Journal of Information System Research (JOSH)
Volume 7, No. 2, Januari 2026, pp 511−518
ISSN 2686-228X (media online)
https://ejurnal.seminar-id.com/index.php/josh/
DOI 10.47065/josh.v7i2.8590

Digital Transformation of Smart Parking: A Design Science Research Study

Eliyah Acantha Manapa Sampetoding*, Andi Ahmad Fa'il Fudhayl, Kelvin Leonardo Sianipar, Mario Valerian Rante Ta'dung

Faculty Mathematics and Natural Sciences, Information System, Hasanuddin University, Makassar
Jl. Perintis Kemerdekaan No. 10, Tamalanrea Indah, Tamalanrea District, Makassar City, South Sulawesi, Indonesia
Email: [1,*]eliyahacantha@unhas.ac.id, [2]fudhaylaaf22h@student.unhas.ac.id, [3]sianiparkl22h@student.unhas.ac.id, [4]tadungmvr22h@student.unhas.ac.id
Correspondence Author Email: eliyahacantha@unhas.ac.id
Submitted: **23/10/2025**; Accepted: **31/01/2026**; Published: **31/01/2026**

Abstract−This research discusses the design and development of a digital transformation concept for a parking system in the context of smart city development in Makassar, Indonesia. This research was conducted in response to the problems of illegal parking and low accountability for parking revenues, which impact regional income and the quality of parking services. This research resulted in an information system in the form of an artifact model, developed using a Design Science Research (DSR) approach, including the stages of design, model building, demonstration, and conceptual evaluation of the artifact. The resulting model has not been implemented as an operational mobile application, but rather compiled as a conceptual and technical design that is validated through presentations and discussions with relevant stakeholders and potential users (the public) as part of the demonstration phase within the DSR framework. The research methods include needs analysis, system design, technology selection, system architecture design, and conceptual evaluation based on the Hevner Design Science Research methodology. The proposed system model uses the Model/View/ViewModel (MVVM) architecture and is designed to integrate with supporting services, including Firebase, the Google Maps API, and the Midtrans Payment Gateway. This artifact model serves as a basis and initial recommendation for the Makassar City Government in developing a tangible, operational digital parking application that can be implemented and tested in subsequent research or policy phases. The research results indicate that the proposed digital parking system model has the potential to increase transparency and accountability in parking management and support sustainable smart city planning, particularly in Makassar.

Keywords: Digital Transformation; Smart Parking; Smart City; Makassar

1. INTRODUCTION

Makassar, one of the cities with a rapid growth rate of vehicle users [1], is faced with the problem of the availability of parking lots without an automation system. The Makassar City Regional Government has provided roadside parking available in several locations in the city of Makassar [2], for example, on the roadside as an effort to overcome the problem. However, this solution raises irresponsible individuals to use a new problem: the roadside parking location provided to collect illegal levies [3].

Illegal parking attendants have affected regional income derived from the implementation of roadside parking [4]. Data released by PD Parking shows a decrease in the percentage of revenue target realization from roadside parking management [5]. The decrease in the percentage can affect the income of the Greater Makassar Parking PD, which is expected to be one of the regional revenues that will support the development of infrastructure facilities in the city area [6]. In addition, the discrepancy between the target and the revenue realization can reduce public awareness of paying for parking at the Makassar Raya Parking PD when using the parking lot[7].

Smart City is an innovative breakthrough implemented by policymakers to overcome various problems and improve the quality of life of humans and local communities[8]. In line with this concept, the Makassar city government has also made a breakthrough through the presence of a smart city program with the vision of "Accelerating the Realization of Makassar as a World City that is "Sombere' and Smart City" with Strong City Immunity for All" since 2015 [9]. This program is oriented toward providing facilities to help people access public services more efficiently and comfortably[10]. The central government's policy to move the National Capital to the island of Kalimantan, which is also close to the city of Makassar, can improve the status of the economy and other aspects related to increasing industrial mobility[11]. This can be a stimulus in accelerating the implementation of smart cities in Makassar.

The Makassar Smart City program can be implemented properly if various parties and/or activities on various lines run as they should, including parking management[12]. We are here to offer a solution in the form of a roadside parking system that is integrated with the application and can be accessed by parking users. This solution will be useful to minimize illegal parking on the roadside and the placement of vehicles to be more neatly arranged. Regional revenue accountability can be realized through digital parking levies[13]. The results of the parking levy carried out through the application can be directly channeled to the Greater Makassar Parking PD. PD Parking Makassar Raya can improve revenue management through an application that is part of the roadside parking system [14].

The application of modern technology is undoubtedly very helpful in improving the ongoing roadside parking governance system. Through this parking system, it is hoped that the parties involved will find it easier to

Journal of Information System Research (JOSH)
Volume 7, No. 2, Januari 2026, pp 511−518
ISSN 2686-228X (media online)
https://ejurnal.seminar-id.com/index.php/josh/
DOI 10.47065/josh.v7i2.8590

review conditions in the field and become an essential point in implementing an integrated parking system. The proposed concept and platform is an effort to improve accountability in better parking management[15].

The Design Science Research (DSR) approach is highly appropriate for developing digital parking models in the Smart City context because, academically, it not only explains phenomena but also produces tangible artifacts in the form of models, systems, or prototypes that can be systematically tested and evaluated. In terms of contributing to information systems research, DSR enriches the literature by developing structured, design-based solutions that are relevant to local contexts and are empirically validated for system effectiveness, transparency, and accountability to digital parking system [16]. Meanwhile, from a practitioner's perspective, this approach provides applicable implementation guidance from identifying revenue leakage issues, designing data-driven systems, to digital monitoring mechanisms so that the resulting solutions do not stop at the conceptual level, but can actually be adopted by local governments in supporting efficient, transparent, and sustainable parking governance within the Smart City ecosystem [17].

Implementing the proposed digital parking system will help stakeholders manage roadside parking in Makassar. PD Parking Makassar Raya, a stakeholder who manages roadside parking in the city of Makassar, can use this system to improve parking services. Users will feel the same benefits because this digital parking system can make it easier for users in several aspects. Finding a parking lot, complete access to detailed parking lot information, and support for parking payments with various payment methods through mobile applications. An easily accessible and orderly parking location on the roadside will support collaboration between the Makassar City Transportation Office and the Makassar Raya Parking PD for joint parking lot management.

2. RESEARCH METHODOLOGY

The method used in this study is Design Science Research (DSR), proposed by Johannesson & Perjons (2014). This method offers a design framework as a guide in designing artifact models[18]. The framework allows the research team to associate each research stage with an existing knowledge base[19], thus supporting knowledge development cumulatively. Using the DSR framework, we obtained a more systematic framework to assist teams in choosing strategies and ensuring the integration of research with existing knowledge[20]. Based on the adaptation of the DSR framework, we have compiled five stages of research implementation, as shown in Figure 1.

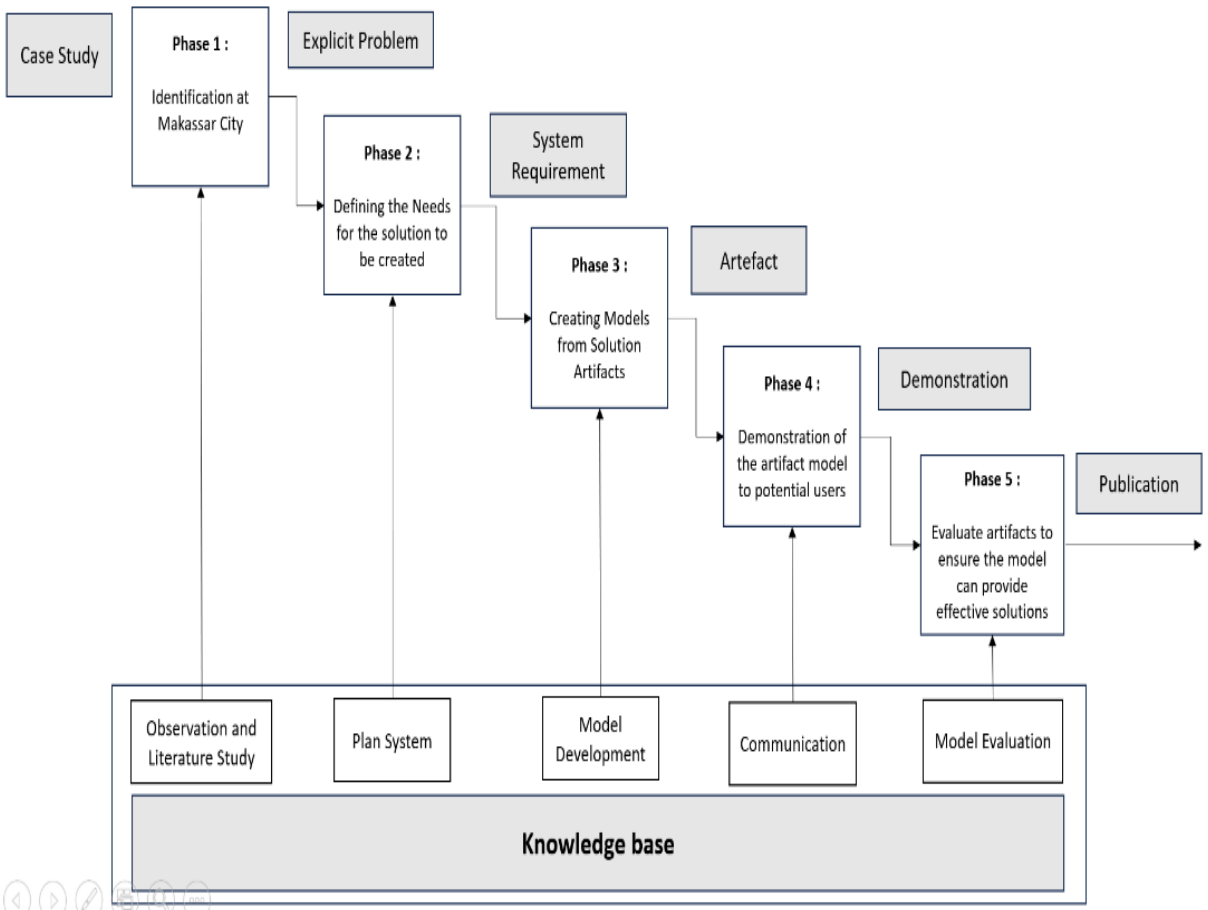


Figure 1. Design Science Research Diagram Makassar Smart Parking

Journal of Information System Research (JOSH)
Volume 7, No. 2, Januari 2026, pp 511−518
ISSN 2686-228X (media online)
https://ejurnal.seminar-id.com/index.php/josh/
DOI 10.47065/josh.v7i2.8590

The development of a digital parking system is a series of processes designed from Phase 1 to Phase 5 to become later an effective, efficient, accountable, and functional system. The following are the steps taken in developing a digital parking system, namely MASSAPA' (Makassar Smart Parking) based on DSR.

2.1 Phase 1

The first phase is the Explicit Problem stage. The population in this study includes users of the Makassar Smart Parking (MASSAPA') system: PD Parkir, the manager; parking attendants, as field operators; and the public, as parking service users. The research sample was determined purposively based on direct involvement in the operation and use of the system. Data collection techniques included in-depth interviews and field observations to obtain a comprehensive understanding of user needs, responses to the model, and the dynamics of system implementation in real-world conditions. In addition, data analysis related to the existing parking system is also carried out to understand the challenges faced. We also engage users by conducting surveys to explore their expectations and needs for the ideal parking system in the city [21].

2.2 Phase 2

In the second phase, the researcher carefully designed the digital parking system after identifying the community's needs. Through a survey of government regulations and programs related to the parking system, we ensure that this design follows the applicable policies so that it can be implemented effectively in Makassar City. This design focuses on Makassar Smart City, launched by the Makassar City Government, and the digital parking system can contribute to the development of a more modern and integrated city.

2.3 Phase 3

In the third phase of the parking system artifact model development, the researcher designs the architecture and design of the system by involving various stakeholders and mapping an efficient business process flow. The user interface (UI) is designed to be more intuitive, allowing users to easily check-in, pay, and check parking availability. To ensure methodological consistency and clarity in the system development phase, the specific technologies used in this study are explicitly stated. The choice of technology, development platform, programming language, and QR code for check-in is crucial in implementing this digital system, including the use of Firebase as a real-time database and Midtrans as a payment gateway to support transaction transparency and security. We divide software development into separate modules. Then, this model is followed by integration testing to ensure smooth interaction between all components. In addition, the user interface with the parking management system and collaboration with stakeholders such as the Parking PD and the Makassar City Transportation Office are integrated for optimal supervision and management.

2.4 Phase 4

Before launching the model to the public, the Research Team analyzed the digital parking system's functionality. Next, the Research Team presented prototypes to potential users through structured interviews, enabling them to identify potential problems and gather feedback on usability, functionality, and transparency. The Research Team then systematically analyzed this feedback and used it to refine the artifact in an iterative process between demonstration and redesign stages. Once refined, the Research Team socialized artifacts using the Makassar Smart Parking application model to the public before the final evaluation.

2.5 Phase 5

The artifact model was evaluated by assessing the extent to which the Artefact model met expectations and the extent to which this model was able to solve parking problems in Makassar City. The evaluation process was conducted to test the effectiveness, reliability, and feasibility of implementing the developed model before recommending it as a policy basis. The evaluation was conducted through a Focus Group Discussion (FGD) involving stakeholders from PD Parkir and the Makassar City Transportation Agency, and supported by a limited trial at one parking location in Makassar City to assess the system's performance under real-world operational conditions.

3. RESULT AND DISCUSSION

This Section presents the results of the artifact development in the form of a digital-based parking system model designed using the Design Science Research Methodology (DSRM) framework. The discussion not only explains the system components built but also describes how the model is integrated operationally, technically, and institutionally within a Smart City. To provide a systematic understanding, the results and discussion are divided into five main aspects, namely business processes, system architecture, governance and regulations, a digital-based parking management artifact model, and a data management and accountability model. These five sub-chapters show how the developed artifact not only functions technically, but also aligns with the operational needs, policies, and transparency of parking management in Makassar City.

Journal of Information System Research (JOSH)
Volume 7, No. 2, Januari 2026, pp 511−518
ISSN 2686-228X (media online)
https://ejurnal.seminar-id.com/index.php/josh/
DOI 10.47065/josh.v7i2.8590

3.1 Business Process

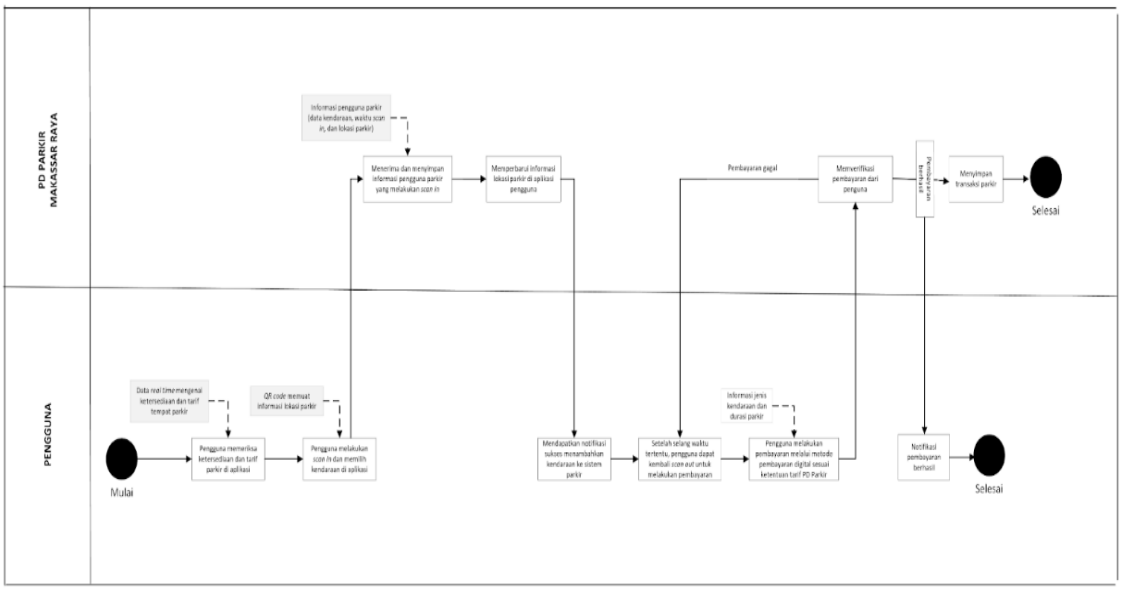


Figure 2. Business Process on the Check-In and Check-Out Features of MASSAPA'

Figure 2 shows the flow of the parking lot business process. The user plays the role of an object who will use the application to rent a parking lot. Users scan the QR code and fill in the data for parking space reservations. Then, the Makassar Raya Parking PD will receive a message sent through the user application, which is automatically confirmed by the system. Users must complete the transaction to use the parking lot.

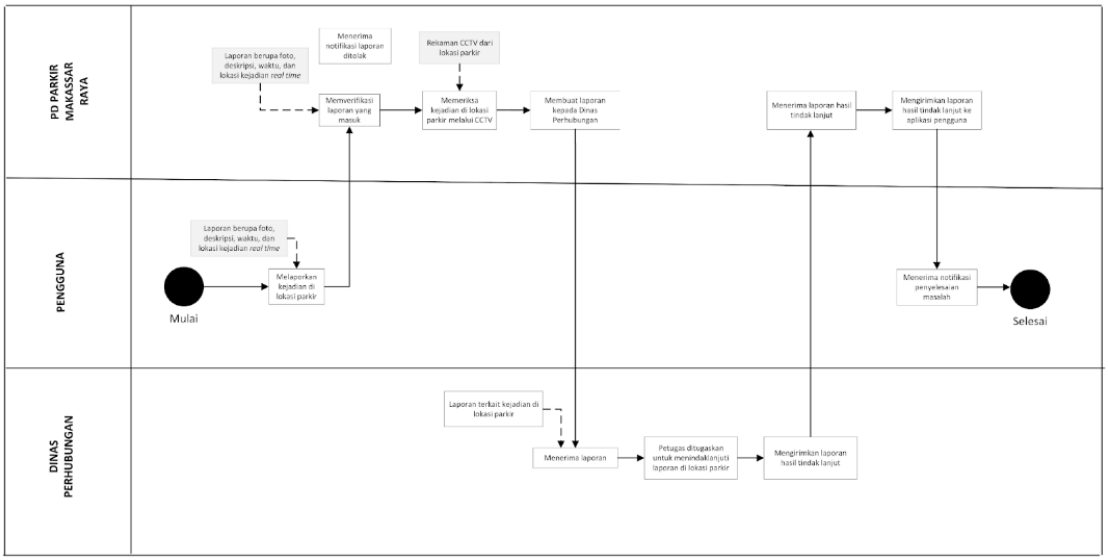


Figure 3. Business Process of Reporting Feature on MASSAPA'

Figure 3 shows the flow of business processes when users report an incident in the parking lot. The user plays the role of a reporter who will fill in data about the incident. The Makassar Raya Parking PD will receive the report and then verify it. The Makassar Raya Parking PD Rapid Reaction Team will respond to public reports, and the Transportation Department will monitor the reported incident.

3.2 System Architecture

The architectural pattern adopted in MASSAPA's application development context is Model/View/ViewModel (MVVM). In a publication titled "A Comparison of Android Native App Architecture: MVC, MVP, and MVVM," it was argued that the MVVM architecture can efficiently separate tasks between developers and designers[22]. MVVM has advantages in terms of performance compared to the MVC architectural pattern. MVVM is an architecture that combines three core components: View, Viewmodel, and Model. The "view" component acts as the application's user interface (UI). The Model represents the information or business logic underlying the application. Between the two, the "viewmodel" is an intermediary tasked with transforming information and expressing accessible communication between the Model and the View.

Journal of Information System Research (JOSH)
Volume 7, No. 2, Januari 2026, pp 511−518
ISSN 2686-228X (media online)
https://ejurnal.seminar-id.com/index.php/josh/
DOI 10.47065/josh.v7i2.8590

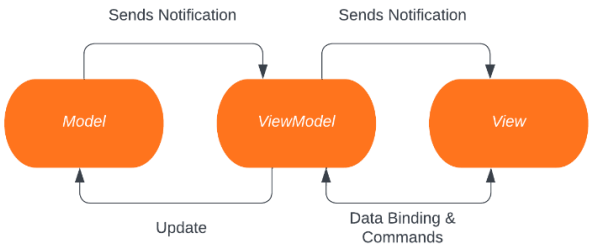


Figure 4. MVVM Architecture Structure

The development of the MASSAPA' application is carried out using the Flutter framework, a tool that utilizes the Google Dart programming language. The use of Flutter to support the creation of modern user interfaces is considered very suitable for applying the MVVM architectural pattern. Additionally, Flutter offers flexibility in multiplatform app development, significantly simplifying the app development process. MASSAPA' app system is connected to the central database stored in Firebase. The Firebase API serves as a link between the MASSAPA' application and the cloud-based information system service. In this context, Firebase not only acts as a store of information but also functions in the authentication process of the MASSAPA' app user account.

In addition to Firebase, Artefact MASSAPA' also integrates an API service from Google, namely the Google Maps API. Mapping-related features can be available in the MASSAPA' application through system integration with Google Maps API. Thus, users can easily access the necessary position data. In addition, to support digital payment transactions, the MASSAPA' application is also integrated with the Midtrans Payment Gateway service. Integration with Midtrans API allows users to make online payments conveniently and effectively. This API service serves as a link between the MASSAPA' application and the Midtrans digital payment system. Communication between the Makassar City Parking PD and users in one direction can be realized by integrating Twilio with the application, which can send transaction messages, socialization broadcasts, and OTPs through the messaging application.

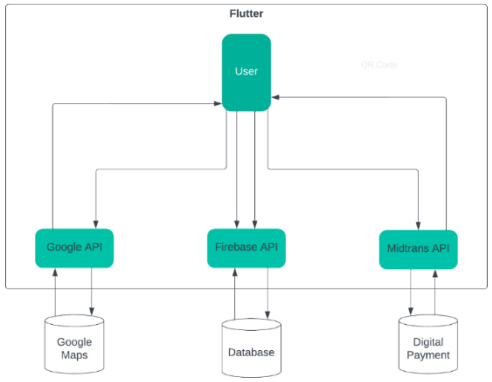


Figure 5. MASSAPA' Application System Diagram

The admin dashboard application is created in the form of a local website. This application can display reports or feedback from the community and data and infographics from all parking lots in Makassar. This application uses React library technology to improve its performance. The React Library is a JavaScript library used to build a website's user interface (UI). This tool allows developers to create UI components that can be set separately and changed without recreating the entire page. React uses the concept of components, where each UI part is broken down into components that can be set separately. React also implements virtual DOM and allows for efficient UI updates by minimizing direct interaction with the actual DOM.

3.3 Management and Regulation

Regulations for Parking Facilities have been explained in PP No. 43 Tahun 1993. Chapter 7 of sections 47-50 explains in detail what is meant by parking facilities for the public, how to determine/determine the location, and the implementation of parking facilities for the public. Then, this regulation explains the levy, which is a fee that the community must pay for services obtained from the government and parking, including the object of the levy. Undang-Undang No. 28 Tahun 2009 chapter 110 stated that parking is included in the public service levy, which is then further explained in section 115, that the object of the parking service levy on the side of public roads is the provision of parking services determined by the Regional Government[23].

Journal of Information System Research (JOSH)
Volume 7, No. 2, Januari 2026, pp 511−518
ISSN 2686-228X (media online)
https://ejurnal.seminar-id.com/index.php/josh/
DOI 10.47065/josh.v7i2.8590

Figure 6. Makassar Raya Parking PD Office

The City of Makassar regulates parking management through Peraturan Daerah No. 17 Tahun 2006. This regulation determines the parking location carried out based on the proposal of the Board of Directors of the Greater Makassar Parking PD. The Makassar Raya Parking PD can organize parking lots, including setting levy fees. The quick reaction team at the Parking PD plays an essential role in ensuring smooth operations and parking services. They respond to emergencies and technical problems through reports received through the application and monitor parking areas using CCTV. In addition, this team is also responsible for maintaining equipment and infrastructure, conducting periodic inspections, and immediately taking corrective action if there are any technical problems. Thus, the rapid response team functions in incident handling and proactively maintains the quality of parking services.

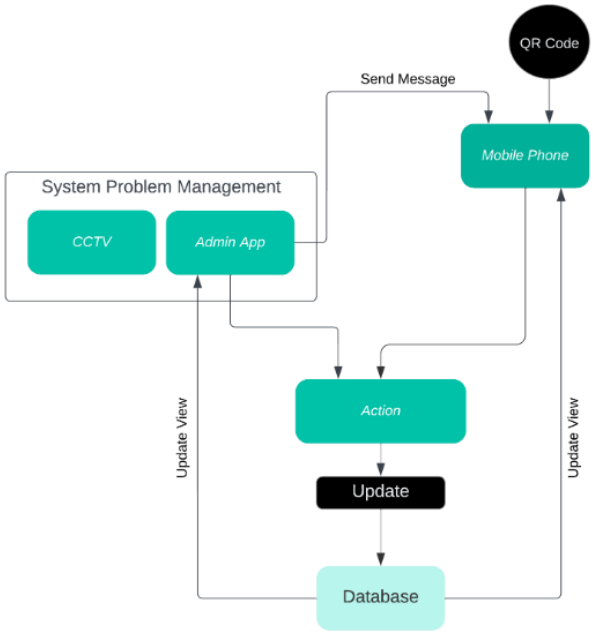
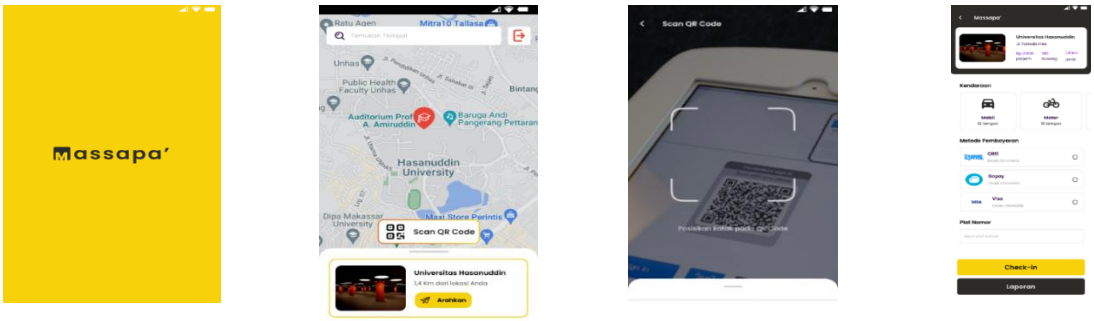


Figure 7. System Workflow

3.4 Digital-Based Parking Management Artifact Model

The designed parking management system integrates technology, including mobile devices and monitoring through CCTV. QR codes can be used for the scanning process by users when using the parking lot, as well as to report incidents at the parking lot. The mobile application we developed is designed to be easy to use and can be downloaded for free by users. The app provides real-time information regarding the availability of parking spaces in different city areas, including available parking listings, rental price information, and parking locations. In addition, users can report incidents at parking locations managed by PD Parking Makassar Raya. The app also supports digital payments, which contributes to the city government's revenue management accountability from parking levies. This application will help users utilize parking lots and have more accessible access through the information provided in the application.

Journal of Information System Research (JOSH)
Volume 7, No. 2, Januari 2026, pp 511−518
ISSN 2686-228X (media online)
https://ejurnal.seminar-id.com/index.php/josh/
DOI 10.47065/josh.v7i2.8590



(a) (b) (c) (d)

Figure 8. Page view, (a) splash scene, (b) application homepage, (d) scan-in feature, (d) payment feature

The artifact provides a scan-in feature for users before using the parking lot. Payment can be made through the application using various methods per the provisions of the Makassar Raya Parking PD. Additionally, these artifacts have been integrated with navigation services, so users can see parking locations around them and get direct directions to those parking spaces. Integration with the map application will make it easier for users to find parking lots to save time. The navigation also helps managers regulate parking lots and maintain order for users in parking their vehicles.

3.5 Data Management and Accountability Model

Data on parking availability, use, reporting, and transactions will be collected and submitted to relevant agencies for follow-up. Reports of suspicious incidents at the parking location will be forwarded to the Transportation Department, responsible for policing the roadside parking area. In addition, the Makassar Raya Parking PD can directly report the income from payments received by the community to the Makassar City Government.

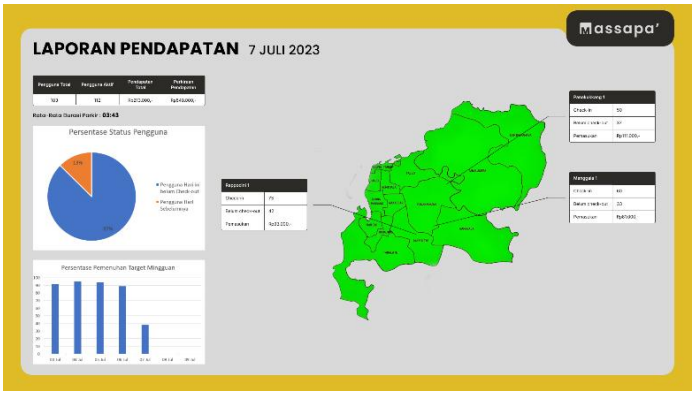


Figure 9. Admin dashboard view to monitor revenue and system accountability

MASSAPA' model application is a system integration model developed based on the Design Science Research Methodology (DSRM) framework. This model is designed as a systematic conceptualization of solutions before they are realized in operational applications. Therefore, before the application development stage, a validation process and approval from relevant stakeholders are required to ensure the proposed system design aligns with institutional needs, regulations, and field conditions. This approach aims to ensure that the application to be developed is truly relevant and implementable, and does not become an unused solution (an underutilized system), thereby providing practical value and sustainability in the context of Smart City in Makassar City.

4. CONCLUSION

The development of the Makassar Smart Parking (MASSAPA) application model, based on the Design Science Research Methodology, is part of the digital transformation and a strategic step toward addressing illegal parking and increasing accountability for parking revenue in Makassar. Based on the results of demonstrations, FGDs with stakeholders, and limited trials (pilot tests) during observations and interviews, this system is considered proven to operate functionally, facilitate a faster digital check-in process compared to manual mechanisms, and increase transparency in real-time transaction recording. Support for technology integration, such as Firebase, Google Maps API, Midtrans Payment Gateway, and Twilio Messaging Gateway, helps maintain system stability and connectivity among services in a Smart City environment. However, the developed artifact still has room for improvement, particularly in the development of AI-based predictive analytics for parking occupancy estimation, expanding implementation to more parking zones, and further integration with the city's smart transportation

Journal of Information System Research (JOSH)
Volume 7, No. 2, Januari 2026, pp 511−518
ISSN 2686-228X (media online)
https://ejurnal.seminar-id.com/index.php/josh/
DOI 10.47065/josh.v7i2.8590

system. Thus, MASSAPA' is not only conceptually feasible but has also been operationally tested as an initial model that can be further developed to support the Makassar Smart City ecosystem. It is hoped that Makassar City Government stakeholders, through PD Parkir, can implement this Model into an Application in the Makassar City parking system.

REFERENCES

[1] R. Marzuki, "1,7 Juta Kendaraan di Makassar, Penduduknya 1,5 Juta," Harian Fajar, Oct. 15, 2022.
[2] N. Adelia, A. F. Afrisal, and N. Tompo, "Implementasi Peraturan Daerah Kota Makassar Nomor 17 Tahun 2006 Tentang Pengelolaan Parkir Tepi Jalan Umum Kota Makassar," Publician J. Public Serv. Public Policy, Adm., vol. 4, no. 2, pp. 105–111, 2025.
[3] N. A. Ikhsan, I. Malik, and N. Khaerah, "Kolaborasi Organisasi Pemerintah dalam Penertiban Parkir Liar di Kota Makassar," Kolaborasi J. Adm. Publik, vol. 9, no. 3, pp. 421–434, 2023.
[4] R. M. Uyuun, A. I. Anwar, and S. U. Nurbayani, "Analisis Permintaan Jasa Parkir Non Resmi (Illegal Parking) di Kota Makassar," Econ. Digit. Bus. Rev., vol. 4, no. 2, pp. 121–126, 2023.
[5] H. Harianti, M. Muhammadiah, and R. Azikin, "Pengawasan Perusahaan Daerah Parkir Dalam Penertiban Parkir Liar Di Jalan Balaikota Kota Makassar," Kolaborasi J. Adm. Publik, vol. 1, no. 3, 2015.
[6] A. Azis, A. Mahsyar, and N. Tahir, "Pelaksanaan Pengawasan Parkir Liar Oleh Perusahaan Daerah (PD) Parkir Makassar Raya," Kaji. Ilm. Mhs. Adm. Publik, vol. 2, no. 4, pp. 1384–1397, 2021.
[7] T. Triratnawati, S. N. Sari, and M. H. Paramita, "Tinjauan pemungutan retribusi parkir di tepi jalan umum kota Makassar," Income Journal., vol. 1, no. 2, pp. 59–62, 2022.
[8] F. P. Appio, M. Lima, and S. Paroutis, "Understanding Smart Cities: Innovation ecosystems, technological advancements, and societal challenges," Technol. Forecast. Soc. Change, vol. 142, pp. 1–14, 2019, doi: https://doi.org/10.1016/j.techfore.2018.12.018.
[9] Tempo.co, "Makassar Kota Dunia yang Sombere dan Smart City," Tempo.co, 2022.
[10] I. Unhas, "Walikota Makassar Bahas Program Sombere dan Smart City," Identitas Unhas, 2019.
[11] A. Nurdiassa, A. Zulfikar, F. Rasyid, and A. T. Wulandari, "Implementasi Kebijakan Smart City dalam Mewujudkan Makassar Kota Dunia," J. Public Adm. Gov., vol. 3, no. 1, pp. 37–46, 2021.
[12] M. Madani and M. Nasrulhaq, "Concept of smart city governance in Makassar City," in International Conference on Administrative Science (ICAS 2017), Atlantis Press, 2017, pp. 154–156.
[13] S. W. Sulistyono, M. S. W. Suliswanto, P. K. Dewa, S. Santosa, and C. Astina, "Revenue optimization strategy through digitizing retribution parking in Kota Batu," J. Revenue Pricing Manag., vol. 21, no. 4, pp. 455–461, 2022, doi: 10.1057/s41272-021-00333-y.
[14] Batarainfo, "PD Parkir Makassar Luncurkan Program Parkir Berlangganan, Warga Bisa Hemat Hingga Rp450.000 per Bulan," Batarainfo, 2024.
[15] J. Jumaisa, M. I. Ansari, and A. Masyar, "Inovasi Sistem Terminal Parkir Elektronik (TPE) di Kota Makassar," Kaji. Ilm. Mhs. Adm. Publik, vol. 1, no. 1, pp. 71–86, 2020.
[16] T. Yigitcanlar, M. Wilson, and M. Kamruzzaman, "Disruptive Impacts of Automated Driving Systems on the Built Environment and Land Use: An Urban Planner's Perspective," J. Open Innov. Technol. Mark. Complex., vol. 5, no. 2, p. 24, 2019, doi: https://doi.org/10.3390/joitmc5020024.
[17] B. Anthony Jnr, S. Abbas Petersen, M. Helfert, D. Ahlers, and J. Krogstie, "Modeling pervasive platforms and digital services for smart urban transformation using an enterprise architecture framework," Inf. Technol. People, vol. 34, no. 4, pp. 1285–1312, 2021, doi: https://doi.org/10.1108/ITP-07-2020-0511.
[18] P. Johannesson and E. Perjons, Design Science. Springer, 2014.
[19] J. vom Brocke, A. Hevner, and A. Maedche, "Introduction to Design Science Research BT - Design Science Research. Cases," J. vom Brocke, A. Hevner, and A. Maedche, Eds., Cham: Springer International Publishing, 2020, pp. 1–13. doi: 10.1007/978-3-030-46781-4_1.
[20] Hevner, March, Park, and Ram, "Design Science in Information Systems Research," MIS Q., vol. 28, no. 1, p. 75, 2004, doi: 10.2307/25148625.
[21] J. Mueller, H. Lu, A. Chirkin, B. Klein, and G. Schmitt, "Citizen Design Science: A strategy for crowd-creative urban design," Cities, vol. 72, pp. 181–188, 2018, doi: https://doi.org/10.1016/j.cities.2017.08.018.
[22] T. Lou, "A comparison of Android native app architecture MVC, MVP and MVVM," Eindhoven Univ. Technol., 2016.
[23] P. R. Indonesia, "Undang-Undang Republik Indonesia Nomor 28 Tahun 2009 tentang Pajak Daerah dan Retribusi Daerah," 2009.