Parking lot reservation service based on multi-agent systems

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Abstract— In most of today's major cities, the search for parking spaces is an increasingly frequent problem. It has been shown that the average time required to find an on-street parking space is eight minutes. In addition, traffic problems in the city are generally caused by cars that travel to park. The concept of the smart city implies the use of technology for the collection, processing and transmission of information. In this paper we will pre-sent an indoor parking system based on the Internet of Things and multi-agent systems that will allow drivers to book their parking spacesand benefit from other services easily.

Index Terms— Smart Cities, Smart Parking, IoT, SMA, artificial intelligence.

1 INTRODUCTION

Cruising for parking is detrimental for both individuals and the society. On the one hand, individuals consume time and fuel consequently environmental pollution and congestion has increased. On the other hand, the unregulated prices of parking spaces provide an economical incentive to cruise for parking which, in combination with the lack of awareness, creates more problems regarding the availability of parking spaces.

Existing solutions regarding parking availability fall into the following two categories: (1) Infrastructure-based [1][2] and (2) Crowd-sourced parking solutions [3][4]. In order to provide real time space availability information, first we need to deploy sensors on parking spaces and car parks. A significant holdback of this infrastructure-based solution is the costly nature of sensors as well as of their deployment and maintenance. Regarding the second solution, the information is gathered from the participants of the system. The trade-off between the two solutions is that crowd-sourced solutions provide uncertain and incomplete information at low costs, whereas infrastructure-based solutions yield more information at higher costs.

Moreover, to solve the parking problem, the systems will have to be autonomous, capable of managing complex requests, capable of making decisions according to criteria in real time, efficient and sustainable. Parking systems must allow drivers to plan their days in advance in order to minimize the search time for space and subsequently improve the state of urban mobility. In this, paper we present a system that provides solutions to these issues. We will start by presenting the state of art, after we will be describing the architecture of our system, after and before concluding we will present the multi agent architecture and the reservation process.

2 STATE OF ART

Big cities suffer from traffic jams, especially during rush hours. At the level of these traffic jams we find many of drivers who are looking for a parking space. These traffic jams are due to the blind search of the places, a random search without planning and which is done in the same area, automatically these searches will engender a loss of time, emission of gases and atmospheric pollution and other problems. The proposed parking solutions, and indeed even the first version of the solution that we proposed, focus just on the parking offer how to transmit the number of available places and the location of car parks, these solutions do not allow drivers to plan their days in advance, or to guarantee their places on arrival. To remedy these problems, the option of booking seats has been proposed by several researchers.

In [3], the authors presented a GPS vehicle navigation system to find a parking lot. After the user indicates the destination address and the vehicle parking distance, the GPS system identifies the current position and location of the destination address already specified. The system then specifies the shortest way in order to have an estimated time of arrival, and according to the history of the parking lot, the probability of their availability is calculated and communicated to the driver. With the help of the historical and the real information on the availability of the parking spaces, the predictions are realized with a process of Poisson, which makes it possible to have a place of parking with a maximum probability of obtaining it upon arrival.

[5], have proposed a system of reservation of parking spaces, the solution manages a limited number of place at the city center, the reservation is done according to a linear program in order to have an optimal allocation of places. [6] also proposed a system with two options: a time-sharing reservation service (TSS) and a real-time reservation service (RTS).
[6] have proposed for the city of Austin both a booking service and a service of the most optimum way to take to reach the parking lot. Indeed, these services could be realized thanks to the decision process of markov, thanks to these services the situation of the parking has been well improved at the level of the town center. Drivers can book their seats just by SMS, this option is possible thanks to the systems deployed by [7], these SMS are processed by Micro RTU which is responsible for confirming the reservation by sending the password to you the lot number by SMS which will be used later to access the reserved place.

On the other hand, and in order to improve the solutions dedicated to parking, researchers have opted for the use of multi-agent systems, Author [8] makes a mix between a Machine to Machine based architecture using MAS for the governance of the solution, according to them the use of MAS will

allow them to work under complex conditions in distributed environments. [9] used a SAM-based simulation environment to analyze the behavior of motorists looking for parking spaces in urban areas. [10] modelled the driver by an agent who has the behavior of driving, looking for a parking space, parking and departure. In addition, what they have deployed includes reactions to different scenarios such as price variance, or lack of places

The examination of this work allowed us to conclude that some solutions do not cover a large area, or one of the solutions that rely on citizen participation (in the case of crowdsourcing). Furthermore, the proposed solutions do not exploit the different choices that the Iot offers, solutions that rely on the client/server paradigm, that do not take into consideration the option of booking palaces in advance. In this perspective, and in order to have an efficient, durable system, capable of making decisions in real time, we have opted for a solution based on multi-agent systems bringing together different connected objects and offering a reservation service.

3 THE PROPOSED SOLUTION

3.1 General Overview

In recent years, several projects have been launched to make Casablanca an attractive financial hub in Morocco and Africa. Therefore, the city has grown at the level of citizens, and so has the number of cars. Therefore, the city began to suffer from several problems such as a higher demand on parking places, congestion, pollution, unregulated parking fees. These problems are due to several factors including poor management or the lack of an infrastructure dedicated to parking.

To address these issues, we have implemented a system for drivers offering parking space availability, reservation via a web application after authentication or registration. With this solution, the search and parking process will be simple and efficient.

At the web application, the user can perform several actions such as checking the parking status (if there is a place available for parking), pay his subscription, reserve his place beforehand, present a claim, etc. This user can be either a (1) Subscriber or (2) a visitor. For (1), they can use the car park almost daily, so they have a subscription card, or they benefit from our services with an average of 7-10 times a month have a rechargeable card. Every time they use the parking service, the amount is subtracted from the main balance. Regarding (2), they consult the application without registering and they can use the parking through payments on the spot.

The infrastructure of our smart parking is composed of several types of equipment such as :

- Magnetic sensors
- Cameras
- RFID reader
- Driver's Devices (Laptop or mobile phone)

The system is divided into three layers: he Application Tier, the Cloud Tier, and the Parking Tier. Each layer has a specific mission, but it communicates with the other two in order to accomplish the tasks assigned to it. In addition, we have opted for a distributed architecture that will allow the system to remain operational if one of the three layers stops working.

3.2 Multi-Agent Architecture

In terms of the system, we have deployed agents with very specific missions. In this paper, we will focus on how these agents interact to manage the reservation service, but first, we will define the notion of agent and multi-agent systems.

Definition

An agent is defined as an autonomous entity, based on its initial communication skills, perceptiveness and ability to act on an environment in order to acquire new behaviour, it can satisfy an objective assigned to it. In an environment of multiple agents, they can communicate and cooperate with each other. Indeed, in a MAS Multiagent System, an agent can inform other agents of the facts, collaborate with them to achieve an objective, reject or negotiate proposals, in order to maximize his gains, his integration at the level of a group can in no way affect his internal structure or his mission as an individual [11].

Architecture

At the car park level, we opted for a distributed architecture at the task execution level and a centralized one at the control level. When a car arrives in front of the car park, the entry agents, in collaboration with the control agent, authorize or unauthorize the access. if access is authorized, the control agent shares this information with the rest of the system. The preference agent, display and sensor collaborate with each other to ensure that the driver has a place that meets his needs. The system agents communicate with each other either by sending messages or sharing information. Indeed, the agent of preference is responsible for determining whether the customers have specific needs, like customers with reduced mobility, have a difficulty in parking in certain positions, who need a charging station for their electric cars, etc. In such cases, the customer will share such preferences with the display agents to guide them to their places . The sensor agent is responsible for the deployed magnetic sensor network and communicates the available spaces in real time to the control agent. The latter must ensure that the number of places occupied corresponds perfectly with the number of incoming cars considering the outgoing cars.

For example, if the number of places occupied reported by the sensor agent is higher than the incoming cars, the control agent in this case uses the cameras, and by means of image processing, it detects whether a car is badly parked. On the

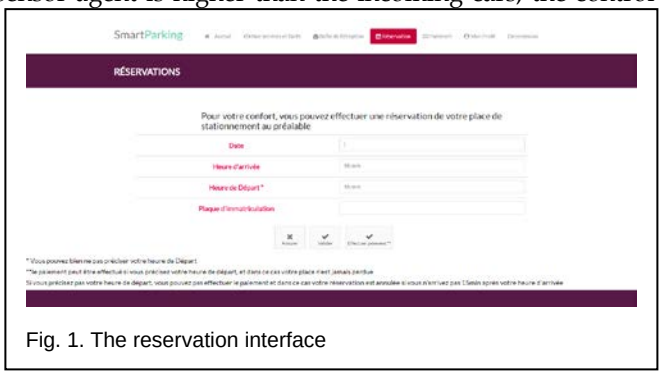

Fig. 1. The reservation interface

other hand, if the agent a sensor fails, the two agents collaborate with each other to provide the parking status in real time.

4 RESERVATION SYSTEM

4.1 The Reservation Process

For the reservation, different agents who intervenet to succeed this service. At the application layer called "reservation agent" manages the different reservations. this agent gathers information about the reservation via a web interface as shown in fig.1. Indeed, to reserve a parking space, the driver must connect to the application and access the booking interface and complete the form containing the date and time of entry and exit and the license plate of the car. After the agent must check the availability and the history of the parking during the chosen date so that he can confirm / reject the reservation, If the chosen period is occupied then in this case the booking agent must propose an interval available time close to the chosen one, if the driver validates it then the reservation is confirmed. After confirmation the reservation data are subsequently communicated to the entrance agent. The latter communicates it to the preference agent to have the best place which must be reserved for this user (electric car, person with reduced mobility ... etc).

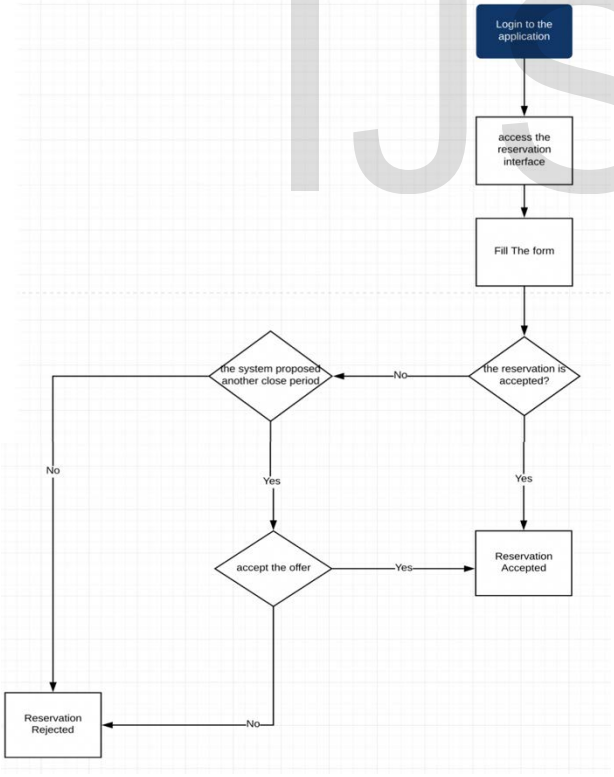

Fig. 2. Flowchart of reservation process

It should also be noted that there are two types of reservation:

- Closed reservation: the driver indicates the time of arrival and departure and makes the payment. In this case it is enough to arrive in the indicated interval so that he can access the car park.
- Open reservation: the driver just indicates the arrival time, in this case the system reserves the place for him just 15 minutes after the indicated time, if he does not show up then his place is lost.

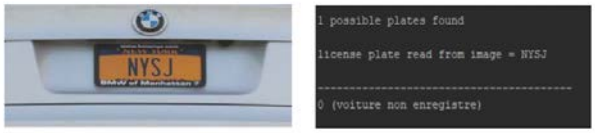

Fig. 3. example of license plate detection

4.2 Reservations detection at the parking entrance

For this paper, and to show how the booking request is handled, it will be assumed that the moment the customer showed up the parking is full (there's no available places).

When the customer arrives, the entry agent initiates the license plate capture process if there is a reservation in the arrival period, otherwise it sends a message to the display agent to post an apology message to the customer.

As shown in the figure 3 the license plate is subsequently converted to a string is sent to the entry agent for verification, if the license plate matches the license plate entered at the time of booking the entry agent must check the type of booking and the arrival time.

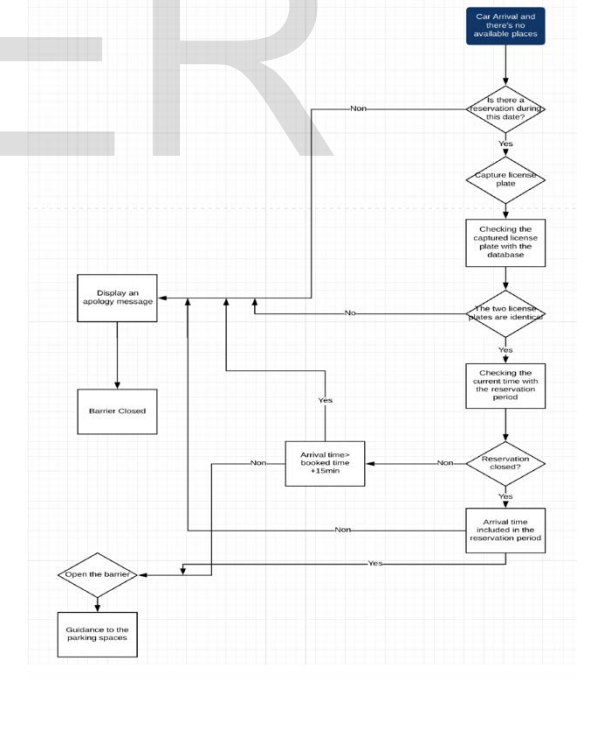

Fig. 4. Flowchart of rthe entrance process

if the reservation is closed and the departure time is higher

than the arrival time, or the arrival time does not exceed 15 minutes of the time specified at the time of reservation, the agent authorizes the entry and the display agent in collaboration with the preference agent guides the driver to his place.

Otherwise, an apology message is displayed and the barrier remains closed. The figure 4 shows a flowchart of this process.

4 Conclusion

Parking is the starting and arrival point for all cars and negatively affects traffic if it is poorly managed. To remedy this, we have proposed a solution that will allow drivers, in addition to having the parking status in real time, to plan their day in advance via the space reservation option.

With the use of multi-agent systems, we have an autonomous and efficient system capable of acting in real time in response to requests. In addition, the advantage of multi-agent systems that they are entities that learn from past experiences, this advantage will allow us to satisfy users and maximize parking revenues with good reservation management

In perspective, we will detail the agents of each layer of the system as well as the communication between them.

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