A Comparative Review on Car Parking Technologies

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Abstract

Information technology embeds microchips and sensors within vehicles, traffic lights, roads and makes transportation system to communicate using wireless technologies. Intelligent transport system embodies several functionalities such as traffic monitoring, parking assistant, and vehicle monitoring by making the system smarter. Parking plays a vital role amongst them. Developing countries are facing major parking management problems. Most of the available parking methods do not satisfy the user's requirements. The biggest challenge in parking lies in how well the monitored information is being communicated from sensor nodes to users effectively and also the method being employed to carry out this. Timeliness, accuracy, reliability, and security are some of the important characteristics in a parking management system to be considered. Any parking management system must be able to provide features like accounting, dynamic allotment of slots, security management, statistical reporting along with detecting the count of vehicles inside a parking zone. This paper discusses some of the commonly used techniques in parking management and identifies the problems present in their methodologies.

Keywords: Parking management system, Parking techniques, WSN, RFID, Zigbee

I. Introduction

Many developing countries suffer from traffic congestion problems because of the inefficient traffic management system. Car parking is the main factor adding to congestion problem. Efficient parking management is needed in a developing country. Major issues related are that people park vehicles on sides of the road as there are no enough parking spaces available. The present parking spaces are not maintained properly. The users are not guided efficiently to park the vehicles. They need to search for a free slot to park their vehicle. These problems finally end up with traffic congestion, fuel consumption, pollution, wastage of energy and time. Many techniques are being examined to solve these parking issues. Some of the factors contributing to an efficient parking assistance are the usage of different technologies, system complexity, scalability and cost.

In general, the user follows the below steps to park the vehicle.

1. The user enters the parking zone
2. Searches for the available parking slot
3. Parks the vehicle in an empty slot
4. Pays the amount for the vehicle.
5. The user leaves the parking zone.

All these steps can be incorporated and monitored by a parking management system. Parking guidance approaches can be classified into four groups, such as traditional blind search (TBS), parking information assistant (PIA), reservation based parking system (RPS), centrally-assisted parking system (CPS). In TBS, the driver blindly searches for parking spaces available. The driver parks the vehicle if there are any unoccupied spaces; else he needs to keep searching till he finds one. It is a very simple approach used in very small parking space. In PIA, the parking information is displayed in large electronic displays. The users can park their vehicles based on this information. Though it guides the users, but sometimes it leads to confusion. The reason is that the display shows few slots as unoccupied that are actually reserved. There is always some delay in updating the information on the display. In RPS, the users can reserve the parking slot by logging in to the website provided. They can login to the site using an ID given to the users. The reservation can also be made through phone calls, and SMS. A drawback with this approach is that when any slot is reserved, the other users cannot use it although it is unoccupied. The slot remains empty till the reserved person parks the vehicle. CPS is controlled completely by a centralized server. The server takes all decisions related to parking. The users are asked to submit parking request to the server along with their destination. The approach fails because they lack in fairness [1]. It takes time to park the vehicle during busy hours of the day and also has a complex infrastructure. These general approaches use either wired or wireless technology. Wireless Sensor Network is used in several applications such as industrial monitoring, remote sensing, environment sensing, structural monitoring, agriculture, health monitoring, tracking and so on. Today, WSNs are also used in vehicle communication and navigation where the

sensors are placed in parking slots that are able to detect the presence of vehicles, and they are able to inform the user whether the slot is occupied or not. Different sensors are used in vehicle technologies such as ultrasonic sensors, infra red sensors, and magnetic sensors and so on. The other wireless techniques used in parking management system are Zigbee, RFID, Bluetooth, etc. In this paper, a survey is made on the different parking techniques and analyzed based on some parameters that how these systems are managed efficiently.

II. Classification

The parking management technologies, in general, may be grouped under different communication techniques. Each communication technique performs the main functionalities such as providing parking lots to users, updating the status of parking lots, accounting and billing, collection of payment either at the entry or exit. The communication is broadly classified into two major networks, namely, wired networks and wireless networks. Most of the parking technologies used fall under the category of wireless communication.

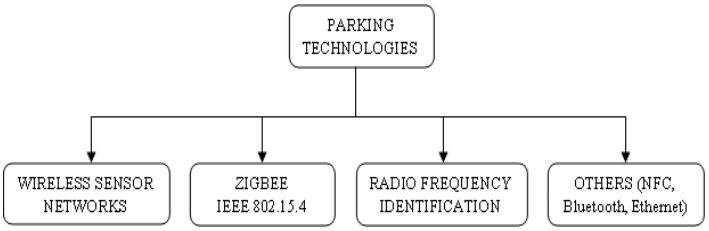

Fig 1 Classification of parking management technologies

Fig 1 shows that wireless sensor networks, Zigbee, RFID are the most commonly used approaches in parking management systems. The other techniques included are vision-based technology, embedded Ethernet access technology, internet technology, CAN, and short range communication such as NFC, Bluetooth, WiFi and others.

III. Comparative study

A. Wireless Sensor Networks (WSN)

Wireless sensor networks are a rapidly emerging technology as they are being used in wide and diverse applications. WSNs are now also employed in vehicle parking systems because of its high performance. Any parking system using WSNs include different type of sensors to sense the information, gather the data and transmit them to their nearest control center or a base station.

Rachid SOUISSI et al [2] proposed a parking technique using wireless sensor networks. The sensor nodes communicate with the base station through their neighbors as shown in the fig 2 below.

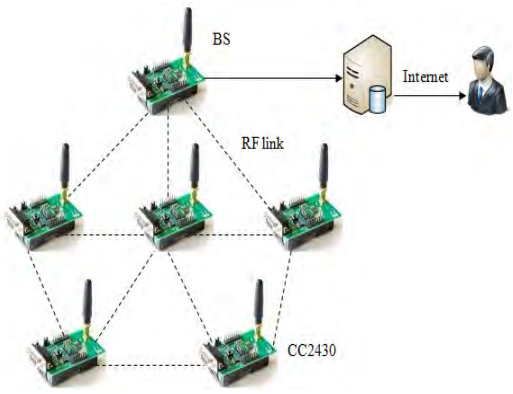

Fig 2 Communication between different sensor nodes

The position of each parking slot is informed to base node through neighboring nodes. The status is sent to its next nearest node. The neighbor node passes the data to the next nearest node. This process continues till the data reaches the base station. The state of parking space is denoted as a binary value which may be either 0 or 1. When the state value of parking space is 1, it indicates the car is been parked. Similarly, when the parking space is 0, it shows an empty lot. All these information is updated in the base station regularly. Users are connected to parking management system through internet. Web application developed can be used to reserve slots online, to book using digital maps. The method is simple to execute but has a severe disadvantage of energy and bandwidth consumption. The information transmitted consumes more power.

S.V. Srikanth et al [3] discussed another smart parking system using WSN technology. The system with several advanced features such as monitoring of vacant lots from remote places, guiding users autonomously, and slot reservation facilities for the user are being embedded in them. It consists of WSN system, sink node, parking management subsystem, automated guidance for users, display unit, and slot reservation subsystems for various clients. WSN is responsible in monitoring the status of the parking slots. The status can be occupied, free or reserved. WSN subsystem includes modules such as sensing the vehicles parked in respective slots, routing the information to the control center, disseminating data, and status modules to inform and update the present state of parking lots. The information from sensor nodes is collected by the sink node and sends them to the parking management system and they act as gateway to forward information between WSN subsystem and other networks. The status of the parking management system is forwarded to the guidance subsystem. The display located at the entrance shows the user about the availability of slots and allows them to reserve the parking slots. Another is present inside the parking zone, which displays the status of the parking lot. Any changes in the database are automatically updated in the display. Guiding nodes helps the user to spot a free lot in a very less time and they are informed about the changes in parking management through sink nodes. This method is real time and cost effective. Problem is with maintenance of the system.

B. Zigbee

Another important wireless communication technology is Zigbee communication, which uses a higher level of communication protocol. They are based on IEEE specifications and allow data transmission over long ranges.

Fan Jianying et al [4] discussed the design of a Zigbee network and implementation of parking system using Zigbee technique. The system uses Zigbee serial network as shown in the fig 3. Terminal nodes are the Zigbee modules that are placed in parking lots. For every three parking lots, one Zigbee module is used in the system. Terminal nodes act as end devices that gather information from parking slots and pass them to their coordinator. The data transmission between terminal nodes and coordinator takes place using routers in order to speed up the transmission process. The information is transferred from the coordinator to the control centre through data concentrators.

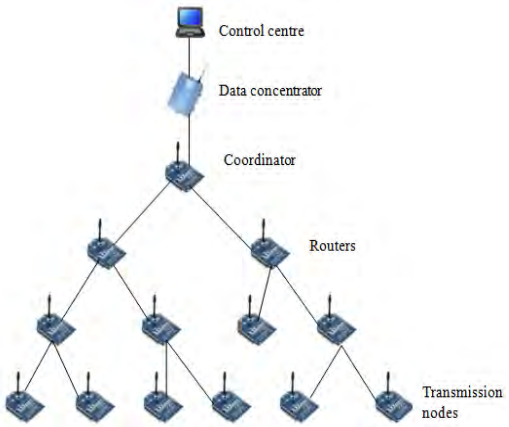

Fig 3 Structure of Zigbee network

The vehicle is detected using Zigbee module, and the parking information is sent to the coordinator through routers. The control centre has a database that saves all these information. The communication system consists of host controller and Zigbee network. IEEE 80.15.4 is used as a communication protocol. The function of a host controller is to connect the control centre and communication system. Zigbee terminal node is present in client side and a network of Zigbee nodes is fixed inside the parking spaces. Information about the vehicle and the user is saved stored in the client side. All these details are finally stored in the control centre for further processing. Though the method is simple to use, yet it makes the system more complex. The functioning of the system using such architecture becomes difficult and cannot be used in very big parking slots.

R Vishnubhotla et al [5] proposed a system using Zigbee technology to find out the vacant parking slots in a multi level parking system. This system comprises of vehicle detection module, Zigbee subsystem, entrance display and a patron reservation system. The vehicle detection module is to determine the presence of vehicle in the parking slot. Use of ultrasonic sensors in the vehicle detection module informs the user whether the slot is occupied or remains empty. Zigbee routers are located at different places inside the parking zone. This parking zone has multi level and therefore it requires many routers to be placed. A router can be placed at every level. All these routers are connected to a single Zigbee coordinator. Finally, Zigbee coordinator is connected to a control center, where the database is updated frequently. Whenever, a change in the lots takes place, Zigbee coordinator transmits the status to the control center. Displays at entrance help the user to know the availability

of number of parking lots at every level. This method is very simple to implement and real time but the efficiency and performance of the system is not satisfied.

C. Radio Frequency Identification (RFID)

RFID technology makes use of radio frequency signals in data transmission. RFID tags are attached to objects are automatically identified and detected. This method is nowadays used in determining the parking slots in a parking zone.

Zeydin PALA, Nihat INAN [6] proposed a smart parking management system using RFID technology. The system includes RFID components such as RFID readers, RFID labels, a barrier for controlling the operation of the gate and software. The software is responsible for handling parking management, controlling, reporting money transaction details, and controlling the tasks in parking lots. The system works in the following manner. RFID readers are attached to the vehicles and are connected to the computer's USB port. The parking entrance has a barrier that controls the operation of a gate. The barrier is connected to one of the USB ports of the computer. The vehicle is detected using RFID readers and the gate is opened. A database created consists of parking lots available in the city. All the information about the vehicle is stored under a separate table in the database. This table includes several fields such as Vehicle ID, plate number, type and model. Another sub table is created in the database which consists of information about the parking lots available, check-in and check-out details, time, parking fees payable. The database created can be a predefined one. When any registered vehicle enters the parking lot, the table is verified. If it does not have any check-ins record, the details are entered in the respective fields. Once the registration is done completely, the barrier is lifted for the vehicle to enter. The same process is carried out, when the vehicle leaves the parking lot. Check-out record is checked to find out the check in time and date. The check-out information is updated in the field. A remote database is maintained to continue the process when the internet is disconnected. The use of RFID technology provides security to the parking management system. This makes the system less reliable when more than one tag responds at the same time.

D. Bluetooth

R. W. Tri Hartono, Mervin T. Hutabarat [7] explains an innovative design for the parking management system that relies on E-commerce Solutions to Parking Space Optimization (ESPSO) and uses Bluetooth. This ESPSO service is embedded as a single product called Product-Service System (PSS). ESPSO comprises of the following sections.

1. Data communication takes place between user's mobile phone and the main ESPSO server through Bluetooth.
2. Information is distributed from ESPSO server to clients through wireless local area network.
3. Automatic License Plate Identification System (ALPIS).

ALPIS is present at the entrance of the parking zone and the vehicle's license plate image is captured and stored for further processing. The process consists of following steps: The system undergoes sequence of different image processing techniques to identify the vehicles. Normalization is done on the image and the number plate image is enhanced further. Optical character recognition (OCR) is used to separate the alphabets and numbers from the number plate.

The ESPSO system uses Bluetooth technology to transmit all the parking information to the mobile phones of the users. The information is also displayed in the entrance screen. Cameras are fixed at the entrance and exit of the parking zone to capture the image of the unauthorized users. When vehicle leaves the parking zone, the license number image is compared with the recorded image. If this matches, the parking amount and parking time is displayed at the screens located at the exit gates. Bluetooth technology allows the user to be recognized at the entrance and exit gates. The system keeps monitoring the parking time of the vehicles. The working method is summarized below.

Users log on to ESPSO system through their mobile phones from any spot. The parking space availability is sent to the user through Bluetooth. The camera captures the vehicle's number from the license plate when it enters the parking entrance. Image information is sent to ESPSO server gateway. The system sends a response to the mobile phones equipped with Bluetooth technology. A copy of the information is recorded as a database in the server. The display at the entrance shows the picture and license plate number. The barrier is opened after registration process. The user can park the vehicle in the available slot. The same procedure is repeated at the exit point. The image of the car and the license number plate is compared. If it matches, the user has to pay the parking fees. After this, the barrier opens for the vehicle to leave the parking zone. The system improves security by placing wireless video cameras inside the parking lots. ESPSO can be accessed through Web, SMS, WAP.

Other technologies include,

1. Vision based technology that uses video cameras along with image processing, in order to identify vacant slots within the parking zones [8].

2. Embedded internet access technology uses TCP/IP protocol based on HTTP web server to handle different functionalities such as detection of parking space, parking management to improve the traffic guidance system. UDP is used in exchanging parking spaces available, whereas TCP is used in transferring control data [9].

IV. Conclusion

In this paper, parking technologies that allocate optimal parking slots for users are studied. These methods are analyzed on the basis of system complexity, scalability, cost, fairness, and techniques used. For a small parking area, it is not essential that the system must provide very high fairness. Moderate fairness, less complexity, low-cost factors can provide an efficient parking management system. For a large parking space, the fairness should be high. There are possibilities that when fairness of the system is increased, their complexity and cost is also increased. Efficient parking can be provided in large cities only when the system has a good fairness. Thus there should always be a balance between fairness and other characteristics of the parking management system.

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