Automatic Toll Collection Systems using WSN (RFID)

Mr. Aadesh Kamble[1] Mr. Vijay Shinde[2] Mr. Ashok Bade[3] Mr. Vijay Hambir[4]
[1,2,3,4]Department of Computer Engineering
[1,2,3,4]K. J. College of Engineering and Management Research

Abstract— Wireless Sensor Networks gaining market in this era has revolutionized the world by making the world faster and more robust. Using this fact, Automated Systems using WSN are developed for the transportation to make it easy and fast, by using Radio Frequency Identification for cars we can make the journey unstoppable on the highways. Cars stop in queues on highways to pay the toll tax, instead we can use Active RFID and WSN to make the toll process automated and easy.

Key words: Radio Frequency Identification, Wireless Sensor Networks

I. INTRODUCTION

Automated Systems using WSN are used in industry everywhere to make everyday process faster and better. WSN is used in offices for the employees to enter the office by using identity card and their attendance will be registered in the database. Similarly, we can use it in multiple places such as attendance in schools, colleges etc. We can also use Sensor networks in libraries, mobile phones and PDA's to detect books and other mobile phones for location tracking etc. We are approaching towards a new and better trend to reduce traffic deadlocks on busy highways to allow all vehicles to move on highways without stopping on the way to pay the toll which leads to traffic on busy highways. We make use of Wireless Sensor Networks (WSN) in this process of making the traffic flow smooth on highways by applying Active RFID's in vehicles and scanners where the toll tax is supposed to be deducted. A WSN scanner and RFID are the major parts of Wireless Sensor Networks used here (Fuhrer and Guinard,2005). RFID's will be compulsory installed in the vehicles travelling on the highways in order to deduct the toll. When a vehicle is travelling on highways it crosses the toll booth with the same speed as it is already on and the scanner will automatically detect the RFID on the vehicle(Krotov and Junglas, 2008). This RFID is an Active RFID so no need of physical initiation is required to start the process of toll deduction. As soon as the RFID is scanned by the scanner all information will be stored in a global database, information in database will contain car owners entire details such as name of the car, name of the car owner, car type model and colour, owners bank account details, mobile number, etc. When the toll is deducted a message is sent to owner on his cell phone about the balance deducted and the details about the toll. Such system using WSN makes life simple at busy highways and reduces the amount of traffic and the need to waste time where everything can be made simple just by installing a scanner, RFID and making a global database. This also reduces the manpower required at the highways where they are in constant danger to get hit by vehicles. Cost of infrastructure is reduced.If any emergency case is running through highway such as a police chase or a patient who needs medical help will get its way faster if all the vehicles do not stop on the toll both to pay the toll.

Transponder(tag), reader/writer, antenna, and computer host are required for a complete RFID system. The transponder is also known as tag comes in a compact package with an antenna system combined with a microchip on it. The microchip contains logic and memory circuits to send and receive data back to the reader. These transponders are classified as either passive or active tags. Active tags have a longer reading range due to its internal batteries, while passive tags have a shorter reading range because they are powered by the signal from its reader. Passive RFID does not have any internal power source; to operate them they require some external power source. Electronic signals are received from the readers to power the tags. Received electromagnetic signal charges an internal capacitor on the tags, which acts as a power source and supplies the power to the chip. Though these passive tags have both LF and UHF.UHF tags have high read range and they are capable of reading multiple tags simultaneously which in turn may lead to collision. Strip can be used so that only one tag at a time can be read. Existing systems lack the strip in them so they were capturing multiple tags at a time which leads to collision.

Existing techniques such as using Microwave Technology, Optical Camera Recognition, GPS, RFID technology (active) proved to be inefficient and these are discussed below. In optical camera recognition the whole object will be captured therefore it is a time consuming process and error rectification difficult in laser cameras. Microwave technology requires different tags and produces various problems regarding reflection. The Active RFID technology also did not prove to be efficient because the reader used has long read range which can result in reading multiple tags at a time resulting into collision. RFID having small read range but which can read efficiently is required as well as it must not have problems of reflection, and problem of tags.

RFID's in wireless sensor networks for making the vehicle system or transportation system automated on the go uses Active RFID device and a scanner with RFID detector. We can integrate detector in scanner and automate the toll system. This system is also beneficial to monitor the speed of the vehicles on highways which will allow us to detect the vehicle drivers which break the rules and drive faster than the speed limit on highways. We can detect the distance between two vehicles which is not very useful for customers but it will be useful for police surveillance records in case of any investigation is to be carried out if any accident. Hence we reduce the need of manpower and use the automated machinery for our benefits.

II. MATERIALS AND METHODS

A. Details of Existing System:

Active tag monitoring solution is developed and deployed by Active wave Inc. For receive link 433 MHz is used and for transmit link 916 to 927 MHz is used on operations they

have a range of up to 30 meters. 256 Kilo Bytes of fixed memory is used in products produced by Active waveinc.The total weight is 14 grams and the tag is powered with 3 V batteries. Beeping sounds and blinking LED are used as elementary signals. Smart key Access Control Systems have a client server model based system with an SQL server handling multiple vehicle monitoring systems. They have designed a user interface using the Microsoft .NET Framework. Smart key has a small range of 30 meters and operate in 900MHz. Active RFID tag which uses car battery power is integrated in products .Their design has two modules Base Module and Vehicle module. The two modules communicate via RF modem connected to each module. ISM Frequency Range of 902 – 928 MHz is used for communication between them Thus as seen in the existing system we have a product which provides us the benefits but is not upgraded and cost effective. We made this simple by using better devices and upgraded systems which may not reduce the cost but will increase the efficiency of the system for sure which will be more simpler to use then the existing system.

III. TECHNOLOGIES USED FOR DESIGN AND DEVELOPMENT

A. RFID Frequencies:

Frequencyis a radio wave that is used to communicate between RFID components and systems. RFID systems have three operating frequencies in low frequency (LF), high frequency (HF) and ultra-high frequency (UHF) bands. Radio waves behavior changes at each of these frequencies with disadvantages and advantages associated with using each frequency band. UHF Generation 2 is the fastest growing segment of RFID market. If an RFID system operates at lower frequency, it has a slower data read rate and shorter read range. It has increased capabilities for reading on liquid or metal surfaces. If a system operates at a higher frequency it has faster data transfer rates and longer read ranges. They are more sensitive to metals and liquids having radio wave interference.

B. LF RFID:

The LF band covers the frequencies from 30 to 300 KHz. They operate on 125 KHz and some of them operate at 134 KHz. They have a read range of 10 cm which is considered as short read range and therefore has slower read speeds. They are not very sensitive to radio wave interference. They consist applications such as livestock tracking and access control. LF spectrum is not considered as global application as it has slight differences in frequency and power levels throughout the world.

C. HF RFID:

The HF band ranges from 3 to 30 MHzHF RFID systems operate at 13.56 MHz, they have read ranges between 10 cm and 1 m. They have moderate sensitivity to interference. HF RFID is used for data transfer, payment and ticketing applications.HF RFID standards such as the ISO 15693 standard for tracking items, and the ECMA-340 and ISO/IEC 18092 standards for Near Field Communication (NFC), is a technology have short range. MIFARE technology HF standards include the ISO/IEC 14443 A and ISO/IEC 14443, which used in proximity cards and smart cards and the JIS X 6319-4 for FeliCa, is used in electronic memory cards which are supposedly to be used as smart cards

D. UHF RFID:

The UHF band is 60 times more efficient for RFID operations than the HF band.It has range from 300 MHz to 3 GHz. 860 to 960 MHz band is used in systems which are having UHF Gen2 standards. It has region to region variance in frequency. 900 and 915 MHz are used in most of the countries to operate on UHF RFID systems.It has 12 m Passive read range, and UHF RFID has a faster data transfer rate than HF or LF. Tags and readers are developed by many manufactures using many different innovative ways to match with the performance in certainty of environments, but UHF manufactures make tags that are less sensitive to interference.Pharmaceutical, inventory management, ant counterfeiting to wireless device configuration UHF RFID is used.

UHF	HF and LF
Single Worldwide Gen2 standard	Multiple competing standards
20x the range and speed of HF	HF based NFC for secure payment
The technology for item tagging	Used in immobilizers, ticketing payment.

Table 1: Difference between frequency families

E. Active RFID Systems:

Active RFID systems have their own power source and own transmitter on their transponders, they mostly use batteries to get the power supply. Active contain their information stored on microchips and they are able to broadcast this signal on their own.Active RFID operates on UHF having range of 100 m. Objects which require long distance tracking such as reusable containers and rail cars as well as large assets make use of Active tags.There are two types of active tags: transponders and beacons.Transponders initiate their working as soon as they receive radio signal from the reader and they respond by transmitting a signal back to the transponder. They power on when they receive the signal till then they are on sleep state to reduce the usage of batteries.Transponders conserve battery life as they will never activelyradiate radio signals unless they receive any of the reader signal from one of the objects. To track locations precisely and continuously real time locating systems are used which are integrated into Beacons.Beacons emit signals on pre-set intervals which is not present in transponders, beacons are not powered by reader signal.Beacons emit signals in every one second depending upon the accuracy required.Reader antennas catch the beacons signal and these antennas are placed in a perimeter of a particular area where the signals are tracked and then send and receive the transponders position and information such as id etc.

F. Passive RFID Systems:

Transponders receive radio signals from the reader and the reader antenna in Passive RFID systems. The energy is reflected back to the reader by through the transmitted signal as the RIFD is powered on when it receives the signal.They operate on all three Frequency bands such as LF, HF and UHF. The radio signal is reflected back to the reader is

known as backscatter and this occurs only in devices having range of less than 10 m.Depending on the requirements there are many ways to package the Passive tags based in RFID application.They can be sandwiched or they can be mounted on substrate to create a smart RFID label.To make the tag resistant to harsh chemicals and extreme temperatures passive tags are embedded in packages or devices having a huge variety.They are used to monitor asset movement by setting them in warehouses and distribution centers.

G. Battery Assisted Passive Systems (BAP):

Active tag feature can be incorporated using battery assisted passive RFID which is a passive RFID. RFID transponders use energy from RFID readers signal and fetch the power to initiate the tag chip and backscatter to the reader, an integrated power source is used in BAP tags to power on chips. They don't have their own transmitters unlike transponders.

H. RFID G2:

They consist of a short read range, lager tag populations, fast inventory, files and file management, file privileges, cryptographic security, loss prevention, item authentication, long range read, consumer privacy.

IV. Results and Discussion

A. Proposed System:

We can build an automated system using RFID and various materials which is custom designed after purchased. Proposed system includes tag reader, a E-Z pass tag, traffic monitoring camera and other related hardware which is remote and is fitted into vehicle as well as on road. As shown in the figure all hardware parts will be installed in such a way where they all can function properly without interference.

Fig. 1: Demo of WSN Based RFID System

The car passing on the roads will contain a Pass tag which is known as pass transponder, which will be active inside the car. Pass transponder will be active but it will be in steady state while not in contact with any reader. As soon as the car passes the toll tax booth, tag pass will initiate its working when it comes in contact with tag reader. The tag reader will read the unique id of the car. Tag reader is connected with a traffic monitoring camera for physical surveillance of the vehicle. The tag reader and the Pass tag contact and communicate with each other using HF RFID wireless sensors. Marriage of these two technologies gives us the perfect solution to communicate with database. A global database is maintained in which all the information of the car owner, bank account details, car type, car history, car owners address; car owners contact information will be maintained. Our aim is to collect toll tax fees without being stopped to pay it. The database serves this purpose and when the car is detected via the tag reader, all the details will be checked and the toll amount will be deducted from the bank automatically. A ticket will be sent via a message to the owner of the car about the money deducted from his bank account for what purpose the ticket will contain a unique id associated with the tag id on which it is scanned. Here our purpose of taking the toll without the car being stopped is solved.

B. Security:

Here the major problem is the security of the owner's bank details. Security is maintained through the user itself by providing a web portal which will give direct access to the user to make any changes to the bank details which will be confirmed via the bank within a short period of time and if confirmed ok then they will be updated to the database. This is the security for bank. If the car owner does not have any money in his bank then the user will be allowed to drive the car in the highway or on any road where the toll tax is to be paid and user will get the messages for tickets. The user will get a short notice of 3 days to pay the money via an online portal. If this is not done a penalty will be charged and police verification and further legal procedures will be carried according to rule and regulations of the country.

C. Communication between the Hardware:

The RFID tag will transmit the data to the RFID reader and the reader will intern communicate with computer host. RFID tag will contain the owners required information. This will be transmitted to RFID reader via HF wireless network in specified frequency band. Cognitive network such as cognitive radio will be used in communication of all the devices to reduce the congestion in between multiple cars. This will increase the cost but reduce the overhead of genuine maintenance and service. This radio is most probably in RFID reader to catch the frequencies. The best function of the cognitive radio is to take the unused frequency bands and make the device use them. This will make use of the wireless hardware up to fullest. Following image is the hardware setup.

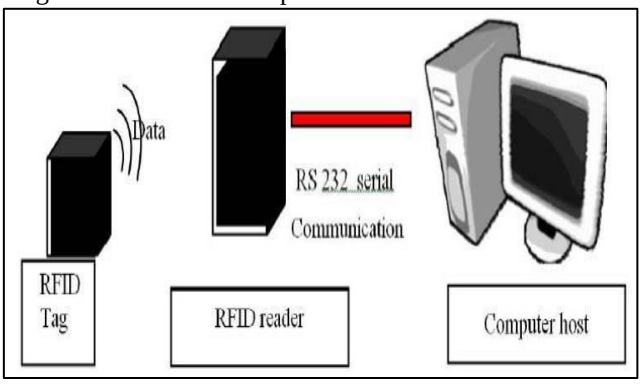

Fig. 2: Communication between the Hardware Devices

The RFID reader will communicate with the local computer host via RS 232 serial cable and transmit data to be stored. The data associated with the camera will be stored in same file for making it easy to hit and retrieve by the global database. This hardware setup requires an average amount of accuracy as in wireless sensor networks the

hardware devices need to place in certain direction and at a frequent range. High quality supporting devices are used throughout independent of the tag fitted in the vehicle.

D. Proposed System Can Be Used In Many Applications With Multiple Purposes And Goals:

Proposed system contains automatic money deduction, camera surveillance, speed detection and all three connected to one another giving us the combination to acquire knowledge of car, its owner and any illegal procedure detection. We can use the system at multiple places such as custom duty on highways, custom duty for yellow platted tourist vehicles in India. Speed detection in police agencies to get direct data without chasing the car. Spot location of car from anywhere. Keeping track of vehicle from where it passes at what time and date for security reasons.

V. CONCLUSION

Thus, from the overview of the study, we can implement a better solution in the field of automation in WSN and find an innovative solution which has multiple purposes serving multiple goals in setting up the world more atomized and easy for living.

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