GEOGRAPHICAL ROUTING IN PEER TO PEER OVERLAY NETWORKS

Project Report submitted in partial fulfillment of the requirement for the degree of Bachelor of Technology.

In

Computer Science & Engineering

Under the Supervision of

Dr.Hemraj Saini

By

Priyanka Dubey (111277)

To

Jaypee University of Information and Technology

Waknaghat, Solan – 173234, Himachal Pradesh

Certificate

This is to certify that project report entitled **"Geographical Routing in Peer to Peer Overlay Networks**", submitted by **Priyanka Dubey** in partial fulfillment for the award of degree of Bachelor of Technology in Computer Science & Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date:

Dr.HemrajSaini
Assistant Professor

Acknowledgement

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DATE: **Priyanka Dubey**

Table of Contents

List Of Figures

List of Tables

ABSTRACT

The project aims to devise geographical routing techniques for the peer to peer overlay networks. The project in its final stages will simulate the peer to peer overlay network in a network simulator and routing strategy namely greedy perimeter stateless routing (hybrid of the greedy forwarding and flat face routing techniques) and compare results of on the basis of packet delivery ratio,throughput, and delay with the changing number of nodes.

The P2P overlay networks are nowadays used widely in the field of telecommunication, file sharing over the internet and cloud computing.

Telecommunication: Overlay networks are those networks that combine the various logical layers, operated and built by various entities and permitted the buildup of a broad set of services that otherwise could not have been proposed by a single telecommunication operator.

Cloud Computing: Cloud Computing is a virtual extension for storing additional files, programs and network resources.All files and applications use the virtual resources of the cloud and not the local network.

Internet: forms the basis for more overlaid networks that can be constructed in order to permit routing of messages that are not specified by an IP address. These are all important and extensively used ways to share information, communicating and research work

Therefore, in today's world, it is becomes extremely important to devise Secure routing techniques that:

- Efficiently chooses the shortest path between the interacting nodes.
- Stores the minimum information in the routing table of the various nodes.
- Optimal utilization of channel capacity
- Keeping into mind the incremental dynamic nature and changing topology of P2P OVERLAY NETWORKS

Chapter 1: P2P overlay networks

1.1 WHAT ARE PEER TO PEER (P2P) NETWORKS?

In a P2P network, the "peers" are computer systems which are connected to each other via the Internet. Files can be shared directly between systems on the network without the need of a central server. In other words, each computer on the P2P network becomes a file server as well as a client.

The only requirements for a computer to join a peer-to-peer network are:

1. Internet connection
2. P2P software.

Peer-to-peer systems are distributed systems that operate without centralized organization or control. To find a particular piece of data within the network, P2P systems explicitly or implicitly provide a lookup mechanism, or *locator function,* that matches a given string, or *key*, to one or more network nodes responsible for the value associated with that key. P2P nodes interoperate by using the same software or the same set of network-based APIs.

Peer-to-peer (P2P) is an alternative network model to that provided by traditional client-server architecture. P2P network uses a distributed model in which each machine, called a peer, functions as a client with its own layer of server functionality. A peer plays the role of a client and a server at the same time. That is, the peer can initiate requests to other peers, and at the same time respond to incoming requests from other peers on the network. It differs from the traditional client-server model where a client can only send requests to a server and then wait for the server's response. With a client-server approach, the performance of the server worsens with the increase in the number of clients.

However, in P2P networks overall network performance actually improves as an increasing number of peers are added to the network. The peer computers organize themselves into ad-hoc groups while they communicate, collaborate and share

bandwidth with each other to complete the tasks at hand (e.g. file sharing). Each peercomputer can upload and download at the same time, simultaneously new peers are free to jointhe group while old peers quit at any time. This dynamic re-organization of group peer members is transparent to end-users.

Another characteristic of a P2P network is its capability in terms of fault-tolerance. When a peer goes down or is disconnected from the network, the P2P application will continue by using other peers. For example, in a Bit Torrent system, any clients downloading a certain file also serve as servers. When a client finds one of the peers not responding, it searches for other peers, picks up parts of the file where peer was not responding and continues the process. In a client-server model all communication will stop if the server is down whereas in a P2P network it will not happen, it is more fault-tolerant

1.1.1 Classificationof P2P Networks

There are two types of P2P networks:

1.Pure P2P Network

2.Hybrid P2P Network

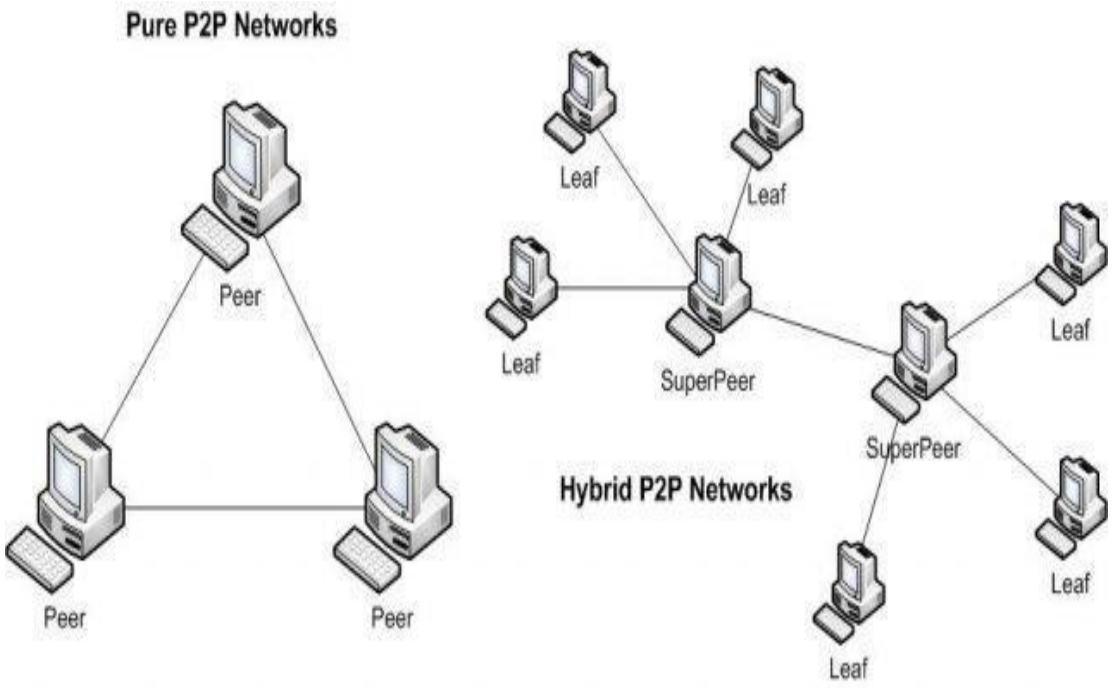


Figure 1: Classification of P2P Networks

PURE P2P NETWORK:

In a pure P2P network, all participating peers have equalstatus, plays the role of both client and server. The system does not rely on a central server to control, coordinate, or manage the exchanges among the peers Gnutella and Free net are examples of a pure P2P network.

HYBRID P2P NETWORK:

A central server performs certain "administrative" functions to facilitate P2P services. For example, in Napster, a server helps peers to "search for particular files and initiate a direct transfer between the clients". Only a catalogue of available files is kept on the server, while the actual files are scattered across the different peers on the network. Another example is Bit Torrent (BT), in which a central server called a tracker helps to coordinate communication among BT peers in order to complete a download

The central distinction between the two types of P2P network is that hybrid P2P networks have a central entity to perform certain administrative functions while there is no such server in pure P2P networks. Compared to the hybrid P2P architecture, the pure P2P architecture is simpler and has a higher level of fault tolerance. On the other hand, the hybrid P2P architecture consumes less network resources and is more scalable than the pure P2P approach.

1.1.2 PROS AND CONS OF P2P Networks:

Table 1 : Pros and Cons of P2P Networks

Pros	Cons
• As a peer joins the network, it adds resources to the existing network, adding more members to the system, increases the capacity or resources of the system itself. The throughput of the network increases. Such networks also scale better, as increase in members increases efficiency • Very robust as there is no single point of failure. If one peer fails, just that connection is lost, the network will go on functioning\ • Since the machines are independent of each other, operation and set up is easier and cheaper than client-server model machines	• P2P networks have high bandwidth consumption rates, due to multiple request and responses taking place at the same time from different peers • Lack of security, no checking of authentication takes place. So anyone can send and receive data from anybody

1.2 OVERLAY NETWORKS:

An overlay network constructs a user level graph on top of an existing networking Infrastructure such as the Internet, using only a subset of the available network links and nodes. An overlay link is a virtual edge in this graph and may consist of many actual links in the underlying network. Overlay nodes act as user-level routers, forwarding packets to the next overlay link toward the destination. At the physical level, packets traveling along a virtual edge between two overlay nodes follow the actual physical links that form that edge.

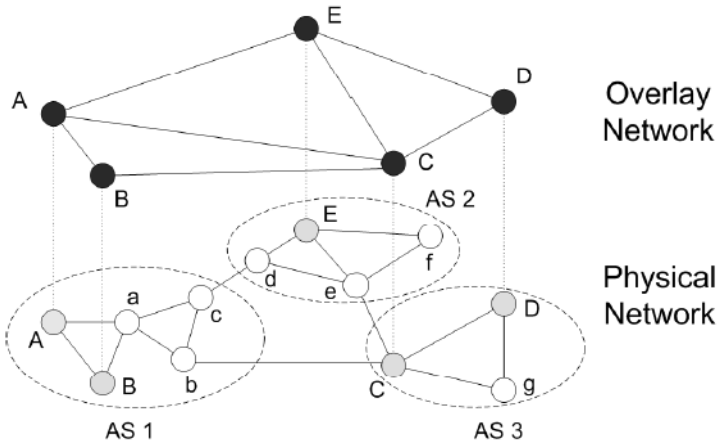


Figure 2: Overlay Network

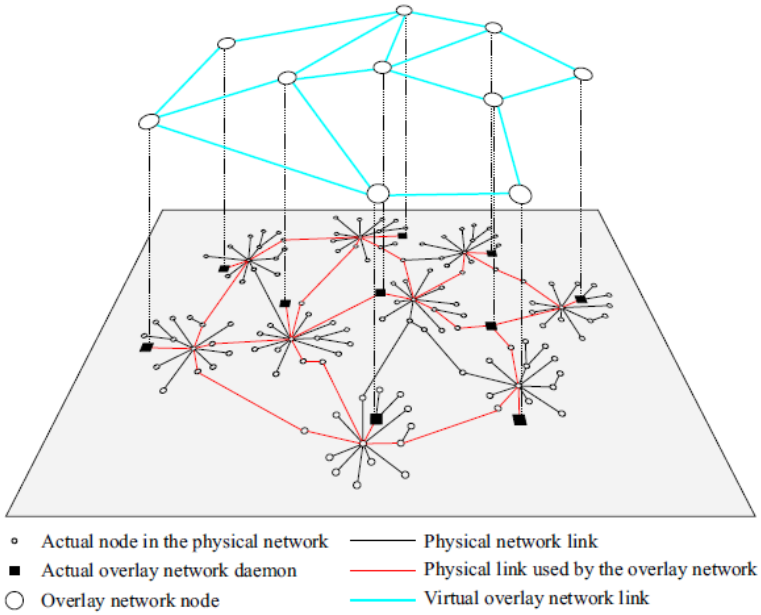


Figure 3 : Example of Overlay Network

Table 2

Link overlay	Physical path
A-B	A-B
A-C	A-a-b-C
A-E	A-a-c-d-E
B-C	B-a-b-C
C-D	C-D
C-E	C-e-E
D-E	D-C-e-E

1.2.2 CLASSIFICATION OVERLAY NETWORKS:

There are 2 types of overlay network:

1.Structured overlays

2.Unstructured overlays

1.2.2.1 STRUCTURED OVERLAYS:

Object IDs and peer IDs share same ID space

• Every object ID is assigned to one single peer

• Lookup possible: = routing to peer being responsible for desired

Object ID.

Peers and objects have identifiers;objects are stored on peers according to their ID.

1.2.2.2 UNSTRUCTURED OVERLAYS:

Objects IDs not assigned to peers

• Objects hosted by “up loaders” directly

• Only search possible: find nodes with interesting objects

objects have no special identifier, location of desired object a priori not known

Each peer is only responsible for objects it submitted

1.2.3 PROS AND CONS OF OVERLAY NETWORKS:

Table 3: pros and cons of overlay networks

PROS	CONS
Flexible Routing: • Quick adaptation to network problems • Selecting paths based on different metrics Customizing Packet Delivery: • Recovering from packet loss • Quality-of-service differentiation Scalability: • Small number of nodes • Balancing the trade-offs • Simple routing protocol	Processing delay: Packets going through multiple software nodes Network Performance: Propagation delay on circuitous path Network congestion from extra load Financial cost: Bill for traffic going in/out of intermediate node Bandwidth overhead: Probe traffic between two nodes Propagating probe results to other nodes Limited accuracy of end-to-end probes: Available bandwidth of logical link Losses due to congestion and failure Limited visibility: Logical links may share underlay routers/links May be hard to detect the dependencies

1.2.4 APPLICATION OF OVERLAY NETWORKS:

IN TELECOMMUNICATION:

From a physical standpoint overlay networks are quite complex as they combine various logical layers that are operated and built by various entities (businesses, universities, government etc.) but they allow separation of concerns that over time permitted the buildup of a broad set of services that could not have been proposed by a single telecommunication operator

Over the Internet:

The Internet is the basis for more overlaid networks that can be constructed in order to permit routing of messages to destinations not specified by an IP address.Overlay networks have also been proposed as a way to improve Internet routing, such as through quality of serviceguarantees to achieve higher-quality streaming media.

On the other hand, an overlay network can be incrementally deployed on end-hosts running the overlay protocol software, without cooperation from ISPs. The overlay has no control over how packets are routed in the underlying network between two overlay nodes, but it can control, for example, the sequence of overlay nodes a message traverses before reaching its destination.

Types of P2P Overlays

Centralized P2P Overlays:

Server is used to search for file owner

Later: direct P2P communication is established

Example: Napster, centralized DHT also possible

Figure 4 :Centarlized P2P

Homogeneous P2P Overlays:

All peers have equal duties, homogenous roles

Example: Chord, Kademlia, Gnutella

Figure 5: homogenous network

Heterogeneous P2P Overlays:

Peers have different duties, heterogeneous roles

Example, unstructured P2P overlays: KaZaA, eDonkey

Example, structured P2P overlays: Adaptive-Chord

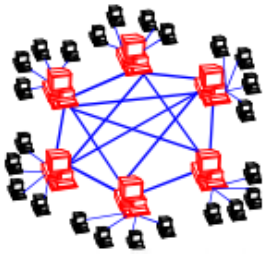


Figure 7: Heterogeneous P2P Overlay

Flat and Hierarchical P2P Overlays:

Flat: just one network

Hierarchical: (idea: Chordella, CANdemlia)

• Overlay graph is clustered

• Inter-cluster routing, sometime different ID space

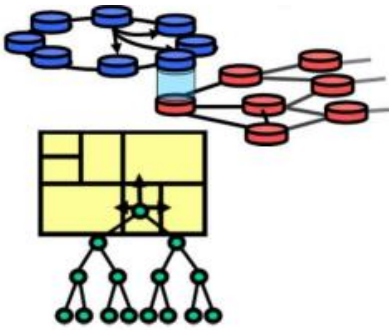


Figure 8: Flat and Hierarchical P2P Overlay

CHAPTER 2 – ROUTING IN PEER TO PEER OVERLAY NETWORKS

2.0: ROUTING:

Routing is the process of selecting best paths in a network. In the past, the term routing was also used to mean forwarding network traffic among networks. However this latter function is much better described as simply forwarding. Routing is performed for many kinds of networks, including the telephone network (circuit switching), electronic data networks (such as the Internet), and transportation networks.

Routing schemes differ in their delivery semantics:

UNICAST: delivers a message to a single specific node
BROADCAST: delivers a message to all nodes in the network
MULTICAST:delivers a message to a group of nodes that have expressed interest in receiving the message
ANYCAST: delivers a message to anyone out of a group of nodes, typically the one nearest to the source
GEOCAST: delivers a message to a geographic area

2.1: TYPES OF ROUTING TECHNIQUES: [6]

there are 3 types of routing techniques:

- Proactive techniques
- Reactive techniques
- Hybrid techniques

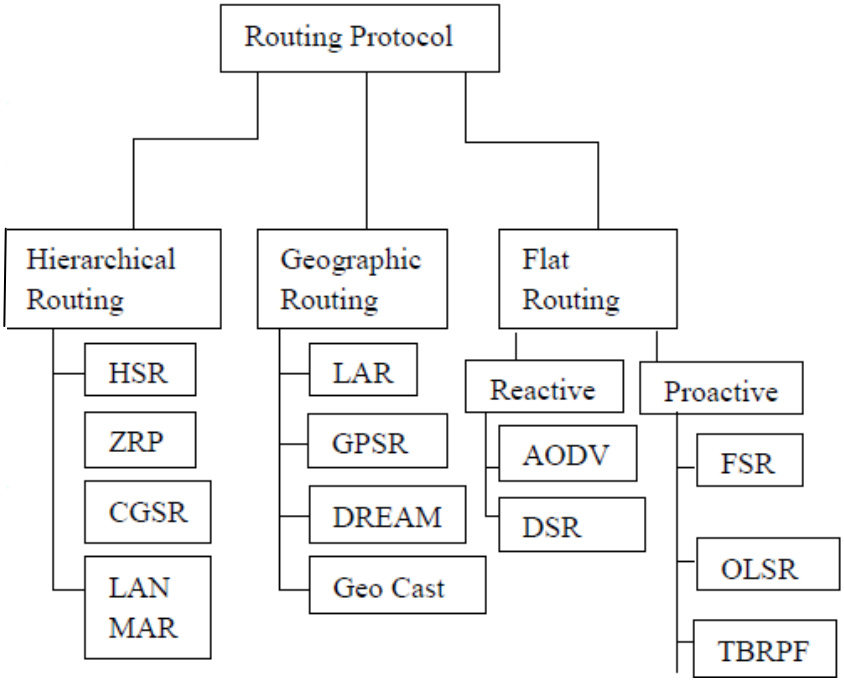


Figure 9: Types of Routing Protocol

2.1.1: PROACTIVE PROTOCOLS (table -driven):

Each node in the network maintains information about every other network edge by using periodic or event-triggered routing update exchanges. These types of routing protocols generally have very high overhead due to the route. Updates exchanged periodically but very low latency for packet forwarding, as the requested route path is already known.

2.1.2: REACTIVE PROTOCOLS (on-demand driven):

These protocolsdo not maintain permanent route table. Instead, routes arebuilt by the source on demand. These types of routingprotocols determine route paths when required by usingdata dissemination techniques such as flooding. On-demandprotocols are generally associated with lowoverheads and have been known to have good scalabilityproperties due to the transmission of control messages inthe system only when necessary. They usually have a highlatency for packet forwarding as the routing pathdiscovery is initiated when there is data to be sent

2.1.3: HYBRID PROTOCOLS:

Hybrid protocol combine characteristics from active andpassive routing protocols to achieve properties such ashierarchical routing. These types of protocol are generally Implemented in clustered networks, where nodes aregrouped into small clusters to form smaller networkswithin a large network. Intra-cluster routing among nodes Are usually proactive, while Inter-cluster routing is doneon-demand. Examples are Zone Routing Protocol (ZRP).Some of these protocols have been submitted for RFCs (Request for Comments) to the IETF while others are stillbeing improved upon.

CHAPTER 3: GEOGRAPHICAL ROUTING

3.0: GEOGRAPHICAL ROUTING:

Geographic routing (also called **rerouting** or **position-based routing**) is a routing principlethat relies on geographical position information. It is mainly proposed for wireless networks and based on the idea that when a sender sends a message to the destination, it uses the geographic location instead of using the network address. The idea of geographical location for routing was first proposed in the 1980s in the area of packet radio networksand interconnection networks. Geographic routing requires that each node in the network can determine its own location and that the sender node is aware of the location of the destination node. With this information a message can be routed to the destination address without the knowledge of the network topology or a prior route discovery.

ASSUMPTIONS OF GEOGRAPHICALROUTING:

1.Nodes know their own geographical location
2.Nodes know their 1-hop neighbors
3. Each packet can hold a small amount(O (1)) of routing information.

Geographic routing protocols scale better for wireless networks mainly for two reasons:

1) There is no necessity to keep routing tables up-to-date.
2) No need to have a global view of the network topology and its changes.

These geographic approaches allow routers to be nearly stateless because forwarding decisions are based on location information of the destination and the location information of all one-hop neighbors. Most of these protocols keep state only about the local topology (i.e., neighbors' location information). No routing table is constructed. As a result, establishment and maintenance of routes are not required, reducing the overhead considerably. Early proposals for geographic routing were based on pure greedy approaches: a packet at an intermediate node is forwarded to the

neighbor who is the closest to the destination.Each intermediate node applies this greedy principle until the destination is reached.

3.1: TYPES OF GEOGRAPHICAL ROUTING

There are 2 types of geographical routing:

1.Greedy Routing

2.Face Routing

3.1.1: GREEDY FORWARDING

Greedy forwarding is geographical routing protocol in which packets are forwarded to the neighbor node located closest to the destination node at each hop.Greedy forwarding tries to bring the message closer to the destination node in each step using only local informationconsisting of the geographical location of the node. Thus, each node forwards the message to the neighbornode that is most suitable from a local point of view. The most suitable neighbor node can be the one who minimizes the distance to the destination in each step.Greedy is the most basic type of geographical routing algorithm; tracing its routes back to an approach known as Cartesian routing which was introduced for routing in large-scale internets. Greedy forwarding is a simple form of geographic routing in which packets are forwarded to the neighbor located closest to the destination at each hop.

Advantages of greedy forwarding:

- Simple to understand and implement.
- Efficient, having a worst-case complexity of O (d^2).

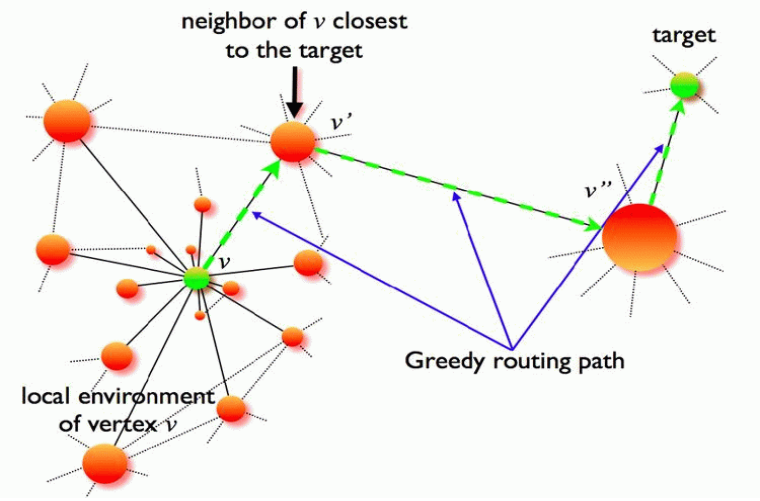


Figure 10: Greedy Forwarding

- **POINT OF FAILURE:**

The main problem with greedy routing is that it does not guarantee delivery to the destination even if there is a path from the source to the destination. This is called a local minimum [figure 11].When a node is unable to find a neighbor node closer to the destination than itself it drops the packet,to prevent the packet from travelling backwards. It can have the adverse effect of leading the packets to be dropped where a route to the source is possible.Due to increased communication overhead, stateless algorithms based on routing in planar geometric graphs attracted more attention as recovery mechanisms. Therefore, greedy routing is often used in combination with a recovery strategy, which is responsible for handling the packet as long as greedy routing fails. In other words, greedy routing continues until it reaches a local minimum and fails. Then it switches to the recovery strategy. However, the recovery solution returns to greedy routing after it meets a node that is closer to the destination than the greedy failure node. The return happens either immediately or after some time depending on the type of strategy used. This node may either be the current packet receiver or one of its neighbors. The most prominent recovery strategy is Face Routing, which is explained in the next section.

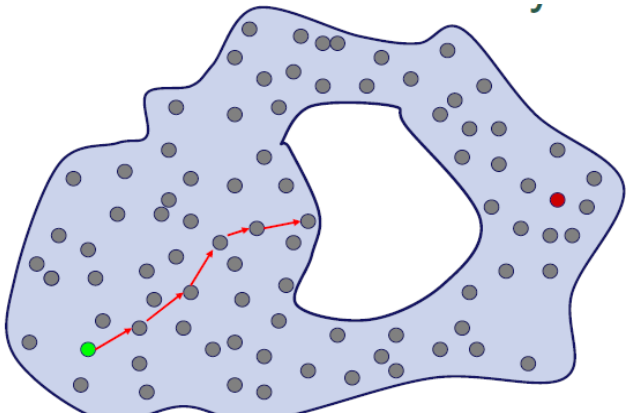


Figure 11:Point of failure of greedy forwarding

3.1.2:FACE ROUTING:

This technique represents the entire network as a planar graph:

- Keep left hand on the wall, walk until hit the straight line connecting source to destination.
- Switch to the next face.
- Face routing guarantees delivery
- When no way to destination found, it fails.

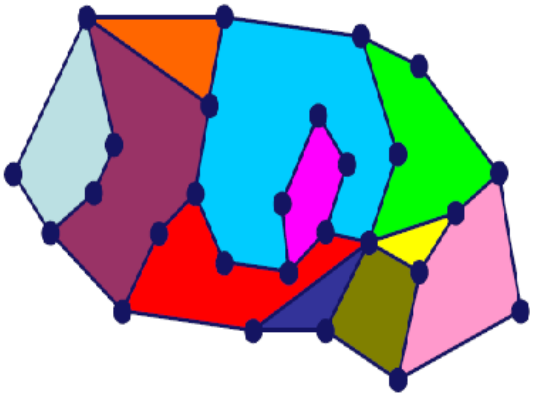


Figure 12: face routing

Face routing is derived from Compass Routing II where faces on a planar graph are traversed using a technique known as the 'right hand rule' (sometimes left hand rule instead) in which the algorithm keeps track of all the times it crosses the line connecting the source to destination. Once an entire face has been covered, the algorithm moves onto one of the intersections nearest the destination and explores that with the algorithm continuing to do so until it eventually reaches the destination. The

application of the Compass II algorithm to Unit Disk Graphs (UDG) as well as an algorithm for plan arising UDGs was first presented and can be considered the first face routing algorithm. The UDG in which two nodes are connected if their disks overlap is a common abstraction for ad-hoc networks. Generally, the UDG is used as a base-model for a planarization algorithm; typically based on the Gabriel Graph. The Gabriel Graph is a planar sub-graph in which two points are connected if they are endpoints of a circle's diameter.

The main advantage of face routing is that it guarantees delivery, however disadvantages include its possible inefficiency; and its reliance on planar sub-graphs, which calls into question its effectiveness in non-planar environments.

CHAPTER 4: Related work

Peer-to-Peer Overlay in Mobile Ad-hoc Networks (Marcel C. Castro1, Andreas J. Kassler1 Carla-Fabiana Chiasserini,Claudio, Casetti, and Ibrahim Korpeoglu) [2]

The paper presents how Peer-to-Peer Overlay is used in Mobile Ad-hoc Networks. It also describes the various traffic routingstrategiesfor Multihopnetworks. Giving detailed description of flat routing protocols, hierarchical routing protocol topology based schemes and then geographical location based schemes

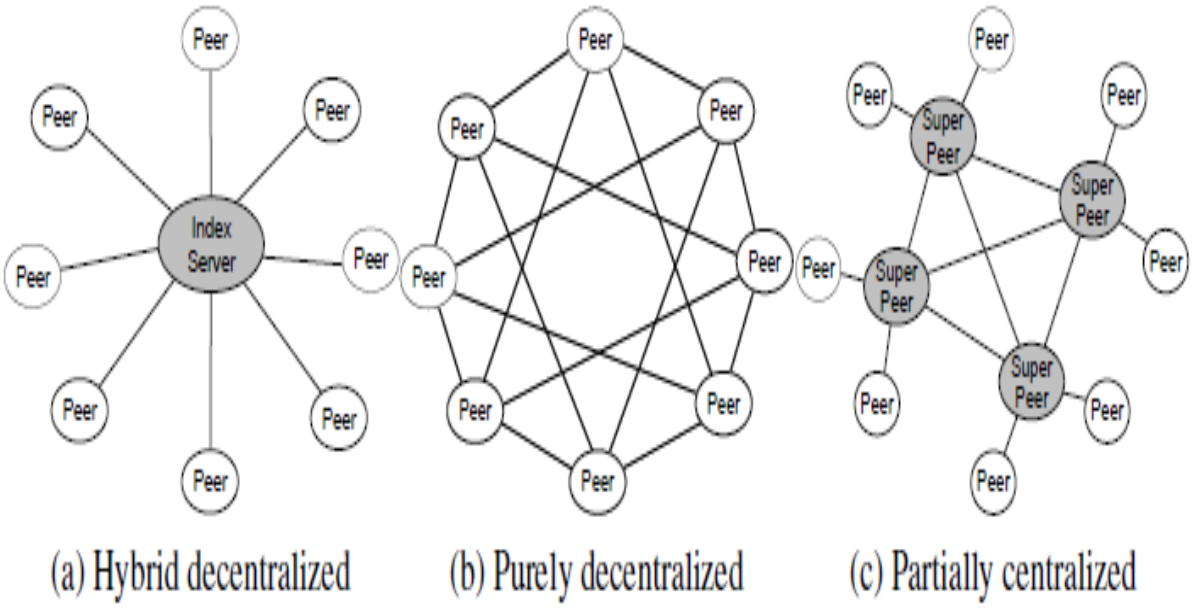
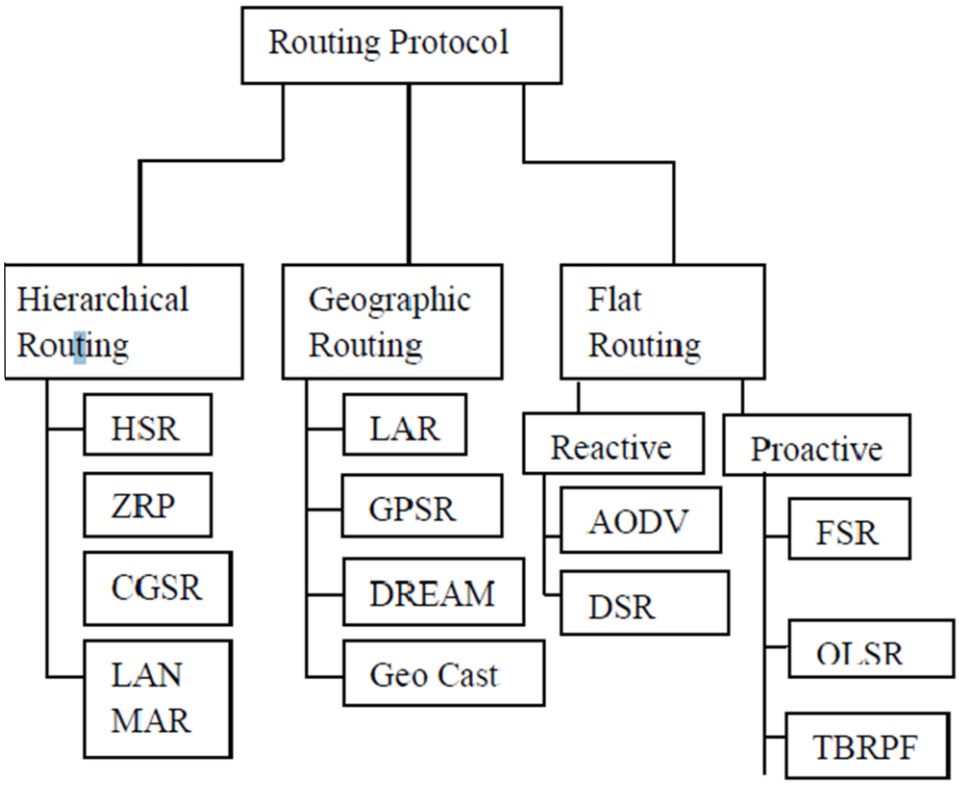


Figure 13: types of peer-to-peer overlay networks

Performance Analysis &Behavioral Study of Proactive & Reactive Routing Protocols in MANET (Deepak Kumar Patel, Rakesh Kumar, A.K. Daniel) [6]

The paper presents the simulation& comparison of the performance between two types of routing protocols, Table Driven (Proactive) and On-Demand (Reactive) using the NS-2 simulation tool. These routing protocols compared in terms of packets delivery ratio, average delay and speed.



1) HSR (Hierarchical State Routing Protocol):

TheHierarchical State Routing (HSR) is a multi-levelcluster-based hierarchical routing protocol. In HSR, mobile nodes are partitioned into clusters and a clusterhead is chosen for each cluster. The cluster heads of lowlevel clusters again organize themselves into upper level clusters.

3) CGSR (Cluster Gateway Switch Routing):

The Cluster head Gateway Switch Routing (CGSR) isa hierarchical routing protocol. The cluster structureimproves performance of the routing protocol becauseit provideseffective membership and traffic management.

4) LANMAR (Landmark Ad hoc Routing):

The Landmark Ad hoc Routing (LANMAR) isproposed as a modification of FSR and it focuses toimprove scalability in contrast to FSR;it is a non-uniformrouting protocol of mobile ad hoc networks. In LANMAR,nodes are divided into predefined logical subnets according to their mobility patterns. Using LANMARevery mobile node has a hierarchical address that includesits subnet identifier. A node maintains the topologyinformation of its neighbors and all landmark nodes, which represent logical subnets. Similar to FSR,neighboring nodes in LANMAR periodically exchangetopology information and the distance vector of landmarknodes.

5) LAR (Location Aided Routing):

Location aided routing decreases the overhead of routediscovery by utilizing location information for mobilehosts. Such location information may be used using Global Positioning system (GPS). The LAR protocol useslocation information (which may be out of date) to reducethe search space for a desired route.

*6) GPSR (Greedy Perimeter Stateless Routing***):**

GreedyPerimeter Stateless Routing, GPSR, is a responsiveand efficient routing protocol for mobile, wirelessnetworks. Unlike established routing algorithm which usesgraph-theoretic notions of shortest paths and transitivereach ability to find routes, GPSR exploits thecorrespondence between *geographic position* andconnectivity in a wireless network, by using the positionsof nodes to make packet forwarding decisions.

7) DREAM (Distance Routing Effect Algorithm forMobility):

DREAM protocol is a restricted floodingrouting protocol used in infrastructure less architecture.

In this protocol each node maintains a location table aboutthe position of all nodes of the network and periodicallybroadcasts location packet, called control packet, toupdate the position information maintained by itsneighbors

8) Geo-cast Routing Protocol:

Geo-cast [30] stands for the delivery of information to agroup of destinations in a network identified by theirgeographical locations. It is a special case of multicastaddressing used by some routing protocols for mobile adhoc networks.

9) FSR (Fish Eye State Routing):

Fisheye State Routing is a link state type protocolwhich maintains a topology map at each node. To reducethe overhead incurred by control packets, FSR modifies

The link state algorithm in the following three ways. First,link state packets are not flooded. Instead, onlyneighboring nodes exchange the link state information.

Second, the link state exchange in only time-triggered, noteven-triggered. Third, instead of transmitting the entirelink state information at each iteration.

A Survey of Geographical Routing in Wireless Ad-Hoc Networks (Fraser Cadger, Member, IEEE, Kevin Curran, Senior Member, IEEE, Jose Santos and Sandra Moffett*)* [1]

The paper aims to*:*

- Provide a comprehensive survey of existing literature in the area of geographic routing in wireless ad-hoc networks.
- Strength of the paper: the approach is of 'challenges and solutions'.

The Paper:

- Discusses the various challenges facing geographic routing
- How existing protocols are affected by the challenges and in turn how some of those protocols address such issues.

Paper proposal:

- Proposes a hybrid type of efficient routing technique:
- Greedy forwarding along with face routing is used
- Greedy forwarding is used till the neighbor node nearer to the destination is identified
- Face routing is used when greedy forwarding fails
- There is switching between the 2 routing techniques as when any of them is most efficient.

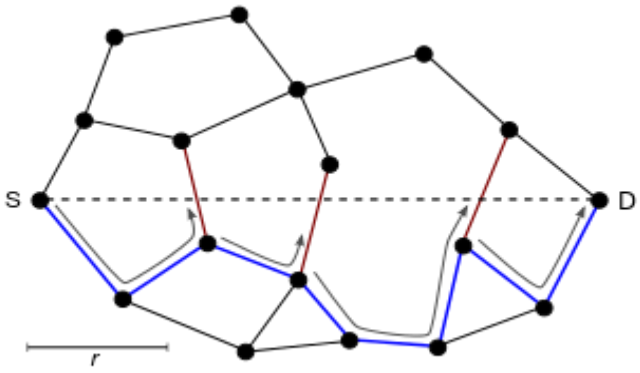


Figure 14 :perimeter routing

Efficient Routing for Peer-to-Peer Overlays (Anjali Gupta, Barbara Liskov, and Rodrigo Rodrigue, MIT Computer Science and Artificial Intelligence Laboratory) [4]

The research proposes 2 hierarchal routingschemes:

1. One –hop routing scheme to show how disseminate information about membership changes quickly enough so that nodes maintain accurate routing tables with complete membership information.
2. Two-hop routing scheme for large scale networks for a few million nodes where bandwidth requirement of one hop routing becomes too large. The scheme keeps a fixed fraction of the total routing state on each node, chosen such that the first hop has low latency, and thus the additional delay is small

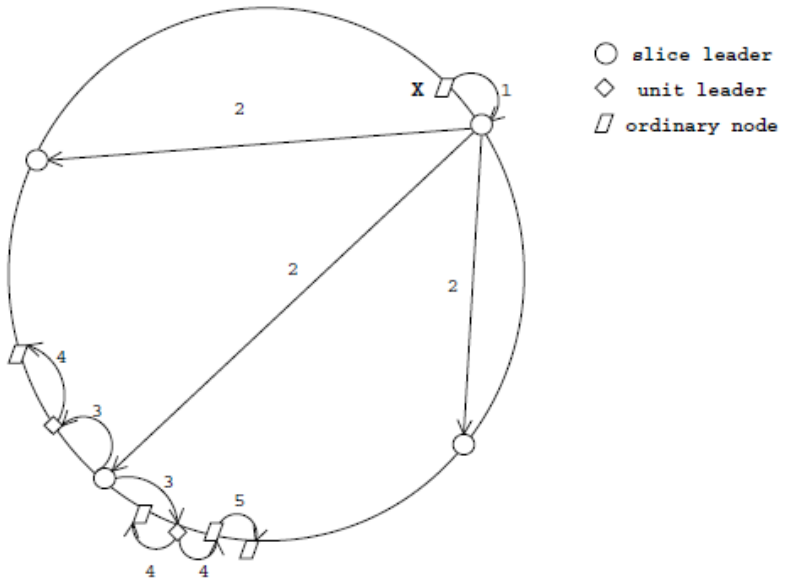


Figure 15: Flow of event notifications in the system

(1). The slice leader collects all event notifications it receives fromits own slice and aggregates them for tbig secondsbefore sending a message to other slice leaders

(2). to spread out bandwidth utilization, communication with die_rent slice leaders is not synchronized:the slice leader ensures only that it communicates

With each individual slice leader once every tbigseconds. Therefore, messages to di_erentslice leaders are sent at di_erent points in time and contain different sets of events. The slice leaders aggregate messages they receive for a short time period twait and then dispatch the aggregate message to all unit leaders of their respective slices

(3). A unit leader piggybacks this information on its keep-alive messages to its successorand predecessor

(4) Other nodes propagate this information in one direction: if they receive information from their predecessors, they send it to their successors and vice-versa. The information is piggybacked on keep alive messages. In this way, all nodes in the system

Receive notification of all events, but within a unit information always owes from the unit leaderto the ends of the unit. Nodes at unit boundaries donot send information to their neighboring nodes outside their unit. As a result, there is no redundancy

In the communications: a node will get informationonly from its neighbor that is one step closer to itsunit leader.

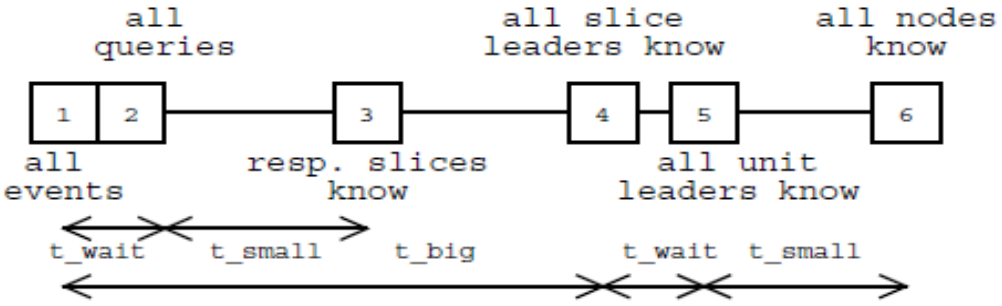


Figure 16: timeline of events

CHAPTER 5: Proposed work

Greedy Perimeter Stateless Routing [3]:

In P2P Overlay networks, the routing problem is to find a path from a data source to its final destination, through a series of intermediate nodes in spite of the rapid change in network topology.

These networks require a reactive routing algorithm that finds valid routes quickly as topology changes. However, the limited capacity of the channel network requires routing algorithms, which do not lead the network in a state of congestion when they learn of new routes.

For this reason, most routing protocols designed for such networks are geographic routing protocols because they can prevent overload of information exchanged between the nodes that seek to obtain the network topology and routing tables. These geographic routing protocols are based on the fact that all nodes know their position, for example, with GPS equipment (Global Positioning System) or by a positioning system distributed.

Geographic routing (also called **rerouting** or **position-based routing**) is a routing principle that relies on geographical position information. It is mainly proposed for wireless networks and based on the idea that when a sender sends a message to the destination, it uses the geographic location instead of using the network address.

Greedy Perimeter Stateless Routing, GPSR is a reactive and efficient routing protocol for P2P Overlay networks. In contrast to routing algorithms implemented before, using the concepts of graph theory, the shortest path and transitive accessibility to find routes, GPSR exploits the correspondence between the location and connectivity in a wireless network, using the positions of the nodes to make packet-forwarding decisions.

The routing of GPSR packets is done in two modes according to the density of the network: the "Greedy Forwarding" and "Perimeter Forwarding" (respectively called GF and PF in the following).

Greedy Forwarding

The GF constructs a road browsing the nodes from the source to the destination where each node receives a packet that forwards it by a jump to the intermediate node closest to the destination in its coverage area.Greedy forwarding's great advantage is its reliance only on knowledge of the forwarding node's immediate neighbors. The state required is negligible and dependent on the density of nodes in the wireless network, not the total number of destinations in the network.1 on networks where multi-hop routing is useful, the number of neighbors within a node's radio range must be substantially less than the total number of nodes in the network.

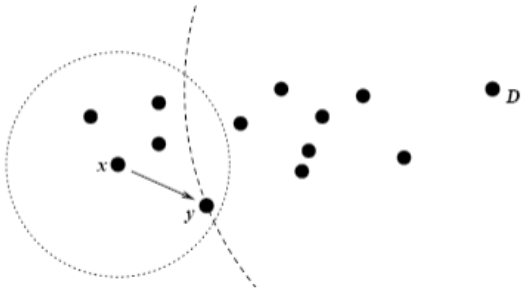


Figure 17:y is the neighbor of x closest to the destination D.

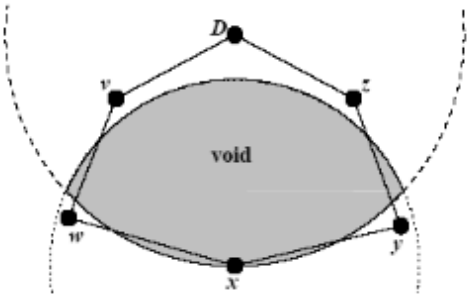


Figure 18: X is closer to that of its neighbors y, w.

```
GREEDY-FORWARD(p)
 1  n_best = self.a
 2  d_best = DISTANCE(self.l, p.l)
 3  for each (a, l) in N
 4  do d = DISTANCE(l, p.l)
 5     if a == p.a or d < d_best
 6        then n_best = a
 7             d_best = d
 8             if a == p.a
 9               then break
10  if n_best == self.a
11    then return greedy forwarding failure
12    else  forward p to n_best
13          return greedy forwarding success
```

Figure 19 :Pseudo code for greedy forwarding

Figure 17 shows the pseudo code for greedy forwarding

The power of greedy forwarding to route using only neighbor nodes' positions comes with one attendant drawback: there are topologies in which the only route to a destination requires a packet move temporarily farther in geometric distance from the destination.

The method "Perimeter Forwarding" is used when a node does not find any neighbor closer than him to the destination or destination is not within reach of it.

Perimeter Forwarding:

The method "Perimeter Forwarding" consists to transform the network topology in a planar graph (not containing of edges that intersect). This graph can be either (Relative Neighborhood Graph) RNG or (Gabriel Graph) GG

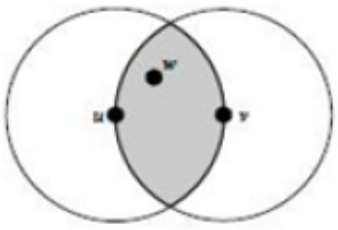


Figure 20: Relative Neighborhood Graph

RNG: the node u considers that v belongs to the graph RNG if the hatched area is empty.

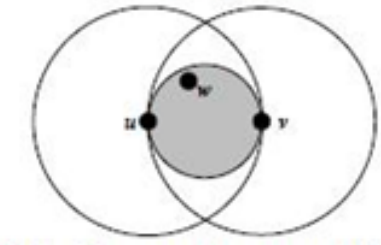


Figure 21: Gabriel Graph

GG: the node u considers that v belongs to the graph GG if the hatched area is empty.

Then the packet traverses the graph to the destination using the right hand rule defined as follows: When a packet arrives at a node x from node y, the way forward is the next node that is in the opposite direction of clockwise starting from x and the segment [by] while avoiding the "crossing links" (road already traveled).

GPSR protocol by combines the two routing methods.

A GPSR packet contains a header field for the routing mode. This field contains "Greedy» when the routing is "greedy forwarding" and "Perimeter" when routing is "Perimeter forwarding". A node x receives a packet in "Greedy" mode examines the table of neighbors. If it finds the nearest neighbor of the destination, it transmits the packet to this neighbor. Otherwise, the node will change the mode field of the header of the packet with "Perimeter" and record its location. Then it constructs a planar graph of its neighbors and transmits its packet through this graph. Figure 5 shows an example of this mode of transport.

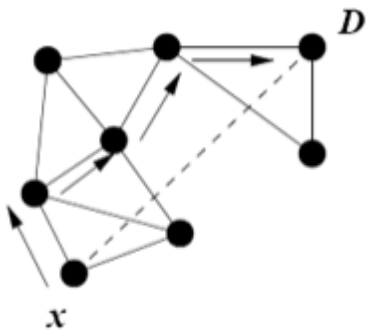


Figure 22Perimeter forwarding. D is the destination; x is the node where the packet enters in Perimeter mode.

```
RIGHT-HAND-FORWARD(p, n_in)
 1  b_in = NORM(ATAN2(self.l.y − n_in.y, self.l.x − n_in.x))
 2  δ_min = 3π
 3  for each (a, l) in N
 4  do if a == n_in
 5        then continue
 6     b_a = NORM(ATAN2(self.l.y − l.y, self.l.x − l.x))
 7     δ_b = NORM(b_a − b_in)
 8     if δ_b < δ_min
 9        then δ_min = δ_b
10             a_min = a
11  return a_min
```

Figure 23 :Pseudo-code for perimeter routing

FIGURE 21 shows the pseudo-code for perimeter routing using right hand forwarding rule.
Right

PSEUDO-CODE FOR GPSR ROUTING ALGORITHM:

```
FACE-CHANGE(p, t)
1  i = INTERSECT(t.l, self.l, p.L_p, D)
2  if i ≠ NIL
3     then if DISTANCE(i, D) < DISTANCE(p.L_f, D)
4             then p.L_f = i
5                  t = RIGHT-HAND-FORWARD(p, t)
6                  t = FACE-CHANGE(p, t)
7                  p.e_0 = (self.a, t)
8  return t
```

```
PERI-INIT-FORWARD(p)
1  b_in = NORM(ATAN2(self.l.y − p.D.y, self.l.x − p.D.x))
2  δ_min = 3π
3  for each (a, l) in N
4  do b_a = NORM(ATAN2(self.l.y − l.y, self.l.x − l.x))
5     δ_b = NORM(b_a − b_in)
6     if δ_b < δ_min
7        then δ_min = δ_b
8             a_min = a
9  return a_min
```

Figure 24 :Pseudo-code for perimeter and face change functions

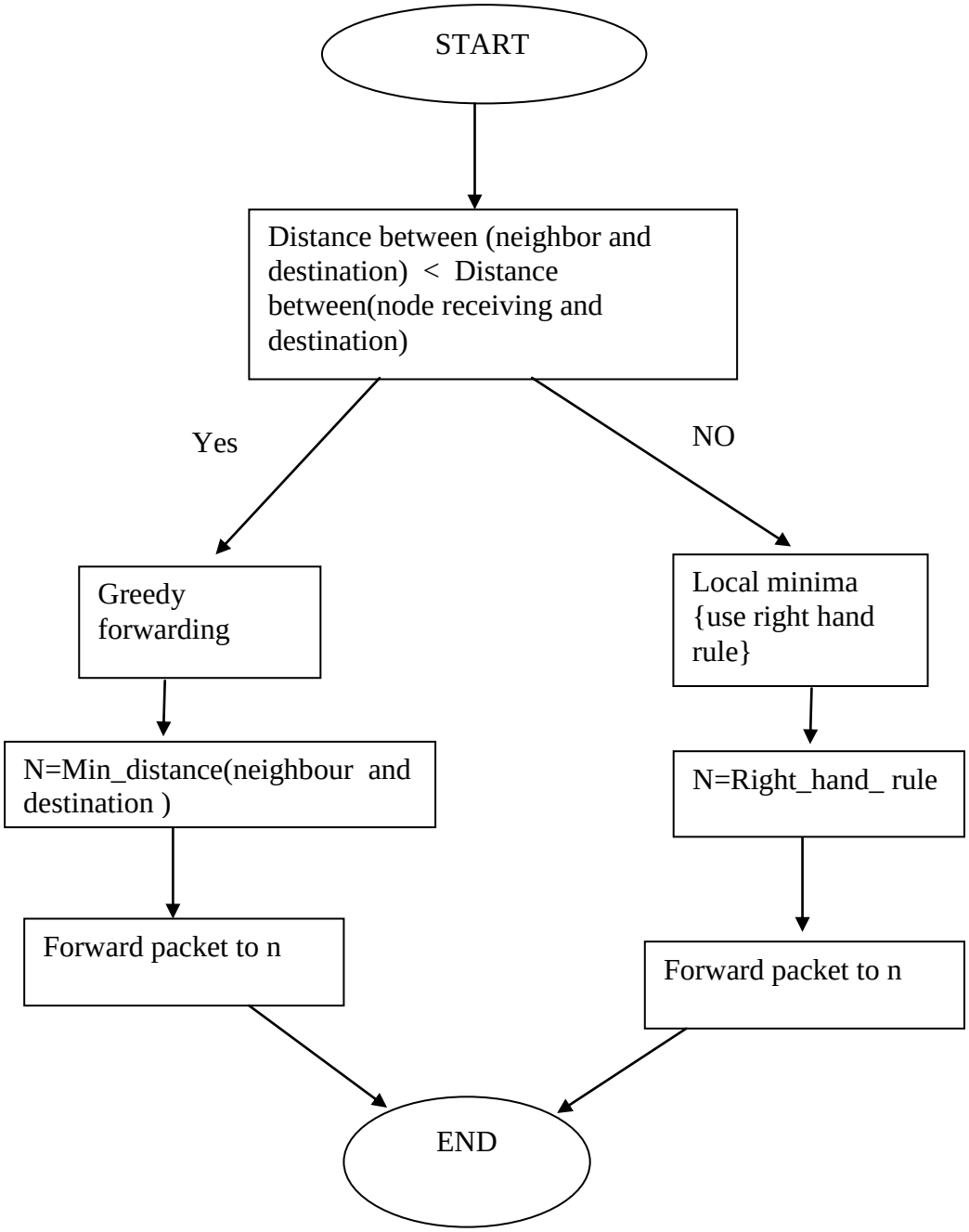
```
GPSR-FORWARD(p, n_in)
 1  if p.d == self.a
 2    then receive packet
 3    else switch
 4           case p.M == greedy data :
 5                if GREEDY-FORWARD(p) == failure
 6                  then p.M = perimeter data
 7                       p.L_p = p.L_f = self.l
 8                       t = PERI-INIT-FORWARD(p)
 9                       p.e_0 = (self.a, t)
10                       forward p to t
11           case p.M == perimeter data :
12                if DISTANCE(self.l, p.D) < DISTANCE(p.L_p, p.D)
13                  then p.M = greedy data
14                       GREEDY-FORWARD(p)
15                  else t = RIGHT-HAND-FORWARD(p, n_in)
16                       if p.e_0 == (self.a, t)
17                         then drop p; destination unreachable
18                         else t = FACE-CHANGE(p, t)
19                              forward p to t
```

Figure 25:pseudo-code for GPSR

Figure 22 and 23 shows pseudo-code for the GPSR forwarding algorithm. Note that we assume throughout this pseudo-code that RIGHT-HAND-FORWARD, FACE-CHANGE, and PERI-INIT-FORWARD operate on a pre-planar zed graph, with crossing edges already removed; we omit this detail in the pseudo code. GPSR-FORWARD is the top-level forwarding function called for all arriving packets, with arguments p, the packet being forwarded, and nine, the neighbor from which the packet arrived.4 If p is a greedy data packet, and greedy forwarding fails, GPSR-FORWARD sets the locations where the packet entered perimeter mode (p ✂Lap) and where the line to the destination intersected the current face (p ✂ L f) to the router's own position. PERI-INIT-FORWARD finds the next router t counterclockwise from the line to the destination, using the same algorithm as RIGHT-HAND-FORWARD. Fey, GPSR-FORWARD sets the first edge taken on the perimeter in the packet (p ✂ e0), and forwards the packet to t. Upon receiving a perimeter-mode packet, GPSR-FORWARD first determines whether the packet has reached a node closer to the destination than the point where it entered perimeter mode; if so, it returns the packet to greedy mode, and forwards it greedily. Otherwise, GPSR-FORWARD calls RIGHT-HAND-FORWARD to determine the next hop

router dictated by the right-hand rule. If this next edge is the same as the first edge the packet traversed on the current face (p ✂ e0), the packet has toured the entire face, and the destination is unreachable, so the packet is dropped. If the packet hasn't toured the entire face, GPSRFORWARD calls FACE-CHANGE to determine whether the packet has reached an edge that crosses the line to the destination. FACE-CHANGE returns the appropriate next hop for the first edge on the next face if such a crossing edge has been reached, or the unchanged next hop found by the right-hand rule if no crossing of the line to the destination is found. Note that changing faces amounts to treating the next hop on the current face as the previous hop, and applying the right-hand rule. FACE-CHANGE calls itself recursively, because it is possible that a single node borders multiple edges that cross the line to the destination. The recursion terminates upon reaching the edge that crosses the line at the closest point to the destination; it must terminate because there is always an edge that crosses the line at a point farther than this closest point.

FLOWCHART:


START
Distance between (neighbor and destination) < Distance between(node receiving and destination)
Yes
NO
Greedy forwarding
Local minima {use right hand rule}
N=Min_distance(neighbour and destination)
N=Right_hand_ rule
Forward packet to n
Forward packet to n
END

CHAPTER 6:SIMULATION RESULTS AND EVALUATION

Network simulator 2 (NS2) has been used to simulate and analyze the performance of the GPSRrouting protocol on the peer to peer overlay network...NS2 provides support for both wired, wireless and mobile networks but doesn't extend support for geographical routing in standard form.
Therefore, the need to use an additional patchhas arisen; hence I used the gpsr patch provided by Kiess that maintains Karp'soriginal implementation of GPSR. The patch simulates IEEE 802.11 MAC layer with a node range of 500m. It provides support for mobility through the random way point model.

Geographical routing is used as GREEDY PERIMETER STATELESS ROUTING PROTOCOL , in which each source node takes greedy forwarding first and then face routing when greedy forwarding fails ,and greedy routing again (whenever possible)to its destination node .For the purpose of simulating the algorithm , source nodes and destination nodes are randomly chosen. Geographic routing takes all routing decisions based on thelocal one hop neighborhood. The remaining protocol operations justauthenticate node locations and public keys without affecting routing. Therefore, we change only the local routing behaviorof geographic routing in order to assess the performanceof GSPR.

The objective of this performance analysis is to find out how the performance parameters like throughput, packet delivery ratio and delay changes as our simulation scenario changes (i.e. the network expands).

6.1 SIMULATION ENVIRONMENT

Simulation is for networks having 50, 100,200 nodes in the network, of which some are mobile and some are stationary .we use identical simulation parameters for the three of them to get the true picture of the changes in throughput, delay and packet delivery ratio.

Table 4: Simulated Topography characteristics

NODES	REGION (m2)	CBR FLOWS
50	500X500	150
100	500x500	150
200	500x500	150

We evaluate GPSR using three metrics: packet delivery ratio, throughput, end to end delay.The first measurements presented are for 50-node topologies and mobility characteristics. Thereafter, the measurements on networks with 100 and 200 nodes are presented anddiscussed. Finally, I conclude if the protocol works better in a larger network or smaller network.

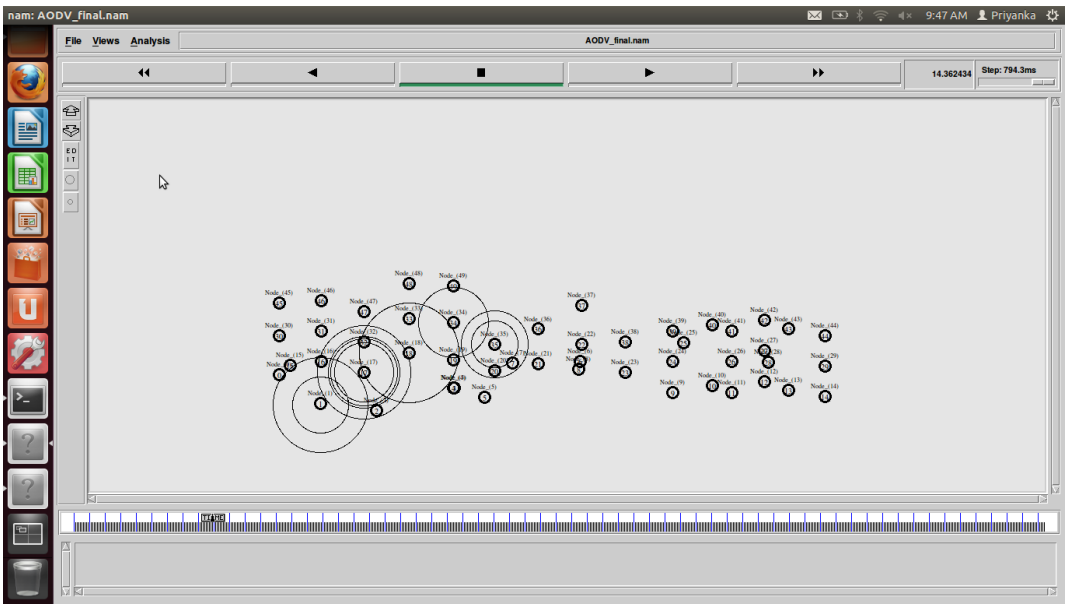


Figure 26: simulation of a50 node network

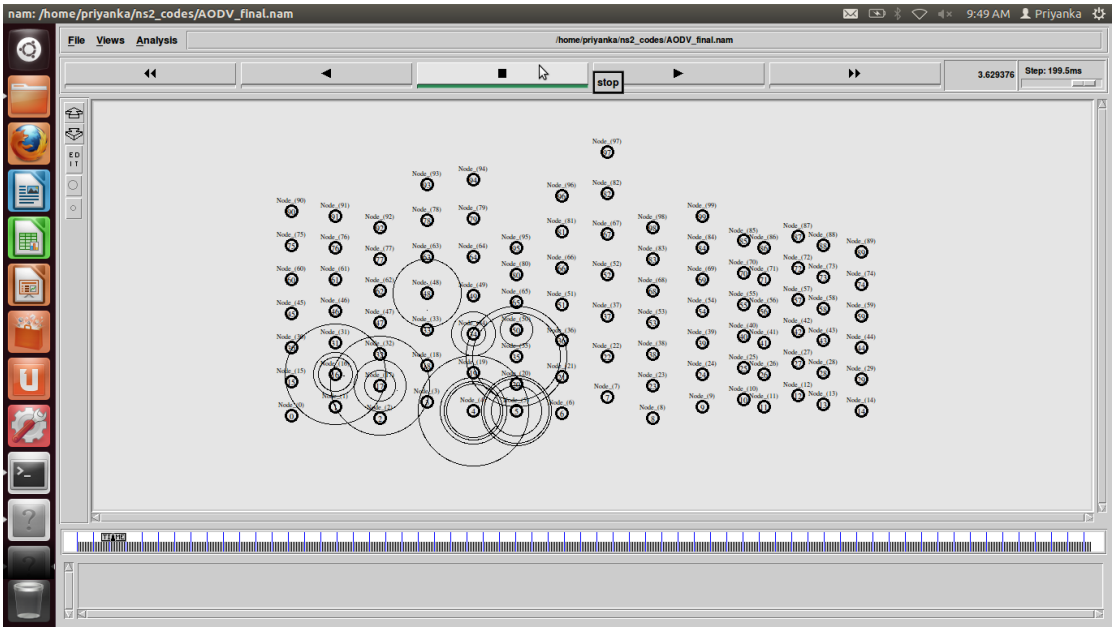


Figure 27: simulation of a100 node network

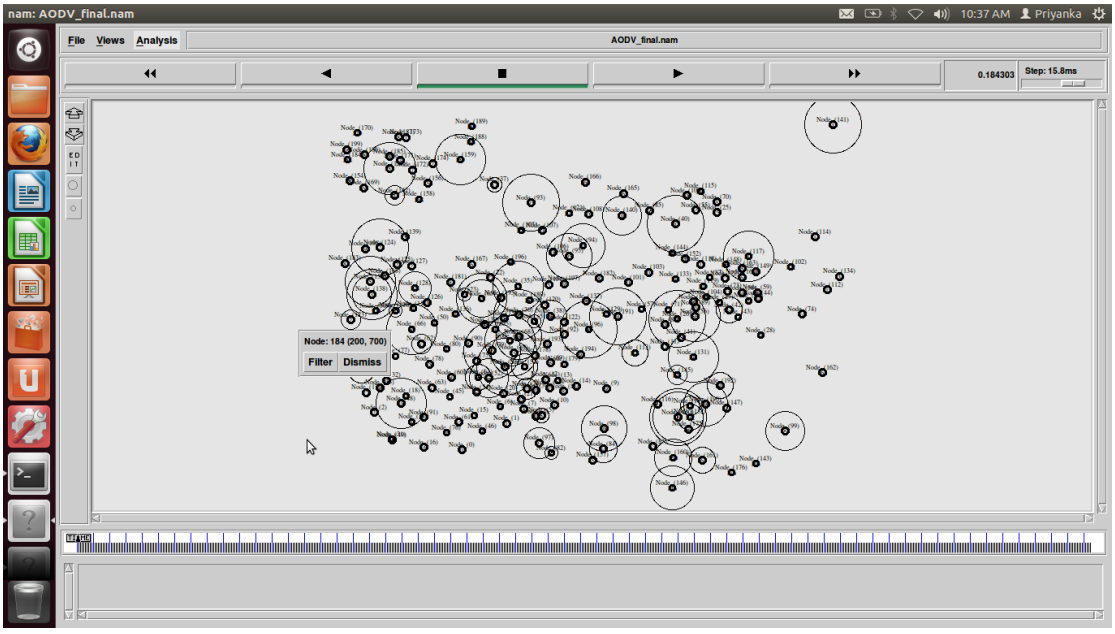


Figure 28: simulationof a200 node network

6.2 PACKET DELIVERY RATIO (PDR)

The ratio of the number of delivered data packet to the destination to the number of sent data packets. PDR illustrates the level of delivered data to the destination.

PDR = (∑ Number of packet receive / ∑ Number of packet send)

FIGURE 23 is a graph showing the PDR of the three networks having 50, 100 and 200 nodes respectively. Thus we conclude the following from the graph:

- PDR for a 50 nodenetwork is greater than that of any other network in the starting when the simulation begins, and continues to be larger for the 50-node network.

- PDR for the 100- node network is greater than the 200-node network and less than the 50-node network and by the end of the simulation also that remains with a slight deflection in the middle of the simulation.

- PDR for the 200 node network is the least at the starting of the simulation and there is increase and a deflection in the graph , the reason being there is a increase in the number of data packets sent by the sources and hence an increase in the number of packets received .

- PDR is maximum for 50-nodenetwork, which means the algorithm is most efficient for that network according to this metric.

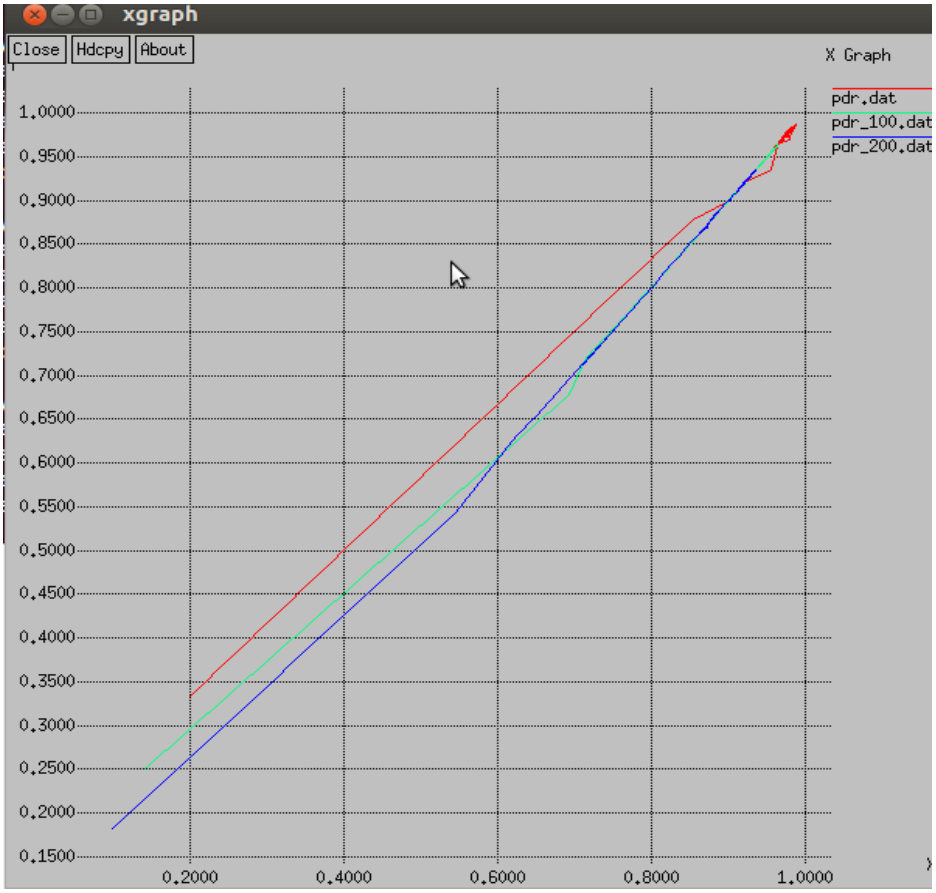


Figure 29 : graph showing the PDR of the three networks

6.3 THROUGHPUT

Throughput is the amount of data per unit time that is delivered from one node to another node via communication link. The throughput is measured in bits/second.

Figure 24 is graph showcasing the throughput for the 50-node network. It is clear from the graph that the throughput increases steadily from the beginning of the simulation.

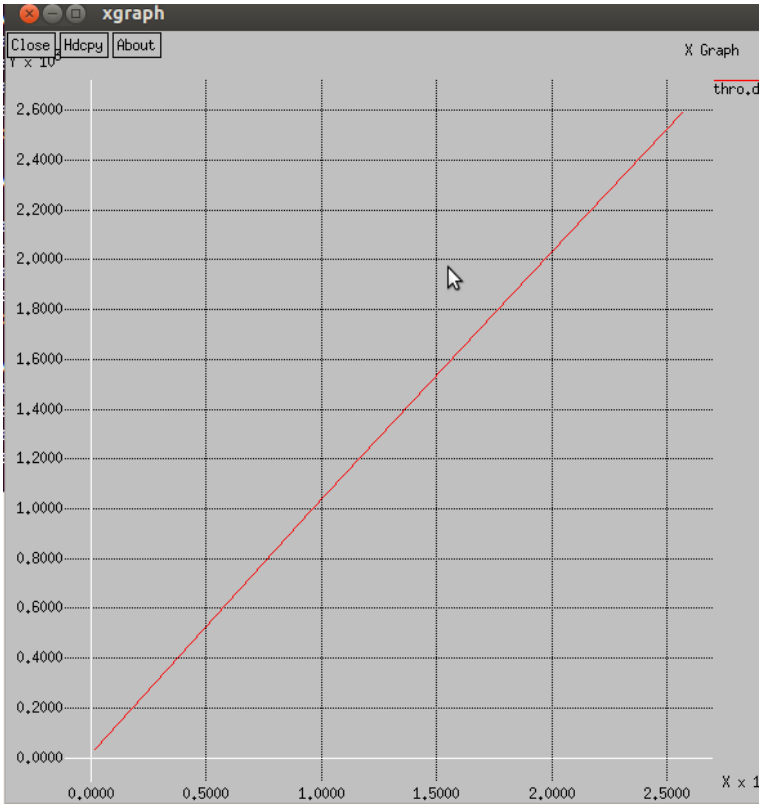


Figure 30 graph using throughput of 50 node network

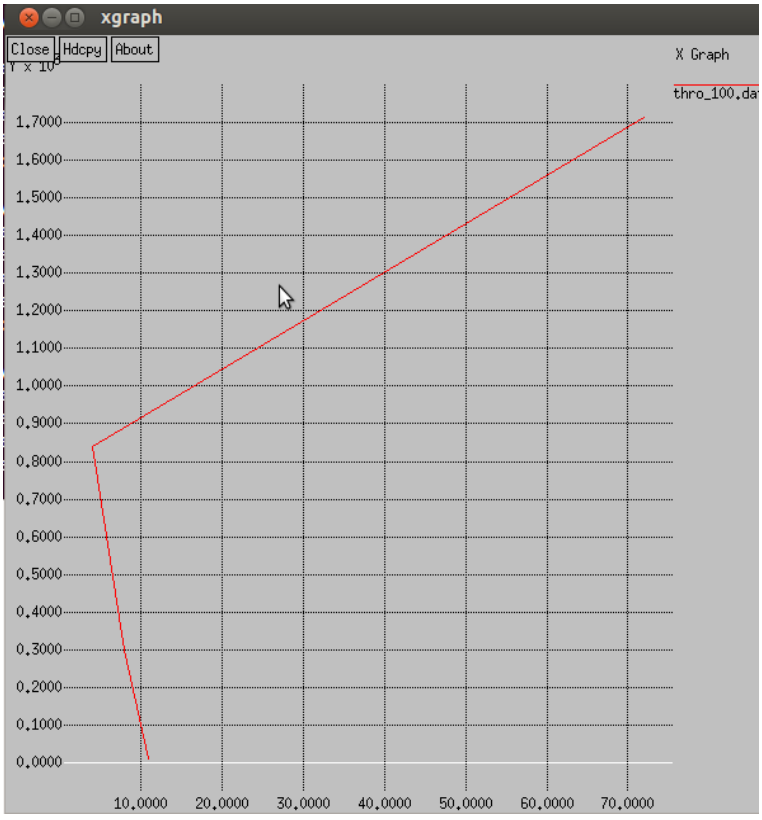


Figure 31: graph using throughput of 100 node network

Figure 25 is graph showcasing the throughput for the 100-node network. It is clear from the graph that the throughput, first decreases reaches its minima and then steadily increases and reaches its maximum value. This irregularity may be due to the mobility of the nodes and the source unable to send packets.

Figure 26 is graph showcasing the throughput for the 200-node network. It is clear from the graph that the throughput, first increases reaches its local maxima, decreases to a minimum value and then steadily increases and reaches its maximum value. This irregularity may be due to the mobility of the nodes and the source unable to send packets.

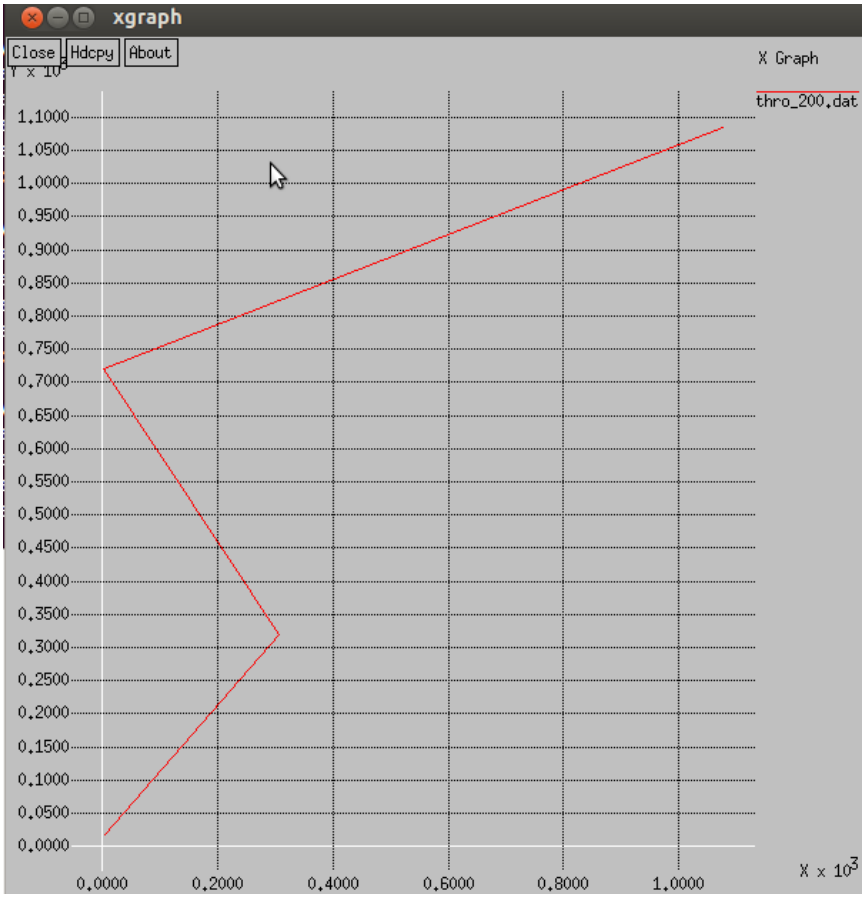


Figure 32: graph using throughput of 200-node network

Having read the 3 graphs and after doing a comparative study. The following conclusions are made:

- The throughput of the network increases with the increase in the number of nodes as the throughput per node adds up and hence greater throughput.

6.4 END-TO END DELAY

The average time taken by a data packet to arrive at the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations are counted. Therefore, end-to-end delay partially depends on the packet delivery ratio. As the distance between source and destination increases, the probability of packet drops increases. The average end-to-end delay includes all possible delays in the network i.e. buffering route discovery latency, retransmission delays at the MAC, and propagation and transmission delay.

DELAY = ∑ (arrive time – send time) / ∑ Number of connection

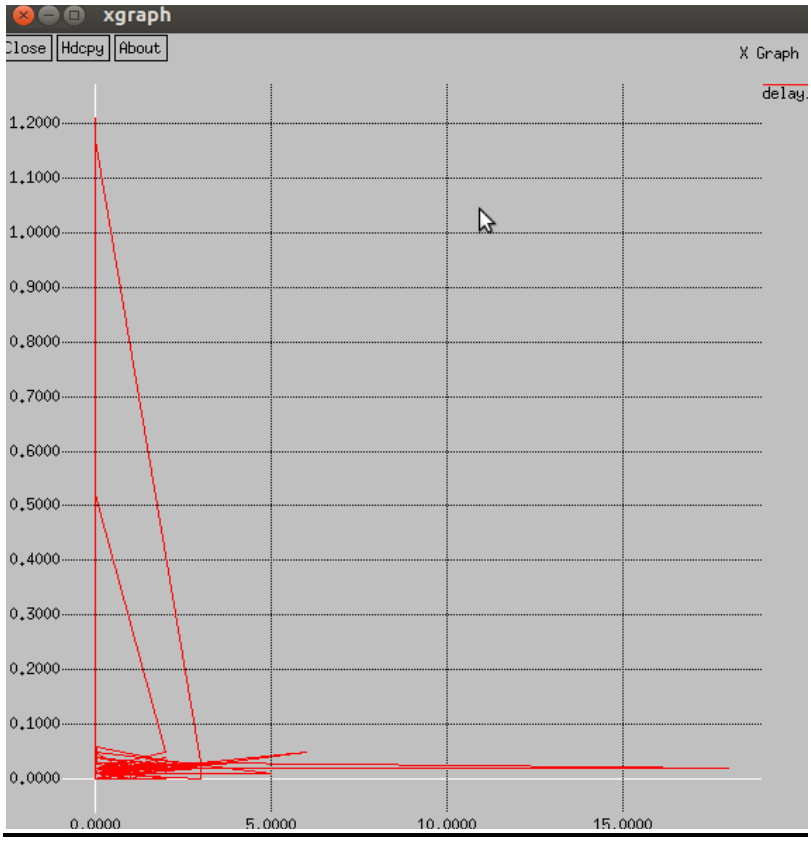


Figure 33 : graph showing the delay for a 50 node network

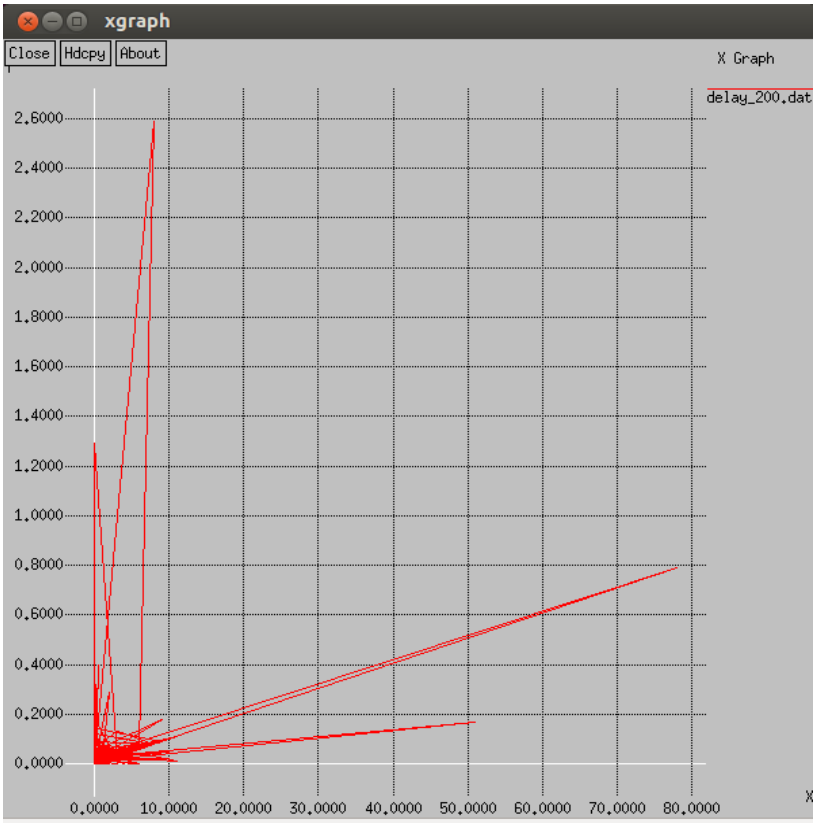


Figure 34 :graph showing the delay for a 200 node network

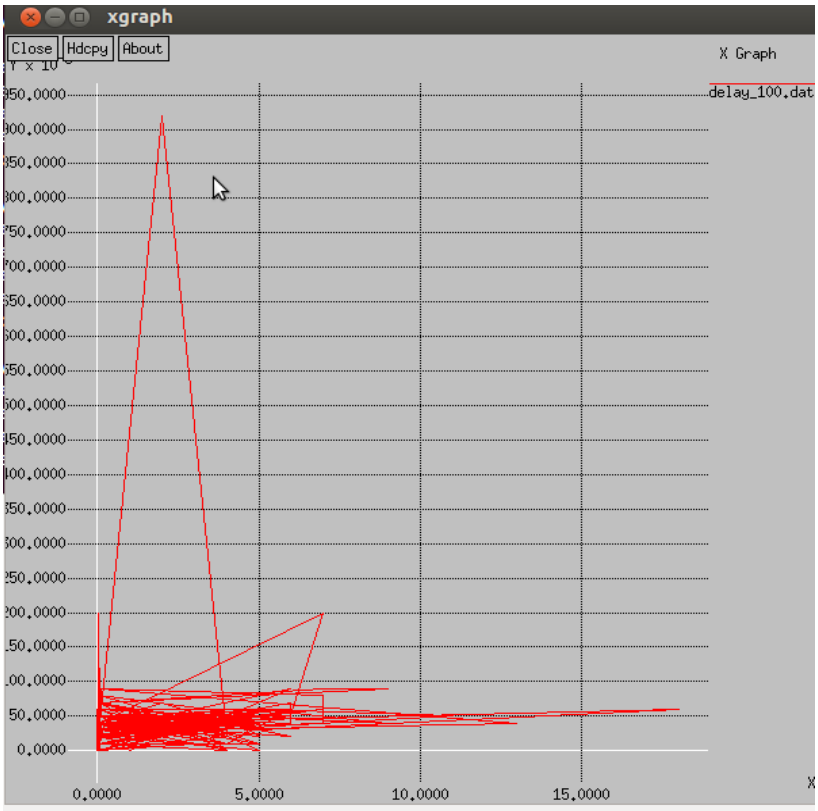


Figure 35 :graph showing the delay for a 100 node network

Figure 27, 28, 29 are graphs showing the delays for 50,200 and 100 –node network respectively. After reading the graphs the following is concluded:

- The network with the highest number of nodes has the highest delay. I.e. the 200-node network has the highest delay and 50-node has the least delay. The reason being that as the number of nodes increase, the path length also increases and so does the delay as the data packets are sent from the sender and received.
- The distortion in the graphs is because of the motion of some nodes and as it s the cumulative delay of different source.

CONCLUSION:

My work represents a pin-dept background study of the peer –to –peer overlay networks, geographical routing techniques in these networks and various algorithms to do the same the network and the routing algorithm has been simulated on the network simulator and is thereafter analyzed with the help of the performance metrics like throughput , delay and packet delivery ratio. The routing algorithm is considered most efficient when the throughput is high, delay is low and packet delivery ratio is high. In the case of my simulations the routing algorithm shows mixed results.

On the basis of throughput:
50-node network < 100-node network < 200-node network
On the basis of delay
50-node network < 100-node network < 200-node network
On the basis of Packet Delivery Ratio:
50-node network > 100-node network > 200-node network

FUTURE WORK

The greedy perimeter stateless routing algorithm is a hybrid algorithm of two basic algorithms namely greedy forwarding and flat face routing, hence it is more reliable than the two of them, having done the performance analysis, it is observed that the routing algorithm doesn't work in the same way for different sizes of network and its difficult to analysis its efficiency as different performance metrics point to different conclusion.

Hence, the future scope of this project is as follows:

IMPROVING PERIMETER MODE:

One assumption in the use of planar perimeters we would like to investigate further is that a node can reach all other nodes within its radio range. The GG and RNG planarization's both rely on a node's ability to accurately know if there is a witness w within radio range, when considering elimination of an edge to a known neighbor. Our use of the GG and RNG can disconnect a graph with particular patterns of obstacles between nodes. This disconnection is easily avoided by forcing the pair of nodes bordering an edge to agree on the edge's fate, with two rules:

- Both nodes must decide to eliminate the edge, or neither will do so.
- If both nodes decide to eliminate the edge, they must agree on a common w (i.e., theremust be a transitive path through a witness they can both reach).

Throughput-delay tradeoff[10]:

Improvement to be made in the algorithm to balance the throughput-delay tradeoff.

The three important features that influence the throughput and delay in wireless networks:

- The number of hops
- The transmission range
- The node mobility and velocity.

Schemesmust be proposed that exploit these three features to different degrees to obtain different points on the throughput-delay curve in an optimal way.

USING VIRTUAL COORDINATES[11]:

In this project, the implemented GPSR algorithm uses the original coordinates of the nodes at which they are placed in the simulation area in ns2. But when this algorithm will be implemented in real time scenarios in which the nodes are spread across various squarekms of areas it will become difficult to make calculations and forward packet to next neighbor therefore increasing time complexities.

Thereafter, a new algorithm can be designed,which doesn't require assuming that the nodes already know their position and doesn't rely on the GPS systems required to know the location of the nodes and their one-hop neighbors.

Therefore, the need to design an algorithm to know how to retain the benefits of geographicrouting in the absence of location information.

virtual coordinates can be assigned to each node in the network .These virtual coordinates need not beaccurate representations of the underlying geography but, in orderto serve as a basis of routing, they must reflect the underlying connectivity. Thus, virtual coordinates are could be constructed using onlylocal connectivity information. Since local connectivity informationis always available (nodes always know their neighbors), thistechnique can be applied in most scenarios.

REFERENCES:

[1] A Survey of Geographical Routing in Wireless Ad-Hoc Networks Fraser Cadger, *Member*, *IEEE*, Kevin Curran, *Senior Member*, *IEEE*, Jose Santos and Sandra Moffet

[2] Peer-to-Peer Overlay in Mobile Ad-hoc Networks,Marcel C. Castro1, Andreas J. Kassler Carla-FabianaChiasserini, Claudio Casetti, and Ibrahim Korpeoglu.

[3] UML modelling of geographic routing protocol "Greedy Perimeter Stateless Routing" for its integration into the " Java Network Simulator'' Mohammed ERRITALI Oussama Mohamed RedaBouabid El Ouahidi,*Department of Computer Science, Faculty of Sciences ,Mohamed V University*

[4] Efficient Routing for Peer-to-Peer Overlays, Anjali Gupta, Barbara Liskov, and Rodrigo Rodrigues ,MIT Computer Science and Arti_cial Intelligence Laboratory

[5] Routing on Overlay Networks: Developments and ChallengesAdrian Popescu, Dept.of Telecommunication Systems,School of engineering,Blekinge Institute of Technology

[6] Performance Analysis &Behavioural Study of Proactive & Reactive Routing Protocols in MANET ,Deepak Kumar Patel,RakeshKumar,A.K. Daniel

[7] http://www.pdos.lcs.mit.edu/p2psim/.

[8] http://www2.ensc.sfu.ca/~ljilja/ENSC835/Spring08/Projects/thomas/ENSC835_Project_Report.pdf

[9] http://hj.diva-portal.org/smash/get/diva2:133774/FULLTEXT01.pdf

[10] http://www.cc.gatech.edu/~mihail/D.8802readings/adhoc04.pdf

[11] Geographic Routing without Location Information AnanthRao Sylvia Ratnasamy∗ Christos Papadimitriou Scott Shenker † Ion Stoica (University of California – Berkeley)