A Navigation and Reservation Based Smart Parking Platform Using Genetic Optimization for Smart Cities

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***Abstract*—With the development of technology, smart devices are becoming more common in everyday life. The development of devices that can connect to the Internet and transmit data has been a source of inspiration for smart city designs. The common problem in our cities is the difficulty of finding free parking slots. The parking problem causes traffic to congest and people who go to work are looking for a place. In this study, a navigation and reservation based parking proposal system was developed for smart cities. The proposed method involves the development of small devices that send data to the internet using the internet of things (IoT) technology. The free parking space closest to the current location is found by genetic algorithm. The proposed method is tested for different scenarios and accurate results are obtained.**

***Index Terms*— Multi-objective optimization, parking navigation, reservation-based parking, smart city, smart parking.**

I. INTRODUCTION

The smart city applications that aim to improve the quality of life people in the city have gained great popularity in recent years. In the few last years, many studies have been done for smart city applications. The growth of the Internet of Things and Cloud technology concepts allows rising of many possibilities for smart cities. Parking problem that aims to find, reserve, and provide the best location for each driver is an important problem in the city, because of energy consumption and time spending during searching for car parking in the limited parking area.

There are many studies about smart parking approaches in the literature [1-23]. These approaches have been used different information technology concepts such as internet of things, wireless sensor network, cloud systems, mobile application, geographic information systems, and artificial intelligence techniques. In [1], a smart parking guidance algorithm using dispatching rules and dynamic conditions of parking in a city and cars has been proposed. Simulation results have been provided for validation of the effectiveness of the proposed algorithm that has the parking lot, parking manager system, a server, a navigation program and user components. Chatzigiannakis [2] presents a privacy-preserving smart parking application method. This study avoids transmitting some important information between the system components and it is suitable untrusted networks. The performance of this system has been showed in a real-world outdoor IoT experimental setup and analyzed the computational complexity and network overhead with as open source software and availability for developers. A cloud technology based smart parking approach using internet of things proposed in [3]. In the study [4], integration of UHF-RFID and IEEE 802.15.4 Wireless Sensor Network based smart parking system has been presented to information acquisition about the state of parking spaces and the minimum vacant parking location. A system using RESTful Java and Google Cloud Messaging has been carried out and a mobile application provides the users to find a vacant parking location. A block diagram for the proposed approach in this study can be shown in Figure 1.

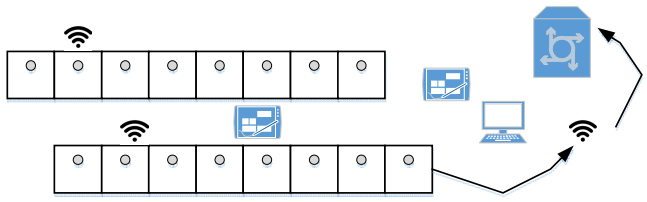

Figure 1. Block diagram for the approach in [4]

Samaras [5] has been given a fuzzy logic based and estimating the vacat size based on energy efficiency of parking areas in the smart cities. Real data obtained by the wireless sensor network are used for generation of fuzzy rules in the study. In [6], a cloud technology based intelligent car parking approach that consists of three layers as using of sensor, provide of communication, and application layer has been presented as a component for smart cities. Barone [8] presents a smart parking system called intelligent parking assistant for the management of the parking locations on the street in the smart cities. In this study, the implemented software and hardware components are presented with details and comparative results have been provided for the effectiveness of the proposed approach in the standard Italian off-street parking management system. A block diagram for this proposed approach can be shown in Figure 2.

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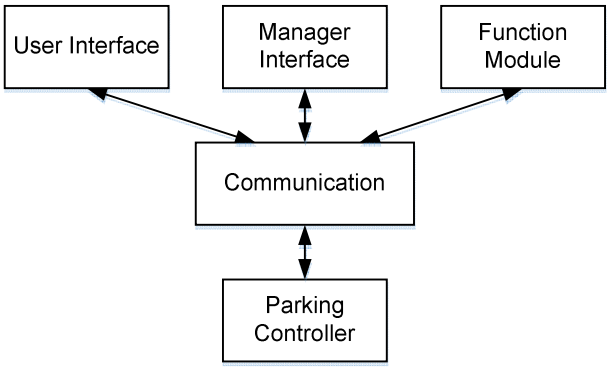

Figure 2. Block diagram for the approach in [8]

Wang [9] has been developed and implemented a smart parking system based on reservation that allows drivers to find and reserve the vacant parking locations. The proposed system in this study is trained the parking status from the wireless sensor networks deployed in parking locations. Simulation results obtained for this study have been shown to reduce search time and traffic to find for parking location. A block diagram of the system architecture can be shown in Figure 3. In [11], intelligent resource reservation and allocation based smart parking system have been proposed. This system is used to provide parking reservations with the lower pricing and searching time for users and resource utilization for parking process. Therefore, this system has some contributions as increasing utilization of parking locations and improving experience of parking process for users by lower pricing, more effective time using. Additionally, the evaluation of shared reservastions and instant reservations provides a dynamic structure for the real time using of parking spaces, and offering the users of choosing many targets and reservations are used in this study. A block diagram for the system architecture can be shown in Figure 4. Lee [12] has been proposed the smart parking system using the Bluetooth communication between the smartphone and wireless sensors. Cai [13] has been proposed a parking navigation system based on the parking sensor network using a Dijkstra optimization algorithm to obtain the optimal parking router. This system uses the ZigBee communication protocol for the real-time parking information of all parking sensors.

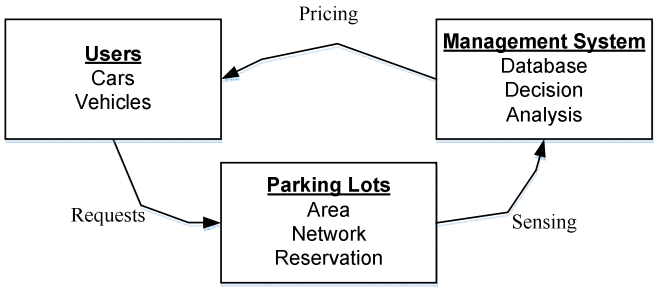

Figure 3. Block diagram for the approach in [9]

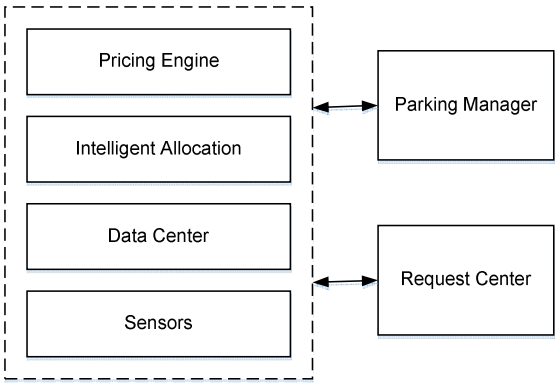

Figure 4. Block diagram for the approach in [11]

In [15], a new approach that increases the performance of the existed smart parking system based on cloud technology has been proposed and a network system based on the Internet-of-Things technology has been developed to help users find a parking location at the minimum pricing based on performance measures to calculate the user pricing using the distance and the total number of parking locations in each vehicle. The proposed approach has been validated by simulation and experimental results in this study. The results are shown that reduces the average waiting time of users for parking. A block diagram for the system architecture can be shown in Figure 5. Zheng [16] an estimation approach for the parking using three feature sets with some parameters to show the utility of these feature sets has been presented and analyzed the performances of some machine learning methods usch as artificial neural network, support vector machines, and regression) in using these features for prediction using available data acquisied from two cities as Melbourne and San Francisco.

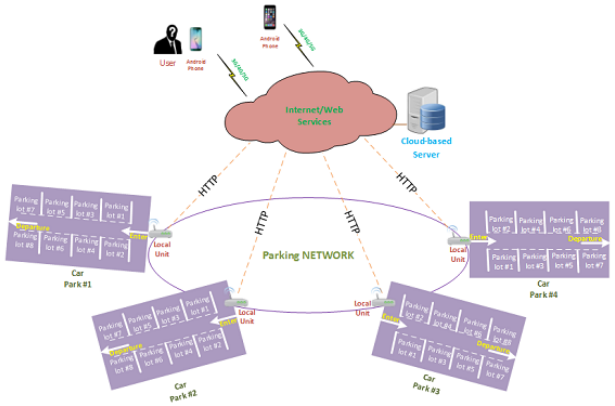

Figure 5. Block diagram for the approach in [15]

Mejri [21] has been proposed multi objective smart parking approach using a simulated annealing based meta-heuristic to optimize the parking location finding problem formulated as a multi objective program. The effectiveness of the proposed approach has been shown using real-like simulation environment.

In this paper, a navigation and reservation based smart parking platform using genetic optimization has been proposed for smart cities. The proposed method involves the

development of small devices that send data to the internet using the internet of things technology. The vacant parking location closest to the current location is found by genetic algorithm. The proposed method is tested for different scenarios and accurate results are obtained.

II. Background of Internet of Things (IoT)

This technology is based on the fact that different objects are connected to each other by cable or wireless and they are communicated in the internet environment. In the IoT, things communicate with each other and send their data among themselves. A thing has three main components: microprocessor, analog digital converter, and wireless module. It can be seen as a global network infrastructure. It is composed of many connected devices and these devices sense the data, send it to each other from networking and have an information processing unit. The main technology of the IoT is RFID that transmit their data by using a microprocessor through a wireless communication. The second main technology of IoT is the wireless sensor networks (WSNs). WSNs collect data from devices located at different places. Advances in wireless sensor networks and RFID technology have made significant contributions to the IoT. The other technologies supporting the IoT is given in Fig.6.

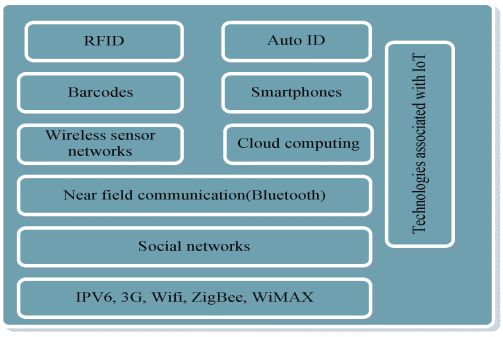

Figure 6. Technologies associated with IoT [24]

As shown in Fig.1, many technologies have a contribution to Io at different levels. The main aim of IoT is to connect different things via wireless or wired network connection [25]. In order to connect the devices to each other in the IoT, a four layer network structure is considered. The layer of IoT is given in Fig. 7.

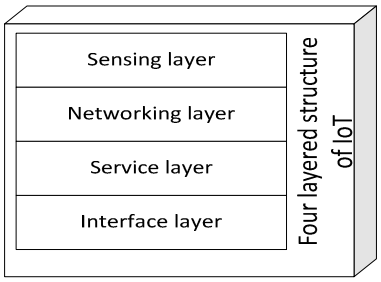

Figure 7. The layer structure of IoT

The sensing layer consists of sensors, actuators, and RFID devices for acquiring data from the physical world. The networking layer transmits the obtained data from analog digital convertor to the other devices over wireless or wired network. The service layer is used to create and manage services. User needs are controlled by this layer. Interface layer represents the interaction of the device with user and other applications.

III. The Proposed Smart Parking System

The smart parking can be considered as an application of IOT. The concept of smart city aims to meet the needs of the people, to provide more efficient use of general resources and to reduce the working costs. In this study, a new approach is proposed for the smart parking system. The proposed method consists of two modules. The first module is the hardware part. This module acquires the condition of the parking slots and send this data to the internet. The second module consists of the software part to determine the nearest free parking slots. The general flowchart of the proposed system is given in Fig.8.

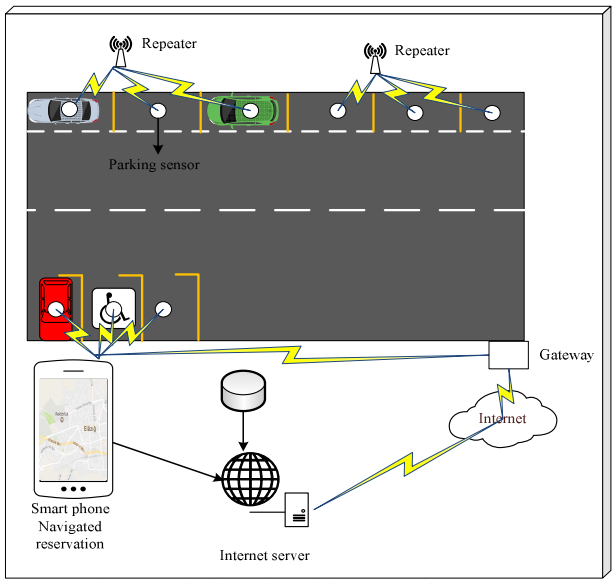

Figure 8. The flow chart of the proposed system

A. *Smart Parking Module*

The first step of the proposed smart parking system is to construct the hardware platform. For the implementation, two streets in the city center of Elazig are considered. These streets are Gazi and Vali Fahri Bey streets. These two streets can be parked for 15 minutes on the roadsides. Each street is assigned a gateway device. These devices acquire the condition of parking lots and send this data to the internet server. The parking sensor has a 802.15.4 transceiver to send its parking condition to the gateway. In the gateway node, the acquired date is transferred to the internet server via GPRS module. A magnetic sensor has been used to determine whether or not a parking slot is free or occupied. The general diagram of the proposed parking module is given in Fig. 9.

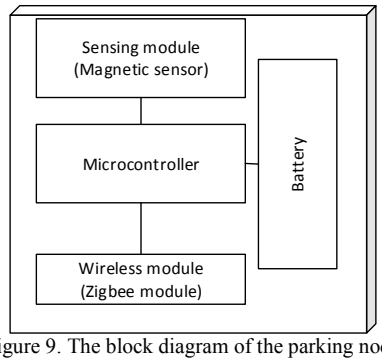

Figure 9. The block diagram of the parking node

B. *Genetic Algorithm Based Navigation and Reservation*

Genetic algorithm is apopulation based optimization method. It uses the general principles of natural selection. It can be used for both constrained and unconstrained problems. The algorithm iteratively changes the population by using three operators: crosover, mutation, and selection. At each step, the genetic algorithm selects parent chromosomes and generates the new indididuals by applying genetic operators. The general steps of the genetic algorithm is given in Fig. 10.

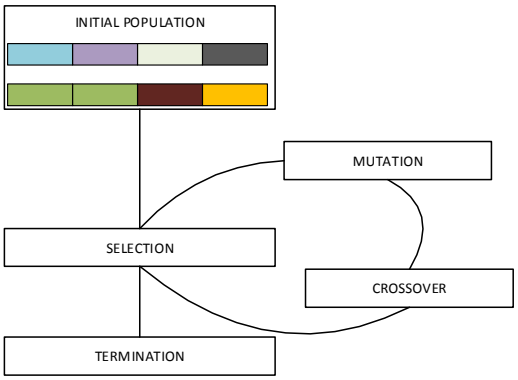

Figure 10. The steps of genetic algorithm

In this study, a route from our current position to the nearest free parking slot is determined by using genetic algorithm. For this purpose, some boulevards leading to two streets in the center of Elazığ are marked. These marked locations provide access to free parking lots with minimum route. Fig. 11 shows the marked location on the map.

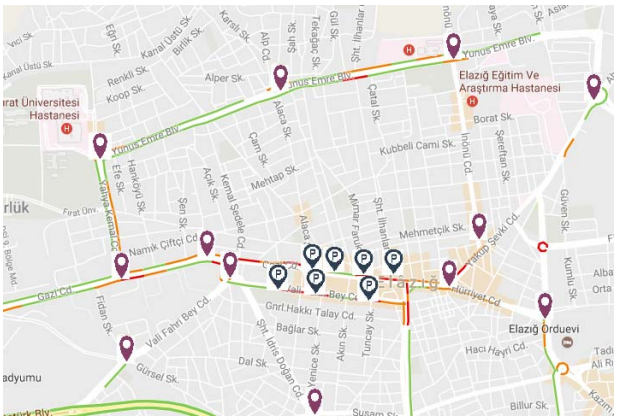

Figure 11. Marked location and parking lots on the map

A permutation coding based genetic algorithm is proposed. Places are saved as numbers. The longitude and latitude coordinates of these places is recorded in the database. The using coding is given in Fig. 12.

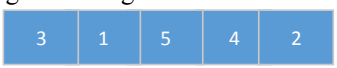

Figure 12. The coding of genetic algorithm

In Fig. 12, the starting point represents the current position taken from the GPS and is fixed and does not change. The ending point can be one of the free parking slots. Mutation is performed by changing two randomly selected genes. Single point crossover operator was applied on two sequential individuals. However, it can be passed twice from the same place as a result of crossover. In this case, the repetitive gene is replaced by the minimum gene that is not in the chromosome.

IV. Application Results

An application program has been developed in the ASP.Net environment for the implementation of the proposed method. The parameters of the genetic algorithm are given in Table I.

TABLE I. THE PARAMETERS OF GENETIC ALGORITHM

Parameter	Value
Population size	70
Number of boulevard	10
Mutation rate	0.65
Crossover rate	0.01

The genetic algorithm uses the roulette wheel method for selection. The interface that shows the parameter entries of the developed program is given in Fig.13. After the genetic algorithm is run, a route to a nearest free parking lot is obtained and this lot can be reserved for this user. In Fig. 14, the result of drawing route obtained from the genetic algorithm result is given. In the implementation, the fitness function should be minimized to obtain minimum route tothe free parking slot. However, this function is maximized dividing the objective function by a large value. The convergence graph of the objective function is given in Fig.15.

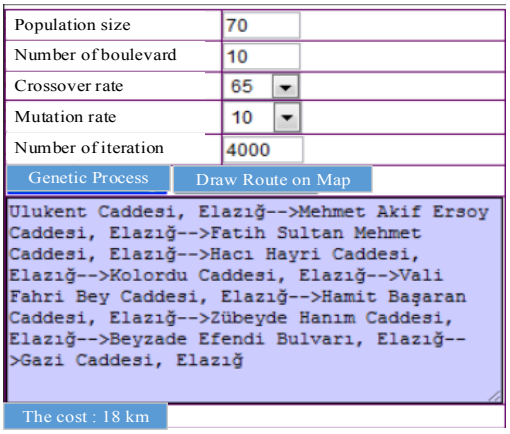

Figure 13. The interface of genetic algorithm based nearest free parking lot detection

Figure 14. The route obtained from genetic algorithm

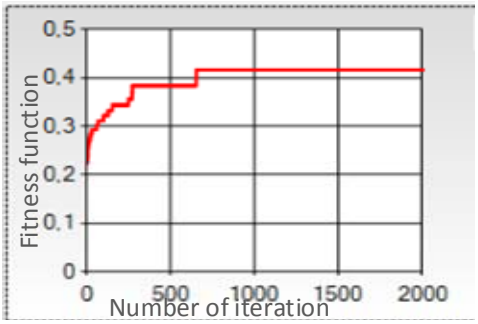

Figure 15. The convergence graph otf the genetic algorithm

IV. CONCLUSIONS

In this paper, a new optimal navigated reservation based approach has been proposed to find the free parking slot in smart cities. The aim of the propsoed method is to find the minimum distance to the free parkins slot. For this purpose, the problem is formulated as an optimization uses a genetic algorithm to find the nearest free parking space.The current position of the driver is taken from the smart phone's GPS and the nearest free pariking slot is found by using genetic algorithm. The advantages of the proposed method are confirmed by different scenarios. The performance results indicate that good results have been achieved.

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