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Smart Parking Solution Using Internet of Things Approach

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Abstract: This paper reveals a work-in progress to capitalize on private land properties for parking, in order to relieve stress on public agencies, create new sources of revenue, and enlist new entities in the intermediary market. These intermediaries, labelled as Parking Service Providers (or PSPs) play a broker role through advertising parking lots on a shared cloud platform. To streamline these business collaborations and related processes, physical parking lots are augmented with Internet connectivity allowing cloud-provided applications tocongregate these lots into a larger inventory. The Internet of Things (IoT) paradigm expands the scope of cloud-based intelligent car parking services in smart cities, with novel applications that better regulate car-parking related traffic. This paper presents a work-in-progress agenda that contributes to new business solutions and state-of-the-art research impacts.

Keywords: Smart parking systems; internet of things; sensor networks; cloud computing; web services.

I. INTRODUCTION

Internet of Everything (IoE) can be defined as the intelligent connection of people, process, data and things. This is a concept that extends the Internet of Things (IoT) based Machine- to-Machine(M2M) communications to describe a more complex system that also encompasses people and processes yielding smart solutions to people. This paper looks into the aspect of how IoE concept could be implemented in the case of smart parking solution in an urban scenario. This makes sense when India has jumped into the bandwagon of creating 100 smart cities. People in cities waste a lot of time in getting a parking slot. In addition to waste of time, other side effects of this are increased fuel consumption, more green gas release, productivity loss, wastage of money etc. This smart parking solution would help the people to identify, locate and pre-book parking slots as per their requirement. Others on the move can also get to know about the nearest parking lot available through this application. One of the causes of this excessive amount of time spent on the road in private road transport isthe need to spend time looking for free parking spaces. Pineda [1] studied the costs generated by the extra distance vehicles have to travel to find a parking space in the cities of Madrid and Barcelona. The costs in consumption for the extra distance and time spent on the road are approximately 347 millio nand 268 million euros per year, respectively. Public transport authorities and the operators of parking spaces are evaluating various solutions to improve parking space management. Solutions based on infrastructure investment are expensive and implementation is slow. Technology-based solutions have been proposed as an alternative with lower costs and faster implementation.

II. LITERATURE REVIEW

Various authors have looked at developing sensor-based technological solutions to improve theuse of parking spaces. According to Bagula [2], intelligent vehicle parking space management systems may be classified according to the type of sensor detection. He distinguishes the systems that only monitor the entry or exit of vehicles from the parking area from the systems that are able to detect whether each parking space is occupied or free. Systems belonging to the first type are easier to deploy and less expensive, appropriate for monitoring the occupancy levels of large outdoor parking areas. Systems belonging to the second type provide more useful and more detailed information to users and may be combined with positioning and guidance services to help locate the available spaces. This type of system is used in indoor parking spaces and is more complex and expensive than the entry and exit monitoring systems, as it requires that each parking space is equipped with sensors and a more sophisticated communications infrastructure. Various parking space management system proposals are described below.

Tang [3] proposed a wireless sensor network deployed in indoor car parks that shows the occupancy status of each parking space. Motes (sensor nodes) equipped with acoustic and light sensors are located in each space, and periodically notify whether the space is occupied or available.

Benson [4] also proposed a network-based wireless sensor system. A communication link is established by ZigBee and the electromagnetic sensors were developed specifically for this system.

Lin [5] proposed a vision-based parking management system to manage an outdoor car park using cameras set up around the parking space, sending information, including real-time display, to the ITS centre database. A scientific solution based on a GPS-based vehicle navigation system and the past and current status of the car park was proposed

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by Pullola [6], who modelled the availability of a car park using thePoisson process. The author also proposed an intelligent algorithm which helps the driver choosethe parking space with the highest probability of being vacant.
Lee [7] proposed a combination ofmagnetic and ultrasonic sensors to control car parks. This system is based on a modified version of themin-max algorithm for detection of vehicles using magnetometers and an algorithm for ultrasonicsensors.
Srikanth [8] proposed an intelligent parking management system, consisting of a wirelessnetwork that uses different types of sensors to detect the presence of a vehicle in every one of theparking spaces; moreover, the system informs users and guides them to the location of the availablespace. The network's sensor nodes communicate by radio frequency.
Yoo [9] described a system,called S3, which is deployed in school zones, which is designed to detect and register vehicles drivingat excessive speeds or parked in prohibited zones. This system consists of a wireless sensor networkthat is divided into two subnetworks: one to detect vehicles parked in prohibited zones and the otherto detect vehicles travelling at excessive speeds. The sensors used are Anisotropic Magneto-Resistive(AMR) magnetic sensors, and the wireless communication link is established by ZigBee. Magrini [10]proposed a vision sensors network to monitor available spaces in public car parks, using distributednetwork nodes to perform the required processing and analysis of images.
Chen [11] proposed a Sensors **2016**, 16, 931 3 of 16system for locating available spaces in indoor car parks and a guidance system to locate the availablespace. The architecture of this system is based on a wireless network of ultrasound sensors that detectthe presence of a vehicle in each of the parking spaces. The status of each space is transmitted bya sensor node that sends this information via RFID to special routing nodes, which communicatewith each other to relay the data packets sent by the sensor nodes to the control centre. The networkhas a tree topology. Assistance in locating the space is provided by LEDs that indicate the statusof the parking space. In the context of public parking space management based on image sensors,
Salvadori [12] described image-processing techniques, using threshold algorithms, to monitor parkingspaces, achieving high-performance detection of their occupancy status.
Alessanderlli [13] proposed the Scan Traffic architecture, which is used to develop a system to monitor traffic flow and parkingspaces at the International Airport of Pisa; this system is also based on a wireless image sensor network.
Liu [14] described the iParking system, which is designed to facilitate the location of available spaces inan indoor car park. The system receives data from sensors located inside the car park, which indicatethe spaces that are free, and is able to guide the driver to a free space using a positioning system forindoor spaces that is based on smartphone capabilities.
Gu [15] proposed a system for managingparking spaces on public roads. The system is called Street Parking System (SPS), and uses a three-axismagnetic sensor to detect vehicles and ZigBee technology for wireless communications, achieving a reliability rate close to 99% in vehicle detection. Reve
[16] also proposed a similar system, based on awireless sensor network and LED display system that indicates the available spaces to drivers at the carpark access points. The sensors are infrared and communications are established by radio frequency(RF). In the context of the Smart City paradigm,
Giuffrè [17] proposed an IPA (Intelligent ParkingAssistant) conceptual architecture that aims to overcome current parking management problems.
Yang [18] presented a prototype Smart Parking Services system, based on Wireless Sensor Networks (WSNs), for finding free parking spaces. The proposed scheme consists of wireless sensor networks, anembedded web server, a central web server, and a mobile phone application. Each parking space has alight sensor node that detects the status of the parking space, reporting periodically to the embeddedweb server via the wireless sensor networks. Using a Wi-Fi network, this information is sent to thecentral web server in real time, displaying the status of the parking spaces on the driver's mobile device.
Geng [19] proposed a smart parking system for urban areas. The system's functions include parkingdetection, reservation guarantee and Vehicle-to-Infrastructure (V2I) or Infrastructure-to-Vehicle (I2V)communication. Considering the requirements of the user, the system assigns and reserves an optimalparking space combining proximity to destination and parking cost, ensuring that the overall parking capacity is efficiently utilised. The system was tested in a garage of Boston University.
Tian [20]proposed an intelligent parking management system based on License Plate Recognition (LPR), whichrecognises the licence plate automatically at the car park access point and provides vehicle information;experimental results show that this parking management system can achieve 95% accuracy, and can beapplied to real-time implementation.
Karunamoorthy [21] proposed an intelligent parking system thatuses image-processing techniques to solve the problem of unnecessary time consumption in findinga parking space in commercial car parks. This parking management system provides informationabout the available parking spaces, as well as an automated payment system for registered users.Caballero-Gil [22] proposed a low-cost service to predict and manage indoor parking spaces. Thisservice is based

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on a central system that predicts the available spaces in the car park using cellularautomata and an application for smartphones that uses various technologies to help drivers find freeparking spaces.

III. STATEMENT OF PARKING LOT PROBLEMS

A. *Difficulty in Finding Vacant Spaces*

Quickly finding a vacant space in a multilevel parking lot is difficult if not impossible, especially on weekends or public holidays. One study showed that 86% of drivers face difficulty in finding a parking space in multilevel parking lots A.Kianpisheh[23]. Finding spaces during weekends or public holidays can take more than 10 minutes for about 66% of visitors. Stadiums or shopping malls are crowded at peak periods, and difficulty in finding vacant slots at these places is a major problem for customersD. B. L. Bong [24]. Insufficient car park spaces lead to traffic congestion and driver frustration M. Y. I. Idris[25].

B. Improper Parking

If a car is parked in such a way that it occupies two parking slots rather than one, this is called improper parking. Improper parking can happen when a driver is not careful about another driver's rights. Sometimes improper parking occurs when a driver parks on or a bitoutside of the lines of a parking space. The driver may notice his improper parking after leaving his car, but may not be willing to unlock his car, restart it, and adjust it to be inside the lines. This matter annoys other drivers and most of the time a driver who wants to park ina small leftover slot will give up and feel frustrated.

C. Parking Fee Payment

Parking fee payment can be a time consuming activity for people. Since many current payment machines just accept small notes and coins, finding the exact amount and queuing for payment is not pleasant for drivers. Therefore, providing services that make payment convenient is desirable. One survey showed that queuing up for payment and finding coins for parking fee payment is troublesome. Moreover, most respondents agreed that using Touch'n'Go (a system that allows simply swiping a card and deduct fees from inside credit) is useful and will decrease queue up timeA.Kianpisheh[23].

IV APPROACHES AND METHODOLOGY

A. *IoT Middleware*

The architecture supporting the evolution of PSP business model is illustrated in Fig. 1. This architecture enlists amiddleware layer to enable diverse connectivity to parking spaces via numerous sensing technologies. In doing so,the functionalities of the expected middleware support a cloud infrastructure for parking services, as illustratedfurther in Fig.2. The cloud facilitates a service-oriented approach to parking, providing a managerial layer thatmonitors the provisioning process of parking services.

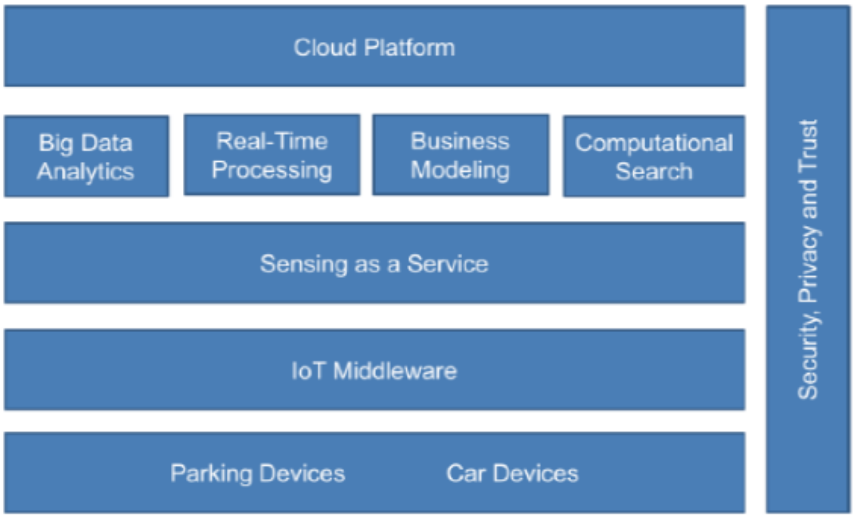

Fig 1. Architectural Building Blocks

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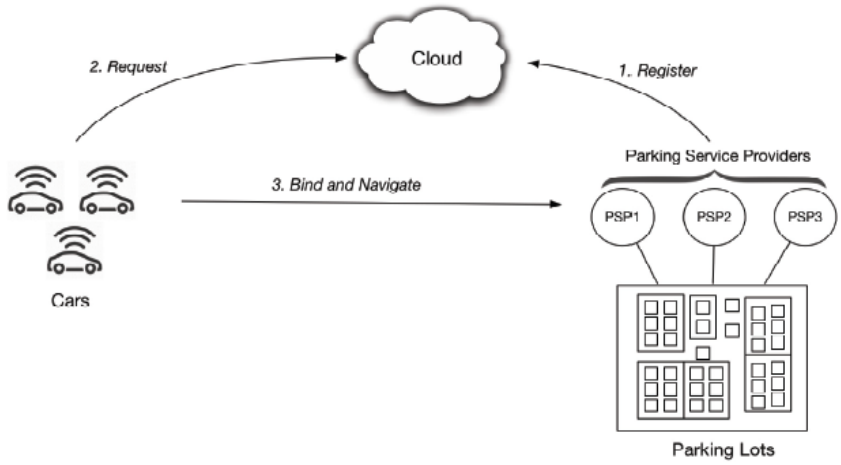

Fig 2. Parking Service Providers Interactions

B. Sensing as a Service

The cloud infrastructure provides a platform to conglomerate various services, including sensing services, whichabstract the metadata associated with sensing devices. A suitable specification for creating standard dictionaries ofsensor-related metadata is proposed. This approach is followed by the elaboration of an ontology and inference rulesto allow applications to reason about parking services. The development of sensing as a service framework supportsthe integration of a parking-service registry and a knowledge base used for value-added services.

C. Data Analytics and Collaborative Search

IoT middleware and sensing service frameworks provide the needed data sources for analytical approaches toestimate or locate best parking spots. However, finding a parking spot is not an end by itself as congestion couldresult when ignoring the paths motorists follow to access or exit parking spots. Hence, the collaborative pathplanningalgorithm research is about planning paths towards vacant parking spaces, while considering mutualprogress. In the search space, nodes are streets and metropolitan junctions. Concurrent agents traverse the searchspace to take decisions that best balance roads occupancy and reduce congestion.

IV. CONCLUSION

This IoE based parking solution offers many benefits likeoptimized parking, reduced traffic,reduced pollution, enhanced userexperience, new revenue streams,integrated payments, increasedsafety, real-time data and trendinsight, decreased managementcosts and increased service andbrand image. The solution can bemade more futuristic by addingmore intelligence and smartnessinto the application for a better userexperience. Main issue at presentis the lack of standardisation of different sensors, which makes compatibility a problem. However, standardisation agencies and research bodies are working on this matter. India has a longway to go to make these thingsavailable with Indian technologies.The software and hardware
technologists, technical bodies,companies and governmentsshould come together to developIndian technology solutions forInternet of Things, which is the nextbig thing happening now along with block chain technology.

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