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**Communication**

# Smart Car Parking Management System Using IoT

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**Abstract:** Proliferation in the number of vehicles is leading to problems of vehicles parking at an appropriate place especially the car parking. This indirectly leads to traffic congestion. This is because of the fact that current transportation infrastructure and car park facility are unable to cope with the arrival of large number of vehicles on the road. To alleviate the aforementioned problem, authors proposed a Smart Parking Management System that helps users to automatically find a free parking space with a smaller amount. Smart Parking involves use of Ultrasonic sensor, Arduino Uno, ESP8266-01 Wi-Fi Module, Cloud server. IOT based new parking platform enable to connect, analyze and automate data gathered from devices and execute smart parking possible. Smart parking would enable vehicle occupancy, monitoring and managing of available parking space in real-time that reducing the environmental pollution. Proposed system provides optimize usage of parking space and get considerable revenue generation.

**Keywords:** Smart Parking Management, Internet of Things, Traffic Congestion, Optimize Parking, Revenue Monitoring

## 1. Introduction

Traffic congestion caused by vehicles is an alarming problem at a global scale and it has been growing exponentially. Car parking problem is a major contributor and has been still a major problem with confined parking spaces in urban cities. Searching for a parking space is a routine (and often frustrating) activity for many people in cities around the world. This search burns about one million barrels of the world's oil every day. These problems will get worse as the global population continues to urbanize without a well-planned, convenience-driven retreat from the car. According to a report Smart Parking could result in saving 2, 20,000 gallons of fuels till 2030 and approx. 3, 00,000 gallons of fuels by 2050 if implemented successfully as shown in Figure 1 [1].

Smart Parking systems obtain information about available parking spaces in a particular geographic area. This process is real-time to place vehicles at available positions. It involves real-time data collection using low-cost sensors and mobile-phone-enabled automated payment systems that allows people to reserve parking in advance [2].

The importance of smart parking is:

1. Accurately sense and predict spot/vehicle occupancy in real-time.
2. Guides residents and visitors to available parking spot.
3. Optimize Parking Space Usage.
4. Simplifies the parking experience and adds value for parking stakeholders, such as merchants and drivers.
5. Helps the free flow of traffic in the city leveraging IoT technology.
6. Enables intelligent decisions using data, including real–time status applications and historical analytics reports.
7. Smart Parking plays an important role in creating better urban environment by reducing the emission of CO2 and other pollutants.
8. Smart Parking enables better and real time monitoring and managing of available parking space which results in significant revenue generation.
9. Provides tools to optimize workforce management.

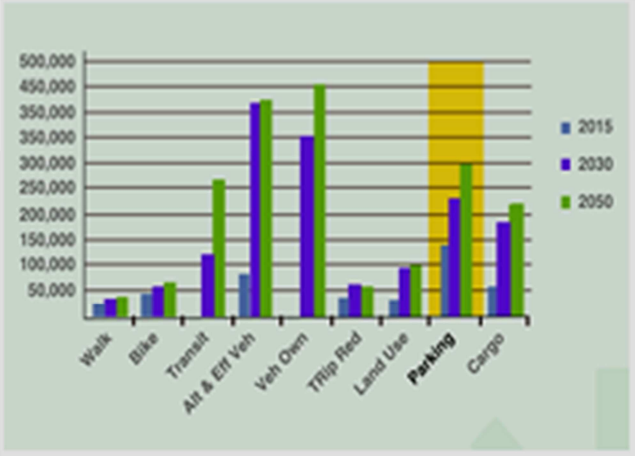



***Figure 1.*** *Estimation of fuel saved (in Gallons).*

Comparison between existing conventional parking and smart parking management system is as shown in Table 1.

***Table 1.*** *Comparison of Conventional and Smart Parking.*

| Conventional Parking System | Smart Parking Management System |
|---|---|
| No optimum use of available spaces | Provides optimum use of all available spaces |
| Congestion may increase due to parking traffic | Congestion can be decreased by diverting traffic to available spaces |
| Increase fuel consumption to search space | Decrease fuel consumption to search space |
| Increases time to search space | Decreases time to search space |
| No Real Time parking space tracking | Provides Real Time Parking space tracking |
| No efficient revenue monitoring | Provides efficient revenue monitoring |

## 2. Proposed Work

### *2.1. Internet of Things*

Moving towards smart city, smart parking is a very good example for a common citizen of how the Internet-of-Things (IoT) can be efficiently and effectively used in our day to day life to provide different services to different users. Proposed application is user friendly and even non-technical person can use it through mobile device. Through this application user can search a free parking slot from anywhere in the world. Proposed system provides well-organized car parking management through isolated parking spot localization. Conventional reservation based car parking method has a limitation of space and time. Proposed smart parking system providing the free parking slot efficiently that saves time and fuel and reduces atmospheric pollution and congestion in cities [3]. IOT based new Parking platform enable to connect, analyze and automate data gathered from devices, and execute efficiently that makes smart parking possible. Figure 2 shows the basic architecture of IoT.

*a.* End -Node

Starting from the front end, the end-node is the first node of any IoT system, without this node the 'T' part of IoT i.e. Things is not achieved. These end nodes are sometimes also called as objects and many times they work as sensing nodes. These nodes usually have dual nature [4]. Examples of end-users are all types of sensors but these sensors are normally basic and a designer can convert it into active device. Proposed system has used Ultrasound Sensors as end node.

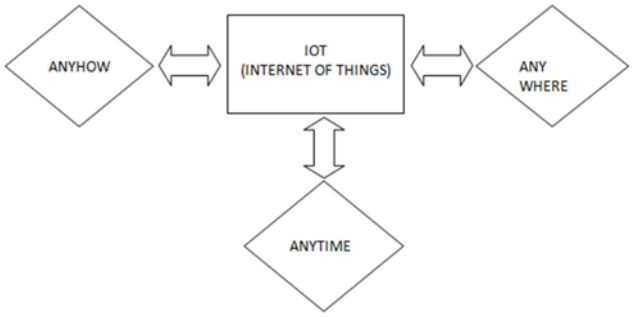



***Figure 2.*** *Basic Architecture of IoT*

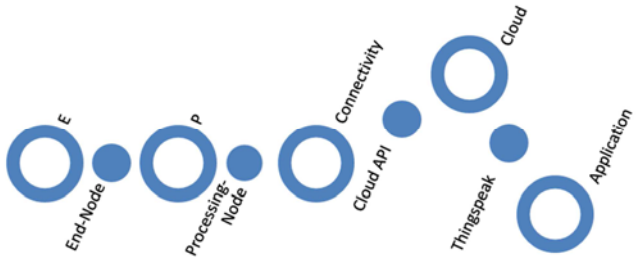


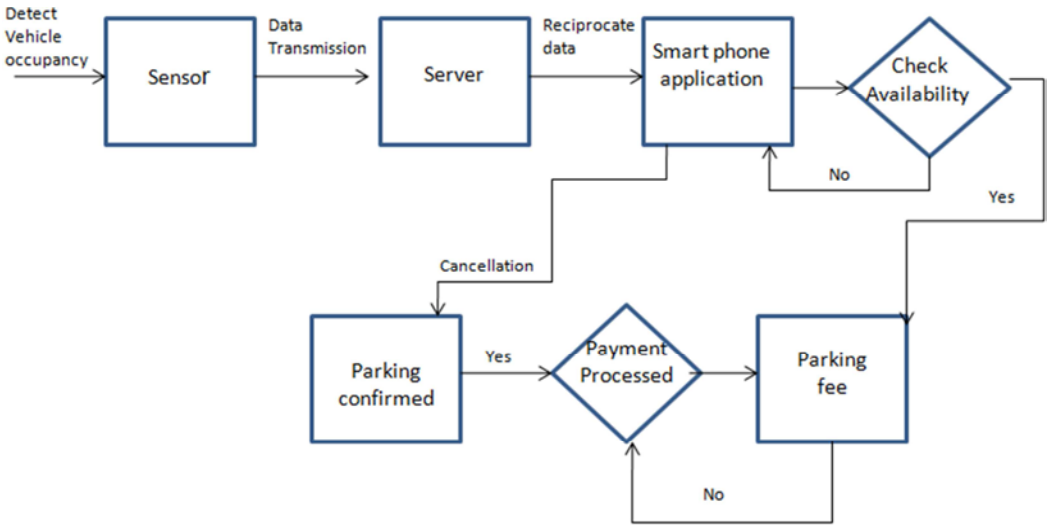

***Figure 3.*** *Node Based Architecture of IoT.*

*b.* Processing Node

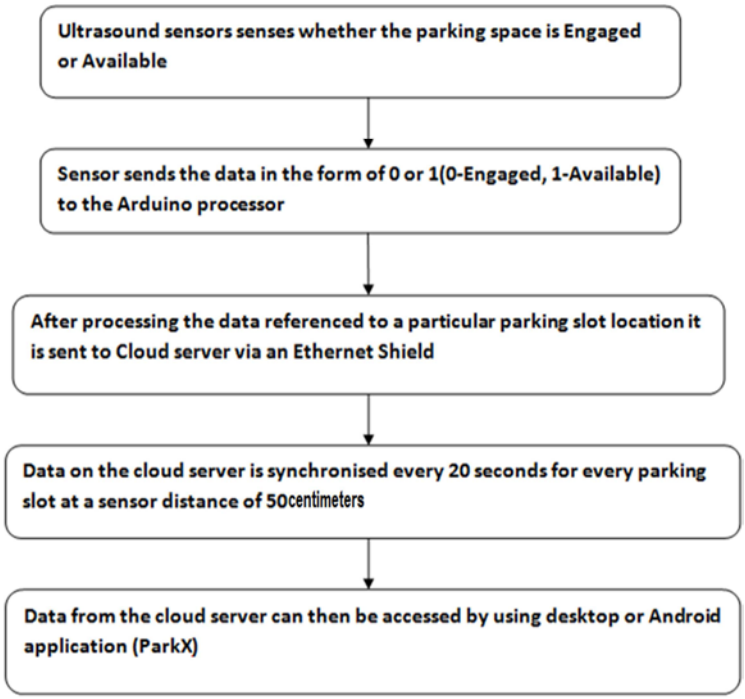
Processing node is the central important block. It is used to provide an artificial intelligence to the whole circuitry. It processes the data and information received from end-nodes and transfers it to further link for next action which in this case is a cloud platform. In our system we have used Arduino Uno as the processing node presented in Figure 3.

### *2.2. Flow of Proposed System*

In any system, wired or wireless Connectivity is important to establish a connection. Proposed system used ESP8266-01 WiFi Module to send data over the cloud. It consists of many network layers to establish a connection between software and hardware. Protocols used in each layer have a specific task as shown in Figure 4. Physical layer deals with the mechanical and electrical support to the system. Every system has a unique MAC address. This system dynamically assigns IP address to each node and users. So a DHCP enabled connection can be used. A secure and fast connection MQTT [1] protocol is used along with TCP (wired connection). This protocol works on pub/sub (publish and subscribe) basis. Pub/sub allows one to many communication and in this the clients are unknown to each other. Flow of Proposed System is as shown in Figure 4.




(a)




(b)

***Figure 4.*** *Flow of Proposed System.*

The application displays the data as per the above mentioned algorithm.

### *2.3. Application*

The end point in IoT system is the Cloud based service provided by Thingspeak which is essential to see the true output of the project or the output of the data send forward end nodes. Users can modify and manipulate the information available on this node easily and can apply various techniques to make its representation effective. In this parking system we have used Thingspeak tools on their website page to view the output. It consists of Application, Transport, Network, Data Link and Physical Layers as shown in Layering Architecture of IoT Figure 5.

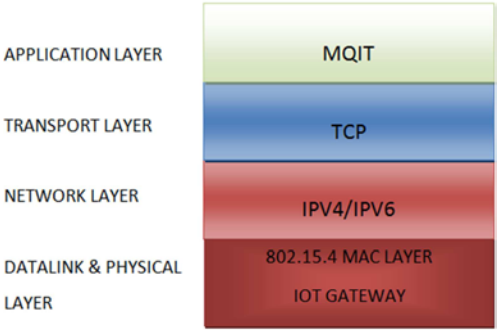



***Figure 5.*** *Layering Architecture of IoT.*

# 3. Framework of Proposed System

The proposed system will have Ultrasonic sensor, Arduino Uno, ESP8266-01 Wi-Fi Module, Cloud server i.e. www.thingspeak.com, User-End Application on Smartphone. The interfacing is shown in Figure 6.

The framework of proposed system is as shown in Figure 7. The ultrasonic sensor is used to determine the availability of the vehicle at the parking spot. It is connected to the Arduino Uno module interfaced with Wi-Fi shield [5]. The Arduino Uno module is connected to the cloud server through an Internet connection to transfer the data from the local car park. At the user end application a software system runs on Android operating system. The user has to install this application on their smart phones and use it to reserve parking spaces.

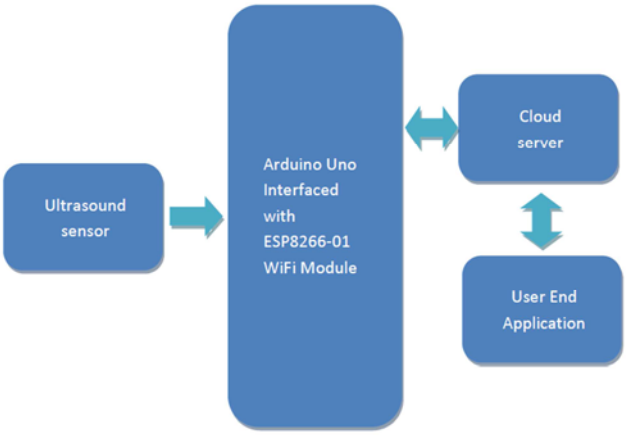
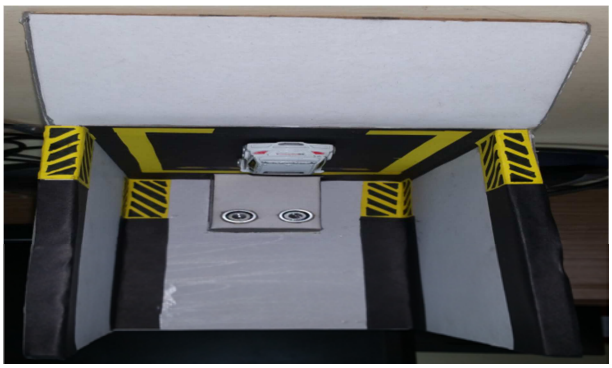



***Figure 6.*** *Framework of Proposed System.*

### *3.1. Analysis and Planning*

The rapid growth in the number of vehicles worldwide is raising the problem of the scarcity of parking space as shown in Figure 7. According to industry data, 30% of the traffic congestion occurs due to the struggle of vehicle drivers to find parking space. These in turn are magnifying the necessity of efficient and smart parking systems [6]. Today's intelligent parking management systems are capable of providing extreme level of convenience to the drivers, automating and simplifying the business operation and administrative functions of the parking site owners. Trends are emerging in Parking some of are the few trends having the greatest effect on Parking Industry [7]. The high growth rate in the registration of new cars worldwide, with major boom from regional economies like Asia Pacific (APAC), will open the window of opportunities for parking management business. The upcoming and ongoing smart city projects worldwide will create room for the intelligent parking management systems.

(a)



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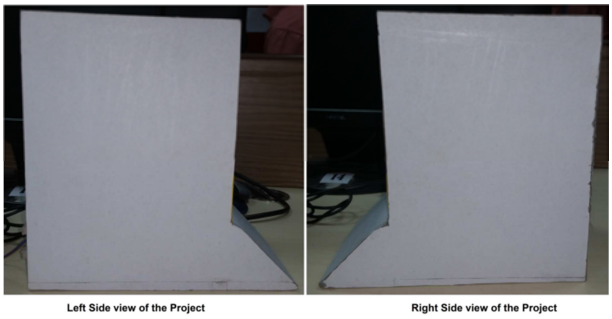



(c)

***Figure 7.*** *Framework of Proposed System (a) top view (b) front view (c) side view.*

From 2014 to 2019 the global parking management industry is expected to expand at a Compound Annual Growth Rate (CAGR) of 11.4%. In 2014 the parking management market is estimated to be at $5,025.9 million. The growth in vehicle ownerships and parking facilities development is expected to grow the market in tandem [2] as shown in Figure 8. The key drivers for the parking management industry are the need for smooth traffic flow, business benefits to the parking site operators, less hardware and connectivity costs. Traffic congestion and gasoline prices lead the list for the major changes having significant influence on parking.

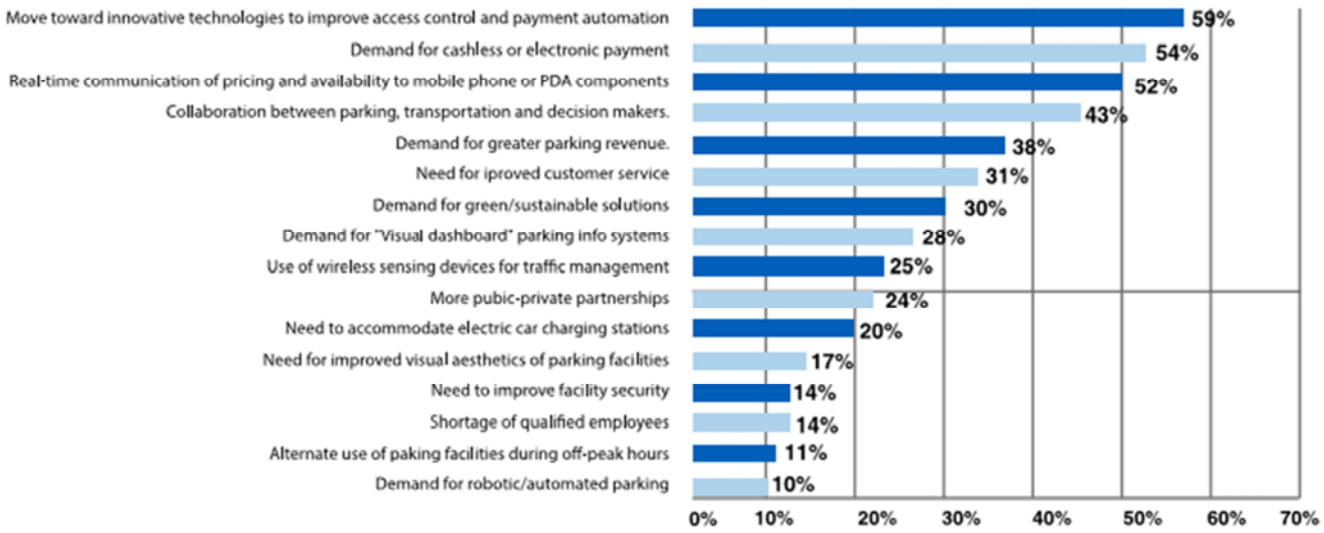



***Figure 8.*** *Demand for various Specialized Area.*

### *3.2. Challenges*

The challenges for the proposed system are wide from protecting the system from environmental conditions and harsh weather so as to making it operational in all weather. Integration of the devices amongst various hardware and software modules [8]. Protection can be provided by using a proper insulator case for the hardware module which will not affect the functionality of the device and also provide durability, resistance against external weather and mechanical forces.

The major challenge in Parking Systems is of system integration due to wide variety of hardware and software platforms involved and hence possess a great concern to the system scalability.

The technology platform supporting P&E, PARC and PUCRS systems comprises of dynamic messaging systems, a myriad of hardware sensors and traffic control devices, wireless and wire line telecommunications systems, computer clients, servers and hardware drivers and application interfaces [9].

Enabling all these devices from thousands of different vendors to communicate with each other and tying them together into one platform is the greatest challenge in reducing the complexity and cost of smart parking.

The variety of infrastructure hardware and software systems that need to be integrated is enormous and an add-on to it the conventional older hardware making investment in Smart Parking solution. It is highly risky and fragmented. Another major pain point comes from the electronic payment vendors [5]. These payment processors provide permit based electronic payment, typically for a convenience fee. Scalability is the key to many of these hosted solutions which is the ability of the transaction processor to support over wide geographical market and service areas with minimal cost. Income based Market evaluation is shown in Figure 9.

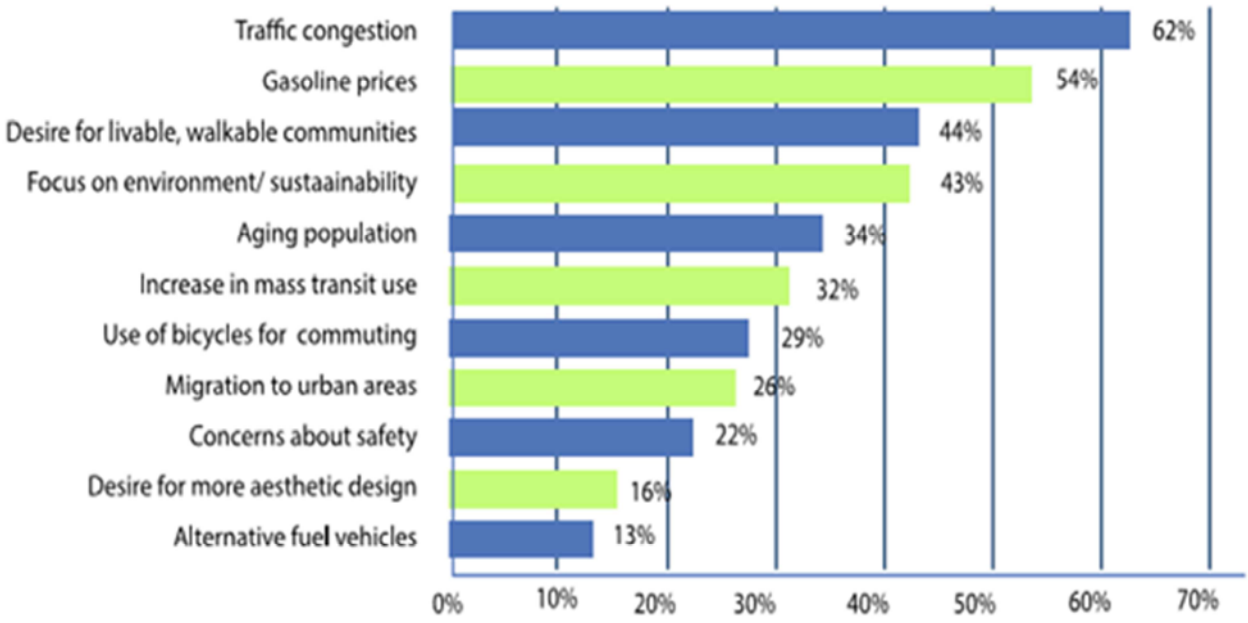



***Figure 9.*** *Income based Market Evaluation.*

### *3.3. Indian Ecosystem Challenges*

Smart Parking Booking page of Mobile application is as shown in Figure 10.

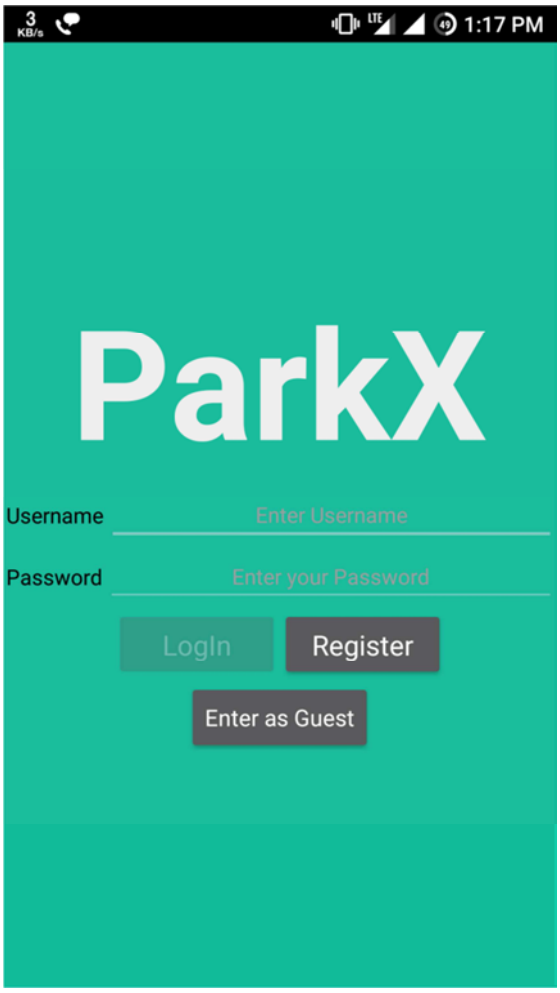
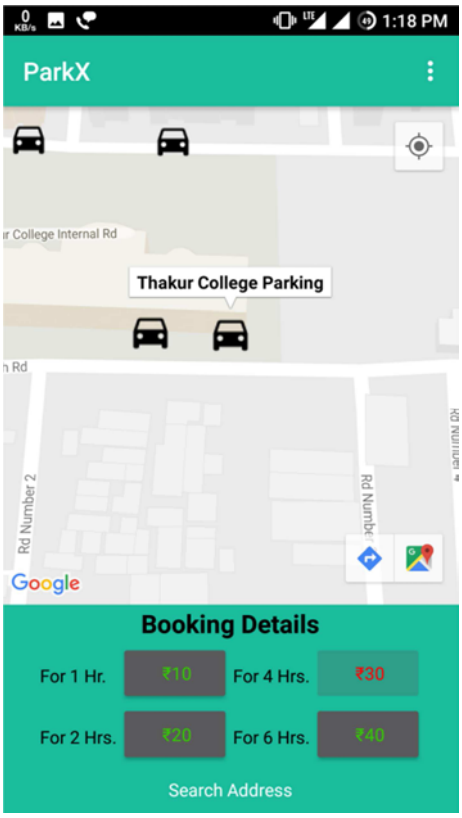



***Figure 10.*** *Login Page of Mobile Application.*

1. Unavailability of matured billing system possibly leading to revenue leakages.
2. Interoperability between devices/lack of standards.
3. Indian standards do not have proper regulatory body for two wheelers parking station.
4. Various Security issues and threats to the installed on-site parking meter.
5. IoT enabled Parking System shall support mechanisms to compare charging data/records from different IoT Application Service Providers.
6. The IoT enabled Parking System shall support triggering Machine-to-Machine Devices to report on-demand information regarding collected data from other Machine-to-Machine Devices.
7. Smart parking providers will need to establish reliable application programming interfaces (APIs) that enable service partners to provide consumers an access to smart parking services on-line through a variety of channels, including the web, mobile phone apps, connected personal navigation devices and car telematics services.

## 4. Results and Discussion

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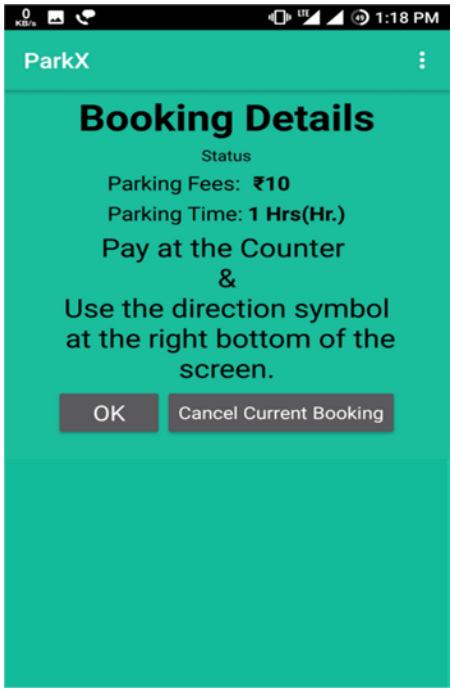


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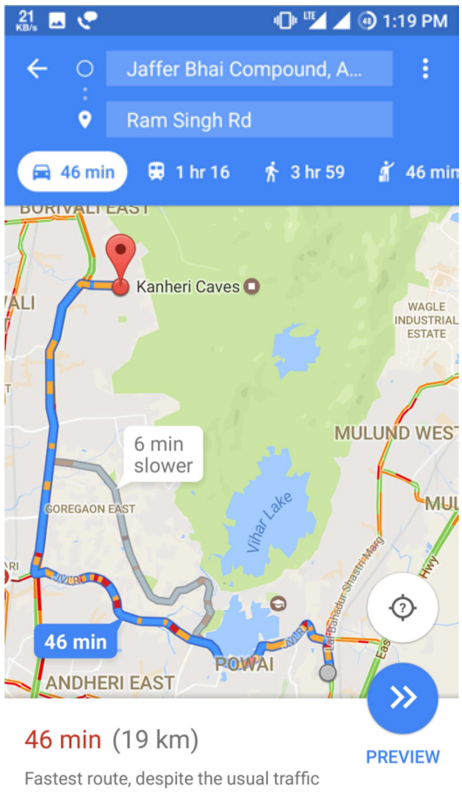


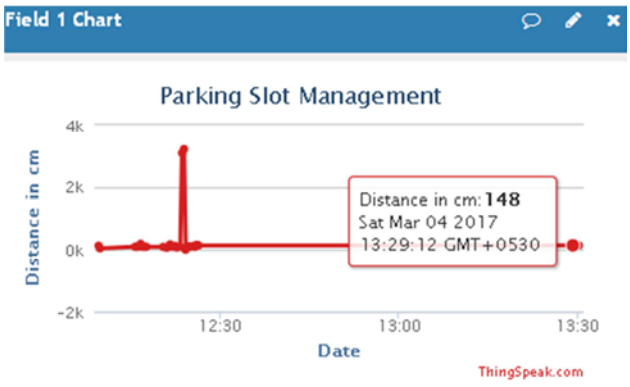

(c)

***Figure 11.*** *Android Application of Smart parking Slot (a) Available Parking Slots (b) Parking Booking Details(c) Navigation.*

Screenshot of the mobile application shows the execution steps for allocation of parking slot as follows.

To access the parking slot application the first step is to register and login. The application shows the availability of parking slots shown in Figure 11(a) if it is free then shows the booking details 11(b) along with fastest route through navigation as shown in 11(c).

The data from the ultrasonic sensor is updated on the cloud server i.e. "ThingSpeak.com" via the Arduino. The data from the hardware is shown in graphical form on the cloud server then read by the application and the user data from the application is then updated on the cloud server for further booking. Figure12 shows execution of the smart parking booking.

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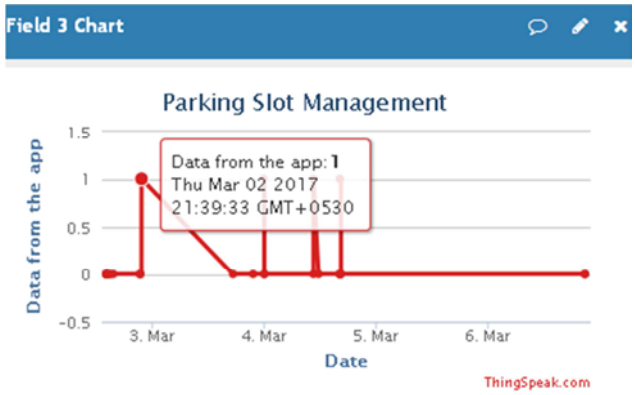


(b)


(c)

***Figure 12.*** *Smart Parking Booking (a) Distance between the sensor and the car (b) Vehicle occupancy (c) Time slot for Parking.*

## 5. Future Scope

The smart parking management system can be broadly applied for many future applications. Apart from its basic role of parking management of cars it can also be applied for plane and ship and fleet management. With the ever growing field of Internet of Things many concepts can be interfaced along with our system.

Smart Parking system can be modified into fleet management of ship and plane with very few external hardware changes and almost the same software just replacing the interface fonts of cars with ship or plane for better Graphic Interface and real world application based visual appearance.

For residential and domestic parking system the device can be interfaced with Home Automation system which can control the various home appliances by sensing whether the user is arriving or departing from the parking space. For instance if the user has arrived then the module will sense the presence and will send information about arrival to the Home automation system which can accordingly switch on the selected appliances like HVAC (Heating Ventilation and Air Conditioning) units, Coffee maker, toaster, Wi-Fi routers etc. Likewise by sensing the departure of the user the module can send the information to Home appliance system which can then switch off all the appliances except the programmed list of refrigerators and misc applications. It can also activate the home security system.

For commercial parking system the device can be interfaced with a module which can sense the arrival of employee and can switch on his computer and HVAC systems and accordingly switch off the appliances when the employee departs. The system can also be used to track the reporting and departing time of the employee for all days with precision thus acting as an attendance system.

Thus many such modules can be interfaced with our system to provide better facility, security, and optimization of electricity and resources with the principle idea of flawless fleet management system [10].

This is a prototype which has a potential market in Indian ecosystem so this project can be developed into product if the implementation is as desired and gives real-time output.

In the long run, smart parking can transform the very makeup of our urban landscapes and making them more manageable to people rather than cars.

## 6. Conclusion

Smart parking facilitates the problems of urban livability, transportation mobility and environment sustainability. Smart Parking technology is used for enhancing the productivity levels and the service levels in operations. It also benefits in terms of lowering operating costs and increases revenues and facility value [11]. Proposed system has developed from traditional servicing channels like toll-booth and parking attendants. It involves the use of Ultrasonic sensor, Arduino Uno, ESP8266-01 WiFi Module, Cloud server. The Internet of Things integrates the hardware, software and network connectivity that enable objects to be sensed and remotely controlled across existing network. Such integration allows users to monitor available and unavailable parking spots that lead to improved efficiency, accuracy and economic benefit.

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