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Submitted to the Faculty of -Computer Science, Military College of Signals

National University of Science and Technology, Rawalpindi

~~A thesis submitted~~

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~~Computer~~ Software Engineering

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Declaration

No portion of the work presented in this dissertation has been submitted in support of another award or qualification either at this institute or elsewhere.

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ABSTRACT

OPTICAL ANTENNA PLACEMENT IN A MESH BASED MOBILE AD HOC NETWORKS[THESIS TITLE]

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This thesis deals with the making of an algorithm and a visual simulation tool for optimal solution of antenna placement in a mesh based mobile ad hoc network. This software- in a mesh based ad hoc network- is developed with the intention of innovation in design and progression of mobile antennas with an algorithm that can read GIS (geological information system) terrain i.e. information about the obstacles in a particular area, which are displayed as three dimensional models DEM (Digital Elevation Model).

This software basically provides an algorithm based in mat lab which can read terrain/height information and land data for antenna placement module called as antenna locator from a source and the phenomenon has been visually simulated in visual C++.

The software in the proposed research was developed to aid the idea that how an algorithm can help in proficient and efficient location of the moving antenna and maintaining communication, even if there are obstacles between those moving antennas. Establishment of communication in such a dynamic environment is quite a tedious task.

The Line of sight principle might sound an easy solution for planning the antenna locations in such environments as most of the UHF-VHF antennas work on LOS but it's a little complex when we work in 3D. Incorporation of DEM and height, curvature of earth and terrain limitation make it complex. It will assist and facilitate the network planners to

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optimally place antennas and thus improve the efficiency and reliability of tracking an antenna and as well as keeping them in contact, for any particular mobile ad hoc network scenario.

Antenna locator in this thesis implements that the minimum number of antennas illuminate the maximum of the desired coverage area. It takes into account the location of antennas, their receiving and transmitting power (range) as well while showing the communication amongst the mobile nodes.

The antenna locator shows the result with the help of the algorithm which establishes the communication between mobile nodes with certain conditions. To illustrate this fact, it animates the mobile antennas as nodes in the form of circular rods continuously moving on the DEM.

By integrating with GPS (Global Positioning System) this software can be used for studying the resource allocation of wireless networks using ad hoc approach under different traffic loads and patters and as well as for the antenna location determination. Also by providing three dimensional traffic data and obstacle data in graphical display, this algorithm generates an idea which can extended not only to study the mobile user locating methods but can be developed into an optimized package which may prove to be very useful in critical warfare situations and military applications.

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DECLARATION

It is declared that the work done for this project is exclusively the effort of this syndicate and no portion of the work presented in this dissertation has been submitted in support of another award of qualification either at this institution or elsewhere.

Wherever help is taken from any other paper or some other material it is appropriately acknowledged and referred to.

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DEDICATION

Dedicated to brave Muslims who are fighting for a just cause in different parts of the world. Indeed they are not only fighting for themselves, but for the whole Muslim Ummah. May Allah Almighty bring glory to them.

Also, this project work is dedicated to our teachers for their unwavering support and guidance, to our parents whose prayers have been with us throughout and to the people who still want to contribute something to this country.

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We would like to acknowledge that Dr. Shoaib A. Khan who made things a lot easy for ~~us especially~~us especially the guidance he gave us and ~~encouragement even~~encouragement even on the accomplishment of ~~minutest tasks~~minutest tasks helped us in achieving our goals without a feeling of laborious work.

We endorse our acknowledgment for CARE faculty specially Mr. Ali Abbas and Cout Group who helped us in understanding of alien languages.

In the end we are thankful to Air Commodore Retd. Dr. Saleem Akbar for being our internal DS and bestowing upon us his guidance throughout the project.

~~Thanks to Allah Almighty for gracing us the knowledge to think, explore and invent. Every thing in the universe is meant to~~

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serve man. Now it is up to us to use the resources to the maximum of our capabilities and for the betterment of the human race

We are extremely grateful to Air Cdr. (R) Saleem Akbar who has shown us the way to reach to this point. He spent much of his precious time with us during the literature review and the actual project work. He was available to us for help and guidance even after the office timings and in the evenings. It is only due to his commitment with us that we were able to do all this project work.

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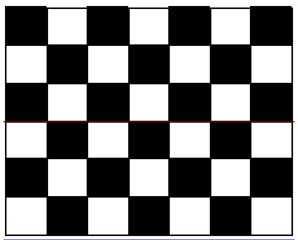

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bibliography

Doe, John B. *Conceptual Planning: A Guide to a Better Planet*, 3d ed. Reading, MA: SmithJones, 1996.

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Smith, Chris. *Theory and the Art of Communications Design.* State of the University Press, 1997

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BIBLIOGRAPHY

[1] **C.-H. E. Chow, J. Bicknell, S. McCaughey, and S. Syed, "**A Fast Distributed Network Restoration Algorithm," Proceedings of 12th International Phoenix Conference on Computers and Communications, **March 24-26, 1993, Scottsdale, Arizona.**

[2] **C.-H. E. Chow, J. Bicknell, and S. Syed,** "Performance Analysis of Fast Link Restoration Algorithms," Journal of Digital and Analog Communication Systems, **1995. Part of the research results published in Proceedings of Globecom 93.**

[3] **B. Adamson,** "Tactical Radio Frequency Communication Requirements for IPng," **RFC 1677, Aug. 1994.**

[4] **S. Corson, J. Macker,** "Mobile Ad hoc Networking (MANET), Routing Protocol Performance Issues and Evaluation Considerations ",**March 1998.**

[5] **C.-K. Toh,** "Maximum Battery Life Routing to Support Ubiquitous Mobile Computing in Wireless Ad Hoc Networks"; **IEEE Communication Magazine June 2001.**

[6] **C.-H. E. Chow, J. Bicknell, S. McCaughey, and V. Narasimhan,** "NETRESTORE: A network simulation system," to be published in 1996 on Journal of Computer and Software Engineering. 15. C.-H. E. Chow, "NETSIM: A network simulation system for the design and analysis of network survival techniques," **CASI proposal, November, 1993.**

[7] **C.-H. E. Chow,** "Resource Allocation for Multiparty Connections," IFIP 3rd International Workshop on Protocols for High-Speed Networks, **May 1992, pp. 121-136.**

[8] **C.-H. E. Chow,** "ATMROS: A Network Design System for ATM Network Optimization and Traffic Management," CASI proposal, November, 1994.

[9] **Suzanne P. Wechsler,** "Digital Elevation Model (DEM) Uncertainty: Evaluation and Effect on Topographic Parameters "

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[10] **Miltiades E. Anagnostou, G. C. Manos,** "Handover Related Performance of Mobile Communication Networks," **Proceedings of IEEE 44 th Veh. Tech. Conf., VTC 94, pp.111-114.**

[11] **FCC,** "Amendment of the Commission's Rules to Establish New Personal Communications Services," **GEN Docket No. 90-314, Oct. 22, 1993.**

[12] **Mischa Schwartz,** "Network Management and Control Issues in Multimedia Wireless Networks," **IEEE Personal Communications, Vol. 2, No. 3, June 1995, pp. 8-16.**

[13] **Leung, Kin K.,** "Traffic Models for Wireless Communications Networks," **IEEE JSAC, Vol. 12, No. 8, Oct. 1994.**

[14] Wireless Networks," *Proc. 2nd ACM international workshop on Modeling, analysis and simulation of wireless and mobile systems*, **pp. 69-73, 1999.**

[15] Special issue on Ad Hoc Networks, **Volume 8, pp. 34-39, February 2001.**

[16] **K.-W. Chin, et al.,** "Implementation Experience with MANET Routing Protocols," *ACM SIGCOMM Computer Communications Review*, **Nov. 2002, pp. 49-59.**

[17] **Z. J. Haas, et al., eds.,** Special Issue on Wireless Ad Hoc Networks, *IEEE J. on Selected Areas in Communications*, **Vol. 17, No. 8 (August 1999).**

[18] **B.-J. Kwak, et al.,** "On the Scalability of Ad Hoc Networks," *IEEE Communications Letters*, **Vol. 8, pp. 503-505. (August 2004)**

[19] **A. Lindgren,** "Infrastructured Ad Hoc Networks," *Proc. 2002 Int'l Workshop on Ad Hoc Networking*, **Vancouver, August 2002.**

[20] **J. Lipman, et al.,** "Optimised Flooding in Ad hoc Networks," *Proc. 2003 Workshop on the Internet, Telecomm. and Signal Proc.* **(WITSP'03), Coolangatta, Australia, December 2003.**

[21] **D. A. Maltz, J. Broch, and D. B. Johnson,** "Quantitative Lessons From a Full-Scale Multi-Hop Wireless Ad Hoc Network Testbed," *Proc.* ***IEEE Wireless Communications and Networking Conference,*** **September 2000.**

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[22] **V. D. Park and M. S. Corson,** "A Highly Adaptive Distributed Routing Algorithm for Mobile Wireless Networks," ***Proc. INFOCOM '97*, pp. 1405-1413.**

[23] **R. Ramanathan,** "Making Ad Hoc Networks Density Adaptive," ***Proc. Milcom 2001*, pp. 957-961.**

[24] **S. Ramanathan and M. Steenstrup,** "A survey of routing techniques for mobile communications networks," **Baltzer/ACM *Mobile Networks and Applications*, vol. 1 (1996), pp. 89-104.**

[25] **E. M. Royer and C.-K. Toh,** "A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks," ***IEEE Personal Communications*, April 1999, pp. 46-55.**

[26] **P. Samar and S. B. Wicker,** "On the Behavior of Communication Links of a Node in a Multi-Hop Mobile Environment," ***Proc. MobiHoc 2004*.**

[27] **C. Tschudin et al.,** "Active Routing for Ad Hoc Networks," *IEEE Communications Magazine*, **April 2000, pp. 122-127.**

[28] **B. Williams and T. Camp,** "Comparison of Broadcasting Techniques for Mobile Ad Hoc Networks," ***Proc. MobiHoc 2002*, pp. 194-195.**

[29] **A. N. Zadeh et al.,** "Self-Organizing Packet Radio Ad Hoc Networks with Overlay (SOPRANO)," ***IEEE Communications Magazine*, June, 2002.**

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Chapter 1

1 Introduction to MANETs

1.1 Wireless Ad Hoc Networks

A wireless ad hoc network is a collection of two or more devices/ nodes or terminals with wireless communications and networking capability that communicate with each other without the aid of any centralized administrator. Each node in a wireless ad hoc network as shown in Figure 1.1, functions as both a host and a router. The network topology is in general dynamic, because the connectivity among the nodes may vary with time due to node mobility, node departures and new node arrivals. Hence, there is a need for efficient routing protocols to allow the nodes to communicate.

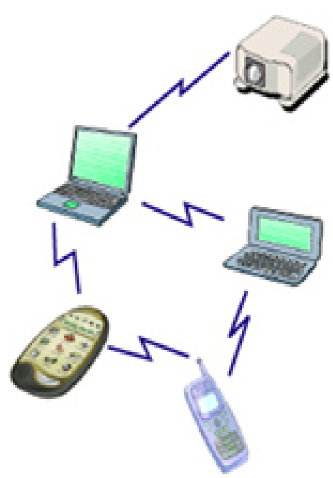

Figure 1.1 Wireless Networks

Ad hoc nodes or devices should be able to detect presence of other such devices to allow communication and information sharing. Besides that, it

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should also be able to identify types of services and corresponding attributes. Since nodes changed on the fly, routing information also changes to reflect changes in link connectivity.

There are two major types of wireless ad hoc networks: Mobile Ad Hoc Networks (MANET) and Smart Sensor Networks.

Smart Sensor Network consists of a number of sensors spread across a geographical area. Each sensor has a wireless communication capability and sufficient intelligence for signal processing and networking of the data.

A MANET is an independent collection of nodes or mobile users that communicate over wireless links. Significant examples of MANET include establishing communication for emergency or rescue operations, disaster relief efforts and military networks. For unexpected scenarios like this, centralized connectivity is not reliable, thus MANET will be an efficient solution. The network is centralized; nodes themselves must execute discovering topology and message delivering. MANETs need efficient distributed algorithms to determine network organization, link scheduling and routing. With MANET, shortest path algorithm does not serve as the optimal algorithm for routing. Factors such as variable wireless link quality, propagation path loss, fading, multi-user interference, power expended and topological changes become important issues. The network must be able to adaptively alter the routing paths to alleviate any of these effects.

The importance in mobile ad hoc networking is to support robust and efficient operation in mobile wireless networks by incorporating routing functionality into mobile nodes. Such networks are forecasted to have

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dynamic, sometimes rapidly changing, random, multi hop topologies, which are likely composed of relatively bandwidth-constrained wireless links.

A Mobile Ad Hoc Network (MANET) consists of mobile platforms e.g. a router with multiple hosts and wireless communications devices known as nodes, which are free to move about arbitrarily. A MANET is an independent system of mobile nodes and it may operate in isolation, or may have gateways to and interfere with a fixed network. MANET nodes are equipped with wireless transmitters and receivers using antennas which may be omni directional (broadcast) and highly directional (point-to-point).

1.2 Mobile Ad Hoc Networks (MANETs)

Latest trends / developments in technology have bought a revolutionary change in the field of communication. As the mobility is growing world wide, there is an increasing need for individuals to be in contact with each other and to have timely access to information regardless of the location of the individuals or the information i.e. access should be for anyone, anytime, any where, basis.

With recent performance advancements in computer and wireless communications technologies, advanced mobile wireless computing is expected to see increasingly widespread use and application. The vision of mobile ad hoc networking is to support robust and efficient operation in mobile wireless networks by incorporating routing functionality into mobile nodes. Such networks are envisioned to have dynamic, sometimes rapidly-changing, random, multi hop topologies which are likely composed of relatively bandwidth-constrained wireless links. The past decade has

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shown a phenomenal growth in wireless communications. Cellular systems have been standardized and Personal Communication Services (PCS) and the 3rd generation radio technology are being used providing wide-band services to mobile users.

Additionally, wireless networking is being used more and more in both fixed and mobile usage scenarios, whereas high quality multimedia (voice, video and data) services over high-speed wireless local area networks (LANs) are becoming a reality. The demand of these multimedia applications has been largely witnessed so far in fixed networks but as life style is rapidly changing, internet-like applications are more and more attractive to mobile users as well.

In parallel with (and separately from) the single hop model for today's cellular/wireless communications, another type of model based on radio to radio multi hopping, has been evolving to serve a growing number of applications which rely on a fast deployable, multi hop, wireless infrastructure. A multi hop mobile radio network, also called mobile ad hoc network (MANET) is a self-organizing and rapidly deployable network in which neither a wired backbone nor a centralized control exists. The network nodes communicate with one another over scarce wireless channels in a multi-hop fashion. The ad hoc network is adaptable to the highly dynamic topology resulted from the mobility of network nodes and the changing propagation conditions.

Thus MANETs are a new paradigm of wireless wearable devices enabling instantaneous person-to-person, person-to-machine or machine-to-person communications immediately and easily. In these applications, where a fixed backbone is not available, a readily deployable wireless network is needed.

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In the next generation of wireless communication systems, there will be a need for the rapid deployment of independent mobile users. Significant examples include establishing survivable, efficient, dynamic communication for emergency/rescue operations, disaster relief efforts, and military networks. Such network scenarios cannot rely on centralized and organized connectivity, and can be conceived as applications of Mobile Ad Hoc Networks. A typical MANET is shown in Figure 1.2.

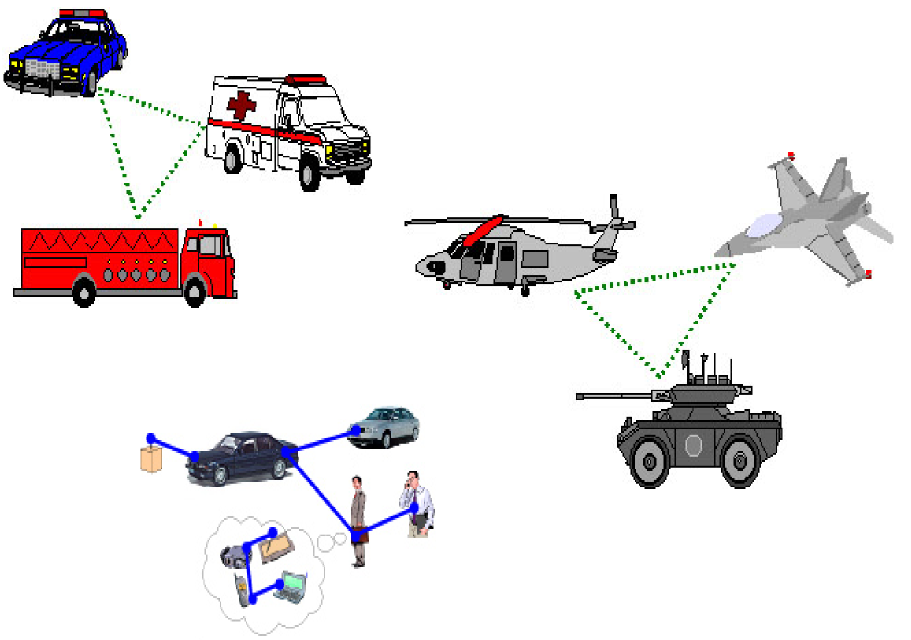

Figure 1.2 Mobile Ad Hoc Networks

A MANET is an autonomous collection of mobile users that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network is decentralized, where all network activity including discovering the topology and delivering messages must be executed by the

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nodes themselves, i.e., routing functionality will be incorporated into mobile nodes.

The set of applications for MANETs is diverse, ranging from small, static networks that are constrained by power sources, to large-scale, mobile, highly dynamic networks. The design of network protocols for these networks is a complex issue. Regardless of the application, MANETs need efficient distributed algorithms to determine network organization, link scheduling, and routing. However, determining viable routing paths and delivering messages in a decentralized environment where network topology fluctuates is not a well-defined problem. While the shortest path (based on a given cost function) from a source to a destination in a static network is usually the optimal route, this idea is not easily extended to MANETs. Factors such as variable wireless link quality, propagation path loss, fading, multi-user interference, power expended, and topological changes, become relevant issues. The network should be able to adaptively alter the routing paths to alleviate any of these effects. Moreover, in a military environment, preservation of security, latency, reliability, intentional jamming, and recovery from failure are significant concerns. Military networks are designed to maintain a low probability of intercept and/or a low probability of detection. Hence, nodes prefer to radiate as little power as necessary and transmit as infrequently as possible, thus decreasing the probability of detection or interception. A lapse in any of these requirements may degrade the performance and dependability of the network.

1.3 Group Communication in Mobile Ad-Hoc Networks

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There are tremendous changes in the wireless industry. We can expect to see future wireless generations supporting deployment of independent mobile users. The idea of supporting mobile users on a peer-to-peer basis in the absence of a centralized controller was reviewed in the mid-nineties. This concept of ad-hoc networking has been successful in the invention of some of the latest technologies, such as Bluetooth and mobile ad-hoc sensors, which are in use on various platforms. A mobile ad-hoc or on the fly network is the collection of mobile nodes that communicate over a wireless medium and do not require any pre installed communication infrastructure. Communication in such a network can be performed if nodes are agreed to exchange packets. Effective support of multicast or group communication is essential for most ad-hoc network applications. There are many applications where group communication as shown in Figure 1.3, is a crucial task. Group communication, both one-to-many and many-to-many, has become increasingly important in mobile ad-hoc networks. In mobile ad-hoc network group communications, issues differ from those in wired networks because of the variable and unpredictable nature of the wireless medium, where the signal strength and propagation varies with the time and the environment. Moreover, node mobility causes continuously changing topology in which routes break unpredictably and new routes form dynamically.

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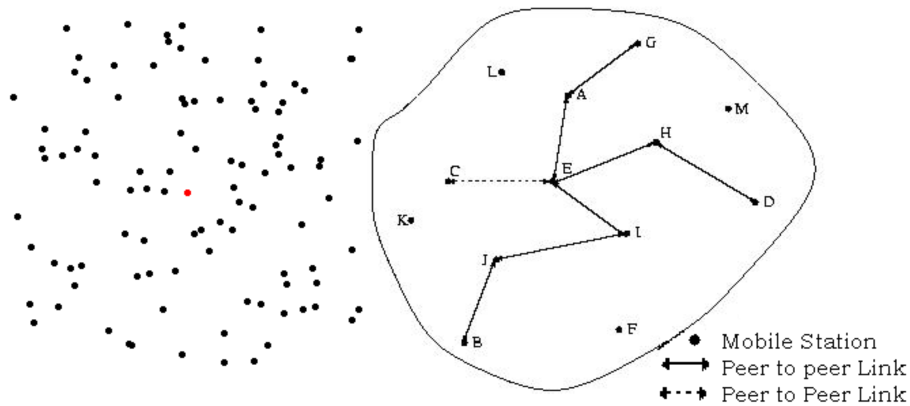

Figure 1.3 Group Communication in Manet

In mobile ad-hoc network, an efficient group communication model can ease effective communication among various groups in the network. At present, multicasting routing in mobile ad-hoc networks as shown in Figure 1.4 is gained by adopting one of two approaches: flooding and tree-based routing. Flooding offers the lowest control overheads with very high data traffic, while tree-based routing reduces data traffic in the network but requires many control data exchanges. Studies show less efficient performance of these techniques on mobile ad-hoc network.

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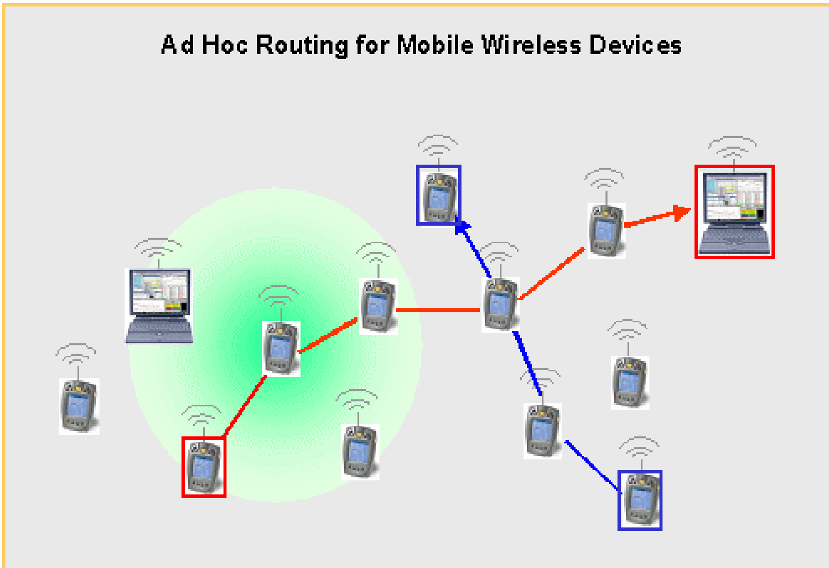

Figure 1.4 Ad Hoc Routing

Group communication technologies have proven their importance in different fields of our daily life, such as education, entertainment, and other industries. Providing efficient group communication is one of the main issues in mobile ad-hoc networks. Moreover, the highly dynamic nature and frequent topology changes make this issue even more challenging. While these networks are rapidly gaining popularity, there is a strong need to develop efficient strategies to support group communication in mobile ad-hoc networks.

1.4 The future of Mobile Ad-Hoc Networks

It has been more than a decade, since wireless networks have been adopted to enable mobility. With the recent advancements in wireless technology, such as Bluetooth, Wi-Fi and HiperLAN (which is spelled with

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an "i" rather than the "y" you might expect), a new concept of network formation has evolved which has made wireless networks more popular in the computer industry.

There are currently two types of mobile wireless networks. The first is known as infrastructure networks, such as networks with fixed and wired gateways. The bridges for these networks are known as base stations. The second type of wireless network is the mobile ad-hoc network. Ad-hoc connectivity is based on peer-to-peer communication.

The mobile ad-hoc network is a collection of wireless mobile hosts dynamically establishing a short lived network without the support of a network infrastructure. In this type of environment, it's expected that a large number of ad-hoc connections will exist in the same region without any mutual coordination. Mobile ad-hoc networks are the future of wireless networks. Nodes in these networks will generate both users and application traffic and perform various network functions.

Future mobile ad-hoc networks will use mobile routers to provide Internet connectivity to mobile ad-hoc users. A mobile router will also allow mobility of an ad-hoc network, where mobile users may use an Internet access within an ad-hoc network domain. Recently, organizations have begun to see potential for such dynamic networks. Mobile ad-hoc networks are of increasing interest for a distributed set of applications, such as distributed collaborative computing, distributed sensing networks, potential fourth generation wireless systems, and response to incidents that destroyed the existing communication structure.

There is current and future need for dynamic ad-hoc networking technology. The emerging field of mobile computing, with its current focus on mobile IP operation, will expend gradually. In the future, mobile

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computing will require highly-adaptive networking technology to manage multi-hop clusters that can operate autonomously and possibly be able to attach at some point to the bigger network.

In conclusion, wireless networks can be deployed in either infrastructure-based mode or on an ad-hoc basis. Although work is being done and prototype protocols are available for experiments, mobile ad-hoc networks still have difficulties. While some basic network control functions and routing procedures have been developed, many other issues require attention. Rapidly changing topology, network partitions, higher error rates, collision interference, bandwidth constraints, and power limitations together pose new challenges in network control; especially in the design of higher level protocols for routing and in implementing applications with quality of service requirements.

1.5 Applications of MANET

MANETs will most likely be used in cases where there is no fixed wired infrastructure. This may be because it is not economically practical or physically possible to set up the necessary infrastructure, or because the situation does not permit its installation.

1.5.1 Daily Life Applications of MANET

Computer science classroom, Adhoc network between student PDAs and workstation of the instructor is a simple and perfect example of an adhoc network. Employees of a company moving within a large campus with PDAs, laptops, and cell phones. Customers spend part of the day in a networked mall of specialty shops, coffee shops, and restaurants .These

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are few examples of the simple daily life applications, which clearly outline the current and future need for dynamic ad hoc networking technology.

1.5.2 Applications in Industrial and Commercial Area

Applications of MANET technology could include industrial and commercial areas involving cooperative mobile data exchange. In addition, mesh-based mobile networks can be operated as robust, inexpensive alternatives or enhancements to cell-based mobile network infrastructures.

There are also existing and future military networking requirements for robust, IP-compliant data services within mobile wireless communication networks --many of these networks consist of highly-dynamic autonomous topology segments. Also, the developing technologies of "wearable" computing and communications may provide applications for MANET technology. When properly combined with satellite-based information delivery,

1.5.3 Emergency Operations

MANET technology can provide an extremely flexible method for establishing communications for fire/safety/rescue operations or other scenarios requiring rapidly-deployable communications with survivable, efficient dynamic networking. There are likely other applications for MANET technology, which are not presently realized or envisioned by the authors. It is simply put, improved IP-based networking technology for dynamic, autonomous wireless networks. There are likely other applications for MANET technology, which are not presently realized or envisioned by the authors.

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1.6 MANET Architecture

MANET architectures for providing network connectivity can be categorized as

1.6.1 Flat-routed Architecture (*zero*-tier)

All nodes have equivalent routing roles. A Flat-routed architecture is shown in Figure 1.5. All the nodes are equal and the packet routing is done based on peer-to-peer connections, restricted only by the propagation conditions.

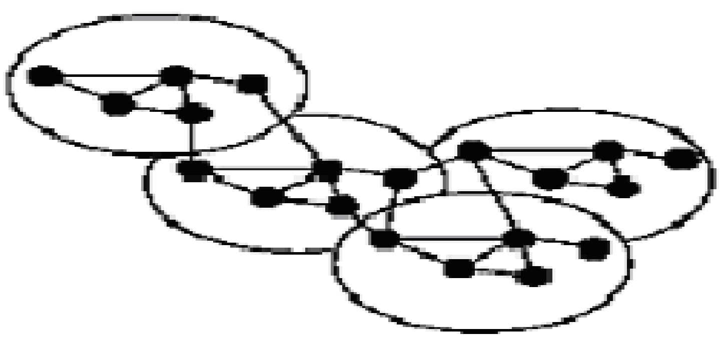

Figure 1.5 Flat-Routed Architecture

1.6.2 Hierarchical Architectures (*N*-tier)

1.6.2.1 Cluster Nodes have Different Routing Roles

There are at least two layers; in the hierarchical networks, on the lower layer, in geographical proximity create peer-to-peer networks are created

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by the nodes. Each one of these lower-layer networks, at least one node is designated to serve as a "gateway" to the higher layer. These "gateway" nodes create the higher layer network, which usually requires more powerful transmitters/receivers. Although routing between nodes that belong to the same lower-layer network is based on peer-to-peer routing, routing between nodes that belong to different lower-layer networks is through the gateway nodes.

1.6.2.2 Control the Traffic Between Cluster and other Clusters

As it is hierarchal therefore it tends to control traffic between cluster and other clusters as well. A Two-Layer Ad Hoc Network is shown in Figure 1.6.

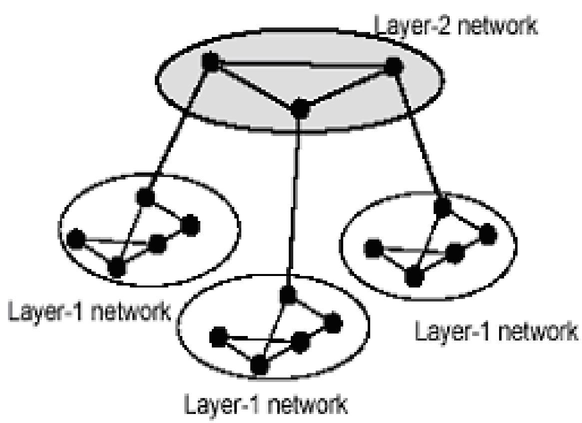

Figure 1.6 Two-Layer Ad Hoc Network

1.7 Characteristics of MANETs

Mobile adhoc networking allows users to exchange information in a wireless environment without the need for a fixed infrastructure. Each

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user (or node), equipped with one or more radios, is free to roam about while communicating with others. The path between any pair of users can traverse multiple wireless links and the radios themselves can be heterogeneous, thus enabling an assortment of different types of links to be part of the same adhoc network.

The mobility of the nodes results in a network whose topology is dynamic. The job of the network is to discover the links between the mobile nodes and to build paths so that any user can communicate with any other user, as long as each has a link to the adhoc network. Within the adhoc network, each node acts as a router and forwards packets on behalf of others.

1.7.1 No Fixed Infra Structure

A MANET (Mobile Ad hoc Network) has no fixed infra structure and thus it consists of mobile platforms thus it may be a router with multiple hosts and wireless communications devices—and can also be simply referred to as "nodes"--which are free to move about in arbitrarily directions. The nodes may be located in or on moving vehicles like ships, trucks, cars, or even aero planes, perhaps even on people or very small devices, and there may be multiple hosts per router.

1.7.2 Variable System

The system may operate in isolation, or may have gateways to and interface with a fixed network. Thus it is an autonomous system. MANET nodes are equipped with wireless transmitters and receivers using antennas which may be omni directional (broadcast), highly-directional (point-to-point), possibly steer able, or some combination thereof.

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1.7.3 Networking Constraints

At a given point in time, depending on the nodes' positions and their transmitter and receiver coverage patterns, transmission power levels and co-channel interference levels, a wireless connectivity in the form of a random, multi hop graph or "ad hoc" network exists between the nodes. MANET nodes are equipped with wireless transmitters and receivers using antennas. This ad hoc topology may change with time as the nodes move or adjust their transmission and reception parameters.

1.7.4 Mobility

Due to mobility, topology of network can change frequently. Nodes are free to move arbitrarily; thus, the network topology--which is typically multi hop--may change randomly and rapidly at unpredictable times, and may consist of both bidirectional and unidirectional links.

1.7.5 Nodes can be Temporarily Off-line or Unreachable

As the Nodes are mobile and the terrain can be undulating or a built up area with a lot of potential obstacles so it’s always a chance that the nodes can be temporarily offline or disconnected. Moving Nodes need more resources in the form of equipment cost, fuel in case of vehicles and other issues.

Some or all of the nodes in a MANET may rely on batteries or other exhaustible means for their energy. For these nodes, the most important system design criteria for optimization may be energy conservation.

1.7.6 Memory and CPU Constraints

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One effect of the relatively low to moderate link capacities is that congestion is typically the norm rather than the exception, i.e. aggregate application demand will likely approach or exceed network capacity frequently. As the mobile network is often simply an extension of the fixed network infrastructure, mobile ad hoc users will demand similar services. These demands will continue to increase as multimedia computing and collaborative networking applications rise.

1.7.7 Bandwidth Constraints

Wireless links will continue to have significantly lower capacity than their hardwired counterparts. In addition, the realized throughput of wireless communications--after accounting for the effects of multiple access, fading, noise, and interference conditions, etc.--is often much less than a radio's maximum transmission rate.

1.7.8 Limited Physical Security

Mobile wireless networks are generally more prone to physical security threats than are fixed-cable nets. The increased possibility of eavesdropping, spoofing, and denial-of-service attacks should be carefully considered. Existing link security techniques are often applied within wireless networks to reduce security threats. As a benefit, the decentralized nature of network control in MANETs provides additional robustness against the single points of failure of more centralized approaches.

1.8 Vital Parameters of MANET

Vital parameters of mobile adhoc networking include:

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1.8.1 Rate of Change in the Topology

The topology of MANET is dynamic therefore the speed with which a network's topology is changing shows the topological rate of change for that network. The size of any particular network is measured in the number of nodes, which are present in that network.

1.8.2 Connectivity in the Network

The average degree of a node (i.e. the average number of neighbors of a node). In other words the neighborhood nodes of any specific node tell the connectivity of that network. Effective link speed measured in bits/second, after accounting for losses due to multiple access, coding, framing, etc. How effective is a simulation tool in adapting to non-uniform or bursty traffic patterns is also an evaluating parameter for MANET.

Chapter 2

3 Literature Review

For the better understanding of this proposed thesis, a lot of research was conducted by us that involved reading from internet sites, white papers and research papers by different authors inland and abroad which have been duly mentioned in the References. The most relevant research or literature review consisted of another research thesis named **"Dynamic Mission Critical Network for Mobile System"** by Centre for Advanced Research/ studies in Engineering **(CARE)**. For a clearer perceptive we would like to include few of their thesis parts in the research review section

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2.1 “Dynamic Mission Critical Network for Mobile System”

2.1.1 Abstract

A decentralized GPS (Global Position System) aware mobile ad hoc wireless network architecture is presented in which back bone nodes form the cluster’s center and dynamically update their position with topological changes caused by nodes’ motion, nodes’ failure and nodes’ insertion. The motion of cluster center provides optimal connectivity with respect to line of sight, power and SNR (Signal to Noise Ratio). In our field trials, the backbone nodes provide stable connectivity to the mobile nodes in the clusters. The scenarios that motivate this research include applications requiring systematic and coordinated movements of troops. These include military applications (special operations, battlefield scenarios, etc.), disaster relief (fire, earthquake, and flood), etc.

2.1.2 Introduction

Since the appearance of wireless networks in 1970s, they have become more and more popular in the computing industry. Currently, there are two main kinds of wireless networks. The first is known as the infrastructure network with fixed and wired gateways. The bridges for these networks are known as the base stations. Mobile units will connect with the nearest base station within their communication radius. As the mobile unit travels out of the range of one base station to another, it will continue communicating seamlessly. Mobile Ad-hoc networks (MANET) are a new paradigm of wireless communication for mobile hosts. No fixed infrastructure such as base stations and mobile switching centers are

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required. Nodes within each radio range communicate directly via wireless links while those, which are far apart; rely on other nodes to relay messages. Recently, there has been an increased interest in infrastructure less Mobile Ad hoc

The cellular network involves base stations for the network to establish, for that huge towers are required to be erected. The network is not feasible especially for mission critical applications due to the time constraints and the centralized control. The network will be of no or little use if the base station is destroyed, moreover due to the stationary nature of the base stations, the network cannot move with the movement of the troops strictly from point of view of military applications. The MANET on the other hand does not require any infrastructure to establish the network. It is a self forming network and it can provide the connectivity if sufficient number of mobile nodes are available that ensure the availability of the routing path. In case of sparse network, the network is partitioned into sub-networks and connectivity will be lost which is a serious drawback for disaster relief or military applications. Another pitfall of the ad hoc network is that it cannot be used for long distance communication with fewer nodes, due to limited transmitting power. The design of Wireless Mobile Network specially for defense applications requires optimum connectivity and involves real challenges like dynamically changing topologies/routes, limited communication bandwidth, short battery lifetime, variable capacity links, security and broadcast nature of the communication system. A critical requirement of military applications is the rapid deployment of the connected network, in which each node in the network has a path to every other node in the network. In our approach, a new concept of mobile backbone in the hybrid architecture has been introduced that overcomes the shortcomings of the existing solutions and provides the assurance of connected network. A novel approach exploiting

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the ad hoc networks' concept and dynamic backbone feature enabling long distance communication is presented in this paper. The systemic and coordinated movement of the troops in the network were considered and implemented a GPS aware ad hoc network. In the design, the backbone nodes equipped with DEM form the clusters and update their positions dynamically to ensure that the network is always connected.

2.1.3 Network Architecture

The proposed architecture is a hybrid network where there is backbone composed of mobile nodes with additional processing power and the normal user mobile nodes. The clusters are initially formed by the approximate placement of the backbone nodes depending upon the communication range with one backbone node per cluster. Once the backbone is established, the other mobile nodes become part of either of the clusters as in case of cellular network by the K-mean clustering algorithm and also depending upon some other parameters discussed in the section [2.1.4]. The nodes within a cluster are directly connected to each other while connectivity with other cluster's nodes is through the backbone. The backbone nodes can be army vehicles and the rest of the mobile nodes can be mobile sets, PDAs and Laptops. All the nodes (either backbone or normal users) are equipped with GPS, providing the current position of the node in terms of x, y coordinates. The backbone nodes are additionally provided with digital maps of the terrain and have the sufficient processing power to implement the DEM (Digital Elevation Model) algorithm. The mobile node entering into the network backbone is assigned to a particular cluster depending upon the minimum distance constraint and implemented using K-mean algorithm.

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2.1.4 K-Mean Clustering

The K-Mean Clustering algorithm is used to group mobile nodes into N number of groups. The grouping is done by minimizing the sum of squares of distances between mobile nodes and the corresponding cluster's centroid and maximizing SNR and the line of sight constraint.In the defense applications, the network topology is systematically changes as the units move. The connectivity of the network in the battlefield and with the central command is of paramount importance. In the proposed architecture the mobile backbone nodes achieve optimal connectivity. The backbone nodes calculate their new positions based on minimum distance, line of site and SNR.

2.1.5 Minimum Distance

Every GPS aware mobile node broadcasts its current coordinates, the backbone nodes calculate line of sight by using digital map and also store its SNR. The K-Mean Clustering algorithm is employed to partition the network into clusters. The new node xi entering the network will be assigned to that particular cluster containing the backbone node pi for i=1 whose distance from the new node is minimum as compared to the distance of new node from some other backbone node pi for i=2,3,4 . The backbone node will adjust its position based on the allocated mobile nodes and connectivity with the backbone. The antenna adjustment works with the knowledge base of DEM, information provided by the cluster nodes and the location of other backbone nodes and their antenna heights and directions.

2.1.6 Line of Sight

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The algorithm/architecture is quite robust, the antennas mounted on the backbone nodes are provided with a motorized control. As the backbone nodes move to a new location depending upon the minimum distance requirements b/w cluster node and other backbone nodes, the antennas are also adjusted accordingly. This antenna adjustment works with the knowledge base of DEM, information provided by the cluster nodes and the location of other backbone nodes and their antenna heights and directions. This is possible because of immense computing power in the backbone nodes.

2.1.7 SNR

In mobile networks, the SNR received at a node must be greater than some predefined threshold value for successful transmission and guaranteed connectivity. Therefore, it is an important constraint in our design. The SNR from host 'a' to host 'b' is required to satisfy the equation 2.1.

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$$SNR_a = \frac{P_a G_{a,b}}{\sum_{a \neq b} P_c G_{c,b} + \eta_a} \psi_a$$

where a is the transmission power of the host η_a

$G_{a,b}$ is the path gain between the host η_a and η_b

ψ_b is the predetermined threshold value.

Equation 2.1 SNR

2.1.8 Redundancy

Apart from other considerations in the network design, another powerful feature is the redundancy of the backbone nodes. This important characteristic of the design is especially helpful in situations when any of the backbone nodes disappears/fails because of any unforeseen reason. The network must converge and becomes stable to and must restore to its original status within minimum span of time. This capability is achieved by means the rescue center or network monitoring center where the current parameters of all the backbone nodes are being mirrored continuously.

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In a scenario where any backbone node fails, the rescue center replaces the failed node immediately with a healthy one by copying the data of failed node to a new node (army vehicle).

2.1.9 Inter Cluster Migration

The backbone nodes are the centroids of the clusters and each of the user mobile nodes is associated to either of the clusters. In the presented hybrid architecture, the user mobile nodes are dynamically added to a cluster or deleted from the other cluster. As the node pi migrates from one clusters having backbone node xi and enters within the communication range of the other backbone node xj for i ˆj. then the node xj indicates xi that the node pi is in its cluster. Both of the backbone nodes xi and xj calculate their new mean positions according to the K-mean algorithm as a consequence of the migration of one of the mobile user nodes pi.

2.1.10 Routing Protocol

The routing protocols on the MANET can be broadly classified as table driven (proactive) protocols, Source-Initiated on demand (reactive protocols) and hybrid protocol. Proactive protocols need to maintain consistent, up-to-date routing information tables from every node in the network. When there is a change in the topology, the nodes propagate the messages throughout the network in order to keep the consistency of the routing information.

For example, DSDV (Destination Sequenced Distance Vector Routing Protocol), OLSR (Optimized Link State Routing Protocol) and FSR (Fisheye State Routing Protocol) are few of the routing protocols.

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The main drawback of these approaches is that the maintenance of unused paths may occupy a significant part of the available bandwidth if the topology of the network changes frequently. Reactive protocols create routes only when desired by the source node. When a node requires a route to a destination, it initiates a route request process. And once the route has been established, it is maintained by the route maintenance procedure unless the route is inaccessible. For example, DSR (Dynamic Source Routing Protocol), AODV (Adhoc On- Demand Distance Vector Routing Protocol) and ABR (Associatively Based Routing Protocol).

The advantage of the proactive schemes is that, once a route is requested, there is little delay until route is determined. In reactive protocols, because route information may not be available at the time a routing request is received, the delay to determine a route can be quite significant. Because of this long delay, pure reactive routing protocols may not be applicable to real time communication.

Hybrid routing protocol is based on the notion of routing zones. It maintains a small amount of routing information in each node and incurs very low overhead in route determination. There is no overhead of wireless resources to maintain routing information of inactive routes. Zone based hybrid routing protocol combines both a proactive and a reactive approach. In our architecture we employed modified OLSR as a routing protocol. The routing protocol is tailored for exchanging GPS aware mobile nodes current position. However, the proposed scheme can be employed in any MANET routing protocols.

2.1.11 Example Scenario

A dynamic mission critical network for mobile system comprising of a backbone of four nodes (p1, p2, p3 and p4) is shown in Figure 2.1. The

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other nodes are the user nodes and their number change dynamically according to the mobility of the users.

The establishment of the network can be distributed in three parts. The first one is the initialization of the backbone nodes' positions with some random or approximate values. This location of the backbone node is the mean of a particular cluster. The second step is the node allocation step. Here the allocation of the node to the respective cluster is then performed by calculating the Euclidean distance between that node and each of the backbone nodes. The node is then allocated to that cluster whose backbone node is nearest to that user node. The third and final step is the mean update step; the mobile backbone nodes adjust their positions according to the cluster mean. The node allocation and mean update steps are repeated until the network converges. Figure 2.1 depicts the allocation of user nodes to backbone node, having the minimum distance from the node xi. The pi nodes will calculate their new positions according to new cluster mean. After a few iterations, the network will converge as shown in Figure 2.2.

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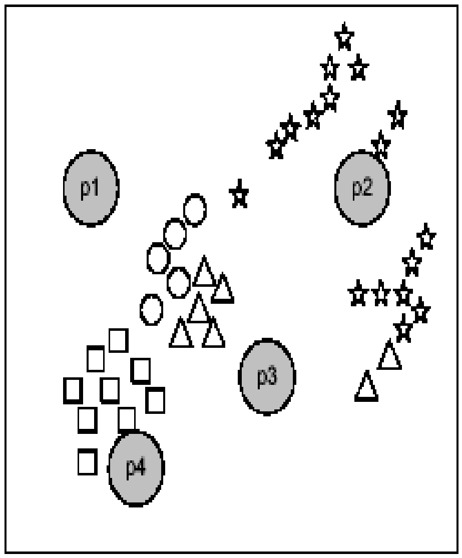

Figure 2.1 Allocation of User Nodes

The pi nodes are placed in the coverage area with approximate distances between pis's. The user nodes are represented with circle, star, triangle and square shapes to indicate their proximity to a particular cluster.

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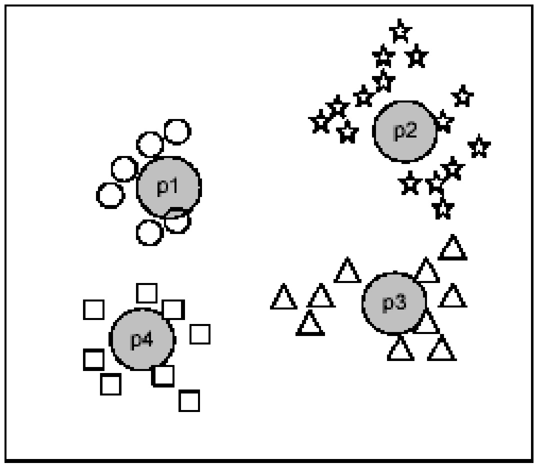

Figure 2.2 Converged Network

2.1.12 Experience Network

The proposed architecture is deployed and tested in the actual field with five backbone nodes to cover an area of 4Km2. The backbone nodes were deployed on the vehicles, with 12 dBi antennas and ORINOCO Classic Gold PC Cards. The users with laptops having GPS cards and 802.11 based wireless cards were allowed to move inside the backbone. A modified version of OLSR was the core routing protocol running on the nodes. The new paradigm of mobile backbone was tested by coordinated movements of the users in different environments, with varying signal interference and SNR. The network was always connected even in bad terrains, having strong interference and sparse users.

2.1.13 Conclusions

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The architecture provides connectivity among mobile users without requiring a fixed infrastructure. The exploitation of hybrid architecture with the concept of dynamic backbone infrastructure has opened a new area of research in the field of MANET for mission critical applications in general for example disaster relief and defense applications .in particular. Depending on the traffic, mobility patterns, and SNR factors, the network reconfigures itself for optimum connectivity. New metrics like minimum end to end delay, utilization of minimum battery power and the optimum transmitting power are inherent features of the deigned network for optimum connectivity.

2.2 Antennas

An antenna is electrical circuit of a special kind. In simple words we can define an antenna as any piece of conducting material will work as an antenna on any frequency. Even a straightened paper clip will work on 160 Meters. All to be done is properly match the transmitter to the paper clip, and the paper clip will radiate all of the power fed to it.

2.2.1 Basic Theory of an Antenna

As mentioned above antenna can also be called as a special type of an electrical circuit. In the ordinary type of circuit the dimension of coils, capacitors and connections usually are small as compared with the wavelength that corresponds to the frequency in use. When this is the case most of the electromagnetic energy stays in the circuit itself and either is used up in performing useful work or is converted into heat. However, when the dimensions of wiring or components become appreciable compared with the wavelength some of the energy escapes by the radiation in the form of electromagnetic waves. When the circuit is

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intentionally designed so that the major portion of the energy is radiated we have an antenna. The only reason for building sophisticated antennas is to allow us to control the radiation pattern. Focusing the radiated energy controls the radiation pattern. The geometry of the antenna and the proximity of near-by objects are the main controlling factors.

Knowing the location of the closest node or antenna site is very important and plays a vital role in placing an antenna effectively with respect to other nodes or antennas to have maximum use of it. The appropriate location information will assist not only in positioning antennas and but also enable to do a path check between the other nodes and your location for any man-made or natural obstacles. Thus, the type of antenna and quality of the antenna are critical elements when placing them in any network as both of these factors determines the clarity and reliability of signal transmission and reception between them.

As the man-made and natural obstacles such as buildings, water towers, mountains, hills and trees can cause the signals to deteriorate or even can block the signal. Therefore, no matter what type of antenna is being used, propagation patterns vary, so does the reception. Try different locations to achieve the best results, even if a given location appears adequate. Once the best antenna type and location is determined, mount the antenna.

2.2.2 Types of Antennas

There is much kind of antennas like omni directional (broadcast), highly-directional (point-to-point), possibly steer able, or some combination thereof. The important types of antenna include directional antennas and omni directional antennas.

But we are only interested in omni directional antennas.

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2.2.2.1 Unidirectional Antenna

Unidirectional antenna would surly consume less battery (Power) but would double and sometimes triple the cost of equipment specially when used in partial mesh. A Unidirectional Antenna is shown in Figure 2.3.

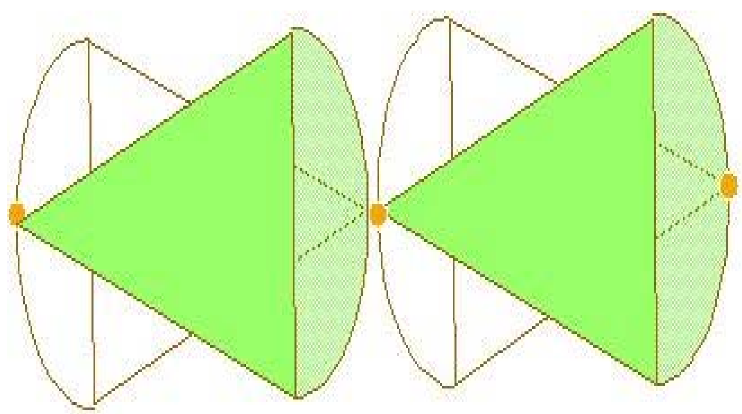

Figure 2.3 Unidirectional Antenna

2.2.2.2 Omni Directional Antenna

This type of antenna radiates the transmitted power in all directions. Or simply it can be said that they cover in all directions. If the radiated power was visible, it would look like a globe surrounding the antenna. This type of antenna is referred to as a "unity gain" antenna. Thus Omni directional antennas are those which have circular range of field as shown in Figure 2.4 and Figure 2.5.

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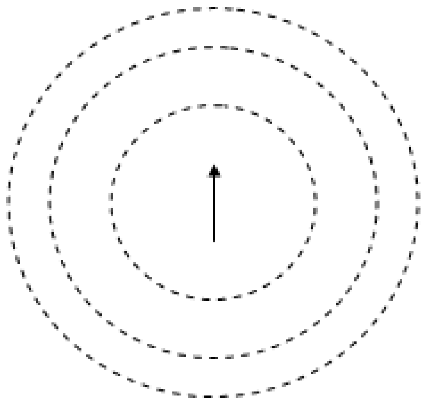

Figure 2.4 Field of Omni dir. Antennas

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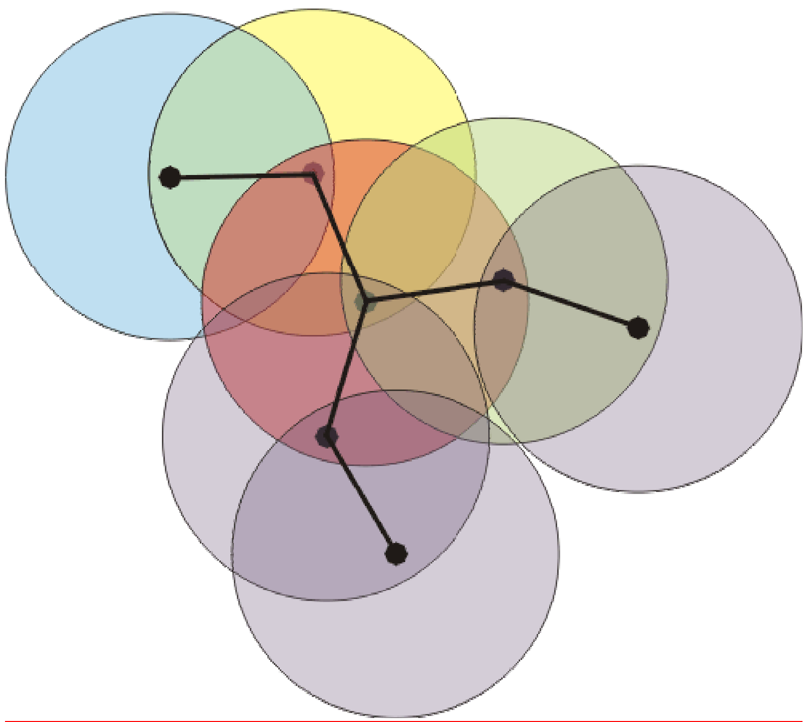

Figure 2.5 View of Omni dir. Antennas

2.3 Mesh Topology

Mesh topology can be defined as a network topology in which there are at least two nodes with two or more paths between them. According to point-to-point topology, one node connects directly to another node. Mesh is a network architecture that improves on point-to-point topology by providing each node with a dedicated connection to every other node.

2.3.1 Approach

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Meshing is a fundamentally different approach to routing through networks, and does not follow the conventions of network design. In a mesh network nodes get given their basic rules of the road, and then they are left to establish their connections autonomously. The node may discover many potential routes through the network, and it will select the most suitable route based upon the shortest distance to reach the other node. Other criteria, such as the quality of the connection, can influence the decision, but ultimately the router decides on the routes itself, and the manager only provides the ground rules. As each mesh node is autonomous, there fore, discovering routes on demand, there is no central control to act as a bottle neck. As the network grows the routing task for each node does not grow exponentially, as they only build routes to the resources that they need. Routes are established on demand, and un-used routes are flushed out after a short time.

2.3.2 Characteristics of Mesh Topology

Mesh topology can be defined as a network topology in which there are at least two nodes with two or more paths between them. The following characteristics of mesh topology make the base of using it in the desired research.

It is scalable no matter how many nodes are added to an existing mesh based network it continues to work as the routing configuration is automatic, and there is no exponential rise in complexity as the network grows. Multi multi-hop networks extend wireless range around obstacles and over greater distances in other words they are wide ranging. Each node works the routing out for itself, saving time and effort in administration so in short they are self organizing. Mesh networks have ability to reassemble themselves to fit changing environments. The self

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organizing functions run continuously, so when changes occur to connections and reception the mesh will automatically re-route around blockages in real time. So they are resilient. It is affordable as each mesh node is inexpensive. As there are no central controllers needed there fore the costs are linear. Mesh networks are used in locations when the nodes are located at scattered points that do not lie near a common line. Mesh networks are powerful - The unique features of the mesh make it a very powerful tool for building data networks

2.3.3 Types of Mesh Topology:

There are two types of mesh topologies. The both Mesh topologies are shown in Figure 2.6.

2.3.3.1 Full Mesh Topology

Each node (workstation or other device) is connected directly to each of the others in the full mesh topology. The greatest advantage of the Full mesh topology is the connectivity. Even if some nodes are down, the network will provide connectivity, because they will always present some paths to route the traffic. In this topology the node load increases because of each node has to keep record of every other node.

2.3.3.2 Partial Mesh Topology

In the partial mesh topology, some nodes are connected to all the others, but some of the nodes are connected only to those other nodes with which they exchange the most data.

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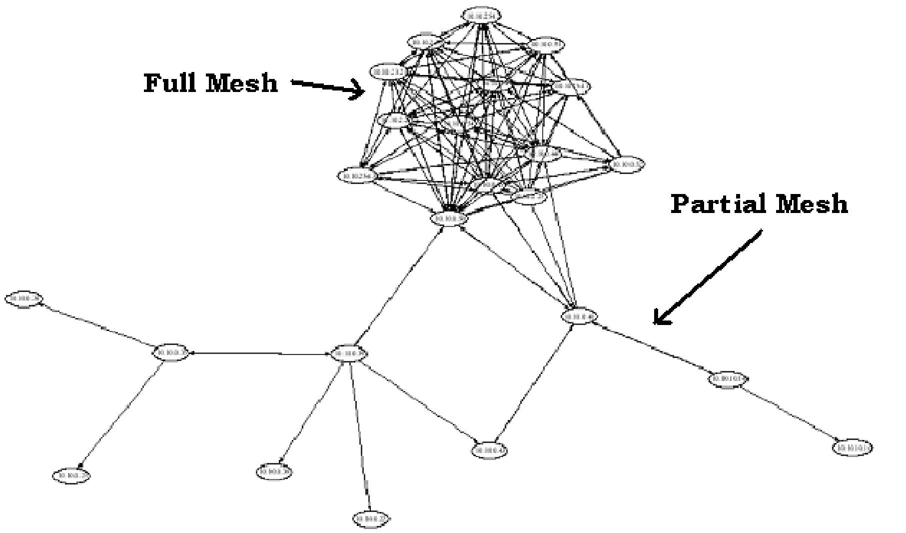

Figure 2.6 Mixture of Full & Partial Mesh

In this proposed research we will make use of partial mesh topology as few of our mobile nodes will be directly connected to each other while some will be connected to the connecting mobile nodes and through them will be indirectly connected to others, which may or may not be connected directly.

2.4 Digital Elevation Model

The DEM is a valuable data source for many resource-related GIS applications. This project will have Digital Elevation Model (DEM) for the graphical display of obstacles. Digital Elevation Models (DEMs) are digital files consisting of points of elevations, sampled systematically at equally spaced intervals. By Digital elevation model the most thoroughly designed and documented digital elevation dataset to date can be obtained. In the DEM there are hurdles/obstacles, which are going to be considered for

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placement of antennas. So, the antennas will be locally placed after considering elevations.

The USGS (United States Geological Survey) DEM (Digital Elevation Model) format describes raster elevation scans of the Earth's surface (essentially a specialized type of height field). It has been superseded by the USGS's own SDTS format but the format remains popular due to large numbers of legacy files, self-containment, relatively simple field structure and broad, mature software support.

It is a digital representation of a continuous variable over a two-dimensional surface by a regular array of z values referenced to a common datum. Digital elevation models are typically used to represent terrain relief. DEM is a digital representation of the earth's surface in terms of elevation values (X, Y, Z where Z represents the surface elevation).

The DEM, as its name implies, is a model of the elevation surface. A typical DEM is shown in Figure 2.7. However, the DEM is often not treated as a model, but is accepted as a "true" representation of the earth's surface. The DEM requires orthorectify your satellite or aerial imagery, require 3D visualization, and also need to extraction information that has a height element. This is the very reason we are using digital elevation model as it measures the highest point below a nominal observer hovering over the earth. These datasets therefore include buildings, trees and any other objects that protrude from the earth's surface and are resolvable by the observer.

The term digital elevation model or DEM is frequently used to refer to any digital representation of a topographic surface with inherent errors that constitute uncertainty.

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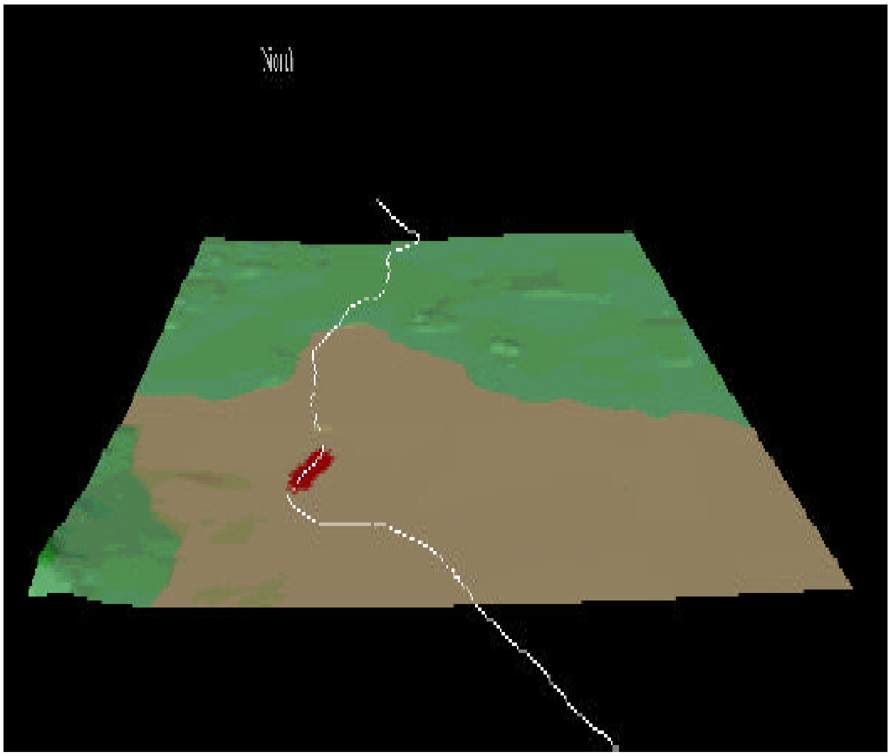

Figure 2.7 Digital Elevation Models, Animating Mobile Traffic

Chapter 3

4 Global Positioning System

3.1 The Global Positioning System (GPS)

It is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. GPS uses these "man-made stars" as reference points to calculate positions accurate to a matter of meters. In

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fact, with advanced forms of GPS you can make measurements to better than a centimeter. In a sense it's like giving every square meter on the planet a unique address. The basic structure of GPS is shown in Figure 3.1.

GPS receivers have been miniaturized to just a few integrated circuits and so are becoming very economical. And that makes the technology accessible to virtually everyone. These days GPS is finding its way into cars, boats, planes, construction equipment, movie making gear, farm machinery, even laptop computers. Soon GPS will become almost as basic as the telephone. Indeed, at Trimble, we think it just may become a universal utility.

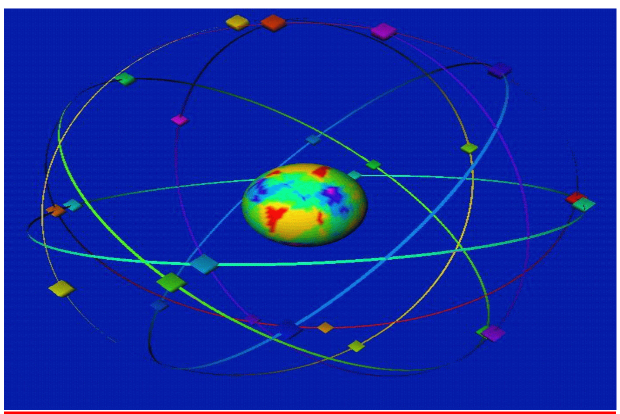

Figure 3.1 GPS

3.1.1 What is GPS

GPS, a navigation system using about 20 satellites in 12-hour orbits, distributed evenly around Earth. These satellites continually broadcast their positions. And a small instrument, receiving signals of 3 or more such satellites, can calculate its position within about 10 meters. The

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system was created by the US military, which can get from it even more accurate positions. The Russian GLONASS system is similar.

A system of satellites and receiving devices used to compute positions on the Earth. GPS is used in navigation, and its precision supports cadastral surveying.

GPS for short is a system of satellites that allows one's position to be calculated with great accuracy by the use of an electronic receiver.

GPS A satellite based device that records x,y,z coordinates and other data. GPS devices can be taken into the field to record data while driving, hiking, or flying. Ground locations are calculated by signals from satellites orbiting the Earth.

3.1.2 Purpose of GPS

Trying to figure out where you are and where you're going is probably one of man's oldest pastimes. Navigation and positioning are crucial to so many activities and yet the process has always been quite cumbersome. Over the years all kinds of technologies have tried to simplify the task but every one has had some disadvantage.

Finally, the U.S. Department of Defense decided that the military had to have a super precise form of worldwide positioning. And fortunately they had the kind of money ($12 billion!) it took to build something really good. The result is the Global Positioning System, a system that's changed navigation forever.

3.2 How GPS Works

GPS works in five logical steps:

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1. The basis of GPS is "triangulation" from satellites. 2. To "triangulate," a GPS receiver measures distance using the travel time of radio signals. 3. To measure travel time, GPS needs very accurate timing which it achieves with some tricks. Along with distance, you need to know exactly where the satellites are in space. 4. High orbits and careful monitoring are the secret. 5. Finally you must correct for any delays the signal experiences as it travels through the atmosphere.

3.2.1 Triangulating

Improbable as it may seem, the whole idea behind GPS is to use satellites in space as reference points for locations here on earth. That's right, by very, very accurately measuring our distance from three satellites we can "triangulate" our position anywhere on earth. Forget for a moment how our receiver measures this distance. We'll get to that later. First consider how distance measurements from three satellites can pinpoint you in space.

Suppose we measure our distance from a satellite and find it to be 11,000 miles. Knowing that we're 11,000 miles from a particular satellite narrows down all the possible locations we could be in the whole universe to the surface of a sphere that is centered on this satellite and has a radius of 11,000 miles. Next, say we measure our distance to a second satellite and find out that it's 12,000 miles away. That tells us that we're not only on the first sphere but we're also on a sphere that's 12,000 miles from the second satellite. Or in other words, we're somewhere on the circle where these two spheres intersecting.

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If we then make a measurement from a third satellite and find that we're 13,000 miles from that one that narrows our position down even further, to the two points where the 13,000 mile sphere cuts through the circle that's the intersection of the first two spheres. So by ranging from three satellites we can narrow our position to just two points in space.

To decide which one is our true location we could make a fourth measurement. But usually one of the two points is a ridiculous answer (either too far from Earth or moving at an impossible velocity) and can be rejected without a measurement. A fourth measurement does come in very handy for another reason however, but we'll tell you about that later. Next we'll see how the system measures distances to satellites.

In Review: Triangulating

1. Position is calculated from distance measurements (ranges) to satellites. 2. Mathematically we need four satellite ranges to determine exact position. 3. Three ranges are enough if we reject ridiculous answers or use other tricks.

3.2.2 Measuring Distances

We saw in the last section that a position is calculated from distance measurements to at least three satellites. But how can you measure the distance to something that's floating around in space? We do it by timing how long it takes for a signal sent from the satellite to arrive at our receiver.

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In a sense, the whole thing boils down to those "velocity times travel time" math problems we did in high school. Remember the old: "If a car goes 60 miles per hour for two hours, how far does it travel?"

Velocity (60 mph) x Time (2 hours) = Distance (120 miles)

In the case of GPS we're measuring a radio signal so the velocity is going to be the speed of light or roughly 186,000 miles per second.

The timing problem is tricky. First, the times are going to be awfully short. If a satellite were right overhead the travel time would be something like 0.06 seconds. So we're going to need some really precise clocks. We'll talk about those soon. But assuming we have precise clocks, how do we measure travel time? To explain it let's use a goofy analogy:

Suppose there was a way to get both the satellite and the receiver to start playing "The Star Spangled Banner" at precisely 12 noon. If sound could reach from space (which, of course, is ridiculous) then standing at the receiver we'd hear two versions of the Star Spangled Banner, one from our receiver and one from the satellite. These two versions would be out of sync. The version coming from the satellite would be a little delayed because it had to travel more than 11,000 miles. If you wanted to see just how delayed the satellite's version was, you could start delaying the receiver's version until they fell into perfect sync.

The amount we have to shift back the receiver's version is equal to the travel time of the satellite's version. So you just multiply that time times the speed of light and BINGO! and got your distance to the satellite.

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Only instead of the Star Spangled Banner the satellites and receivers use something called a "Pseudo Random Code" - which is probably easier to sing than the Star Spangled Banner.

The Pseudo Random Code (PRC, shown above) is a fundamental part of GPS. Physically it's just a very complicated digital code, or in other words, a complicated sequence of "on" and "off" pulses as shown here. The signal is so complicated that it almost looks like random electrical noise. Hence the name "Pseudo-Random."

There are several good reasons for that complexity: First, the complex pattern helps make sure that the receiver doesn't accidentally sync up to some other signal. The patterns are so complex that it's highly unlikely that a stray signal will have exactly the same shape.

Since each satellite has its own unique Pseudo-Random Code this complexity also guarantees that the receiver won't accidentally pick up another satellite's signal. So all the satellites can use the same frequency without jamming each other. And it makes it more difficult for a hostile force to jam the system. In fact the Pseudo Random Code gives the DOD a way to control access to the system.

But there's another reason for the complexity of the Pseudo Random Code, a reason that's crucial to making GPS economical. The codes make it possible to use "information theory" to "amplify" the GPS signal. And that's why GPS receivers don't need big satellite dishes to receive the GPS signals.

We glossed over one point in our goofy Star-Spangled Banner analogy. It assumes that we can guarantee that both the satellite and the receiver

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start generating their codes at exactly the same time. But *how* do we make sure everybody is perfectly synced? Stay tuned and see.

In Review: Measuring Distance

Distance to a satellite is determined by measuring how long a radio signal takes to reach us from that satellite. To make the measurement we assume that both the satellite and our receiver are generating the same pseudo-random codes at exactly the same time. By comparing how late the satellite's pseudo-random code appears compared to our receiver's code, we determine how long it took to reach us. Multiply that travel time by the speed of light and you've got distance.

3.2.3 Getting Perfect Timings

If measuring the travel time of a radio signal is the key to GPS, then our stop watches had better be darn good, because if their timing is off by just a thousandth of a second, at the speed of light, that translates into almost 200 miles of error.

On the satellite side, timing is almost perfect because they have incredibly precise atomic clocks on board.

Both the satellite and the receiver need to be able to precisely synchronize their pseudo-random codes to make the system work. If our receivers needed atomic clocks (which cost upwards of $50K to $100K) GPS would be a lame duck technology. Nobody could afford it.

Luckily the designers of GPS came up with a brilliant little trick that lets us get by with much less accurate clocks in our receivers. This trick is one of the key elements of GPS and as an added side benefit it means that every GPS receiver is essentially an atomic-accuracy clock.

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The secret to perfect timing is to make an *extra* satellite measurement. That's right, if three perfect measurements can locate a point in 3-dimensional space, then four imperfect measurements can do the same thing. This idea is so fundamental to the working of GPS that we have a separate illustrated section that shows how it works. If you have time, cruise through that.

If our receiver's clocks were perfect, then all our satellite ranges would intersect at a single point (which is our position). But with imperfect clocks, a fourth measurement, done as a cross-check, will NOT intersect with the first three.

So the receiver's computer says "Uh-oh! There is a discrepancy in my measurements. I must not be perfectly synced with universal time." Since any offset from universal time will affect all of our measurements, the receiver looks for a single correction factor that it can subtract from all its timing measurements that would cause them all to intersect at a single point.

That correction brings the receiver's clock back into sync with universal time, and bingo! - You've got atomic accuracy time right in the palm of your hand. Once it has that correction it applies to all the rest of its measurements and now we've got precise positioning.

One consequence of this principle is that any decent GPS receiver will need to have at least four channels so that it can make the four measurements simultaneously.

With the pseudo-random code as a rock solid timing sync pulse, and this extra measurement trick to get us perfectly synced to universal time, we

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have got everything we need to measure our distance to a satellite in space.

But for the triangulation to work we not only need to know distance, we also need to know exactly where the satellites are.

In Review: Getting Perfect Timing

Accurate timing is the key to measuring distance to satellites. Satellites are accurate because they have atomic clocks on board. Receiver clocks don't have to be too accurate because an extra satellite range measurement.

3.2.4 Satellite Positions

In this tutorial we've been assuming that we know where the GPS satellites are so we can use them as reference points. After all they're floating around 11,000 miles up in space. A typical Satellite positioning is shown in Figure 3.2.

That 11,000 mile altitude is actually a benefit in this case, because something that high is well clear of the atmosphere. And that means it will orbit according to very simple mathematics. The Air Force has injected each GPS satellite into a very precise orbit, according to the GPS master plan.

On the ground all GPS receivers have an almanac programmed into their computers that tells them where in the sky each satellite is, moment by moment. The basic orbits are quite exact but just to make things perfect the GPS satellites are constantly monitored by the Department of Defense. They use very precise radar to check each satellite's exact altitude, position and speed.

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The errors they're checking for are called "ephemeris errors" because they affect the satellite's orbit or "ephemeris." These errors are caused by gravitational pulls from the moon and sun and by the pressure of solar radiation on the satellites. The errors are usually very slight but if you want great accuracy they must be taken into account. Getting the message out.

Figure 3.2 Satellite Positioning

Once the Dodd has measured a satellite's exact position, they relay that information back up to the satellite itself. The satellite then includes this new corrected position information in the timing signals its broadcasting. So a GPS signal is more than just pseudo-random code for timing purposes. It also contains a navigation message with ephemeris

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information as well. With perfect timing and the satellite's exact position you'd think we'd be ready to make perfect position calculations. But there's trouble afoot. Check out the next section to see what's up.

In Review: Satellite Positions

To use the satellites as references for range measurements we need to know exactly where they are. GPS satellites are so high up their orbits are very predictable. Minor variations in their orbits are measured by the Department of Defense. The error information is sent to the satellites, to be transmitted along with the timing signals.

3.2.5 Error Correction

Up to now we've been treating the calculations that go into GPS very abstractly, as if the whole thing were happening in a vacuum. But in the real world there are lots of things that can happen to a GPS signal that will make its life less than mathematically perfect. To get the most out of the system, a good GPS receiver needs to take a wide variety of possible errors into account. Here's what they've got to deal with.

First, one of the basic assumptions we've been using throughout this tutorial is not exactly true. We've been saying that you calculate distance to a satellite by multiplying a signal's travel time by the speed of light. But the speed of light is only constant in a vacuum. As a GPS signal passes through the charged particles of the ionosphere and then through the water vapor in the troposphere it gets slowed down a bit and this creates the same kind of error as bad clocks.

There are a couple of ways to minimize this kind of error. For one thing we can predict what a typical delay might be on a typical day. This is

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called modeling and it helps but, of course, atmospheric conditions are rarely exactly typical. Another way to get a handle on these atmosphere-induced errors is to compare the relative speeds of two different signals. This "dual frequency" measurement is very sophisticated and is only possible with advanced receivers.

Trouble for the GPS signal doesn't end when it gets down to the ground. The signal may bounce off various local obstructions before it gets to our receiver. This is called multi path error and is similar to the ghosting you might see on a TV. Good receivers use sophisticated signal rejection techniques to minimize this problem.

Even though the satellites are very sophisticated they do account for some tiny errors in the system. The atomic clocks they use are very, very precise but they're not perfect. Minute discrepancies can occur, and these translate into travel time measurement errors.

And even though the satellites positions are constantly monitored, they can't be watched every second. So slight position or "ephemeris" errors can sneak in between monitoring times. Basic geometry itself can magnify these other errors with a principle called "Geometric Dilution of Precision" or GDOP.

It sounds complicated but the principle is quite simple.

There are usually more satellites available than a receiver needs to fix a position, so the receiver picks a few and ignores the rest. If it picks satellites that are close together in the sky the intersecting circles that define a position will cross at very shallow angles. That increases the gray area or error margin around a position.

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If it picks satellites that are widely separated the circles intersect at almost right angles and that minimizes the error region. Good receivers determine which satellites will give the lowest GDOP.

In Review: Correcting Errors

The earth's ionosphere and atmosphere cause delays in the GPS signal that translate into position errors. See a summary of error sources. Some errors can be factored out using mathematics and modeling. The configuration of the satellites in the sky can magnify other errors. 4. Differential GPS can eliminate almost all error.

3.3 Putting GPS to Works

GPS technology has matured into a resource that goes far beyond its original design goals. These days scientists, sportsmen, farmers, soldiers, pilots, surveyors, hikers, delivery drivers, sailors, dispatchers, lumberjacks, fire-fighters, and people from many other walks of life are using GPS in ways that make their work more productive, safer, and sometimes even easier.

In this section you will see a few examples of real-world applications of GPS. These applications fall into five broad categories.

Location

The first and most obvious application of GPS is the simple determination of a "position" or location. GPS is the first positioning system to offer highly precise location data for any point on the planet, in any weather. That alone would be enough to qualify it as a major utility, but the accuracy of GPS and the creativity of its users are pushing it into some surprising realms.

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Knowing the precise location of something, or someone, is especially critical when the consequences of inaccurate data are measured in human terms. So slight position or "ephemeris" errors can sneak in between monitoring times. Basic geometry itself can magnify these other errors with a principle called "Geometric Dilution of Precision" or GDOP.

For example, when a stranded motorist was lost in a South Dakota blizzard for 2 days, GPS helped rescuers find her. The Location is shown in Figure 3.3.

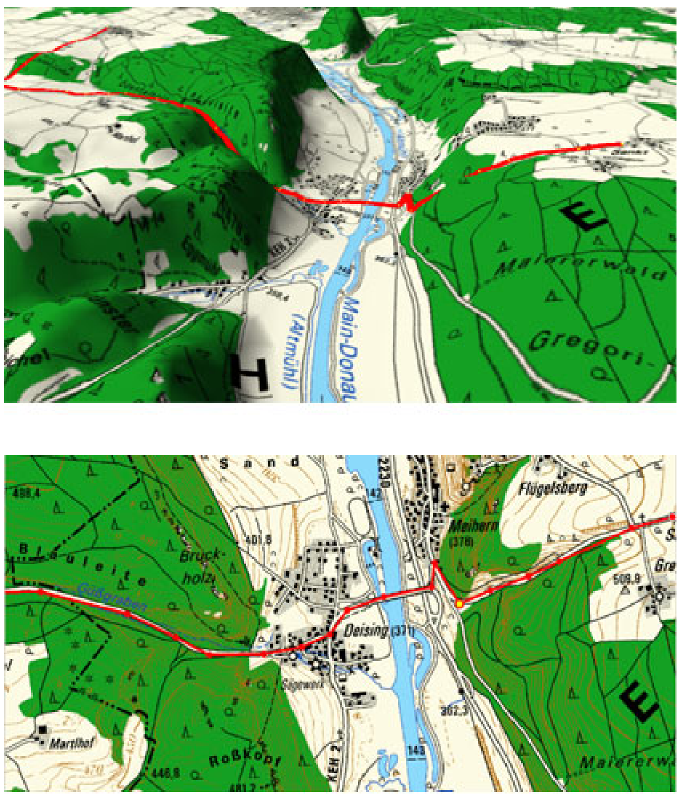

Figure 3.3 Location

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GPS is also being applied in Italy to create exact location points for their nationwide geodetic network which will be used for surveying projects. Once in place it will support the first implementation of a nationally created location survey linked to the WGS-84 global grid.

Sometimes an exact reference locator is needed for extremely precise scientific work. Just getting to the world's tallest mountain was tricky, but GPS made measuring the growth of Mt. Everest easy. The data collected strengthened past work, but also revealed that as the Khumbu glacier moves toward Everest's Base Camp, the mountain itself is getting taller.

Navigation

GPS helps you determine exactly where you are, but sometimes important to know how to get somewhere else. GPS was originally designed to provide navigation information for ships and planes. So it's no surprise that while this technology is appropriate for navigating on water, it's also very useful in the air and on the land. The Navigation is shown in Figure 3.4.

It's interesting that the sea, one of our oldest channels of transportation, has been revolutionized by GPS, the newest navigation technology. Trimble introduced the world's first GPS receiver for marine navigation in 1985. And as you would expect, navigating the world's oceans and waterways is more precise than ever.

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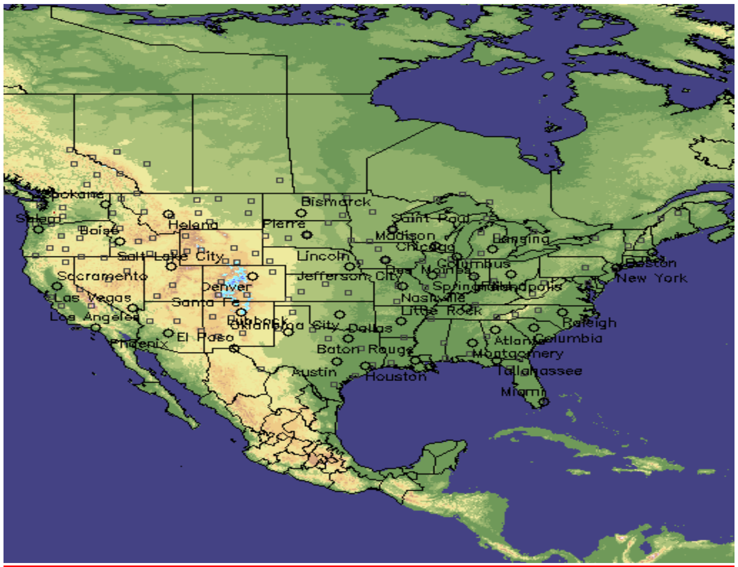

Figure 3.4 Navigation

Today you will find Trimble receivers on vessels the world over, from hardworking fishing boats and long-haul container ships, to elegant luxury cruise ships and recreational boaters. A New Zealand commercial fishing company uses GPS so they can return to their best fishing holes without wandering into the wrong waters in the process.

But GPS navigation doesn't end at the shore.

Flying a single-engine Piper Cub or a commercial jumbo jet requires the same precise navigation information, and GPS puts it all at the pilot's fingertips as safely as possible.

By providing more precise navigation tools and accurate landing systems, GPS not only makes flying safer, but also more efficient. With precise point-to-point navigation, GPS saves fuel and extends an

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aircraft's range by ensuring pilots don't stray from the most direct routes to their destinations.

GPS accuracy will also allow closer aircraft separations on more direct routes, which in turn mean more planes, can occupy our limited airspace. This is especially helpful when you're landing a plane in the middle of mountains. And small medical evac helicopters benefit from the extra minutes saved by the accuracy of GPS navigation.

But you don't need your head in the clouds to use GPS for navigation.

Finding your way across the land is an ancient art and science. The stars, the compass, and good memory for landmarks helped you get from here to there. Even advice from someone along the way came into play. But, landmarks change, stars shift position, and compasses are affected by magnets and weather. And if you've ever sought directions from a local, you know it can just add to the confusion. The situation has never been perfect.

Today hikers, bikers, skiers, and drivers apply GPS to the age-old challenge of finding their way. Borge Ousland used Trimble GPS to navigate the snow and ice to ski his way to the top of the world and into the record books. And two wilderness rangers employed GPS to establish a route across the Continental Divide for horse riders and packers.

Tracking

If navigation is the process of getting something from one location to another, then tracking is the process of monitoring it as it moves along.

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Commerce relies on fleets of vehicles to deliver goods and services either across a crowded city or through nationwide corridors. So, effective fleet management has direct bottom-line implications, such as telling a customer when a package will arrive, spacing buses for the best scheduled service, directing the nearest ambulance to an accident, or helping tankers avoid hazards.

GPS used in conjunction with communication links and computers can provide the backbone for systems tailored to applications in agriculture, mass transit, urban delivery, public safety, and vessel and vehicle tracking. So it's no surprise that police, ambulance, and fire departments are adopting systems like Trimble's GPS-based AVL (Automatic Vehicle Location) Manager to pinpoint both the location of the emergency and the location of the nearest response vehicle on a computer map. With this kind of clear visual picture of the situation, dispatchers can react immediately and confidently.

Chicago developed a GPS tracking system to monitor emergency vehicles through their streets, saving precious time responding to 911 calls. And on the commercial front, two taxi companies in Australia track their cabs for better profit and improved safety.

Mapping

It's a big world out there, and using GPS to survey and map it precisely saves time and money in this most stringent of all applications. Today, Trimble GPS makes it possible for a single surveyor to accomplish in a day what used to take weeks with an entire team. And they can do their work with a higher level of accuracy than ever before.

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Trimble pioneered the technology which is now the method of choice for performing control surveys, and the effect on surveying in general has been considerable. You've seen how GPS pinpoints a position, a route, and a fleet of vehicles. Mapping is the art and science of using GPS to locate items, and then create maps and models of everything in the world. And we do mean everything. Mountains, rivers, forests and other landforms. Roads, routes, and city streets. Endangered animals, precious minerals and all sorts of resources. Damage and disasters, trash and archeological treasures. GPS is mapping the world.

Timing

Although GPS is well-known for navigation, tracking, and mapping, it's also used to disseminate precise time, time intervals, and frequency. Time is a powerful commodity, and exact time is more powerful still. Knowing that a group of timed events is perfectly synchronized is often very important. GPS makes the job of "synchronizing our watches" easy and reliable.

There are three fundamental ways we use time. As a universal marker, time tells us when things happened or when they will. As a way to synchronize people, events, even other types of signals, time helps keep the world on schedule. And as a way to tell how long things last, time provides and accurate, unambiguous sense of duration.

GPS satellites carry highly accurate atomic clocks. And in order for the system to work, our GPS receivers here on the ground synchronize themselves to these clocks. That means that every GPS receiver is, in essence, an atomic accuracy clock.

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Astronomers, power companies, computer networks, communications systems, banks, and radio and television stations can benefit from this precise timing. One investment banking firm uses GPS to guarantee their transactions are recorded simultaneously at all offices around the world. And a major Pacific Northwest utility company makes sure their power is distributed at just the right time along their 14,797 miles of transmission lines.

Chapter 4

5 Design Philosophy

This chapter entails all the modules of the project in a sequence, in order to achieve the result. In the DEM there are hurdles/obstacles, which are going to be considered for placement of antennas. So, the antennas will be locally placed after considering elevations and depressions. Considering antenna as a node, each node may be connected directly to each of the others. In this case it will become full mesh topology. The antennas will also be placed in such a way that some of the nodes are connected to all the others but some of the nodes are connected only to those other nodes with which they will exchange the most data, finally a mesh network is achieved via antennas. In this case it will be partial mesh topology.

4.1 Taking Input for the Mobile Nodes

The first step in the proposed research software was to take input from the user to place the nodes on the terrain, regardless of the obstacles present there. The input from the user is not fixed. After taking the first input from the user a randomized function will be used that will continuously change the movement of nodes.

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Second very difficult task was to keep a track of all the moving nodes after every movement and to check whether they are still in contact with each other or not despite the fact that they are moving in an area which has obstacles in them. Third important step was to read the information about the obstacles present in the given terrain. In this particular project we are only dealing with elevations.

4.2 Communication Between the Mobile Nodes

The next step was to implement logic to see that if the moving nodes are not in contact than what is the reason which is causing it. Either one of the node is isolated from the rest or all the nodes present in our assumed area have formed clusters which can vary in number after every movement and are not communicating with each other because either the distance between them has increased than the range of those antennas or some obstacle has caused the hindrance for communication between those moving nodes.

4.3 Checking Obstacles

When the information of connected nodes as far as the communication range of the nodes is complete an obstacle check will be made to if the connected nodes have some obstacles in them. If they are clear they still be connected otherwise go for an obstacle solution and placement of alt con nodes. When the connected nodes information is complete a check will be made to see if the cluster exists. The cluster information would be stored separately for the reference of final solution as the algorithm commences. The clusters if formed by the range differences would be eliminated by placing control nodes at appropriate locations.

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4.4 Identifying Clusters

After accomplishing the previous step the next step was to find the places where connecting nodes can be inserted, these connecting nodes will not only locate the moving nodes in accordance to the distance limit which is specified in the algorithm but will also shift in between the nodes so they remain in connection directly or indirectly with each other by taking the help of these mobile connecting nodes. An obstacle check will be made on the control nodes that are being placed to reduce the cluster and to provide extra connectivity. If cleared the nodes would be placed as a solution otherwise the obstacle solution would be implemented on control nodes. Recursive obstacle check will be made while giving away the solution of obstacles. Every alternate connecting ode will check itself on the new position for obstacles and distances with previous nodes and destination. The final step was to place the connecting nodes between the mobile nodes to give a more reliable and more efficient mesh based ad hoc network.

4.5 Basic Design

Figure 4.1 shows the basic design of FLEXMAN in the appropriate hierarchy and order. In the Figure every step of the algorithm is written. In the first place a check is made based on the distance between every two nodes. If the distance is less than their communication range, then they are connected otherwise disconnected. Then this node placement is updated by checking the obstacles between the nodes. In order to connect the entire network control nodes are inserted. In the DEM there are hurdles/obstacles, which are going to be considered for placement of antennas. So, the antennas will be locally placed after considering elevations and depressions. Considering antenna as a node, each node

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may be connected directly to each of the others. In this case it will become full mesh topology. The antennas will also be placed in such a way that some of the nodes are connected to all the others but some of the nodes are connected only to those other nodes with which they will exchange the most data, finally a mesh network is achieved via antennas. In this case it will be partial mesh topology.

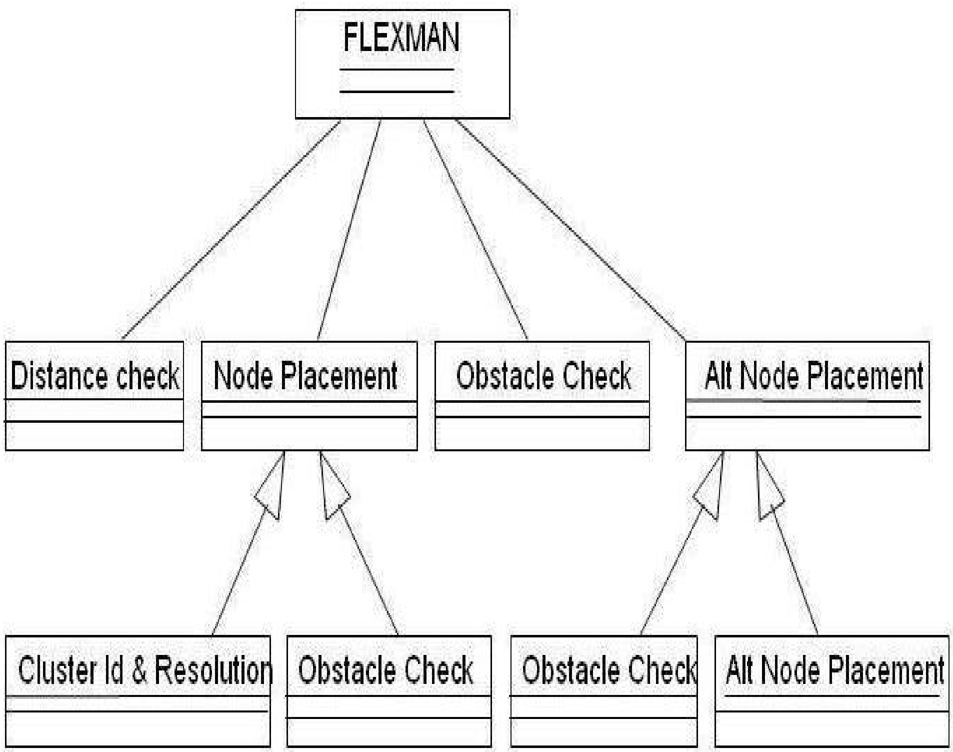

Figure 4.1 Basic Design

4.6 Flow Chart of FLEXMAN

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The flow chart shown in Figure 4.2 explains the detailed skeleton for working and design of FLEXMAN. In this every step which the algorithm goes through, is written in detail and is self explanatory. At first every node updates its location from GPS. After that the connectivity matrix is updated based on the updated positions of the nodes. If the distance is less than their communication range, then they are connected otherwise disconnected. Then this node placement is updated by checking the obstacles between the nodes. In order to connect the entire network control nodes are inserted.

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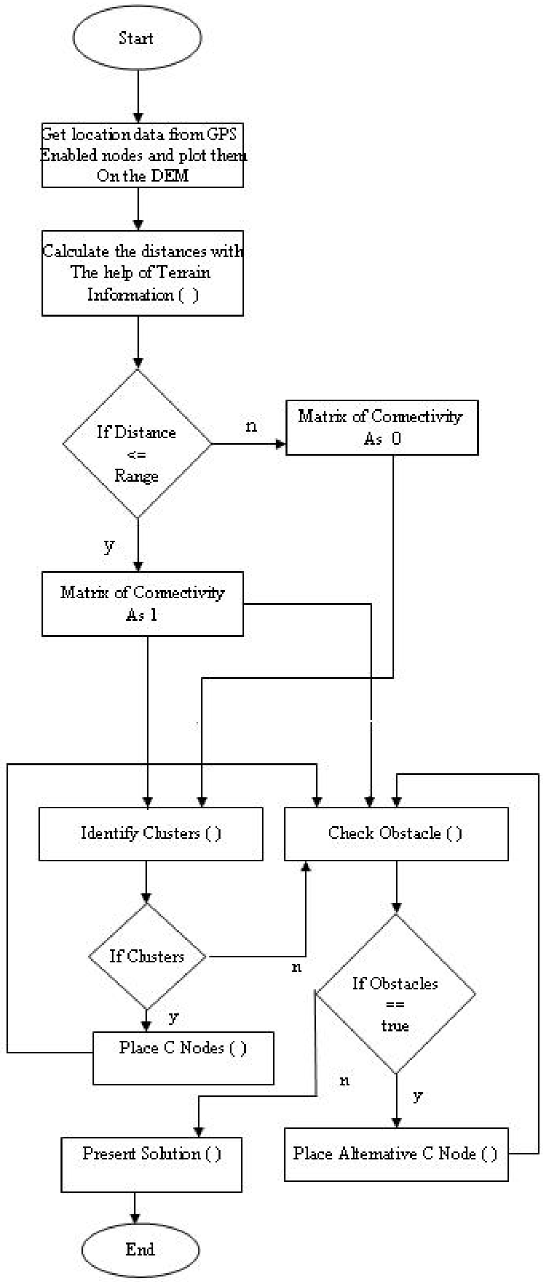

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Figure 4.2 Flow Chart of FLEXMAN

4.7 Development of FLEXMAN

To accomplish the final version 1.21 of FLEXMAN we went through different steps of development. The processing of development of the algorithm has almost been evolutionary. Gradual increments in the first attained version brought us second and so on, a brief explanation how it went through the process and a little overview with analysis of each version is as follows

4.7.1 VERSION 1.0

The version 1.0 lacked the implementation of obstacles. It worked in the following manner:

It used to get data first and located the positions of the mobile nodes. When positions were located, it created the nodes. Next step was to get the distance between all nodes. Check for connectivity IF. Connected, formed connectivity matrix and after checking the clusters from it, Placed connecting nodes AND reduced clusters by joining the clusters till a single cluster was formed in which all the nodes were connected to each other.

4.7.2 VERSION 1.1

The version 1.1 is same as above i.e. version 1.0, but had some extra features like

It used to get data first than located the positions of the mobile nodes. When positions were located, created the nodes. Next step was to get the distance between all nodes, checked for connectivity IF Connected, form

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connectivity matrix and after checking the clusters from it, Placed connecting nodes AND reduced clusters by joining the clusters till a single cluster was formed in which all the nodes were connected to each other. *THAN* Checked obstacles in all connected nodes IF Checked, Place alternative connecting nodes.

But this version was implemented with obstacles without taking into account the slope conditions.

4.7.3 VERSION 1.11

The version 1.11 included the slope conditions for the obstacles while placing the connecting nodes.

It used to get data first and than located the positions of the mobile nodes. When positions were located, created the nodes. Next step was to get the distance between all nodes. Than it checked for connectivity IF Connected, formed connectivity matrix and after checking the clusters from it, placed connecting nodes AND reduced clusters by joining the clusters till a single cluster was formed in which all the nodes were connected to each other, THAN checked obstacles in all connected nodes for slope conditions, IF Checked, Placed alternative connecting nodes.

4.7.4 VERSION 1.2

The version 1.2, also same as above but include

It used to get data first and than located the positions of the mobile nodes. When positions were located, created the nodes. Next step was to get the distance between all nodes. Than it checked for connectivity IF Connected, formed connectivity matrix and after checking the clusters from it, placed connecting nodes AND reduced clusters by joining the clusters till a single

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cluster was formed in which all the nodes were connected to each other, THAN checked obstacles in all connected nodes for slope conditions, IF Checked, Placed alternative connecting nodes by checking the distance. ALSO checked for the obstacles present in the connecting nodes location. IF no obstacles, simply placed connecting nodes. It also implemented obstacle check for all the rest mobile nodes for the same obstacle.

4.7.5 VERSION 1.2.1

Same as above but it doesn't place the connecting nodes after checking the clusters by distance.

It used to get data first and than located the positions of the mobile nodes. When positions were located, created the nodes. Next step was to get the distance between all nodes. Than it checked for connectivity IF Connected, formed connectivity matrix and after checking the clusters from it, placed connecting nodes AND reduced clusters by joining the clusters till a single cluster was formed in which all the nodes were connected to each other, THAN checked obstacles in all connected nodes for slope conditions, IF checked, made obstacle check between all available connected nodes. Than determined the likely positions of the connecting nodes by distance. ALSO checked obstacles between node positions and likely connecting node positions. IF no obstacle present, place connecting nodes. ELSE place alternative connecting node by obstacle avoiding algorithm and distance check. .

4.8 Techniques used in FLEXMAN

4.8.1 Distance Check and Cluster Technique

Create nodes ( )

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Initialize nodes ( )

Get position of the nodes

Calculate the distance of each node from other

If dist is less than A than connected

Else

Disconnected

Make a matrix of connected Nodes

Identify clusters ( )

IF clusters

THAN reduce clusters ( )

Check the distance of each node of cluster a from cluster b

Get min distance; DEVIDE it by range -1 to get number of control nodes

Identify loc for control node

Create node, Initialize node

IF clusters THAN Reduce Clusters ( )

Get the directly connected nodes

Check Obstacles ( )

4.8.2 Obstacle Avoiding Technique

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If a node is present on a location assumed to be (x1, y1) and another node is present at location (x2, y2), where as there is an obstacle present at location (x,y) as shown in Figure 4.3, than after applying the equation of line between the two nodes we will get the obstacle position justified.

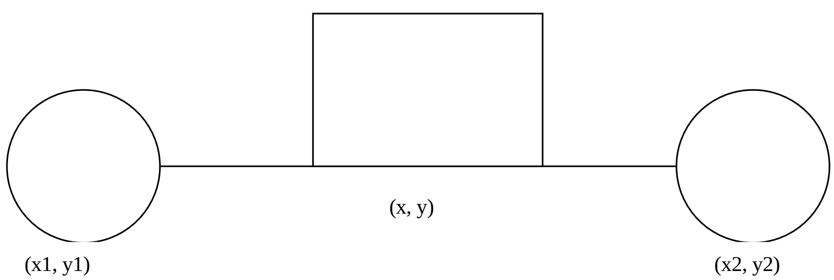

Figure 4.3 Showing nodes and obstacle

if any obstacle is present at (x, y) our algorithm will move at x or at y and place a connecting node there, and it moves along x as shown in Figure 4.4.

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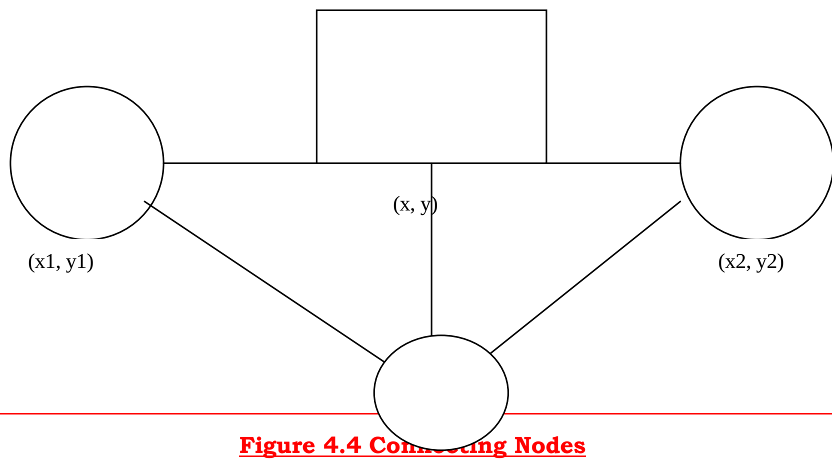

Figure 4.4 Connecting Nodes

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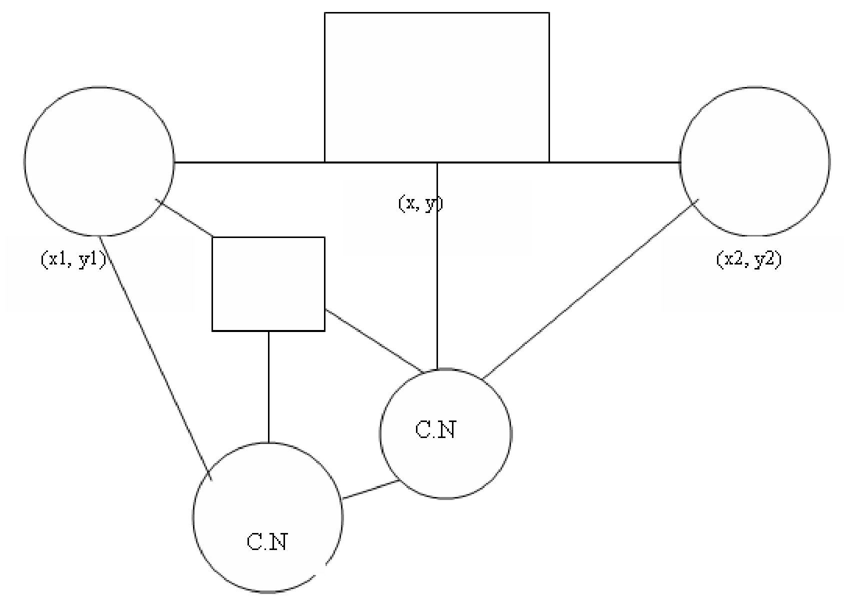

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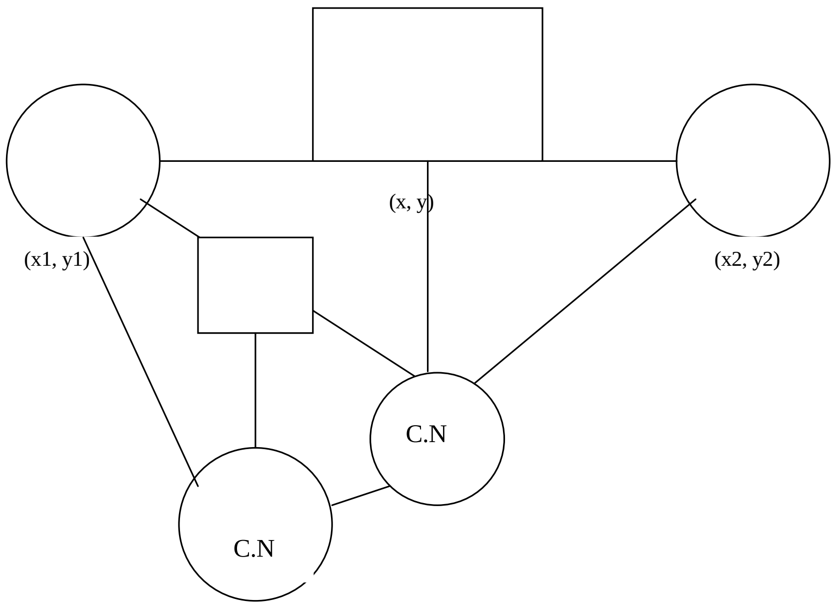

Figure 4.5 Showing Connecting Nodes in Obstacle Avoiding Algorithm

Now similarly if there is another obstacle present between (x1, y1) and newly moved position the algorithm will follow the above mentioned process again and place a control node between (x1,y1) and the previous control node as shown in Figure 4.5.

As for as the Algorithm is concerned it checks the following matrix'd' which all nodes are connected directly. Check for all rows, Like in matrix'd' example

1 0 0 1 1 0

0 1 1 0 0 0

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0 1 1 0 0 1

1 0 0 1 1 0

1 0 0 1 1 1

0 0 1 0 1 1

This matrix shows that we need to run this check for just

1-1, 1-3 1-4 for first node

And 2-2 2-3 for second node and so on

with an extra condition of If dist==0 like checking matrix 'k' for same position if the value there is not zero so that it should not check obstacle in 1-1 or 2-2

4.8.3 Suggested Function

When the position of the two points are passed by respective x y components, it will simply put the values in eq-1 above and save the expression say 'line expression'

Solve and save the coefficient of 'x' in 'sln'.

And save the heights if two points in 'nl' (less high) and 'nh' (higher).

Now run two loops from xl to xh and yl to yh. Put all these points in line expressions x and y.

Check for the equivalence of two sides by a condition

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If LHS=RHS or (LHS - RHS) < .6 or (RHS-LHS) < .6

If condition is true check for the height of the same point and store it in a variable 'inth ' n as save x y of the point in 'xint' and 'yint'.

Check for all points which satisfy expression if their height is greater than "inth'.

Replace values and save the x y values of the point as well in xint yint. Compare inth with nl and nh. If it's greater than both.

Give 'obs' value of 1 and smaller than both give obs value 0.

If greater than one and lesser than other.

Put the xl yl xint and yint in line expression and get the value of coefficient of 'x' and.

Compare with sln.

if cox is greater than sln.

give obs value 1 else 0.

Return obs.

END

Chapter 5

5 CODE IMPLEMENTATION

5.1 Process of Development

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Process of development of FLEXMAN is shown in Figure 5.1, Figure 5.2 and Figure 5.3. State Chart of FLEXMAN is shown in Figure 5.4.

In the Waterfall model we first get the requirements of the project, and then a detailed analysis is carried on the basis of the information gathered. After getting the complete information a comprehensive design was made. On this design implementation was carried and finally testing of the whole software was carried.

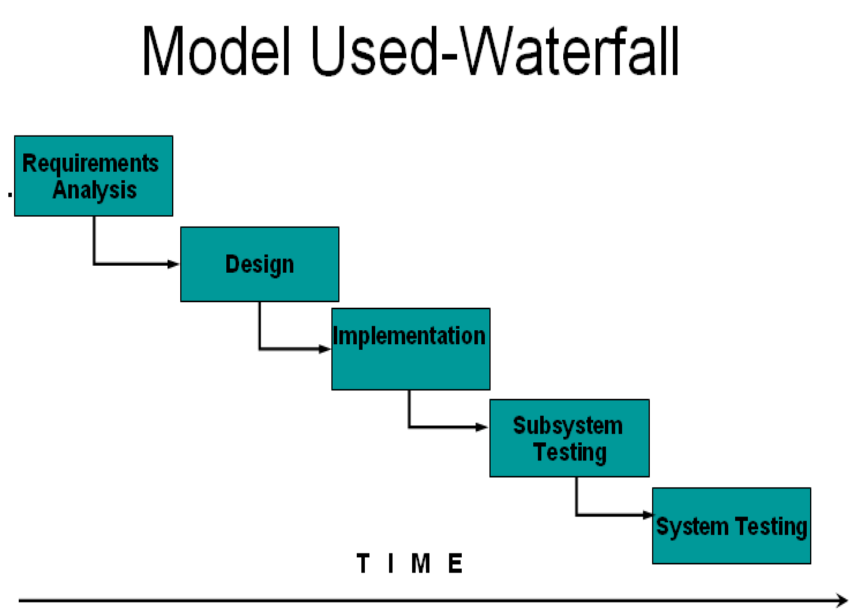

Figure 5.1 Water Fall Model

Waterfall model is used because it reducing risks as we move long the project. As shown in the Figure 5.2, as we move long the time, chances of

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the risk reduces. Also we used this model iteratively. This further minimized the risk

waterfall model reduces risks, as the development of the project goes on.

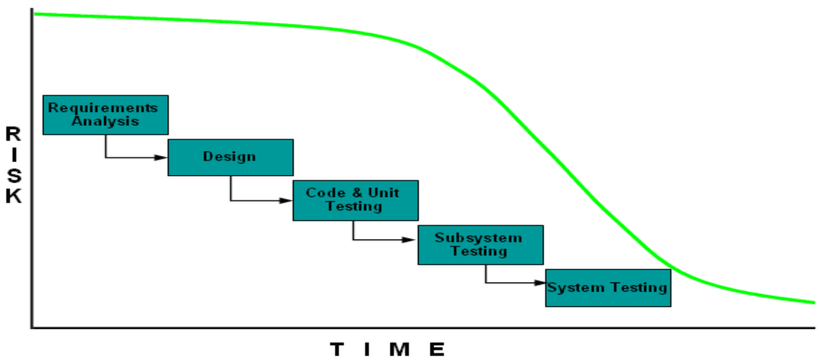

Figure 5.2 Reduction of Risk

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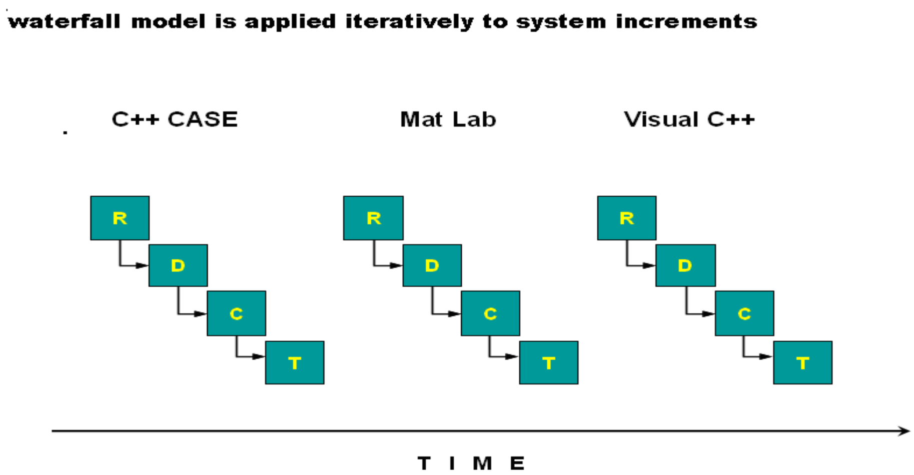

Figure 5.3 Water Fall Iteration Implanted

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state chart of the development process

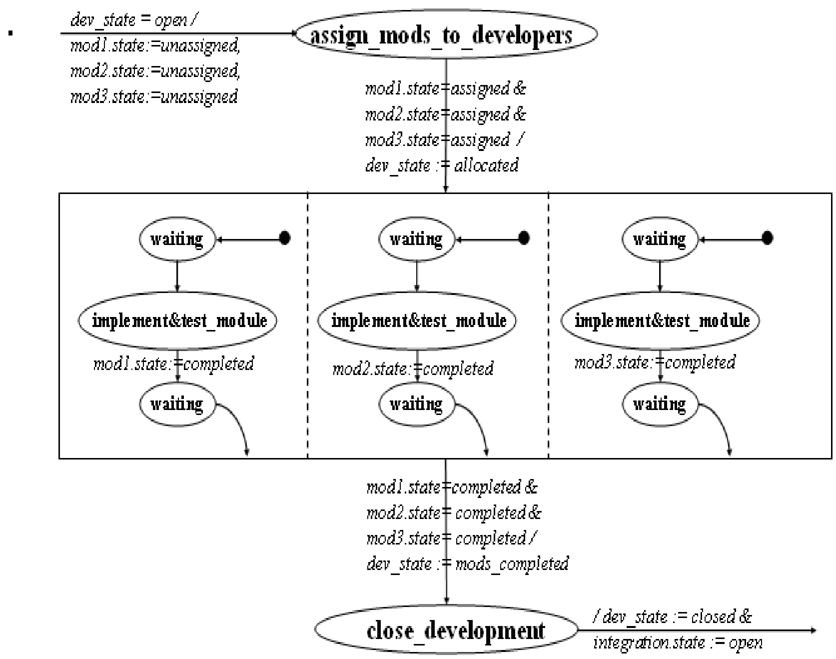

Figure 5.4 State Chart

5.2 Matlab

We have divided the project in the following modules:

5.2.1 Module 1

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This module deals with the formation of nodes, concept of range, connected mobile nodes and non-connected nodes.

5.2.1.1 Formation of Nodes (input by user)

When we started the project we decided to keep the number of nodes fixed. For this we introduced the method of randomization so that the algorithm was creating the nodes itself in a randomized manner. But as an after thought for making the algorithm more generalized we later decided to take the nodes location or the node formation values from the user. For this purpose the user has to enter the x and y coordinates and the nodes are formed in accordance to the given values. The user can now enter as many nodes as he wants to enter in the following manner:

x=input ('Enter No. OF X Coordinates Like [6 15 58 54 92 90 97] =')

y=input ('Enter No of Y Coordinates Like [9 15 53 58 94 90 92] =');

5.2.1.2 Range of the Antenna

For the proposed research we have taken the range of the antennas in DEM or GL q unit. Here the range specifies the distance in which the mobile nodes will be in communication with each other. The mobile nodes with in the range of each other will be assumed to be connected to each other. The mobile nodes which are not going to be with in the range of each other will be assumed to be not connected to each other.

5.2.2 Module 2

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This module deals with finding distance between the nodes in the desired coverage area. The mobile nodes with in the range of each other will be assumed to be connected to each other. The mobile nodes which are not going to be with in the range of each other will be assumed to be not connected to each other.

5.2.2.1 Finding Distance Between the Nodes

First of all the distance between the first node is checked with itself, which is found to be zero of course. After that the distance of the first node will be checked with the second node, in the next step with the third and so on till its distance with all the nodes will be checked.

The same process will be repeated for second node, third node and so on till the distance of the last node will be checked with all the nodes and it self.

To calculate the distance between the mobile nodes we have used the following distance formula which in turns provides the algorithm the absolute distance for each node with all the other nodes present in the assumed coverage area.

Distance = sqrt ((x2-x1) ^2 + (y2-y1) ^2))

In this step the distances found for each node with respect to all the other nodes will be compared by the range of the assumed coverage area given by the user in the start.

In this step when the first processing will be carried out, the distance which was found out of the first node with the second node previously be compared to the range. Now if the distance of the node is found to be either less or equal to the range than it will depict that the mobile node is

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with in the range, thus will be represented in the binary form as **1.** Where as the nodes which will not be in range will be portrayed as **0**.

At the end of this iteration all the values will be in the binary form of 1's and 0's. All the 1's showing that the particular node is connected to any other node which also has a binary value of 1. This will be the end of the first iteration; all the iterations for other nodes will proceed in the similar manner.

5.2.2.2 Finding Connectivity among Nodes

We will OR all the values with each other to see which nodes are connected to each other directly or indirectly.

At the end of this module we will have values as such

	node1	node 2	node 3
node 1	1	0	0
node 2	0	1	0
node 3	0	0	1

The above matrix obtained will now be checked row wise for the value of 1's, starting with the first row. In the first row there is only one 1. The index for this will get stored in an array. The algorithm will now check for the 0's in the first row and will store the indexes of those 0's in another array. In the next step the algorithm will look for the first indexed 0 position and will jump on that row

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	node1	node 2	node 3
node 1	1	0	0
node 2	0	1	0
node 3	0	0	1

The process will continue for the second row and the third row respectively.

5.2.2.3 Formation of Clusters

Here the number of cluster is basically found by dividing the

No. of clusters = Distance / Range

So in accordance to above mentioned example three clusters are formed.

5.2.3 Module 3

The module will find the location for the placement of the mobile connecting nodes.

5.2.3.1 Finding the Connecting Nodes

The clusters which are formed now will be checked for the possible placements of control nodes.

The location of connecting nodes is found by

x of 1^{st} node – x of 2^{nd} node / total no. of connecting nodes + 1.

Similarly:

y of 1^{st} node – y of 2^{nd} node / total no. of connecting nodes + 1.

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When the location of connecting node is found to be greater than a single node, they are stored in an array.

5.2.4 Module 4

This module checks for the obstacles

5.2.4.1 Checking for Obstacles

Obstacles are checked by using equation of line and also for slope conditions. Using the equations.

y - y1 / y2 - y1=x - x1 / x2 - x1 Eq-1

y = mx + c, where C = y intercept Eq-2

Once the obstacles are checked, connecting nodes will be placed as needed.

5.2.4.2 Randomize

Every x location of the mobile node and also the y location or the coordinate is changed by a randomized function. Thus after a specified time the location of the nodes continue to change in the DEM. And after every change, again the connections among the nodes are checked.

A check is also placed on the fact that the randomized values for the mobile nodes do not exceed the value of the desired or assumed coverage area.

5.3 Visual C++

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For this part the terrain was developed by using Open GL methods. As shown in the figure below.

Where as the moving nodes are shown as conical or long and narrow circular shaped cylinders by incrementing the positions of the nodes on the terrain depicted by the DEM. Nodes are also created by Open GL methods and shape of the antenna is also shown.

Different colors are used to differentiate between the mobile nodes, which are connected from those which are not connected and also the color of the connecting node is also different. A typical Area without Control Nodes is shown in Figure 5.6.

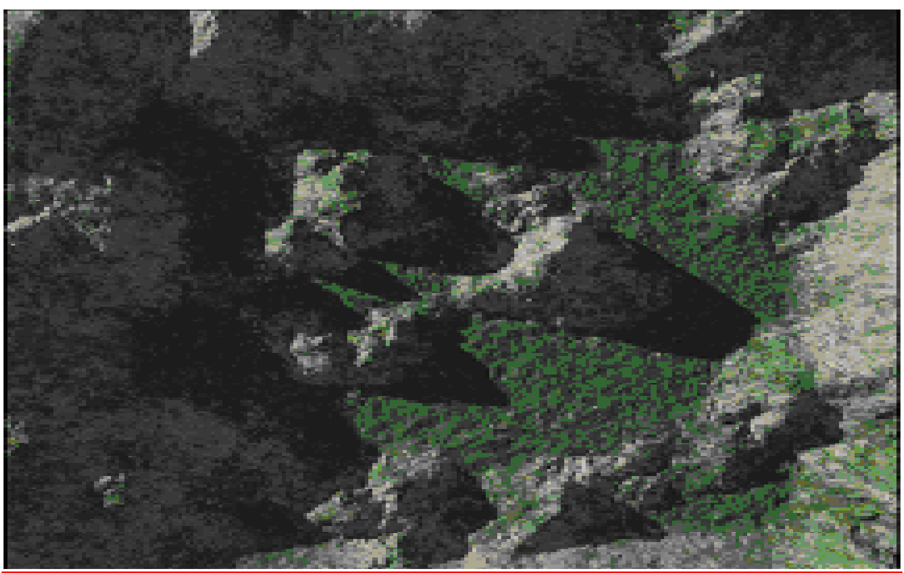

Figure 5.5 A Typical Terrain

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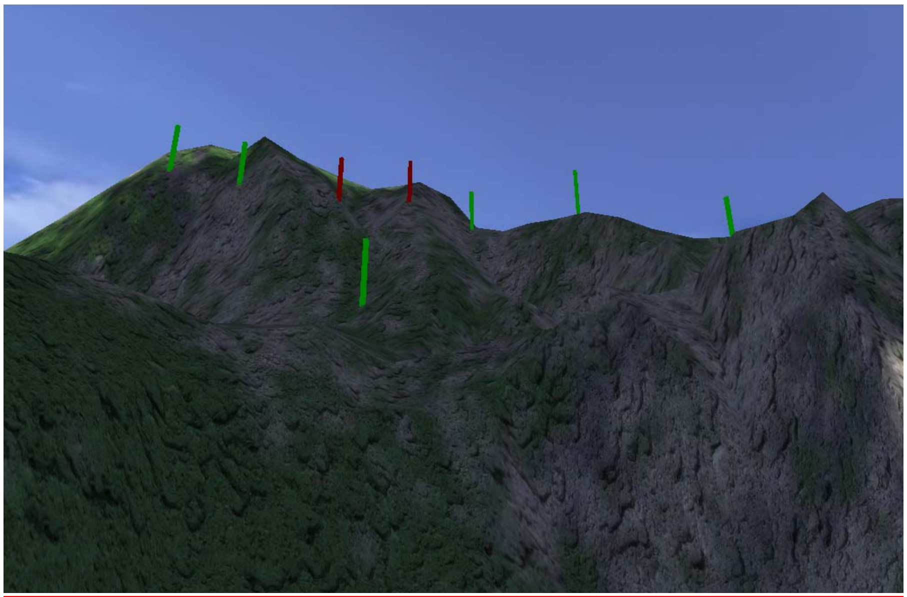

Figure 5.6 Terrain without Control Nodes

On the terrain green colored moving nodes show connection among them, where as moving red colored node show that they are not connected nodes where as blue colored nodes show the connecting nodes as shown in the Figure 5.7.

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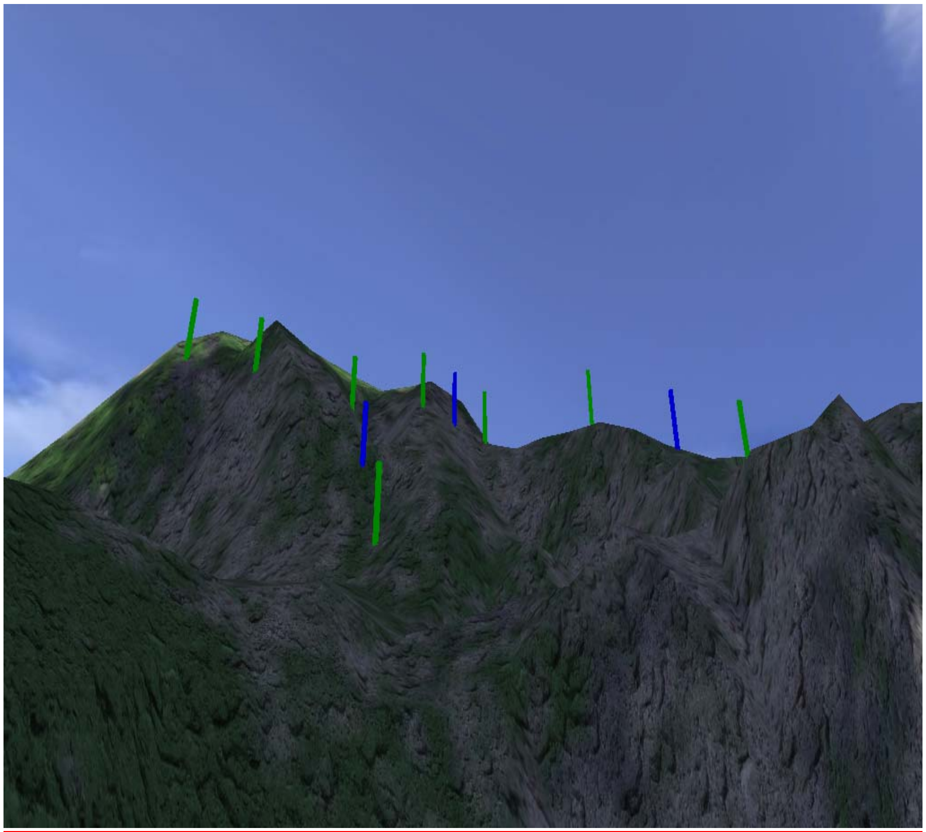

Figure 5.7 Terrain with Control Nodes

5.3.1 Functions Used

Following are the functions which are used in the simulation of the proposed research.

For the creation of nodes we have used the function named as initNode node .First of all a Structure of all nodes have been made. Then all the

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data members of the structure have been initialized.And then they have been created in the Create node function (initNode).code to create one such node looks like:

```
objects[0].range = 30;

objects[0].type = 0;

objects[0].x = 0;

objects[0].y = 0;

objects[0].z = 0;
```

The movement of nodes is catered by the code segment in the function chkDisconnectivity(). The code increments the x and z axis of the node by a factor inc.The nodes as a result then moves in the 3D scene .The code segment looks like:

```
for ( int a = 0; a < 12; a++){

objects[a].x += inc;

objects[a].z += inc;

if ( objects[a].x == 1024 )

objects[a].x = 0;

int ht = Height(g_HeightMap, (int)objects[a].x, (int)objects[a].z)+20;

objects[a].y = ht;}
```


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The function () is used for checking the distance between different nodes. And on the basis of this distance connectivity and disconnectivity is checked.Followin code segment checks the distance.

```
float Ht1=Height(g_HeightMap, (int)objects[a].x, (int)objects[a].z);

float Ht2=Height(g_HeightMap, (int)objects[a+1].x,        (int)objects[a+1].z);

float dist1=objects[a].z;

float dist2=objects[a+1].z;
```

Obstacles are checked by an algo which in each frame calculates whether there is any obstacle which is interfering the line of sight of any two nodes.

```
while(dist1<=dist2){

float tempHt1 = Height(g_HeightMap, (int)objects[a].x, (int)(dist1+1));

dist1+=1;

if(tempHt1 > Ht1 || tempHt1 > Ht2){

//glColor4ub(255,0,0,200);//color red

for(int i = 7;i<9;i++){

if(i==7){

int objtype = objects[a].type;

objects[a].type = i;

displayObject(objects[a].x, objects[a].y,objects[a].z,a);
```

```
objects[a].type = objtype ;

if(i==8){

int objtype2 = objects[a+1].type;

objects[a].type = i;

displayObject(objects[a+1].x, objects[a+1].y, objects[a+1].z, a);

objects[a].type = objtype2 ;}}}}

break;}
```

Color for nodes is being changed once the disconnectivity function verifies that the two nodes are disconnected. The function looks like :

```
void displayObject(float x, float y, float z, int objNo){

glPushMatrix();

// Start a new matrix scope

glTranslatef(x, y, z);                    // Move the cylinder over so it's centered aro

if(objects[objNo].type==0)

glColor4ub(0,255,0,200);//color red

else if(objects[objNo].type==1)

glColor4ub(0,255,0,200);//color blue

else if(objects[objNo].type==2)
```

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```
glColor4ub(0,255,0,200);//color blue
else if(objects[objNo].type==3)
glColor4ub(0,255,0,200);//color blue
else if(objects[objNo].type==4)
glColor4ub(0,255,0,200);//color blue
else if(objects[objNo].type==5)
glColor4ub(0,255,0,200);//color blue
else if(objects[objNo].type==6)
glColor4ub(255,0,0,200);//color blue
else if(objects[objNo].type==9)
glColor4ub(0,255,0,200);//color blue
else if(objects[objNo].type==10)
glColor4ub(0,255,0,200);//color blue
else if(objects[objNo].type==7 || objects[objNo].type==8)
glColor4ub(255,0,0,200);//color blue
else if(objects[objNo].type==11 ||objects[objNo].type==12 ||objects[objNo].type==13 )
glColor4ub(0,0,255,200);//color blue    }
```

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The solution given by the solution function is that all the nodes that were not connected, an interconnecting blue node were inserted between them. And the communication was established between all the disconnected nodes.

5.3.2 Test Cases

5.3.2.1 CASE 1

This is a simple case in which all the mobile nodes represented as circles are connected to each other, as shown in Figure 5.8, through the connecting nodes shown as blue colored triangles, where as straight blue lines depict obstacles, as shown in the Figure 5.8.

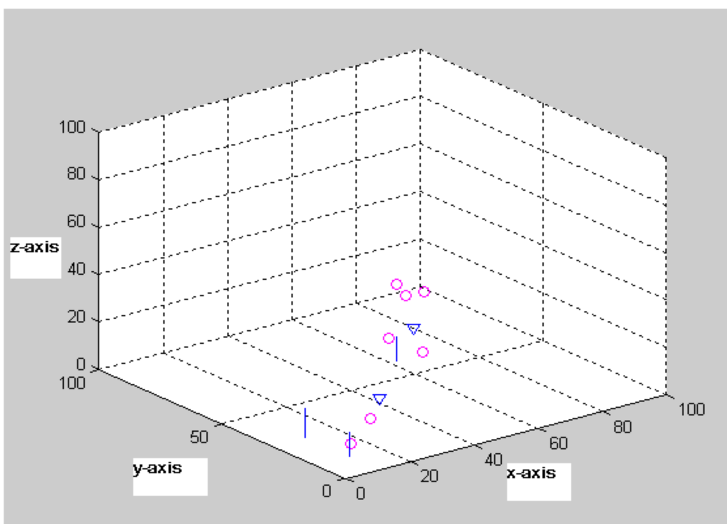

Figure 5.8 All Connected Nodes

5.3.2.2 Case 2

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In this cases one connecting node is placed between the two mobile nodes as shown in Figure 5.9, because of an obstacle present in between them, which is represented as a magenta colored triangle, where as the mobile nodes are magenta colored circles and obstacles are shown as blue colored lines. The blue colored triangles are also the connecting nodes but they are just connecting the mobile nodes or the cluster formed by them, which were not communicating due to increased distance as shown in Figure 5.9.

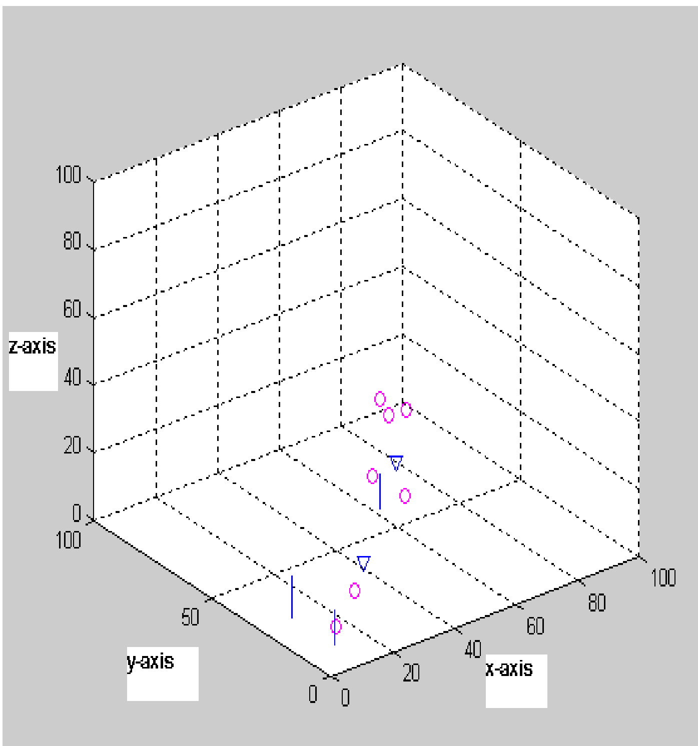

Figure 5.9 Showing the Clusters

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5.3.2.3 CASE 3

In the Figure 5.10, the mobile nodes have moved forward therefore there is no need of the magenta colored connecting node between the mobile nodes to communicate any more as was needed in the previous scenario due to the presence of the obstacle.

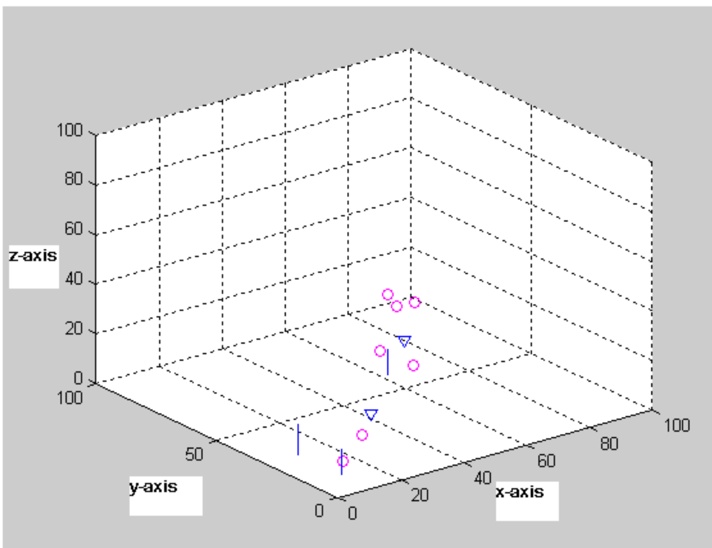

Figure 5.10 Removing the Clusters

5.4 Performance Analysis of FLEXMAN

The performance analysis of FLEXMAN is shown in Figure 5.13 and 5.15.

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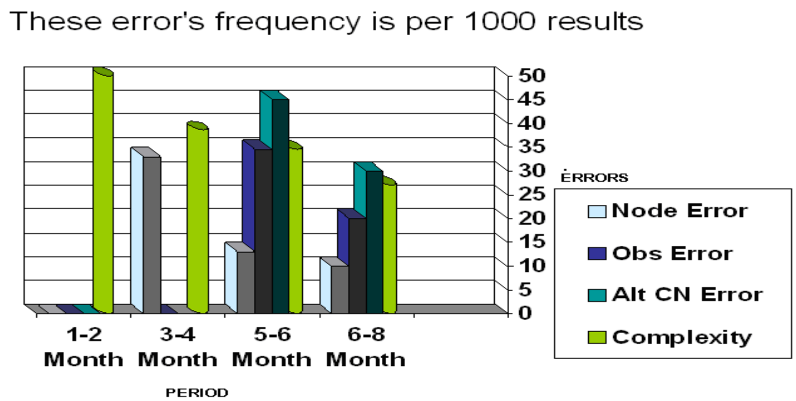

Figure 5.11 Performance Analysis

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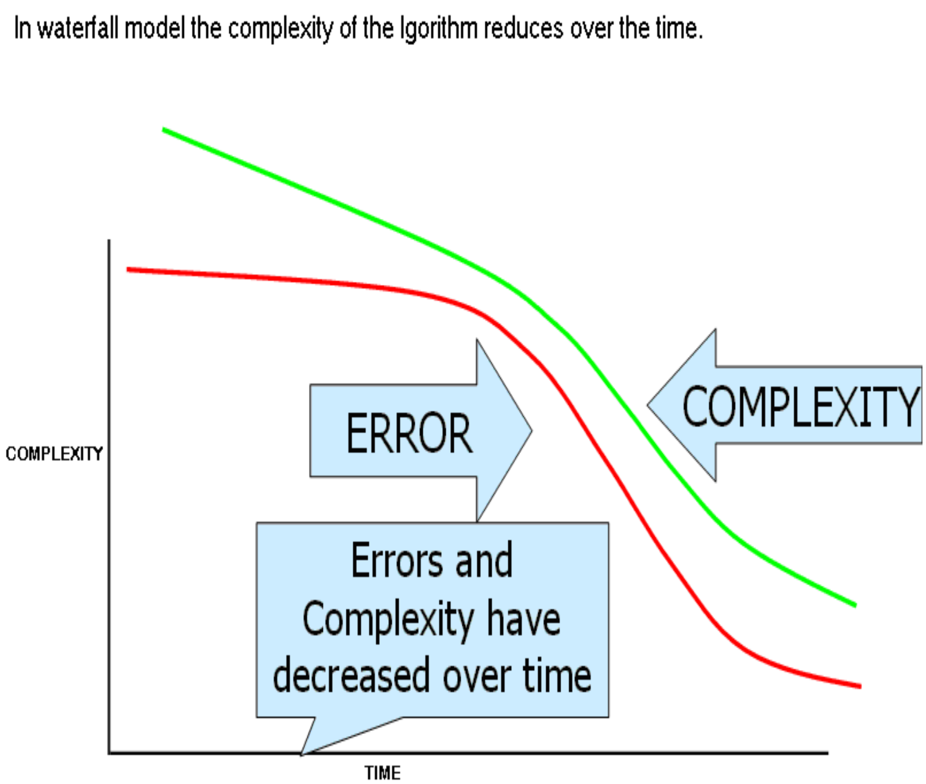

Figure 5.12 Performance Analysis

5.4.1 Battery Consumption

Power Consumption has been a very important Issue in consideration in the development of algorithm.

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N-Tier Network Idea was dropped because the backbone nodes consumed much more power and hence required more batteries, making them expensive. Power failure at backbone node will jeopardize the network

5.4.2 Comparison of Power Consumption b/w N-tier and FLEXMAN

5.4.2.1 Battery Consumption of N-tier

The battery consumption of N-tier's backbone is much more than that of others nodes. Therefore the life of backbone nodes is much lower than that of other nodes.

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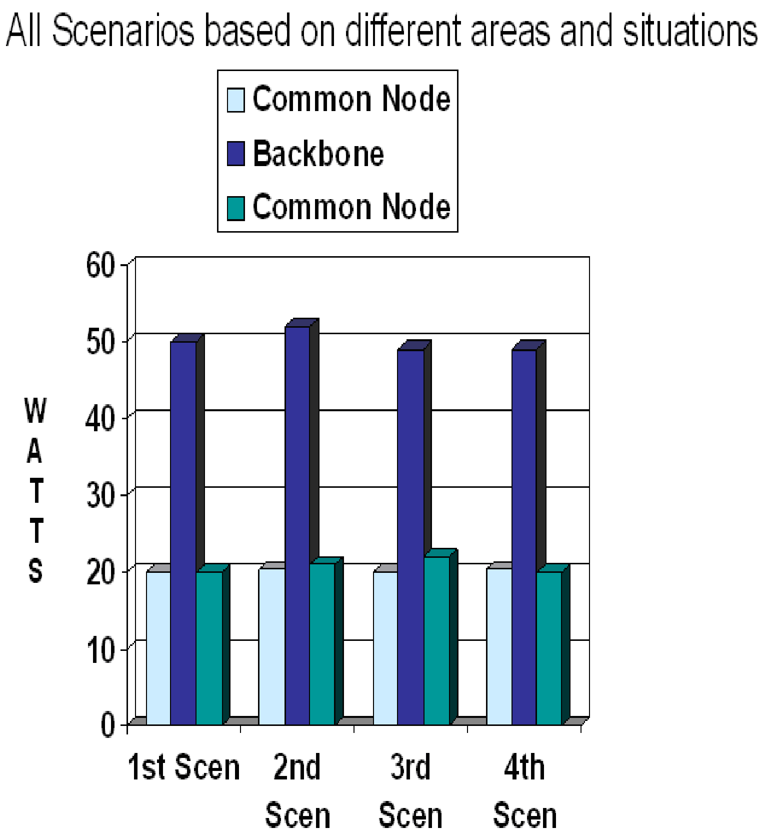

Figure 5.13 Battery Consumption of N-tier

5.4.2.2 Battery Consumption of FLEXMAN

The battery in each node of FLEXMAN is same. Every node acts almost the same s other nodes, there is equal load sharing on every node, because of this the network is more reliable.

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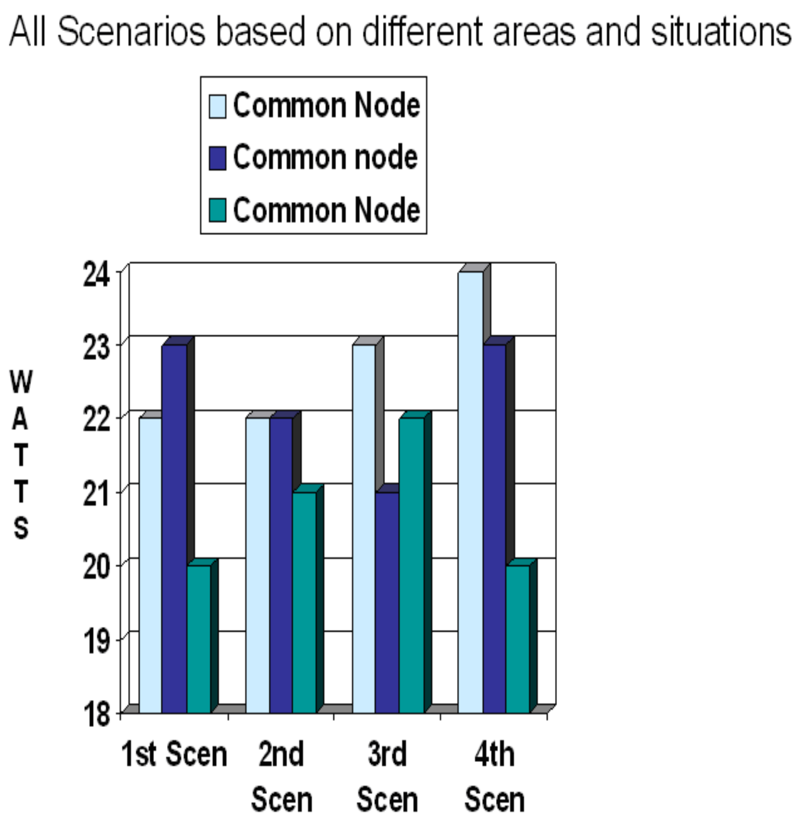

Figure 5.14 Battery Consumption of FLEXMAN

5.4.3 Fault Tolerance

Fault Tolerance has been implemented by multiple routes available for one node to communicate with other.

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As Partial Mesh has been implemented we see that one node has many options to reach the destination. Control nodes unemployed provide extra connectivity to the network.

No dependency on any backbone node makes battery consumption and probability of network collapse due to failure of backbone node considerably less.

5.4.4 Final Analysis

The minimum errors are found in the detection of an obstacle between different clusters of mobile nodes due to the implementation of equation of line and also checking for slope conditions for all the obstacles. There are more errors in placing the mobile connecting nodes by distance due to any likely presence of obstacle between them. A typical Error analysis as shown in Figure 5.14.

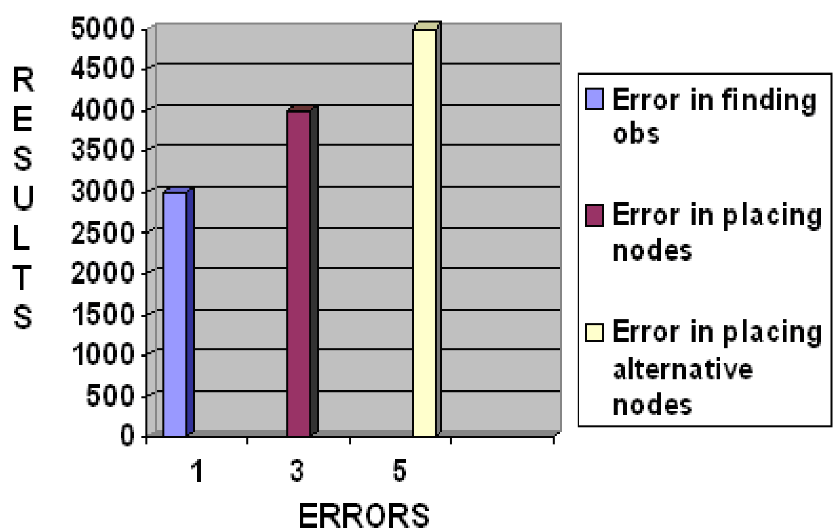

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Figure 5.15 Error Analysis

The maximum errors are found in placing alternative nodes due to presence of obstacles between the mobile nodes because the probability of occurrence of obstacle is three times more than the other cases.

Errors reduced over time as different versions of FLEXMAN were developed iteratively focusing on accuracy and performance of the Algorithm. The illustration of this is shown in Figure 5.11.

5.5 Conclusion

In a world of increasing mobility, there is a growing need for people to communicate with each other and have timely access to information regardless of the location of the individuals or the information.

The project was based on the idea of incorporating a Digital Elevation Model (DEM) in the process of planning the location of antennas. Digital Elevation Models (DEMs) are digital files consisting of points of elevations, sampled systematically at equally spaced intervals. By Digital elevation model the most thoroughly designed and documented digital elevation dataset to date can be obtained.

In the DEM there are hurdles/obstacles, which were considered for placement of antennas. So, the antennas were locally placed after considering elevations and depressions. The antennas were placed in such a way that some of the nodes were connected to all the others but some of the nodes were connected only to those other nodes with which they would exchange the most data, finally a mesh network was achieved via antennas. This is called partial mesh topology. In order to achieve the aim

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Directional and Omni directional antennas were used for better illumination.

Placement of antenna in mesh based ad hoc network is a complete research and a very tough and tricky task. We contributed in this research by development of a workable algorithm. A lot of work has already been done on devising different ways of solving antenna placement problems. The major area of this research has been the obstacle handling and we have put forth our work in this regard.

The algorithm was tested on numerous maps of different areas, and the results were very accurate. Especially the obstacle handling was up to the task. The placement of the control nodes was very precise. The algorithm placed the control nodes at the optimal places.

5.6 Recommendations

FLEXMAN works with in its given parameters and scope. The idea of problem solving of antenna placement might is not new but the idea of solving the problem with the help of a DEM opens up a way to conduct further research on the same issue. The new and better methodologies to the same job in a more befitting manner can be sought. The signal propagation can be studiers and incorporating reflection of rays can be considered. As a matter of fact it has provided with a lot opportunity for brainstorming the field of MANETS and addressing various issues that may include improving Quality of Service of algorithm.

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Page xiii: [47] Formatted	@(\ /)!R H@R@L	4/28/2005 9:17:00 AM

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Page xiii: [48] Formatted	@(\ /)!R H@R@L	4/28/2005 12:04:00 PM

Line spacing: single

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Page xiii: [53] Formatted	NT	5/19/2005 8:00:00 AM

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Page xiii: [63] Formatted	NT	5/19/2005 8:01:00 AM

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Page xiii: [67] Formatted	@(\ /)!R H@R@L	4/29/2005 5:34:00 PM

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Page xiii: [72] Formatted	NT	5/19/2005 9:32:00 PM

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Page xiii: [77] Formatted	NT	5/19/2005 9:32:00 PM

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Page xiv: [96] Formatted	@(\/)!R H@R@L	4/28/2005 9:30:00 AM

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Page xiv: [97] Formatted	@(\/)!R H@R@L	4/28/2005 9:34:00 AM

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Page xvi: [154] Formatted	@(\/)!R H@R@L	4/28/2005 12:04:00 PM

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Page xvi: [159] Formatted @(\/)!R H@R@L 4/29/2005 6:01:00 PM

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Page xvi: [160] Change @(\/)!R H@R@L 4/28/2005 10:01:00 AM

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