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IOT BASED SMART PARKING WITH AUTOMATED LIGHTING

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ABSTRACT

As the world is changing with the advancements being made in Computer Technology, we are entering the new era of ubiquity dominated by Internet of Things. IoT is making quick advancements and is seeking everyone's attention. This trending technology is being employed in almost every field: Engineering, Medical, Business, Services, Transportation, Administration, etc. With the increase in population comes increase in number of vehicles on road which demands efficient and feasible Parking System- Parking Spaces that are Smart. Keeping in mind the overpopulation issues, and car parking problems we intend to design a model that demonstrates a Smart Parking System, using cloud to notify the administrator about vacancy, if any and also, to display the vacancies available to the customers, notifying them the total number of occupancies and vacancies inside the parking lot. Coming to the parking lots in apartments, shopping malls, offices, etc the parking is in the cellar. This demands continuous utilization of lighting system. Lights switched on for the whole day is not really a good idea keeping in mind the existing energy resources. Therefore we come up with the idea of automated lighting which switches on the lights only when a vehicle's presence is sensed. Hence combining Smart Parking with Automated Lighting is an efficient, feasible and convenient idea.

Keywords: *Smart Parking, Automation, Sensors, Microcontrollers, Cloud, Application*

I. INTRODUCTION

Internet of Things (IoT) is a networking of physical objects that contain electronics embedded within their architecture. They communicate and sense interactions between each other with respect to the external environment. IoT with the aid of internet helps to establish connectivity among devices and systems and makes automation easy.
With the increase in global population, comes an increase in use of vehicles for transportation. This demands parking spaces. Parking problems are common in most of the cities. It is quite frustrating and a time consuming activity for drivers to search for a vacant parking space in an area or parking lot without knowing the availability of parking space. This concern attracted strategic investments from industry sectors to boost parking revenues through technology-enabled solutions. The price for parking expansion is usually expensive or extremely high. Smart parking utilizes various technologies to efficiently manage a Parking Area. Moving towards the idea of Smart City, Smart Parking is a very good example where IoT and can be effectively used in our day to day life to provide different services. The idea of creating a Smart City is being accomplished with the emergence of the Internet of Things. Also in today's world, it is very important to address the ways to reduce power consumption keeping our energy resources in mind. Hence a Parking System with Reduced Power Consumption by Lights would prove to be a systemized, proper and effective Parking System.

The proposed model works on Arduino Uno and NodeMCU ESP8266. Ultrasonic sensors sense the presence of a car, and upload the data on the cloud. Then the administrator is notified about the total number of vacancies and occupancies in the lot. This helps to give the accurate data about the slots available in the parking lot. Automation of Lights in the Parking Area is facilitated by using the ultrasonic sensors that turn lights ON and OFF by calculating the distance when the car is in front of the sensor. The range of Ultrasonic Sensor being 2cm to 400cm which is enough to measure distance so that the availability of slot can be known. This availability is being published on cloud. The cloud we are using here is IBM Cloud. The Node-RED flow helps us in developing a website application for the Parking System. NodeMCU Board is the brain of the Parking System while Arduino Uno takes care of Light Automation. The two- Smart Parking and Light Automation are being implemented on two different boards. The reason being that is we want the status of availability of the slot to be displayed on web application so that the

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administrator can sit and monitor easily. The Automation of lights is for conserving energy and to have cost-effective bills. Automation is where things are connected in a way that they communicate through each other without the necessity of a network. A simple code fed in the board with necessary connections is enough for this Light Automation. Hence when these two ideas are clubbed up it makes a Simple Parking Lot a Smart Parking Lot. This model is designed especially for parking in Residential Apartments, Shopping Malls, Hospitals and Offices where parking is in Cellar and demands continuous use of lights in manual operation. However, when Automation comes into use it helps in reducing power consumption.

II. RELEVANT WORK

Dr. Antonio Carlos Bento in his paper "IoT: NodeMCU 12e X Arduino Uno, Results of an experimental and comparative survey" compares the two microcontroller boards- NodeMCU and Arduino Uno- their pros and cons, etc. The major difference being that Arduino Uno requires installation of new devices to connect to a network. NodeMCU on the other hand has direct connection to Wi-Fi. NodeMCU being more beneficial than Arduino- having many benefits beside this like decrease in size, increase in processing speed, operating voltages, Larger RAM, Flash Memory, etc. However Arduino has comparatively more number of pins and hence does not require Shield or Expansion Board for more connections [1].

A.K. Shrivastava et al. in "Distance Measurement of an Object or Obstacle by Ultrasound Sensors using P89C51RD2" made use of Ultrasonic Sensors for distance measurement as it was the cheapest solution and a Phillips P89C51RD2 microcontroller based system. They are versatile and useful for measurement in air and underwater. They are used to calculate distance indirectly from speed of sound in air and time taken for ways to travel, hit the object and return back to source [2].

Maher Hassan Kadhim in the paper, "Arduino Smart Parking Manage System based on Ultrasonic Internet of Things (IoT) Technologies" proposes the Smart Parking architecture. The flow of operation is registration, booking request, book parking and then park car. The proposed system improves the performance by decreasing the empty space in a parking, and also saving the fuel wasted in searching for a parking [3].

G. Revathi et al. in the paper "Smart Parking Systems and Sensors: A Survey" highlights a three-tiered functionality of a Parking System. They are named as Sensing functionality, Data Forwarding functionality and the Upper-tier Handling Data Storage, Processing and Client interfaces. Classification of Parking Systems is done as Centralized assisted search, Opportunistically Assisted, etc. Various technologies being used in Parking Systems are Ultrasonic Sensors, Passive Infra-Red Sensors, Electromagnetic Sensors, etc [4].

Yuvaraju M. et al. in his paper "IoT Based Vehicle Parking Place Detection using Arduino" presents a model that uses Infrared Sensors along with the Arduino and updating data to the cloud using GSM. Infrared Sensors are placed on slots which are connected to Arduino Board. The information is updated to GSM which gives user the information about the parking space availability. In the end the user has to make payment based on time for which the slot was occupied [5].

Aniket Gupta et al. in the paper, "Smart Car Parking Management System Using IoT" proposed a system that provides well-organized car parking management and analyzes spot localization. The reservation based car parking method has a limitation of space and time. This smart parking system provides free parking slot efficiently that saves time and fuel and reduces atmospheric pollution and congestion in cities. IOT based new Parking platform enables to connect, analyze and automate data gathered from devices, and execute efficiently that makes smart parking possible [6].

AbhirupKhanna et al. in the paper "IoT based Smart Parking System" emphasizes on the need for the IoT cloud integration, as IoT has witnessed a large evolution in the recent years. This paper presents an IoT based cloud integrated parking system that consists of on-site deployment of IoT module, which gives the availability of each slot along with a mobile application that helps the user check the availability and book a slot accordingly [7].

JatupornChinrungrueng et al. proposed the paper, "Smart Parking: an Application of optical Wireless Sensor Network" which demonstrates the development of wireless sensor network (WSN) for monitoring the traffic, and extending it to apply on the parking lots in order to know the count of vehicles present in, by installing sensor nodes at the entry and exit gates. The occupied or available slots are calculated and displayed to the driver, directing them to the nearest vacant slot available. All this is extended with an addition of transit based information, auto-parking and smart payment, and auto-parking to serve customer's various needs [8].

Rongxing Lu et al. in the paper "SPARK: A New VANET-based Smart Parking Scheme for Large Parking Lots" focuses on minimizing the hassle and inconvenience faced by the drivers, mainly during the rush hours. A parking scheme through vehicular communication for large parking lots has been proposed, to provide the drivers with real-time parking system with navigation service. It has been specially designed to provide an anti-theft and a friendly parking system. It can efficiently reduce the searching time delay and indirectly contribute to saving fuel too [9].

E. Cassin Thangam et al. proposed the paper, "Internet of Things (IoT) based Smart Parking Reservation System using Raspberry-Pi" aims on the issue faced by the people for finding parking space. It is making use of Raspberry-Pi. It gives a solution to the traffic congestion and makes it easy to get a parking slot. If a space is vacant, it will be denoted by a green light whereas an occupied position could be denoted by a red light. This makes the entry of the car in the parking slot quite easier once a vehicle enters into the slot, the drivers face is scrutinized and identity has to be verified [10].

R. Subhash et al. in the paper "IoT Based Smart Parking System" proposed a Parking System integrated which makes use of Cloud. The availability of parking slot is sent to cloud and a mobile app allows user to check the availability of space. This space can then be booked accordingly. The components used are Infrared, Passive Infrared, Ultrasonic Sensors and Raspberry Pi. The Programming Language used is Python and Arduino IDE software [11].

Basavaraju S R in his paper "Automatic Smart Parking System using Internet of Things (IOT)" presents a design of Parking System which is applicable for covered parks, open parks and street side parking. Raspberry-Pi is being used as microprocessor. Other components include Centralized Server, Image Capture, Navigation System, Display Device and User Device [12].

YacineAtif et al. proposed the paper "Internet of Things Approach to Cloud-Based Smart Car Parking" outlines the agenda to enable value added services to parking systems. This work contributes to finding the most mutually beneficial paths when entering and exiting parking. Such a system helps in reducing the search time as well as reduces the fuel wastage. It uses embedded wireless sensor networks to connect physical parking space infrastructures with information and communication technologies, where cloud-based smart management services are provided [13].

Ms. M KoKilavani et al. in their paper "Smart Street Lightning System Using IoT" describes about the smart street light system. The smart light system by detecting the movements of objects on the street automatically turn ON and OFF the light, thereby reducing the energy consumption. This paper throws light on how energy consumption can be reduced by installing smart street light controller on the light pole, and the data collected by the sensors associated is transferred to base station [14].

TanujaMagan et al. in their paper "Smart Lightning in Street Lights Based on IOT" emphasize on reducing the power consumption by the street lights. It put forwards the statistics on how the conventional system is having a bad impact on society and thereby provides a smart solution by describing a Smart street lightning system which is envisaged to cut down the cost of the conventional system by 50-60% and thereby adding to the improvement of economy. This system is equipped with a strategy by sending the message to the street light management department if any fault occurs, which helps in minimizing the road accidents [15].

ChetnaBadgaiyan et al. in their paper "Smart Street Lightning System" describes a strategy where, a sensor array(consisting of different sensors) collect the information of vehicles, pedestrians and is passed to control terminals to check for the status of lights and take appropriate actions. It focuses on providing a scheme which aim to reduce the human error in operating the street light by means of wireless technologies. The system is intended to lower the power consumption by addressing the sleep modes of the devices connected [16].

PrashanthKeni et al. in their paper "Automated Street Lighting System using IoT" put forward theidea of reducing power consumption using Automated Lighting. They provided a smart solution which works on 3 states OFF mode, Active mode, ON mode. It uses solar panels of 10 watts for converting the sunlight into electrical energy, which results in the decrement of power consumption [17].

SnehalBhosale et al. in their paper "IoT Based Dynamic Control of Street Lights for Smart City" emphasize on designing smart lighting system which is scalable, expandable. This system additionally provides a client - server mechanism that facilitates a user to interact with web application to monitor the status of street light. The goal is to control the machine from human end along with the feedbacks (sensor data) obtained from sensors. The system proposed, works by utilizing the solar energy. The panel gets charged in the morning and automatically get into ON state when encounters darkness [18].

VismitaKolvekar et al. in their paper "Intelligent Automatic Street Light Control System" employ the use of Light Dependent Resistor (LDR) and Infrared (IR) Sensors with Raspberry Pi. The street lights get switched on during night when LDR sensors detect absence of light. They are switched off in day. The lights also get switched on when IR sensor detects any motion. Raspberry Pi acts as brain to control the Parking System which uses Python for Coding [19].

Prakash et al. in their paper "Internet of Things Based Intelligent Street Lighting System for Smart City" emphasize on reducing the power consumption. The micro controllers, sensors and wireless modules are to be installed on pole lights which control the LED street lighting depending on the sensor data. This system use LDR's whose resistance is inversely proportional to the light falling on it. The system proposed is cost efficient, eco friendly solution, where information can be accessed from anytime and anywhere [20].

III. PROPOSED ARCHITECTURE

The proposed architecture consists basically of the following layers:
The first layer of architecture is the sensing layer. In the sensing layer, we have 3 ultrasonic sensors (2 for Smart Parking and 1 for Light Automation). The microcontroller calculates the effective distance when the code is uploaded into the board which serves the purpose of the sensed data which is further pushed on the next layer.
In the next layer, we use Wi-Fi or Mobile Hotspot for communication.

In the next layer, we publish the data on the cloud using MQTT protocol because it is envisaged of providing better services, as the published data is automatically updated which is reflected on the web/desktop application we provide.

Finally in the last layer the status of the parking slot is given on the Web Application.
For the Light Automation, the microcontroller sends a logic 1 signal to the LED depending on the entry of the car and the LED switches ON else it remains OFF.

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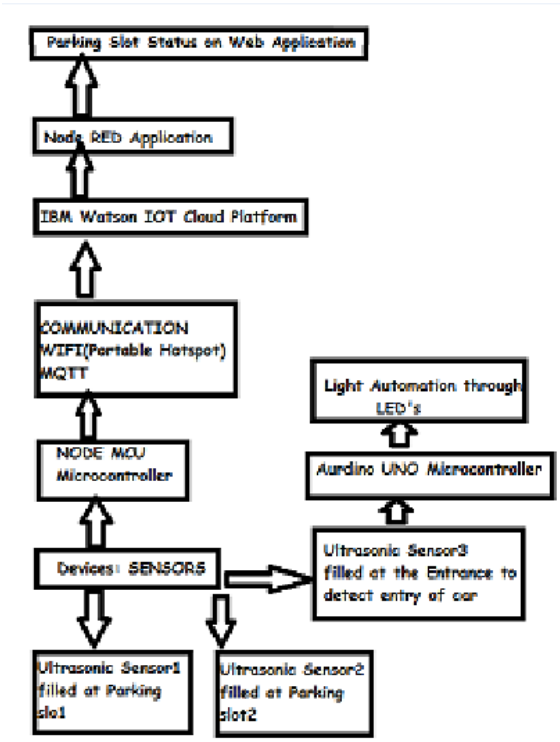
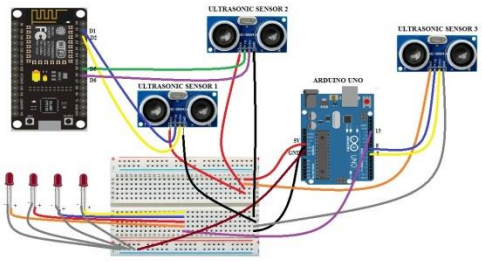
The architecture is summarized in Figure 1.
Figure 1:



Proposed Architecture: Smart Parking System with Automated Lighting

IV. DISCUSSION

The connections for the demonstration are shown below in the figure:
Figure 2:



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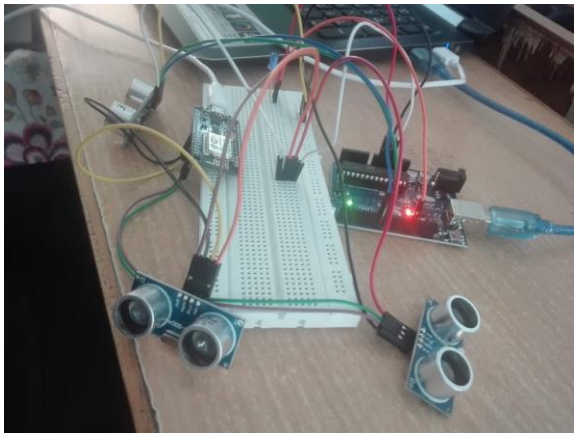


IoT Based Smart Parking System with Automated Lighting Connections

Ultrasonic Sensor: It uses SONAR (SOund Navigation And Ranging). It has a transmitter and receiver within it. A square pulse is transmitted in the surrounding. When the pulse encounters an object, it gets reverted, which is received by receiver in sensor and is acknowledged at echo pin.

Working Principle of Ultrasonic Sensors: The time taken by the square pulse generated by transmitter to return back to the sensor, is calculated by the function pulseIn().

Distance = Speed of sound (340m/s)*(time/2). Here time calculated, is the time to travel from the sensor to obstacle and back to sensor (hence it is divided by 2).

We use 3 Ultrasonic sensors of which 2 sensors are used to smart parking system and 1 for the automated lighting system.

In smart parking system, when the car is at a distance of 8cm and more, the status shown is vacant. When the car is parked the parking slot, the distance is less than 8 cm, which shows, the status as occupied.

In automated lighting system, when the presence of car is sensed, the sensed data results in the computation of distance and the actuator used here is the LED which glows.

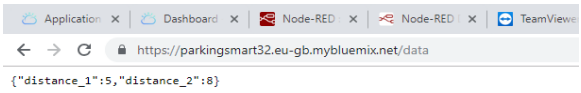
LEDS: Whenever presence of a car is sensed the LEDs get switched ON for a while and then get switched OFF.
Arduino Uno: The Arduino Uno Microcontroller runs the code for Automated Lighting. The distance is calculated indirectly from the Ultrasonic Sensor data (Sensor present at the entrance of Parking Area). Depending on this distance lights(LEDs) are switched ON and OFF.

NodeMCU ESP8266: The code for implementation is written in Arduino IDE where the code is written and uploaded. The code for Smart Parking System is uploaded in the NodeMCU board. Ultrasonic sensors are fixed on walls of the parking slot. Whenever a car is present in a parking slot, the distance between the car and the sensor is quite very small say maximum about 10cm. Similarly when a car is not present the distance calculated in the code will be more than 10cm and this implies that the slot is vacant. This distance is hence the parameter to determine the status of the parking slot and hence this is published on the Cloud-IBM Bluemix. The reason why the Arduino is not being used for implementing this is-Arduino Uno does not have a built in Wi-Fi module and hence requires an external device to connect to a network which increases its cost. NodeMCU on the other hand has a built in Wi-Fi Module and is also inexpensive.

IBM Bluemix: It is a cloud platform developed by IBM. It is a cloud Platform as a service(PaaS). It provides a platform to develop IOT applications-the IBM Watson IoT platform and a very efficient programming tool- Node-

RED. NodeMCU is connected to the IBM Cloud that sends and receives data.

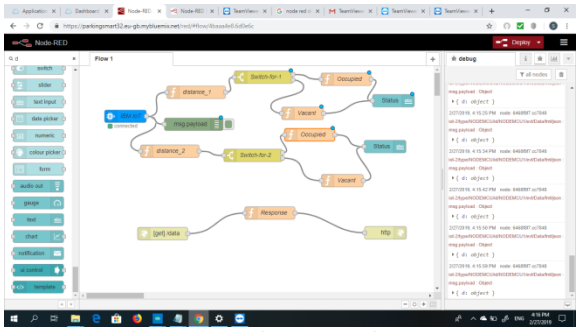
Figure 3:



Distance values being published on the IBM Cloud

Node-RED Flow Editor: It is a tool for visual programming. It is used to connect hardware devices and online services. It uses JavaScript and makes use of JSON objects. It provides different functionalities in the form of nodes. Through JSON parsing data(values of distances) is receivedfrom the device. Switch nodes are used to select the status of parking slots using the distances obtained and comparing them with a value of maximum distance given. The UI text node publishes the data on the web application when the flow is successfully deployed.
Figure 4 gives the final view of the Node-RED flow for Smart Parking System.

Figure 4:



The Final View of Node-RED flow editor for Smart Parking System

MQTT (Message Queuing Telemetry Transport): The
MQTT protocol is based on Publisher-Subscriber model. It is preferred over http as in MQTT it is not necessary to make request whenever a change is made in the data unlike http. To manage connection and data between publisher-subscriber we require a Broker. The IBM Bluemix cloud is the Broker being used here. Web Application uses this protocol.

V. RESULTS AND CONCLUSION

The project as planned, gives the data of the parking slots, using 2 ultrasonic sensors for two parking slots. First, it senses the closeness of the car with the individual sensor. When the car is within 6-7 cm range of the sensor, it shows occupied since the slot is in use. If not, then it shows vacant. This data is successfully uploaded to the cloud, and the administrator can easily access it knowing the status of the slots. The data of each slot is given separately on the cloud, so we can know the status of the slots individually. Apart from this, the third sensor senses the presence of the car nearby and switches on the lights of that particular area. Hence, we achieve smart parking and automated lighting to save fuel, time and energy resources contributing to a healthy and a better environment.

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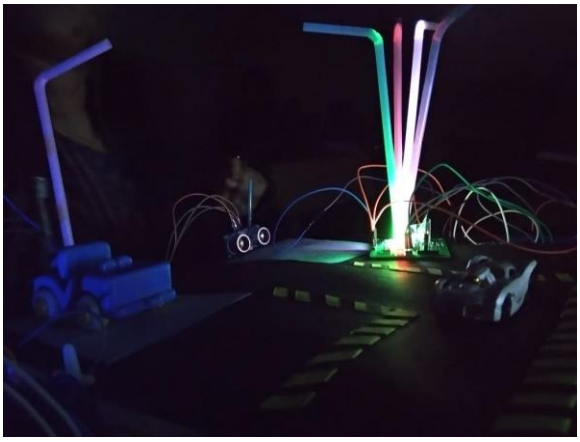
The entire project is demonstrated in Figure 5, which implements Smart parking with Automated Lighting.

Demonstration of the Light Automation is shown in the Figure 6. When a car passes by the third sensor, lights of that area are switched ON for a period of time. As the car moves away, lights automatically switch OFF.

Figure 5:

Smart Parking with Automated Lighting Demonstration Setup

Figure 6:



Automated Lighting Demonstration

Figure 7 shows both the slots are empty, and not occupied. The sensors sense that no car is present in front of it and result on the web application is given as both Slot1 and Slot 2 are vacant as shown in Figure 8.

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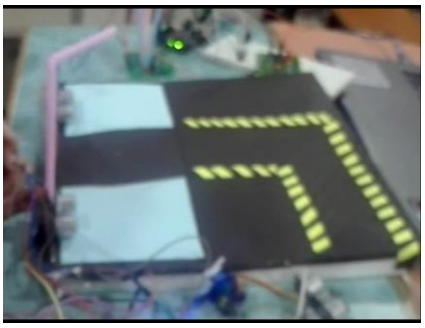
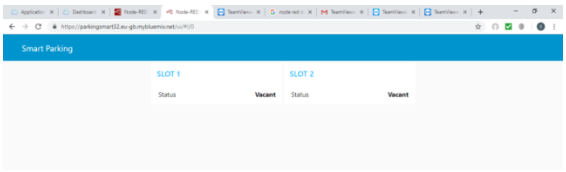
Figure 7:



No cars present in either of the parking slots

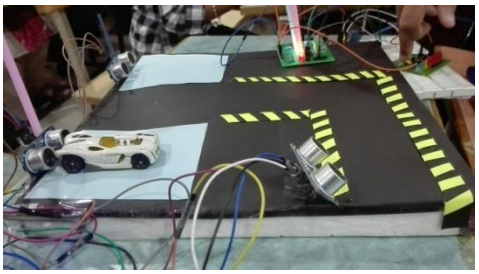
Figure 8:



Status shown on Web Application: Slot 1 and Slot 2 are Vacant

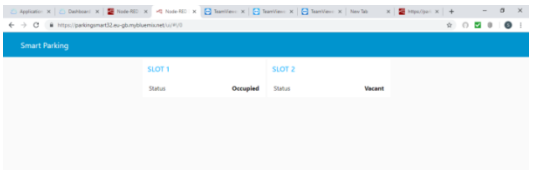
Figure 9 demonstrates one slot being vacant and the other occupied. When the slot1 sensor senses the presence of a car, it shows occupied for that slot on Web Application as shown in Figure 10. The other sensor detects no presence and hence shows vacant.

Figure 9:



Car present in Parking Slot 1

Figure 10:



Status on Web Application as per Figure 9

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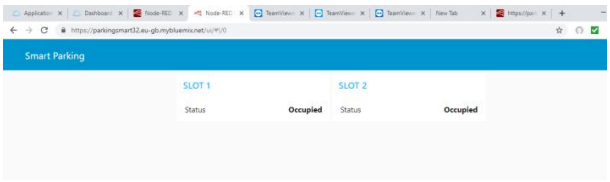
Figure 11 shows cars parked in both the slots, the sensors detect their presence and upload the data as occupied on the WebApplication as in Figure 12. With this, the administrator gets the information that his parking lot is completely full.

Figure 11:

Cars parked in Slot 1and Slot 2

Figure 12:



Status on Web Application as per Figure 11

VI. CONCLUSION AND FUTURE WORK

To make the project better and more efficient, we plan to add a Servo Motor at the entrance of the gate, along with an ultrasonic sensor. This sensor senses the presence of the car at the entrance, and will allow the servo motor to open only if any one or both the slots are vacant. When a car is at the entrance, and both slots are full, the servo motor doesn't function and will not allow the car to enter in the parking slot. This will reduce the time wasted for searching a slot when there is no empty slot available, and will direct the driver to go to another parking area.

Furthermore, we can add more lights and sensors to light the parking lot when the car is sensed in different places inside the lot. This is when we aim for large lots with more space and slots.

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