ON MOVE DYNAMIC LOCATION DETECTION WITHOUT GPS IN VANETS

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ABSTRACT

ON MOVE DYNAMIC LOCATION DETECTION WITHOUT GPS IN VANETS

High density of vehicles made the possible threats and road accident increased. Wireless Technology aims to equip technology in vehicles to lessen these factors by sending beacons to each other. Vehicular ad hoc networks (VANET) enable vehicles to communicate amongst themselves i.e. Vehicle to Vehicle communication (V2V) and Vehicle to road-side infrastructure communications (V2I). VANETs help in making driving on roads a safe task by informing drivers about immediate environmental conditions, e.g. vehicle collisions, road blocks, traffic jams.

In the project, autonomous information from stored digitized maps and from vehicle sensors is combined with information received via RF links from nearby vehicles and the infrastructure. A spatial database named local dynamic map is the project deliverable which reflects all relevant stationary, transitory and dynamic information in the noticeable range of a stationary object (road side unit) or moving object (vehicles and other road users).

DISSERTATION

No portion of the work existing in this thesis has been submitted in support of another award or qualification either at this institution or elsewhere.

DEDICATION

In the name of ALLAH, the Most Beneficent, the Most Merciful

DEDICATED TO OUR PARENTS

ACKNOWLEDGEMENTS

We would like to specially thank and express our heartily gratitude to our supervisor Maj. Dr. Asim Rasheed. It is true to say, most of the things in the work would not have been possible without his mature and professional support. He has been a true guidance in difficult times and always providing insightful comments. We are thankful for his corrections and editing of this report. We would like to pay all the gratitude to the faculty of Electrical Engineering Department for providing us a congenial environment. We are obliged to their support and guidance. We have found people here very cooperative and fun to work with.

We are grateful to Madam Sana Ajmal for working with us. As co-supervisor, her support and guidance has always been a valuable asset for the project. Her keen interest and discussions over the work always provided a ray of hope in difficult times. We feel motivated and optimistic every time we attend their meeting. Without their motivation and guidance this project would not have materialized. We are really thankful to her worthless contributions in the project work.

In the end, we would like to thank National University of Science & Technology for funding and for providing various equipment support and facilities for this project. We are also grateful to the whole staff of the Department of Electrical Engineering especially to Chief Instructor (CI) of the department for his support in form of equipment for developing vehicular ad-hoc network.

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ABBREVATIONS USED

GPS	Global Positioning System
VANET	Vehicular Adhoc Network
V2V	Vehicle to Vehicle
V2I	Vehicle to Infrastructure
LBS	Location based service
PDA	Personal digital assistant
LDM	Local Dynamic Map
DSRC	Dedicated Short Range Communication
ITS	Intelligent Transportation System
IVC	Inter-Vehicle Communication
RVC	Roadside-to-Vehicle Communication
MAC	Media Access
RSU	Road side unit
LCR	Level crossing rate
ACF	Auto correlation function
AOA	Angle of Arrival
MUSIC	Multiple Signal Classification
MS	Mobile Station
DSP	Digital Signal Processing
DSK	DSP Starter Kit
DOA	Distance of Arrival
MDL	Mobile Data Link
DRAM	Dynamic Random Access Memory

CPLD	Complex Programmable Logic Devices
USB	Universal Serial Bus
CCS	Code Composer Studio
API	Application Program Interface
GIS	Geographical Information System
LOS	Line of Sight
QAM	Quadrature Amplitude Modulation
PSD	Phase shift Density
NHTSA	National Highway Traffic Safety Application
CVIS	Cooperative Vehicles and Infrastructure Systems
MANET	Mobile Adhoc Network
IEEE	Institute of Electrical and Electronics Engineers
NHT	National Highway traffic

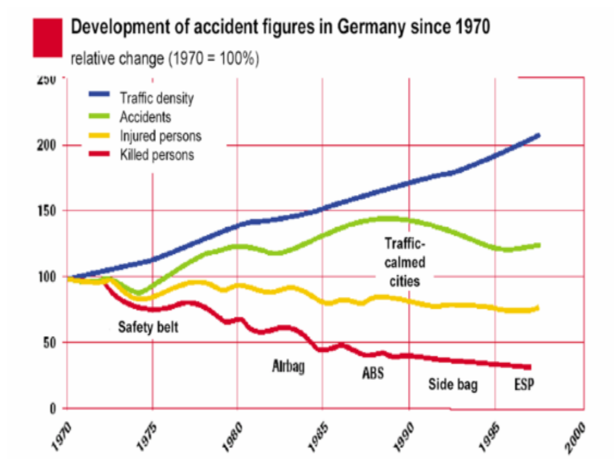
CHAPTER 1

INTRODUCTION

This thesis proposes the "**On Move Dynamic Location Detection and Updation without the use of GPS**". The suggestion incorporates an organization that is a foremost step towards the on-move communication between vehicles, without using GPS.

Traffic obstruction on the roads today is a large problem in big cities. Nonexistence of road traffic safety takes a tone of valuable individual lives and poses a dreadful hazard to the atmosphere as well. According to NHT safety management, the subsequent statistics indicate the results of car accidents.[1]

6.3 million Accidents were reported, 43,000 individuals were killed, and Millions of citizens were wounded. The financial system deficit caused due to those accidents were more than $230 billion



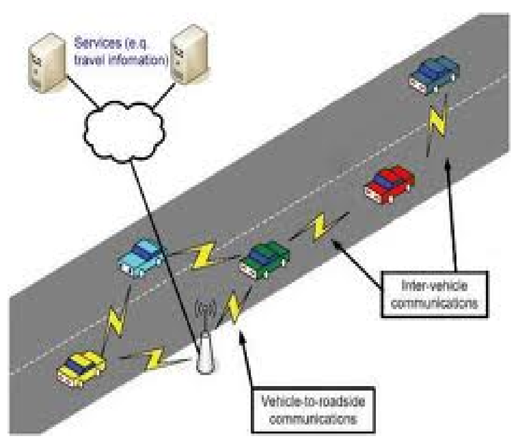
1.1: Development of accident figures

On highway, a vehicle cannot presently calculate the speed of other vehicles. However, with use of sensors, computer and wireless message equipment, speed is premeditated and a warning beacon sent every 0.5 seconds can limit the risk of potential accidents.[2] A vehicular adhoc network (VANETs) uses the notion of continuously varying vehicular motion. The nodes or vehicles in VANETs can move with no boundaries of direction and speed.

1.1 BACKGROUND

Community is becoming more and more cognizant and responsive of the technology demands and changes that are mandatory in routing for their own benefit and safety. With the speedy increase in technology, internet and communication is becoming a prerequisite for a normal individual and it is required 24 hours whether at home or away, while walking, flying, travelling and driving etc. In order to accomplish communication needs the entire instance in all the circumstances and in affordable rates, we require an arrangement which can be installed on every vehicle and can converse with the external world from within the vehicle while driving.

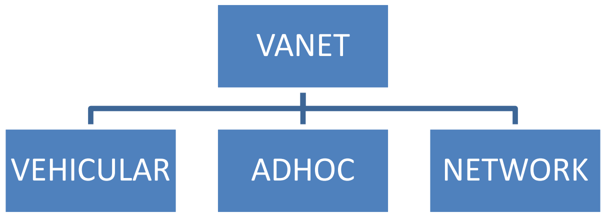
VANET's are employed to endow with services such as internet, toll payments, and announcements in community places like nearest restaurants or gas stations. It allows vehicles to cooperate openly with other vehicles in close proximity and with the nearby roadside infrastructure, thus giving out information on the latest traffic dynamics for greater security, competence and a better environment. Ad hoc networks (VANET) enable vehicles to communicate amongst them-selves (V2V communications) and with road side infrastructure (V2I communications) making driving on roads a safe task by informing drivers about surrounding conditions, e.g. automobile collisions, road blockage, traffic jams. Such networks show various functionalities in terms of vehicular safety, traffic congestion diminution, and position based service (LBS) applications. [3]



1.2: Roadside communication model

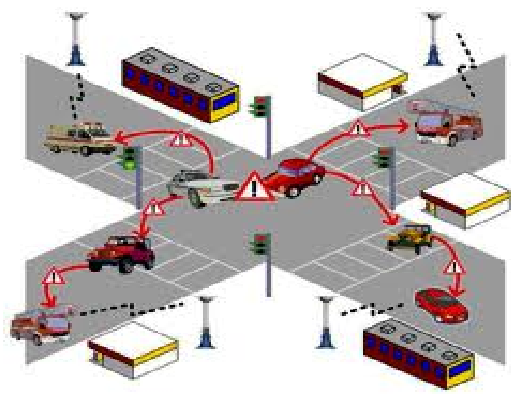
1.2 VANET-THE GROWING TECHNOLOGY

VANET is basically composed of three parts.



1.3: Meaning of VANET

The first part is the Vehicular Part and it is there because of use of vehicles as intermediate nodes for packet transference. Along with communication between vehicles only, we can also communicate between roadside objects and vehicles.



1.4: Inter vehicular communication

Ad-hoc mode is a method for wireless devices to directly communicate with each other. Working in ad-hoc mode enables wireless devices within range of each other to discover and communicate in peer-to-peer fashion without involving central access points. An ad-hoc network tends to feature a small group of devices all in close proximity to each other.

In case of VANET, a network of cars is established which are interconnected by communication channels that not only facilitate communication but also allows sharing of resources and information among interconnected devices. The information in this case is shared in the form of packets.

1.3 NEED FOR VANET IMPLEMENTATION

In VANET, vehicles are used as nodes to form and deform the network as a replacement of more obvious mobile devices like laptops and PDAs. VANET is an emerging technology and will take over the world of trafficking in near future due to the following facts:

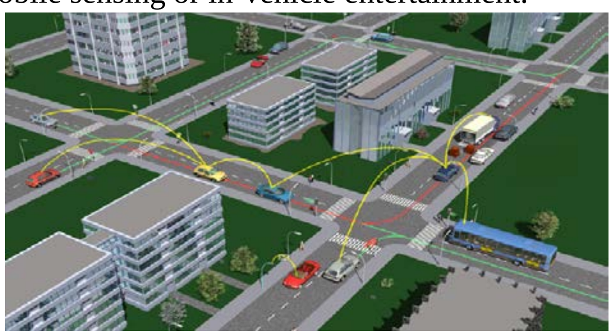
Mobility patterns of vehicles are somehow predictable as movement is constrained by road infrastructure. In some cases such as road travel, the mobility atterns become very knowable. Also, vehicles travel over long distances and traffic information may be useful to vehicles hundreds of miles away. And power consumption is not a foremost apprehension. Vehicles are movable power plants. Vehicles have a sky-scraping expenditure and therefore can be equipped with additional sensors without significantly impacting the total cost. VANET's topology is extremely dynamic as vehicles go in and out of transmission range quite rapidly and vehicles travel extensive distances in a little amount of time when compared to other mobile networks.

1.4 PROBLEM STATEMENT

The project is "Deployment of Vehicular Ad-hoc Networks (VANETs) architecture for location updating." The project involves deployment of VANET architecture for updating local dynamic map using non GPS architecture. Updating of Angle of Arrival and relative distance is done and the results are plotted on a LDM. The newly emerging VANET technology is the basis for this architecture.[4]

1.5 OVERVIEW

This project aims to develop inter and intra vehicular ad-hoc networking, computing and sensing of data for next generation smart vehicles. Such vehicles have embedded computers, short-range wireless network interfaces, and potential access to in-car sensors and the Internet. Additionally, they can communicate with road-side wireless sensor networks. These capabilities, as shown in figure 1.5 can be leveraged into distributed computing and sensing applications over vehicular networks for safer driving, dynamic route planning, and mobile sensing or in-vehicle entertainment.



1.5: Communication via antennae

1.6 OBJECTIVE OF THE PROJECT

The project aims at determining the exact location of all the vehicles on a highway and updating the calculated coordinates on a local dynamic map. Some of the specific objectives are:

The Development of a LDM, which shows the position of nearby vehicles on it. Then LDM is updated with the help of sensors, which determines the change in position of vehicles. These sensors are interfaced with a signal processing unit, which measures several parameters like Angle of arrival, Distance between vehicles, Direction of motion and Direction of link.

Thereby, wireless communication between nodes helps us to determine above parameters which are further used to pinpoint the exact position of a node on a LDM present in every car.

1.7 TECHNOLOGIES SUPPORTED VANET

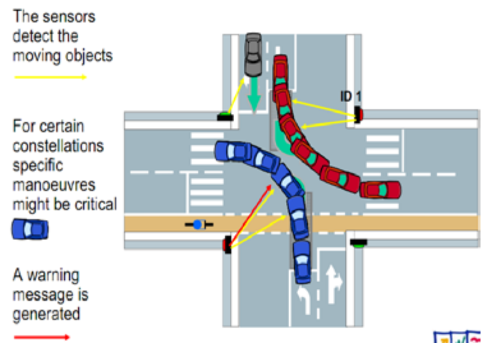
A number of wireless technologies are required to be implemented in VANET, DSRC (Dedicated Short Range Communication) being the main ingredient. Other entrant technologies of wireless are Satellite system, WiMAX and Cellular. Vehicular Ad-hoc Networks (VANET) can be considered as a device of ITS (Intelligent Transportation Systems). Vehicular networks have conceived ITS (Intelligent Transportation Systems). Automobiles are permitted by IVC (Inter-Vehicle Communication) to communicate with each and RVC (Roadside-to-Vehicle Communication) allows them to connect to the stations.[5]

1.8 AIMS TO BE ACHIEVED

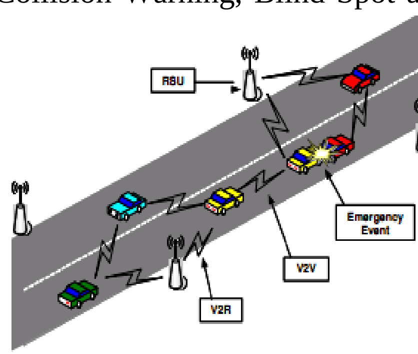
Goals are to determine the angle of arrival of the signal on the antenna, the received power of the signal, the relative distance of the vehicle. Then, calculating the exact most probable location of the vehicle with respect to the vehicle and updating this location on a local dynamic map. Then at the end, it involves refreshing the map after every few seconds.

1.9 APPLICATIONS

Knowing the whereabouts of the car is a big advantage in the fast going world today. One can not only be precautious but can also serve to take the required actions in case of emergency. Some of the major applications of the project include providing road safety to vehicles mainly on highway where their position may change up to several meters in seconds, helping vehicles in case of road blockage whereby, they can divert their way if required, helping to prevent terrorist attacks as LDM will show all suspicious vehicles on highway, aiding in the provision of road side services like workshops etc. It also provides Vehicle-to-Infrastructure (V2I) Communications for Safety [6] such as Intersection safety, run-off-road, and speed management. Vehicle-to-Vehicle (V2V) Communications for Safety [7] includes Emergency Brake Light Warning, Forward Collision Warning, Blind Spot and Lane Change Warning. Predictive speed reduction and Real-Time Data Capture and Management Data communicated between vehicles is captured by certain organization and on basis of this, roadside information is obtained.[8]



1.6: Sensors detecting decreased distance



1.7: Road Side Communication Model

CHAPTER 2

LITERATURE

The chapter includes all the research work done to make this project a reality. A number of papers and books were thoroughly studied before actually finalizing each step towards the project completion.

2.1 REVIEW

This chapter embraces all the paper works and related research as well as the studies with regards to this project. The chapter includes all the important studies which have been done previously by other research work. The related works have been referred carefully since some of the knowledge and suggestions from the previous work is implemented for this project.

Literature review was an ongoing process throughout the project. It is very essential to refer to the variety of sources in order to gain more knowledge and skills to complete this project. These sources include suggestion books, theory, proposal, journals and also the information obtained from internet.

A list of important research/ term papers were went through to understand the concept of VANETs are as under:

Angle of Arrival Estimation by Received Signal Strength with Directional Antennas by Sean Winfree: This paper helped us in the determining the type of antenna suitable for the project requirements.

‘3d’-a Doppler, Directivity and Distance based architecture for selecting stable routing links in VANETs By Asim Rasheed and Sana Ajmal: We are basically implementing this term paper. It gave us the concept of how to proceed in the project and what parameters need to be determined that will help us in the achievement of the goals.

Mobile Velocity Estimation in Multipath fading by Bin Zhou: This book helped us in designing the algorithm at receiver side, which helped us in the determination of mobile velocity.

Wireless Communications Andrea Goldsmith, Stanford University: Chapter 3 and chapter 4 of this book helped us to understand the DSP part of the project. It helped us to understand the way signal propagates through channel and how it is received.

Dynamic Maps for Long-Term Operation of Mobile Service Robots by Peter Biber and Tom Duckett: This IEEE research paper helped us in understanding the concept of Local Dynamic Map (LDM) and how to update its data after regular intervals.

Digital signal processing lab Department of Electrical Engineering University of Engineering & Technology, Lahore: This paper helped us to understand the project hardware i.e. DSP KIT.

Root-MUSIC-Based Azimuth-Elevation Angle-of-Arrival Estimation with Uniformly Spaced but Arbitrarily Oriented Velocity Hydrophones Kainam Thomas Wong and Michael D. Zoltowski: From this paper, we learned the concept of MUSIC algorithm which is used to determine the angle of arrival of the received signal

CHAPTER 3

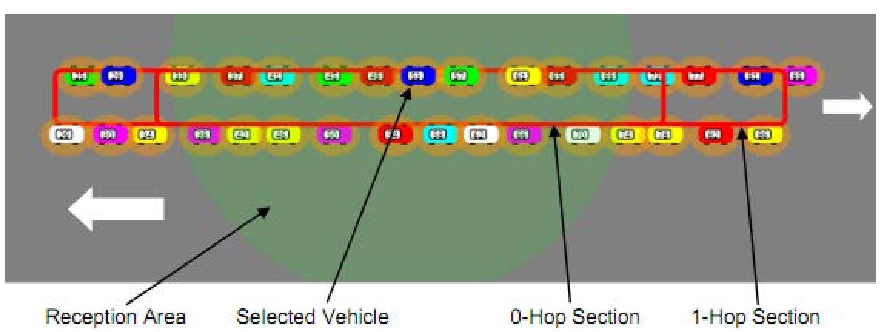
DESIGN

3.1 PROJECT FRAMEWORK

The project consists of following modules or steps which need to be determined.

Determine the angle of arrival from the ray coming from a nearby vehicle and falling on the antenna present on each car. Angle of arrival of the signal from a particular vehicle helps in determining the Doppler shift. This Doppler shift then aids in finding the relative speed of vehicle if the transmitter and receiver are both mobile. RSL (received signal level) algorithm will be used to determine the distance between vehicles. Using above information, the exact most probable location of the vehicle with respect to the vehicle is calculated. This information is then updated on LDM. Refresh the map after regular intervals to show change in position of nodes. The requirement of the project at the initial basis is implemented on two cars separated a distant apart and are to be tested in different environment which requires transmitter and receiver at both cars:

Both Car 1 and Car 2 are stationary, Car 1 is stationary and Car 2 is moving, Car 2 is stationary and car 1 is moving, both the cars are moving.



3.1: Reception Area and Hop Selection

3.2 INPUT AND OUTPUT PARAMETERS OF EACH BLOCK

Each block in the project is serving a unique purpose and so each block has specific input quantities, output quantities and some bounding parameters that define them.

3.1: Input and output parameters of block diagram

PARAMETERS	INPUT QUANTITIES	OUTPUT QUANTITIES
DOPPLER SHIFT	Maximum Doppler frequency	Nodes velocity
DIRECTION OF MOTION	Signal strength (doppler shift)	Vehicle approaching or receding
ANGLE OR ARRIVAL	Multiple received signal	Angle of arrival of signal components
DISTANCE BETWEEN NODES	Transmitted and received power	Relative position of vehicles
LINK DIRECTION	Angle of arrival	Forward or backward

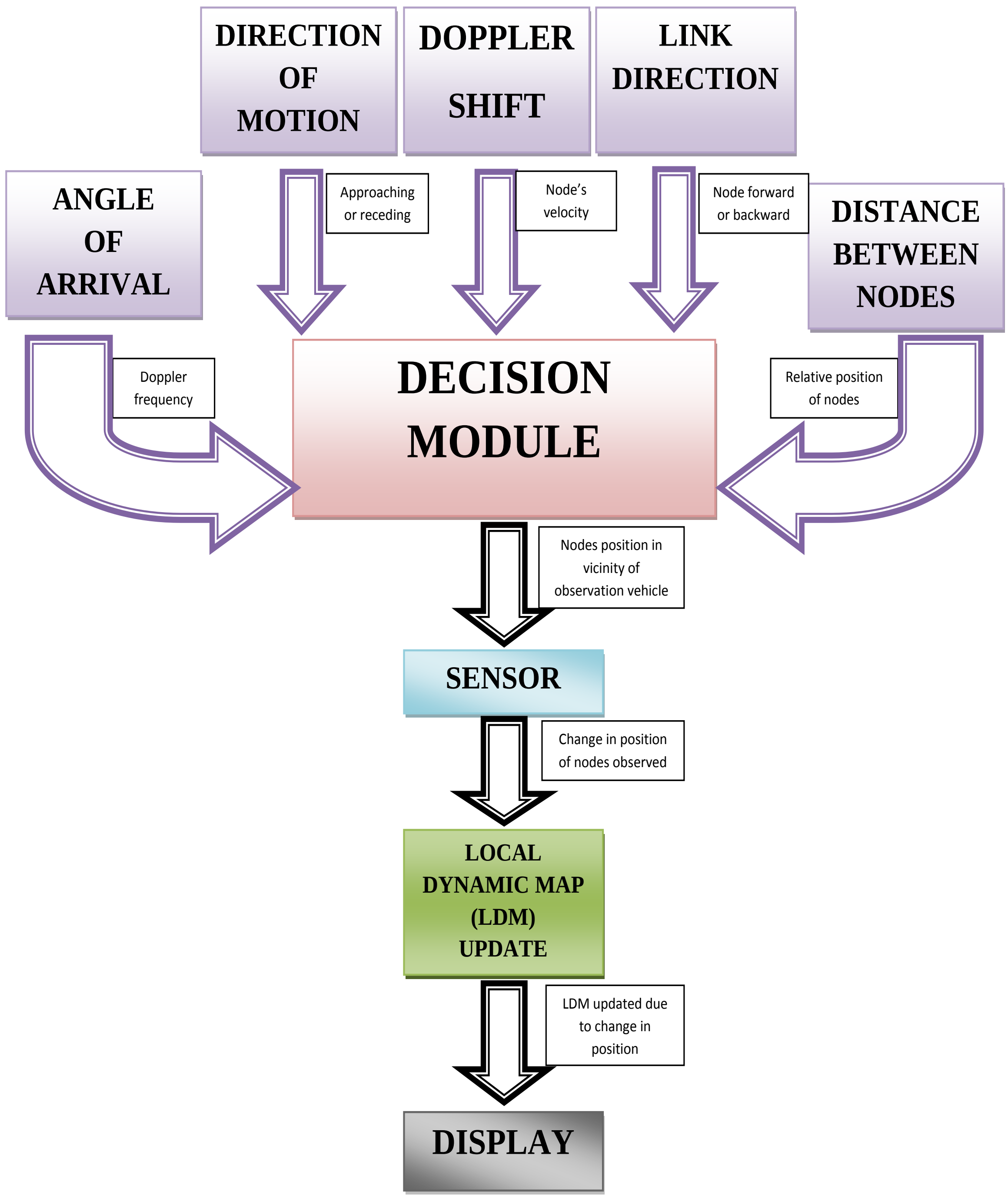
Once the sensor module takes in all the input parameters, The DSP kit runs a number of algorithms to carry out processing on them. This processing involves extensive algorithm implementations. After the processing is completed, the output parameters that are computed are displayed for the user to see.

Once these output parameters are determined, we are able to compute the unknown coordinates of a vehicle in the vicinity of our reference vehicle.

These coordinates are then plotted on a local dynamic map, with shows correct position of the vehicle on the map.

3.2.1 BLOCK DIAGRAM

The different modules of the project approach the decision module in a unique and specific way which defines their connectivity as well as the algorithms.



3.2: Block Diagram of the project

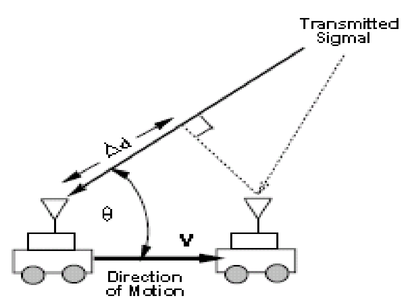
3.2.2 DOPPLER SHIFT

The Doppler shift is change in frequency of a wave due to the relative motion of the vehicles. Using Doppler Effect we can determine the speed of the moving vehicle with respect to the vehicle under observation. Tracking of received signal strength is necessary, as it gives us the idea of maximum Doppler spread which is in turn proportional to mobile velocity.

There are two main approaches to determine mobile velocity through Doppler shift. These are LCR (level crossing rate) and ACF (auto correlation function). After detailed research on both methods, we came to the conclusion that ACF method gives better simulation results which are closer to the practical value and it is less complex as compared to LCR method. Apart from this, in ACF method, which helps us to find signal's dominant frequency, mobile's velocity is independent of sampling rate, because of which, we do not need to adjust sampling frequency with change in mobile speed.

We can implement the following equation to find maximum Doppler frequency using which, we can determine mobile vehicle's velocity. fm= (1/2π) Jo^ (-1) [Φ11 (1) / Φ11 (0)]

From this, we can compute mobile velocity using: v= [fm * Fs * c / Fc] where, fm is maximum Doppler frequency and v is the speed of mobile vehicle.[11]



3.3: Doppler Shift

Doppler shift from the carrier frequency fc occurs when the distance between the mobile receiver and the transmitter is changing. The Doppler frequency fm is often called fading bandwidth or fading fate of the channel.

The geometry associated with the Doppler shift is shown in figure.

From maximum Doppler frequency, Doppler shift was found using $Fd=fm \cos(\theta n (t))$ where, θn (t) gives angle of arrival of each component received.[12]

On highway, vehicles have a short range mobile-to-mobile channel that will contain a much stronger direct line-of-sight component, possibly also with a strong round reflected wave. Hence the Rician channel was simulated. The simulations were started with Rayleigh channel, as received signal was easier to process for it. At present, work is in progress on the conversion of Rayleigh to Rician channel and modifying the algorithm for Rician channel mainly at receiver side.

For channel, narrow band fading model was considered as it gives less inter symbol interference giving better results at the end of receiver.[13]

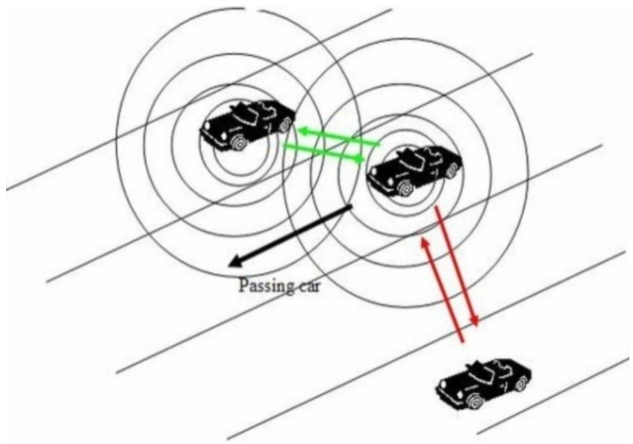
In order to find distance between nodes, we are making use of following formula:

$$Prec = Ptransmitted/d^\alpha$$

Where, Prec is the power received at antenna, Ptransmitted is the transmitted power, Factor α is path loss. α is normally 3 or 4 in VANETs.[14]To proceed with this, strength of signal transmitted and received must be measured.

In order to find the direction of motion, it was needed to determine the signal strength at receiver side and compare it with previous received signal from same mobile vehicle.

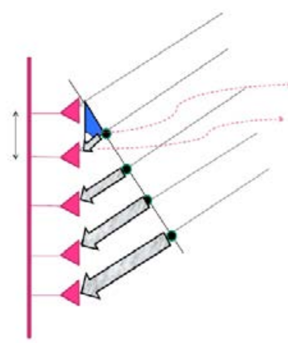
If the signal strength has decreased, then the mobile vehicle is moving away from vehicle under observation. While if signal strength has increased, then the vehicle is approaching the vehicle under observation. If no signal is received from a particular vehicle, this shows that the vehicle has gone out of vicinity of the vehicle under observation.



3.4: Overlapping Antennas Radiations Used to Determine Received Power

3.2.3 ESTIMATION OF ANGLE OF ARRIVAL (AOA):

Angle of Arrival (AOA) is defined as the angle between the propagation direction of an incident wave and some reference direction, which is known as orientation.[15]It is the angle subtended with the normal, received by each element of the antenna array. Thus AOA gives you an estimate of what exactly is the direction of arrival of the signal received by the element.



3.5: Angle of Arrival

There are several methods of estimation of AOA which had both their pros and cons but we have decided to use the best suitable of it. The general methods usually include [16] Correlation, Maximum Likelihood estimation, MUSIC, ESPIRIT, RSS and Directional antennas, TDOA dependent /Triangulation technique.

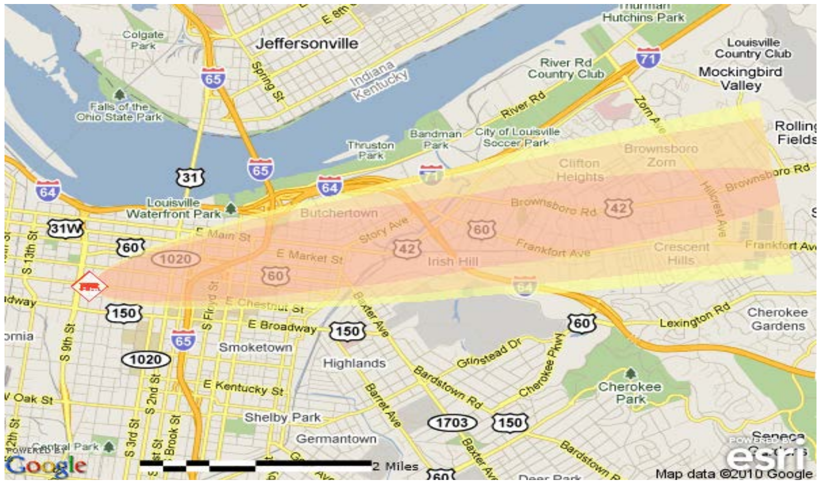
Out of all the available method MUSIC was selected due to its suitability to purpose. MUSIC stands for “Multiple Signal Classification”. The reasons for selecting this method are [17] that it is especially designed for narrowband, suits the purpose, adaptive, allow maximum number of MS for all major adaptive techniques, accurate and it can be improved by applying root music in certain scenarios (not suited to this project), and gives the optimum performance as compared to other such methods reducing the computational load.

It gives us the number of signals received at the array. It also gives us the Angle of Arrival which in turn gives us the Direction of Arrival of the incoming signals.

3.2.4 LOCAL DYNAMIC MAP (LDM):

Local dynamic map is a time and location referenced database that forms layers on top of an accurate digitized map. The layers on map enable things such as landmarks, road symbols and vehicles are separately located on a digital map. It performs data fusion. There are basically two types of layers we are interested in for the project which are:

It is the layer which is not changing with time. It remains same over a period of 10 years. i.e. buildings, trees, railway lines



3.6: Static Layer

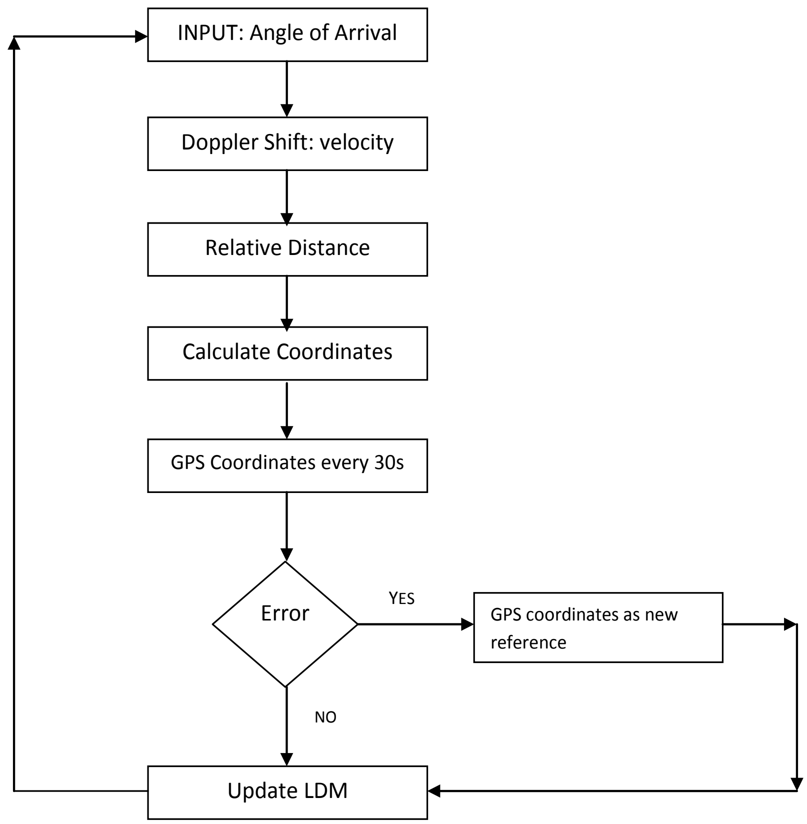
It is the layer which is changing with time and is also continuously updated as well. It includes cars, trains e.t.c.

3.7: Dynamic layer

After the determination of the parameters mentioned before, and feeding the information in DSP kit, we moved to the final stage of project which is updating of local dynamic map. In order to update this map, NetBeans and GPS inspector will be used. NetBeans is the software whose code is open source and can be changed or modified. It uses java language coding.

3.3 DECISION MODULE:

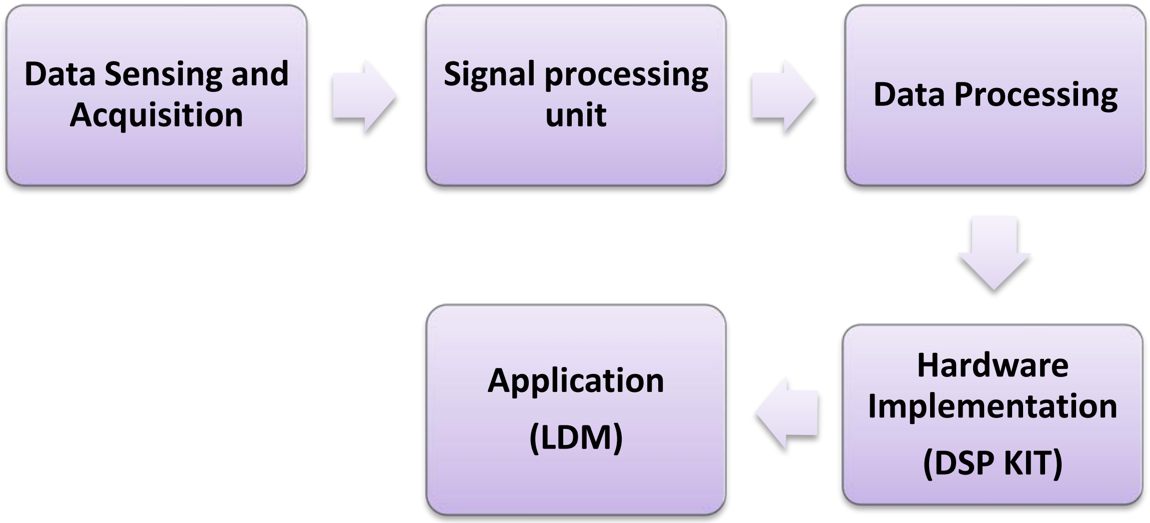
Decision module helps to update the position of node after regular intervals. If the decision module shows that position of a vehicle has been changed w.r.t reference time, it will be updated on LDM otherwise, no change in the positon of that particular node will be observed.



3.8: Decision Module

3.4 SYSTEM DESIGN MODEL

The system design model has been developed in view of the scope of the project. The model shows the various modules from the DSP kit to the application running at the host PC.



3.9: System Design Model

3.5 PROJECT FRONTS

The proposed project proceeds on five fronts simultaneously

Data Sensing and Acquisition: Data (signal) will be sensed by the antenna, which will then be transmitted to signal processing unit for further processing.

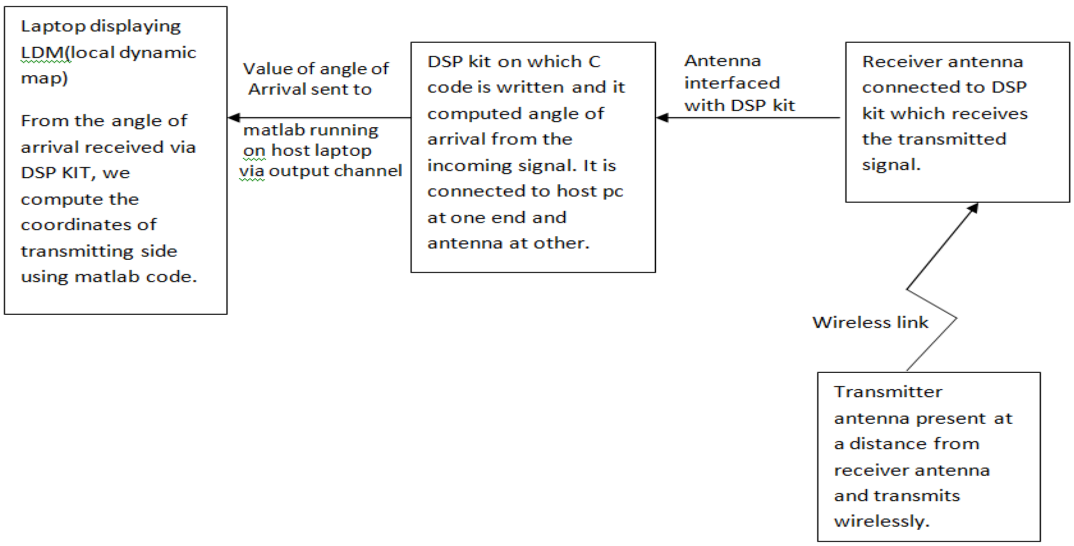
Signal processing unit: Signal processing unit will be set according to VANET environment. Parameters will be defined accordingly.

Data Processing: Different techniques will be used to aggregate the data sent by the different paths and determine the required parameters using the signal received. This is an integral part of the project as it helps in reducing the volume of data received and to determine the position of nearby vehicle.

Hardware Implementation (DSP kit): The hardware including sensor boards, antennas, signal processing kit and database will be configured and implemented according to the layout that has been defined above. Hardware configuration will be done in C language.

3.6 ARCHITECTURE

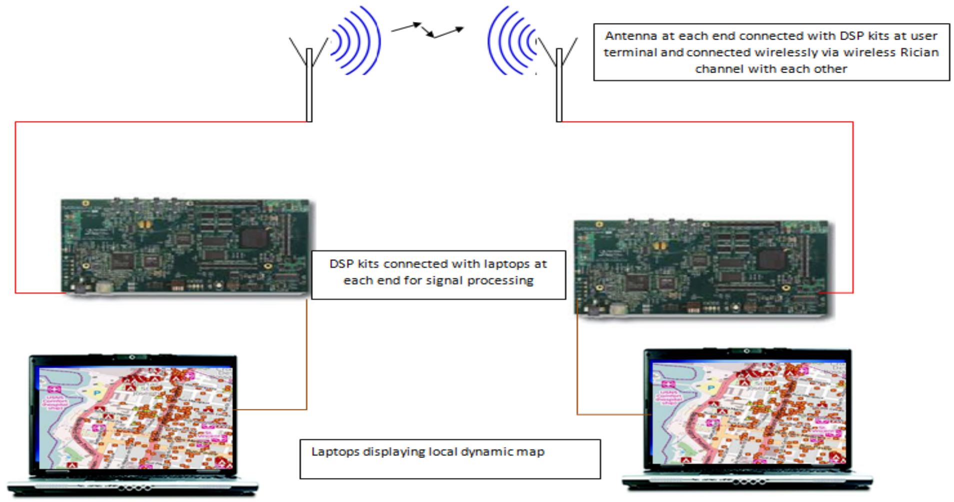
The composite architecture of the overall project is quite complex in nature and the different modules are linked on many levels and stages.



3.10: Project Architecture

3.7 PROJECT HARDWARE OVERVIEW

The overall displayable project is just a decision module and the supporting device. such as a laptop, connected to it.



3.11: Project Hardware Overview

3.8 APPLICATION

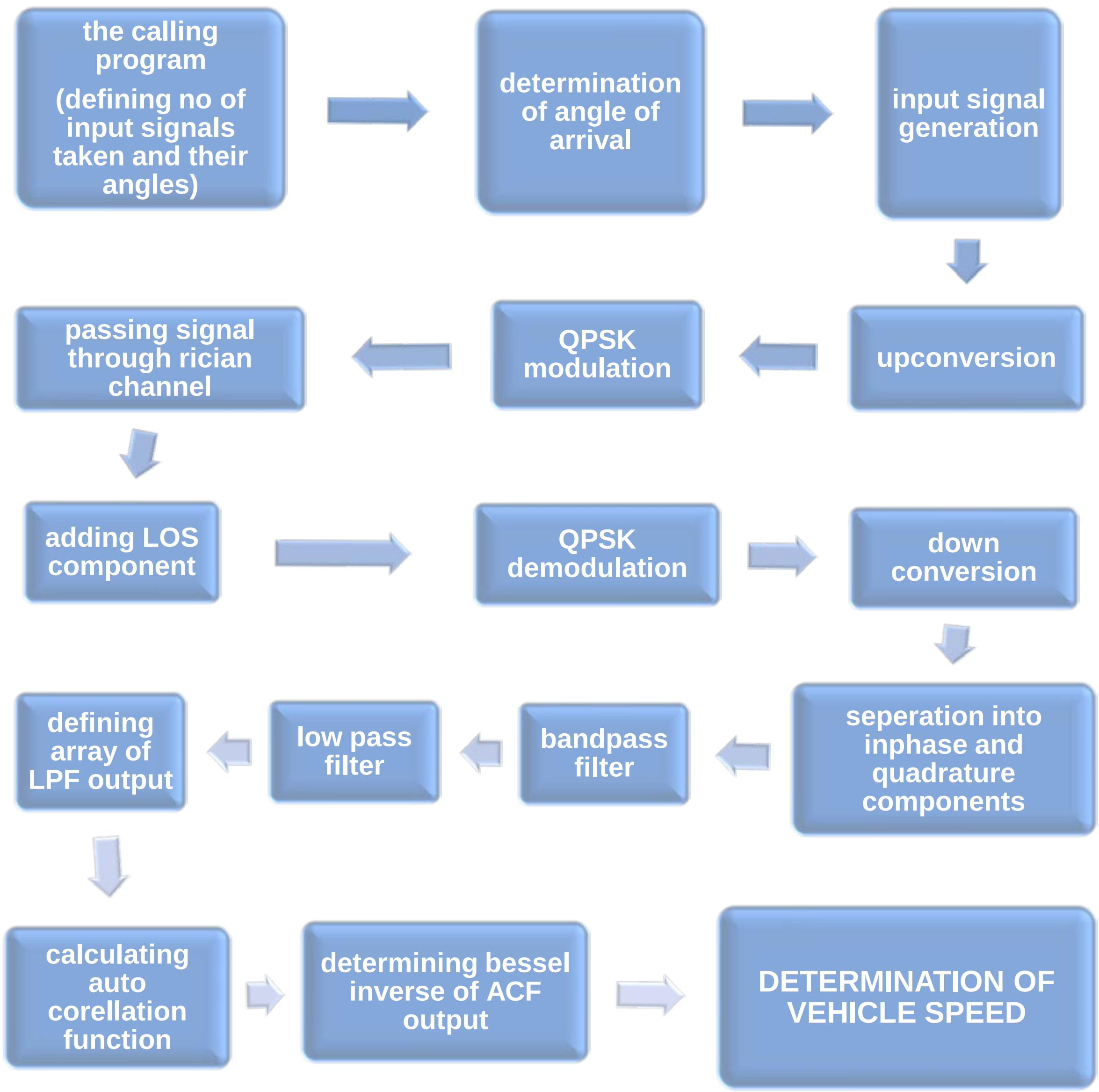
The application or deliverable of the project is a local dynamic map, which will display the position of all vehicles in the vicinity of a reference vehicle. This is important in terms of security. Knowing which car is where makes it easier to determine one’s next move.

For security point of view, the project is extremely efficient and should be employed in order to reduce the number of accidents that take place everyday.

CHAPTER 4

ALGORITHMS

Different algorithms are used in the project according to the interfacing techniques used and then the main programming is done for the AOA part.



4.1: Project Algorithm

4.1 ANGLE OF ARRIVAL (AOA)

Angle of Arrival is defined as "The angle between the propagation direction of an incident wave and some particular location direction, which is known as orientation"

The aim of the software is to implement the MUSIC algorithm that enables an antenna array to estimate the number of incident signals on the array and their directions of arrival.

Let there be m elements in array. If x(i) is the input at the ith element of the array and x =_x(i)_. According to the MUSIC algorithm, the covariance matrix formed as S = xx_ (where x_ denotes conjugate transpose) has n repeated minimum eigen values (for uncorrelated noise) that represent the variance of the noise. The magnitude of signals incident is given by d = m−n. Further, the eigenvectors corresponding to these eigen values are orthogonal to the array manifold (the gain and phase change provided by the array elements to the incoming signal directions) at the values of the incoming signal directions. Hence, when a matrix EN of these eigenvectors is formed and plotted, peaks at the values of theta corresponding to the incoming signal directions are formed.

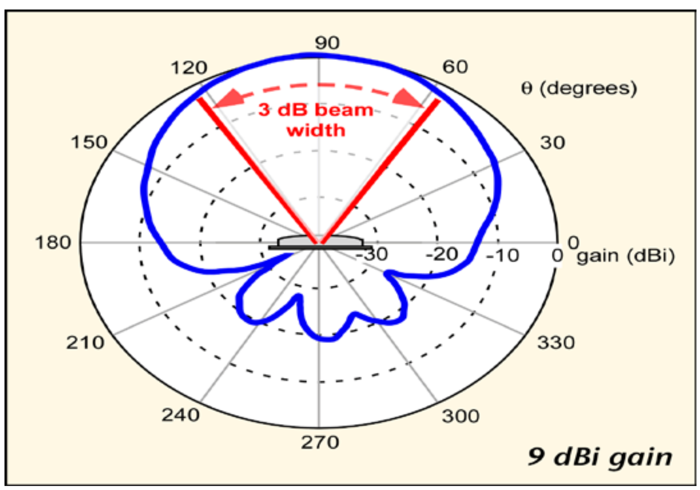
This part is a sample calling program which is designed to validate the functioning of the music algorithm. The sample program is simulating a sine wave input that is arriving at the array in the form of planar wave fronts (the source is assumed sufficiently far away). The array itself is assumed to be an m (NOOFELEMENT) element linear array with no directional properties (could be an array of dipoles) in the given plane.

The number of elements can be continuously changed. Along with this, the frequency of the input signal can be changed.

dfactor stands for division factor of wavelength that represents the distance between the elements (for e.g: if dfactor = 2, distance between elements = _2). Thus we can handle both the frequency and the distance between elements in terms of the frequency given. The sample variable shows the number of samples that we wish to take for the given input and fs represent the sampling frequency. These two major variables can be controlled to simulate the processor accessible, the amount of precision and the system refresh rate. For example , if we chose a high value of samples , amount of memory utilization increases and the refresh rate (rate between consequent measurements) decreases however the accuracy of calculations increases (assuming input signal lasts for that long a time). x is the matrix in which the signal received at the array elements is stored. xi(tj) represents the value of the input function detected at the ith element at the jth time instant (including noise).

Therefore, f1 is the requisite input function and r is the noise matrix.

The noise is zero mean with variable variance which can be changed by changing the multiplying quantity. When array manifold function is defined in a different file (refer PART II) all the user has to do is call the music1d function to get the estimate of the number of signals and a plot of PMU () versun _.



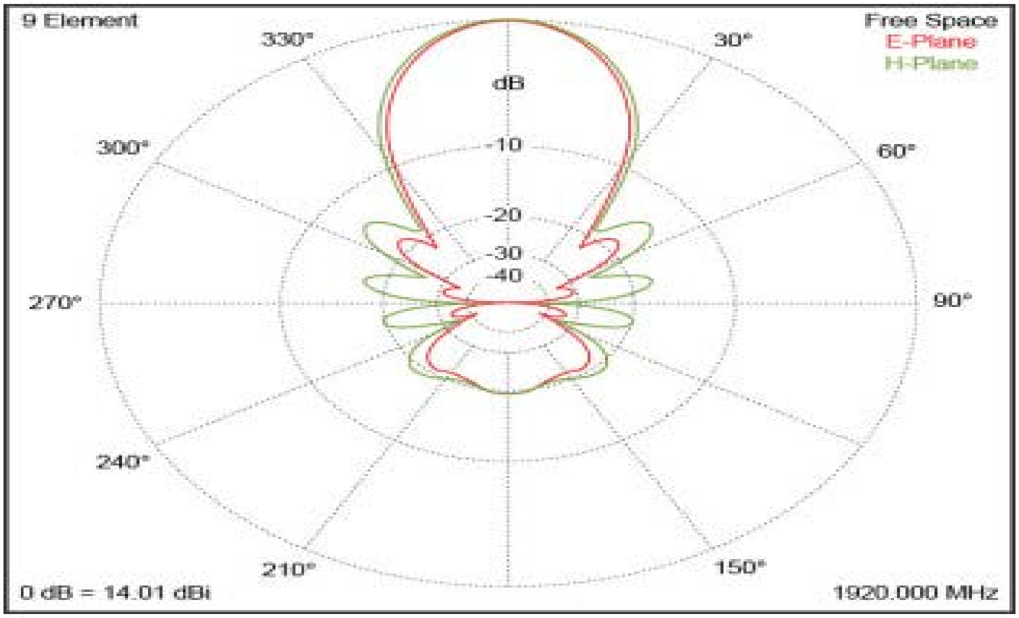
4.2: Antenna Beamwidth

The array manifold is defined as the gain and phase change provided by the array elements to a given signal direction. The array manifold is a function of _ and is saved in the file manifold. The variables NOOFELEMENTS and dfactor are global and hence can be accessed by the manifold too.

The third part consists of the actual implementation of MUSIC algorithm. The function returns an estimate of the direction of signal arrival. It takes the x matrix as an input. From this x matrix, the number of elements and the samples is determined. We have to calculate the covariance matrix as a first step.

In the next step, calculation of the eigenvalues and eigenvectors of S is done. After determining the minimum eigenvalue, the multiplicity of this value is obtained. The multiplicity is obtained using a naive comparison. The final aim is to use MDL criterion to find the number of incident signals.

The next step is to obtain the noise eigenvector matrix of these minimum eigenvalues and form the matrix ‘nev’. Using this matrix, we plot it to get direction of arrival in either a single dimension or multiple dimensions. The program presented works only for a planar angle. The end goal is to get signals direction of arrival in using azimuthal angle and elevation angle.



4.3: Directive Beamwidth

4.2 TESTING

Ensure that all the files (main, manifold, music1d) are in same directory.

Initially, we run the main program in MATLAB and write the number of signals and the angle in degrees for each of the signals.

The result will give the amount of signals as output along and the plot. Now we obtain the values of the highest d peaks to get the direction of arrivals.

Firstly, enter the value for number of signals as 1 and change the angle from 10 to 80, Then, observe the output. We observe sharp peaks for single signal.

Enter an arbitrary value for number of signals which should be less than about 3/4th of the number of elements for better results.

Enter the values of the angles and determine the output.

4.3 DESIGN FEATURES AND OBSERVED RESULTS

There are a number of parameters for which changes can be made and varying results are found. These parameters are:

Number of elements: Increasing the number of elements increases the resolution for numerous sources. If the number of signals is increased, then a higher element array predicts the directions of arrival better.

Noise: At lower noise, the peaks are sharp. The occurrence of noise causes a scattering effect on the peaks.

Number of samples: Increasing the number of samples does not bring about a greater improvement in the figures. However, total samples must be greater than number of incident signals for desirable results. 100 samples work well for an array of 15 elements.

Distance between elements: The distance between elements can be varied. This means that for a particular frequency of the input wave, the centre frequency is changing that is the frequency at which the recognition is best. A lower wavelength and higher frequency gives no resolution at all. On the other hand, a higher wavelength gives a lot of false peaks. It is observed that for best results, the distance between elements must be 2.

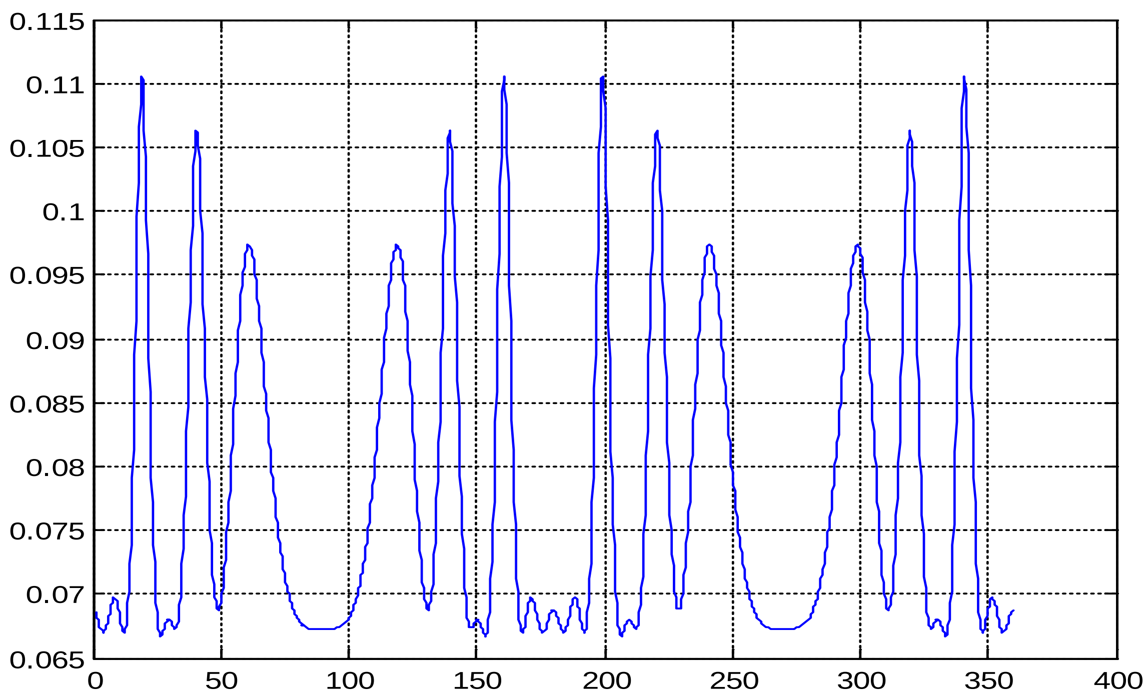
Kind of input wave: The kind of input wave can be changed. Results were confirmed for sine waves and FM-modulated waves. The plots obtained match those in theory. However the algorithm could not detect sin2 waves even on removing the DC offset of the waves.

Obtain 2-d direction: It can also be extended to the MUSIC algorithm to 2-d with the two dimensions being the plane angle and the elevation angle respectively. However the results obtained in 2-d are not so encouraging in terms of the number of peaks obtained.

4.4 FURTHER WORK

Further work can advance on the following counts

Using the MDL criterion to find the number of incident signals to get a better estimate and Delve into why the algorithm does not work satisfactorily for inputs like sin2 waves. The graph below shows the results of the simulations done with MUSIC algorithm. The simulation was done to test the accuracy of the algorithm. The three angles that we were used as inputs were displayed at the output by the algorithm hence verifying the results.



4.4: Angle of Arrival with Three Input Signal at 20, 40 and 60 Degrees.

Therefore, it is concluded that peaks are obtained at the instant of time when we receive a high intensity signal from transmitting side. Then calculate the angle of arrival of this higher intensity signal and then using Friss transmission equation, followed by the calculations of the received power thereby calculating the unknown coordinates.

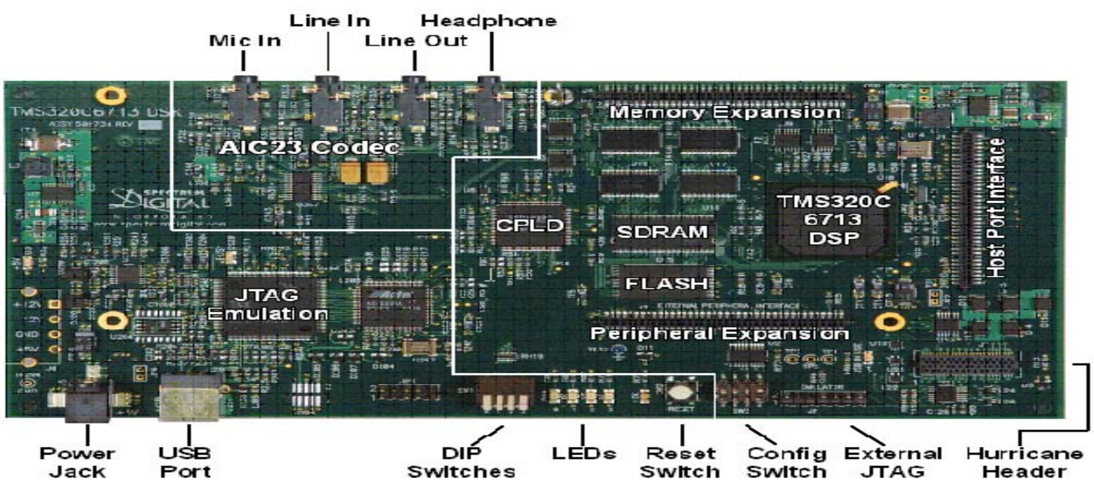
CHAPTER 5

HARDWARE

The project under discussion is hardware and software based project. Initial work needs to be done on the software module. However, Hardware is equally important and cannot be neglected. Interfacing of all the hardware components involved is an essential The following hardware is implemented in this project.

5.1 TMS320C6713 DSK (DSP STARTER KIT)

The C6713 DSK is a standalone low cost development platform that enables users to develop DSP applications. It operates at 225MHz and has 8Mb of synchronous dynamic RAM.[18]

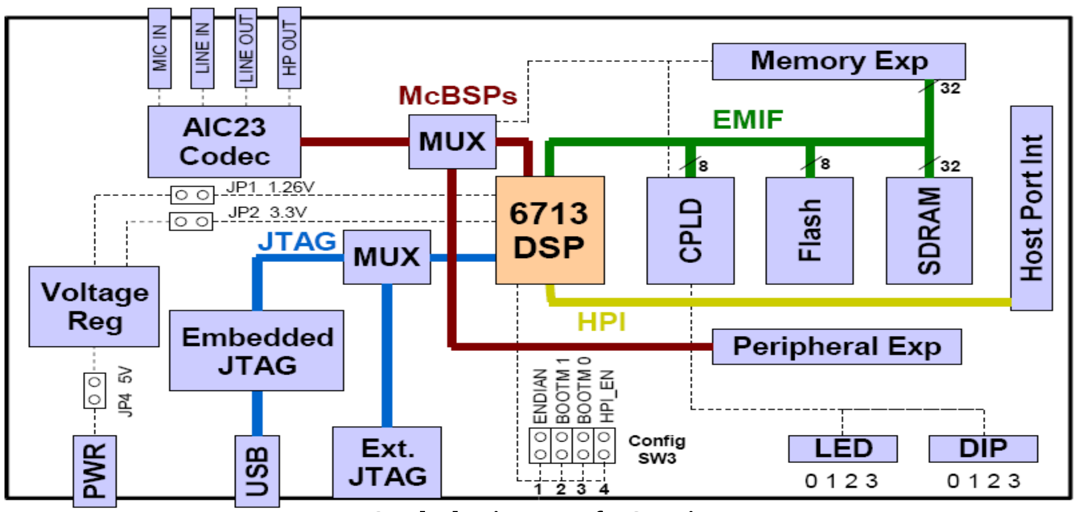


5.1: DSP Kit

Software based configuration is possible through registers implemented in CPLD

It contains expansion connectors for daughter card use. It has built in schematics, logic equations and application notes to ease hardware development and to make it compatible with applications of any kind. Single voltage supply of +5V.[19]

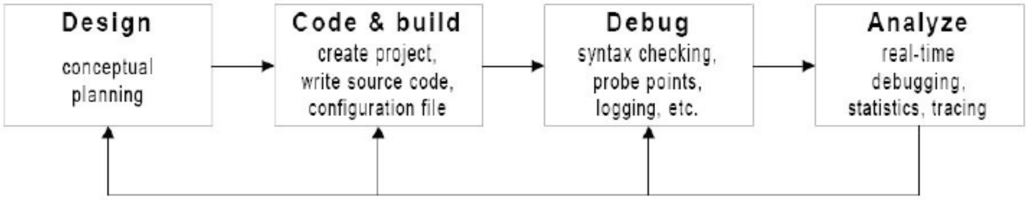
It is used as DSK usage in the project. 5V external power supply is needed to power the board. USB port connects DSK with laptop. Audio I/O jack is for the I/O operations. Code Composer communicates with DSK through an embedded JTAG emulator with a USB host interface. It contains a Flash memory a SDRAM and a dedicated USB port for other interfacing purposes. The main SDRAM, Flash memory and the main processor are connected to the HPI.



5.2: Block Diagram of DSP Kit

5.2 DSP KIT WORKING

The Code Composer Studio Environment works on a one by one step process. First of all design the concept then the code is written on the DSK, after the code the files are debugged and then analyzed for errors and warnings.



5.3: CCS Environment

CHAPTER 6

LOCAL DYNAMIC MAP

Local dynamic map is the deliverable of the project under discussion. It is used to plot the coordinates calculated using various algorithms. LDM is local and dynamic which means that the map is sequentially updated and the focal point is always the car at the centre of the map.

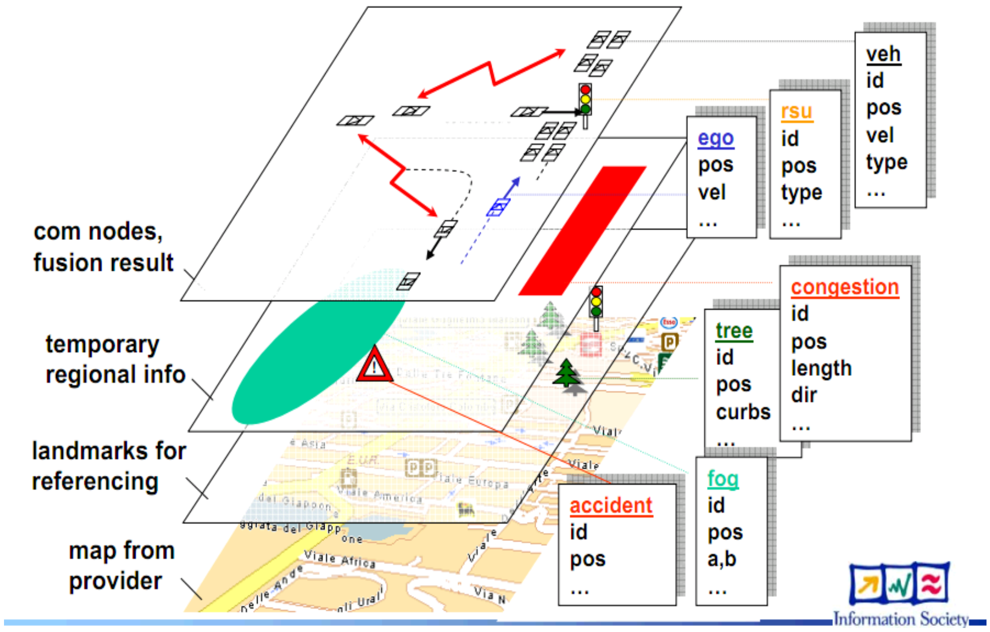
6.1 LAYERS

Local Dynamic Map shows vehicles and objects logically organized in layers with respect to their dynamics. A real time updatable Local Dynamic Map is defined as: Integration of standard digital maps with dynamic (short time) and local (short range) layers of information collected by the infrastructure or by the vehicles (road status, obstacle presence.)[20]

Local dynamic map is a time and location referenced database that forms layers on top of an accurate digitized map. The layers on map enable things like landmarks, road symbols, and vehicles to be located on a digital map. It performs data fusion. The local dynamic map will include real-time data as result of provided preprocessed sensor in vehicle and infrastructure data.

The local dynamic map model relies on the notion of a perception area and comprises at least surrounding objects like vehicles, hurdles and landmarks, for example in terms of relative positions, estimated dynamic states as well as associated confidence measures, road segments, e.g. in terms of geometrical parameters and attributes (road state, width etc.), traffic information/status for individual road segments or regions of the map, weather or visibility status for individual road segments or regions of the map.

There are basically two types of layers which are actually dealt with in the project which are the static and the dynamic layer. Static layer is the layer which is not changing with time i.e. buildings, trees, roads etc. Whereas, dynamic layer is the layer which is changing with time. It includes cars, trains etc.



6.1: LDM Layers

6.2 LDM ARCHITECTURE

The local dynamic map is a highly vibrant data store with a relation to the road network and enables storage and updating of objects including type, location and other features, and retrieval of selected information for further processing and situation analysis, like calculation of trajectories, and determination of hazardous obstacles and potential conflicts with other road users. If the object that maintains the local dynamic map is moving, the map window is moving with the object as its centre position. The local dynamic map is constructed on top of a digital map database and conceived as a four layer structure with increasing dynamics. [21]

6.3 LDM INTERFACES

The application program interface (API) will consists of two parts. The transaction part needs to be able to create and remove instances of all defined dynamic objects, and to set and change object attributes values of dynamic objects that are stored in the local dynamic map, as well as of static objects for which dynamic attributes are defined. The sensor data processing and fusion module of the system have write access to the local dynamic map for transactions. It is used to edit LDM.

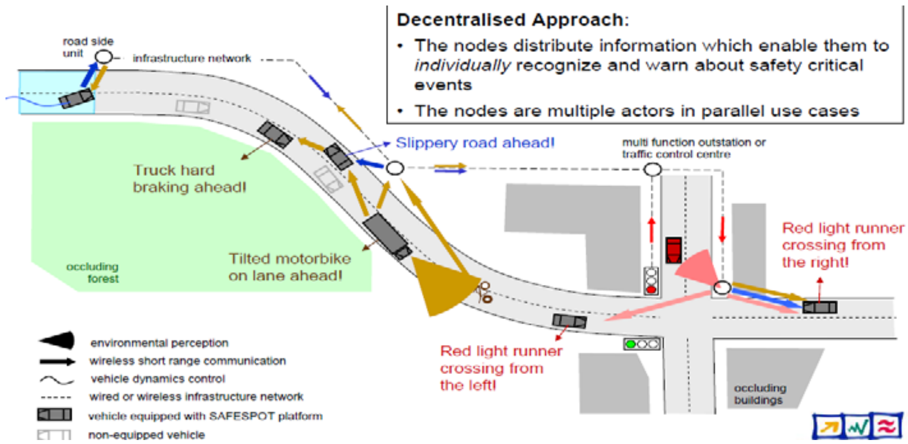
The query part needs to be able to extract information from the local dynamic map concerning all object types. It needs to be able to query the database using filters for geographic location, object types and object attributes. All modules and applications of the system, including the data dispensation and data fusion module, will have access to the local dynamic map for queries. It is used to get the required information.[22]

LDM focuses on new contents and information that is provided in real-time. It needs high efficiency algorithms, an adaptive optimal coverage range and compatibility with some standard digitized maps

The main target is to provide a representation of vehicle's and infrastructure surroundings with all static and dynamic safety relevant elements. The local dynamic map model relies on the notion of a perception area (i.e. the coverage area of the ego-vehicle perception) and comprises at least.

The surrounding objects, like vehicles, hurdles and landmarks, for example in terms of relative positions, estimated dynamic states and associated confidence measures, road segments, e.g. in terms of geometrical parameters and attributes.

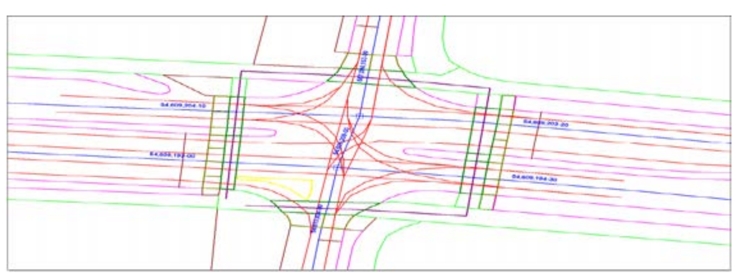
traffic information/status for individual road segments or regions of the map, weather or visibility status for individual road segments or regions of the map.



6.2: Traffic Warnings Due to Information on LDM

6.4 METHODOLOGY

Mark road junctions, road elements, lanes e.t.c. separate these roads by buildings, parks where they are located. This gives us the static layer. In case of change in static layer, change can be incorporated accordingly in the static layer.



6.3: Road Junctions

Above the static layer, a dynamic layer will be made, which changes with time. For dynamic layer, a time interval is defined after which, we want to update the information on dynamic layer. The lesser the duration, the better it is. There is a tradeoff between updating duration and memory. If updating is done fast, fast processors would be required, which would be expensive.

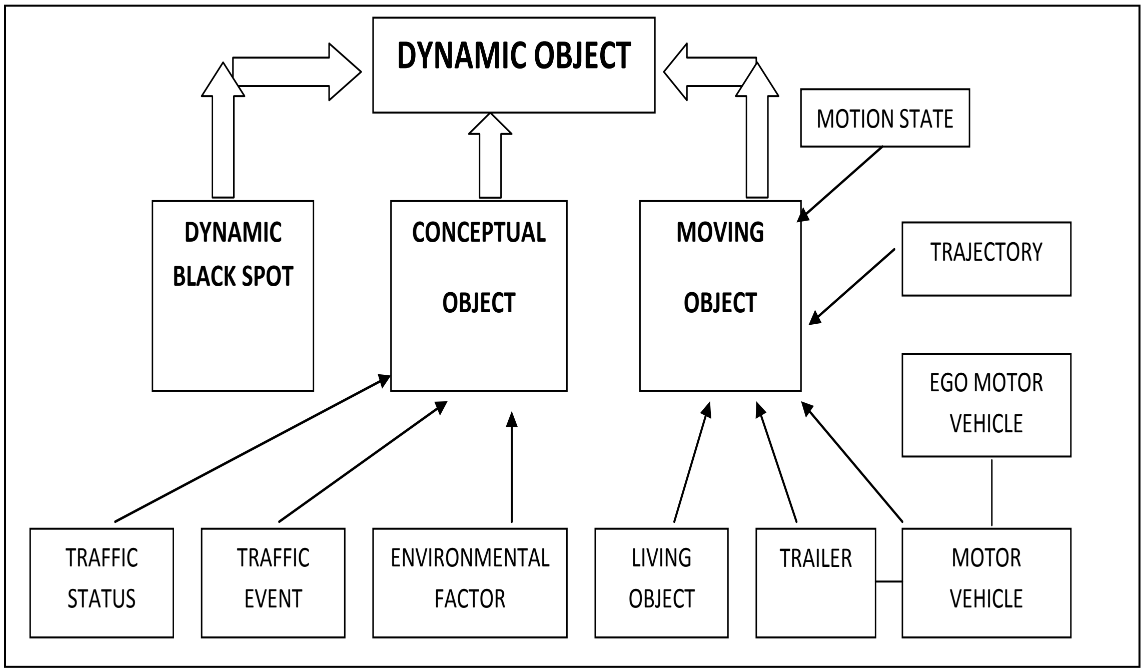
6.4: Manually Created Static Layer

6.5 LDM UPDATING

After feeding the information in hardware i.e. DSP kit, we move to the final stage of project which is updating of local dynamic map. Each Vehicle and Road Side Unit maintains an LDM containing the current state of its surroundings. In order to update this map, GIS (Geographical Information System) software e.g. GPS Inspector will be used. It is the software whose code is open source and can be changed or modified.

6.6 LDM STRUCTURE

The dynamic layer structure is the most complex with different entities joining together to form the dynamic object. The Dynamic Black Spot is the main dynamic feature on the LDM along with the conceptual object and the moving object. The Conceptual Object hemisphere includes all traffic events, traffic status and the environmental factor whereas all other things are included in the Moving Object part.



6.5: LDM Structure

6.7 VANET SIMULATOR

After the determination of the parameters mentioned before, and feeding the information in hardware i.e. DSP kit, we moved to the final stage of project which is updating of local dynamic map. Each Vehicle maintains an LDM containing the current state of its surroundings. In order to update this map, NetBeans will be used which further plots the position of vehicle using GPS inspector.

GPS inspector is a software on which we display local dynamic map and show the position of vehicle which is updated after regular intervals of time.

CHAPTER 7

SOFTWARE AND DELIVERABLES

7.1 APPLICATION DEVELOPMENT

The languages used to do the coding work of project and the algorithm enhancement include C/C++, MATLAB and JAVA.

For the DSP kit, software mainly used were C6713 DSK CCS (code composer studio) and 6713 DSK Diagnostics Utility.

For local dynamic map the software includes NetBeans and GPS inspector.

7.2 GPS COORDINATES

Initially, when the calculation starts, the task is to gather the first set of the car's own coordinates from GPS and are taken as the coordinates at initial time. Using 3D approach, we compute the coordinates of other vehicles and update the local dynamic map accordingly. To verify the calculated location after a particular duration, we can use GPS which will give us an output coordinate after every 30 sec. This can even be used as an error reduction technique, where we can make the error zero and start calculating the location once again using fresh GPS coordinates as new reference.

7.3 DELIVERABLE

The deliverable of the project which is a local dynamic map is a versatile entity itself.

These pictures show the local dynamic map of the project result. The car was moved from one building of the college to another and the results are shown above. The map is updated after every 3 second which is again the processing delay involved in software implementation. Before starting, a road side unit is taken as reference and coordinates are calculated according to the triangulation geometry.

7.1: Project Deliverable

.

Path traversed by a vehicle is shown in the figure. The position is updated in real time and accurate coordinated have been calculated which are correct up to 6 decimal places. The time span between updating is very less therefore, at higher speeds, this time span will reduce further and so, coordinates and distance between vehicles is determined more efficiently in highway scenario.

7.2: LDM Updated

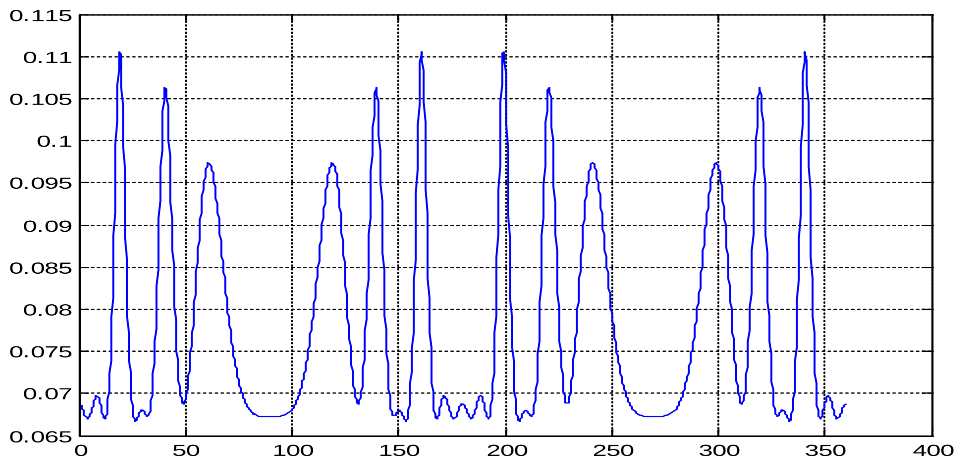
CHAPTER 8

ANALYSIS AND TESTING

8.1 ALGORITHM EXPLAINED

In the calling program, were defined the number of input signals considered and the angle of each signal received on antenna. Using the MUSIC (Multiple signal classification) algorithm, the angle of arrival of these signals and the intensity of the signals received was determined.

The signal with highest intensity becomes the LOS (line of sight) component.

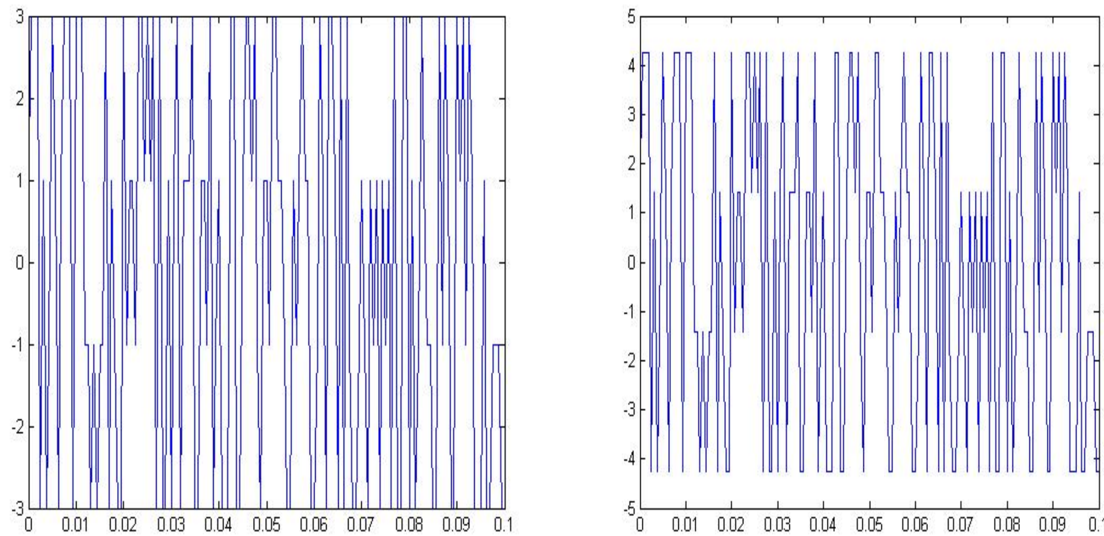


8.1: Angle of Arrival with Three Input Signals at 20, 40 and 60 Degrees

Input signal with all ones is generated and its power spectral density is found to determine the frequency range within which it is lying.

QPSK modulation is performed as it is one of the most efficient modulation schemes in case of wireless communication.

The input signal is them unconverted to carrier frequency which we have taken to be 2GHz for ease. In case of VANETs, this carrier frequency is 5GHz.

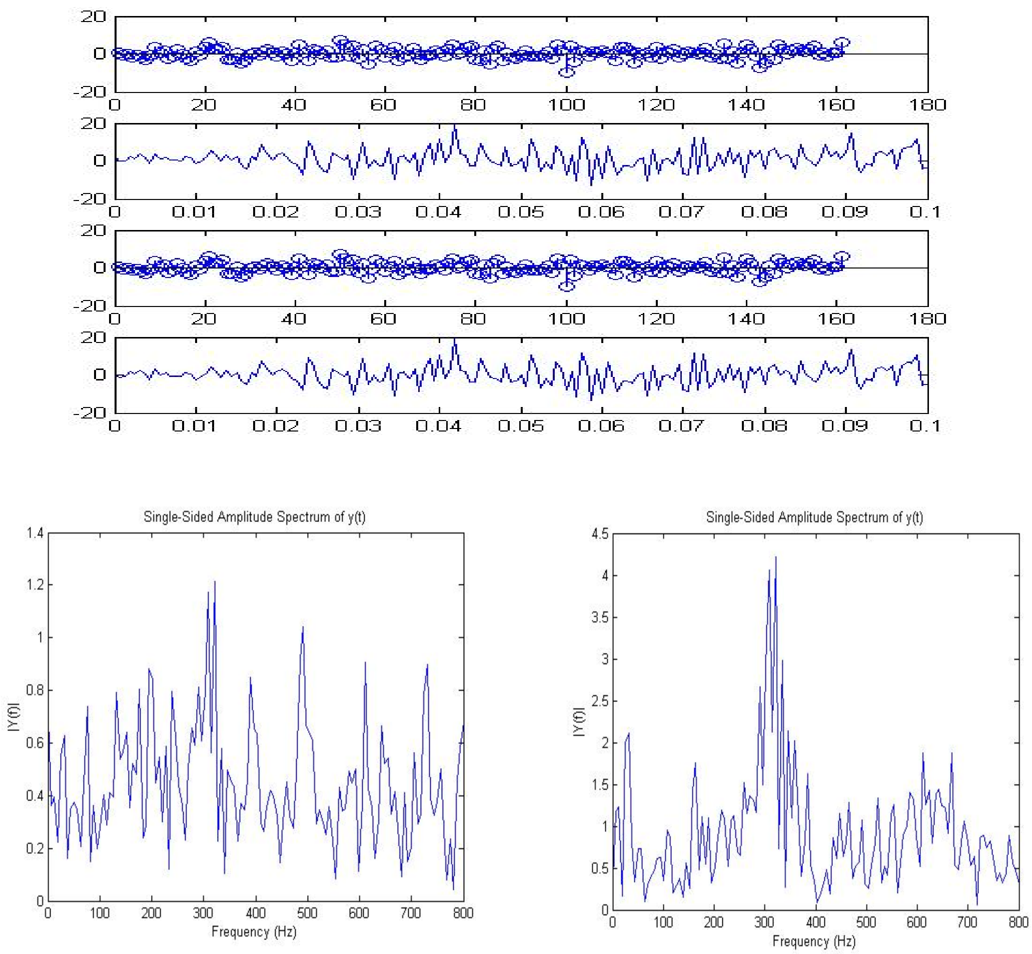


8.2: Modulated and Up Converted Signals

After the generation of signal at transmitter, we have simulated transmitting wireless channel, which is Rican channel having a dominant LOS component.

8.3: Channel Simulation with 4 Propagating Paths

In the above figure, signal has traversed from transmitter to receiver in 4 paths. At the receiver side, we add the LOS component to get the final signal received.



8.4: Received Signal

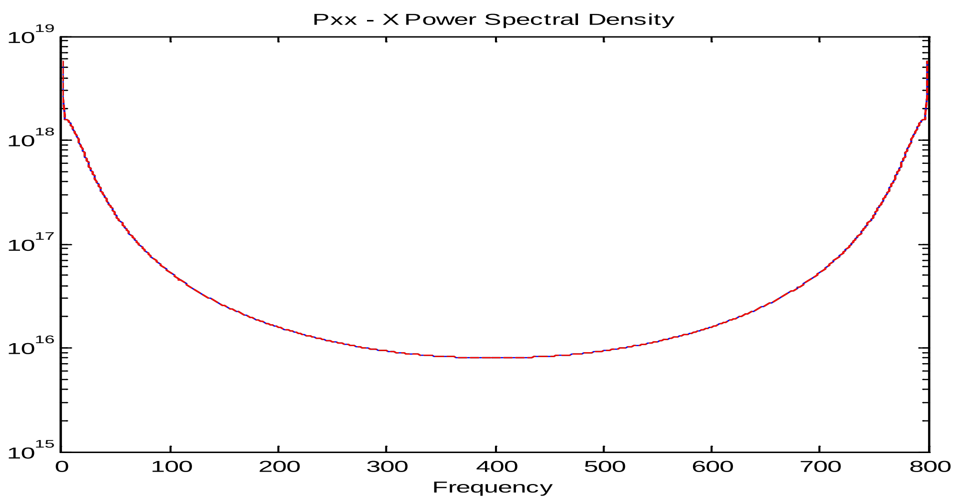
Signal is then passed through a band pass filter to process the signal in desirable bandwidth region and to get the desired results.

After this, we separate the signal into its in phase and quadrature components as in the case, we will process on the in phase component.

Down conversion is performed and signal is passed through a low pass filter which blocks the higher frequencies and noise present in the signal. We then take the PSD of this signal.

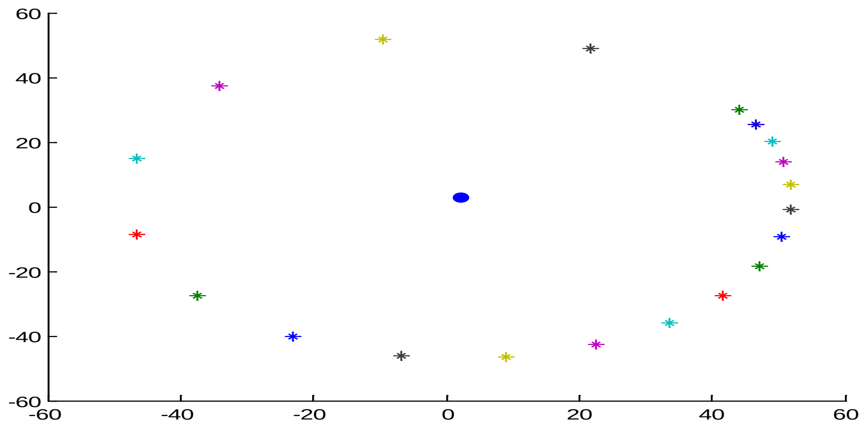
8.2 RESULTS

The PSD of demodulated and down converted signal is shown in following figure. This PSD is exactly in accordance to the standard PSD curve for VANETs.[23]



8.5: PSD of Final Demodulated, Down Converted Signal

Project simulation is shown in the position as it changes. Central mark shows the reference car and the path traversed by another vehicle is shown in circular path which have been updated after regular intervals.



8.6: Vehicle Path Traversed Around Reference Vehicle

8.3 ANALYSIS

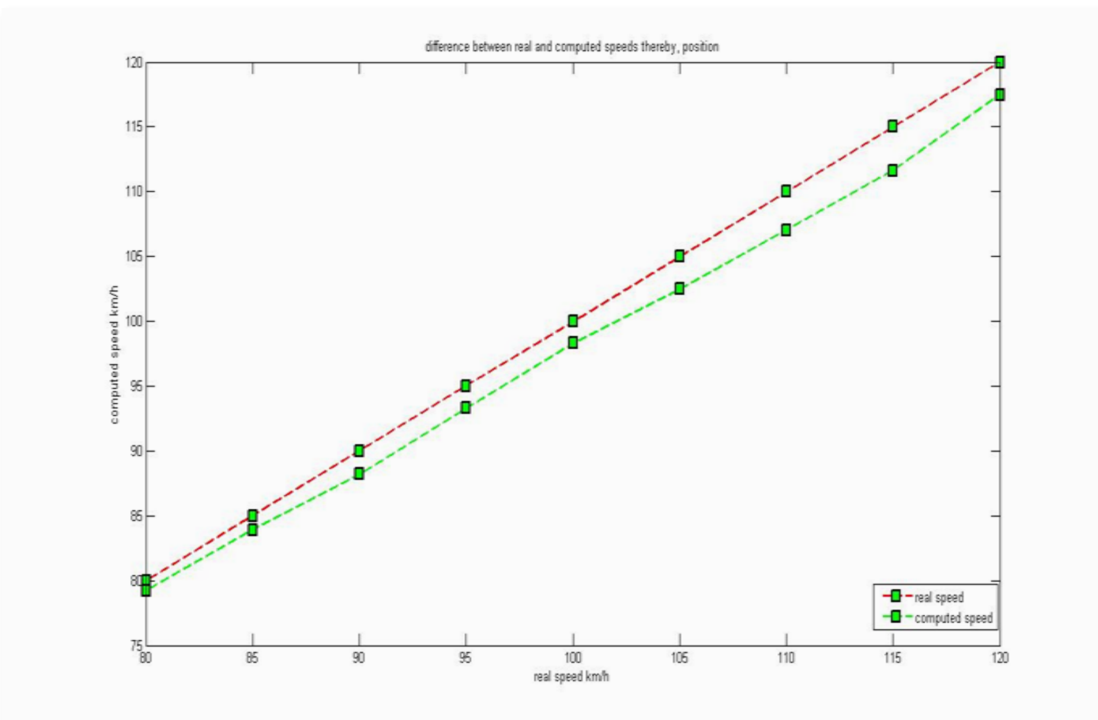
In the MATLAB code, we started off implementing the best approach out of all the possible options in order to reach the result. It's a way of verifying the methods and calculating the degree of error involved. The code concentrates on designing a transmitter and a receiver together with the channel. At the transmitter, general signal processing is involved. The signal passing through the channel, Rician in this case will encounter various phenomenons, which results in a number of received signals. These received signals are further processed at the receiver end to calculate firstly the angle of arrival using MUSIC approach (as defined above). The code will provide us with the angle of arrival of the signal on the antenna element and the updated coordinates after regular intervals.

8.4 GPS COORDINATES

Initially, when out calculation starts, we gather the first set of the coordinates from GPS and we take it as the coordinates at initial time. Using 3D approach, we compute the coordinates of other vehicles and update the local dynamic map accordingly. To verify the calculated location after some time, we can use GPS which will give us an output coordinate after every 30 sec. This can even be used as an error reduction technique, where we can make the error zero and start calculating the location once again using fresh GPS coordinates as new reference.

8.5 SIMULATION RESULTS

We computed angle of arrival which changes as the position of vehicle change. This helps us to find the computed speed of vehicle, which is shown in the following graph.



8.7: Simulation Results

The results of all calculations were tabulated in the format. Different Angle of Arrivals for different signals of different speed and strength were calculated after sheer testing and experimentation to reach the output of difference of speed.

8.1: Difference in Computed Speed

Original speed	80	85	90	95	100	105	110	115	120
Angle of arrival	20	40	15	24	25	64	30	40	12
Speed computed	79.25	83.9	88.2	93.3	98.3	102.5	107.02	111.62	117.48
Difference In speed	0.75	1.1	1.8	1.7	1.7	2.5	2.98	3.38	2.52

8.6 SIMULATION ANALYSIS

From the simulation, it is observed that as the vehicle speed increase, the difference between real and computed speed also increase. Therefore, at higher speeds, we need to cater for this increase in the speed difference. To cater for this difference, we will be using GPS coordinates after every 30sec to bring the vehicle position back to its original coordinates. Hence, vehicle speed will be computed using signal processing techniques whereas, we will use GPS coordinates to correct any variation in the vehicles position to give us accurate position.

8.7 FUNCTION OF MAIN COMMANDS USED IN THE CODE

Some of the main commands used in the code are:

noofsignals=music1d1(x)

This command is used to apply MUSIX algorithm to calculate the angle of arrival and the intensity of the signal received at different angles.

fsig=fftshift(fft(double(signal)))

It is used to compute the PSD if signal which is afterwards plotted to determine the frequency spectrum of signal.

chan = ricianchan (Ts, fd, k, tau, pdb);

It is the command for Rican channel simulation. In it, Ts is the input sample period, fd is the maximum Doppler shift of signal, and k is the Rican k factor which is ratio between the powers of considered ray to the power of LOS component. tau is the shift in signal or time delay in each signal component and pdb defines average path gains.

xxxx=xxx+d*sin(AoA)

yyyy=yyy+d*cos(AoA)

These commands are used to calculate new set of coordinates (latitudes and longitudes) using the information of angle of arrival and previously determined coordinates.

8.8 RELIABILITY

By putting the devices on every vehicle, the reliability of network as a whole is increased. The likelihood of many nodes failing all at once is less than in the case of a central component failing. Consistency is increased due to redundancy. Vehicles close to each other are all capturing and transmitting virtually the same information.

CHAPTER 9

CONCLUSION AND FUTURE TRENDS

9.1 CONCLUSION

VANET is an upcoming technology, which will broaden the horizons and will make driving lot safer. As far as the project is concerned, after the completion and implementation of it, it will be a huge step towards road safety especially in case of highway traffic, where we have fast moving vehicles. Uninterrupted processing, sensing and updating location of nearby vehicles will help us to keep the mobile velocity under control. Apart from this, we would be able to divert the way in case of necessity and we would know at all times the location of neighboring vehicle with respect to this project.

9.2 FUTURE TRENDS

With the advent of wireless system, researchers are keen to use them in almost every walk of life. Starting from satellites to transportation system, wireless technology is mounting progressively. Wireless mobility in vehicles has been utilized to guarantee road safety to avoid potential accidents as much as possible. Software based simulations are designed to provide an alternative to obtain the required results. VANET has gained attention due to its highly vibrant features thus helping in selecting a protocol suitable for VANET implementation the use of realistic mobility model should be considered. VANET simulation requires that a traffic and network simulator should be jointly used with a powerful feedback between them to render the simulation results as accurate as real life.

Recent research has focused on topology related problems such as range optimization, routing phenomena, address mechanism and security issues like traceability or message encryption. Along with this, there are very detailed research interests such as the effects of directional antennas for VANETs and minimal power consumption for sensor networks. Most of the research focuses on either a general approach to wireless networks in a broad setting or focus on an extremely specific issue. There are many areas for future work that can expand this research.

Multifarious traffic modeling and forceful behaviors (mobility models) that incorporate lane changing and multiple entry and exit points can be incorporated.

Along with highways, we can apply the advanced form of the algorithm to inner-city traffic where more complex topologies and external events such as traffic lights exist.

Efficient broadcasting protocols for VANETs including hybrid protocols that use V2V and V2I communications.

To study the results of communication losses, vehicle participation, transmission power and other physical characteristics of the underlying network may have in the effectiveness of congestion detection.

Use of blocking information for proficient routing, including the use of congestions characteristics like size, age and number of vehicles as well as statistical data to forecast future traffic

9.3 SIMILAR PROJECTS

VANET is basically a newer term introduced to communicate between vehicles. In past, GPS was used to determine the position of nodes whereas, in the specific project, we would be using Doppler shift instead of GPS in order to determine nodes position accurately without and time delay. A few researches have studied the problem of using VANETs to discover and disseminate traffic congestion information. In recent years, several researchers have addressed the issue of distributed detection and propagation of traffic congestion information. This system is centralized and relies on wireless internet connectivity which is not widely available on roads and highways around the world. Because the collecting entity is a central and a trusted location, therefore privacy concerns are mitigated. In 2008, the European Union took a major first step towards deployment of systems relying on V2V and V2I communications by reserving a radio frequency across the EU for vehicle applications aiming at enabling co-operative systems between carmakers. The EU expects this action to lead to the eventual roll-out of the first production examples early next decade with the first efforts expected to be focused in the area of road safety. An application oriented study done by NEC Europe researchers for analyzing the networks mobility and their deploy ability approaches in VANET milieu. The union of IP and Network mobility within VANET is clearly highlighted with VANEMO term.

9.4 PROGRESS WORK DONE ABROAD

So far, no such project involving VANET has been done at MCS. Some work is done on VANET and on Local Dynamic Map (LDM) in different universities like Muhammad Ali Jinnah University (MAJU). Some of the projects done abroad are:

GrooveSim [24] was the first tool created for evaluation of VANET performance mainly motivated by vehicular traffic flow and broadcasting. The concept of application involves testing the possibilities of real time events as time-critical safety messages. GrooveSim was coded in C++ and Matlab provides GUI for drawing buildings and graphs. GrooveSim could operate in five different modes which are:

Predetermined mode, on-road mode, simulation mode, hybrid mode and research mode. A group of five vehicles travelling around the city and highway were simulated for recording certain parameters like message dissemination, delay in messages, vehicle grouping, dropped packets etc and packet TTL values were calculated in the simulator.

NHTSA (National Highway Traffic Safety Application) provided VANET estimation and focused on a global perception of VANET performance. It is a computerized tool and accepts a text file during vehicular simulation. The main purpose of NHTSA project was to promote DSRC reliability and a GPS receiver. The platform is very user friendly, easily expandable and flexible for researchers to alter the configuration according to the requirements.[25]

The CARLINK project was developed to provide a wireless traffic service platform among the vehicles. Vehicles used for the purpose were outfitted with wireless transceivers to communicate with road-side infrastructure. Along with this, vehicles were able to form ad-hoc network for communication. The base station collected car real-time data and all information about current traffic and pass them to central unit for updating of data, which is then sent back to the vehicles driving past the base-station. The purposes of the applications were to facilitate researchers to apply their tests in simulated environment before being installed into the real ad-hoc network. This applications can be installed into the laptops or PDA.[26]

CVIS (Cooperative Vehicles and their Infrastructure Systems) is a project with the purpose to increase road safety and effectiveness and reduce the environmental impact on the safety of road. CVIS tests a number of technologies to permit vehicles to communicate with each other and nearby road side. CVIS controls traffic control systems and to reach the destination with different routes.

APPENDICES

APPENDIX A- MANET (MOBILE ADHOC NETWORK)

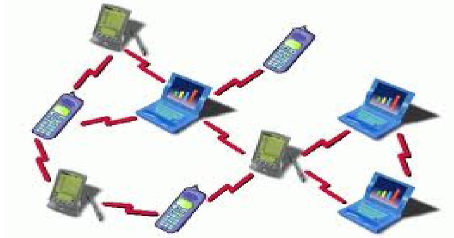
A mobile ad-hoc network (MANET) does its configuration itself and is an infrastructure less network of mobile devices connected by wireless links.

Each device in a MANET is free to move independently, and so, changes its links to other devices quiet often. Each vehicle must forward traffic unrelated to its own use, and therefore act as a router. The main focus in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. These networks operate themselves or may be connected to the larger Internet. MANET has three types:

Vehicular Ad-hoc Networks (VANETs) needed for communication among vehicles and between vehicles and roadside equipment.

Intelligent vehicular ad-hoc networks (InVANETs) which is kind of artificial intelligence that helps vehicles to behave in an intelligent manner during vehicle-to-vehicle collisions, accidents, drunken driving etc.

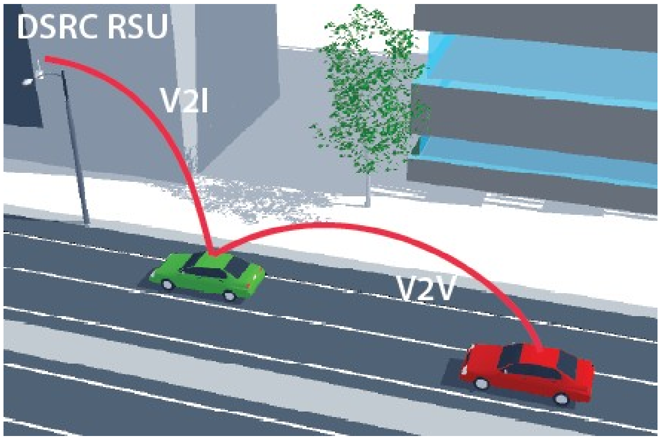
Internet Based Mobile Ad-hoc Networks (iMANET) are ad-hoc networks that link mobile nodes. In such type of networks normal adhoc routing algorithms don't apply directly.



A.1: MANET (mobile adhoc network)

APPENDIX B- DSRC

Dedicated short-range communications are a single way or two-way short- to medium-range wireless communication channels specifically designed for automotive use and a corresponding set of protocols and standards.



B.1: DSRC (Dedicated short range communication)

APPENDIX C- GPS

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into its particular trajectory by the U.S. Department of Defense. GPS was initially intended for military applications, but later on, in the 1980s, the government made it available for public use. GPS works in any weather and atmospheric conditions, anywhere in the world and all along a day. There are no contribution fees or setup charges to use GPS.

APPENDIX D- WIRELESS COMMUNICATION

In telecommunications, wireless communication may be used to transfer information over short distances (a few meters as in television remote control) or long distances (thousands or millions of kilometers for radio communications). It encompasses various types of fixed communication, mobile communication, portable two-way radio communication, cellular telephony, personal digital assistants (PDAs) and wireless networking among vehicles.

APPENDIX E- CODES

PART I:

```
clc
clear all
close all

%%%%%%%%%%% PART I - THE CALLING CODE%%%%%%%%%%%%

global NOOFELEMENTS;%no of elements
NOOFELEMENTS=15;
m=NOOFELEMENTS;
w=1000000000; %frequency (not angular) taken 1 GHz
global dfactor; % distance between elements= wavelegth / dfactor
dfactor=2;
nos=input('enter no of signals')
angl(nos)=0; % array to store the angles of arrival
for i=1:nos
angl(i)=input('enter angle in degrees')
theta(i)=angl(i)*pi/180;
end
samples=100; % no of samples of the input signal taken
fs=(.0001*w-1); % sampling frequency - rate at which samples are taken

%%%%%%%%% SIMULATION OF INPUT TO THE%%%%%%%%%%%
%%%%%%%%%%%%%%%5 MUSIC ALGO %%%%%%%%%%%%%%%%%%%%%

f1(m,samples)=0; % array of sampled signal ie signal values at different
% elements at diff instants
for k=1:samples % no of time instants
for i=1:m % no of elements

for ctr=1:nos
f1(i,k)=f1(i,k)+sin(2*pi*w*(k/fs+(1-i)/dfactor*sin(theta(ctr))/w));
% sine wave sampled - this function can be changed
end
end
end

r=0.3162/1.414*randn(m,samples); % random variable representing added noise
x=f1+r; % adding noise to the input signal array to get the possible output

noofsignals=music1d(x) % calling the music1d function (1-d music)
```

PART II:

```
%%%%%%%%%%%%% PART II - ARRAY MANIFOLD %%%%%%%%%%%%%

function a=manifold(angle)
global NOOFELEMENTS dfactor
no=NOOFELEMENTS;
for k=1:no
a(k,1)=cos((1-k)*2*pi*sin(angle)/dfactor)+sin((1-k)*2*pi*sin(angle)/dfactor)*j;
end
```

PART III:

```
%%%%%%%%%%%%% PART III - MUSIC ALGO%%%%%%%%%%%%%

function estimate=music1d(x)

temp=size(x); % returns the size
m=temp(1); % m is the number of elements
samples=temp(2); % no of samples of the incident signals
%finding covariance matrix

s(m,m)=0;
for i=1:m
for k=1:m
for n=1:samples
s(i,k)=s(i,k)+x(i,n)*x(k,n);
end
s(i,k)=s(i,k)/samples;
end
end
% eigenvalues of s
[evec eval]=eig(s); % evec is the set of eigenvectors and eval is the
% set of eigenvalues
minevalue=eval(1,1);% finding the minimum eigenvalue
for i=2:m
if(minevalue>eval(i,i))
minevalue=eval(i,i);
end
end

% finding multiplicity of minimum eigenvalue
n=0; %multiplicity
for i=1:m
```

```
if(eval(i,i)<(1+minevalue)) % assuming that all the roots less than
% 1+minevalue are minimum roots
% have to get a better approximator of
% multiplicity
n=n+1;
end
end
'Multiplicity of min root'
n
'no of incident signals'
m-n
8
% forming the eigenvector matrix
nev(m,n)=0; % noise eigenvector matrix
for i=1:n
for l=1:m
nev(l,i)=evec(l,i);
end
end

% now to plot using this matrix
ctr=1;
for angle=1:0.25:360 %in degrees
indep(ctr)=angle;
rad=angle*pi/180;
a=manifold(rad); % returns the array behaviour for a signal
% incident from certain direction
c=a'*nev;
d=c*c';
pmu(ctr)=1/abs(d); % pmu(theta) is the function that is to be
% plotted as a function of theta
ctr=ctr+1;
end
plot(indep,pmu) % will plot PMU(theta) versus theta
grid
estimate=m-n % estimate of the number of incident signals
```

1.3

```
%%%%%%%%%%%%%%music algorithm will come here%%%%%%%%%%%%%%

figure(1)

ccsboardinfo     %board info

cc = ccsdsp('boardnum',0);   %set up CCS object
```

```
reset(cc)                          %reset board
visible(cc,1);     %for CCS window
enable(cc.rtdx);     %enable RTDX
if ~isenabled(cc.rtdx)
    error('RTDX is not enabled')
end
cc.rtdx.set('timeout', 30);   %set 30sec time out for RTDX
open(cc,'dsp_code_1.pjt');     %open project

load(cc,'./debug/dsp_code_1.out'); %load executable file
run(cc);      %run
configure(cc.rtdx,16384,6);   %configure two RTDX channels
% open(cc.rtdx,'ichan','w');   %open input channel
open(cc.rtdx,'ochan','r');   %open output channel
% open(cc.rtdx,'ochan2','r');
pause(3)      %wait for RTDX channel to open
% open(cc.rtdx)
% enable(cc.rtdx,'ichan');   %enable channel TO DSK
% if isenabled(cc.rtdx,'ichan')
%     writemsg(cc.rtdx,'ichan', single(indata)) %send 16-bit data to DSK
%     pause(3)
% else
%     error('Channel "ichan" is not enabled')
% end
% close(cc.rtdx,'ichan');         %close input channel
```

```
enable(cc.rtdx,'ochan');   %enable channel FROM DSK
% enable(cc.rtdx,'ochan2');
if isenabled(cc.rtdx,'ochan')
   AoA=readmsg(cc.rtdx,'ochan','single') %read 16-bit data from DSK
   close(cc.rtdx,'ochan')
%     enable(cc.rtdx,'ochan2')
%     outdata1=readmsg(cc.rtdx,'ochan2','single')
%     pause(3)
else
   error('Channel "ochan" is not enabled')
end
if isrunning(cc), halt(cc);      %if DSP running halt processor
end
disable(cc.rtdx);     %disable RTDX

xxx=33.5780124;
yyy=73.0625371;
scatter(xxx,yyy,'filled')
axis;
hold on
%rsl needs to be determined separately for each run
Pr= 50;
Pt=1;
alpha=3;
for n=0:0.1:2;
```

```
for d=50;
    AoA=exp(n)
%d=(Pt/Pr)^(1/alpha);
    hold on
       xxxx=xxx+d*sin(AoA);
       yyyy=yyy+d*cos(AoA);
    axis;
scatter(xxxx,yyyy,'*')
end
end
%(this is the real code dat will be used when rsl and aoa will vary)
 d=(Pt/Pr)^(1/alpha);
 while d<250
     xxxx=xxx+d*sin(AoA)
     yyyy=yyy+d*cos(AoA)
     scatter(xxxx,yyyy)
 end
```

RTDX CODES

```
#include <std.h>
#include <log.h>
#include <sys.h>
#include <mem.h>
#include <sio.h>
```

```
#define CHIP_6713

#include "dsk6713.h"

#include "dsk6713_aic23.h"

#include <rtdx.h>           //RTDX support file

#include "target.h"       //for init interrupt

#ifdef _6x_

extern far LOG_Obj trace;

//RTDX_CreateOutputChannel(ochan);

#define BUFLEN 128

#define BUFALIGN 128

#else

extern LOG_Obj trace;

#define BUFLEN 128

#define BUFALIGN 1

#endif


RTDX_CreateOutputChannel(ochan);

 //RTDX_CreateOutputChannel(ochan);

SIO_Handle inStream, outStream;

/* Function prototype */

static Void createStreams();

static Void prime();

/*

 * ======== main ========

 */
```

```
Void main()
{
   LOG_printf(&trace, "tsk_audio started");
}
/*
 * ======== createStreams ========
 */
static Void createStreams()
{
   SIO_Attrs attrs;
   attrs = SIO_ATTRS;
   attrs.align = BUFALIGN;
   attrs.model = SIO_ISSUERECLAIM;
   /* open the I/O streams */
}
/*
 * ======== prime ========
 */
static Void prime()
{
   Ptr buf0, buf1, buf2, buf3;
   LOG_printf(&trace, "Allocate buffers started");
   if (buf0 == NULL || buf1 == NULL || buf2 == NULL || buf3 == NULL) {
   }
   if (SIO_issue(inStream, buf0, SIO_bufsize(inStream), NULL) != SYS_OK) {
```

```
    }
    if (SIO_issue(inStream, buf1, SIO_bufsize(inStream), NULL) != SYS_OK) {
    }
    if (SIO_issue(outStream, buf2, SIO_bufsize(outStream), NULL) != SYS_OK) {
    }
    if (SIO_issue(outStream, buf3, SIO_bufsize(outStream), NULL) != SYS_OK) {
    }
}
Void echo()
{
    Int i;
    Int nmadus;
    MdUns *inbuf, *outbuf;
    createStreams();
    prime();
    for (;;) {
        if ((nmadus = SIO_reclaim(inStream, (Ptr *)&inbuf, NULL)) < 0) {

        }
        for (i = 0; i < (nmadus / sizeof(short)); i++) {
            outbuf[i] = inbuf[i] & 0xfffe;
        }
  //data transfer DSK-->PC
 //RTDX_CreateOutputChannel(ochan);
TARGET_INITIALIZE();
```

```
 while(!RTDX_isOutputEnabled(&ochan))
  puts("\n\n Waiting to write ");
 RTDX_write(&ochan,outbuf,sizeof(outbuf));//send data from DSK to PC
 puts("\n\n Write Completed");
 while(1) {}      //infinite loop
}
    }
```

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