**PROJECT REPORT**

Summary

The Internet of Things has the ability to connect physical sensors, actuators and edge devices to form an interconnected network and allow those devices to collect and exchange information. Therefore, IoT can be used in many applications to automate tasks, reduce cost and improve performance for those services. One of those applications that could be improved by IoT is parking services. Traditional parking services requires manual labour such as parking lot attendants to manually manage customers, collect fees and open the gate for the drivers; moreover, the customers also has to spend much time to find an available parking space when the parking lot is crowded. For this reason, this report will propose an IoT-enabled Smart Parking System that use sensors to automatically manage customers, monitor entries to the parking space and track the number of available parking slots without the need of human labour. Moreover, the system also comes with a web-based interface that allows the manager to see the customer list, analyze collected data, change the passcode for the parking space and interact with the physical devices in real time.

In particular, the proposed system consists of 2 components: hardware and software. The hardware component include a microcontroller, an edge device, multiple physical sensors, and actuators while the software component includes a web-based user interface as well as a database to store and analyze the collected data. The microcontroller is the central of the hardware component as it connects both the physical sensors and the edge device installed on a virtual machine. In terms of hardware, this system consists of multiple sensors and actuators including an ultrasonic sensor to detect a vehicle, a RFID reader to read the customer’s information on the mifare card, a **flame sensors to detect fire**, a LCD screen to display the number of available parking space, and finally a servomotor to control the gate. Next, the software component includes a MySQL database that stores the customer information as well as the entries to the parking space. Moreover, the edge device also host a simple website interface for the manager to see the collected data, change the password for the gate and interact with the physical gate in real time.

The proposed solution can brings many benefits as it can operate without human labour and therefore, reduce cost and improve efficiency. Moreover, the system also make the parking process more convenient for the customers. When a driver want to use the parking lots, they just needs to put his Mifare card on top of the RFID reader. If the Mifare card has the correct password, the gate will be automatically open and allows the driver to get inside. Furthermore, the customers can look at the LCD screen to see how many spaces are available before going inside parking lot.

Chart

Description automatically generated

# Conceptual Design

Diagram

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Overall, the proposed system can be divided into 2 main units: the hardware and the software component. The hardware consists of every physical devices including the microcontroller, the edge device, different sensors and actuators while the software part is made up of the web-based user interface and a MySQL database. In terms of the hardware component, the microcontroller is the central unit that connect all physical devices together. It can receive and process data collected from the physical sensors and control the actuators. Each sensors and actuators serve a purpose and have different functionalities:

* RFID Reader: This device can be used to read the data written on the customer’s Mifare card which include a customer ID and a string of characters that has to match the passcode of the gate.
* Ultrasonic Sensor: An ultrasonic sensor is installed at every parking slot to detect the presence of a vehicle in the parking space. By connecting to the sensors corresponding to the parking slots, the microcontroller can calculate the total number of free parking spaces and display it on the screen.
* LCD Screen: the screen is used to display the number of available parking slots in the area.
* Servomotor: the servomotor is used to control the gate of the parking space.

Besides the sensors and actuators, the microcontroller is also connected to an edge device via the serial communication. The functionality of the edge device is to received data sent by the microcontroller and organise the collected information into a database. Moreover, the edge device can also send a command back to the microcontroller to control the servomotor and open the gate. In addition, the edge device also host a web-based interface that can display and analyze relevant data from the database, change the password for the gate and allows the manager to open the physical gate via a button.

Next, we will look at the way the proposed solution actually works step by step and how physical devices interact with each other in more details. Below is the flowchart of the program installed on the microcontroller:

Diagram

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Firstly, the microcontroller read the ultrasonic sensors’ values to determine the number of available parking slots and display it to the LCD screen. Then, it reads from the serial line to check if the edge device has sent an “open” command, if that is the case, the microcontroller will control the servomotor to automatically open the gate. Especially, when the customer place their Mifare card on top of the RFID reader, the microcontroller will read the CustomerID and the password that was written on the card and send those data to the edge device. Here, the edge device will check the password written on the card against the password stored locally on the device. If the passwords matches, the edge device will send an “open” command to the arduino to open the gate and record the entry to the database. Finally, the whole process gets repeated again in a forever loop.

# Implementation

## Sensors

* Ultrasonic sensor: The sensor that is used in the prototype is the HC-SR04 module. The ultrasonic sensors are installed at every parking slots to detect the presense of a vehicle. As a result, the microcontroller can use this information to determine the total number of available parking slots at the current time. In particular, the ultrasonic sensor works by sending high frequency sound waves and wait for the waves to reach an object and bounce backs to the sensor. Then, the device can estimate the distance between the sensor and the object based on the amount of time for the waves to travel to the object and returns backs to the sensor. To connect the ultrasonic sensor to the microcontroller, we can connect the Trigger and Echo pins on the sensor to two digital pins on the arduino. The Trigger pin can be used to trigger the ultrasonic sound pulses and the Echo pin is used to detect when the bounced back waves returns.
* RFID reader and Mifare cards: In this application, we can use the RFID technology to verify the customer identity. When the customer registers for the parking space, they are provided with a Mifarecard that has a chip with the customer ID and a password written on it. When the customer wants to enter the parking lot, they just need to tap their Mifare card on a RFID reader. The RFID reader can read the data on the Mifare chip via wireless radio waves. If the password written on the Mifare card is correct, the microcontroller will open the gate and allows them to get inside. Notably, The RFID reader used in the prototype is the RFID-RC522 module which can be connected to the Arduino via SPI protocol.

## Actuators

* LCD Screen: The LCD screen is used to display the number of available parking slots for the customers. The prototype use the LCD1602 screen which can be easily connected to the arduino via an I2C module.
* Servomotor: In the proposed design ,a servomotor is used to control the gate for the parking lot. In particular, when the microcontroller receive the “open” command from the edge device, it will control the servomotor to open the gate for the customers. For the prototype, a 9G micro servomotor was chosen.

## Software/Libraries

* Web-based interface: The proposed solution also comes with a web-based user interface that allows the manager to see the the collected data and interact with the physical devices in real time. The backend of the website was written using Python Flask framework while the frontend is made up of HTML,CSS and Javascript code. When the manager go to the homepage, the website will display a list of customer as well as some analysis such as the number of entries to the parking lot in the last 7 days and the average number of entries per day. Moreover, the user can also change the password and remotely open the physical gate on the website using websocket. Furthermore, the application use multiple threads both run the website and listen to the serial line at the same time. Therefore, it can handles HTTP requests and receive data from the serial line at the same time. When the customer put their card on top of the reader, the microcontroller will send the data to the edge device. Here the edge device will check the password and send the “open” command back to the microcontroller if it is correct. In addition, the application also record the customer ID and the time when the customer enter the parking space into a database for analysis.
* MySQL: This application use a MySQL database to record the customers’ information as well as the entries to the parking lot. The database has 2 tables: Customer and Parking\_Entry. The first table record the customer ID, first name, last name, phone number, car model, and their plate, while the second table stores the time when a customer enter the parking lot and their customerID. Therefore, the application can use the Parking\_Entry table to calculate the number of entries in a day and do simple analysis such as finding the average daily usage.