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Designing Smart Parking System through the Use of IoT and Big Data

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ABSTRACT

One of the endless problem in Jakarta is the potential loss of DKI Jakarta regional government revenue related to parking fees. This study was made to overcome this problem by proposing the utilization of IoT and Big Data technology for smart parking system as a contribution to the Jakarta Smart City plan. Actual real time data of parking management by utilizing IoT brings out the collaboration of tools and technologies which may provide controlling and monitoring features to smart parking system. Furthermore, big data technology allows DKI Jakarta government easily predicts the potential revenue from each parking location spread throughout the city. This paper will discuss about the requirements, system architecture, detection methods and technologies based on commodity hardware and a group of Hadoop MR Platforms to investigate the ability of intelligent parking platforms to process and analyze large data in Jakarta.

Key words: IoT, Big Data, Smart Parking, Parking, Hadoop, Jakarta

1.INTRODUCTION

In DKI Jakarta there are still many locations that still have the potential to do parking management and become supporting facilities and infrastructure for existing transportation, especially mass transportation [1]. On the other hand, the parking management unit of the DKI Jakarta transportation department who has managed parking in public facilities, social facilities, and public spaces owned by the DKI Jakarta government recognizes that there are still people who charge illegal parking fees in these parking areas and cause loss of revenue in the DKI Jakarta [2]. From a study conducted in 2012, the potential for receiving parking fees in the South Jakarta area is Rp. 8.997.669.020, while the calculation based on the Governor's Decree No. 110 in 2010 has a potential of Rp. 5.130.951.000 [3]. In 2019, the Jakarta Regional House of Representatives set a target for DKI Jakarta parking fees of 750 billion [2]. The DKI Jakarta Government has implemented electronic parking terminals in several parking lots. However, the lack of controlling and integration of electronic payment systems has caused this implementation does not answer the problem of maximizing the potential revenue of DKI Jakarta to reach the desired target.

The last few decades, continuous innovation from the internet and information technology has various socio-economic impacts on modern society. Technology has changed the way we communicate through the internet using wireless devices, which is known as Internet of Things (IoT). IoT introduces new ways to interact between physical objects. The purpose of IoT is to enhance technological development by connecting smart objects through internet using sensors, actuators, Bluetooth, RFID, etc. which is able to react to their surroundings and create interactive environment [4]. With IoT, devices autonomously process and provide the services needed to complete certain tasks. The majority of developed countries have adopted IoT as a national strategy for resolving intangible service level problems [5]. Through the process of connecting and communicating, IoT produces large amounts of data, known as Big Data that can be shared and used by individuals and organizations [6]. The difference between big data and data in general is volume, variety, and velocity [7]. Big data might be user data, equipment data, product data, data management, and internet interactive data. In Indonesia, the opportunity for the utilization of big data on government sector is highly potential, where the variation and distribution of these data has not been regulated and stored centrally from each government agency. By analyzing data based on user needs and choices, cities become smarter [5]. Thus the use of big data is a form of contribution to Jakarta Smart City plan.

Looking at the existing problems and the potential usability of IoT and big data technology, the study was conducted with the aim of providing solutions by utilizing IoT and big data technology for smart parking system in Jakarta as the contribution to Jakarta Smart City plan.

Smart parking system is designed to present actual real time data related to vehicles going in and out of various parking zones for drivers. Previous studies that discuss the design of IoT-based smart parking systems or using big data technology in Jakarta mostly proposes solutions for parking system in office buildings, malls, or apartments. While the

design we offer can also be an on-street parking solution. Previous research also has not used image recognition technology to read vehicle numbers even though this technology has been developed for E-Tilang system in Jakarta.

The novelty of this research is the use of image recognition camera that can automatically detect the vehicles number and its integration with the automatic entrance gate of the parking area owned by the DKI Jakarta regional government as one of the implementations of IoT. This study also has a novelty in terms of utilizing the smart parking system for on street parking seeing the number of public facilities, social facilities, and public open spaces owned by the DKI Jakarta regional government are not well managed. Hence, some people are still collecting illegal parking fees in these areas.

The design proposed in this study is intended as a solution for the DKI Jakarta regional government, especially the DKI Jakarta transportation department, not only to achieve the parking fee target set by the Jakarta Regional House of Representatives but also to maximize the revenue that has been lost over the years with transparency provided from the proposed system.

2.LITERATURE REVIEW

In [8-10], the authors describe a multi-layer IoT-based platform for smart city projects that include smart parking as one of its components. However, only the data management and processing layer on this platform is implemented using Hadoop MR for batch processing or Spark for streaming processing to do big data analysis. In addition, scalability results are demonstrated through performance and processing time when the platform runs on a single node (Hadoop Pseudo-Distributed Mode) [8-10] or two-node cluster [9]. These results only model the efficiency and feasibility of platforms on a larger scale of big data, but they can hardly provide enough information for city dwellers or authorities, and most of them present very little information about parking for car drivers.

The study described in [12-14] was conducted on a smart parking system that provides parking information for drivers and parking operators; However, they only conduct evaluations on a smaller scale. Mackowski et al. [12] proposed a dynamic pricing model for smart parking systems that allows parking owners to adjust parking prices at certain parking spaces in real time and maximize parking occupancy. However, the authors use a personal computer to demonstrate this model with a small dataset from only one parking space, regardless of competition with other parking spaces in the same area.

In [13] He proposed an algorithm that helps motorists search and find free parking spaces in the nearest parking lot based on the distance from the driver's location. After the simulation, the authors apply it in an actual parking situation that includes seven parking spaces at a university where the maximum parking space for one parking space is limited to only 80 spaces. The system runs in the cloud using the Apache Hadoop and Apache HBase databases.

Regarding smart parking projects in their implementation, many smart parking systems operate in many cities throughout the world, such as Montpellier (France) [14], Santander (Spain) [15], Gliwice (Poland) [16], Perth (Australia) [17], London (United Kingdom) [18] and Wellington (New Zealand) [19] can be taken as examples. Most of them have used a single smart parking sensor that is embedded in each parking space to record parking space usage data.

Other works that discuss smart parker solutions, such as those listed in [20], [21] and [22] most generally do not discuss the reliability and effectiveness of their solutions. The main requirements are vehicle detection and presentation of parking space status to users, which are carried out in various ways between solutions. In [20] proposed a parking system, called SPARK, based on Wireless Sensor Network (WSN) technology because of the need for an automatic parking system, easy to use, cost effective and real time. The system is able to monitor and manage single parking spaces and provide parking space reservation services to users. In addition, SPARK works with light sensors to detect vehicles and parking location data is transmitted to the subsystem using a radio frequency (RF) system. All data generated is stored on the local server.

In the proposed paper [21] a system is developed that sends information about parking and makes parking reservation services available to users. Sensor networks that use the ZigBee1 module are adopted to monitor the status of the parking space in real time filled or empty. Each module has a luminosity and vibration sensor that is used to detect vehicles, and a Bluetooth module that is responsible for communicating with the user's smartphone and validating their identity. Users can also book a parking space with their own smartphone via the Internet. Based on the status of the parking lot, the system can analyze parking locations, determine parking prices, notify users about prices periodically.

In writing [22] it discusses the rapid development of smart parking systems following the Platform as a Service (PaaS) approach because it allows the development of simple, fast and complex applications. The system architecture consists of the WSN layer, the IoT middleware layer and the front end layer as an end user interface that provides data reporting to users.

The Big Data framework is a structured approach that consists of six core capabilities that organizations need to take into consideration when setting up their Big Data organization. The Big Data Framework is depicted in the figure 1 below:[23]

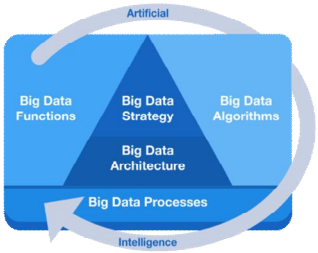

Figure 1: Big Data Framework

Finally, we did not find any analysis of reliability and effectiveness, so we cannot compare the solutions on how many times they fail, for example. This would be important, since they use different sensors and techniques to determine a parking space status. So we only can discuss about the requirements, system architecture, detection methods and technologies.

3.PROPOSED SYSYEM AND IMPLEMENTATION DESIGN

Smart parking is one of the smart city part. The key concept of smart parking is getting the right information in the right place on the right device, making people decisions to park their vehicle easier. Various wired and wireless sensors, surveillance cameras, road emergency buttons and other fixed devices have been introduced to develop smart parking based on IoT. The main challenge in this regard is to realize smart parking systems and to connect data generated by smart systems in one place. This section presents a proposed system, which includes a detailed description, architecture, and implementation model.

3.1.Smart Parking System

Figure 2 describe how the smart parking system works by implementing image recognition technology and automatic parking gate.

First of all, citizens have to install smart parking system mobile application, create an account, and register a vehicle number. The citizens can monitor the number of available parking lots and reserved a parking lot through a mobile application.

When the citizen comes to the parking area, smart camera takes a picture of the vehicle number. Picture taken from the smart camera will be processed to recognize the vehicle number as registered in the mobile application. This data will determine the decision of the automatic parking gate. If the vehicle number is recognized and citizen has been reserved a parking lot, the entrance gate will open automatically. If the vehicle number is not recognized then the entrance will remain closed. After the entrance gate is open, the citizen can go directly to the parking lot that has been reserved to park the vehicle and in-ground parking sensors will count the parking duration.

When the citizen leaves the parking lot, citizen can pay the parking fee in a cashless method because the smart parking system is integrated with various electronic payments such as e-money and e-wallet.

After payment process is completed, citizen reaches the exit gate and the smart camera will recognize the vehicle number and check whether the payment has been completed. If payment is complete, the exit gate will automatically open and the vehicle may leave the parking area.

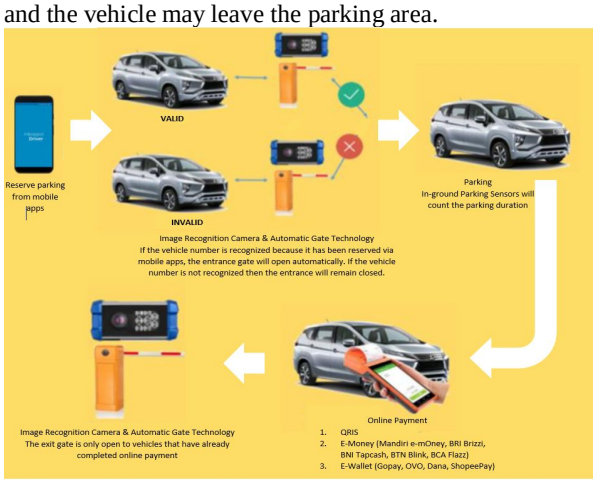

Figure 2: Smart Parking System

3.2.Integration with Smart City System

Figure 3 shows an overview of the system, including the smart system used to build smart parking. We suggested that various types of sensors be placed in different places to collect and analyze data. Smart Parking helps control vehicles entering and leaving different parking areas. Therefore, smart parking can be designed. Smart car parking data, as part of a smart city, brings many benefits for traders and citizens. With our system, citizens can easily get real-time information about the closest available parking. Likewise, citizens get smart city information in a better place to park their car. This system reduces car fuel consumption.

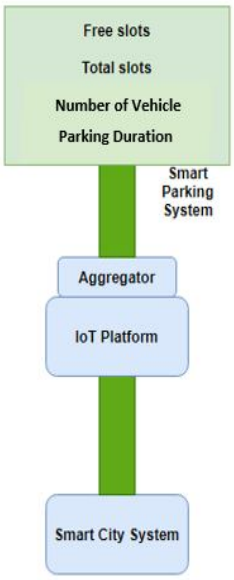

Figure 3: Smart Parking System Integration To Smart City System

3.3. System Architecture and implementation model

Based on the needs of smart parking technology, we first propose a four-level architecture to analyze data generated by IoT-based smart systems to build smart parking. Figure 4 shows the complete architecture.

- Level 1 - Lower Layer: This layer handles the creation of data through various IoT sources, gathering and combining that data. Because many IoT sensors participate in making data, they produce various types of heterogeneous data in different formats and with different origin and periodic. In addition, some data have security, privacy and quality requirements. Also, with sensor data, metadata is always greater than actual measurements. Therefore, this layer applies preliminary filtering and recording techniques to filter out unwanted metadata and repetitive data.

- Level II - Intermediate Layer I: This layer is responsible for communication between sensors, which is passed through ZigBee technology, based on GW or BTS, and can use various communication technologies on the Internet. The analysis side between the different analysis servers uses Ethernet.

- Level III - Intermediate Layer II: This layer is the central layer of the entire analytic system and is responsible for data processing. Real-time analysis of intelligent systems is required. Therefore, a third-party real-time processing tool is needed to join Hadoop. Therefore Spark is used for real-time deployment. However, you can use Storm, VoltDb instead. The lower layer of Hadoop uses the same structure for MapReduce and HDFS. The system also manages the database (in memory or offline) using HIVE, HBASE and SQL, and can also store historic city planning information.

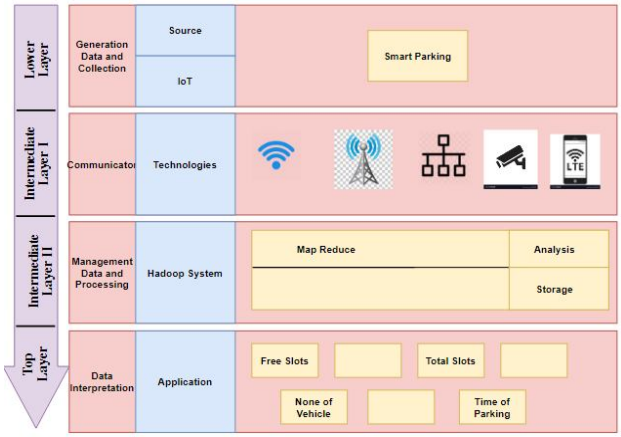

Figure 4: IV-Level Architecture for IoT Big Data Analytics for Smart Parking System

All data are stored on Hadoop using HDFS, and analysis is done at the secondary level II. The last layer is the interpretation layer, which uses the results of the analyzed data to produce reports.

Figure 5 shows a complete model of planning the implementation of the system. It details all the steps that occur between data processing and decision making. The system has a relay node that is responsible for collecting data from all sensors in the system. Communicate with sensors using ZigBee technology.

The relay collects data from all sensors and sends it to the analysis system via GW and the Internet. The sensor has a lot of metadata and also produces heterogeneous data. Therefore, all unnecessary metadata and excessive data are discarded. In addition, data is classified by message type and identifier. After classification, confidential data is converted to a format that can be understood by the Hadoop ecosystem, such as sequence files.

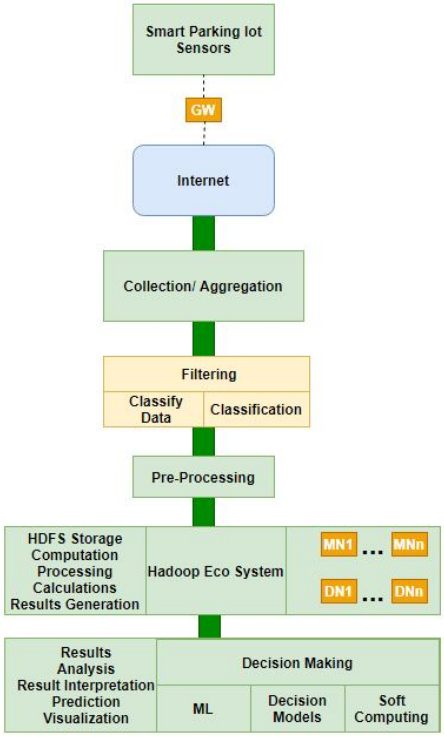

Figure 5: Proposed Implementation Model

3.4. Use of Big Data in the Cloud

Cloud provides data storage and computing resources for car parking services. It stores at the 'big data', among others availability of car parks, car parking areas, car location, users, location and profile, etc.

All data updates are stored in Hadoop's HBase database to support in real time all question as verification, while historical data is serialized to HIVE (a form of data warehouse in Hadoop).[24]

For computing, a number of Map / Reduce Algorithms are used, such as the recommendation algorithm to suggest 'best' parking locations for users, based on the user parking profile update algorithm, etc.

4.CONCLUSION AND FUTURE WORK

In this paper, we have proposed an IoT-based system that performs smart parking, makes real-time decisions based on current parking decision scenarios, and makes it easier for citizens and governments in Jakarta to reduced illegal parking and store parking fee to the government to earn income. Use the top-level Hadoop and Spark ecosystems to process large amounts of data at breakneck speeds. Test and evaluate system efficiency using existing intelligent system data sets. In the future, we plan to implement systems with smart parking systems that are practical and test the actual implementation and feasibility of the system.

This paper also proposes a system for analysis of large-scale parking data based on commodity hardware and a group of Hadoop MR platforms to investigate the ability of intelligent parking platforms to process and analyze large data in Jakarta. Collection of individual parking data is processed by the Hadoop to provide information about parking conditions, such as parking occupancy in the rush hour window every Sunday, for the driver or driver. Provides

parking operators. Hourly parking data for selected days. Or the average daily, weekly, or monthly work in the parking lot. In addition, this parking analysis supports parking operators to immediately detect unusual behavior related to parking operations and detect low-level infrastructure.

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