Recommended Architecture for Car Parking Management System based on Cyber-Physical System

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Abstract— **A joint combination of interacting network of physical components and computational algorithms form cyber-physical system (CPS). Cyber-physical systems are intended to improve the quality of life by forming a sound basis of emerging smart services. There is a need to apply CPS in different fields to acquire the prominent result and therefore, we have applied CPS in the car parking management system. Looking for parking space waste a lot of time as a user has to search for parking space, since lack of car parking information. It results in traffic congestion, environmental pollution making the environment more badly. A lot of approaches have been developed to solve this problem but they are insufficient either they are not sufficient to cope with the user needs and they are not able to communicate properly with the external interfaces or they are much costly. The proposed solution based on CPS, solve the problem of car parking system. The proposed solution is effective and efficient as the user will enter location details using the smartphone app and send it to the server. The server will search for the available parking slots, getting information from sensors and send it back to the user with the route directions. The user will follow that particular route and park vehicle at the area designated by the server. The proposed solution is a novel approach to solve the car parking problem using cyber-physical system.**

Keywords— Cyber-physical system (CPS); car parking; centralize server; sensor; recommended architecture; smartphone app.

I. INTRODUCTION

Cyber-Physical Systems (CPS) are the systems of systems that combine the physical world with the world of information processing. CPS interacts with heterogeneous components, that includes electronic chips, software systems, sensors and actuators, which interact with the real physical world to make a CPS. Therefore, CPS environment is quite different and more complex as CPS automatically adapt the current environment according to situation, which creates the complexity of heterogeneous components.

CPS is similar to Internet of Things (IoT) and create further interaction between physical and computational elements [1, 2]. The interaction between cyber-physical systems and their environment which consists of users, the physical environment and systems are important features of CPS. This particularly claims integration, interoperation, monitor and control of cyber-physical system components. Unlike standalone devices, CPS has chain of inputs and outputs associated with interacting elements [3, 4]. Furthermore, application of CPS cannot be narrowed down to any particular field, rather it's useful in almost every field [5]. Therefore, we have applied cyber-physical system for car parking management system and concluded that CPS could be more beneficial if applied to other field of information technology.

With the increase in urban population, significant issues are arising due to congestion of car parking [6]. As the number of private vehicles is rising day by day there are some traffic issues in worldwide, which need to be addressed properly. It is indeed a frustrated way to search a parking space as there is a lack of information available for car parking place. Normally in the cinemas, functional halls, shopping malls, government offices, airport, railway station where offices are located extreme busy areas, this ambiguity can be clearly specified. Long Queues of vehicles are seen waiting to find the parking slot [7]. In some cases, they have to park on the main road after some time local traffic police have to arrive and lift up the vehicle as it was also blocking the way for incoming vehicles. In another case, if they find the space to park their vehicles like in cinemas, shopping mall or some government offices they have to purchase a token and again long queues can be seen waiting for the token as there is no automated system available for issuing the token. The car parking management system is of utmost importance to reduce congestion control, traffic pollution and environment disorder [8,9].

There should be an efficient and effective way to manage the car parking system in order to control congestion, time and security of the vehicle. Several approaches have been presented to resolve this issue in all over the world. Pala and Inanc [10] have proposed RFID for entering and existing parking slot. According to Wang and He [11], LCD for showing the number of available spaces indicate green light to the user if it has some empty space in the parking slot else red will brink means it's not empty. Hanif et al [12] have proposed the SMS based parking reservation system. There were some systems developed which draw the details of the user, send the map to the user and park it on most feasible space available [16,18]. All of these approaches were exceptional but still they suffer from external integration as there was no runtime awareness that should be provided to the user in minutes before arriving at the destination, hence the user can proceed further according to the instruction provided by some parking management system.

In this paper, a simple and effective methodology for car parking management is presented. Hence, to manage congestion control, environment pollution and ensure the security of the vehicle. A cyber-physical system based management of car parking system is introduced in this paper. The proposed system consists of smartphone app, centralize server and sensor to sense the vehicle entering the parking slot. When a user request for parking, the user will be informed timely about the availability of parking slot and route of the vehicle will send to the user smartphone app. The server will analyze if any parking slot is available in communication with the sensor.

A. Car parking issues

With the increase of vehicles, traffic congestion and the shortage of parking space is a major issue now a day [13]. The problem of parking space is not considered seriously as there is no devised plan to handle the parking's around rushed cities. There is a wide gap in this technological advancement field. Most of the car parking systems are designed and managed manually. They are not well maintained and well organized. Some private car parking, owners just provide the parking space without maintaining the proper parking slots and offering without proper management system. The parking space provided by the owner is managed manually by a single guard at most of the places. They do all the procedures manually include the manual input of vehicle registration number, payment and an issue of slip to the vehicle owner. Peoples parked their car in their own way and according to their own relevance. This is one of the most common problems causing fact for parking congestions and traffic problems outside the parking areas. This whole procedure takes a lot of time and waste of time [14].

II. RECOMMENDED ARCHITECTURE

Clear specification of system architecture for car parking of cyber-physical system is very important as it serves as a roadmap for system development. In addition to that, it provides a blue print for the system to be easily analyzed and explained. System architecture shows interaction of different modules in the system. Since cyber-physical systems are still in their infancy, it is particularly important that we develop a clear architecture for car parking management system based on CPS. Moreover, to the best of our knowledge no standard design exists for such a system to date. As we aim to set a milestone in cyber-physical system, clearly outlining our vision and approach become more vital. The recommended architecture consists of following components:

A. Smart Phone App

The first step that the user has to installed the car parking management app in the smartphone. When the user is near to the parking place, the user has to login into the smartphone app and place the request for the parking space. The user has to provide the vehicle type and vehicle registration number for security purpose then the user has to verify and proceed to the next step, after verification the request for the parking lot will be placed on the server.

B. Architecture and Usage of Smartphone App

The development of smartphone app is on android, IOS and windows. The smartphone app has two major security levels that include: Admin and user level. Admin is responsible for managing the whole procedure of the car parking management system include verifying the vehicle information. In user level, the user has to create an account to login into the application and has to provide the vehicle registration number. After logging user can request for the available slot for parking the vehicle.

C. Centralize server

The centralize server is the responsible for the communications between user and sensor. It manages to allocate free slot of car parking and inform to the user. App server has the application server and web server have the web application running on this centralize server. Once the web application receives the request, the schedule will run against this request and system will automatically search for the available parking lots. On finding the available parking lot, the system will send the information back to the user. The system will also send the map to the user, hence the user is able to specify place easily.

D. Web server

The web server has web application running on it and it is the first interface to get a request from the user. The basic functionality of the scheduler to check the request after every

minute and process the request. After looking for slots in the database, it sends a request in the work queue to the application server.

E. Application server

The application server is responsible for carrying all information from the user and web server and entertaining all request from the system. The web application sends a request to the app server that will be viewed by different users who will confirm of allocation slot after doing some basic checks.

F. Sensor with microcontroller

Sensor-equipped with a microcontroller that senses the vehicle entering the parking lot, convert these analogue signals to the digital signals and transmit it to the server. The web application will check the registration number of vehicle and update the record accordingly.
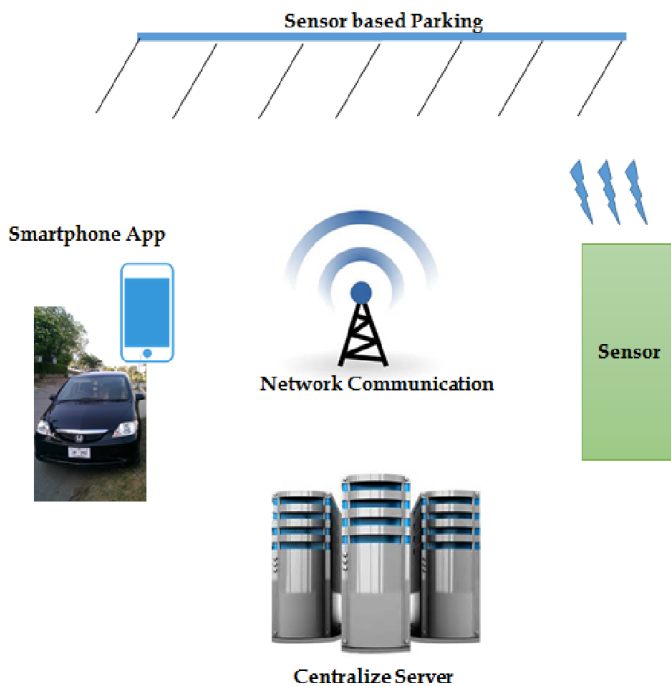

Figure 1. Recommended Architecture

III. PROCESS FLOW DIAGRAM

The process flow diagram consists of the following steps and also shown in fig 2:
1. User has to login to the smartphone app.
2. User request for the free slot to park the vehicle by entering the registration number.
3. Centralize server will receive the allocation request from the user.
4. Centralize server will search for the available slots in the system.

5. If the slot is available, centralize server will allocate the slot to the user against registration number and update the user about the slot allocation.
6. If the slot is not available, centralize server will update the user about the availability of slot.
7. When the user park the car in the assigned parking slot, sensor will capture the registration number of the vehicle and update the centralize server about the vehicle entrance.
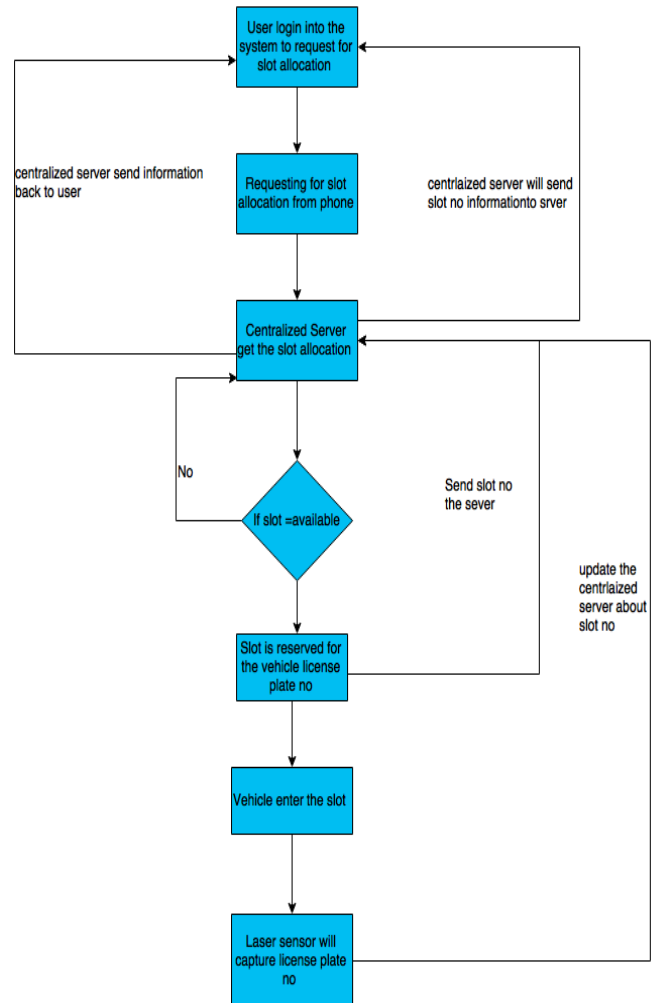8. Centralize server will mark the slot as filled in the database.

Figure 2. Process Flow Diagram

A. Benefits of using this system

Following are some benefits of using this car parking management system:
1. No need to search for a parking space and hence saving precious time.

2. No need to remember where the car is parked as the smartphone app will help the user to navigate the car location.
3. No fear that someone might have parked in your way and user have to wait for a long time.
4. The security of the vehicle is highly ensured.
5. The user will not have to track record on papers, it is automatically saved in user app.

B. Challenges

The following are the major challenges of car parking management system:

1. The biggest challenge is the user acceptance for this automatic system, to get complete and consistent requirements from the user and the owner of the parking area if they are willing to automate this system.
2. The generic approach should be developed in such a way that the system should be deployed in major cities. Therefore, there is a need to cater some more requirements that to be implemented.
3. Monitoring parking space from a remote location, hence the parking owner is well aware of the parking space and utilization as all the vehicles are parked correctly and utilized the space properly.
4. There is a need to develop security framework for car parking of cyber-physical system. At the moment CPS is considered very complex because of integration of many constitute elements.
5. To measure the size of a vehicle and allocate a slot according to its size thereby efficiently utilizing the space.

IV. RELATED WORK.

This section provides the brief overview of literature that have been done in the area of car parking management system.

The Benhassine et al [15] describes the network of intelligent agents, which facilitate user to save time for finding the car parking space. Intelligent Parking are a great challenge to facilitate traffic. Traffic congestion, traffic noise, traffic Pollution, fuel consumption and insecurity are some of the issues which need to be resolved. The solution presented in this paper is based on multi-agent system. Vehicle agent send the vehicle information to the station agent. Station Agent send the information of the vehicle that searching for parking to the global traffic agent. It generates the routes for the vehicle to the parking way and produces the map of route plan, which it obtains from the parking agent. This information is send it back to the station agent and station agent then send it to the vehicle having GIS, where map of the parking will be displayed and user will be successfully able to park its vehicle. The system has been deployed in Tunis and result shows that the traffic congestion is decreased to 4.7%. These results are due to minimization of time looking for parking spaces.

Grazioli et al [16] have presented the modular, service based architecture including web based application for parking. Mobile app and the marketing controller to facilitate the user for parking. All the previous approaches have limited integration among different modules and with external interfaces. RFID and LCD to display the number of vehicles, PS to show the location and park area selection, MS park reservation system. They all are implemented standalone and not able to connect with external interfaces. The proposed approach involves a web and mobile app for the end users and parking operators. Operators draw the parking areas such as parking space with the help of web application and the prizes. End users will use mobile app and send location to the web app server and in reply it will be guided to the most nearest and available parking space. Controllers will check if the end users have paid the fee and keep an eye on all the available cars. Actual test has been evaluated on Campus by providing the application to the end user and the teachers and according to the evaluation the result seem to be pretty impressed as success rate of the application was 75%. In future municipal interest will be looked in order to test the application in large scenario, alternative for discovering free spaces will also be checked.

Yeh et al [17] have proposed the cloud system and smart mobiles with streaming server for parking lots to plan a city integration system. Finding a parking space near destination takes a lot of time and if user find the parking space, the next step is to find the most optimized parking space. As technology emerges the world is switching toward smart phones and cloud technologies to maximize the facilitation to the user in user friendly way. This paper present both parking guidance system and parking navigation system involving the smart app and Microsoft cloud server. Parking guidance system involve as user on the smart phone and GPS the location of the user will be sent and user will request for the car parking space. System centre will record user location and send them to the cloud server. The cloud server will work on user request and will send the information back to the user in smart app. Parking navigation system involves when user enter the parking lot they will give the parking card which will be detected by RFID scanner. The parking server will receive the information of the user. After that the parking server will send detail of the parking space, where user car is parked to the user smart app and user can easily locate the car. This approach not only provides the user with the parking lot but also provides real time information about the parking spaces to the user. This approach provides the local municipal committees to plan accordingly the parking area in future.

Banerjee et al [18] have presented the parking and guidance system using image processing. The proposed system in this paper involves image capturing with the help of web camera. RGB to gray conversion is performed. To achieve image enhancement gamma correction is done. Edge detection is done with the help of prewitt edge detection operator. The image of the car entering the parking lot is again captured and the same procedure is applied to the original image as well. After that both the images are matched the previous one that captured with web camera and the new one of the car entering the lot. If the match is more than 90% the car is allowed to enter the parking lot and in this approach only 10 parking lots are

defined. The experiment is performed on the designated area and it gives the much impressive results. In the future the number of parking slot will be increased and also the scope of designated area will be enhanced.

In paper Renuka and Dhanalakshmi [19] have proposed android based smart parking system. According to this paper the car driver almost takes 8 minutes to park vehicle in proper place. It leads to 30% to 40% of traffic congestion. To solve this problem this paper has presented smart parking and smart allocation system based on dynamic algorithm. User will book the place with the help of android app. On getting the request, the parking area control unit which check the free slots and if any slot is free, the car will be allowed to enter the parking area with the help of green and red light blinking at the top of each parking slot. Red indicate that the slot is occupied and green indicate the slot is available. When user enter the slot the time of parking of user will be calculated with the help of RFID tag and total cost will be calculated. This system is efficient for controlling congestion and for short term parking. This system will be extended to full time multilayer system in the future.

Lee [20] has proposed an efficient Parking space algorithm. As efficient algorithm will reduce the parking space and more vehicles can be accommodated. Many vehicles have embedded automatic parking system that assist these to automatically park in the parking space. The drawback is that the environment by distort the image signal and may be misread by vehicle automatic parking system. Two turn algorithms were proposed in this paper. First the vehicle entering the parking area will be captured with the RF reader that fitted inside the vehicle and location will be send to the microcontroller that fitted in RF reader. The Microcontroller will analyse the vehicle, generate the algorithm and send it back to the automatic parking system of vehicle through another microcontroller installed inside the vehicle. When user go to the respective slot and press the parking button, vehicle will be automatically parked in the slot. This experiment was performed on emulation vehicle which size 50cm* to 20cm and the results were optimal. Chip will be introducing in the future to improve the system response time.

Most of the researchers have focused on the mobile app and RFID based work, which lacks to produce the efficient and effective car parking system. This leads not to only resolve the security problems but also reliability of the system as discussed in [21 & 22]. Our proposed system solves these problems as it is solely based on cyber-physical system, which is the most optimize way to solve the future problems using sensors and actuators.

V. CONCLUSION

The solution provided in this paper is the best possible solution to the parking problems using cyber-physical system. Runtime services to the user will have a great impact on and the user will be informed in advance of the situation of the parking slot. Therefore, we presented smartphone app, hence the user can request in advance for parking slot which will be entertained by the server and will inform the user about the parking space. The centralize server gather all information from the sensor and update the user accordingly. In future, an efficient cost management system will be introduced into the system to cope with the requirements of the user. The cost module will be installed in the application server and will calculate the cost for each slot and send it to the user along with slot information.

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