Investigation of Smart Parking Systems and their technologies

Completed Research Paper

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Abstract

The literature review conducted for this paper offers an in-depth review of the recent advances in sensing and communication technology concerning parking systems. In addition, this paper presents a survey and analysis of an academic, qualitative literature review. It includes an in-depth study of the selected topics and provides a step by step implementation process. It reviews different smart parking systems used for parking guidance and parking facility management and gives an insight into the technical aspects and specifications analysis of such systems that have been published in academia during the last 15 years

Keywords: Literature review, IoT, smart parking, M2M, RFID

Introduction

In the last fifteen years, academic research on outsourcing smart parking systems has evolved rapidly, growing so fast that, to date, there has been scant opportunity for the research community to take a collective breath and complete a global assessment of research activities. Almost every cosmopolitan city in the world suffers from traffic congestion, which causes drivers frustration especially when searching for a parking space. Therefore, interest in this domain has become timely for scientists and researchers. Solving such a problem or even trying to alleviate it will certainly offer several benefits, such as reducing drivers' frustration and stress by saving time and fuel, and reducing gas emissions, which in turn, will affect levels of pollution. Current systems have created an environment in which most of the modern statistics indicate shocking findings regarding the waste of fuel during the search for parking places. Most of the popular parking systems in the world use coins and tokens. However, despite the widespread use of these systems, they cannot be counted as smart parking, as they do not give precise information regarding booking a specific parking space. Usually, such a system relies on counting how many cars have entered the parking area and calculating the difference between this figure and the maximum number of parking spaces to estimate the number of spaces available. These types of system usually need a person in charge of the location in case something goes wrong due to variations in the number of parking spaces, for example, due to badly parked cars or drivers parking in booked spaces. The field of smart parking service systems is part of intelligent transportation systems (ITS). The paper begins by considering the most general aspects of the topic and gradually focuses on the main purpose of this paper as mentioned in the abstract. The process of formatting this research journey involved the following steps: searching relevant bodies of literature, managing search results, synthesizing the research literature, and finally, writing a discussion and

conclusion of the literature review. This research aims to investigate and discover different types of smart parking systems.

Research method, strategy, and limitation

This section describes the methodology adopted for the literature review. This paper represents an exploration of the contributions that have already been made in the academic field. Moreover, the literature review is a contribution that is intended to assemble the appropriate research on smart parking. It aims to gather all available information using "Google Scholar" and "ScienceDirect" and other sources available in academia. There are two important issues. First, the number of publications written in this domain is limited. The second issue is related to this promising technology itself (smart parking); this has not yet extended in the real world to most countries, especially developing countries, where the people have more need to alleviate stress and reduce the amount of time spent searching for vacant spaces. Such improvements would lead to a decrease in pollution and many other issues that will be mentioned below. All that the field requires is more effort to adopt these systems. In this research, it has been difficult to include several types of research in the industrial field due to non-disclosure issues, so the plan was to give details of the most frequently cited papers. In addition, all the proposed papers that have been reviewed are listed in the reference section. Inclusion/exclusion criteria are applied to select primary studies. One of the limitations of the review is that although an attempt has been made to include all relevant journal articles, some are not listed on the databases. In addition, it is sometimes hard to determine whether a paper presenting a hybrid approach should be included or not. Another limitation of our research is the fact that conference proceedings, books, book chapters, and other literature in languages other than English are not included in the review. Nevertheless, the majority of English journal articles on smart parking methods since the year 2000 are included in the review. The selected journals and conferences are shown in the section about related work. In addition, papers that were irrelevant or that did not explain all the details of the technique used in the transformation of requirements were excluded. When there was more than one paper describing the same or similar approaches, only the most recent one or the one with a complete description of the approach is included. When a single approach was presented in more than one paper describing different parts of the approach, all these papers are included, but are still considered as discussing a single approach. Moreover, papers with insufficient technical information regarding their approaches were excluded as well, for example, papers that did not provide a detailed description of the requirements.

Contribution and Research Gap

The main contribution was a focus on clarifying all the systems that are explained in published academic papers. In this regard, more than 60 papers were selected (according to the above mentioned criteria) related to this topic from different research centres and universities, as well as all specific conference proceedings and journal papers. Regarding the research gap, there were contributions by conference papers or articles in the academic field, according to the inclusion criteria, which include stakeholders in the design process and evaluation. From this review, it is clear that there is a pressing need for a smart parking system solution, with the existing problem being exacerbated as time passes. The review found that there were no previous studies published in the literature related to the assessment of these systems that took into account the views of stakeholders.

Smart Parking History

It seems that the word ''smartness" or ''smart" holds different meanings according to the requirements of people and their location in the stream of time. Over the years, the number of parking-system-related technologies has increased. Car parking systems have been around almost since the time cars were invented. In any era where there has been a significant amount of traffic, there have been car-parking systems (Melsen 2013). Car parking systems were first developed in the early 20th century in response to the need for storage space for vehicles. (Melsen 2013) Indeed, the using of e-smart parking systems dated back to the 1920s, as automated parking systems appeared in U.S. cities such as Los Angeles, Chicago, New York, and Cincinnati. In addition, one of the Kent automatic parking garages in New York is an art deco landmark that was converted into luxury condominiums in 1983. A system that is prevalent all over Japan

is the “Ferris-wheel,” or “paternoster system”, which — was created by the Westinghouse Corporation in 1923 and built in 1932 on Chicago’s Monroe Street.

In the past two decades, the concept of intelligence in terms of smart parking systems became more popular in the most vibrant cities, especially in malls and shopping centres. (Melsen 2013) In the mid-80s, the systems used for parking relied mainly on the traditional method of pushing a button in the device next to the checkpoint to get a parking ticket and on exiting, the driver must pay before inserting their ticket in order for the barrier to rise. This was the method used to determine how many cars came in and out the system each day, and it was used to count the number of vacant spaces available. It began by utilizing different methods such as sensors or barriers to be able to know the status of parking lots. All these methods developed dramatically further until recently the term ‘smart city vision’ emerged.

Challenges of the Proposed Smart Parking Systems

There are major challenges facing today’s transportation systems and drivers on a daily basis regarding special parking systems for which smart city engineers and designers have to be prepared. Numerous recent studies have led to the conclusion that new smart parking systems are needed in almost every metropolitan city in the world especially in the next ten years to alleviate many problems, such as petrol consumption and pollution emission, and to improve time-saving and reduce frustration when looking for a parking space. Therefore, for any proposed system to be considered smart in relation to the parking process, it should have as a minimum, the following factors and specifications:

. Be able to accurately sense vehicle occupancy in real-time

. Provide guidance for users about available parking

. Simplify the parking experience and add value for parking stakeholders, such as drivers

. Enable intelligent decisions to be made using data, including real–time status applications, and historical analytic reports

. Be able to provide the user with all the necessary information about the status of any changes in the parking area that might happen in real time

These challenges must be addressed from the very beginning to ensure that the system will work efficiently. Many studies related to traditional smart parking systems in the last decade have indicated that they satisfy neither the drivers’ requirements nor the parking facility’s budget.

Related Work and Classification of Smart Parking Systems

This section discusses the different methodologies used for smart parking. Also in this section, all related studies are gathered into groups based on the techniques used (conference papers, articles) specifically in the academic domain. It is very clear from all the references below that categories and classifications of smart parking vary from source to source. Some rely on the technology used while others rely on data processing to get information about the parking statues. For example, in the centralized assisted parking search, the information processing will be stored on the central processor (server). The non-assisted parking search does not have a server, and no information will be provided to a user. Numerous technological methods are grouped into the following classification:

Smart parking systems based on agent model

The systems based on this technique have been proposed in academia (Mateo et al. 2009; Yang et al. 2009; Chou et al. 2008; Longfei et al. 2009; Adler et al. 2005; Khoukhi et al. 2010; Li et al. 2004; Balbo; et al. 2005). These types of system can be any entity capable of observing facts via sensors, as the system is acting upon the changes of the environment through exchanging information and interaction upon that act. It has useful characteristics, such as autonomy, reactivity, and adaptability (Mahmud 2013). Essentially, a multi-agent system is a modelling method developed to represent systems with entities, autonomy, and interaction. Agent-based intelligent parking systems are a form of mobile agent technology with a multi agent system. The following section considers a few selected works, chosen according to the aforementioned criteria.

(Li et al. 2004) proposed a multi-phase navigation method based on a two-layer traffic map, which is employed for parking route negotiation and guidance. The distribution approach involves building an active parking guidance information system (APGIS). The APGIS is composed of cars, car parks, and a parking information service centre (PISC), which has four functions: parking space searching, parking price negotiation, parking space booking, and parking route negotiation and guidance. Khoukhi et al. (2010) proposed a multi-agent system; this contains a main control kernel agent, a learning navigation agent, a localization agent and, finally, a communication agent. The system worked well in a simulation environment and the results were promising and encouraging. (Longfei et al. 2009) developed a multi agent system called a multi agent based intelligent parking negotiation and guidance systems (ABIPNGS) parking system. They proposed a negotiation algorithm based on the human bargaining process. The system operation mechanism was outlined in Longfie's paper.

Smart parking systems -based on Fuzzy logic

Since 1965, when fuzzy logic was introduced by Professor Zadeh (1996), it has played an outstanding role in design and production in industry. Actually, fuzzy control systems are control systems based on the fuzzy logic system, which analyses analog input values in terms of logical variables that take on continuous values between 0 and 1, while digital logics operate on discrete values of either 1 or 0. Nowadays, fuzzy logic has become a standard technology, which is applied in data and sensor signal analysis. Fuzzy code is designed to control something, usually something mechanical. Some proposed systems based on this technique are selected as follows. This type of system is proposed in (Sharafi et al. 2010; Mohammadi et al. 2011, Song et al. 2006, and Zhao et al. 2005). The following proposals as examples are chosen in order to clarify the principles of this technique. (Song et al. 2006) proposed a system that depends on an FPGA-based fuzzy logic controller (FLC). The benefit of using an FPGA-based FLC compared to software FLC is that takes less time to process the information. First, a Fuzzy Control System is chosen. Then, the implementation of the fuzzy rule-based system takes place upon the neural network architecture. It is the main reason for learning and adapting from the training data: "The neuro-fuzzy system has the ability to reason like human beings as well as it has expert knowledge". (Benson et al. 2006) proposed that an RF transceiver and antenna with an ATMega 128 L micro-controller system could operate by monitoring the availability of car-parking spaces and send this information to customers and facility administrators. (Sharafi et al. 2010) presented a fuzzy approach for the control of the backward movement of trucks and trailers in a dynamic environment. This method was then expanded to circumstances in which there are obstacles in the truck's pathway. In the first scenario, it is assumed the obstacles are constant. The second scenario assumed by the authors is that there are moving obstacles which can mean the truck must be directed to the parking facility. The parking process is completed due to the intelligence of fuzzy logic. The proposed ultrasonic sensor identifies objects and obstacles longitudinally. (Zhao et al. 2005) developed and demonstrated a robust automatic parking algorithm for parking, using a genetic algorithm's learning ability for space detection errors by employing a Kinematic model for a skid steering autonomous ground vehicle.

Wireless sensor networks-based systems

These types of systems have generated increased interest in researchers since 2005. They are the most popular technique in the last decade with researchers, as wireless sensor networks have various advantages, such as flexibility, intelligence, reasonable cost, rapid deployment, and sensing, as it usually consists of sensor nodes. The following papers discuss WSN-based parking systems (Yan and Olariu 2008; Yan et al. 2009; Miura et al. 2006; O'flynn et al. 2005; Kumar et al. 2007; Lee et al. 2008; Park et al. 2008; Tubaishat, et al. 2009; Reve et al. 2012; Sharma et al. 2011; Boda et al. 2007; Haranguing, et al. 2007; Cheung et al. 2005; Wenzhi et al. 2006; and Agarwal, et al. 2009). This type of system, which utilizes sensors to monitor environmental conditions, is widely used, especially in academia, due to the ease of installation and configuration, and the reasonable price. (Zheng et al. 2006) developed a system using crossbow products, which have a low unit cost. This system enables a car to detect entry to the car park, and it efficiently guides the driver to an empty parking space through signs displayed to the driver. (Kianpisheh et al. 2012) presented a new smart parking system using an ultrasonic detector. For each individual car park, one sensor is fixed on the ceiling above each parking space. Ultrasonic sensors operate based on echolocation. The sensor transmits a sound, which hits a solid object (car or ground) and is reflected back to the sensor. (Mathur et al. 2009) discussed the research challenges relating to parking technology and proposed some possible solutions. In the centralized solution, some cars are equipped with ultrasonic sensors as well, which drive past the parking spaces to collect occupancy data and upload the data to the centralized database. The cars that need to park simply query the centralized database. (Lee et al. 2008) proposed the use of a combination of magnetic and ultrasonic sensors for the accurate and reliable detection of vehicles in a parking lot, and described a modified version of the min max algorithm for the detection of vehicles using magnetometers.

Smart parking systems based on Vehicular to infrastructure communication (V2I)

Other studies (Stibor el al. 2007; Holfelder et al. 2004; Yousefi et al. 2006; Bilstrup et al. 2008; Panayappan et al 2007; Geng et al. 2012; Lu et al 2010), proposed using the term (CVT) to refer to Connected Vehicle Technology which depends on wireless data transmission between vehicle and infrastructure (V2I). This promising technology emerged recently. It proposes a new smart parking technique that depends on developing a new VANET-based smart parking to be used for smart steering and smart parking. It refers to Vehicular Communication Systems, in which vehicles and roadside units are the communicating nodes, that is, they communicate and exchange information with each other, such as safety warnings or supplying the traffic congestion information and even for finding vacant parking spaces. Basically, vehicular networks are considered to contain two types of nodes: vehicles and roadside stations (Geng et al. 2012). Both are categorized under the term 'Dedicated Short Range Communications' (DSRC) devices. DSRC works in 5.9 GHz bands with a bandwidth of 75 MHz and a range of about 1000 m. This is a two-way method of communication including Vehicle-to-Infrastructure (V2I) and Infrastructure-to-Vehicle (I2V) communication. In the "smart parking" system, usually, V2I communication includes drivers sending their parking requests, providing driver information, and confirming that reservation to the system. I2V communication involves the DRPC sending allocation results, driving directions, payment details, and more, back to vehicles. It is worth mentioning that cellular networks are usually applied in V2I and I2V solutions. (Stibor el al. 2007) proposed a novel parking system called SPARK, which consists of four parts: system setting, real-time parking navigation, intelligent anti-theft protection, and friendly parking information dissemination. In (Lu et al. 2010), the SPARK scheme is characterised by employing a parking lot's RSUs to provide surveillance and manage the whole parking lot using VANET communication technology. The system uses light sensors, and in the proposed SPARK scheme, the whole parking lot is under the surveillance of the three parking lot RSUs. (Panayappan et al. 2007) described a parking system in VANET which locates any available parking spaces. This system depends on roadside units deployed to relay parking messages and GPS to locate parking positions.

Smart parking systems based on Global Positioning Systems GPS

Global Positioning Systems (GPS) technology (also known as *Satnav*) is used to determine and track a vehicle's precise location. In this domain, it is used to offer information about the location and availability of parking spaces at the destination. This technique proposed in (Pullola et al. 2007; Chon et al 2002; Hanif et al. 2010). Chon et al presented a location-based system called NAPA. The server in the system associates buildings on the campus with parking lots in the order of distances to the building. After locating the nearest available parking lot, the user sends the NAPA server a message that he/she has parked. Then the server updates the information about the lot accordingly. When the user leaves the parking lot, the NAPA server can automatically charge the appropriate parking fee if necessary. (Hanif et al. 2010) proposed a new smart parking system using SMS services. This system is capable of finding parking spaces in specific car park areas. A parking reservation system is developed in such a way that users can book their parking spots over short message services (SMS) using the GPS. The SMS is processed by a wireless communication instrumentation device called a micro-RTU (Remote Terminal Unit). The proposed porotype have the following specification; the circuit has a simple design, the reliability level is high, and the system accuracy is excellent.

Smart parking systems based on Computer vison

Recently, many researchers have focused on these methods (Takizawa et al. 2004; Xu et al. 2000; Zhu et al. 2007; Funck et al. 2004; Fabian et al 2008; Tan et al. 2009; Jung and Choi el al. 2007; Tanaka et al. 2006; Jung et al. 2010; Banerjee et al. 2011). This field of study includes methods for acquiring, processing, and analysing images. It uses computers to emulate human vision, including learning and being able to make inferences and take actions based on visual inputs, also called computer vision. The goal of computer vision is to make computers efficiently perceive and process visual data, such as images and videos, and act upon changes in these images. Usually, the technique involves analysing a few frames per second and then sending the data to a central database, after which, the user can retrieve information about the changes at the parking lot. In (Takizawa et al. 2004), their system utilized CCTV in a vehicle detection stream to detect the presence of a car or vehicle in a particular parking lot. Pixel detection is used to detect the presence of a vehicle in each parking lot. A certain number of pixels in the grayscale are used as the threshold to differentiate pixels from the vehicle and from the unoccupied lot. Another parking system, called CCTV, uses images to detect parking spaces. CCTV cameras are fitted in car parks to automatically detect car parking spaces. However, these methods may incorrectly detect parked vehicles. The system is targeted on cases where occupancy values are required. The reliability is high and the system is very accurate; however, all other parameters are unclear in the paper. (Funck et al. 2004) proposed a system that uses CCTV cameras that are fitted in car-parks to automatically detect car parking spaces. However, these methods are not always accurate in cases where occupancy values are required. (Bong at el 2008) proposed a research project which was developed to acquire car-park occupancy information using an integrated approach of image processing algorithms. Motivation for developing this system came from the fact that minimum cost is involved because image processing techniques are used rather than sensor-based techniques. This project is called the Car-Park Occupancy Information System (COINS).

Smart parking systems based on RFID technology

This technology (RFID) is proposed in the following selected systems (Pala and Inanc 2007; W Gueaieb and M s Miah 2008; Jian et al. 2008 ;Cervantes et al. 2007; Hsieh et al. 2008; Liu et al. 2010; Zhang et al. 2006; Šolić, et al. 2015). In many academic papers, smart parking's RFID solutions make it possible to manage permit parking easily, especially in the prototype stages. The main mechanism of RFID technology depends on an electromagnetic field to identify and track tags attached to objects automatically. (Pala and Nihat 2007) used RFID technology in automation. Their system uses a software program for controlling and reporting changes in the status of the parking space, and for the operation of tasks such as choosing the closest vacant parking space, and it then sends the report to the driver. Meanwhile, (Jian et al. 2008) proposed a system containing Gate-PC Controller and Embedded Gate Hardware, an RFID System, and a Modular Parking Management Platform: *"Most systems in the Modular RFID Parking Management System are modulated and can be substituted for any other similar system or hardware*".

Other hybrid, M2M, IoT Systems:

(Yeh et al. 2016; Pham et al. 2015; Alhammad et al. 2012; Foschini et al. 2011) and others use certain kinds of hybrid techniques and mixed methods. As mentioned earlier, it is difficult to classify each type with a certain group, but it is useful to do so for the sake of clarity. (Lee et al. 2016) proposed a smart system that detects and finds the parked location though systems based on IoT, smart sensors, and actuators, with the middleware connecting clients with terminal devices. The system is dependent on Bluetooth communication between the smartphone and wireless sensor motes. (Fraifer and Fernström 2014) proposed a smart car parking prototype using camera nodes and an OpenCV algorithm to detect the vacant parking space to facilitate the parking service to the users. (Foschini et al. 2011) presented and discussed the design and implementation of an M2M application in the field of road traffic management. This study used an integrated IoT retractable bollard management system to allow vehicular access to restricted city areas, based on standard infrastructure and software components; the authors have invented an intelligent parallel technique which involves using RFID technology with fuzzy logic controllers and two ultrasound range sensors. This system contains a Gate-PC Controller and Embedded Gate Hardware, an RFID System, and a Modular Parking Management Platform. As mentioned previously, most systems in a Modular RFID Parking Management System are modulated and can be substituted for any other similar system or hardware. Finally, check-ins and checkouts of the parking lots are under the control of RFID, reader, labels, and barriers. (Klappenecker et al. 2014) modelled a parking lot as a continuous-time Markov chain. The parking area is modelled as a grid, and schemes for information aggregation and dissemination over the grid are proposed. Moreover, in (Foschini et al. 2011), M2M system technology has recently emerged as a promising enabler for the development of new solutions in a plethora of IoT application domains including transportation, healthcare, smart energy, smart utility metering, supply and provisioning, city automation, manufacturing, and others (Foschini et al. 2011). M2M enables highly scalable direct communications among wireless enabled heterogeneous terminals, called M2M devices. Basically, the principal of M2M applications that realize M2M communication involves four stages: 1) data collection, 2) transmission of specific data over a communication network, 3) assessment of the data, and 4) response to the available information. All these specifications make the involvement of the M2M desirable in smart parking systems. The M2M networking architecture for IoT connectivity uses aggregator devices to serve multiple end nodes. A gateway connects to a cellular network for eventual Internet attachment. Specifically, the end M2M nodes contain one or more sensors that report physical conditions to a remote site or that are used with local embedded intelligence.

Table 1. Overview of smart parking system based on different technique

Technique Based	Reliability	Communication method	Circuit Complexity	Detection Accuracy
RFID	High	Wi-Fi	Complex	Accurate
CCTV coins	High	Wi-Fi a, g	N/A	False detection may occur
light sensor	High	Zig-bee	Complex	Accurate at day time Cannot be used at night
Acoustic sensor	High	RF	Complex	Seriously influenced by environmental noise
Optical sensor	High	Blue-tooth	Complex	Very accurate
Ultra-sound	High	Switch and LAN	Simple	Accurate
SMS	High	GPS	Simple	Accurate
Magnetic sensors	High	WIFI /RF	Simple	Accurate
Infrared	High	RF/Wi-Fi	Simple	Too sensitive Maximum accurate at day time

Analysis and Discussion of the Results

In relation to the points above, the review has identified several techniques of modified versions, especially sensor-based smart parking technology. Numerous different smart parking systems have been chosen to fulfil the same purpose with a different technique and the data have been analysed according to different factors, such as technique's cost, reliability, scalability, accuracy, communication type, circuit complexity, method of operation and ease of installation, as illustrated in Table 1

Discussion and Findings of the Results:

• Many studies have used different techniques, such as VANETs or RFIDs with wireless sensor networks (WSNs), and indeed, more new ideas to set up smart parking system have emerged onto the market because of all these ideas and prototypes. Accordingly, smart parking systems have been developed by combining the following factors and types of technology including WSNs, ZIGBEE, EEE802.15.4, RFID, NFC, and Bluetooth. In fact, the majority of these systems have control of the entrance and exit, and use vehicle detectors as an essential element to provide smart parking. As mentioned earlier, intelligent parking systems are divided into two important categories, namely, a centralized architecture and distributed architecture.

•According to the selected studies, all of the sophisticated smart parking systems proposed in academia depend on the knowledge of real-time parking information, based on which the system makes and upgrades allocations for drivers. Current sensing technologies provide several options to monitor parking spots. In general, designing any smart parking system that depends on sensors working either by sensors being deployed in each parking spot or by the construction of a network of wireless sensors with sink, which connects all sensors together and transmits sensing data to the gateway and then to the driver through GUI via the server (Geng et al. 2012). Typically, several Mesh networks supports multi-hop routing through which data packets can be relayed from one to another. Thus, sensors far away can still transmit data to the gateway via this technology.

•Of the parking systems proposed that use RFID, one paper of the many that were published during the last decade has been selected to consider in more detail one of the best systems regarding reliability. However, it is still costly and needs tags for each user in order to identify the vehicles that enter and leave the system. In addition, the system circuits are complex, and the system has many disadvantages and limitations (RFID Journal LLC 2016). For example, the RFID tags do not function sometimes, as the tags cannot be read unless they are within range of a reader. In addition, the accurate reading rate is very low, and the reader itself is quite expensive; therefore, these systems are found only in the academic but not in the industrial literature due to the additional cost-related hardware and networks.

•Some of the systems previously suggested utilize the integration of RFID and WSNs. Any system that has been designed by combining WSNs with RFID provides many advantages. Users are able to read tags from a distance of up to a couple of hundred meters, which is well beyond the normal range of readers (Zhang 2006). That means that the integration of RFID and WSN can enable RFID to work in the multi hop to extend the application of RFID to operate in a wider area. Furthermore, RFID systems integrated with WSNs offer the advantages of the specification of wireless communication. The transmission and processing of data and information can be facilitated without the need for the burden and inconvenience of wired transactions. Portable RFID readers can further speed up the collection of data and ease procedures in various applications. Integrated tags with WSN can communicate with other tags and form a multiple loop network. Each integrated node transmits not only its unique ID number, but also details of its sensed data to all other nodes. The integrated tag listens to the RFID reader radio of neighbouring nodes. In all RFID-based systems, the systems were costly but effective, though circuit complexity needed to be of a high grade. In addition, reliability was high for the three relative systems, though the circuits employed were complex. In relation to the detection accuracy, this was found to be very high based on the experiments for all systems using RFID tags. For scalability, the first two types chosen were at a high level and the latest was at a medium level in the author's opinion.

• Regarding sophisticated systems which depend on M2M communication, applications can be used to orchestrate and deliver services in remote endpoints without the need for human intervention.

•Almost all the ideas centre on utilizing smartphones to identify or book a specific parking spot. All the limitations for almost all the current smart parking systems are related to the cost of installation or the complexity of manufacturing or even the difficulty of operation, as most of the systems need to change the whole infrastructure to be installed and used. In this paper, trends in smart parking research during a 15-year period (2000 to 2016) are presented. Figure 1 illustrates the general orientation of researchers and their growing research trends. It is important to consolidate the latest knowledge and information to keep up with the research needs. As the line chart demonstrates, most of the research centres had varied ideas and yet there is no specific trend in this field. It shows only that recently the focus has been on using WSNs and IoT.

•Graph analysis according to the below Figure 1 To conclude, research in this field is not limited to a specific technique.

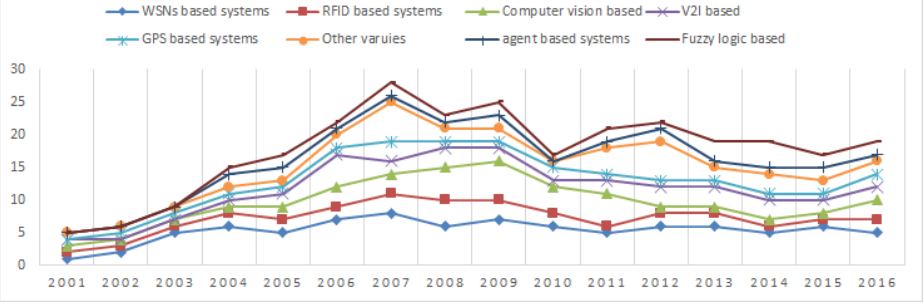

Figure 1. Trend of smart parking porotypes in academia

The latest knowledge and information is needed to keep up with the research needs. The selected conference and journal papers have been selected carefully according to the aforementioned research criteria in the field of smart parking engineering, specifically these which published in the last fifteen years. It is highly anticipated that in the near future, vehicular communication systems will be more effective in many transportation research areas especially for avoiding accidents and traffic congestion. Some new technology will be demonstrated in order to give a new and broader perspective for sophisticated communication systems. According to the aforementioned criteria, a number of different smart parking systems have been developed based on different factors and types of technology. The main findings from the survey results show that searching for parking is a priority, where the majority of drivers will search for a parking spot as they approach or arrive at their destination. Those systems that use computer vision and CCTVs in particular have scalability, and reliability is very high in this system, but regarding accuracy, false detection may occur.

Problems and Challenges Facing Today's Parking Systems:

As society increasingly relies on computer-based information systems to improve efficiency, smart parking systems are rapidly increasingly in number. Smart parking systems have become a necessity, especially in dense population centres. While designing with a user-centre approach, two main issues emerged, regarding, first, operational issues and second, specific technical challenges. These challenges must be addressed from the very beginning to ensure that the system will work efficiently in situ. All the available studies related to traditional smart parking systems in the last decade indicate that they do not satisfy drivers' requirements.

Operational and technical challenges, issues, and problems

From all the selected prototypes in academia, it is clear that some systems only guarantee a vacant parking space virtually, but do not indicate where it is exactly; these types of systems depend on counting how many cars have entered the parking space and how many cars have left, thus continually calculating the number of parking spaces available. These systems rely on the driver then finding the available parking space by driving around until they see it. One of the greatest challenges for smart parking systems when users employ these systems is how to engender trust in the system: How can we ensure the users can trust the system and can trust each other when being directed to a pre-booked space? In the City of Westminster, London, there is a smart parking system that uses a wireless sensor network with no barrier, but the parking area is still constantly monitored by CCTVs so that when cars park in the wrong places, they can be clamped. However, this system is still not "smart" enough to identify and then match specific cars to their pre-booked parking spots, and so relies on customer complaints after the fact. To sum up, most of the recent proposed smart parking systems that have been investigated depend on wireless sensor networks which, in reality, need to be placed in small holes in each parking spot, so applying this system involves changing the infrastructure in addition to many complex requirements regarding circuits, etc. In addition, system operation is inconsistent, as environmental factors such as snow or dust (or anything that might cover the sensors, including the units being covered deliberately) could result in the failure of the whole system. Despite comprehensive research, systems that depend on image processing are still not accurate or reliable in practice, especially at night or when cars are parked incorrectly.

Discussion of Identified Research Gaps

From this review, it is clear that there is a pressing need for a smart parking system solution, with the existing problem being exacerbated as time passes. The review found that there were no previous studies published in the literature related to the assessment of these systems that also took into account the views of stakeholders. There is a general trend among scholars to use WSNs due to the aforementioned reasons and, in the last five years, there has been a trend to utilize the IoT principle. This review has identified a number of gaps in the literature. It appears that there is no consensus on the best technological solution package, as each possible solution has deficiencies in one area or another. My findings in my academic research show that each solution has different technological requirements in relation to all of the previously mentioned factors, using different methods to facilitate parking services for the user. Each prototype system has advantages and disadvantages in terms of the following criteria: cost, reliability, scalability, accuracy, communication type, circuit complexity, reliability, method of operation, and ease of installation/usability of the system. Many types of research have influenced the ways in which the existing systems have been designed, measuring their performance and quality from the perspective of the designer, engineer, or developer, and not the stakeholders. From a HCI perspective, there is an inadequate research base to inform fully how to design and evaluate smart parking systems for stakeholders; therefore, this issue requires further investigation.

Conclusion

Various research gaps have been discussed to illustrate that there are not enough studies describing how to design IT smart parking system for stakeholders. Therefore, this issue needs further investigation, and this was my main question posed in the research. In this paper a comprehensive literature review of conference papers and journal articles is performed, where various systems that provide smart parking services are discussed. These systems can resolve the parking problems that arise due to the unavailability of a reliable, efficient, and modern parking system. The main purpose of this review is to find out the current research contributions by searching for valuable contributions, and so identify the issues that can help in developing a new smart parking system. These papers were then assessed for the quality of the evidence they produced and so were categorized. A major goal of this review was to gain greater clarity on the evolutionary patterns of smart parking, as well as its role. At least two research gaps have been identified, which was the primary focus of this research.

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