بسم الله الرحمن الرحيم

Sudan University of Science and Technology

Faculty of Post Graduated Studiesand Scientific Research

MSc- Program in Computer Engineering

Vehicle to Infrastructure Communication for Adaptive Traffic Management

الإدارة المتوائمة لحركة المرور عن طريق الإتصال بين المركبة والبنية التحتية للطريق

A Research Submitted in Partial fulfillment for the Requirements of M.Sc. in Electronics Engineering (Computer Engineering)

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الآيـــــــــة

بسم الله الرحمن الرحيم

قال تعالى : (وَمَا أُوتِيتُم مِّنَ الْعِلْمِ إِلَّا قَلِيلًا)   صدق الله العظيم

(سورة الإسراء الآية85)

Dedication

To all whom I care about; to my family, to my friends, to Muslim's nation.

To School of Electronics Engineering Sudan University of Science and Technology.

Acknowledgement

It is a great pleasure for me to express my thanks and heartiest gratitude to all those who have help me during the development of the project.

My most sincere thanks to Dr. Abuagla Babiker for his co-operation and who has always been guiding, encoring and motivating me through- out the research with his experience and knowledge.

All gratitude to my lovely mother; to here ultimate care and love, without here I would not reach this point, to my father, to all my family

I also want to acknowledge the assistance of my husband Eng. Tahia Zaroog to her patient and ultimate help.

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Abstract

Congestion problem is increased in a dramatically way due to increased Population and travel means in Khartoum. The associated consequences for this problem made it extremely bothering. Since the expansion of the traffic network is no longer a socially attainable solution, the existing control systems have to be used in a more intelligent way in order to increase the traffic throughput and decrease total travel times Intelligent transportation systems ITS had been developed to overcome the Congestion problem, undertake to identify the real number of cars present in the street, but there is some limitation arises (existing of blind spots counting the car more than one and such problems). So the necessity for smarter ITS technology based on an elegant way to identify the real number of cars is emerged via using RFID technology.

A Radio frequency Identification (RFID) reader is mounted in the vicinity of the traffic signal, which communicates with the microcontroller and interrogates the RFID tags on each RFID tagged vehicle at the roadway intersection. The RFID reader in combination with the processor counts the number of RFID tagged vehicles present in each traffic flow direction at the roadway intersection. The implemented system has several good features such as prioritizing emergency cars. Moreover, an adaptive time adjustment of the traffic signal has been simulated using visual basic.

تجريده

مشكلة الاختناق المروري في زيادة م ضطردة،بالعاصمة الخرطوم وذلك للزيادة في السكان وبالتالي الزيادة في المركبات .وهذه مشكلة مزعجة وتحتاج الحل .ونظراً لأن التوسع في الشوارع والبنية التحتية لم يعد الحل الأمثل بسبب ارتفاع التكلفة .لذلك برزت الحوجة الملحة والضرورية إلى نظام يتحكم في المرور بطرق ذكية .من أجل ذلك صممت أنظمة التنقل الذكية (ITS) وهذه الأنظمة لها خاصية التعرف على عدد المركبات فى الطريق وغيرها ولكن أيضاً لها قصور مثل عد المركبة أكثر من مرة وكذلك صعوبة الرصد للمركبات عند مرورها بالنقطة الخفية .ومن هنا أتت الحوجة لنظام تحكم أذكى مبنى على رصد المركبات بصورة أكثر دقةً عن طريق وذلك باستخدام نظم اتصال بين البنية التحتية للطرق والمركبات التي تعبر الطريق وهى تقنية يتم فيها التعرف على الأشياء عن طريق موجات (RFID)قاري الترددات الراديوية (الراديو .

هذا النظام مبنى على وجود متحكم دقيق عند تقاطع إشارة المرور .ويقوم بالتحكم في إشارة المرور بحيث يبنى التحكم باستخد ام مؤقت ،أو معلومات واقعية متجددة ،هذه المعلومات يتم إرسالها عبر القارئ الذي يتم وضعه عند التقاطع .وكذلك يتحكم في مرور مركبات الطوارئ .وذلك عبر تصميم دائرة عملية لذلك الغرض . كما تمت محاكاة التحكم الزمني في الإشارات المرورية اعتماداً علي عدد المركبات في الطريق المعني باستخدام لغة فجوال بيسك.

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List of Symbols and Abbreviation

Term	Meaning
V2I	vehicle-to-infrastructure
V2V	vehicle-to-vehicle
RFID	Radio Frequency Identification
RF	Radio-frequency
DSRC	Dedicated Short Range Communications
ITS	Intelligent Transport Systems
ITMs	Intelligent Traffic Management system
ADAS	Advanced Driver Assistance Systems
GP S	Global Positioning System
VICS	Vehicle Information Communications System
I2V	Infrastructure-to-vehicle
SIG	Special Interest Group
RTLS	Real-Time Locating System
AT	Assistant Tag
IEEE	Institute of Electrical and Electronics Engineers
WPS	Wi-Fi positioning systems
MAC	Media Access Control
SSID	Service Set Identifier
WPANs	wireless personal area networks
FT	Fixed-time

RT	Real-time
RAM	Random Access Memory
ROM	Read Only Memory
µC, µC or MCU	microcontroller
ALU	Arithmetic Logic Unit
AIDC	Automatic identification data collection
LCD	Liquid Crystal Display
DTE	Data Terminal Equipment
DCE	Data Communications Equipment
SCI	Serial Communications Interfaces
VB	Visual Basic
RAD	Rapid Application Development
GUI	Graphical User Interface
DAO	Data Access Objects
RDO	Remote Data Objects
ADO	ActiveX Data Objects
ID	Identification number
ADC	Analog to Digital Convertor

Chapter One

Introduction

Chapter One

Introduction

1.1 Overview

Interconnection between new transport technologies and analysis methods grow more powerfully all the time. The development of a communications network on the roadway infrastructure and in the vehicles has the potential to improve transportation and quality of life in ways not imagined a generation ago. In the near future, vehicles will communicate with one another in a cooperative way in order to control speeds, obtain traffic information and to improve safety. It is predicted that the urban infrastructure will have sensors that can communicate and interact with the vehicles, using traffic signals, traffic cameras, ramp meters, bus priority systems, etc.(Cairncross, 2001, Graham and Marvin, 2001, Chowdhury and Sadek, 2003, Treiber and Kesting, 2013)

V2V (vehicle-to-vehicle) is a technology designed to allow vehicles to serve as data sensors and anonymously transmit traffic and road condition information from every major road within the transportation network as can be seen from figure (1.1).

Figure 1.1: Vehicle-to-vehicle

V2I (vehicle-to-infrastructure) is the direct wireless exchange of information between vehicles and the fixed (Papadimitratos et al., 2008, Jurgen, 2012, Daher, 2012) Infrastructure as referred by figure (1.2)

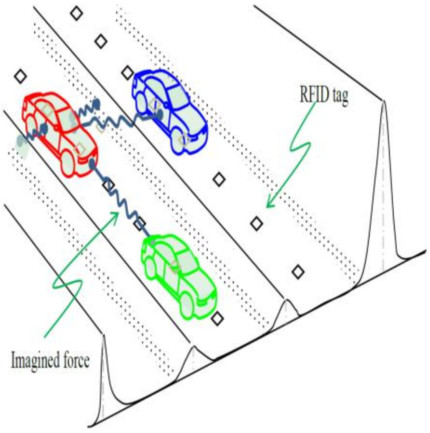


Figure 1.2: Vehicle-to- Infrastructure

Figure (1.3) Application of RFID positioning in operational control of connected vehicles (RFID-Based Vehicle Positioning and Its Applications in Connected Vehicles)

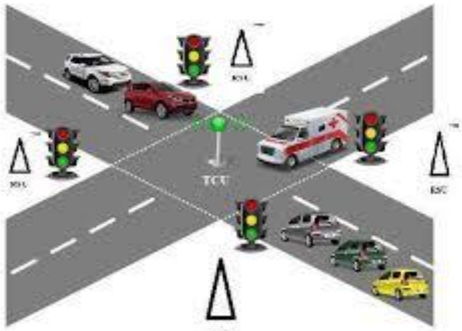


Figure 1.3: V2I communication

Traffic congestion in Khartoum centers KHARTOUM has grown tremendously over the last years(Mohammed Osman, 2015, AL-SHAZALI and AWAD, 2007). The one fundamental goals of this research is to assess the value of intelligent traffic management system to test the thesis that the use of vehicle to- infrastructure (V2I) communication technologies and protocols can significantly reduce traffic congestion, and reduce fuel consumption and emissions from mobile sources. Increase in traffic congestion has been simultaneous with increase in Khartoum population. The pace of adding new road capacity has been affected by the current lack of physical space within the national and local budget to fund major road improvement projects. Therefore, the increase in vehicle demand combine with the lack of adequate road space has resulted in traffic congestion extending well beyond the usual peak hour periods. Traffic congestion threatens the quality of life in most Khartoum cities when emergency services such as Ambulance, Police and Fire services are finding it more difficult to travel short distances without experiencing excessive delays a used by traffic congestion as referred by Figure 1.4.

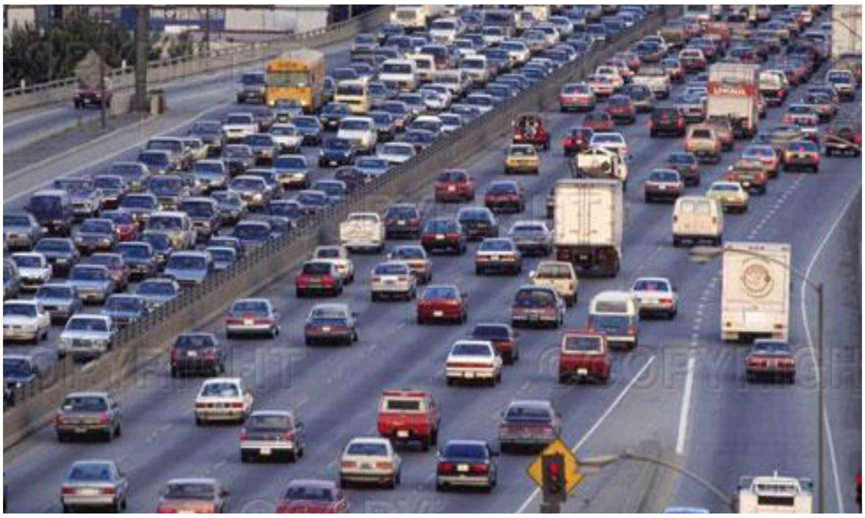


Figure 1.4: Traffic congestion

Development of transportation system with efficient traffic control on road, rail and air. Transportation of goods, industrial products, manpower and machinery are the key factors which influence the industrial development of any country. Mismanagement and traffic congestion results in long waiting times, loss of fuel and money. It is therefore utmost necessary to have a fast, economical and efficient traffic control system for national development. The monitoring and control of city traffic is becoming a major problem in many countries. With the ever increasing number of vehicles on the road, the V2I communication for intelligent traffic management Authority has to find new methods of overcoming.

Traffic management on the road has become a big problem of today's society because of growth of the urbanization, industrialization and population; there has been a heavy traffic. With this traffic, there is occurrence of some problems too; these problems include traffic jams, accidents and traffic rule violation at the heavy traffic signals(Buchanan, 2015). This in other hand has an adverse effect on the economy of the country as well as the loss of lives. So problem given above will become worst in the future.

Traffic lights play an important role in traffic management, they are the signaling devices that are placed on the intersection points and used to control the flow of traffic on the road and have installed in most cities around the world. Most of the traffic lights around the world follow a predetermined timing circuit. Sometime the vehicles on the red light side have to wait for green signal even though there is little or no traffic. It results in the loss of valuable time .Traffic control at intersections is a matter of concern in large cities. Several attempts have been made to make traffic light’s sequence dynamic so that these traffic lights operate according to the current volume of the traffic. Most of them use the sensor to calculate current volume of traffic but this approach has the limitation that these techniques based on counting of the vehicles and treats a emergency vehicles as the ordinary vehicles means no priority to ambulance, fire brigade or V.I.P vehicles. As a result, emergency vehicles stuck in traffic signal and waste their valuable time.

1.2 Problem statement

Population increases in Khartoum centers as result continuous increase demand for goods and services accordingly, increases in traffic congestion. Although it’s important to improve regional transportation infrastructure to support national development, it should not be done at the expense of congestion mitigation programs in Khartoum .Road congestion is an ever growing problem as the number of vehicles increases and the road infrastructure is not continuously updated. Due to congestion, Vehicle may slow down, subsequent slowing down of the vehicles causing traffic congestion which effect in Economic, life, environment and etc

Thus, the automatic cooperation between vehicles and infrastructure is highly required while achieving low cost.

1.3 Objective

The main objective is to design an Infrastructure to Vehicle Communication for Intelligent Traffic Management System according to the following sub objectives:

1 - To design an adaptive traffic light control system

2 -To propose an algorithm that adjusts the red, green and yellow times efficiently between the busy and non-busy roads, thereby ensuring minimal traffic congestions

3-To run simulation of the proposed system.

4 -To give priority for emergency vehicles

1.4 Research Scope

The focus of this work is related to vehicle to Infrastructure communication rather than V2V communication. The system covers adaptive and controlling light signal by design circuit using microcontroller Atmega32 and connected with RFID &Traffic light signal, depending on vehicles number or type, density, times and speed.

1.5 Thesis Organization

This thesis is a written documentary that contains records such as the idea generated, concepts applied, activities done and the final MCs project product itself. It consists of five chapters. Following is a chapter-by-chapter description of information in this thesis.

In Chapter one, presents a brief overview on what the project is really all about, such as the Introduction of the project, the project objectives, problem statement and the scopes of project that been elaborated.

Chapter two looks into the literature review that has been done especially on the Theoretical concepts on the various methods and applications in stability V2I communication for intelligent traffic management of high rise buildings currently being practiced. This chapter discusses the background study, the stability of the system and the suitable technique being used. Besides that, this chapter provides the preview on the concepts and fundamentals of Radio Frequency Identification (RFID), Image Processing, and Global Positioning System (GPS), Dedicated Short-Range Communication (DSRC) and the basic concepts of the system applicable to achieve the objectives of the project.

Chapter three is regarding the project Adaptive Traffic Light Control System that involves the necessary tasks and activities to be undertaken to complete the project such as hardware descriptions, development and software development that form the major size of the project.

Chapter four explores the results from the research as well as the corresponding discussion. It also discusses on the improvement that can be done in this project. Besides that, this chapter also describes how to integrate the hardware and software to function as complete system.

Finally, Chapter five concludes the thesis and gives some recommendations for future researchers the summary of the final project. The conclusion, suggestions or recommendations for improvements can be implemented in future are discussed as well.

Chapter Three

Adaptive Traffic Light Control System

Chapter Two

Literature Review

2.1 Vehicle to Infrastructure Communication

Vehicle-to-infrastructure (V2I) communications is the wireless exchange of critical safety and operational data between vehicles and roadway infrastructure, intended primarily to avoid motor vehicle crashes and congestion. It is a key component of the connected vehicle research program of the Intelligent Transportation Systems.(Tellis et al., 2013, Olariu and Weigle, 2009, Chou et al., 2009)

Vehicle-to-infrastructure communications for Intelligent Traffic Management which can collect traffic information from individual cars and share the road traffic information over a wide area network to dynamically control the traffic signaling cycle, also intended primarily to prevent congestion and avoid or mitigate motor vehicle crashes but also to enable a wide range of other safety, mobility, and environmental benefits. V2I communications apply to all vehicle types and all roads, and transform infrastructure equipment into “smart infrastructure” through the incorporation of algorithms that use data exchanged between vehicles and infrastructure elements to perform calculations that recognize high-risk situations in advance, resulting in driver alerts, traffic light signals and warnings through specific buzzer. One particularly important advance is the ability for V2I to communicate the signal phase and timing information to the vehicle in support of delivering active safety or it provides a safe passage for vehicles by adaptive traffic light signals Figure (2.1). Early implementation of the V2I application can enable near-term benefits from V2I communications in the form of reduced crashes, which in turn demonstrate benefits that can help accelerate deployment.

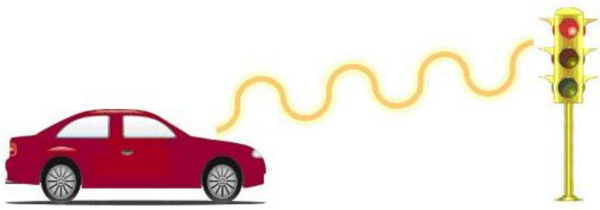


Figure 2.1: Vehicle to infrastructure communication

2.2 Intelligent Traffic Management System

Is the integration of information and communications technology with transport infrastructure, vehicles and users, to manage factors such as vehicles, roads and routes to improve safety and reduce traffic times, air pollution, fuel consumption and solve traffic congestion? On Brief definition of The Intelligent Transport Systems (ITS) encompasses the application to the transport network of technology such as communication systems, control, and information processing technology.(Manikonda et al., 2011, Vaid et al., 2002, Barfield and Dingus, 2014)

2.3 Communication for ITMs applications:

1. Intersection safety

2. Roadway departure prevention

3. Speed management

4. Transit safety and operations

5. Commercial vehicle enforcement and operations also Priority assignment for emergency

2.4 Traffic Congestion

Automobile revolution and respected companies prompted people to own vehicles. So the number of vehicles in our country started increasing also the infrastructure of road has developed. As an adverse effect, traffic congestion became the most challenging problem in the field of transportation. So, we intend to do a project which becomes very good solution for the traffic congestion.

Information about the current state of a transport network, process that information and either directly manage the network (e.g. through traffic signals) on the future system has worked to allow people to decide how best to use the network (e.g. travel news). The systems are also capable of storing historical traffic data and using it for modeling purposes, thus making the information provided to both traffic managers and the travelling public more accurate.

Also in future systems can help reduce the number of accidents on the road by providing drivers with more information about the conditions on the roads they are using and through in-vehicle information provided to drivers. The systems can be used to warn drivers about accidents and seek to reroute traffic through the road network to mitigate congestion caused by the accident we have entitled our system “Vehicle to Infrastructure Communication for Intelligent Traffic Management”.

2.5 Traffic control strategies

Traffic control strategies have improved since the installation of the first traffic controller. The strategies can be classified. The most important strategies are as follows:

1. Fixed-time (FT) strategies. The control (signal plan) is calculated in advance, using statistical data.

2. Real-time (RT) strategies. The real-time data about traffic processes are used to determine control or its modification.

The first type of control uses a preset cycle time to change the lights. The other type of control combines preset cycle time with proximity sensors which can activate a change in the cycle time or the lights. The main control measure in urban road networks is the traffic lights at intersections. Traffic lights, besides ensuring the safety of road crossings, may also help in the minimization of the total time spent by all the vehicles in the network, provided that an optimal control strategy is applied.

2.6 Communication mode

This is divided into three types defining the source and destination of the communication:

1. Infrastructure-to-vehicle (I2V) communication
2. Vehicle-to- Infrastructure (V2I) communication
3. Vehicle-to-vehicle (V2V) communication.

In both I2V and V2I modes, the communication is centralized where there is a central control or administration i.e. fixed infrastructure. This is not the case with the V2V mode, where the vehicles communicate in an *ad hoc* manner i.e. decentralized communication.

Although sometimes the application may require both I2V and V2I, but when mentioning the communication mode for the applications below, we mention only the one that performs the most important part of the application, for example, in the case of an infrastructure warning approaching vehicles, the communication mode is I2V although V2I is also involved in sending the necessary information from the vehicle to the infrastructure.

Vehicle-to-infrastructure communication is always point-to-point while infrastructure-to-vehicle can either be point-to-point or point-to-multipoint communication(Hsu and Walrand, 1993, Singh et al., 2014).

2.7 Typical Wireless Communication Devices and Techniques

Typical wireless communication systems or devices include Bluetooth, RFID, and Zig Bee. Wi-Fi is not a wireless communication, but it can be of great assistance to the transmission of wireless information through combined usages. In V2I, V2V, and even V2P communication systems, it is always a need to identify the position of a vehicle, a roadway infrastructure, or a person (a worker, or a pedestrian). Therefore, it is important to know the various position techniques, including the wireless position techniques and GPS based positioning techniques. All these will be reviewed in the following sections(Daher, 2012, Wu et al., 2013).

2.7.1 Bluetooth

Bluetooth was invented by the Swedish company Ericsson, and was named after Harold Bluetooth, a legendary Nordic king of the late 1900s that all Swedes are taught about in grade school. Bluetooth is a technology that allows electronic devices to communicate without wires. It was designed for low power consumptions and is based on low-cost transceiver microchips. Bluetooth communicates using radio waves with frequencies between 2.402 GHz and 2.480 GHz which is within the 2.4GHz ISM frequency band, a frequency band that has been set aside for industrial, scientific and medical devices by international agreement. The Bluetooth specification was conceived in 1994 and is now managed by the Bluetooth Special Interest Group (SIG) (Chen et al, 2011).

The first version of Bluetooth provided 1Mbps speed, which is certainly enough for some applications, although the 3 Mbps provided by the second version are beneficial when more devices are connected and when the data requirements are higher, such as when connecting a printer or Smartphone being used as a wide area network modem. Bluetooth is divided into three classes, class 1, class 2 and class 3, which range located from 100M, 10M and 5M. In order to avoid interference, Bluetooth uses spread-spectrum frequency hopping technology which makes it unlikely that two devices will transmit the same frequency and therefore minimizes the risk of interference.(Qu et al., 2010, Davis and Nihan, 1991)

2.7.2 Radio Frequency Identification (RFID)

Radio frequency identification (RFID) is also a short range wireless communication device, but is more oriented towards the identification of a nearby object (including animals and people) via its negative tag. Factors such as attenuation, cross paths of signals, and interference from other RFID tags, RFID readers and RF devices, may affect the communication between the tag and RFID readers. Though there is some overlap at the higher level of RFID devices, the technology generally assumes that an RFID tag will be brought within a few centimeters of a reader in order to scan its specific and unique ID and possibly to obtain a small amount of additional information. By contrast, the general definition of short range wireless devices assumes that devices communicate from a static location or anywhere within a certain radius of other short range wireless devices and can communicate whenever the device decides that it needs to. Although RFID could be called "Ultra Short Range", it is really the nature of the application that is different (Lee et al, 2012). The extreme shortness of range is just a reflection of the need to bring an object near to a reader before communications can occur.

RFID is most applicable when an object can easily be brought to a particular location to be scanned, such as an automated checkout counter at a supermarket, or a gate through which trucks enter and exit a port with tagged containers. The development of an RFID-based Real-Time Locating System (RTLS) has three aspects essential to a robust and accurate RTLS: localization methods, wireless networking technologies, and an Assistant Tag (AT) (Ham and Hargrove, 2011). The localization method minimizes localization errors and retains high accuracy in localization against obstacles, whereas the wireless networking technology deals with data on a real-time basis and has a strong signal-transfer capability that could minimize information loss during signal transfer. In addition, the AT is a virtual reader that aims to maintain signal availability when many obstacles that hamper signal transfer are present. This section will discuss details about these three aspects and will be followed with a discussion on how the system has been developed (Ting et, al, 2011)(Kale and Dhok, 2013b, Ning, 2013).

2.7.3 Zig Bee

Zig Bee is a short range wireless technology. Compared with other similar technologies, Zig Bee has advantages like being low cost and having enough data rate to transfer information between car and hurdle. What's more, ZigBee devices can work for years without worrying about replacing batteries, which makes it an excellent choice to be used in areas where power is a major concern. However, Iqbal and Yukimatsu (2011) found that there is a problem while communicating between Zig Bee Host and Sensor if there are hurdles like trees or buildings. Zig Bee relays could be a solution to increase the communication range. Figure 1 is an illustration of Zig Bee's sample applications in ITS.(Ning, 2013, Mahmood et al., 2015)

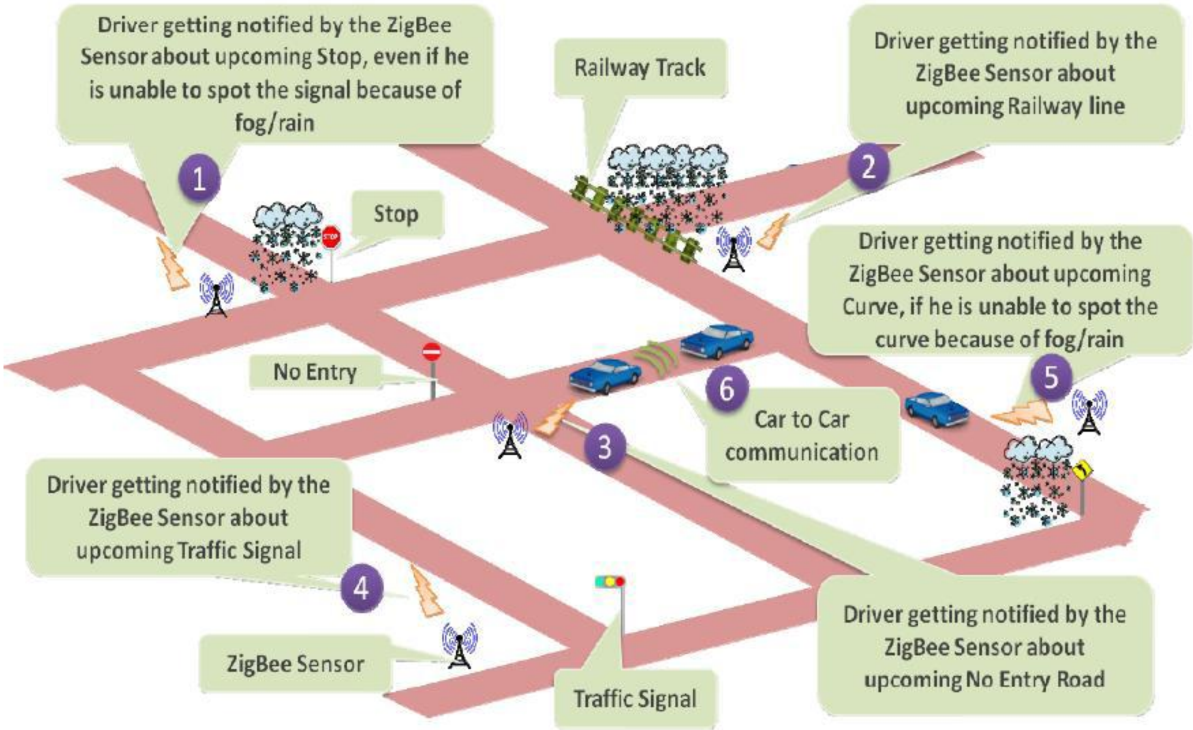


Figure 2.2: Samples of ITMs communication

2.7.4 Wi-Fi

Wi-Fi is typically used for general purpose wireless LAN and always relies on a base station. From this end, Wi-Fi cannot be called as a short-range wireless system. Short range wireless systems have carved out niches beneath Wi-Fi, compensating for a lower bandwidth with significantly lower power consumption and smaller form factors, and also with niches above Wi-Fi's providing higher speed for specific applications. The IEEE 802.11 family is the king of the wireless LAN, and it does not seem like to reduce in rank from its current position as the protocol best suited to the moderate fast interconnection of a huge number of computers and shared devices, such as internet routers, printers and cloud servicer. Wi-Fi positioning systems (WPS) were established that rely on wireless access points for location coordinates. For the proper functioning of a wireless architecture, IEEE project 802 defined a standard which assigns a Media Access Control (MAC) address to local area network devices. In a WPS, the MAC address for a Wi-Fi access point becomes an index for a geo-location reference point. The Service Set Identifier (SSID) is an additional identifier for Wi-Fi access points. Collecting and locating Wi-Fi access points for a WPS database is the major method using Wi-Fi to locate (Cavoukian and Cameron, 2011)(Hossain, 2013).

2.8 Challenges in Implementing V2I Communication for ITMs

Here rise up very important question, why have ITS systems not been deployed more broadly, especially in lagging nations? In fact that ITS face a range of challenges, including system interdependency, network effect, scale, funding, political, institutional and other challenges. And the most important one is the funding.

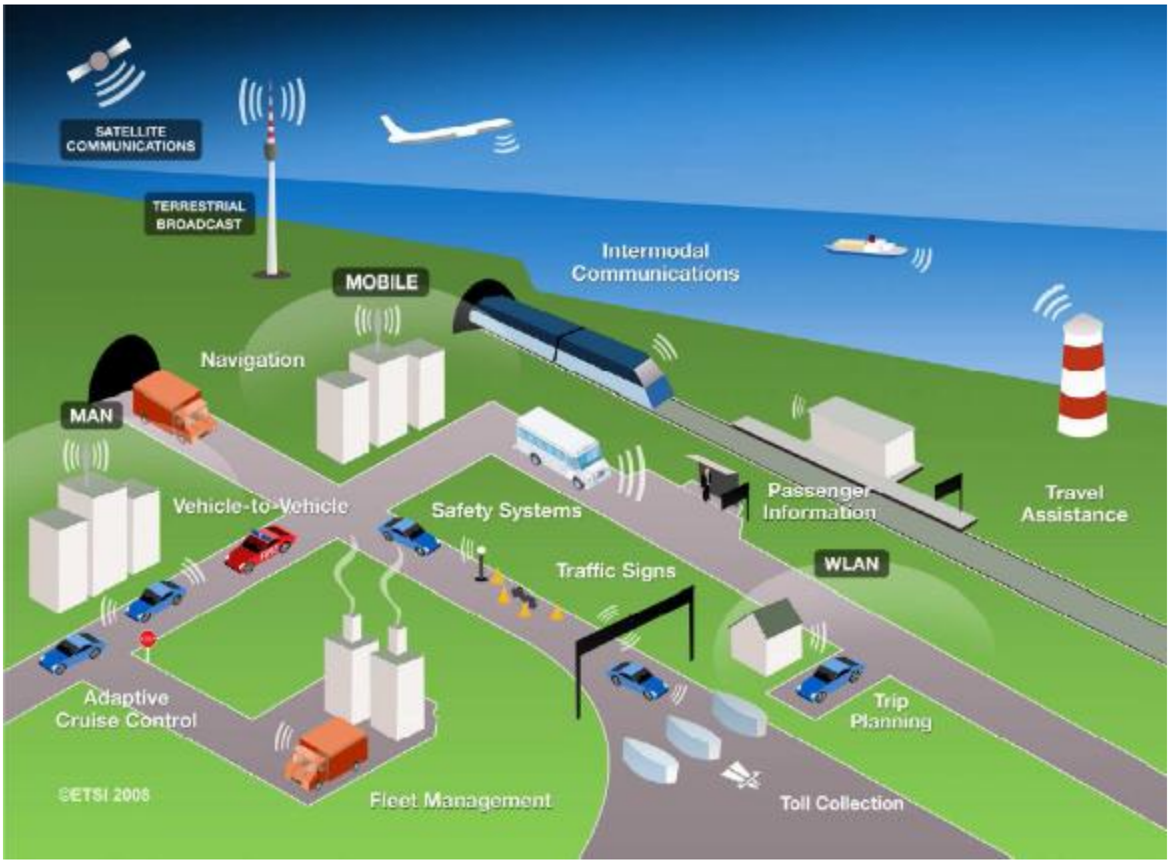


Figure 2.3: Different types of ITS application

2.9 Different types of Intelligent Traffic management Systems

1. An Intelligent Transportation System Using Zig Bee as a Communication Medium
2. Intelligent V2I-Based Traffic Management System
3. Dynamic Traffic Light Sequence.
4. Car navigation system.

5. Automatic number plate recognition or speed cameras to monitoring using technologies such as CCTV.

6. Emergency vehicle notification systems.

7. Electronic toll collection.

8. Advanced Driver Assistance Systems (ADAS)

9. A Wireless Communications for Vehicles

10. Underlying technologies used for V2I Communication for ITMs (Kale and Dhok, 2013a)

Many papers have been written on vehicle infrastructure communication, vehicle-to-vehicle (Council et al., 2000) and traffic congestion solve(Croce et al., 2008) . As for V2V communication, secure mobile computing has been discussed in (Sklavos et al., 2007), and vehicle ad-hoc networks (VANETs) have been proposed in (Kumar et al., 2014) and (Al-Sultan et al., 2014). With V2I communication, much research has already been conducted utilizing the current data gathering methods of inductor loops and estimating the speeds based on the occupancy, number of vehicles, and average length of a vehicle(Treiber and Kesting, 2013) . Further, using this data to attempt routing of vehicles along fastest paths has been done in (Petty et al., 1998).

Many applications based on speed and location data from vehicles have also been proposed, such as incident identification, characterization of traffic flows , fastest path retrieval, and trip planning (Bauza and Gozálvez, 2013). Many papers have been written on traffic prediction (Araniti et al., 2013), and many simulators exist that attempt to implement these and other ITS applications. A good overview of traffic simulators is presented in, and the work discussed in this paper utilized Free Sim(Noori, 2013) due to the fact that V2V and V2I communication are built into the framework, and FreeSim is open source, free, and easily extensible for other applications, including implementing the V2I architecture. Representing a transportation network as a graph and determining fastest paths from one node to another has been discussed in (Eiselt and Sandblom, 2013). Static graph algorithms, such as Dijkstra's(Yershov and LaValle, 2012, Preparata and Shamos, 2012) , Bellman-Ford's (서희종, 2012), and Johnson's algorithms were extended to enable dynamic edge updates and constant queries by Demetrescu and Italiano in . Miller and Horowitz added to the dynamic nature of the graph algorithms and customized the algorithms for ITS applications by utilizing a pre-processing step in (Miller, 2008). Throughout all of these applications, it is assumed that the data is gathered either via a V2I or V2V architecture. However, the feasibility of a hybrid of these two a architectures has not yet been discussed. Combining these architectures and utilizing the benefits of both provides a new paradigm for ITS applications known as the V2I architecture. , these solutions are:

2.9.1 Embedded System

Intelligent Traffic Signal Control System by Dinesh Rotake & Prof. Swapnili Karmore(Rotake and Karmore, 2012). Here system uses IR sensors, AVR-32 microcontroller with programmable flash memory and built in 8-channels ADC. IR (i.e. Infrared) sensor is programmed to detect emergency vehicle and microcontroller is designed in such a way to give red signal to all other lane but one with emergency vehicle. Limitations: Here IR sensors are used, due to various climate conditions present in India, IR sensors may need to keep in safe place or a strong box. Price factor of implementation of this system is high. So it is not advisable to implement this system.

2.9.2 Intelligent Ambulance

Design of Intelligent Ambulance and Traffic Control by Sarika B. Kale, and Gajanan P. Dhok (Kale and Dhok, 2013a). Ambulance will consist of Heart Beat and Temperature sensor. When key is pressed, heart beats and temp values will be sent to pre-defined mobile phone (Hospital) using GSM. On signal there will be two RFID readers which will detect traffic density on two roads. When ambulance is detected on any road signal for that side will be green. Limitations: All ambulances must equip with special instruments other than medical. Some other integration also needs to implement this system.

2.9.3 Inductive loop detection

It can be placed in a roadbed to detect vehicles by measuring the vehicle's magnetic field.(Koerner, 1976, Bauza and Gozálvez, 2013) .The simplest detectors simply count the number of vehicles during a unit of time. Loops can be placed in a single lane or across multiple lanes.

Figure 2.4: Inductive loop detection

Drawbacks:

1. The error rate is quite high.

2. Maintenance is very tedious.

3. Traffic cannot be managed locally.

2.9.4 Video Data Analysis

Video feeds from the cameras. The built-in software harvests information from that video. Information (vehicle volume, average velocity, etc.) then fed into the fuzzy system. That outputs the level of traffic congestion. (Bramberger et al., 2004, Gubbi et al., 2013)

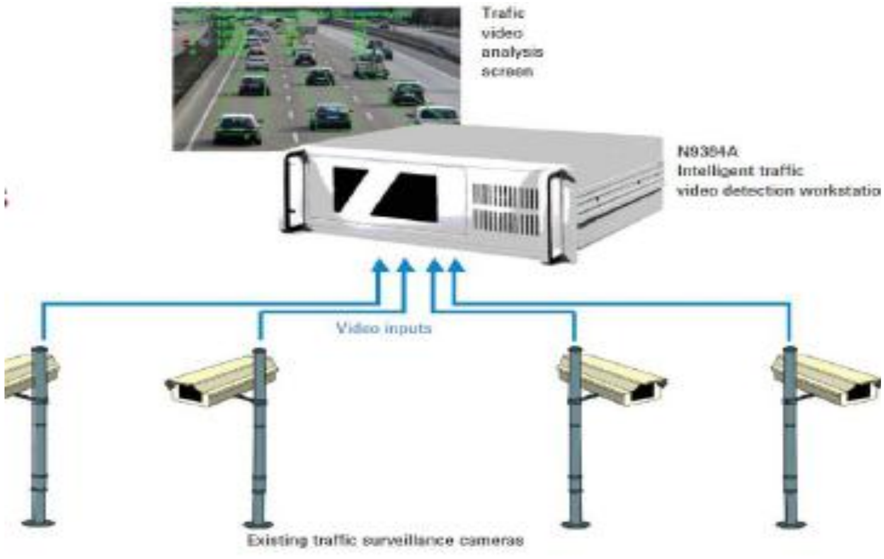


Figure 2.5: Video Data Analysis

Shortcomings:

1. The overall system is quite expensive.

2. The fuzzy algorithm is not very accurate.

2.9.5 Image Processing

Image Processing Based Intelligent Traffic Controller by Vikramaditya Dangi, Amol Parab, Kshitij Pawar and S.S Rathod (2012). A camera is fixed on polls or other tall structures to overlook the traffic scene. Images extracted from the video are then analyzed to detect and count vehicles. Then depending on the signal cycle, time is allotted to each lane. The system also takes into account the emergency vehicles at the intersection. If such a vehicle is detected, the lane is given priority over the others Limitations: Camera used, have to be robust. When ambulances arrive from more than one lane system fails, it gives green light to all lanes.

2.9.6 Wireless Sensor Network

Magnetic sensors are deployed by the road intersection to detect vehicles. By Shruthi K R and Vinodha K (2012).The sensors send the collected data to the Intersection Control Agent (ICA). ICA processes the data and dynamically controlled the traffic light

A high vehicle density in a particular lane causes a traffic signal in that particular direction to remain open for larger duration thus adaptively controlling the signal.

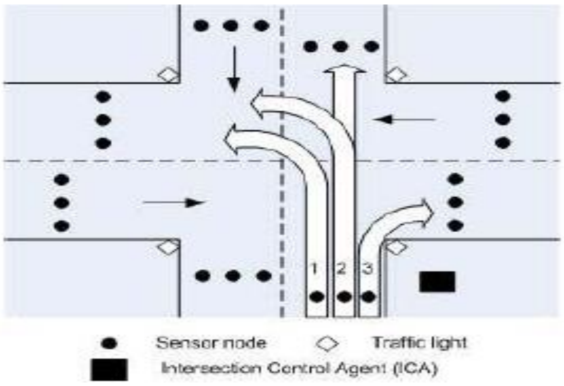


Figure 2.6: Wireless Sensor Network

2.9.7 Expert System

Expert System based Traffic Light Controller described by Findler and Stapp . An expert system uses the set of rules to decide the next action. In traffic Light control such an action can change some of control parameters that means the totally new system implementation required.(Wiering et al., 2004, Geng and Cassandras, 2012)

2.9.8 IEEE 802.11p Vehicle to Infrastructure Communications in Urban Environments

IEEE is working on a variation of 802.11 standards that would be applied to support communication between vehicles and the roadside, or, alternatively, among vehicles themselves, operating at speeds up to 200 km/h, handling communication ranges as high as 1,000 meters. PHY and MAC layers are based on IEEE 802.11a, shifted to the 5.9 GHz band (5.850-5.925 GHz within US).The technology is promoted by the car industry both in Europe (Car2Car CC) and US (VSCC, VII). Estimated deployment cost is foreseen to be relatively low due to large production volumes(Gozálvez et al., 2012)

2.9.9 Radio Frequency Identification (RFID)

Radio-frequency identification (RFID) is a technology that use for the purpose of identification and tracking using radio waves. Most RFID tags contain at least two parts. One is an integrated circuit for storing and processing information, modulating and demodulating a radio-frequency (RF) signal, and other specialized functions. The second is an antenna for receiving and transmitting the signal.

There are two types of RFID devices:

1. Active RFID device contain a battery and can transmit signals autonomously.

2. Passive RFID devices have no battery and require an external source to provoke signal transmission.

2.9.10 Global Positioning System (GPS)

Embedded GPS receivers in vehicles' on-board units (OBUs, a common term for telemetric devices) receive signals from several different satellites to calculate the device's (and thus the vehicle's) position. This requires line of sight to satellites, which can inhibit use of GPS in downtown settings due to "urban canyon" effects. Location can usually be determined to within ten meters. GPS is the core technology behind many in-vehicle navigation and route guidance systems. Several countries, notably Holland and Germany, are using or will use OBUs equipped with satellite-based GPS devices to record miles traveled by automobiles and/or trucks in order to implement user fees based on vehicle miles traveled to finance their transportation systems.(Al-Sultan et al., 2014, Singh and Agrawal, 2014)

2.9.11 Dedicated-Short Range Communications (DSRC)

DSRC is a short- to medium-range wireless communication channel, operating in the 5.8 or 5.9GHz wireless spectrum, specifically designed for automotive uses. Critically, DSRC enables two-way wireless communications between the vehicle (through embedded tags or sensors) and roadside equipment (RSE). DSRC is a key enabling technology for many intelligent transportation systems, including vehicle-to-infrastructure integration, vehicle-to-vehicle communication, adaptive traffic signal timing, electronic toll collection, congestion charging, electronic road pricing, information provision, etc. DSRC is a subset of radio frequency identification (RFID) technology. The technology for ITS applications works on the 5.9GHz band (United States) or the 5.8GHz band (in Japan and Europe). At present, DSRC systems in Europe, Japan, and the United States are generally not compatible (although there are indications that Europe may be trying to migrate to 5.9GHz). In 2004, the U.S. Federal Communications Commission (FCC), atypically for a U.S. regulator, prescribed a common standard for the DSRC band both to promote interoperability and to discourage the limitation of competition through proprietary technologies.(Cheng et al., 2011, Yamazato et al., 2014)

2.9.12 Wireless Networks

Similar to technology commonly used for wireless Internet access, wireless networks allow rapid communications between vehicles and the roadside, but have a range of only a few hundred meters. However, this range can be extended by each successive vehicle or roadside node passing information onto the next vehicle or node. South Korea is increasingly using Wipro, based on WiMAX technology, as the wireless communications infrastructure to transmit traffic and public transit information throughout its transportation network.(He et al., 2014, Martinez et al., 2010)

2.9.13 Mobile Telephony

ITS applications can transmit information over standard third or fourth generation (3G or 4G) mobile telephone networks. Advantages of mobile networks include wide availability in towns and along major roads. However, additional network capacity may be required if vehicles are fitted with this technology, and network operators might need to cover these costs. Mobile telephony may not be suitable for some safety-critical ITS applications since it may be too slow.(Godoy et al., 2013, Nickolaou and Grimm, 2013)

2.9.14 Radio wave or Infrared Beacon

Japan's Vehicle Information Communications System (VICS) uses radio wave beacons on expressways and infrared beacons on trunk and arterial roadways to communicate real-time traffic information. (Arterial roadways are moderate capacity roadways just below highways in level of service; a key distinction is that arterial roadways tend to use traffic signals. Arterial roadways carry large volumes of traffic between areas in urban centers.) VICS uses 5.8GHz DSRC wireless technology(Seii et al., 2013, Roxin, 2014).

2.9.15 An Intelligent Transportation System Using Zig Bee as a Communication Medium

Zig Bee (IEEE 802.15.4) and Bluetooth (IEEE 802.15.1) are designed for wireless personal area networks (WPANs) with smaller coverage area and lower power consumption. Zig Bee operates at the frequency spectrum of 902 to 928 MHz and 2.4 GHz, whereas Bluetooth operates at 2.4 GHz. The transmission range of Zig Bee is 100 m, while that of Bluetooth is only 10 m. On the other hand, the data rate of Zig Bee is only 20 to 250 kbps, while that of Bluetooth is 1 Mbps. Because of their low data rates and transmission range, these protocols are not considered for vehicle networks.(Iqbal et al., 2011, Atzori et al., 2010).

V2I communication in solved Congestion problems which are a condition on road networks that occurs as use increases, and is characterized by slower speeds, longer trip times, and increased vehicle queuing. The most common example is the physical use of roads by vehicles.

When traffic demand is great enough that the interaction between vehicles slows the speed of the traffic stream, this results in some congestion.(Downs, 1992, Garber and Hoel, 2014).

As demand approaches the capacity of a road (or of the intersections along the road), extreme traffic congestion sets in. When vehicles are fully stopped for periods of time, this is colloquially known as a traffic jam or traffic snarl-up. Traffic congestion can lead to drivers becoming frustrated and engaging in road rage.(Button and Verhoef, 1998)

Chapter Three

Adaptive Traffic Light Control System

Chapter Three
Adaptive Traffic Light Control System

3.1 Introduction to Microcontrollers

The main control item of the V2I communication for adaptive traffic management is the microcontroller Atmega32. The controller is the core system of the project or any electrical circuit since it acts like the brain that takes decisions and receives and sends output accordingly. The controlling function in this project shall use the microcontroller rather than digital IC's. In fact, it is really a good chance to learn about microcontroller and how to program and design microcontroller based circuits since almost all controlling functions in electronic devices are made using micro controllers. Also, it gave flexibility in changing programs or modify or enhance the functionality easily since all it requires changing the program and downloading it to chip

Whereas in digital IC's we have to change the physical hardware configuration to meet the required result which will be time consuming in addition complexity.

However, there are several types of microcontrollers in the market. The selection of the microcontroller was based in how common it is in market and availability. Also, it depended on the size of the program memory, RAM and the clock frequency (speed), how many I/O it can accommodate as well as interrupts.

Basically, a microcontroller is a device which integrates a number of the components of a microprocessor system onto a single microchip and optimized to interact with the outside world through on-board interfaces. So, it is in fact a little gadget that houses a microprocessor, ROM (Read Only Memory), RAM (Random Access Memory), I/O (Input Output functions), and various other specialized circuits all in one package.

On the other hand, a microprocessor is normally optimized to co-ordinate the flow of information between separate memory and peripheral devices which are located outside it. Connections to a microprocessor include address, control and data busses that allow it to select one of its peripherals and send to or retrieve data from it. Because a microcontroller‘s processor and peripherals are built on the same silicon, the devices are self-contained and rarely have any bus structures extending outside their packages.(Beeby and White, 2014, Mukhopadhyay and Postolache, 2014)

3.1.1 Microcontroller Definition, Option, and Selection

A microcontroller (sometimes abbreviated µC, µC or MCU) is defined as a small computer on a single integrated circuit containing a processor core, memory, and programmable I/O peripherals. Neither program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM Microcontrollers are designed for embedded applications.(Wankar and Wankhede, 2014, Bates, 2013).

3.1.2 Atmega32 Microcontroller

It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board. Atmega32 can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs.(Juang and Lum, 2013, Wankar and Wankhede, 2014)

The common used microcontrollers which are suitable for my project are:

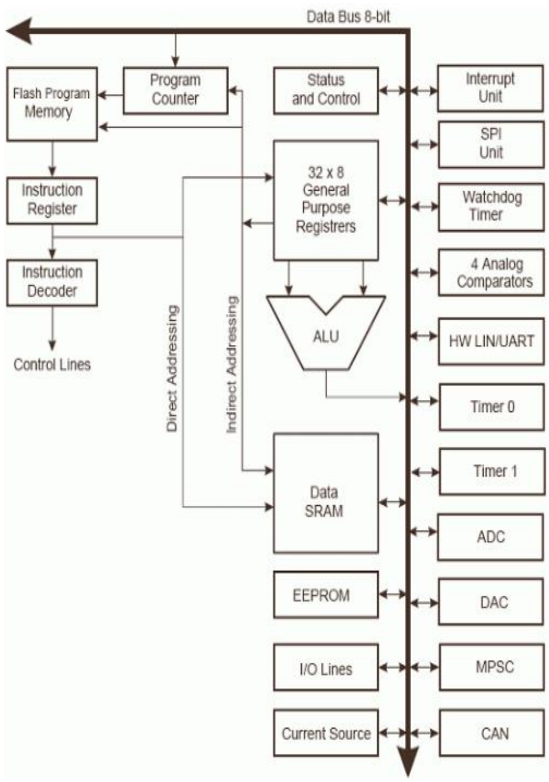


Figure 3 .1: Functional scheme of MC ATmega32

3.1.2.1 Atmega32

The ATmega32 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega32 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed. The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers. The ATmega32 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega32 is a powerful microcontroller that provides highly-flexible and cost-effective solution to many embedded control applications.(Wankar and Wankhede, 2014).

ATMEGA32 is 8-bit AVR Microcontroller. It has total 40 pins and four input/output ports that mean 32 I/O pins, one VCC, AVCC, Reset and two GND pin are also exist figure 3.3 .

Figure 3.2:ATMEGA32 microcontroller.

3.1.2.2 Pin Descriptions

The ATMega32 has 4 ports, these are defined as PORTA, PORTB, PORTC and PORTD. Each of the port pins can be used for simple I/O, some cases contain dual function for a peripheral function within the microcontroller.

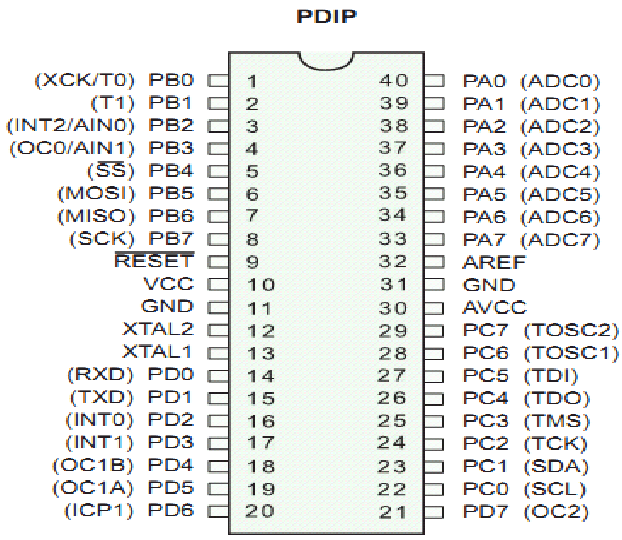


Figure 3.3: Pin out of Atmega32

3.2 Radio Frequency Identification (RFID)

Radio-frequency identification (RFID) is a technology that uses communication via electromagnetic waves to exchange data between a terminal and an object such as a product, animal, or person for the purpose of identification and tracking. Some tags can be read from several meters away and beyond the line of sight of the reader. Radio frequency identification involves interrogators (also known as readers) and tags (also known as labels). RFID systems can be classified into two categories according to the tags power supply: active RFID systems or passive RFID systems. In passive RFID tags require no power source, are highly resistant to dust or obstacles and of very small size. Tags are so cheap that they can be installed in large numbers. RFID tags store information by a small integrated circuit that will communicate via antennas that located on the tag reader. RFID readers are capable to reading information on the tag and send the information to a computer terminal or micro controller. It millrace vie a radio frequency from RFID tag before it sends to computer.(Wen, 2010) RFID reader and tag must follow the same standard to make a communication between readers and tag successfully Figure below shows the components block of RFID systems figure 3.5.(Sheikh et al., 2014, Chu, 2015)

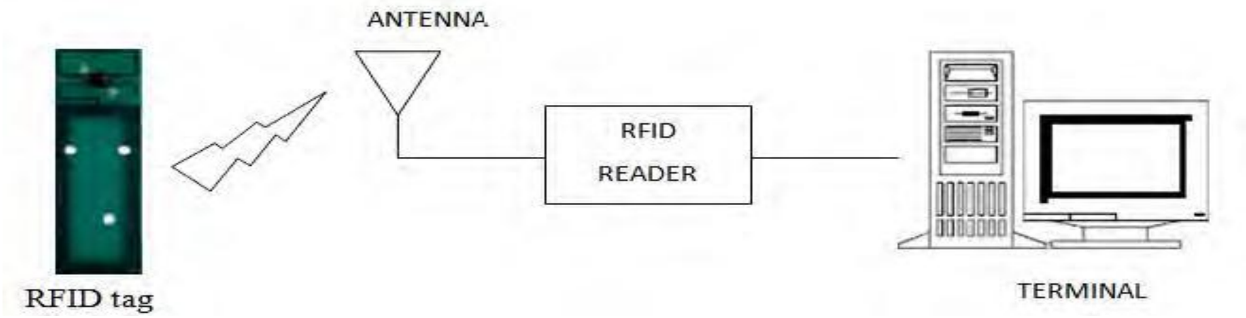


Figure 3.4: RFID Components

This RFID technique deals with a multi-vehicle, multilane, multi road junction area. It provides an efficient time management scheme, in which a dynamic time schedule is worked out in real time for the passage of each traffic column. The real time operation of the system emulates the judgment of a traffic policeman on duty. The number of vehicles in each column and the routing are proprieties, upon which the calculations and the judgments are based.(Mandal et al., 2011, Pineles et al., 2014)

RFID technology is one of the most rapidly growing segments of today's automatic identification data collection (AIDC) industry. ″RFID tags″ on objects or assets, and ″RFID readers″ are used to gather the tag information. The propose system based on RFID is designed for all legally registered vehicles which must hold RFID tags. When these vehicles travel along a road or intersection in which a propose system is installed the vehicle tag information is read and sent immediately to the microcontroller unit for the purposes of real time monitoring and management of vehicle movement conditions.(Wang et al., 2014)

3.2.1 Data Collection from RFID

When the vehicle passes over the RFID reader, the reader reads the vehicle ID from the RFID tags attached to the vehicle. The reader is interfaced with the Microcontroller. The vehicle ID is then transmitted. This microcontroller acts as sink to which vehicle ID comes wirelessly from all reader. After collecting vehicle ID from all vehicles passing over the reader it decides the time slot to be allocated to each lane according to the traffic density corresponding to that particular lane.

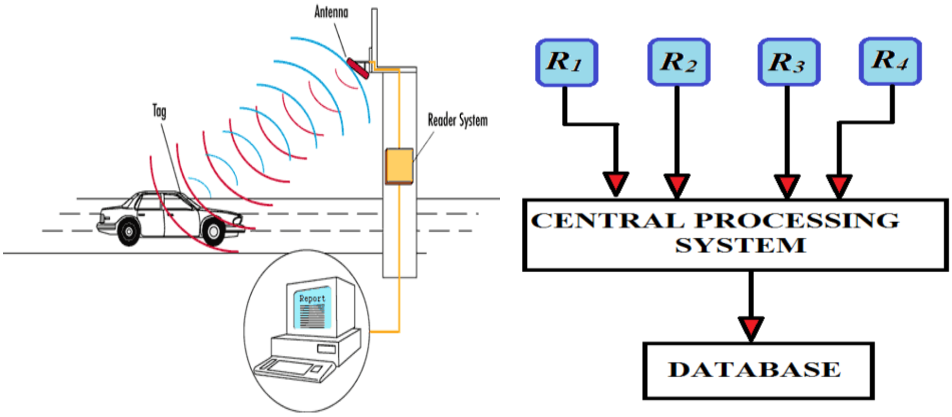


Figure 3.5: Communication between tag &RFID reader

3.2.2 RFID System

The core functionality of an RFID system is the communication between a reader and a tag. The communication is carried out using RF waves, which are basically the EM waves with frequencies from the sub spectrum of EM frequency spectrum called radio frequencies (Figure 3.7)

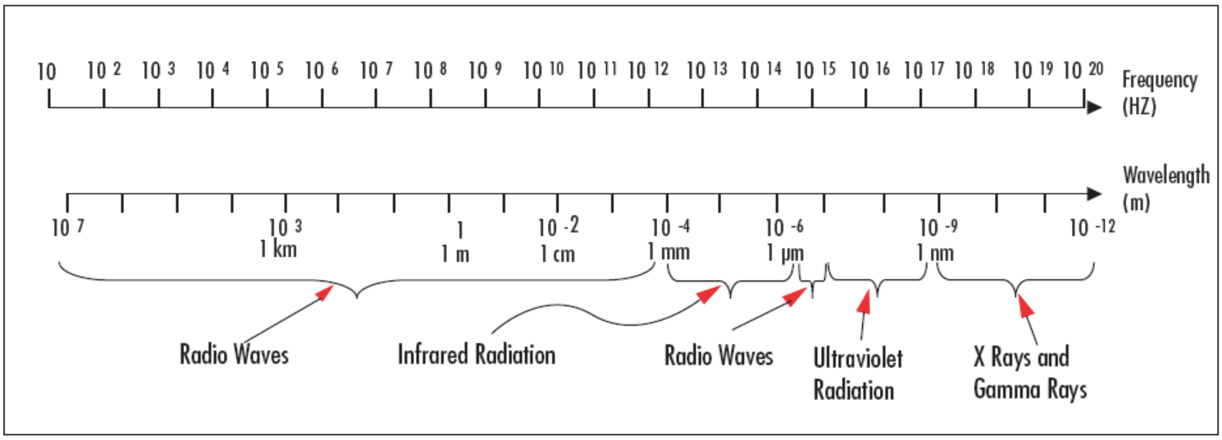


Figure 3.6: RFID system

3.2.3 Communication Techniques

Communication is basically the transfer of information that is to send information from one location and to receive it at another. In the RF world, this is accomplished by the transfer of energy (which contains the information coded in it) through RF waves. There are two main communication techniques that the RFID readers and tags use to communicate with each other. These techniques are coupling and backscattering.(Jedermann et al., 2014).

3.2.3.1 Inductive Coupling

The reader and the tag use coils as antennas. These coils create magnetic fields. The variations in the magnetic field are used to transfer power (and data) between the reader and the tag. In technical terms, the energy is transferred between two circuits (tag and reader) by virtue of the mutual inductance between the circuits. This technique limits the read range because it only works in the near field of the coils. Therefore, inductive coupling requires that the reader be close to the tag. This leads to a read range of about 4 inch for LF tags to 1 meter for HF tags.(Ghovanloo et al., 2014)

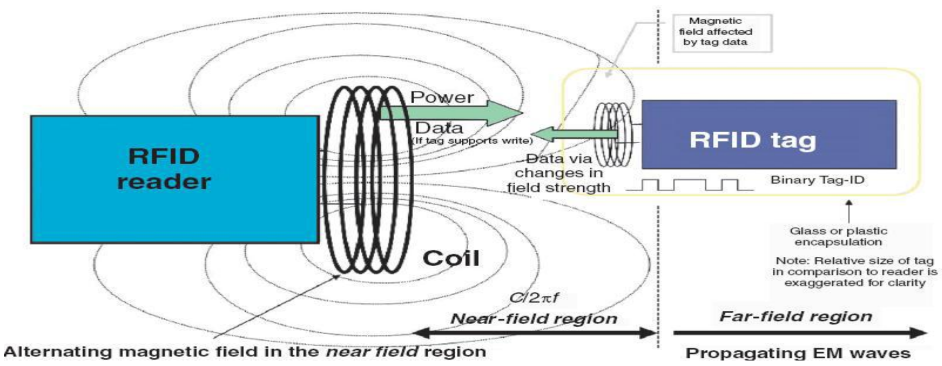


Figure 3.7: Communication techniques

Figure 3.8: Using induction for power coupling from reader to tag and load modulation to transfer data from tag to reader

3.2.3.2 Backscattering

Also called backscatter coupling. Backscattering is typically used by UHF passive tags. Because backscattering works beyond the near field, it allows larger read ranges. For example, the read range of a UHF passive tag using backscattering can be larger than 3 meters (Decarli et al., 2014).

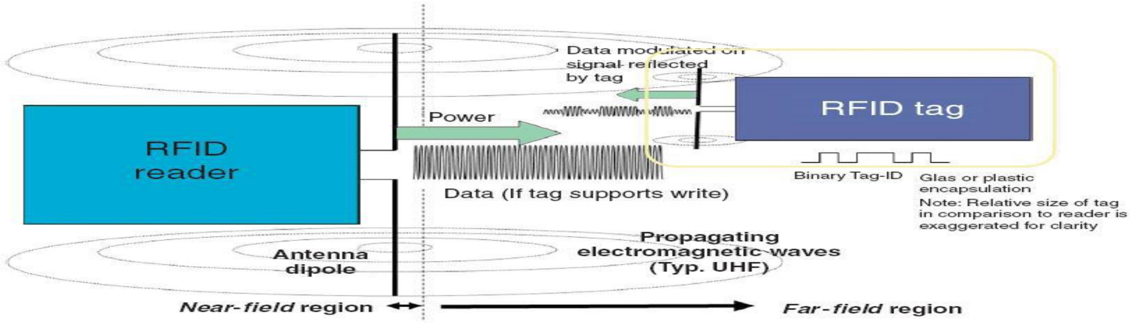


Figure 3.8: Using electromagnetic (EM) wave capture to transfer power from reader to tag and EM backscatter to transfer data from tag to reader.

3.2.4 RFID system Component Tag

A tag contains information about the item to which it is attached and has the capability to provide that information on request (He et al., 2015).

3.2.4.1 Tag Components

Chip: The chip is used to generate or process a signal and store information. It’s an integrated circuit (IC) made of silicon. The chip consists of logical unit, memory, modulator and power controller

Antenna: In an RFID system, a tag's antenna receives the signal (a request for information) from a reader, and transmits a response signal (identification information) back to the reader. It's made of metal or a metal-based material. Both readers and tags have their own antennas.

The antennas are usually used by tags (and readers as well) operating at UHF and microwave frequencies.

The tags (and readers) operating at LF and HF use inductive coils (as antennas) to send and receive signals in the inductive coupling communication technique.

Substrate: This is the layer that houses the chip and the antenna. Substrates can be made of different materials such as plastic, polyethylene terephthalate (PET), paper, and glass epoxy. Substrate material can be rigid or flexible, depending on the usage requirements

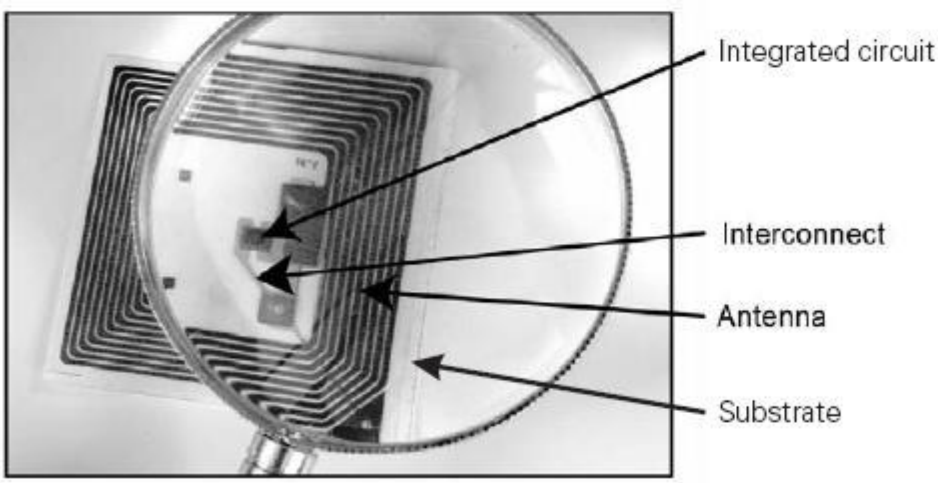


Figure 3.9: Tag's components

3.2.4.2 Tag Types

The tag types are determined according to its ability to initiate communication and if it has a power source or not. It is divided to:

1. Passive tags.

2. Semi passive tags.

3. Active tags.

4. Extended Capability

5. Others : Antenna types , Tag attachment , Tagging Position

3.2.4.2.1 Passive Tags

A passive tag is a tag that:

1. Does not have its own power source, such as a battery. Therefore it cannot initiate the communication.

2. It takes power to start processing from the reader's signal. So it must be inside the interrogation zone to get enough power to generate a response.

3. Since no battery, passive tags tend to be smaller in size and have a shorter read range compared to active tags. Have a longer life. The memory capacity of passive tags varies from 1 bit to several kilobytes.

It works as follows:

1. The passive tag's antenna (or coil) receives the signal from the reader.

2. The antenna sends the signal to the IC.

3. Part of the signal power is used to power up the IC.

4. The IC powers up, processes the incoming signal, and sends the response.

3.2.4.2.2 Semi passive Tags

A semi passive tag is a tag that has its own power source such as a battery but does not initiate communication. It responds to the signal sent by the reader by taking power from the reader's signal.

3.2.4.2.3 Active Tags

An active tag is a tag that has its own power source such as a battery and can initiate communication by sending its own signal. It does not rely on the power from the reader to run its circuitry or to create the signal. Since it has its own power source it has bigger read range and sizes

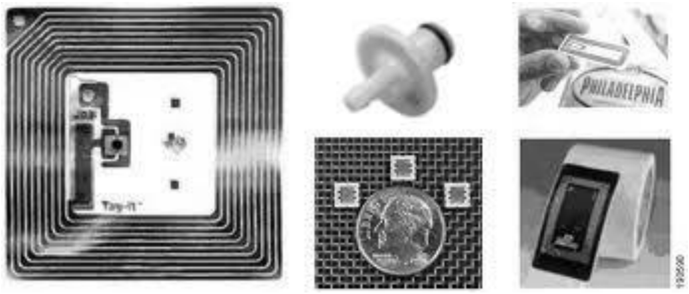


Figure 3.10: Active Tags

	Active RFID	**Passive RFID**
Tag Power Source	Internal to tag	Energy transferred from the reader via RF
Tag Battery	Yes	No
Availability of Tag Power	Continuous	Only within field of reader
Required Signal Strength from Reader to Tag	Low	High (must power the tag)
Available Signal Strength from Tag to Reader	High	Low

Table 3.1: Compared between RFID types

Frequency refers to the size of the radio waves used to communicate between the RFID systems components.

RFID Systems typically use one of the following frequency ranges:

Low frequency (or LF, around 125 and 134.2 kHz), high frequency (or HF, around 13.56 MHz), ultra-high frequency (or UHF, around 868 and 928 MHz), or microwave (around 2.45 and 5.8 GHz).Furthermore the read range of a tag ultimately depends on many Factors:

The frequency of RFID system operation, the power of the reader, and interference from other RF devices. Balancing a number of engineering trade-offs (antenna size vs. reading distance vs. power vs. manufacturing cost), the Parallax RFID Read/Write Module's antenna

Name	Frequency Range	Wave Length Range	ISM Frequencies	Read Range for passive Tags
Low Frequency (LF)	30-300KHz	10 m –1Km	<135 KHz	< 50 cm

was designed specifically for use with low-frequency (125 kHz) passive tags.

3.2.5 Operating tag frequencies

Since other radio services have been operating before the arrival of RFID systems; Radio, television, mobile radio services (police, security services, and industry).Therefore, it is important to ensure that these services are not disrupted or impaired by the RFID newcomers. This requirement significantly restricts the suitable operating frequency ranges available for RFID systems. Therefore, the so-called industrial, scientific, and medical (ISM) frequencies, originally reserved for noncommercial uses in industrial, scientific and medical fields, are generally used for RFID systems. (Heino et al., 2014).

High Frequency (HF)	3-30MHz	100m –10m	(6.78,8.11,13.56, 27,12)MHz	< 3m
Ultra High Frequency (UHF)	300MHz-3 GHz	1m – 10cm	(4.33,869,915)MHz	< 9m
Microwave Frequency	3GHz-300GHz	30 cm – 1mm	(2.44 ,5.80)GHz	> 10m

Table 3.2: Radio Frequency Ranges in Which RFID Systems Can Operate and the Corresponding Read Ranges for Passive Tags

Read range of a tag it is mainly determined by the following four characteristics:

1. Operating frequency
2. The maximum allowed power emission
3. Tag type: active or passive
4. Communication technique: inductive coupling or backscattering

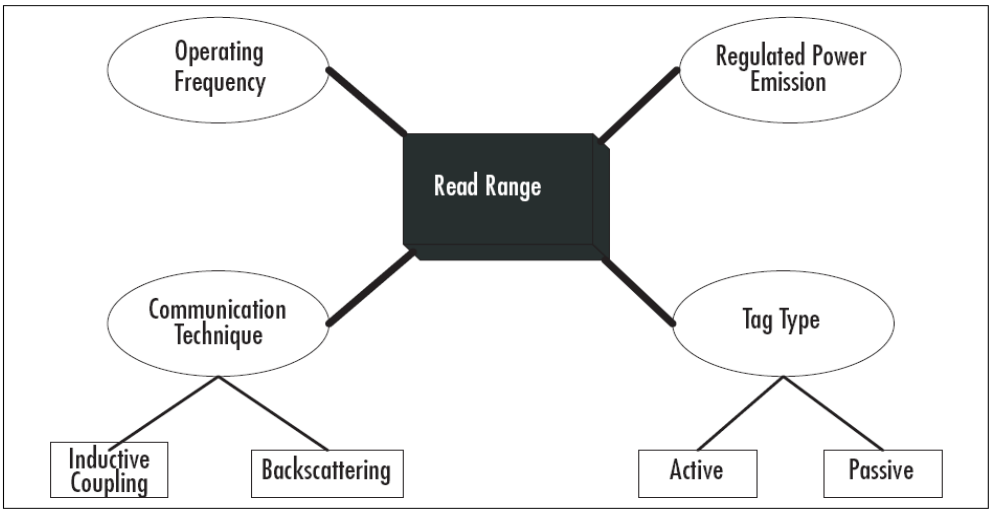


Figure 3.11: Factors affect the read range

3.2.6 Tag Classification

The tags are classified into the following classes according to several properties shown in the following table.

Tag class	Type	Memory	Communication	Additional Properties
Class 0	Passive	Read only	Doesn't initiate communication	The EPC number is encoded on to the tag during manufacture and can be read by a reader
Class 0+	Passive	Same as class 0, but you can write once	Doesn't initiate communication	
Class 1	Passive	Read and write once	Doesn't initiate communication	The EPC number is not encoded by the manufacture but can be encoded later in the field
Class 2	Passive	Read and write once	Doesn't initiate communication	Encryption
Class 3	Semi Passive	Read and rewritable	Doesn't initiate communication	Class 2 capabilities plus extra such as integrated sensors
Class 4	Active	Read and rewritable	Can initiate power their tag –to –tag communication possible	Class 3 capabilities plus extras
Class 5	Active	Read and rewritable	Can initiate power their tag –to –tag possible	Class 4 capabilities plus extras

Table 3.3: Characteristics of different RFID Tag Classes

3.2.7 Tag Placement and Orientation

The orientation of a tag with respect to the reader is an important factor that impacts reading performance of an RFID system.

1. The exact positions of the tag and the reader and the antenna orientations should be determined to ensure that the tag will be in the read zone (optimal power transfer).
2. For optimal power transfer between the reader antenna and the tag antenna, the polarization of both antennas should match.
3. Orientation in Inductive Coupling:

These systems are relatively less sensitive to orientation, for transfer the maximum power; the two coils should be in the same plane.

3.3 Interrogator (reader)

An interrogator is the RFID component that collects information from tags and sends it to a host system. The process of collecting the information from the tags is called reading the tags, and for this reason an interrogator is also called a reader.

3.3.1 Information collection process

1. The reader gets a request for information from the host system.
2. The reader sends the request for information to a tag within its interrogation zone.
3. The tag responds with the requested information.
4. The reader sends the collected information to the host system.

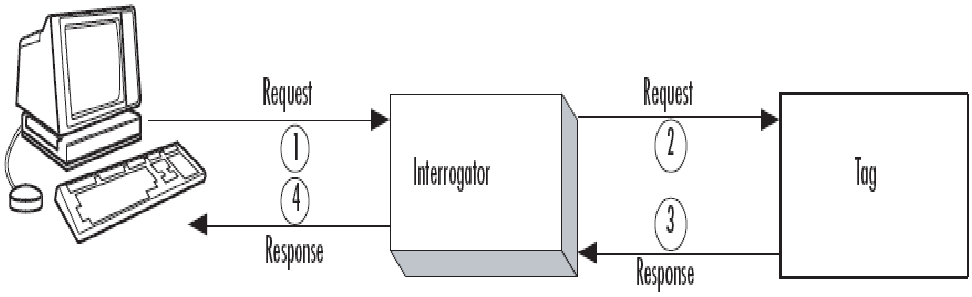


Figure 3.12: The Role of reader in the Information Collection Process

3.4 How to select RFID system

RFID system specifications are determined so to meet the application performance requirements. RFID systems are available at different frequencies. To select the right frequency for the system first need to understand how the various performance parameters, such as read range, tag response time, and storage capacity, depend on the frequency as mentioned the previous sections

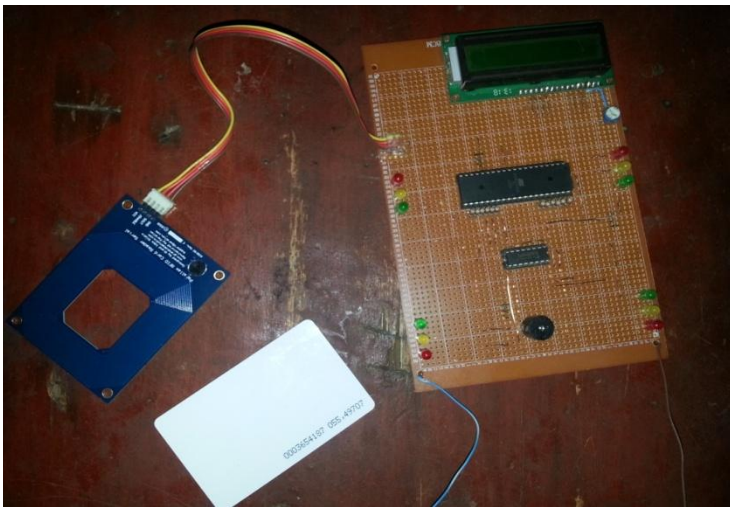


Figure: 3.13 :RFID systems selected

3.4.1 Selecting Operating Frequency

These are the main factors that should be considered in selecting operating frequency:

3.4.1.1 Application types

Because all applications in each application type such as retail, automatic toll collection, and animal tracking have a common set of requirements, most application types are associated with specific frequencies.

In conclusion, the most common used are RFID system, infrared sensors, CCTV, WSN and ultrasonic sensors. By comparing these types of sensors and systems according to the accuracy, simplicity, security, reliability, health, and cost, it is recommended to use RFID system

3.4.1.2 Read range

Read range depends on frequency, among other factors. So, the read range

Requirement of the application will give a very good idea about which frequency should be selected for the system.

Frequency Band	Advantages	Disadvantages	Typical RFID Application
LF	Can work well around water and metal , accepted worldwide	Short read range and slow read speed	Animal identification ,product authorization ,close read of items with high water content
HF	Better accuracy and read speed, easier to read at distance , can carry more information	Requires higher power	Building access control ,airline baggage , libraries
UHF	Faster read speed , easier to read at distance , can carry more information	Does not work well near water or metals	Parking lot access , automated toll collection , supply chain
Microwave	Faster read speed	Does not work well near water or metals	Vehicle identification , automated toll collection , supply chain

Table 3.4: Characteristics of Various Radiofrequency Ranges

3.5 Traffic Control RFID System

In this module we are using Atmel 32 microcontroller as a base unit and RFID reader is connected with serial port of the system. The conventional traffic signal controller works on the principle of Time division depending on timer has programmed on microcontroller. It is rigid method and does not consider traffic density in a particular direction. Here we are proposing a low cost modified adaptive architecture with RFID enabled system. We use RFID Card Reader, Serial (#28140) based readers.

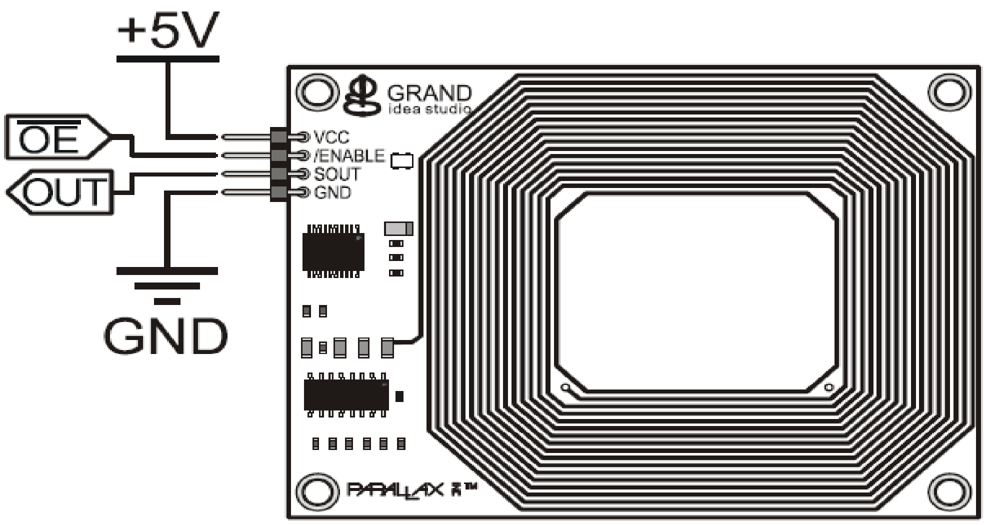


Figure 3.14: RFID system connected

3.5.1 Features

Low-cost method for reading passive, 125 kHz RFID transponder tags

Two easy-to-use versions: Serial interface for microcontrollers and USB for direct connection to PC, Macintosh, or Linux machines

Bi-color LED for visual indication of status

By having a general overview about our research and project, and after a very hard work, we can conclude that, the RFID is a multiple use technology that could be a suitable to solve the bothering congestion problem and it achieves the connection between the road infrastructure and vehicles, because it's a very precise measure to evaluate the almost exact number of cars passing on the congestion region without very hard processing to the information of the street as the CCTV technology' application does, just need a well constructed network and communication between the different parts of the system.

Despite of the limitation of UHF and microwave frequency in working well in hard weather such as extreme humidity and rain water but that would be overcome by upgrading special RFID modules with the aid of telecommunication engineering so that to minimize these defects.

Because of successive development to this technology (RFID), since it's started to be used in this field (traffic management), by a pioneered countries in the information technology such as Japan. We expect that it will be the most used technology in the traffic management field in the near future, and that due to multiple reasons; the most important on is that its increased manufactures decrease the cost of implementation. That would give a rise of the probability of using such technology as ITS technique in developing countries such as our country Sudan.

3.5.2 Operating conditions

The conditions under which the system will operate are a significant factor. For example, if there is water (or water-related conditions, such as mud or snow) or metal in the vicinity of the RFID system, LF and HF are the ideal frequency selections. This is because LF and HF can penetrate through these materials better than UHF and microwave frequencies can.

3.6 LCD

LCD-Liquid Crystal Display is an electronic device for displaying text or characters. We are using 14 pin LCD. 16*2 represents 16 characters and 2 line display.

3. 6.1 SELECTION OF LCD

A liquid crystal display (LCD) is an electronically-modulated optical device shaped into a thin, flat panel made up of any number of color or monochrome pixels filled with liquid crystals and arrayed in front of a light sour (backlight) or reflector.LCD’s are economical and easily programmable and can easily display special and custom characters.

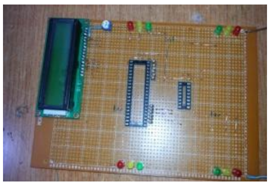



Figure 3.15: LCD 16*2 &Connected OF LCD on board

3.6.2 Pin description is as follows

ITEM	SYMBOL	LEVEL	FUNCTIONS
1	VSS	0V	Power Ground
2	VDD	+5V	Power Supply For Logic
3	V0	—	Contrast adjust
4	RS	H/L	H:data L:command
5	R/W	H/L	H:read L:write
6	E	H. H→L	Enable singnal
7-14	DB0-DB7	H/L	Data Bus
15	LEDA	+5V	Power supply For LED Backlight
16	LEDK	0V	

Table 3.5: Pin description

3.7 Basics of Serial Communication

In serial communication the whole data unit, say a byte is transmitted one bit at a time. While in parallel transmission the whole data unit, say a byte (8bits) are transmitted at once. Obviously serial transmission requires a single wire while parallel transfer requires as many wires as there are in our data unit. So parallel transfer is used to transfer data within short range, while serial transfer is preferable in long range.

3.7.1 DCE and DTE Devices

DTE stands for Data Terminal Equipment, and DCE stands for Data Communications Equipment. These terms are used to indicate the pin-out for the connectors on a device and the direction of the signals on the pins. The computer is a DTE device, while most other devices such as modem and other serial devices are usually DCE devices.

RS-232 has been around as a standard for decades as an electrical interface between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE). It appears under different incarnations such as RS-232C, RS-232D, V.24, V.28 or V.10. RS-232 is used for asynchronous data transfer as well as synchronous links such as SDLC, HDLC, Frame Relay and X.25.

3.7.2 Synchronous data transfer

In program-to-program communication, synchronous communication requires that each end of an exchange of communication respond in turn without initiating a new communication. A typical activity that might use a synchronous protocol would be a transmission of files from one point to another. As each transmission is received, a response is returned indicating success or the need to resend.

3.7.3 Asynchronous data transfer

The term asynchronous is usually used to describe communications in which data can be transmitted intermittently rather than in a steady stream. For example, a telephone conversation is asynchronous because both parties can talk whenever they like.

The difficulty with asynchronous communications is that the receiver must have a way to distinguish between valid data and noise. In computer communications, this is usually accomplished through a special start bit and stop bit at the beginning and end of each piece of data. For this reason, asynchronous communication is sometimes called start-stop transmission.

3.7.4 Using serial communication

Serial communication has multiple advantages over parallel communication such as:

Serial Cables can be longer than Parallel cables. The serial port transmits a '1' as -3 to -25 volts and a '0' as +3 to +25 volts where as a parallel port transmits a '0' as 0v and a '1' as 5v. Therefore the serial port can have a maximum swing of 50V compared to the parallel port which has a maximum swing of 5 Volts. Therefore cable loss is not going to be as much of a problem for serial cables as they are for parallel.

No need as many wires as parallel transmission. especially when the device needs to be mounted a far distance away from the computer then 3 core cable is going to be a lot cheaper that running 19 or 25 core cable.

Microcontrollers have also proven to be quite popular recently. Many of these have in built SCI (Serial Communications Interfaces) to communicate with the outside world. Serial Communication reduces the pin count of these MPU's. Only two pins used (TXD) and Receive Data (RXD)

Much software has been used for programming and interfacing of the microcontroller to RFID as well as LCD display. They are as follows:

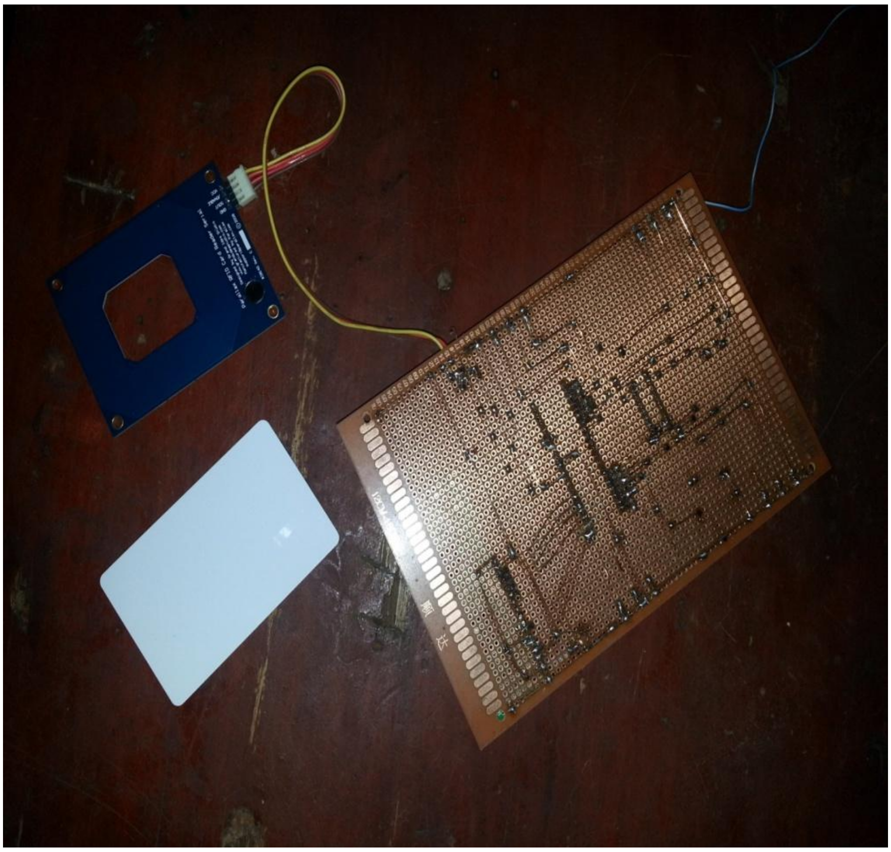


Figure 3.16: Using serial communication

3.8 Bas com AVR

For more hasty and efficient programming, we went bascom AVR which is especially for AVRs like ATMEGA32. It is because it has build in functions for UARTs, LCD etc. So and also by simulation we can check the output on virtual LCD. Also by direct connection of AVR, we can burn the program from bascom AVR only

3.9 Visual Basic

Visual Basic (VB) is a software and programming language developed by Microsoft Company. It is derived from the BASIC and can be used in Rapid Application Development (RAD) for advanced graphical interface or Graphical User Interface (GUI). VB on the database is using tools such as Data Access Objects (DAO), Remote Data Objects (RDO), or ActiveX Data Objects (ADO) and ActiveX objects.

Writing programming languages such as VBA and VBScript is commonly used in VB through in different methods. Programming in VB is a combination of a visual component parts or control over the form, setting properties and actions of each component. Lines are addition to writing code for the display system of multiple functions. Because of the properties and actions have been determined for each component, it can facilitate the process manual for the construction of more simple program.

3.10 Traffic priority on intersection

Each intersection on the road has 4 traffic lights as shown in the figure: 4. 3. Each lane has its own RFID reader that reads the vehicles tag and stores the vehicles passing through it with interval time through this interval time the normal mode will be running.

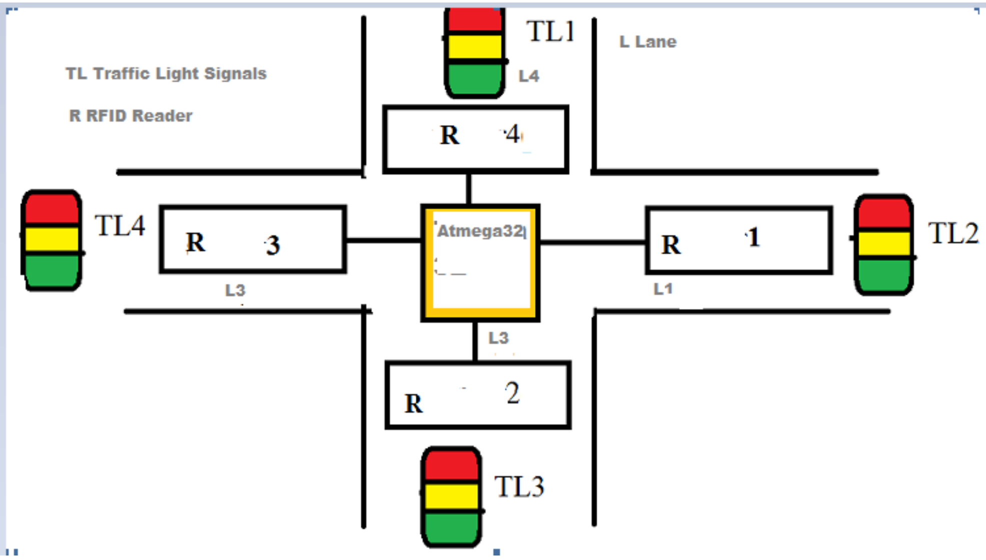


Figure 3. 17: Traffic lights -intersection

Features work on the basis of the timer on microcontroller, we find the violators. For this purpose we store the vehicle tag. So the vehicles coming on the corresponding light are allowed to move in any direction depend on priority.

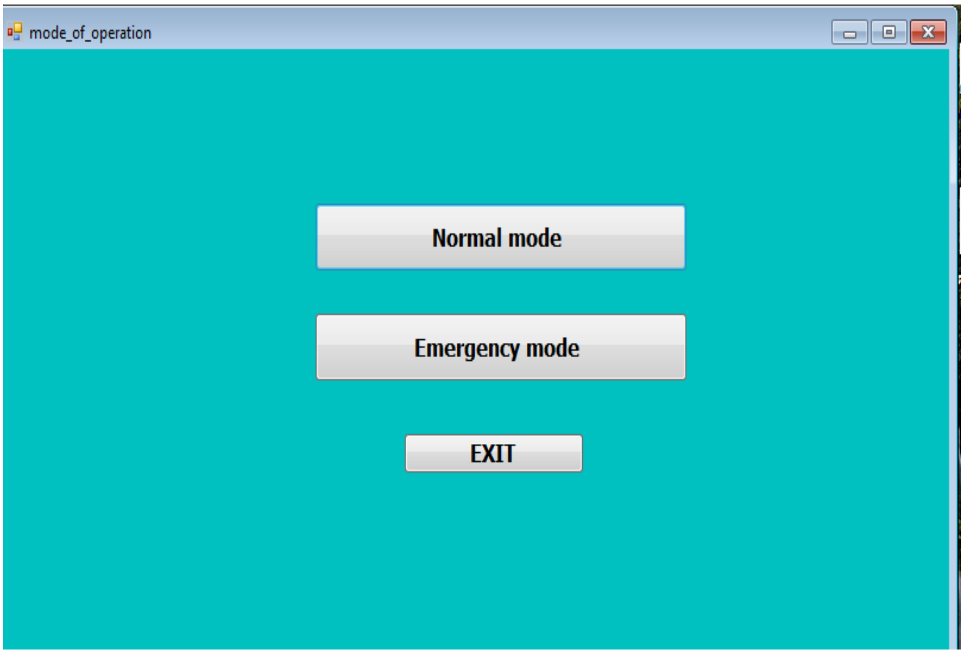


Figure 3.18: Main Screen

During this time reader corresponding to red light stores the vehicles passing through the lane.

A system and method for regulating the flow of traffic at a roadway intersection having one or more traffic signals by positioning a microcontroller in the nearness of the intersection to work and store cycle times of the traffic flow directions, mounting an RFID reader in the nearness of each traffic signal in communication with the microcontroller, communicating with the RFID reader an RFID tag on each RFID-tagged vehicle at the roadway intersection to count the interval time of RFID-tagged vehicles present in each traffic flow direction at the roadway intersection, calculating an unused time slice of the cycle time for a first traffic flow direction at the intersection; reducing the cycle time for the first traffic flow direction in accordance with the unused time slice; and, increasing the cycle time for a second traffic flow direction at the intersection in accordance with the unused time slice read in this chapter, the approach used in order to achieve the objectives of this project are to implement a wireless communication between the vehicle and the infrastructure , to design a suitable system sequence for the emergency vehicle to trigger and also to return to the normal traffic light sequence once the emergency system sequence is ended is discussed in detail.

After obtaining a basic idea and knowing what to do, the next appropriate step is to identify the suitable microcontroller to be used. Next, is identifying the suitable method for the communication between the emergency vehicle and the traffic light. After the suitable microcontroller and method of communication had been identified, the programming process can be initiated in order to integrate the RFID with the microcontroller. The final step for this project would be developing the hardware to serve as a prototype. These steps are illustrated in the following figure: 3.19

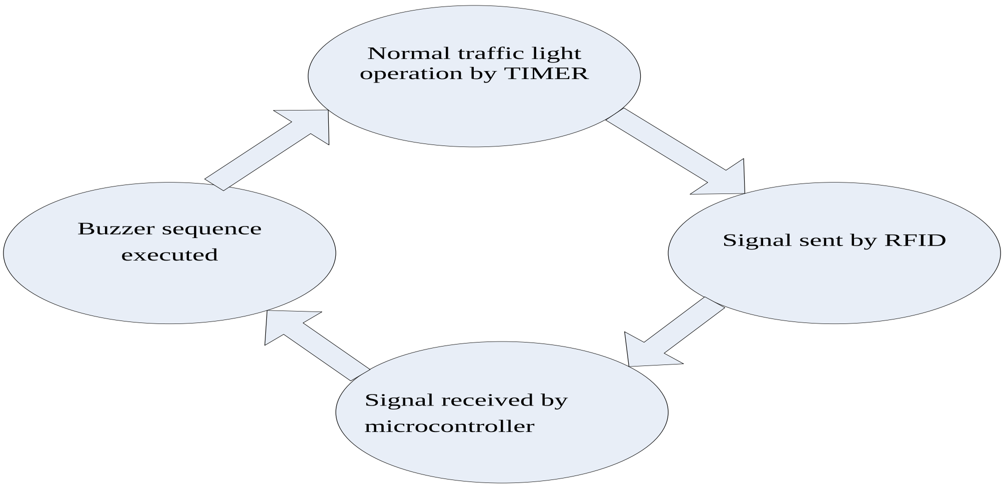


Figure 3.19: Traffic priority on intersection

Chapter Four

System Design and Results

Chapter Four

System Design and Results

4.1 Overview

The main idea of design of the V2I communication for intelligent traffic management is to manage freeway traffic and reduce the congestion traffic by using microcontroller, traffic light signals (LEDs) with resistors, RFID system (Reader and Tag), LCD connected with Rheostat, ULN Driver 2003(Pattipati et al., 2012) and buzzer (ALARMs) .Show the figure: 4.1

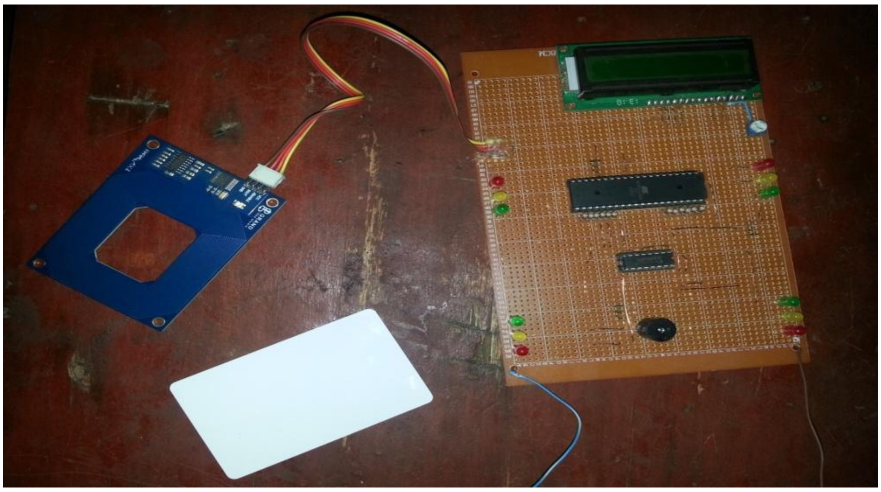


Figure :4.1 Hardware system components

4.2 Project Design

The whole project consists of two main sections as illustrated in figure: 4.2 traffic light intersection control unit and control system.

The traffic light intersection control unit is a local station in each traffic intersection to sense the status of each road and manage the traffic light sequence accordingly, and collect ID numbers of cars to be used in application giving priority to emergency cars and in other application on the future in (tracking specified cars).

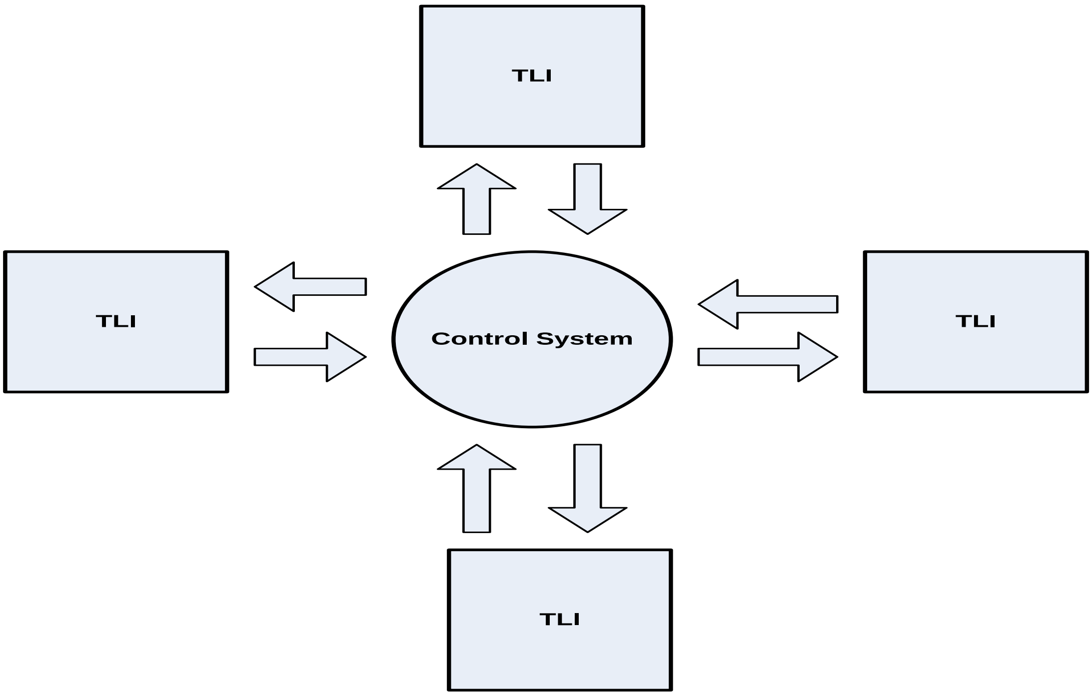


Figure 4.2: General overview of the project

4.3 System analysis

Under the research work, each intersection contains 4 RFID readers show figure 4.2. The road is divided into two lanes. Each lane has its RFID reader to track the vehicles passing through it. Each intersection point has its own microcontroller to store the information regarding the vehicles that passed from it with times and traffic light. Every vehicle has a RFID sticker TAG enabled device that stores a vehicle identification number (ID). Every vehicle has its unique ID number that provides the information regarding the priority of the vehicle and type of the vehicle. With the help of ID we can uniquely identify the vehicle & its owner.

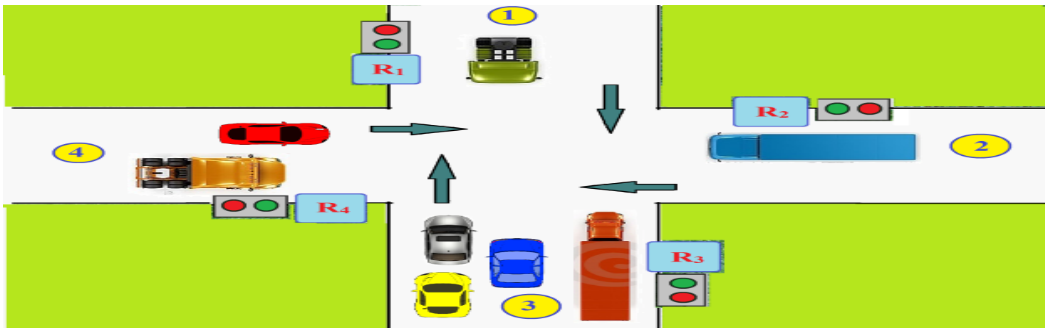


Figure: 4.3: Basic Concept of Proposed V2I Communication For ITM

4.4 Vehicle Identification Number ID

In the proposed work RFID tag will store a Vehicle Identification Number. This number is divided into three parts:

First part: Priority of the vehicles.

Second part: Type of vehicle.

Third part: Vehicle number.

4.5 Priority

In the proposed work, different types of vehicles have the different priorities. The total vehicles are divided into fourth Durations or Categories:

4.5.1 First System Emergency Cars

(Ambulance, Fire Brigade vehicles and V.I.P vehicles). These vehicles have the highest priority.

4.5.2 Second Prayed Passenger's Cars

Includes the buses and school & college vehicles. These cars need to reach their destination on time so these vehicles also need a fast service.

4.5.3 Third Category

Includes the Car, Motor Cycles and scooters.

4.5.4 Fourth Category Includes the Heavy Vehicles

Day time priority of there'd category is high as compare to fourth category but during night hours the priority of the heavy vehicles high.

All these priorities cannot present on the project now expected the emergency cars it has been implemented practically on my research and it has been worked successfully. Priority to emergency has been designed and tested. But in the future have been implemented all these priorities

4.6 Theory of Operation

When the vehicle passes over the RFID reader, the reader reads the vehicle id from the RFID tags attached to the vehicle. The reader is interfaced with the at mega 32 bit microcontroller. The vehicle id is then transmitted serially, from the RFID reader, to microcontroller. This microcontroller acts as storage to which vehicle id comes wirily from all reader. After collecting vehicle id from all vehicles passing over the reader it decides the time slot to be allocated to each lane according to the traffic density depend on software programming timer corresponding to that particular lane.

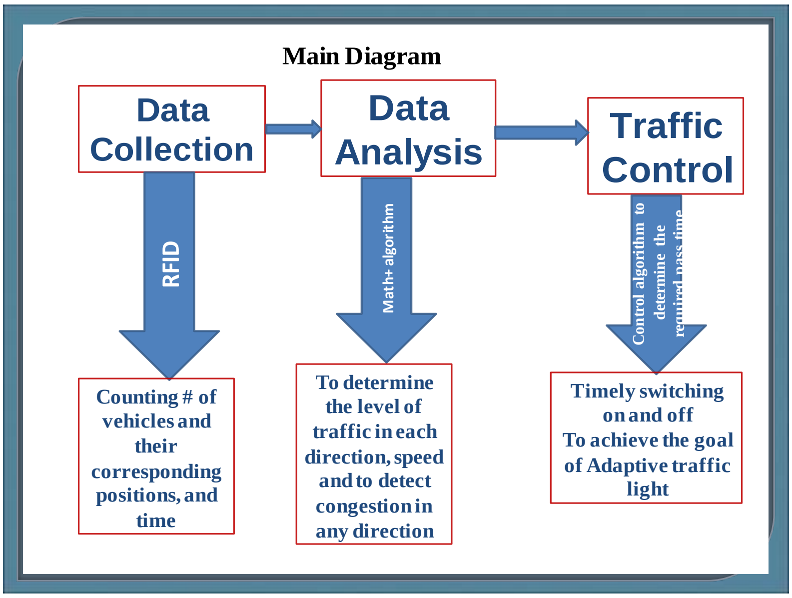


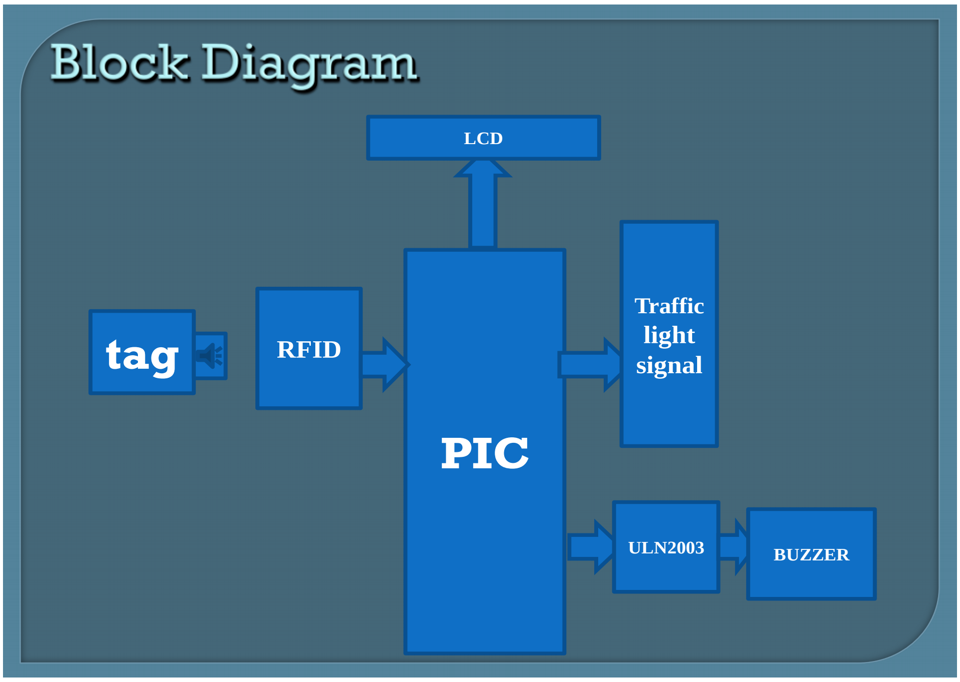
Figure 4.4: The operation system

The basic idea of V2I TM is to alter the traffic signal according to the density of traffic on road or emergency vehicles. In current scenario, the traffic signals consist of timer system which manages the traffic in a constant manner. In V2I, the traffic at the cross road junction is managed in real time, depending on the current traffic density or timer. Considering a four lane junction, the RFID readers (R1, R2, R3 and R4) are mounted on the surface of road. Now, as the vehicles passes over these readers, a special car id is read by the reader from the tag attached to the vehicle. This reading is done through load modulation and inductive coupling technique. In this approach, the RFID reader provides a short range alternating current magnetic field that the passive RFID tag uses for both power and as a communication medium. Via a technique known as inductive (or near-field) coupling, this magnetic field induces a voltage in the antenna coil of the RFID tag, which in turn powers the tag. The tag transmits its information to the RFID reader taking advantage of the fact that each time the tag draws energy from the RFID reader's magnetic field; the RFID reader itself can detect a corresponding voltage drop across its antenna leads. Capitalizing on this event, the tag can communicate binary information to the reader by switching ON and OFF a load resistor to perform load modulation. When the tag performs load modulation, the RFID reader detects this action as amplitude modulation of the signal voltage at the reader's antenna. Load modulation and inductive coupling can be found among passive RFID tags using frequencies from 125 to 135 kHz and 13.56 MHz

4.7 System Block Diagram

I will try to install the system at places where traffic congestion occurs frequently and traffic light signals placed on (intersection road). The first system consists of RFID systems including Tag and RFID reader, the second is Microcontroller, third one ULN 2003 drivers, and fourth traffic light signals (LEDs) fifth LCD and the last one is BUZZER.

The whole system is programmed and development on future to function at peak hours of congestion and in places where congestion accurse and traffic light signals installed. Show figure (4.3) block diagram.



. Figure 4.5: System block diagram

4.8 Schematic Diagram

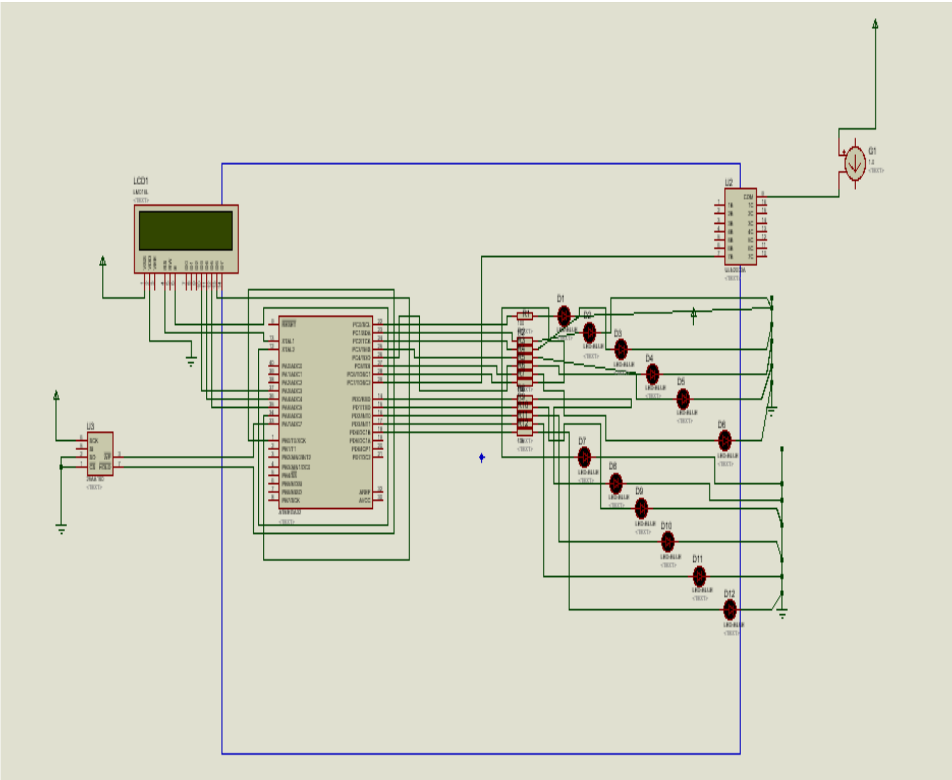


Figure 4.6: Schematic representation to the system

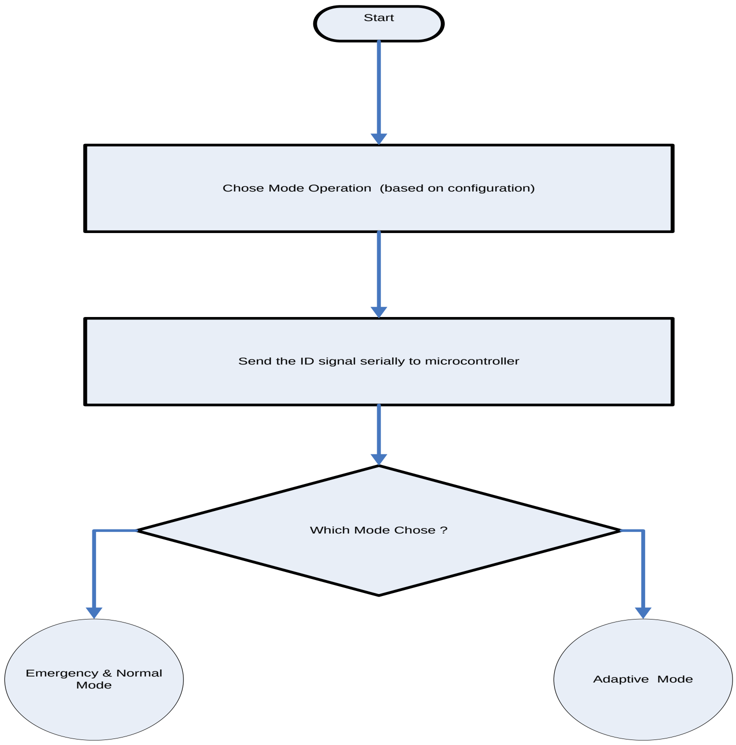
4.9 Flowchart

My scheme ensures the following to control traffic congestion:

1. Smooth traffic flow on road
2. Congestion detection and control at any road leading to a junction
3. Priority-based traffic control

The system is programmed to repeat this cycle all the time of day 24 hours.

The following flow charts (figure 4.8, figure 4.9, and figure 4.10) represent the flow charts of the main modes, specific flow chart for normal/emergency modes, and finally the adaptive mode respectively.



. Figure 4.7: flow chart modes

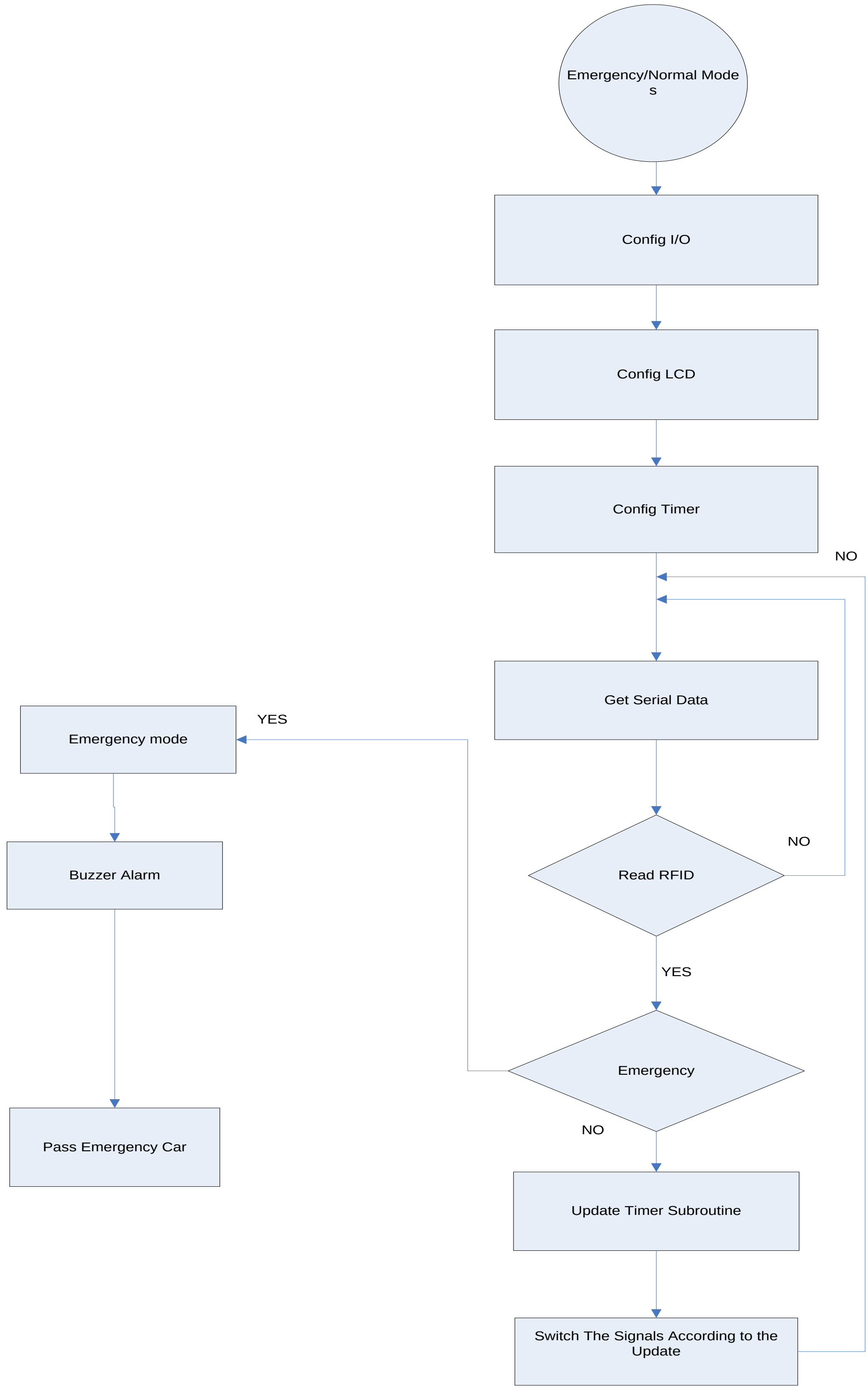


Figure 4.8: System flowchart 1(how to main circuit run) Normal mode

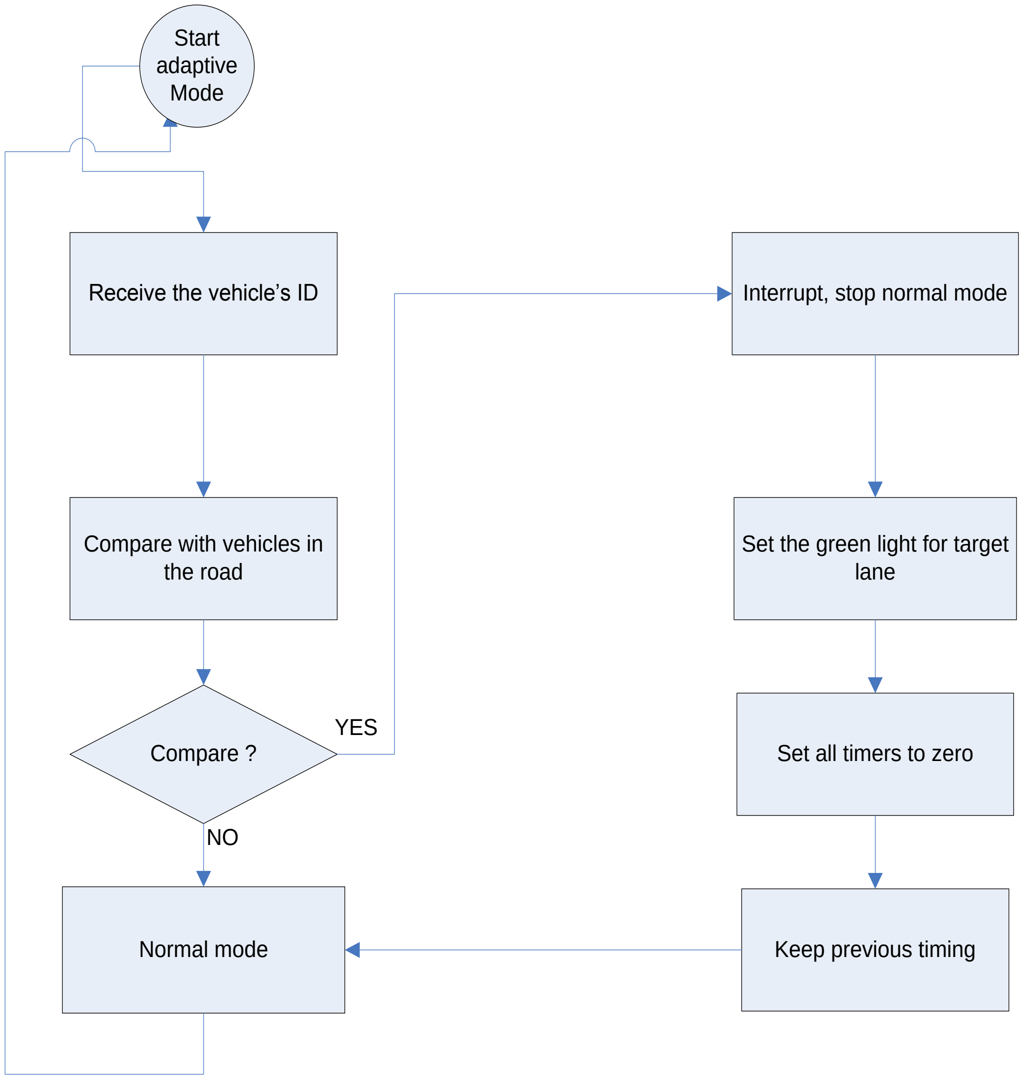


Figure 4.9: flow chart of adaptive mode

4.10 Proposed Method and Design for Emergency Cars

The proposed V2I Communication For TM consist of high-performance, low power AVR-32 microcontroller with 32kbytes of in-system programmable flash memory and in-built 8-channel ADC which required to process the input from RFID reader network. So complexity of system reduces as no additional ADC required.

4.10.1 Case1

When single emergency car comes on the signal and number of vehicles will be available in front of the emergency vehicle. In this situation, RFID reader detects the emergency car and then opens traffic signal in green light to pass the car. As the signal will be red for other vehicles, so no possibility of accident.

4.10.2 Case 2

When two emergency cars come on the signal and number of vehicles will be available in front of the emergency vehicle. In this situation, RFID reader detects the emergency cars and then opens traffic signal to pass the cars.

Arrows will indicate the possible direction. The RFID system is used to open and close the signal when emergency vehicles pass through it. The proposed V2I Communication combines the advantages of hardware and software and we can easily control the traffic system through movement area.

4.11 Results

4.11.1 Choose mode of operation

Allow the supervisor to choose the required mode of operation and to send the associated control signals Via the GUI. Selecting several parameters cause a control signals transfer serially to the MCU(figure (4.11)), based on these values the main program will chose the appropriate function as explained in figure(4.8).

Divide the work into three parts system designed to consolidate the work product. This works very well, in fact, a fitter and works on an ongoing basis and completely successfully Figure (4.10) flow chart explain the sequence of operation.

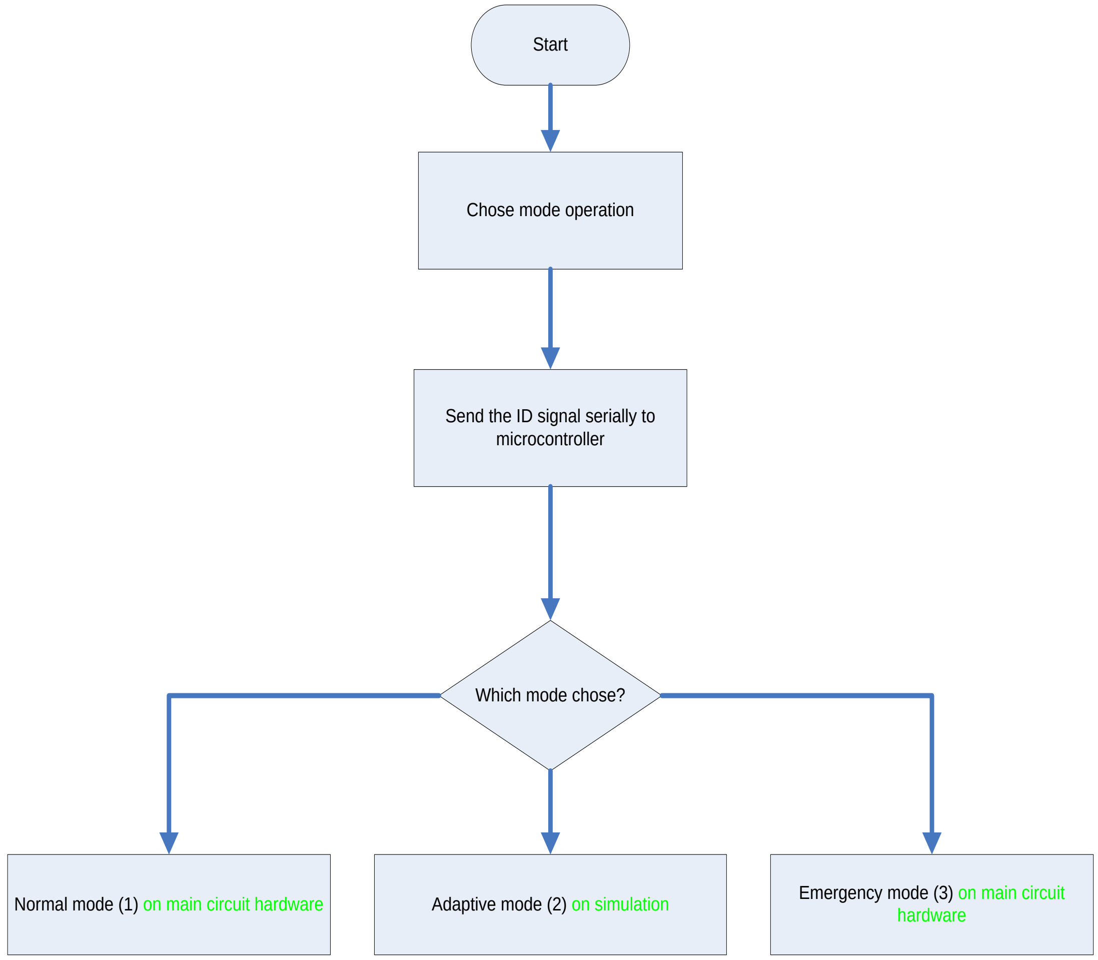


Figure 4.10: Flow charts explain the mode of operation.

4.11.2 Steps to run Normal mode

1 – Choice normal mode operation figure 4.11:

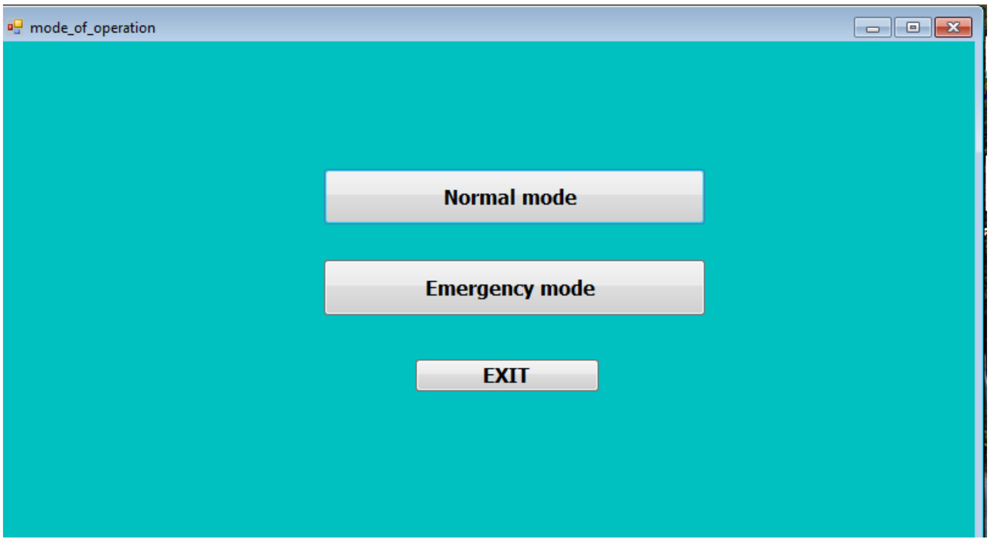


Figure 4.11: Normal mode operation

2- Read tag (enter number of vehicles using keyboard) as explained in figure 4.11:

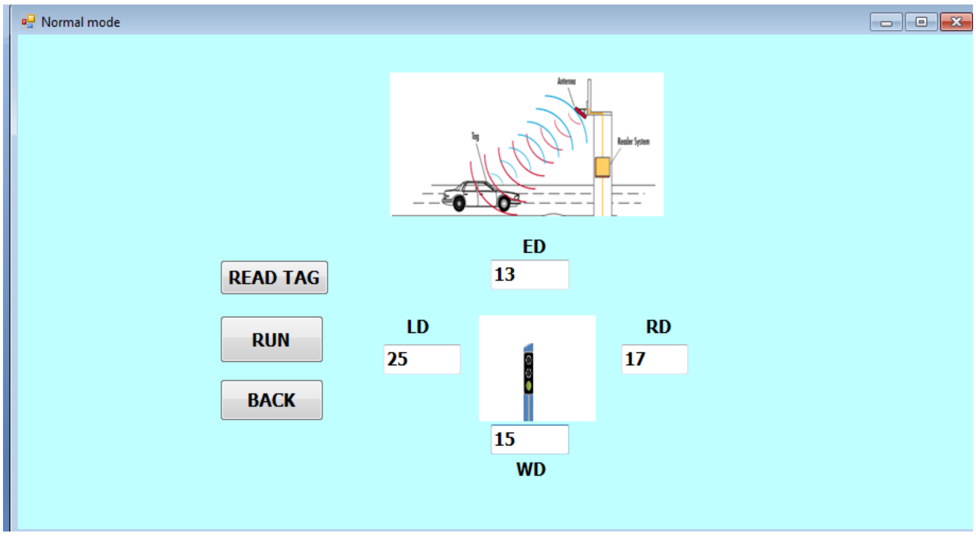


Figure: 4.12 Normal mode processes

3- Run the normal mode as explained in Figure 4.13 :(green signal run of the traffic direction)

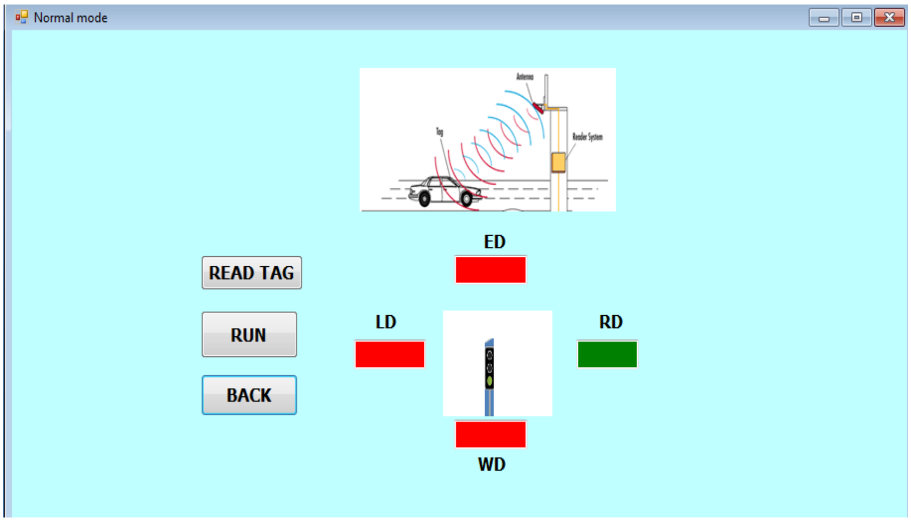


Figure 4.13: Normal mode executed

4.12 Steps to run emergency mode

1 – Choice Emergency mode operation from figure 4.11:. Also flow chart explains the operation of emergency on figure: 4.8.

2- Inter em for emergency figure 4.13: Emergency mode type em for operation mode

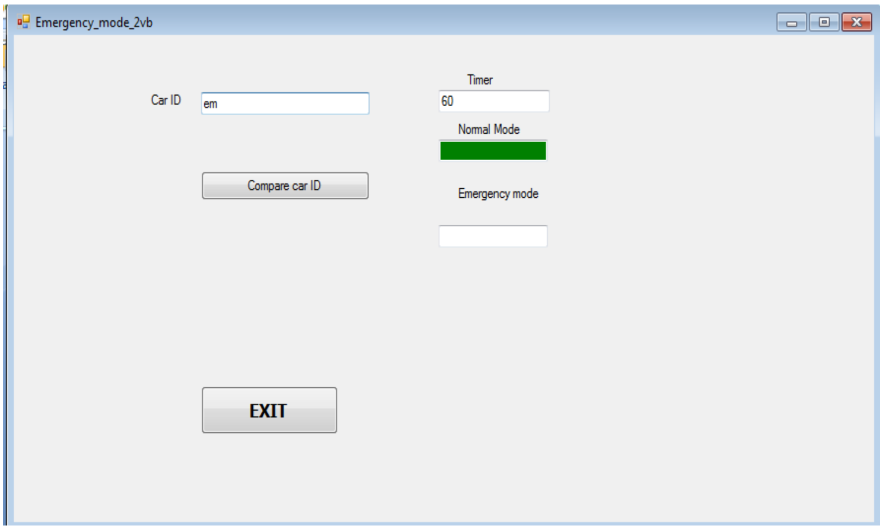


Figure 4.14: Emergency mode

3- Emergency mode executed figure 4.15:

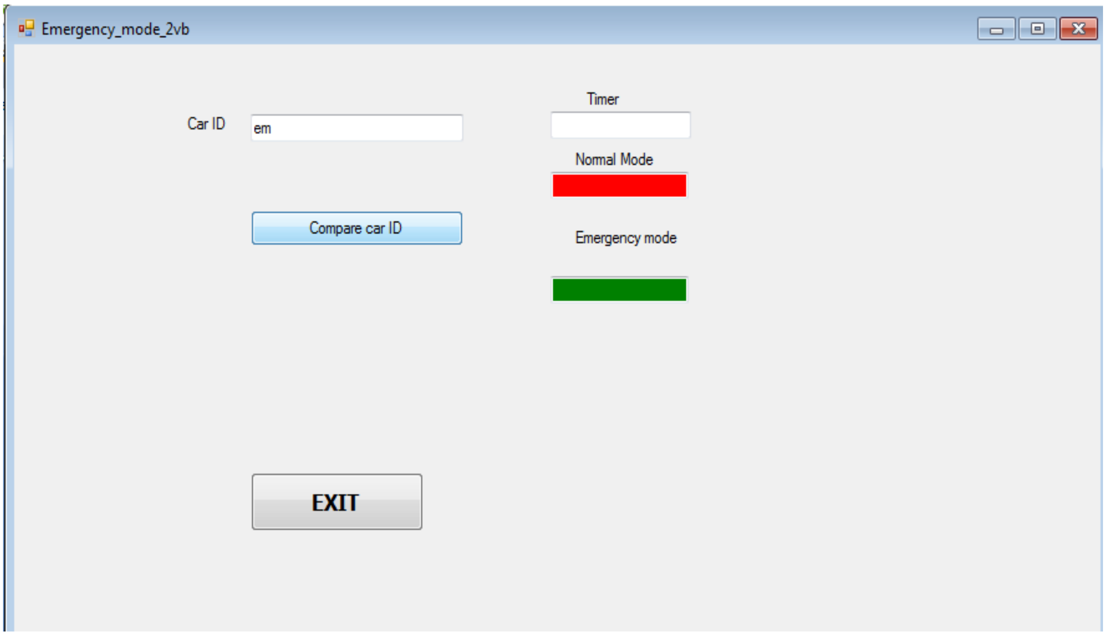


Figure 4.15: Emergency mode executed

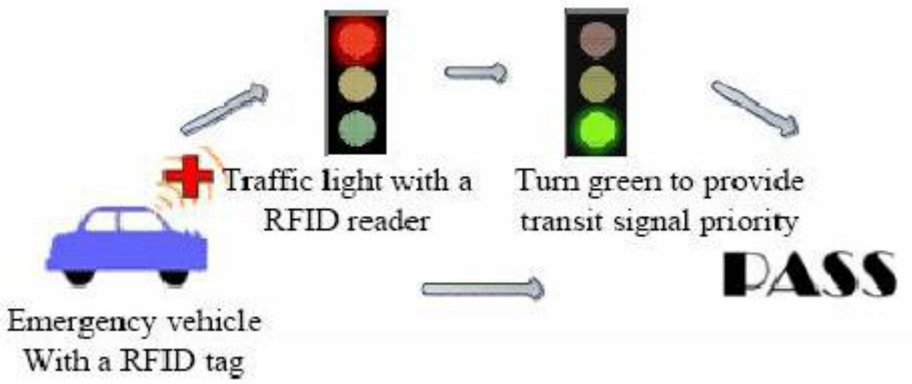


Figure 4.16: Emergency Vehicle Pass

4.13 Steps to run Adaptive mode

For effective and adaptive traffic light signals detection and congestion control, the System carries out the following steps:

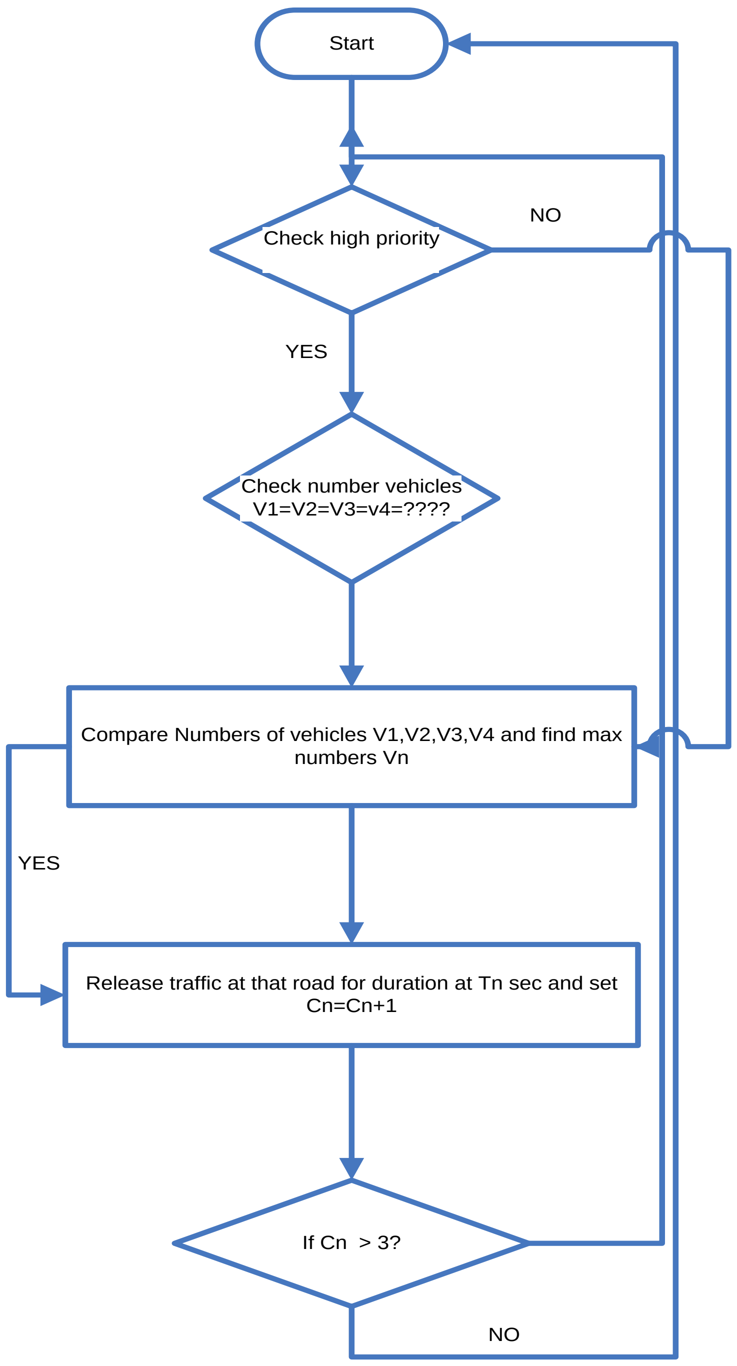
1. Since volume of traffic can fluctuate very rapidly, it is not possible to alter traffic signals based only on this factor. So, a minimum time is set for which traffic signal remains constant before checking for the volume of traffic again.

2. A maximum time is set after which a constant traffic signal must change irrespective of the volume of traffic. This is done to ensure no vehicle has to wait too long at the crossing.

3. Speed of vehicle is determined by the time taken for it to cover the distance between two readers. If speed of a vehicle is below a specified threshold, it is detected as congestion and the System notifies the preceding traffic signal about this. On receiving such information, traffic on that corresponding road is halted for certain duration to avoid congestion on the proceeding road. This step avoids accumulation of too many vehicles at any road leading to a junction.

4. Vehicles assigned higher priority is let immediately after the duration of Red signal at the corresponding road ends irrespective of the volume at other roads.

This working can be explained by the following flowchart figure 4.18:



Flowchart figure 4.17: for Adaptive mode

1 – Choice Adaptive mode operation figure 4.18:

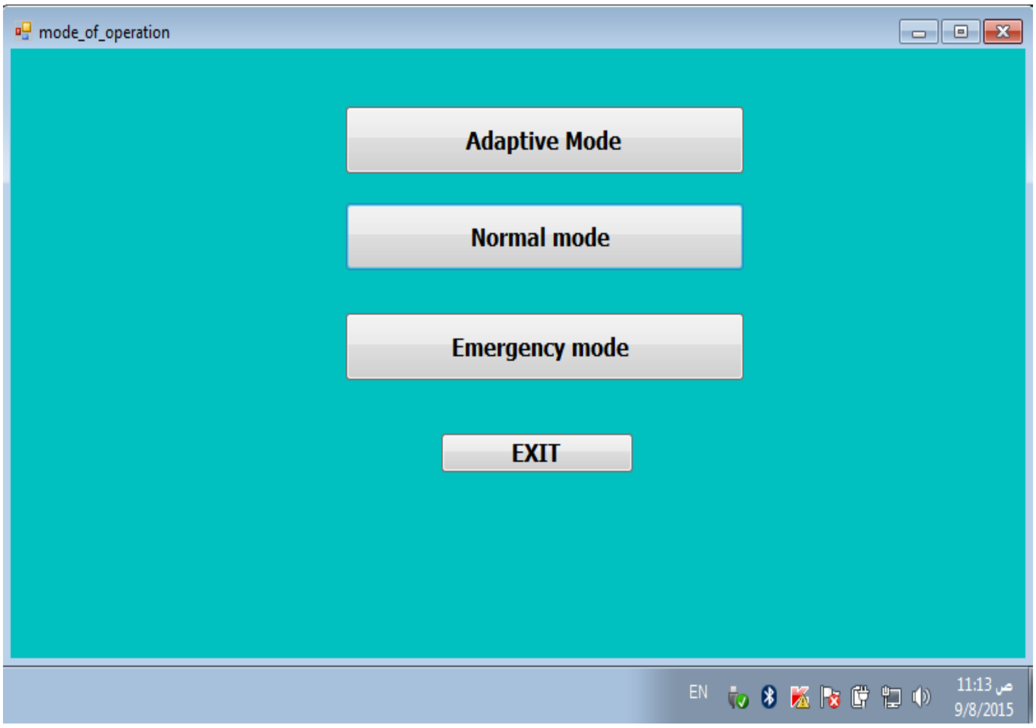


Figure 4.18: GUI for Adaptive mode

2- Inter numbers of vehicles from keyboard and press COPARE Vs button to run. Figure 4.18: for operation

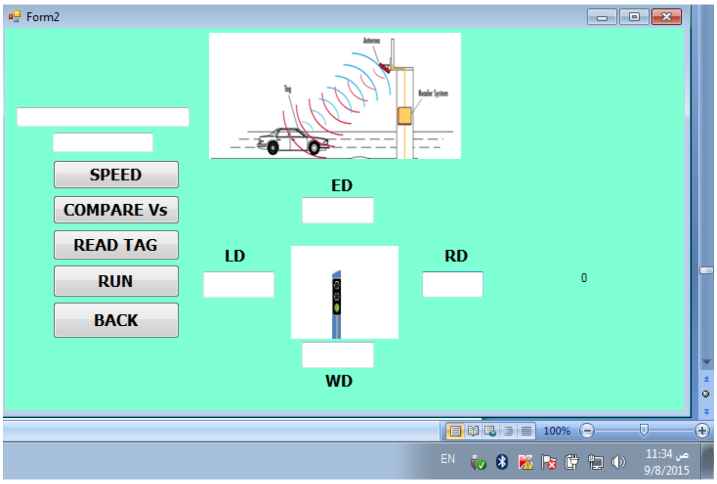


Figure 4.19: Operation Adaptive mode

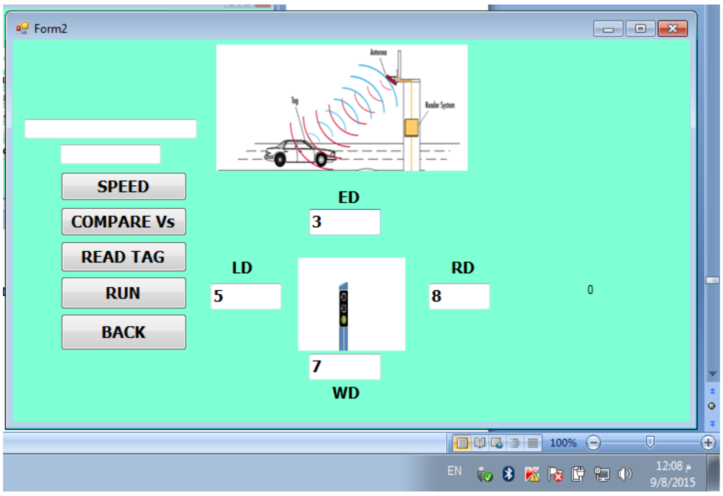


Figure 4.20: Numbers of vehicles on different lanes

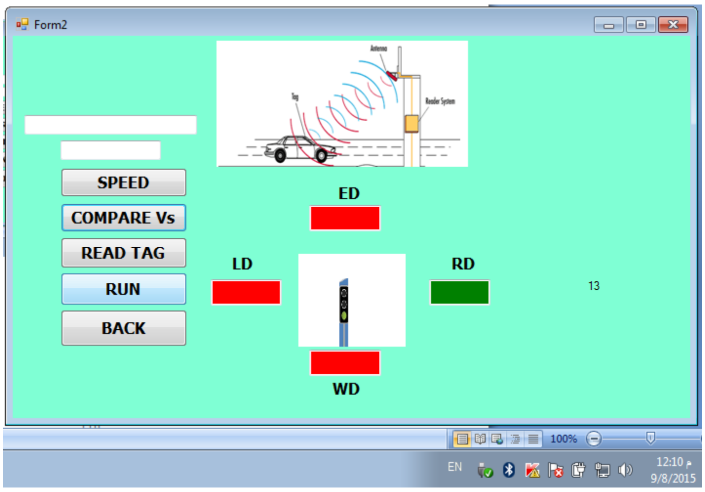


Figure 4.21: Comparing and open the green traffic light signal

2- Inter distance value example 10 and calculate average speed by equation a\b, a: constant value, b: random time .Also determined average number of vehicles.

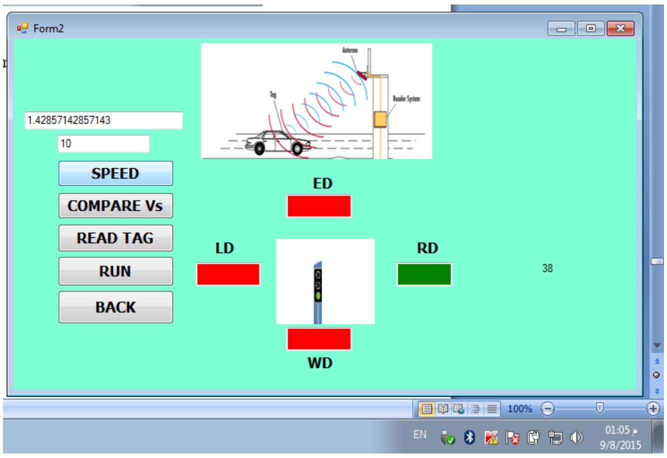


Figure 4.22: Speed calculating

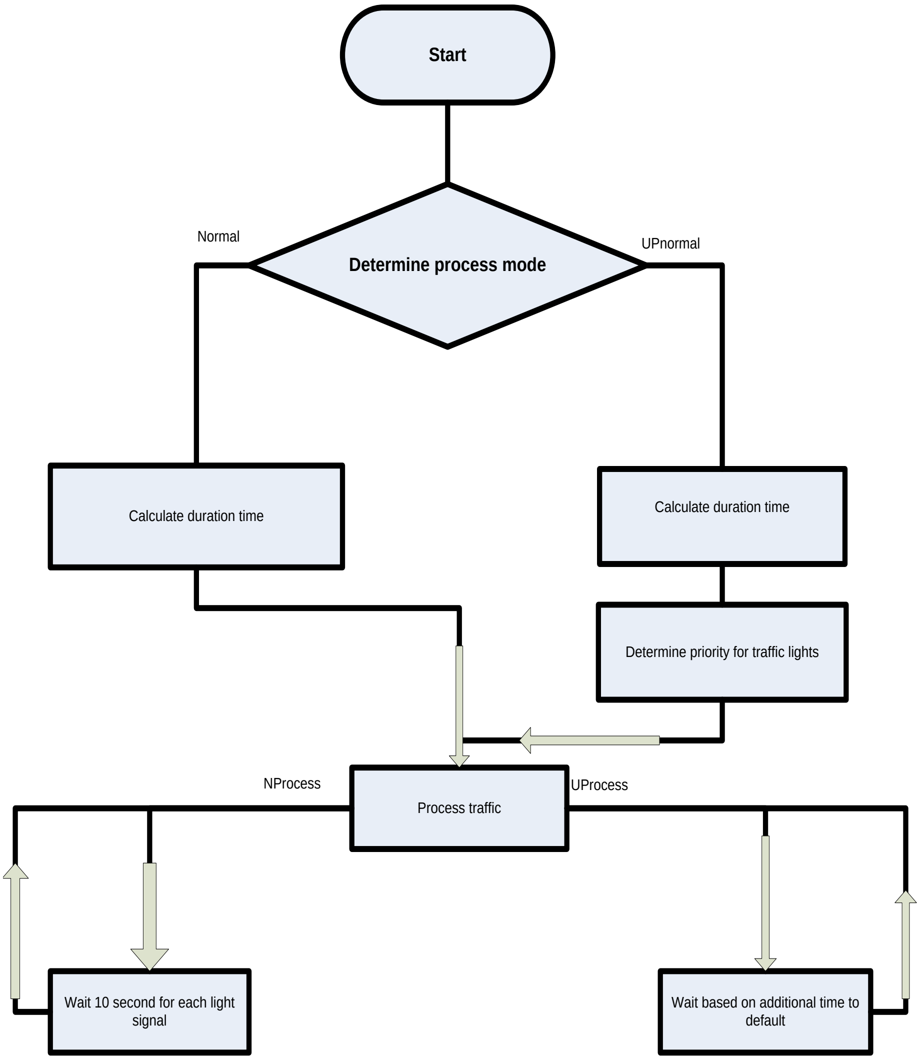


Figure 4.23: Flow chart adaptive mode(how to run on simulation)

Chapter Five

Conclusion and Recommendations

Chapter Five

Conclusion and Recommendations

5.1 Conclusion

In this research, an adaptive and Vehicle to Infrastructure communication system for efficient traffic management has been developed practically, more over the system has been tested in real life using RFID card &reader to emulate the number of cars (Normal cars as well as emergency)

The system successfully be laved as expected, by giving emergency cars highest priority while warring others ,fur than more the system control, the traffic signal in adaptive manner according to the congested direction .

More than that the design an adaptive traffic light control system,

make an algorithm that adjusts the red, green and yellow times efficiently between the busy and non-busy roads, thereby ensuring minimal traffic congestions and reduce congestion in Khartoum State city centers, save time for both drivers and passengers, there will be further improvement according to data collection which is already done in the product these improvements can be summarized as follows:

- Develop V2I active safety applications that address some of the most critical crash scenarios, including applications using the traffic signal phase and timing information that is sent to vehicles via a wireless network.

- Provide objective data and information that will support decision making among practitioners regarding nationwide infrastructure deployment.

In addition to that the work of the project there is some points deserve to point to such as: the importance of dividing the project to smaller modules as much as possible that would simplify the implementation in all aspects especially the hard one. Making sure that all communication is right, especially if using a development kit that is internally connected, and the circuit diagrams from a trusted resource. Simply you can remove and adding any module as needed, also maintenance has been easier.

5.2 Recommendation

The success of this project could be a good start and guidance in the future. In addition, it can increase the use of applications in wireless communications technology. Here are some suggestions that can be used to improve this system to be more effective in the future, namely:

Replacing the use of passive RFID active RFID system makes it more effective.

This is because active RFID reader signal covering an area larger than the Passive RFID. This system should be applied to roads in other areas and not just limited to low-speed region.

1. Using RFID tag reader can operate in all environmental conditions and not easily distracted tag ID signal caused by changes in weather such as rain and dusty road conditions.
2. Using the technology of other wireless systems such as GPS is more effective in controlling the speed of vehicles as they can determine more accurately the position of the vehicle. GPS has the advantage of direct communication with the satellite.
3. Replacing an audible signal to warn of VB2008 software voice signals to provide greater effectiveness to the driver of the vehicle.
4. This system also can combine with GPS system in order to give information to the driver. This system also can be upgrading by combining the system with engine car. At the same time when the system display the traffic sign, automatically will controlled the speed limit car.

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APPENDIX A

A1 Sample of the source Code (ATMEGA 32 and LCD) for explanation purposes /* you may need to modify it so that it can well functioning*/

```
$regfile = "m32def.dat"

$crystal = 8000000

$baud = 2400

Config Porta.0&portc as the  Output                              'led

Config Lcd = 16 * 2

Config Lcdpin = Pin , Db4 = Portb.2 , Db5 = Portb.3 , Db6 = Portb.4 ,
Db7 = Portb.5 , E = Portb.1 , Rs = Portb.0

Cursor Off

Locate 1 , 1

Lcd "**************"

Wait 1

Dim X As Byte

Dim S As String * 10

Config Timer1 = Timer , Prescale = 64

Enable Interrupts

Enable Timer1

On Ovf1 Rfid

Dim C As Byte

Cls

Start Timer1

Do

S = ""

cls

Locate 1 , 1

Lcd "     Ready"
```

```
X = Waitkey()

If X = &H0A Then

Do

X = Waitkey()

If X <> &H0D Then

S = S + Chr(x)

End If

Loop Until X = &H0D

End If

Locate 1 , 1

Lcd S

If S = "670037C22B" Then

C = 0

Timer1 = 0

Gosub Sig1

Locate 2 , 1

\\Lcd "Emergency Car" configuration

Sig1: loop configuration for signals and wait time
```

A2 VB CODE

```
Public Class Form1

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Button1.Click
        mode_of_operation.Show()
        Me.Hide()
    End Sub
    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Button2.Click
        If Val(RD.Text) > Val(LD.Text) And Val(WD.Text) And
Val(ED.Text) Then
            RD.BackColor = Color.Green
            LD.BackColor = Color.Red
            WD.BackColor = Color.Red
            ED.BackColor = Color.Red
            LD.Text = ""
            RD.Text = ""
            WD.Text = ""
            ED.Text = ""
        End If
        If Val(LD.Text) > Val(RD.Text) And Val(WD.Text) And
Val(ED.Text) Then
            LD.BackColor = Color.Green
            RD.BackColor = Color.Red
            WD.BackColor = Color.Red
            ED.BackColor = Color.Red
            LD.Text = ""
            RD.Text = ""
            WD.Text = ""
            ED.Text = ""
        End If
        If Val(WD.Text) > Val(LD.Text) And Val(RD.Text) And
Val(ED.Text) Then
            WD.BackColor = Color.Green
            RD.BackColor = Color.Red
            LD.BackColor = Color.Red
            ED.BackColor = Color.Red
            LD.Text = ""
            RD.Text = ""
            WD.Text = ""
            ED.Text = ""

        End If

            ED.BackColor = Color.Green
            RD.BackColor = Color.Red
            WD.BackColor = Color.Red
            LD.BackColor = Color.Red
            LD.Text = ""
            RD.Text = ""
            WD.Text = ""
            ED.Text = ""
        End If
    End Sub
```

A3 READ TAG

```
    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Button3.Click
        ED.BackColor = Color.White
        RD.BackColor = Color.White
        WD.BackColor = Color.White
        LD.BackColor = Color.White
        RD.Text = ""
        LD.Text = ""
        ED.Text = ""
        WD.Text = ""
        RD.Focus()
    End Sub
End Class
```

A4 EM FORM

```
Public Class Emergency_mode_2vb

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Button1.Click
        mode_of_operation.Show()
        Me.Hide()
    End Sub

    Private Sub Emergency_mode_2vb_Load(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles MyBase.Load
        tm.Text = Timer1.Interval

    End Sub

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Button2.Click
        If carid.Text = "em" Then
            nm.BackColor = Color.Red
            em.BackColor = Color.Green
            tm.Text = ""
        Else
            nm.BackColor = Color.Green
            em.BackColor = Color.White
            tm.Text = 60
        End If
    End Sub
End Class
```

A5 MAIN FORM

```
Public Class mode_of_operation

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Button1.Click
        Form1.Show()
        Me.Hide()
    End Sub

    Private Sub Button2_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Button2.Click
        Emergency_mode_2vb.Show()
        Me.Hide()
    End Sub

    Private Sub Button3_Click(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Button3.Click
        End
    End Sub
End Class
```