**Constructive Investigation with IoT: Case of Smart Parking**

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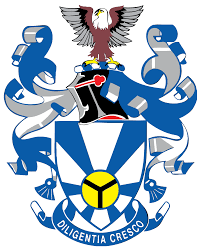
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**Abstract**

This paper aims to clearly show the development of the project using the Project Based Learning (PBL) principles and will describe the use and constructive investigation of the embedded system for smart car parking. The system can be used for booking for parking lots where the data will be stored on a database to be analyzed in real time for better optimization. The proposed project is divided into two parts using the principles of PBL. Part one is based on the hardware, where formation of the circuits takes place using suitable components (sensors, breadboards, etc.) in order to collect data that will be monitored. For part two, focuses on outcome of the prototype demonstration using the concepts of the Internet of Things.

**Keywords**: Internet of things, constructive investigation, Project Based Learning.

**Introduction**

The Project Based Learning (PBL) is a method/approach where students learn by actively engaging in real-world problems to determe how to address them and gather solutions cooperatively [1].

Using the principles of PBL as the guiding reference in engaging on the IoT project, which is meant to contribute to the constructive investigation [2] in the technical domain of methodologies and to the formation of the new form of teaching/learning, which can be collectively constructed, updated and reformulated.

With the high percentage of vehicles ownership that seem to keep increasing, parking or finding a parking slot in metropolitan areas has become a conflicting and frustrating situation for many people.

Whether one is at an airport, shopping malls, and bus stations, problems of finding a secure parking are daily struggle to any driver. A recent study shows that any random driver will take about 8 minutes to park his vehicle because of spending more time searching for a parking slot, which leads to 30 to 40% of traffic congestion. The lack of good parking can hurt local businesses and decrease the quality of life for residents. Due to the need of the parking, many cities have observed and analyze parking programs. The following shows few or many reasons of problems that normally occur in a community:

* **Not enough information for motorists:** on whether parking is available or not and how costly it is. Vehicle owner always get frustrated by expecting abundant and unoccupied parking slots find limited or expensive parking, or by wasting a lot of time trying to find a parking slot.
* **Excessive vehicle use:** creates many problems on society as the number of people owning vehicle increase yearly. The greater number of vehicles the greater the costs of residential parking and increases accident risks. External costs include increased road and parking facility costs, congestion, accident damages, and environmental degradation.
* **Inefficient use of existing parking capacity:** Local zoning ordinances, building codes, and other development practice can create an oversupply of parking spaces.
* **Demand for handicapped parking slots:** These type of lots are found in both garages and surface lots, as nearer to access ramps and curbs as possible.
* **Low parking turnover rate:** This usually occurs when vehicles are parked in the same space/lot for at least 4 hours (on average).
* **Insufficient parking at event site:** Special events can disturb normal traffic flow and require crowd management. Every event can create its own transportation issues.
* **Inconvenient parking options:** Parking within a reasonable walking distance is hard to allocate during busy times especially at the end of the month.

The above scenarios can lead to high damages and losses, Thus the use of smart parking with alleviate this problems by assisting vehicle drivers to give them enough information about parking lots before they even leave their homes [4], be able to book for a parking lot before getting there, get premium privileges for regular customers, park your vehicle at a safe smart parking zones.

The Internet of Things (IoT) is the computing concept which describes the idea of everyday physical objects being connected to the internet and being able to communicate and also to identify themselves to other devices in order to store a huge amount of data in the Cloud, where once they are processed and analyzed they produce information and service on a big scale [5].

This paper shows the objectives of finding a solution to this problem at hand, thus making smart parking monitored in real time, and a mobile application for booking for parking lots by using project-based learning principles.

The Arduino Ethernet Shield allows an Arduino board to connect to the internet. It is based on the Wiznet W5100 ethernet chip providing a network (IP) stack capable of both TCP and UDP [6]. It supports up to four simultaneous socket connection. The ethernet library is used to write sketches which connect to the internet using the shield [7].

For the safe booking of parking lots, the use of real Ultra Sonic sensors HC-SR04 to detect vehicles and the use of servo motor for entrance and exit. The sensors are connected to the Arduino boards and Ethernet Shield, which will connect to the database to save data for later consumption [8]. The system also has a mobile app which will be used for booking parking lot and to communicate with the users.

**Bibliographic Review**

The Ethernet Shield is an ideal microcontroller for IoT applications. It looks like an Arduino board and is connected on top of the Arduino board. A software was developed to make looking for a parking lot easier than it is now. If there is no car parked in any parking lot, the green LED is lit as a sign for a “free parking lot”. If a red LED is lit, the parking lot has a vehicle in it which indicates that it is “occupied”. When all parking lots are occupied, no car should pass through the entrance [9]. Each vehicle detail that uses our system will be stored on the database Firebase.

In some study [10], the writers proposed a new algorithm for treatment planning in real-time parking as a solution. What they did first, the chose to use an algorithm to schedule the online problem of a parking system into an offline problem. Next, a linear problem of a mathematical model describing the offline problem. Lastly, they designed an algorithm to solve the linear problem. Then evaluated the proposed algorithm experimental simulation of the system. The results showed timely and efficient performance. But this paper failed to mention the resource reservation mechanism, the mechanism for accessing and interacting with the system, the mechanism to guide the vehicle to the parking space, the mechanism for dealing with the with situations when the request for service is denied and when it is accepted. Also, the calculation of the average time for waiting and the average total time that each vehicle spends on the system was not clearly specified.

Another study [11] was aimed to automate the car and the car parking. The paper discusses a project which presents a miniature model of an automated car parking system that can regulate and manage the number of cars that can be parked in a given area at a given time based on the availability of the parking slots. This automated parking system allows the parking and exiting of vehicles using sensing devices. The only short-coming with this system is the lack information a driver needs to know whether there is a parking lot available or not, for how long before even gets to the parking slots.

The present project (Smart Parking System) [12] proposes a solution in low effective cost using the microcontroller Ethernet Shield that costs in the market around R 210, 00 ZAR in 2019. The data is sent via ethernet cables to a database. The use of the Wi-Fi network allows the system application to be installed in places where the Wi-Fi network is already available, thus being a project with low complexity of installation and maintenance.

**Systems Architecture and Operation**

**Hardware and software components:**

**Arduino microcontroller** it is a physical programmable circuit board, used to send programmable commands to physical entities like ultra-sonic sensors to achieve a certain task.

**Arduino IDE** is a cross-platform application that is written in the programming language Java, C, C++. It also supplies a software library that the wiring project, which contain many common input and output procedure.

**Android Studio** is the official integrated development environment for android application development.

**Arduino Ethernet Shield** It is the device that allows an Arduino board to connect to the internet.

**Ultrasonic Sensors** is a device that can measure the distance to an object by using sound waves.

**Servo Motor** it’s a rotary motor that allows for a precise control in terms of angular position, acceleration and velocity.

**LED and Resistors** the logic behind the LED’s is that it will go red as soon as the parking is booked indicating an occupied slot. If the parking slot is unoccupied, the LED turns green indicating a free/unoccupied slot. The resistor is used to control the flow of current.

The instrumental part of the project is the designing and implementation of a backend hardware. This system will undertake the task of:

* Checking to see which parking lots are vacant and book them.
* Identifying vehicle at the entrance
* Generate security codes to be sent to user and parking lot
* Mapping parking slots against vehicle
* Mapping verification code against user and parking lot
* Store the data in a database and keep updating the database

The whole entire system of a smart parking lots was scaled down to accommodate real-time simulation.

The hardware prototype provides back-end hardware support for users to book and access a parking slot. The algorithm was fine-tuned to reduce run time to an absolute minimum, making the user experience a smooth and fast as possible. To book for a parking lot, the system conducts 4 steps process as follows:

* Read data from the sensors
* Save data on database
* Check conditions of all parking lots
* Book for an available parking lot
* Generate a random password
* Match input of password to open gate in front of parking

**Application’s Features**

Find the closest parking slot from the user’s current location in terms of distance and travel time.Guide vehicle to the nearby parking slot through the shortest possible path considering travel time as the primary factor and further optimized by the number of turns in route, real time traffic and some other parameters.

Reserve a parking slot for the user and display the time to reach that spot. On exceeding the time limit let the user know that the booking has been cancelled and ask if he wants to make another request.Forward the user to another slot if available if he makes another request. Store user’s subscription history.Store frequently used parking slot under the tab called “Premium Users”.

**Database Design**

Here we make use of the Google’s Firebase Database as the main database for the application. Advantages of Firebase:

* **Real-time:** Instead of typical HTTP requests, the Firebase Real-time Database uses data synchronization. Every time data changes, any connected device receives that update within milliseconds. It provides collaborative and immersive experience without thinking about network code.

* **Offline:** Firebase apps remain responsive even when offline because the Firebase Real-time Database SDK persists your data to disk. Once connectivity is reestablished, the client device receives any changes it missed, synchronizing it with the current server state.
* **Accessible from Client Devices:** The Firebase Real-time Database can be accessed directly from a mobile device or web browser; there’s no need for an application server. Security and data validation are available through the Firebase Real-time Database Security rules, expression-based rules that are executed when data is read or written.

**Limitations**

A real working prototype is created but we need much more time to make it deliverable.

Thus, for now we are following any ideal structure or model. The hardware part was implemented with Arduino which has a very limited amount of ram and motivated us to think critically to make the project work. As for now the project covers a smaller span of people for ideal scenario and therefore Arduino is working fine in here, but soon, the app will have to cover a wider group of people with much more complex scenario will need a more stable system like Raspberry Pi. Firebase being a database platform is good for certain amount of data handling. Massive data handling may result in a cumbersome scenario. But we shall make it robust soon with a dedicated database. The data request and data retrieval system are conducted among the app, the Arduino and the database which may make the processor a little bit slower. As a student I lacked knowledge of cloud system beforehand. As a result, we learnt about the system and then go to work.

A transaction system could have been implemented with PayPal API which is at present, is not included.

**Future Work**

Multi-Platform application, the project is currently an android-platform mobile application.

It can be rebuilt in a multi-platform structure so that windows and iPhone users can also use this app. Data Size, with more time, the database handling features will improve and with premium database, the application will be able to provide more edgy service. Car Application**,** soon with enough modifications, we can build up an application suitable for every vehicle available in the world. Walkthrough**,** someone with no prior knowledge of booking a parking lot might be interested in the application, thus snapshots and sequential steps on how to use the app will be included in the system. Simultaneous Access, the application is in the prototype version. As a result, it might fail to handle many users at the same time. Handling more users at the same time is what we strive to achieve soon. Security,we are currently using basic security protocols for the application and the cloud database. But when the application is considered for real life implementation, more advanced security measures will be used or considered. Feedback, initially we will take feedback from the users in old fashioned way. Live conversations feature can be incorporated into the application

**Conclusions**

The ease of parking system is quite a challenge in modern days. Since the advent of industrialized cities, the number of vehicles has been increasing and day by day people are bigger problems while trying to manage their vehicles into parking lots. Such scenario of parking crisis gives rise to new solutions with the of Internet of Things (IoT), thus managing car parking systems especially in this fourth industrial revolution era. This paper addresses this crisis of vehicle parking across any remote city and comes out with an IoT based assistant mobile application system.

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