Automated parking management system

# Abstract

We all would have been in a situation in which we would have struggled to find a parking space manually. Especially in locations with big parking space, during rush hours it will be hard to find one. The latest development on the Internet of Things (IoT) in Web development can be used to solve this lasting problem. In this article, we are proposing a solution using IoT and a web application that will help the users to park more efficiently and make the process of parking more streamlined. Even though this solution works for most of the parking scenarios, there needs to an initial construction overhead with the setup, and users should adopt and use their mobile phones to use this system. Thus, this system works well in Urban areas. The concepts involved in these projects are modular and fast-evolving, so custom changes can be inducted as per the specific implementation.

# Introduction

The Internet of Things (IoT) means the network of physical objects that are connected via the Internet. The network is formed by physical objects that have embedded sensors in them, they are controlled by software, and is connected to the Internet. Embedded, network, and software engineering concepts realize the Internet of Things. Nowadays, IoT is ubiquitous in the form of smartphones, smart speakers, etc. IoT devices have a presence in an extensive number of fields like Consumer (Smart home, phones), Organizational (Healthcare, transportation), Industrial (Manufacturing, agriculture), infrastructure (Smart cities, energy management), and military (Weapons, surveillance), etc.

From the beginning of the 21st century, due to efficient manufacturing and increasing interest in mobile phones. There are 3 billion smartphones as of December 2020. This increased interest in smartphones has brought so many appealing use cases that can be accomplished using your smartphones. For example, you can order your groceries, book a ride, shop online all using a mobile phone. The widespread availability of the Internet also plays an equally important role in the increased presence of Smartphones in our everyday life.

This article takes advantage of both the IoT and Smartphones to implement an efficient parking management system that reduces the hassle while parking. In the scope of this project, a parking space is defined as a specific space designated with markings for parking a vehicle. Typically, we can see in the malls, cinemas, convention centers, etc., a great deal of manpower is required to coordinate the parking process. In cities, the majority of parking spaces is controlled by manpower. Shockingly hardly any data on the use of these spaces is available. This is changing rapidly and parking data from sensors are considered a prominent part of that. With information from parking sensors, it is easy for users to navigate to the correct parking spots easily. In the future, several improvements can be made over the current system such as automatic billing, violation and theft alert, etc.

Implementing the above system doesn’t happen straightforwardly. Sensors must be installed in parking spaces; users who intend to use the system should be able to seamlessly access real-time parking data using smartphones. Continuous maintenance is required, and user participation is critical to the success of the system. Due to the nature of the system, the project is most suitable for crowded large urban parking spaces.

# Literature survey

Parking is a nagging problem in urban transportation and planning for some years now. Parking is a nagging problem in urban transportation and planning for some years now. Try to park at a parking space in the city during work hours or on weekends. You will know that finding a parking space is very difficult, not to mention a waste of fuel and time [5].

Blazquez et al. [6] propose a system that allows users to select a parking facility according to their preferences, quickly park their vehicles without searching for parking, and pay their reservation in advance avoiding queues, interact with their mobiles to get real-time information such as capacity, parking fee, and current parking use. By adopting a new automatic parking management system, it is possible to reduce the number of miles traveled by each vehicle, average travel time, traffic congestion, energy consumption, and air pollution. This article inspires solving this problem and proposes a solution to this problem.

Using the recent developments in IoT and Smartphones, we proposed an architecture that uses sensors [1] to collect data from parking slots and process it in a centralized processor in each parking garage and store it in Cloud [2-3].

A case study [4] was conducted in San Francisco on how peak-based forecast pricing can improve parking systems compared to the passive methods currently used (Fabusuyi et al). The case study also found that compared to existing methods, parking spaces are optimized and the turnaround time for finding parking spaces is reduced.

Quinn [7] proposed a system for providing instant notification of vehicle parking space availability and locations of vehicle parking spaces to users. Sensors sense the presence or absence of vehicles in a specific parking space and convey the space identification and status information to the computer network.

# System design

Diagram

Description automatically generated

Figure xxx is the overall architecture of the proposed system. There are 4 main components in the architecture.

1. Sensing module
2. Processing module
3. Cloud module
4. User module

## Sensing module

The sensing module in the architecture is the entry point to the system. Each sensing module will have an Infrared (IR) sensor. This sensor will be able to detect if there is something that is obstructing its field of vision. If there are obstacles it means that there is a vehicle currently parked in that spot. Each spot in the project setup will be fitted with one sensor. Each one of the sensors will be reporting its status continuously to the processing module.

One change that can be made to the sensing module is to use infrared sensors instead of ultrasonic sensors (US). This is because when there are obstacles such as dust and smoke, it is difficult for the ultrasonic sensor to detect the distance. When the external light is insufficient, even the infrared sensor has a problem. According to Tarek Mohammad [1]. The inconsistencies can be cured by taking a multi-part approach, which includes, placing sensors in proper angles, arrange ample external light sources in all conditions, using both US and IR sensors at once, and using more than one sensor, which will take care of errors.

Diagram

Description automatically generated

Figure xxx is a state diagram of the sensor. It depicts all the possible state’s in which a sensor can be in and based on that what will be the output. The states that a sensing module can be at any point of time include, “Active”, “Out of Service”, “Maintenance”, “High Output”, and “Low output”.

## Processing module

The processing module is responsible for collecting data from all individual sensor modules, summarizing it, and then processing it into meaningful data. This module is also responsible for the management of abnormal conditions, for example, when the sensor module stops running, it will veto the sensor's behavior.

Also, this module is in charge of transmitting data to the cloud where the current state of all the parking lots that are currently working will be stored. This idea is different from storing data in the processing module itself. Storing the data locally was the norm from the early days of computing, but due to recent developments in cloud computing. The adoption of cloud computing is increasing rapidly. The advantages of cloud computing include “reliable, customized and Quality of Service (QoS) guaranteed dynamic computing environments for end-users” by Wang et al. [2].

Diagram

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Figure xxx is a state diagram of the processing unit. It describes all possible states that the processing module may be in at any point in time. The possible states are “Idle”, “Processing”, “Transmitting”, and “Inactive”.

## Cloud module

The cloud module is behind the storage of the whole of parking data. In addition to that, cloud computing has advantages such as easy management, cost reduction, uninterrupted services, disaster management, and green computing [3]. No need to store all data locally but put everything in place. Cloud computing can easily solve many potential problems that may occur in the local data infrastructure.

## User module

The user module contains a user interface, the user can use the user interface to understand the status of the parking lot. The smartphone application is chosen to be the primary interface for the users. You must download the application before you can use it. During the first access to the application, all necessary permissions, such as location and notification permissions, need to be requested from the user.

When the user is using the application, the user’s location is retrieved, and the nearby parking lot’s status is shown to the user. The user can then use this information to make a calculated decision of which parking space to take up.

# Results and accuracy

## Sample setup

We tried to build a prototype using the architecture suggested above. The prototype has 8 parking spaces, of which 3 are equipped with cars and 5 are empty. “1” is sent as input from the filled slots and “0” from empty slots.

Diagram

Description automatically generated



## Accuracy

In the sensing module, we discussed problems that can lead to inaccurate sensing of parking status. This problem can be rectified in two different ways.

Chart, line chart

Description automatically generated

The first approach is to simply increase the number of Infrared Sensors (IR) sensors. Because there is more than one source of data for each parking lot, the status of each parking lot is calculated using the combination of more than one IR sensor. This can reduce the chance of errors.

Another way to improve accuracy is to use an ultrasonic (US) sensor that can detect distance. In this way, together with the infrared sensor, when the data output by the infrared sensor conflicts, we can use the data of the US sensor to conclude the state of the parking lot. This way, we can rely on status.

# Future work

The proposed architecture provides essential functions that are required for a parking management system. We have divided improvements into two categories, user side, and system side improvements.

## User side improvements

* Currently, users don't have instant notification alerts to inform them about the parking lot. Having a real-time notification system will be useful for the users to know about the status of the parking lot, and also alert them about unfortunate events like theft.
* Another feature that will improve the quality of service is to enable a booking option, this will give peace of mind for a user who wants to reserve in advance.

## System side improvements

* When the system collects enough data about patterns of availability thought-out a week demand-based pricing can be applied to parking spots at prime times. This has proven to evenly distribute the congestion and also reduce circling time while searching for parking [4].
* If the data proves that the parking garage is full most of the time, it can be used to determine the expansion plan of these parking garages.

# Conclusion

In this article, we discussed the issues plaguing the existing parking system. Then, we analyzed how to use the latest developments in the Internet of Things (IoT) and smartphones to build a better parking management system.

We proposed a four-part architecture, namely a sensor module, a processing module, a cloud module, and a user module, and detailed the working methods of each module. Then, discuss the accuracy and other complications that may occur when implementing the proposed system.

Finally, we discussed future improvements that can be made to the proposed system that will increase efficiency and make it more reliable.

# References

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