyond the local zone, route discovery happens reactively. The source node sends a route requests to its border nodes, containing its own address, the destination address and a unique sequence number. Border nodes are nodes which are exactly the maximum number of hops to the defined local zone away from the source. The border nodes check their local zone for the destination. If the requested node is not a member of this local zone, the node adds its own address to the route request packet and forwards the packet to its border nodes. If the destination is a member of the local zone of the node, it sends a route reply on the reverse path back to the source. The source node uses the path saved in the route reply packet to send data packets to the destination.

Zone-based hierarchical link state (ZHLS)

ZHLS [34] routing protocol where a hierarchical structure is defined by non-overlapping zones with each node having a node ID and a zone ID. These IDs are calculated using an external location tool such as GPS. The hierarchy is divided into two levels: the node level topology and the zone level topology. There are no cluster heads in ZHLS. When a route is required for a destination located in another zone, the source node broadcasts a zone-level location request to all other zones. Once the destination receives the location request, it replies with the path. In this technique, only the node and zone IDs of a node is required to discover a path. There is no need for updates as long as the node stays within its own region and the location update is required only if the node switches regions. The only drawback of ZHLS is that all nodes should have a preprogrammed static zone map to recognize the zones created in the network. This may not be possible in scenarios where the network boundaries are dynamic in nature.

Scalable location update routing protocol (SLURP)

SLURP [5] are routing protocol in which somehow similar to ZLHS the nodes are grouped into a number of non-overlapping zones. However, SLURP [Scalable Routing in Ad Hoc Networks] reduces the cost of maintaining routing information by eliminating a global route discovery. This is achieved by assigning a home region for each node in the network. [5] The home region for each node is one specific zone (or region), which is determined using a static mapping function, f(NodeID regionID), where f is a many-to-one function that is static and known to all nodes.

2.4.2. Position-based routing protocol

Mobile ad-hoc networks change their topology frequently and without prior notice as a result of mobility, makes directing in such networks is a challenging task. [35] Position- based steering algorithms get rid of some of the limitations of topology-based directing conventions by exploiting additional information, ie physical position or area data of the participating nodes in the network. By employing position information or area data, such directing strategy do not need to establish and maintain routes, thereby get rid of routing table construction and maintenance [36]. Geographic routing protocols scale better for ad hoc networks mainly for two reasons:

First, there is no necessity to keep routing tables up-to- date and then no need to have a global view of the network topology and its changes. Nodes in such type of routing protocol determines its own position through the use of GPS or some other type of positioning or location service [35,36]. Position based routing is mainly focused on two issues: one; A location service is used by the sender of a packet to determine the position of the destination and to include it in the packet's destination address and two; A forwarding strategy used to forward the packets [9,34]. By the use of location services and forwarding strategies its performance is much better than topology based routing protocol. It exhibit better scalability, robustness against frequent topological changes [9]. These routing protocols are designed to improve efficiency and performance of the network. Routing is done in a hop-by-hop fashion to forward the data packets. It is designed to handle networks that have many nodes. One advantage of this kind of routing is that it is totally based on local information to forward the data packet, rather than to keep the network wide information. This will lead to much reduced routing overhead and increase the packet delivery rate. [36] Position information of each node is determined by the use Location Services and Forwarding strategies are used to forward the data packets. Several position based algorithms have been presented including DREAM, LAR, GLS, and GPSR.

2.5. Graph theory in AdHoc Network's

Mathematics plays important role various field of studies. One of the important area of mathematics is the thought of graph theory used in structural modeling in different discipline. [38] Even if, the concept of graph theory is old subject it has many absorbing or interesting modern application. Especially in the area of computer science such as data mining, image segmentation, clustering, image capturing and networking [37,38].

In the study of MANETs two areas are of great importance[39]: The first is understanding the fundamental issues like connectivity, scalability and routing and Network modeling and simulation. Since a network topology can be modeled mathematically as a graph of course the Graph Theory play an important role in analyzing these fundamental issues. It is known that the main task of network is to facilitate or ease the communication or exchange of information between nodes. This can happen only when the network is connected. Thus, connectivity is one of the fundamental and most important issues of the MANETs. Most importantly, transmission range and mobility of node affects the connectivity. Some of the concepts of graph theory that are extensively used to study the connectivity issues are graph spanners, and proximity [39]. Scalability is ability to increase the network size and handle properly the growing amount of work without losing quality of services. This is one of the important issues in ad-hoc networks, because, Addition of nodes to the network may cause the network be disconnected to start with. This necessitates topology control [37,39]. Some of the fundamental questions that arise during topology change are how the performance of the network and routing will be affected? A lot of work has been done related to topology control utilizing the graph theory concepts like graph clustering, graph partitioning, and graph evolution [38]. The other topic in transporting the data packets among the nodes of a MANET or even to outside is Routing. The factors which can impact the routing are connectivity, mobility of the nodes and the traffic of the network [36]. Routing protocols in mobile ad-hoc networks are more complex than in static networks. Basically Graph [37, 38, 39] are defined as set which consist a number of vertices and edges, where an edge is a relation between two vertices. In Ad Hoc terminology, a vertex is a node and an edge is a wireless link between two nodes. Mathematically, a graph G is a triplet consists of Vertex Set V(G) , Edge Set E(G) and a relation that associates two vertices with each edge. An edge between two nodes n1 and n2 is represented as (n1,n2) and by using usual notation, E(G) can be written as

$$E(G) \subseteq \{(n1,n2) \mid \exists\, n1,n2 \quad V \text{ and } (n1,n2)=(n2,n1).$$

[39] Two vertices are said to be adjacent to each other, if there exist an edge between them, i.e when they have common edge. Two edges are said to be adjacent to each other, if the one of the end vertex of the edges are same, i.e when they have common vertex. If each edge of a graph is associated with some specific value, graph is said to be weighted graph. The number of edges associated with the vertex is called degree of any vertex v is denoted by d(v). More often than not, the concept of graph theory is hired to model the network topology in the proposed steering engineering or study, So that, the model can be used to form the smaller Districts and to perform routing the proposed architecture.

2.5.1 Network Models

Network in the concept of graph theory can be modeled as Unit Disk Graph, Quasi-Unit Disk Graph, Undirected Graph and Directed Graph [40].

Unit Disk Graph (UDG)

A UDG is a special instance of a graph used to model a network, in which each node is identified with a disk of unit radius r=1, and there is an edge between two nodes n1 and n2 iff the distance between them is at most 1 [40]. The edges, which connect nodes, are drawn as straight lines. This model is very simple yet captures the behavior of broadcast radio transmission, thus it is good for modeling ad hoc and sensor networks. It may be also suitable for modeling ad hoc networks located on unobstructed environments. Moreover, since this model is open for theoretical analysis due to its geometric properties, it is an important playground for the approximation algorithm designers. Although UDG [40] is a widely used networking model, it has drawbacks caused by its simplicity. In real configurations, the wireless transmission may be disturbed by even small obstacles between communicating parties, therefore UDG is not a realistic model for ad hoc networks located on areas consisting of heterogeneous objects. It does not model the signal quality between nodes, so it may result in poor topology control for multi-hop communication.

Quasi Unit Disk Graph (QUDG)

This is another model used to model Ad Hoc networks, in this [40,43] model each node is identified with two disks, one with unit radius r=1 and other with radius q=(0,1]. It can be observed that a QUDG with q=1 is an UDG. The edges between nodes d away from each other are identified with respect to the following rules: First, There is an edge between two nodes if d=(0,q). Second, There is a possible edge connecting two nodes if d=(q,1]) and the third is, There is no edge between two nodes if d=(1,∞]. QUDG [Modeling and Simulation of Mobile Ad hoc Networks] is an extended model of UDG in which probabilistic links can be modeled. Also in QUDG model the effect of the small obstacles located in the network area can be handled by adjusting the q parameter. Although the QUDG model has these advantages over the UDG model, the other disadvantages of the UDG model given in the mentioned in UDG still exists in the QUDG model also.

Undirected Graph

The Undirected Graph [39] model is simple and very common for various types of networks. There are many cases where modeling ad hoc networks with UG is suitable. Also there is significant amount of research on UG model. In this model, the geometric properties of the wireless networks cannot be applied. Thus this model results in more complicated approximation algorithm designs with probably higher resource requirements compared to the models with defined geometric property like UDG. By not assuming a geometric wireless transmission pattern, this model may also be defined as pessimistic. One of the most important disadvantage of this model compared to UDG and partially QUDG is the undirected link assumption where in real networks it may not be realistic. Also in UG, node and edge weights cannot be modeled.

Directed Graph

Directed Graph [38, 40] is an extended model of UG which captures the behavior of the heterogeneous ad hoc networks of nodes with different transmission range. Like UG, DG cannot assume a geometric transmission property and does not model the edge and node weights.

2.6. Representation of Graphs models

In this piece of writing, we introduced some possible representations of charts or graphs with their respective pro and cons, to show that there is no single representation mechanics which may be applicable for all purposes. This results in the requirement for the implementation of algorithms to be applicable to different representations.[41] The explanation of graph suggests to represent a graph as a set of nodes and a set of edges, Some container, e.g. a linked list or an array is used to store the nodes and representing their relationship [39,41]. If there is no additional property maintained for the elements of the container, for example that the directed edges are ordered such that all edges leaving a certain node are consecutive in the container, this representation is normally insufficient to get an efficient implementation of an algorithm: Often it is necessary to have efficient access to the edge incident to a certain node or to have efficient access to the edge incident to two nodes. There are many different representations of graphs. Here are some common representations [41]: A graph can be represented as an adjacency matrix, an incidence matrix, a set (i.e. a linked list, an array, etc.).
Of adjacency lists, or one of various representations delineated or described in the coming section.

2.6.1. Adjacency List

One of the flexible way to represent any graph is adjacency lists as shown in figure 2.4:

The graph is represented as a container of nodes and container of edges. There are different ways to implement a representation as a set of adjacency lists. There are several choices for the containers, e.g. singly linked lists, doubly linked lists, arrays, or trees. [41, 42] The choice of the container for the nodes is independent from the choice of the containers for the edges and the containers for the edges can potentially even vary. If a linked list is used, every node stores an adjacency list. Actually, the list is an incidence list as it stores the edges incident to a node and not only a list of the adjacent nodes but this is basically the same if the graph does not contain parallel edges. [40, 42] The distinction is only important if there are parallel edges between two nodes. The adjacency-list representation of a graph [39] G = (V, E) consists of an array Adj of |V| lists, one for each vertex in V. For each vertx v is an element V, the adjacency list Adj[v] contains all the vertices such that there is an edge .(u,v) is an element of E. That is, Adj[u] consists of all the vertices adjacent to v in G.

2.6.2. Adjacency matrix

Adjacency matrix is the other way used to represent the graph. A graph [42] G =(V, E) can be represented as |V| x |V| matrix M = { a_{ij} } called adjacency matrix. The node corresponds to i^{th} row and j^{th} column: The element a_{ij} in the i^{th} row and the j^{th} column is 1 if there is an edge two vertices (vi,vj) and 0 otherwise as shown in the figure(c) [40, 42]. Accessing to the set of nodes in this representation is efficient, the efficiency of access to the set of edges depends on the number of edges present in the graph: Access to the set of edges is only efficient, if there are many edges (E is an element Ω (|V| ^{2}) because the matrix has to be searched for edges taking O (|V|^2) time. If there are fewer edges, it is necessary to maintain additional information, e.g. a linked list, to access the set of edges efficiently.

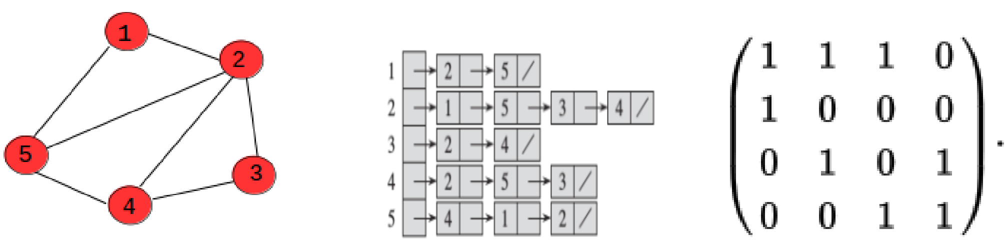
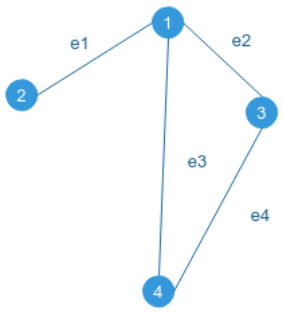


Figure 2.4: Representation of graph; (a) Graph model, (b) Adjacency list of the graph model, (c) Adjacency matrix of the graph model

Likewise, the efficiency of accesses to the set of edges incident to a node depends on the number of edges. The advantage of this representation is the possibility to access an edge incident to two given nodes in time: All what has to be done is to access the corresponding element in the matrix.

2.6.3. Incidence matrix

This is the other method in representing graph, used to represent the relationship between two different classes of objects within graph. If the first class is X and the second is Y, the matrix has one row for each element of X and one column for each element of Y [39]. Such matrix is known by representing the relationship between vertex and edge, referred as vertex-edge incidence matrix as shown in the figure 2.5. The entry in row and column is 1 if the first and second are related, that means if there is a relation between the edge and the corresponding vertex and 0 if they are not [38,39].



$$\begin{pmatrix} 1 & 1 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 \end{pmatrix}.$$

Figure.2.5: Graph model and its incidence list

Each representation mechanics has their own merit and demerit. Some situations, or algorithms that we want to run with graphs as input, call for one representation, and others call for a different representation. Selection of the appropriate representation methodology is depends on three criteria including:-

1. How much memory, or space, we need in each representation.
2. How long it takes to determine whether a given edge is in the graph.
3. How long it takes to find the neighbors of a given vertex.

More often than not, [53] The following table summarize the time complexity cost of per- forming various operations on graphs, for each of these representations, with |V| the number of vertices and |E| the number of edges

2.7. Forwarding strategies

The doctrine of position based directing convention is necessary to determine the area data of the goal before a parcel can be sent, location services take such kind of duty. While reasoning about the rule of directing in various kinds of networks, it is appropriate to consider two different activities, firstly, determining the optimal course data and secondly, transferring or imparting the information groups (called packets) through an internetwork.

Operation	Adjacency list	Adjacency matrix	Incidence matrix
Represent the graph	O(|V|+|E|)	O(|V| ²)	O(|V|.|E|)
Add vertex	O(1)	O(|V| ²)	O(|V|.|E|)
Add edge	O(1)	O(1)	O(|V|.|E|)
Remove vertex	O(|E|)	O(|V| ²)	O(|V|.|E|)
Remove edge	O(|E|)	O(1)	O(|V|.|E|)
Query: are vertices x and y adjacent?	O(|V|)	O(1)	O(|E|)

Table 2.3: Comparison of Graph representation

The later concept is called as packet switching or forwarding which is straight forward, and the path determination could be very complex[1]. It is just an act of pushing a packet through an interface. There are three main packet forwarding strategies for position-based routing: [36] greedy forwarding, restricted directional flooding and hierarchical approaches, which will be discussed in the following section.

2.7.1 Greedy Forwarding

A greedy as its identification speaks, always makes the choice that looks best at that moment or it is just a rule that builds up a solution piece by piece, always choosing the next piece that offers the most obvious and immediate benefit. It makes a locally optimal choice in the hope that this choice will lead to a globally optimal solution. Such concept are applied on the routing protocol i.e greedy forwarding. Greedy forwarding is one of the main strategies used in geographic routing protocols. [44] Using greedy forwarding, the sender node includes the approximate position of the receiver node in the packet header, such information is gathered with the aid of appropriate location service. [36] When halfway nodes acquire a parcel it will forward it to a neighbor closer to the destination than itself. These process carried on until it reaches the final destination node. However, there is possible situations where greedy forwarding rule goes wrong, i.e if there is no any halfway node that is much closer to the destination than itself [36, 44]. In such case, recuperation or recovery plan of action or strategies is employed to deal with such failure. One of such recovery technique is Face Routing discussed latter. Several greedy forwarding strategies utilize few steering procedures, defined in terms of progress, distance and direction towards the destination.

Progress

Progress [36] is the distance between source node S and the projection neighbor node A' of a neighbor node A onto the line connecting source node S and destination node D as shown in figure below). As the distance is becoming larger, the neighbor progress to the destination will be more. One of the algorithm which uses this principle is, the Most Forward within Radius (MFR).

Distance

Distance [44] is another greedy strategy, which applies the same principle as progress, however it uses the notion of distance, and more specifically, the Euclidean distance. That is, an intermediate node forwards the packet to the neighbor with least distance d to the destination, who is closer to Destination D than Source S as node B in Figure 2.8

Direction

Direction-based [46] greedy strategies are also called compass routing, which uses the deviation as a criterion. The deviation [36] is defined as the angle between two lines: the line connecting the current node and the next hop, and the line connecting the source and the destination. The deviation is used to select the neighbor closest in the direction to destination D as node C in Figure 2.6.

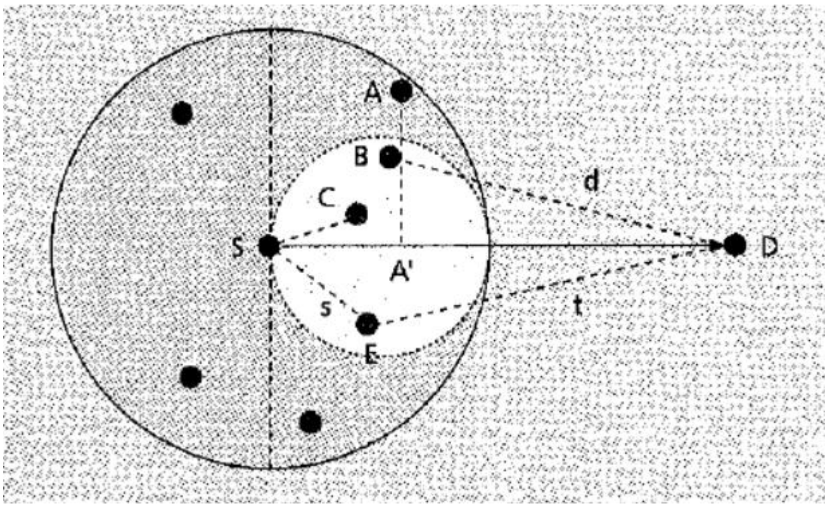


Figure 2.6: Greedy routing strategies based on progress, distance and direction [36]

2.7.2. Restricted directional flooding

In this type of forwarding [36] scheme the source node forward the packet to all one-hop neighbor in the direction of the destination node. The source node calculates the region to determine the direction that likely contains the destination node. The region is referred as expected region as shown in figure 2.7 The region [36,44] is a circle around the position of the destination node as it known to S. However the position information of may be obsolete due to the movement of nodes. The radius r of the expected region is set to $(t_1)-(t_0)V_{max}$, where t_1) is the current time, t_0) is the timestamp of the position information Source has about Destination node. And V_{max} is the speed of the node moving in Ad Hoc network. As shown in the figure 2.9 the direction toward the destination node D is defined by line Source node S and destination node D and the angle Φ. so each neighbor node iteratively perform this operation until it reaches to the destination.

2.8. Recovery Strategy

2.8.1. Face routing

As examined in section 2.7.1, the main problem of greedy routing is it doesn't guarantee delivery of the parcel to the goal node even if there is course towards to destination.

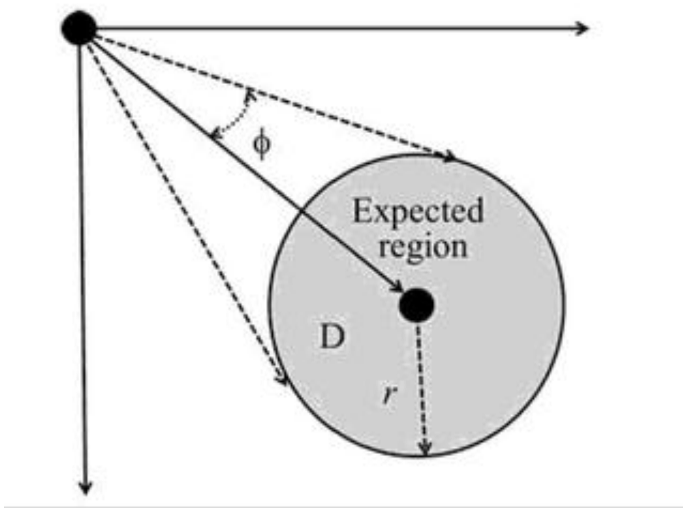


Figure 2.7: Principle of restricted directional flooding [36]

In such case recuperation mechanics is required to assure the delivery of message. One of such recovery mechanism is Face routing. Confront or face directing rules is a recovery mechanism in wireless ad-hoc networks. In Geographic routing principle this face routing is used in conjunction with the greedy routing.[47] It only uses area data or location information of nodes and it provably guarantees message delivery in static connected plane graphs. However, a static connected plane graph is often difficult to obtain in a real wireless network. Most of the face routing techniques are based on the concept of graph planarity.

Planar graph

The graph formed by any type ad hoc network is mostly not planar, Because the transmission range of each node contains all the other nodes and this will result with crossing edges in the network, therefore, the graph is not planar [44]. For this reason, before planar graph routing can be performed, a planar subgraph must be extracted from the absolute network graph. A planar graph is a graph which can be embedded in the plane, i.e., it can be drawn on the plane in such a way that its edges may intersect only at their endpoints. [39]. Given an embedding of a planar graph in the plane it created small region, such region of the plane that is connected when the edges are removed a face. The outside is also a face as shown in the figure 2.8 below.

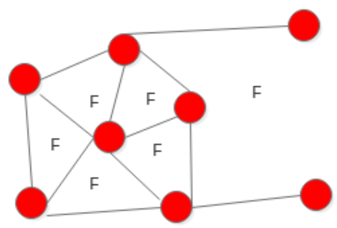


Figure 2.8: Planar graph with its respective faces

Three different techniques were developed that are used to locally build up a planar graph from the complete graph [75]. By employing these techniques, each node is given a consistent view on the planar graph by removing those outgoing edges that do not comply with the criteria applied to the construction of the planar graph.

Gabriel Graph (GG):- A node keeps all outgoing edges n1n2 that form a circle with diameter |uv| that passes through u and v and there is no other neighbor node in between [36].

Relative Neighborhood Graph (RNG):- A node u keeps its outgoing edge uv if circles with centers u and v and radii |uv| contains no other node than v [26] as in Figure 2.9 (b) [34].

Localized Delaunay Triangulation (LDT):- Each node calculates the Delaunay triangulation on its own set of neighbors. The Delaunay triangulation contains all triangles with the following condition: the circle passing through the triangle end points does not contain any other node as in Figure 2.9 (c) [36]. Now among all its outgoing Delaunay edges, each node preserves all of those that are preserved by the node on the other edge end point as well.

Once the planar subgraph is constructed using the above techniques, then the face routing can be performed. The main idea in face algorithm is to forward a packet along the interiors of a sequence of adjacent faces that are intersected by the straight line SD connecting the source node s with the destination node p1,p2 as shown in Figure 2.10 , which are providing progress to the destination D.

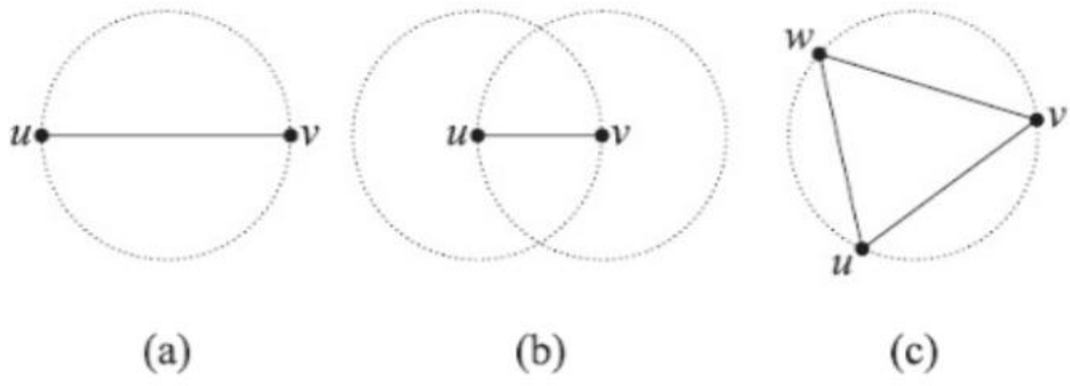


Figure 2.9: planar graph based on (a) Gabriel graph, (b) relative neighborhood graph, and (c) Delaunay triangulation adopted [36]

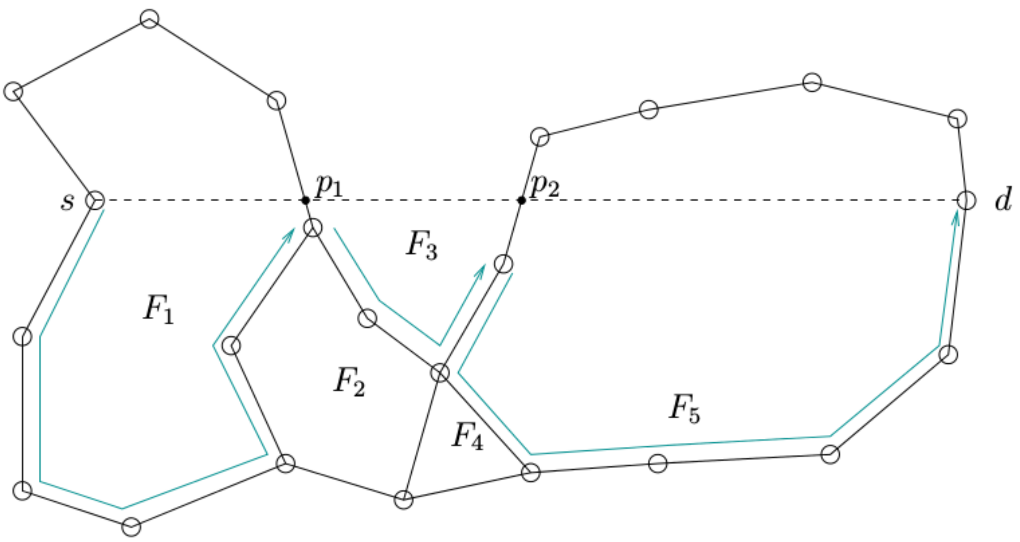


Figure 2.10: Face routing adopted [47]

2.9. Related Works

This section of the study present review on literature pertaining steering conventions in wireless ad hoc networks.

Nicklas Beijar[22] was the first one who discuss the problem in proactive and reactive routing protocol. Proactive routing uses excess bandwidth to maintain routing information, while reactive routing involves long route request delays. Reactive routing also inefficiently floods the entire network for route determination. So they propose ZRP protocol, which address the problems of proactive and reactive by combining the best properties of both approaches.

Number of node /Node density has genuinely shown the effect on the performance of the ZRP protocol [26]. As the compactness, changes ZRP attribute Zone radius has to be changed to get good performance. Result shows that configuration of Zone radius according to what type of application in which we use ZRP protocol. The high-density increases may increase the discovered services but it deteriorates there quality in terms of availability.

Simulation is carried out in [26] using Qualnet wireless network simulator. The study assumes random way point mobility model and constant bit rate to simulate the movement of nodes and the network traffic within the simulation area respectively with variable pause time. Results depicted that throughput of the ZRP having smaller zone radius decreases as compared to ZRP having higher zone radius as the node density increases. The possible reasons are as node density increases number of neighbor around the node increases and number of zones in the area increases.

Study in [24] analyses the performance of ZRP by using OPNET simulator , varying the number of nodes(i.e. 20,40,60) in three different scenarios of mobile nodes. The pause time and traffic load are kept constant under all the scenarios. The result shown that with the increase in number of mobile nodes ZRP gives high throughout. Overhead increase with increase in nodes with high overhead, the delay is also high but this study doesn't consider the effect of zone radius on the performance.

Study in [28] shows that the ZRP has been simulated and evaluated with respect three performance metrics under varying the node density and varying zone radius by fixing other simulation parameter fixed such as the size of network, pause time, maximum speed of nodes and transmission rate are constant. Experimental result shows under varying node density the performance decrease significantly in terms of two metrics, i.e throughput, routing overhead) and low zone radius (for radius 2,3 and 4 hops provides better result in terms of throughput and routing loads, whereas high zone radius provides less end-to-end delay but the study doesn't mention the optimal values in relation to network size and radius for this protocol.

Result from [48] the dependence of proactive Intrazone Routing Protocol (IARP) control traffic on the routing zone radius. The reactive IntErzone Routing Protocol (IERP) performance is demonstrated by the average traffic produced by each route query. The total ZRP control traffic (i.e., the sum of the control packets from the Intrazone and interzone protocols), gives an indication of the performance of our hybrid routing scheme. The amount of control traffic depends on both node mobility and route query rate. Since this research mention theoretical aspect of the zone radius it doesn't point out for what optimal zone radius the protocol has better performance.

Ranga Raju and Mungara [49] presents enhanced ZRP route computation strategy for wireless Ad-hoc networks. The improvement was done to the original ZRP protocol in the areas like quick route reconfiguration, route acquisition delay, low mobility scenarios is implemented. The model of standard ZRP, which has overlapping query messages. These messages overload the system and degrade the system efficiency. Hence the query control mechanisms proposed in [49] allow ZRP to offer routes to all accessible network nodes, with less control traffic than purely proactive link state or purely reactive route discovery, and with less delay than conventional flood searching. Simulation in this study shows that, enhanced ZRP has better transmission delay, route convergence time, the last packet reception time, system efficiency and system throughput.

Husain et al. [50] is attempted, to evaluate the performance of three routing protocols, two from topology based (AODV and DSR) and the other from position based routing (LAR), were evaluated for vehicular ad hoc network. The three protocols were tested against node density for various metrics. It is found that position based routing protocol (LAR) outperforms topology based routing protocols (DSR and AODV) in different VANET environment. For most of the metrics LAR has the better performance. Overall, it can be concluded that position based routing protocol gives better performance than topology based routing protocols in terms of packet delivery ratio, throughput, and end-to-end delay for Ad Hoc network.

According to Ranjan et al. [51] simulation study has been conducted using network simulator QualNet 6.1 for the performance comparison of FSR, LAR1 and ZRP protocols. There is an improvement in ZRP when compared to other protocols. Hence the study conclude that ZRP is best when compared to all other routing protocols and suitable for low mobility but it experiences very high average end-to-end delay with high mobility.

Extensive simulation [55] experiment has been done in order to compare the performance of three MANET routing protocols i,e AODV, OLSR and ZRP. The purpose of the simulation was to compare the efficiency of these routing protocols under different network state and network size using three performance metrics, Packet delivery ratio, end-to-end delay and throughput. Result shows that in a Low density network, AODV has a better packet delivery ratio. Far more with the increase in number of nodes, packet delivery ratio of OLSR and ZRP drops significantly. This could be due to their proactive nature, which introduces many control overheads when the network size grows, leading to higher packet losses and consequently lower packet delivery ratios. AODV and OLSR have the lowest average end-to- end delay. ZRP has significantly higher end- to-end delay. Furthermore AODV has a relative good throughput while ZRP has a poor throughput in the low density network. These results suggest that ZRP is best suited for small network size.

In a High density network [55], AODV has a best performance in terms of packet delivery ratio; while OLSR has performed relatively better in terms of packet delivery ratio as compared to ZRP. AODV and OLSR have the lowest average end-to-end delay while ZRP has significantly high average end-to-end delay. In High density network of up to 150 nodes, the AODV and OLSR has approximately same throughput but after 150 nodes the throughput of OLSR dropped sharply. Again it is due to proactive nature, which introduces many control overheads when the network size grows, leading to higher packet losses and consequently lower throughput.

In th study [56] representative protocol has been selected from proactive (i.e OLSR), reactive (i.e AODV) and hybrid routing (i.e ZRP) to compare the performance, From the simulation Examination, it can be determined that the performance of OLSR which is a proactive protocol is best when we compare on the basis of jitter. AODV has the poorest performance amongst the three protocols examined. ZRP which is a hybrid protocol has moderate performance, but as the number of nodes increase to 80 an more its performance deteriorates considerably, so ZRP can be used for small networks.

From the above related work, we understood that, combining distinct philosophies, where each of them are applicable for specially appointed antithetic system, i.e. Hybridization, is good chemistry to have better routing process. As a result of this, we proposed a methodology that comprehensively consolidate different directing guidelines. The major distinction between our methodology from the existing hybrid routing philosophy, in addition to handling distinct network size arrangement, it is devised to combine routing principle from different sort of steering/routing protocols of MANET, i.e. topology-based and position-based routing protocols. The following chapter discuss detail of the proposed steering methodology

Chapter Three

Proposed Model and Algorithm

In this study an attempt is made to consolidate distinctive directing methodology, that works productively crosswise over extensive variety of operational condition and system arrangement in Ad Hoc network, i.e. convention Hybridization. At all the more encouraging rule for hybridizing diverse directing methodology is quite recently to have the base convention which works all the while in various extension. Let say we have given more than one convention, every convention is most appropriate for various Ad Hoc network Scenario, this give a sense to gain by every convention's quality by consolidating them into single structure.

3.1. Proposed Framework

In the proposed framework two distinctive steering routing standards or principles are combined, i.e. from topology-based and position based directing standard. The principle distinction between this routing framework from the current mixture directing structure is recently unified to handle both little network Scenario's and extensive-measure (large network) network Scenario. Be that as it may, the current steering conventions join directing standards in one sort of directing convention particularly Topology-based directing convention. One of the outstanding Hybrid topology based directing convention is Zone Routing Protocol, which joins the best element of proactive and responsive steering convention where the execution degrade as the network size is expanded. By not embracing or applying both convention together, such approach free its ability on the potential execution, Obviously which would improves the directing convention singular convention for given system given situation. Figure 3.1 delineates the proposed model for District-Based Proactive-Geographic routing protocol is two layered. And comprehensively joins proactive and position-based directing standard.

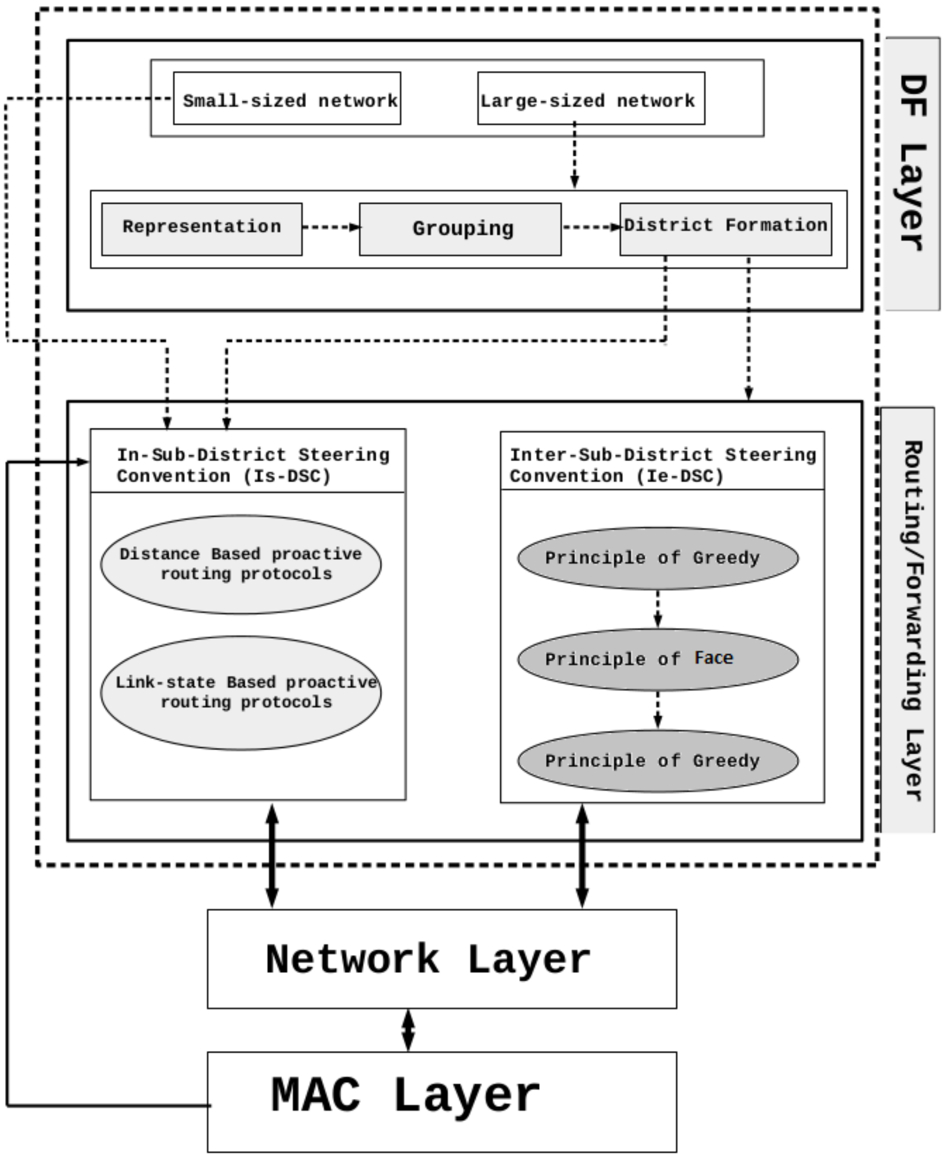


Figure 3.1: The layered Architecture of DB-PGSC

The scope of proactive steering methodology is limited within smaller districts , referred as In-Sub-District Steering convention (Is-DSC) , in view of Distance vector and Link-state, where as any correspondence between nodes in various district or region can be completed by utilizing position-based directing with the assistance of succession of Greedy and face steering approach, known as Inter-sub-area (Ie-DSC) Routing Protocol. The DF layer is designed to divide the large size network into multiple smaller networks called districts, and to do so the layer is equipped with three facilities which facilitates distinct district formation, Representation, Grouping and district Formation The bottom layer is forwarding or routing layer which consists of Is-DSC and Ie-DSC for communication. Each of this is described below in the remaining part of the chapter.

3.2. District Formation Layer

3.2.1 Representation

We demonstrated the topology of the network as accumulation of focuses in 2-Dimensional Euclidean space, where the point speak to a nodes and the line fragment between the nodes is utilized to speak to the remote connection. Subsequently we utilized less complex Graph display used to extract these topology as appeared in the figure 3.2. Graph are utilized to speak to numerous genuine application, for example, network as portrayed in [37,38], so the network is displayed as network Graph. Diagram should be spoken to in a path reasonable for Computers. So in the proposed Architecture we embraced one of the representation mechanism, i.e. Adjacency List for speaking to the chart as appeared in the figure 3.3(b). As Described in section 2 of this thesis report the main purpose behind selecting such system from the other diagram representation is because of its straightforwardness and the time it takes to speak to the entire network Graph.

Now we gave an algorithm, REPRESENTATION, which is utilized to speak to the network chart in the frame appropriate for Computer handling. The information parameter for these calculation is the aggregate or the total number of nodes in Val(nn) and the Number of neighbor of different nodes in the network. The Output is representation of the network topology as List.

As it is specified in the algorithm, it will takes the extent of the network that implies the aggregate number of nodes, and the quantity of neighbors of nodes in the network with the end goal that it makes the nodes and embed it into a rundown or summing up into called TOPO REP LIST. TOPO_RE_LIST comprises of neighbors node of every node in the network as appeared in the figure 3.3(b).

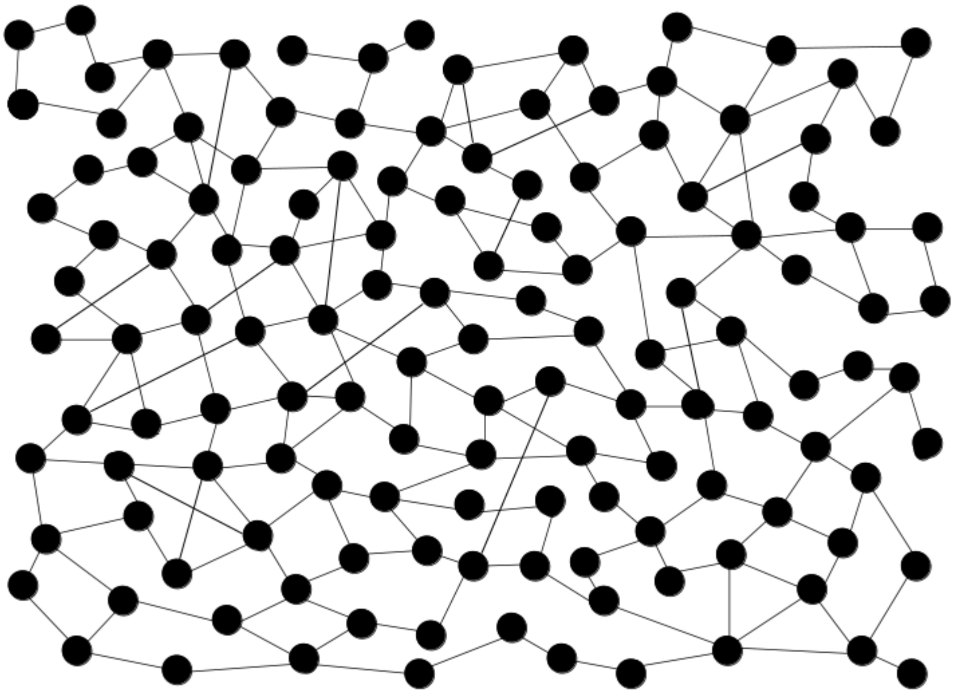


Figure 3.2: Representing Network topology as Graph

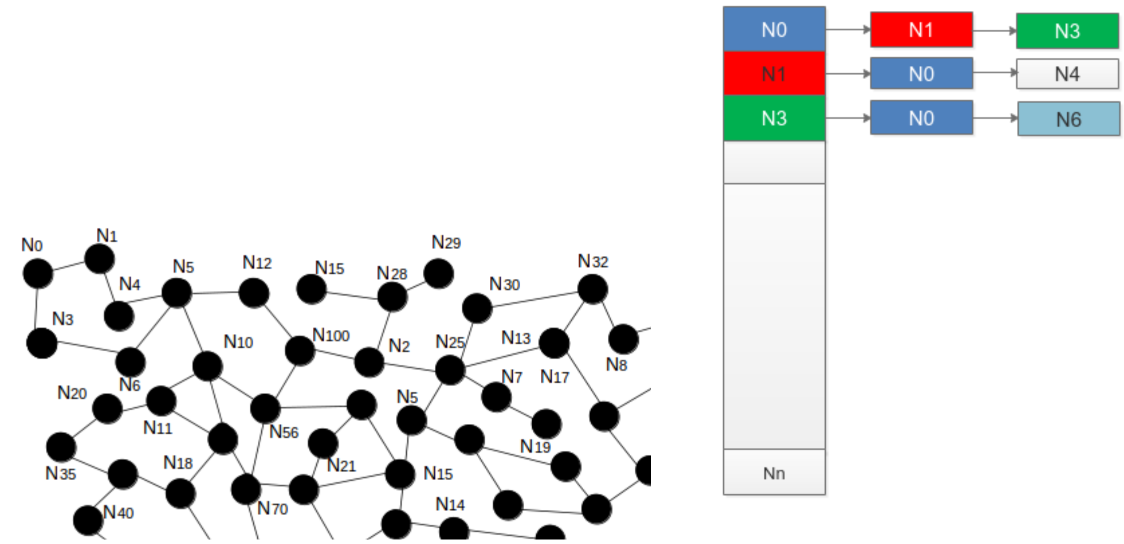


Figure 3.3: Representation (a) Network graph (b) Adjacency List of the graph

Algorithm 1: REPRESENTATION

```
Input: Total Number of node Val(nn), Neighbor nodes of
       nodes Val(Neighbor_node)
Output: Representation of the topology TOPO_REP___
        LIST[nodes]
  for i ← 0 to Val(nn)do
    Val(Neighbor node) ← Enter Number of Neighbor for each
    node
    for j ← 0 to Val(Neighbor node)do
      node (j) ← create node
      TOPO_REP_LIST[nodes] ← INSERT(node(j))
    end for
  end for
```

3.2.2. Grouping

MANET is ordinarily one of remote specially appointed network in which the nodes bolster multi-hop steering. At the point when the accessible number of nodes in the network is huge the neighbor nodes might be near each other. For this situation transmission control level for correspondence with neighbor kept low. The second movement after representation is gathering. Gathering is a strategy for collaboration between hubs where nodes in a similar transmission range or nodes which are near each other are assembled together to frame area called District, in the proposed steering model. It is realized that gathering nodes gives better execution to the gathering and to the entire system, in this way maintaining a strategic distance from pointless message sending and extra overheads. Gathering nodes can streamline the node arrange. Gathering of nodes might be based on area, neighborhoods, work, reason, location and others. Henceforth in the proposed directing engineering just neighborhoods are utilized as essential criteria to gathering nodes together to frame various smaller region. Below we provide an algorithm that execute Gathering of nodes.

The general thought of the above algorithm is clarified following after. To gather nodes the algorithm takes TOPO_REP _LIST, No of Nodes in district nn, that implies the quantity of nodes to be assembled or gathered together and Total Number of nodes

Val(nn), i.e. the network estimate as information. In light of the last two data, that implies organize measure and the nodes number to be assembled, the calculation processes the quantity of locale Num_ Region(n), which is acquired by isolating the aggregate number of node.

Algorithm 2: GROUPING

```
Input:  TOPO__REP__LIST, No of nodes in region nn, Total
        Number of node Val(nn)
Output: Group of Nodes(MemberList of [di])
    District(n) ← Val(nn)/nn
    D={d1, d2, d3, ...dn }
   for i←1 to Num_Region do
     Select node with minimum ID node(MIN)
      if node(MIN) is in TOPO_REP_LIST then
       while di != nn do
        for j←1 to Val(Neighbor node) do
         if node(j) is in di then
           MemberList of [di] ← node(j)
         else
           stop
         end if
            FIND neighbor of node(j) in TOPO_REP_LIST
       end for
      end while
     else
         Print No Such Node exist
    end if
   end for
```

with the quantity of nodes to be gathered together as in the third line of the calculation or the algorithm. With the end goal that each of these locale are spoken or expressed to as in the fourth line of the calculations. For best execution the GROUPING algorithm choose a node with most reduced or least index. On the off chance that the chose node exist in the TOPO_REP_LIST [Nodes] the calculation begins to gathering its neighbor node and it individual neighbors amass or accumulate their neighbors until the nn is fulfilled as it is appeared in the figure 3.4, that is node within a similar gathering appeared with a similar shading or region. There is a case with the end goal that the node might be taken in another area so that the calculation proceed to the following stride (step).

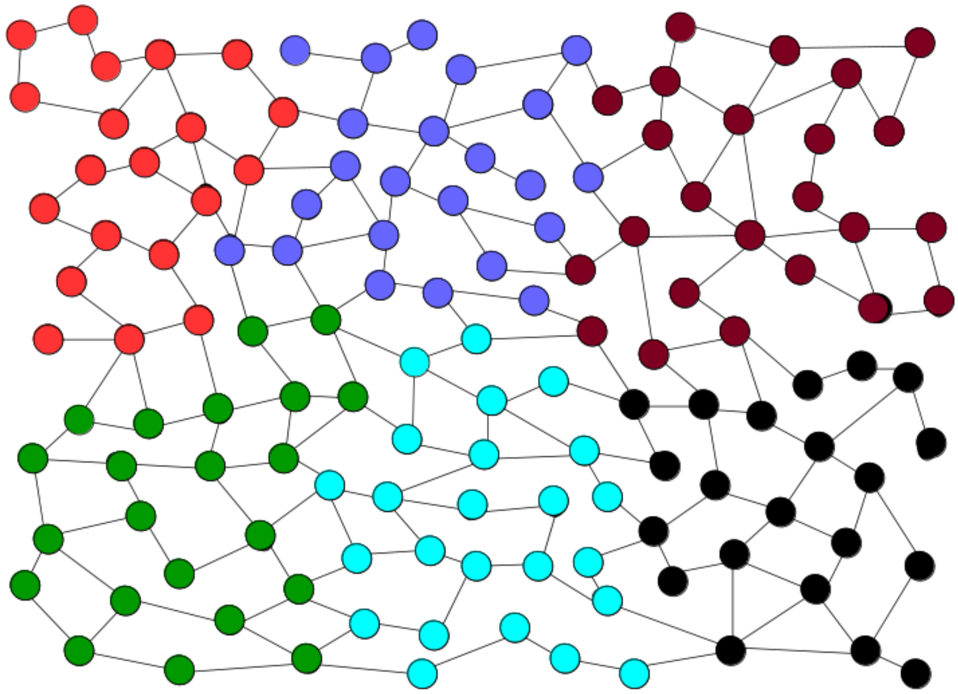


Figure 3.4: Gathering neighbor nodes

3.2.3. District Formation

The last usefulness of the top layer of the proposed Model for District Based Proactive-Geographic Routing convention is recently to frame the district utilizing the nodes gathered by the Grouping usefulness. Steering in portable impromptu systems ought to be productive and asset sparing [52]. Be that as it may, as size of the system become large the relating steering table of the nodes of node likewise develops relatively. Thus, the proficiency of the steering convention will be influenced either certainly or unequivocally (unambiguously).

Furthermore, Resource utilization likewise develop relatively. So to minimize the directing passage, that implies steering overhead, and to enhance directing assignment for various system situation the proposed model of District based proactive-Geographic Routing utilize area arrangement, i.e District formation. The accompanying algorithm portray or represent how district are shaped from the yield of the GROUPING Algorithm (i.e. MemebrList[D_i]).

Algorithm 3: DISTRICT_FORMATION

```
Input:   Group of Nodes MemberList of [Di]
Output:  Districts D={D1,D2,D3,...Dn}
D={D1,D2,D3,...Dn}
         for i ← 0 to n do
             Di ← Find the nodes in MemberList[di]
             Makes nodes in MemebrList[Di] in the same
         region
   end for
```

DISTRICT_FORMATION, the algorithm takes group of nodes from the result obtained from GROUPING. Then it finds nodes in the MemberList[di], afterward it makes those nodes in the same MemberList[d_i] in the same region as shown the figure 3.5.

3.3. Routing Layer

The base layer is eluded as the Forwarding layer which is amiable while the nodes yearning to transmit. Clearly, the fundamental goal of any directing convention is to give ideal course between nodes with sensibly less overhead. As it is talked about in the past section of this thesis diverse Mobile Ad Hoc directing convention (routing) have been created by the steering data utilized as a part of the parcel sending. One is Geographic Routing, such directing families utilizes physical location of nodes to forward the packets whereas topological based steering utilizes the topology of the network while sending. In this way, the proposed directing model or engineering joins these to steering systems: Proactive and Geographic directing convention as appeared in figure 3.1.

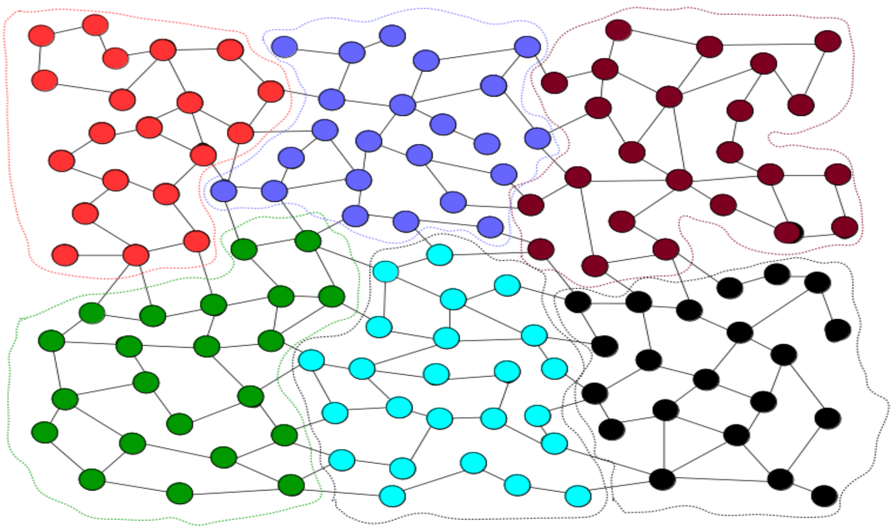


Figure 3.5: District Formation

3.3.1. In-Sub-District Steering Convention (Is-DSC)

In-sub-District steering conventions are separation based or interface based proactive directing conventions which permit a network nodes to utilize the steering/routing table to keep courses data for every other node inside district. In DB-PG directing model it is accepted that every nodes keep up two diverse table. The main table is called Path-table, this table keeps way/path to every other node inside a district or region, every section in the table join the following middle of the road node or intermediate node utilized as a part of the way to the goal, dismissing whether the line is really essential or not [53]. The table is overhauled or maintained frequently to demonstrate the network topology changes, and should be communicate occasionally to the neighbors. Therefore, way to goals nodes will dependably be open when required. This directing conventions usually rely on upon most brief way calculations to figure out which path will be sent bundle to the proposed goal. The second table is Location Table which keeps geographic or physical information of node within its region, i.e, destination x-coordinate and y-coordinate.

This information is obtained either by location services such as Global positioning system (GPS) or other type positioning services [35, 36, 44]. Locationservices is used by the sender of packet to determine the position of the destination. Nodes in MANET move subjectively throughout a network, accordingly,
connection or link breakage would happen while nodes move. Keeping in mind the end goal to identify new neighbor nodes and connection disappointments, DB-PG directing convention work in-intersection or in collaboration with Neighbor Discovery Protocol (NDP) gave by the Media Access Control (MAC) layer as appeared in the figure 3.1. Neighbor Discovery Protocol (NDP) pass on “HI” guides message at endorsed or consistent interims. After getting the message, the neighbor node upgrade its table.
In the event that nodes doesnot get the guide message inside recommended interim of time, it will be expelled from the table. Be that as it may, if the MAC layer does exclude a NDP, then the common sense is offered by Is-DSC as in the Zone Routing protocol (ZRP) [22]. So the course upgrade brought about by NDP which tells Is-DSC when the neighbor table is overhauled.

3.3.2. Inter-Sub-District Steering convention (Ie-DSC)

Inter-sub-District steering convention are second routing components of the District-Based Proactive-Geographic (DB-PG) directing convention. Between sub-district directing conventions are second steering parts of the District-Based Proactive-Geographic steering convention (DB-PG) which utilize the utilization of area data, i.e location information to forward the bundle starting with one locale then onto the next locale. Not at all like, Is-DSC, Ie-DSC doesn't require up and coming directing table development and upkeep And it is likewise superfluous to have worldwide perspective of the network topology and changes, because of these two primary reason they scale better.

Greedy Algorithm

Ie-DSC has two sub directing part utilized while sending the information bundle when the two imparting/transmitting nodes dwell or lie in various district. A grouping Greedy and face directing rule utilized, i.e Greedy-Face-Greedy. As examined in section 2, this sending strategy dependably settles on the decision that takes a frequent solution and there it is only a decide that develops an answer piece by piece, continually picking the following piece that offers the most evident and quick advantage. Furthermore, it utilize a few steering procedure (i.e Progress, Distance and Direction). Ie-DSC utilize the idea of separation to locate the ideal arrangement when the source node has no data about how to send a parcel or packet to the goal/Destination. Geographic directing convention accept that the source node knows the physical area of the goal/Destination node [36,44] , so receive this rule. The accompanying Algorithm clarify the eager guideline of Inter-sub-locale directing convention. at the point when the source node needs to forward a bundle/packet to other node in the network, it first check in its Path Table to discover a course or path to the goal, if the way discovered DB-PG steering convention will enlist Is-DSC steering standard to forward the parcel But in the event that the way is not known to the goal the source node realizes that the goal node is in various district, so it needs to discover middle of the road node, i.e Intermediate node that will forward the parcel to other area. The source node will compute the separation/Distance from its area and different nodes area inside the locale to goal since the goal physical area is accepted that known.

In the wake of computing the separation/Distance, the source node chooses a node with least distance, that node is chosen as middle of the road node, the source node send the packet to this node. However there are cases greedy comes up short, that is the point at which the node does not locate an intermediate node with least separation than itself, for this situation Face steering is connected which will be talked about later. The following Algorithm demonstrate the above theoretical calculations.

Algorithm 4: GREEDY

```
Input:  Group of Nodes MemberList of [Di]
Output:  Select IntermediateNode and forward the packet
   if source doesn't know how to send the bundle then
        goto LocationTable
        for each node in i LocationTable do
            Calculate the distance between node i and
            Destination node as D=sqrt[(Xd-Xi)^2+(Yd-Yi)^2]

        end for
        IntermediateNode ← Select Dmin
        Forward Pkt →IntermediateNode
   end if
```

Assume that nodes appeared with the same color dwell within the same district as shown in the figure 3.6. N_0 is source node and has parcel to deliver to N_0 identified as the destination node. As it is mentioned earlier the source node aware of where the destination node lie that means, it knows the X-coordinate and Y-coordinate of N_0. Following are the two table of the source node.

Destination	Nxt_intermidate node	Distance
N_1	N_1	1
N_2	N_1	2
N_3	N_1	3

Table 3.1: Path-Table of Source node of figure.8

Based on the data in the Location-Table the source node calculate the separation from each node in its district, including itself, to other destination. So that the node with minimum distance get the chance to be middle of the road node.

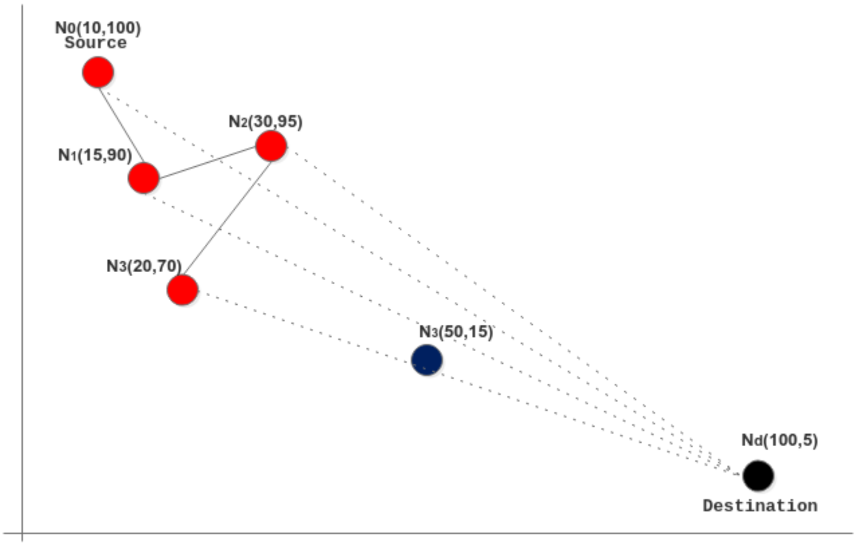


Figure.3.6: Network Graph in 2-D Euclidean space

Destination	X-coordinate	Y-coordinate
N_1	15	20
N_2	30	95
N_3	20	70

Table 3.2: Location-Table of Source node

Based on the formula in the GREEDY algorithm, D $=\text{sqrt}[(X_d - X_i)^2 + (Y_d - Y_i)^2]$, it is found that the distance from N_0 to N_d is 130.86m, from N_1 to the goal node the distance is 120.20, from N_2 to destination node 114.01 And from N_3 to destination node is 103.077. Thus the Greedy select the minimum distance, N_3 will take over the chance to be the middle of the road node than other nodes to forward the packet to the destination. Then after intermediate nodes apply the face steering convention to find node that is closer to the destination than itself. In the following section the authors discussed How Face routing is applied on the intermediate node to forward the packet away from the source node district.

Face Algorithm

Confront steering are recuperation or recovery strategies in land directing conventions which guarantee the conveyance or delivery of parcel from source to the goal and they primarily depend on the idea of diagram planarity and connected on a plane subgraph of the network chart. This directing guideline more often than not utilized as a part of intersection when the node confronts greedy. Because neighborhood least. So, such calculation is utilized as recuperation instrument when greedy fizzles.

In any case, the recuperation procedure comes back to operation directing after it meets a node that is nearer to goal than the disappointment node. The arrival happens either instantly or after some time possible upon the strategy used [47].

Confront steering begin with the development of planar/plane diagram. As it is examined in the past section planar diagram, parcel the plane into a few inward and external faces that are limited by the nodes. The line section between the source node and the goal node crosses a few faces as appeared in the figure 3.7. In face directing, the parcel is sent along the limits of these appearances, i.e along the boundaries of the confronts. A particular face steering convention gives an arrangement of principles to every node to choose where to send a parcel utilizing just the nearby data or local information about its neighbors and the data in the bundle header.

Confront directing utilized as a part of most geographic steering convention develop planar diagram before sending the bundle utilizing the techniques talked about in the past section. However separating or development of planar chart is tedious. Therefore, we received the idea of virtual diagram.

Adroitly, virtual node is included at every purpose of where at least two edges cross, and separated the edges at these virtual nodes. [47] A virtual node can't get or send a parcel basically keep up directing tables at genuine nodes to empower messages to be sent to and from virtual hubs. In this manner, virtual plane diagram will be acquired that comprises of the original node and the virtual node.

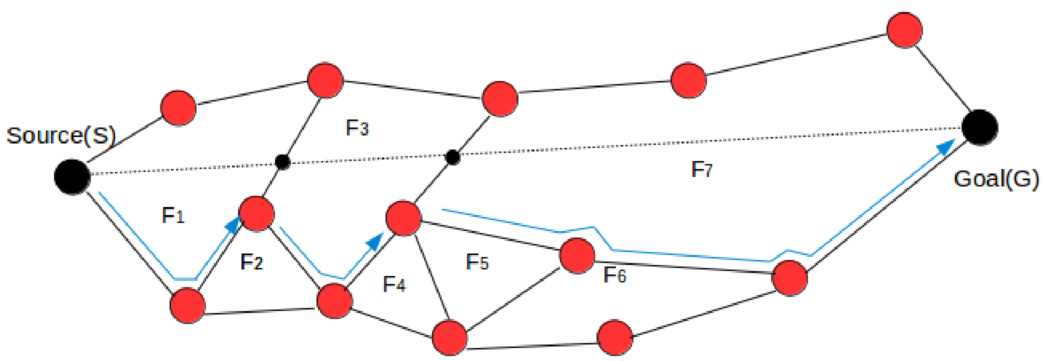


Figure 3.7: Face Directing Guideline

If the first chart is associated, so is the virtual plane diagram, and if confront steering is connected in this virtual plane diagram, it would discover a way to the goal [47]. This way is a virtual way because it contains unrealistic node. Such unrealistic node simply used to figure out the real path that comply the virtual course line in the system or network chart. The accompanying calculation indicates how virtual diagram is shaped from the non-planar chart.

Algorithm 5: VIRTUAL GRAPH

```
Input:  IntermediateNode I_node, link l (i.e. [I,NodeD_j]
Output: Virtual node V_n, Real path R_path and Path from node Di
        to node Dk,
        if there is path  intersect  [Inode ,N odeDj ] then
              V_n ← IntersectionPoint
              [NodeD_j,NodeD_k] ← link contain next virtual link
              D_path ← path from I,nodek
        else
              V_n ← NodeD_j
              [NodeD_j,NodeD_k]  ← next link l
              R_path ← I, NodeD_j
        end if
```

The input to this algorithm is the intermediate ,ie I_{node} obtained from the GREEDY and the path from this node to whatever other node in various district. What's more, the yield is Virtual node V_n , Real way R way and Way from node i to node(Rk). In the figure beneath the node assigned as I_{node} is chosen as halfway node by GREEDY. Since this node has data about nodes in its own particular locale or district. So it doesn't know to which node will forward the bundle. Clearly, nodes which are near the goal are found around the visitor of the district so nodes at the guest are accepted has connection with nodes in neighbor locale. As appeared in figure 3.2, The chart defined by an ad hoc network mostly not planar as a result of transmission orbit of all node, that means, each node comprise all the other node with intersecting edges in the network.

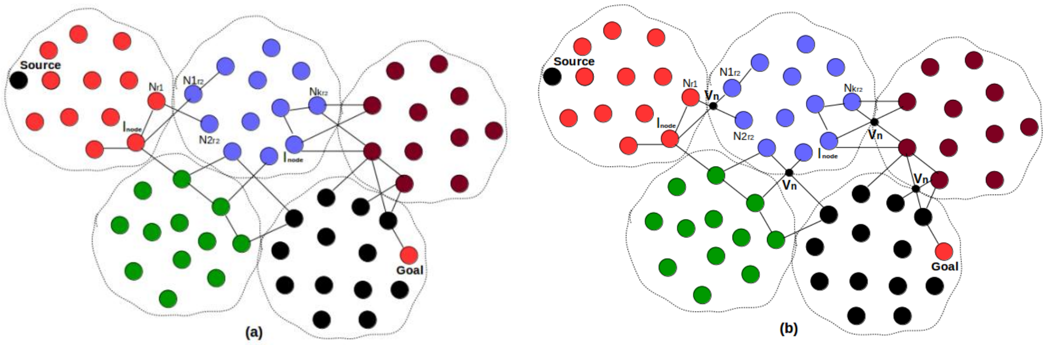


Figure 3.8: Virtual Graph formation (a) nodes with crossing edges (b) After Dis- covering the virtual nodes

In the event that there is another way that cross edge between the half way node and the other node in various locale as appeared in the above figure 3.8. the point of crossing point will be assigned as Virtual node V_n as appeared in figure 3.9 and [NBr1, N2r2] will be the connection the contain the coming virtual connection and R_{path} is the genuine way from halfway node to a Node that cross the first edge, i.e [I_{node} , N2r2] in another area as appeared in the figure 3.9: along which the bundle can be forwarded. On the off chance that there is no edge which cross the transitional node, the virtual node is N2r2, with the goal that it executes the GREEDY.

Once the middle of the road node found , it needs to decide the bearing or direction to which confront the traversal start in light of the fact that At the source node or at a middle of the road node where another beginning stage is found, the node needs to decide the heading or direction of the principal virtual way on the virtual face to be crossed.

The input to this algorithm is the beginning stage i.e. the transitional node of the virtual face to which the traversal start. The main virtual way is on the principal or first way from the line to the goal node in the other district, i.e. in clockwise request around the beginning stage. BUNDLE NAVIGATION allocates the network link that comprise the next virtual link along the boundary of the current virtual face to next.link, allots the beginning stage of the following virtual way to last.node. [I,N odeDj] is the connection that the bundle going to navigate in clockwise.

Algorithm 6: BUNDLE _NAVIGATION

```
Input: IntermediateNode I
    [I,NodeDj] ← way in clockwise direction to be navigated
    [NodeDk,NodeDj] ← next.link
    last.node ← Vn
```

heading beginning from the middle of the road hub to the middle destination N2r2 as shown in figure 3.11, next.link basically stores a path that contain the following virtual way around the limit of the current virtual face ,i.e. it stores away from [$NodeD_k$,N $odeD_j$]; . Furthermore, it is figured at every progression. last.node stores the beginning stage of the virtual way contained in next.link i.e. Vn.

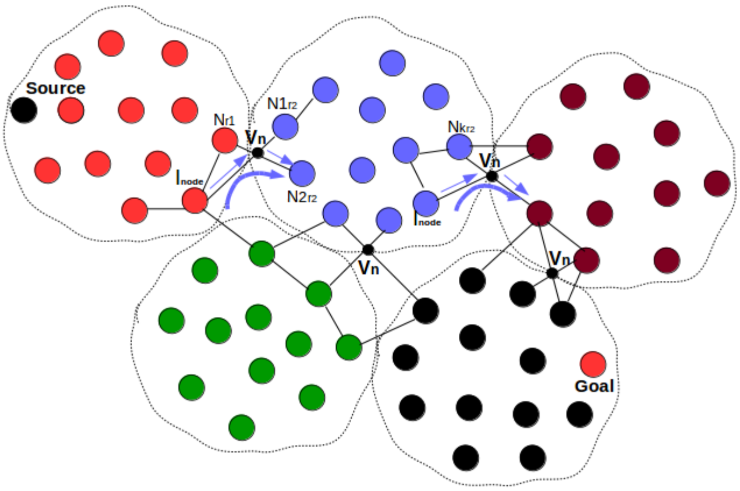


Figure 3.9: Bundle Direction Guideline

The general thought of the District Based proactive-Geographic steering convention as examined theoretical, consolidating two steering convention which follow distinct doctrine. The algorithm beneath depict the directing rule of the proposed steering convention. When the source node has a bundle for other node, which may lie in the same district or outside, Consequently, the source node find out a way how to send the bundle, thus, it checks its path-table, on the off chance if a way is saved in the steering table, the initiating individual apply In-Sub-District steering convention to deliver the parcel otherwise it calls GREEDY- -VIRTUAL GRAPH- BUNDLE NAVIGATION - GREEDY sequentially until the source bundle reaches to the goal node.

Algorithm: District-Based Proactive-Geographic steering convention

```
Input:  Total Number of node Val(nn)
if val(nn) is large then
    REPRESENTATION(Val(nn),Val(Neighbor node),TOPO_REP_LIST[Node])
    GROUPING(REPRESENTATION, MemberList of [Di])
    DISTRICT_FORMATION(GROUPING, Districts{D1, D2,D3,...Dn })
else
     Apply Is-DSC
end if
 if source has packet pkt to send then
    goto PathTable and check if there is way
         if Path found then
                Apply Is-DSC to send pkt
         else
                Apply GREEDY(MemberList of [Di],Inode)
                Apply VIRTUAL_GRAPH([Inode ,NodeDj])
                Apply BUNDLE_NAVIGATION(Inode)
         end if
                until the bundle reaches to Goal node
  end
```

More often than not, the proposed solution is intended to hybridize two different routing guidelines, i.e. topology-based and position-based routing schemes, so as to appear as one single separate routing protocol which operate in small-sized and large-sized network. Where the scope of the routing philosophies limited inside and outside of the smaller districts. Among the algorithms developed for different activities involved, we implement proactive part, based on the routing principle of DSDV and greedy algorithms based on distance difference between two points. In addition to this, the proposed solution has been tested for three scenario, to study how it respond to different network size scenario.

Chapter Four
Simulation and Result

Simulation can be characterized as "Impersonating or evaluating how occasions may happen in a genuine situation".[70]. It can be worried with complex numerical displaying, pretending without the guide of innovation, or blends. The esteem lies in the putting you under sensible conditions, that change therefore of conduct of others included so you can't expect the arrangement of occasions or the ultimate result [69].

4.1. Changes in NS2

NS [73] is "discrete event driven network simulator developed at UC Berkeley that simulates variety of IP networks" and the simulator maintains list of event and executes one event after another. It is embedded to TCL, and it supports to implement the protocols such as TCP, UDS, FTP, CBR, and for router queuing managements such as Drop tail, Telnet.

Since NS-2 [72, 73], support a multi-hop wireless environment, wireless channel module, support the existed module with updated files; like .cc and .h files. NS-2 come up with having all-in-one module then this work is done for mobile ad-hoc network protocols.

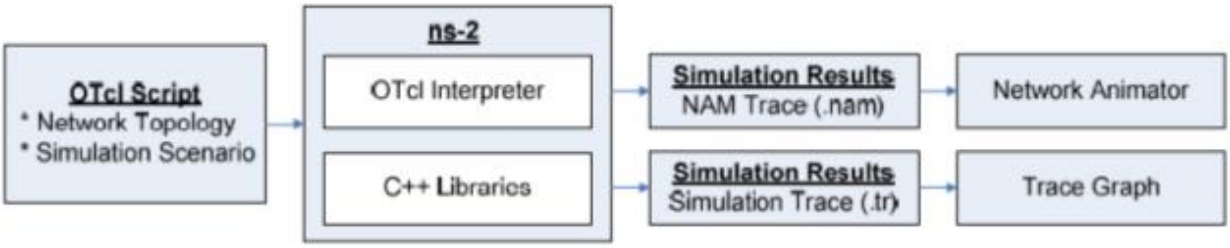


Figure 4.1: NS-2 schema [72]

NS-2 [70] is written in C++ and OTCL (Object-oriented Tool Command Language). The OTCL language's file extension is TCL, in addition to the above good function of NS-2, it supports two languages that are C++ and OTCL, TCL language is also compatible with C++ programing language.

In general OTCL is written by the developer and interpreted by NS-2. During interpreting of OTCL, NS-2 generates two result from the TCL script at the time of simulation [68, 69, 70]. The first is **NAM (Network Animator):** file extensions of .Nam that shows the visual/ animation of the simulation, and the second is;

Trace file: with having .tr file extensions and which records the events occurred in the simulation result. NS 2.35 is used in the simulation which is all-in-one package and installed the package in the Linux environment using Ubuntu 14.04, and we write **.tcl** file extension and the result is analyzed by integrating to another text file.

GOD (General Operations Director); is the body, and its function is for storing an information about the whole environment and status of the network [69]. So we have made some changes while implementing the district based proactive geographic steering convention in MANET.

In general, every routing implementation in network simulator consists of three functional blocks [70,74]: Routing agent, Route logic and Classifiers sit inside a node. The route logic utilize the data collected by routing agents or the global topology database to perform the actual route computation where as the classifiers placed inside a node for packet forwarding[69,70]. When implementing a new routing protocol, one does not necessarily implement all of these three blocks.

The following are the basic steps to implement a new MANET routing protocol (routing agent) in NS2; detailed explanation can be found in [71]:

- Creating a new packet type and declaring the contents of this new packet, then this new packet is bound to a Tcl Interface.
- Creating a new routing agent for the new routing protocol; this is done by creating a new class and then it is bound to a Tcl interface.
- Creating a new routing table for the new routing protocol

The following changes have to be made in the existing NS2 files to integrate the new protocol with NS2:

Common/packet.h - the new packet type must be specified (I.e #define HDR_DBPG(P) hdr_dbpg::access(p)))

trace/cmu-trace.h & trace/cmu-trace.cc- to provide trace support for the newly implemented protocol. void format_dbpg(packet *p, int offset);

tcl/lib/ns-packet.tcl:- adding the new routing protocol to list of existing routing protocols.

tcl/lib/ns-default.tcl:- specifying the default value for the parameter of the routing protocol

tcl/lib/ns-lib.tcl :- add procedure for creating wireless node with the new routing protocol as the routing protocol

queue/priqueue.cc :- setting the priority for routing packets of the new routing protocol

Makefile -- adding the object files, so that the new protocol is compile when NS2 is built.

The proposed solution is implemented in ns2.35. The protocol folder containing files.

Dbpg.h:- declares the function and the header files.

Dbpg_pkt.h:- declares the structure of the new packet (PT_DBPG) for DBPG

Dbpg_rtable.h:- declares the different data structure of the routing table.

Dbpg.cc:- implements the DBPG algorithm discussed in chapter three.

Dbpg_rtable.cc:- implements the routing table and the other data structures for storage

4.2. Testing procedure

Two sets of test are available [73]; the first test is called as tuning tests and the other is the comparison tests. But in this study we only perform the tuning test which mainly aimed at showing the effects of different parameter settings on the performance of the DBPG protocol. Comparison testing is aimed at comparing the performance of two other different routing protocols and left as future work. The same traffic models and mobility pattern is used for different simulation setting.

We have made the simulation on three different simulation setting changing couple of parameters to see the performance of the routing protocol.

The researchers created different scenario to measure the performance of the proposed Solution and the simulations were performed using Network Simulator 2 (Ns-2.35). Traffic used in simulation is TCP. Simulations were done by varying network size (i.e 50 and 100). The key reason of adopting such number of nodes is, [23,25,28] different simulation based studies consider a node 25-50 as small network size and a node improved to 100 are assumed as large-sized nerwork, In our simulation scenario it is assumed that all node are cooperative, secured, there is no malicious node and since the half of the proposed model is left as future work grouping of node is not considered.

4.3.1. Simulation result for Small size network

The first simulation scenario is done by setting the density of nodes to 50 and change the mobility speed of nodes to 50m/s (see table 4.1 below). The simulation were run for 50sec. The pause time was kept constant at 20 seconds in a simulation area of 500mX500m and 1000X1000 for mentioned number of nodes respectively.

Parameter	Value
Simulator	Network Simulator 2 (NS2)
Simulator Area	500mX500m
No. of Mobile Nodes	50 nodes
Simulation Time	50 sec
Mobility Model	Random way
Routing Protocols	DBPG
Traffic Sources	TCP
Max. Speed	20m/s

Table 4.1: Scenario one simulation setting

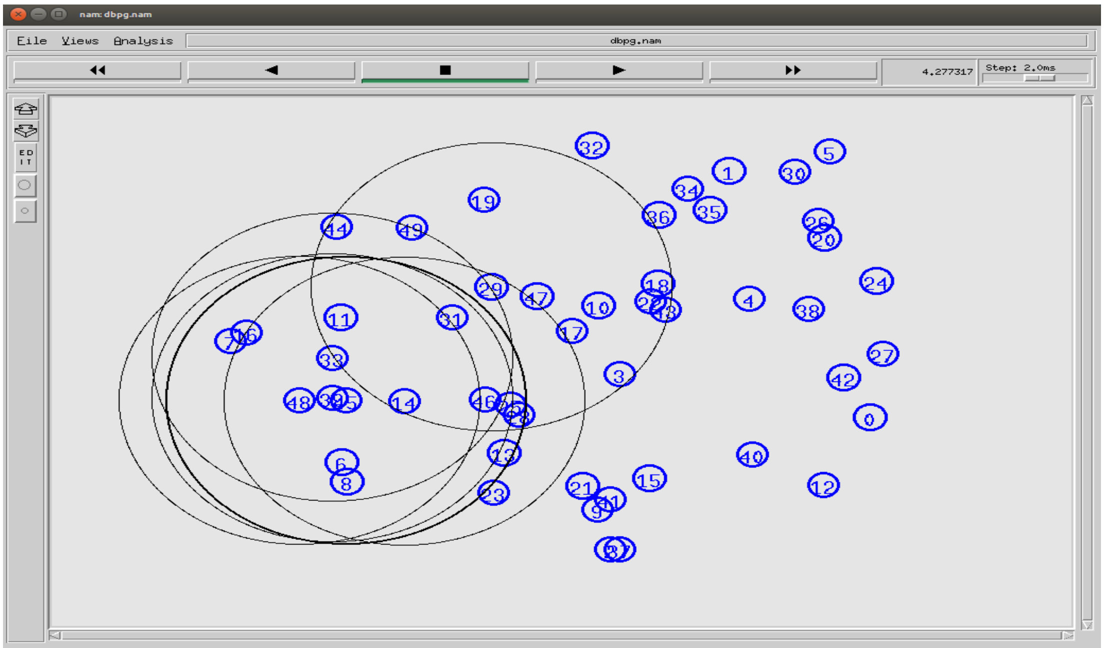


Figure 4.2. Simulation environment during simulation for the above simulation setting

In the simulation it is assumed that all nodes are cooperative, secured, there is no malicious node and since the half of the proposed model is left as future work grouping of node is not considered. Table 4.1 speaks the simulation parameters or simulation setting used during the simulation.

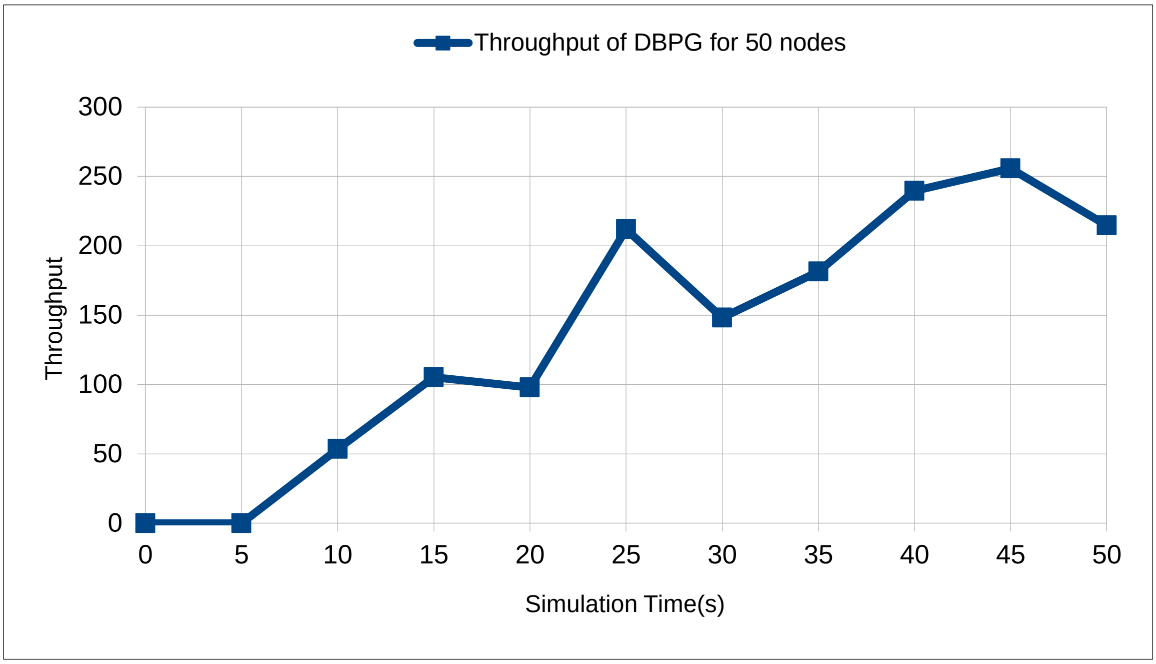


Figure.4.3: Throughput Vs Simulation Time Analysis.

Figure 4.3 shows the result obtained from the simulation based on the proposed routing philosophy. Considering the above simulation parameters the throughput of the proposed solution is almost negligible until the simulation time reaches 5 sec as it is shown in the figure. This is due to dissemination of parcel start at the fifth second. From the time onwards the throughput is progressively increases this is because of the proposed solution entirely inherits the philosophy proactive routing where such ideology performs better than other when the number of nodes is small.

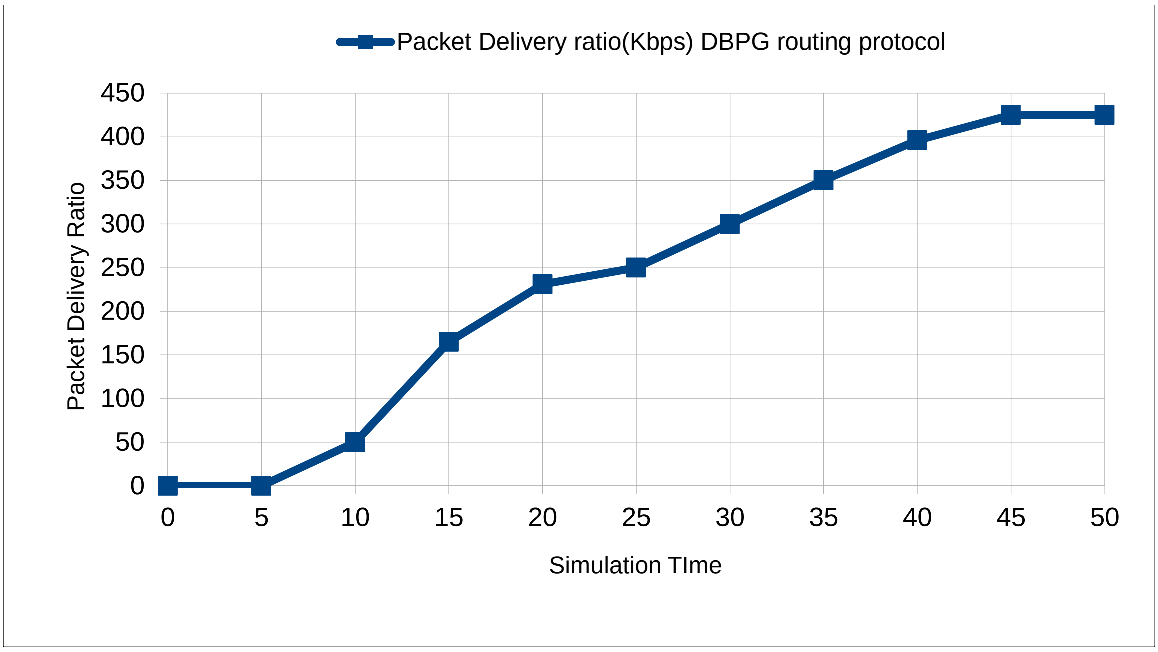


Figure 4.4: Packet Delivery Ratio Vs Simulation Time Analysis

Figure 4.4 depicts the ratio of data packet received by the destination to those generated by the source as it is shown x-coordinate of the graph indicate the simulation time and the y-coordinate speaks the PDR . from the initial second until fifth second the value of PDR is zero because no communication. after the time data dissemination begins PDR of the proposed model increases unpredictably rate.

4.3.2. Simulation result for Big size network

The second simulation scenario is considering that the density of nodes improved from 50 to 100 in an area of 1000m X 1000m and changing the mobility speed of nodes to 50m/s , the simulation were run for 100sec. This will enable us to understand the response of DBPG when the number of nodes is increased. The following table summarize the second simulation scenario.

Parameter	**Value**
Simulator	Network Simulator 2 (NS2)
Simulator Area	1000mX1000m
No. of Mobile Nodes	100 nodes
Simulation Time	100 sec
Mobility Model	Random way

Routing Protocols	DBPG
Traffic Sources	TCP
Max. Speed	50m/s

Table 4.2: Simulation setting of scenario Two

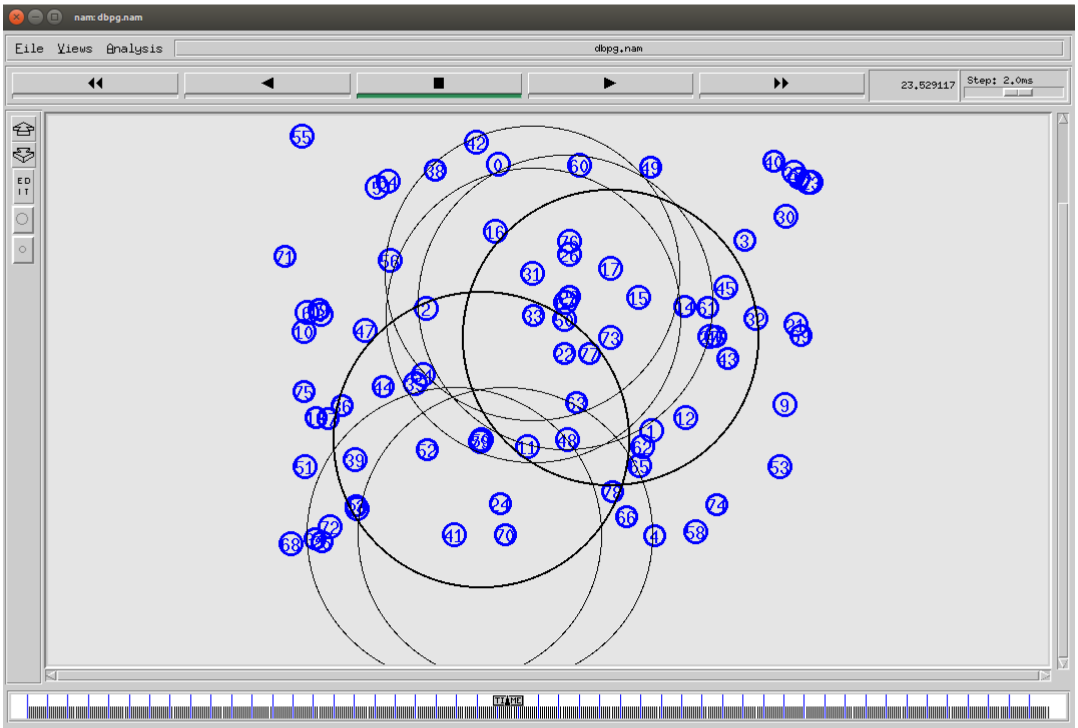


Figure 4.5: Simulation environment during simulation for the above simulation setting

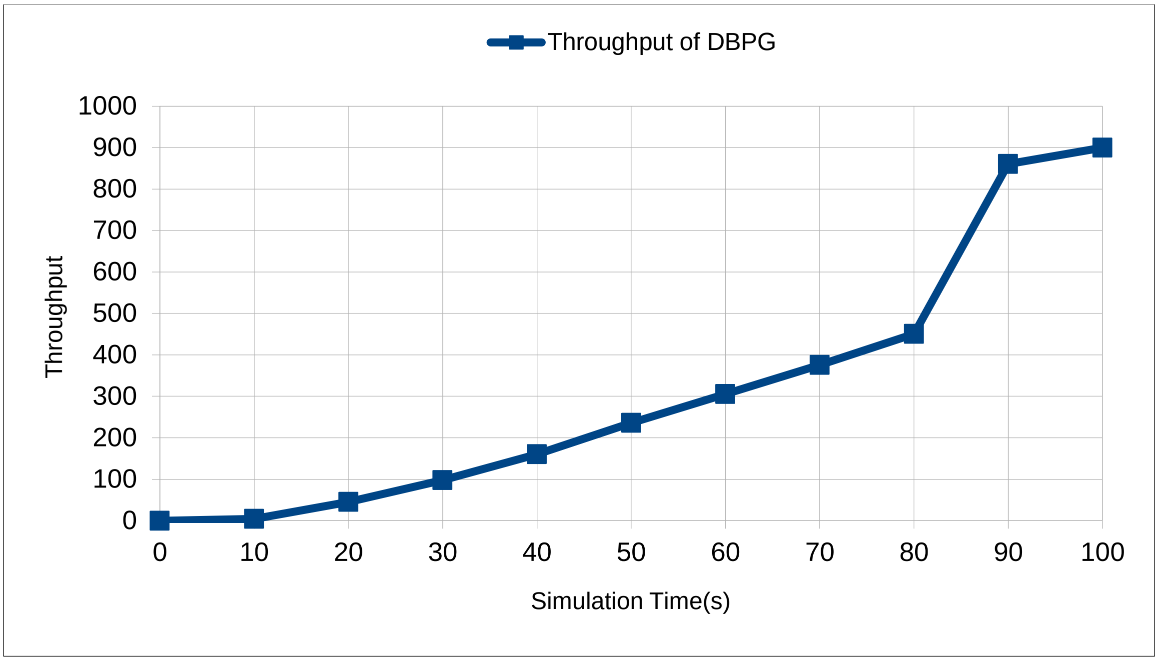


Figure.4.6: Throughput Vs Simulation time Analysis

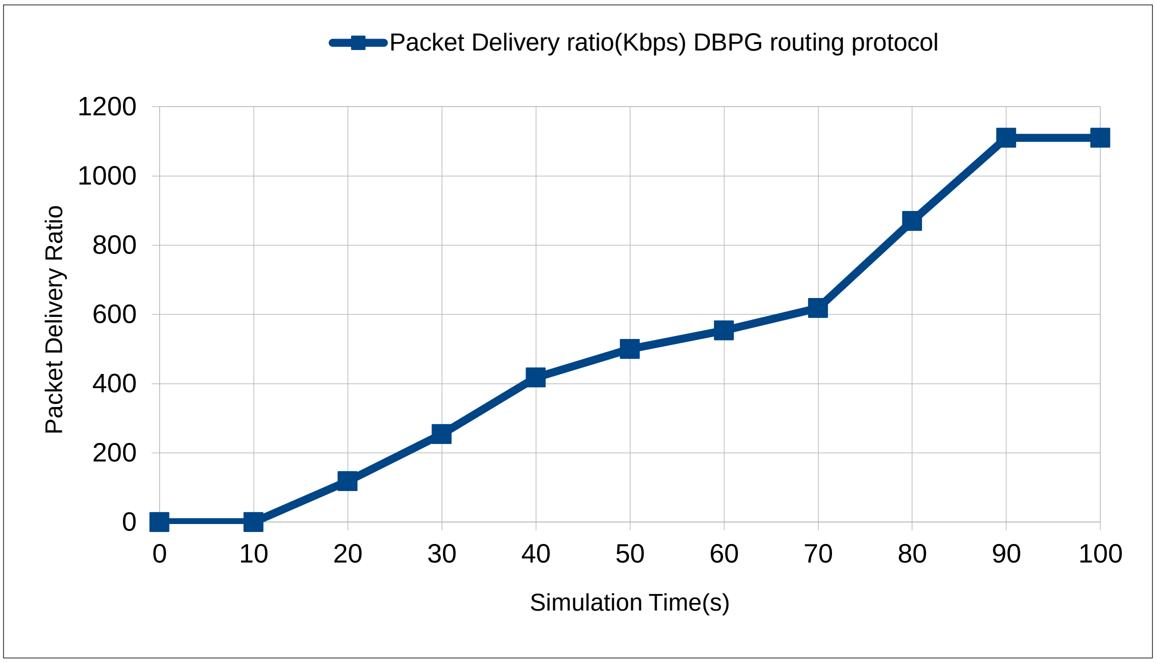


*Figure 4.7**:** Packet Delivery Ratio Vs Time Analysis*

As shown in the figures above at the start of simulation the both throughput and delivery ratio of the model is almost zero because the communication or the dissemination of bundle from the source node to the Goal nodes begins at tenth second of the simulation. After this time onwards the number of parcel that is passing through the channel in a particular unit of time and the delivery ratio of the proposed model is increased until the simulation ends.

4.3.3. Simulation result by varying network size

Besides the above two simulation setting we have made simulation by varying the number of node from 20 to 100 to understand the performance of the DBPG. We employ two different metrics throughput and packet delivery ratio of the steering convention, as depicted in figure 4.8 and 4.9 the protocol shows perform better in the case of both metrics as the network system or size increased However further simulation should be done by increasing the network size.

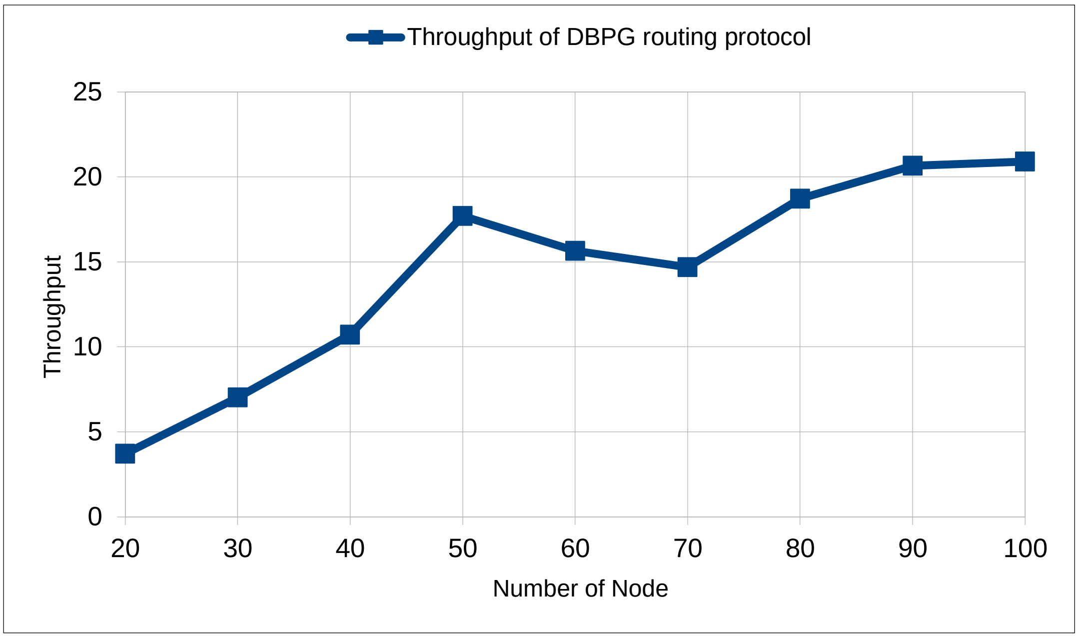


Figure 4.8: Throughput Vs Number of nodes Analysis

Figure 4.8 Depicts that there is a inclination in throughput with an increase in network size. However there is certain declination as the number of node gets between 50 to 70. The possible reason behind this is that fact that a small change in the network topology causes frequent table update of every intermediate node which reside in smaller districts. So in order for this protocol to perform better we need to keep only 30 node within smaller districts. Hence hybridizing proactive and geographic steering convention scale better for Mobile Ad Hoc networks.

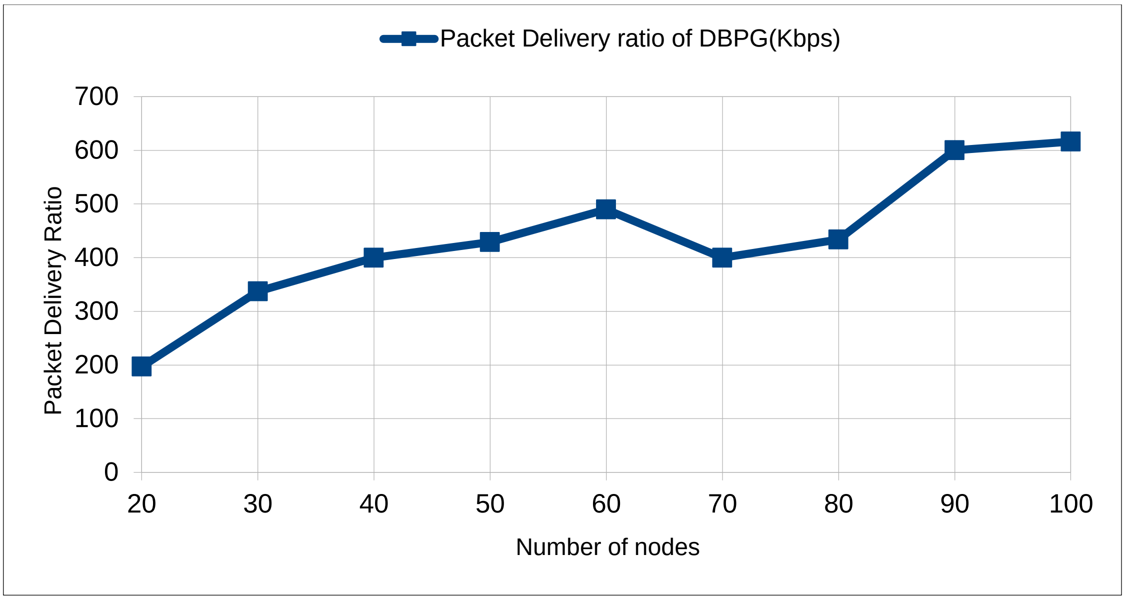


Figure 4.9: Packet Delivery Ratio Vs Number of node

The packet delivery ratio of the proposed model is depicted in figure 4.8. The figure speaks that the delivery is increased as the network size increased however it show some declination in as the number of nodes improved from sixty to seventy node, this is due to the generated packet at the source node is more as compared to the received packet. And regain its increasing delivery ratio as node goes away from the point of the declination.

4.3. Findings of the study

In this research study, we explored a new hybrid adaptive routing model for MANET, where the model consist of Architecture and algorithms for functionalities involved in the Architecture. The architecture is two-layered where the top layer is utilized to facilitate the division during extensive sized network, to do so it has three equipped with different functionalities, i.e representation, grouping and district formation. In-line with this, in this study we developed an algorithms for those aforementioned functionalities. Initially the topology is taken as accumulation of nodes in 2-D Euclidean space as graph. Then we used one of the data structures list, particularly Adjacency list to speaks the nodes to the Machine. After the nodes represented they are grouped together based on neighborhood, then they will be framed together to form district based on the number of node given from the user. The bottom layer has two routing component, Is-DSC is used when the yearning nodes are in the same district where as Ie-DSC is when the node reside in remote district.

It is concludable from the simulation result it is found that, the proposed model shows better performance in terms of throughput and packet delivery ratio as the network size grows from 20 to 100. This is due to inheritable nature of proactive and area data based routing approach together as single and standalone directing guideline. As the network size is smaller (i.e 50 nodes) the proposed model adopt the behavior of proactive ,so that the path to the nodes is known so it can easily disseminate the parcel to the intended node, whereas the node density is growing the proposed routing scheme utilize separation to identify the intermediate node and deliver the packet. So hybridization makes the proposed solution to show better performance in-terms aforementioned performance metrics.

Chapter Five

Conclusion and Future Work

5.1. Conclusion

In this study, an attempt is made to introduce new steering engineering that consolidate two different routing approaches, topology-based and position assisted steering convention for adhoc network specifically for Mobile Ad Hoc Network (MANET). One important part of the study was to find an appropriate model through which the researchers can able to understand the difficulty in active hybrid steering convention so as to find a way to came up solution for those difficulties and make the proposed model applicable for various network scenario, i.e small and big network.

The researchers used a graph model to represent the system topology which enable to clearly and properly segment or divide the system network into smaller districts, so as to improve the routing process and efficiency of District-Based proactive-Geographic steering convention than active hybrid directing rules.

To do so, we introduced a model that can be applied for small and large network scenario, where yearning nodes inside districts employ sub-steering guideline, Is-DSC and a sequence of greedy, face followed by greedy algorithm is utilized to communicate a node outside of the respective district with the aid of area data or location information of nodes called IntEr- Sub-District routing protocol (Ie-DSC). Greedy is basically utilized to explore the halfway node and face to forward the message outside the district. We also employ the concept of virtual graph to avoid the tedious task, planar graph construction in face routing.

This study shows the strength of hybridization, i.e given multiple routing scheme, each suited for a various network scenario of the ad hoc network design space, it makes sense to capitalize on each protocol's strengths by combining them into a single framework which is a better solution for scalable routing.

Following are some of challenges the needs further investigation

- Implementation of the top layer and virtual graph formation.
- There needs to be a mechanism for the proposed solution to consider distnict routing direction during the BUNDLE_NAVIGATION.
- Further simulation under different simulation setting with different performance

metrics.

5.3. Contribution of the Study

This study mainly focuses on two main things. First, it review the current state-of-art in relation to trends and approach in Mobile Ad Hoc Network, So as to propose model or architecture of District-based proactive-Geographic routing protocol. In addition to this, the current study contributes the development of algorithm for the proposed model besides the development of the architecture. Thus, proposed model is designed to support for the small network and large-scale network scenarios.

5.2. Future Work

The research presented in this thesis seems to have raised more questions that it has answered. There are several lines of research arising from this work which should be pursued. To prove the feasibility and performance of proposed hybrid steering convention, further studies are required:-

- All the algorithms developed in the model should be fully programmed or implemented to convey or carry for further performance study in comparison with the active steering conventions already implemented

- Further Simulation is required, I.e evidently it is necessary to analyze the performance of proposed steering model with active hybrid steering model under distinct simulation setting and performance metrics such as end-to-end delay and routing overload or overhead.

- Since we made one of the testing procedure, tuning test which mainly concerned with how the proposed solution respond to distinct network scenario, further comparison test is required after the proposed solution is fully programmed to validate and evaluate with active hybrid Models

- Lastly but not least, optimization proceeds after the above two works. DBPG may require optimization after simulation study can be carried out, and we recommend to employ bio-inspired steering optimization principle which may improve the performance of our steering convention.

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