Re-SPark: Reservation based Smart Parking system using FRDM KL-25Z

Meena Murumkar[1], Jagruti Divse[2], Sushmitha Shetty[3]

*[1,2,3] Students, Electronics and Communication Engineering, Usha Mittal Institute of Technology (SNDT) &
Research interns, C-DAC, Mumbai, India*

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Abstract – *Parking in metro cities, with dense traffic, directly affects the traffic flow and also the life of the people. So a smart parking system that is based on intelligent space allocation, reservation and pricing scheme can be implemented and this proposed system solves the current parking problems by offering guaranteed parking reservations with the lowest possible cost. In this paper, we present a prototype of smart parking system using sensor network and an application by which the user can reserve a spot well in advance. Using a sensor network connecting each individual parking spot, their statuses (occupied or vacant) are detected and transmitted to a database. This information then is accessed by users through the website or mobile app (application) that will serve as a platform to receive real-time data. With the successful implementation of Re-SPark , the economic as well as the time costs associated with traffic jams, the cost that comes along with wastage of gas & fuel, and the time wasted looking for an empty parking space will be significantly reduced.*

Key Words: Re-SPark, smart parking, reservation, prototype, application, platform, status, sensor network.

1. INTRODUCTION

Smart parking has become a need hence is amongst the fastest growing smart city technologies, from airports, shopping malls to any busy location these are just a few examples where we can see sufficient demand for systems with such significant benefits to both users and the parking lot management. The ability to keep devices connected, to analyze and use this data gathered from connected devices is described as the internet of things, is what makes smart city possible.

Since this comes under smart city it involves the use of low-cost and easily available sensors, hence no specially designed sensors are used, real-time and data application which allows user to monitor the available and booked or reserved parking slot, the goal here is to automate and decrease time wasted manually by searching for the optional parking lot or floor, spot or vacant lot. Some solution provides a complete suite of services such as online payments, parking floor, spot and a vacant lot, arrival-departure timings and car searching functionalities for very large parking lots. [2]

Parking solutions can be of great use to both the user and the lot owner. Availability of parking spaces is a major problem in metro cities. With new affordable and easy-n-quick loan services provided vehicles appearing on the street every day, in such cases the need for parking has always been a conundrum and need for parking facilities is constantly on the rise. In this paper, a 'Re-SPark'- a smart parking system using FRDM for the very first time is presented. This smart system automates the process of detecting an available parking spot and by a predetermined pricing scheme for a desirable parking spot, payment can be collected online. The system consists of a smartphone application and an integrated sensor network, and it matches the parking requirements in a mall or office park with multiple areas to park in.

The sensor networks have varied advantages like scalability, low cost, easy deployment, easy availability and more sensing point, being an essential function. Because of these advantages, they found their way in the variety of application domains such as environment monitoring, intelligent buildings, disaster relief applications etc. In this work, we will be developing a prototype of Re-SPark i.e. a smart parking management system that can track available parking slots economically and an application with which user can reserve a parking space in advance, this is very reliable and in turn, it contributes considerably to fuel and time conservation. An emerging trend in wireless sensor networks is its use in parking facility management. Typical car parking management systems monitor the number of cars passing the entry and exit points for estimating the free slots available. This result is then displayed at strategic locations for assisting the user, but Re-SPark not only serves this function also it has many additional functionalities for eg. it keeps the past record in its database and many other facilities that will be introduced later.

1.1 Project Objectives

- To detect a vacant parking spot and send the information to the web server.

- To receive real time data via a platform and reserve a vacant parking spot successfully.

- To charge according to a predetermined pricing scheme.

- To check for service validation.

2. SYSTEM ARCHITECHTURE

Smart parking systems consist of three fundamental parts: parking space detection, Reservation Pricing and User notification.

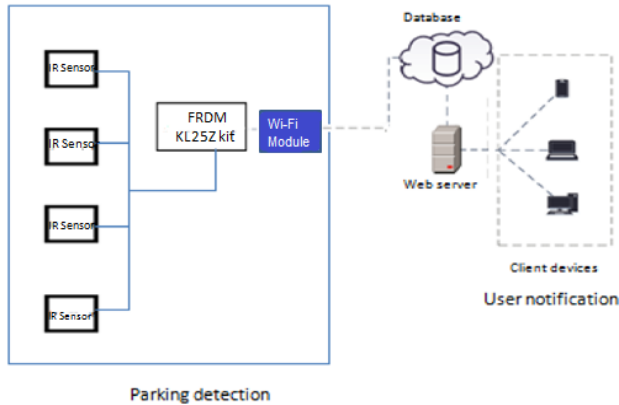A typical Re-Spark System is presented in the following figure.

Fig -1: Re-Spark System

Many components for selecting the most useful one for this prototype were studied and the main objective of the research is to distinguish and characterize between the controller, sensors and wireless communication module which can be used to develop this prototype.

The literature survey is been divided further into four major fields:

1) Controller boards
2) Sensors and Wi-Fi module
3) Web server
4) Application design
Following were the selected components that were the most suitable ones for this prototype.

2.1 FRDM KL25Z

The Freescale's 'FRDM-KL25Z' is a package of software and hardware tools used for evaluation. This prototype is a controller based application. The Freescale freedom which is used is a simple yet a subtly designed kit which features a kinetics L series microcontroller. FRDM KL25Z is used to evaluate both KL1 and KL2 kinetics L series devices from which the maximum operating frequency of 48 MHz, 128kb of flash, and a full-speed USB controller is present in the kl2 family. This platform of FRDM KL25Z hardware is compatible with Arduino. This interfaces which are on board also includes a tricolor RGB led, an 80 LQFP package capacitive touch slider and a 3 axis digital accelerometer.[5] This hardware circuit provides more facilities for serial communication, run control debugging and flash programming. It has flexible power supply options like USB, cell battery, and external source.

This kit is an OpenSDA debug interface which is programmable with several applications that are as follows :

-Its a mass storage flash programming Interface
-The P&E interface gives facility of run- control debugging with a good compatibility with many IDE tools.
-CMSIS-DAP interface is the latest ARM standard which is for embedded debugging interfaces.
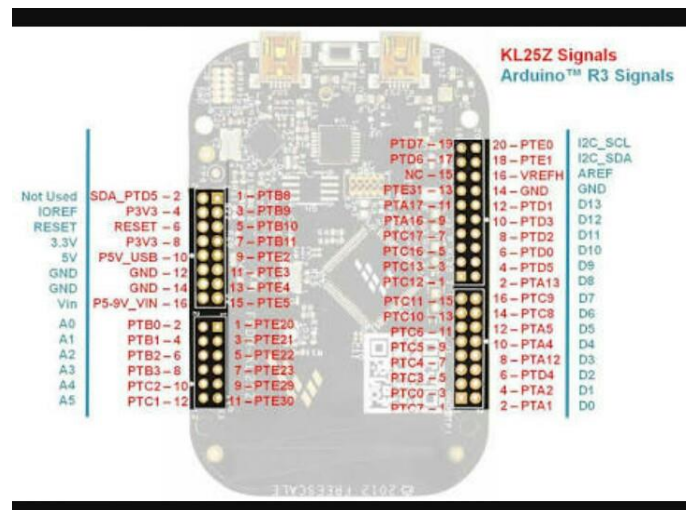- It provides data logging applications.[7]

Fig -2: FRDM KL25Z Pin configuration

2.2 IR Sensors

The infrared sensors that we are using are small electronic devices which sense light wavelength of its surrounding environment by either emitting or by detection of the infrared spectrum. They function as same as ultrasonic sensors. They are also capable of measuring heat emitted by an object. The LED glows after IR sensor detection. Every IR sensor has an emitter and a detector. For every emitter and detector, there are two resistors of which one is to maintain the voltage of led that will show the parking slot vacancy status to customers. When no object is detected in front of IR detector it returns the value TRUE, i.e. HIGH volt output from the sensor and FALSE when an object is detected which means low volt output.
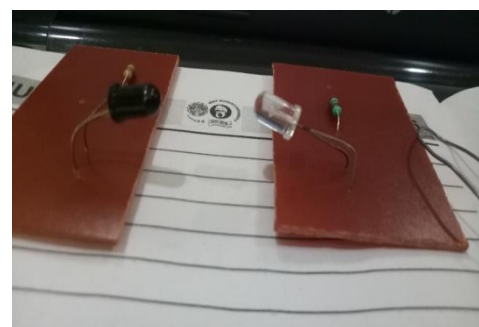

Fig -3: IR Sensor; Emitter- Detector pair

2.3 ESP 8266

Espressif system smart connectivity platform (ESCP) is a high-performance SOC's that are wireless and are used by mobile platform designers. It provides the ability to embed Wi-Fi capabilities within different systems, at a lower cost but with greatest functionalities. It is a self-contained SOC with integrated TCP/IP protocol stack that allows any microcontroller the access to your Wi-Fi network. It is suitable for the implementation of various projects working as a mediator between the FRDM KL25Z and other platform applications. It is a cost-effective board having on-board processing storage capability that allows it to be compatible with many sensors and other applications specific devices with minimal loading during the runtime. The high degree of chip integration allows very less external circuitry and has an increased flash disc size from 512kb to 1 Mb.
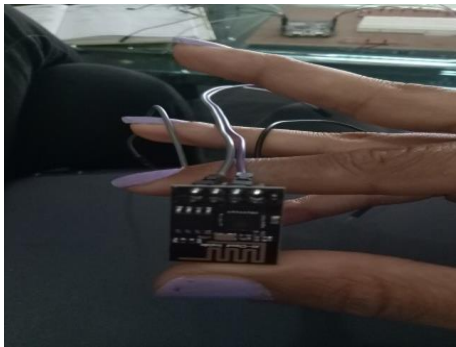

Fig -4: ESP 8266 Wi-Fi module

2.4 Parse

Parse is an open source web server framework that allows the implementation of the back end server. It is suitable for implementation of a prototype for various projects. Parse works as a mediator between the FRDM KL25Z and other Platform applications. Parse handles the MySQL database behind the system. It also facilitates the use of push notifications through its services.[3]

2.5 Management Dashboard

The management gets all the data from various sources in JSON format on this dashboard. This dashboard is controlled by the admin and it shows the activity logs, the reserved slots and the vacant slot available. It is also capable for allocating parking spots to different users.

3. SYSTEM REALISATION AND WORKING

3.1 Parking Detection

Re-SPark works on real-time data of the parking information based on which it makes slot reservation on the spot allocation of parking spaces for drivers. Several technologies are available to monitor real time status of the parking lot like ultrasonic sound, RFID, camera, NIC etc but for prototype implementation we are using IR led sensors which provides high efficiency with a less power consumption. It keeps transmitting infrared rays to some range and then if some object is detected in that range, the IR waves hit the object and comes back at some angle, where the detector next to IR detects the infrared rays reflected from that object. [2]

Thus if the object or say car standing in front of the IR sensors gets detected, providing the status whether that slot is available or already reserved.

3.2 Real time data updation

For efficient use of resources, a reliable and effective two-way communication is necessary between the driver and the allocation centre. In this system, the first way of communication involves the drivers who will be sending the reservation request providing drivers information status of slot available for reservation and utilization of resources to the system. In the other way of communication, the system reserves the space for the driver and the application provides it with the confirmation with reserved slot number and a QR code for service validation. Both these communication ways are implemented through an Android application and other on Windows or web application. [3]

3.3 Confirm Reservation

A resource is allocated to a particular user and the service should not be provided to any user other than the genuine requesting party. So to successfully implement this QR code generation technology is introduced in Re-SPark. The management system does the verification of QR code at the entrance of the parking lot with the help of QR code scanner which is placed on the system entrance. The user along with its application reserves a parking slot, at the very moment QR code, is generated which provides a unique ID for every user on every successful transaction.
This QR code has to be presented in front of the scanner. The system scans it and detects the unique ID i. e. basically it verifies the ID from the database.

3.4 Allocation

An essential feature of Re-SPark is to determine the vacant parking slot for the user and successfully send this information to the web server so as to update the database with real-time information of parking lot statuses.

The management dashboard fires the query on the database via the application in a way that it returns only the vacant parking spaces. On this information which is received on the application the user can reserve the vacant parking space and hence book the desired parking slot. This gives an optimal allocation of the resources of the Re-SPark system.

3.5 Backend

For effective functioning and communication of the server, application and database backend devices use server-side languages to build an app and the tools for data storage to find change or save data and to serve it back to the user.

The system uses MySQL database management system which contains a comprehensive set of advanced features management tools and technical support to achieve scalability, security, reliability, and uptime which is essential for proper functioning of Re-SPark. [3]

JSON (Java Script Object Notation), this format is lightweight and is used for data interchanging. Instead of using XML as a primary data format JSON is a more preferred format. It functions as a web service response.

3.6 Data Analysis

Data is analyzed for three main purposes;

1) For resource allocation:

Here the admin fires the query to get the information on vacant parking space. The resource is not allocated by 'nearest allocation' scheme but Re-SPark allows the user to reserve any vacant parking space as the user desires.

2) QR scanner:

Whenever the user reserves parking slot, a QR code is generated which represents the confirmation of the slot. This code is verified with the database by scanning the QR code through the Scanner. This helps in service validation too if the user crosses his reserved time. Only after successful authentication via QR code, the user is allowed to enter into Re-SPark parking lot.

3) Activity logs:

The system log is produced on the management dashboard showing all the activities completed under Re-SPark in the past. It includes the username, vehicle number, ID for every transaction, the slot number which was allocated to the user in the respective Re-SPark system, arrival and departure timings, the date of slot reservation.

3.7 Platform

An Android application is designed using Android stud which is developed using JAVA compiler, JAVA class files are converted from the source files. The resources of an Android application with the .dex file are packed into Android package (.apk file). This resulting .apk file contains all the data necessary to run the Re-SPark Android application and can be installed on an Android devices using adb tool.

Slot reservation is done using slot allocation method in this application are developed for smart parking feature of Re-SPark. The request from the user is updated from the server which is forwarded to the management of the parking lot. In this way, we can say the application is the mediator between the user and the parking lot management. This platform allows the user to enter the desired arrival and departure of the reserved parking space. This ensures the duration and date of the reservation of any parking space.

4. PROTOTYPE IMPLEMENTATION

The prototype we proposed here is implemented and tested in C-DAC labs. User devices are connected via TCP/IP protocol to the parking database, which is updated in real-time with the occupied or vacant statuses.

4.1 Hardware Prototype

The system hardware is organized by 3 main components, the IR led sensor network, the web server, and the platform. The hardware prototype contains 8 IR sensors which represent 8 parking spaces of the parking lot. These parking spaces are named as P1 to P8.

These IR sensors are connected through wires to the FRDM25Z. The Wi-Fi module is connected to this kit. The circuit diagram and the FRDM connections are shown as follows.

Fig -5: Hardware implementation of prototype
(When all parking slots are vacant)

Fig -6: Hardware implementation of prototype
(When car is parked on slot no. 5 i.e. P5)

4.2 Re-SPark's Android Application Prototype

The Android application offers the parking area of only one parking lot implementing Re-SPark. The parking spaces P1 to P8, which are present in the hardware prototype. The layout of the application is shown, which depicts whether a slot is available or booked with 'green' or 'red' car notation. It contains the name or parking area, parking slot number, and other user information.

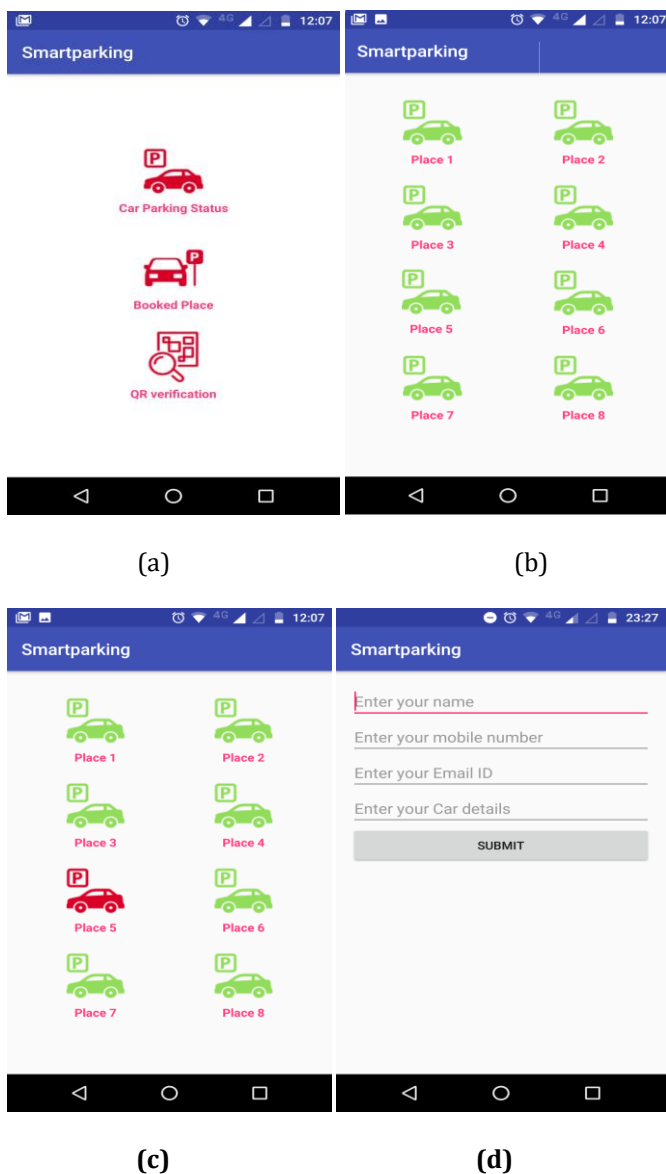Some screenshots of the actual mobile applications are shown in the following pictures.

(a)   (b)

(c)   **(d)**

Fig -7: Mobile application screenshots

(a) Application opening options

(b) When all parking slots (P1-P8) are available

(c) When P5 is occupied

(d) Details to be filled for reserving a vacant slot

5. CONCLUSION

This prototype designed is a smart parking system which is economic and gives an effective solution to reduce carbon footprints that is resulted by wastage of fuel in the atmosphere. It is well managed, easy to access and low maintenance system. The parking slots can be reserved from any remote location through mobile application. Thus it reduces the extra efforts and time required for finding the parking slots in any parking area. It is cost effective as the main controller board is FRDM KL25Z, which is inexpensive. It doesn't not require any specially designed components to convert any parking space into an occupancy status detectable one. In fact any parking lot can be modified into 'Re-SPark' at minimal cost and great advantages. Thus, in conclusion it's a very reliable as it is based on the real-time parking information and it is a complete Smart City solution making the management of any parking lot more effective by decreasing by the need of human labor. The paper will help researchers for innovating various new and advance method to administrate and provide solutions to solve the issues faced by drivers regularly.

6. FUTURE SCOPE

In future, the prototype can be adopted and extended not only for private parking lots like Malls, Corporate offices etc. but it can also can be implemented over a large public parking area where the parking issues and need for such system is more. By adopting this system the reservation can be done on any web browser just the way it is completed on specially designed mobile application, which will help the user to book any parking space of any parking area without installing several different applications for different parking lots or a specially designed application can be designed which can reserve parking slots of all Re-SPark implemented system in a given location. Also, some advancement in mobile application can be made to send reservation notifications to user's smart phone about the location, direction, etc of the reserved parking lot.

ACKNOWLEDGEMENT

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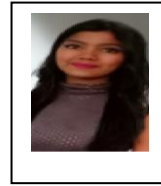
BIOGRAPHIES

Meena D. Murumkar
The author was born in Maharashtra, India. She received the B.Tech Degree in Electronics and Communication Engineering (with first class honors) from Usha Mittal Institute of Technology. Mumbai, India in 2017 has worked as a Research intern trainee in Centre for development of Advance Computing (C-DAC), India. Currently is working as Research Intern in Reliance Jio. Her research interests are in the area of Internet of things [IOT] and Networking.

Jagruti Divse
The author received her B.Tech Degree in Electronics and Communication Engineering (first class) from Usha Mittal Institute of Technology. Mumbai, India in 2017 has worked as a Research intern trainee in Centre for development of Advance Computing (C-DAC), India. Her research interests are in the area of Internet of things [IOT] for Smart city applications.

Sushmitha Shetty
The author received her B.Tech Degree in Electronics and Communication Engineering (first class) from Usha Mittal Institute of Technology. Mumbai, India in 2017 has worked as a Research intern trainee in Centre for development of Advance Computing (C-DAC), India. Her research interests are in the area of Wireless Communication and IOT for Smart city applications.