24/7 ROAD NETWORK INTELLIGENCE SYSTEM

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ABSTRACT

Changes in the scale and pace of development of recent science and emerging technologies and the growing need to improve performance efficiency and standard of services combine to present a series of challenges and opportunities for exponentially growing organizations. The flexibility and power of wireless technologies like RFID offer solutions to many of these growing business needs and demands. We are motivated by the goal of developing flexible RFID technology based system, that as an automatic identification method can be used in road applications to provide a practical and cost effective solution to a number of traffic monitoring problems. One such solution can be to provide a system to gauge and control the location, movement and speed of automobiles. This system of monitoring, checking, tracking and reporting of vehicles on road networks will make the customary patrolling process completely automated. The ability to perform all these operations greatly expedites processes that would otherwise cost considerable time, finances and other resources. With software to monitor roads/highways/freeways there is no longer any need for the slow monitoring processes that cost considerable resource utilization to the organization. Once this system is put into practice, it can operate without manual processing and minimal resources oversee. With the ability to cut costs, save time and increase productivity, this software is a system that companies will long reap benefit from.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter throws light on the different aspects of the data capture technologies that are currently prevailing, world-wide. A broad brush regarding the extensive work, which has been conducted in the field of RFID, has been given in this chapter.

1.2 Radio Frequency Identification Concept

RFID is an automated data capture technology that can be used to electronically identify, track, and store information about groups of products, individual items, or product components. The technology consists of three key concepts, RFID tags, RFID readers and a data collection, distribution, and management system.

RFID tags contain information about a product or an identification number that corresponds to information that is stored in a database. The tags can be located inside or on the surface of the product or item. RFID readers interrogate or send signals to the tags and receive the responses. These responses are transferred to the data collection system. Lastly, data collection systems consist of computers running data processing software, which typically are networked with a larger information management system. RFID technology relies on the transfer of packets of information through radio waves or electromagnetic waves [1]. A typical RFID system is shown in Figure 1.1.

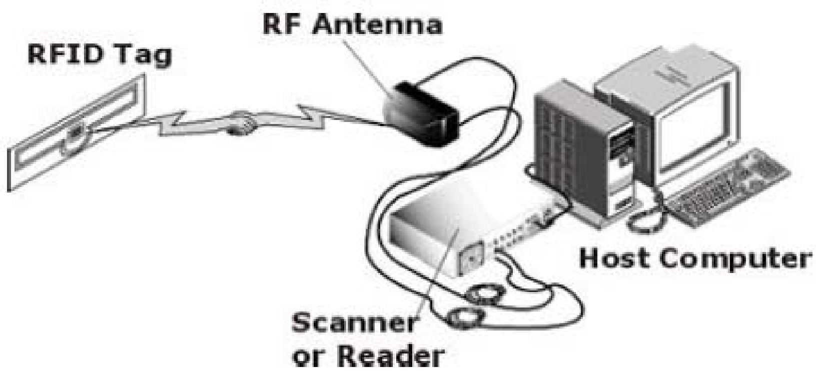


Figure 1.1: A Typical RFID System

It has been the exponential growth in information and communications technologies coupled with the expansion of global production and trade that has resulted in RFID technology becoming useful for managing and tracking large shipments and product sales, and as a means of identification for security purposes and supply chain management. In future years the new worldwide setting is likely to transform the conventional ways of managing road networks, augmenting access to primary sources, such as the actual run time data generated by the road traffic itself enabling improved service and efficiency for road network monitoring.

It is still too early to anticipate the full impact of RFID technology as a solution to traffic problems because of its possible diverse applications. Our project will highlight the prospects for using it in this field and present a practical and useful application of this technology.

1.3 Objective

We are motivated by the goal of developing flexible RFID technology based system, that as an automatic identification method can be used in road applications to provide a practical and cost effective solution to a number of traffic monitoring problems. One such solution can be to provide a system to gauge and control the location, movement and speed of automobiles. This system has the potential to grow in accordance with the emerging and growing organizational needs rather than embodying fixed structures based on any limited technology. This will direct the establishment of the system and we anticipate that this system will gradually become self-sustaining and independent as it is put onto practice and evolved to expand.

1.4 Opportunity

Frontier Works Organization stands as a synonym with the largest construction agency in Pakistan owing to expertise in field of engineering development. Modern business practices for growing organizations demand to replace obsolete methods of operations by centralized computer streamlined systems to encourage productivity improve standards and produce skill. One area where a computerized system can be fully utilized is monitoring, checking, tracking and reporting of vehicles on road networks making the customary patrolling process completely automated. The ability to perform all these operations greatly expedites processes that would otherwise cost considerable time, finances and other resources.

Our system was developed to meet all these needs of organizations such as FWO. With software to monitor roads/highways/freeways there is no longer any need for the slow monitoring processes that cost considerable resource utilization to the organization. Once this system is put into practice, it can operate without manual processing and minimal resources oversee. With the ability to cut costs, save time and increase productivity, this software is a system that companies will long reap benefit from.

1.5 Road Network Intelligence Concept

RFID has become indispensable in a wide range of automated data capture and identification applications, from monitoring and access control to industrial automation. 24/7 ROAD NETWORK INTELLIGENCE SYSTEM is one such application making the best use of this technology for the completely automated monitoring of traffic on highways and other roads bringing both over speeding and under speeding under control. Such and other similar problems add to the already increasing problems of traffic. As a solution to these concerns the proposed system will form a landmark in the field of RFID. It is a complete all purpose system that collects the run time data about the traffic from the RFID readers and is able to automatically monitor, control and track vehicles at run time. This, as an operational support system provides a unique forum for traffic monitoring through the medium of an automated network. The system's goal is to provide a successful operational solution to present traffic problems through automated vehicle monitoring, tracking and control. This system can be deployed on national highways and freeways. It also has an important application in sensitive military areas. This smart system provides a completely automated solution to the problems caused by traffic speed as well as the growing security concerns.

24/7 RNI system can be incorporated as an operational support system. This system will shield the highway monitoring system from possible lags in its performance. Concerned authorities will be able to accomplish effective and accurate road monitoring in all possible terms. The traffic itself is enabled to provide run time data which is then used to calculate the required statistics for decision making. This in turn generates output results that can be used to measure performance against permitted driving rules and road ethics. With the ability to cut costs, save time and increase productivity, this software is a system that companies will long reap benefit from.

1.6 Achievements

This project was done with guidelines from FWO so that it becomes practically deployable on national highways and/or motorways in Pakistan.

It was presented to ENGINEER in CHIEF, Pakistan Army along with other higher officials from FWO and NHA. The project was discussed in detail in all its aspects and working operations and was highly appreciated. It was also approved for grant of resources for further work on it.

1.7 Organization Of Report

This project report has been divided into nine chapters. Chapter 1 gave an introduction to the technology used and to the road network intelligence concept. Chapter 2 gives the literature review in detail along with the appropriate references. Chapter 3 is based on the detailed analysis of system requirements. Chapter 4 gives the system description of the ROAD NETWORK INTELLIGENCE SYSTEM with the description of its operations and constraints. Chapter 5 describes the system design and architecture and explains the way project is organized. Chapter 6 describes the system development with all the details of the system functions and explains the way they have been implemented. Testing and validation of the system is explained in chapter 7 and a detailed analysis of the system performance analysis has been done in chapter 8. Finally, chapter 9 describes all our achievements in our project and the forums we presented our project on including the valuable learning experience we had during the entire duration of our project.

CHAPTER 2

LITERATURE REVIEW

2.1 Technical and Functional Characteristics of RFID

In general terms, RFID represents a way of identifying objects or people using radio frequency transmissions (or using radio waves). Identification is possible by means of unique numbers identifying objects, people, and information, stored on microchips, which can be read automatically. RFID is sometimes called dedicated short range communication (DSRC) [2] [3].

2.1.1 General Description

RFID systems consist of three components, RFID Tag/ Transponder, RFID Reader/ Transceiver and RFID Middleware/ Interface**.**

An RFID tag is a microchip combined with an antenna in a compact package; the packaging is structured to allow the RFID tag to be attached to an object to be tracked. Tags can be both read-only (programmed during manufacture) or, at higher complexity and cost, read-write, or both. Internal structure of an RFID tag is shown in Figure 2.1; different types of tags are shown in Figure 2.2 and 2.3.

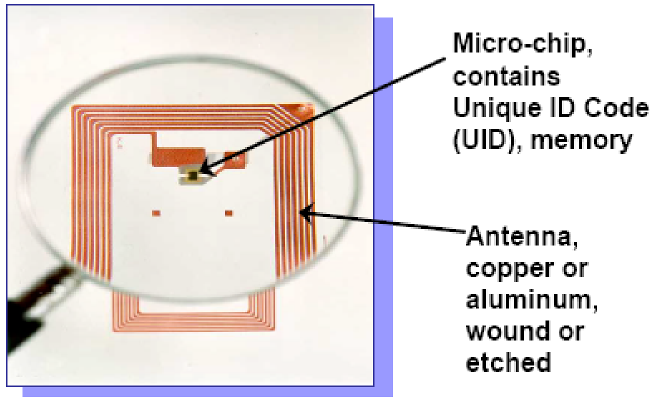


Figure 2.1: Internal Structure Of RFID Tag

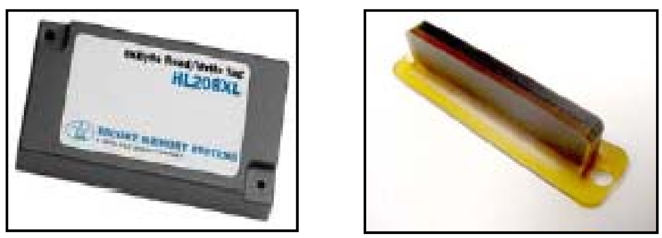


Figure 2.2: Metal Tags

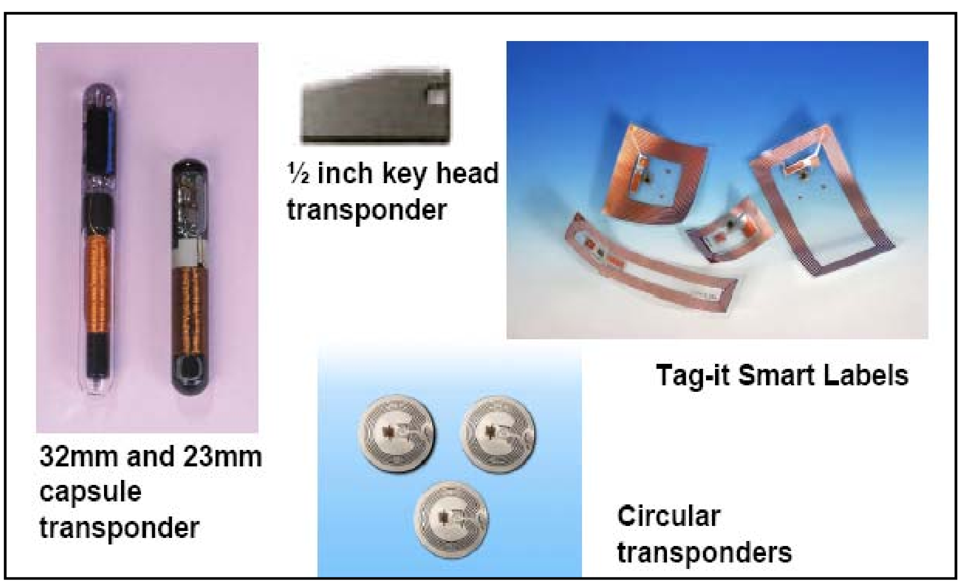


Figure 2.3: Different Types Of RFID Tags

An RFID reader is a device that is used to interrogate an RFID tag. The reader has an antenna that emits radio waves; the tag responds by sending back its data. Depending on the application and technology used, some interrogators not only read, but also remotely write to, the tags. Different types of readers and reader circuitry are shown in Figure 2.4.

Figure 2.4: RFID Reader

Middleware is the interface needed between the reader and the existing company databases and information management software. This unit interfaces the reader to an intelligent device.

2.1.2 Working Of RFID System

RFID tags are programmed with information about a product or with a number that corresponds to information that is stored in a database. The tags can be located inside or on the surface of the product, item, or packing material. RFID readers are querying systems that interrogate or send signals to the tags and receive the responses. These responses can be stored within the reader for later transfer to a data collection system or instantaneously transferred to the data collection system through an interface (typically Serial or TCP/IP). Lastly, data collection systems consist of computers running data processing software, which typically are networked with a larger information management system [4].

As shown in Figure 2.5, when a transponder enters a read zone, its data is captured by the reader and can then be transferred through standard interfaces to a host computer, printer, or programmable logic controller for storage or action.

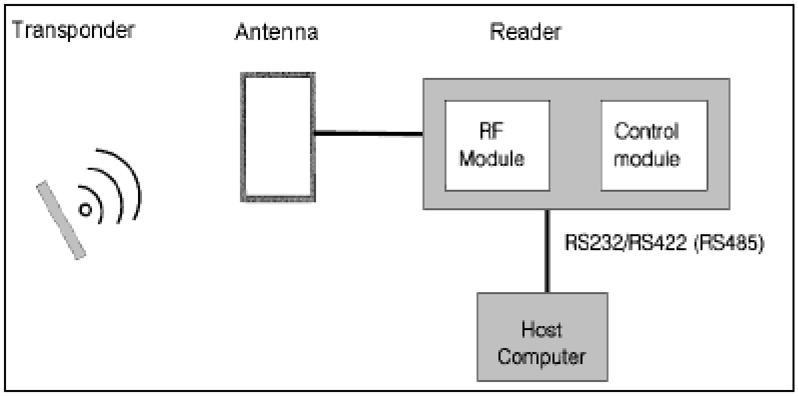


Figure 2.5: General Description Of RFID System

2.1.3 RFID Principles

Two fundamentally different RFID design approaches exist for transferring power from the reader to the tag, magnetic induction and electromagnetic wave capture. These two designs take advantage of the electromagnetic properties associated with the RF antenna, the near field and the far field.

2.1.3.1 Near Field RFID Communication

Faraday's principle of magnetic induction is the basis of near field coupling between a reader and tag [5]. A reader passes a large alternating current through a reading coil, resulting in an alternating magnetic field in its locality. If you place a tag that incorporates a smaller coil as shown in Figure 2.6, in this field an alternating voltage will appear across it. If this voltage is rectified and coupled to a capacitor, a reservoir of charge accumulates, which you can then use to power the tag chip. Tags that use near-field coupling send data back to the reader using load modulation. Because any current drawn from the tag coil will give rise to its own small magnetic field which will oppose the reader's field the reader coil can detect this as a small increase in current flowing through it. This current is proportional to the load applied to the tag's coil (hence load modulation). This is the same principle used in power transformers found in most homes today although usually a transformer's primary and secondary coil are wound closely together to ensure efficient power transfer. However, as the magnetic field extends beyond the primary coil, a secondary coil can still acquire some of the energy at a distance, similar to a reader and a tag. Thus, if the tag's electronics applies a load to its own antenna coil and varies it over time, a signal can be encoded as tiny variations in the magnetic field strength representing the tag's ID. The reader can then recover this signal by monitoring the change in current through the reader coil. Its working is shown in Figure 2.6.

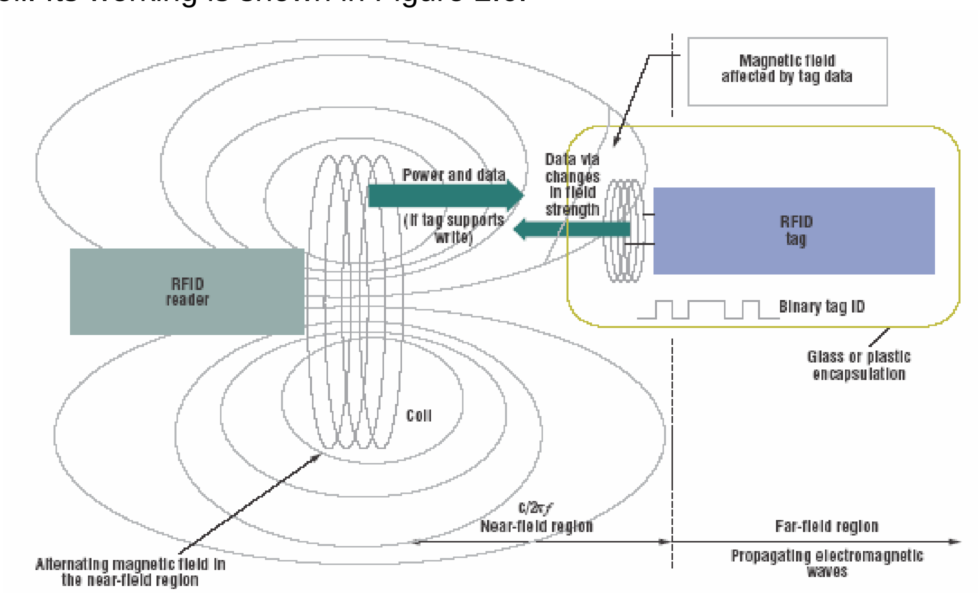


Figure 2.6 Near Field Communication For RFID Communication

2.1.3.2 Far Field RFID Communication

RFID tags based on far-field emissions as shown in Figure 2.7, capture EM waves propagating from a dipole antenna attached to the reader [5]. A smaller dipole antenna in the tag receives this energy as an alternating potential difference that appears across the arms of the dipole. A diode can rectify this potential and link it to a capacitor, which will result in an accumulation of energy in order to power its electronics. However, unlike the inductive designs, the tags are beyond the range of the reader's near field, and information can't be transmitted back to the reader using load modulation. The technique designers use for commercial far-field RFID tags is back scattering. If they design an antenna with precise dimensions, it can be tuned to a particular frequency and absorb most of the energy that reaches it at that frequency. However, if an impedance mismatch occurs at this frequency, the antenna will reflect back some of the energy (as tiny waves) toward the reader, which can then detect the energy using a sensitive radio receiver. By changing the antenna's impedance over time, the tag can reflect back more or less of the incoming signal in a pattern that encodes the tag's ID as shown in Figure 2.7. In practice, we can detune tag's antenna for this purpose by placing a transistor across its dipole and then turning it partially on and off.

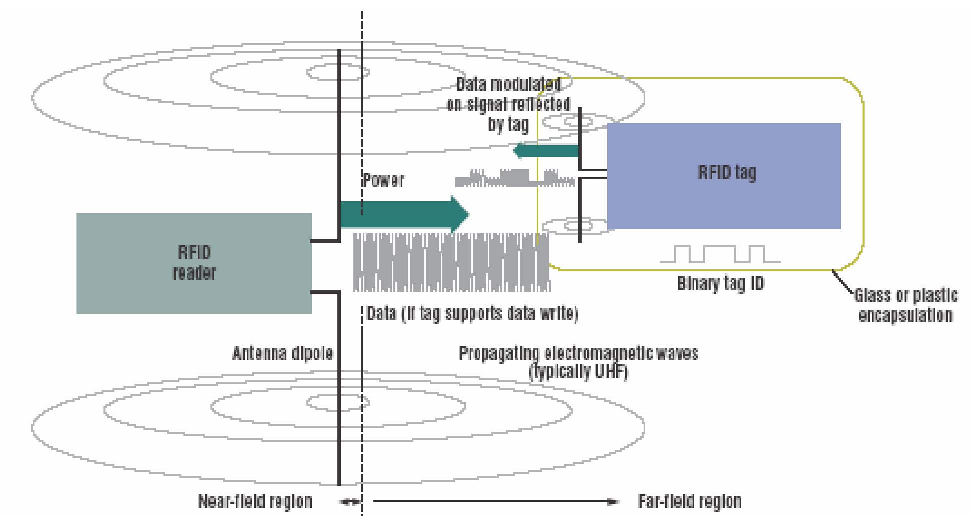


Figure 2.7 Far Field Communication For RFID Communication

2.1.4 Frequency Bands Used for RFID

Frequency band allocation for the use of radio devices is regulated by federal agencies such as the FCC in the US, PTT in Germany, and so on. There are limitations to the bands available within which RFID systems can function [6]. However, several bands have evolved throughout the spectrum where you find these systems in use. There are definite tradeoffs to consider for each band. Therefore, it is important to understand the application requirements before selecting a particular type of RFID system. The different ranges of frequencies are given in Figure 2.8 and a comparison of these frequencies is given in Table 2. The design approach to the implementation of the technology differs according to the performance requirements of the application.

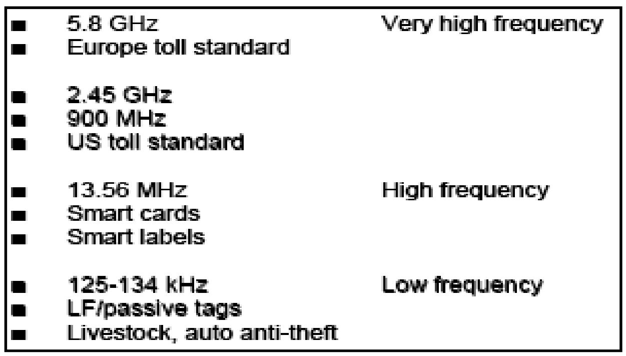


Figure 2.8: Frequencies Used For RFID

Table 2.1: Comparison Of Frequencies

Low Frequency	**High Frequency**
Below 500 kHz	Above 1 MHz
Short to medium range	Medium to long range
Medium data rate	Fast data rate
Not orientation sensitive	Orientation sensitive
Read through non-metallics	Less able to penetrate
Low power levels	High power levels
Inexpensive	Expensive
Noise sensitive	Not noise sensitive

2.1.5 History of RFID Technology

The roots of RFID technology can be traced back to World War II. The Germans, Japanese, Americans and British were all using radar which had been discovered in 1935 by Scottish physicist Sir Robert Alexander Watson-Watt to warn about approaching planes while they were still miles away. The problem was there was no way to identify which planes belonged to the enemy and which were a country's own pilots returning from a mission. The Germans discovered that if pilots rolled their planes as they returned to base, it would change the radio signal reflected back. This crude method alerted the radar crew on the ground that these were German planes and not allied aircraft. This was, essentially, the first passive RFID system. Under Watson-Watt, who headed a secret project, the British developed the first active identify friend or foe (IFF) system. They put a transmitter on each British plane. When it received signals from radar stations on the ground, it began broadcasting a signal back that identified the aircraft as friendly. RFID works on this same basic concept. A signal is sent to a transponder which wakes up and broadcasts a signal.

Advances in radar and RF communications systems continued through the 1950s and 1960s. Scientists and academics in the United States, Europe and Japan did research and presented papers explaining how RF energy could be used to identify objects remotely. Companies began commercializing anti-theft systems that used radio waves to determine whether an item had been paid for or not. The First RFID Patents Mario W. Cardullo claims to have received the first U.S. patent for an active RFID Tag on January 23, 1973. That same year, Charles Walton, a California entrepreneur, received a patent for a passive transponder used to unlock a door without a key. The U.S. government was also working on RFID systems. In the 1970s, Los Alamos National Laboratory was asked by the Energy Department to develop a system for tracking nuclear materials. A group of scientists came up with the concept of putting a transponder in a truck and readers at the gates of secure facilities. The gate antenna would wake up the transponder in the truck, which would respond with an ID and potentially other data, such as the driver's ID. This system was commercialized in the mid-1980s when the Los Alamos scientists who worked on the project left to form a company to develop automated toll payment systems. These systems have become widely used on roads, bridges and tunnels around the world. At the request of the Agricultural Department, Los Alamos also developed a passive RFID tag to track cows. The problem was that cows were being given hormones and medicines when they were ill. But it was hard to make sure each cow got the right dosage and wasn't given two doses accidentally. Los Alamos came up with a passive RFID system that used UHF radio waves. The device drew energy from the reader and simply reflected back a modulated signal to the reader using a technique known as backscatter. Over time, companies commercialized 125 kHz systems and then moved up the radio spectrum to high frequency (13.56 MHz), which was unregulated and unused in most parts of the world. High frequency offered greater range and faster data transfer rates. Companies, particularly those in Europe, began using it to track reusable containers and other assets. Today, 13.56 MHz RFID systems are used for access control, payment systems and contactless smart cards. They’re also used as an anti-theft device in cars. A reader in the steering column reads the passive RFID tag in the plastic housing around the key. If it doesn’t get the ID number it is programmed to look for, the car won't start.

In the early 1990s, IBM engineers developed an ultra high frequency (UHF) RFID system. UHF offered longer read range (up to 20 feet under good conditions) and faster data transfer. IBM did some early pilots with Wal-Mart, but never commercialized this technology. When it ran into financial trouble in the mid-1990s, IBM sold its exclusive rights foe this system to Intermec, a bar code systems provider. Intermic RFID systems have been installed in numerous different applications, from warehouse tracking to farming. But the technology was expensive at the time due to the low volume of sales and the lack of open, international standards. UHF RFID got a boost in 1999, when the Uniform Code Council, EAN International, Procter & Gamble and Gillette put up funding to establish the Auto-ID Center at the Massachusetts Institute of Technology. Two professors there, David Brock and Sanjay Sarma, had been doing some research into the possibility of putting low-cost RFID tags on all products made to track them through the supply chain. Their idea was to put only a serial number on the tag to keep the price down. Data associated with the serial number on the tag would be stored in a database that would be accessible over the Internet.

Sarma and Brock essentially changed the way people thought about RFID in the supply chain. Previously, tags were a mobile database that carried information about the product or container they were on with them as they traveled. They turned RFID into a networking technology by linking objects to the Internet through the tag. For businesses, this was an important change, because now a manufacturer could automatically let a business partner know when a shipment was leaving the dock at a manufacturing facility or warehouse, and a retailer could automatically let the manufacturer know when the goods arrived.

Between 1999 and 2003, the Auto-ID Center gained the support of more than 100 large end-user companies, plus the U.S. Department of Defense and many key RFID vendors. It opened research labs in Australia, the United Kingdom, Switzerland, Japan and China. It developed two air interface protocols, the Electronic Product Code (EPC) numbering scheme, and a network architecture for looking up data associated on an RFID tag on the Internet. The technology was licensed to the Uniform Code Council in 2003, and the Uniform Code Council created EPCglobal, as a joint venture with EAN International, to commercialize EPC technology. The Auto-ID Center closed its doors in October 2003, and its research responsibilities were passed on to Auto-ID Labs.

Some of the biggest retailers in the world like Albertsons, Metro, Target, Tesco, Wal-Mart and the U.S. Department of Defense use EPC technology to track goods in their supply chain. The pharmaceutical, tire, defense and other industries are also moving to adopt the technology.

2.1.6 Applications of RFID

Potential applications for RFID may be identified in virtually every sector of industry, commerce and services where data is to be collected. The attributes of RFID are complimentary to other data capture technologies and thus able to satisfy particular application requirements that cannot be adequately accommodate by alternative technologies. Principal areas of application for RFID that can be currently identified include transportation and logistics, manufacturing and processing, security.

A range of miscellaneous applications may also be distinguished, some of which are steadily growing in terms of application numbers. They include animal tagging, waste management, time and attendance, postal tracking, airline baggage reconciliation, road toll management. As standards emerge, technology develops still further, and costs reduce considerable growth in terms of application numbers and new areas of application may be expected.

Some of the more prominent specific applications include electronic article surveillance - clothing retail outlets being typical, protection of valuable equipment against theft, unauthorized removal or asset management, controlled access to vehicles, parking areas and fuel facilities - depot facilities being typical, automated toll collection for roads and bridges -

since the 1980s, electronic Road-Pricing (ERP) systems have been used in Hong Kong, controlled access of personnel to secure or hazardous locations, time and attendance - to replace conventional “slot card” time keeping systems, animal husbandry - for identification in support of individualized feeding programs, automatic identification of tools in numerically controlled machines - to facilitate condition monitoring of tools, for use in managing tool usage and minimizing waste due to excessive machine tool wear, identification of product variants and process control in flexible manufacture systems, sport time recording, electronic monitoring of offenders at home, vehicle anti-theft systems and car immobilizer. RFID systems round the globe have been developed to provide domestic as well as industrial solutions. One such system is Plug & Play RFID, Traffic Monitoring & Control that is developed as an intermediate middleware for the system processes and provide sophisticated integration solution for systems. In its second portion it provides an algorithm for congestion alleviation in metropolitan cities. Another RFID system is Traffic Flow Optimizer Using RFID Based Integrated Network done in FAST in 2007 which presents a scheme for optimizing the traffic signals according to the current density and flow of traffic.

A number of factors influence the suitability of RFID for given applications. The application needs must be carefully determined and examined with respect to the attributes that RFID and other data collection technologies can offer. Where RFID is identified as a contender further considerations have to be made in respect of application environment, from an electromagnetic standpoint, standards, and legislation concerning use of frequencies and power levels.

For more information on RFID see Appendix B.

2.2 Geographical Information System

Geographic Information System (GIS) is defined as an information system that is used to input, store, retrieve, manipulate, analyze and output geographically referenced data or geospatial data, in order to support decision making for planning and management of land use, natural resources, environment, transportation, urban facilities, and several other application areas [7].

In this context, GIS, spatial information technology has offered a great potential to capture data through variety of earth observation platforms, and integrate them through their common spatial work station. This advanced approach justifies the involvement of object oriented database structures in the decision making process as this digital framework is an efficient system for the storage of larger volume of data, maintaining data records, data management, data repository and data accuracy for easy access and planning.

2.2.1 Overview

Geographic Information System (GIS) is a computer based information system used to digitally represent and analyze the geographic features present on the Earth's surface and the events that takes place on it. The meaning to represent digitally is to convert analog (smooth line) into a digital form.

Every object present on the Earth can be geo-referenced, is the fundamental key of associating any database to GIS. Here, term 'database' is a collection of information about things and their relationship to each other and 'geo-referencing' refers to the location of a layer or coverage in space defined by the coordinate referencing system.

GIS technology integrates common database operations, such as query and statistical analysis, with maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for planning strategies and managing infrastructure.

2.2.2 Components

A working GIS integrates five key components: hardware, software, data, people, and methods.

Hardware is the computer on which GIS operates. Today, GIS runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are a database management system (DBMS), tools for the input and manipulation of geographic information, tools that support geographic query, analysis, and visualization and a graphical user interface (GUI) for easy access to tools.

May be the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or bought from a commercial data provider. Most GIS employ a DBMS to create and maintain a database to help organize, manage, and document data.

GIS technology is of limited value without the people who manage the system and to develop plans for applying it. GIS user ranges from technical specialists who design and maintain the system to those who use it to help them do their everyday work.

A successful GIS operates according to a well-designed plan and business rules, unique to each operation. All its components aer shown in Figure 2.9.

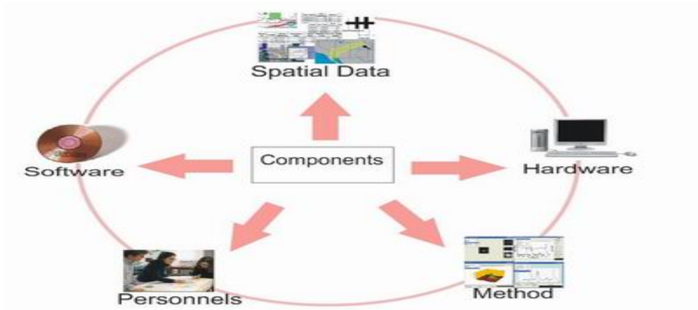


Figure 2.9 Gis Components

2.2.3 How GIS Works

Geographical data describe the objects from the real world in three forms, their position with respect to a known coordinate system, their attributes that are unrelated to position (such as color, cost, pH, incidence of disease, etc) and their spatial interrelations with each other (topographical relations), which describe how they are linked together or how one can travel between them. Data input covers all aspects of transforming data captured in the form of existing maps, field observation and sensors (including aerial photography, satellites and recording interments) into a compatible digital form. Topology and attributes of geographical elements (points, lines and areas representing objects on the earth’s surface) are structured and organized, both with respect to the way they are handled in the computer and how they are perceived by the users of the system. The computer program used to organize the database is known as a Database Management System (DBMS). Data output and presentation concerns the ways the data are displayed and the results of analysis are reported to the users.

2.3 ArcGIS 9.2

ArcGIS provides a scalable framework for implementing a geographic information system (GIS) for a single user or for many users on desktops, in servers, over the Web, and in the field. ArcGIS 9.2 is an integrated collection of GIS software products for building a complete GIS [8]. It consists of a number of frameworks for deploying GIS including ArcGIS Desktop, an integrated suite of professional GIS applications, ArcGIS Engine, embeddable developer components for custom GIS applications and ArcGIS Geodatabase, short for geographic database, is a GIS and database management system (DBMS) standards-based physical data store and is implemented on a number of multi-user and personal DBMSs and in XML [9] [10].

CHAPTER 3

REQUIREMENT ANALYSIS

3.1 Introduction

Requirements analysis encompasses those tasks that go into determining the needs or conditions to meet for a new or altered product, taking account of the possibly conflicting requirements of the various stakeholders, such as beneficiaries or users. Systematic requirements analysis is also known as requirements engineering. Requirements analysis of the Road Network Intelligence system is done in this chapter.

3.2 Existing System

The present system used for checking speed violations and monitoring on road networks uses conventional ways of operation. For speed checking, laser guns are used manually along road sides at certain locations. The fine generation is dependant on the duty staff who gives tickets in case of any violation. The fine is paid at specified fine collection centers. Continuous patrolling is done to monitor the vehicles for breakdowns or an accident.

3.3 Problems in the Existing System

The system currently used presents many problems. First of all, speed checks are done manually with speed guns, hence less accountability and more violations go unnoticed. Also the speed checking at night/dark hours is much limited because the equipment presently used for this purpose is inefficient to be used in dark. Furthermore, speed checks are done at limited places only. Round the clock patrolling in every 10 km area is considerably costly and less effective. The present system has much dependability on manpower resources for its operations. Vehicles meeting accidents/breakdowns can not be detected unless reported upon or being checked by patrolling police. Also there are very less checks on vehicle stopping other than rest areas. The fine collection system presently used is less convenient & more costly in terms of finances as well as time. With tickets issued manually tendency of individuals getting in unnecessary arguments with police is fairly high.

3.4 Requirements Consolidated

Based on the problems of the current system and the guidelines form FWO, requirements for our project were consolidated. It was desired that the system should provide complete road monitoring under all conditions throughout the road network. It should be able to check and detect speed of the vehicles. It should also keep a record of any speed violation, including both over and under speeding. The system should be able to automatically compute and record the fines for violations of road ethics. The system should also provide automated ticket generation. There is a need of a system that provides efficient tracking of vehicles based on the run time data generated by the vehicles. To detect for the vehicles that stopped other than the permitted rest areas in case of breakdown or an accident should also be catered as part of he tracking part. Detection of stolen vehicles on the road network should be done. The system should provide all operations in user friendly software that allows its operations in a single click.

3.5 Specific Requirements

Specific requirements of a system are a comprehensive description of the intended purpose and environment for software under development. They fully describe what the software will do and how it will be expected to perform. System features like interfaces, functions and performance are catered in this portion.

3.5.1 External Interfaces

The input to the system comes in two ways. The first is the data that lies within the system. This is designed to be entered into the system manually and includes the cars and tags identification numbers. Only the clients will be allowed to enter this data.

The other part of input to the system is the information sent by the readers. This is given to the system to update its database about the flow and control. Both these information sections combine to produce information needed to monitor the traffic on roads. This is also used to compare the record of traffic with the predefined rules to identify any possible violations. The same information pool is used to generate reports and output results. The output of the system is provided through a user interface that provides consolidated information regarding traffic records.

3.5.2 Functions

The system is required to perform these operations. The data is entered into the system, manually form the clients and automatically from the readers. The system offers an operation that calculates the statistics about the road traffic and log them into the database automatically. This all information is used to evaluate the desired results and evaluations. The evaluation process is internal to the system. Evaluations should be done both on the server and the client(s) when requested for them. Based on the evaluations just done, output should be given to find and evaluate the violations with effective accuracy. The output may be tailored to fulfill any other related requirements if needed.

3.5.3 Performance Requirements

The system is subject to some static and dynamic numerical requirements placed on the system and on readers' and clients' interaction with the system. The system's scope, presently, is a network of monitored highways and freeways. The numbers of clients are presently limited to the number of terminals on the road. Likewise, the amount of information to be handled by the system is limited to the complete road under observation. Dynamic Performance Requirements, such as response time of transactions, are dependent on the system's design, development and evaluation. These requirements can be accurately measured after development during testing/evaluation.

3.5.4 Design Constraints

The database design should adhere to the rules of a relational database for compliance with the international standards of operation. It should avoid redundancy at all costs and ensure data integrity. There are no design constraints for the system. It is subject to the developer's choice. All the hardware/software support required for system's development is currently available.

3.5.5 Standards Compliance

The software system should be developed in compliance with internationally accepted ISO15693 standard for development of RFID applications. ISO 15693 is a standard for Vicinity Cards, i.e. cards which can be read from a greater distance as compared to Proximity cards.The database for the system will follow the relational database rules.

3.5.6 Software System Attributes

There are a number of attributes of RNI system that serve as requirements. These required attributes are highlighted here so that their achievement can be objectively verified.

3.5.6.1 Reliability

The system's reliability is important for its functional working and availability. It should be reliable enough to work well with both the system's data and the input data. Its reliability is most important in case of its output where accurate results and comparisons are required. It is required and expected to be available to the clients all the time. Any chances of unavailability or malfunctioning should be minimized. This involves operations at the client as well as the server end.

3.5.6.2 Security

The system is limited by a few security constraints. The cars and tags definition and manipulation will be done with security checks. Also, only the authorized clients (terminals) would be given access to the server operations. System data should be critically checked to maintain data integrity. System backups should be taken manually, initially.

3.5.6.3 Maintainability

The system is intended to be an easy-to-maintain one. The data input is done, partially manually and partially through readers input. Both ways, the information should go into the system's database and recorded and maintained there. Its operations are consistent and will need infrequent maintenance, when needed.

3.5.7 Organizing the Specific Requirements

This is to decompose the problem into component parts. The act of organizing software's specific requirements in a well-designed format organizes information, places borders around the problem, solidifies ideas, and helps break down the problem into its component parts in an orderly fashion. Therefore, the specific requirements must contain sufficient detail so that a design solution can be devised.

3.5.7.1 System Mode

The system should be designed to operate partially in manual and partially in automated mode. Part of input, car information coming from the terminals, is given manually. Rest of the input, coming from the readers and other operations are automated. Using the given information, the system should do the evaluations internally and generate desired outputs.

3.5.7.2 Objects And External Features

The main objects that the system should interact with are the RFID readers and the cars. These and other related entities should be explained and modeled in the system's design. There are no external features that interact with the system. It is a stand alone system that interacts only with its own application components and objects.

3.5.7.3 Response

The system should respond to the operations performed on/by it. It should acknowledge the information input to it by the clients. This will also confirm the successful input of the data. Outputs should be generated based on the input and given as a response to the client's or server's own requirement to be given the comparison result.

CHAPTER 4

RNI SYSTEM DESCRIPTION

4.1 Introduction

24/7 RNI is an independent system. It is developed as a self centered system and can be extended to include more advanced features. Furthermore, it can be provided internal and/or external support if required to support possible extensions. The users of the system are external actors to it and can communicate with it via system's interfaces. Input is taken form the traffic itself on runtime and the system's clients. It uses it to do evaluations and generate results. Outputs are given as reports and maps to achieve traffic monitoring and control. This operation is shown in Figure 4.1.

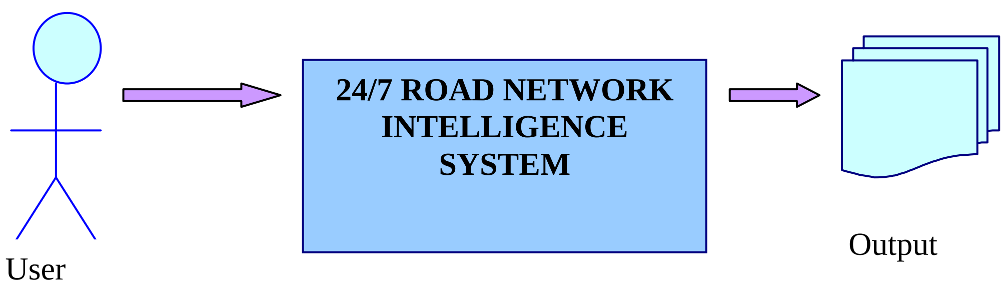


Figure 4.1: System Overview

4.2 Interfaces

The system interacts with the incoming traffic information. For this interaction, the interfaces are developed to support information maintenance including data entry, manipulation and deletion. The main information source that the system interfaces with is the traffic that generates run time data to be operated upon. More external interfaces can be integrated if needed by providing the required system support.

4.2.1 System Interfaces

The system provides user interfaces to support its operations. It provides an interface for the server side to check work information. This information, coming from the RFID readers is taken as input and given to the system for operations. Another interface, for output(s) gives reports, maps and graphs. It also gives consolidated information about the traffic monitoring status and marks any possible violations and unusual operations. More interfaces can be developed and integrated if required by the user/system.

4.2.2 Hardware Interfaces

Presently, following hardware components and interfaces are used but more can be required if advance level support/functionality is desired of the system: One RightTag USB Hand-Held RFID Reader, RFID Tags and Computers to create Client Server Environment.

4.2.3 Software Interfaces

RNI system interfaces with these softwares Microsoft SQL Server, JVM and Arc GIS. It provides client server architecture for user interaction and follows the distributed systems protocols. More software interfaces can be added at the time of design and/or development.

4.3 Memory Constraints

The system database is developed in Microsoft SQL Server to overcome the problems of database crashes and performance. Further constraints are subject to the extension of the system, presently none.

4.4 Operations

The system operations are active without any unattended/inactive sessions. The mode of operation is manual where user interaction is involved and automated for system's internal process(es) involving automated data reception from the readers into the server. Also, the system remains operational all the time without any effects of operational issues.

4.5 System Salients

The system's objective for its development was to guide the traffic control based on the information extracted form this application for decision making. RFID readers are deployed along the road sides. This practice follows the entire length of the road under observation. Care is to be taken so that the placements of readers do not leave out any portions of the road uncovered outside their range. As cars enter the road, their valid information in taken and a tag is assigned to each car. This tag id, along with car id is used further for decision making. Readers on road sides read the tags on cars as they pass by. Readers on road sides read tags on stationary cars in case of any such occurrences. All the readers transfer the tags information they read form the cars to the central system. The server has operational functions that take the incoming information from the clients, the terminals and the road side readers. This information is used to perform the desired computations, such as speed calculations.

The authentic results are entered into the database. The information in the system database is used to perform accurate run time tracking of vehicles on roads. This makes use of the car information and the data sent in by the readers. All the terminals, here modeled as clients to the central server system, can access database if needed. This enables them to get information about the cars, check them for violations and track them when needed. The information in the central server is used to generate reports as output for violations checking. Other information in the same system is used to generate maps in event of run time vehicle tracking.

4.6 User Characteristics

The users of the system are expected to be admin staff on both server and client end that will be authorized to perform operations on valid data present in the system's database. Also, the system's users are expected to interact through the user friendly interfaces that the system will offer them to interact with.

4.7 System Constraints

The system is subject to a few operational constraints for its design and development. This can be refined and extended if needed. Develop a software system that is capable of operating ISO15693 Standard. Develop a system that uses RFID readers of optimum range and frequency. Provide interface(s) between the server and client applications. Parallel operation of client and server at all times. Develop a system that fulfils the distributed client server architecture requirements. Reliability of operation and data integrity.

CHAPTER 5

SYSTEM DESIGN AND ARCHITECTURE

5.1 Introduction

The software design and architecture of a program or computing system is the structure or structures of the system, which comprise software components, the externally visible properties of those components, and the relationships between them. This chapter covers the layout of our project. All resources available, the components designed and their link with each other is explained here in detail.

5.2 System Components And Layout

Our project was divided into components for its design namely RFID Tags, RFID Readers, Server and Clients. Figure 5.1 explains the layout of the system components and their relation with each other. It also shows the working of our system when all components are put to work together.

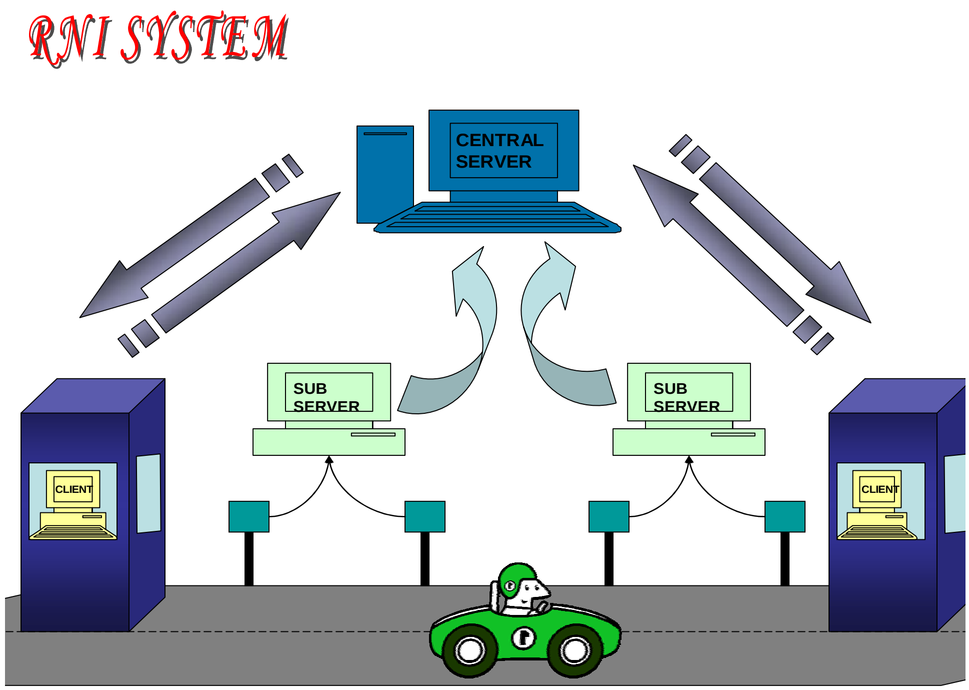


Figure 5.1: RNI System Layout

5.3 System Design

RNI is designed as an independent software that works at the application layer. At the implementation layer, it is integrated with the hardware layer to establish communication with the RFID layer. Figure 5.2 explains system design where the RFID layer handles connection between the system software and the hardware exchanging information with the tags and reader.

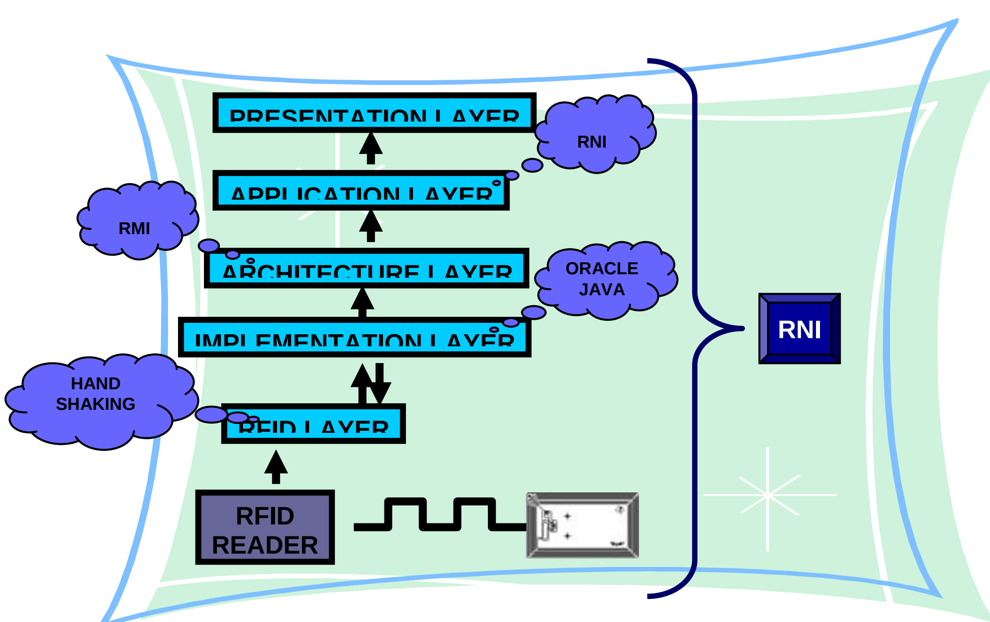


Figure 5.2: System Design

5.4 System Architecture

RNI acts as an independent software integrated with RFID. It uses REMOTE METHOD INVOCATION technique for a distributed design of the system and is built on CLIENT SERVER PARADIGM. Two servers and one client are developed to perform and access operations respectively. The comprehensive system architecture is shown in Figure 5.3.

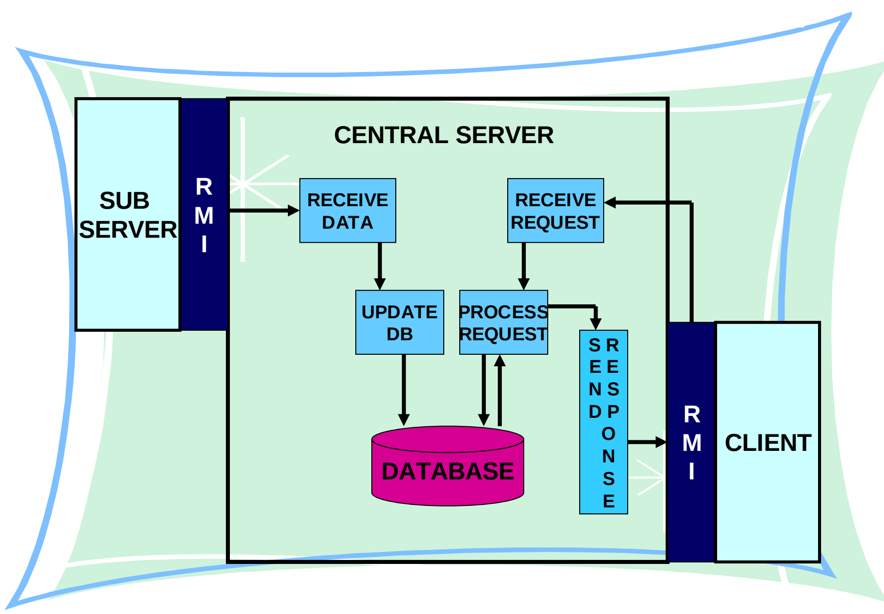


Figure 5.3: System Architecture

5.4.1 Remote Method Invocation

RMI applications often comprise two separate programs, a server and a client. A typical server program creates some remote objects, makes references to these objects accessible, and waits for clients to invoke methods on these objects. A typical client program obtains a remote reference to one or more remote objects on a server and then invokes methods on them. RMI provides the mechanism by which the server and the client communicate and pass information back and forth. Such an application is sometimes referred to as a distributed object application [11].

Distributed object applications need to, firstly locate remote objects. Applications can use various mechanisms to obtain references to remote objects. For example, an application can register its remote objects with RMI's simple naming facility, the RMI registry. Alternatively, an application can pass and return remote object references as part of other remote invocations. Secondly, they need to communicate with remote objects. Details of communication between remote objects are handled by RMI. To the programmer, remote communication looks similar to regular Java method invocations. And lastly, they have to load class definitions for objects that are passed around. Because RMI enables objects to be passed back and forth, it provides mechanisms for loading an object's class definitions as well as for transmitting an object's data.

Figure 5.4 depicts an RMI distributed application that uses the RMI registry to obtain a reference to a remote object. The server calls the registry to associate (or bind) a name with a remote object. The client looks up the remote object by its name in the server's registry and then invokes a method on it. It also shows that the RMI system uses an existing web server to load class definitions, from server to client and from client to server, for objects when needed.

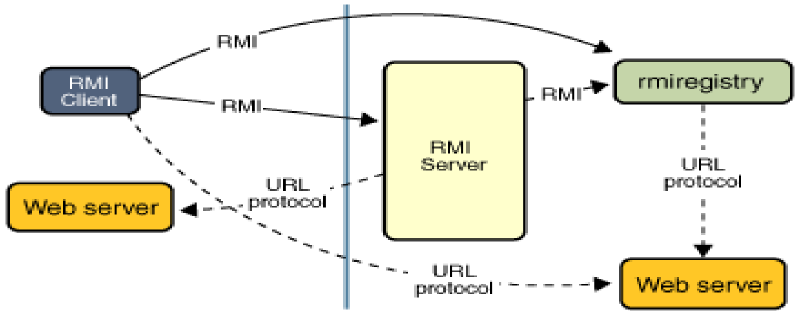


Figure 5.4: Remote Method Invocation

5.4.1.1 Advantages of RMI

One of the central and unique features of RMI is its ability to download the definition of an object's class if the class is not defined in the receiver's Java virtual machine. All of the types and behavior of an object, previously available only in a single Java virtual machine can be transmitted to another, possibly remote, Java virtual machine. RMI passes objects by their actual classes, so the behavior of the objects is not changed when they are sent to another Java virtual machine [12]. This capability enables new types and behaviors to be introduced into a remote Java virtual machine, thus dynamically extending the behavior of an application.

5.4.1.2 Remote Interfaces, Objects, and Methods

Like any other Java application, a distributed application built by using Java RMI is made up of interfaces and classes. The interfaces declare methods. The classes implement the methods declared in the interfaces and, perhaps, declare additional methods as well. In a distributed application, some implementations might reside in some Java virtual machines but not others. Objects with methods that can be invoked across Java virtual machines are called remote objects [13].

An object becomes remote by implementing a remote interface, which has a remote interface extends the interface java.rmi.Remote and each method of the interface declares java.rmi.RemoteException in its throws clause, in addition to any application-specific exceptions.

RMI treats a remote object differently from a non-remote object when the object is passed from one Java virtual machine to another Java virtual machine. Rather than making a copy of the implementation object in the receiving Java virtual machine, RMI passes a remote stub for a remote object. The stub acts as the local representative, or proxy, for the remote object and basically is, to the client, the remote reference. The client invokes a method on the local stub, which is responsible for carrying out the method invocation on the remote object.

A stub for a remote object implements the same set of remote interfaces that the remote object implements. This property enables a stub to be cast to any of the interfaces that the remote object implements. However, only those methods defined in a remote interface are available to be called from the receiving Java virtual machine.

5.4.2 RNI Server

The system is designed in a distributed way to achieve the client server paradigm. Two servers were designed to reduce complexity and distribute load and to increase the overall efficiency of the system. The description of these servers is given below.

It is a distributed server whose purpose is to establish communication between the central server and the RFID equipment. It provides communication with the readers. It receives tag information from the readers and sends it to the CENTRAL SERVER.

This is the main server where the database of the entire system is maintained. It receives traffic information from the SUBSERVERS and vehicle information from the CLIENTS respectively and automatically updates the database. It receives and processes requests from the CLIENTS and responds to them, thus providing them its services.

5.4.3 RNI Client

This is the part of the application that sends vehicle information to the CENTRAL SERVER to register or unregister it on the road network. It requests the services of the CENTRAL SERVER to perform the available functions. These operations are performed through a connection with the CENTRAL SERVER'S database.

5.5 Knowledge Base Design

Relational Model is today the primary data model for commercial data-processing applications. The knowledgebase, as shown in Figure 5.5, has been designed for minimizing the response time and to maximize the throughput and the operational speed so as to update the DB swiftly and avoid functional problems.

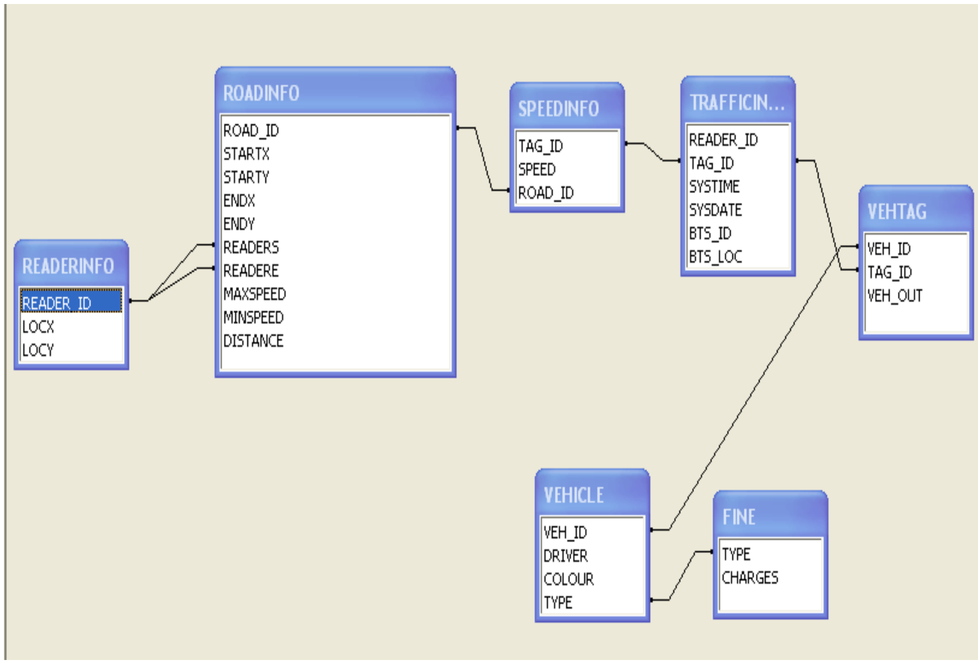


Figure 5.5: Database Design Diagram

5.6 UML Design

Modeling has been an essential part of engineering, art and construction for centuries. Complex software designs that are difficult to describe textually can readily be conveyed through diagrams. Modeling provides three key benefits: visualization, complexity management and clear communication [14]. UML, the Unified Modeling Language, is a visual language for specifying, constructing, and documenting the artifacts of systems. UML was approved by the OMG as a standard in 1997. Over the past few years there have been minor modifications made to the language.

The Unified Modeling Language (UML) is a standard language for specifying, visualizing, constructing, and documenting the artifacts of software systems, as well as for business modeling and other non-software systems. It is a very important part of developing objects oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects. Using the UML helps project teams communicate, explore potential designs, and validate the architectural design of the software [15].

Using the UML modeling, we developed the class diagram of our system using the tool Rational Rose [16]. The class diagram is shown in Figure 5.6.

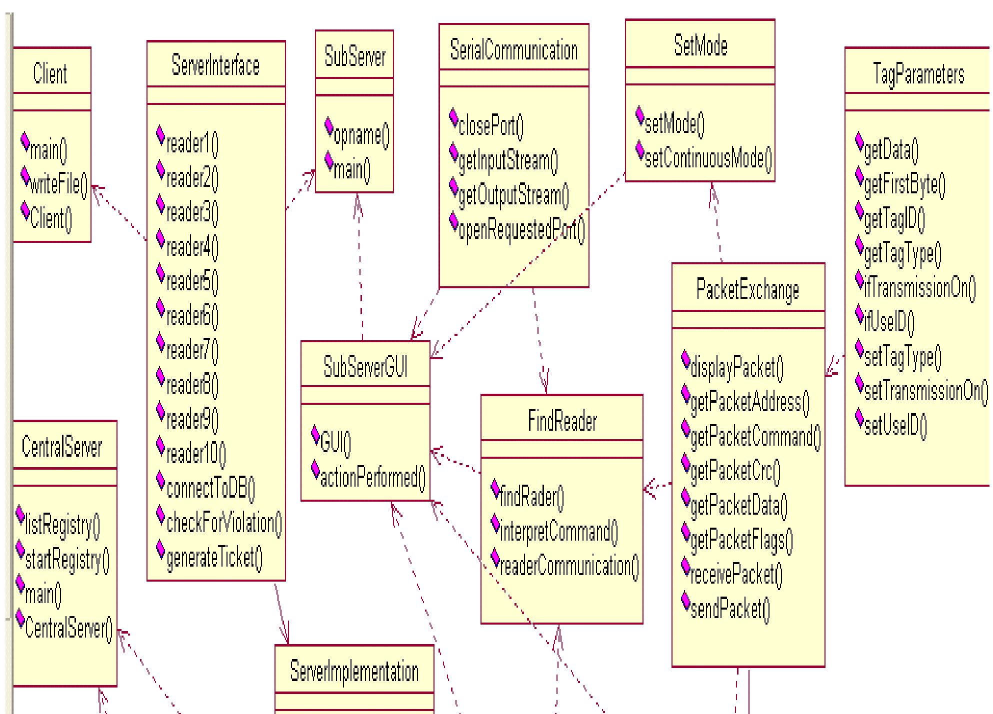


Figure 5.6: Class Diagram

CHAPTER 6

SYSTEM IMPLEMENTATION

6.1 Introduction

This chapter gives a closer look at the detailed aspects of system implementation. The chapter starts with a discussion about the software and hardware used and its configuration. Next, the system modules developed are explained.

6.2 Tools and Platforms

The system is developed using the following languages: Java [17], C# and SQL. The software tools used for system development are JDK 1.5.0, Eclipse 3.3.0, Microsoft SQL Server 2000, Visual Studio 2005 DotNet 2.0 and ESRI ArcGIS ArcInfo 9.2.

6.3 RFID Reader

Because of limited resources, we used one RightTag USB Hand-Held RFID Reader shown in Figure 6.1.

Figure 6.1: RightTag Reader

This reader is used for collecting the runtime data from the traffic. In real time such readers are to be deployed along road sides. The data sheet of the used reader is given in Figure 6.2.

Table 6.1: RightTag Reader Data Sheet

Part	RFID Readers
Operating Frequency	13.56 MHz
RF Power	Max 200 mW
Read Range	14 cm with credit card size tag
Antenna bandwidth	1MHz @ -3dB
Antenna Impedance	50 Ohm@ 13.56 MHz
Tag Compatibility	ISO15693, Tag-it
Communication Interface	RS232 or USB
Host Data rate	9600, 19200, 57600 or 115200 N, 8, 1
Operating Temperature	-20°C to +55°C (including self-generated heat)
Storage Temperature	-40°C to +80°C

6.4 RFID Tags

The Tag-it HF-I Plus Transponder Inlay family of Texas Instruments RFID is based on the ISO/IEC 15693 standard for contact less integrated circuit cards (vicinity cards) and ISO/IEC 18000-3 standard for item management [18]. The passive (no battery) transponder inlays are thin and flexible, offer a general purpose read/write capability and are designed to be easily converted into paper or plastic labels. User data is written to and read from memory blocks using a non-volatile EEPROM silicon technology. Each block is separately programmable by the user and can be locked to protect data from modification. Once the data has been locked then it cannot be changed. The tag structure is shown in Figure 6.2 and its cross section is shown in Figure 6.3.

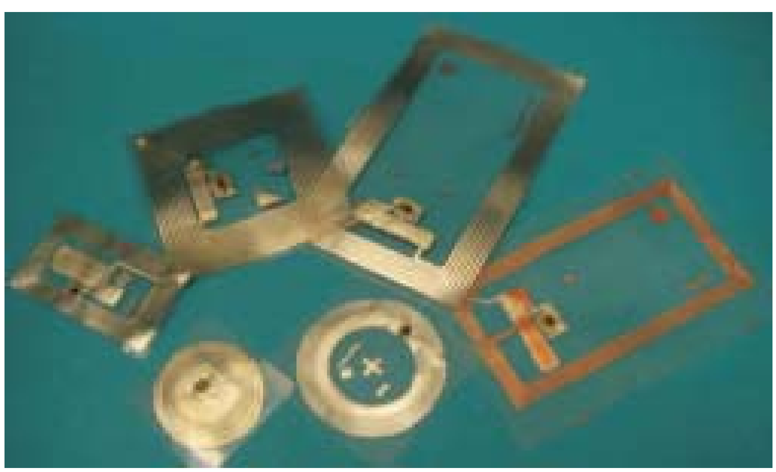


Figure 6.2 RFID Tags

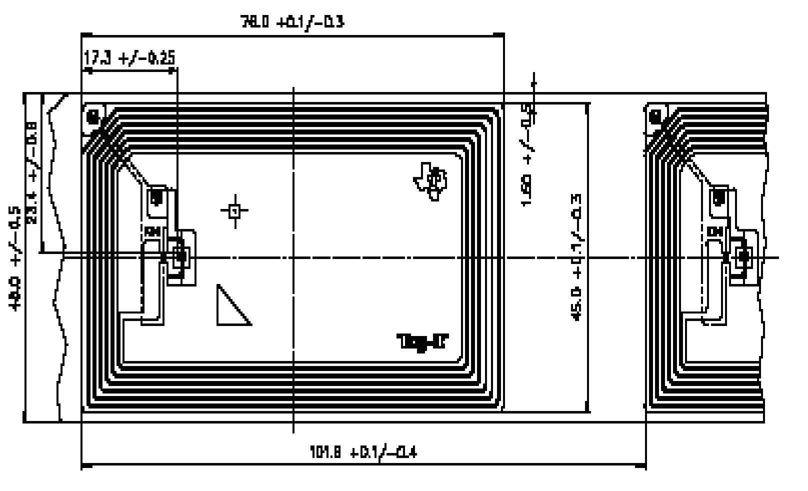


Figure 6.3: Tag Crossection

6.5 Memory Organization of RFID Tags

User data is read and stored in a 256-bit nonvolatile user memory that is organized in 64 blocks. Each block with 32 bit is user programmable and can be locked individually to protect data from modification. Once set, the lock bit cannot be reset. The user memory is field programmable per block. Two levels of block locking are supported: Individual block locking by the user (U) or individual block locking of factory programmed data (F) during manufacturing. Bit 2 of the “Block Security Status” byte defined in ISO 15693-3 is used to store the Factory Lock Status of the Block. Factory Block locking irreversibly protects the locked data from any further reprogramming. A factory-programmed block contains the IC reference and the physical memory info (Block size and Number of Blocks). This is shown in Figure 6.4.

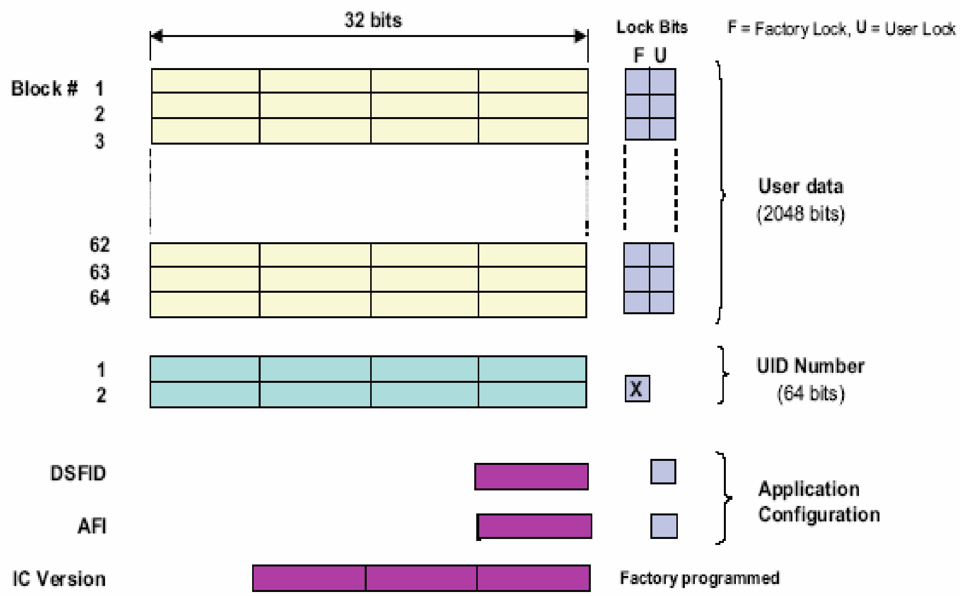


Figure 6.4: Memory Organization Of Tag-It HF-I Plus Transponder

The detailed organization of tag memory and standard commands is given in Appendix C.

6.6 SubServer Implementation

RNI SubServer was implemented in Java using the tool Eclipse for its development. The RFID reader was installed using its driver and configured for the system. The implementation was carried out using serial comm ports for which the external package javax.comm was used. For details refer to Appendix A.

6.6.1 Front End Development

The front end of the SubServer is a graphical user interface which provides easy operations for communication between the RFID equipment and the SubServer. The main functions of this module are to connect to hardware device, on click of a button; the SubServer connects itself with the RFID reader by a function call. With the given options, the user can select the reader to put it in read mode. It allows setting the reader in continuous read mode or turning it off using a radio button and an output area displays the data read by the readers. For details refer to user manual of SubServer given in Appendix A.

Figure 6.5 shows the view of the SubServer GUI.

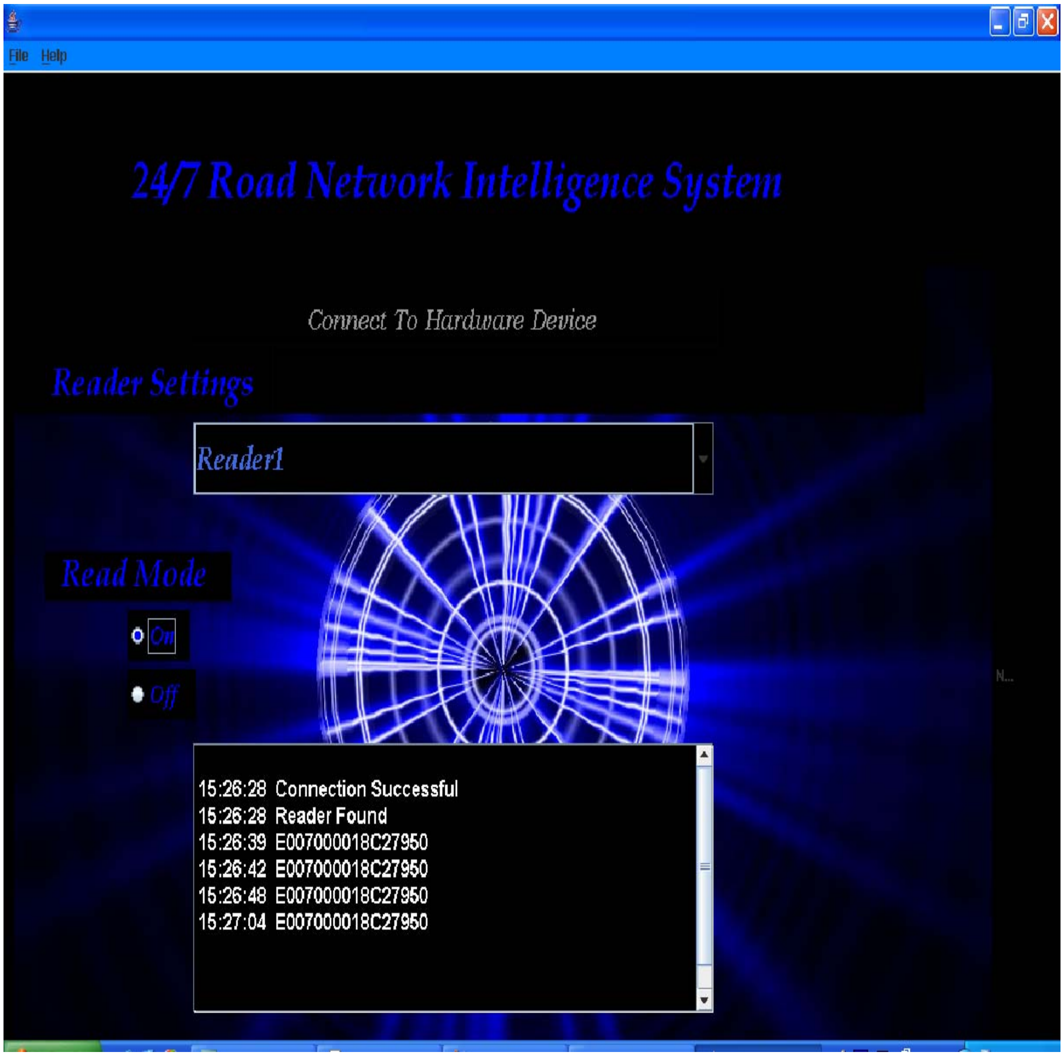


Figure 6.5: SubServer Front End GUI

6.6.2 Back End Development

The back end of the SubServer is developed in Java using JDK 1.5.0. For reader detection, the SubServer checks all serial comm ports and detect the readers attached to them. A data packet is sent to the detected readers and another data packet is read from the reader. This establishes handshaking between the reader and the SubServer. Depending upon the selected option on the GUI the reader is turned on or off. As soon as the reader detects a tag in its range, it reads the tag data and sends the information to the SubServer. The SubServer looks up the object of the Central Server using a remote interface and uses its function to connect to it. The SubServer sends information from the readers to the central server based on which the central database is update. The SubServer checks the stopped vehicles by checking their data coming from the readers; any such vehicle is reported immediately to the central server.

6.7 Central Server Implementation

RNI Central Server was implemented in Java using the tool Eclipse for its development. A central database was created which contains all the information in the system. Functions for database connection, updating the database and for manipulating the data are implemented here.

6.7.1 Front End Development

The front end of the Central Server is a graphical user interface which provides easy operations to be accessed by the user. It provides the basic functionalities which might be required at the central server. The Central Server GUI is shown in Figure 6.6. For details refer to Appendix A.

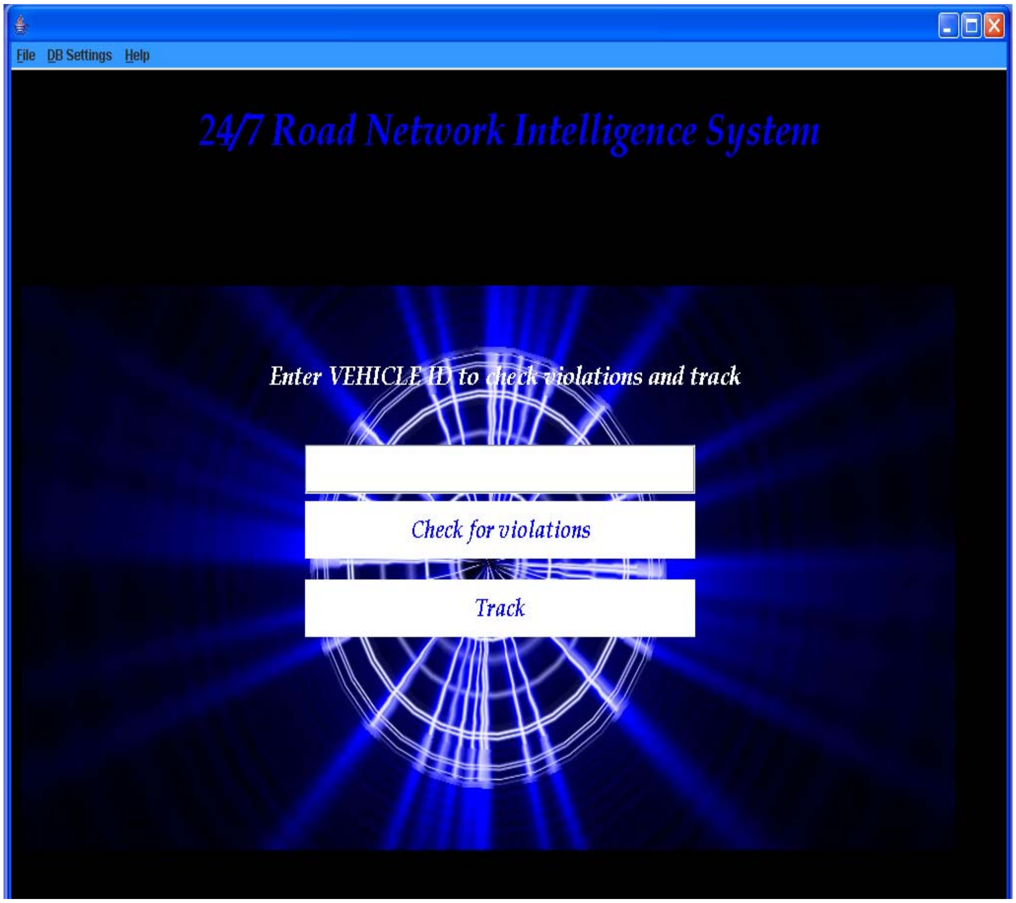


Figure 6.6: Snap Shot Of Central Server Front End

6.7.2 Back End Development

The back end of the Central Server is developed using Java and Microsoft SQL Server. Its main functionalities include connectivity with central database. The Central Server contains the database of the system which contains all the records of the system components (for details read section 5.6). Through its functions, the Central Server provides connectivity for the SubServer and the client so that they can access its operations using the remote interface. The Central Server provides functionality to register or unregister any vehicle, updating the database accordingly.

The Central Server takes data from the SubServer and uses it to calculate the speed of vehicles. This is done by recording the time at which each reader reads the tag and calculating the time taken to cover the distance between two consecutive readers. The distance, already known for the road network and stored in the database is extracted and speed is calculated using the formula given below:

$$Speed=distance/time$$

The Central Server also provides a function to check for any speed violation based on the vehicle identification number. It calculates fine for vehicles violating speed rules on the road network, these fines are calculated based on different vehicle types. Tickets are generated using the fines calculated and are saved to file for permanent record. Tracking is done using the runtime data generated by the traffic and plotted on a digital map using ArcGIS software.

6.8 Client Implementation

RNI Client application is implemented in Java and C#. Functions for database connection, updating the database and for manipulating the data are called here. This section provides all the complete working features of the RNI system collectively.

6.8.1 Front End Development

The client is that application module of the system which is designed to be implemented on terminals on the road network. The user interface ids designed and developed to be user friendly so that it is easy to operate keeping in view the nominal computer literacy level of the expected user. A GUI is developed that provides all the operations of registering the vehicle, unregister the vehicle, checking vehicles for speed violation and vehicle tracking. Figure 6.7 shows the front end of the client application. For it detailed working and use, see Appendix A.

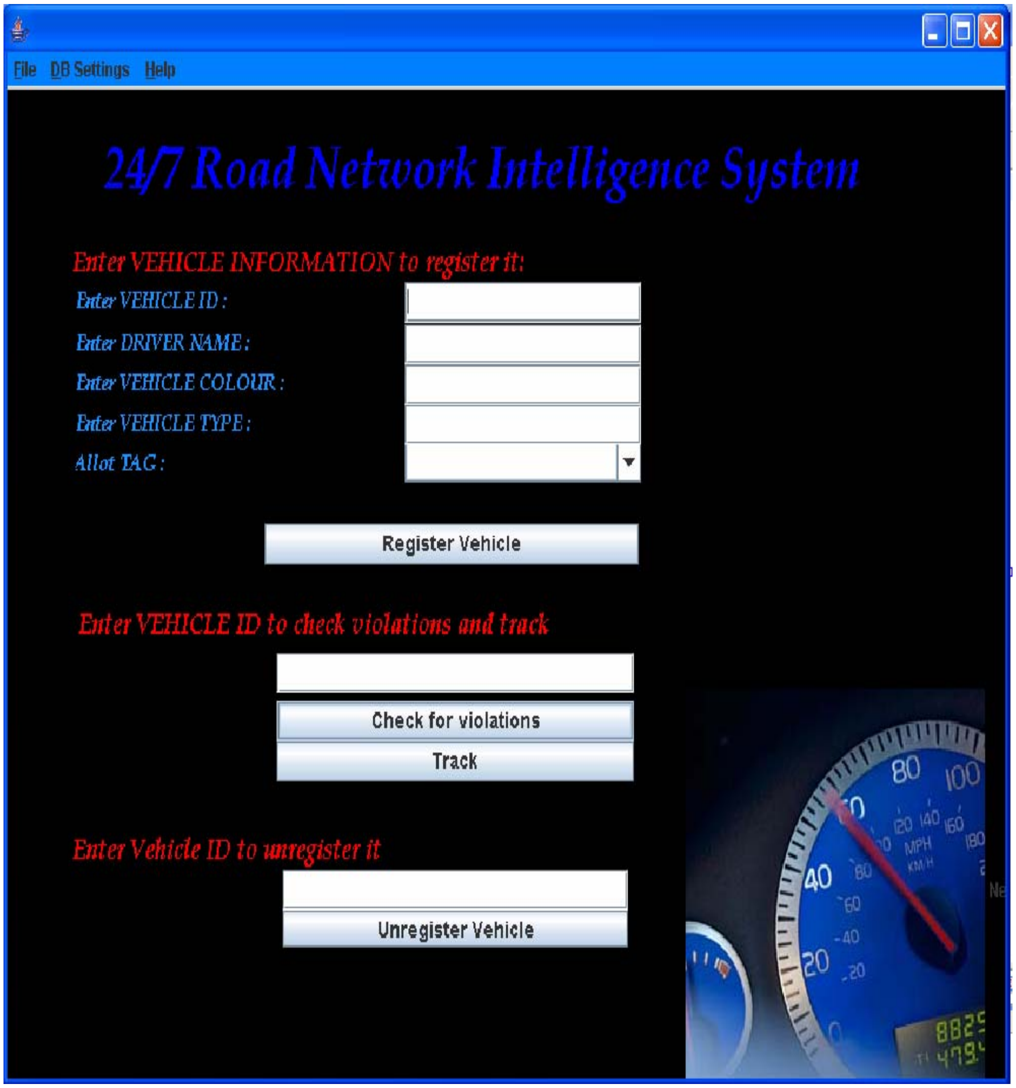


Figure 6.7: Client Front End GUI

6.8.2 Back End Development

The client back end is used to connect to the central server. It takes input from its user and updates the data base by using the functions of the Central Server. The back end is used to retrieve the result of operations performed by the central server on the request of the client. Tracking of the vehicles is also the part of client back end which will be discussed in detail in Section 6.7.3.

6.8.3 Tracking of vehicles

This module is done by integrating the Tracking Portion of the project GEOGRAPHICAL INFORMATION SYSTEM BASED TRACKING AND PLOTTING (GTrap) .The system is integrated with this module so that it retrieves information from the central database and plots vehicles on it's digital map using the runtime data generated. Up to 5 vehicles can be plotted on the digital map simultaneously. This limit can be extended if need arises. Retrieving information about location and status of the vehicles from the central database is enabled. This module allows plotting the received information of vehicles on a digital map, thus updating its current situation. It presents the information of vehicle position to the requesting client enabling concerned authorities to track the movement of a single or more vehicles simultaneously.

CHAPTER 7

SYSTEM TESTING AND VALIDATION

7.1 Introduction

Software testing is one element of a broader topic that is often referred to 'Verification and Validation' (V&V). Verification refers to the set of activities that ensure that software correctly implements a specific function. Validation refers to the different set of activities that ensures that the software that has been built is traceable to customer requirements [19]. Figure 7.1 explains the testing process.

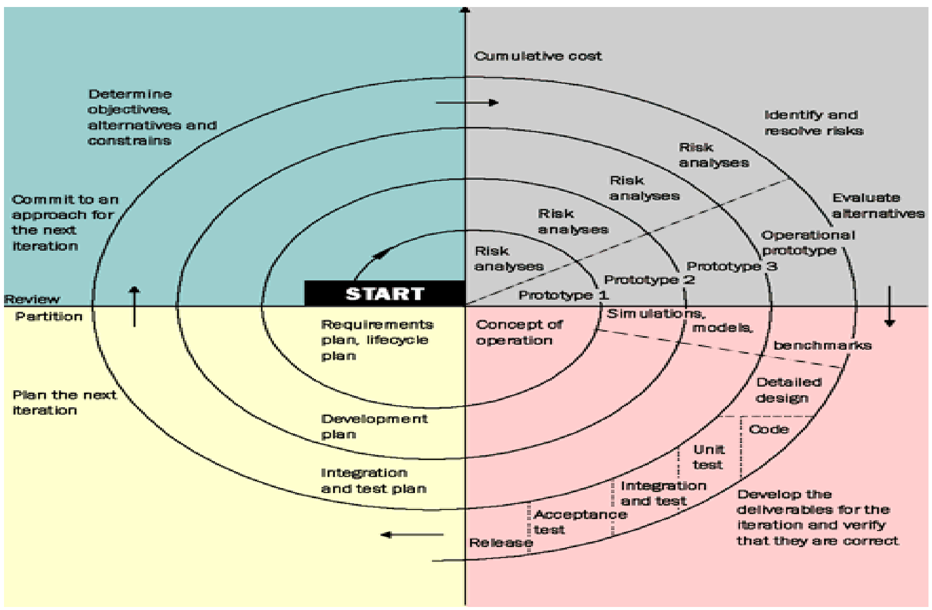


Figure 7.1: Software Testing Process

7.2 Validation And Verification

Validation and verification is intended to be a systematic and technical evaluation of the system and its processes. To effectively deal with the increased complexity and functionality, systems need practical techniques that can help improve software quality using the validation and verification process. RNI system was tested for validation by giving it different inputs and getting the desired outputs. In verification testing it was assured that software meets all functional, behavioral, and performance requirements.

7.3 Unit Testing

In computer programming, unit testing is a procedure used to validate that individual units of source code are working properly. A unit is the smallest testable part of an application. Unit testing concentrates on each unit of the software as implemented in source code. The goal of unit testing is to isolate each part of the program and show that the individual parts are correct. In our system each component as developed is individually tested so as to check for possible errors that could occur.

7.4 Integration Testing

Integration testing is the phase of software testing in which individual software modules are combined and tested as a group. It follows unit testing and precedes system testing. In integration testing focus is on design and the construction of software architecture. We have structured the classes as per the user requirement so the extensibility of the software is guaranteed. The system is constructed and tested ensuring conformity with the basic objectives of the software testing strategy. The design is fully based on user specification.

7.5 Black Box Testing

Black box testing takes an external perspective of the test object. These tests can be functional or non-functional, though usually functional. The test designer selects valid and invalid input and determines the correct output. There is no knowledge of the test object's internal structure. The requirements established as part of software requirements analysis, are validated against the software that has been constructed. RNI has been fully validated as per meeting user requirement. It provides final assurance that the software meets all functional, behavioural, and performance requirements. Black box testing techniques have been used exclusively during validation.

7.6 System Testing

In software testing the software and other system elements are tested as a whole. System testing of software or hardware is testing conducted on a complete, integrated system to evaluate the system's compliance with its specified requirements. System testing takes, as its input, all of the integrated software components that have successfully passed integration testing and also the software system itself integrated with any applicable hardware system(s). The purpose of integration testing is to detect any inconsistencies between the software units that are integrated together. System testing is a more limiting type of testing; it seeks to detect defects within the system as a whole. For the RNI system, it has been verified that all elements connect together properly and that the overall system function/performance is achieved.

CHAPTER 8

RNI SYSTEM ANALYSIS

8.1 Introduction

System analysis is the interdisciplinary branch of science, dealing with analysis of systems and the interactions within those systems. This field is closely related to system testing and follows the testing processes. In general, analysis is defined as the procedure by which we break down an intellectual or substantial whole into parts or components to check the system for its technical and functional attributes.

8.2 Technical Analysis

In its purest form, technical analysis considers only the functional behavior of the product or system, based on the premise that it reflects all relevant functions of the system. Technical analysis involves analyzing the characteristics of a system in order to estimate its working efficiency. Technical analysis takes a completely different approach; it doesn't care one bit about the "value" of the commodity but analyses it functional and working conditions to evaluate its performance. The 24/7 ROAD NETWORK INTELLIGENT SYSTEM was analyzed technically to authenticate all its functional features.

8.2.1 RFID Equipment Configuration

The RFID equipment used includes the RFID reader and tags. The reader was installed and configured with the system with the available driver for this device. The reader was installed correctly and showed correct data reads. Its installation procedure is shown in Appendix A. The RFID tags do not need any installation or configuration for their use. They were used as available and found to be working correctly with the installed reader.

8.2.2 Tags Read

The RFID reader used was designed to read tags within a range of 14 cm (approximately 5.5 inches) with credit card size tags. The reader data sheet is given in section 6.3, Table 6.1. In actual practice, the tags were found to be read within approximately 12 cm range accurately. Beyond this range the reader was found to be unable to detect the tags or read them. This gives 85.7% accuracy of reader. This analysis gives the percentage of error that occurs in the tag detection and reading. It is therefore suggested that other powerful readers. When procured for this system must be analyzed first with a minimum margin of 15% error in its tag detection range.

The available reader reads up to three tags simultaneously. It was tested for the working range of the device. It was also found that the tags were read when hindered with some solid object like a wooden piece or in case it is interfered by electronic devices like mobile phones. However, it is noted that the reader read range is further reduced to approximately 50% when the tag is enclosed in a thick solid object like a book.

The read range of the reader and its support to read multiple tags simultaneously are subject to its design and working efficiency. The available RFID reader's level of efficiency is less than the required level. However, the level of accuracy of this reader is approximately 100%. Other more advanced and powerful readers are available that can be used instead. The data sheet of one such device is given in Appendix D.

8.2.3 Database Updates

The central database, residing at the Central Server is continuously updated by both the SubServer and the Client applications. The data coming into this database was tested. It was found that this operation is performed correctly and the data is entered into the right tables without any error. The database is updated from the SubServer and the Client accurately giving 100% results for this analysis test.

8.2.4 Database Retrievals

The central database for the system is used to retrieve information for decision making. This information is retrieved by the Client and if needed by the Central Server as well. These retrieving functions were tested and found that the data retrieved was accurate and involved no errors. This means that the operations requested to the Central Server are performed without any error. See Appendix A for system operations. This gives 100% accurate results for the system operations.

8.2.5 Response In Event Of Incorrect/Incomplete Input

The data input from the Client application can have errors in it. These errors can be in the form of incomplete information while registering the vehicle, or in form of an incorrect or invalid vehicle ID while checking it for speed violations or when it is unregistered. Such events are also handled by the system. The system generates appropriate error messages informing the requesting application about the error found in the input data. These error messages are shown explicitly in Appendix A.

8.2.6 Simultaneous Operation Of System

The system was also tested for its distributed structure. As required, the Central Server was maintained at single host and three Client applications were created. The Central Server was accessed and requested simultaneously from all the three Clients and it was found that each client was serviced by the Central Server with 100% correct results. For the SubServer, multiple applications were created and all were found to connect correctly with the Central Server but could not be tested for the data input because of the availability of only one RFID reader. However, the same RFID reader was found to be working correctly with all the applications of the SubServer.

8.3 Operational Analysis

Operational analysis is the name given to an approach to performance evaluation that relies on basic system and resource measurements to provide information about the practical effectiveness of the system. The system may consist of a single application or a collection of separate applications. Profitability improvement, organizational effectiveness, and practical operability are three important components of the operational analysis. Here is done an operational analysis of the system with an eye on its practical usefulness in real world.

8.3.1 Resource Optimization

The 24/7 ROAD NETWORK INTELLIGENCE SYSTEM provides resource optimization by reducing the need for human resource, finances, fuel consumption and other equipment and vehicles used for road monitoring and speed checking on road networks. This system reduces the manpower needed to monitor the road networks under observation. Staff would be needed only to operate the Client application and to maintain the Central Server. Once put into operation, the SubServer works independently and accurately. With the automated monitoring provided by this system, there would no longer be need of the customary patrolling thus eliminating the requirement of the large number of staff and vehicles presently occupied for this purpose. This would reduce the fuel consumption greatly which at present, costs a fairly large amount to the organizations like FWO and NHA. For detailed statistics see Appendix E.

Another operational advantage of this system is that when put into operations, it will capture a significant number of violations that presently go unnoticed because of the obsolete method of speed checking used.

This would not only cover the system's deployment cost but will also generate revenues in great amount for the roads monitoring organizations. With the ability to cut costs and generate revenues, this is a system that organizations like FWO and NHA will long reap benefit from.

8.3.2 Conditions Independent

This system is designed as a system which is independent of most of the working conditions. The RFID equipment used works in all weather conditions within a temperature range of -20 degree Celsius to +55 degree Celsius. Other RFID readers and tags are available that operate beyond these limits as well. Apart form temperature range; the RFID readers are capable of working in all light conditions. This expedites the presently used speed checking equipment which is subject to the availability and strength of light for its operation. The RFID equipment however, is capable or working in all weather and light conditions round the clock.

8.3.3 Product Life

The life of RFID equipment varies form vendor to vendor. The optimum life of the equipment used is 7-10 years. Within this period, the RFID reader and tags work correctly and after this time expires, their working is not guaranteed. The RFID equipment that was found to be the most optimum for this system has a lifetime of 10 years. This is shown in the equipment data sheet given in Appendix D. Life of the application software is subject to its maintenance and usage and can be extended with system improvements.

CHAPTER 9

CONCLUSION AND FUTURE WORK

9.1 Achievements in Project

In the start of our project, we presented and discussed in detail the idea of our project with GS0-1 O&M Lt. Col. Fayyaz at FWO. The project and all its functional characteristics were greatly appreciated and were found useful in actual practice due to which they provided guidelines throughout the project duration.

Working with a growing organization like FWO was a great learning experience for us. This also helped us to develop our system on the lines of a useful software that is practically deployable on national highways/motorway in Pakistan.

Based on our performance and the outcome of our project, we were invited to present our work to the ENGINEER in CHIEF, PAKISTAN ARMY Lt. Gen. Shahid Niaz. The presentation was attended by higher officials of Engineer in Chief branch. At this presentation, our project was discussed and critically analyzed for its practical utility, efficiency and reliability to be deployed on highways or motorway in Pakistan.

Our project was highly appreciated and it was unanimously decided to grant resources for this system for real time testing with E in C branch and FWO.

9.2 Conclusion

Knowledge is shared through many abstract forms. Attempts to eloquent and explain human experience and understanding use these abstractions which are summaries of a larger body of knowledge. Abstractions, such as text, language, mathematics and statistics, music and art, drawings, images, and maps, are used to record and communicate experiences, culture, and history from generation to generation.

RFID, as an automated data capture technology allows the capture and sharing of knowledge across networked systems such as the ROAD NETWORK INTELLIGENT SYSTEM. Simultaneously, Radio Frequency Identification technology is evolving and provides better methods to represent, manage, and communicate the many aspects of electronic identification services round the globe.

9.3 Future Work

Road Network Intelligent system can be integrated with the existing electronic toll collection system deployed on motorway sections M1 and M2. This would require further work to develop interfaces that act as middleware between the two systems.

Global System for Mobile communications is the most popular standard for mobile phones in the world. The ubiquity of the GSM standard has been advantageous to both consumers (who benefit from the ability to roam and switch carriers without switching phones) and also to network operators. Road Network Intelligence System has the provision to be integrated with the GSM system. An application can be developed that can use the electronic mobile devices in vehicles to store and send information about the vehicle. The existing GSM network can be used to capture and send the data to the RNI system.

APPENDICES

AND BIBLIOGRAPHRY

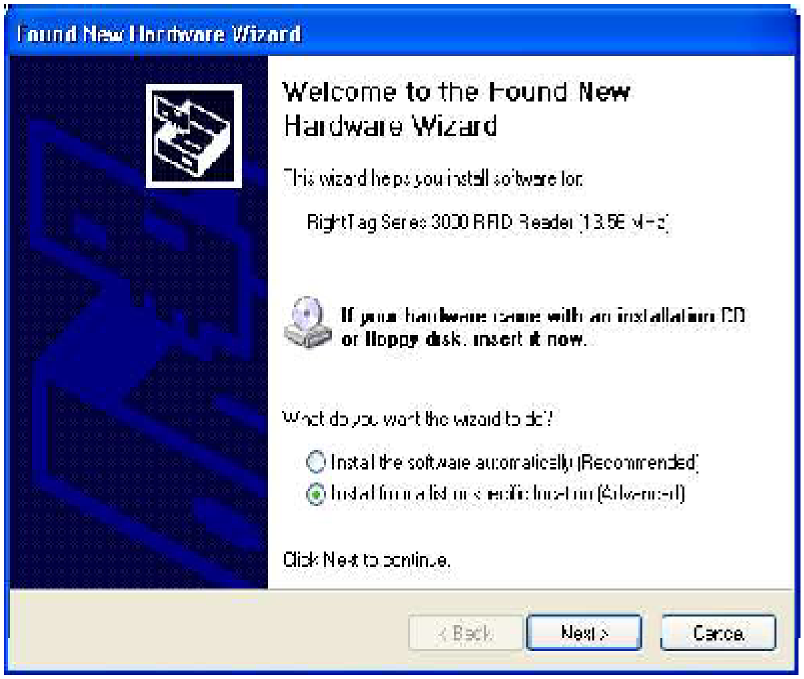
APPENDIX A

USER MANUALS

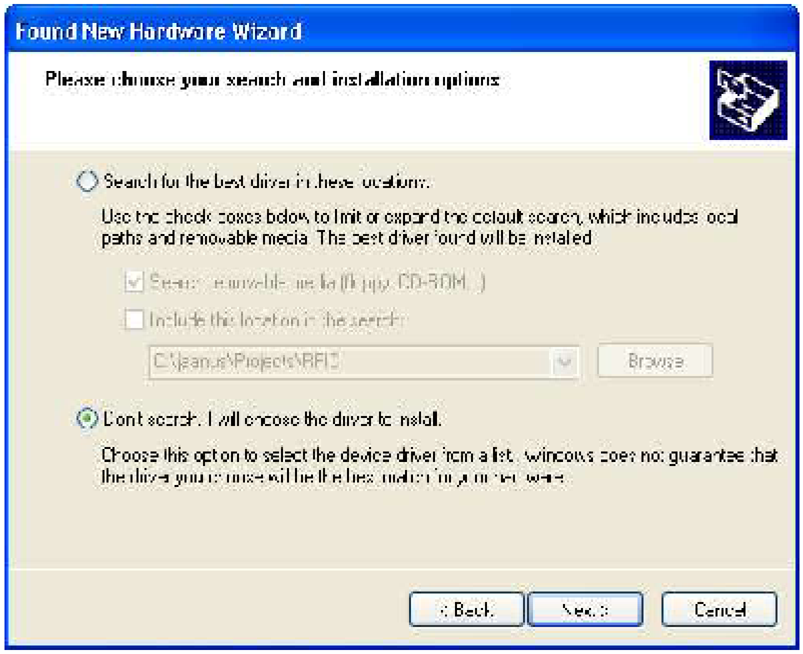
Reader Installations

Follow the given steps to install the RFID reader:

1. Plug the reader device into a free USB port. The "**Found New Hardware**" dialog will appear. Below is described install procedure for Windows XP.

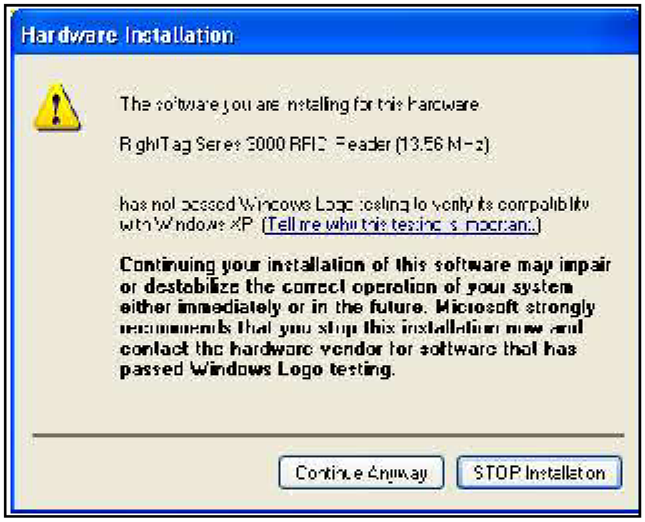


2. Choose “**Install from a list or specific location (Advanced)**” and click “**Next**”.



3. Choose “**Don’ t search. I will choose the driver to install**” and click “**Next**”.

4. Now click “**Have Disk …** ” and select the folder that contains the driver file given in the project CD. Then click “**Next**”.



5. Click “**Continue Anyway**”. This will install the driver.

6. Now click “**Finish**”. Your computer should now have one more COMM port – virtual COMM port “RightTag Series 3000 RFID Reader (13.56

MHz)”. Communication between PC and reader can be through real COMM port.

Java Installations

For running the software, you require a JDK1.5.0 installed in your computer. One extra package javax.comm is used for serial port communication, that separate package needs to be added manually. This package is given in the project CD and can be installed using the following steps.

1. Copy `win32com.dll` to your `JDK bin` directory.
2. Copy `comm.jar` to your `JDK lib` directory.
3. Copy `javax.comm.properties` to your `JDK lib` directory.
4. Add `comm.jar` to your classpath.

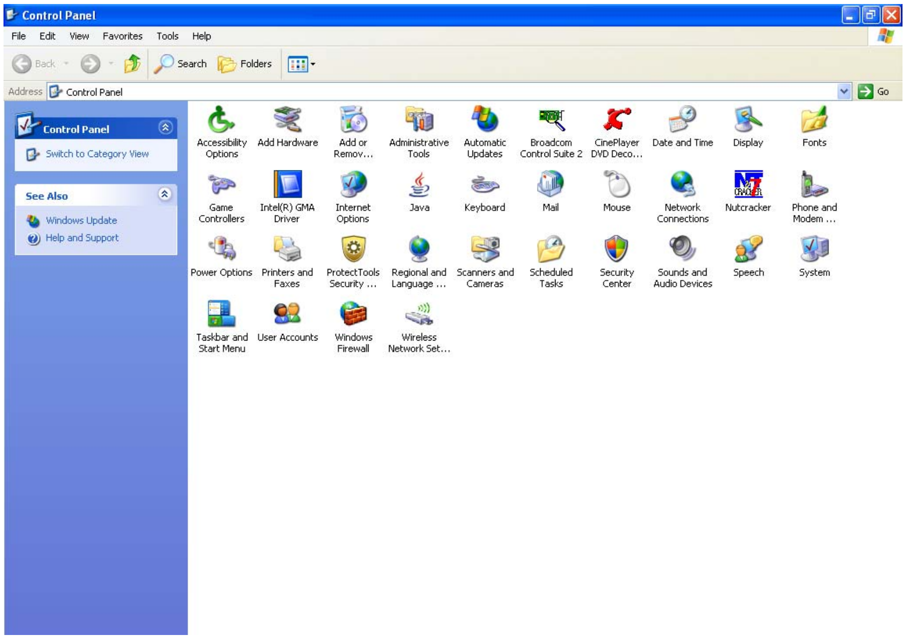
Following these steps will add javax.comm package to your JDK.

The program is tested using Eclipse 3.3.0.

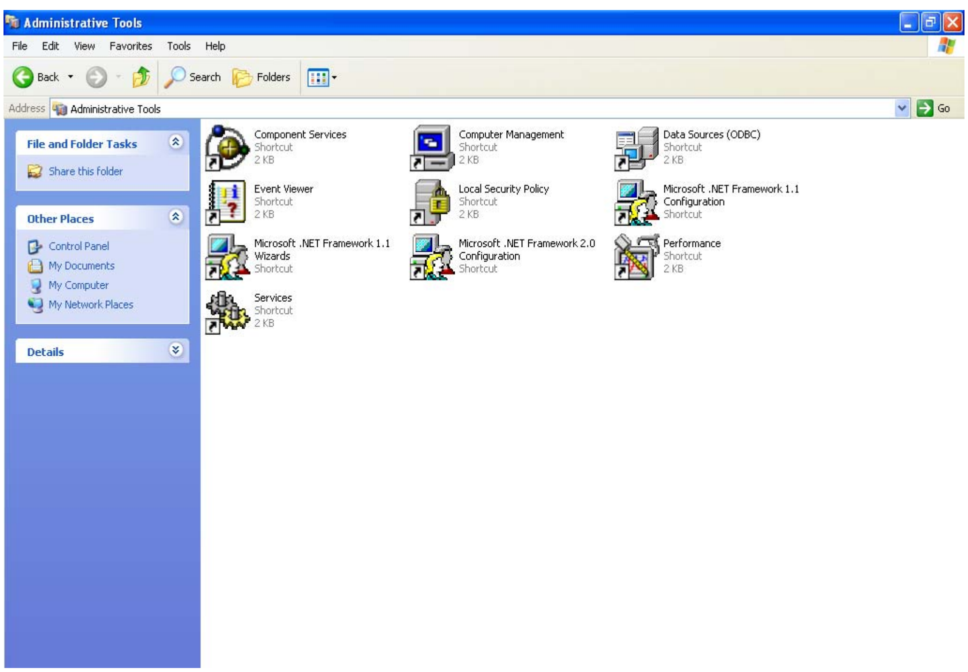
Database Settings

Follow the under given steps to register the project database with the system:

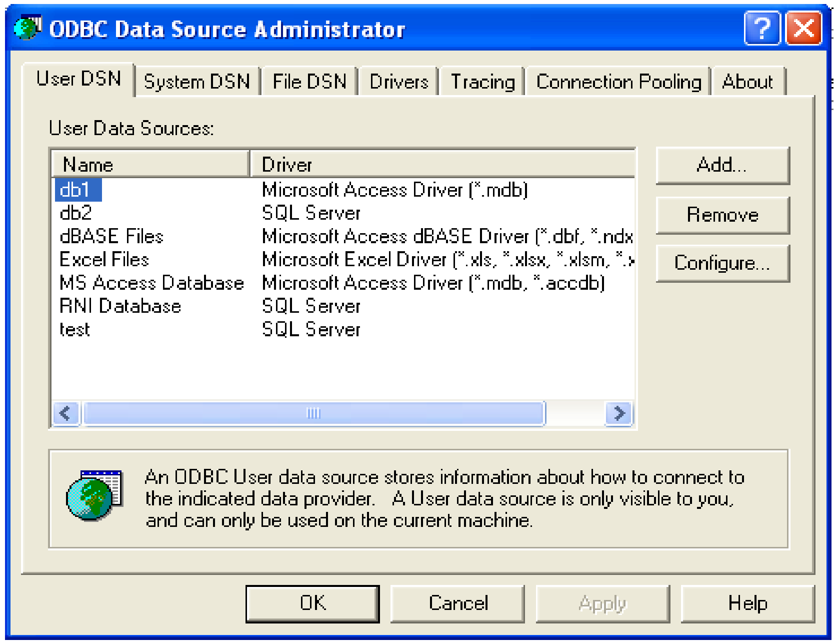
1. Go to the control panel.



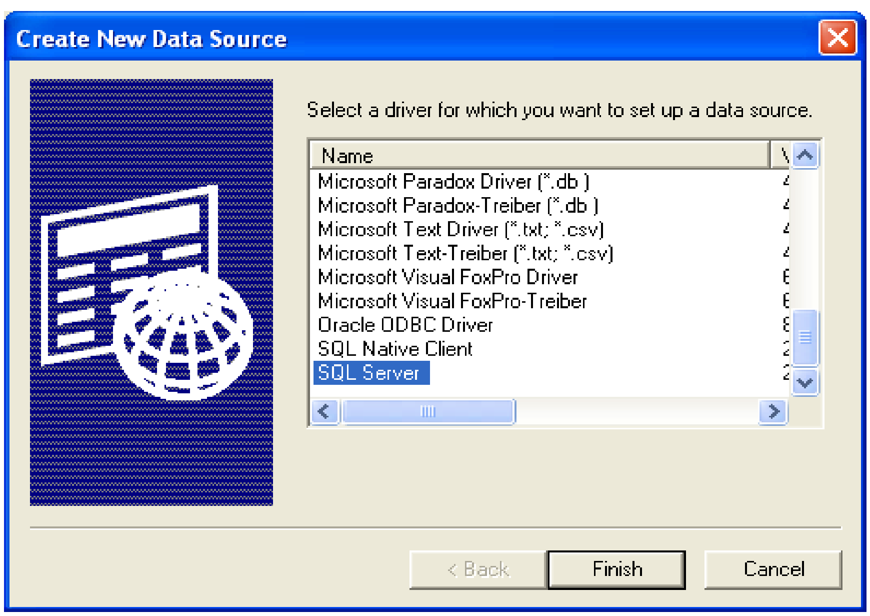
2. Then select the administrative tools.



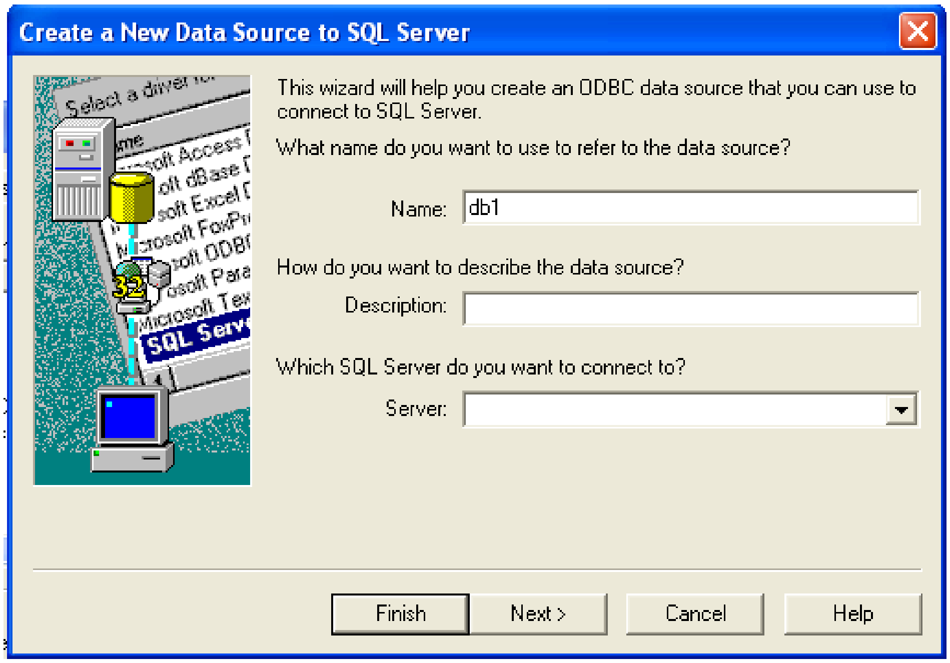
3. Then go to Data Sources and press the add button.



4. Select the option and press finish.



5. Give the name of the database and press the select button and select the location of the database. Press the OK button.



6. Press OK. This will load the Database driver into your system.

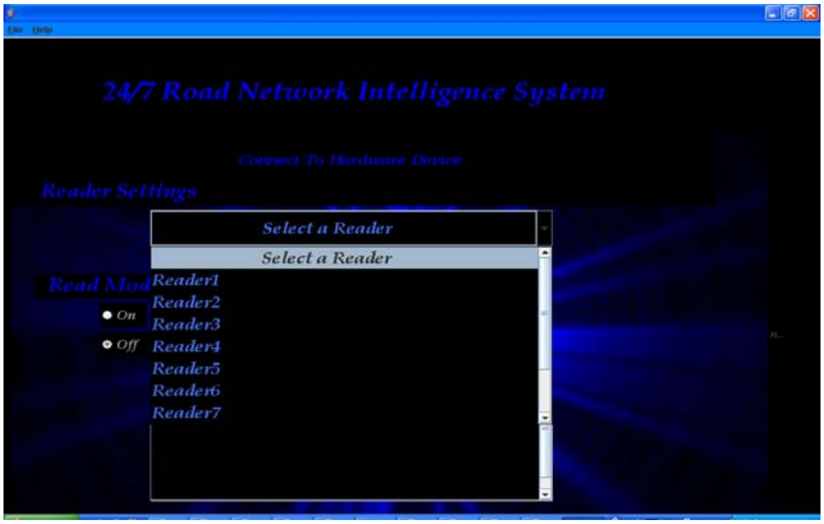
<u>SubServer Setup</u>

The following steps should be followed to run the SubServer of RNI System:

1. Run the SubServer class to activate the SubServer.

2. Click on the "**Connect to Hardware Device**" button to detect the RFID reader(s).

3. Select the reader from the drop down menu "**Reader Settings**" given to turn it on or off. The on and off buttons in "**Read Mode**" are used for this purpose.

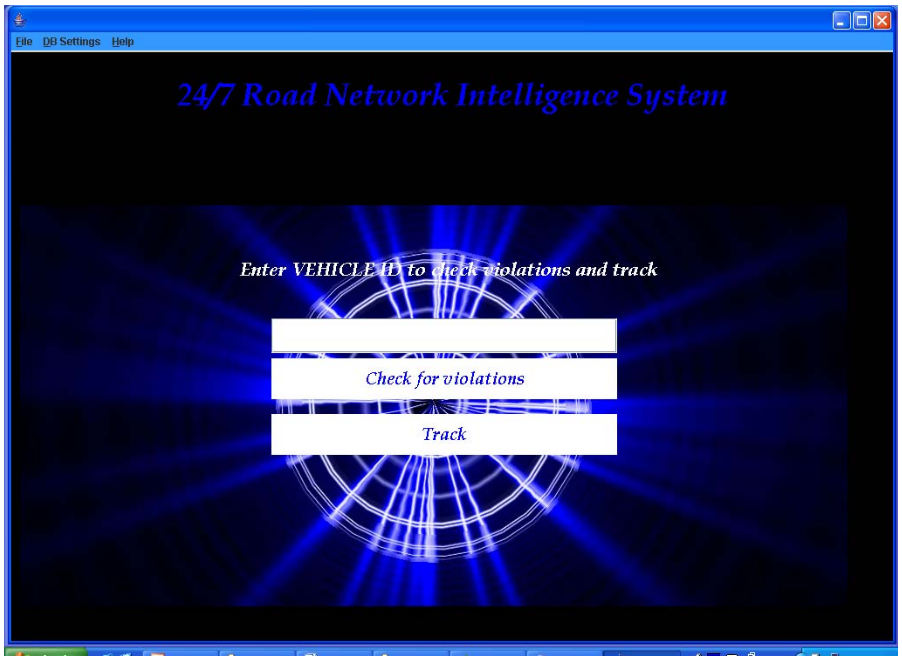


4. This puts the reader in continuous read operation to detect the tags and read their data. The data read is shown at the SubServer in the output display area.

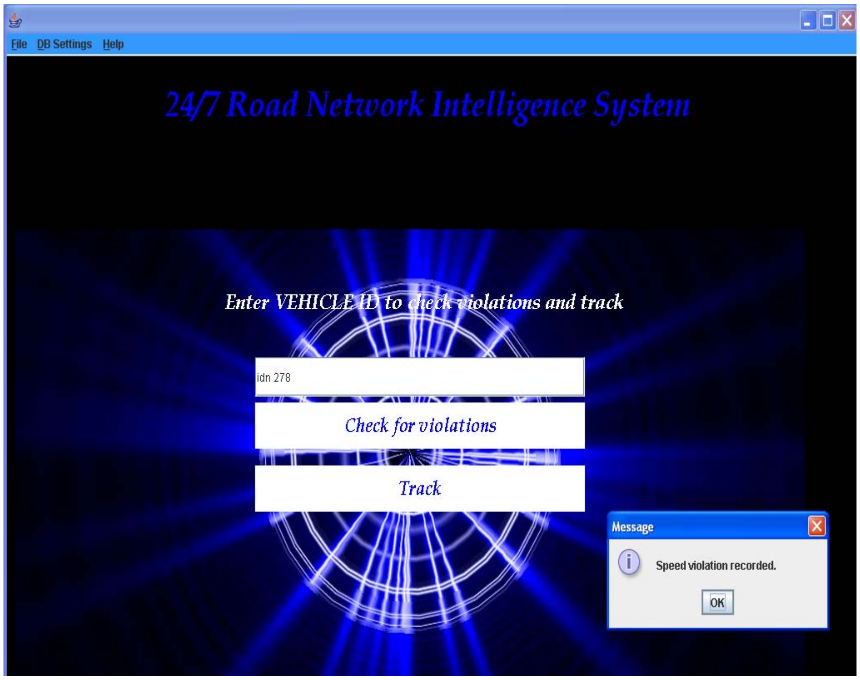
Central Server Setup

The following steps should be followed to run the Central Server of RNI System:

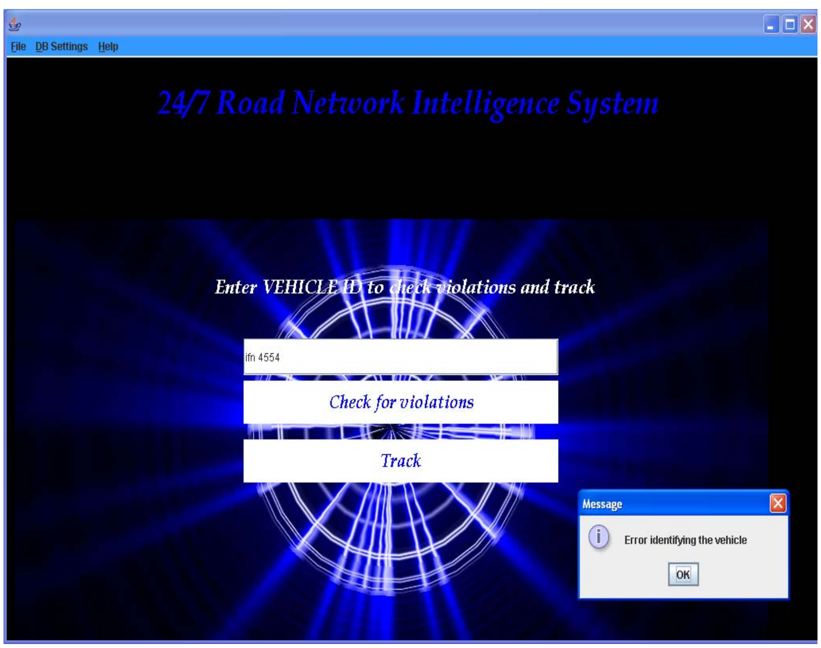
1. Run the Central Server class to activate the Central Server.



2. Enter the VEHICLE ID for which violations are to be checked and press the "**Check for Violations**" button. This will give the result whether any speed violation occurred or not.



3. The vehicle that was not registered is also detected.



4. In case of any violation recorded, the data will be saved in a file.

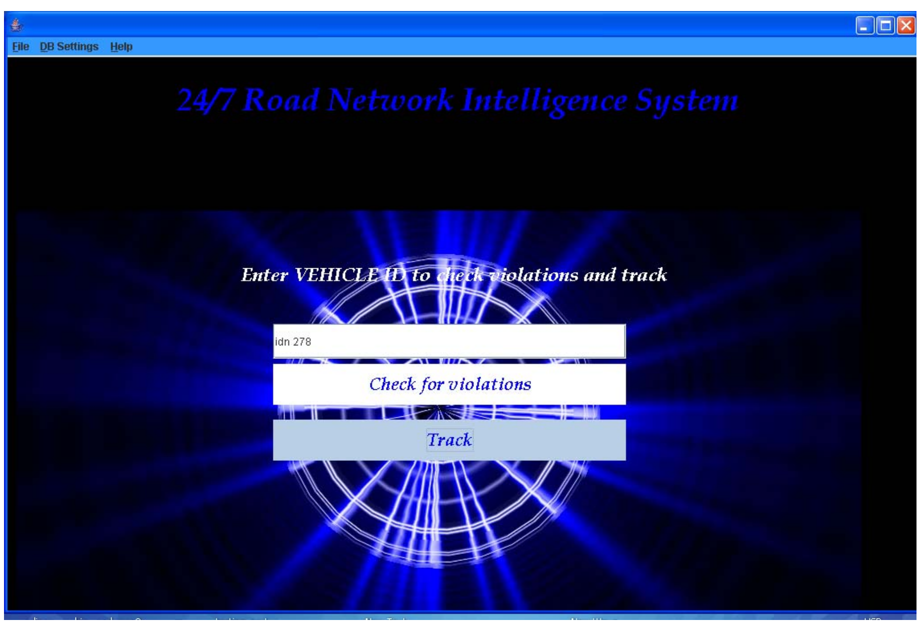
```
*********************************************
                    TICKET

*********************************************
VEHILE NUMBER = IDN 278
DRIVER NAME = Amna
VEHICLE COLOUR = White
VEHICLE TYPE = Car
AREA OF VIOLATION = r1
TIME = 10:33:58
DATE = 14-12-2007
MAX SPEED LIMIT ALLOWED = 100.0 km/hr
MIN SPEED LIMIT ALLOWED = 20.0 km/hr
SPEED RECORDED = 150.0 km/hr
FINE CHARGED = Rs. 200

*********************************************
                    TICKET

*********************************************
VEHILE NUMBER = HH 406
DRIVER NAME = Momina
VEHICLE COLOUR = Silver
VEHICLE TYPE = Car
AREA OF VIOLATION = r2
TIME = 11:50:08
DATE = 14-12-2007
MAX SPEED LIMIT ALLOWED = 100.0 km/hr
MIN SPEED LIMIT ALLOWED = 20.0 km/hr
SPEED RECORDED = 10.0 km/hr
FINE CHARGED = RS. 200
```

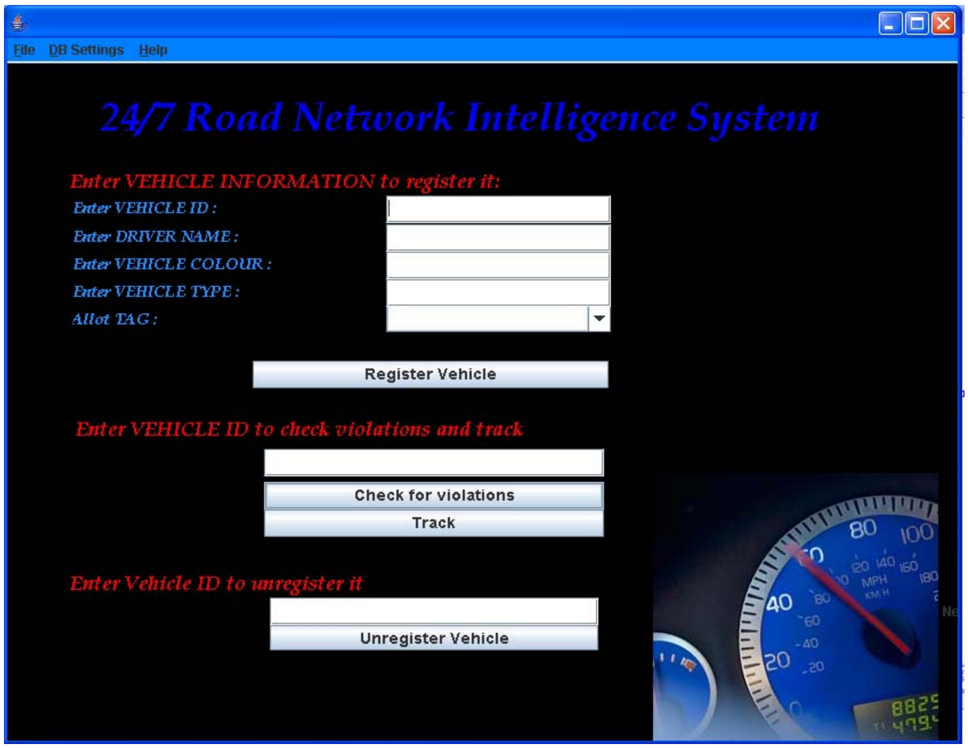
5. To track any vehicle enter the Vehicle ID in the given field and press the "**Track**" button.



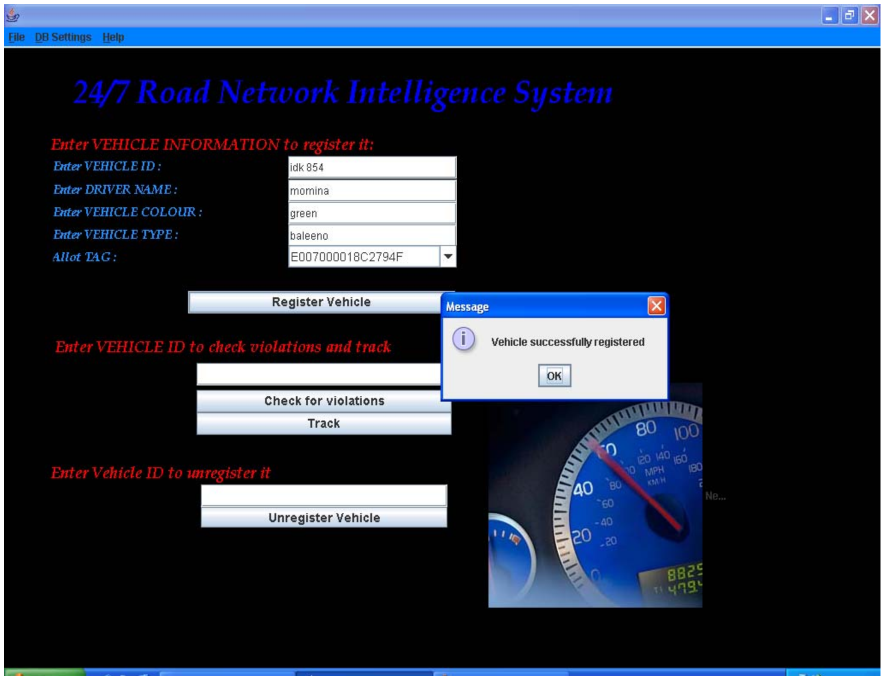
Client Setup

Follow the under given steps to run the client of the RNI system:

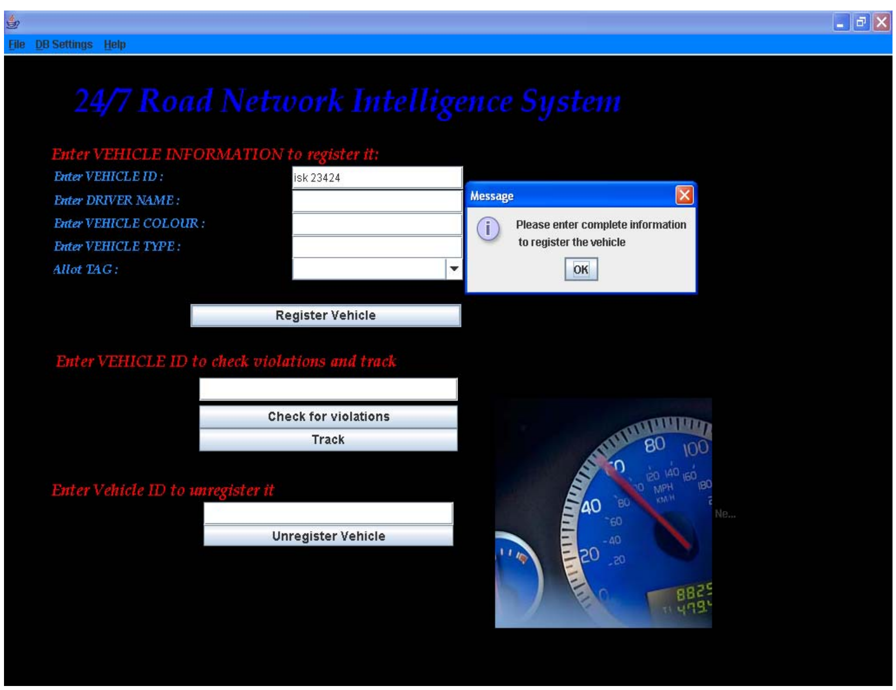
1. Run the Client class. The following screen will appear.



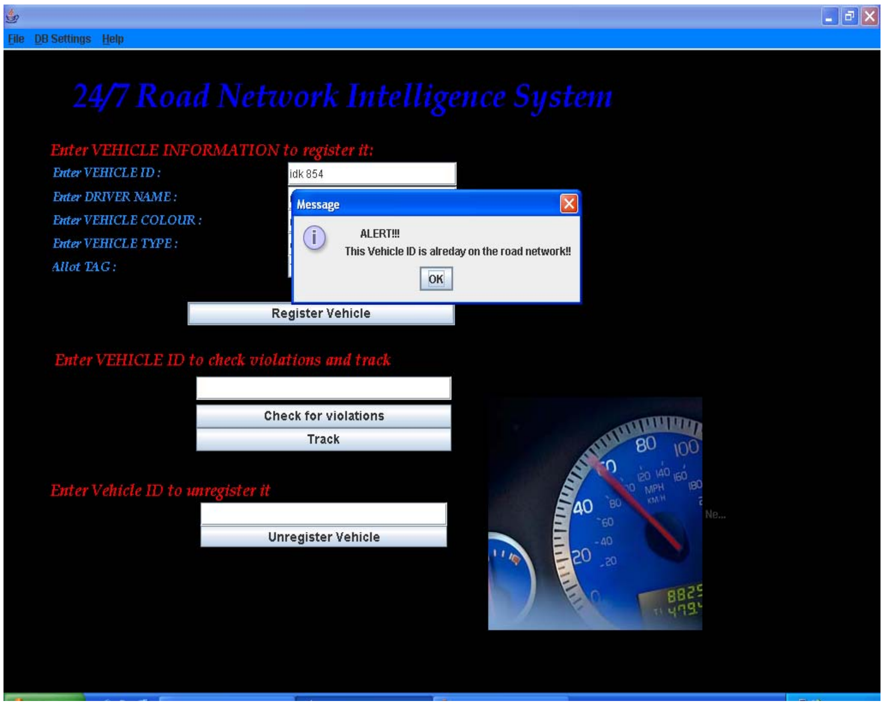
2. Enter the vehicle information to register it. Then click “**Register Vehicle**” button to register it.



3. An error is generated if Vehicle information is incomplete.

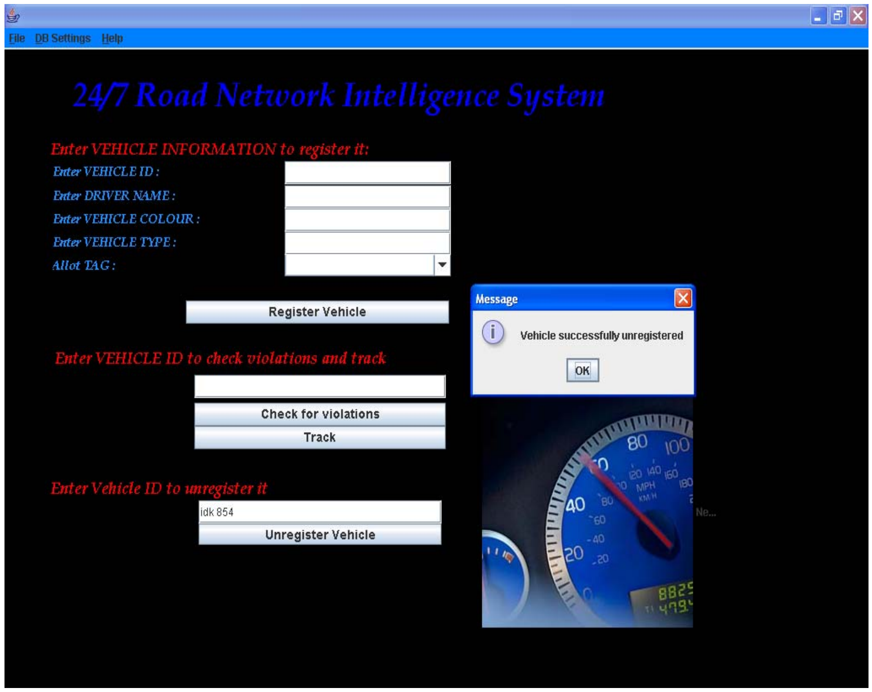


4. While registering the vehicle, the system checks if the vehicle was already registered on the road network. An alarm is generated in this event.

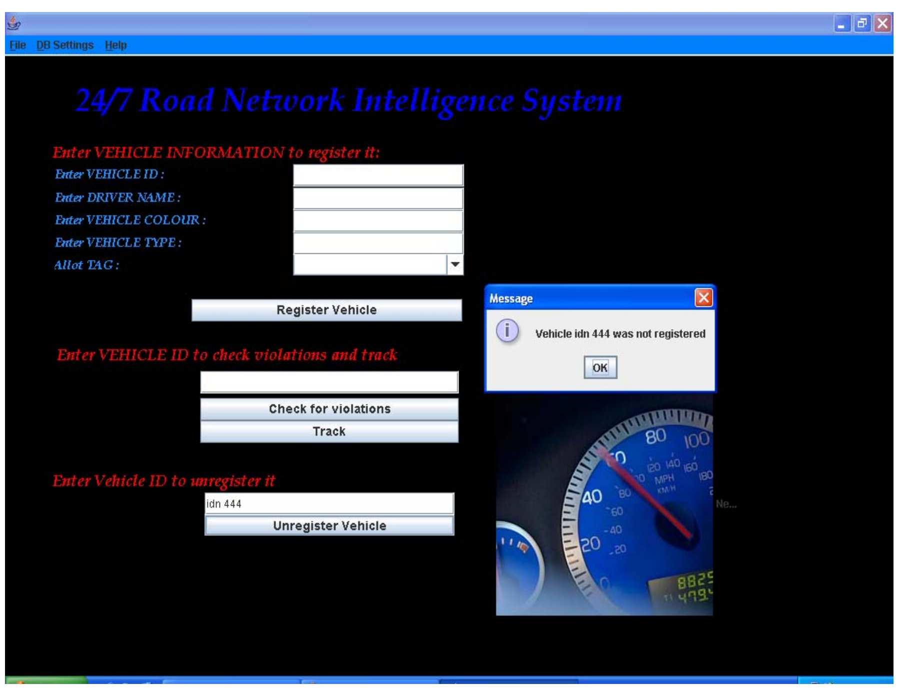


5. For checking the speed violations and tracking the vehicles “Check for violations” and “Track” buttons are used as described in section 9.4

6. Enter the Vehicle ID to unregister it.



7. An alarm is generated if the vehicle was not registered.



APPENDIX B

Frequency range	Applications and comments
Less than 135kHz	A wide range of products available to suit a range of applications, including animal tagging, access control and track and traceability. Transponder systems which operate in this band do not need to be licensed in many countries.
1.95 MHz, 3.25MHz, 4.75MHz, and 8.2MHz	Electronic article surveillance (EAS) systems used in retail stores
Approx. 13 MHz, 13.56MHz	EAS systems and ISM (Industrial, Scientific and Medical)
Approx. 27 MHz	ISM applications
430-460 MHz	ISM applications specifically in Region 1
902-916 MHz	ISM applications specifically in Region 2. In the USA this band is well organized with many different types of applications with different levels of priorities. This includes Railcar and Toll road applications. The band has been divided into narrow band sources and wide band (spread spectrum type) sources. In Region 1 the same frequencies are used by the GSM telephone network.
918-926 MHz	RFID in Australia for transmitters with EIRP less than 1 watt
2350 - 2450 MHz	A recognized ISM band in most parts of the world. IEEE 802.11 recognizes this band as acceptable for RF communications and both spread spectrum and narrow band systems are in use.
5400 - 6800 MHz	This band is allocated for future use. The FCC have been requested to provide a spectrum allocation of 75 MHz in the 5.85-5.925 GHz band for Intelligent Transportation Services use. In France the TIS system is based on the proposed European pre-standard (preENV) for vehicle to roadside communications communicating with the roadside via microwave beacons operating at 5.8 GHz.

1

Technical Standards
Radio Frequency Identification (RFID)

ISO/IEC 15963 Information Technology- AIDC Techniques - RFID for Item Management- Unique Identification of RF Tag and Registration Authority to Manage the Uniqueness

Introduction: ISO/IEC 15963 consists of the following parts, under the general title Information Technology- AIDC Techniques - RFID for Item Management- Unique Identification of RF Tag and Registration Authority to Manage the Uniqueness

- Part 1: Numbering system
- Part 2: Registration procedure and management guidance and rules

The present standard for unique identification of RFID Tag is defined to insure interoperability between RFID tag. This standard permits addressing three main domains of the RFID system:

- The traceability of the Integrated Circuit itself for quality control in their manufacturing process
- The traceability of the RF tag during their manufacturing process and along their life in the applications where they are used
- Anti-collision of multiple tags in the reader's field of view

Scope: This International standard ISO/IEC 15963 specifies the numbering system for the identification of RF Tag, the registration procedure and the use of it.

The numbering system provides to the automatic data capture application based on RFID tag a means to identify uniquely an RF tag and to determine if the integrated circuit contents the necessary information to perform the application. This number is encoded in the Integrated Circuit of the RFID Tag .

Technical Standards
Radio Frequency Identification (RFID)

ISO/IEC JTC 1/SC 31/WG 4/SG 3
RFID for Item Management Air Interface (ISO 18000)

- ISO 18000-1 - Generic Parameters for Air Interface for Global Interface
- ISO 18000-2 - Parameters for Air Interface <135 kHz
- ISO 18000-3 - Parameters for Air Interface at 13.56 MHz
- ISO 18000-4 - Parameters for Air Interface at 2.45 GHz
- ISO 18000-5 - Parameters for Air Interface at 5.8 GHz
- ISO 18000-6 - Parameters for Air Interface at 860-930 MHz*
- ISO 18000-7 - Parameters for Air Interface at 433.92 MHz**

*Proposed Name Change- UHF

**New Proposed Work Item

Regulation issues

- ***Contactless Cards*** : frequency 13,56MHz, format of support : credit card
  - **ISO/IEC 10 536** : « Close coupling Contactless Cards » : remove contacts
  - **ISO/IEC 14 443** : « Proximity Coupling Contactless Card » : Ticketing, Credit cards, Electronic Purse
  - **ISO/IEC 15 693** : « Vicinity Coupling Contactless Card » : Access control
- ***Item management*** standards: « Automatic Identification – Radio Frequency Identification for Item Management
  - ISO/IEC **18000-2** below 135 kHz
  - ISO/IEC **18000-3** at 13,56 MHz
  - ISO/IEC **18000-4** at 2,45 GHz
  - ISO/IEC **18000-5** at 5,8 GHz
  - ISO/IEC **18000-6** at UHF
- ***Test & Conformance*** standards:
  - **ISO/IEC 10 373** Test and Conformance methodology
  - **ISO/IEC 18046** Test for conformance methodology
  - **ISO/IEC 18047** Test for performance methodology

RFID Installations - Checklist

- Frequency
- Memory
- Temperatures
- Read Only vs. Read/Write
- Active vs. Passive
- Read/Write Range
- Mounting Methodology
- Disposable vs. Reusable Tags
- Line Speeds
- PLCs or PC
- Network Type, Connectivity, and Limitations
- Target Number of TAGS for Pricing
- Number of Read Stations
- Required On-site support

Installation Checklist:

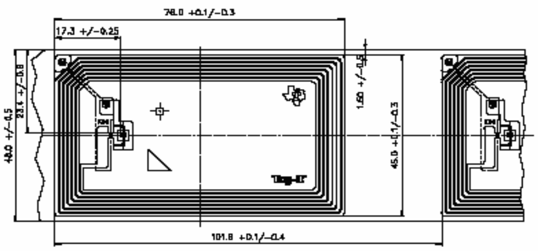
- Know your application requirements.
- Know the benefits you expect to achieve.
- Select experienced integrators.
- Develop list of environmental concerns: metal, monitor emissions.
- Train in-house personnel, regardless of data capture experience.
- Rely on integrator to assist programmers and electricians.

APPENDIX C

RADIO FREQUENCY IDENTIFICATION SYSTEMS

Tag-it™ HF-I Transponder Inlay
- Rectangle-Large -

The Tag-it HF-I Transponder Inlay is compliant with the ISO/IEC 15693 standard. With a user memory of 2k bits, organized in 64 blocks, the Tag-it HF-I Transponder Inlays allows advanced solutions for a variety of applications, including product authentication, ticketing, library management, supply chain management etc. The thin and flexible Tag-it HF-I Transponder Inlays can be easily converted into paper labels.



Specifications:

Part Number	***RI-I12-112A***
Supported Standard	ISO 15693-2,-3
Recommended Operating frequency	13.56 MHz
Passive Resonance Frequency (at +25°C)	13.86 MHz ± 200kHz (includes frequency offset to compensate further integration into paper)
Typ. required activation field strength read (at +25°C)	94 dBµA/m #
Typ. required activation field strength write (at +25°C)	97 dBµA/m #
Factory programmed Read Only Number	64 bits
Memory (user programmable)	2k bits organized in 64 x 32-bit blocks
Typical programming cycles (at +25°C)	100,000
Data retention time (at +55°C)	> 10 years
Simultaneous Identification of Tags	Up to 50 tags per second (reader/antenna dependent)
Antenna size	45 mm x 76 mm (~1.77 in x ~2.99 in)
Foil width	48 mm ± 0.5 mm (1.89 in ± 0.02 in)
Foil pitch	101.6 mm +0.1mm/-0.4mm (4 in)
Thickness	Chip: 0.355mm (~0.014 in) Antenna: 0.085mm (~0.0033 in)
Base material	Substrate: PET (Polyethylenetherephtalate) Antenna: Aluminum
Smallest bending radius allowed	18 mm (~0.71 in)
Operating temperature	-25°C to +70°C
Storage temperature (single inlay)	-40°C to +85°C (warpage may occur at upper temperature range)
Storage temperature (on reel)	-40°C to +40°C
Delivery	Single row tape wound on cardboard reel with 500 mm diameter Reel outer width: approx. 60 mm (~2.36 in) Reel inner width: approx. 50 mm (~1.97 in) Hub diameter: 76.2 mm (3 in)
Typical quantity of good units per reel	5,000

Note: For highest possible read-out coverage we recommend to operate readers at a modulation depth of 20% or higher
After integration into paper

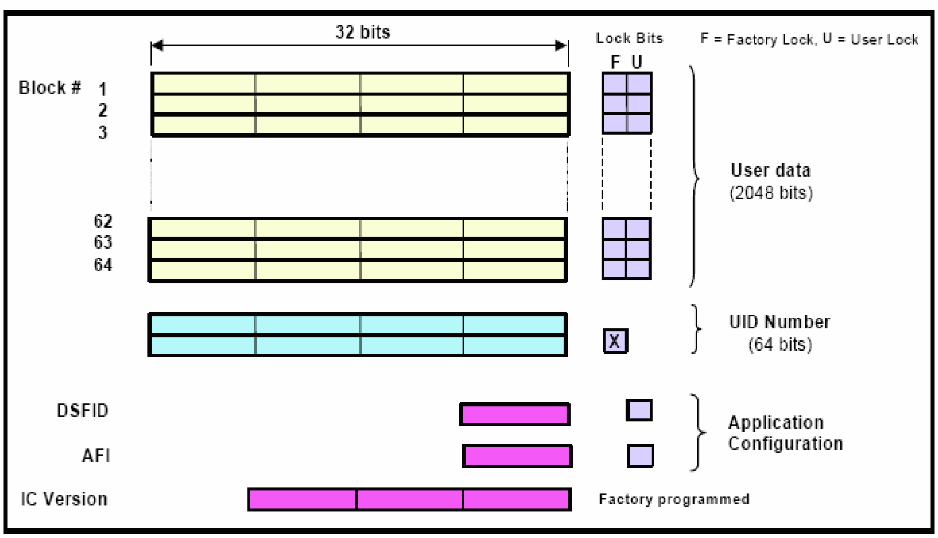
For more information, contact the sales office or distributor nearest you. This contact information can be found on our web site at: **http://www.ti-rfid.com**

Supported Command Set

Request	Request Code	Request Mode: Inventory	Addressed	Non-Addressed	Select	AFI
ISO 15693 Mandatory and Optional Commands						
Inventory	0x01	✓	-	-	-	✓
Stay Quiet	0x02	-	✓	-	-	-
Read_Single_Block	0x20	✓	✓	✓	✓	✓
Write_Single_Block	0x21	-	✓	✓	✓	-
Lock_Block	0x22	-	✓	✓	✓	-
Read_Multi_Blocks	0x23	✓	✓	✓	✓	✓
Write_Multi_Blocks	0x24	-	-	-	-	-
Select Tag	0x25	-	✓	-	-	-
Reset to Ready	0x26	-	✓	✓	✓	-
Write_AFI	0x27	-	✓	✓	✓	-
Lock_AFI	0x28	-	✓	✓	✓	-
Write DSFID	0x29	-	✓	✓	✓	-
Lock DSFID	0x2A	-	✓	✓	✓	-
Get_System_info	0x2B	✓	✓	✓	✓	✓
Get_M_Blk_Sec_St	0x2C	✓	✓	✓	✓	✓
TI Custom Commands						
Write_2_Blocks	0xA2	-	✓	✓	✓	-
Lock_2_Blocks	0xA3	-	✓	✓	✓	-

✓: Implemented
- : Not applicable

Memory Organization



APPENDIX D

IP-X UHF High Performance Integrated Reader

IPICO
RFID REALISED

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Description

The UHF High Performance readers are available in a wide range of power and frequency versions, and comply with ETSI (Europe) and FCC (USA) standards. The power level can be set to any value from 0.1 W to 4 W EIRP, and the frequency from 860 to 960 MHz, fixed or hopping. Some typical settings are:

- 4 W EIRP frequency-hopping in the 902 – 928 MHz ISM band – (USA and some South American countries)
- 1 W EIRP frequency-hopping in the 902 – 928 MHz ISM band (Australia)
- 500 mW ERP fixed frequency in the 869.4 - 869.65 MHz band (Europe)
- 4 W EIRP fixed frequency at 915.3 MHz (South Africa)

The standard data output is RS232 with programmable baud rate and flow control. Optional outputs include RS485, Ethernet, and Wiegand with RS232. All received IDs are date- and time-stamped in the reader. Supply is either from 12VDC or 90 - 264VAC.

Read-Only and Read/Write readers are available. For reading all the data pages transmitted by tags operating in "TTO" mode, the Read/Write reader must be used. The Read-Only version can read only the unique 64-bit ID code of the tag.

Key Features

- Read-Only or Read/Write, compatible with EM4222, EM4122 and EM4444 chips
- Can comply with any spectrum allocations in the UHF band (860 – 960 MHz) up to 4 W EIRP
- Long range (up to 10 m depending on TX power and tag type)
- Robust anti-collision protocol (up to 240 tags read simultaneously)
- High tag read rate – up to 200 tags/sec in multi-read application
- Standard output RS232; RS485, Ethernet, Wiegand outputs optional
- Real time clock (RTC)
- IP-65 enclosure and connectors
- Software, hardware and diagnostics control
- Built-in test and diagnostics
- Front panel status LED

Power setting (-rfp-)	0.5 W ERP	1.0 W EIRP	4.0 W EIRP
Read range	**Typical read ranges (depends on reader placement and tags used)**		
	1 – 3 m	3 – 5 m	6 – 8 m
Power supply (psu)	**Mains input type:** 90 - 264 VAC @ ~1.4A, 50/60 Hz **Low voltage input type:** 11.7 – 12.3VDC @ 2.5 A max (typ 600mA for 500 mW reader) (12V device is reverse protected up to 20V max. Provision must be made for additional surge protection and regulated power if necessary)		
Antenna type	Internal 4 dBil circularly polarised		
Communication	Binary or ASCII RS232 with programmable baud rate and flow control **Options:** Galvanic Isolated RS485/RS422, Wiegand with RS232, Ethernet.		
Data storage	Standard: Internal circular FIFO spool buffer for 64 tags. This data is transmitted as a free running stream and needs to be captured externally by a PC or by a DIMI controller, or other device. Serial protocol manual available. Reader can be configured to send only the first instance of each tag ID it receives, with a settable time-out.		
Electrical interface	12 Pin (P1) circular connecter for DATA with 6m cable with 9 Pin D type female connector at the other end 3 Pin (P2) circular connecter for POWER with 6m cable with no connector at the other end		
Environmental	Operating temperature range: -10 to +60C, Storage temperature range: -20 to +85C Humidity: 5 to 95% non-condensing, IP rating: IP 65, UV protection: Yes		
Physical	Dimension: 305 (W) x 805 (L) x 60 (H) mm, (Height excludes mounting brackets) Weight: Approx. 6.5 Kg unpacked, 10Kg Packed for shipping.		
Mounting	Two pole-mounting brackets dia. < 60 mm diameter		
Approvals	EMC: CE approved EN 300 683, EN 300 220-1&3, EN 6100-3-2&3, FCC pre-compliance, (Full FCC compliance pending) Safety: CE approved IEC 60950, (Full UL safety compliance pending) Environmental: IEC 60068-2-1,2,5,28, IEC60529, IP65		

IPICO

RFID REALISED

Ordering Information

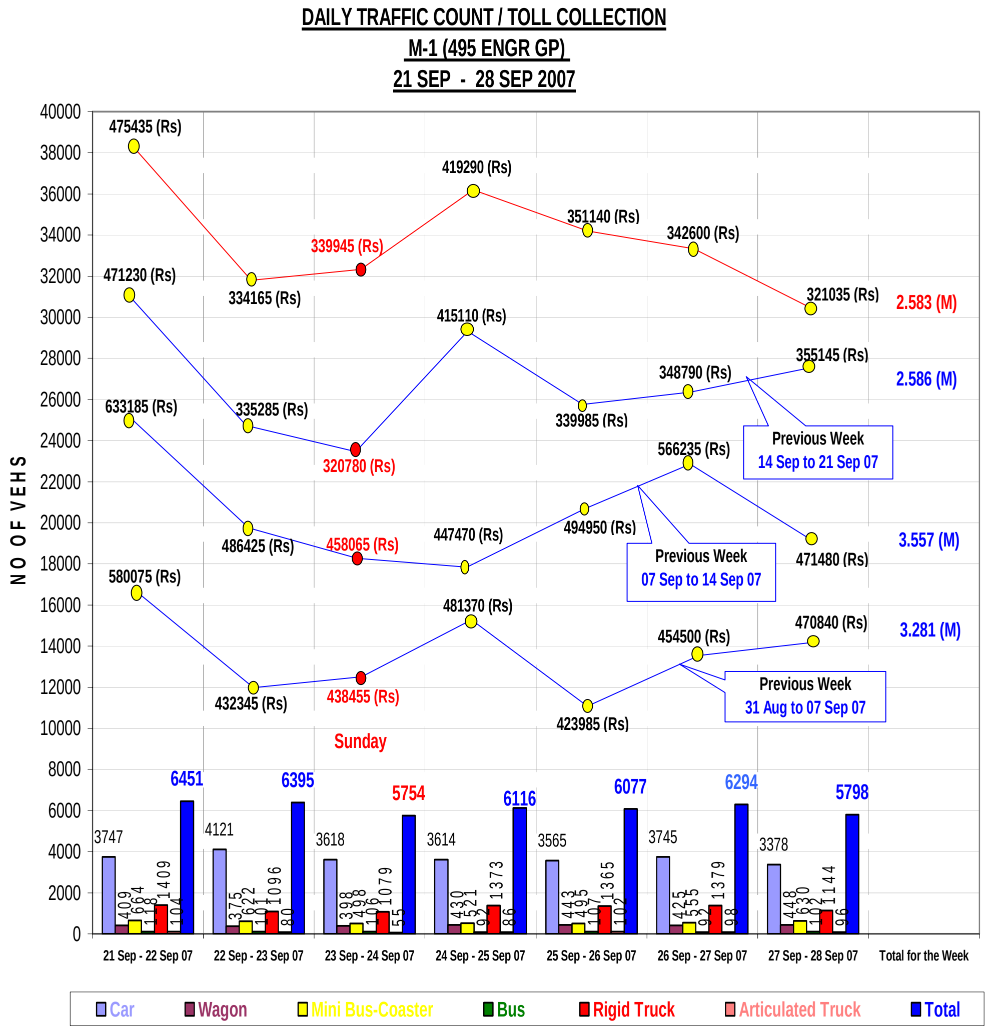
Product Name	Product Code	Description
UHF High Performance Reader, 12V Ethernet RO	IP3293	IP-X URDR-HP-rff-rfp-12V-E-RO
UHF High Performance Reader, 12V Ethernet RW	IP3294	IP-X URDR-HP-rff-rfp-12V-E-RW
UHF High Performance Reader, 12V RS232 RO	IP3177	IP-X URDR-HP-rff-rfp-12V-R-RO
UHF High Performance Reader, 12V RS232 RW	IP3274	IP-X URDR-HP-rff-rfp-12V-R-RW
UHF High Performance Reader, 12V RS485 RO	IP3320	IP-X URDR-HP-rff-rfp-12V-S-RO
UHF High Performance Reader, 12V RS485 RW	IP3323	IP-X URDR-HP-rff-rfp-12V-S-RW
UHF High Performance Reader, 12V Wiegand RO	IP3313	IP-X URDR-HP-rff-rfp-12V-W-RO
UHF High Performance Reader, Mains Ethernet RO	IP3229	IP-X URDR-HP-rff-rfp-MNS-E-RO
UHF High Performance Reader, Mains Ethernet RW	IP3271	IP-X URDR-HP-rff-rfp-MNS-E-RW
UHF High Performance Reader, Mains RS232 RO	IP3142	IP-X URDR-HP-rff-rfp-MNS-R-RO
UHF High Performance Reader, Mains RS232 RW	IP3056	IP-X URDR-HP-rff-rfp-MNS-R-RW
UHF High Performance Reader, Mains RS485 RO	IP3318	IP-X URDR-HP-rff-rfp-MNS-S-RO
UHF High Performance Reader, Mains RS485 RW	IP3321	IP-X URDR-HP-rff-rfp-MNS-S-RW
UHF High Performance Reader, Mains Wiegand RO	IP3319	IP-X URDR-HP-rff-rfp-MNS-W-RO
UHF High Performance EVI Reader Mains Ethernet RW	IP3315	IP-X URDR-HPEVI-rff-rfp-MNS-E-RW

Symbols and their meanings

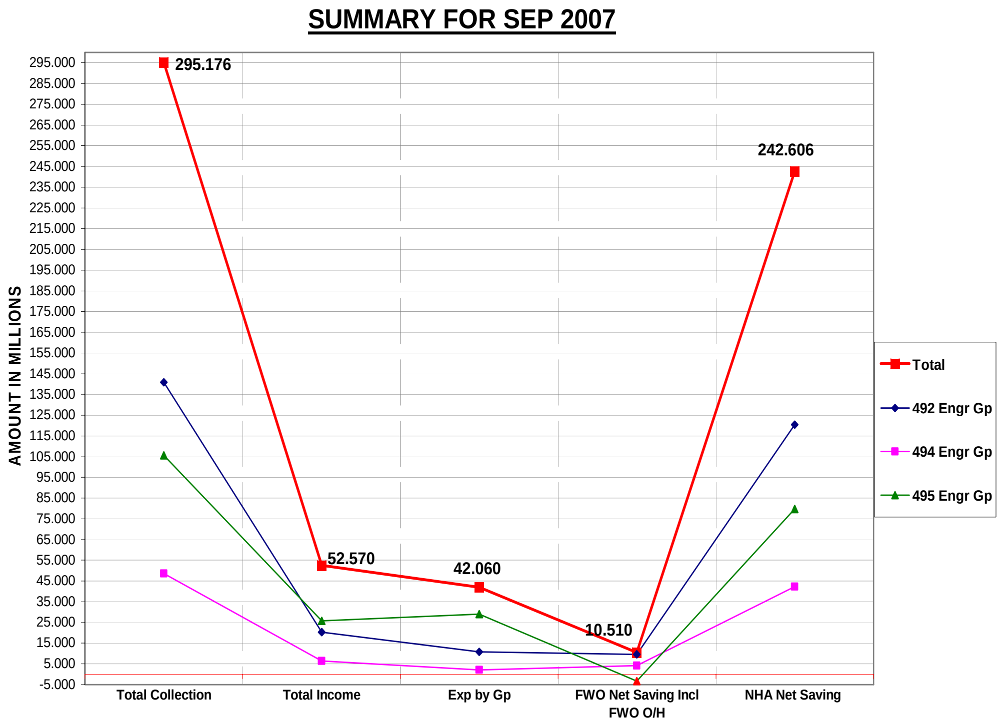
IP-X	IPICO's Multi-Read protocol
URDR	UHF RFID Reader, operating the band 860 – 960 MHz
HP	High performance (up to 8W EIRP)
HPEVI	High Performance, Linearly polarised antennas for reading horizontal ENP tags (Electronic Number Plate labels, windscreen mounted), or Industrial Vehicle Tags
RO	Read-Only (reads only unique ID, not other data pages from tags set for TTO mode)
RW	Read/Write (reads all data from "TTO" read/write tags, writes to all data pages)
rff	RF frequency, MHz (to be specified with order)
rfp	RF radiated power, expressed in W ERP or W EIRP (to be specified with order)
MNS	AC Supply, 90 – 264 VAC, 50 – 60 Hz
12V	DC supply, 12V
R	RS232 data/control
S	RS485 data/control
W	Wiegand data output (with RS232 connection for data/control)
E	Ethernet connection for data/control

APPENDIX E

(COURTESY FWO)



(COURTESY FWO)



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