# Bluetooth Approach

# For

# Toll Tax Application

**A Thesis Report**
**Submitted in the partial fulfillment of the requirements**
**for the award of the degree of ME in Software Engineering**

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# CERTIFICATE

This is to certify that the thesis work entitled “Bluetooth Approach for Toll Tax Application” submitted by Sona Rani, in the partial fulfillment of the requirement for the award of the degree of Master of Engineering (Software Engineering), Thapar Institute of Engineering and Technology (Deemed University), Patiala, is a record of candidate’s own work carried out by her under my supervision and guidance.

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# ABSTRACT

The bluetooth wireless technology was created to replace the cables used on mobile devices with radio frequency waves. The technology encompasses a simple low-cost, low-power, global radio system for integration into mobile devices, which can form a quick ad-hoc secure “piconet” and communicate among the connected devices. This technology creates many useful mobile usage models because the connections can occur while mobile devices are being carried in pockets and briefcases. Therefore, there are no line-of-sight restrictions. Bluetooth technology operates at a short-range radio frequency (RF) and is capable of transmitting voice and data. The effective range of bluetooth devices is 32 feet (10 meters). Bluetooth transfers data at the rate of 1 Mbps.

The bluetooth specifications use frequency-hopping spread-spectrum technology, which entails the transmitter’s jumping from one frequency to the next at a specific hopping rate in accordance with a pseudo-random code sequence. Bluetooth wireless technology uses 79 hops per second displaced by 1 MHz, starting at 2.402 GHz and stopping at 2.480 GHz. Frequency hopping makes the transmission more secure and resistant to noise and fade. In spread spectrum technique used by bluetooth, the signal is taken apart or “spread” so that it sounds more like noise to the casual listener. Using the same spreading code as the transmitter, the receiver correlates and collapses the spread signal back down to its original form. With the signal’s power spread over a larger band of frequencies, the result is a more robust signal and it makes voice and data communications more secure.

In my thesis work, I have implemented the bluetooth technology in the application of toll tax system. In the current system the difficulties are time management, payment collection and processing, long queues and manual operations. These difficulties can be removed by implementing the system using bluetooth technology. This will make the system automatic, secure and easier to operate and maintain.

# CHAPTER 1
# INTRODUCTION

Bluetooth is a radio frequency (RF) specification for short-range point to point and point to multipoint voice and data transfer. Bluetooth has enabled to connect to wide range of computing and telecommunications devices without the need for proprietary cables that often fall short in terms of ease of use.

Bluetooth is a computing and telecommunications industry specification that describes how mobile phones, computers, and personal digital assistants (PDAs) can easily interconnect with each other and with home and business phones and computers using a short-range wireless connection. Using this technology, users of cellular phones, pagers, and personal digital assistants such as the Palm Pilot will be able to buy a three-in-one phone that can double as a portable phone at home or in the office, get quickly synchronized with information in a desktop or notebook computer, initiate the sending or receiving of a fax, initiate a print-out, and, in general, have all mobile and fixed computer devices totally coordinated.

Bluetooth requires that a low-cost transceiver chip be included in each device. The transceiver transmits and receives in a previously unused frequency band of 2.45 GHz that is available globally (with some variation of bandwidth in different countries). In addition to data, up to three voice channels are available. Each device has a unique 48-bit address from the IEEE 802 standard. Connections can be point-to-point or multipoint and can range maximum upto 10 meters exchanging data at a rate of 1 Megabit per second (up to 2 Mbps in the second generation of the technology). A frequency hop scheme allows devices to communicate even in areas with a great deal of electromagnetic interference.

## 1.1 Technology

Bluetooth wireless technology is implemented in tiny, inexpensive, short-range transceivers in the mobile devices, either embedded directly into existing component boards or added into an adopter device such as a PC card.

Bluetooth wireless technology used the globally available unlicensed ISM radio band of 2.4 GHz and 2.4 to 2.484GHz, which do not require an operator's license from the federal communication committee or any international regulatory authority. The use of a common frequency band waves that you can bring devices using the bluetooth specification virtually anywhere in the world and they will be able to link up with other such devices regardless of what country you happen to be visiting.

### 1.1.1 Types of Links

Asynchronous Connectionless Links (ACL): It support symmetric (maximum data rate is 433.9 Kbps for sending and receiving) or asymmetric (max. data rate is 723.2 Kbps for one direction and 57.6 Kbps for the other), packet-switched, point-to-multipoint connections, typically used for data. Synchronous Connection-Oriented Links provide symmetrical, circuit-switch, point-to-point connections, typically used for voice.

### 1.1.2 Adhoc Networking

A device equipped with a radio using the Bluetooth specification establishes instant connectivity with one or more other similarly equipped radios as soon as they come into range. When it comes to adhoc networking for data, a device equipped with a radio using the bluetooth specification establishes instant connectivity with one or more other similarly equipped radios as soon they come into range. Each device has a unique 48-bit Medium Access Control (MAC) address as specified in the IEEE 802 standards for LANs. For voice when a mobile phone using bluetooth wireless technology comes within range of another mobile phone with built in bluetooth wireless technology conversations occur over a localized point to point radio link.

Since the connection does not involve a telecommunications service provider, there is no per minute usage charge.

### 1.1.3 Voice over Bluetooth

The bluetooth specification allows telephone handsets built to conform to it to be used in three different ways.

First, telephones in the home or office may act as cordless phone connecting to the PSTN and incurring a per-minute usage charge.

Second, telephone using the Bluetooth wireless technology can connect directly to other telephones for the purpose of acting as "walkie-talkie" or handset extension (intercom) incurring no charges from the carrier.

Third, the telephone may act as mobile phone connected to the cellular infrastructure and incurring mobile phone charges.

### 1.1.4 Video over Bluetooth

The Bluetooth specification is capable of supporting video transmissions between devices. An IC developed by Toshiba supports video signal encoding and decoding in the MPEG-4 format with significant reductions in power consumption, making them suited for power-contained wireless applications, including those run on the third generation of mobile computing and communications products and devices using Bluetooth wireless technology.

### 1.1.5 Radio Link

The radio link itself is very robust, using frequency-hopping spread spectrum technology to mitigate the effects of interference and fading.

### 1.1.6 Security

The Bluetooth security architecture relies on PIN codes for establishing trusted relationships between devices. While not practical to go through all the combinations of uses of PIN codes, it should be noted that once a trusted pairing is established between devices, these codes could be stored within the device to allow more automatic/simple connections. The key to Bluetooth simplicity will be establishing the trusted relationship between commonly used devices. For random ad-hoc connections that require authenticated connections (such as ensuring you are connecting to who you think you are connecting to, something that is not always obvious with invisible radio waves), PINs would have to be exchanged (depending on how the devices are configured).

### 1.1.7 Frequency Range

Bluetooth operates in the 2.4 GHz range referred to as the Instrumentation, Scientific and Medical (ISM) band. This band provides license -free operation in the United States, Europe, Japan and most industrialized nations worldwide.

### 1.1.8 Power Requirement

The bluetooth specification limits the radio output power exactly to that actually required. For instance, the receiving radio indicates that it is only a few meters away, the transmitter immediately modifies its signal strength to suit the exact range. This feature dramatically reduces the radio's power consumption as well as its radio interference. Furthermore, the radio chip automatically shifts to a low-power mode as soon as traffic volumes becomes low or stops. The low power mode is only interrupted by very short signals with the purpose of verifying the established connection.

The radio with bluetooth wireless technology consumes less than a few percent of the power consumed with a modern mobile phone. The transmission mode is only used as necessary and always for the shortest possible period of time.

## 1.2 Goal

Bluetooth is the code name for the rapidly emerging global specification for wireless connectivity for mobile PCs, handheld computing devices, wireless phones, headsets, other wearable devices and computer peripherals including printers, in addition to human interface devices such as data pads and mice. Led by Intel, Ericsson, IBM, Nokia, and Toshiba, the Bluetooth Special Interest Group (SIG) was established to create a global specification for wireless communications interface and control software, in order to ensure device interoperability.

### 1.2.1 Open Specification

The SIG is now actively engaged in working out regulatory issues around the world. To encourage the widest possible deployment of the technology, Bluetooth is an open industry specification that will be made available to Bluetooth SIG members on a royalty-free basis. The growing momentum behind Bluetooth is indicated by the fact that the SIG recently enrolled its 500th member company.

To create a specification for the connection of mobile devices without cables, Intel and other SIG members needed to address three important issues:

➢ The relatively high cost of adding wireless communications capability to mobile computing devices;

➢ The need to adapt to the established usage models for mobile computing devices and phones-and the need for a device-independent, interoperable technology;

➢ The absence of a global wireless standard, with no one networking standard currently available worldwide.

The goal of the Bluetooth SIG is to deliver cable-free mobile devices at the right cost, the right size and the right power consumption. The concept of simply embedding a cellular phone within a mobile computer was rejected early on because of its prohibitively high cost, coupled with the fact that the 2-mile range of cellular phones is unnecessary. Most mobile computing devices are used within close proximity to existing networks in offices and homes-including LANs and Public Switched Telephone Network (PSTN) equipment. Network access points can provide Bluetooth radio links to mobile equipment.

### 1.2.2 Low-Power Frequency Hopping Radio

A low-power radio interface was chosen, operating on the globally available 2.45 GHz band. The radio air interface features nominal antenna power of 0 dBm and complies with FCC rules for the ISM band. Spectrum spreading is accomplished by frequency hopping, with 79 hops spaced by 1 MHz, between 2.402 GHz and 2.480 GHz. The frequency hopping rate is 1,600 hops/sec., and the nominal radio link range ranges up to 10 meters, although range can be extended up to 100 meters by increasing the transmission power.

It is estimated that integrating compliant radios into device will initially cost about $30 (USD) per unit. This includes the antenna and software components. It is expected that unit costs will ultimately drop to the vicinity of $10 (USD) or lower, depending on the partitioning, volumes, and certification requirements. The Bluetooth specification targets power consumption at 30 µA in "hold" mode to a transmitting range of 8-30 mA.

### 1.2.3 Voice and Data

The Bluetooth radio supports different transfer types for different needs. Both isochronous transfers for voice and asynchronous links for data applications are supported, and there are various error detection and correction schemes available. The asynchronous channel supports 721 Kbits/sec in either direction and 57.6 Kbits/sec in the return direction, or a symmetric link of 432.6 Kbits/sec. The voice channels each support links of 64 Kbits/sec. The system can support three simultaneous voice connections.

### 1.2.4 Making Mobile Devices More Useful

Bluetooth technology has been termed the "personal area network" because it will allow users of phones and mobile computing devices to use the Internet and other networking applications any time and anywhere they happen to be. For example:

- With Bluetooth technology, a single phone could serve a LAN-based intercom in the office, a portable phone at home and a mobile (cellular) phone on the road.
- Mobile PCs and handheld computing devices can be used to surf the Web via either a mobile phone link, PSTN, ISDN LAN.
- A cordless headset can keep users connected to a mobile PC, or to any wired connection.

For developers, the best way to learn more about Bluetooth technology is to join the 500 companies who have already become members of the Bluetooth SIG. They are about to provide "Connected PCs to go" at the right cost, the right size, and the right power consumption.

## 1.3 Features of Bluetooth

Bluetooth technology provides a 10 meter personel bubble that support simultaneous transmission of both voice and data for multiple devices. Up to 8 data devices can be connected in a piconet and up to 10 piconets can exist within the 10-meter bubble. Each piconet supports up to 3 simultaneous full duplex voice devices (CVSD).
The gross data rate is 1 MB/sec, but the actual data rates are 432 KB/sec for duplex transmission, 721/56 KB/sec for asymmetric transmission. A time division duplex scheme is used for full duplex transmission.
Version 1.0A of the bluetooth specification was completed and released July 28, 1999. Subsequently, the bluetooth SIG allowed for the publication of errata to the "original" specification, and version 1.0B was published in December 1999. In November 2000 the bluetooth SIG released version 1.1 of the bluetooth specification. PC card solutions and bluetooth devices have hit the market late 2000 and 2001.

## 1.4 Security

The way that the Bluetooth radio system is used in mobile devices and the type of data carried on these devices (e.g., a corporate mobile computer) makes security an extremely important factor. While most wireless systems will claim that being a spread spectrum radio provides security, the volumes projected for Bluetooth radios eliminate this barrier. As such, link layer and application layer security is part of the basic Bluetooth radio requirements.

At a link layer, the Bluetooth radio system provides Authentication, Encryption, and Key Management of the various keys involved. Authentication involves the user providing a Personal Identification Number (PIN) that is translated into a 128-bit link key that can be authenticated in a one- or two-way direction. Once the radios are authenticated, the link can be encrypted at various key lengths (up to 128-bits in 8-bit key increments). The link layer security architecture provides a number of authentication schemes and a flexible encryption scheme that allows radios to negotiate for key length. This is important, as radios from different countries will be talking to each other. Security policies in these countries will dictate maximum encryption key lengths. Bluetooth radios will negotiate to the smallest common key length for the link (for example, if a USA radio is enabled for a 128-bit encryption key and a Spanish radio is enabled for only a 48-bit encryption key, the radios will negotiate a link with 48-bit encryption key). The Bluetooth architecture also supports authorization of different services to upper software stacks. For example, when two computers have created a Bluetooth link to exchange business cards, authorization must be created to extend these services (such that one computer could not examine other services on that computer unless enabled to do so).

### 1.4.1 Security Architecture

The Bluetooth security architecture relies on PIN codes for establishing trusted relationships between devices. While not practical to go through all the combinations of uses of PIN codes, it should be noted that once a trusted pairing is established between devices, these codes can be stored within the device to allow more automatic/simple connections. The key to Bluetooth simplicity will be establishing the trusted relationship between commonly used devices. For random ad-hoc connections that require authenticated connections (such as ensuring you are connecting to who you think you are connecting to, something that is not always obvious with invisible radio waves), PINs would have to be exchanged (depending on how the devices are configured). Link layer security architecture is shown in figure(1.1)

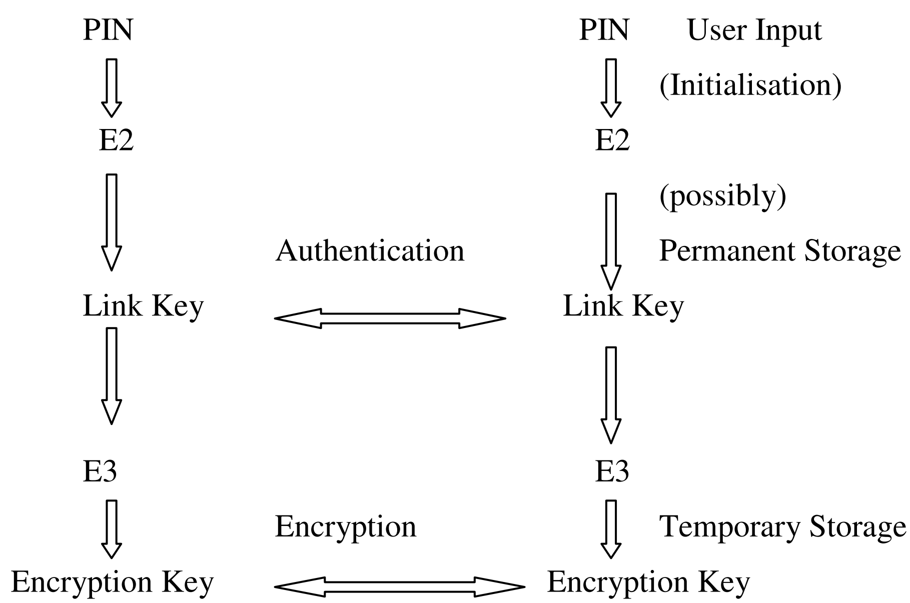



Figure 1.1 Link Layer Security Architecture

### 1.4.2 Security Levels

Bluetooth has several different security levels that can be defined for devices and services. All the devices get a status when they connect the first time to another device.

**Device trust level**

The devices can have two trust levels: trusted and untrusted. The trusted level requires a fixed and trusted relationship and it has unrestricted access to all services. The device has to be previously authenticated. The untrusted device does not have fixed relationship and its access to services is limited. An untrusted device can also have a fixed relationship, but it is not considered as trusted. A new device is labeled as unknown device and it is always untrusted.

**Security level of services**

When the connection is set there are different levels of security where the user can choose. The security level of a service is defined by three attributes:

**Authorization required**:

Access is only granted automatically to trusted devices or untrusted devices after an authorization procedure.

**Authentication required**:

Before connecting to the application, the remote device must be authenticated.

**Encryption required**:

The link must be changed to encrypted mode, before access to the service is possible. On the lower level the services can be not to be accessible to all devices. Usually there is a need for restrictions so the user can set the service so that it needs authentication. When the highest level of security is needed the service can require authorization and authentication. At this level trusted device has access to the services, but untrusted device needs manual authorization.

### 1.4.3 Security Modes

In the Bluetooth Generic Access Profile (GAP) the bed-rock on which all other profiles are based), 3 Security modes are defined:

**Security Mode 1**: non-secure

**Security Mode 2**: service level enforced security

**Security Mode 3:** link level enforced security

In Security mode 1 a device will not initiate any security - this is the non-secure mode. The essential difference between Security Mode 2 and Security Mode 3 is that in Security Mode 2 the Bluetooth device initiates security procedures after the channel is established (at the higher layers), while in Security Mode 3 the Bluetooth device initiates security procedures before the channel is established (at the lower layers).

At the same time **two** possibilities exist for Device's access to services:

**"Trusted Device" and "Untrusted Device".**

The trusted devices have unrestricted access to all services. The untrusted device doesn't have fixed relationships and its access to services is limited

**Link Level Security Parameters**

There are 4 entities used to setup/maintain the security at the link level

The Bluetooth device address (BD_ADDR), which is a 48-bit address that is unique for each Bluetooth device and defined and allocated by the IEEE.

Private link key, which is a 128-bit random number used for authentication purposes.

Private encryption key, 8-128 bits in length that is used for encryption.

A Random number (RAND), which is a frequently changing 128-bit random or pseudo-random number that is made by the Bluetooth device itself.

### 1.4.4 Key Management

There are several kinds of keys in the Bluetooth system to ensure secure transmission. The most important key of these is the link key, which is used between two Bluetooth devices for authentication purposes. Using the link key an encryption key can be derived. This secures the data of the packet and is regenerated for all new transmissions. Finally, although not a key there is the PIN code, which can be used to help identify devices to each other**.**

**Link Key**

There are four types of link keys possible. All the link keys are 128-bit random numbers and are either temporary or semi-permanent.

Unit key, "KA", is derived at the installation of the Bluetooth device from a unit "A".

Combination key, KAB, is derived from two units A and B. This key is generated for each pair of devices and is used when more security is needed.

The Master key, Kmaster, is used when the master device wants to transmit to several devices at ones. It over rides the current link key only for one session.

The Initialization key, Kinit, is used in the initialization process.

**Encryption Key**

Encryption key is derived from the current link key. Each time encryption is needed the encryption key will be automatically changed. The reason for separating the authentication key and encryption key is to facilitate the use of a shorter encryption key without weakening the strength of the authentication procedure.

**PIN code**

This is a user selected or fixed number, normally 4 digits in length, but it can be anything between 1 to 16 octets. The user can change it when it wants to and this adds security to the system. The PIN can be used entering it into one device (fixed PIN), but it is safer to enter it to both units.

**Key Generation and Initialization**

The exchange of the keys takes place during an initialization phase, which has to be carried out separately for each two units that want to implement authentication and encryption. All initialization procedures consists of the following (Figure 1.2)

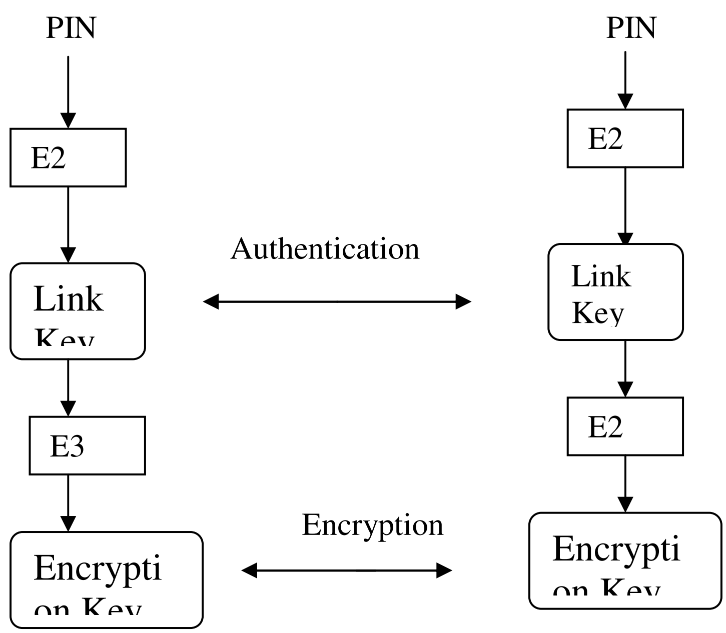



Figure 1.2 Key Control

- ❖ Generation of an initialization key
- ❖ Authentication
- ❖ Generation of link key
- ❖ Link key exchange
- ❖ Generating of encryption key in each unit

After this procedure the link is either built or aborted.

### 1.4.5 Authentication

The Bluetooth authentication scheme is essentially a challenge-response strategy, where a 2-move protocol is used to check whether the other party knows a shared identical secret key (a symmetric key). Basically the protocol checks that both devices have the same key, and if they do authentication is successful. also during the authentication procedure , an ACO value (Authenticated Ciphering Offset) is generated and stored in both devices. This ACO value is used (in a roundabout way) to generate the encryption key later on.

The Authentication scheme works as follows (figure 1.3).

Step 1 The verifier sends the claimant a random number to be authenticated.

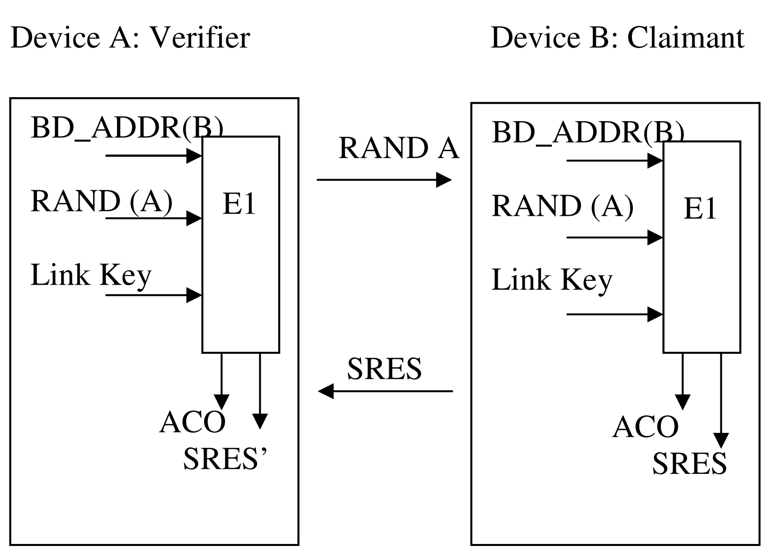


Figure 1.3 Description of The Authentication Process

Step 2 Both verifer+claimant use the authentication function E1 with the RAND (random number), the claimants BD_ADDR and the current link key to get a response.

Step 3 The claimant sends the response to the verifier, who then makes sure the responses match.

This application indicates who is to be authenticated. Note this means that the verifier may not necessarily be the master, as some of the applications may require only one way authentication, (only one party is authenticated), rather than mutual authentication. If the authentication fails, there is a period of time (the waiting time) that must pass until a new attempt at authentication can be made. This can subsequently increase or decrease depending on the results of previous authentication attempts (until preset timers have been exceeded).

### 1.4.6 Encryption

The Bluetooth encryption system systematically encrypts the payload of each packet. (figure 1.4 )This is done with a stream cipher E0, which is re-synchronized for every payload. The E0 stream cipher consists of 3 elements:

First the payload key generator combines the input bits in an appropriate order, then it shifts them to the 4 LFSR (Linear Feedback Shift Registers) of the key stream generator.

There are several encryption modes available (depending on whether a device uses a semi-permanent link key or a master key). If a unit key or a combination key is used, broadcast traffic is not encrypted. Point-to-point traffic can be either encrypted or not. If a master key is used, there are three possible modes. In

**Encryption mode 1,** nothing is encrypted.

**Encryption mode 2,** point-to-multipoint (broadcast) traffic is not encrypted, but point-to-point addressed traffic is encrypted with the master key.

**Encryption mode 3**, all traffic is encrypted with the master key.

As the encryption key size can vary from 8 to 128 bits, the size of the encryption key used between the two devices must be negotiated, with either device (master and slave) proposing, or rejecting each other's key size suggestion.

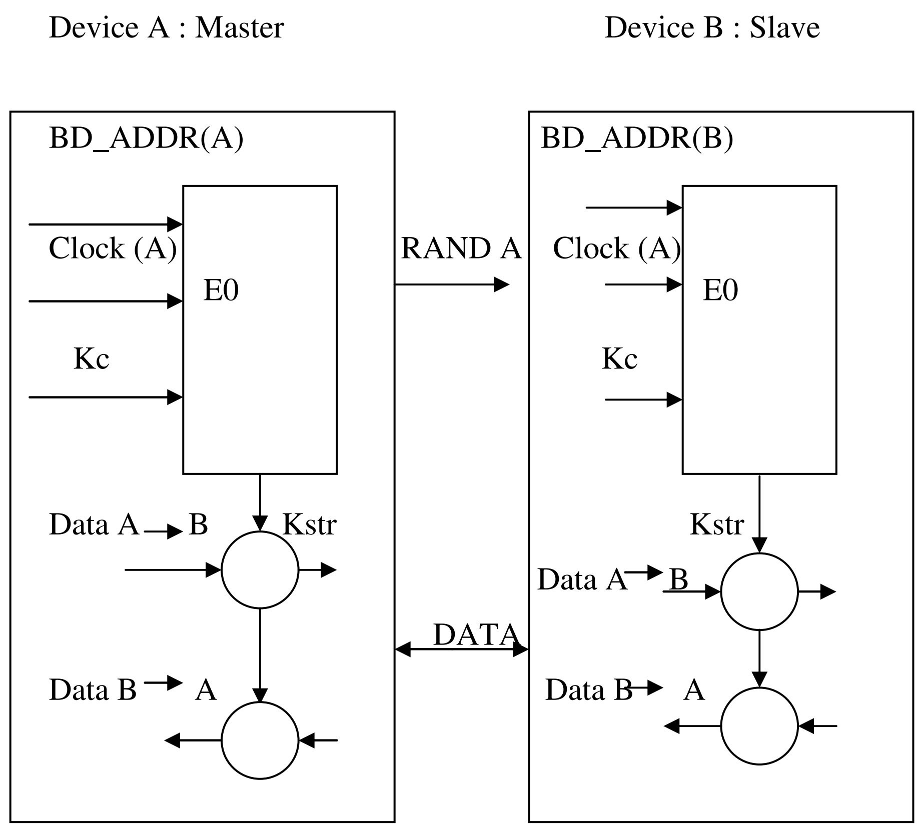



Figure 1.4 Description of The Encryption Process

Some boundaries are placed on the negotiation though. In each device, there is a parameter defining the maximum allowed key length. Also in every application there is a defined minimum acceptable key size, and if this min key size requirement is not met by either of the participants in the (encryption) key size negotiation, then the application aborts the negotiation and the encryption cannot be used. This is required due to the possibility that a malicious device could force a lower encryption setting to do harm.

### 1.4.7 Applications

Bluetooth technology was designed to be small and inexpensive. Bluetooth technology has no line of sight requirements making it a potential replacement for infrared ports. Bluetooth can operate through walls or from within your briefcase. Portable PCs can wirelessly connect to printers, transfer data to desktop PCs or PDAs or interface with cellular phones for wireless can access to corporate networks or the internet.

In the office and on the road, Bluetooth eliminates cabling and provides added mobility. Users no longer have to cable a cell phone to a handheld of notebook computer. Users no longer have to keep the computer and cell phone aligned to maintain a connection using the infrared port. Bluetooth allows users to leave the cell phone in a briefcase and still make that connection back to the office to update their calendar or to the Internet for the latest stock quote. Bluetooth allows the mobile computer to synchronize with our desktop computer when the mobile computer is dropped off on the desk. Designed to be an extremely low cost technology, other peripherals are likely to contain bluetooth such as fax machines, cameras alarm system and virtually any other electronic device. Unlike other technologies available today, bluetooth is designed to be a bubble of connectivity that moves with you. Incorporating bluetooth into these other peripherals allows you to just walk up to the machine and use it services or for it to detect your presence and initiate a pre determined program or routine.

**Cable Replacement**

Bluetooth enables the users to connect a wide range of computing and telecommunications devices easily and simply, without the need to buy, carry or connect many proprietary cables. It delivers opportunities for rapid ad hoc connections, and the possibility of automatic, unconscious connections between devices. It increases your freedom by connecting your mouse or the keyboard wirelessly to your computer.

**Simultaneously Linked Devices**

By installing a Bluetooth network in your office you can do away with the complex and tedious task of networking between the computing devices, yet have the power of connected devices. No longer would you be bound to fixed locations where you can connect to the network. Each Bluetooth device could be connected to 200 other devices making the connection of every device with every other possible. Since it supports both point to point and point to multipoint it will virtually make the maximum number of simultaneously linked devices unlimited.

**The Internet Bridge**

We can use the laptop to surf the internet wherever you are and regardless if you are cordlessly connected through a mobile phone( cellular) or through a wire-bound connection.

**The Automatic Synchronizer**

Automatic background synchronization keeps you up to date - automatic synchronization of your desktop, portable PC, notebook (PC- PDA) and your mobile phone is made easier with bluetooth. For instant, as soon as you enter your office the address list and calendar in your notebook will automatically be updated to agree with the one in your desktop or vice versa.

**Instant Transfer of Documents**

Connect all participants for instant data exchange in meetings and conferences, you can share information instantly with all participants, and without any wired connections. You can also cordlessly run and control for instant a projector, this is not officially supporting in the 1.0 specification, but other companies are working on this application.

**The Instant Postcard**

Send instant photos and video clips from any location wirelessly connect your camera to a portable PC. Add comments and send them instantly to a receiver anywhere in the world

**Still Video Images**

If your digital cameras in Bluetooth enabled, you can send still or video images from any location to any location without the hassle of connecting your camera to the mobile phone on the wire-line phone.

**Three Way Phone**

Bluetooth allows us to have three way phones. At home, your phone functions as a portable phone (fixed line charge). When you're on the move, it functions as a mobile phone (cellular charge). And when your phone comes within range of another mobile phone with built-in Bluetooth wireless technology it functions as a walkie-talkie (no telephony charge).

**The Cordless Computer**

Connect your portable PC to a peripherals or to the LAN- bluetooth enables a cordless connection of your portable PC to printers, scanners and to the LAN. Increase your sense of freedom in everyday work by cordless connection of your mouse and keyboard to your portable PC.

**Automatic Message Delivery**

Compose e-mails on your portable PC while you're on an airplane. As soon as you've landed and switched on your mobile phone, all messages are immediately sent.

**Email while PC is Still in the Briefcase**

When your portable PC receives e-mail, you will get an alert on your mobile phone. You can also browse all incoming e-mails and read those you select in the mobile phone's display.

# CHAPTER 2

# BLUETOOTH IN TOLL TAX APPLICATION

## 2.1 Toll Tax System

Through the toll tax system, the government has implemented the rule to collect the road tax on the highways. The purpose of this tax is to invest this collected money to improve the condition of roads. The amount of tax is different for the different type of vehicles. The toll tax amount at different toll tax checkpoints is also different from another station. For example the toll tax amount at the Shambu toll tax station for the car/van /jeep is Rs 30.00, light commercial vehicle is Rs 55.00, heavy construction Machinery & heavy construction machinery & Earth moving equipment is Rs 225.

## 2.2 Problems in Existing System

In the existing toll tax system, I have observed the following limitations. The very first is the mismanagement of time. In this system when one vehicle reaches at the station, the employees there first take the payment for the toll tax from the owner and then the operator at the computer feeds the amount, vehicle number and other information etc. in the computer and then gets the printed slip from the computer and give it to the owner. During this period, there may be a long queue for the payment of toll tax. Due to this problem, the traffic system may be disturbed.

The next problem which I have observed is that there may be the case when one vehicle may pass through the station without giving the toll tax due to the negligence of the employees or may be due to more manual load. The last problem which may be considered is that the payment in cash which is collected, the proper attention is given to deposit the amount to the government and risk of cash at the toll tax stations and security forces are there for this purpose.

## 2.3 Why Bluetooth

In the existing system due to above limitations and problems, I have proposed the bluetooth technology for the same. In the bluetooth system, the very first is that the system will become automated and time management will be done efficiently and also the cash problems will be removed. Due to its inquiry procedures, nobody will escape from the paying the toll tax and the problem of long queues and traffic blockages will be removed. Moreover the bluetooth chip is not so much costly and the people can afford it easily.

In the new design, we require that bluetooth chip be included in each vehicle and at every toll tax station, the bluetooth transmitter and receiver will be there, the credit card system should be there and also the toll tax stations must have collaboration with the credit card system with the networking.

## 2.4 Functionality of New Toll Collection System

As part of my thesis work, I have given the idea of implementing the bluetooth technology in the application of toll tax system. In this system I have seen the difficulty of payment systems and long queues and manual system. By introducing the bluetooth technology, we can make this automatic and easier system. The bluetooth chip should be included in each vehicle and these addresses should be stored in the database of toll tax system. When a vehicle will come within the range coverage area the computer will give a signal and the net balance of amount of the prepaid system will be shown on the screen. According to the vehicle (scooter, car, jeep, bus, truck etc) toll tax amount the accounts will be updated. The amount system should be prepaid . If the balance of a vehicle will be lesser than the amount required, a red signal will be given for the alert and cash on the spot will be received as shown in Figure 2.1. In this application we can solve the problem of mismanagement of time and problem of long queues and problem of maintenance of accounts. When the vehicle will come within the range of bluetooth receiver installed at the toll tax stoppages, the database at the receiver will be checked and registration of the passing vehicles will be done after deducting the amount from the prepaid account of that vehicle otherwise a red alert signal will be sent.

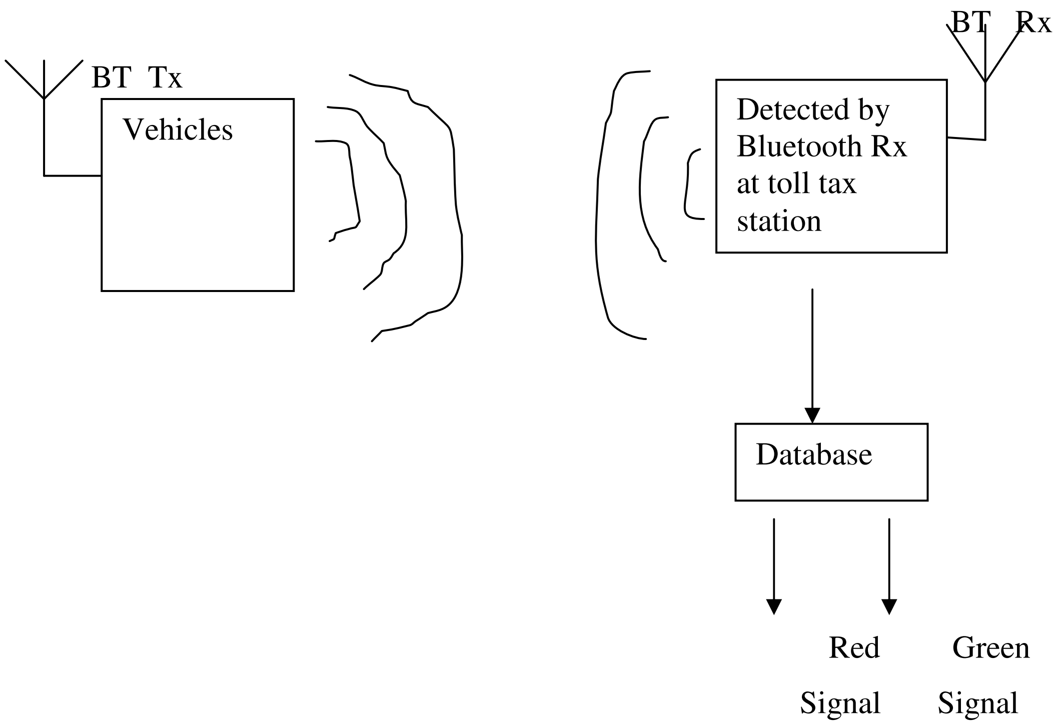



Figure2.1 Functionality of the system

In the traffic management, the database contains the information about the vehicles, their type, owner, vehicle no, credit card no etc as shown in figure 2.2. Road patrol will give the indication if some rules and regulations of the traffic system is not followed, peripheral services will contain the extra queries from the customer about the system. In this system before billing of the vehicles, the rating of the amount of tax is done and payment will be deducted from the card.Flow chart of the system is shown in figure 2.3.

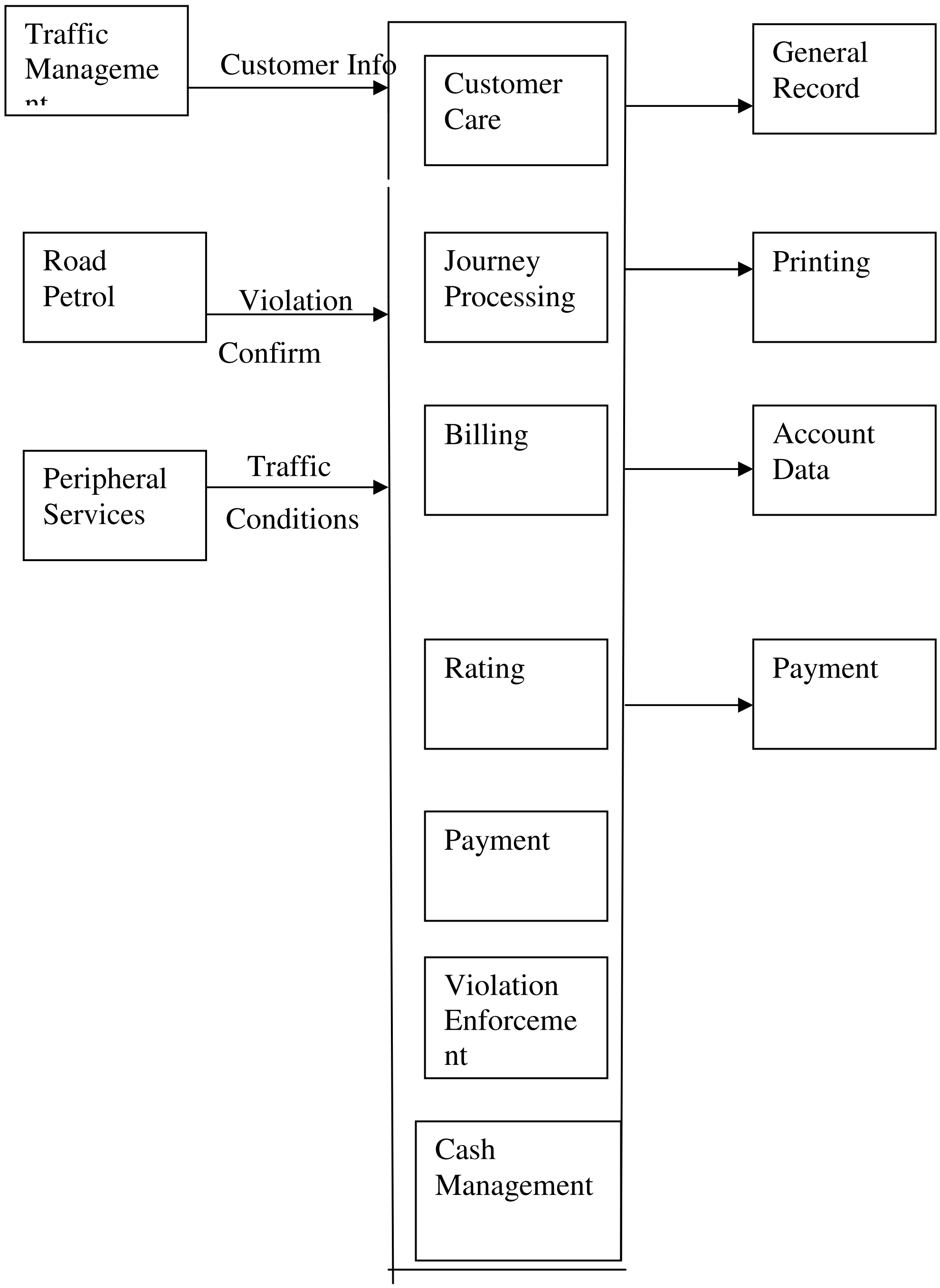



Figure2.2 Operational Model of the Toll Tax System

## Algorithm of Functionality

- ✓ Input: Vehicle Number, Type, Toll Tax Amount, Credit Card Number, Balanced Value, Name of the owner, etc.
- ✓ Range Detected
- ✓ If vehicle is detected, search out vehicle number in database.
- ✓ If it exist in then update the amount of credit card and give the green signal
- ✓ If it does not exist then alert by displaying red signal
- ✓ If the balance is not equal to or greater than the toll tax amount then also give red signal

**Flow Chart**

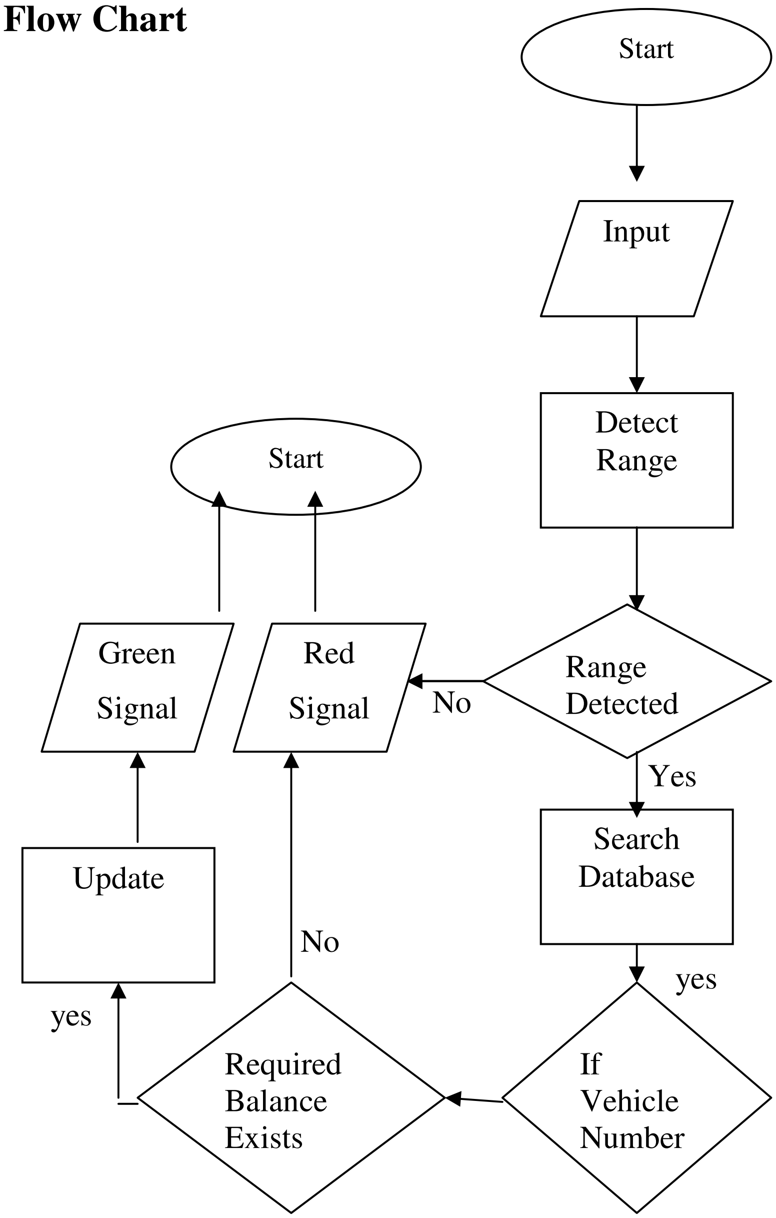



Figure2.3 Flow Chart of the Toll Tax System

## 2.5 Connection in the Bluetooth Based Toll Tax System

**Piconet Concept**

Bluetooth nodes that are in range of each other can set up an ad hoc connection forming a so-called piconet. For the communication between nodes a frequency hopping radio is used with a hopping rate of 1600 hops/s. Time is divided into 625 µs intervals, which are called slots. In each slot different hop frequency is used. Consecutive slots are alternately used for transmission and reception. Nodes participating in a piconet share the same physical channel. One of the units of a piconet becomes the master of the piconet, all others become slaves. Only one master can exist in a piconet at any time, but there can be up to seven active slave devices. The nodes can change the master and slave roles.

Every unit in the piconet uses the master identity and clock to follow the hopping channel by selecting the appropriate frequency used in the corresponding slot. To generate the master's clock in a slave node, the slave adds an offset to its own native clock (Figure 2.4).

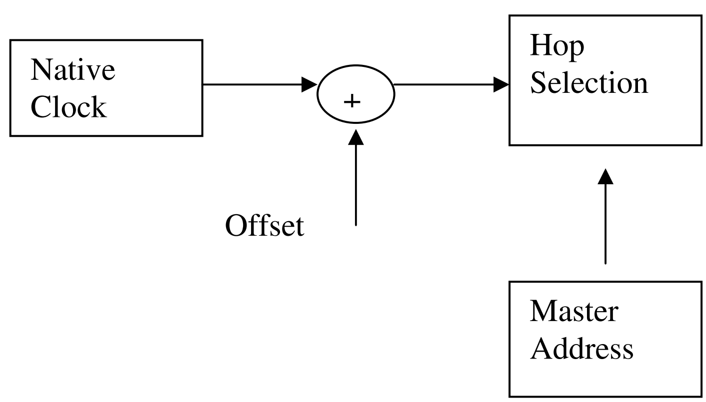



Figure2.4 Hop Frequency Selection

A time division duplex (TDD) scheme is used where the master and slave alternately transmit. Master starts transmissions only in even, slave only in odd numbered time slots.

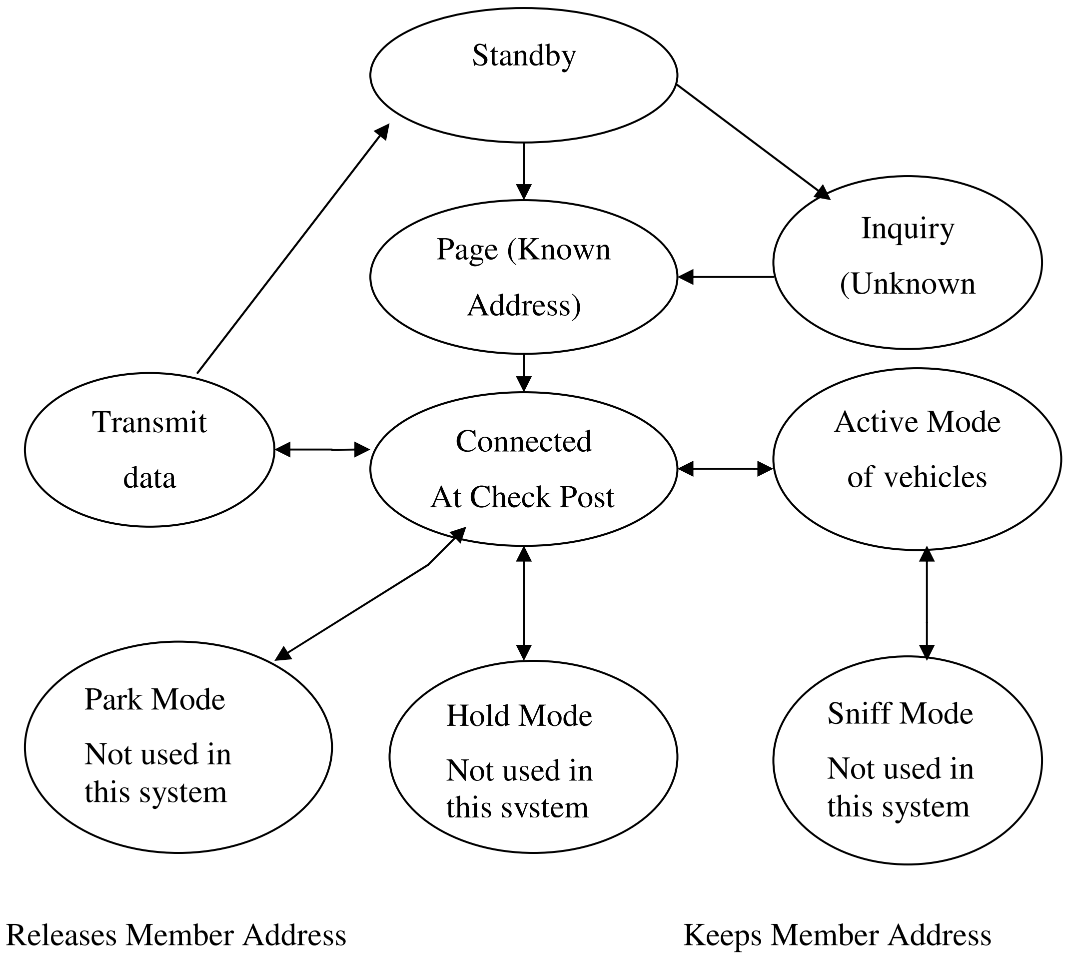



Figure 2.5 Connection –State Machine

A bluetooth unit leaves the standby or the connection state periodically to do inquiry or inquiry scan. Inquiry procedures enable a unit to discover which units are in range and their device addresses and clocks. When the unit wishes to establish a connection with one of the other bluetooth unit in range it initiates a paging procedure. At the end of this procedure both units are in the connection state as either a master or a slave.

In this application when the bluetooth device at the check-post of the toll tax station sends its inquiry messages, the devices which are in range, sends the reply and the connection is made between them after paging procedure.

In this the inquiry is mandatory, the bluetooth device at the toll station always needs to discover the vehicles in range.

There are four processes of inquiry and paging ( as shown in figure 2.5)

1. Inquiry
2. Inquiry scan
3. Paging
4. Paging scan

In inquiry processes, naturally several units might respond to an inquiry at the same time, so there must be a procedure for slave inquiry response in order to avoid or minimize the probability of collisions. When the vehicle receives an inquiry message it will generate a random number between 0 and 1023 , freeze the current input value to the hop selection scheme, then returns to connection or standby state for duration of random slots. The period of inquiry scan can be 0s (continuous scan)-R0,1.28S, R1 mode or 256S-R2 mode. In this system, we use continuous scan i.e. R0 mode because at any moment of time, any vehicle can come. The receiver of the scanning device listens on a single frequency (toll tax station) determined by the inquiry scan hopping sequence and the current value of the device's clock. The scanning device changes its listening frequency, according to inquiry hopping sequence, every 1.28s. When the master at the check-post wants to make a connection to the vehicles in range, it pages that unit. Paging means sending an ID packet with a certain DAC in it over and over again until a response is received. The master does not know exactly when the slave wakes up and on which hop frequency, therefore it transmits a train of identical DACs at different hop frequencies and listens in between for responses. The master uses the slave's BD_ADDR and an estimate of the slave's clock to determine the page hopping sequence. To compensate for the uncertainty in the knowledge of the slave's clock, the master will send its page message during a short –

time interval on a number of wake-up frequencies. During each transmission slot the master sequentially transmits on two different hopping frequencies. After the paging procedure, the master at the toll tax station must poll the slaves by sending POLL or NULL packets, to which the slave responds.

## 2.6 Routing in Toll Tax Application

Sending a packet to all destinations simultaneously is called broadcasting. In this application, we can use the broadcast routing, because we have to send messages to all the destinations. When a message or signal is to be sent to the vehicles from the toll tax station it is easy to send the desired message by the broadcasting method. But if we want to make the queries from the specific vehicle (device), then the unicast routing can be used i.e. the receiver will response to the device only which has asked and moreover if we use the CDMA, it will be better because in CDMA only the desired receiver will understand the message, whether it is sent by the broadcasting method. The key to CDMA is to be able to extract the desired signal while rejecting everything else as random noise.

CDMA allows each station to transmit over the entire frequency spectrum all the time. Multiple simultaneous transmissions are separated using coding theory. In CDMA each bit time is subdivided into m short intervals called chips. Typically there are 64 or 128 chips per bit, increasing the amount of information to be sent from bits/second to mb chips/second can only be done if the bandwidth available is increased by a factor of m, making CDMA a form of spread spectrum communication. With CDMA, each station uses the full bandwidth.

CDMA is typically used for wireless systems with a fixed base station and many mobile stations at varying distances from it. The power levels received at the base station depend on how far away the transmitters are. A mobile station receiving a weak signal from the base will use more power than one getting a strong signal.

In this application I have implemented a protocol for routing in Bluetooth scatternets. The protocol uses the available battery power in the Bluetooth (BT) devices as a cost metric in choosing the routes.

I have devised two techniques, namely

a) Battery power level based master-slave switch
b) Distance based power control, to increase the network lifetime in scatternets.

The master-slave switch technique is motivated by the fact that a piconet master has to handle the packet transmissions to/from all its slaves, and hence may drain its battery soon. I propose a role switching idea where each bluetooth device in a piconet may have to play the master role depending on its available battery power ( as shown in Figures 2.6 and 2.7 ).

In the second technique, I propose that the bluetooth devices choose their transmit powers based on their distances from their respective masters. A considerable gain in network lifetime can be achieved using these two techniques.

**First Technique- Battery Level Based Master-Slave Switch**

The master-slave switch technique is motivated by the fact that a piconet master has to handle the packet transmissions to/from all its slaves. If we consider all the devices in the scatternet, including the piconet masters, to operate on, then the masters may drain their batteries sooner than the slaves. The slaves may have substantial residual battery energy after the master runs down its battery completely.

In order to achieve a more uniform residual battery energy profile and to increase the network lifetime, I propose a role switching idea where each BT device in a piconet may have to play the master role depending on its available battery power. That is, a master in a piconet is dynamically chosen based on the available battery power. The proposed available battery level based master-slave switch procedure is described as follows. The current master at the toll tax station in a piconet periodically monitors its own as well as its slave's available battery power levels. If its own battery power is less than a fraction of the maximum available battery power amongst its slaves, then it initiates a master slave switch procedure with the slave having the maximum battery power.

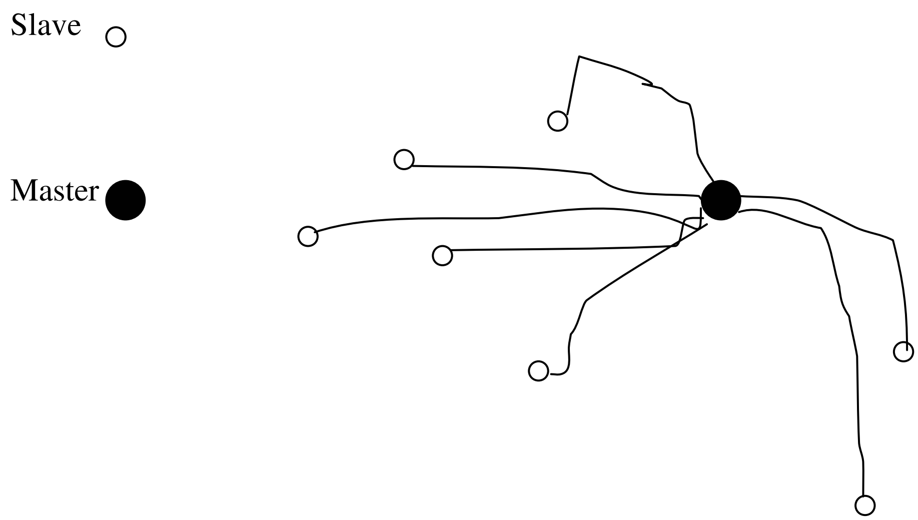



Figure 2.6  Master Slave Switch-A

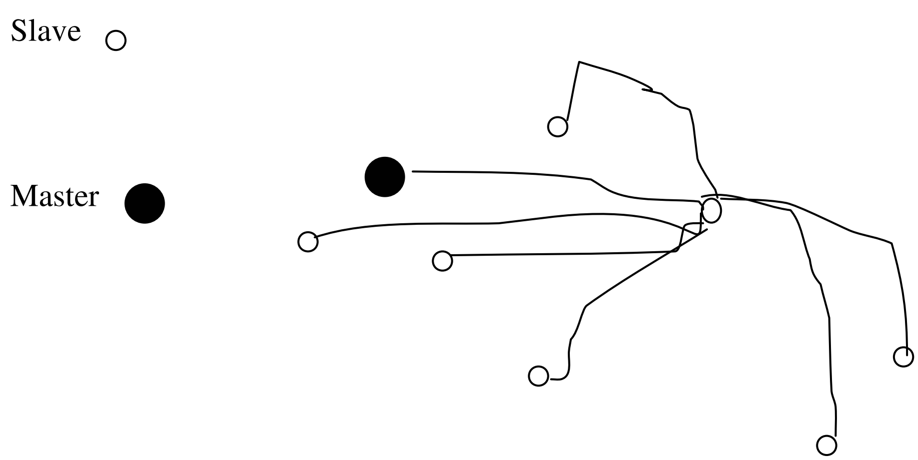



Figure 2.7  Master Slave Switch-B

The slave then assumes the role of the master, and informs all the devices about the role switch. The new master then will start periodically checking for the master-slave switch criterion to be satisfied. When the criterion is satisfied another master-slave switch would occur. This process will continue. It is noted that a finite time gets elapsed in completing a master-slave switch. frequent master-slave switches can thus degrade the system performance. In this study, we assume that all the nodes in a piconet are within listening distance of each other so as to avoid reconfiguration of the topology every time a switch takes place.

**Second Technique- Distance Based Power Control**

Power control can be used not only to reduce interference but also to extend the life of battery in a device. The standards define three power classes each with a different power transmits range. Transmit power step sizes in the range 2 to 8 dB have been specified. I have choosen the transmit power of the master/slave based on the distance, d, between the master and the slave (as shown in figure 2.8). It is assumed that the distance between a master and a slave is known both to the master and the slave.

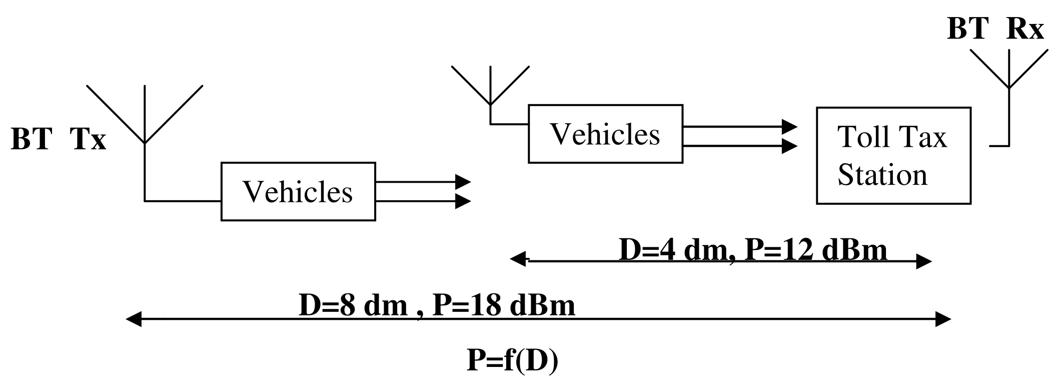



Figure 2.8 Distance Based Power Control

I devise the power control strategy in such a way that the transmitter chooses its transmit power based on distance, according to following Table 2.1 and Figures 2.9 & 2.10 shows the relationship between distance and power as the Bar chart representation and in the Graphical way respectively.

**Table 2.1 Distance Based Power Requirement**

| Distance, d (m) | Tx. Power |
|---|---|
| d <1 | 0 dBm |
| 1 < d <2 | 6dBm |
| 2 < d <4 | 12 dBm |
| 4 < d < 8 | 18 dBm |
| 8 < d < 10 | 20 dBm |

## Bar Chart of Distance Based Routing Method

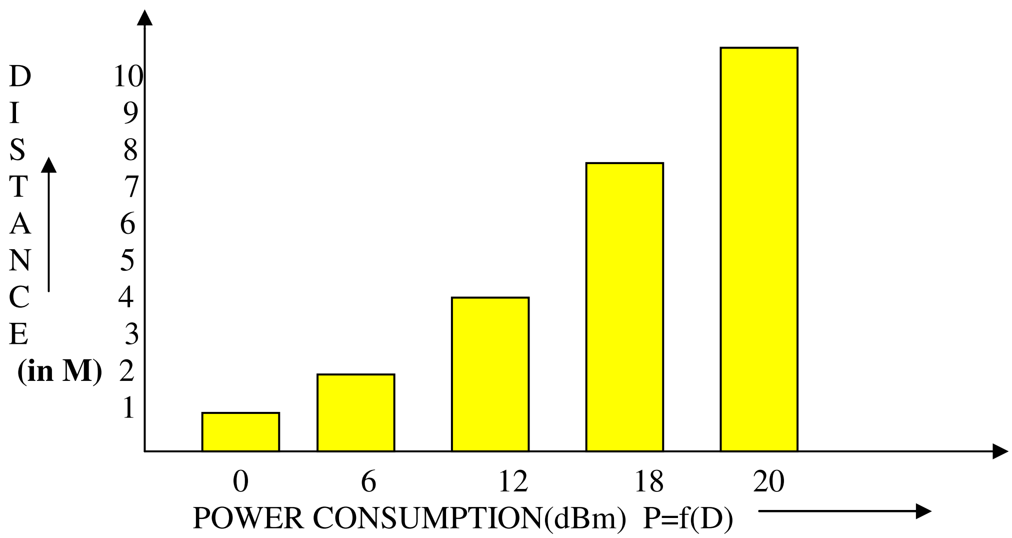



**Figure2.9 Bar Chart of Distance Based Routing System**

Graph of Distance V/s Power Consumption

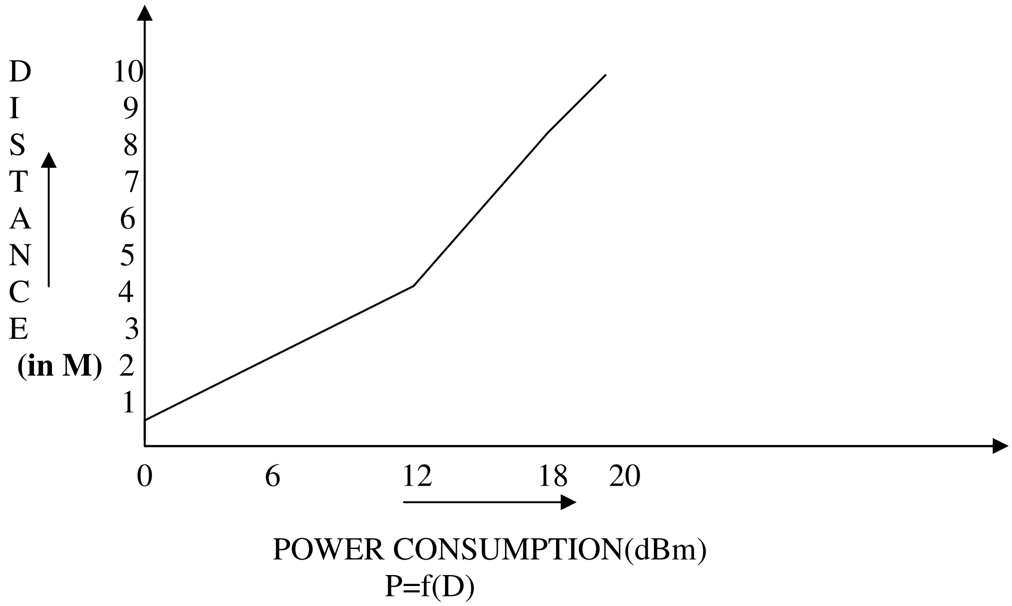



Figure2.10 Graphical Representation of Distance Based Routing System

But in this application, the technique which is applicable is the distance based power control because the other technique of battery level based master slave switch can not be applied because in this toll tax application, the master has to give the instructions at the toll tax station, so we can not apply this. The only way to reduce the power consumption is that we use distance based power control. When any vehicle at the toll tax station reaches near the head, as the distance decreases power consumption will increase and vice-versa. So in the routing in this application, the power transmit will be a function of distance.

## 2.7 UML Diagrams of Bluetooth Based System

In the UML diagrams (Figure 2.11 –2.14), the procedure for the registration at the toll tax system is explained. At the toll tax station there is a database where the vehicle no, credit card no, amount of card, owner of the vehicle etc are placed. And when some transactions are made, updation will be done in the database accordingly. There are mainly four classes of this system (as shown in Figure 2.11). These are vehicle, account system, registration system and toll tax system. In the registration system the vehicles, which are passing, are registered.

The bluetooth device (Rx) at the toll tax will inquire continuously, when some vehicles will come in the range of the receiving station, the communication will start automatically. The nature of routing will be adhoc in nature. When the devices will come in range, the connection will be established simultaneously (as shown in figures 2.12 &2.13). For each type of vehicle (car, bus, scooter, truck, jeep etc.) a different bluetooth receiver will be there for the sake of good management. There may be a single device for responding all the devices or may be different devices for different type of vehicles. If there is only one device, the inconvenience will be more and management will be difficult but if the different devices for different type, good management and time saving will be there. And suppose there is a case when the vehicles of same type will come in parallel, then the receiver will face difficulty. So we can design the path so that only one vehicle will be there near the receiver by making the queue near the station as such in the manual system. In the collaboration diagram (Figure 2.14) , I have shown how the messages will be transferred between the different modules i.e. vehicles, database, accounts and registration.

**Class Diagram**

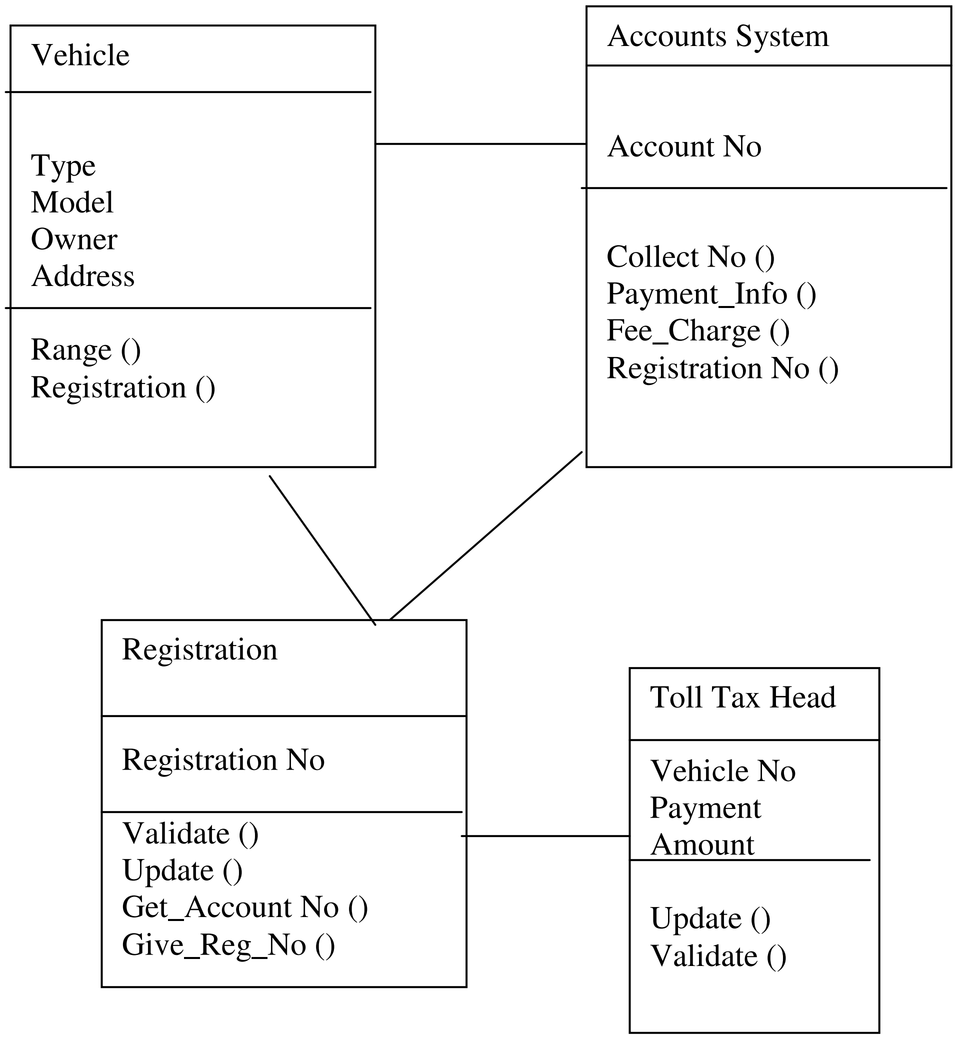



Figure 2.11 Class Diagram

## Activity Diagram

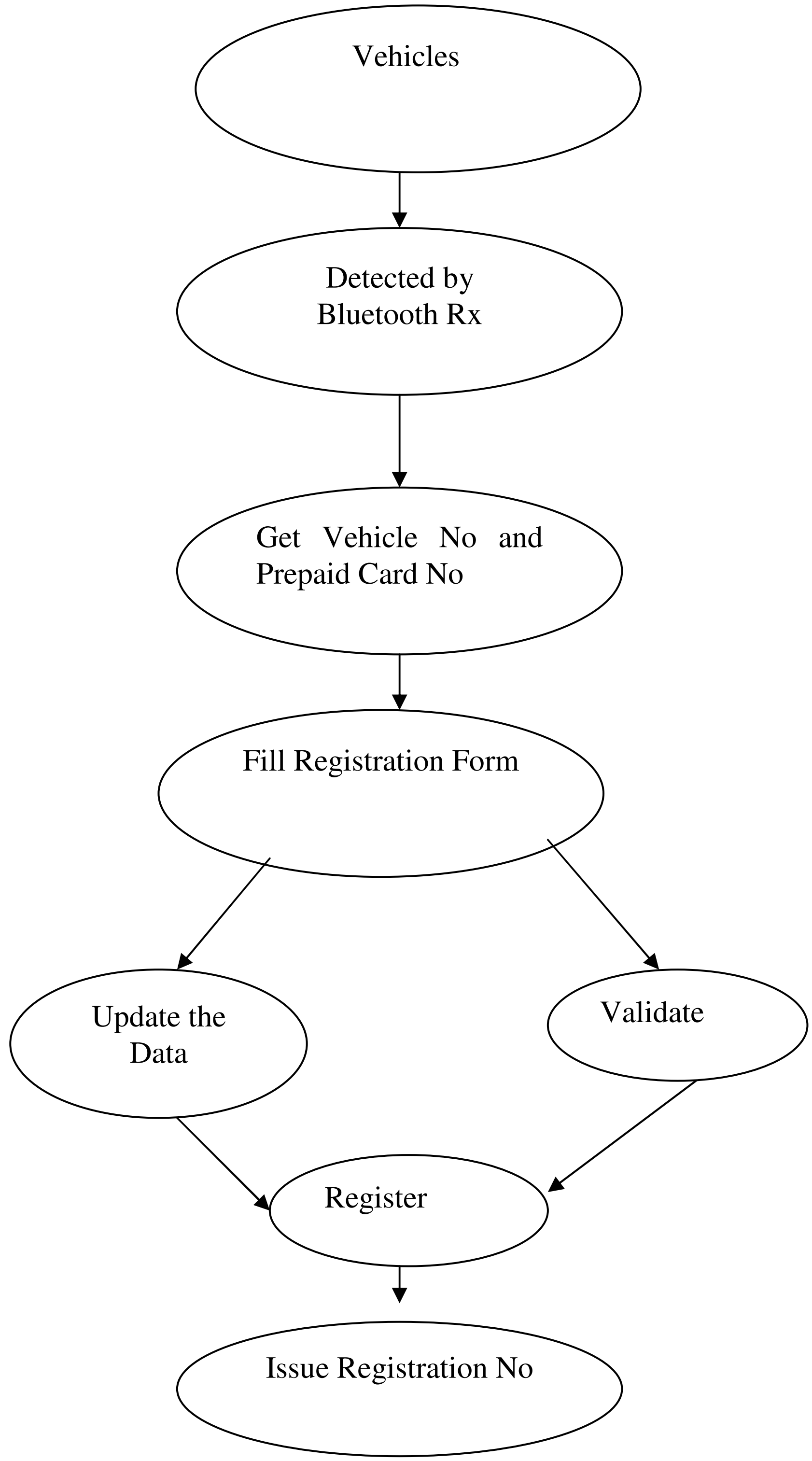



Figure 2.12 Activity Diagram

**Sequence Diagram**

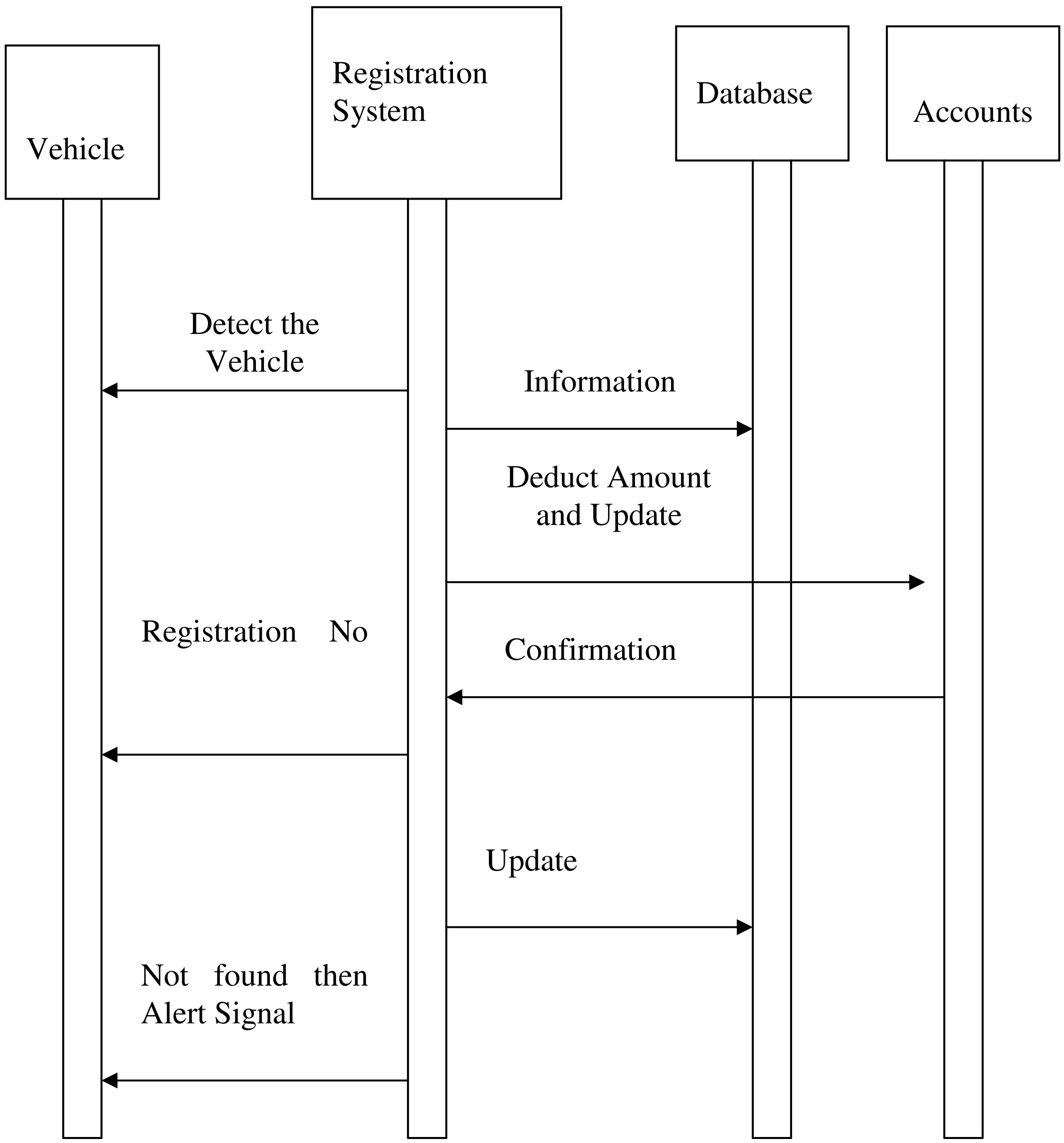



Figure 2.13 Sequence Diagram

**Collaboration Diagram**

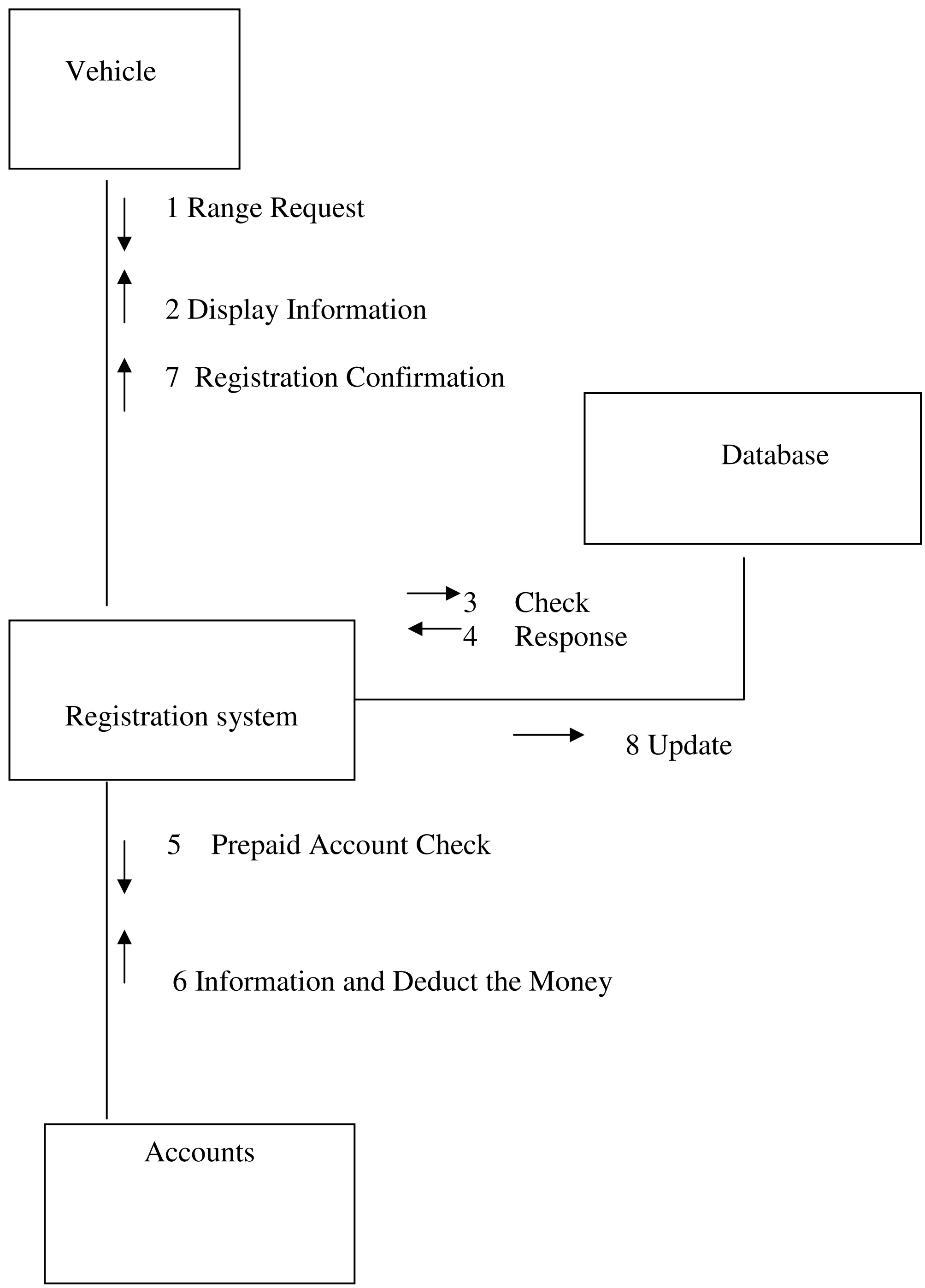



Figure 2.14 Collaboration Diagram

The mode of payment will be credit card or prepaid card system. There will be credit cards, which will be issued to each vehicle. The amount of card will be dependent on the owner of the vehicle. The owner can purchase the card of different amount according to his requirement. When the person will purchase the card, the database will be updated at the receiver station of toll tax simultaneously. In the database the card number, amount and vehicle number, type, name of the owner etc all things will be there. When the vehicle will come within the range of the receiver station at the toll tax station, the number of the vehicle will be searched out in the database and the amount of the card will be displayed on the screen automatically and the toll tax amount will be deducted from the card and the balance will be updated. Suppose if some vehicle have not required balance amount for the payment, then there will be a beep or red signal will be there for the cash payment, which will be manual system.

## 2.8 Billing System

In the toll tax application we can use accounting management architecture for the purpose of measuring the bill amount for the vehicles, which I have explained below.

Accounting management requires that resource consumption be measured, rated, assigned, and communicated between appropriate parties. The act of determining the price to be charged for use of a Resource is called as rating. and the act of preparing an invoice is called as billing.

**Usage Sensitive Billing**

A billing process that depends on usage information to prepare an invoice can be said to be usage-sensitive. In contrast, a process that is independent of usage information is said to be non-usage-sensitive.

**Accounting Management Architecture**

The Figure 2.15 illustrates the accounting management architecture. The accounting management architecture involves interactions between network devices, accounting servers, and billing servers. The network device collects resource consumption data in the form of accounting metrics. This information is then transferred to an accounting server. Typically this is accomplished via an accounting protocol, although it is also possible for devices to generate their own session records. The accounting server then processes the accounting data received from the network device. The processed accounting data is then submitted to a billing server, which typically handles rating and invoice generation. Session records may be batched and compressed by the accounting server prior to submission to the billing server in order to reduce the volume of accounting data and the bandwidth required to accomplish the transfer.

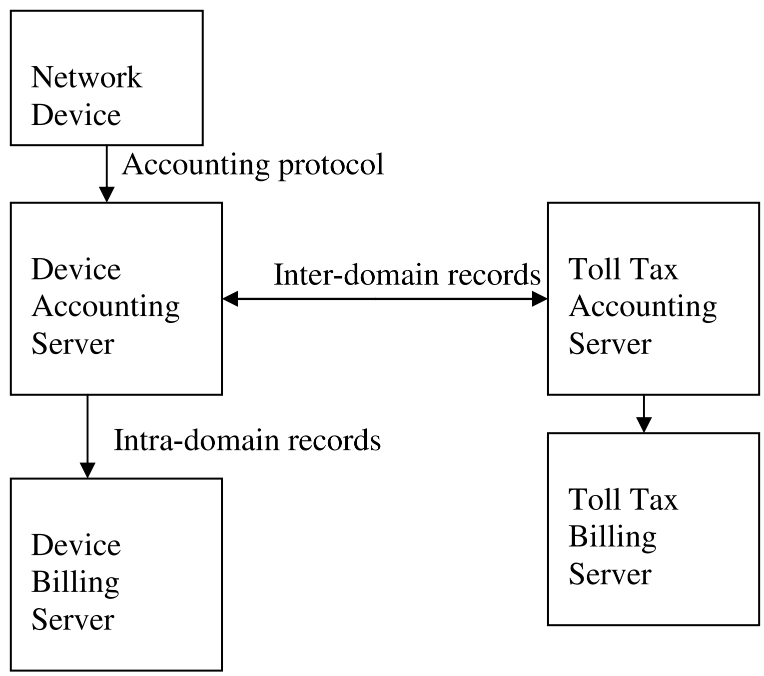



Figure 2.15 Accounting Management Architecture

**Intra-domain and Inter-domain Accounting**

Intra-domain accounting involves the collection of information on resource consumption within an administrative domain, for use within that domain. In intra-domain accounting, accounting packets and session records typically do not cross-administrative boundaries. As a result, intra-domain accounting applications typically experience low packet loss and involve transfer of data between trusted entities.

In contrast, inter-domain accounting involves the collection of information on resource consumption within an administrative domain, for use within another administrative domain. In inter-domain accounting, accounting packets and session records will typically cross-administrative boundaries. As a result, inter-domain accounting applications may experience substantial packet loss. In addition, the entities involved in the transfers cannot be assumed to trust each other.

In this application the inter-domain records are transferred between the device and toll tax accounting servers and intra-domain records are transferred between the accounting and billing servers of the device and toll tax separately.

When a vehicle approaches near the toll tax station, the message between the both are transferred as I have explained earlier. After that the billing amount is calculated according to specific vehicle and it is deducted from the credit card number of that vehicle and records are updated at the toll tax billing server as well as the device billing server.

# 3 2.9 Benefits of the New System

When a vehicle (Car, Bus etc.) passes the toll station, the toll fee is automatically charged to the vehicle driver's account with the bluetooth road operator. A bluetooth chip (transponder) inside the vehicle contains its electronic identity.

**<u>Benefits of System</u>**

- Charging accuracy: all fees due are reliably collected.
- Charging flexibility: ability to accommodate varying charging rates.
- Charge type flexibility: ability to support several means of payment.
- Enforcement accuracy: correctly locating violators and non enforcing non-violators.
- Upgradeable as additional charge points are added.

**<u>Benefits to Society (Nation)</u>**

- Economy
- Environment
- Safety

Bluetooth toll collection stations allow the traffic to flow continuously, and vehicle having avoided stopping and starting again. This in combination with reduced fuel consumption has positive effect on environment.

Society and the business community also gain from the system as it results in faster transport. The system does not require special road lanes to be built at the toll stations.

Furthermore, only a minimum of traffic disruption is caused during installation. The system also increases safety ,as bottlenecks and long queues are avoided.

**Benefits to Operator**

- Increased capacity
- Economy
- Ensured payment

This system is cost-effective and easy to install, which benefits the operator. Because traffic flows through continuously, the system increases capacity. The system's flexibility makes it easy to install various payment methods and differentiated charges. No cash is handled using the system, which means it is not open to abuse and ensures payment.

**Benefits to Users**

- Time-saving
- No queues
- Convenient
- Ensured payment
- Easier to gauge travel time

Road-users save a lot of time, as the traffic flows continuously and it becomes easier to gauge travel times. Bottlenecks and long queues are eliminated, both at the toll stations and near slip roads. This also help increase the convenience factor, no money needed, no need to select the right lane etc. because the system cannot be cheated, tolls can be kept down, which also benefits road-users.

# CHAPTER 3

# ESTABLISHING CONNECTIONS

To manage connections two methods are defined the inquiry, which is optional (if the message is to be sent to all devices in range then it is optional), and the page procedure, which is mandatory. With the inquiry procedure the unit discovers its neighbors in radio range. During inquiry the node sends IAC signals through the radio interface. Other Bluetooth devices that want to be discovered and receive this signal send an inquiry response with their own identity. If the node already knows the destination's identity, the page procedure is used to establish connection. The nodes use dedicated frequencies to communicate in page mode. The unit identity determines these frequencies, which are a subset of the total set of carriers. The nodes choose one of these dedicated carriers pseudo-randomly according to a pseudo random hopping sequence determined by their clocks. If the receiver node detects its access code (DAC), activates itself and sets up a connection with the other node (Figure 3.1).

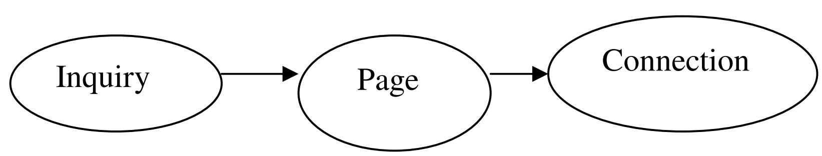



Figure 3.1 Connection-establishment procedures

We can see the typical times associated with establishing connections in Table 3.1.

Table 3.1 Times Establishing Connection

| | Inquiry | Page |
|---|---|---|
| Typical Time | 5.12 s | 6.64s |
| Maximum Time | 15.36s | 7.68s |

## 3.1 Connection State and Power Consumption

The master has to send packets to all slaves in Connection State periodically to keep them synchronized to the channel. Any packet type can be used for this purpose, since the slaves only need the channel access code to synchronize with. If the slave which is addressed in the poll packet receives the packet, it can respond with any type of Bluetooth packet. In the different operation modes different time periods are used to send the poll packets.

Units can be in four operation modes during the Connection State. In active mode the unit actively participates in the piconet. Active slaves listen in the master to slave slots for packets addressed to them. If an active slave is not addressed, it may sleep until the next master transmission. The type indication in the packet header shows the number of slots the master has reserved for the following transmission. During this time the non-addressed slaves do not have to listen to these slots. In active mode the receiver is activated 10 $\mu s$ before the start of the next slot. The receiver searches for channel access code for 20 $\mu s$ (Figure 3.2). This is called the receive window. If no correct channel access code is received the receiver goes to sleep until the next slot. If a valid access code is received the receiver remains open to receive the rest of the packet.

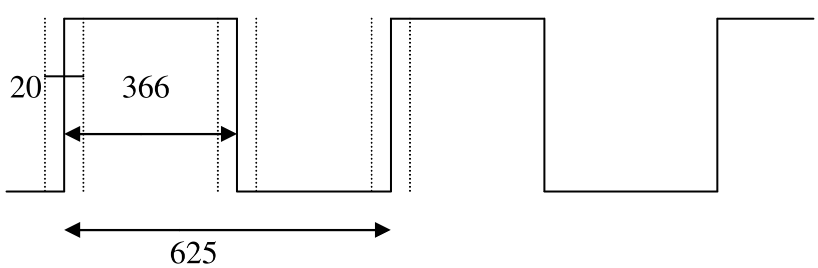



Figure 3.2 Receive window

Furthermore, special power-saving modes are defined to save battery when the traffic is low. In sniff mode the master can start transmission to the slaves only in specified time slots which are called sniff slots and are spaced regularly with an interval of T *sniff*. The slave listens for the number of D *sniff* slots in every sniff period. If a slave wants to enter in the sniff mode, it asks the master about the value of T *sniff* and D *sniff* . In hold mode the unit keeps its active member address (AM ADDR), but it will not receive any packets from the piconet. During hold mode the slave can do other things,

like scanning, paging, inquiring or attending another piconet. Before entering the hold mode master and slave agree on the time duration the slave remains in the hold mode.
In park mode the slave gives up its AM ADDR. It uses two other addresses: the park member address (PM ADDR) and the access request address (AR ADDR). The PM ADDR is used to distinguish the parked devices and the master uses it in the master initiated unpark procedure. The AR ADDR is used by the slave in the slave initiated unpark procedure. The parked slave wakes up at regular intervals to listen to the channel in order to re-synchronize to the master. The number of units participating in a piconet is limited to 255, but maximum seven slave nodes can be in active, sniff or hold mode. The others are in park mode, where they consume the least amount of energy. The active slave devices can use the sniff and hold modes to deactivate their radio transceivers and save battery power. The less the transceiver is turned on, the less power is consumed.

## 3.2 Scatternet

Several piconets can be created at the same place with overlapping radio areas. The group of overlapping piconets is called scatternet (Figure 3.3). Every piconet has its own hop sequence, and so the nodes in different piconets can simultaneously transfer data. Because of this the throughput in a scatternet is much greater compared to the case when every node participates in the same piconet.

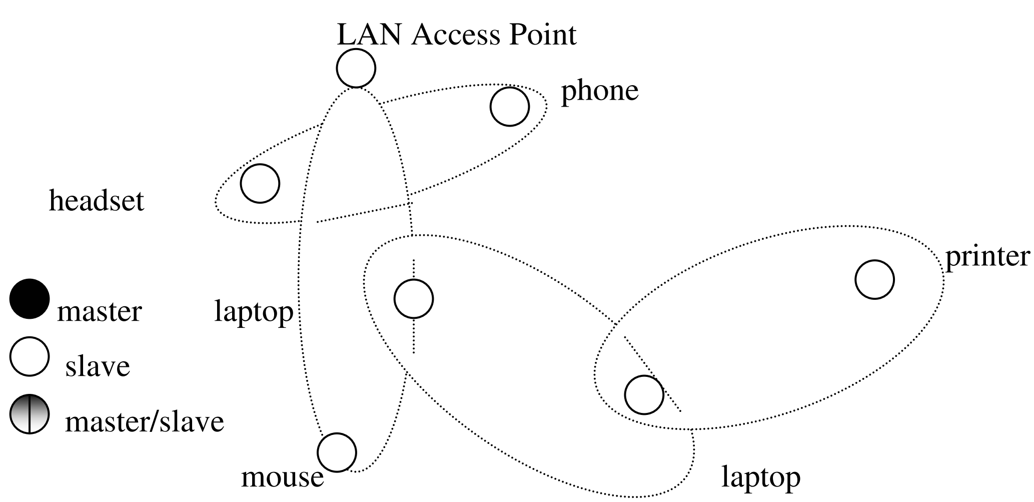



Figure 3.3 Scatternet

A node can be slave in several piconets, but it can be master only in one, since the master identity and clock determines the hopping sequence and this must differ in each piconet.

Changing piconets the nodes have to select the proper master identity and clock offset to synchronize with the desired piconet. Before changing they inform the master about the time they will not be accessible in the current piconet. A master can also change piconets.

In this case the transmissions are stopped in the piconet until the master returns. A multihop ad hoc network can built with nodes which are participating in several piconets.

**4**

## 3.3 State Diagram

A Bluetooth unit leaves the Standby or the Connection state periodically to do Inquiry or Inquiry Scan. Inquiry procedures enable a unit to discover which units are in range, and their device addresses and clocks. When the unit wishes to establish a connection with one of the other Bluetooth units in range ( the user of the device wishes to connect to some other device) it initiates a paging procedure. At the end of this procedure both units are in the Connection state as either a master or a slave (Figure 3.4).

### 3.3.1 Standby State

Standby state is the default state of the Bluetooth device. In it the device uses a low power mode and only the native clock (CLKN) is running.

### 3.3.2 Inquiry

It is not specified how often a unit should leave standby or connection to perform inquiry. It might be periodic or upon user request. These choices are left up to the implementer. A unit that wishes to discover other bluetooth units in range enters an inquiry substate. It continuously transmits the inquiry message at different hop frequencies. In the inquiry state the transmitting and receiving frequencies follow the inquiry hopping sequence and inquiry response hopping sequence and are determined by the General Inquiry Access Code (GIAC) and the native clock of the discovering device.

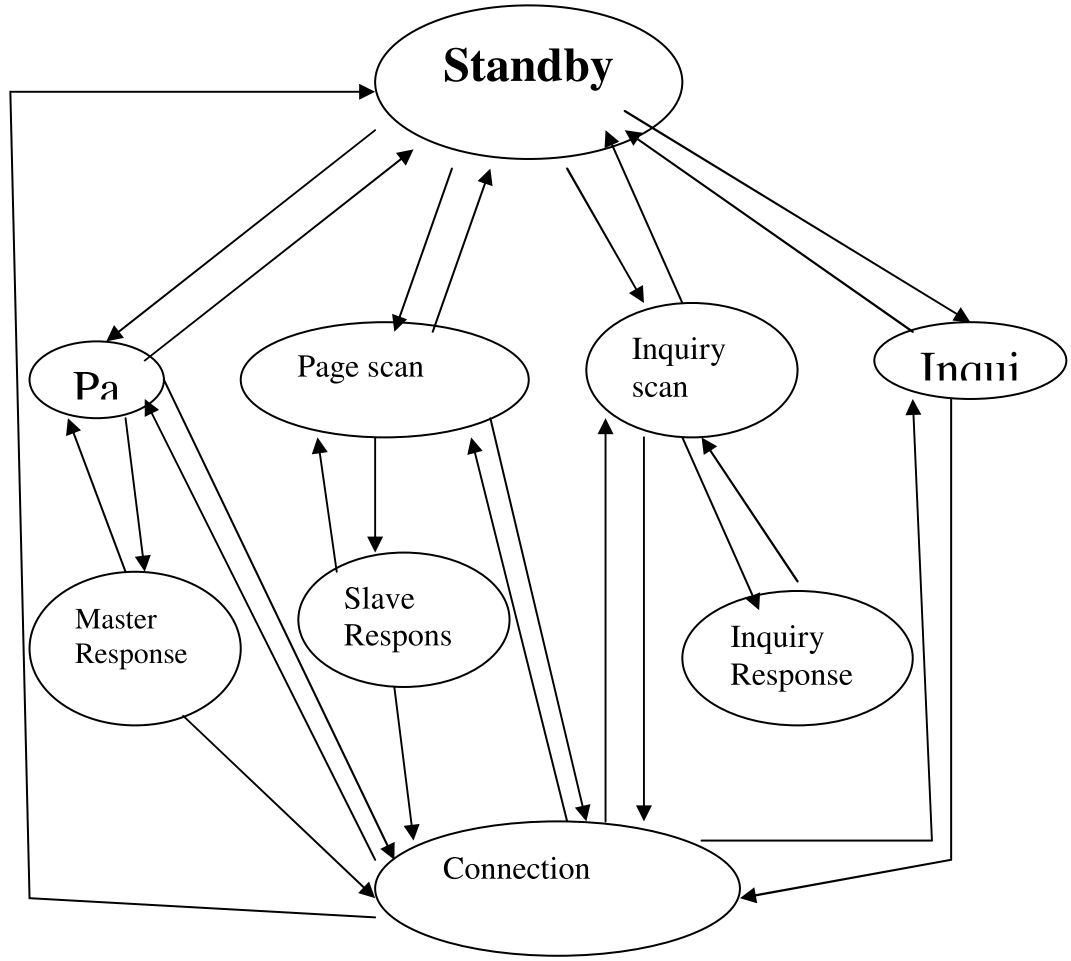



Figure 3.4 Connection Establishment's Finite State Machine

A hopping sequence consists of two groups of frequencies: train A and train B (each of which is 16 frequencies long). Between inquiry transmissions the unit listens for responses, (which is an FHS packet). If the response is received it is not acknowledged and the probing unit continues with the inquiry transmissions. The unit leaves inquiry state either when it received a predetermined number of responses or when the InquiryTO timer runs out.

According to the Bluetooth standard a single train must be repeated N inquiry =256 times before another train is used. At least three train switches are needed (4 train sequences). Since each train is 10ms long the inquiry procedure can take up to 10.24s.
Because several units might respond to an inquiry at the same time, we need a protocol for slave inquiry response in order to avoid or minimize the probability of collisions.

Thus, when a slave receives an inquiry message it will generate a RAND number between 0 and 1023, freeze the current input value to the hop selection scheme, then returns to Connection or Standby state for duration of RAND slots. Then it returns to the Inquiry Response substrate and on the first inquiry message received it will answer with an FHS packet.

### 3.3.3 Inquiry Scan

As was mentioned above, Bluetooth units leave Standby or Connection to scan the channel for inquiries periodically. The period of inquiry scan can be 0s (continuous scan) – R0, 1.28s – R1 mode, or 2.56s – R2 mode. A scanning unit listens for an IAC for Tw_inquiry_scan seconds. Tw_inquiry_scan should be long enough to scan 16 frequencies (1 train). Because one train lasts for 10ms, Tw_inquiry_scan should also be 10ms. During these 10ms the receiver of the scanning device listens on a single frequency determined by the inquiry scan hopping sequence and the current value of the device's clock. The scanning device changes its listening frequency, according to inquiry hopping sequence, every 1.28s.

### 3.3.4 Page Scan

Page scan works similarly to inquiry scan, however, in page scan a unit listens for its own unique DAC and it alone can respond. There are 32 paging frequencies, which comprise a page hopping sequence, determined by the paged unit's BD_ADDR. Every 1.28s a different listening frequency is selected. During a scan window the unit listens on one frequency.

### 3.3.5 Page

When a Bluetooth unit wants to make a connection to another unit it pages that unit. Paging means sending an ID packet with a certain DAC in it over and over again until a response is received. The Master does not know exactly when the slave wakes up and on which hop frequency, therefore it transmits a train of identical DACs at different hop frequencies and listens in between for responses. The master uses the slave's BD_ADDR and an estimate of the slave's clock to determine the page hopping sequence.

To compensate for the uncertainty in the knowledge of a slave's clock, the master will send its page message during a short time interval on a number of wake-up frequencies. During each transmission slot the Master sequentially transmits on 2 different hopping frequencies. The page hopping sequence of 32 frequencies is divided into two trains of 16 frequencies each, A and B. Train A includes the 16 hop frequencies surrounding the current predicted hop frequency f(k). Thus, train A consists of f(k-8), f(k-7), …f(k), f(k+1), f(k+2), …,f(k+7). When the difference between bluetooth clocks of the master and the slave is between –8*1.28s and 7*1.28s, one of the frequencies used by the Master will be the hop frequency the slave is currently listening to. Because the master doesn't know when the slave will be in the page scan state, it has to repeat train A for Npage times or until a response is received. When the difference between the bluetooth clocks of Master and Slave is less than –8*1.28s or greater than 7*1.28s, more distant hops must be used. Train B consists of f(k-16), f(k-15),…, f(k-9), f(k+8), f(k+9),…,f(k+15). Alternate use of train A and B is continued until a response is received or timeout value Page to is exceeded. Figure 3.5 shows what happens during a response to paging procedures.

In the figure 3.5, we have a scenario where a slave responds to the first out of two paging messages in a slot. The response packet is the same as the paging packet and is sent on the same frequency. The master responds with an FHS packet on the next frequency in the page hopping sequence. The master's FHS packet has to be acknowledged by the slave. After that both units are in Connection state. Now the master controls all transmissions. It polls the slave to see if it has data to send, and the slave has to respond with a data packet if it has something to send or with a NULL packet if it doesn't The slave will keep listening while FHS packet is not received until pagerespTO is reached. Every 1.25s it will change the hop frequency according to page hop sequence. If nothing is received the slave will return to page scan for 1 scan period. If it doesn't receive any pages during this interval it continues scanning and then returns to whatever state it was in before. If poll packet is not received by the Slave or response is not received by the Master within new connection TO number of slots, they will return to page/page scan states.

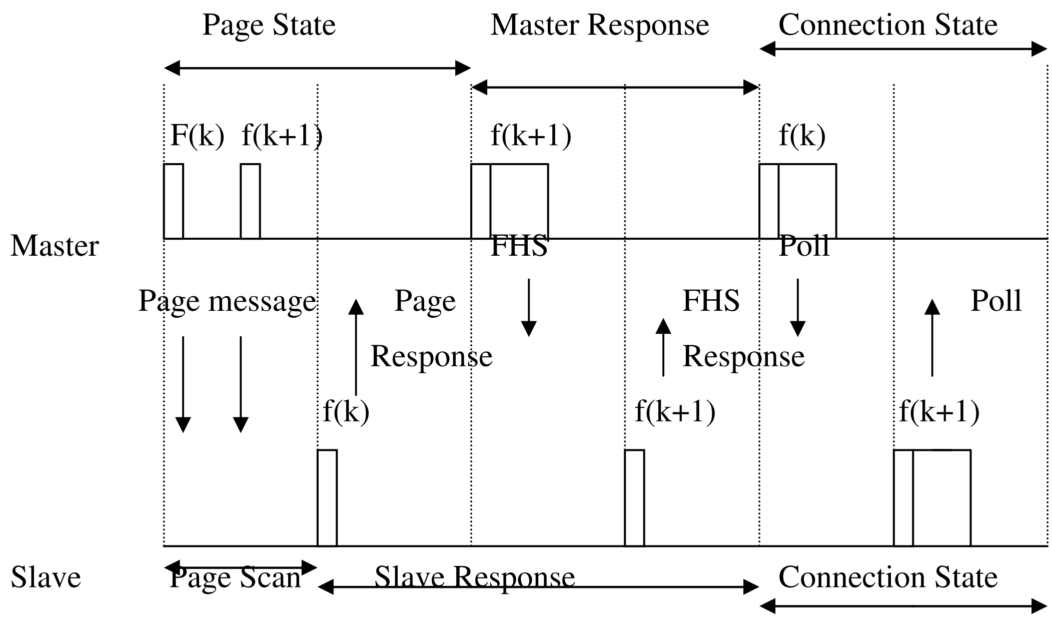



Figure 3.5 Master and slave page response procedure

Note: f(k)-frequencies of the page hopping sequence indexed by k
$f(k)^3$-frequencies of the page hopping sequence
g(k)-frequencies of the channel hopping sequence indexed by k

## 3.4 Connection State

In the connection state channel hopping sequence is used. It is derived from the master's BD_ADDR. The unit in connection state may be in one of four modes described below.

### 3.4.1 Active Mode

In the active mode the Master schedules the transmissions based on traffic demands to and from different slaves. Active slaves listen in master-to-slave slots.

### 3.4.2 Sniff Mode

In order to save battery power a sniff mode can be used. In this mode the duty cycle of slave's listen activity is reduced. To enter sniff mode, the master shall issue a sniff command via the Link Manager (LM) protocol. This message will contain the sniff interval Tsniff and an offset Dsniff. Master-to-slave sniff slots shall be initialized on the slots for which the clock satisfies one of the following equations (depending on which initialization procedure is used):

CLK27-1 mod Tsniff = Dsniff or (CLK27,CLK26-1) mod Tsniff = Dsniff

### 3.4.3 Hold Mode

During hold mode the ACL link to a slave will, temporarily, not be supported.
The slave unit keeps its active member address (AM_ADDR) during hold mode. Before entering hold mode both Master and Slave agree on holdTO value, upon expiration of which hold mode ends.

### 3.4.4 Park Mode

When a Slave does not need to participate on the piconet channel, but still wants to remain synchronized to the channel it enters park mode. In this state the Slave gives up its AM_ADDR, but gets two new addresses: Parked Member Address (PM_ADDR, 8 bits) and Access Request Address (AR_ADDR, 8 bits). The former is used in master initiated unpark, the latter in slave-initiated unpark. Parked slave wakes up at regular intervals to listen to the channel to resynchronize and to check for broadcast messages. A beacon channel is established to support parked slaves.

# CHAPTER 4

# RESULTS

The results has been performed by taking the values of data from the Shambu toll collection station from Mr Balvir Singh . a comparison between the existing and proposed system is made to show the benefits of implementing the bluetooth technology in the toll collection system. The bar charts and graphical representation of the results are drawn.

## Table 4.1 Results

Number of vehicles passes through toll collection are 15,000 per day

| System / Arguments | Existing System | Proposed System | Remarks/Saving |
|---|---|---|---|
| Pollution<br>1000 Vehicles/Hr | 2.4 % by Volume | NIL | |
| Man Power | 30 x 3=90 | 8 x 3=24 | 63% |
| Petrol Saving<br>Per Day<br>*Assume vehicles stay for 2 minutes | NIL | 100 Liters | Rs 3,000 per day (i.e.Rs 90,000 per month) |
| Queue Size | Number of vehicles in queue =10 | Nil or One | |
| Cash Risk | Yes (Rs 5 Lacs to 6 Lacs per day) | Nil ( very-very less) Negligible | |
| Day Book Record | Complicated | Easy & simple | |
| Public Opinion | 29% | 48% | 23% No Suggestion |
| Initial Cost | Very Low( Cost of PCs ) | Very High(5$/car +cost of PCs) | |
| Operating Cost | Very High(Rs 5,00,000 per month) | Very Low(Rs 1,00,000 per month) | |
| Total Cost | High | Consequently Low | |

* Other expenditures like electricity, telephone bill etc and facilities like transportation for staff, refreshment etc. assumed to be same.

Bar Chart of Pollution created between existing and bluetooth technology based toll collection system

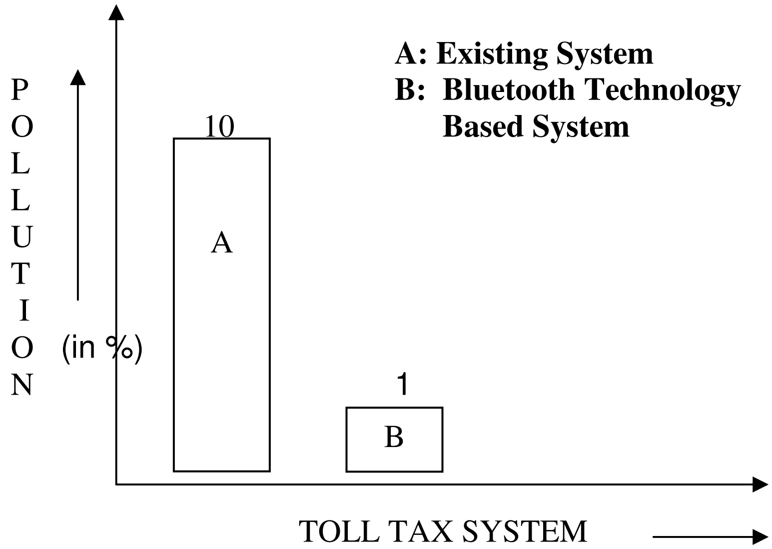



**Figure 4.1 Bar Chart of Pollution Created**

Graph of Pollution created between existing and bluetooth technology based toll collection system

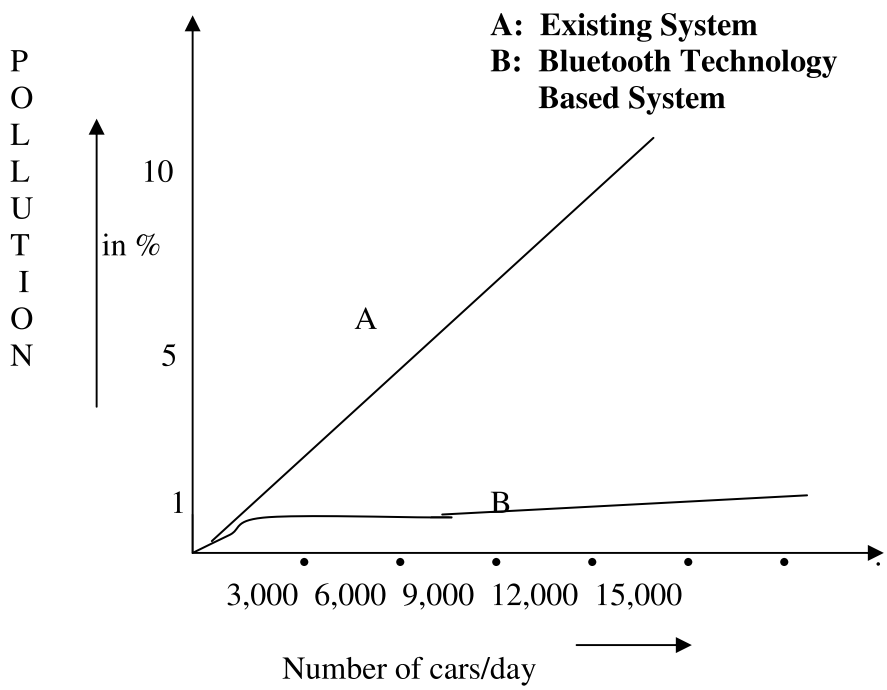



**Figure 4.2 Graph of Pollution Created**

Bar Chart of Cash Risk during collection between existing and bluetooth technology based toll collection system

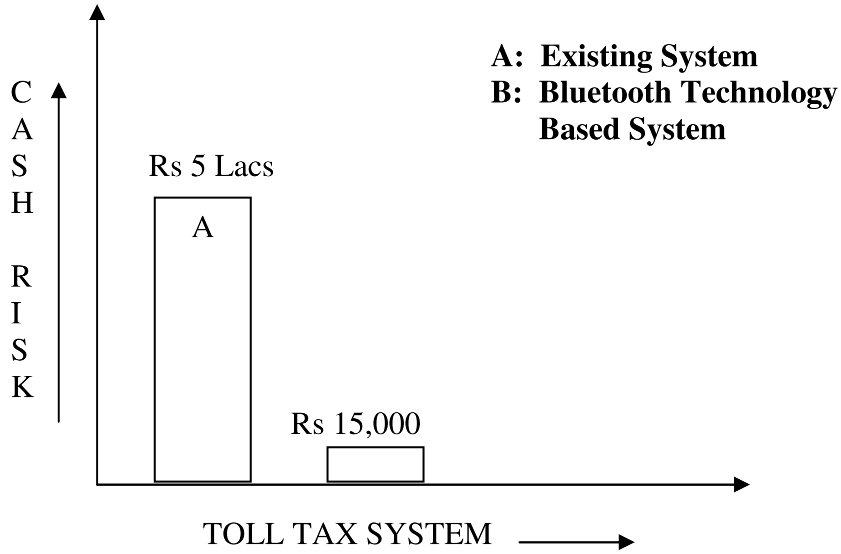



**Figure 4.3 Bar Chart of Cash Risk**

Graph of Cash Risk V/s Number of cars during collection in existing and bluetooth technology based toll collection system

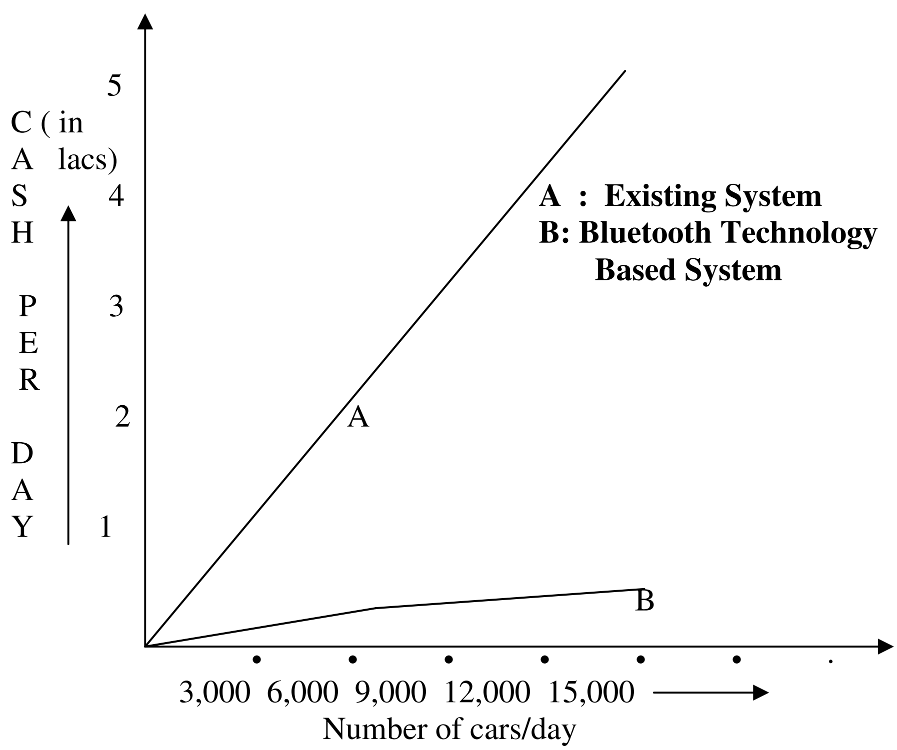



**Figure 4.4 Graph of Cash Risk**

Bar Chart of Man Power between existing and bluetooth technology based toll collection system

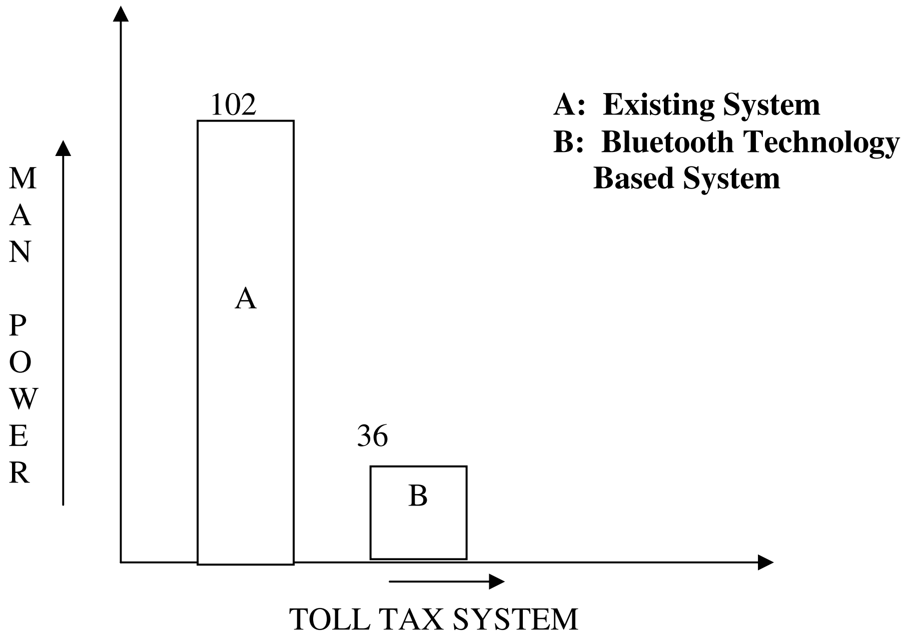



**Figure 4.5 Bar Chart of Man Power Required**

Graph of Man Power V/s Number of cars in existing and bluetooth technology based toll collection system

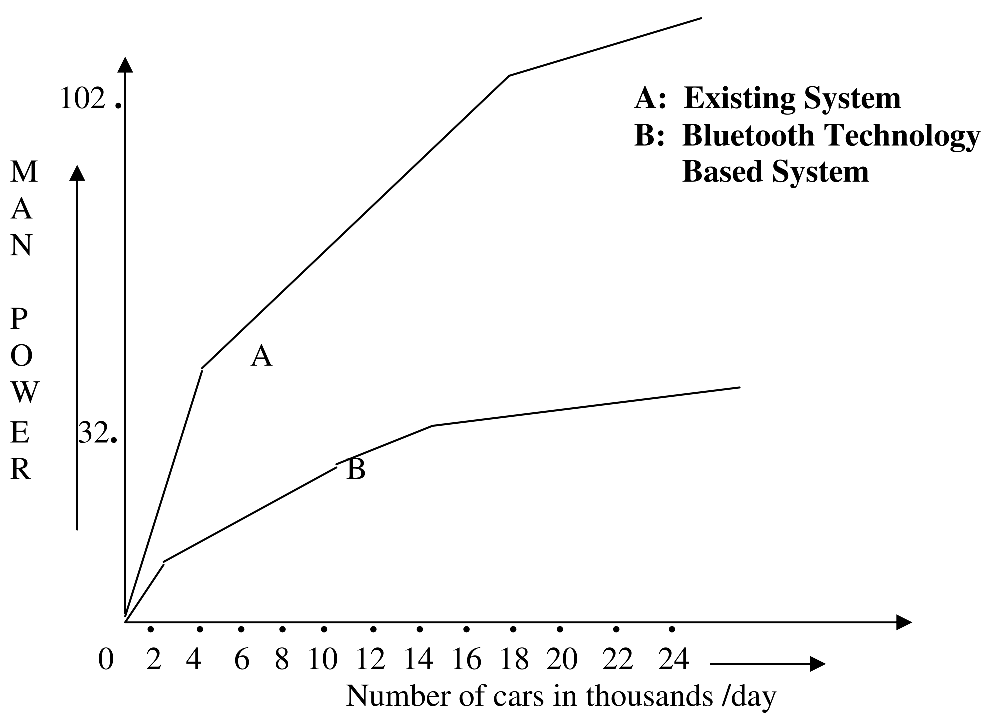



**Figure 4.6 Graph of Man Power Required**

Bar Chart of Queue size between existing and bluetooth technology based toll collection system

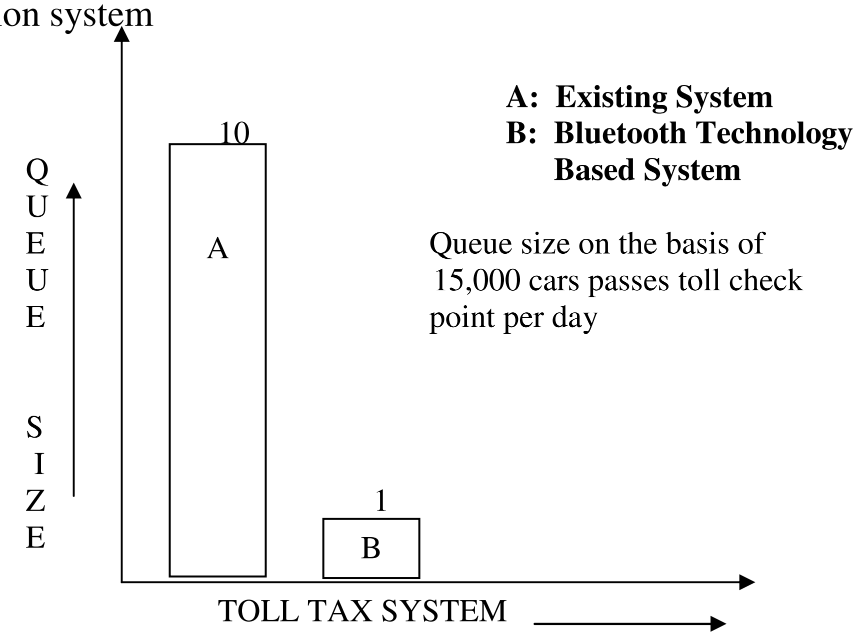



**Figure 4.7 Bar Chart of Queue Size**

Graph of Queue size V/s Number of cars passes toll collection in existing and bluetooth technology based toll collection system

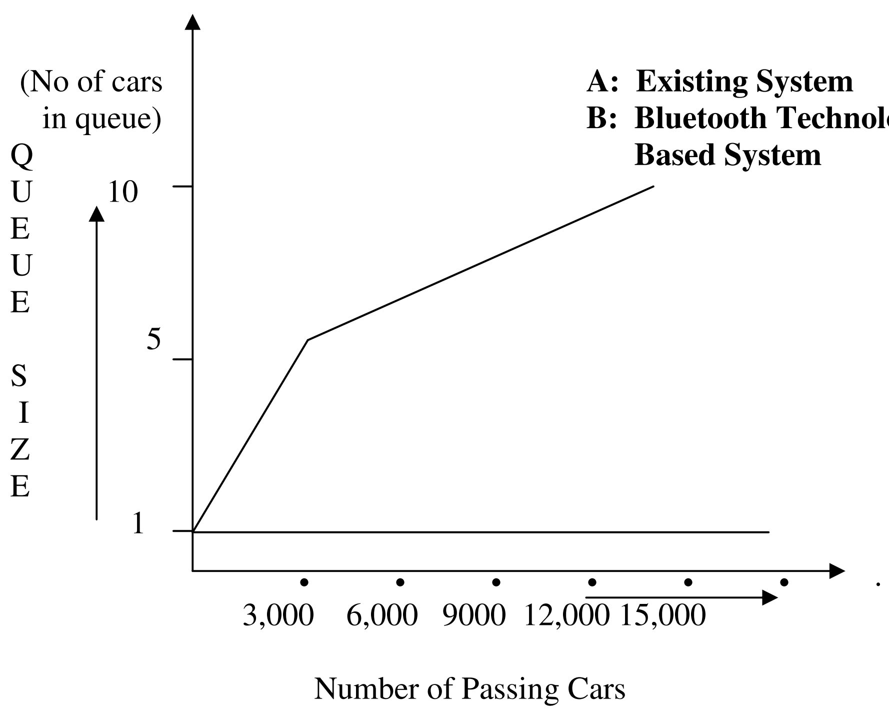



**Figure 4.8 Graph of Queue Size**

Bar Chart of Petrol saving per month during collection between existing and bluetooth technology based toll collection system

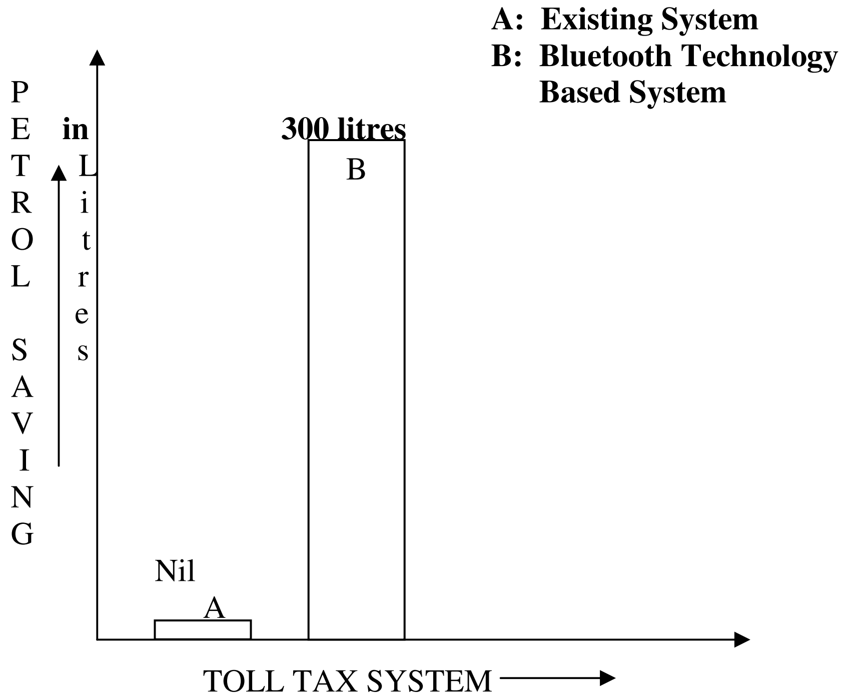



**Figure 4.9 Bar Chart of Petrol Saving**

Graph of Petrol saving in litres V/s Number of cars during collection in existing and bluetooth technology based toll collection system

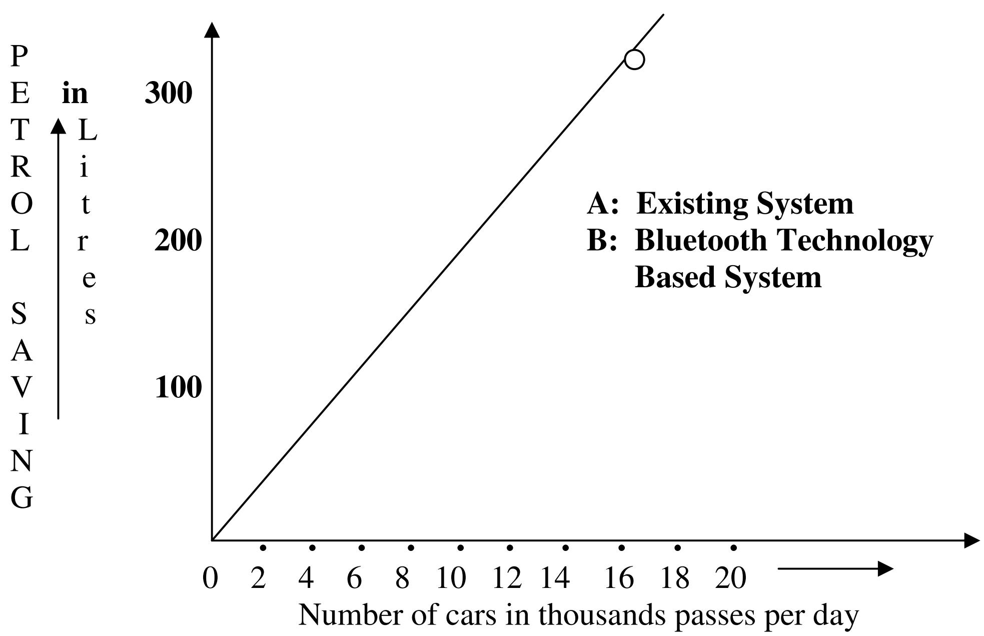



**Figure 4.10 Graph of Petrol Saving**

Bar Chart of Cost (Initial and Working) per year between existing and bluetooth technology based system

**A: Existing System = $A_1+A_2$**
**B: Bluetooth Technology = $B_1+B_2$**
**Based System**

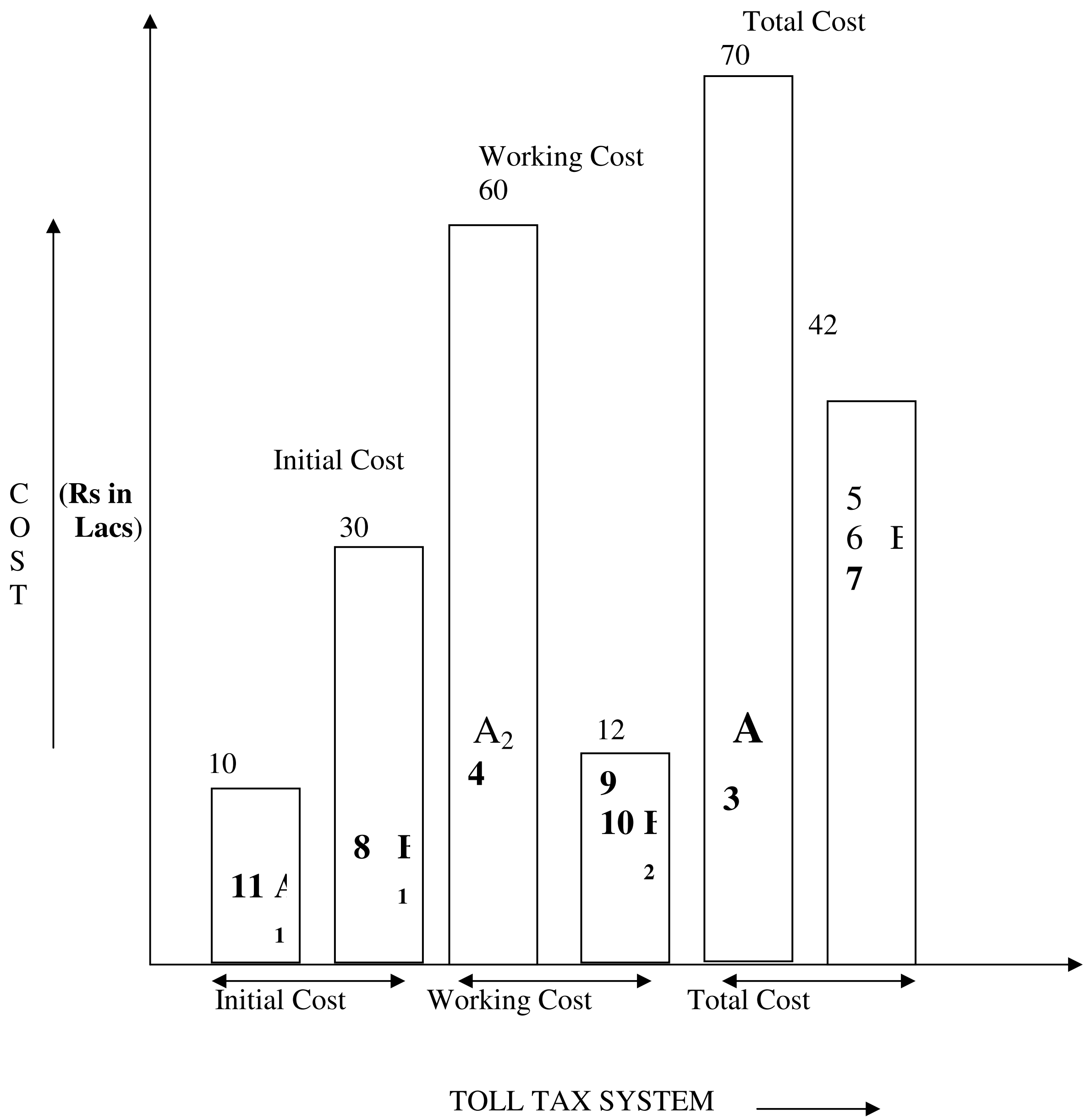



Figure 4.11 Bar Chart of Total Cost

The initial cost of BT system is higher than the current system but the working cost of the BT system is very less than the existing system as shown in figure 4.11.Hence it will overcomes the initial cost of the new system within six months.

# CONCLUSION

In my thesis, I have presented the implementation of bluetooth technology in the application of toll tax system. Bluetooth toll collection stations allow the traffic to flow continuously and vehicle having avoided stopping and starting again. This in combination with reduced fuel consumption has positive effect on environment i.e. pollution created will be minimum. Implementing the bluetooth technology is also not so much costly as its price is only $5 .Man power and cash risks are also reduced to minimum. Furthermore, only a minimum of traffic disruption is caused during installation. The system also increases safety, as bottlenecks and long queues are avoided. Society and business community also gain from the system as it results in faster transportation. The system is cost-effective, time saving and easy to install., which benefits the operator as well as user.

It is to say that this bluetooth technology is only recently developed only in the middle of 2000, two years of its incoming is a very smaller period. Much work and experiments based possibilities are yet to work. After about few years, the real fruit of this technology can only be tasted in many fields of science and technology. Smart cards should be integrated with this technology as these are secured electronic devices that are used for keeping data and other information in a way that only "authorized" users are permitted to see or write the data.

# FUTURE SCOPE

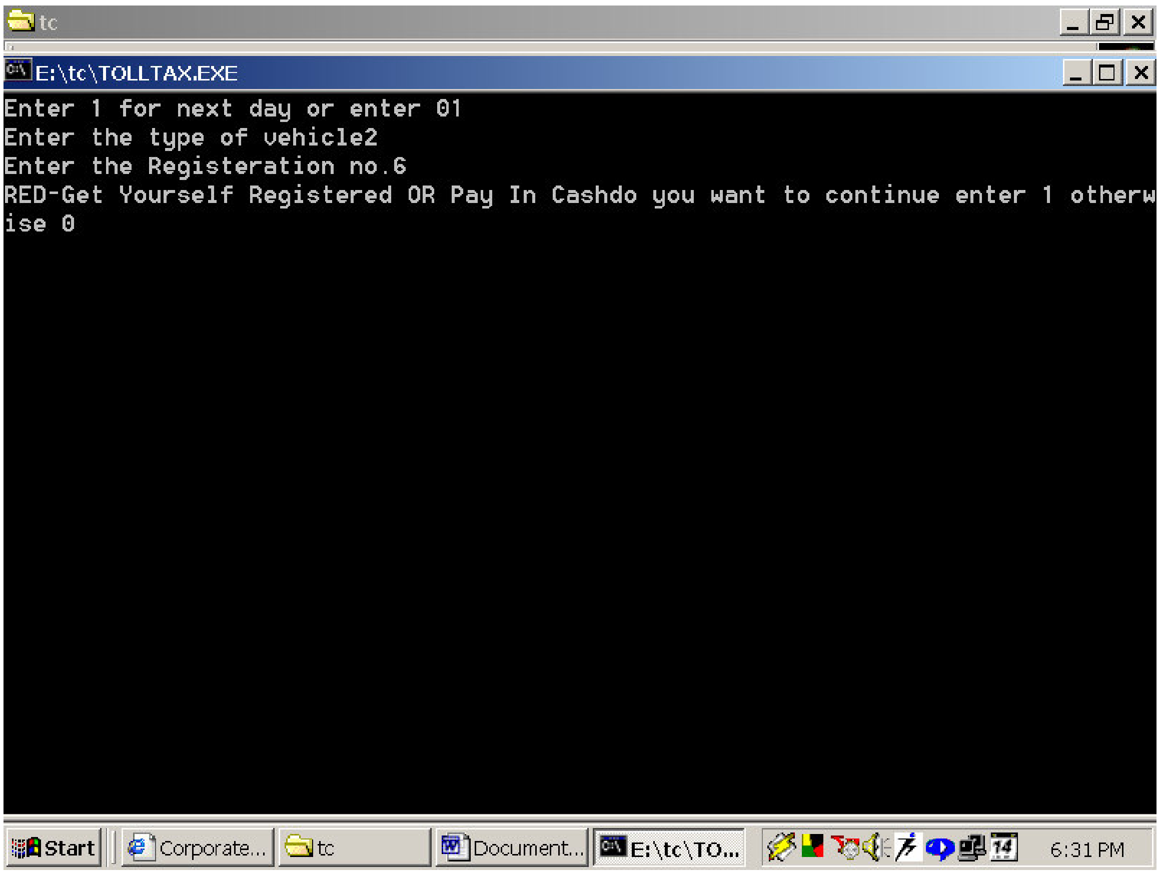
The objective of the Bluetooth standard is to enable seamless communications of data and voice, over short-range wireless links between both mobile and stationary devices. The bluetooth specification can ease connection not only to the phone system or the Internet but also between devices. Indeed, the focus of bluetooth wireless technology on low-cost, high levels of integration and ease of configuration has the potential to change current mobile computing and network connectivity paradigms.

I can say with confidence that the work of toll tax be an easy one when bluetooth technology will be fixed for this purpose. Let us hope that our future experiments will be beneficial to the whole of the world due to this technology.

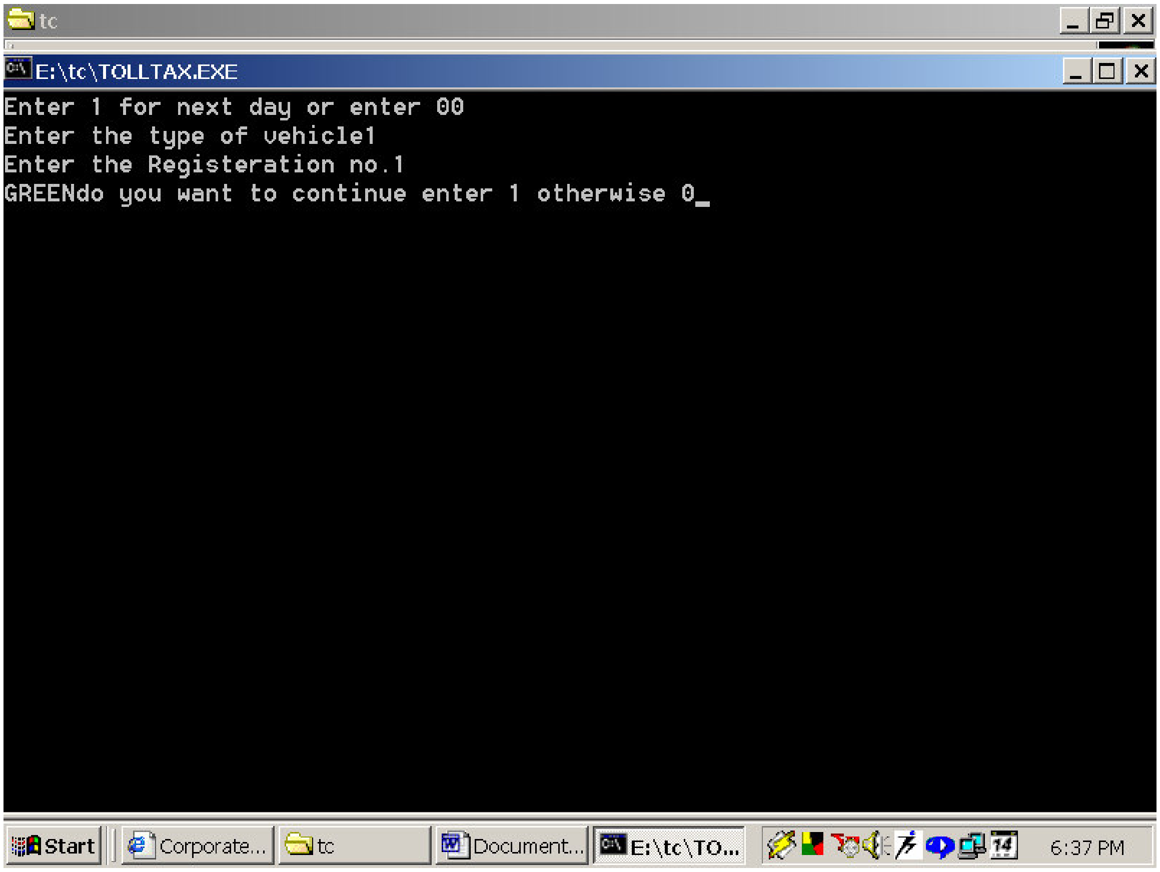
This work can be further implemented in the field of Road Tax Office for the collection for road taxes, which are applicable on motor vehicles and may be for the collection of insurance fee of the motor vehicles.

# APPENDIX

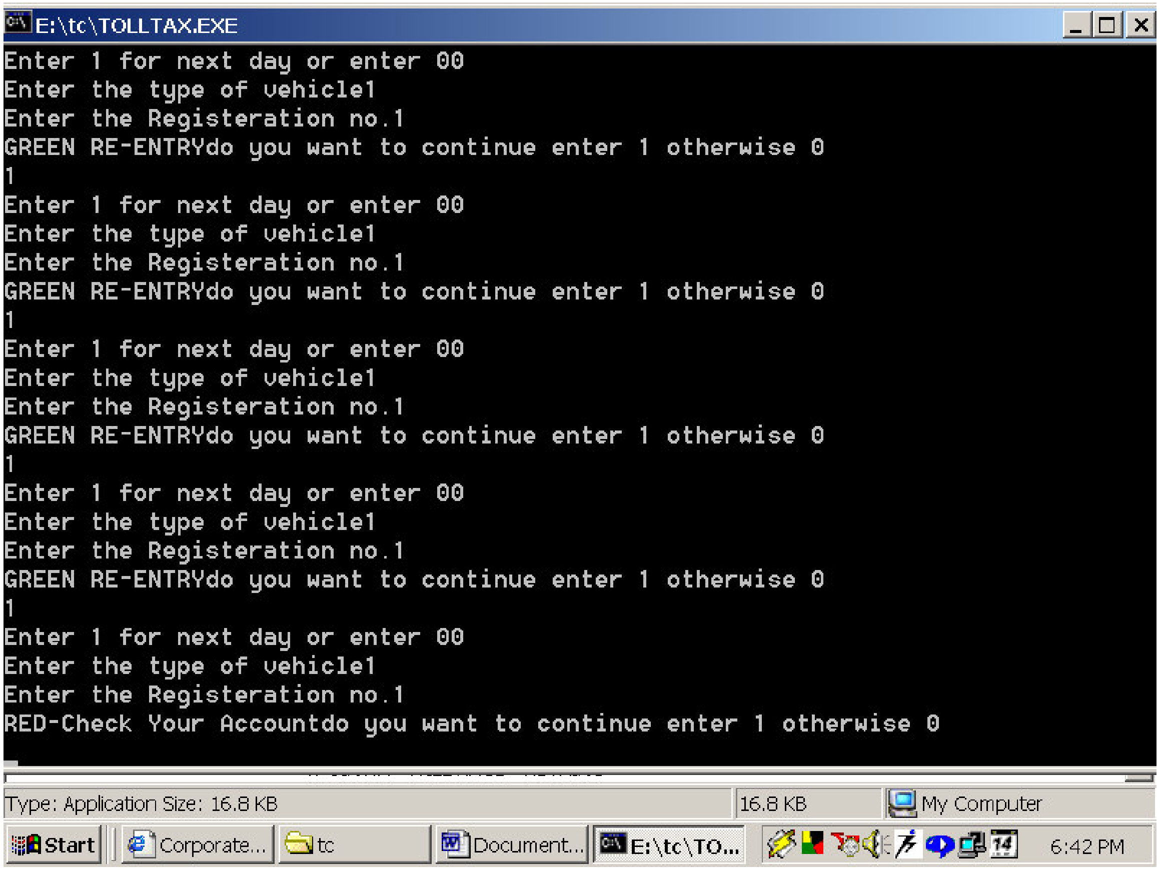
## SCREEN SHOTS FOR BILLING OF BLUETOOTH TOLL TAX SYSTEM




In this entry of data, the red signal is displayed because the entered registration number is not correct.




In this entry green signal is displayed because the required balance is there in the credit card as well as the registration number is correct.




In this entry the first four signals are green because required balance of credit card exists and also the registration number is correct. But according to the last entry, the red signal is displayed because the credit card account shows the less balance than the required amount.

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# Paper Publications and Presentations

## Papers Publications

1. Sona, Lalit Garg, " Bluetooth Secutity" in the Proceedings of Institution of Engineers (India), February 2003, Page No. 375-381.

## Papers Presented

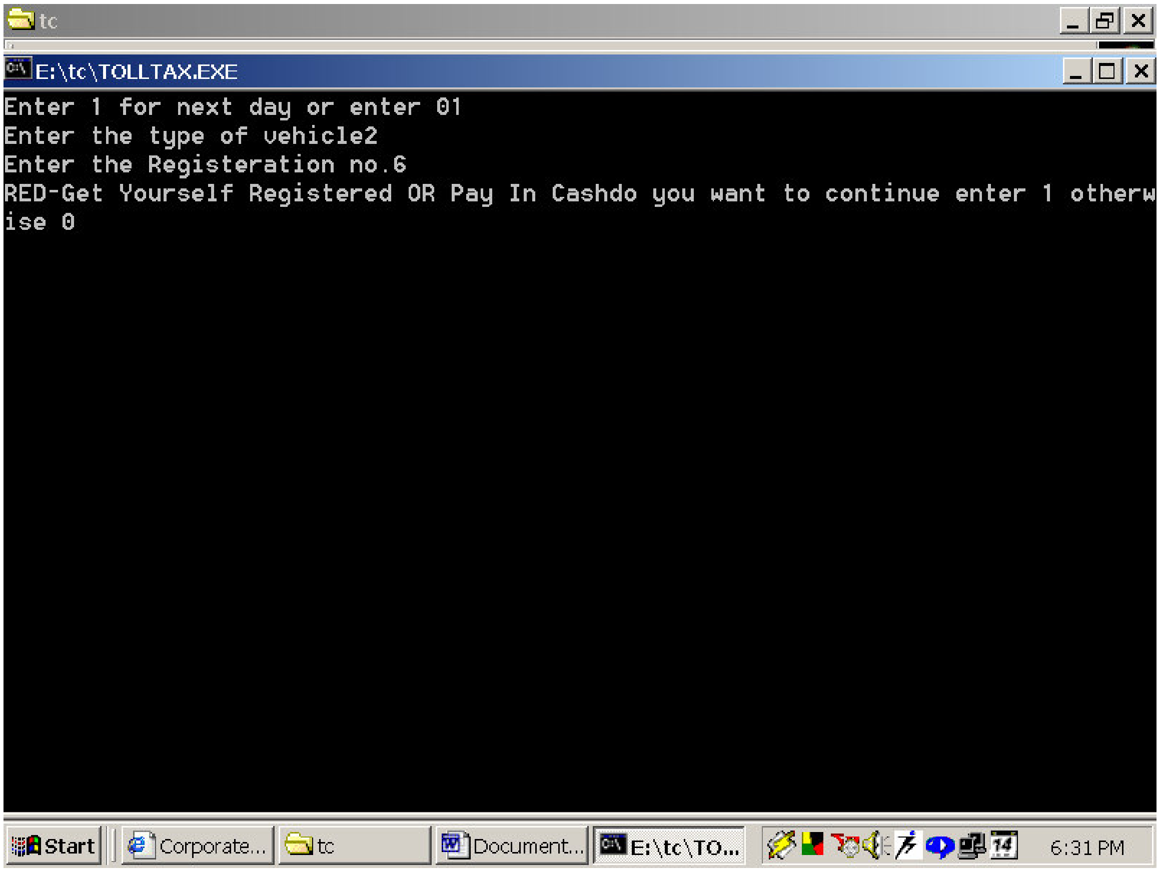
1. Sona,Lalit Garg, " Bluetooth Revolution" Presented in Institution of Engineers(India),National Conference at Murthal, February 2003.
2. Sona, "E-governance- An Approach to Toll Tax Application", National Conference at JMIT (Yamunanagar), April 2003.

## Papers Accepted

1. Sona, Lalit Garg, " New Trend in Toll Tax Application (Bluetooth Revolution)", Second National Conference at Amrita Institute of Engineering ,Coimbatore.

## Papers Communicated

1. Sona, " Bluetooth – Approach to Toll Tax Application", IMC 2003, $18^{th}$ International Maintenance Conference, Clearwater, Beach ,Florida (USA)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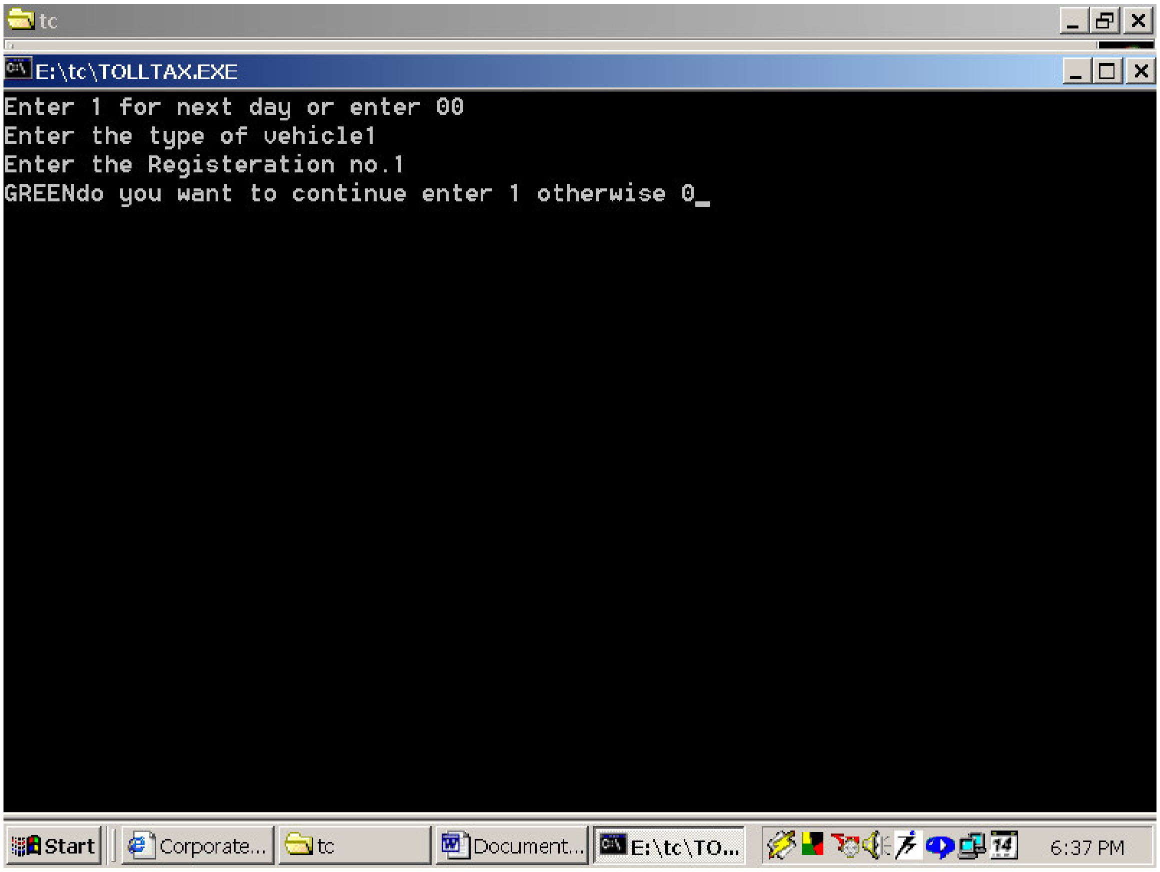
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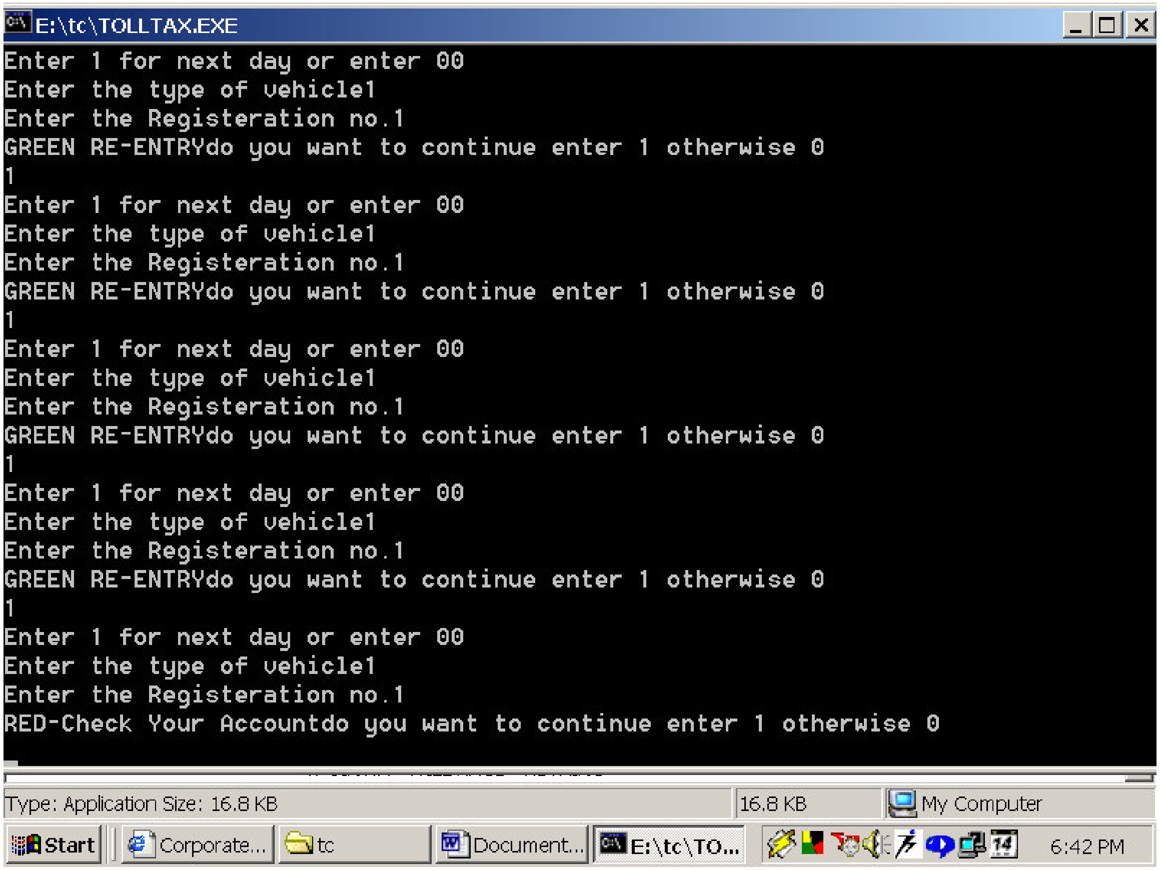
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