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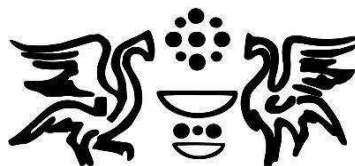
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# Editorial Foreword

Prof.Dr. Bekim Fetaji

**Editor**

ACKNOWLEDGEMENT

Welcome to the new Issue of the SEEJSD Journal with ISSN: 2545-4471. The topics covered by this Issue are related to the current trends of research, original research that uncovers sustainable development.

SEEJSD Journal as an international journal that effectively provides a forum for academics, professionals, graduate and undergraduate students, fellows and associates to share the latest developments and advances in knowledge and practice of Economics and Business; Information Technology and Engineering, Technics and Technology; Humanities and Social Sciences. Our interest in promoting high-quality research is clearly reflected in having an established peer reviewing process and a high-profile expert group of Associate Editors and Editorial Board Members.

Hopefully you find this Issue valuable and we definitely look forward to receiving your high-quality studies for the next issue of the Journal.

Prof. Dr. Bekim Fetaji  
Editor

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# Modeling and Implementation of Smart Parking System

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## ABSTRACT

With increasing economic development and urbanization, car ownership is growing rapidly, exacerbating the imbalance between parking supply and demand. Most countries face problems related to the lack of parking spaces and car parking is a major problem in urban areas around the world. Drivers have to spend a long time searching for a parking space, which not only increases time costs, fuel consumption and exhaust emissions, but also increases traffic congestion. Recently, the concept of smart cities where one of the most important parts is smart parking has gained great popularity. Thanks to the evolution of the Internet of things, the idea of a smart city now seems to be achievable. Consistent efforts are being made in the field of IoT in order to maximize the productivity and reliability of urban infrastructure. Problems such as, traffic congestion, limited car parking facilities and road safety are being addressed by IoT.

Parking is creating problems mainly because people have to cruise around to find a vacant parking spot in the urban network. A clear need for applications that can reduce those external effects of parking has arisen, especially the last few years. With parking pricing policies reaching their limits in many European cities, possible improvements could be found in Intelligent Transport Systems (ITS).

## KEYWORDS

Smart parking system, Internet of Things, Free parking space

## 1 Introduction

People moving into cities and buying cars at an exponential rate have created a major problem: how to handle parking in places with lots of people. Conventional parking methods don't always make good use of parking spots, which leads to traffic jams, lost time, higher emissions, and angry drivers. Despite the existence of parking zones and multi-storey garages, the problems with parking lots and finding a free parking space are a problem that the citizens of Skopje face every day. The public parking lot that is responsible for managing parking lots on the territory of the city is not an SPS, that is, it does not use a smart system. In fact, not a single parking lot has been completely transformed into a smart one, although there are attempts and test phases in certain areas of the city, but they are in an early stage and there is not enough data on the opportunities that would be offered to future customers as well as the potential positive outcomes in terms of traffic in the city. Hence, it is necessary to establish an SPS system, especially in public parking lots.

Putting together Internet of Things (IoT) technology with smart parking systems looks like a good way to solve these problems. The problem of parking cars in urban areas actually means that there is a gap between the number of cars that need parking space and the number of parking spaces sufficient for the cars that need parking. Due to the lack of free parking spaces in the city center or near the center, drivers park their cars in the surrounding residential areas of the city because they want to park closest to their destination and avoid paying parking fees. This type of parking increases the pressure on these areas, which causes resentment among the population of the city district, who then have difficulty finding a parking space for their cars. Due to the lack of sufficient parking spaces in the city districts, there is an illegal way of parking, that is, parking in areas not intended for that purpose. Vehicles parked illegally on the roadway endanger the safety of pedestrians, reduce the available walking space, increase the load on free traffic lanes, increase the deterioration of roads and land next to residential buildings, cause traffic jams, disrupt vehicle traffic, and cause conflicts between residents and their residences.

Internet of thing (IoT) has the ability to transfer data through network without involving human interactions. IoT allows user to use affordable wireless technology and also helps the user to transfer the data into the cloud. IoT helps the user to maintain transparency. The idea of IoT started with the identity of things for connecting various devices. These devices can be controlled or monitored through computers over internet. IoT contains two prominent words "Internet" and "Things", where Internet is a vast network for connecting servers with devices. Internet enables the information to be sent, receive or even communicate with the devices. The parking problem

causes air pollution and traffic congestion. The solution for the problems that is being raised. The smart parking can be a solution to minimize user's time and efficiency as well as the overall cost of the fuel burnt in search of the parking space. In this, the data is collected from the sensor and through analyzing and processing, the output is obtained.

Thanks to the Smart Parking technology, it is now possible to know in real-time the location of free parking spaces and to help drivers to get to their ultimate destination. A variety type of vehicle detectors has been used in parking information acquisition. These vehicle detectors mainly include the inductive loop, acoustic sensor, infrared sensor, or ultrasonic sensor. System using video camera sensor technologies have been.

## 2 Related works

Currently, many research missions have an excellent parking management in favor of the concept of wireless sensor networks to detect parking information of free spaces. Many studies conducted in different cities around the world indicate the long-term and short-term benefits of smart parking, with the short-term ones certainly referring to the reduction of congestion and congestion as well as the significant reduction in the time needed to find a parking space. On the other hand, the long-term ones are more related to the reduction of CO<sub>2</sub> emissions, fuel/electricity savings and general time savings.

A study dealing with the different types of smart parking systems from 2020 indicates the benefits of SPS. Namely, the study is based on studies of 274 publications and case studies relating to SPS systems and their evaluation in practice (Ogas, etal, 2020). The study also indicates the best systems, i.e. those that allow an algorithm to calculate a route for the user and a free space in a smart parking lot in the shortest possible time. Another research conducted on this topic in 2021 points to the opportunities that IOT (Internet of Things) offers, which relate to networking and the transfer of information from the server to the user (Biyik, etal, 2021). Other research also points to other problems with current PSP (Smart parking system) that are active in buildings around the world. Current parking systems use a single gateway-oriented solution (i.e. cloud) for data processing, which leads to the possibility of a single point of failure, data loss and high delays. In addition, the parking space selection process takes into account criteria that do not maximize parking utilization and revenue. The pricing strategy does not achieve high revenues because a fixed price rate is used (Balfaqih, etal, 2021).

Parking systems can be divided into categories such as manual parking, smart parking and automatic parking. Parking spaces are segregated into slots and sensors installed in these slots detect occupancy based on sensor readings. The built system is a combination of different technologies. (Gupta, etal, 2020). When it comes to the Republic of North Macedonia, especially the capital city of Skopje, it can be said that the problem of traffic, especially parking, is a problem that citizens have been facing for a long time. Namely, due to the increasing population and the need for cars, as well as inefficient public transport, they contribute to constant congestion, especially at certain times of the day, and the problem of parking is also a major challenge that needs to be solved. In addition to IoT and machine learning, robotics is emerging as a critical technology in smart parking management, enhancing efficiency and automation. Various research efforts have explored the role of robotic control systems, AI-based optimization, and dynamic modeling in autonomous systems. Robotic control systems can be integrated into parking management, leveraging nonlinear dynamics and machine learning algorithms to automate parking processes, optimize vehicle movement, and enhance decision-making (Knights, Petrovska & Gajdoš Kljusurić, 2024; Antoska-Knights & Petrovska, 2024). Smart parking by implementing autonomous robots that guide vehicles to available spots, minimizing human intervention and safety (Knights et al., 2024). AI and machine learning contribute to smart parking optimization by predicting parking space availability, demand patterns, and user behaviors, leading to more intelligent and adaptive parking systems (Knights, Petrovska & Prchkovska, 2024; Knights & Prchkovska, 2024;).IoT security remains a major concern in smart parking systems. Research on vulnerability detection and prevention in IoT-based infrastructures provides insights into securing parking management systems against cyber threats (Knights & Gacovski, 2024).

## 3 Internet of Things and Smart Parking System (SPS)

"IoT" first appeared in 1999, introduced by Kevin Ashton, who was the co-founder of the Center for Auto-Identification at the Massachusetts Institute of Technology. Gartner, a company that researches new technologies on a global scale, announced that IoT is one of the top ten most important strategic technologies in the world. IoT is based on communication over a network or some other form of transmission such as Bluetooth or, for example, RFID (radio frequency identification) which works on the principle of radio frequency. The entire system is based on the sensor-microcontroller-software-user relationship.

IoT enables integration, interaction, and communication with digital electronic devices, sensors, and actuators that provide the necessary services to more effectively achieve certain goals. IoT security uses various security measures, making it a matrix for other technological advances. Due to the exponential growth and development of IoT and cloud-based smart systems, the concept of developing smart cities has gained a new dimension. The goal of a smart city is to reduce operating costs, improve city management, improve efficiency, and improve productivity (Brown, 2018). AI-Fagih et al., (2013) proposed an Architectural model of IoT public sensing consisting of Data collectors (mobile and static), Gateway and Access Point for the main components (Figure 1).



## 4 Analysis of parking lots in the city of Skopje

On the territory of the city of Skopje there are open parking lots that are of a closed nature. Ramps are used to control access and exit to the parking area. Parking lots in the city of Skopje are organized into 4 (four) zones according to the degree of restriction and the location of the parking lot, i.e. the distance from the central city area, as follows:

1. First degree of restriction
2. Second degree of restriction
3. Third degree of restriction
4. Fourth degree of restriction

In 2009, the Public Enterprise City Parking - Skopje introduced another way of regulating parking - zone parking. The purpose of zone parking is to enable uninterrupted circulation in traffic, especially in the parking area. Such an approach to parking has enabled a drastic reduction in the time lost in searching for a free parking space.

### 4.1 Data Collection

For the purposes of this paper, three parking locations were selected on the territory of the city center of Skopje, according to the division made by the Public Enterprise City Parking. Counting the number of parked vehicles in parking spaces is done by walking around the location, observing and recording each car in the parking position for a certain period of time. A complete record of the parking capacity of the parking lots gives us a realistic and current picture of the absolute capacity of the parking lots. For the purposes of the research, the following data were required:

- The occupancy rate of the selected parking lot, taken at the beginning,
- Number of vehicles entering the parking lot during a certain time interval,
- Number of vehicles leaving the parking lot
- Final occupancy rate of the parking lot
- Percentage of occupancy
- Data on the parking time of each vehicle that used that parking lot

The research was conducted in three randomly selected parking lots in the center of Skopje, on five consecutive days between 07:00 and 21:00.

The data for the three selected parking locations, which were collected from the field for all five days, are shown in the following tables.

Час	Понеделник			Вторник			Среда			Четврток			Петок		
	Влез	Излез	Застапеност	Влез	Излез	Застапеност	Влез	Излез	Застапеност	Влез	Излез	Застапеност	Влез	Излез	Застапеност
07-08ч.	83	2	93	90	17	76	75	3	82	74	2	90	74	4	90
08-09ч.	2	77	84	24	0	90	11	0	93	4	16	78	3	0	93
09-10ч.	9	17	76	3	42	51	1	26	68	11	24	66	1	23	69
10-11ч.	1	14	63	18	9	50	15	15	68	22	8	80	21	28	62
11-12ч.	29	2	90	0	12	38	8	11	65	3	0	83	18	3	67
12-13ч.	5	0	95	30	2	46	28	2	91	10	1	92	23	0	90
13-14ч.	0	33	62	42	0	88	4	1	94	3	0	95	5	2	93
14-15ч.	8	46	24	4	2	92	0	14	80	29	17	59	2	0	95
15-16ч.	57	3	78	3	0	95	15	33	62	8	31	36	0	17	78
16-17ч.	14	0	90	0	24	71	8	26	44	6	2	40	13	46	45
17-18ч.	4	9	85	16	27	61	53	16	81	24	2	62	41	20	66
18-19ч.	0	18	67	11	14	47	14	3	92	10	5	67	10	6	70
19-20ч.	23	3	87	13	31	19	0	17	75	13	0	70	7	0	77
20-21ч.	5	0	92	49	3	65	13	26	62	19	4	85	15	3	90

Figure 2: Data collected – 1<sup>st</sup> location

Час	Понеделник			Вторник			Среда			Четврток			Петок		
	Влез	Излез	Застапеност	Влез	Излез	Застапеност	Влез	Излез	Застапеност	Влез	Излез	Застапеност	Влез	Излез	Застапеност
07-08ч.	101	17	110	112	3	128	124	4	139	124	7	140	116	2	160
08-09ч.	54	3	151	36	5	159	31	0	170	31	0	171	11	0	171
09-10ч.	7	22	136	3	59	103	2	37	135	7	54	124	71	37	135
10-11ч.	21	43	114	7	0	110	14	60	89	21	9	136	22	14	143
11-12ч.	29	39	104	53	26	137	62	6	145	28	2	162	26	42	127
12-13ч.	65	58	169	35	0	172	27	9	163	9	1	170	40	3	164
13-14ч.	3	71	101	1	0	173	5	46	122	2	32	140	6	11	159
14-15ч.	60	3	158	0	39	134	17	55	84	27	3	164	12	0	171
15-16ч.	12	92	78	11	7	138	43	5	122	8	0	173	2	0	173
16-17ч.	38	1	115	14	81	71	51	0	173	0	46	127	0	53	120
17-18ч.	29	7	137	66	2	135	21	30	143	16	67	76	13	25	108
18-19ч.	30	4	163	30	0	165	0	5	159	55	1	130	3	0	111
19-20ч.	8	84	87	1	40	126	8	2	165	38	3	165	55	6	160
20-21ч.	14	69	32	13	54	79	6	93	78	3	73	95	4	29	135

Figure 3: Data collected – 2<sup>nd</sup> location

Час	Понеделник			Вторник			Среда			Четврток			Петок		
	Влез	Излез	Застапеност	Влез	Излез	Застапеност	Влез	Излез	Застапеност	Влез	Излез	Застапеност	Влез	Излез	Застапеност
07-08ч.	63	7	70	75	6	86	74	0	82	60	5	80	54	18	46
08-09ч.	28	3	95	12	15	83	14	5	91	14	0	94	23	4	65
09-10ч.	8	1	102	20	1	101	12	4	99	10	0	104	30	12	83
10-11ч.	2	0	104	3	0	104	4	1	102	0	0	104	7	11	79
11-12ч.	1	19	86	0	24	80	2	0	104	0	14	90	15	4	90
12-13ч.	13	34	65	9	32	57	0	11	93	8	19	79	8	10	88
13-14ч.	37	11	91	44	1	100	4	17	80	24	3	100	14	16	86
14-15ч.	9	4	96	0	13	87	6	20	46	2	27	75	10	5	91
15-16ч.	4	0	100	15	20	82	51	7	90	28	20	83	4	2	93
16-17ч.	1	51	50	22	0	104	11	3	98	20	4	99	7	7	93
17-18ч.	16	4	62	0	14	90	4	0	102	4	0	103	11	27	77
18-19ч.	36	0	98	12	5	97	1	14	89	0	12	91	20	33	64
19-20ч.	4	4	98	3	37	60	11	5	95	8	25	74	0	10	54
20-21ч.	6	11	93	45	31	74	2	48	49	2	13	63	1	23	31

Figure 4: Data collected – 3<sup>rd</sup> location

## 4.2 Regression analysis

A regression model is a statistical model that, using mathematical formulas and appropriate assumptions, best describes the quantitative dependence between the variations of observed phenomena in reality. A regression model shows the average agreement of the variations of the examined phenomena. It is not a goal in itself, but rather it is only a means by which we are able to evaluate and predict the behavior of the dependent variable for the desired value of the independent variable. When investigating the mutual relationships between two variables, simple (linear and nonlinear) regression models are applied. Simple linear regression is when we have two phenomena between which there is a linear dependence. In this research, a regression analysis was performed using the parameters vehicle occupancy and hours of the day for each of the parking locations individually for five days.

From the collected field data for the first location, dependence, number of vehicles and occupancy over 5 working days are shown. It is concluded that the peak hour in the morning is 08-09h with an occupancy of 438 vehicles and in the afternoon 13-14h. with an occupancy of 432 vehicles. Also, we have the lowest load in the afternoon from 13h to 14h.

From the collected field data for location 2, dependence, number of vehicles and occupancy over 5 days are shown. It is concluded that the peak hour in the morning is 10-11 am with an occupancy of 493 vehicles and in the afternoon 1-2 pm. with an occupancy of 457 vehicles. Also, we have the lowest load in the evening from 8 pm to 9 pm.

From the collected field data for location 3, dependence, number of vehicles and occupancy over 5 days are shown. It is concluded that the peak hour in the morning is 08-09h with an occupancy of 822 vehicles and in the afternoon 12-13h. with an occupancy of 838 vehicles. Also, we have the lowest load in the evening from 20h to 21h.

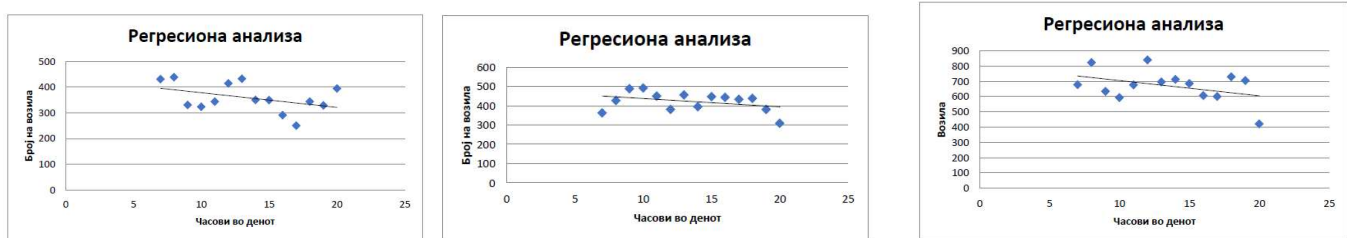
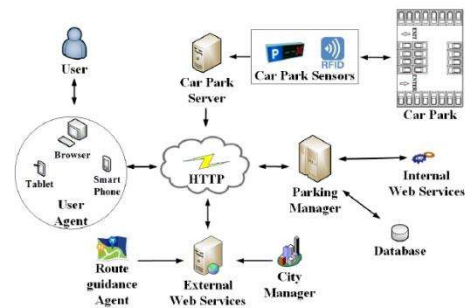


Figure 4: Regression analysis for Location 1, 2 and 3, for each hour over a period of five days

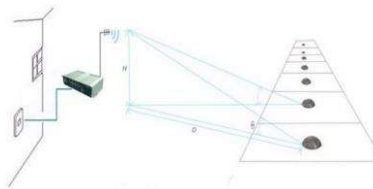
## 4.3 Proposed solution for smart parking at selected locations in Skopje

In order to reduce traffic congestion at parking locations, especially during peak hours, and to facilitate the process of searching for free parking spaces for drivers, we propose to introduce smart parking based on a mobile application. The way this proposed smart parking system works is as follows: first, the user requests information from the mobile application. In this case, the user can request where parking is available, location of the available parking space, payment information, etc. The following image shows the architecture of the proposed smart parking model.



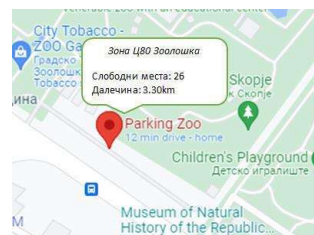
**Figure 5: Smart Parking System**

Sensors placed at each parking space detect whether the parking space is available or unavailable and wirelessly transmit the information to the database and then to the user. The mobile application then displays information stored from the database in the server and resolves the user's request in real time. Vehicles can park in the available space and the user can pay for the parking space and locate the car at any time using the mobile application. At each parking space at each of the parking locations, electromagnetic sensors are installed that detect the status of each parking space and send all the information about the occupancy to the central management unit. To deliver the occupancy status of each parking space, the sensors are connected to an IoT network. The sensors operate on batteries and continuously register the presence of a vehicle in the parking space and wirelessly send the data to the receiver. The receiver, which operates in the range of 865 Mhz to 867 Mhz, updates this occupancy data to the server in the control center via the Internet using a wired network, as shown in the Figure 6.



**Figure 6: Example of placement of sensors and receiver at a parking location**

Users can check the availability of a parking zone, as well as receive information about the location and availability of parking locations through the mobile application installed on their mobile phones. The mobile application also shows users the occupancy of parking zones in real time. The application offers two ways for drivers to select the desired parking location, by searching for parking locations via the nearby button and by entering the address of the desired parking location. After selecting the desired address, the coordinates are sent to the management system which then updates the data in real time. If the user selects the nearby button, the GPS system locates the user's current location and the application displays the distance and availability of parking locations as shown in the Figure 7.



**Figure 7: Parking location information**

## 5 Conclusion

In this paper there is a developed version of the smart parking system. The system has implemented a smart parking system with online booking through an Android application. This system helps to save our time in this busy world. This optimal parking system has a computerized approach to parking issues, which effectively controls traffic congestion during peak hours during business hours. This system helps to avoid excessive traffic, which leads to lower fuel consumption and the content of CO<sub>2</sub> in the atmosphere. The advancement of internet of things and cloud technologies has given rise to the new possibilities in terms of smart cities. Smart parking facilities have always been the core of constructing smart cities. The system provides a real time process and information of the parking slots.

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