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NFC BASED PARKING SYSTEM FOR SMART CITIES

Abraham Sudharson Ponraj[1] and Christy Jackson[2]
[1]SENSE, VIT University, Chennai, India
[2]SCSE, VIT University, Chennai, India
E-Mail: christyjackson.j@vit.ac.in

ABSTRACT

With the evolution of Internet of Things, the concept of smart cities has gained popularity in the recent times. IoT can help maximize the productivity and reliability of urban infrastructure by addressing problems such as traffic congestion, limited car parking facilities and road safety. In this paper, we present NFC based Smart Parking System that solves the current parking problems by offering guaranteed parking reservations with the lowest possible cost and searching time for drivers. The customer needs to install the ParkZapp application beforehand. By using the mobile app, the customer may reserve parking lot in advance. Instead of using the conventional ticket, ParkZapp uses the NFC function of smartphone or NFC tag as a parking ticket. The customer only needs to tap the NFC tag on the designated reader to enter the car park and tap again on the way out to complete payment.

Keywords: smart parking, internet of things, smart city, near field communication.

1. INTRODUCTION

Parking in major cities, particularly with dense traffic, directly affects the traffic flow and people's life. [1] This was the motivation behind this paper to contribute in the development of traffic management systems by providing an intelligent parking system to reduce the cost of hiring people and for optimal use of resources for car-park owners [2]. Largely, the most usual method to find a parking space is based on fortune and past experience and is done by the driver, who usually ends up finding a parking space in the street. This process might not work out on all occasions and the drive when in a high vehicle density area might end up in a worst case of not finding a space to park, eventually wasting time and effort.

Do we need a better Parking Management system? [3] A car is parked for 95% of its lifetime and only on the road for the other 5%. [4] If we take England in 2014 as an example, on average a car was driven for 361 hours a year according to the British National Travel Survey yielding about 8404 hours in which a car would be parked. [5] On average, 30% of traffic is caused by drivers wandering around for parking spaces. [6] In 2006, a study in France revealed estimation those 70 million hours were spent every year in France only in searching for parking which resulted in the loss of 700 million euros annually. [7] In 2011, a global parking survey by IBM states that 20 minutes is spent on average in searching for a coveted spot.[8] With these statistics, it can assumed that a great portion of global pollution and fuel waste is related to cruising for parking.

2. LITERATURE SURVEY

NFC is a method of wireless data transfer that detects and then enables technology in close proximity to communicate without the need for an internet connection. It's easy, fast and works automatically. NFC-enabled devices can act as electronic identity documents and key cards. NFC's short range and encryption support make it more suitable than less private RFID systems. However, in case of a QR code, the mobile device's camera can scan a code or QR can be displayed on phone and scanned by POS.

In order to get a perspective and ideas we explored several research papers which helped us get valuable inputs on the current parking systems and their suggested solutions. The first research paper, namely 'A Cloud-Based Smart- Parking System Based on Internet-of-Things Technologies' introduces a novel algorithm that increases the efficiency of the current cloud-based smart-parking system and develops a network architecture based on the Internet-of- Things technology. It proposed a system that helps users automatically find a free parking space at the least cost based on new performance metrics to calculate the user parking cost by considering the distance and the total number of free places in each car park. The simulation results in the paper show that the algorithm helps improve the probability of successful parking and minimizes the user waiting time.

The next research paper, 'iParker-A New Smart Car-Parking System Based on Dynamic Resource Allocation and Pricing' speaks about a new smart parking system that is based on intelligent resource allocation, reservation, and pricing. The proposed system solves the current parking problems by offering guaranteed parking reservations with the lowest possible cost and searching time for drivers and the highest revenue and resource utilization for parking managers. New fair pricing policies were also proposed that can be implemented in practice. The new system was based on mathematical modelling using mixed-integer linear programming (MILP) with the objective of minimizing the total monetary cost for the drivers and maximizing the utilization of parking resources.

Malicious and selfish nodes are the ones which construct the attacks. The attacks are usually caused in physical, data link, network, and application layer. Routing protocols commonly exhibited to two types of attacks active and passive attacks. Nodes that perform attacks with the intention to damage other nodes by stimulating a network breakdown are called as active

attacks. Nodes which perform attacks with the aim of saving battery performance and life for their own communications are called passive attacks. These nodes can easily put down network performance and eventually partition the network [12].

Another research paper that we explored, namely 'Smart Parking Applications Using RFID Technology' helped us realize the various advantages it could present over the current parking system. For instance, check-ins and check-outs were handled in a fast manner without having to stop the cars so that traffic jam problem would be avoided during these processes, drivers would not have to stop at the circulation points and parking tickets would be out of usage during check-ins and check-outs, ticket jamming problems for the ticket processing machines could be avoided, vehicle owners wouldn't have to make any payments at each check-out thus a faster traffic flow would be possible. Also, since there wouldn't be any waiting during check-ins and check-outs the formation of emission gas as a result of such waiting would be avoided. The research paper also included an atomized income tracking system, a car tracking system for charging and a central parking-car tracking system.

Finally, we explored 'iSCAPS - Innovative Smart Car Park System integrated with NFC technology and e-Valet function'. This paper highlighted the advantages and shortcomings of their app-iSCAPS. In the app, beforehand, the smart phone is installed with the android apps to fully enjoy the functions of iSCAPS. By using the mobile apps, customer may reserve parking lot in advance, to enable the customer to park at a later time. Instead of using the conventional "Season Pass" or ticket, iSCAPS uses the Near Field Communication (NFC) function of smart phone as parking ticket. With the mobile apps, communication will occur when the smart phone is placed near the NFC reader. Therefore, customer only needed to tap the smart phone on the designated reader to enter the car park and tap again on the way out to complete payment. Arduino microcontroller was used as the brain of the system and control the input/output of the system. Furthermore, vehicle searching function was included, which helps customers to locate their vehicle when forgotten.

Table-1 shows the dominance of NFC technology over the other WPAN technologies thus making it suitable for our application.

Table-1. Comparison of WPAN technologies.

Parameter	Bluetooth	Zigbee	NFC	RFID	IrDA
Coverage	10-100m	10-100m	4-10cm	0-3m	0-5m
Transmission Rate	0.8-2.1Mbps	0.02-0.2Mbps	0.02-4Mbps	0.02-4Mbps	0.11-4 Mbps
Power Usage	High	Medium	Low	Medium	Medium
Operational Frequency	2.4 GHz	2.4GHz	13.56 MHz	13.56MHz	300 Ghz
Security	Low	Low	High	Low	Low
Network Topology	Piconets, Scatternets	Star, Tree, Mesh	One to One	One to One	One to One
Usability	Moderate, Data Centric	Easy, Data Centric	Easy, Human Centric	Easy, Human centric	Moderate, device centric
Personalization	Medium	Low	High	Medium	Low
Setup and initialization Time	Approx. 6 sec	Approx. 0.5 sec	Less than 0.1 sec	Approx 0.2 sec	Approx 0.15 sec

Table-2 highlights the main advantages and disadvantage of NFC which at the moment limits the number of NFC-enabled mobile phones, while QR Code can be read with any camera-enabled mobile phone. Also, QR codes can be printed on an ordinary piece of paper using basic tools such as a printer and can be used accordingly. Whereas, NFC requires special devices to write on them.

Table-2. Comparison of NFC and QR Code.

Parameter	QR Code	NFC/RFID
Availability in mobile phones	High: Mobile Camera is sufficient, however plenty of apps are available	Low: Very few NFC-enabled devices
Expense	Low: Common paper can be used for printing tags	Medium/High: Dependent on the NFC/RFID tag or smartcard to be used
Usability	Low: Awareness of mobile camera is very high these days	Medium: Fundamental Steps for NFC is required
Security	Low: Code can be used by any camera enabled device	High: Devices must be close to each other to read
Damage resistance	Medium: Provides 30% reconstruction for distorted and damaged codes	Low: Tags become un readable if there is any physical damage
Visibility requirement	High: Environment should be well lit	None: Tags can be hidden

3. PROPOSED APPROACH

3.1 Approach to system operations for parking entry

Firstly, the user is required to book a slot at a parking lot convenient to him by logging in or by creating an account on the ParkZapp website or the android application. He is then requested to provide his/her NFCID which is a unique ID associated with each NFC enabled device. After providing said information the user needs to book a slot as per the availability of slots. Once this is done, the user's NFCID will have been added to the database and its authentication would be complete.

When the user enters the parking lot he/she is required to flash his NFC enabled device at the NFC reader. At this point the system checks if the NFCID exists in the database, if it does the gat opens and the time stamp is noted and the user can proceed further to his convenient parking space and the count of the available parking lots will be updated accordingly. If the NFCID doesn't already exist in the database, the user will not be allowed to enter the parking lot.

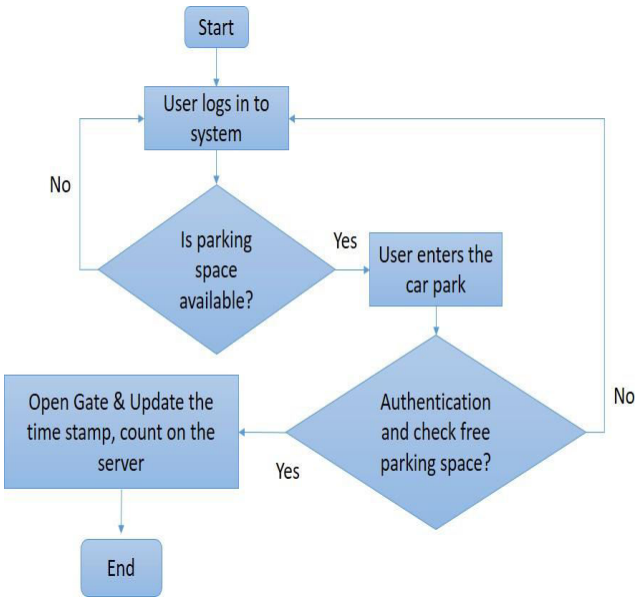

Figure-1. Algorithm for system operations - entry.

3.2 Approach to system operations for parking exit

Once the customer is done parking he/she will be prompted to proceed to the exit gate and the availability database will be updated accordingly. The user will have to flash his/her NFCID at the exit gate too. Upon this the NFCID will be again be checked in the database. If it already exists, the gate will open and the database entry of the NFCID will be deleted. This will ensure that the user books the slot again whenever needed. If the NFCID is not found in the database, the user will be blacklisted and suitable actions will be taken. [3] Timestamp will again be noted when the user flashes the NFCID again at the exit gate. The entry and the exit timestamp will be used to calculate the fare and the user will be prompted to pay the amount before the gates are opened.

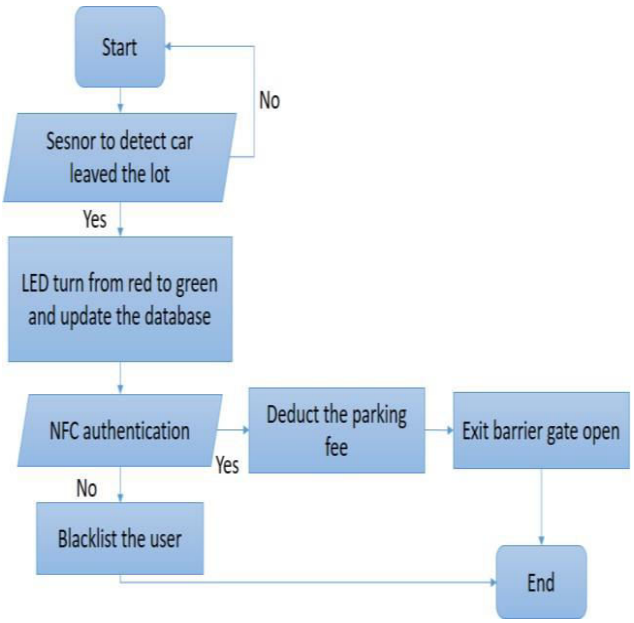

Figure-2. Algorithm for system operations - exit.

3.2 Parking slot booking

To avoid false and redundant booking each user will be given a fixed amount of time to reach his booked parking lot. After the user books, a parking slot he will be

given a fixed amount to reach the parking lot. Failing to do so would cancel the user's booking and the database would be updated accordingly.

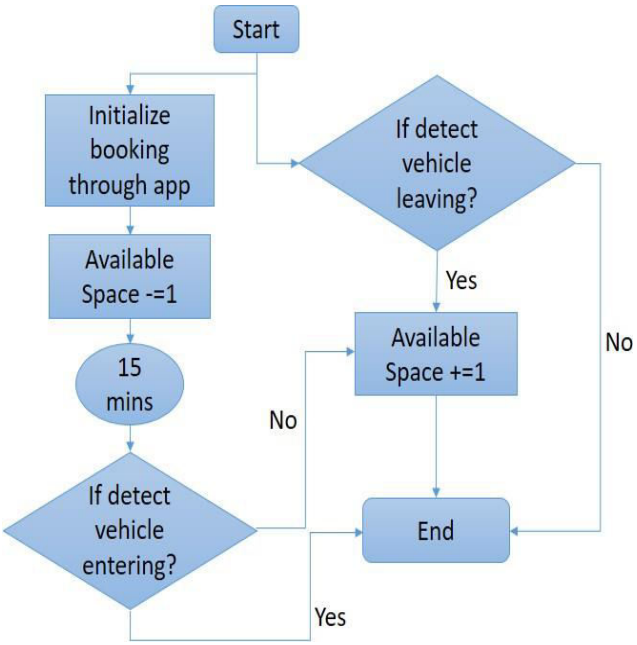

Figure-3. Algorithm for updating the status of the car park.

4. IMPLEMENTATION

4.1 Software system

We designed an application that runs on a smartphone based on the Android platform. Users who want to book the parking slot must be registered as a member of the system. Our cloud based server is hosted on Microsoft Azure where we have hosted a web app and a MySQL database. Figure-4(a) shows the login interface of the system. Figure-4(b) shows the booking page.

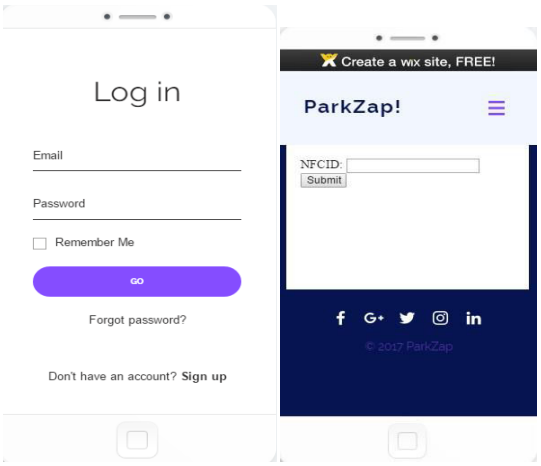

Figure-4. Implementation of software system: (a) login interface (b) booking page.

Hardware system

Figure-5 shows the demonstration module of the hardware system. The Hardware system contains the LED display along with the barricade gate which opens on being authenticated.

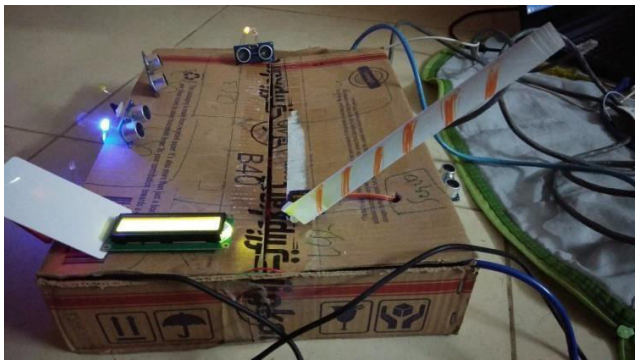

Figure-5. Implementation of hardware system.

The user signs in into the ParkZapp app and books a parking slot. He then reaches the parking slot within 15 minutes and enters the parking slot by flashing his NFC tag as shown in Figure-6. The user flashes his NFC tag at the parking entrance gate and tries to enter without booking the slot for himself on the ParkZapp application. In this case the user will be displayed a message called not registered as shown in Figure-7 and will not be allowed to enter the car park. Then comes the slot booking scenario where User signs in into the ParkZapp application and tries to book a slot that is available. If the slot is available, then the slot will be booked as shown in Figure-8(a). If the slot is not available, then the booking will not be allowed as shown in Figure-8(b). After booking the slot on the ParkZapp application, the user enters the parking slot within 15 minutes, his/her booking will be confirmed. The user will now be allowed to enter the parking slot upon flashing his/her NFC tag and his entry will be authorized. In another case if the user after booking the slot on the ParkZapp application, does not enter the parking slot within 15 minutes, his/her booking will be automatically cancelled. The user will now not be allowed to enter the parking slot and his entry will be unauthorized. When the vehicle exits the parking slot, the driver flashes his NFC tag at the gate. The fare is shown on the LCD screen as shown in Figure-9. The fare is calculated based on the amount of time the vehicle was at the parking slot. After successful payment, the gate is opened. The user will also be notified whether a slot is booked or not booked in the car parking slot.

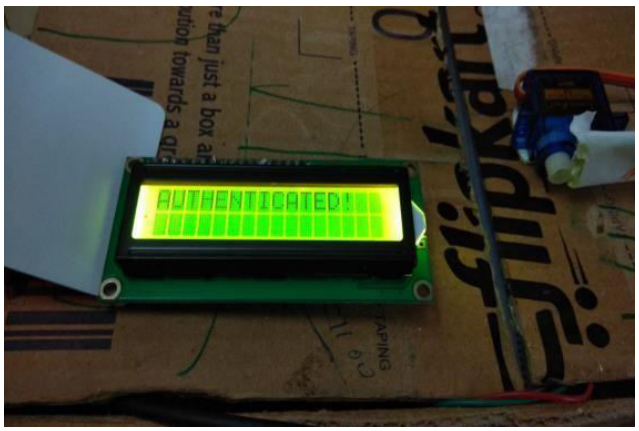

Figure-6. Authorized entry.

Figure-7. Unauthorized entry.

Figure-8. Booking a slot: (a) Successful booking (b) Unsuccessful booking.

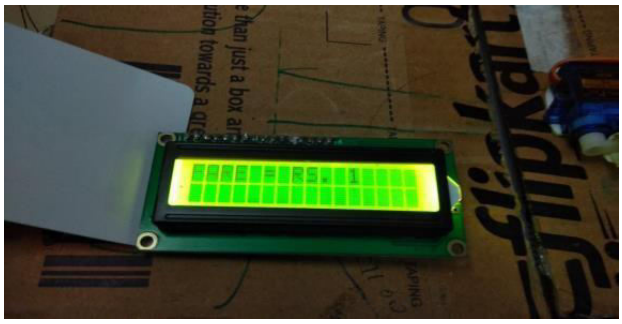

Figure-9. Fare display.

5. RESULTS AND DISCUSSIONS

The results from the implemented system are now represented and analysed. Initially the scanning time for QR codes is represented. The illumination settings are categorized in to three categories. High with 60 lx, Medium 30lx and Low 10lx. The time taken for scanning in a highly illuminated environment is less when compared to low lit environment as shown in the figure below.

In comparison with QR code scanning, NFC tags achieved a relatively lesser time. The following figure shows the scanning time of NFC tags with different materials. The average time taken for a test which had 25 scans for each material is given in the Figure. It is clear that NFC is more stable than QR codes.

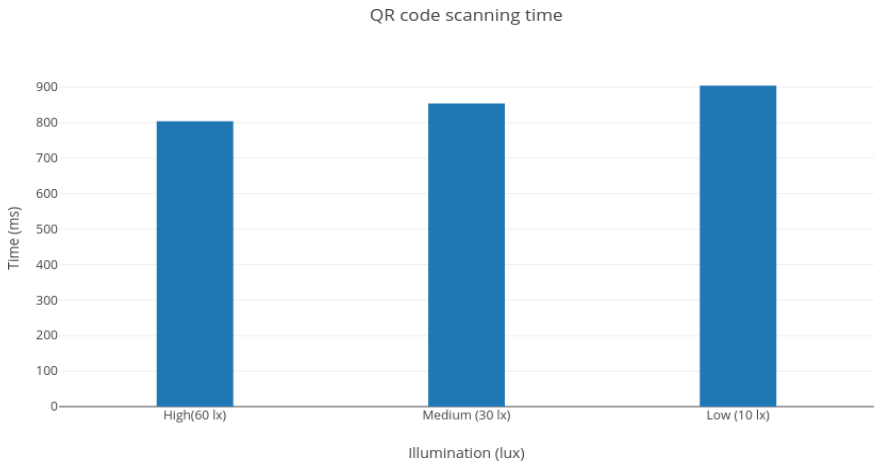

Figure-10. QR code scanning time.

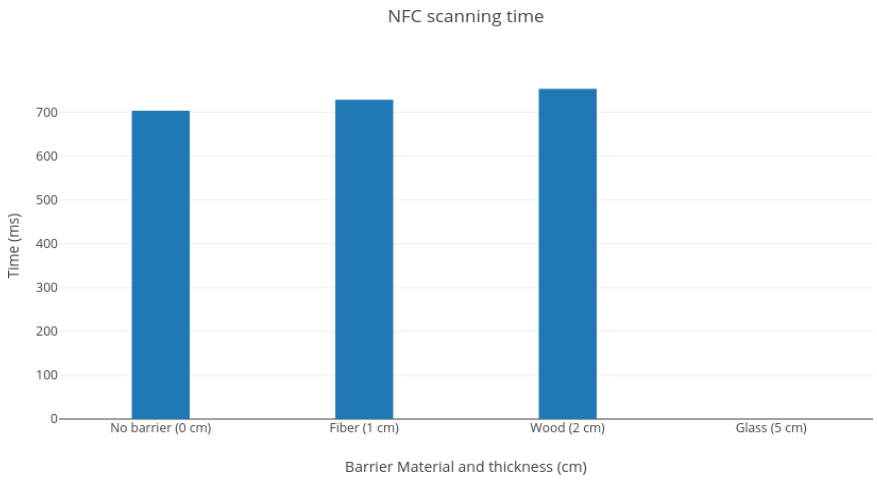

Figure-11. NFC tags scanning time.

6. CONCLUSIONS

As a conclusion, ParkZapp is an Innovative Car Parking System for Smart Cities with the latest Near Field Communication (NFC) technology. Through ParkZapp, we strive to bring about pivotal changes and improvements to the current parking system by introducing a ticketless, cashless and a completely automated parking system which requires minimum to nil manual labor. ParkZapp requires customers to book the parking slot at their convenience using the website or the android application and authenticating their NFC ID which plays and important role acting as the sole resource for identification of the vehicle and validation of ticket, the user's phone itself could solely act as the ticket. Further, the unique NFC ID along with a cloud based database, are used to avoid any unauthorized entry into the parking lot as well as to avoid duplication of data. This technology is meant to curb the problems underlying with the current parking systems and provide a much more efficient, modern and eco-friendly solution. ParkZapp strives not only to make the parking experience more convenient for the users but also to help increase the revenue of the cities/ parking lots by reducing the costs for labor.

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