Journal of Engineering and Applied Sciences 12 (Special Issue 8): 8302-8308, 2017
ISSN: 1816-949X

Wireless IoT Based Smart Parking Solutions using Sensor Technology in the Context of Planned Smart Cities in India

K.A. Maheshwari and P. Bagavathi Sivakumar
Department of Computer Science and Engineering, Amrita School of Engineering,
Coimbatore, Amrita Vishwa Vidyapeetham, India

Abstract: One of the major issues faced in day-to-day life is parking of the vehicles in offices, malls, complexes, multiplexes and other public places. It becomes a tedious task to find first of all where the parking area is and then to find whether parking slots are available or not. As the number of vehicle increases every day, nearly people spent 30-35 min in finding the parking area during peak hours. Smart parking is an envisioned solution for this. With the advancements in wireless internet of things technology it becomes easier to design and implement cost effective solutions for realizing automated smart parking systems especially in developing countries. This becomes extremely relevant especially in the context of planned smart cities in India. This research is motivated on this. A low cost wireless internet of things based smart parking solution has been designed and implemented. The system through a user friendly interface helps in finding the vacant slots. The status of slots are administered and monitored through a server.

Key words: Smart parking, smart city, wireless IoT, parking occupancy status, occupancy rate, ESP8266, ultrasonic sensor

INTRODUCTION

Major properties of smart cities are smart physical, social, economic and institutional infrastructure (Yan *et al*., 2011; Axhausen *et al*., 1994; Kianpisheh *et al*., 2012). Smart parking and smart transportation (Vijai and Sivakumar, 2016; Kumar and Krishnaiah, 2013) are the growing need for smart cities (Hanif *et al*., 2010). India has around 40 million vehicles. Parking is one of the major issues faced everyday (Teodorovic and Lucic, 2006; Yan *et al*., 2011). The concern in majority of the areas is the traffic on roads and parking space. The 45% of the traffic occurs due to the improper management of parking lots. With every new launch of cars and the affordability to buy a car adds to the vehicle population. The 40% of road space is used for parking. The traffic may also be caused by the hindrance due to parking leading to accidents (Sastry *et al*., 2016). The reasons for parking problems are weak implementation of parking regulations, rising number of vehicles, improper footpath construction and parking prices. So, to avoid all the problems, there is a need for designing an automated parking slot detection and management.

One of the growing demands of planned smart cities in India is smart parking. Automated parking system has to be implemented in airports, railway stations, universities, shopping centres. Smart parking is an application based on internet of things. Internet of things has the ability to connect, automate and analyze data which is gathered from devices. So, internet of things is an automatic choice for smart parking.

Smart parking consists of real-time data capturing using sensors and application that allow users to monitor the occupied and unoccupied parking slots. This can be achieved by automating the parking slot that decreases time spent for searching the vacant parking slot and floor by floor in case of multiple basements. Smart parking solution has benefits to users and owners. Some of the benefits are reduced traffic, optimized parking, enhanced user experience, reduced pollution, new revenue streams, increased safety, integrated payments and decreased management costs.

In this research, a low cost design and implementation of smart parking has been attempted. Occupancy status of the parking lot is detected using sensor and internet of things technology and real-time data is visualized using user interface.

Motivation: The statistics shows that the usage of the vehicle increases 25% every year. Parking the vehicle is major issue in the cities. Searching of parking area leads to traffic jam, consumption of time, wastage of fuels and

Corresponding Author: K.A. Maheshwari, Department of Computer Science and Engineering, Amrita School of Engineering, Coimbatore, Amrita Vishwa Vidyapeetham, India

increase in pollution. Even after the introduction of novel odd even scheme and other measures the situation has not improved much. Still searching for the parking area and traffic jam continues. If the proposed system is implemented it would considerably save users time and fuel. Moreover, the management of parking lots both on and off-street becomes effective.

Challenges in ecosystem:

- Disobeying of traffic rules and regulation in India
- Usage of the technology is less as compared to other countries
- Profits leakage due to the absence of a robust billing platform
- IoT enabled parking system should support triggering machine to machine communications
- IoT enabled parking system should support to receive and send data from and to other devices

Literature review: Many cities use advanced technologies to monitor the flow of traffic in and around the surroundings. These help people to plan their trips ahead of time and therefore avoid traffic congestion in finding available parking slot and save time (Geng and Cassandras, 2011; Rawat, 2016). Reservation of the parking slot facilities is also available in many countries (Yan *et al*., 2011; Wang and He, 2011). For example, cities like Melbourne in Australia has IoT deployment and Santander deployments. Wireless in-ground sensors (Hirakata *et al*., 2012; Srikanth *et al*., 2009) have been installed in every parking slot to record the parking events and availability of the parking Slots. Each sensor has advantages and disadvantages depending on the area and object to detect. There are many types of parking currently in India like on street, off street, parallel, 30, 45, 60° and right angle which further complicates. The various types of sensors that can be applied in the design related to parking status detection are reviewed below.

Sensors

Induction proximity sensor: Induction proximity sensor is currently being used for the detection of vehicles in entry and exit of the parking IoT (Chinrungrueng *et al*., 2007). This is an underground sensor. To detect the vehicle, sensor is placed under the ground. By measuring the changes in the earth magnetic field, sensor got detected. When the threshold value varies certainly, the sensor detects that the vehicle has passed over the entry or exit point. This concept is used in parking status detection to detect the occupancy status. In each slot the sensor is placed under the ground, if the vehicle parks on the slot, the magnetic field changes will be noticed. This sensor is enable the detection without contact, of metal objects at distances of up to 60 mm. It is time consuming and installation is a huge process.

RFID sensor: This sensor is used in the detection of vehicles and says if vehicles are occupying the parking IoT. The RFID sensors has chip. It has capacity to receive the power from the wireless signals and transmit the own signal back to it. The chips which is placed in the vehicles will respond back to the transmitters placed in the each lots. When vehicles in the parking lot area are detected, RFID sends the signal to MCU. This serves as a major advantage as it does not detect other objects but the major disadvantage is that it needs the RFID to be placed on the vehicle.

LIDAR sensor: The LIDAR sensors sends laser light to a surface which is upto 150,000 pluses/sec (Pham, 2015). In ultrasonic sensor, light emit from the sensor to calculate the distance between the object and sensor. Here the distance is measured as the time taken for each pulse to bounce back. The accuracy of the sensor is high and work for longer range also. It is more expensive than ultrasonic sensor.

Camera detection: For detecting the parking lot occupancy the cameras serve (Pham, 2015) as a good device. To check the parking slot is occupied or unoccupied using single camera image processing techniques can be used. Image processing techniques can able to view the entire parking slot in a single view. The objects other than vehicles cannot be detected in the sense that this should be accurate.

Smart parking

San Francisco: Smart parking system is undertaken by SF park. They deployed 8200 sensors in parking IoTs. Sensors have been installed in both on street and off-street. To find the occupancy rate, the sensor has been placed in ground in all the areas. Each sensor has a magnetometer that looks for changes in the earth's electromagnetic field and is calibrated to detect vehicles in the surrounding area (Zheng *et al*., 2015). Wireless network is used to collect the data and make available in public for research use. The SF park system makes easier in finding the parking area and payment. The occupancy status is updated in website and users can also reserve a slot and view the occupancy status of any particular area. Payment can be made through credit/debit cards, coins or parking card. This saves time and more convenient for the users.

Melbourne: Melbourne has installed 4,600 sensor in parking spaces. The data from the sensor helps the parking management to operate the parking area, effectively. Melbourne government made the sensor data available in open for public use. With the help of open data secure parking company gives an application to the Melbourne people for booking parking spot before they reach the place (Zheng *et al*., 2015). Payment can also be done through secure parking application.

Westminster council, London: West end of London has installed 3,000 in-ground sensors when the smart parking is introduced. This smart parking system saves 15 min of user's time in searching the parking space. Then 7,000 sensors have been installed in London. Sensor has the ability to detect the RFID chips. Mapping RFID number to customer wallet make cashless parking possible. Payment rate will be automatically detected from the payment wallet however long they stay.

Real-time application

Parkifi: Parkifi is a real-time application to find the vacant parking area in Denver. This application finds nearby parking area in real time and helps the drivers to park the vehicle in respective slot. In the application drivers just need to give the destination and it shows the nearby parking available area, thus, saves time and fuel consumption.

Features:

- 19,000 and more nearby parking spot can be accessed easily
- Sensors have been connected to real-time GPS map
- Nearby available parking area will be highlighted using colours

Benefits:

- Save an average of 15 min in finding the vacant parking slot
- Reduces traffic congestion
- Less stress for drivers
- Avoids double circling

Spaceek: Spaceek smart parking is implemented in Texas USA. This parking system uses ground sensor in every parking slot. Then the senor is connected to the cloud to store the data. From the cloud resource the occupancy status of every area is found. Dashboard is available to monitor.

Streetline platform: Streetline is hybrid smart parking system. Hybrid smart parking system deploys machine learning techniques to merge multiple data sources into a cohesive set of occupancy data for real-time parking guidance and analytics. The hybrid smart parking system fuses information from sensor with payment and other data sources to continuously learn and provide accurate parking trends in the city. Application for hybrid smart parking gives the nearest parking space availability.

Advantages of automated car parking system: Now is the ideal time to realize and implement such automated parking systems in India especially in planned smart cities. This research is an attempt towards that which has IoT of benefits:

- The automated parking system increases the number of cars that can be parked in a garage. It provides more parking spaces since the cars are well organized parked
- Using of automated parking system requires only a less area
- This system enables safe parking of cars as compared to the ramp-style parking facilities
- This method of parking is easy for the drivers and they don't need to walk in search of parking slot
- The chances of vehicle getting damaged due to wrong parking are considerably reduced in automated car parking system

MATERIALS AND METHODS

Hardware: In designing this solution the hardware plays major role. The hardware used in this work is ESP8266, Ultrasonic sensors and WiFi. ESP8266 is type of Arduino with WiFi inbuilt to sense the signals. Ultrasonic sensors are used for the detection of vehicles. WiFi is for transferring the data from ESP8266 to database. The detailed descriptions regarding the selection of hardware are given.

ESP8266: The ESP8266 is a WiFi chip supported with full TCP/IP stack and microcontroller unit is attached with it. Figure 1 shows the ESP8266 hardware. It is low-cost device. It is designed for power and space constrained mobile platform designers. It has embed WiFi capabilities with other system or standalone application with minimal space requirement. When the application is hosted ESP8266 boots up from an external flash directly. In such application integrated cache has been placed to improve

the performance efficiency. In ESP8266 there are 16 GPIO pins available. The following are the main features of ESP8266:

- Integrated low power 32 bit MCU, 10 bit ADC, TCP/IP protocol stack, integrated TR switch, balun, LNA, power amplifier and matching network, Integrated PLL, regulators and power management units
- Supports antenna diversity
- WiFi 2.4 GHz, support WPA/WPA2
- Deep sleep power <10 uA, power down leakage current <5 uA
- Wake up and transmit packets in <2 msec
- Standby power consumption of <1.0 mW (DTIM3)
- Operating temperature range -40~125°C

Ultrasonic sensor: Figure 2 shows the ultrasonic sensor. Two pins labelled Vcc and GND is used to send power to the device and another two pins Trig and Echo for input and output. Trigger is used to detect the sequence generated by ECHO signal. Signal must be provided by the circuit and this causes the device to transmit an ultrasonic signal. Frequency of ultrasonic sensor can be extended to 20 kHz. This means that the width of the pulse available at the ECHO pin is related to the distance to the nearest object in the field-of-view. The following things are mainly considered for using ultrasonic sensor: the size of the field-of-view, longest and shortest range detectable, the characteristics of the trigger signal and the resolution, i.e., how small an object can be detected.

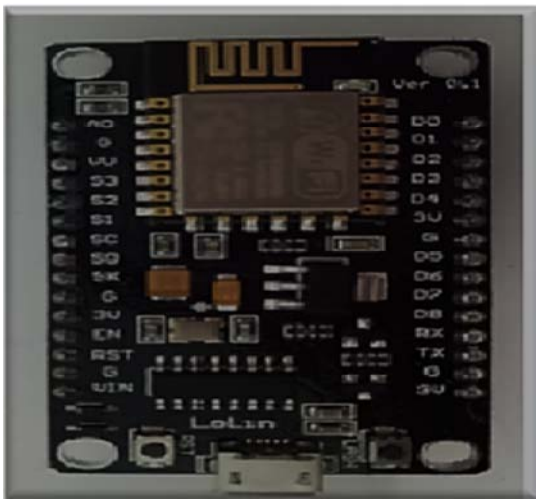

Fig. 1: ESP8266 hardware

Fig. 2: Ultrasonic sensor

RESULTS AND DISCUSSION

Proposed architecture: Figure 3 shows the system model of smart parking system. Smart parking system has two fundamental modules; parking status detection and user interface notification. Parking status detection is responsible for detecting the occupancy status of the parking area. For detecting the slot an ultrasonic sensor is used. The sensor data helps in finding whether the slot is occupied or unoccupied. The status is communicated to the server. From server notifications are issued to users. User interface is designed that displays the status where the slot is occupied or unoccupied. Web interface also has been designed to view the status of the parking slot. The major steps are described:

Step 1: Ultrasonic sensor senses the object and sends the distance as the output to MCU.

Step 2: In MCU the distance is converted into binary value (0 or 1). The code is written using Arduino Software.

Step 3: The binary value gets updated for each slot in cloud from serial monitor. Sensor sends the signal for every 15 sec.

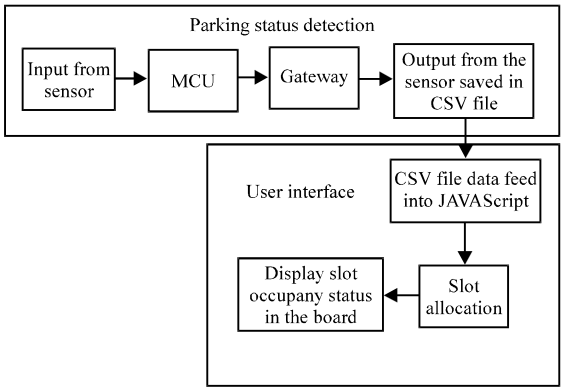

Fig. 3: System model

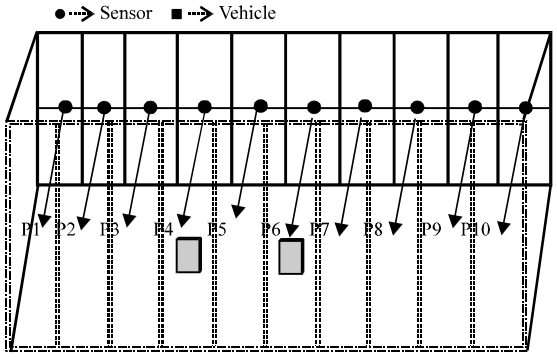

Fig. 4: Design and deployment of sensors in parking slots

Step 4: For front end, cloud data is taken as input and for user friendly red and green colours are used to indicate the occupancy of the slot, instead of binary values (0 or 1). Red colour indicates that the slot is occupied and green colour indicates unoccupied.

Parking status detection: Occupancy status of a parking area is detected using ultrasonic sensors. The working of ultrasonic sensor is described below.

Active ultrasonic sensors: These sensors are used in the detection of vehicles. The working of ultrasonic sensor 4 is by sending the high frequency sound pulse and the time taken by the echo signal to return is counted. Using this information the distance to the object based on the frequency of pulse is calculated. These sensors are highly used in detecting the objects at the parking lot but the drawback is that it fails to distinguish between the vehicle and the objects. For example, let's consider a person standing in the parking lot. For this case, the sensors reports that it is occupied space.

Figure 4 shows the prototype of parking area. Each sensor is connected to an ESP8266 microcontroller that is running on Arduino Software (Version 1.8.1). When the object that is the vehicle is sensed the distance is calculated from the time taken for the echo to return. Along with the Trigger line minimum 10 μS is sent. Threshold value is fixed by default in all the sensors, when the threshold value is below then it indicates that the slot is occupied by vehicle. From the MCU the data is sent in the form of binary value. If binary value is '1', it is inferred that the slot is occupied and for '0' the slot is unoccupied. This binary value is sent to cloud database viva WiFi in ESP8266. Cloud data is then given as input for the interface.

Connecting ESP8266 with ultrasonic sensor: Figure 5 wiring connection between the ESP8266 nodes MCU with

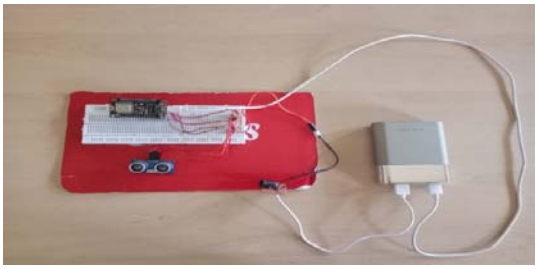

Fig. 5: Hardware set up

Ultrasonic Raging Sensor HCSR04 is shown. In the sensor trigger pin is connected to D4 which is pin 4 in Arduino Board and the ECHO is connected to D5 which is pin 7 in Arduino board. The Vcc in ultrasonic sensor is connected to 3v in ESP8266 which is pin 5 in Arduino board and both the GND are connected which is pin 6 in Arduino board.

Notification: Ultrasonic sensors are need to connect to notification system. In this system sensors transfer data through WiFi which is inbuilt in ESP8266. When the distance range differs from default range then the signal send the value to notification system to indicate that the slot is occupied.

User interface: In order to organize and store the data from the sensors effectively, a database has been designed. Each sensor sends the binary value to the cloud database using IDE. For every 15 sec the sensor updates the value in the same cell in cloud database. Figure 6 shows the cloud storage where the output from ESP8266 are stored. Using JavaScript the user interface is designed. Excel sheet is taken as input for the JavaScript. Using the database the real-time visualization of the parking slot is designed.

Figure 7 shows the real time visualization of parking slot using 6 sensors where the red colour indicates the occupied slot and green colour indicates the unoccupied slots. This can be extended to any number of slots in a similar way. Thus, the status can be put on a web server and at the entry itself the slot can be allocated to the user. Even a wrongly parked can be found out easily by cross verification. This would result in fewer resources as the entire operations can be automated and remotely monitored. If a user comes to know in advance that the occupancy is almost full he or she can look at other options available nearby to park the vehicle. This would also help in further implementing a payment rate based on occupancy rate. Registered users can also avail the facility of advanced reservation of parking slot which would further increase the revenue.

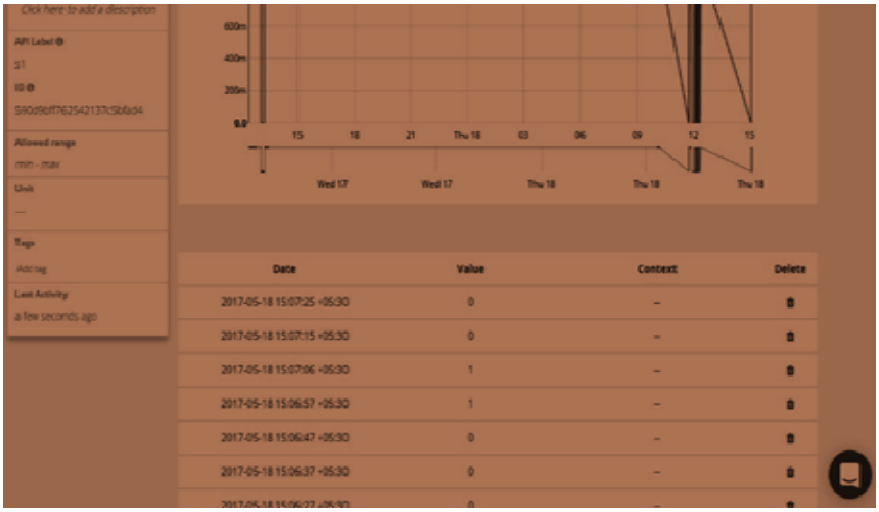

Fig. 6: Cloud database

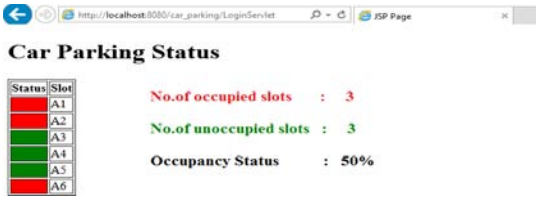

Fig. 7: User interface

Table 1: Cost estimation

Items	Quantities	Cost (Rs.)
Ultrasonic sensor	6	720 (each 120)
ESP8266	1	650
WiFi	Use of surrounding connection	-
Wiring	-	200
Battery	2	150
Total		1720

Wireless IoT standards: The 3 wireless communication standards layer of IoT are Physical layer, network layer and application layer. In network layer for transferring high range of data IEEE 802.11(WiFi) is used. Normal IEEE802.11 can't be used for IoT application. IEEE 802.11 working group initiated 802.11ah task group to develop a standard that supports low overhead, power friendly communication suitable for sensors and motes. 802.11ah is designed for low-power sensors and hence, it allows a long sleep period of time and waking up infrequently to exchange data only. Cost estimation for 6 slots is shown in Table 1.

CONCLUSION

In this research keeping in mind the requirements of planned smart cities in India, a low cost design of an automated parking lot has been proposed and designed. The solution can be further extended and scaled up to meet the requirements of any number of parking slots of various types. The system designed has the means of finding the occupancy status and thereby the occupancy rate. By deploying wireless internet of things, this would facilitate real time update of the parking status. The hardware used has the capability of transferring the data through wireless network. Supplemented with an android app, this would result in hassle free experience of parking. The system also would help in better management of parking lots and increased revenue generation.

REFERENCES

Axhausen, K.W., J.W. Polak, M. Boltze and J. Puzicha, 1994. Effectiveness of the parking guidance information system in Frankfurt am Main. Traffic Eng. Control, 35: 304-309.

Chinrungrueng, J., U. Sunantachaikul and S. Triamlumlerd, 2007. Smart parking: An application of optical wireless sensor network. Proceedings of the International Symposium on Applications and the Internet Workshops, January 15-19, 2007, IEEE, Hiroshima, Japan, ISBN:0-7695-2757-4, pp: 66-66.

Geng, Y. and C.G. Cassandras, 2011. A new smart parking system based on optimal resource allocation and reservations. Proceedings of the 2011 IEEE 14th International Conference on Intelligent Transportation Systems (ITSC), October 5-7, 2011, IEEE, Washington, USA., ISBN:978-1-4577-2197-7, pp: 979-984.

Hanif, N.H.H.M., M.H. Badiozaman and H. Daud, 2010. Smart parking reservation system using Short Message Services (SMS). Proceedings of the 2010 International Conference on Intelligent and Advanced Systems (ICIAS), June 15-17, 2010, IEEE, Kuala Lumpur, Malaysia, ISBN:978-1-4244-6625-2, pp: 1-5.

Hirakata, Y., A. Nakamura, K. Ohno and M. Itami, 2012. Navigation system using ZigBee wireless sensor network for parking. Proceedings of the 2012 12th International Conference on ITS Telecommunications (ITST), November 5-8, 2012, IEEE, Taipei, Taiwan, ISBN:978-1-4673-3071-8, pp: 605-609.

Kianpisheh, A., N. Mustaffa, P. Limtrairut and P. Keikhosrokiani, 2012. Smart Parking System (SPS) architecture using ultrasonic detector. Intl. J. Software Eng. Appl., 6: 55-58.

Kumar, B.S. and R.V. Krishnaiah, 2013. Arm based an real time implementation based on transportation systems. Intl. J., 1: 11-15.

Pham, C., 2015. Large-scale intrusion detection with low-cost multi-camera wireless image sensors. Proceedings of the 2015 IEEE 11th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob), October 19-21, 2015, IEEE, Abu Dhabi, United Arab Emirates, ISBN:978-1-4673-7701-0, pp: 484-491.

Rawat, D.B., 2016. Adaptive Connectivity, Security and Privacy in Transportation Cyber Physical Systems. Springer, Berlin, Germany,.

Sastry, J.K.R., Divisushma, Y. Aslesh and J. Sasibhanu, 2016. Visualisation method for effective traffic management within smart cities. J. Eng. Appl. Sci., 11: 1598-1605.

Srikanth, S.V., P.J. Pramod, K.P. Dileep, S. Tapas and M.U. Patil, 2009. Design and implementation of a prototype smart PARKing (SPARK) system using wireless sensor networks. Proceedings of the International Conference on Advanced Information Networking and Applications Workshops, May 26-29, 2009, IEEE, Bradford, UK., ISBN: 978-1-4244-3999-7, pp: 401-406.

Teodorovic, D. and P. Lucic, 2006. Intelligent parking systems. Eur. J. Operat. Res., 175: 1666-1681.

Vijai, P. and P.B. Sivakumar, 2016. Design of IoT systems and analytics in the context of smart city initiatives in India. Procedia Comput. Sci., 92: 583-588.

Wang, H. and W. He, 2011. A reservation-based smart parking system. Proceedings of the 2011 IEEE International Conference on Computer Communications Workshops (INFOCOM WKSHPS), April 10-15, 2011, IEEE, Shanghai, China, ISBN:978-1-4577-0248-8, pp: 690-695.

Yan, G., W. Yang, D.B. Rawat and S. Olariu, 2011. Smart parking: A secure and intelligent parking system. IEEE. Intell. Transp. Syst. Mag., 3: 18-30.

Zheng, Y., S. Rajasegarar and C. Leckie, 2015. Parking availability prediction for sensor-enabled car parks in smart cities. Proceedings of the 2015 IEEE 10th International Conference on Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), April 7-9, 2015, IEEE, Singapore, ISBN:978-1-4799-8055-0, pp: 1-6.