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RSSI Based Implementation of Smart Tollgate Automation

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ABSTRACT: This project presents a new prototype that aims to design, develop and implement Received Signal Strength Indicator (RSSI) based smart tollgate automation which is used to achieve an improved form of tollgate billing system. The existing system provides the customer with a smart card which contains the details about him. Few of existing projects based on RFID tag, which consume more power because reader and tags required power. Active tags are expensive because of their complexity. In the proposed system there is no need of smart card. Once the end user (motorist) comes to chargeable zone; the Zigbee transceiver receives the signal that the vehicle has entered the chargeable zone particular LANE, then automatically the unique id of the motorist (Vehicle ID) has been read via on-board unit, which has been attached to every vehicle and collects the daily road pricing charge. The system is implemented to automatically register vehicles getting on or off a motorway or highway, cutting the amount of time for paying toll in large queues. If the user crosses the tollgate without paying bill more than two times, the petrol valve of the vehicle is closed using relay with the help of on-board unit.

KEYWORDS: Electronic Toll Collection(ETC), Received Signal Strength indicator(RSSI), Solid State Relay(SSR), Radio Frequency Identification(RFID)

I. INTRODUCTION

Electronic toll collection (ETC) is a technology, enabling the electronic collection of toll payments. With the development of the freeway, at present Electronic Toll Collection (ETC) system more and more is used in the freeway management system, which can finish identification of the vehicle and vehicle toll without parking automatically. Freeway business enterprise can get good economic and social benefits in the aspect of the operating management mode and running cost and vehicle traffic capacity by this means. With the development of the short wireless communication technologies, such as RFID, WiFi, UWB and Bluetooth reveal the great application prospects in the freeway ETC system and promote the research and development of new ETC system. Radio Frequency Identification (RFID) is a grown automatic identification technology and nowadays widely used in the ETC system with the advantage of the short transmission distance, no-touching and fast response.

This paper put forward the RSSI technology to use in the vehicle localization to improve the efficiency of the freeway ETC system. RSSI (IEEE 802.15.4 standard) is a rising wireless network technology which is of short space, low complicity, low power consumption, low data rate and low cost. RSSI technology can be introduced to satisfy the function of the vehicle position and tracking, through which highway management system can get the more information of the vehicle and effectively reduce the Vehicles blocking rate.

The architecture is made up of a set of block called layers. Each layer performs a specific set of services for the layers. The IEEE 802.15.4 standard defines the two lower layers: the physical layer and the medium access control (MAC) sub-layer. The RSSI Alliance builds on this foundation by providing the network

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(NWK) and the framework for the application layer, which includes the application support sub-layer (APS), the node device objects (NDO) and the manufacture defined application objects.

RSSI is the received signal strength in a wireless environment, in arbitrary units. It is an indication of the power level being received by the antenna. Therefore, the higher the RSSI number, the stronger the signal. It is a measurement of the power present in a received radio signal. RSSI is a generic radio receiver technology metric, which is usually invisible to the user of the device containing the receiver, but is directly known to users of wireless networking of IEEE 802.11 protocol family. The freeway electronic toll gate system is composed of the vehicle terminal, coordinator and toll gate system, which can collect automatically, analyze and handle every node data on the basis of the IEEE802.15.4/protocol. Record and gain vehicles detailed information, when passing through toll station. Data request of the vehicle terminal can transmit to gateway coordinator by the wireless information channel and transmit data to toll gate system to handle.

II. BLOCK DIAGRAM DESCRIPTION

The model this paper describes doesn't need smart card. The vehicle is enabled with an on-board unit, which contains the vehicle ID and information. Since WSN can address 16-bit addressing, more number of vehicles can pass freely. Uses bloom filter for network traffic problem.

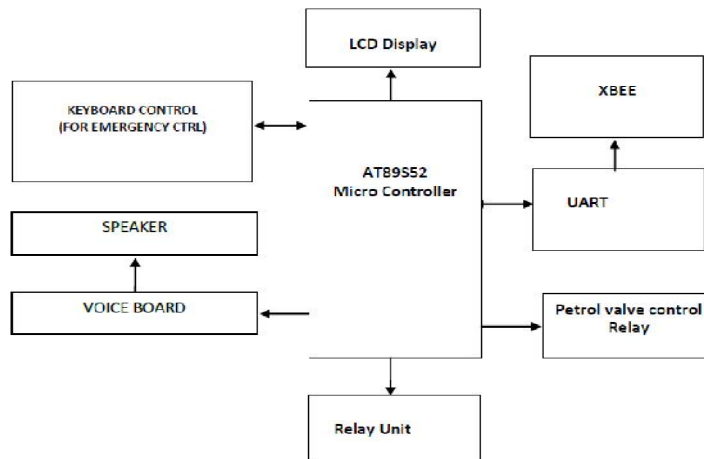


Fig. 1: Block Diagram Of Transmitter Model

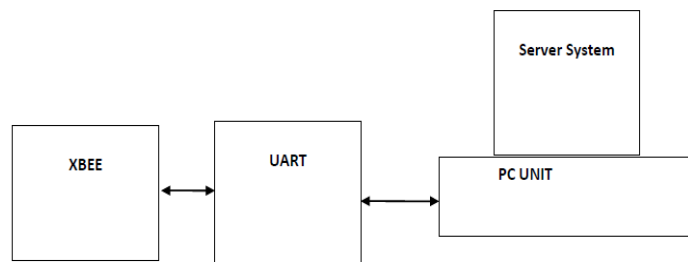


Fig. 2: Block Diagram of Receiver Model

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III. WORKING DETAILS

Here once the vehicle reaches the toll gate, Received Signal Strength Indicator (RSSI) shows the RF signal strength in terms of dBm. If the strength value is -50 to -59dBm, it alters the vehicle owner that the toll gate is about to reach. It also gives a voice message as “Welcome to Toll gate”. Now the user has to select the trip as, one way or two ways through the keyboard interface. User toll gate amount will be displayed according to the trip selection. As the vehicle reaches the toll gate, the RSSI value increases to -30 to -39dBm. Now it alters the vehicle owner that it has reached the toll gate. Radio frequency Identification tag will automatically detects the vehicle and connects to the server by Zigbee wireless communication network. After transaction is made, the barrier automatically opens and the vehicle crosses the toll gate without waiting in the queue lane. Once the vehicle crosses the toll gate, voice message indicates that the vehicle has crossed the toll gate. User can cross the toll gate for maximum of two times with zero balance in the user account. This is made in order to facilitate the user who may be in emergency and not aware of the thing in advance. If user crosses more than two times without any transaction amount, automatic relay unit which is in-build with the system closes the petrol value and thus the vehicle stops automatically.

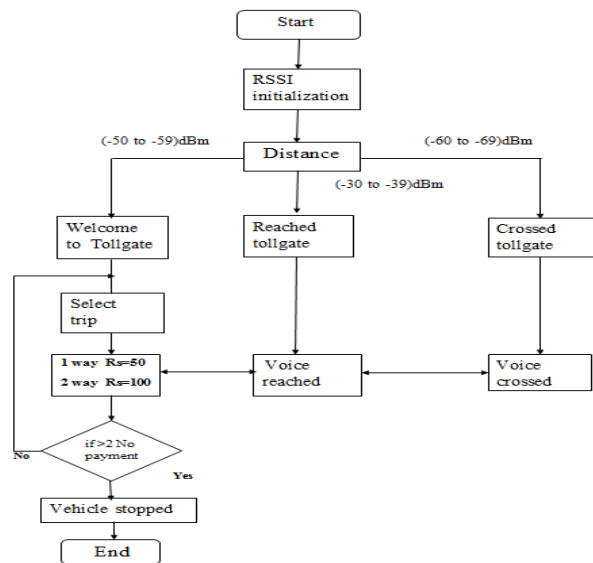


Fig. 3: Flowchart of the Process

IV. METHODOLOGY

In this paper, once the end user (motorist) comes to chargeable zone, the Zigbee transceiver receives the signal that the vehicle has entered the chargeable zone particular LANE, then automatically the unique id of the motorist (Vehicle ID) has been read via on-board unit, which has been attached to every vehicle and collects the daily road pricing charge. Here, two nodes are used. Each Node contains two individual tags to identify the authentic person. Tags are based on passive RFID(Radio-frequency identification), so that one tag of one node cannot be used in another node. Each Tag has unique code number for authentication. If we use another tag instead of specified tag, then buzzer will produce a sound and usage of tags can be monitored in host.

A. Hardware

(i) ZIGBEE:

The past several years have witnessed a rapid development in the wireless network area. So far wireless networking has been focused on high-speed and long range applications. However, there are many wireless monitoring

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and control applications for industrial and home environments which require longer battery life, lower data rates and less complexity than those from existing standards. What the market need is a globally denied standard that meets the requirement for reliability, security, low power and low Cost. For such wireless applications a new standard called Zigbee. It uses the standard of IEEE 802.15.4 physical and MAC (Medium Access Control) layers to provide standards-based, reliable wireless data transfer. Zigbee adds network structure, routing, and security (e.g., key management and authentication) to complete the communications suite. Zigbee uses the license-free ISM bands, which provide unrestricted geographic use. Zigbee and the underlying 802.15.4 standard offer the system designer several classes of devices: the reduced-functionality device (RFD), the full-functional device (FFD), and the network coordinator. All Zigbee networks have at least one RFD or FFD and a network coordinator. Most sensor applications fall natively into the RFD class, with extended networks making use of both FFDs and network coordinators to form bridges and links required by the network topology. Zigbee networks can form autonomously, based on connectivity and function. The IEEE 02.15.4 standard targets home and building control, automation, security, consumer electronics, PC peripherals, medical monitoring, and toys.

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking. Zigbee transceiver is used as Received signal strength indicator (RSSI).



Fig. 4: Zigbee module

(ii) RECEIVED SIGNAL STRENGTH INDICATOR (RSSI):

Received Signal Strength Indicator (RSSI) measures the strength of the radio signal received. RSSI ranging need less communication overhead, lower implementation complexity and low cost. So it is very suitable for the nodes in wireless sensor networks which have limited power.

RSSI is always done in an intermediate frequency (IF) stage before the IF amplifier. RSSI output is often a DC analog level. It can also be sampled by an internal ADC and the resulting codes are available directly or via internal processor bus. There are four units of measurement that are all used to represent RF signal strength. These are: mW (milliwatts), dBm ("db"-milliwatts), RSSI (Receive Signal Strength Indicator), and a percentage measurement. All of these measurements are related to each other, some more closely than others.

The "dBm" (dB-milliwatt) is a logarithmic measurement of signal strength, and dBm values can be exactly and directly converted to and from mW values. A mW measurement is first converted to a base-10 logarithm. It turns out that the logarithm values are quite small; convention multiplies this value by 10 with the resulting value called dBm.

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Fig. 5: RSSI Device

(iii) SOLID STATE RELAY:

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches.

A Solid State Relay (SSR) is an electronic switch, which, unlike an electro-mechanical relay, contains no moving parts such as coil, spring or mechanical contact switch. Hence their switching response time is much faster than electromechanical relays. Also it has a long life time. Extremely low input current and small packaging make SSR ideal for microprocessor and logic control switching. The three types of SSR are photo-coupled SSR, transformer-coupled SSR, and hybrid SSR. The advantages of mechanical relays are, SSRs are faster than electromechanical relays; their switching time is dependent on the time needed to power the LED on and off, typically on the order of nanoseconds, Increased lifetime due to the fact that there are no moving parts, and thus no wear, Clean, bounce less operation, decreased electrical noise when switching, can be used in environments where a spark must not be generated during turn-on, totally silent operation, relays can switch AC and DC, transistors can only switch DC, relays can switch high voltages, transistors cannot, relays are a better choice for switching large currents (> 5A), relays can switch many contacts at once.

(iv) 16x2 LCD DISPLAY:

The 16x2 parallel LCD is an 8 bit or 4 bit parallel interfaced LCD. This unit allows the user to display text, numerical data and custom created characters.

(v) UNIVERSAL ASYNCHRONOUS RECEIVER/ TRANSMITTER:

A universal asynchronous receiver/transmitter (UART) is a type of "asynchronous receiver/transmitter", a piece of computer hardware that translates data between parallel and serial forms. UARTs are commonly used in conjunction with other communication standards such as EIA RS-232. A UART is usually an individual (or part of an) integrated circuit used for serial communications over a computer or peripheral device serial port. UARTs are now commonly included in microcontrollers. Basically UART contributes of two components viz, Max232 IC, RS232 serial cable. The features of UART are 9-bit address mode with hardware address detection, BAUD rates from 10 – 921600 bps or arbitrary up to 3 Mbps, RX and TX buffers = 1 – 65535, detection of Framing, parity and Overrun errors, Full Duplex and Half Duplex.

(vi) KEYPAD:

A keypad is a set of buttons arranged in a block or "pad" which usually bear digits, symbols and usually a complete set of alphabetical letters. If it mostly contains numbers then it can also be called a numeric keypad. Keypads are found on many alphanumeric keypads and on other devices such as calculators, push-button telephones, combination locks, and digital door locks, which require mainly numeric input. The features of Keypad are, 4*4 matrix keypad, Length: 10cm, Width: 3.1cm, Contact Rating: 20mA, 24VDC, Contact Resistance: 200ohms Max, Life: 1,000,000 cycles per key.

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(v) Voice Board:

Advancement in technology has developed an intelligent man-machine interface technique that facilitates computers or machines or robots to be operated using the voice commands of human without using any input systems, such as keyboards or mouse. This human-machine interface (HMI) can be achieved using voice recognition modules. Voice recognition is a technique that facilitates natural and convenient human-machine interface using the voice recognition module. It extracts and analyses voice features of human delivered to a machine or computer through the mic.

HM2007 is a single chip CMOS voice recognition module. It is an on-chip analog front end large-scale integrated circuit with voice analysis, speech recognition and voice recognition system control processes. HM2007 can be operated in two modes: manual mode and CPU control mode.

In manual mode of operation, the voice recognition module HM2007 is used to build simple recognition system by connecting components such as keypad, SRAM of 8Kbyte memory and other components. In the recognition mode, if the WAIT pin is H, then the HM2007 is ready to accept the voice and begins recognition process. If the WAIT pin is L, then the HM2007 doesn't accept the voice that is to be recognized. In the CPU control mode of operation, several functions such as RECOG, TRAIN, RESULT, UPLOAD, DOWNLOAD, RESET functions of the voice recognition module HM2007 are provided in this mode. Similar to a manual mode of operation, in this mode also power on, recognition, training, resulting, uploading, downloading and reset operations are performed based on different criteria.

(vi) ATMEL MICROCONTROLLER:

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

The Atmel microcontroller has more advanced and developed features when compared to its previous series. The important features of AT89s52 series are Compatible with MCS®-51 products, 8K Bytes of In-System Programmable (ISP) Flash Memory- Endurance: 1000 Write/Erase cycles, 4.0V to 5.5V Operating Range, fully Static Operation: 0 Hz to 33 MHz, three-level program memory lock, 256 x8-bit internal RAM. 32 programmable I/O Lines, three 16-bit timer/counters, eight interrupt sources, full duplex UART serial communication.

B. Software

(i) KEIL C CROSS COMPILER:

KEIL is a German based software development company. It provides several development tools like IDE (Integrated Development Environment) Project Manager, Simulator, Debugger, C Cross Compiler, Cross Assembler, Locator/Linker, KEIL software provides you with software development tools for the family of microcontrollers. With these tools, you can generate embedded applications for the multitude of 8051 derivatives. KEIL provides following tools for 8051 development, C51 Optimizing C Cross Compiler, A51 Macro Assembler, 8051 Utilities (linker, object file converter, library manager), Source – Level Debugger/Simulator, Vision for Windows Integrated Development Environment. The KEIL 8051 tool kit includes three main tools, assembler, compiler and linker. An assembler is used to assemble your 8051 assembly program. A compiler is used to compile

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your C source code into an object file. A Linker is used to create an absolute object module suitable for your in-circuit emulator.

(ii) VISUAL BASIC 6.0:

Visual Basic is a third-generation event-driven programming language and integrated development environment (IDE) from Microsoft for its COM programming model first released in 1991. Microsoft intends Visual Basic to be relatively easy to learn and use.[1][2] Visual Basic was derived from BASIC and enables the rapid application development (RAD) of graphical user interface (GUI) applications, access to databases using Data Access Objects, Remote Data Objects, or ActiveX Data Objects, and creation of ActiveX controls and objects. A programmer can create an application using the components provided by the Visual Basic program itself. Programs written in Visual Basic can also use the Windows API, but doing so requires external function declarations. Though the program has received criticism for its perceived faults, version 3 of Visual Basic was a runaway commercial success, and many companies offered third party controls greatly extending its functionality. A dialect of Visual Basic, Visual Basic for Applications (VBA), is used as a macro or scripting language within several Microsoft applications, including Microsoft Office.

Like the BASIC programming language, Visual Basic was designed to accommodate beginner programmers. Programmers can not only create simple GUI applications, but to also develop complex applications. The final release was version 6 in 1998. Microsoft's extended support ended in March 2008 and the designated successor was Visual Basic .NET (now known simply as Visual Basic). Though VB6 is no longer officially available there remains a sizable number of developers who still prefer VB6 over .NET. A dialect of Visual Basic, Visual Basic for Applications (VBA), is used as a macro or scripting language within several Microsoft applications, including Microsoft Office. Like the BASIC programming language, Visual Basic was designed to accommodate beginner programmers. Programmers can create both simple and complex GUI applications. Programming in VB is a combination of visually arranging components or controls on a form, specifying attributes and actions for those components, and writing additional lines of code for more functionality. Since VB defines default attributes and actions for the components, a programmer can develop a simple program without writing much code. Programs built with earlier versions suffered performance problems, but faster computers and native code compilation has made this less of an issue.

V. RESULT

Automatic Tollgate system is designed based on RSSI signal strength without wasting the user time in waiting in the tollgate queue. As mentioned earlier, this system consists of following modules which can be integrated to design a complete model.



(a)



(b)



(c)

Fig. 6 : (a) AT89s52 Microcontroller assembly set, (b) Speaker section, (c) Receiver section

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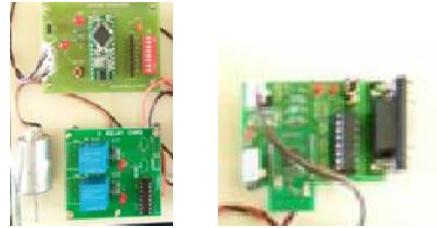


Fig. 7: (d) Relay control unit, (e) UART section

Figure (a) shows complete assembly set of AT89s53 microcontroller with necessary interfacing kits. Figure (b) shows speaker system which is used to alter the user while tollgate is arrived. Figure (c) shows the receiver section through which the information is communicated to the server, installed in the toll gates. Figure (d) shows the relay unit which is used to control the petrol value of the user vehicle. This petrol value automatically locks the injection of the fuel to the engine, if the vehicle crosses the toll gate without balance in the user account in payment for more than two times. Figure (e) shows the UART section by which the signal from the system is communicated to the toll gate system using Zigbee module. Figure (f) shows the complete integrated segment of implementation of automatic toll gate system using RSSI.

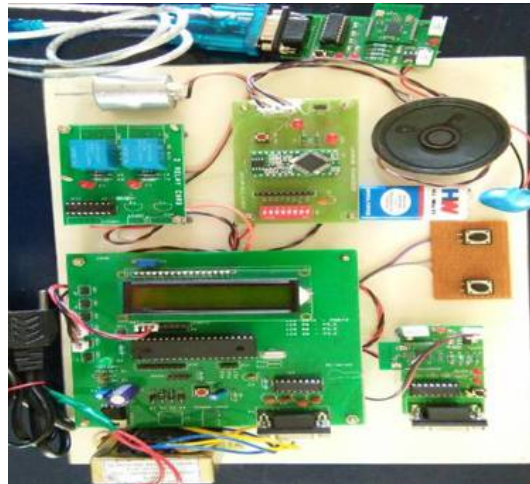


Fig. 8 : Implementation of Automatic Toll gate system using RSSI model

VI. CONCLUSION

In this paper, the major objective has been to quantify how good and accurate is the RSSI model in a wireless sensor network to estimate the location of a cooperative target. The system proposed here doesn't need smart card. The vehicle is enabled with an on-board unit that contains the vehicle id and information, where tollgate payment is carried out at particular RSSI value. Results are encouraging and are able to achieve an accuracy of nearly 1.1 meters with 90% probability in indoor environment. If have a good quantification of the signal strength model, it can be implemented for location estimation scheme on this basis. In order to enhance this system, we can use Global positioning system (GPS) for giving alert messages about transaction to the user mobile, providing messages about an amount transaction and insufficient amount in an account of the user.

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BIOGRAPHY



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