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Cloud With Iot In Smart Parking

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Abstract: ***The notion of emerging smart cities integrated with internet of things and clouds to make data and service available everywhere helps to create a boon artefact which makes human life very easy.. Regarding smart cities flow of data after its generation and it manipulation to get a desired result is most important. This need can be easily fulfilled by the use of Internet of Things with clouds to perform data generation and information exchange (DGIE). IoT for smart city may include new generation devices such as smart phones, GSM and various sensors along with the available web services such as Google Firebase in order to promote internet-as-a-service. Applications precisely focusing on smart parking system implemented with Internet Of Things (IoT) ,clouds and web services has been proposed in the paper. Further, the system is also designed to create an application for a-priori booking of parking slot to reduce the hassle at parking areas. In addition, a theoretical comparison is presented to show various systems against various metrics.***

Keywords: ***Smart Parking, Raspberry pi, PIR motion sensor, cloud, web services, Internet of Things (IoT), Firebase, Twilio, Python, Android.***

I. INTRODUCTION

Urbanization with Information and Communications Technologies (ICT) have been evolving in the latest years. The technological advancement and the economic support over the years have greatly contributed to the development of urban areas. This lead to the fostering of urbanization which eventually which later caused serious problems in terms of environment and its resources.[13] Urbanization demands the need of energy, land, infrastructure, food and other resources to serve the urban population which may grow tremendously[28]. In this scenario, the concept of smart cities comes up, that is, cities able to solve urban issues while trying to save the environment. Smart city focuses on smart growth which implies a community-driven reaction to solve traffic congestion, school overcrowding, air pollution, loss of open space and skyrocketing public facilities cost.

A smart city is a dream to incorporate multiple information and communication technology (ICT) and Internet of Things (IoT) solutions in a secure way to manage a city's assets. Smart city helps in improving quality of life by means of urban informatics and technology to improve the efficiency of services and meet the crowd's needs. ICT allows the city population to interact with the community and city infrastructure, control city happenings, evolution of city and to get a better quality of life. Through the use of sensors integrated with real-time monitoring systems, data are collected from citizens and devices – then processed and analysed. The information and knowledge gathered are keys for tackling inefficiency. In this paper we focus on one important area that includes smart parking system.

In the existing parking systems, only the parking administrator has the knowledge about the parking spaces occupied or available at a point of time. It does not enable proper information exchanging for the drivers, thus is not the most efficient parking solution. A better solution here would be the use of smart sensors and some middleware software.

II. RELATED WORKS

The problem of parking is very ancient and to cure it various technologies has been developing from years. In the present date the implementation of smart parking system is done using various technologies including sensors, microprocessors, cameras and complex algorithms [1]. Some of those includes sensors such as RFID[27],PIR (Photo Infra-Red), UV(Ultra Violet Sensor), Magnetometer , Microwave Radar ,Piezoelectric sensor, Inductive loop detectors, Electromagnetic parking sensor and many more. Including these many systems also contains complex parking lot finding algorithms such as min-max detection algorithm [2]. Many systems have also developed to incorporate Centralized assisted parking search (CAPS) ,Non-assisted parking search (NAPS), Opportunistically assisted parking search (OAPS),

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Parking Guidance and Information System (PGIS),Car Park Occupancy Information System (COINS),Intelligent Parking Assist System (IPAS)
,Smart Payment System, Agent Based Guiding System (ABGS),Automated Parking[28] etc. All these systems focuses on creating an urban conceptual smart parking system.

III. DATA GENERATION AND FLOW BETWEEN IOT AND CLOUD

The major fashion of data generation and flow between the IoT sensors[14], mobile applications and the cloud is hybrid in nature. For an instance the raw data generating from the sensors can be uploaded to the cloud database which can be accessed directly by the mobile application as well as the web application used by the end user and the administrator respectively. Secondly, this type of flow also ensures data availability, prevents data congestion and helps in seamless working process.

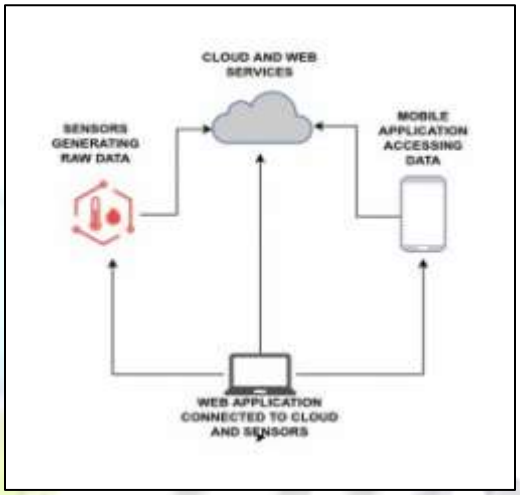

Fig. 1. Hybrid Connection in Smart City Data Flow

The data flow also includes some processes such as login, registration and booking of the parking slot. So the IoT continuously generates data which flows in the whole system either between the inter-connected sensors, applications and cloud or between the intra- connection between the various processes of the mobile and web application.

IV. MODEL OF THE PROPOSED SMART PARKING SYSTEM

The proposed system primarily focuses on the three main parts of smart parking system which includes a prior booking of parking slots using an end user mobile application, vehicle identification at the time of receipt of vehicle and accordingly calculate parking fine and push notification alert by using web services. Upon integration of all the three parts we are able to build a parking system which helps users to book their parking slot one hour prior to their reach and automatically generates a receipt of amount to be paid by their mobile application. Further, the notification service also helps user to get notified.

A. RASPBERRY PI BASED IOT IN PARKING SLOTS

A microcomputer with a Linux based operating system installed with various sensors such as PIR motion sensor and a pi-camera is used in parking slots to run the python scripts and collect the data using their GPIO pins. The GPIO pins operate in a high low state and all the 40 pins have various functionality. To get a medium amount of power supply 3.3volt power pin is used to intake of input voltage and other pins such as pin 11 and 13 are used to fetch the output

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data generated by the input given by the user via mobile application. This pin is also used to make the system respond. For instance the system here uses LEDs to indicate the state of parking slot. The state may be an empty one or full one. The state changes by the user input and slot availability. The blinking green LED ensures that the slot has been booked.

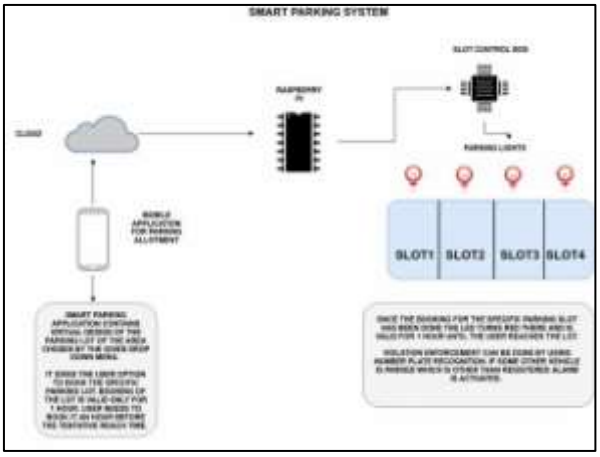

Fig. 2. Connection of Raspberry Pi and Parking Lights

B. PIR MOTION SENSOR AND RASPBERRY PI CAMERA TO DETECT VEHICLE AND GENERATE BILL

A photo infra-red motion sensor[4] responds by the changing heat of the near body. The sensor here operates to activate the camera at a particular distance to universalise the billing algorithm for every category of vehicle. This in turn also ensures the power efficiency of the system because the camera doesn't need to be kept on every time. The camera used here is a Raspberry-pi installed camera which detects the category of vehicle by calculating the dimension and in turn generate the bill. To implement the system for demonstration purpose this camera has been used. Otherwise a high resolution camera can also be used to get more precise results for calculating the dimensions and calculating bill amount.

C. WEB SERVICE AND CLOUD

For the experimental purpose we have used Google Firebase to implement the system and a twilio messaging and mailing API for push notification. The firebase cloud can be used for various uses but here it is basically used for data-base purpose and for creation of a shared variable which can be shared by the mobile application and the web application as well. Secondly, the database is also used to check the existing user account and generate bill for the particular user who registers and books slot.

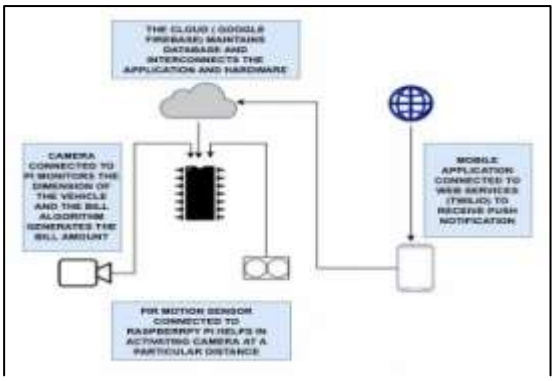

Fig. 3. Inter-Connection of Raspberry Pi,Motion sensor, camera and web services with mobile application

V. PROPOSED ALGORITHM FOR CALCULATION OF PARKING FINE AND NOTIFICATION SERVICE

STEP-BY-STEP PROCESS

The algorithm generally works in 4 basic steps which includes
1. Searching of parking slots in a particular area chosen by the user.[6]
2. Response of the IoT on choosing the slot.[5]
[6]. This also includes checking the free slot and resource allocation for reservation.[23]
3. Calculation of bill amount by using vehicle categories.
4. Push notification service using web services.

- Initialise the IoT and mobile application.
- Start monitoring data acquisition system.
- Activate the IoT if any valid input given by user.
- Calculate the bill amount

if some_vehicle passed : detected by motion sensor
Activate Camera
Take image : start image dimension analysis

if (dimension category = Small Vehicles)
bill_amount = x
else if (dimension_category = Large Vehicles)
bill_amount = y

- Send bill amount to user mobile application by using Firebase Cloud and a push notification such as text message.

This algorithm demonstrates the entire work of the IoT and the data flow using the clouds and web services. This algorithm is embedded in the form of a python script in the secondary memory of raspberry pi. The script uses some API such as PIL (Python Imaging Library), firebase API for cloud, twilio API for notification web services and some other packages which are open source. These scripts are kept in pi- secondary memory and used to run when the system is activated.[19]

IV. DIMENSION CALCULATION ALGORITHM

The system implements dimension calculation using PIL (Python Imaging Library)[30]. This includes series of image processing paradigms primarily by exploiting numpy python package and OpenCV[29]. NumPy gives fundamental operations for scientific computing. To get the dimension of the image we follow these following steps -

- PIL opens the image and NumPy converts it into numpy array
- Detect the image of the vehicle by assuming that every pixel has blue value larger than the median of all blue values.
- The next step includes calculation of rotated bounding box which finally gives the
- coordinates of all the corners of the image and in turn gives the height and width of the image.

Let the four corners be -
C1 (x1,y1) C2(x2,y2) C3 (x3,y3) C4(x4,y4) For reference x1=y1=0 , y2=x3=0

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C1 is (0 ,0) , C2 (x2,0) ,C3(0 ,y3), C4(x4,y4) Width = x2
Height= y3
x4 and y4 may arise some defeclection but can be ignored. If its deviation from x2 and y3 is more it can be normalised. Then the height and width can be calculated as -
Width = x4+x2/2 (mean) Height =y3+y4/2 (mean)

These normalised height and width can be used for exact calculation of the bill amount for parking. Further the bill algorithm proposed in section III is used to generate cost by making some category of vehicles.

V. "INTERNET OF THINGS" BASED EXPERIMENTAL SETUP

The basic experimental setup includes as Raspberry-pi microcomputer installed with a pi-camera, PIR motion sensor and 4 LEDs to indicate the state of the slot which may be empty or filled[11]. Secondly a user friendly mobile application is also demonstrated connected with Firebase database and Twilio web services. The first part is the hardware part which acts as a data acquisition unit upon getting connected by cloud database. This is done using python and cloud API (Application Programming Interfaces)[3]. Second part of the experimental setup includes the software which consists of end user mobile application[10] and administration website which is also in turn connected to cloud to fetch data.

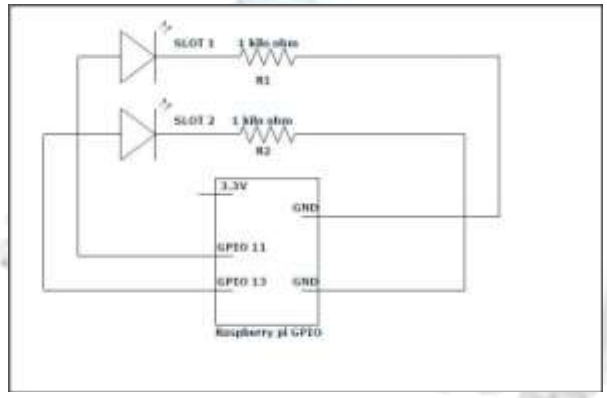

Fig. 4. Circuit Diagram of the interconnection of Pi and LED's

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Fig. 5. Mid-sized Raspberry Pi connected to pi camera

Fig. 6. Connection of LED's and PIR motion sensor

VI. RESULTS AND METRICS

RESULTS

The figure illustrates the system generating the output with a step by step working flow. The results are enlightened using android application and terminal of Raspberry-Pi and the background working code has been generated by using python and PHP. For the demonstration process the application contains only two slots.

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Fig. 7. Android Mobile Application

A comparison between existing systems and proposed system has been made on the grounds of various parameters such as cost, speed and performance, ease of access, scalability and heterogeneity. The proposed system is scalable because the services operates for more than expected number of users without degrading the performance. Secondly since the sensors, clouds,

and web services which belong to different genres, the system proves to maintain heterogeneity. Moreover the usage of APIs with python helps integrating thing in a better way. Table 1 gives a brief explanation of the metrics which has been used to compare.

VI. CONCLUSION

In this paper the design and implementation of a smart parking system has been demonstrated with usage of Internet Of Things, Clouds and Web services. It shows a prior booking of a parking slot with an added functionality of bill amount calculation using PIR sensor and camera image processing by dimension analysis using various libraries of python programming language. As compared to the current available systems this system is more robust, heterogeneous, scalable , fast and user friendly which removes one of the most important and deadly problem of today's smart cities which is parking problem. This in turn also reduces vehicle congestion and helps in establishing clean traffic. The implementation of cloud based IoT for parking has been highlighted in this paper.

System	***Parameters***					
	Cost	***Performance***	***Speed***	***Ease of Access***	***Scalability***	***Heterogeneity***
Proposed System	Low	Depends on network connections	Fast and reliable	UI provides easy way to access the services.	Yes. Devices can be upgraded.	Yes. Devices from different genres can be added.
RFID	High	Depends on transponders	Fast	No interface	No	No
GPS capable System	High	Depends on network connections with GPS satellite.	Slow	No ease of access.	No	No

Electromagnetic Parking Sensor	Low	Good but generally used in reverse parking.	Fast and Reliable	Easy to access	No	No
Active Infrared System	Low	Depends on the quality of sensor. Some are much sensitive to environment.	Slow	Not easy to access.	Yes	Yes
Magnetometer based system	High	Depends on weather conditions.	Slow	Not easy to access	Yes	No

Table 1: Comparison of proposed system with other systems based on various parameters.

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