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Parking Guidance System Using Internet of Things

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ABSTRACT: In recent years due to globalization and increase in competition to capture market share, the customer is having many options of cars at much affordable prices .This has led to tremendous amount of cars on the road. The big cities in India are normally crowded and the city's existing infrastructure falls short to satisfy the growing needs. This problem is also combined with the inefficient use of parking space and uneven distribution of traffic which leads to congestion in vehicular traffic. This paper introduces a novel technique based on Internet of Things platform to improve efficiency of the existing parking systems. It guides driver to find nearest parking slots. The prototype uses cloud based architecture of Internet of things. There is minimum delay in finding an optimal parking slot which helps to ease the traffic congestion. The proposed system also helps users automatically find a free parking space at the smallest distance based on Haversine formula if nearest parking region is full.

KEYWORDS: Internet of Things; ThingWorx; mashup; cloud computing; GPS.

I. INTRODUCTION

With the increase in technological support in Internet of Things (IoT) various applications are coming to surface using this technology. Various gateways are available which are dedicated and are having built in capabilities for networking. The various applications where IoT is used are weather, agriculture, transportation, industry, health -care, smart homes etc. The IoT enables hardware to see, hear, think and do preventive or informative jobs by having them communicate together, to share information and to make decisions.[1] Over time, the IoT will have significant applications, to contribute to the quality of life and to grow the dependence of people on automation and services related to cloud computing. IoT changes the traditional way of looking at the sensors and systems. It transforms a simple sensor into a smart sensor, with the help of which a process can be monitored and controlled with the help of collective sensor readings.

A city could become a smart city by making each part of city smart, such as the electricity distribution system, water supply system, smart health-care unit, smart transport. Making all this systems smart and efficient would lead to a city which has less carbon footprint. Thus improving each of the system is necessary to transform the city. Traffic monitoring is one of the major systems in city. Thus managing the whole traffic is a very vast job. Hence this system needs to be first distributed and then solved separately. The parts to manage the traffic are adaptive traffic signals, smart parking, and smart route finder. Smart parking which is one of the important part of this system is discussed in this paper.

A smart parking was created to cut the time spent by the driver to find a parking space to park his car. While looking for parking space driver spends a large amount of time on road looking for a place to park his car. During this he

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spends his time and fuel in the unfruitful work of searching space. This causes traffic jams in rush hours. Studies show that 28 to 45% of traffic accumulation in urban areas is due to drivers looking for a place to park, a situation in which regular citizens waste tons of hours in their entire life [2]. This may lead to increase in the pollution level in the city.

The rest of paper is arranged as follows. Literature related to the topic is reviewed in section 2 where state of art in parking assistance system is elaborated. Section 3 discusses the architecture of the system developed. Detailed overview of the system is given in section 4. Simulation and experimental results are detailed in the last section.

II. RELATED WORK

In the last two decades, there have been many researches in the car parking systems with the various technologies available at that course of time. Some of the researchers used Parking Guidance and Information systems. These systems gave the drivers the real time count of the available parking space using message boards. They used sensors at the entrances and exit gates to count the cars which can be accommodated in their parking system [3]. In the system proposed in [4] a sensor is deployed in each parking slot to show exact location of vacant parking slot.

As the driver is only given information about the vacant place, this leads to many drivers rushing to occupy the same place. This could lead to traffic jams if the parking system is situated at a heavy traffic flow areas. They are not provided with the alternative place which is in close vicinity [5-6]..

Some of the parking systems had cameras, magnetometer radar systems to locate the presence of a vehicle. Using cameras for monitoring the parking area causes a lot of data generation, hence this type of monitoring uses a lot of bandwidth. In [7] license plate recognition, infrared sensor are used with ZigBee based Wireless Mesh network is used to control LED lights based on the traffic density and distribution, which helps to reduce the harmful emission and also greenhouse gasses. In the drivers can access this cyber-physical system with their personal communication devices. And the status is changed when the car physically moves out of the slot. The system uses Zigbee sensors to check the parking status for each slot and update the central system using 802.15.4.

In [8] images obtained from cameras are used to detect cars. Here the image matching technique is used to detect car. The available spaces and number of cars in the parking area are counted and compared thus giving number of slots available.

Some of the papers had Short Message Service (SMS) as a reservation system by using GSM system, micro-controller, as a remote terminal unit [10]. These units were used as a medium to trigger the I/O pins. Reservation of a slot were made possible by the use of wireless sensor network, using ZigBee and a sensors such as pressure sensor to detect the parking slot is occupied or is empty [11].

Internet of Things provides an edge over the other systems by having various edge devices are readily available to connect things to the internet. It has an advantage that it has cloud computing as an integral part, it enables systems to use distributed computing available in various components. IoT combines this distributed computing using cloud. Thus it gives an edge over other systems. Thus many applications can be made using real time data and an example can be fault detection in the industrial system using the data obtained from various sensors in the process can help to detect it. Thus troubleshooting time can be reduced and losses can be minimized.

III. IOT ARCHITECTURE

IoT is going to be the future of network of smart things, so it should be able to interconnect millions of smart objects to the internet. Hence there is a need for flexible architecture layers. As the applications vary in various walks of life, they have different architecture, hence there is not a single architecture termed as a model architecture [12]. In [13] the architecture has three layers namely Hardware, Middleware and Presentation layer. The Hardware layer consist of sensors, actuators and embedded communication hardware, Middleware has on- demand cloud storage and the computing tools. Presentation layer has the easy to understand visualization. There are many architecture proposed for various applications, but basically it has 3-basic layer consisting of the Application, Network, and Perception Layers. The architecture layers are as shown in Fig 1. In this system same three layer architecture is followed.
node to the destination. This can be identified by delivery probability. Delivery probability is defined by the number of received messages to the number of sent messages.

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Application Layer
Network Layer
Perception Layer

Fig. 1.Architecture Layers

A. Perception Layer

The first layer is the object or perception layer, it uses a physical sensor to monitor the process and collect information. Actuators are also included in the object layer. Sensors such as temperature, humidity, accelerometer, weight, motion etc. are used to collect information. Here the information about the process is obtained in digital form, and is further forwarded to the network layer through the channel securely. All the data in the system is generated in this layer.

B. Network Layer

This layer transfers the data created in the perception layer to the cloud. Various technologies are used to transfer the data namely 3G, GSM, Ethernet, Wi-Fi, Bluetooth, ZigBee, etc. The transfer of data is secured using these technologies. And the data is transferred using protocols such as HTTP and FTP. This layer also performs the process of cloud computing and data management. It also manages the pairing of a service with its requester based on names and address. It enables the programmer to work with objects without knowing or considering the specific hardware platform. It also makes decision on the data received from the layers below it.

C. Application Layer

This is the layer where the services are requested by the customers. According to the applications this layer provides the information to the customers such as the temperature and air humidity readings, etc. In this system it provides the real time data of parking system. This layer is most important as it provides the highly precise and vast set of data in a systematic manner. It avoids confusion as it represents the data in a hassle free manner.

IV. **OVERVIEW OF THE SYSTEM**

The proposed system consist of the sensor, a gateway, a cloud for computing the raw data, a mashup for representing the data, an application used to communicate the information. The data of each slot is transferred to the cloud via a gateway, the computing is done on the data and is represented in the mashup. The end users can see the status of the parking on an application. The architecture is as shown in Fig. 2. This systems works in the following form:

A. Identification of an Object

Identification is the most important for IoT to provide accurate data and representation. Here in this case the sensors need to be identified and named uniquely so that the data obtained from it is not mixed or represented on other parking slot. This would lead to malfunctioning of the system.

The sensors are named uniquely according to the area they are situated. Firstly the position of sensor in the parking slot is considered and named it S1 as the sensor at parking slot 1, similarly S2 as the sensor at parking slot 2, and so on. Then prefix is added to the sensor name according to the region where the parking system is situated. The different region are named in advanced as R1, R2, and so on. Then the parking slot 1 in region 1 is named as R1S1. Similarly for region 2 slot 1 is named as R2S1 as shown in Fig. 2.

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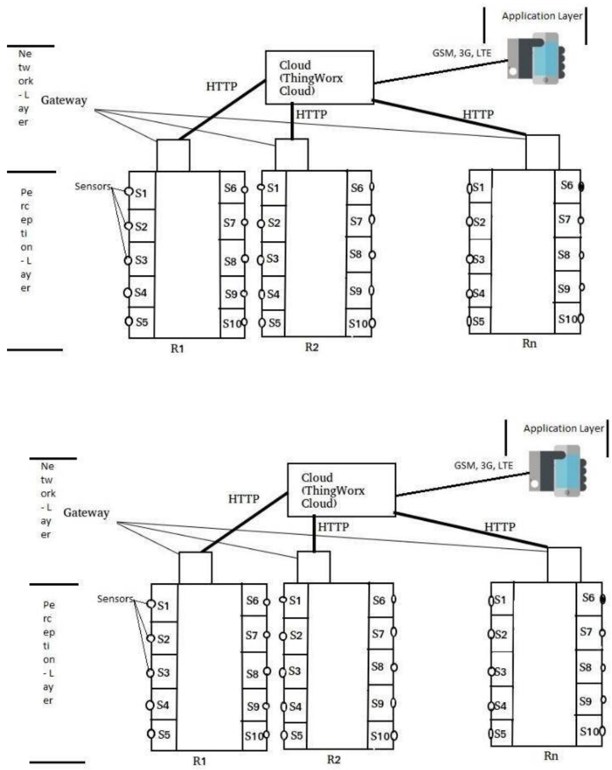

Fig. 2. System Architecture

B. Sensing the Slot

For sensing the slots there are many sensors which work on various principle such as the Light Dependent Resistance (LDR), Passive Infrared Sensor, and ultrasonic sensor. The ultrasonic sensor (HC-SR04) is used in this system. It is a sturdy and very accurate sensor and has very less error due to temperature changes. The slot's actual status is known by using an ultrasonic sensor. The sensor is placed on the side of the parking slot. The sensor is placed in middle portion at the side on the edge of the footpath or at the edge of the slot. The sensor is placed at a height so that the ultra-sonic sound waves can reflect from the plane body surface of the car.

And the other option is to place the sensor just below the surface of the road and monitor the slot from below. When the car is parked in the slot the ultrasonic sensor senses the car and the distance reading obtained reduces. Hence according to the vehicles used in the city a common threshold distance is set. Hence information about each slot and from all the Regions are collected and is stored in the central processor until it is forwarded securely to the cloud.

The ultrasonic sensor output obtained during the work done is as follows. The range of sensor is four meters. The readings are linear for most of the range, as the distance increases the deviation in the readings occur, and become considerable at 325cm and 350cm the error is of 5cm and 10 cm respectively. The sensor can withstand harsh condition of cold and hot weather of the city. The threshold is predefined and when the reading exceeds that threshold it detects that the slot is empty, else it is occupied. Hence depending on the position of the sensor and car parking area the threshold is set to 150.

C. Computation

A single Board Computers are used in IoT products for they have built in security functionalities. One of such board is Intel® Galileo Gen 2 Development Board. It also has RJ45 Ethernet, Power over Ethernet capable (PoE) [11]. Hence using this feature additional power supply is not needed. An Ethernet cable can provide both connectivity and power supply also.

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The ultrasonic sensors are connected to the board using wired connections. The board is connected to the cloud using a RJ45 Ethernet cable. The data is transferred using HTTP to the cloud server. The cloud service used in this system is of ThingWorx it is a PTC Business. This is an IoT platform specially created to connect the digital and physical worlds. ThingWorx is the only technology platform designed from the very starting for IoT cloud services. Here the data coming to the cloud is coded and has API key for the cloud server. The things which want to connect to the server need to have the API key to get registered into it, they are treated as properties and mashups are created using these properties. The ThingWorx cloud provide various services such as Google Maps, Twilio, gauges, tables, time series chart, images and LED display. Using the services a custom mashup page can be created.

D. Nearest Region Finder

In some case it may happen that the parking region initially selected by the driver is fully occupied, the mashup may show that there is no more space available for a new car. In that case an algorithm is designed as follows in Fig. 3. Here the location of the parking region is fixed hence the coordinates of their location will not change. The latitude and longitude of the parking regions can be used to calculate the shortest distance. This distance can be calculated using the Haversine formula [14]. This formula gives the great-circle distance between two points on a sphere usingtheir latitudes and longitudes. Below are the Haversine formula equations:

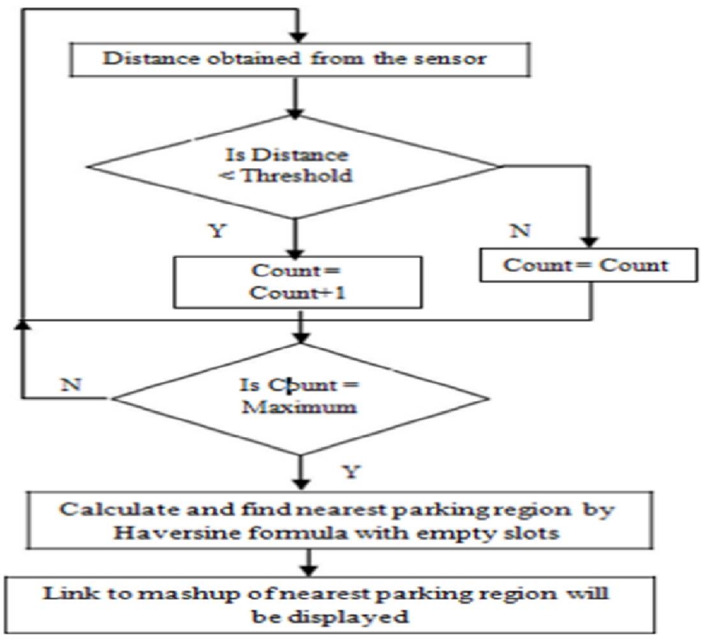

Fig. 3.Nearest Region Algorithm

$$\text{Haversine}(\Theta) = \sin^2(\Theta/2) \quad (1)$$

$$D = \sin^2(\Delta lat/2) + \cos(\Delta lat) + \sin^2(\Delta long/2) \quad (2)$$

$$R = 2*(\tan)^{\wedge}(-1)\ (\sqrt{(D(1-D))}) \quad (3)$$

$$\text{Distance} = D*R \quad (4)$$

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Using the above equations the distance between the two points is calculated along with it the other condition considered is that of the availability of empty slot in those parking region. If the parking region does not have empty slots then next nearest parking region will be suggested.

E. Network of Parking Region

There are five parking regions deployed in the neighboring places. This regions form a network of parking region. The following Fig. 4(a). shows all the five parking regions and the path needed to be followed to reach the parking region. The location of the parking region is shown in the map.

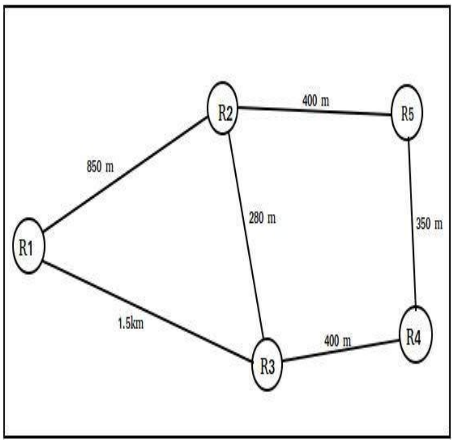

Fig. 4. (a) Location of parking on map along with route, Fig.4.(b) Distance map of the parking region.

In Fig. 4(b) is the distance map of the parking region, it shows the distance between any two parking region. Here distance between Region 1 and 2 is represented as D_{12} = 850m, D_{13} = 1.5 km, D_{23} = 280 m, D_{25} = 400 m, D_{34} = 400 m and finally D_{45} = 350 m. For example a driver is interested in parking his vehicle in region R2. If the Region has an empty slot, then the Driver will park it in his car in that slot. But if the Region is fully occupied then by using Haversine formula, the system will calculate the next nearest parking region with R2 location being the origin and other region location as the destination. In this case R3 is the closest of all, and if this region is also fully occupied, it will calculate next nearest region which is R5. Thus the system finds the nearest region with an empty parking slot.

V. RESULTS

Using ThingWorx as a cloud the data is transferred securely using HTTP. The cloud allocates an API Key for its authorized user. This key is required to be included in every program which runs in the gateway for security of the data and far the cloud. This API key authenticates every sensor connected to the gateway which has the key. Hence, the communication is secured and free from the unauthorized gateways. Thus the information provided via the cloud to the application on the end user mobile device is secure and correct information. Following are the screenshots of the application and also the results obtained from the system.

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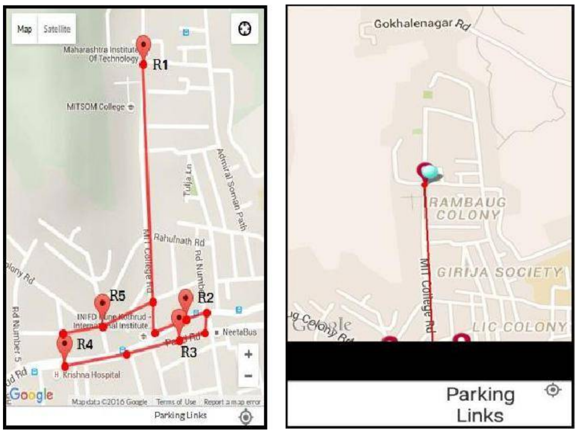

Fig.5: Location of Parking area

Fig. 5. Shows the expected user interface which shows the location of the parking area are shown. They are indicated by the red markers on the Google maps application along with the user location is indicated by the blue dot the user can find his location relative to the location of the parking area he can see the nearest parking slot and can see the status of the parking area using the Parking Links button at the bottom.

VI. CONCLUSION

This paper proposes cloud based architecture for parking guidance system. The system guides the driver to find the empty parking slot. Ultrasonic sensor is used because of its suitability to the condition of the city. The other sensor such as the PIR and LDR fails due to the principle on which the sensor works or due to the facilities available in the surrounding areas as a whole. This system provides the basic information about the parking slot if they are available, If the nearest parking region is full then with the help of Haversine formula the driver is informed about next nearest parking region with a free parking slot. This system can be further developed by including reservation feature for some areas where the parking places frequently. It can also display the latitude and longitude of the nearest parking slot.

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