A Novel Approach to RFID based Automated Parking Charges Collection System

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ABSTRACT
This paper presents a study of current applications of Radio Frequency Identification (RFID) for on-road vehicles. RFID has shown a remarkable performance in the state of art Industrial applications. In recent times, RFID can be considered to be one of the most promising and vital wireless communication technologies. A large gamut of applications employing RFID in moving vehicles is in the nascent stage in different parts of the world. These are location and position of four-wheelers/two-wheelers, Automation of Toll Challan System, Traffic violations, congestion on roads, theft of vehicles, parking allotment etc. An automated e-payment system for parking lots is one of the vital utility that has been presented here and this further resolves in reducing the processing time for the collection of parking payment/charges.

General Terms
Radio Frequency Identification (RFID), Vehicle Monitoring and tracking, Traffic Violations.

Keywords
RFID Tags, RFID Reader, RFID Applications, Automated Parking system, Intelligent Parking Charges Collection System, RFID based vehicle monitoring, Internet of Things, Smart Parking System.

1. INTRODUCTION
The Indian Road rules, also known as the, 'Rules of the Road Regulation', came into effect in July 1989 and has remained so, to date [16]. These rules and guidelines list the violations and offences under various categories, along with their sections under the Indian Motor Vehicle Act and corresponding penalties. These rules are relevant to the Indian drivers, while on the road, to make sure of a systematic traffic and a safe drive. Violating, transgressing or disrespecting any of these rules is a serious offence according to the city specific traffic police rules as well as the Indian Motor Vehicle Act.

These traffic laws – (decrees, rules, code of practice and acts), if implemented effectively, can bring own the escalating road accidents considerably. According to the regulations, the lawbreakers are dealt by issuing challans in their names, which might motivate them to internalize the law. Penalty payment and legal hassles were thought to be effective punishments, which in most cases they are, but have proven ineffective due to negligence or lack of resources. Taking into account the number of increasing road accidents every year, necessary steps must be taken. And it all begins with us abiding by the traffic rules and dealing with the lawbreakers strictly.

In recent times, the usage of Radio Frequency Identification (RFID) has become extremely popular for vehicle monitoring on roads in urban areas due to its easy availability and low cost. The RFID tags are usually placed inside the vehicle and RFID readers are placed on roads. The data relating to traffic can be fetched with the help of RFID tags. This data can be used to curb the perpetrators of law. The process that is presented in this paper can be used in context of a city that contrives to install RFID based traffic and vehicular monitoring system. RFID is a contactless and wireless technology that enables the remote identification of objects automatically via radio waves [14]. Fig. 1 shows some of the basic components of an RFID system.

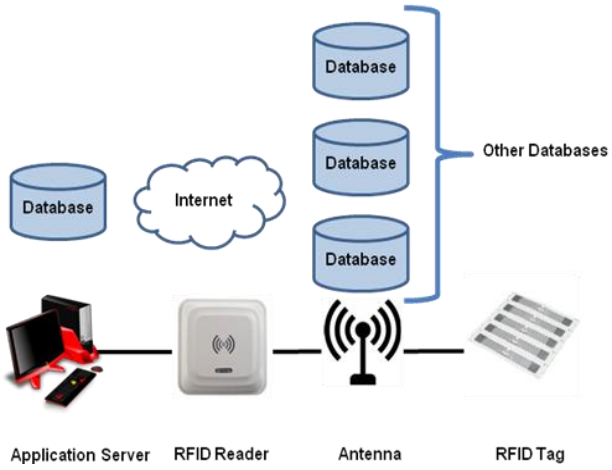

Fig. 1: RFID Components

These components are RFID reader that can also be called interrogator, an antenna, a tag or transponder, and an application server that stores the database which can be connected to a larger network.

2. RFID COMPONENTS AND ITS FUNCTIONS

The RFID technology was first used in World War-II, by the British, to find whether a plane belongs to an enemy or not. It was worked upon continuously. During 2004, RFID tags gathered popularity in commercial markets and were used on items and goods to store pricing or any other inventory related data [6]. This segment explains the key components of an RFID system along with their basic functionalities. The current RFID system comprises of mainly four components: tag, reader, central database and an antenna.

In every RFID system, the tags within antennas' range are detected and thereon different operations onto each tag can be performed. The effectiveness of an RFID system depends on how effectively all RFID constituents connect together logically and whether they are compatible with each other or not. That's why an in-depth discussion of these separate components is necessary.

2.1 RFID Tags:

One of the crucial parts is the RFID tag, which is otherwise called transponder. It can be embedded in a key, card or any electronic device. It is partitioned into two parts: chip and antenna. A chip contains the memory, used to store the desired information. The antenna transmits the tag's data to the reader. For identification purposes, each tag has a unique ID. Depending upon the environmental conditions and usage, an RFID tag can have different physical features and capabilities, such as it can be embedded in paper, clothes, pallets etc. It can have anti-collision property, which makes it easier to distinguish between different tags, or tags that have encrypted data handling property. Based on power source, there are active tags, having their own battery, and passive tags, which derive their power from the RFID reader, by the use of power sharing methods. The third kind is semi-passive, having a battery to support data storage and power the tag circuit. Tags can also have different data writing capabilities such as Read Only, Read Write, which enables the used to modify the data frequently and Write Once Read Many. Any tag has one of the communication methods: one way (half duplex) or two ways (full duplex).

2.2 RFID Readers

Another important element of RFID systems is an RFID Reader and it is used to read an RFID tag. The reader contains an antenna that emits radio waves and the tag responds by sending back its data. The reader is responsible for communication with the tags, processing the received data, establishing a connection with the server etc. It also provides an effective communication path between the tags and the monitoring systems.

There are several factors that might influence the distance, at which a tag can be read. Some are: the frequency used for identification, antenna gain, orientation and polarization of the reader antenna as well as the transponder antenna, the placement of the tag on the object to be identified etc. These may have an impact on the RFID system's read range [24].

2.3 Central Database

The Central database runs database software, which operates for object-matching, tracking as well as storing. Most of the RFID readers have a networking component, which connects any RFID- read event with the central server. This data is stored in the database that can be used for monitoring purposes in future.

3. MAJOR RFID APPLICATIONS FOR ON-ROAD VEHICLES

This section exhibits some trending RFID applications for two-wheelers/four-wheelers vehicles.

3.1 Red Light Violation

The existing Traffic Control and monitoring system has several drawbacks. One of the shortcomings in today's scenario is the exponentially increasing number of vehicles on road. Jumping red light is a serious offence, which often results into severe injuries or even deaths. The traffic violation cases are manually booked, which is time-consuming. Secondly, there is no way of managing the records of previously occurred violations. Also, the method is not transparent and further facilitates corruption. Even the use of cameras to catch the perpetrators, has several limitations such as the blurry image because of the camera's motion; poor image resolution because the number plate may be at large distance or there may be lack of light etc. In order to overcome this vital problem, use of RFID technology is recommended. RFID tags are seen as replacement for barcodes. Barcodes can be read by a barcode reader only when in line of sight of the reader whereas RFID reader uses radio waves to read tags and hence does not require being in line of sight. RFID tags are to be applied to every vehicle and RFID readers are to be placed in position every traffic signals.

Singh Carpal et al. [8], proposes that each road would have its unique RFID reader, which will keep the track of the vehicles passing through it. A separate database will be maintained for each intersection point that will record the data regarding the vehicles that passed it, along with time-stamp value and traffic signal number. Each vehicle would be furnished with an RFID tag that memorizes its unique identity number called vehicle identification number (VIN) which incorporates the data regarding the priority, type etc of the vehicle. It also helps to uniquely identify the vehicle & its owner. Every road has two lanes, each having its own RFID reader that tracks every vehicle passing through the red light storing the time stamp. Bases on this hived time stamp, the violators can be easily caught. To achieve this, the continuance of the green light is stored. The vehicles approaching on the tallying light are permitted to actuate in any direction. Throughout the process, for each red light, the time reader stores the information about the vehicles moving through the lane. To discover the lawbreaker, the reader's data corresponding to the red light lane is compared with the data recorded by the reader corresponding to green light. In case any discrepancy is found i.e. if any vehicle is found missing in the reader's data corresponding to green light and the same vehicle was present in the record of the reader corresponding to Red light, then the law-breaker can be easily identified.

3.2 Congestions on roads

The ever-increasing numbers of vehicles on roads have brought congestion and immense traffic jams, resulting in the huge journey time for commuters and reduced speeds. If it goes on for long, then there are surely choked roads, delicate environmental conditions, leading to health problems and in a long run these cities will not be suitable for human livelihood.

To this purpose, numerous researches have been using probe vehicle methodology to accumulate real time traffic data in order to ascertain the quality of traffic. Generally, the probe vehicle methodologies are utilized for determining the link travel time [7] whereby they make use of Global Positioning System (GPS) technology. The significant drawback of GPS

technology is that the receiver accuracy of a typical GPS is approximately 10 meters, which makes it hard to tell exact location of crossing for the aim of congestion measurement. Secondly, it is observed that GPS keeps sending erroneous velocity data even when the vehicle is stationary.

With the use of RFIDs, it is possible to dissolve the above stated problem and detect as well as manage congestion more precisely. In paper [7], the system uses roadside active wireless devices to gather signals from active RFID tags connected to the probe vehicles. The objective is to design a system that would follow the travelling time of probe vehicle as it go across the roadside devices, providing with the average trip time.

In another study [15], the author proposes a scheme that checks the average speed of vehicles as they approach the junction. If the average speed of vehicles is below stated threshold at any peculiar stretch, the system observes that as congestion and measures the volume of congestion equating the detected data with the normal traffic speed data already registered for that stretch. In this scenario, a message is aired to the junction behind the current junction in that stretch, expecting them to block all inflow of vehicles in that stretch. As the system bids the real-time congestion detection, thus, as the congestion is freed, another message is automatically aired to the previous junction, advising to resume flow of vehicles. This automation prevents the system from any manual intervention.

The speed detection is done by reading the RFID tag, as soon as a vehicle crosses the router. The active RFID tag of that vehicle airs a beacon to the closest router, which in turn, sends on it to the coordinator. When the coordinator gets the router's message, it instantly preserves the message and look for another message from the same tag when it crosses the coordinator. As soon as the same tag trespass that coordinator it beams another beacon to the coordinator. On receiving the beacon, using the recorded timestamp, speed of the vehicle is computed by the coordinator and is posted to the control station via Global System for Mobile (GSM) network.

3.3 Theft of vehicles

M. A. Meor Said et al. [5] presented the function of Wireless Security Car Using RFID System. It proposes to replace car keys with RFID cards. The car engine does not start unless the RFID reader reads the RFID passive tag embedded in the card. Thereafter, the control is shifted to PIC16F84A, which commands the car motor, car lock and alarm system.

Jayendra G. et al. [11] presented a novel radio frequency identification (RFID) based vehicle immobilizer system, which while preserving the safety of the riders, in case of hijacking, also featured a low hacking probability. The immobilizer system described in the paper employs the active RFID technology wherein the tag is generated with relatively large character sets. It basically consists of a transmitting unit, receiving unit, and intelligent vehicle interfacing unit. The receiving unit is smartly incorporated into the three control circuits i.e. ignition circuit, power control unit, and automatic gear changing system in the vehicle, so the vehicle can be brought down to zero speed in a safe manner. The data receiver is embedded in the intelligent vehicle control system; on the other hand the transmitter unit is kept with the owner of the vehicle. These results in an active communication path between the owner/ driver and the vehicle, condition being, the two have to be within the operating range of 200m. In comparison to the other security systems, which are embedded within the vehicle key, this system has a relatively high probability of misguiding the hijackers, while also giving the power to the vehicle owner to immobilize the vehicle from a safer distance.

Rakhi Kalantri et al. [3] propose that the stolen vehicle can be identified on various automated toll collection booths. The central database has the registration data for the reportedly stolen vehicles. Each time a vehicle passes a toll booth, with same ID as already present in stolen vehicle category will be easily identified.

3.4 Automated Toll Collections

Each one of us who have paid toll taxes, are aware of the long waits and slow processing speed of the manual system. Rakhi Kalantri et al, Pranoti Salunke et al [3, 4] propose an automated toll collection system where it makes the use of prepaid RFID tags. Whenever a registered vehicle comes near to the toll booth, initially the infrared sensors will discover the presence of the vehicle that activates the RFID circuit which in response will read the RFID smart card present on the vehicle. This starts the transaction, reckoning upon the balance available, charges/toll will be deduced directly or the vehicle will be channelized towards another lane where the charges/toll is required to be paid manually. The system later modifies the details in the centralized database server and also inducts mechanism to yield the bill which is communicated to user via text message.

3.5 Parking Space allotment

Thanh Nam Pham et al. [10] brought in a new Smart Parking System (SPS) architecture based on Internet of Things (IoT) and framed a mathematical model of the system operation. Foremost, the proposed algorithm adopts a technique to search car parks at the least monetary value. If the current car park is full, they adopt the technique to move the vehicles to some other car park. They intended a network of car parks in which every car park is a node in a network. Each node incurs the information from the adjacent node, hence insuring fluid drift of vehicles at minimum cost and enhancing the probability of discovering a free parking space. The system attains better performance compared to other parking systems. The proposed system shrinks the count of vehicles facing difficulty finding parking space along with depreciating the costs of moving to the car park.

4. MOTIVATION

Currently, the parking charges collection system is manually handled, for which there little or no is training, hence it is very much prone to human errors. The process is time consuming and results in long waiting hours, especially at peak time/days (weekends and festivals). The current system also has several drawbacks considering environmental issues. During long waiting queues, normally the engine is on, which leads to wastage of fuel as well as unnecessary pollution. The system also requires paper billing and cash payments, which deems manual presence compulsory.

Due to lack of a centralised monitoring system, there can be security issues and breach of norms. A person may be lenient and may allow free parking to his/her near and dear ones. The officials do not have any record to track vehicles parked on a certain date for further analysis or enquiry. In case, an owner reports theft of a vehicle and claims its presence in the parking lot, there is no way to confirm the data. As happened recently in India, due to sudden demonetization, people were facing cash crunch. It was difficult to find hard cash for essential payments let alone parking charges. As reported, in some cases, the authorities were forced to waive-off the charges for

certain duration, due to which they had to endure great monetary loss.

After studying this scenario, there was an urgent need of an automated system, which is proposed in further sections.

5. PROPOSED METHODLOGY OF INTELLIGENT RFID BASED PAYMENT SYSTEM FOR PARKING

As the number of vehicles on road, are increasing exponentially day by day, therefore, monitoring of this immense volume is becoming a challenging task for the places that have to deal with vigorous movements of these vehicles. There are legion of applications that can make use of RFID to automate the system, out of which some are described in previous section.

Currently, parking has become major problem in the urban areas. RFID has been used to solve many of the problems, one of which is finding the parking space in optimal way. Other problem that is generally faced before finding the vacant slot is to pay for the parking. After demonetization, the frequent problem encountered by common people was the unavailability or scarcity of hard cash.

The main objective of carrying out RFID based parking charges collection system is to automate the procedure, thereby, cutting down the lengthy queues at the exit booth. This paper is hereby proposing a solution that will automate the parking system completely.

On purchase of the vehicle, the owner initially is required to get the vehicle registered at the Regional Transport Authority (RTO) agency. The functionaries there will allot an RFID enabled card/tag along with the number plate to the user. This RFID card will be mapped with the registered vehicle only and will have a unique identification number. Along with the number plate allotment and RFID card mapping, the officer will also create an account that will maintain the database maintaining the transactions done through that card. The card issued will be pre-paid RFID card, to which user needs to deposit some minimum amount. The parking area will be equipped with the RFID readers.

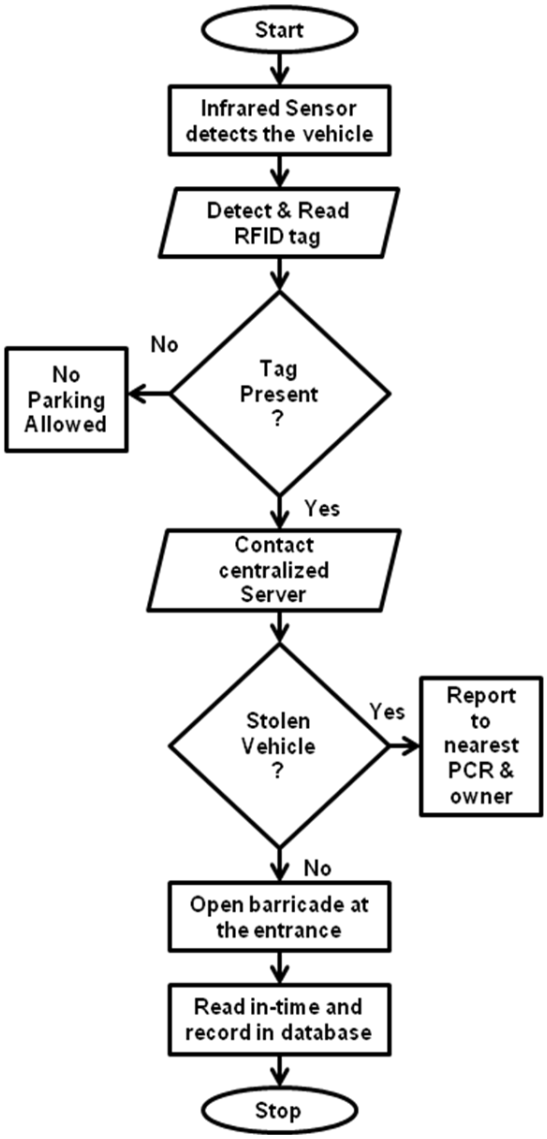

Fig. 2: Flowchart of RFID based parking system at the entry point

The working of system is done in two-phase, as explained below:

5.1 At the time of entry:

The first phase triggers on the first appearance of the vehicle. As shown in fig. 2, on the entrance of a registered vehicle, the infrared sensor detects the bearing of tags. If vehicle does not have the RFID tag, it is prohibited to enter. The RFID circuit remains passive when there is no vehicle detected. This reserves the battery of reader, therefore, increasing its durability and performance. The presence of the tag will trigger the RFID circuit which in turn will ask the system to read RFID tag available on the windscreen/front-view of the vehicle. The database that is already present in on the centralized server will be contacted to assert authenticity of the vehicle. If the vehicle is not stolen one, then it is permitted to enter the premises. The reader will make a note of vehicle's entry time and will save it in database. The algorithm is as follows:

Required Databases:
Parking Database:
V_TAG: RFID Unique Identification Number

LPN: License Plate Number

OWNER: Name of the Owner

t_{IN}: In-time

t_{OUT}: Out-time

Balance: Pre-paid balance amount (Initial Balance Rs. 500/-)

pAmount: Computed Charges

Date: Date of Parking

Stolen_Vehicles Database:

Stolen_LPN: License Plate Number of the stolen vehicle

Stolen_V_TAG: RFID Unique Identification Number of the stolen vehicle

Owner: Name of the Owner

Date_FIR: Date when FIR was filed

FIR_No: Unique FIR number

Police_Station: Police Station where FIR was registered

Contact_No: Contact number of the owner

At Entry Point:

1. Set INFRA_SENSOR=TRUE

2. Set F_STOLEN=FALSE

3. As vehicle approaches, Read V_TAG

4. If V_TAG != NULL

Read LPN

For (All stolen_LPN from Stolen_Vehicles Database)

If (LPN==stolen_LPN or V_TAG==stolen_V_TAG)

Set F_STOLEN=TRUE

Contact Owner and nearest PCR

Entry Denied

Else

Read LPN, Name of the Owner, Balance and enter the data in the Parking Database along with the in-time t_{IN}.

Else Entry Denied

In case, the vehicle is involved in some illegal activity, this recorded data can be used by authorised users in future to track the vehicle's activities.

5.2 At the time of exit:

The second phase starts, when the vehicle is ready to leave the parking lot. As fig. 3 shows, there will be another RFID reader installed at the exit gate which will be activated when vehicle will approaches the terminal.

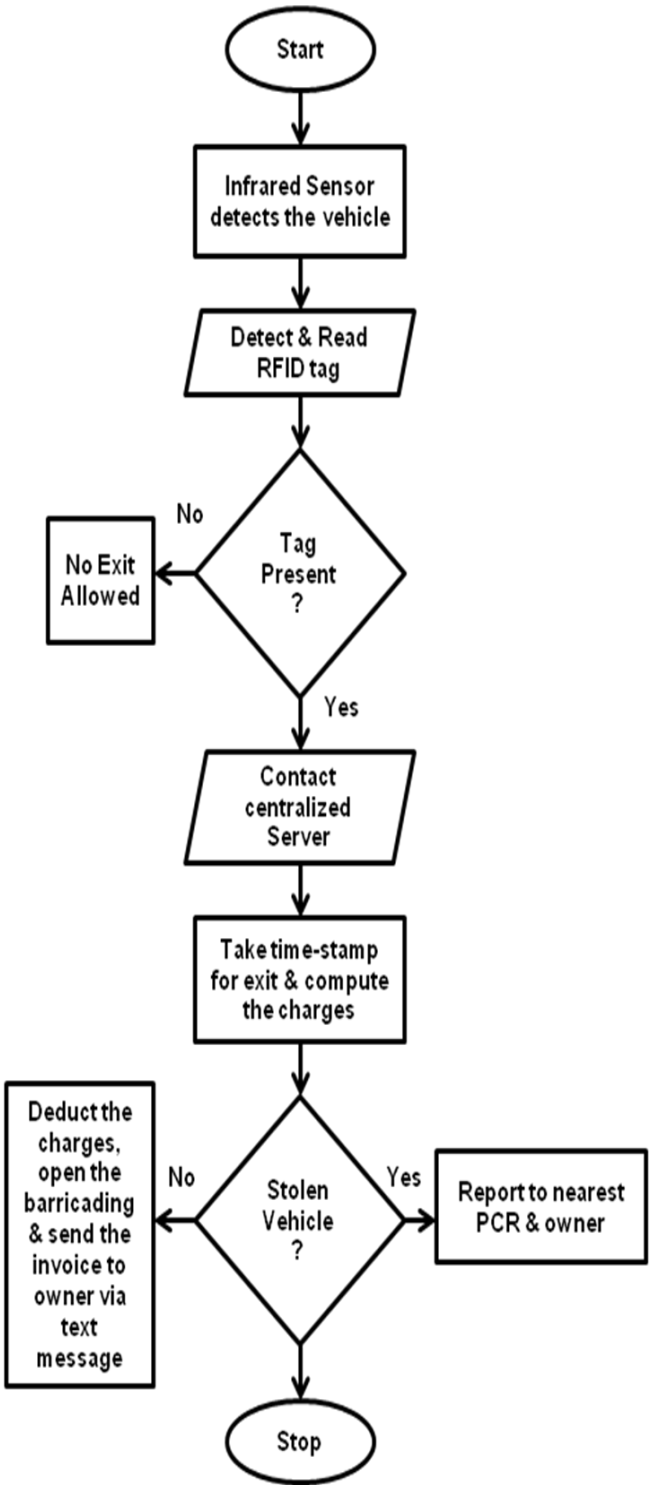

Fig. 3: Flowchart of RFID based parking system at exit point

The tag will be read, the server will be contacted to find out the in-time of vehicle. Based on the number of hours, the parking charges will be calculated and depending on the balance available in the card, the vehicle will be directed to appropriate lane. If the card has sufficient balance that the parking charges can be deducted from the account of the user, else, the vehicle will be directed to another lane where the driver of the vehicle will have to pay in hard cash. This lane can also be used by the users in case someone has tempered the tag or there is some technical problem with the RFID

reader. The designed scheme will then update the record in centralized database at the server. The user will also get invoice via a text message. The algorithm is as follows:

At Exit Point:

1. Set INFRA_SENSOR=TRUE

2. If V_TAG!=NULL

Read the out-time t_{out}.

Compute the time $t_{CHARGES} = t_{OUT} - t_{IN}$ and

corresponding charges pAmount (according to

Rules or pAmount = $t_{CHARGES}$* hourly_Charges)

If pAmount>Balance

Then Direct Towards Manual System

Else

Balance = Balance – pAmount

Send the invoice via SMS.

Else Exit Denied and Investigate further.

Table 1. Comparison between Manual System and RFID-based Automated System

Criteria	Manual System	RFID-based Automated System
Efficiency	Prone to Human Errors	Automated system, hence, more Efficient
Speed	Time consuming process	Fast Processing
Resources	• Fuel Consumption is more due to waiting in long queues • Paper bill is generated. • Manual Intervention required	No wastage of Fuel or Paper. Manual Input is required in few cases.
User Friendly	Long waits and requires cash payments	Quick and easy processing, with automated invoice through SMS
Security	No monitoring of Vehicles	The Officials can keep track of vehicles being parked, on a daily basis.
Analysis	Difficult to analyze Parking data	Ease of Analysis, can detect peak hours and days
Demonetization	Does not support Demonetization	Cashless transactions mostly, Supports Demonetization

6. LIMITATIONS OF RFID

Popularity of RFID for various applications is growing each day. It is replacing the use of barcodes in stores, Employee IDs, tracking of animals, car keys etc. But according to some researchers, RFID poses some potential security threats for example RFIDs are being used to store critical data, which can be hacked easily and misused. Even though RFID fleck have limited storage capacity, they can direct malicious data to unbarred back-end databases and other systems that are fragile to usual attacks like denial- of-service (DoS), viruses, buffer overflows, etc. Also, hackers can easily create and embed viruses in RFID tags. Such a tag when encountered with the reader could transmit the crucial data to the application that uses it. This could lead to the exploitation of the vulnerabilities of the application, causing a buffer overflow or any other problem that could affect the back-end system [17]. Hackers with the proper equipment could record data from an RFID chip. The imposed system could also be problematic as numerous new vehicles may not ignite without RFID tags, which might not be a good idea. Tags can be locked by some users who intentionally want to mess with the system as some RFID tags have writable memory. But, wads of users might not do so as they either might not know how to lock the memory or do not want to outlay the time unnecessarily.

The novel RFID applications involve highly crucial data therefore, need to be protected smartly. These applications will necessitate measures such as secure and firmer encryption algorithms or passwords. However, in near future, profound software-development proficiencies can aid in building much secure and reliable RFID.

7. CONCLUSION

In this paper, a novel approach of automated parking charges collection system in parking lots based on RFID is put forward. The proposed methodology aims to be more user-friendly and secure. Since the system will automate the complete procedure, therefore, requiring less resources such as manual intervention, less usage of paper bills, cash money, lower fuel consumption (due to waiting in queues) etc. It has the characteristics of less time consumption and high efficiency. The data for vehicles entering the premises is being stored in the central database, which can be useful to keep track of the particular vehicle whenever required. The system also facilitates the capturing of stolen vehicle. It not only meliorates the technology level, but also ameliorates the transit power thus reducing the waiting time in queues to a large degree. This minimizes the manual labor and delays that often occur. The managers of the parking area can also keep track of happening in the parking lot as they can easily maintain and view logs.

If limitations of RFID tags like Global standards, security issues, installation etc are overcome in future, then this technology can transform the parking system. RFID tags can also be used to automate multiple daily activities.

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