

Smart parking Systems:

Abstract— Not finding a parking space for you sometimes is indeed a critical issue. The number of vehicles is also increasing daily adding to the parking vows at public places. Cities noticed that their drivers had real problems to find a parking space easily especially during peak hours, the difficulty roots from not knowing where the parking spaces are available at the given time. Even if this is known, many vehicles may pursue a small number of parking spaces which in turn leads to traffic congestion. The traffic on roads and parking space has been an area of concern in majority of cities. So, parking monitoring is an important solution. To avoid these problems, recently many new technologies have been developed that help in solving the parking problems to a great extent. Firstly, this paper gives an overview about the concept of smart parking system, their categories and different functionalities. Then we present the latest developments in parking infrastructures. We describe the technologies around parking availability monitoring, parking reservation and dynamic pricing and see how they are utilized in different settings. In addition, a theoretical comparison is presented to show advantages and drawbacks of each different smart parking system to discuss results and open directions for future research.

Keywords— Smart parking Systems, sensors, Smart parking Technologies, Smart parking services, Internet of things (IOT), Multi-agent systems, Expert systems.

I. INTRODUCTION

The parking problem in big cities, especially the mega-cities, has become one of the key causes of the city traffic congestion, driver frustration and air pollution. So researchers are recently turned to applying technologies for management of parking area by designing and implementation of a prototype system of smart parking that allows vehicle drivers to effectively find the free parking places. In the future the demand for the intelligent parking service will increase because the rapid growth in the automotive industries. An effective solution to this service can be provided by many new technologies. Smart parking, allowing drivers to access parking information through their smartphones. Many cities

have been launching their smart parking projects and apps, yet still very few drivers can really benefit from them. That is because this technology still has to be improved from different perspectives: the robustness of sensor devices, the stability and timeliness of sensor networks, the quality and agility of urban service.

In this paper, firstly we give an overview about the concept of smart parking system, their categories and different functionalities. Then we make a survey of the Smart parking research and implementations. We describe the technologies around parking availability monitoring, parking reservation and dynamic pricing and see how they are utilized in different settings. Finally a theoretical comparison is presented to show advantages and disadvantages of each different smart parking systems and a comparison of technologies used in every system.

II. SMART PARKING SYSTEM

The numbers of vehicles on the road are increasing tremendously [1]. Smart parking is a parking garage system that utilizes various technologies to efficiently manage the garage [2]. Many cities have been starting smart parking projects. Smart parking is a way to help drivers find satisfied parking places efficiently through information and communications technology, especially for on-street parking. Smart parking can also be defined as a parking system that helps drivers find a vacant spot using sensors that detect the presence or absence of a vehicle, and finally direct incoming drivers to available locations.

Smart parking systems can be categorized into many systems: parking guidance and information system (PGIS), transit based information system, smart payment system, E-parking and automated parking [2]. Every System uses different Technologies to detect the presence of car in the slot, the author in [3] divided vehicle sensors and detector system into two main categories: intrusive and non-intrusive sensors.

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- Intrusive sensors are sensors which are installed in holes on the road surface, by tunneling under the road which leads to invasive procedures of installation. Examples of intrusive sensors: Active infrared sensors, Inductive loops, Magnetometers, Magneto resistive sensors.
- Non-intrusive sensors can easily be installed and maintained and does not affect the surface in the process. Non-intrusive sensors encompass microwave

radar, passive acoustic array sensors, passive infrared sensor, RFID, ultrasonic and video image processing.

III. SURVEY ON PARKING SYSTEMS

Cities noticed that their drivers had real problems to find a parking space easily especially during peak hours, the difficulty roots from not knowing where the parking spaces are available at the given time. Even if this is known, many vehicles may pursue a small number of parking spaces which

in turn leads to traffic congestion. Various approaches and researches are made to overcome the difficulties of parking Area. As a result, many systems and technologies are developed for parking.

The author in [4] present the design and implementation of a smart parking system based on wireless sensor networks that allow vehicle drivers to find the free parking places. The scheme is based on WSNs, Embedded Web-Server, Central Web-Server and Mobile phone application. The driver can detect the state of the parking slot using mobile devices thanks to sensor node in each parking slot which detect the state of this one and report it to embedded web-server and finally the information is sent to central web-server using Wi-Fi networks in real time.

This paper [5] present an invention that could be applied to monitor and manage vehicles in a parking garage by informing drivers about the number of available parking spaces and in which area should they be directed to. The scheme is based on the modification of the original WSN and use of RFID and ZigBee technology. To evaluate other meaningful metrics such as time etc. The information obtained from each sensing node is processed collaboratively in two manners either in distributed or centralized manner.

The objective in [6] is to design an intelligent parking guidance and information system with ARM8 microcontroller which can run on an embedded system. The author also introduce an important feature like fetching the above said status of the parking slot on the web or internet and status can update particular time. The webcam finds the free slots for parking. It can capture slots at a time and display it on touch screen LCD. It will display red color box on LCD if any car is present in the slot. If the slot is free it will display empty slot number on the LCD. If any person wants to book the slot, send slot number through SMS. The controller receives the slot number information through GSM. After receiving the information the controller keeps the slot free.

The implemented prototype model is based on image processing technique [7]. The system captures and processes the image of parking lot and produces the information of the empty car parking spaces.

Drivers in big cities wasted time searching for the available parking spaces which increase traffic and pollution. To resolve this problem Yee H.C & al [8] have proposed a smart secure parking reservation system based on GSM technology. This system is divided on two modules parking lot monitoring and security reservation module. The contribution of this work is the use of password in and out. The main hardware and software functions in this system are Pic Microcontroller, Visual Basic, LCD to inform the driver if the password is wrong, motor driver which control the barrier gate it is active when the password is wright, and finally the GSM which play the role of interface between the user and PC.

The author proposes [9] a monitoring parking space system using wireless technologies. The system is divided on two modules: monitoring and master modules in order to help drivers finding vacant parking slot. The presence of vehicles is detected by the use of digital infrared sensors which is interfaced with the microcontroller. The ZigBee will receive the status information and master module will check for the vacant places in parking.

Every day vehicle drivers have to find a vacant parking space especially during the rush hours. It is time-consuming and it is

leading to more traffic, and air pollution. Singh, H. & al [10] presented a solution based on secure vehicle parking management and reservation scheme using wireless technology. The system is divided on three modules: monitoring module, parking lot reservation module, and security module.

In [11], the authors proposed an automated parking system using Bluetooth as a means of access which is a wireless technology standard for exchanging data over short distances. This system uses a mechanical system that transports vehicles to and from parking lots without intervention of the driver. When the driver enter to the parking the vehicle is placed on a movable platform he starts his Bluetooth and start the parking process, the Bluetooth reader fetches the user's Bluetooth id and stores it in database, the ARM microcontroller compares the ID with numbers stored. In the case of new vehicle the parking process is initiated in the other case the vehicle which has already been parked needs to be retrieved and the retrieving process is started.

The integration of networked sensors and RFID technologies [12] is considered in an automatic car park management. Authors proposed a scalable and low cost car parking framework (CFP). These include driver guidance, automatic payment, parking lot retrieval, security and vandalism detection. In this paper the author proposes the clustering of a bunch of sensors and the use of hybrid wireless communications instead of mote in every spot which have a lot of drawbacks in terms of cost and energy consumption. The implementation of CPF includes 3 parts: parking manager, gate manager and parking spots manager.

The author in [13] presents a wireless system for locating parking spots remotely via smartphone. This system automates the process of locating an available parking spot and paying for it. The sensors detect if there is a car in the parking spot, if the car is located no action occurs but if the spot is available the wireless sensor node transmits the location to the servers at each parking area. The servers send the details to the back end. Once user is within 2 km of the parking the server determines the closest available parking spot and sends location to the user.

An agent based coordination network between drivers and car parks is proposed [14]. The prototype is designed through the MaSE methodology. The system considers 3 criteria for driver demand: negotiation of parking fees, the distance from the current location to the chosen car park and finally park's booking and reservation. The negotiation algorithms are employed to bargain on parking prices and to calculate the shortest path for driver.

In this study [15]. The author designs an automatic smart parking using internet of things which enables the user to find the nearest parking area and the available slot in that area. The architecture of the parking system consists of several components: centralized server, Raspberry PI, image capture, navigation system, display device and user device. The cloud based IOT architecture contains cloud service to store information about status of parking slots and the centralized server which stores smart parking system information. The driver can access and map the status of parking slots from any remote location through web browser. But in [16] the author introduced a smart parking system using cloud-based platforms as a service (Paas). The (Paas) provides the tools and services needed to create smart parking solution. We

distinguish two types of Paas: IOT middleware platform as back-end data platform and front-end dashboard platform for virtualization and reporting. The IOT middleware contains 3 modules: data storage module, device management module and processing module. The utilization of Paas has resulted in the creation of faster smart parking system which has a lot of benefits.

The author in [17] designs a prototype for IOT based car parking management system for smart cities using infrared sensors, RFID and IOT. This prototype offers a lot of services: finding parking space availability, IOT maintains the database of parked vehicle through a shared server, booking slots and finally theft management. It has also some advantages: less human interaction, increases flexibility and security. This system consists of different modules: online booking, parking entrance system, parking exit system and parking management.

The (table I) contains advantages and disadvantages of various parking systems implemented by researchers. In (Table 2) we divided the parking system into 6 parts:

- Collection: relies on sensors to collect the real-time parking.
- Processing: concerns technologies used to process data sensors and which type of data.
- Deployment: deals with the communication methods. •

Urban Services: can be provided to the user once the data storage and information monitoring are done. •

Connection: concerns the IOT layer which maintains the database of the parked vehicles through a shared server.

- IHM: means the technologies used as interface between human and the parking system.

IV. DISCUSSION

From this two tables shown below (Table I, Table II), we can see that only one smart parking system has used an intelligent agent system. For that reason we will propose a multi-agent parking system based on expert systems that offers many services for the driver. Agent-based systems technology has been hailed as a new paradigm for conceptualizing, designing, and implementing software systems. Agents are sophisticated computer programs that act autonomously on behalf of their users, across open and distributed environments, to solve a growing number of complex problems. Increasingly, however, applications require multiple agents that can work together. A multi-agent system (MAS) is a loosely coupled network of software agents that interact to solve problems that are beyond the individual capacities or knowledge of each problem.

TABLE I. Advantages and disadvantages of different smart parking system

Ref year	Advantages	Disadvantages
[3] Yang, J., Portilla, J., & Riesgo, T. (2012)	-WSNs Technologies are easy to deploy in existing parking lots and give flexibility to connect with cheap sensors for keeping track of vehicles. -Thanks to mobile device the driver can detect the parking slots state in real time. -The parking slots state is saved in database.	-The driver can't make a reservation in mobile interface. -There is no multilevel parking inside an infrastructure. -The driver can't make a remote payment.
[4] Patil, M., & Bhonge, V. N. (2013)	-The RFID can be used for secure, fast and easy checking in and checking out of the vehicles within less time. -ZigBee Wireless Technology provides secured data transfer. -The system checks whether the vehicle that comes to parking is registered, the check in information is stored in database. -Information about parking slots is displayed on the LCD screens placed in the parking area and driver is guided to	-The system allows one by one parking, is time consuming and thus preventing multiple check-ins or check-outs at a time. -The driver can't make a reservation of slot via a mobile device. -The use of RFID increases the cost. -Node-to-node implementation requires more time.

	particular slot. -The system can be installed conveniently, there is no need to change the existing parking system and it is compatible with the existing wired networks.	
[5] P.DharmaReddy, A. Rajeshwarao, Dr. Syed Musthak Ahmed (2013)	-The parking system is easier and flexible to their person fetching the above said status of the parking slot on the web or Internet view and book the slot from anywhere. -Using image processing technique it identifies car only but if any object other than car is at parking slot it doesn't considered that slot is booked. - The system shows real time information.	-The cost of implementation is High. -User will have to inquire for every slot available. - When many incoming information are occurring in a short time GSM system creates bottlenecks.

[6] Al-Kharusi, H., & Al-Bahadly, I. (2014)	<ul style="list-style-type: none"> -The camera can be easily moved to detect different car parking lots and the presence of many cars at once. -The processed information extract from the image was used to guide a driver to an available car park rather than wasting time to find one. -Using camera is efficient and inexpensive. 	<ul style="list-style-type: none"> -The weather conditions affect the visibility of the park lots. -The camera should be placed in a fixed position where can clearly see all the car parks and not be obstructed by any objects.
[7] Rahayu, Y., & Mustapa, F. N. (2013)	<ul style="list-style-type: none"> -The driver can know the parking lot status thanks to layout animation. -A password is provided for users who make reservation to enter and exit the parking. -The process of reservation is more easy and simple -The system improve the parking performance like reducing time, traffic and enhance the safety of vehicle in parking. 	<ul style="list-style-type: none"> -When many incoming information are occurring in a short time GSM system creates bottlenecks. -If the database is off the system can't send the confirmation to the user.
[8] Yee, H. C., & Rahayu, Y. (2014)	<ul style="list-style-type: none"> -To detect the presence of vehicle the author used digital infrared sensor due to its waterproof, high precision and can protect from corrosion. -Low cost for ZigBee implementation. -ZigBee has low power consumption and its long range data integrity can sense up to 30m in indoors and 90m in outdoors. -The system reduce the time used to search for parking slot and reduce traffic problems 	<ul style="list-style-type: none"> -The cost of implementation is high. -No password is provided for users. -Drivers can't make reservation to enter and exit the parking.
[9] A.Poojaa (2015)	<ul style="list-style-type: none"> -The status of parking lots is provided to drivers in real time. -Driver can access to their reserved parking lot via a .Net application. -If an illegal person accessed to user's vehicle the system will not allow the vehicle to exit from the parking and SMS based warning will be provide. -The system is very effective and very easy to execute in real time. -The user is guided to the fixed space in the lot thanks to the space number flashed on the Display. -Security code is assigned to the arrived car and it is checked at the exit. 	<ul style="list-style-type: none"> -This system suits well for multilevel and closed underground car parking. -Node-to-node implementation requires more time. -The cost of implementation is high. -When many incoming information are occurring in a short time GSM system creates bottlenecks.
[10] Singh, H. & al (2014)	<ul style="list-style-type: none"> -There is no redundancy in the system because Bluetooth has a unique registration number. -Bluetooth reader and device is very cheap. -The automated parking system eliminates the wastage of space and the need for manual intervention. -Bluetooth has very low power consumption. -The system allows the drivers to save time and fuel. -Availability of Bluetooth in every device. 	<ul style="list-style-type: none"> -The time and cost of implementation is high. -If several vehicles arrive simultaneously there will be a deadlock situation due to single entry and exit point. -Low Bluetooth range.
[11] Karbab, E & al (2015)	<ul style="list-style-type: none"> -Use of gathering protocol LIBP to manage energy in heterogeneous wireless sensor network. - CPF provides a lot of services for the driver. - The CPF gives two classes of performance in terms of energy consumption and financial cost deployment. 	<ul style="list-style-type: none"> -The parking don't prevent the user in the case of car theft
[12] Orrie, O., Silva, B., & Hancke, G. P. (2015)	<ul style="list-style-type: none"> -The user can locate an available parking space and pay for it from smartphone. -GPS give real time location and guidance toward destination. 	<ul style="list-style-type: none"> -The smartphone application is efficient if the user is within 2 Km of the location. -Addition of security features to protect the user privacy
[13] Chou, S & al	<ul style="list-style-type: none"> -the driver can search for available parking spaces, negotiate the parking fees and make a reservation and payment. 	<ul style="list-style-type: none"> -the system is available only in In-Vehicle advanced information systems which are the standard equipment in the expensive and luxurious cars.

(2008)	<ul style="list-style-type: none"> - The system gives the user the distance from the current position to the chosen car park. 	<ul style="list-style-type: none"> -high cost of deployment
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[14] Basavaraju S R. (2015)	-Internet of things plays a vital role in connecting the surrounding environmental things to the network and made easy to access those things from any location. -The driver can find the nearest area and the available slot in that area. -This system reduces the time in finding lots and the fuel consumption.	-The system doesn't provide guidance and payment for the driver. -The availability of spaces couldn't be displayed on a smart phone application. - Addition of security features to protect the user privacy.
[15] Suryady, Z & al (2014)	-The utilization of PaaS development environment has resulted in the creation of faster smart-parking system. -The benefits from using PaaS are : <ul style="list-style-type: none"> • Reducing Time. • Reducing Cost and maintenance. • One platform can flexible collaborate with another platform. 	- The system doesn't provide guidance and payment for the driver. -The availability of spaces couldn't be displayed on a smart phone application. - Addition of security features to protect the user privacy.
[16] Gandhi & al (2016)	-User can find parking space availability -IOT provide data storage, processing and collection of data -Drivers can book slots -Theft management -Less human interaction -Increases flexibility and security	-Absence of illegal parking detection service. - Suitable in the case of indoor and multilevel parking.

TABLE II. Different Technologies and services used in smart parking systems

Ref	Collection	Deployment		Services								Connection	Processing		IHM		
	Type of sensor	NetS	NetU	GY	PY	LR	SE	RE	GM	AC	PM	IOT	BD	CC	SP	WA	VICS
[4]	Light sensor	WiFi	WiFi-3G			+				+	+				+	+	
[5]	Reflection sensor+RFID	ZigBee		+		+			+								
[6]	CMOS Camera		GSM	+	+	+	+										
[7]	Camera			+	+	+											
[8]			GSM			+	+	+	+	+						+	
[9]	digital infrared sensor	ZigBee		+		+				+						+	
[10]	Infrared Sensor	ZigBee	GSM		+	+	+	+			+				+		
[11]			Bluetooth		+	+	+				+				+		
[12]	ultrasonic sensor,+RFID	ZigBee	Wifi-3G		+	+	+	+	+	+	+				+	+	
[13]	Sensor+RFID				+	+		+			+				+		
[14]	agent	Contract net		+	+	+	+	+									+
[15]	Pi camera	WiFi				+				+		+		+		+	
[16]	ferromagnetic sensor	ZigBee				+				+		+		+		+	
[17]	Infrared sensor+RFID				+	+			+	+	+	+		+	+	+	

GY:GUIDANCE PY:PAYEMENT LR:LOT RETRIEVAL SE:SECURITY RE:RESERVATION GM:GATE MANAGEMENT
 PM:PARKING MANAGEMENT USING SMARTPHONE AC: AVAILABILITY CHECKING OVER INTERNET IOT:INTERNET OF
 THINGS BD:BIGDATA CC:CLOUD COMPUTING WA:WEB APPLICATION SP:SMARTPHONE VICS:IN-VEHICLE SY (+) : THE
 TECHNOLOGY OR THE SERVICE IS USED IN THE PAPER

V. FUTURE WORK

In the future work we will propose a dynamic smart parking architecture based on multi agent systems. Our system will be divided to different process:

- Communication module: It will concern the request send by the driver to the system.
- Coordination module: at this level we find agents which have the role of displaying information to the user in a suitable manner taking into account constraints of the device.
- Processing module: the main role of this module is the processing of different queries sent by the user e.g.: reservation, payment, check-in, check-out, etc.
- Data module: it contains data of the parking saved on real time.

The contribution of our system will concern the data analysis process which is the node of our system .For that reason we will use different modern techniques such as Expert Systems and SMA. We should integrate the two different technologies together in order to achieve a system which is the most efficient, reliable, secure and inexpensive. Expert systems have a lot of attractive features:

- Increased availability.
- Reduced cost
- Reduced danger
- Permanence
- Increased reliability
- Explanation
- Fast and complete response at all times
- Intelligent Database
- Multiple expertise

VI. CONCLUSION

In this paper, we define the concept of the smart parking system, their Types and the classification of different technologies. After we give a survey of different parking systems which was implemented by many researches to resolve the growing problem of traffic congestion, wasted time, wasting money, and help provide better public service , reduce car emissions and pollution, improve city visitor. The table contains advantages and disadvantages of various parking systems implemented by researchers. As a future work we will propose a dynamic architecture based on multi-agent systems and expert systems for smart parking management.

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