A Proposed Model for Parking Guidance and Information (PGI) System using Near Field Communication (NFC) and Global Positioning System (GPS)

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Abstract— With increasing vehicular population, multi-level parking systems are emergent. However, it is arduous to find a parking slot in these complicated layouts. Driver's waste significant time locating empty slots and sometimes may not even find one. Also, sometimes drivers face difficulty in locating their parked cars. Most parking management systems do not reflect the real time status on a granular slot level. These systems make of use of parking tickets, which are volatile to handle.

The paper presents the design and implementation of a Parking Guidance and Information System which uses GPS based search on Android powered devices to locate available parking slots in a localized radius. By using NFC technology, we facilitate real time reflection of parking layout status and availability. Furthermore, the system can monitor on a user level and hence can automate the billing procedure.

Index Terms— NFC; GPS; Parking Guidance and Information System; Android

I. INTRODUCTION

The average number of vehicles plying in any city is in the order of millions. And this number is on an upward curve. Most of the existing parking infrastructure systems are not intelligent and efficient. On the other hand, the sophisticated parking systems are expensive and require complex installation procedures. Maintenance of these systems also requires significant resources in terms of manpower and cost.

Finding parking layouts with available slots cannot be pre-deterministic. A driver has to search around endlessly to find one. This becomes extremely tedious and hectic especially in commercial spaces. During busy hours, a driver may have wandered around for a significant with futile results. At times, a driver may unknowingly park his vehicle in a non-designated parking area leading to parking violations for which he/she may be fined.

In most developing countries, the parking infrastructure systems are non – intelligent and rely on human guidance. In such systems parking attendants, guide the vehicles towards the empty slots with limited guidance and most burden lies on the user to locate his free slot, thereby driving around the parking level to find a suitable slot to park his vehicle. The work levied on the parking attendants varies with the time of the day. During peak hours, the attendant may not be able to successfully cater to all the incoming vehicles. The inclusion of human element also brings in the corollary nuances. Unlike automated systems, human controlled ones fall short on continuous availability and reliability. Furthermore, there is always room for human errors which are inevitable. In some cases, the integrity of these attendants cannot be assured leading to the driver being fraudulently charged.

Alternatively, sophisticated parking systems require high capital for installation that may not be affordable by all organizations and establishments. Installation of these systems alone is a cumbersome process that requires certain levels of expertise. Replacement of system components or general maintenance is a costly affair.

Also, in both such systems when a driver returns to pick up the parked vehicle, he/she may have difficulty to identify and locate his/her parked slot after a period of lapsed time. The attendants or even the automated systems will be of no help in such times.

In our proposed parking guidance and information system, the driver will be able to locate parking layouts within a localized radius from his current location. On selecting a suitable parking layout, according to his convenience, he will be able to view the available slots across all parking levels. He may choose to park his car in any of the available slots. On parking, he can register the slot by just a tap of the phone to the NFC tag of the corresponding slot. Unregistering is also done in a similar fashion and the parking bill receipt is generated instantaneously. This eliminates the hassle of carrying around the parking ticket.

He can also locate his vehicle registered on his

android-powered phone.

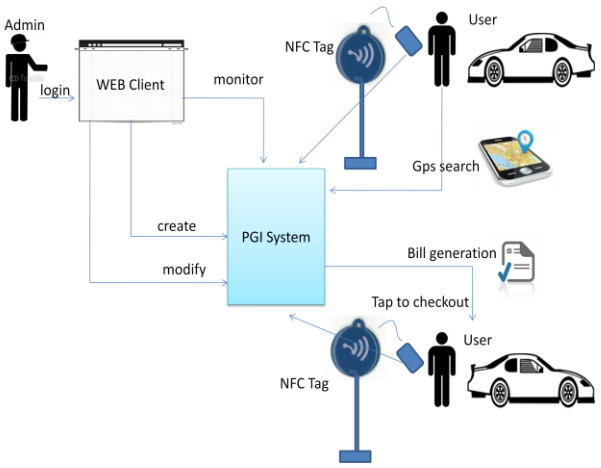


Figure 1: Overview of the PGI System

The deployment of this system is an easy task in existing parking layouts with no additional construction. All this system requires is that every parking slot is mapped to the centralized system with a powerless and relatively cheap NFC tag. The virtual mapping of these layouts is maintained in the centralized server system which also provides capabilities for real time monitoring.

II. NEAR FIELD COMMUNICATION

Near field communication is a set of standards established by the Near Field Communication Forum. Smartphone and similar devices can establish radio communication with each other by bring them together in close proximity. Communication is also possible between an NFC device and an unpowered NFC chip called tag. NFC standards cover communications protocols and data exchange formats and are based on existing radio-frequency standards including ISO/IEC 14443 and FeliCa.

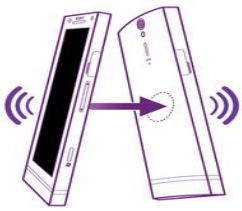


Figure 2: Communication between NFC devices

Figure 3: Communication between a NFC device and NFC tag

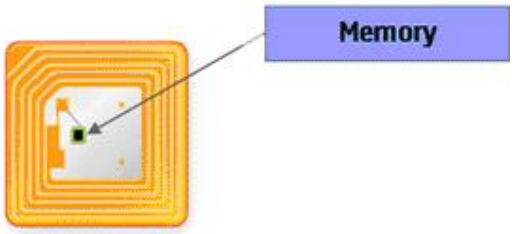
NFC is an open-platform technology, which is being standardized in the NFC Forum. It is based on and extends on RFID (Radio Frequency Identification). It operates on 13.56 MHz frequency. It communication range is up to 10 cm. It is however recommended that the devices are in touch with each other. NFC standard supports different data transmission rates such as 106kbps, 212 kbps, and 424 kbps.

The tag and the reader:

NFC-based communication between two devices is possible when one device acts as a reader/writer and the other as a tag. The tag is a thin simple device containing antenna and small amount of memory. It is a passive device, powered by magnetic field. Depending on the tag type the memory can be read only, re-writable, and writable once.

The reader is an active device, which generates radio signals to communicate with the tags. The reader powers the passive device in case of passive mode of communication.

Figure 4: Powerless NFC Chip



Communication Mode:

NFC devices support two communication modes.

Active Mode: In this mode, the target and the initiator devices have power supplies and can communicate with one another by alternate signal transmission.

Passive Mode: In this mode, the initiator device generates radio signals and the target device gets powered by this electromagnetic field. The target device responds to the initiator by modulating the existing electromagnetic field.

Operation modes:

NFC devices can operate in three different modes based on the ISO/IEC 18092, NFC IP-1 and ISO/IEC 14443 contactless smart card standards.

Read / Write Mode: In this mode, the NFC enabled phone can read or write data to any of the supported tag types in a standard NFC data format.

Peer to peer Mode: In this mode, two NFC-enabled devices can exchange data. For example, you can share Bluetooth or Wi-Fi link set up parameters to initiate a Bluetooth or Wi-Fi link. You can also exchange data such as virtual business cards or digital photos. Peer-to-Peer mode is standardized on the ISO/IEC 18092 standard.

Card emulation Mode: An NFC-enabled phone acts as reader when in contact with tags. In this mode, the phone can act as a tag or contactless card for existing readers.

NDEF: NFC Data Exchange Format

Most NFC tags are passive elements those store data for reader (for NFC enabled mobile phones) in NDEF (NFC Data Exchange Format) format. When we touch our phones with any NFC forum enabled tags, actually we read the NDEF message by our application. Those happen via NFC application to protocol stack then low level driver and finally the radio frequency (RF) parts to retrieve data from tags. The NFC Data Exchange Format (NDEF) specification defines a message encapsulation format to exchange information. An NDEF message is composed of one or more NDEF records. There can be multiple records in a NDEF message. Basically NDEF message is array of NDEF records.

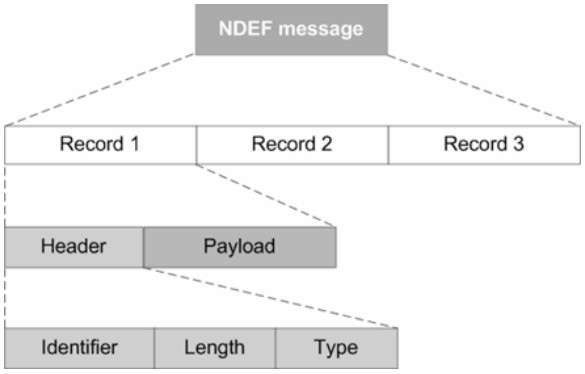


Figure 5: NDEF message

III. DESIGN AND IMPLEMENTATION

The proposed design for the parking guidance and information system consists of mainly three modules.

(1)Web server and database.

(2)Web client.

(3)Android client.

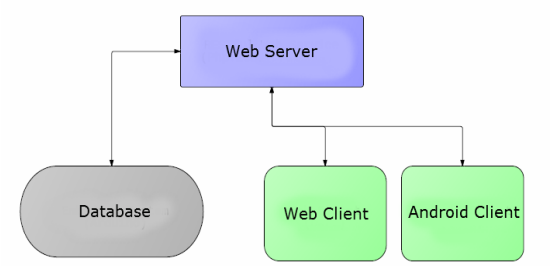


Figure 6: High Level Design

Module 1: Web server

The first module of the parking guidance and information system is the web server. This can be either a windows server or apache web server. The database of the various parking layouts and structures are maintained here. For simplicity in implementation for the Web client and Android to interact easily, we can preferably use REST based architecture for the web service. The advantages of this is that is easier to implement and scalability is a positive factor. Also, additional functionalities can be added without affecting the existing ones.

The database will contain all the information related to each parking layout and also its corresponding structures and levels. Using this central-server based architecture we achieve integrity of real time information and consistent data is reflected to all clients across platforms accessing them.

All the computation involved in the system is shifted on to the server because of its high computational capability and also with the motive of keeping the client systems very light and minimal in computational aspect. The server performs two very important computations. Firstly, on receiving the current GPS position from the android client, the server calculates the distance between the current GPS position and the GPS positions of all the layouts present in the database. Then it sends back the layout information of those layouts which are within a convenient distance or radius, as configured during deployment of the system. Secondly, it also is involved with the computation of the parking rate for each user who checks out or unregisters. This is done by calculating the difference between the check in time with the check out time and applying the suitable parking rate on this difference time to get the total parking rate. The rate per time is decided by the administrator at the time of creation of the layout.

Module 2: Web Client

A web based client is provided by the system for two purposes. The first one being that it provides an administrative portal for managements of organizations and institutions to create, modify and monitor their parking systems and layouts. The web based approach is easier to handle and operate. The second purpose of the web based client is to provide a portal for non-Android users to use the system. And driver with an internet enabled phone, which is not android powered can still make use of the system by visiting the web client over his phone to identify free slots near him as well as make registrations on parking. Thus, for he mentioned two purposes of the web client module, there are two types of accesses provided. The first one being the administrator access, which is the role of the parking layout manager enabling him/her to perform all administrative tasks such as create a new layout, modify an existing layout or even a specific layer of a layout, restrict a specific user from accessing the system etc. the second type of access is the user access or driver access. This is limited to viewing the layout in which the car was parked, unregistering from a parked slot etc. The approach suggested in implementing the web client could preferably be PHP as in can interact very well with the REST APIs of the server.

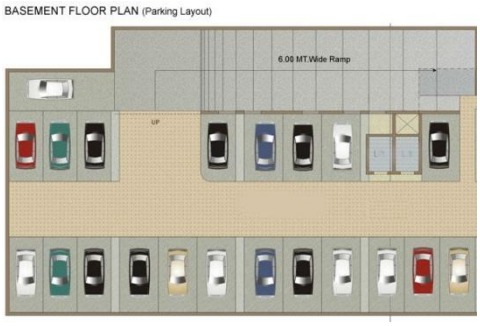


Figure 7: Virtual mapping of parking layouts.

Module 3: Android Client

The third module of this parking guidance and information system is the android client. This module is intended for the end level users or the drivers. The android client locates available parking slots in nearby parking layouts based on the current GPS position of the driver's device location. Based on a localized radius based search he can scan through a list of available parking slots in nearby parking layouts of establishments and organizations. Also, on locating and parking on an available slot, he can then register the slot using his NFC enabled phone by tapping it against the NFC tag provided to each parking slot.

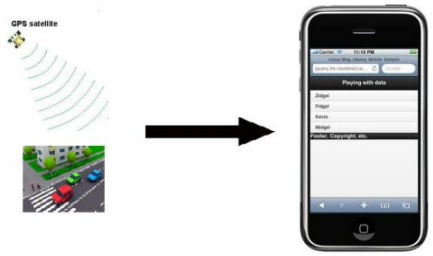


Figure 8: List of available slots- GPS search

Figure 9: Parking maps as viewed by the android user.

Another advantage being that he has a list of parked spaces on his phone which can be extremely helpful in locating where he has parked in car. While un-parking or un-registering, the driver just needs to tap his phone against the same tag and the bill receipt will be transmitted over his phone instantaneously. This amount can then be paid at the exit or be accounted against his name for periodic billing.

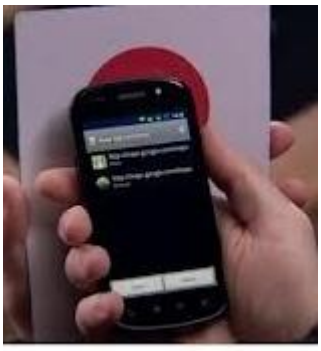


Figure 10: Tap phone against the NFC-Tag.

IV. CONCLUSION

The Parking guidance and Information system incorporating the NFC technology provides an effective solution against the problem of finding a parking lot and eliminating all hassles of going around searching for one. It also attempts to promote the use of a relatively new and emerging technology of Near Field Communication. The PGI system also coupled with other features such as real-time monitoring and automated billing makes it resourceful software. The only possible limitation of this automated system can be that it may require a person in the layout to monitor and check that every car is being registered /unregistered in a right way to avoid misuse by the driver. The PGI system will be extended by considering the reservation of parking slots beforehand by the driver.

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