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Characteristics and Cost Efficiency Analysis of an IoT- based Smart Breaker used as Automation in Buildings

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Abstract:- This research analyzes the working system of an Internet of Things-based smart breaker equipment used as a building automation system for application in the Boarding House Ampera building in Jakarta, Indonesia. This research was obtained from PT. Benih Par Sada, based on the request of the building owner, wanted to try a developing control system at a relatively affordable price. In Indonesia, there are already several providers of IoT-based control equipment, with varying prices offered by these providers. Therefore, this analysis of the working system focuses on cost efficiency and functional similarities of the smart breaker equipment compared to the building automation system commonly implemented in buildings in Indonesia.

***Keywords**: Cost, Building Automation System, Internet of Things, and Smart Breaker.*

I. INTRODUCTION

This research stems from the development of IoT equipment in Indonesia today and the demand for affordable market prices for a building automation control system. Along with the development of this IoT, there are already several breaker devices that can be controlled with an internet network and relatively affordable prices (Nugraheni, 2022) . Where this research wants to see how cost efficiency and control capabilities are using IoT-based equipment.

Building automation control generally consists of a multi-touch screen and direct digital control to be able to communicate with the controlling relays on the load breaker. And generally, the system can run after programming on the monitoring equipment and initializing every device you want to control, and generally, programming depends on the provider. To build automation equipment in a building using common equipment in a building, there are 2 things that the general owner thinks about. This is the cost and dependence of the owner on the provider if the equipment has problems during use. An overview of the equipment in the building automation system can be seen in Figure 1.

Fig. 1: Schema Building Automation System at Building

(Nugraheni, 2022; Paolillo et al., 2019; Rayes & Salam, 2017; Sharma et al., 2019; Siddula et al., 2018; Singhvi et al., 2019).

Whereas in the current IoT equipment, the applications promised by the provider are very friendly. Where software applications in IoT are quite easy to understand by some users. Both from installation to operation of the IoT equipment. In general, IoT equipment is divided into IoT Applications, IoT Management Service Platform, IoT Networks, and IoT Devices. Can be seen in Figure 2.

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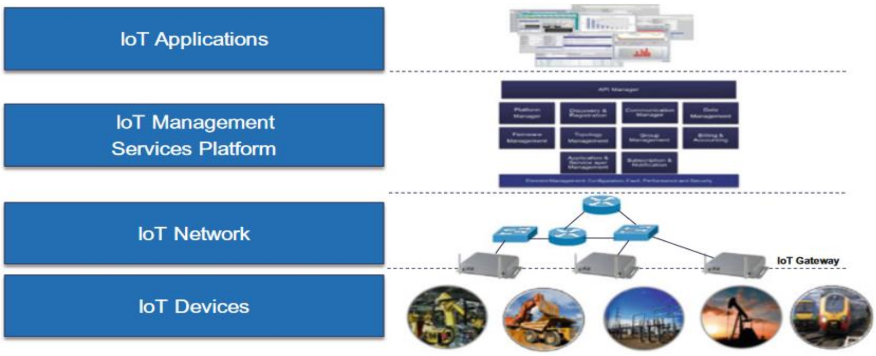

Fig. 2: IoT Level

II. METHOD

A. Object

The object of the equipment application will be the Boarding House Ampera building located in South Jakarta, Indonesia. The application will specifically focus on the parking area of the building for the lighting control system.

Fig. 3: Boarding House Ampera - Jakarta (Indonesia)

B. Topology

An illustration of the implementation of this control system is divided into two parts, namely, from the electricity and network side; it can be seen in Figure 4. The distribution side is limited; from the web, a smart breaker is used to be able to communicate with wireless systems, and from the electrical side, it appears that there are several protection components, namely electricity, magnetic contactors, and lights.(Alam et al., 2019).

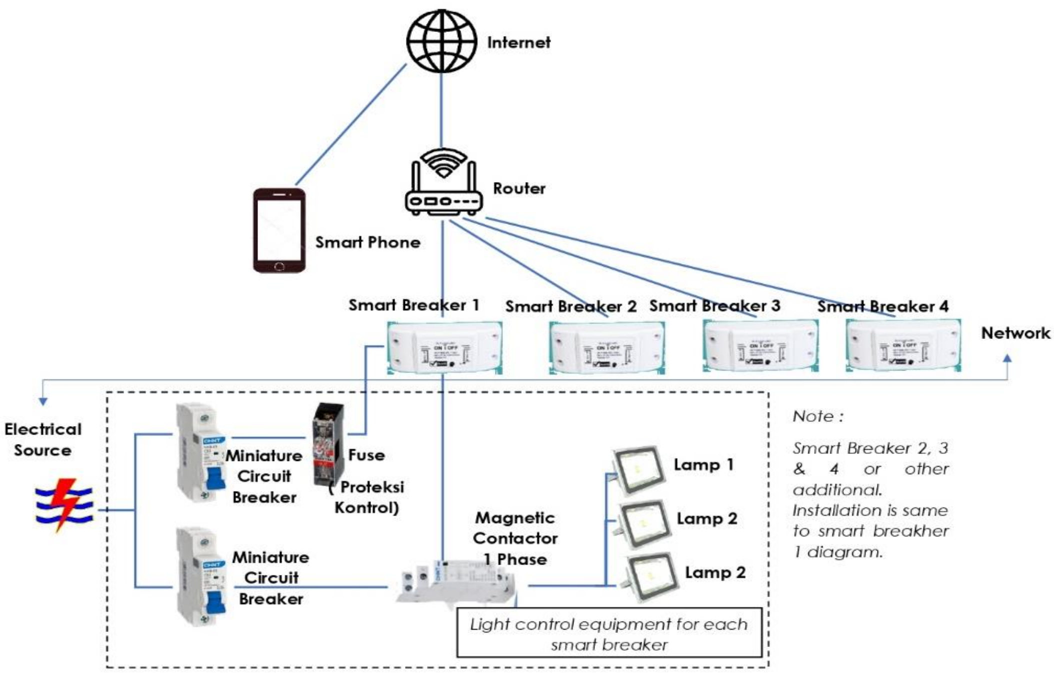

Fig. 4: Illustrates The Topology for The Application Of The Smart Breaker As A Building Automation System

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C. *Testing Plan*

In this system, the equipment will be tested by comparing two control systems, namely:

- Conventional control system
- Automation control system (application with smart breaker)

This is done to understand the functionality of the smart breaker equipment when used as a building automation system. The criteria for the smart breaker equipment to be considered suitable for a building automation system are as follows:

- Integration within a single control system
- Equipment can be monitored from a centralized monitoring panel
- Energy efficiency improvement after replacing the conventional system with automation
- Cost efficiency improvement after replacing the conventional system with automation.

D. *Equipment Data*

The equipment data to be analyzed consists of two types of equipment:

- Automation with a smart breaker
- Automation with commonly used equipment in buildings as a building automation system

The purpose of collecting data on the mentioned equipment is to assess the efficiency achieved by the smart breaker when used as a building automation system compared to the commonly used one. Data for conventional equipment is not collected as it is only used to test the functionality of the smart breaker system, and conventional systems are typically cheaper but have independent control.

The specifications of the tested equipment data are as follows:

- 12 Digital Inputs (as normally open and closed inputs for push buttons)
- Digital Outputs (as supply coils for main contactors/relays)

Table 1: Smart Breaker Equipment Data

No	Description	Quantity	Unit
1	Tablet/SmartPhone	1	Pc
2	Smart breaker, 1 Supply (220 Volt) & 1 Output (220 Volt)	6	Pcs
3	Lighting Board	1	Unit
4	Internet Installation (By Tekom)	1	Ls

The equipment data includes:

- Control equipment with a smart breaker
- Control equipment with Digital Direct Control (commonly used BAS applications in buildings)

Table 2: Direct Digital Control Equipment Data

No	Description	Quantity	Unit
1	Multi-Touch Panel 7 Inci & Digital Direct Control (12 Input & 6 Output)	1	Ls
2	Lighting Board	1	Unit
3	Internet Installation (By Tekom)	1	Ls

III. IMPLEMENTATION & RESULT

A. *System Functionality Testing*

Can be seen in Figure 5—the actual application of an intelligent breaker control system for a lighting system.

Fig. 5: Automation System with Smart Breaker

Through the system functionality testing, it was observed that the smart breaker met the criteria of a building automation system. This can be seen in Table 5.

Table 3: Testing Point For Smart Breakher

No	Description
1	Can the equipment be integrated into one system?
2	Can the equipment be monitored in one monitoring panel?
3	Can the equipment controlled by a smart breaker work automatically?
4	Does it result in efficiency?

Based on each testing point mentioned above, the following observations were made:

- Testing point no. 1, as shown in Figure 10, demonstrated that the smart breaker equipment could be integrated into a single system using an application that supports the installed smart breaker on a smartphone functioning as a multi-touch screen monitor.

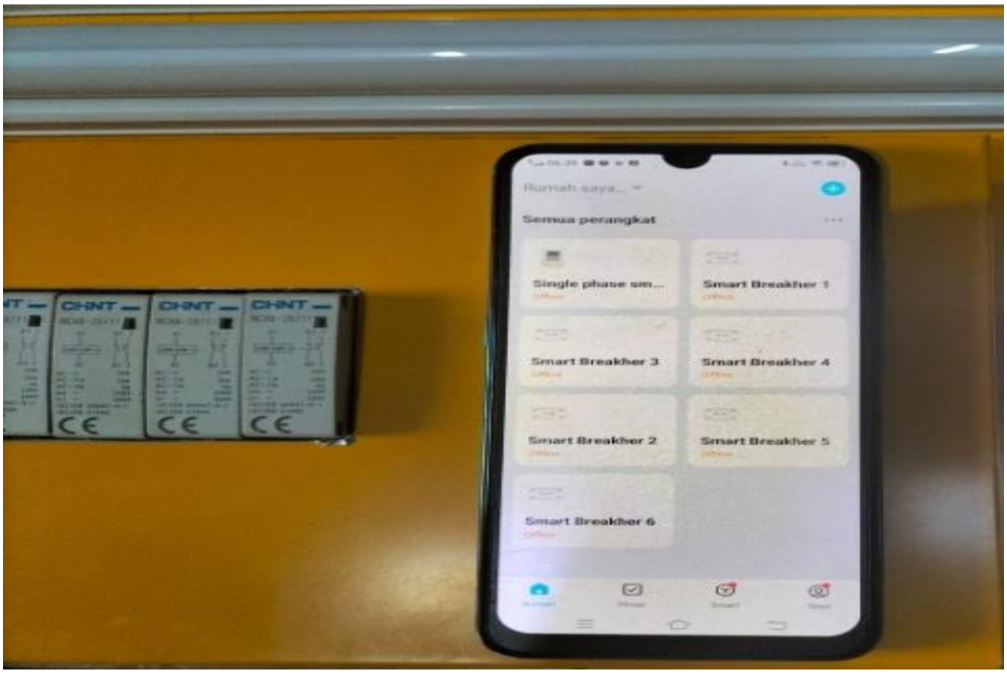

Fig. 6: Display On appication screen on smartphone

- Testing point no. 2, as depicted in Figure 7, showed that each smart breaker equipment could be monitored on a single monitoring panel. The smartphone displays information about each piece of equipment and its condition, allowing real-time control of the load controlled by the smart breaker.

Fig. 7: Display of Equipment on a section of the application screen

- Testing point no. 3, as seen in Figure 13, demonstrated that the smart breaker could be set based on time and sensors and controlled remotely by multiple users.

Fig. 8: Control Screen Display and Time Control Option for smart breaker control

- Testing point no. 4, dari pengujian diatas. Pengontrolan dengan menggunakan smart breaker dapat dilakukan pada waktu nyata dan tidak perlu menempuh jarak ke ruang kontrol, karena monitor sistem kendali dapat dikondisikan secara mobile. Sehingga menghilangkan waktu terbuang pada sistem kontrol konvensional.

B. Cost Efficiency:

The equipment data obtained in section 3 has determined the providers' prices of the equipment applications. The prices of the two control equipment options for building automation systems are shown in Table 3 for the smart breaker control equipment and Table 4 for the Direct Digital Control equipment.

Table 4: Cost Of Smart Breaker Control & Cost OF Direct Digital Control.

Item	Price (IDR)
Smart Breaker (6 Pcs x 1 Input & 1 Output)	289.400
Smart Phone (as Monitor Multi-Touch)	2.999.000
Lighting Board	7.360.000
Internet Installation (By Tekom)	341.100
Summary	**10.989.500**

Item	Price (IDR)
Multi-Touch Panel 7 Inci & Digital Direct Control (12 Input & 6 Output)	51.255.000
Lighting Board	7.360.000
Internet Installation (By Tekom)	341.100
Summary	***58.956.100***

The obtained prices show a significant cost efficiency(Scandizzo, 2021) when implementing the smart breaker as a building automation system compared to the commonly used building automation system in Indonesian buildings. Please refer to Figure 9.

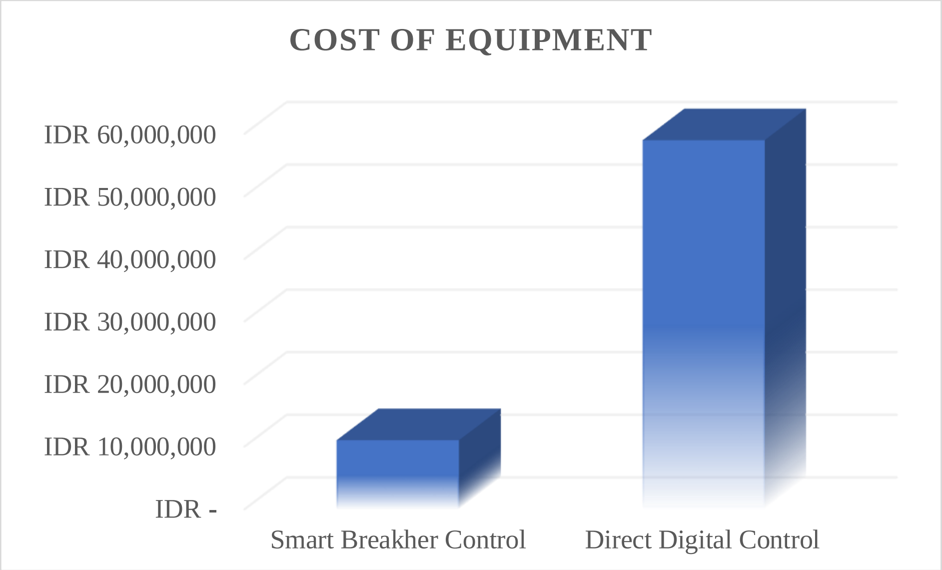

Fig. 9: The price difference between Smart Breaker Control and Direct Digital Control

Figure 10 shows the layout plan of the first-floor area in Boarding House Ampera. There is a distance between the panel room and the office area. When using conventional control, there is wasted time due to the distance traveled to the panel room.

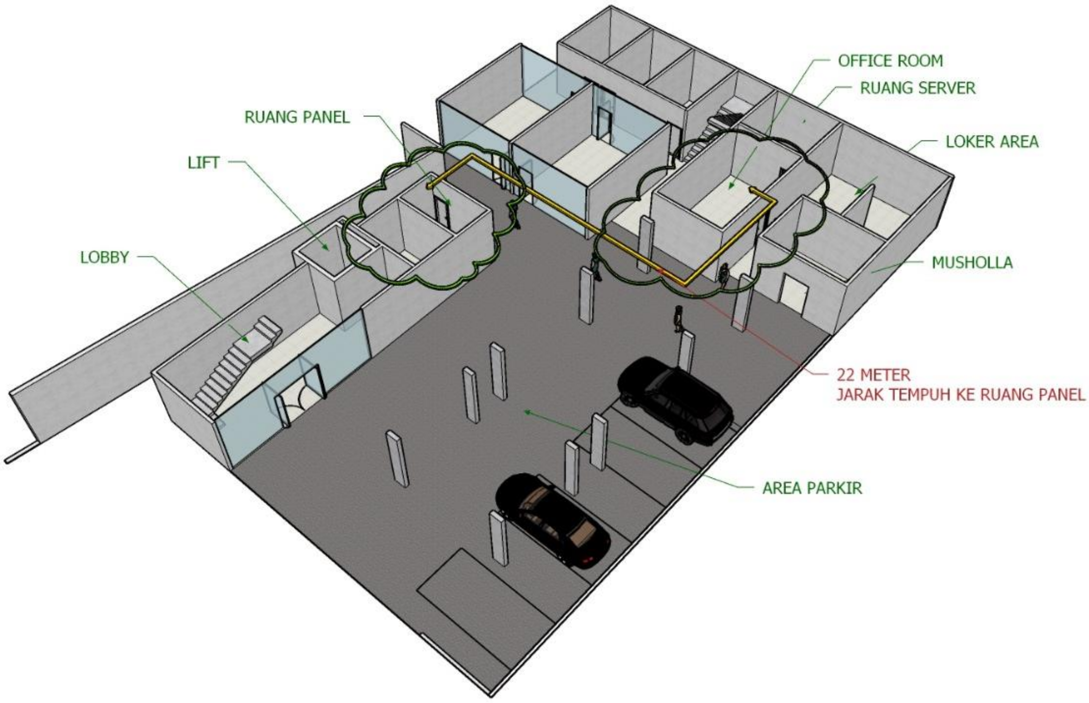

Fig. 10: Technician room to panel room condition and control distance traveled

The time wasted can be calculated based on the distance from the office area to the panel room. Assuming a standard walking speed of 1.5 m/s (Debauche et al., 2020) and a distance of 22 meters, the formula can be formulated as follows ("Kecepatan," 2023):

$$V = {}^{r}/_{t}$$

$$t = {}^{r}/_{V} \qquad (1)$$

Where:

V = Velocity (meter/second)
r = Distance (meter)
t = Time (second)

Thus, the wasted time is calculated as follows:

t = (22 meters) / (1.5 m/s)
t = 14.6 seconds

With the conventional system, there is wasted time and, consequently, wasted electricity consumption for lighting. Additionally, costs are incurred for the wasted electricity paid to the national electricity company (PLN) by the user. In contrast, the smart breaker system makes real-time control possible, eliminating wasted time(Chorshanbiev et al., 2020).

The object of the equipment application will be the Boarding House Ampera building located in South Jakarta, Indonesia. The application will specifically focus on the parking area of the building for the lighting control system.

IV. RESULT

So, based on the obtained test results, it can be concluded that the smart breaker meets all the criteria required for a building automation system. These conclusions are presented in Table 5.

Table 5: Result For Testing Point

No	Description	Yes	No
1	Can the equipment be integrated into one system?	√	
2	Can the equipment be monitored in one monitoring panel?	√	
3	Does the equipment controlled by the smart breaker work automatically?	√	
4	Does it result in cost efficiency?	√	

I recently discovered a significant cost difference between smart breaker control equipment and common BAS equipment in buildings. It's quite surprising how much of a difference it can make.

V. CONCLUSION

From the characteristic and cost efficiency, building automation systems can be considered to be developed in many buildings, especially with the current development of IoT. See the characteristics of one of the IoT equipment, such as a smart breaker. It can have similarities with the characteristics of common building automation system equipment in buildings. From a cost standpoint, it is also quite minimal for a building to apply an automation system to its equipment.

And many more engineering designs can be developed with IoT equipment to minimize wasted costs and control time.

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