Proceedings of the International Conference on Intelligent Sustainable Systems (ICISS 2017)
IEEE Xplore Compliant - Part Number:CFP17M19-ART, ISBN:978-1-5386-1959-9

Low Cost Smart Parking System for Smart Cities

D.Vakula and Yeshwanth Krishna Kolli
Department of Electronics and Communication Engineering
National Institute of Technology, Warangal
Telangana, India - 506004
Email: yeshwanthkolli@gmail.com

***Abstract*—Nowadays the idea of Smart Cities had become very popular. With the advent of Internet of Things, the concept of smart cities can be readily achievable. An extensive research is ongoing in the field of Internet of Things to increase the quality of services offered in cities and to improve the productivity and reliability of urban infrastructure. Internet of Things is addressing the most common problems faced in cities like availability of car parking and traffic jams. This paper presents an Internet of Things based Parking system for Smart Cities. The proposed parking system contains an IoT module deployed on-site for managing the available parking spaces. A platform providedin the form of portal for booking the parking spaces.**

***Index Terms*—Internet of Things; NodeMCU; Smart Parking; ESP8266; Raspberry Pi3; Smart City; IoT.**

I. Introduction

THE concept of Smart Cities has gained the utmost importance in past couple of years. With extensive development of ICT Infrastructure and IoT, the goal of building 100 Indian Smart Cities can easily be achieved. However, one of the prominent problem experienced by people in smart cities is the scarcity of car parking amenities and traffic supervision.

With the advent growth of urban population, the number of vehicles on the road are increasing day by day exponentially. According to a survey, In India, Delhi has the highest number of four wheeler vehicles at 7.35 million, which is followed by 4.1 million in Bangalore, 3.7 million in Chennai, 3.3 million in Hyderabad and 2.2 million in Pune. The above data accounts to density (per Km of road) of vehicles as Chennai (2093), Pune (1260), Hyderabad (723) [15].

The above data clearly illustrate the demand for parking infrastructure. In busy cities like Hyderabad and Pune, it is near to impossible to find a vacant parking slot easily during peak hours. The drivers tend to move around in search of parking slots which indirectly leads to traffic jams and traffic congestion. The groping around for parking leads to increase in utilization of Petrol/Diesel which indirectly cause pollution and affect the environment. Accident chances tend to raise as the driver's mind would be half occupied in searching parking.

Smart Parking system is an Internet of Things based parking system wherein which drivers can identify vacant parking slots easily with the help of their Smart Phone or a Computer. Smart parking system also accounts for online booking of a parking slot. The main idea behind this concept is computerized allocation of parking slots without any human intervention.

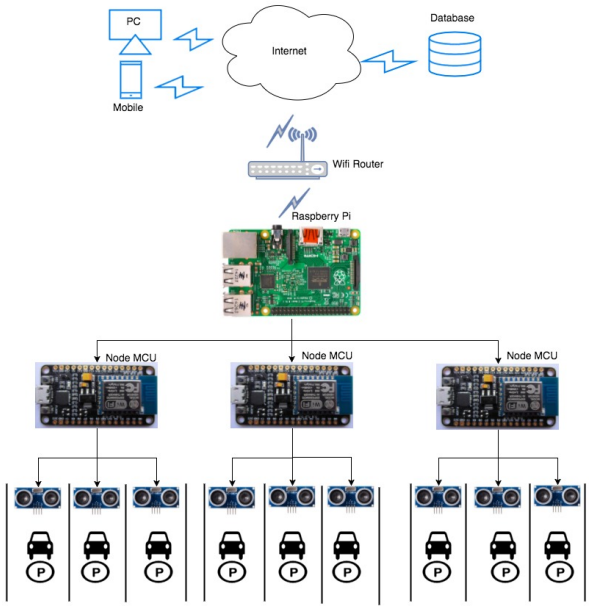

Fig. 1. Block Diagram of Smart Parking System

The proposed system helps user to book their parking slots online, by monitoring the parking spaces on a real-time basis for their availability. The rest of the paper is sorted in the following manner. Section II talks about the parking challenges in Hyderabad city. Section III presents the Smart Parking Architecture. Section IV describes the Working of the system and its Implementation. Section V gives an overview of all hardware components used. Section VI addresses challenges faced in implementing smart parking system and Section VII concludes the paper.

II. Parking challenges in Hyderabad

Hyderabad is one of the fastest growing metropolitan cities in India. It is the capital city of Telangana state and is the fourth most populous city in India. The area of Hyderabad is 650 square Kilometres and has a population of 10.1 Million (in 2016). According to 2011 census, the population noted was 6.1 million which clearly shows an increase of 65 percentage of the population in the span of 5 years [16].

The four-wheeler population in December 2016 is 0.85 million which were 0.375 million in 2008 which shows an

increase of vehicles by 126 percent in the span of 8 years. The projections clearly show that parking in Hyderabad would be one of the biggest concern in very near future.

On studying and analysing the current parking problems in Hyderabad city the following are identified as the major categories of problems:

- **Search of Parking space:** Searching for parking space is a tedious and time-consuming process. It increases the frustration levels among the drivers as is completely based on trail and error basis. In addition to the above fuel is wasted in this process.
- **Parking Fees:** Currently the parking places accepts only cash mode of payment and the availability of coins to pay for exact change is a problem. Another problem faced is that the minimum charged amount which is charged irrespective of considering the time utilized.

By analysing the above problems, the deployment of Smart parking system is clearly advantageous, as it saves both time and fuel. In addition to the above Online booking system eliminates the problem of carrying exact change and the amount charged is based on time the parking is utilized.

III. Smart Parking Sytem Architecture

In many cities, people would appreciate their luck if they could find a parking slot smoothly. People keep roaming around in search of vacant parking slots, and after a lot of struggle, they find one. Due to lack of a proper mechanism to identify free parking slots, they move randomly in search of parking space wasting a lot of time. This problem can be solved if the drivers could check the availability of parking spaces in and around their intended destination.

The proposed system addresses the parking problems faced in the city of Hyderabad and will be useful for future deployment in Smart cities. This system monitors the number of free parking spaces on a real-time basis and displays vacancy status on a portal. It also provides an interface for the user to book a slot online. Fig.2 shows a flowchart for Online booking and Fig.3 shows a flow chart for Smart Entry Management System.

A. Online Booking

The user queries for the availability of vacant slots and the system checks the Database for the existence of free slots. The system displays the number of free slots and the user is prompted to select a slot and proceed for payment to book the desired slot. After the confirmation of payment, the database is updated, and a barcode is generated for the user.

B. Smart Entry Management System

The Entry Management system contains a Barcode scanner, DC Motor, and a Display. When a user enters the premises of parking, he first scans the barcode in the barcode scanner. The display shows the booked slot, and then the DC Motor opens the gate. The system also provides a facility to park the vehicles offline. The offline user manually pays the cash to book a slot, and the paper-based barcode is generated.

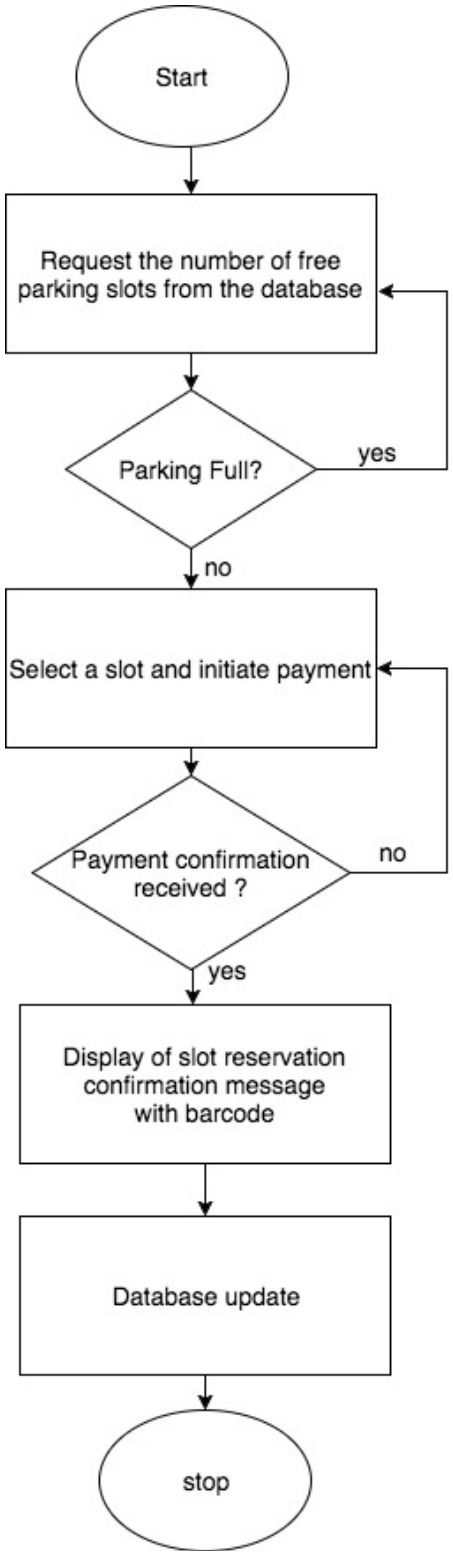

Fig. 2. Flowchart for Online Booking

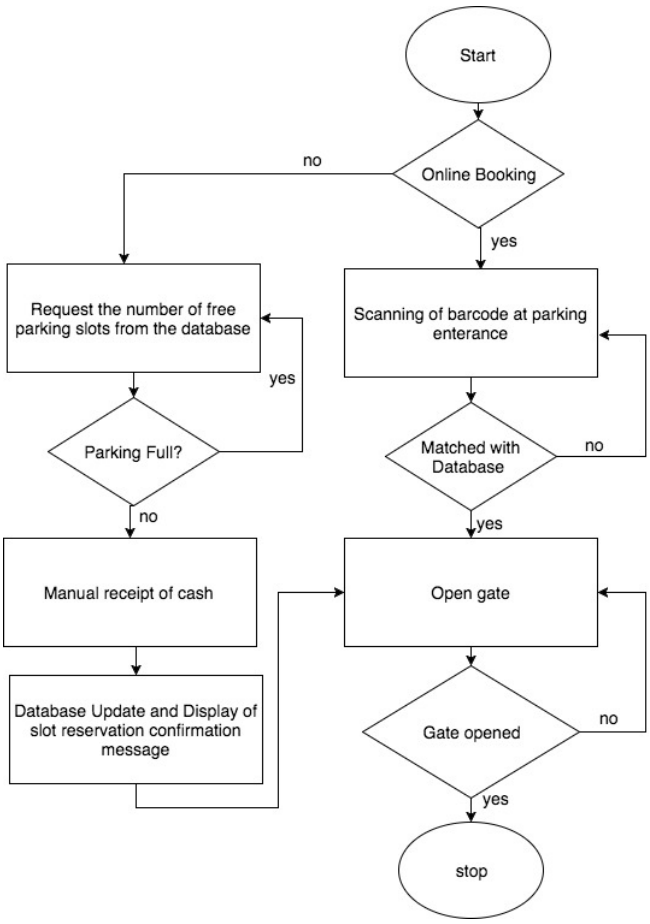

Fig. 3. Flowchart for Smart Entry Management System

IV. Implementation and Working

Each parking slot is fitted with an ultrasonic sensor which checks the status of the parking slot (Occupied or Vacant). This section provides a typical connection diagram for three parking slots in a parking facility. The three ultrasonic sensors (HC-SR04) are interfaced with ESP8266 based NodeMcu board as shown in Fig.4. Esp8266 has 3.3V tolerant pins. Hence Echo pin of HC-SR04 is connected to Esp8266 via resistor network formed using 2.2K and 4.7K. Here 2.2K is connected to Echo pin, and 4.7K is grounded.

The Trigger pin of 1st HC-SR04 is programmed with GPIO04 (D2), and Echo pin of it is programmed with GPIO05 (D1) of the board via above resistor network. Similarly, the Trigger pin of 2nd HC-SR04 is programmed with GPIO12 (D6), and Echo pin of it is programmed with GPIO14 (D5). The Trigger pin of 3rd HC-SR04 is programmed with GPIO15 (D8), and Echo pin of it is programmed to GPIO13 (D7) of the board via above resistor network.

NodeMcu is connected to Raspberry Pi3 as shown in Fig.4. The Rx pin and Tx pins of NodeMcu are connected to GPIO14 and GPIO15 of Raspberry Pi3 respectively.

VCC pin of all sensors, 5V pin of Raspberry Pi3 and Vin pin of NodeMcu board is connected to 5 V. The GND of all the sensors and GND of both ESP8266 board and Raspberry

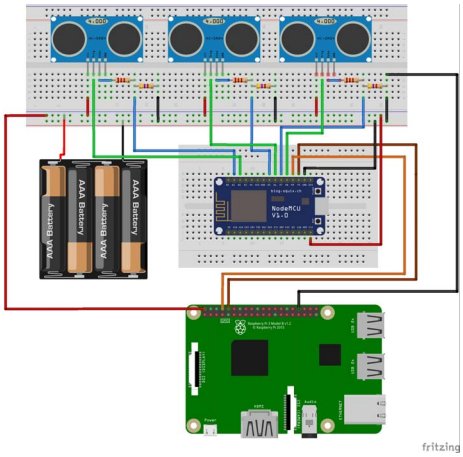

Fig. 4. Circuit connection of the system

Pi3 module are connected to Ground as shown in Fig.4.

Each of HC-SR04 sensor finds the parking slot is empty or occupied and send the data from Echo pin to NodeMcu, which is programmed in such a way that it processes the data and communicates the number of free parking slots to Raspberry Pi3 every 30 seconds. The Raspberry Pi3 collects information from all the NodeMcu's and updates the database with the total available free slots.

Mobile application and an online portal are developed to display the number of free parking slots in a location by obtaining data from the database. A user interface to book a parking slot online is also provided to the users.

V. Hardware Aspects

A. Node MCU

NodeMCU is a low-cost development kit based on ESP8266 which integrates GPIO, PWM, I2C, ADC, UART, SPI in one board. It includes USB-TTL. It contains 10 GPIO pins which can be programmed to PWM, I2C or 1-wire. It also contains and on-board WI-FI module and a PCB antenna. All the application specific devices and sensors are integrated to ESP8266 using GPIO Pins.

The Esp8266 present inside the NodeMcu is integrated with 32-bit TenSilica L 106 microcontroller unit which features extra low power consumption[13]. The low power management

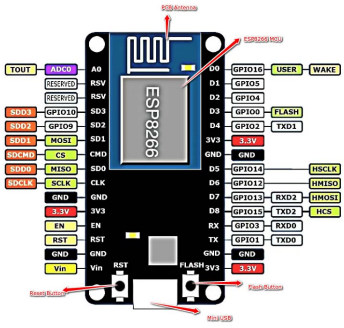

Fig. 5. Node MCU Development Board

is due to the power saving architecture as it operates in three modes: Sleep mode, Active mode and Deep Sleep mode. There are 13 GPIO pins in NodeMCU, Hence it can be interfaced with 6 HC-SR04 sensors.

TABLE I
NODEMCU SPECIFICATIONS

Specifications	Values
MCU	32 bitTenSilica L 106
RAM	36Kb
Clock Speed	80MHz/160MHz
Operating Voltage	3.0V 3.6V
Operating Current	80mA(Average)
Available GPIO Pins	13

B. HC-SR04

HC-SR04 is most popular and low cost Ultrasonic Sensor available in market. It has four pins, i.e., Trigger, Echo, VCC and GND. The GPIO port of NodeMCU triggers a signal of 10us square signal to the TRIG pin of HC-SR04, which sends eight 40khz ultrasonic waves and starts listening for echo. Once the echo is received the distance based on the time spent waiting for the wave to come back is calculated.

The comparison of Ultra Sonic Sensor (HC SR-04) and IR Sensor (SHARP GP2Y0A21YKOF) on the basis of their cost and specifications are shown in Table II [12]. Thus, it shows HC SR-04 sensor is more accurate and profitable for implementing smart parking system.

TABLE II
TECHNICAL SPECIFICATION OF SENSORS

Parameters	IR Sensor (SHARP GP2Y0A21YKOF)	Ultra Sonic Sensor (HC SR-04)
Range	10cm-80cm	2cm-10m
Beam-width	75 Deg	30 Deg
Beam Pattern	Narrow (line)	Conical
Frequency	353 THz	40 KHz
Unit Cost	750 INR.	130 INR.

C. Raspberry Pi 3

Raspberry Pi3 is a Debit card sized single-board computer with an operating system Raspbian installed. The specifications of Raspberry Pi3 are given in Table III [14]. The

Fig. 6. HC-SR04 Sensor

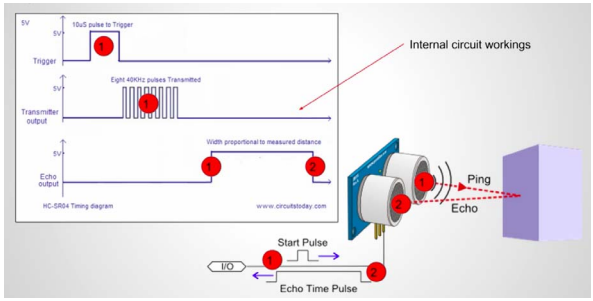

Fig. 7. Working of HC-SR04 [6]

Raspberry collects the number of parking slots from each NodeMCU and processes the data and updates the database with a total number of vacant slots. Fig.8. [18] shows the available interfaces in Raspberry Pi3.

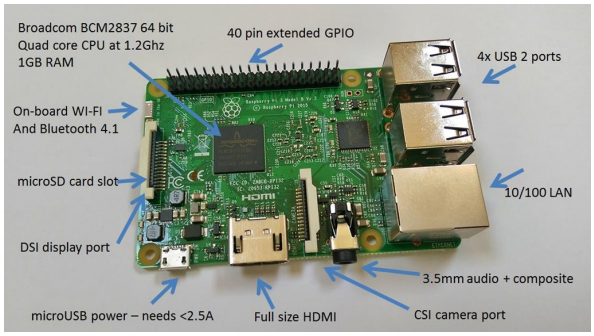

Fig. 8. Raspberry Pi3 Board

TABLE III
RASPBERRY PI 3 SPECIFICATIONS

Specifications	Values
CPU	1.2GHz 64-bit quad-core ARMv8 6
RAM	1 GB
USB Ports	4
GPIO Pins	40
Other Features	Bluetooth 4.1 Bluetooth Low Energy (BLE) 802.11n Wireless LAN Full HDMI port Ethernet port Combined 3.5mm audio jack and composite video Camera interface (CSI) Display interface (DSI) Micro SD card slot VideoCore IV 3D graphics core

VI. CHALLENGES OF SMART PARKING SYSTEM

The following are the Design and Implementation challenges faced in implementation of smart parking system

- Lack of a single technology to take care of all the requirements of the end user.
- Due to lack of Interoperability among all Internet of Things systems design of a perfect system with less cost becomes a difficult job.
- Knowledge of various domains of engineering is required for implementation of smart parking.

- In Internet of Things all the nodes and devices requires Internet and it is a major challenge to provide internet connection at every place.
- The power consumption of all the IoT Devices installed leads to an increase in maintenance cost.
- The theft of installed equipment is also a major concern.

VII. Conclusion

The Smart City Mission is the primary goal of the Government of India. The aim is to develop 109 smart cities all over the country [17]. The present growth in IoT and Cloud Computing makes data accessible anywhere and on any device. In this paper, an online based parking booking and management system are presented to address the parking issues in Hyderabad city and for deployment in Smart Cities. The users can book parking slot at anytime and from any location with their Mobile Phone or with a Computer.

References

[1] S. Lee; D. Yoon, A. Ghosh, Intelligent parking lot application using wireless sensor networks, International Symposium on Collaborative Technologies and Systems 2008, pp. 48-57, 19-23 May 2008, Chicago.

[2] International Parking Institute, 2012 Emerging Trends in Parking.

[3] Rico, J., Sancho, J., Cendon, B., and Camus, M. (2013, March). Parking easier by using context information of a smart city: Enabling fast search and management of parking resources. In Advanced Information Networking and Applications Workshops (WAINA), 2013 27th International Conference on (pp. 1380-1385). IEEE.

[4] Zheng, Y., Rajasegarar, S., and Leckie, C. (2015, April). Parking availability prediction for sensor-enabled car parks in smart cities. In Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), 2015 IEEE Tenth International Conference on (pp. 1-6). IEEE.

[5] A. Khanna and R. Anand, "IoT based smart parking system," 2016 International Conference on Internet of Things and Applications (IOTA), Pune, 2016, pp. 266-270.

[6] A. Dimitrov and D. Minchev, "Ultrasonic sensor explorer," 2016 19th International Symposium on Electrical Apparatus and Technologies (SIELA), Bourgas, 2016, pp. 1-5.

[7] A. I. Niculescu, B. Wadhwa and E. Quek, "Technologies for the future: Evaluating a voice enabled smart city parking application," 2016 4th International Conference on User Science and Engineering (i-USEr), Melaka, 2016, pp. 46-50.

[8] A. Roy, J. Siddiquee, A. Datta, P. Poddar, G. Ganguly and A. Bhattacharjee, "Smart traffic and parking management using IoT," 2016 IEEE 7th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), Vancouver, BC, 2016, pp. 1-3.

[9] Megatrends 2015: Making sense of a world in motion,Uschi Schreiber.

[10] K. Hassoune, W. Dachry, F. Moutaouakkil and H. Medromi, "Smart parking systems: A survey," 2016 11th International Conference on Intelligent Systems: Theories and Applications (SITA), Mohammedia, 2016, pp. 1-6.

[11] T. N. Pham, M. F. Tsai, D. B. Nguyen, C. R. Dow and D. J. Deng, "A Cloud-Based Smart-Parking System Based on Internet-of-Things Technologies," in IEEE Access, vol. 3, no. , pp. 1581-1591, 2015.

[12] S Adarsh and S Mohamed Kaleemuddin and Dinesh Bose and K I Ramachandran "Performance comparison of Infrared and Ultrasonic sensors for obstacles of different materials in vehicle/ robot navigation applications" IOP Conference Series: Materials Science and Engineering,149 (2016) 012141 doi:10.1088/1757-899X/149/1/012141

[13] NodeMcu Documentation, https://nodemcu.readthedocs.io/

[14] Raspberry Pi Documentation, https://www.raspberrypi.org/

[15] Vehicle population in Indian cities, http://www.livechennai.com/detailnews.asp?newsid=18802

[16] Hyderabad Population, http://www.indiaonlinepages.com/population/hyderabad-population.html

[17] Smart Cities Mission, https://en.wikipedia.org/wiki/SmartCitiesMission

[18] Raspberry Pi3 Configuration, http://www.databook.bz/?cat=56"