An IoT based Smart Parking System

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Abstract: **An emerging widely used technology cloud computing which a paddle of computing resources is available for the users. Through internet based the resources could be supplied to cloud consumers on their request. An emerging technique or Internet of things, in short IOT is a system which occupies the attention of researchers. IOT has the capability of transferring data via internetwork without requiring human to computer interaction or human to human interaction. Fog computing or fogging, is a scheme to use edge devices to transfer considerable amount of calculation, storing data, communication locally and routed via internet backbone. In fog computing model processing and data are concentrated on devices rather than cloud. For storage, communication and computation Fog computing appoint a scalable architecture. We have introduced in a smart IOT based parking system using cloud computing, fog computing and IOT. Nowadays, general parking car in a parking lodge is a problem that people are facing because they do not know where an available parking space has. So, we design a smart parking system. In this resource we also used IR obstacle sensor and HC-SR04 ultrasonic sensor. Vehicles are required to be detected and measured in distance within range of sensors. Ultrasonic sensor measures the distance from ground and select points of the vehicles. It is based on time measurement of ultrasonic pulse which is reflected after hitting an object. The IR obstacle sensor used or detecting car and ultrasonic sensor used for measuring the distance of the car. The generated data by sensors have been transfer database then to FOG followed by Cloud server to store the data, as cloud storage is being used for backup of database.**

Keywords: IOT, Android, FOG computing, Cloud computing, CupCarbon, Firebase, Parking System.

I. Introduction

A. Background

Nowadays in Bangladesh we have more vehicles than ever and it is increasing every day. So, the general people are facing several problems like road accident and traffic jams just because many people are parking their car in un-park able spaces on road. People are informed that there are available parking slots around their location but it is kind of troublesome for them to find a parking lodge in time. This created a problem for the availability of parking slots resulting in car parking anywhere. To succeed in dealing with the problem, unwanted gathered of vehicles on the street, we design a smart parking system. To implement the design and representing our proposed scheme, we are introducing IOT, sensor, Android app, cloud computing, fog computing and cupcarbon simulator. The IOT is a system that interconnects several devices using the internet. Using IR obstacle sensor to detect object and ultrasonic sensor to measure the distance of the object in embedded parking slot. Android studio is a Google integrated development environment that is used to develop application in which way it can be connected to the real-time database. These apps are used to communicate with Firebase which works as a database. Firebase real-time database is integrated with android studio where it can be easily accessed without any further implementation. It is a very efficient way to develop apps and connect via internet at the same time [19]. On the other hand, the smart parking systems which contain slots of various devices that are used for simultaneous communicate with the firebase database. This internet hosted data can be managed, stored and processed using cloud computing. It is essential for every IOT system to have a cloud computing system for storing data [10]. Also, a FOG computing is used for further efficiency in a data processing system [12]. As a result, the connection between Android based app, Firebase real-time database and devices in parking slots are highly interconnected which creates a zone of IOT system and store these data as back up in cloud storage. All these things we have visualized in cupcarbon simulator. Cupcarbon is a simulation tool and a wireless sensor network design. So, before developing our smart parking system design we implemented WSN because real implementation is expensive.

B. Motivation

In the present world, it is highly difficult to search for an available parking space in very busy time. To improve this inefficiency and to save time we have proposed a smart parking model in this paper. This will heavily beneficial for the people who are seeking for parking spaces and also reduce illegal car parking which can be caused to decrease traffic jams and road accidents [20]. Also, economically this will be beneficial for those who own the parking spaces and rent these spaces to the seeker.

C. Contribution

In this research work, for managing parking spaces IOT, cloud computing, fog computing is considered. Also for the visualization of the system a WSN simulator (cupcarbon) has been used. The new things we have used in research, Google drive as could storage and the visual assist of the cupcarbon simulator to get a clear vision of sensor's connectivity. This research work has proposed a different prospective of having Google drive as the cost free cloud storage where any developer can use it to store up to 15GBs.

II .Paper Organization

The organization of this paper is as follow: Methodology is described in section (IV), followed by result analysis in section (V). Finally, we concluded our paper in section (VI).

III. Related work

Yacine Atif: et.al [5], this paper has proposed defiance made by parking- interrelated difficulties rotate around seeking & paying for an available parking space. Here, IOT uses WSN to attach physical parking space framework, with PSP which is a smart organization service system. Basically the theme is exciting the parking space managing from a morally physical commercial to a business that converts parking toward a system of computerized service.

Dr Y Raghavender Rao [6], this paper has proposed an IOT based SPS system which is represented a monitor that can check the status of parking slots. Here's, vacant parking lots rejected by reserving the lots through the IOT system. Using Wi-Fi, Microcontroller, Microprocessors, (ESCP), and Sensors for made the project. Thus, the user consumes Wi-Fi usage by a continuous link of that specific parking zone through which the user can assume the access to the new webpage & can also know the slot availability.

Zhanlin Ji: et.al [7], they implemented their search with ultrasonic sensors. Also their architecture based on three-layer architecture.

Nawsheen Promy: et.al [8], proposed on smart android base arking system. Their research relies on smart phone that's why it is cost effective.

IV. Methodolody

To describe the working principle, we have proposed three-layer architecture to explain the interconnectivity of IOT, Fog computing and cloud computing [11] [2].

A. *Proposed Layers*

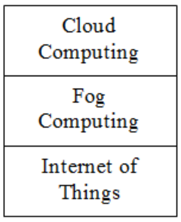

Figure 1 Three Layers Architecture

- *IOT layer*

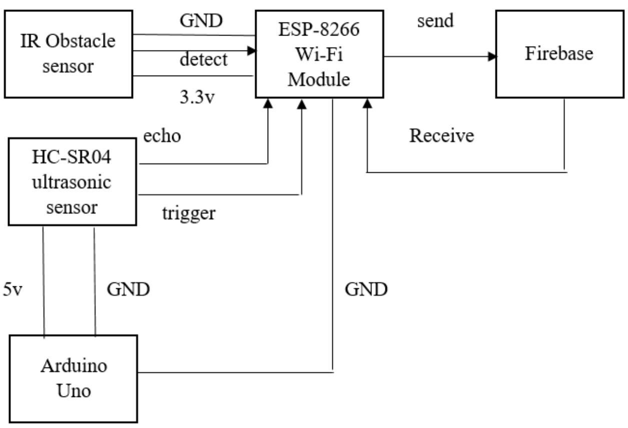

Figure 2 Sensor Connection & Interaction

This proposed Fig (2) explains the lower layer of proposed architecture in Fig (1). We have used two sensors IR obstacle detector for detecting any object within range of 7cm and Ultrasonic sensor to measure the distance up to 196cm [9]. The sensors are connected to ESP-8266 nodemcu V3 to transfer the generated data to the internet. Additionally, we have connected HC- SR04 ultrasonic sensor to VCC on 5v and with ground (GND), as ultrasonic sensors require 5v to work properly. IR obstacle sensor uses IR receiver and IR transmitter to detect any object that comes in range. Ultrasonic transmits waves from echo and trigger as receiver can receive these pulses to calculate the distance of that object. To calculate distance, follow equation is used:

$$\text{Distance} = (\text{duration}/2) / 29.1.$$

Here, duration is the travel time is divided by 2 for the departure and arrival of the sound and 29.1 is the sound of speed, where 343m/s = 0.0343 cm/uS = 1/29.1 cm/uS. These generated data can be showed on console in ESP-8266 and also can be transmitted to firebase. ESP can also receive data from firebase to follow different types of instructions and conditions.

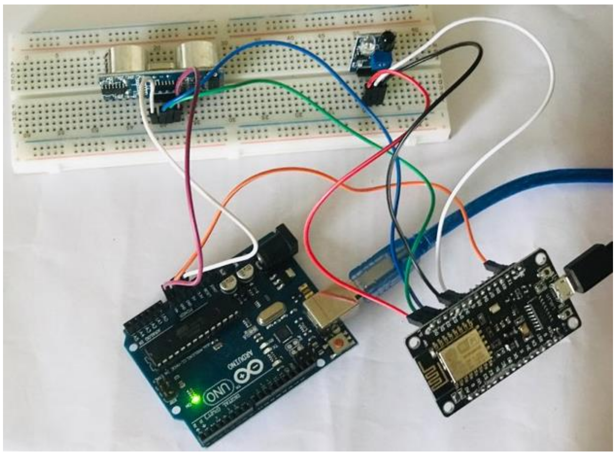

Figure 3 Connection between Arduino, ESP & sensors

We have applied the architecture of Fig (2) to connect and implement sensors using Arduino IDE. The proposed connection is showed in Fig (3).

- *FOG layer & Cloud layer*

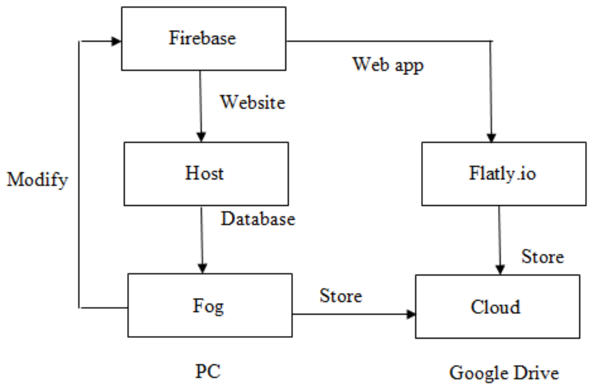

Figure 4 Uses of FOG & Cloud

According to Fig (2), the generated data can be stored in cloud server also it can be hosted by firebase itself and show database on PC browsers. We have used google drive as the cloud storage to store database in google drive. To connect firebase with cloud server have used a web app called

Flatly.io to convert the database in csv format and store that file on google drive. The web app automatically converts and sends the file drive within a scheduled time (1hour). Furthermore, we have used PC as the FOG node. The software required to host the site is called Node.js. It works to setup the command line-interface (CLI) to deploy html files to firebase host. The hosted website contains the whole database synced with the parking slot real-time firebase database; it can be displayed on PC browser where the synced database can be modified and also can manually store database in cloud drive by using JavaScript.

B. *Users Layers*

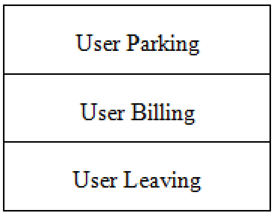

Figure 5 Three Steps of Users

- *User Parking*

User must register via app to login to view all the slots. After login app will get the location of the user using GPS and google map will load all the status of the parking slots from firebase. User can order to reserve a slot directly from the app. A small booking fee will be credited on the user's account. Followed by this action, the sensor embedded on that parking slot will be activated to wait and detect for the arrival of that vehicle [17] [18]. After detecting the vehicle sensors will constantly update the database on the current status [1].

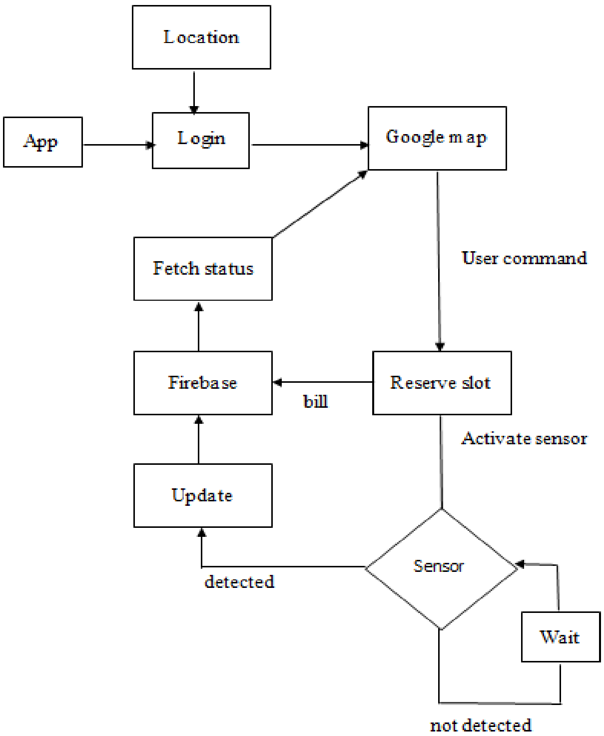

Figure 6 Parking Reservation

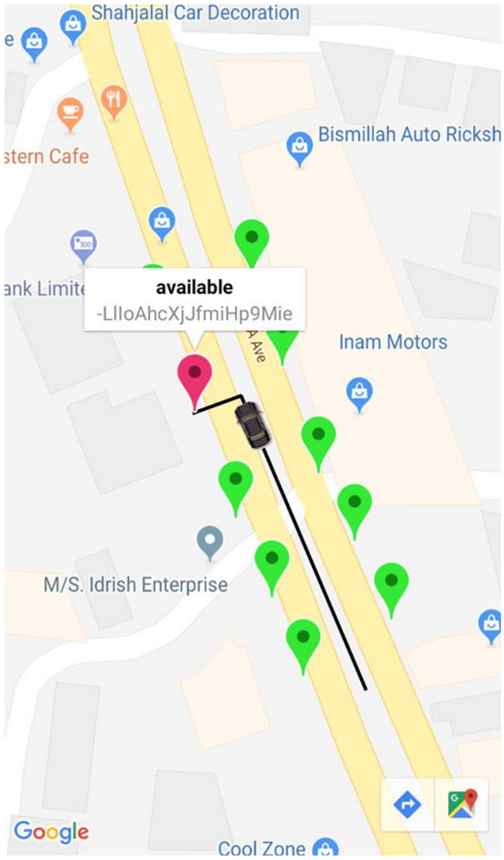

Figure 7 visual representations on booking a slot in app

Fig (7) represents the user interface of the app. After confirming a reservation on a slot a static animation will be provided to guide on that slot. A Google marker denoted as a slot contains visual information as well as showing color to represent availability. Green means available slot, red means selected slot and blue means unavailable slot. After logging in, the user will be redirected toward the parking spaces denoted in the map as a marker [15] [16]. There user can give order to book slots if the slot is available

Following algorithm is used to reserve a parking slot.

Algorithm 1 Booking a slot

Initialization:
1: P ⟵ parking slot from park's table
2: C ⟵ user car from user's table
3: **if** C is true **then**
4: print car already parked.
5: **else**
6: **if** P is true **then**
7: print parking slot is reserved.
8: **else**
9: store user ID on that slot. Reserve that slot
10: **end**

- *User Detecting & Billing*

Following algorithm is applied on sensor and used to detect and communicate with firebase.

Algorithm 2 Sensor Detection

LOOP:
1: I ← User ID from user’s table
2: N ← User Name from user’s table
3: IR ← Obstacle sensor
4: US ← Ultrasonic sensor
5: P ← Parking slot status
6: **if** I! =Null **then**
7: Activate IR; Activate US;
8: **fetch** P from firebase
9: **if** IR && US == true **then**
10: Car detected; Store N in P;
11: Increment bill over time;
12: **Go to** step 6
13: **else**
14: slot is not booked yet
15: **Go to** step 6

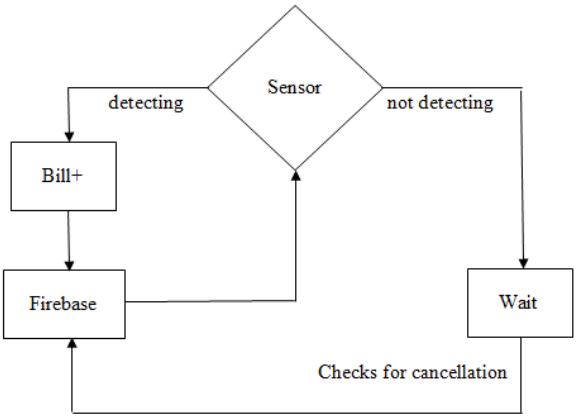

Figure 8 User Billing Systems

After activation of a sensor it waits for a detection of object shown in Fig (8), in this case a vehicle. An initial booking bill is applied to the user and when the user parks the car, the sensor detects and starts applying parking charge. When no vehicle is detected it waits for user cancellation of reserved booked slot which command will be given from the app.

- *User Leaving*

Following algorithm is used when user releases a slot.

Algorithm 3 leaving Park

Initialization:
1: P ← parking slot from park’s table
2: C ← user car from user’s table
3: I ← User ID from user’s table
4: N ← User Name from user’s table
5: **if** P is false **then**
6: Print user released this slot; Reset I & N from P.
7: Set C false in user table.
8: **else**
9: print parking slot is still reserved.
10: **end**

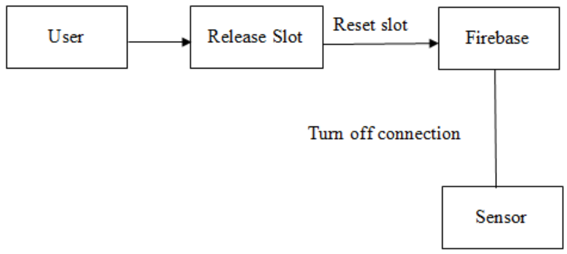

Figure 9 User Leaving Park

The sensors won’t stops charging until user releases the booked slot from the app. After confirming the release slot action, all attributes of the parking slot will be reset and sensors will become inactive by resetting user ID from the park’s table in database.

C. CupCarbon layer

Following algorithm is shows the intercommunication represented with cupcarbon.

Algorithm 4 Sensor Communication

LOOP:
1: Loop
2: C ← Car Detection
3: V ← Get Incoming IDs of activated sensors
4: ID ← IDs of sensors
5: Read V ←
6: **if** C is true **then**
7: **if** V! = ID
8: Mark the inactive sensors
9: **else**
10: all sensors are active
11: **else**
12: No detection
13: **Go to** step 5

In cupcarbon, all sensors are interconnected [14]. Sensors pass their IDs to next sensor when they are occupied. And eventually a sink is used to capture all the ID’s of occupied sensor. Now sink can tell a car which sensor is activated and which are inactivate [4]. The reason for serially communication in cupcarbon is for the sink node has a limited sensing range where it cannot get the ID of furthest sensor node [3]. Fig (10) shows the main cupcarbon interface. As we can set the radius of the sensor, here sensor 10’s radius is set to 15, as it is representing the purpose of ultrasonic sensor and obstacle sensor. Also a mobile is detected on sensor 9 which sends its ID to the next node 10 then to the sink node. Cupcarbon uses SenScript to create scripts to program sensing nodes. These scripts are implemented and embedded in every sensing node. By this it creates a wireless sensor network (WSN) in the whole parking slot. A script is implemented according to algorithm 4 and embedded to the sink node.

Figure 10 CupCarbon simulation

V. RESULT ANALYSIS

A. Billing analysis

We have proposed a billing system in our scheme. An initial booking free will is applied after reserving a slot followed by increasing that same amount after sensor detects a vehicle. Following steps are done in the sensors:

1. Initial amount after reservation, $5.
2. After Detection, initial amount + hourly payment.

ID	Name	Reservation	Vehicle	Bill
1	Nafee	yes	parked	$13
2	Nusrat	no	not parked	null
3	Shakil	yes	not parked	$5
4	Asif	yes	parked	$9

Table 1 User payment table

The further increment of bill is calculated directly on the sensors and transfers to firebase immediately which resulting a fair and accurate payment for the user.

B. Sensor analysis

We have embedded 10 sensors including the sink in cupcarbon to simulate and analyze the interconnectivity of sensor. We have added 3 mobiles (denoted by *) to be detected by 3 sensors. For the serially connected sensors, activated sensor will send the ID to next sensor and eventually the id will be added to the last node sink. Following table shows the final result of detected mobile in the sink in 11 steps:

	id1*	id2	id3	id4	id5*	id6	id7	id8	id9*	id10	sink
Step-1	S1				S5				S9		
Step-2	S1	S1			S5	S5			S9	S9	
Step-3	S1	S1	S1		S5	S5	S5		S9	S9	S9
Step-4	S1	S1	S1	S1	S5	S5	S5	S5	S9	S9	S9
Step-5	S1	S1	S1	S1	S1,S5	S5	S5	S5	S5, S9	S9	S9
Step-6	S1	S1	S1	S1	S1,S5	S1,S5	S5	S5	S5, S9	S5,S9	S9
Step-7	S1	S1	S1	S1	S1,S5	S1,S5	S1,S5	S5	S5, S9	S5,S9	S5,S9
Step-8	S1	S1	S1	S1	S1,S5	S1,S5	S1,S5	S1,S5	S5,S9	S5,S9	S5,S9
Step-9	S1	S1	S1	S1	S1,S5	S1,S5	S1,S5	S1,S5	S1,S5, S9	S5,S9	S5,S9
Step-10	S1	S1	S1	S1	S1,S5	S1,S5	S1,S5	S1,S5	S1,S5, S9	S1,S5, S9	S5,S9
Step-11	S1	S1	S1	S1	S1,S5	S1,S5	S1,S5	S1,S5	S1,S5, S9	S1,S5. S9	S1,S5, S9
Result	active	null	null	null	active	null	null	null	active	null	Id1, id5,id9

Table 2 Sensor intercommunication

By following the table (2), S1 is the detection signal of sensor 1 (id1), S5 is the detection signal of sensor 5 (id5) and s9 is the signal of sensor 9 (id9). Now, sink can tell which sensor is active and which are null or inactive.

VI. CONCLUSION

We have proposed an IOT based smart parking system using Android based app by using android studio, integrated with firebase real-time database. Hosted by firebase to PC as FOG computing and we have used Google drive as cloud storage. Generated data in sensors and connected them with firebase. In future, we will be providing security encryption in several phases in our proposed scheme.

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