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Proposed Design and Modeling of Smart Energy Dashboard System by Implementing IoT (Internet of Things) Based on Mobile Devices

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***Abstract*— Electricity is one of the most important needs of the community, efficient use of electricity is very difficult to do when people lack awareness and discipline in using electricity, one of the problems that often occurs is when the homeowner is not at the location and wants it. to control electrical equipment. Internet of Things (IoT) is a concept with the aim of expanding the connectivity of internet networks connected to global networks, IoT can be used to control electronic equipment remotely or automatically. This study aims to build a remote control device that utilizes internet technology by carrying out the process of controlling existing devices on the internet network through systems on mobile devices, the contribution of this research is to create designs and models that will be used to build smart energy devices that are applied to home features smart by using sensor devices so that electronic equipment can be controlled according to the desired conditions, automatically or remotely on the android application. The smart energy dashboard is designed using the ESP8266 MCU node which is connected to the Firebase cloud which will move the digital signal to the relay as an electrical circuit breaker. Based on the results of system testing at 90.3% usability, 85.8% functionality and 90% Reliability, the Efficiency aspect test obtained the highest level of CPU efficiency at the level of 28% and dropped stably at a percentage of 10%, for the highest memory usage of 119.2MB begins with a memory usage of 47.7MB out of a total allocation of 143.1 MB. The conclusion of this study is that the IoT-based smart energy Dashboard proposal can help in controlling electrical devices in real time.**

Keywords—smart home, smart building, internet of things

I. INTRODUCTION

Electrical energy is one of the most important community needs and as an economic resource that is most needed in various activities. in the future, electricity needs will continue to increase along with the increase and development of both the population, the number of investments, technological developments including the world of education [1]. Electrical energy is one of the basic needs of society which has an important meaning in advancing public welfare, educating the nation's life and improving the country's economy [2].

Savings in using electricity is the first step that can be taken to assist the government in reducing the deficit of electricity resources in Indonesia [3]. Intelligent energy in buildings is an important research area of the IoT, With the advent of the new advances and techniques on Information and Communications Technologies (ICT), every place, everything and everyone can be directly involved with embedded technology that enables connections and communication to run efficiently on the basis of the technology promoted by IoT [4]. Smart building is the next generation of the environment and work, the uniqueness that is owned is by utilizing the use of ICT to coordinate various aspects in order to improve user comfort, energy efficiency and security of users [5]. Reduction in energy consumption can be done by reducing the use of energy services which are less or can be considered as energy conservation, although energy conservation reduces energy services but it can improve environmental quality, national security, personal financial security and higher savings, on a greater, energy savings are an important element of energy policy. Energy conservation is often the most economical solution to energy shortages. Energy saving is very important for all of us, because we rely on energy for everything we do every day, therefore to maintain a good quality of life, we must find ways to use energy wisely [6].

The amount of electrical energy used in a building is a problem in controlling (household electrical appliances) such as lights, fans, refrigerators and televisions. As a result of the difficulty of controlling electricity used by occupants of the building will indirectly affect the cost of using energy used, therefore the need for a solution to how to control electricity use is easy. This study aims to build a system that can be used as a means to control electrical energy so that electricity use can be more efficient in its use, but it can also facilitate building owners to control electricity costs. Internet of Things is a new technology in internet access that can recognize objects of intelligence behavior related to making decisions and can communicate with themselves [7]. IoT consists of smart machines that can be combined and run with other machines, objects, environments and infrastructure, IoT represents a general concept of network devices that can collect data from around the world and then collect that data over the internet that can be processed and used for various purposes interesting [8].

IoT can connect various objects not live through an internet connection and can connect them to share information and be able to carry out automation processes for humans to make their lives easier [9]. The IoT paradigm allows that there are many objects connected to an internet network that surround us in a large and inexpensive manner, with forms such as physical objects and control systems [10].

II. THEORY AND METHOD

IoT is a technology that provides connectivity for anyone at anytime and provides anything and anywhere. With the advancement of technology, we are moving towards society, where something and everyone will be connected [11]. IoT is the ecosystem of physical objects that are connected and can be accessed via the internet. Things in IoT can be someone with a heart monitoring device, an object that has been given an IP address and has the ability to collect and transfer data over the network without manual assistance or human intervention. Embedded technology in objects can help them to interact with internal conditions or the external environment, which in turn affects the decisions that will be taken [12]. IoT is a multidisciplinary field and dynamic universal network infrastructure with independent configuration capabilities based on standard and interoperable communication protocols where physical and virtual objects have unique characteristics, implicit personalities and intelligent interfaces that are easily incorporated into information networks [13].

A. *Architecture IoT*

IoT is considered as the third wave of the world wide web (WWW) after static web pages and social networking's based web. The IoT is a worldwide network that connects different type of objects at anytime and anywhere via a popular internet protocol named internet protocol [14]. Until now there has not been a single consensus agreed upon for the determination of IoT architecture. various architectures are proposed by different researchers such as three-layer architects and five-layer architectures, while the most basic IoT architecture is a three-layer architecture published at the beginning of IoT research [15]. Three-layer and five-layer IoT architecture can be seen in fig. 1 below.

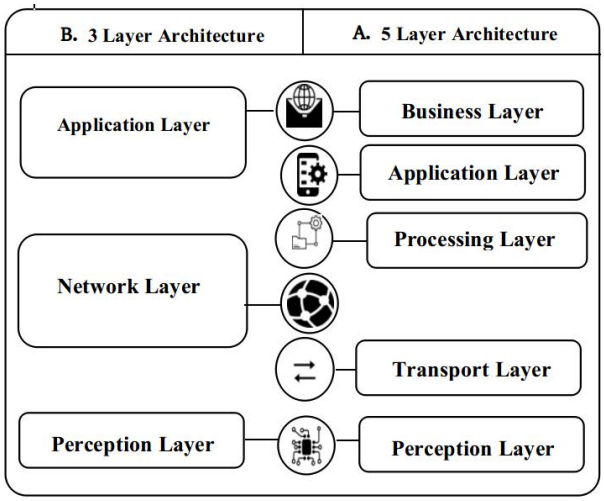

Fig.1. Architecture IoT (three and five layers)

The perception layer can be interpreted as a physical layer that has a sensor device to sense and collect information about the environment, this layer can also sense some physical parameters or identify other smart objects in an environment. The network layer is responsible for connecting intelligent things to network devices and servers, including features related to sending and processing sensor data. The application layer is responsible for sending application services specifically for users, this layer defines various applications where the internet of things can be used, for example smart homes, smart cities and smart health. The three-tier architecture defines the main ideas of IoT, but for some reason the three-tier architecture is felt to be insufficient, so some studies propose a five-layer architecture in a literature, several layers in five-tier architecture: perception, transportation, processing, application and business layer . both architectures have the same role in the application layer and perception layer, three different layers in the five layer architecture are: The Transport layer functions to transfer sensor data from the perception layer to the processing layer. The processing layer is also known as the middleware layer, the function of the middleware layer is to store, analyze and process large amounts of data from the transport layer. The business layer is responsible for managing the whole IoT system, including applications, business models and profits, and user privacy.

B. *Application Overview*

The application layer is responsible for sending application services specifically for users, this layer defines various applications where the internet of things can be used, [15]. in this study we use android, with cellular-based customers that continue to grow, the existence of various handsets and market value of services is an added value for the cellular industry and application developers, on the other hand android has an impressive impact on consumers [16]. Android is a popular open source software architecture provided by the open handset alliance which currently targets mobile devices, such as smart phones and tablet computers [17]. Android is a software stack for mobile devices that includes the operating system, middleware and key applications. The android SDK provides tools and APIs needed to develop applications on the android platform using the java programming language [18].

From an architectural point of view, the android operating system is divided into four layers: kernel layer, library, and run-time layer, application framework layer and application layer, the android kernel is a modified version of the linux2.6 kernel that is updated from time to time with various android versions. The library provides support for graphics, media capabilities, and data storage [19]. The Fire-base Real-time database is a database that is hosted in the cloud. Data is stored as JSON and synchronized in real-time to each connected client. The fire-base real-time database allows us to create collaborative applications by providing secure access to the database, directly from client-side code. Data is stored on a local drive. Even when offline, real-time events continue, so the end user will feel a responsive experience. When the device connection is restored, real-time database will synchronize changes in local data with remote updates that occur during the offline client, so that each difference will be automatically combined [20].

C. *Perception Layer Overview*

The perception layer can be interpreted as a physical layer that has a sensor device to sense and collect information about the environment, this layer can also sense some physical parameters or identify other smart objects in an environment [15]. This layer is basically related to the identification and collection of specific information objects

by sensor devices. Depending on the type of sensor, information can be about location, temperature, orientation, movement, vibration, acceleration, humidity, chemical changes in the air etc, [12].

The information collected is then forwarded to the Network layer for safe transmission to the information processing system. Micro-controller is an integrated collection that has several important features. Central processing units, unit range from 4 bits to 64 bits, it has volatile RAM for storing data, ROM, EPROM, EEPROM, flash memory for programming and storing parameters used, two-way I / O pins that aim to connect and fix problems connections, UART, serial communication interfaces such as I2C, serial peripheral interfaces and control area networks for system interconnections, peripherals such as timers, PWM generators, time controllers, clock generators, ADC, DAC, and debugging support [21]. NodeMCU ESP 8266 is a development derivative module for IoT platform modules, this module functions almost similar to the arduino module platform, which distinguishes this module specifically "connected to the internet". The NodeMCU module is a compact board that is very small and has the ability to be programmed and connected to the network via wireless. In other words, the NodeMCU board is a system on chip (SOC) with integrated TCP / IP protocol. In a network, NodeMCU can function as a server, client or both. In server mode, NodeMCU applies as hosting and in client mode NodeMCU can request on the server.

In addition, NodeMCU has an input / output pin that can be connected to a sensor or actuator so that data from the sensor can be sent to the server and can activate the actuator based on the data received [22]. DHT11 is a module that has a humidity and temperature complexity with a calibrated digital signal output, this module is a combined module to measure humidity and temperature that can provide a calibrated digital signal output. DHT11 can provide very precise humidity and temperature values and ensure high reliability and long-term stability, this sensor has components that can measure humidity, temperature with NTC type, 8-Bit Micro-controller and has a fast and cost-effective response [23]. DHT11 sensor has resistive type humidity, this sensor has a low power range [24].

D. Perception Layer Overview

The Network Layer can also be called the transmission layer. This layer functions to transfer information from the sensor device to the information processing system. The transmission media can be wired or wireless and the technology can be 3G, UMTS, Wi-Fi, bluetooth, infrared, ZigBee, etc., depending on the sensor device. network layer transfers information from the perception layer to the middleware layer. Each device is connected and communicates with only other devices that implement the same type of service. This layer is responsible for service management and has a link to the database. It receives information from the network layer and saves it in the database [12]. overall as in the energy smart architectural drawings (fig. 2).

E. Research Framework

Framework for thinking is the main flow of research with several stages: (1) identification of problems : difficult to control the number of lights in a building, the large amount of electrical energy in the building will have an impact on the cost of energy use. (2) approaches solution : the flexibility of controlling electrical energy through the system, efficient use of electric energy. (3) proposed: building a remote electric tool control system with a system using an IoT-based mobile device. (4) results : make it easier for building owners to control-electricity costs. (5) validation: testing the smart home prototype by using an dashboard control based on IoT. Research is the framework of the relationship between concepts that want to be observed or measured through research to be conducted. This research was conducted based on the problem of the difficulty of controlling the number of lights in the building and the use of electrical energy that has an impact on the cost of expenditure based on the energy used.

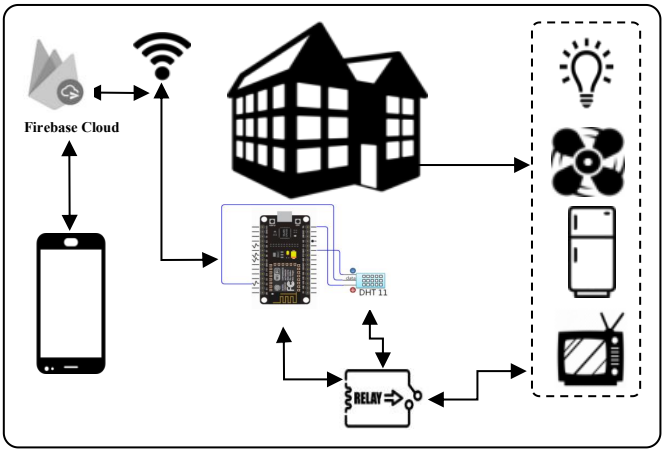

Fig. 2. Smart Energy Architecture

III. DESIGN SYSTEM

A. Software Feature Design & Concept

This section discusses how many electrical devices will be controlled, whether to control only one electrical device or which regulates all electrical devices at one time. the application design stage uses Arduino IDE which is a software downloader for NodeMCU Esp8266, this Arduino IDE program which is the interface between hardware and software. The software design that will be built there is a software control feature. This is intended because in a place that does not all require the same level of lighting, it can be taken for example in one building has seven rooms.In the kitchen room, for example, it is still in a condition with less sunlight intensity while in the living room or garden the intensity of sunlight is bright enough. Therefore, in terms of saving the power used, the design of the software built will be made to adjust the conditions.

This system contains electrical controller devices such as lights, fans and televisions that are integrated in the android application, which aims to make it easier for building owners to control electrical devices in the building remotely. The system is made to be easily used by building managers. System users will be given a dashboard menu consisting of several images of existing rooms in a building. On the dashboard system menu, users are given several room choices to control, including: room space, bathroom and electrical equipment such as televisions and fans using the on / off selection button. As for the design of the tool that will be made consists of: (1) MCU Node Circuit as the main component of the on / off control of the Fan Lamp and

Television Remote. (2) Relay circuit functions as a switch or AC and DC voltage breaker.

B. *Use Case and Flowchart Diagrams*

Use Case diagram is one of the diagrams that make up UML (Unified Modeling Language), serves to identify use cases, a series of actions that one system can run in scenarios, and actors, which represent external factors (users or external systems) that interact with the system [25]. In this study the Use Case Diagram illustrates the expected functionality of a system. Use Case can present an interaction between actors with the system. This process is carried out by the user (user) so that the user can select the required menu, select the sub menu and see the temperature notification.

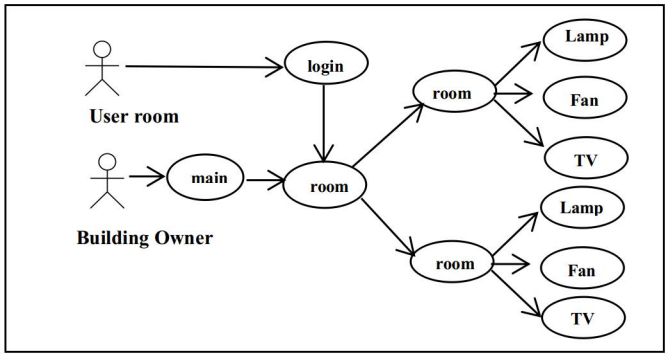

Fig.3. Use Case Diagram

Flowchart is a tool used to explain program logic, in the form of a chart that explains in detail the steps of the program process (Fig. 3, 4). (1) After the system design stage and determining the components, the next step is to assemble the tools in accordance with the system design that has been made. (2) Prototype hardware that has been built is in the form of miniature houses that contain simple equipment such as lights, fans and televisions, then the series that has been built will be connected to the application so that it can be controlled via an android smart phone.

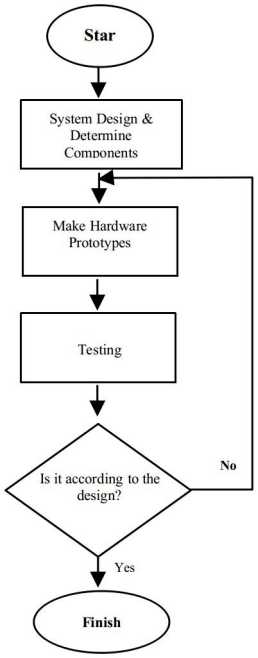

Fig.4.Flowchart Diagram.

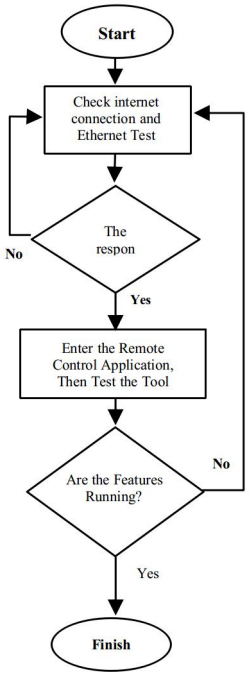

Fig.5. Device Working

(3) If the electronic circuit has been completed, the next step is to build an application program using the arduino IDE, then the application is extracted into the apk form and installed on Android. (4) Furthermore, the success and the applications that have been installed on the smart phone will be tested for success. If the test results are in accordance with the design, the system has been successful. (5) The success rate can be seen based on the accuracy contained in the android as a remote, if there is a change in the tool according to the command it can be concluded that the trial was successful. But if there is a mismatch between the tool and the application, the prototype must be rebuilt. But if it is in accordance with the system, then the system has been completed.

C. *Interface Design*

Interface design is the design of the system equipped with specifications of each image 5 Layer Architecture

and text there are several displays such as menu interfaces, room control dashboards, ser management and control of electrical devices connected to the system. (1) On the main menu interface, the application will display an icon that functions as a function button directing the application user to enter the control system in each room in the building. (2) on the room selection dashboard (Fig.6), it functions as a menu for selecting room choices to be controlled by electrical devices and connected to the system. (3) Login menu functions to set access rights on the electrical device controls in the room, the password is only used for the room manager. On the electrical appliance control menu (Fig.7), there are several buttons or icons that function to control the electrical appliance according to their functions such as lights, televisions, fans, and several other electronic equipment.The button functions for electrical breakers connected to electronic devices. The dashboard menu of room temperature and humidity data (Fig.8) is a function of displaying the temperature of the temperature and humidity in the room which can provide information and be an indicator of fan life when the temperature is > 30 'C.

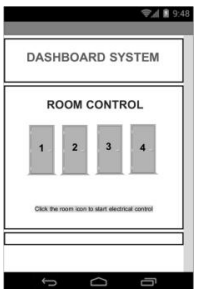

Fig. 6. Room Control.

Fig.7. Device

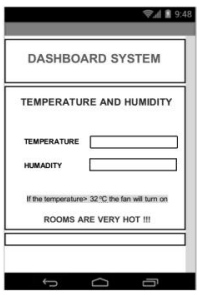

Fig.8. Temperatur

IV. SYSTEM FEASIBILITY TESTING

to ensure quality in the system that is not only needed by the management and management,but also supports strict standards. Through measurements and metrics, the software industry will examine products and services that meet the requirements [26]. International organization for Standardization / International Electronic Commission or called ISO 9126. the purpose of testing is aimed at minimizing errors and discrepancies in the use of the system to match what is expected by the user. Tests carried out on the smart energy dashboard system using ISO 9126. Testing

will be carried out by giving questionnaires to some respondents who function as building managers (admin) and some respondents act as room users (users). Of the several respondents who filled out the questionnaire will conduct tests aimed at testing the quality of the smart energy dashboard system, the respondent's answer to be processed is the respondent who gave a valid questionnaire answer. Respondents' responses to application quality will be measured using the following formula:

$$\text{Result} = \frac{\text{Actual Score}}{\text{Ideal Score}} \text{ x } 100\ \%$$

The actual score is the answer of all respondents to the questionnaire that has been submitted. The ideal score is the highest score or weight or all respondents are assumed to choose the answer with the highest score. the level of software quality is measured in every aspect of quality based on the results of the questionnaire answers that will be obtained by the respondents are as follows [27]. (1) testing based on functionality aspects : The functionality aspect is the ability of the software to provide functions according to user needs, when used under certain conditions, (2) testing based on usability aspects : the usability aspect is the ability of software to be understood, studied, used, and attractive to users when used in certain conditions, (4) testing based on efficiency aspects : the efficiency aspect is the ability of the software to provide appropriate and relative performance based on the amount of resources used. Aspect functionality is software that is suitable for users, compilation is used under certain conditions. Based on testing the level of reliability on the smart energy dashboard in very good criteria, with a percentage of 90%. Testing on the usability aspect is the ability of software to be understood, studied, used, and attractive to users when used in certain conditions, Based on testing at the usability level the application of smart energy dashboard systems is in very good criteria, with a percentage of 90.3% and 85.8% functionality. testing using the efficiency aspect is the ability of the software to provide appropriate and relative performance based on the amount of resources used. Test the aspects of effeciency using the testdroid tool. With testdroid it can be observed the use of memory (RAM), and CPU and in testing the aspects of this effeciency use devices that have been provided by testdroid that uses LG Google Nexus 5 D280 5.0 devices, the following results of testing aspects of effeciency with testdroid tools. Can be seen in the image below:

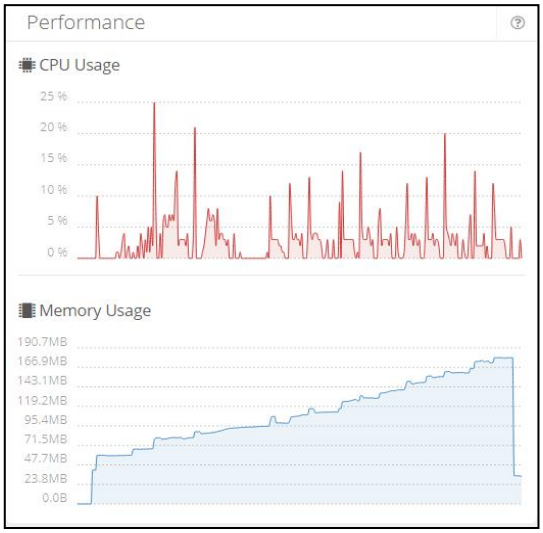

Fig.9. Efficiency Testing 1

The results of the first stage of the Efficiency aspect test on the smart energy dashboard obtained the highest level of CPU efficiency at the level of 25% and decreased stably at a percentage of 10%, for more than 166.9MB of memory beginning with 47.7MB of memory usage from a total allocation of 190.7MB. Furthermore, in the second stage of Efficiency Testing on the smart energy dashboard, the highest CPU efficiency level was at 28% and stably decreased at 10% percentage, for the highest memory usage of 119.2MB starting with 47.7MB of memory usage from a total allocation of 143.1MB

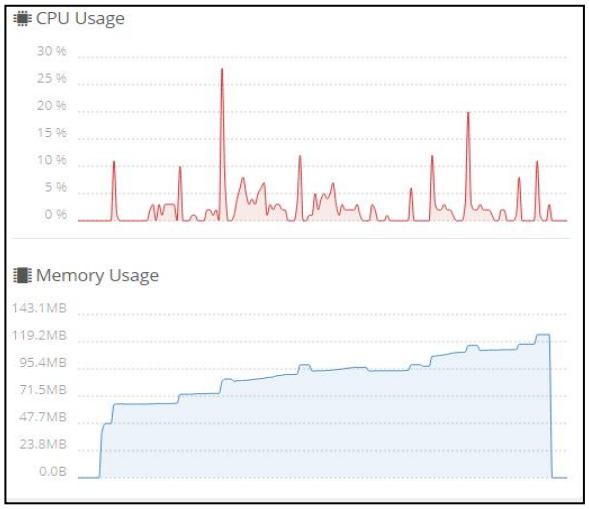

Fig.10. Efficiency Testing 2 & 3

The third Efficiency aspect test on the smart energy dashboard obtained the highest level of CPU efficiency at the level of 28% and dropped steadily at a percentage of 10%, for the highest memory usage of 119.2MB starting with 47.7MB of memory usage from a total allocation of 143.1MB, testing the stage all three get the same value as the second stage of testing. the acquisition of values from all aspects of testing gained 103 in the Functionality aspect, 46 in the Realiability aspect and 158 in the Usability aspect.

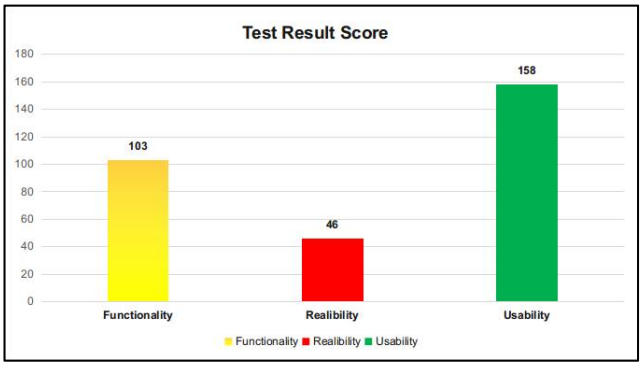

Fig.11. Actual Score on system testing

V. CONCLUSIONS

Based on the results of system testing at 90.3% usability, 85.8% functionality and 90% Reliability, the Efficiency aspect test obtained the highest level of CPU efficiency at the level of 28% and dropped stably at a percentage of 10%, for the highest memory usage of 119.2MB begins with a memory usage of 47.7MB out of a total allocation of 143.1MB. The conclusion of this study is that the IoT-based

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