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A Smart Parking System for a Smart City

[1] Annie Sujith, [2]Chitra S Nair [3]Manjusha Kulkarni [4]Shimi Jeyaseelan
[1][2][3][4]Assistant Professor, Computer Science Engineering,
T.John Institute of Technology, Karnataka, India

***Abstract* - The introduction of a novel algorithm that increases the efficiency of the current cloud-based smart-parking system and develops network architecture based on the Internet-of-Things technology. Here the proposed a system that helps users automatically find a free parking space at the least cost based on new performance metrics to calculate the user parking cost by considering the distance and the total number of free places in each car park. This cost will be used to offer a solution of finding an available parking space upon a request by the user and a solution of suggesting a new car park if the current car park is full.**

***Keywords*: Cloud, Parking Admin, RFID Tags**

I. INTRODUCTION

Here we introduce a novel algorithm that increases the efficiency of the current cloud-based smart-parking system and develop a network architecture based on the Internet-of-Things technology. This system helps users automatically find a free parking space at the least cost based on new performance metrics to calculate the user parking cost by considering the distance and the total number of free places in each car park. This cost will be used to offer a solution of finding an available parking space upon a request by the user and a solution of suggesting a new car park if the current car park is full. The simulation results show that the algorithm helps improve the probability of successful parking and minimizes the user waiting time.

II PROBLEM STATEMENT

Existing system

The common method of finding a parking space is manual where the driver usually finds a space in the street through luck and experience. This process takes time and effort and may lead to the worst case of failing to find any parking space if the driver is driving in a city with high vehicle density.

However, the current intelligent parking system does not provide an overall optimal solution in finding an available parking space does not solve the problem of load balancing, does not provide economic benefit, and does not plan for vehicle-refusal service.

Disadvantages

i. Does not mention the resource reservation mechanism (all parking requirements are derived immediately and are placed in the queue), the mechanism for assessing the resources system.
ii. Does not calculate the average waiting time and average total time that each vehicle spends on the system.
iii. No mathematical equations for the system architecture and does not create a large-scale parking system.
iv. Does not consider the waiting time of each vehicle for service.

Proposed System

This study aimed to provide information about nearby parking spaces for the driver and to make a reservation minute earlier using supported devices such as smart-phone or tablet PCs. The Internet-of-Things technology (IoT) has created a revolution in many fields in life as well as in smart-parking system (SPS) technology. An effective cloud-based SPS solution based on the Internet of Things. Our system constructs each car park as an IoT network, and the data that include the vehicle GPS location, distance between car parking areas and number of free slots in car park areas will be transferred to the data centre. The data centre serves as a cloud server to calculate the costs of a parking request, and these costs are frequently updated and are accessible any time by the vehicles in the network. The SPS is based on several innovative technologies and can automatically monitor and manage car parks. Furthermore, in the proposed system, each car park can function independently as a traditional car park. This research also implements a system prototype with wireless access in an open-source physical computing platform with RFID technology using a smart- phone that provides the communication and user interface for both the control system and the vehicles to verify the feasibility of the proposed system.

Advantages

i. Better performance
ii. Each car park can function independently as a traditional car park.

The SPS is based on several innovative technologies and can automatically monitor and manage car parks. Low Cost.

III PROPOSED ARCHITECTURE

System overview

WSN consisting of RFID technology is used by the system to monitor car parks. The percentage of free parking spaces in each car park is counted by an RFID reader. The main advantage of the system is that it has a mechanism to resolve disputes over car parking and thereby reducing the time to search for a parking space. Here the user has the choice to select a desired parking space; the availability of this space is notified to the user by the system. If the user fails to reserve the parking space within a certain period of time, the system then changes the status of the space from "pending" to "available". Real time updating of the status of the parking system is done periodically unavoidable.

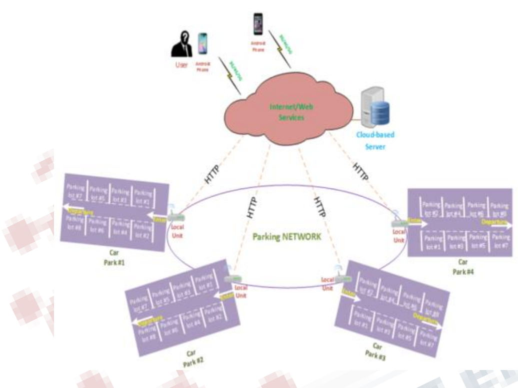

Fig.1.[1] Proposed System Architecture
System Architecture

Fig.1. depicts the proposed smart IoT parking system. **Components of the proposed system:** ***Cloud-Based Server:*** The resource information provided by local units located at each car park is stored in a web entity called Cloud-Based Server. This allows the driver to search and find information on parking spaces from each car park without the need to directly access the local server node by directly accessing the cloud-based server. ***Local Unit:*** This stores the information of each parking space and is located in each car park. Fig.2. shows the same. A local unit consists of:

Control Unit: The control unit is basically an Arduino module, connected using an RFID reader. This reader authenticates the user information and then displays this information on the screen. If the information of the RFID tag or card is authentic, the Arduino module will let the vehicle enter. The Arduino module connects with the cloud server through an Internet connection to transfer data. ***Screen:*** Information necessary to the user about the parking area is displayed on the screen.

RFID Tag: This checks the authentication of the user and determines the percentage of free parking space in each car park.

Software Client: An application based on Android OS that can be installed on any smart-phone, which is used to reserve parking spaces.

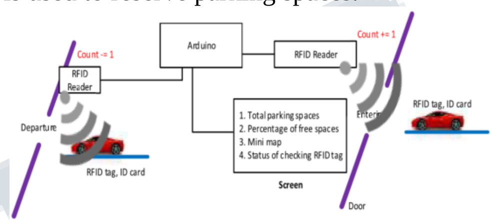

Fig.2.[1] Local Unit

Network Archtecture

The following terms are being used, "user" refers to the driver or vehicle and "resources" refers to the parking spaces.

IV PARKING NETWORK

Fig.3. depicts the CPN (car park network) architecture backbone, the dotted lines represent the wireless link and the solid lines represent the wired link. Routers are a part of this infrastructure to the connected clients, which form a self-configuring and self healing link network. Gateway functionality is used to connect these routers to the internet. Assuming each car park to be a node in a CPN where each car park can be labeled as:

P_1 is car park number 1; N_1 is the total parking spaces in P_1.
P_2 is car park number 2; N_2 is the total parking spaces in P_2.
P_n is car park number n; N_n is the total parking spaces in P_n.
.'.Total Capacity of the system, $N = N_1 + N_2 + N_3 + ... + N_n$
D = Real distance between two nodes in the network
D_{ij} = Distance between nodes P_i and P_j
Following Fig.4. depicts the Parking Network.

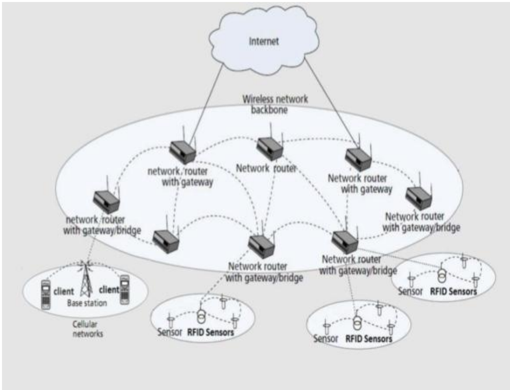

Fig.3.[1] CPN Architecture

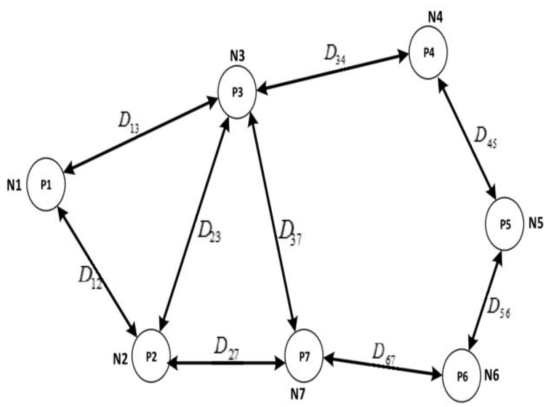

Fig.4.[1] Parking Network

In order to maintain the information on the current status of the network each node is provided with a neighbor table and a queue with a pre-defined length. Neighboring nodes that are directly linked share information with each other using neighbor tables. The number of vehicles forwarded to the node is controlled by the queue, whose main objective is to prevent overloading the number of vehicles beyond the node capacity. A message will be broadcasted by a node to the neighboring nodes when a user joins or leaves the network. This message gets updated in this neighbor table and further gets broadcasted to the next neighboring node. When the neighbor table in each node contains information on the current number of parking resources in the neighboring nodes, it increases the performance of finding a free parking space. This is further used to calculate the cost for choosing a car park.

i. Constructing the neighbour table of nodes:

The cost between the nodes in the network is calculated using a function named F (α, β), which is a weighted link between two nodes in a parking network. This function depends on the distance between two nodes and the number of free parking spaces in the destination node. When two nodes are not linked directly, then F (α, β) =∞. On entering a node if the vehicle finds it full, then it will be redirected to the neighboring node which has the least value for F (α, β) in the neighbor table. The cost function is calculated using the following expression:

$$F_{ij} = F_{ij}(\alpha, \beta) = \alpha \times \frac{d_{ij}}{D_{up}} + \beta \times \frac{t_j}{T_{up}}$$

Eqt. (1)

Where,

α = co-efficient that depends on the length of the path between two nodes

β = co-efficient that depends on the number of free slots in the destination node

d_{ij} = the distance between nodes P_i and P_j

D_{up} = the upper bound of the distance and is a global parameter

t_j = the number of spaces that are occupied at node P_j

T_{up} = the upper bound of the capacity of the overall parking network and is a global parameter

The cost function is inversely proportional to α and directly proportional to β. In order to achieve better network performance we adjust values for α and β, on the basis of one of the two parameters; i.e. either the distance or the free slots. When α = 0, we can only consider the number of free spaces to calculate the cost to the user. Whereas when β = 0, we consider the distance between two nodes to calculate the cost to the user.

V ALGORITHMS

To explain the procedure of the system operation we use this algorithm.

System Operations

When the user successfully logins to the system a request message will be sent to find a free parking slots. The system responds by sending a message including the details of the parking area. Based on the current location of the user the function F (α, β) is used to calculate the closest car park. If the current car park is full then the function F (α, β) calculates the shortest path to the next closest node. A simple and economical method is used where the authorization can be done by RFID technology or by user card scanning. If the details match, the user is allowed to use the parking area. If the parking area is full a new car park will be allotted based on the current car parks neighbor table. This is depicted in Fig.5.

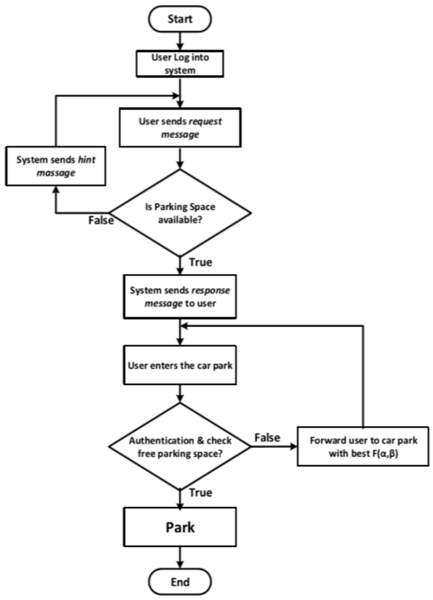

Fig.5. [1] Algorithm of system operations

a. Updating neighbour table and calculation of free parking spaces

To calculate number of free parking spaces in each of the car park we use RFID technology. At each entrance there are RFID readers installed which keep a count of the free car park present in the system.

A variable "C" is used to hold the total number of parking slots in a car park. "C=C+1" when a vehicle enters and "C=C-1" when a vehicle leaves. When C=M_Q , where Q shows the car park is full. When the value of "C" changes a message containing all the updated details is then sent to the cloud server. The server will again update all the neighboring tables. This is shown in Fig.6.

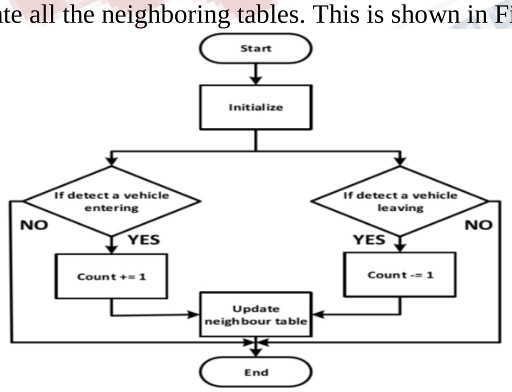

Fig.6.[1] Algorithm for updating the status of car park

6 implementations

a. Software system

Software has been designed that's based on an android platform and runs on smart-phones. Mobile applications that take full advantage of all that a handset offers. Android provides the base to enable developers to build this system for writing Android programs and developing the applications, a set of development tools called the Android SDK tools have been used, which is using an integrated development environment. The system provides services only to the authorized users. Apache Hadoop 2.7.1 is used is used for implementation of the cloud based server, the database which is used is the apache Hbase, that provides a scalable, distributed and huge data storage.

b. Elements

The elements included in the system are RFID tags, which are provided to the user on registration, the RFID reader, to detect the tags on user's entry and exit to the parking lot and check for authorization, the RFID antenna that receives and transmits signals, Arduino Uno R3, Arduino Ethernet Shield, Screen and Cloud-based Server system.

CONCLUSION AND FUTURE SCOPE

This system increases the probability of finding a car park and reduces the cost of moving to the car park which improves the performance and increases the efficiency. The results show the waiting time by the user has been significantly decreased.

The future of the parking industry will have a number of cloud computing based services, mobile. The automotive industry is expected to include real-time parking information along with in-vehicle communication, navigation and infotainment services. Over the next decade, the majority of parking lot navigation and transactions will migrate toward the smart-phone or autonomous in-car meter. Parking to be more integrated and involves participants from automotive, communication, infrastructure, and technology providers, all working together. Parking will be a hot spot for mobility in cities and a dependable revenue generation model.

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