



## Concept of an Intelligent Parking System; Efforts to Resolve Traffic Conflicts Regulations

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### Abstract

Makassar, an Indonesian city, is situated on the south-western coast of Sulawesi Island. It is the largest commercial centre in eastern Indonesia, and traffic congestion is a problem there. Movement management must establish sufficient and well-organized parking areas, as well as a good and transparent system to eliminate unmonitored restitution funds, in order to address these issues. To address parking issues in Makassar, a legal and technical strategy is developed, with an emphasis on inclusiveness and including both legal and illegal parking spaces. The integrated parking concept is comprised of a mobile, everywhere-accessible parking area reservation system, a vehicle registration system based on licence plate numbers, and an effective data management system. 180 million Indonesian Rupiah are spent on all equipment and activity installations (IDR). At least 50 locations utilising this system will be required for a minimum vehicle range of 250,000 units, resulting in an approximate capital cost of 9 billion rupiah. The first clause describes the application of minimum parking fees to flat parking fees (generally 2 thousand rupiah). During a single parking period, it is anticipated that 250,000 vehicles will utilise this parking system if all parking spaces are occupied simultaneously. Government and investors can raise 250 million rupiah in investment capital assuming a 50:50 profit split. Revenue can reach billions of rupiah with just four iterations.

**Keywords:** Congestion; Indonesia; Intelligent Parking System; Parking; Reservation System.

### 1. Introduction

Makassar is a major city in Indonesia, along with Jakarta and Surabaya. Makassar, which is situated on the south-western coast of Sulawesi Island, is the most important commercial centre in eastern Indonesia. This makes Makassar an active and bustling metropolis. Similar to other major metropolitan areas, Makassar faces urban problems such as traffic congestion. The majority of traffic congestion in Makassar City is caused by the number of vehicles that exceeds the road's capacity at certain times and is distributed throughout nearly every suburb. Additionally, roughly all roadside obstructions in Makassar City are occupied by unauthorised parking. Parking on the street reduces road capacity. The parking regulations of Makassar City are not yet fully integrated and regulated. As in the majority of Indonesian cities, parking management in Makassar relies on "parking attendants" to organise and direct vehicles in parking lots. The majority of these parking attendants are unemployed and involved in their respective communities. Regarding the

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distribution of parking tickets in the city of Makassar, they maintain relationships with relevant authorities. 30% of parking fees are allocated to the regional government, while 70% are allocated to operators or landowners in commercial districts such as shopping malls. This management's compensation is frequently a hidden business area for numerous factors. In actuality, neither formal written reporting nor accountability have ever been provided for parking management, let alone parking taxes. The cost of parking fines, which can reach billions of rupiah in a matter of days, makes this an important issue. This tax has been in questionable hands for a considerable amount of time; consequently, the city has lost a substantial amount of money that should have been spent efficiently. In addition to management concerns, movement management must establish sufficient and well-organised parking sites in Makassar to prevent the chaos of parked vehicles due to the large number of vehicles entering the city's activity centre and crowd centre. A good and transparent system must also be created to eliminate unmonitored retribution funds. This will provide the desired service to all parties.

## 2. Literature Review

### 2.1. Legal Point of View

Taxes are payments made to the public treasury in accordance with the law, which allows them to be imposed without direct compensation. The government collects taxes to cover the cost of producing legally required goods and services for the general welfare. Some studies contend that taxes are contributions owed to the state by those who are obligated to pay them according to regulations with no return on performance that can be directly appointed and whose purpose is to fund general expenses associated with the state's responsibility to administer the government [1, 2]. According to Surya et al. [3], tax is the transfer of funds from the people to the state Treasury to cover routine expenditures; the surplus is used for public saving, which is the primary source of funding for public investment [4].

There are eleven types of local taxes, which include the hotel tax, restaurant tax, entertainment tax, billboard tax, street lighting tax, non-metallic and rock mineral tax, parking tax, ground water tax, swallow's nest tax, BPHTB, and rural and urban land tax. Parking tax is one of the potential regional taxes, so its outcomes have the potential to be fairly significant and advantageous as a source of regional funds for regional economic development [5].

Law No. 28 of 2009 defines regional levies as payments for services or the issuance of specific special permissions by the local government for the benefit of individuals and businesses. Retribution is a payment that the people have to make to the state in exchange for the state giving them certain services [6]. These services are considered direct since only the levy payer can get compensation from the state. In line with the rules of the Indonesian law now in effect, only local governments are permitted to collect withdrawal fees [7]. In accordance with Law No. 28 of 2009, regional levies are regional levies collected as payments for services or granting specific permissions offered and/or granted by the regional government for the benefit of individuals and/or organisations [8]. Services are local government activities that enable individuals or entities to enjoy commodities, facilities, or other advantages. Therefore, if the public wishes to use the local government's services, people must pay a tax in accordance with the law [9].

Regional taxes and fees are governed by Act 18 of 1997, as amended by Act 34 of 2000. Eventually, the two laws were consolidated into Law No. 28 of 2009, which regulates regional taxes and levies. In regency and municipal regions organised on the basis of expansive, genuine, and accountable autonomy, Law No. 28 of 2009 concerning regional taxes and regional levies has been fully implemented. With the exception of defense, security, justice, foreign policy, and monetary and religious affairs, the district and city areas enjoy complete autonomy [10].

In the context of implementing regional government authorities in accordance with Law No. 32 of 2004 regarding regional government and Law No. 33 of 2004 related to financial balance between the central and regional governments, monetary rights and obligations arise, necessitating regional financial management [11]. Taxes are obligatory levies that must be paid as a form of citizen contribution to the state, which have their own sanctions when a person or citizen does not fulfil or is late paying their obligations, whereas levies are non-obligatory levies, and there are no sanctions for actions not paying levies; those who do not pay will not receive the same services as those who do pay [12].

Article 1 number 6 of the Makassar Regional Regulation No. 17 of 2006 on the Management of Public Roadside Parking in the City of Makassar defines parking as the temporary stopping and placement of motorized vehicles on the side of a public road within a specified area. The Decree of the Minister of Transportation No. KM 66 of 1993 concerning Public Parking Facilities stipulates the following [13]:

- Parking is the prolonged immobility of a vehicle;
- Off-street parking facilities are specially designed vehicle parking facilities that can appear in the form of parking lots and/or parking structures.
- Public parking facilities are off-street parking facilities in the form of parking structures or parking lots that are run as separate businesses and offer parking services to the public.

As one of the autonomous regions, the City of Makassar achieves growth through the formation of initiatives in policy formulation, planning, and implementation, as well as regional tax collection. Makassar City is one of the most populous and densely populated cities in Indonesia, and per capita income is rising. Due to its location, Makassar City has the potential to become a commercial and business hub [14]. Makassar is well-known as one of the tourist and educational cities in eastern Indonesia; consequently, a large number of individuals come to the city to study and look for work. As a result of the growing population and number of automobiles traversing the city's streets, the city's traffic is becoming more congested. This issue is exacerbated by the ignorance of drivers who park on the road [6, 15]



**Figure 1. The condition of the parking lot in Makassar reaches the road**

To maximise local revenue (PAD), especially from the parking tax and parking fees sector, the Makassar city government, specifically the Makassar City Regional Revenue Agency (Bappenda), which formulates policies, manages, monitors, evaluates, and provides technical assistance, must collaborate with parking area businesses. Makassar Raya, whose primary responsibilities include coordinating parking sector policies and planning, formulating, fostering, and optimising parking fee collection [16] so that there are no gaps or disruptions for parking service users, and most importantly, so that the parking tax and parking fee sectors can contribute.

## 2.2. Technical Point of View

The urban parking problem is complicated by the diverse interests of the community and the increase in vehicle ownership in major cities, which will have an effect on the growth and development of human activities in those areas. The large population and increasing mobility need of urban populations have implications for the expansion of both private and public transportation. In addition to the often-discussed issue of traffic congestion, a number of cities in Indonesia face parking issues (Figure 2) [6, 15].



**Figure 2. Illegal parking violations in the Makassar City area**

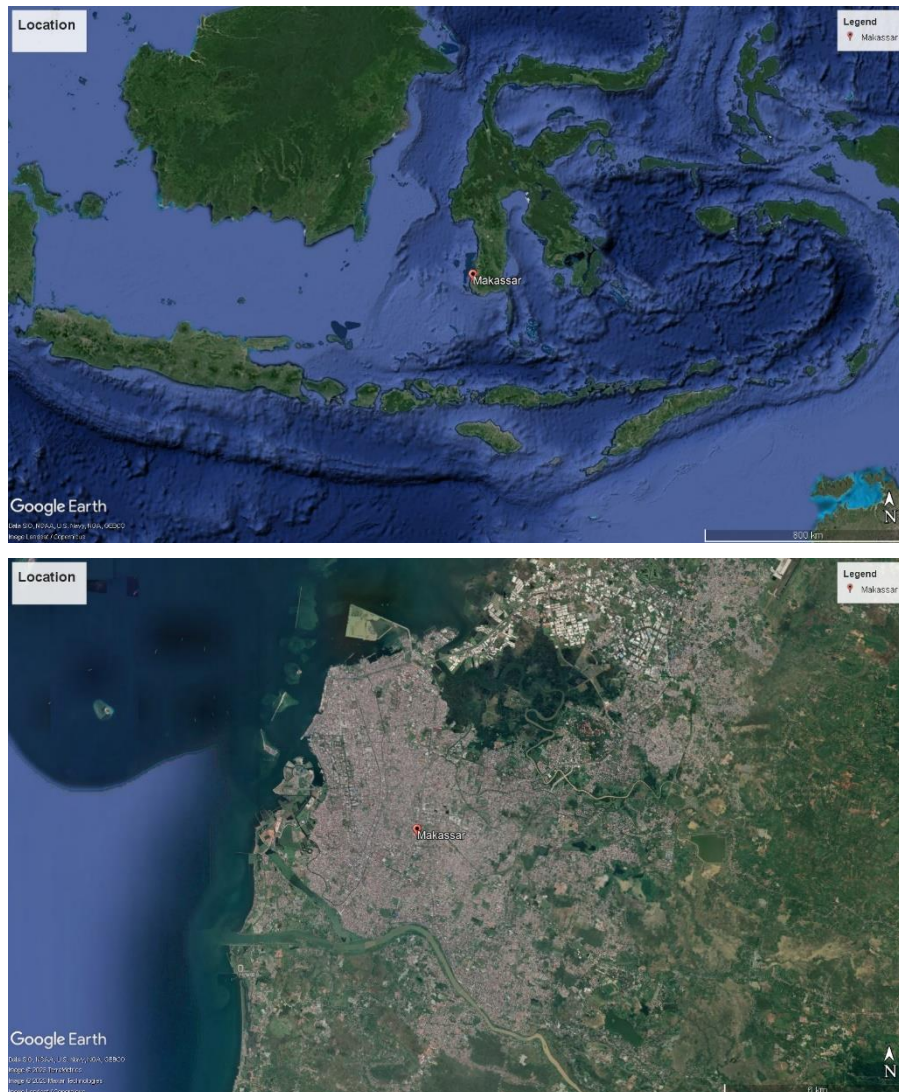
Typically, urban activity hubs comprise a variety of land uses. The activity hub could be a commercial district, university campus, industrial district, or entertainment district. As transportation has become a necessity in modern society, the human propensity to purchase automobiles continues to increase annually [17]. If the number of automobiles continues to increase, the demand for parking spaces is likely to rise as well. As the number of cars increases, it is



essential to have effective parking lot management and to be able to manage parking lots so that they are optimally utilised while maintaining a pleasant parking position layout. The Makassar City Regional Regulation No. 17 of 2006 on the management of public roadside parking in the Makassar City region does not appear to have been fully implemented on the ground [2] due to the fact that a significant number of drivers continue to park on the road shoulder and the parking administration is disorganized. The implementation of this legislation is expected to reduce traffic congestion and illegal, irresponsible parking. Given the presence of arterial roads, it is evident that vehicles are still permitted to park on the side of the road without the intervention of law enforcement officials

### 3. Research Methodology

This research was conducted in Makassar City, South Sulawesi, Indonesia. The location of the study site is depicted in the following map (Figure 3).



**Figure 3. Location of the Study**

The concept of the intelligent parking system was developed primarily through focused group discussions with a number of relevant stakeholders in Makassar, as well as with IT experts. In the beginning of the conception phase, parking management issues in Makassar City are identified. This is achieved through direct observation at a number of locations deemed prone to traffic congestion and illegal parking. After identifying the factors that contribute to congestion, a legal and technical strategy is developed to address parking issues in Makassar. This formulation emphasises inclusiveness in order to provide the government and relevant authorities with effective and transparent management options. In addition, this concept must be able to encompass both legal and illegal parking spots in order to overcome the majority of municipal regions' technical challenges.

Some of the main key aspects that must be considered in this concept are: it is mobile and can be done anywhere; there is a parking area booking system; there is a vehicle registration system based on licence numbers; and there is an efficient data management system.

The process of determining the integrated parking concept begins with:

- Identifying problems, i.e., ineffective parking regulations in Makassar City and other cities in Indonesia, so that new regulatory instruments and concepts can be developed that are anticipated to have a positive impact in the form of an increase in local revenue from parking fees.
- Conduct a literature review and search for the specifications of the required tool components to meet the criteria for a smart parking system capable of resolving problems at the study site.
- Conducting focused group discussions with experts in related fields in order to effectively integrate the various components, followed by small-scale simulations.

Performing estimated calculations of parking spaces, the number of existing vehicles, and parking rates in order to obtain a rough estimate of compensation, along with a profit-sharing scheme with the parking developer/manager.

## 4. Result and Discussion

### 4.1. Supporting and Inhibiting Factors of Makassar City Government in Illegal Parking Management

The failures or successes of the regional government of Makassar City as a result of the establishment of the Makassar Raya Parking Company (PD) based on Regional Regulation No. 17 of 2006 as a parking manager who receives fully delegated local government authority to carry out the duties and responsibilities of the Makassar City Government in the parking sector. The following responsibilities have been assigned to the Mayor of Makassar as a result of the enactment of Law No. 17 of 2006 regarding the management of public roadside parking in the Makassar City Area: Every effort to comprehend the behaviour of bureaucracy must personify bureaucracy as a living entity with human-like characteristics because bureaucracy is composed of a group of living entities, namely individuals who collaborate to achieve goals. There is a significant organ within the government, and that organ is the bureaucracy. In developing nations, bureaucracy will play an outsized and decisive role, particularly when society is so weak and powerless that it cannot meet its own demands. Similarly, when the bureaucracy fails to absorb a community's demands, the interests of one community tend to undermine the interests of another. In order to create an orderly society, the authors may conclude that a bureaucracy in government administration is required to manage the lives of all citizens. Still related to bureaucratic issues as the topic of discussion in writing about the supporting factors for the Makassar City regional government in managing illegal parking in Makassar City, its role is urgently needed in the midst of people's lives that require effective and efficient service, especially in parking services.

### 4.2. Overall Design Concept

The overall system circuit must be divided into two primary circuits: the parking system inside the structure and the parking system outside the structure. In addition, the system must be compatible with the API (application programming interface) on the cloud server (master database), which is also centrally located on the backend control website. In addition, there is a module that detects the location of maps and manages parking data at that location, including transactions, parking spaces, and empty or full parking conditions. Regarding payments, there is a module that collects online payments via an Android application and is coupled with Midtrans (a third-party payment gateway vendor). A user distribution module, such as user, super admin, counter clerk, and other parties based on future development, is intended to permit operation by multiple parties who can clearly view and perform their respective tasks based on their distinct fields of work (Figure 4 to 6).

- Customers register and book a parking space on the mobile application
- The camera detects the vehicle license number using the Python Artificial Intelligence Program with the Support Vector Machine (SVM) method.
- At the parking location for slot marks there are sensors on the roof / front / bottom of the car according to the conditions and requests of the parking location manager
- The Clock Count has a sensor before the sensor portal enters and after the sensor portal exits.
- The clock count sensor is used to count down the parking duration that has been purchased in order to determine the parking fine that must be paid if it exceeds the time limit.
- Online payments can be made before the portal enters according to a registered parking spot order that is integrated with midtrans.
- For the use of outdoor parking areas, parking lots will be equipped with surveillance cameras as replacement sensors, because there are no barriers in open spaces.

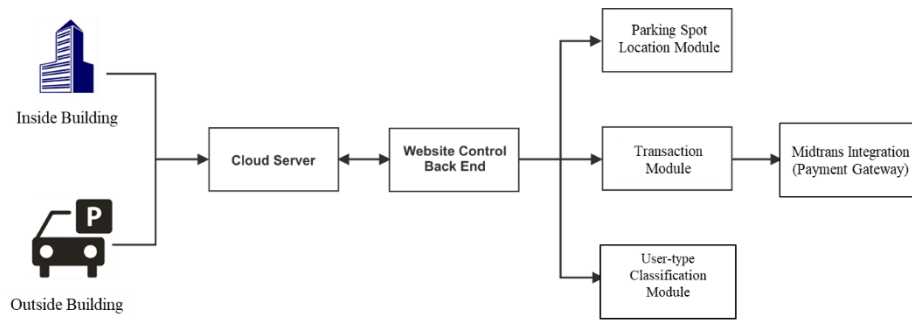


Figure 4. Basic Overall String

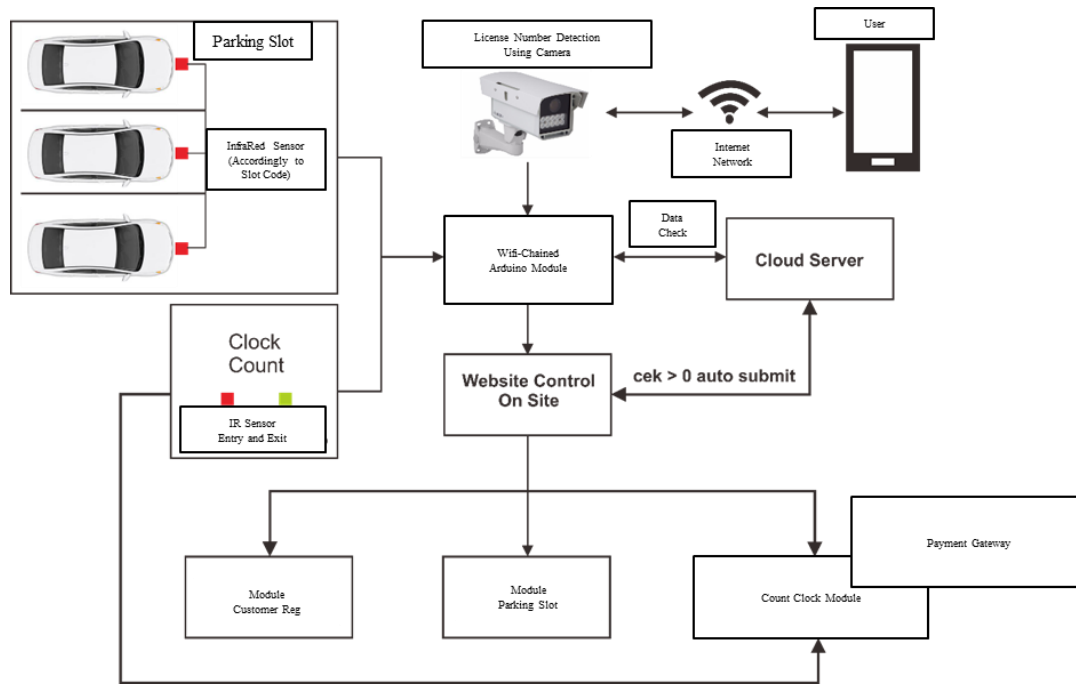


Figure 5. Parking Scheme – Online Scenario

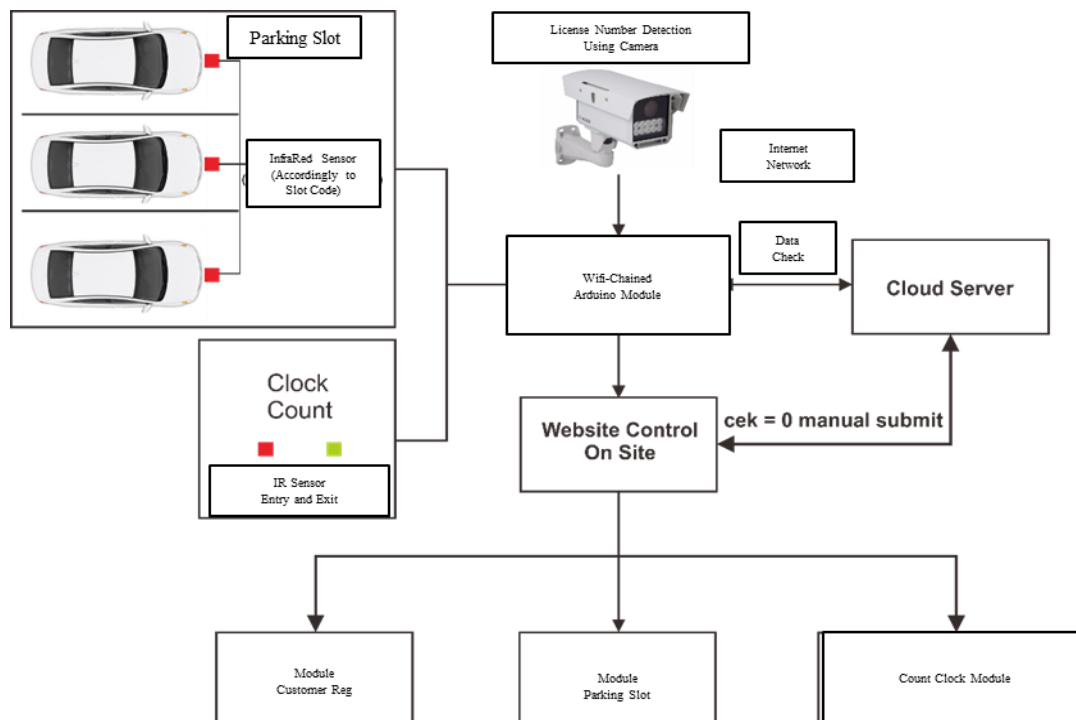


Figure 6. Parking Scheme – Offline Scenario

This intelligent parking system is comprised of identification components, system control components, parking location management components, and automation components. All of these components are interconnected within a smart parking system. The identification component performs the identification procedure on the intelligent parking system, identifying the vehicle as it enters and exits the parking lot. Automatic Number Plate Recognition (ANPR) is used to identify vehicles entering because it can automatically recognise vehicle licence plates (especially car drivers). Identify the vehicle using the QR code as proof that the individual in question is the legal owner.

The Python ANPR software starts by selecting an image of a licence plate captured by the Raspberry Pi camera. The images are stored in the same folder as the ANPR application. The software will terminate if the image is unavailable or if an error occurs while capturing images with the camera. If the image is accessible, the next step is preparation. Cropping the image, converting it to grayscale (a grey image), converting it to blur (a blur image), and thresholding the image constitute pre-processing (a black and white or binary image).

After pre-processing, the next step is character segmentation. This segmentation consists of duplicating the thresholding results, executing the contour function, and highlighting the image's characters. After segmentation, the next step is character recognition. For character recognition, the KNN algorithm is utilised (K-Nearest Neighbor algorithm). The segmentation results will be compared with previously collected training data in float-32 format. The previous results for character recognition will be compiled and displayed in text format. The text will then be sent to an Arduino Uno R3 via USB serial.

The intelligent parking system's control component regulates the entire system, including the automation and parking location management components. A microcontroller is the system's controlling component. The parking location management component is the result of a controlling component that manages and provides information about parking locations. The purpose of parking location management is to determine which parking spaces are vacant; parking location information is the result of this management so that cars entering the smart office are aware of vacant parking spaces. The estimation of the required device per parking lot with about 5,000 vehicle capacity is presented in Table 1.

**Table 1. Estimation of required device per parking lots with about 5000 vehicle capacity**

No	Product Name	Brand	Type	QTY		Value	Total *
1	Barrier Gate Parking (gate in & out)	Duta Parking	Custom	2	set	Rp15.000.000	Rp30.000.000
2	Outdoor IP Camera 1MP	HIK Vision	DS-2CD1001-1	3	pcs	Rp525.00	Rp1.575.000
3	Mini PC (gate in & out)	Raspberry Pi	Pi 4 8GB	2	set	Rp3.100.000	Rp6.200.000
4	Mini PC - Gate	Intel Nuc	i7 gen 11	1	set	Rp12.000.000	Rp12.000.000
5	Sensor Infrared	Proximity	Adjustable	10	pcs	Rp25.00	Rp250.00
6	PCB Control	Hand Made	Custom	1	pcs	Rp750.00	Rp750.00
7	Cabling Sensor	Custom	Custom	1	set	Rp500.00	Rp500.00
8	Cabling LAN	AMP Commscope	Cat 6	1	roll	Rp1.850.000	Rp1.850.000
9	Komponen Elektronik	Custom	Custom	1	set	Rp1.000.000	Rp1.000.000
10	Switch PoE Gigabit 5 Port	Tenda	TEG1105P-4-63W	1	pcs	Rp450.00	Rp450.00
11	Switch Unmanageable Gigabit 5 Port	Tenda	TEG1005D	2	pcs	Rp200.00	Rp400.00
12	Connector RJ45	AMP Commscope	Cat 5	1	pack	Rp105.00	Rp105.00
13	LED Monitor 18.5"	AOC	E970SW	2	pcs	Rp1.275.000	Rp2.550.000
14	Cashier POS Thermal Printer Ethernet	Epson	TM T82	2	pcs	Rp2.295.000	Rp4.590.000
15	Barcode Scanner	Datalogic	QW 2100	1	pcs	Rp1.200.000	Rp1.200.000
16	Power Outlet/Stop Kontak	Broco	6 Socket	4	pcs	Rp60.00	Rp240.00
17	Cable NYM (50 m)	Eterna	3x1.5mm	1	roll	Rp560.00	Rp560.00
18	RFID Reader USB Mifare		Frek 13.56MHz	2	pcs	Rp99.50	Rp199.00
19	Mifare Card Polos		Frek 13.56MHz	10	pcs	Rp2.50	Rp25.00
20	Speaker Mini USB	Robot	RS160	1	pcs	Rp47.00	Rp47.00
21	No Touch Button	Cardteck	CT-SI95	1	pcs	Rp43.80	Rp43.80
							<b>Rp64.534.800</b>

\* 1000 Indonesian Rupiah (IDR) = 0.066 USD

### 4.3. Parking Lots with Reservation Scheme

The system operates based on the following principle: the user initially registers in the programme menu. After completing registration, the parking reservation application must be executed. The user then orders a parking space in a parking lot at a specific time using the licence plate number of their vehicle. The system reduces the user's balance, which is used as payment for a parking space, and sends the order to the parking server after the user orders a parking space. If the order has been placed, the reserved parking space will glow red to indicate it has been reserved. If someone else attempts to access a reserved parking area, the system will generate an alert for stealing a reserved parking space, identify the accounts that trespass, and issue a fee notice immediately. If the parking space does not arrive at the designated time, the system will notify the customer if the reservation will be extended. If not, the parking spot will become available for reservation by another individual. If the reservation is to be extended, the time it will occupy the parking space will be determined by paying additional parking reservation fees. The user arrives at the parking lot to locate a reserved parking space after completing the parking reservation through a smartphone at the designated time. It is no longer necessary to be confused when searching for a parking space, as the system will indicate the level and parking space number, saving time. When entering the parking space, the system will compare the SSID of the licence plate to the SSID of the vehicle. If they do not match, an alarm will sound until the vehicle vacates the space; if the SSID number plate matches, the vehicle is in the correct location.

### 4.4. Estimated Parking Retribution

There are currently at least 3 million motorized vehicles in Makassar. If the daily movement is assumed to be 50% of the total number of vehicles, then the estimated movement that occurs is 1.5. In this case, all assumptions will be estimated at low numbers.

**Table 2. Estimation of Revenue**

Parking Reservations	Gross Revenue (Rp)	Capital (Rp)	Government Revenue Ratio	Developer/Invest or Revenue Ratio	Government Income (Rp)	Developer/Investor Income (Rp)	ROI
250000	500,000,000	9,000,000,000	50%	50%	250,000,000.00	250,000,000	0.03
500000	1,000,000,000	9,000,000,000	50%	50%	500,000,000.00	500,000,000	0.06
1000000	2,000,000,000	9,000,000,000	50%	50%	1,000,000,000.00	1,000,000,000	0.11
1500000	3,000,000,000	9,000,000,000	50%	50%	1,500,000,000.00	1,500,000,000	0.17

Assume that the total installation costs for all equipment and activities in the first scenario amount to 180 million IDR. This sum is adequate to operate a parking lot with a capacity of 5,000 vehicles. At least 50 locations utilising this system will be required for a minimum vehicle range of 250,000 units, resulting in an approximate capital cost of 9 billion rupiah. The first clause describes a circumstance in which flat parking fees use their minimum value (generally 2 thousand rupiah). If all parking spaces are occupied simultaneously, then it is anticipated that 250,000 vehicles will utilise this parking system during a single parking period. In this scenario, assuming a 50:50 profit split, the government and investors can collect 250 million rupiah in investment capital, assuming a 50:50 profit split. The following line indicates whether the parking representative occurs twice, etc. According to the preceding table, revenue can reach billions of rupiah with just four repetitions. In Makassar, where the level of mobility is the highest, it is nearly impossible for a parking space to be occupied only four times per day. Even with this approximation, when a flat fee is applied, the ROI remains promising.

In comparison to similar studies conducted in Indonesia [1, 2], the majority of the present study focuses on only one of the system component links. For instance, recognising vehicle licence plates with APNR [5], detecting vehicles with Arduino [16], or simply discussing parking spaces and legal reviews [8]. This is insufficient to provide a solution for Makassar City's density and traffic issues. There must be a system capable of mapping available parking spaces both inside and outside the building under supervised conditions [18], detecting the suitability and incompatibility of parking slots with reserved vehicles [19], and providing an overview of the value of fees as a control variable for the government as the regulator [20], recipients of fees and providers of community services.

## 5. Conclusion

The most significant findings of this study are that there are currently 3 million motorised vehicles in Makassar and that their daily movement is estimated to be 1.5 million. The total installation costs for all equipment and activities total 180 million Indonesian Rupiah (IDR). At least 50 locations utilising this system will be required for a minimum vehicle range of 250,000 units, resulting in an approximate capital cost of 9 billion rupiah. Minimum parking fees are applied to flat parking fees, and if all parking spaces are occupied simultaneously, 250,000 vehicles will use this parking system during a single parking period. A system must be able to map available parking spaces both inside and outside the building under supervised conditions, detect the suitability and incompatibility of parking slots with reserved vehicles, and provide an overview of the value of fees as a control variable for the government as regulator, recipients of fees, and providers of community services.



## 6. Declarations

### 6.1. Author Contributions

L.C., S.A.A., and P.B.P. contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

### 6.2. Data Availability Statement

The data presented in this study are available in the article.

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### 6.5. Conflicts of Interest

The authors declare no conflict of interest.

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