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Concept And Potential For The Implementation Of Smart Parking System In Indonesia: A Literature Review

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ABSTRACT

The rapid development and growth of the Internet of Things (IoT) has improved the quality of life and strengthened various areas of society. Many cities around the world are looking forward to becoming smart. One of the most popular use cases in smart cities is the implementation of smart parking solutions, as it allows people to optimize time, reduce fuel consumption, and carbon dioxide emissions. Smart parking solutions have a defined architecture with specific components (sensors, communication protocols, and software solutions). Although there are only three components that make up a smart parking solution, it is important to mention that each component has many types that can be used in the implementation of this solution. This article identifies the most frequently used types of each component and highlights the usage trends in the established analysis period. This provides a complementary perspective and is a very useful source of information. society can use this information to decide on the selection of the type of component to be used. implementing smart parking solutions. For this purpose, here we review some of the works related to the implementation of smart parking solutions. To achieve this goal, a semi-cyclical adaptation of the Research Methodology action combined with a systematic review was used to select articles related to the research subject. The most relevant of the types of components that should be considered when implementing smart parking solutions. The implementation of smart parking in Indonesia promises many benefits, especially in increasing efficiency and transparency. However, challenges such as high costs, infrastructure readiness, and technological literacy must be overcome so that this system can run optimally and inclusively.

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1. Introduction

Internet of Things (IoT) has changed people's habitual behavior which gives them a lot of increased convenience. This effect allows IoT solutions to grow rapidly [1]. Internet of Things (IoT) is a concept that aims to expand the benefits of continuously connected internet connectivity. IoT can combine physical and virtual objects through the exploitation of data capture and communication capabilities. Simply put, with IoT, physical objects in the real world can communicate with each other using the help of networks and the

internet[2]. There are several research results that have shown that the number of IoT devices connected to the internet is increasing exponentially and reaching nearly 77 billion by 2025[3].

Internet of Things (IoT) refers to the interconnection and exchange of data between devices/sensors and most IoT applications involve specific requirements such as long range, low data speed, low energy consumption, and profitability. In addition, the user's network coverage may be increased with mobile network technology. However, mobile network technology provides too much power to devices, which is why IoT applications have encouraged wireless transmission technologies such as Low-Power Wide-Area Network (LPWAN). Low-Power Wide-Area Network (LPWAN) is a type of network for wireless telecommunications areas designed to enable long-distance communication. LoRaWAN can be used on communication networks that have a wide range using end device [4]. LoRaWAN. This technology provides long-distance connections: about 10–40 km in rural areas and 1–5 km in urban areas.

With the growth of IoT and cloud systems, smart cities have great opportunities in terms of technological developments and accessibility, creating a revolution in several aspects of people's lives. Smart city applications are being implemented in many countries, as they can improve the quality of life of their citizens and help reduce environmental pollution by optimizing time and fuel consumption [5].

Smart parking is popular among smart cities, as described in an industry article. These studies highlight that smart parking reduces congestion, increases revenue, has a price system that is tailored based on demand availability during peak hours, and strengthens traffic laws by using cameras to detect violators among others. Parking is one of the most important activities in the city, accounting for up to 31% of land use in major cities[6]. On average, the vehicle moves 10% of the time, and the rest of the time it stops either temporarily or permanently. The common method used to find parking spaces is manual as discussed by the author [7]. About 30% of vehicles on the road are looking for a parking spot, and the average time to do so is 7–8 minutes.

In cities with high vehicle density, finding available parking can be a waste of time and resources. The authors found that, in areas like Los Angeles, vehicles looking for parking lots produce more than 730 tons of carbon dioxide and burn 47,000 gallons of gas. The inconvenience caused by the need to find parking spaces leads to some drivers parking in unauthorized zones, coupled with increased vehicle density and carbon dioxide emissions. For example, if the driver has access to a database that contains information about the parking lot in real-time, there will be more opportunities to choose the right route to the desired parking space [8].

Autonomous vehicles are part of smart parking initiatives, as they take into account mobility, fuel consumption, and travel time. Remote Autonomous Valet Parking (LAVP) presents a new approach, making autonomous vehicles temporary parking spaces in urban parking areas. [9] states that the Scheduling Center is at the core, as it coordinates the closest route to the stop and finds the best parking spot. This approach will benefit users by providing a reservation system in a cost-effective manner. Other approaches, such as [10] suggests that customers use the Android app to reserve parking spaces in advance. In this solution, the authors propose the use of a trolley to move the car to the reserved place using genetic algorithms.

There are several studies that aim to provide a classification of several components of smart parking solutions. Classification of parking systems, in which the author lists several types that refer to assisted parking search (APS), Information Systems (IS), payments, automated parking, reservations, parking assistants, and others. Similarly, they list and describe the various technologies used (sensors, image processing, and RFID). The authors have defined the categories mentioned above, but they have not considered reviewing whether all of the categories listed appear in recent works to determine usage trends [11].

In addition, the author [12] conducted an extensive review of several works that implemented smart parking solutions. They have considered a 16-year period for the analysis. The authors have classified the literature based on a categorization of functionality that gets three main ones: Information Gathering (an overview of sensing techniques), Systems Implementation (exploitation of software systems) and Service Deployment (the relationship between information and social features). Although they have classified the selected articles extensively according to specific features and categories, they can supplement their study by identifying usage trends for future use. The time threshold is very broad and is considered an obsolete technology [13].

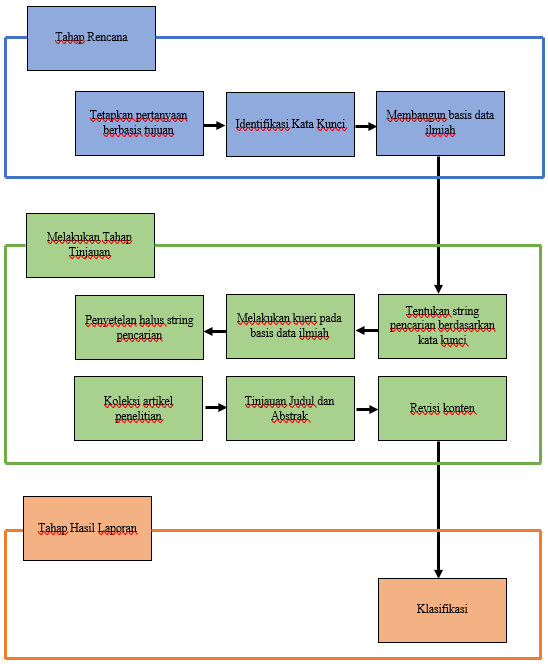
Adopts an approach that describes 13 tools, which are part of the smart parking solution. Items that use one of these tools are marked inside the table. Despite the classification process as proposed in our study, this study seeks to carry out implementation in open space. A review of various parking management works to identify the key requirements for implementing such a solution. They list several types of sensors and management systems in a table and map the reviewed articles to those features. Finally, the authors show the proposed architecture for their parking system. This review does not describe the research methods and considers some limited studies[14].

As explained earlier, there are several approaches to classifying smart parking components. However, there is still work to be done. The authors propose a different approach to classifying these components that are intended to guide researchers in identifying key and new trends related to sensors, software solutions, and networks using iterative research methods. Our journal focuses on recent works (after 2013) to show trends in the use of technology. Because of this review, additional sensor features have been described in a table for proper selection. Note that the sensor is the main point of these solutions, so it is important to choose one that adapts to the surrounding conditions. The authors' review provides technical insights for building smart parking solutions. Finally, the key findings of the current research serve as a guide for future work in areas that have little or no focus at all.

The rest of this journal is arranged as follows. Section 2 shows the information retrieval procedure used to find research articles related to smart parking solutions. Section 3 provides a classification of the various technologies used, in which three different approaches have been identified using sensors, network usage, and service implementation. Section 4 highlights the most prominent findings of the classifications set out in the previous section and the statistical evaluation taken from the survey. Section 5 suggests some features to consider before choosing a particular sensor. Finally, Section 6 presents the conclusions of the findings.

2. Research Method

The main objective of this study is to analyze the tendency of the components used in the solution *smart parking* from a technical perspective as well as to analyze the concept and potential application of the system *smart parking* in Indonesia based on a literature review. So this research uses literature review or literature study. The research method applied is a semicyclic process that is adapted and based on research actions and combined with literature review [15] which consists of three main phases, each of which contains specific tasks executed during the proposed research, as shown in Figure 1.



Picture 1. Detailed Research Methods

3 Result and Discussion

2.1.Planning Stage

The planning stage allows for the determination of search strings and research of digital repositories. The literature review phase is focused on adjusting the search string for each repository, collecting initial results, extracting relevant information, and selecting candidate articles. Finally, a thorough review of the remaining documents is conducted to report relevant findings and results.

This stage is related to the initial preparation before starting the research procedure. The main goal is to narrow down the scope and produce appropriate findings. First of all, the following research questions were set for this study.

What are some smart parking solutions that don't involve algorithms in their implementation?

What systems or sensors are used to implement smart parking solutions?

What is the concept and potential for the implementation of a smart parking system in Indonesia based on a literature review?

The questions set are related to the objective of our research, which is to review the implementation of smart parking from a technological perspective. With the above questions, the following keywords are identified; "smart", "parking", "solution", "sensor", "system", and "algorithm". Then, an initial set of searches such as "smart parking solutions" is established. The set produces large results, and to reduce the number, it is necessary to use logical connectors to combine them with the previous keywords. In addition, the word "algorithm" is excluded from the search series because its purpose is to obtain information about technical aspects, not prediction or optimization algorithms.

The research database was selected to search for articles based on a defined set of searches. The databases selected are ACM Digital Library, IEEE Xplore, Springer, and ScienceDirect. Finally, the set of searches defined per digital repository is shown in Table 1.

Table 1. Hasil kueri IEEE Xplore Digital Library, ScienceDirect, ACM Digital Library, dan Springer.

Perpustakaan Digital IEEE Xplore		Sains Langsung	
String	**Hasil**	**Pencarian String**	**Hasil**
Pencarian ((((parkir cerdas) DAN solusi) DAN sensor) BUKAN algoritma)	49	Solusi parkir cerdas dan sensor	10
(((parkir cerdas) DAN sistem) DAN sensor) BUKAN algoritma)	172	Sistem parkir cerdas dan sesnor	13
Pencarian String	**Hasil**	**Pencarian String**	**Hasil**
+solusi +parkir +pintar +sensor ÿalgoritma	11	pintar DAN parkir DAN solusi DAN sensor DAN BUKAN (algoritma) pintar DAN parkir DAN solusi DAN sistem DAN BUKAN (algoritma)	137
+sensor +parkir +pintar ÿalgoritma	39		53

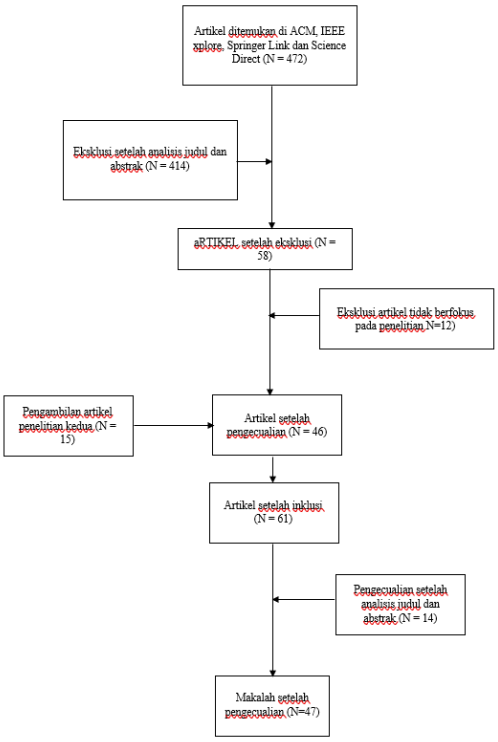
2.2. Conducting the Review Stage

During this phase, specific strings, defined in the previous phase, are searched into each digital research repository. To present the results, a table is created. This table contains the name of the digital repository in its header (one for each repository), the search strings used, and the results obtained for each search string. The results obtained after performing such queries are shown in Table 1. From the search results, only the most recent solution was considered (after 2013) as the technology became obsolete after 5 years, on average, as stated in[16].

First of all, with the help of the results export feature provided by each scientific database repository, CSV is the format chosen for exporting the set of search results, as SpringerLink uses it by default. A CSV document containing the search results is obtained. These files are then loaded in the tool to view information such as title, author, abstract, and year. A tool called Zotero is used to carry out the procedure. Zotero is an open-source tool developed by a non-profit entity. This tool was chosen because it can process and identify records in CSV and BIBTEX formats. Additionally, the tool can generate ".bib" or ".sqllite" files, both of which are powered by Mendeley. This tool makes it possible to conduct a first review of the found articles. Some of them have incomplete information, so they have to be filled in manually. The most important field to check is the DOI, as it contains the main identification of the article. For the next

step, a ".bib" file with the information of all the reviewed articles is created, and a private group for collaboration is created in Mendeley where these records are imported and stored. Then, the PDF document of the selected article is retrieved and uploaded inside the tool. As a result, a small fraction of the previously retrieved articles were obtained[9].

Finally, the protocol for removing articles was followed. The protocol is run manually, and consists of reviewing titles and article abstracts collected from various digital repositories, to find keywords and brief details that can help answer research questions. If there are no terms or information related to the topic, the article is discarded. Then, the remaining articles are analyzed to identify whether they are focused on the research topic. Finally, the second round or process is carried out to obtain a large number of articles for this research. A representation of the disposal protocols followed is shown in Figure 2.



Picture 1. Article Reduction Process

In the first iteration, the first phase ended with a list of 484 articles, which included documents that were not relevant to the study. To sift through the relevant documents, the titles and abstracts are read and analyzed. Screening is done by marking "YES" if the documents are useful and "NO" if they are not relevant. In the first round, 414 articles were removed, as they did not contain relevant information. Then, of the remaining 58 articles, a full review was carried out and it turned out that 12 articles did not focus on the research topic.

A lack of documents was found and for this reason the process started a new iteration to retrieve more information using a new set of 12 keywords, adding "parking zones", "vehicles", "intelligent sensors", which were introduced into the previous series of searches, thus generating 15 more articles to review; However, after analysis, only 14 articles were selected bringing the total to 47 articles that were reviewed in depth.

However, in order to find a clear trend of smart parking implementation solutions and technologies, another iteration of the collection process was carried out. In this round, the search series is readjusted to meet the needs found in the classification. Some of the words added are smart, parking, solution, sensor, system, automatic, and parking, thus avoiding all the results associated with the algorithm.

The addition of new words to the search string results in the acquisition of more articles related to the research topic. The results are presented in a table with the same column structure as before. (see Table 2).

Table 2. Query results from IEEE Xplore Digital Library, ScienceDirect, ACM Digital Library, and Springer For Additional Rounds.

Perpustakaan Digital IEEE Xplore	
String Pencarian	**Hasil**
(((((pintar ATAU e ATAU otomatis)DAN parkir) DAN (sistem ATAU solusi)) DAN sensor) BUKAN algoritma)	24
Sains Langsung	
Rangkaian	**Hasil**
Solusi parkir cerdas dan sensor	765
Sistem parkir cerdas dan sensor	904
Solusi parkir otomatis dan sensor sistem	911
parkir otomatis dan sensor solusi e-parking	1229
dan sensor	1314
Sistem dan sensor e-parkir	1836
Perpustakaan Digital ACM	
Rangkaian	**Hasil**
	26
+solusi +parkir +pintar +sensor +sistem	80
+parkir+pintar +sensor-algoritma	
+otomatis +solusi +parkir -algoritma +sensor	2
+otomatis +sistem +parkir +sensor-algoritma	
+e +solusi +parkir algoritma +sensor +e	80
+sistem +parkir +sensor-algoritma	
	26
	80
Tautan Springer	
Pencarian Spring	**Hasil**
"Parkir cerdas" Dan Solusi Serta Sensor Bukan Algoritma	13
"Parkir cerdas" Dan Solusi Serta Sistem Bukan Algoritma	15
"Parkir Otomatis" Dan Solusi Serta Sensor Bukan Algoritma	9
"Parkir Otomatis" Dan Solusi Serta Sistem Bukan Algoritma	13
"E Parking" Dan Solusi Serta Sensor Bukan Algoritma	87
"E Parking" Dan Solusi Serta Sistem Bukan Algoritma	392

The same removal process is applied. The first stage ended with 2819 articles, which contained documents that were not relevant to the investigation. A web platform called Ryan [1] used to facilitate classification work collectively. Once all the results were loaded, we proceeded to read and analyze the titles and abstracts of each paper. Then, if the content is deemed relevant for classification, a "Maybe" tag is used to tag the article. The "Exclude" tag label is used to mark it as irrelevant to this research article. In the first round, after the disposal process, 104 articles Finally, after the elimination and classification process, 40 additional elements were successfully obtained. obtained, providing a complete collection of 87 articles used for this survey.

2.3.Results Reporting Stage

In the final step of this research methodology, all findings and results are documented. The findings were used to compile the next section that is a core part of this study. In addition, the findings are further analyzed and discussed to establish and identify trends in terms of the use of smart parking solution technology components.

3. Smart Parking Solutions

Motor vehicle production has grown significantly in the last 30 years. Vehicles on the road mean more fuel consumption and time as well as increased demand for parking spaces. These problems can be solved with smart parking solutions. It is one of the most popular use cases in the concept of smart cities and seeks to improve the quality life cycle of cities [17].

The architecture of smart parking solutions is mainly represented by three elements: sensors, network protocols, and software solutions. Sensors are the most important element because they collect information and feed the entire system. The network protocol is governed by a gateway that implements the wireless IoT protocol and connects the sensor to the software system. Finally, software solutions ensure that information is available to everyone through some type of service. For example, people can use this information to view a heat map of the zone with the highest parking slot occupancy.

To implement smart parking solutions, several components of technology are involved, such as sensors, network infrastructure, and software solutions, among others. Regarding smart parking architecture, there are several works that have been presented by industry and the scientific community. Some of them focus on solutions, others on algorithms, software, or systems, while others briefly state sensor technology.

Deep [18] the author discusses various approaches to implementing Smart Parking solutions; It considers the entire ecosystem of those types of solutions which basically involve sensors, gateway selection, edge processing, and data center analysis. Meanwhile, the author [19] describes an architecture that is entirely based on ZigBee technology. In addition, the author [20] suggests artificial intelligence to optimize park search, but hardly specifies the technical details of implementation, such as specific protocols or types of sensors. Similarly, the work proposed in [21] indicates the use of Bluetooth Low Energy (BLE) as a protocol for connecting sensors and gateways. Bluetooth is a wireless protocol that supports connections between end devices. The BLE version consumes very little energy and is part of the wireless IoT stack protocol. Other solutions, such as the one in [22] suggests the use of an IR sensor for its architecture. Smartphones are also considered in this solution specifically to find available space [23] Taking the aforementioned into account, it can be seen that there are no international standards or basic architectures set for implementing smart parking systems. Therefore, it is important to analyze how different components are used as well as identify trends with respect to their use in order to implement smart parking solutions.

Smart parking solutions are developed with a variety of technologies and approaches; Therefore, the classification will be carried out taking into account the points set. In this case, three different perspectives are chosen: the sensors, the network infrastructure, and the services provided to the user. The perspective was chosen based on the importance of the perspective in [24].

3.1 Sensor Type

Regarding transportation planning and traffic management, the most important topic is parking. Currently, determining the availability of parking spaces is difficult if there are no elements that make it possible to identify whether the parking lot is empty or not. The purpose of the sensor is to solve this problem and sense its availability as well as communicate with the parking system through the network gateway. Although sensors solve detection problems, a large number of sensors are required to exercise adequate control over a given space. There are sensors that do not cover a large space, and therefore one sensor per place is required. Therefore, the larger the space, the greater the number and therefore the higher the cost. Note that for sensors to be used properly, they need a technological infrastructure for data transport . This implies the installation of a data network whether it is mobile or gateway-based [25] Additionally, in cases where wireless communication is not possible, a structured wired approach to collecting information should be available. Weather conditions are limitations that need to be considered and supported by sensors. While there are alternatives to using other sensors such as smartphones on cameras in large spaces, there are security issues that need to be addressed first.

Sensors are the most important component of a smart parking system because they provide valuable data to the system. Therefore, the sensor must be reliable and require little to almost no maintenance. Sensors define network technology and data transmission mechanisms). They should not rely on human interaction to provide information about the environment. Energy consumption should be minimal and if possible and have a sustainable energy source (i.e., solar energy). Indeed, the inclusion of Microelectromechanical System Sensors (MEMS) will help reduce size, power consumption, cost, and extend performance and lifespan[26].

3.2 Camera

One approach to information retrieval is to use video cameras in parking lots, which have the ability to process images on their own without the help of external devices or algorithms. This allows the control of multiple vehicles with a single piece of equipment. This approach also leads to the creation of new parts of the system focused on the reception and processing of such images. For this scenario, a common technique is the use of a wide-angle camera in conjunction with a classification algorithm to detect parking lines and determine the status of a space, as described in[27].

The main purpose of this work is to help the driver park his vehicle in a chosen place by using the touch screen. This approach consists of three steps: the construction of the bird's eye view, the introduction of guidelines, and the identification of parking dividing lines. The authors propose a new approach to operating with real-time images. This semi-automated initiative has performed well and does not require hardware modifications according to the authors.

Similarly, it is possible to use a common outdoor camera to improve detection accuracy by training the algorithm with images taken in different weather conditions[28]. The authors also describe another

solution, which involves storing images of areas taken from the camera in a database along with the coordinates of each space, and then comparing the stored images with images sent in real-time to determine whether or not the parking lot has been occupied. In this scenario, it is important to consider that when video cameras are used outdoors, efficiency may be reduced due to weather conditions, even if the training phase is carried out with images of some weather conditions. However, when it comes to indoor parking, this can be a viable option because the image is not affected by weather conditions. The images are stored into the database along with the coordinates of each parking lot, and can be compared with the images sent in real-time to determine whether or not the slot is occupied[29].

There are other solutions that involve users to determine the availability of parking slots through cameras installed in their vehicles. It is intended to help drivers avoid parking in illegal places by offering a real-time system. The author uses an event recorder to gather information. The technique used to determine the availability of space is static image streaming. In this system, the driver makes a parking request through the Android mobile app, and the response contains the location of the parking lot. The mobile app also collects information through the camera. The system collects and processes images and videos to determine and suggest available parking spaces[30].

Today, cameras are an essential element of vehicles, highways, and smartphones. These sensors capture information in real-time with more features than any other sensor. While relying on a powerful backend and the right weather to process data and metadata to produce results, these sensors are a good source of information.

Software solutions are the main core for processing the information collected by sensors and disseminating the results to other end users of the system. The purpose of each solution depends on the needs determined by the stakeholders. Software solutions should not only act as repositories as their information helps reduce time, fuel, and money. Its architecture must be robust enough to handle large amounts of information and provide services to a large number of users. To achieve this, the solution can be used through both private and public cloud infrastructure. This solution combined with a good mobile app is an important working tool as it allows the user to perform certain tasks such as booking a parking space, or finding the nearest parking space at a specific time in the software solution should provide real-time information as this information is important for the driver to make decisions. The data contained in software solutions is a useful tool, especially for governments that seek to improve urban development and mobility[23].

This information can be used to estimate the availability of parking spaces in places that do not have sensors or poor communication coverage. From a commercial perspective, this information is a golden box because service points can be built near locations with high vehicle density. Additionally, construction companies can benefit from this information to determine where to build more parking buildings or to increase the capacity of existing parking buildings. Software solutions are essential and must handle information to be beneficial to the city and users. In the future, the solution should include all of the following features: information management, analytics and predictions, and e-parking services.

3.3 Network

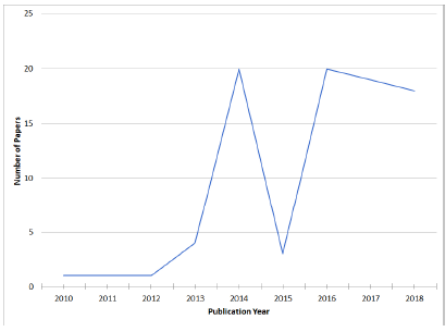
Network protocols are key to relaying information from sensors to intelligent parking systems. Otherwise, it will be difficult to connect every existing sensor to retrieve its data. In smart parking solutions, there are two types of network protocols (one for users and one for sensors). In some cases, the sensor and the user may use the same protocol. However, user protocols consume more power and require Internet connectivity. On the other hand, most censorship protocols are not directly connected to the Internet. Sometimes, those protocols have to pass through gateways (e.g., LoRa, ZigBee, and NB-IoT). This gateway is in charge of translating Wireless IoT protocols to TCP/IP-based [1].

The implementation of smart parking solutions demands a network architecture infrastructure capable of supporting hundreds of thousands of connected and transmitting devices at any given time. This topology should consider short-range and long-distance communication to connect the sensor to the gateway and then to the software solution. The implementation of this network should focus on implementing wireless IoT protocols and mesh networks to cover a wider space and allow sensors to transmit even if the gateway node fails.

4. Discussion

Given the research articles taken and analyzed for this survey and taking into account the distribution of smart parking articles published per year, as shown in Figure 4, this improvement in trend can be realized starting in 2013, where there is a slight increase compared to previous years. In 2014, a large number of research articles related to the subject analyzed were published and highlighted Increasing interest in Smart Parking Lots. Although in 2015 there was an unexpected decline, in 2016 it reached its peak again

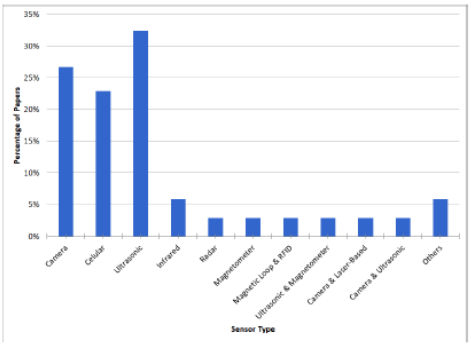
with a steady trend from 2017 to 2018. These trends show that the chosen topic is interesting and reinforces what is described in the industry report [24].



Picture 2. Distribution of Research Articles

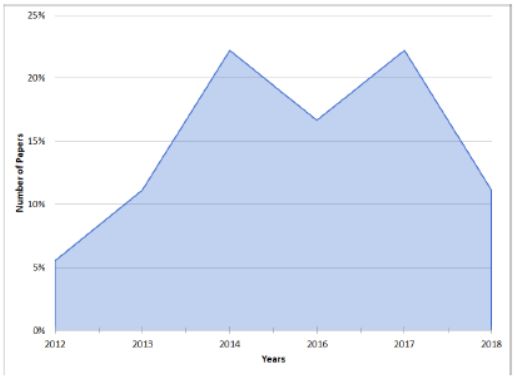
4.1 Sensor Type

Among the research articles considered relevant, only 58% presented detailed information about the type of sensor used. It focuses on proposing solutions without any real implementation. The distribution of sensors found in the research article is shown in Figure 4. The results of the most widely used sensor types are shown in Figure 5. This graph shows that ultrasonic sensors are the most popular among the research community, accounting for nearly 35% of the articles reviewed. On the other hand, cameras with almost 26% are the second type of sensor used to design or implement smart parking solutions. Third, although technically smartphones can include some of the aforementioned sensor capabilities, their use is only 23% in the revised research work[8].



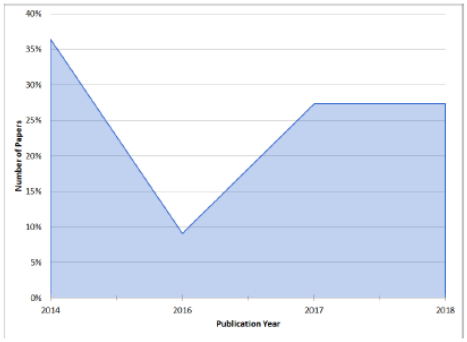
Picture 3. Sensor Type

As is already known, ultrasonic sensors are the most widely used category, and this tendency has reached a maximum point that is still maintained, as shown in Figure 5. The highest peak related to the use of ultrasonic sensors was at 23% in 2014 and 2017. The graph shows an increasing trend in the use of these sensors over time. This may be due to its ease of installation and management, which means that there are a huge number of devices that can be connected via both wired and wireless media.



Picture 4. Use of ultrasonic sensors.

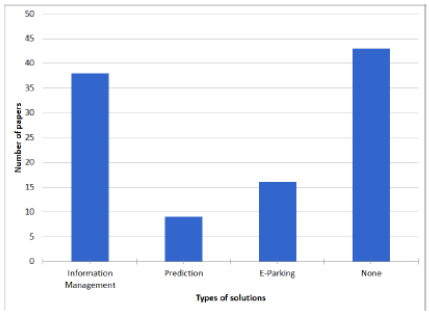
Using video cameras and image processing algorithms can be a complicated process for training and detection; Although, in overcoming these difficulties, it is possible to cover a large area with just one device, resulting in a convenient solution. It does not require any existing infrastructure, resulting in simpler implementation. Figure 6 shows trends regarding camera usage. The trend of camera use has remained in the last two years after a substantial decline. However, due to the percentage of articles that address the subject of sensors and consider trends, it can be established that the importance of building sensors has decreased to focus on developing generic solutions that can take advantage of wireless sensors. The scientific community may focus on an approach to providing infrastructure models that can be tailored to specific needs.



Picture 5. Camera Users

4.2 Software Solutions

After completing a review of all the research articles taken, as shown in Figure 7, it was found that 51% of the reviews did not mention any type of solution, as most only focused on sensing methods and the various algorithms used for smart parking.



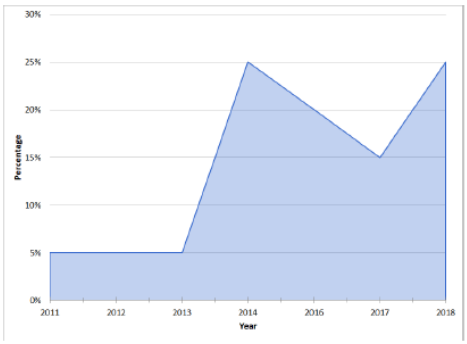
Picture 6. Smart Parking Software Solution.

Among classifications that contained detailed descriptions of how parking information was applied, only 45% contained detailed descriptions of how parking information was handled, which is the classification with the most samples. Almost all of these research articles describe the modules and structures that raw data

must go through from sensors to how the resulting information is presented to the end user. In addition, some of them mention that cloud storage is an important factor for the implementation of Smart Parking, as shown on, since the stored information will be accessed by users over the Internet. The most widely used software solution is Information Management with 38% among the revised articles. From the work studied, it can be seen that the proposed or designed software solution is more aimed at handling information than providing a complete set of services as in the E-Parking solution. The second most mentioned classification is E-Parking, where most of the solutions focus on the interaction between the user and the reservation of parking slots, and one of the main problems is that the user can pursue the same space as mentioned in . We also found that information is presented through this medium but the interactions that users can have with it are not shown in detail apart from visualizations and parking space reservations. Finally, applying algorithms for reservation prediction and parking space assignment accounted for only 11% of the research articles[31].

4.3 Network

Regarding sensor networks, 40% of the selected research articles did not specify the use of specific network protocols or solutions, or their coverage was focused on the presentation of surveys or multiple algorithms. Of the remaining articles, 85% propose wireless implementations using WiFi, Bluetooth, mobile communication technology, or wireless IoT protocols; sometimes implemented as ZigBee, LoRa, or NB-IoT. Most solutions that use wireless technology justify this because the cost of implementing this network architecture is lower compared to wired solutions. Thus, it can be said that wireless IoT protocols and WiFi technologies are the most preferred for sensor communication, taking up 51% and 31% of the classified solutions, respectively, in contrast to the 15% that correspond to 3G and 4G technologies. Meanwhile, on the user side there are several technologies, but all of them are focused on the web. In any case, the network technology used to reach end-users can be 3G/4G, WiFi, cable, etc., as long as the technology can provide access to the Internet. Analyzing the use of wireless IoT protocols per year (Figure 8), we can see an increase in the use of this technology from 2013 to 2014 with a slight decrease in 2017 and a recent increase in 2018. There is a steady trend in the use of wireless IoT technology for smart parking applications[31].



Picture 7. Wireless IoT protocol usage per year.

The implementation of smart parking systems has been widely carried out by other countries. The following is a comparison with other countries that already use a parking system (smart parking):

a. Malaysia

Malaysia, the implementation of smart parking systems is still slow even though the need is also urgent. This study investigated the feasibility of implementing a parking spot detection system using cameras mounted on light poles for outdoor public parking in Malaysia. This study aims to show that systems with lower complexity can be beneficial. The proposed solution combines parking spot detection with parking duration timings to help drivers monitor their parking time. This can be achieved by using image detection and the application of filters to identify parking lot occupancy. Real-time fill data is then exported with excel files and this data is stored for further research and application development[29].

b. Hong Kong

The extent to which a mechanical car park can help address the problem of lack of space depends on the relative cost and performance of facility management. For real-time vacancy information systems, the wide usage depends on the driver's age and previous parking experience. Due to

geographical constraints, only two Asian cities such as Hong Kong, where the use of smart technology is growing rapidly, were included in the study. The survey on car parking apps is still preliminary due to its relatively short implementation in Asia. It is hoped that this phenomenon will quickly spread in the region as more and more smart cities are developed. Outlining the development of modern parking technology in smart cities, the important influence of car parks as strategic facilities on the resolution of traffic congestion and environmental issues is of concern to policymakers, especially the factors influencing strategies to promote the use of parking applications [20].

c. Singapore

IDA is a smart parking application built on a parking guidance information system (PGI). However, the IDA expands the general PGI system by offering advice based on parking fees or proximity to destinations. In addition, IDA makes a new contribution to the existing parking system by adding two new features. The current problem facing modern cities is the increasing flow of traffic and very congested parking lots. To reduce the time and congestion caused by searching for available parking spaces, we propose IDA, Intelligent Driver Assistant. The main goal of the IDA is to help drivers find suitable parking spaces, monitor parking availability online, and direct drivers when the number of available parking spaces drops to critical levels. Unlike other parking apps, IDA uses speech to interact with the driver and be an active helper during the navigation process by dynamically adjusting parking decisions based on traffic situations. This article presents the ongoing work, interaction design aspects, use cases, as well as the first user feedback received during the public event where IDA is exhibited[27].

d. United States

Parking in densely populated urban areas is a persistent and widespread challenge exacerbated by the increasing number of vehicles and limited parking infrastructure. Smart parking systems have emerged as a promising solution to this problem by leveraging technology to optimize the use of parking spaces and simplify the parking process. This study investigated the impact of SPS on parking behavior in the context of university life by leveraging a comprehensive five-year dataset of parking tickets and using a carefully developed LSTM model using a Python-based Keras library. Through the refinement of hyperparameters and the utilization of evaluation metrics such as MSE and R-squared, the study not only validates the predictive accuracy of the model but also provides insight into the nuanced effects of SPS on post-implementation parking patterns. The findings confirm that SPS reduces parking violations, with actual numbers consistently lower than expected, demonstrating the system's ability to improve compliance. The statistically significant difference between the predicted and actual distributions, as validated by the KS test, further amplifies the positive impact of SPS on parking behavior. The analysis of the importance of features highlights the important role factors such as holidays and exam periods in influencing parking violations, with holidays having the greatest impact. In contrast, semester breaks show a smaller effect, which indicates a more stable parking pattern. Overall, SPS not only improves parking management but also provides scalable solutions for the wider urban environment, driving more compliant behavior. Practical implications include better resource allocation, policy refinement, and a better user experience. In addition, SPS contributes to environmental sustainability by reducing fuel consumption and emissions, demonstrating its potential to optimize parking systems and urban mobility. In summary, this study highlights the transformative potential of SPS in addressing parking violations [26].

The advantages of Indonesia implementing a smart parking system include:

a) Time and Energy Efficiency
   The system displays available parking spaces in real-time, so drivers don't have to bother looking for parking spaces. That way, time and fuel can be saved.
b) Reducing Traffic Congestion
   Congestion around the parking lot can be reduced with an integrated and effective system as cars enter and exit more smoothly.
c) Increasing regional income
   Accurate transaction recording using a smart system minimizes parking levy leakage, which usually occurs in manual systems.
d) Accountability and Transparency
   Digitally recorded data and non-cash transactions increase transparency and auditability of management.
e) Increased Security
   The risk of theft or careless parking is reduced with intelligent parking systems, which are usually equipped with CCTV, car sensors, and automated systems.
f) Data Collection and Analysis

Future urban planning can benefit from analysis of vehicle data, parking locations, and time.

Indonesia's weaknesses in implementing a smart parking system include:

a) Expensive initial investment costs
Large initial expenditures are required for the application of technologies such as sensors, cameras, software, and other infrastructure.
b) Network and Infrastructure Limitations
Smart parking operations may be hampered in some places by erratic internet connectivity or inadequate infrastructure.
c) Lack of digital literacy skills
Some users may face challenges, especially those who are not yet familiar with digital apps or cashless payment methods.
d) Problems with Technology and Maintenance
Confusion and inefficiency can occur as a result of system interference (such as sensor errors or offline systems).
e) Opposition from the Traditional group
These reforms may be opposed by manual parking attendants or other groups that have benefited from previous arrangements.
f) Issues with Data Security
Without a robust cybersecurity framework, digital systems are vulnerable to hacking and misuse of data.

5 Censorship Selection Strategy

As part of the research conducted, several features have been identified related to various sensors that have been reviewed previously. The features extracted from the review are invasive, ease of installation, sensor per slot, and detection autonomy. First, invasive characteristics relate to the possibility that the installation of a sensor results in modifications or changes of a physical or logical nature to the beneficiaries of its services (for example, adding additional equipment that is already out of the box to the vehicle to detect that the slot is empty or not or giving a card to the user to access the slot). Second, ease of installation refers to the act of placing sensors in a place, sometimes requiring the use of complex infrastructure such as structured cables, electrical connections, air gutters, and so on, while there are other sensors that only need to be buried in the ground [1]. Hence, the number of sensors per slot is something important because there are some cases where one sensor is used per slot, and the accuracy level is higher to determine if it is free or not while there are other types, such as cameras, that only use one device to cover a large area but the accuracy level is low compared to the previously mentioned Lastly, Detection autonomy is the ability of the sensor to determine on its own whether the slot is empty. or occupied. With cameras, they require additional elements or processing to determine slot availability [24].

4 Conclusion

Based on the literature reviewed, there are several solutions where LPWAN technology is used for smart parking implementations, but the most reviewed research articles use LR-WPAN technology, specifically ZigBee. In any case, there is a trend in using LPWAN solutions as shown in the findings discussed earlier. There are several types of sensors that can be used to implement smart parking solutions. Conditions that dictate using one or more sensors are related to technological advantages, budget, type of solution, and weather. Our research identified that in terms of technological advantages, there are four features to consider: invasive, ease of installation, sensor per slot and autonomy detection. These features will help identify the ideal sensor to use in any smart device, the parking system. Network security implementation is not a concern at the time of solution implementation, although this can be a problem due to the potential misuse of the transmitted information and the reliability of the system. From a client/end-user perspective, most solutions focus on devices that are capable of connecting to the Internet because they allow the system to expand to a wide variety of gadgets. The sensors used to retrieve information in smart parking solutions must have real-time and automated data collection. As a result, almost every implementation described in the reviewed article uses some type of sensor. Although smart parking systems generate a lot of data, some implementations do not implement or propose prediction algorithms from the data captured. In terms of future jobs, one way to improve these surveys is to increase the number of respondents reviewed.

articles and focus on specific systems to narrow down the field. The review focuses more on intelligent parking implementation systems that are capable of working on the street and inside. In addition, we plan to conduct a comparative analysis of the effectiveness of LPWAN or LR-WPAN on Smart Parking to propose a solution to a formal method for selecting sensors based on technical features and the goals to be achieved.

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