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IoT Based Smart Parking System with API Access

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Abstract. ***The currently employed systems to monitor parking can provide information limited to the location and number of parking spaces available in a single parking space on arrival of the user. With the advances in infrastructure in India and rapid urbanization, people are now travelling more than ever. While there have been strides to improve public transportation systems, it simply can't sustain the population of our country. After arrival at a destination, users must indulge in the struggle to find a suitable parking spot which is both time consuming and leads to road congestion. This also contributes to the increased C02 emissions due to unnecessary idling of cars. In order to solve the parking problem, many people will search for the nearest parking lot and navigate themselves using the ever reliable Google maps but this isn't a robust solution.***
Consequently, this paper reviews newer methods to (i) upload, (ii) receive and (iii) process real-time specimen data from multiple parking spaces en route to the user's destination aiding to mobilise traffic. This system is implemented by using Internet of Things (IoT) features integrated with GoogleMaps APIs developed on personal mobile devices.
The review further discusses a method to optimize the flow of parking traffic and help the user localise a parking space before arriving at their destination. The users can also know their respective parking duration and effectively budget the parking cost.

Keywords. ***Ultrasonic Sensor, IoT, Raspberry Pi, NodeMCU, Google Firebase.***

1. INTRODUCTION

IoT or Internet of Things is a technology which forms an ecosystem of devices and peripherals which connect to the internet and have the ability to communicate with each other and exchange data. Inevitably, this interconnectivity yields a plethora of applications in fields where human to human or human to computer interaction can be avoided. Today's Parking System, in particular, lacks an on-site deployment method that is interconnected with multiple parking lots or spaces in the vicinity. With the increase in the number of vehicles, parking spaces have become a critical commodity especially in densely packed metropolitans and urban cities. The difficulty of finding a suitable parking spot which is walking distance from their destination is ever rising. Commuters have to rely on their own limited and sometimes inaccurate knowledge to find an open spot which leads to traffic congestion and bottlenecks while their cars are idling which is a direct cause of pollution & increased CO2 emissions and an expense to the car owner since their engine is running.
Surveys have found, India has 40 cars for every 1000 people (2015) [1]. More than three years later we can safely assume that this number would have increased significantly in contrast to the number of parking facilities available. This paper talks about the benefits of implementing this technology in India's infrastructure to alleviate the problem of finding parking spots in establishments. Moreover, the paper aims to advocate against this age-old problem and offer a "smarter" solution using modern technology.
A mobile application is also conceptualised so that the end user is provided with a forecast of the traffic, parking spots and feasible locations. The paper is included with a high-level design of the system architecture.

2. DESIGN

NodeMCU
It is an open source IoT platform. Node MCU is based on the ESP-12 module and runs ESP8266Wi-FiSoC from Espress if Systems. It runs on Lua scripting language but can also be programmed using C [2].

HC-SR04
HC-SR04 is widely known as an Ultrasonic sensor. Ultrasonic sensors measure the distance by making use of ultrasonic waves. The sensor discharges ultrasonic waves and waits to receive said waves back from the target. The sensor measures the distance by measuring the time between the emission and reception [3]. It is calculated by-

Distance L=1/2*T*C [4][5]
Where L is the distance
T is the time between discharge and reception
C is the sonic speed

Advantages of using ultrasonic sensor:
* Ultrasonic waves can be used to detect transparent surfaces like glass or any kind of liquid.
* Will not be affected by dust and dirt.

Google Firebase
Firebase is an application development platform from Google for mobile and web-based programs. It was developed by Firebase Inc which was later acquired by Google. Firebase allows you to implement high-end mobile and web applications with no server-side programming. It supports iOS, OSX and Android clients. Firebase uses JSON and provides real-time feedback of data. By using Firebase, you don't have to configure the backend of the server [6].

RaspberryPi
Raspberry Pi is a low power, small form factor computer. It's about the same size as your average credit card. The Pi really advanced the IoT revolution as it allowed for more computing power on such a small form factor. It works on its own custom Debian OS called Raspbian [7].

3. IMPLEMENTATION

The system has 3 main layers. The first layer is the Sensor Layer which is comprised of the sensor array which includes NodeMCU and ultrasonic sensors. This layer is responsible for giving information about which parking spots are vacant and which are occupied. The Second layer is the Data Processing Layer. In this layer, we process the information supplied by the Sensor Layer and the coordinates of the user requesting for parking space. We apply the location into the algorithm with calculates the nearest vacant parking space for the user. The third layer is the Application Layer. This is the layer that the users will interact with. It consists of the Android/iOS application and also the API for 3rd party map applications like Google Maps. Users will use this layer to locate and navigate to vacant parking spaces.

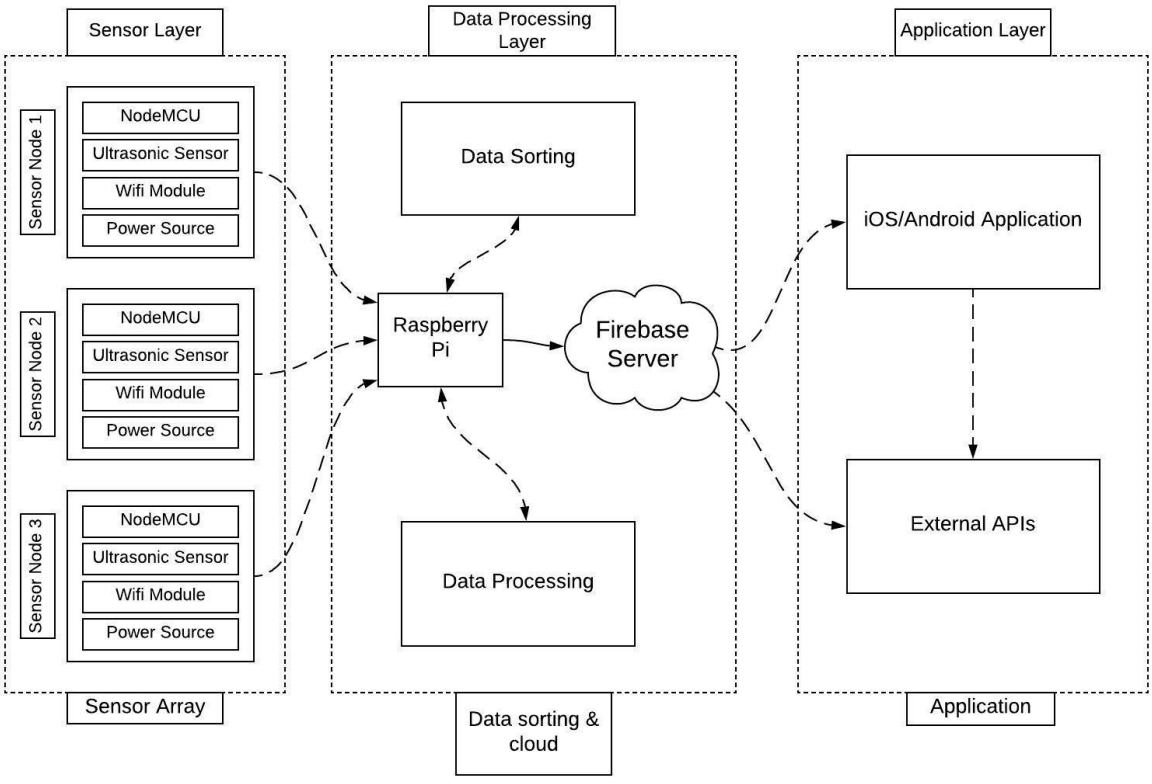

Fig 1. System Architecture

3.1 Sensor Layer:

This layer consists of Node MCU, ultrasonic sensors, LED lamp and a power source.
The NodeMCU sends a refresh signal to the ultrasonic sensor every 3 seconds. On receiving the refresh signal, the ultrasonic sensor scans for change in distance to detect whether the spot is vacant or occupied. It transmits this data to the NodeMCU which in-turn transmits the data back to the Raspberry Pi. The Raspberry Pi will be installed in every establishment and undertakes the data processing job and maintaining a local log of the data. The processed data then is transmitted to the Google Firebase server [8].
The LED lamp will show green colour by default, red when the parking bay is occupied and start flashing red and blue to indicate an emergency and indicate an evacuation.

3.2 Data Processing Layer:

The Raspberry Pi will be installed in every establishment; it undertakes the data processing job and maintaining a local log of the data. The processed data then is transmitted to the Google Firebase server [6][8]. The APP and APIs fetch data from the server. The data from the Pi is also uploaded to Thingspeak [10]. Thingspeak transforms data into graphical charts. It makes histograms and plots charts with respect to time and no. of vacant spots and predicts how busy an establishment will be on any given time [11].

3.3 Application Layer:

This is the layer which is visible to the end user. It is the most important layer as all the data we collected and processed in the previous two layers will be displayed to the user via this layer so the user can find vacant parking spots. This layer shows the real-time availability of parking spots. The coordinated of vacant spaces can be pulled from the cloud server which can easily be navigated through 3rd party navigation apps.
Fig3. represents the parking structure. For this example, the parking structure has 10 parking bays. Each of them is fitted with a sensor node and one LED lamp which indicate whether the bay is vacant or occupied. The LED lamp is low power while possessing high lumens so visibility is high and navigation to avacant bay is easy [12].

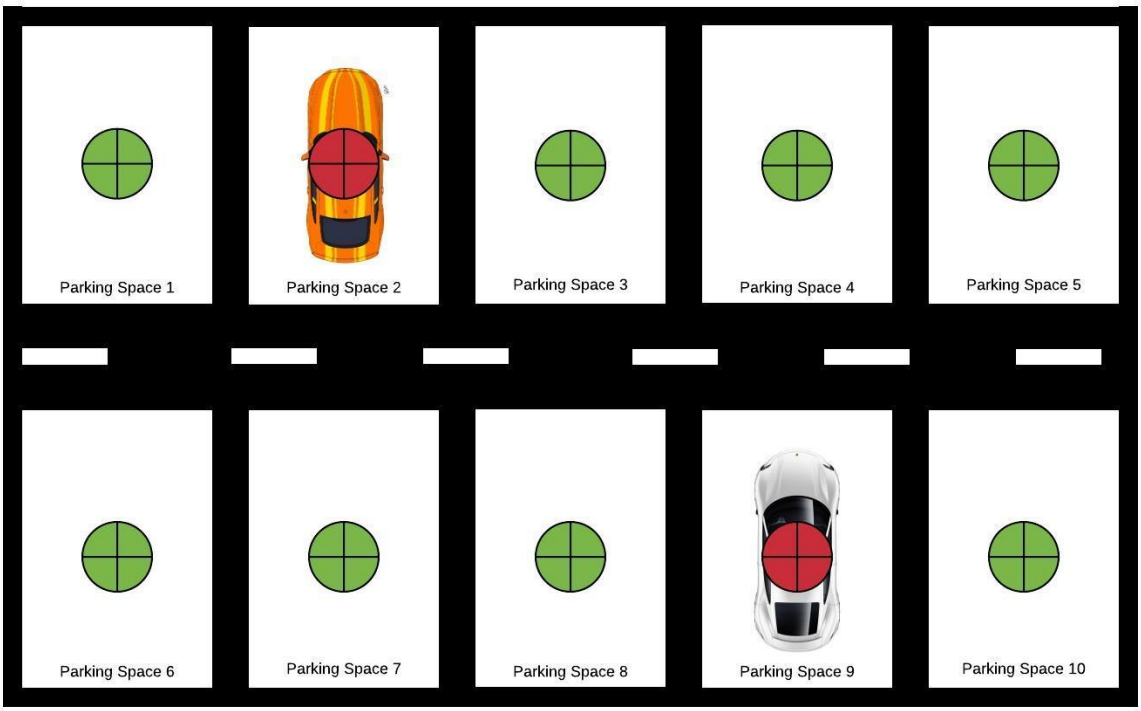

Fig. 2 Parking structure

When a car is parked in any of the bays, the LED changes colour to red (as demonstrated in Parking space 2&9) and the information is relayed to the Raspberry Pi via the NodeMCU.
This information can be accessed via the app or API as it is pushed to the cloud on a real- time basis.

4. Result

The paper discusses how the implementation of IoT in buildings and commercial parking lots can provide a sustainable and feasible solution to help drivers find the nearest vacant parking spot and thus save money and time of the users. Fig. 2 shows how the IoT enabled infrastructure of ultrasonic sensors senses the incoming of a car on a parking space and thus reflects changes immediately by changing the lamp to red when occupied and green when vacant. This indication would assist the driver entering the parking space to spot the parking by just looking for the green lamps and thus will save fuel, money and time which would have been otherwise wasted in moving about trying to locate a suitable spot. The NodeMCU further sends the data to the Raspberry Pi. The Raspberry Pi on-turn updates the status on the Google Firebase cloud server. This updated real-time data of vacant and occupied parking spots is then inherited by the iOS/Android app and the 3rd party APIs. Establishments can take this data via the API and display available parking spots outside the entrance to decongest the lanes. The user necessarily doesn't have to be near a parking structure to check the availability; a user can even check the status of parking space near the intended destination before leaving the house through smart peripherals. The information can be crucial for the user in the context of choosing the mode of transport.

The user can check if the parking slot is available then the user may self-drive to the destination or if space doesn't seem to be available, the user may choose a different mode of transportation. The application of the IoT in parking lots is not just limited to assisting a driver to find parking, but also prove to be rewarding economically. IoT enabled assisted parking guidance service would enable the driver to save more fuel and time. Effects could be seen in the areas of general efficiency of the people driving themselves to offices, which could be due to an elevated mood due to the reduction in the amount of psychological stress that is generated in the process of finding parking. Positive Economic and environmental impacts due to less consumption and burning of fuel that was wasted during the process of finding the parking by guesswork and intuition otherwise.

5. Discussion

With the ever-growing population in the cities which is accompanied by proportional growth in the number of vehicles, space and resources available for the parking of the vehicles are sadly inversely proportional with that pace. As a result, finding parking now takes a lot of effort and time which negatively impact people's lives. The issue is so prominent that people try to look for the parking spaces near the establishment before planning their travel, even if it is a simple task like going to the store or office in the morning. Implementation of IoT enabled network in the establishments can seem like a viable option to tackle the problem, as it can provide the real-time data and stats of the parking space/commercial parking prior or at the time of arrival and even go as far as predicting the vacancy of parking.

While this paper discusses the real-time availability and prediction of the vacancy of parking spaces in an establishment, it particularly does not tackle the task of calculation of fares and fee associated with parking in an establishment. However, this issue can be potentially resolved with the involvement of a RFID system or an image recognition classifier which used Google's Tenser Flow to recognize number plates and calculate parking charges at the time of exit. The scope of this paper is limited to determining the availability of parking spaces in establishments. This paper fails to answer parking problems in unorganized sectors, for instance, in community streets where people generally tend to park haphazardly in unmarked spaces or whenever they desire, the technology and methods described in this paper wouldn't be able to offer a viable solution till we organize these said sectors by outlining and designating parking spaces. With the integration of payment gateways and enabling options to book the slot prior to the arrival is a potential possibility and an application of this paper, as the framework required for the same are available today.

With the trend of computing and electronics supporting the growth of IoT and cloud-based platforms, more efficient and comprehensive solutions can be built in the future which would not only be potentially able to tackle to the issue of parking but also handle the traffic in real time efficiently to minimize the choking and clogging of streets. The power that Internet of Things brings to the table is tremendous, potentially making it easier and efficient to implement policies and make the cities work as an intelligent and responsive organism, where all devices and peripherals work together synergistically and truly form a "smart city".

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