Smart Car Parking System Solution for the Internet of Things in Smart Cities

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***Abstract*—The Internet of Things (IoT) is able to connect billions of devices and services at anytime in any place, with various applications. Recently, the IoT became an emerging technology. One of the most significant current research discussion topics on the IoT is about the smart car parking. A modern urban city has over a million of cars on its roads but it does not have enough parking space. Moreover, most of the contemporary researchers propose management of the data on cloud. However, this method may be considered as an issue since the raw data is sent promptly from distributed sensors to the parking area via cloud and then received back after it is processed. This is considered as an expensive technique in terms of the data transmission as well as the energy cost and consumption. While the majority of proposed solutions address the problem of finding unoccupied parking space and ignore some other critical issues such as information about the nearest car parking and the roads traffic congestion, this paper goes beyond and proposes the alternative method. The paper proposes a smart car parking system that will assist users to solve the issue of finding a parking space and to minimise the time spent in searching for the nearest available car park. In addition, it provides users with roads traffic congestion status. Moreover, the proposed system collects the raw data locally and extracts features by applying data filtering and fusion techniques to reduce the transmitted data over the network. After that, the transformed data is sent to the cloud for processing and evaluating by using machine learning algorithms.**

Keywords Internet of Things (IoT); smart city; smart car parking; Disruptive Car Parks; embedded computing; Cloud data mining; Fog Computing; Distributed Data Analytics;

I. Introduction

The rapid industrial growth in the world is reflected in increased number of cars on the roads globally [1]. It is expected that the number of cars in the world will increase significantly from 841 million cars in 2008 to over 1.6 billion cars in 2035 [2]. Nowadays, the shortage of available car spaces is evident in many public places such as stadiums, market areas, hospitals, shopping malls and airports, hence, governments are looking to improve their existing transportation systems and infrastructures. However, the slow progression of city planning has broaden the issue even more [3]. Finding unoccupied parking spaces is a common problem in most modern cities, especially during peak times of various festivals. This problem appears mostly in the modern cities; individuals come by their cars, resulting in a high number of cars competing for a few unoccupied parking spaces and security for their parked cars. Moreover, in indoor car parks, most of the time is wasted on searching for unoccupied parking place which also creates traffic jam.The situation becomes worse when there are multiple parking slots in every parking lane. Another issue is the air pollution caused by cars in halt, be it in the outdoor or indoor car parks. In addition, most of the population use their own cars for traveling [3], which leads to more congestion in cities which in turn delays the process of finding an unoccupied parking space for the rest of the drivers. An important issue to be considered is how to reduce such data transmission cost and how to save energy as well as provide real-time information quickly - these issues require urgent resolution. The idea of smart car parking systems is recently attracting more attention in many countries owing to the need for a new way of finding available parking places. The IoT provides the capacity to deal with such challenges, as it can be designed to capture sensors data for monitoring points of interest in smart cities.

Recently, researchers have explored the potential use of the IoT in public transportation services and urban computing [4]. Several models have been proposed to provide drivers with real-time information about available car parking bays nearby [5]. Additionally, some of them proposed solution to collect and send the data to the cloud processing center which determines the solutions and provides these back to the car parks. Only a few studies have been conducted where the data about available car parkings on-street parkings was gathered more effectively. It was done by checking the road status if there was a traffic congestion or not and if the parking location was near the user. Adding on that ,some research papers proposed that [6], [7], [8] there is a need to develop a smart car parking that indicates directly the availability of unoccupied parking spaces in the nearest car parks to users while at the same time it makes users avoid the traffic congestion on the user's way to the chosen parking. Optional choice could be added to make the web service display only free-of-charge car parking places to the user.

The main contributions of this paper are as follows. First, the data is collected from different distributed sensors in

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indoor parkings and on-street parkings. Second, the collected data from the sensors will be analysed and processed locally with the help of IoT devices. It is proposed that a real time processing for the smart parking data is extracted from the sensors. The data will be evaluated by using machine learning algorithms, which in turn processes according to predefined conditions. In addition, the system includes mobile phone application that lets users easily check the nearest car parking with avoiding possible traffic congestion via Google API, which provides a real time reading of the traffic status. The cloud web service will collect the data from fog micro-controller distributed devices that are near users location to start analysing and processing data. Then the data will be transmitted to users to indicate the nearest available parking which offers the lowest traffic congestion. Therefore, the user will receive an immediate response from the cloud showing the number of available parking places represented in the map with the less crowded roads from users existing location.

This paper consists of four sections. The first section is the introduction section, the second section is discusses challenges to overcome in the currently used system. In the third section, the proposed approach is represented which demonstrates the overview of the system and the architecture design for the system side as well as for the graphical user interface design. The last section contains the discussion, conclusion and future works.

II. Challenges

There are a number of main challenges in smart car parking projects related to processing the received data from the parking sensors including data fusion and filtering [9]. Data fusion techniques allow to aggregate and integrate sensor data from several sources to produce knowledge. Data filtering is important to minimise as much possible the transmitted data in the network [9]. However, where and how to conduct data fusion and filtering are still open challenges. In-network level data processing is important because the unused, unnecessary and private data is not going to be transmitted over the network. In other words, the continuously generated raw sensors data will not be sent to the cloud, which is costly and expensive. Another challenge is to identify the machine learning algorithms or capabilities that might help to process the collected data. Moreover, it is crucial to make all parties provide an excellent functionality with each other in the real time and avoid occurring of errors as much as possible.

III. Proposed Approach

This section starts by describing the structure of smart car parking system which consists of three main parts: parking part which includes sensor nodes in indoor car parking or on-Street parking, micro-controller devices and smart car parking facilities. The second part will be the cloud which represents the mediator between the car parking and the user mobile phone application. The third part is the user side represented by mobile phone android application. This system has the following functionalities consisting of processing the sensors data locally, displaying the availability of car parking spaces, ability to guide the user to find the location of the parking spaces. It makes the driver avoid traffic congestion as much as possible. Furthermore, the system provides the driver with the closest parking from the user current location. An optional driver feature provided by the system is that if the driver wants only to show the nearest free of charge parking spaces from the driver, then the system will show the available free of charge parking. In terms of communication, wireless communication is used between sensors and micro-controller devices based on technologies such as Bluetooth, as being a low cost option. Also, the communication between users and the cloud will be via HTTP protocol. There are several steps into data management in IoT, from collection to analysis and results presentation. In this part, we are going to represent the data filtering and fusion approach methods of the system. Furthermore, Figure 1 shows the architecture and functionalities of the system and details are explained below.

A. Overview

There are several steps to process the data in IoT including collection, filter, fuse, preprocessing, storing and delivering the data [9]. The data filtering function filters the sensor data to reduce the amount of transmitted data. In addition, data fusion function aggregates and integrates sensor data to provide with more comprehensive information and thus produce more accurate and meaningful information to users. Researchers have shown an increased interest in data fusion and filtering in the field of IoT. Data processing can be done at source, in

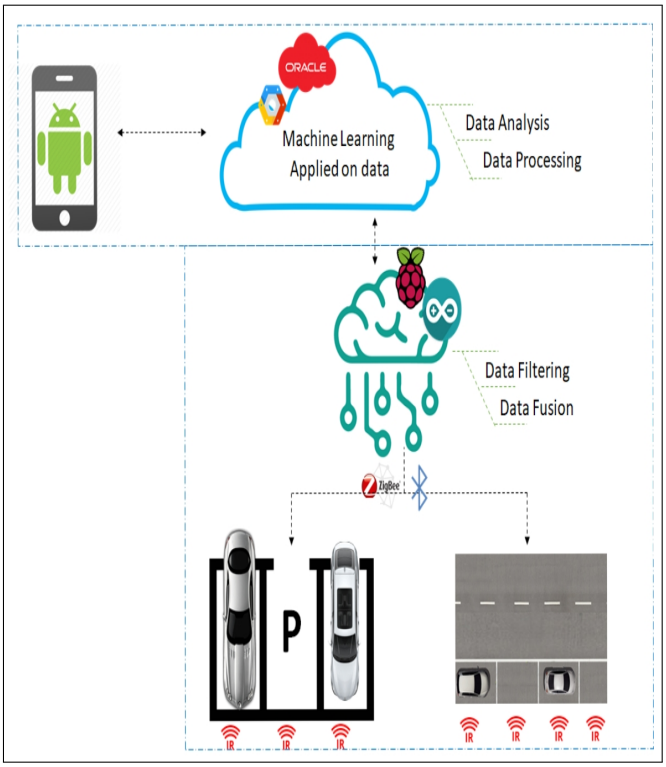

Figure. 1: Functionalities of Smart Car Parking System.

the network and in the Figure. 1: Functionalities of Smart Car Parking System cloud. The research to date focused on cloud processing rather than in-network level processing. It is clear that the cloud computing is important for enabling the vision of IoT from several perspectives such as data storage and high data processing power [10], but this can be enhanced by IoT middle-ware which supports data management including data processing and real-time services to IoT applications [11] in other parts of the network. It is important to know where the data processing will be done most effectively. Therefore, this paper considers that processing sensors' data locally with middle-ware before sending to the cloud for further processing and storage is highly relevant for the internet of things and thus largely overlooked.

The main objective of the research paper is a) an approach to filter sensors' data to discover the existence of vehicles on a parking spaces by using wireless sensor network through localised processing, b) a middle-ware architecture which can manage the generated data from sensors to support the approach, c) present a novel parking system with support of the multi-Edge-Fog which will minimise the traffic congestion by displaying free vacant spaces, ensuring that it shows the nearest parking spaces to users, and also to avoid the traffic congestion as much as possible.

B. Architectures

a) The Sensor node: This IR sensor node is the lowest level of the smart parking system and it is placed in every parking space. The IR sensors are used to detect the obstacles. They are very cheap and easily available on the market. It uses a voltage of about 0.5 volts-0.25 volts and it reduces program complexity. If any vehicle is detected at that time, the IR sensors senses the output which is red and when there is no vehicle at that time its output is shown as green.Then, it sends the data to the middle-wear micro-controller IoT device by using wireless communication.

b) The fog node: It is micro-controller device which is considered as fundamental part of the system. It is functional for collecting sensors data using wireless communication and it does filtering on the collected data from the sensors and processes the data locally. This step is important to minimise transmitted data over the network and to save the energy [12]. Furthermore, it sends the processed data which contains the number of free car parking spaces to the cloud using web protocols such as HTTP or COAP for storing and processing the data.

c) The cloud node: The cloud role will be to receive the processed data from the fog node and then two main tasks are to be done by the cloud. First is to process the received data with help of Google API and mainly apply machine learning algorithms on the data and store them. Second is to send the information to a user's mobile phone application. It is clear that the processing power and storage capability of the cloud is high. This power can be used even more effectively by using the presented approach.

d) The mobile node : "Android is an mobile operating system developed by Google based on Linux kernel and primarily designed for touch screen"[13]. Android operating system is a stack of components that is roughly divided into 5 sections which are Linux kernel libraries, Android Runtime, application framework and component. The smart phone application provides users with an interface to interact with the device. The application provides users with the real time reading of the available spaces for the nearest parkings. Users will be also able to receive a real time reading for the traffic situation for each nearest parking from the user. An additional feature is the Text to Speech module which ensures that the users do not have to look at their phones while driving. Figure 2 shows the android software design.

IV. Related works

Various parking systems have been done in the past. It is apparent that the car parking systems implemented in developed countries are done with advanced technologies deployed in the car park. This section reviews various works conducted on smart car parking systems.

Some available car parking systems researches are sensor based [14], [15], [16] which generally processed the problem of locating an unoccupied car parking place. Similarly the same aspects were observed [17], [18], [19], [20] which may lead to a higher traffic congestion while other parking recourses remain available to use. Moreover, the problem with these systems are that they are unable to find out a solution for previously mentioned issues such as the nearest car park

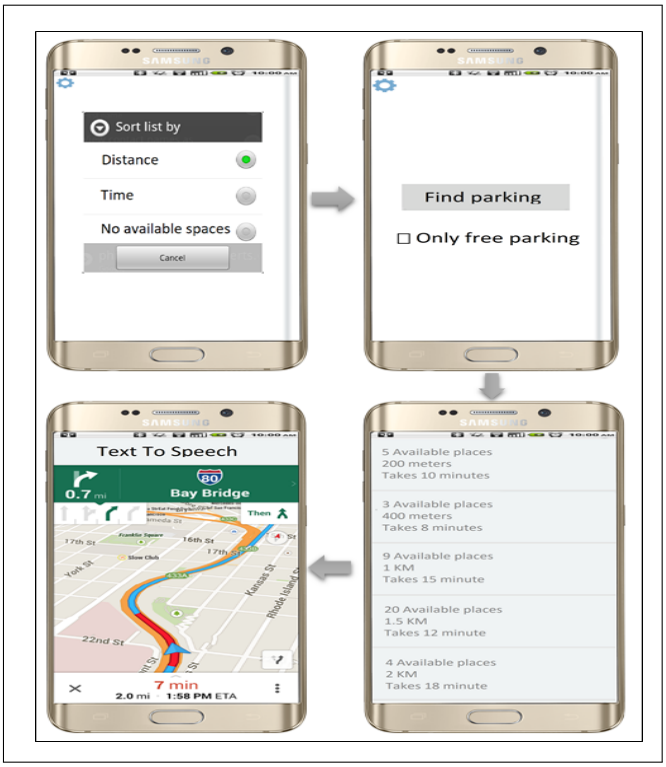

Figure. 2: Software Design.

available and the roads traffic congestions. Hence, the main focus was in determining the occupancy status of parking spaces.

Some of the researches [21], [22] focused on information system and guidance for parkings. Those systems provide users information via some message signs in actual time available parking spaces for a specific zone.The total occupancy is gathered by using the sensors on the both entrance and exit of the parking location. Moreover, in [22] result of the survey shows that there is a huge desire from the participants for more dynamic, accurate and personalised parking information at both before the trip and en-route. However, in the proposed system, the information represented to the user on the map via helping of Google API will be via micro-controller device that will save the energy and reduce the amount of transmitted data, while the final results will be represented on the user mobile application.

The work [23] proposed system finding available parking spaces depending on the visual sensor network. In addition, there were wireless cameras installed in the local area to get the image of the parking lots which sent them to a centralised system for processing. They demonstrated promising outcomes by deploying the system on a visual sensor network and the test presented how good was their method in terms of performance and low requirements. However, this system generates a significant amount of data which is to be transmitted over a network to a centralised system that will increase the transmission cost of data and consume more energy.

Moreover, the study [24] proposed a cloud-based car parking method to reduce the consumption of time and gas while finding car parking spaces. Additionally, they used simulation tools to show their system architecture and they have implemented a real scenario. They used wireless sensor network and RFID to control the car park that produced a large amount of data which were sent to the cloud for processing. The shortcoming of their study was that they did not consider the expensive method of sending the huge amount of generated data.

Furthermore, the work in [25] proposed a car parking system in IoT in the context of airport car parking which allows the registered users to login to the system to check the free spaces in the parking. In addition, GPS is used to show the exact available vacancy in the parking area to users using cloud server. However, all the processed data is transmitted to cloud for processing then the results sent to the users. This means a lot of data is transmitted over the network which involved high cost of data transmission.

Finally, most of the existing approaches did not attempt to localise data processing by moving some decision making closer to the source of the data. This rersearch proposed a the data management approach to process sensor data locally in order to avoid the high volume of data to be transmitted over the network. In that attempt, we used WSN to monitor the car parking spaces. Furthermore, the data filtering and fusion techniques are used to reduce the energy consumption and cost of data transmission in the proposed approach. In addition, the android application shows the user the nearest parking spaces and the road traffic status of intended parking.

V. Discussion

The smart car parking system provides way to save the energy and minimise the transmited data over the network. There are a number of advantages of this system. The first advantage is to help users to save time by providing the right direction of the free car parking space. It also helps to show users many available parking areas close to users' location as well as the traffic situation. Another positive aspect is that the system is automated which does not require any user intervention. Additional feature in the android application is the Text to Speech module which will ensure that users do not have to look at their phones while driving for the purpose of safety. Additionally, using in-network level data processing will increase the privacy by isolating the system from global world because the data processing and storage is done locally rather than sent to cloud for processing. However, if we would try to extend our approach to add some more features, that would be such as reservation service for the available car parking spaces. Moreover, it could be further extended to support other mobile phone operating systems such as Apple IOS and BlackBerry. Furthermore, it could provide users with the information about parking spaces in wider zone in case that a user is travelling and want to know more about the available parking spaces and the traffic situation in the destination. After discussing the advantages and limitations of the system, this system will be useful to provide users with information in the real time to save users time and make them avoid traffic congestion as well as to activate the Text to Speech feature to maintain the safety of the user while driving.

VI. Conclusion and Future Work

This study has proposed a smart parking system that enhances the performance of saving users time to locate an appropriate parking space and reduces the general costs for moving to chosen parking space. The most obvious finding to emerge from this study is that we proposed a smart car parking system that will make ensure reduction of transmitted data through the network and saving the energy in the perception layer. While in the application layer side is to save the user time, avoiding traffic congestion, find available parking spaces and to reduce cars gas emissions from drivers while searching for the empty parking spaces.

Furthermore, we showed the proposed approach of the system and its relevant methods. In addition, on the basis of this presented paper findings, continuous improvement and work on the remaining problems is continuing and will be approached in future papers. Future work will involve implementing the proposed approach in large scales in the real world and test the system to check the results. Finally, the future step would be developing a mobile application for users to find available parking slots and guide them through this application.

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