Indonesian Journal of Electrical Engineering and Computer Science
Vol. 30, No. 2, May 2023, pp. 770~777
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v30.i2.pp770-777

Smart system for controlling and monitoring electronic facilities in budget hotel rooms

Daniel Patricko Hutabarat[1], Robby Saleh[1], Lukas Sebastian[1], Jonathan[1], Senanayake Mudiyanselage Namal Arosha[2]
[1]Department of Computer Engineering, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia
[2]Faculty of Science, University of Brunei Darussalam, Gadong, Brunei Darussalam

Article Info

Article history:

Received Oct 30, 2022
Revised Jan 18, 2023
Accepted Jan 26, 2023

Keywords:

Electronic facilities controller
Microcontroller
Sensors
Smart system
Web application

ABSTRACT

The fundamental attribute of a budget hotel is the provision of essential services at a low cost due to reduced services and facilities. Several services at budget hotels that affect customer choice are related to limitation of accommodation and entertainment services which include the use of television, air conditioning, and other electrical devices. The purpose of this research is to develop a smart system that is used to control and monitor electronic facilities in budget hotel rooms. This system provides budget hotels with the ability to select the electronic facilities that guests want to use in their rooms according to their needs and budget. This system also provides a feature to monitor the use of electronic devices in each room via a web application. The system was developed by using microcontrollers, sensors, radio frequency identification (RFID) devices, a database server, and a web application. The developed system can perfectly provide the room electronic facilities requested by the guest. The system can also monitor the service hour and power consumed by the devices with an accuracy of 99.1% for the service hour and 99.4% for the power consumed.

Corresponding Author:

Daniel Patricko Hutabarat
Department of Computer Engineering, Faculty of Engineering, Bina Nusantara University
Jakarta 11480, Indonesia
Email: dhutabarat@binus.edu

1. INTRODUCTION

Budget hotels are often synonymous with economy accommodation or limited service hotels which are used interchangeably. The fundamental attribute of a budget hotel is the provision of essential services at a low cost due to reduced services and facilities. The budget hotel concept is centered around customers who are millennials, business travelers and solo travelers who prefer lower costs but prioritize comfort over luxury during short stays [1]. Several services at budget hotels that affect customer choice are related to limitation of accommodation and entertainment services which include the use of television, air conditioning, refrigerators, and other electrical devices [2]. The problem that arises is how the budget hotel limits accommodation and entertainment facilities according to the needs of guests and the funds they have.

Applications of microcontrollers today cover almost every aspect of human life. Several applications of microcontrollers in the healthcare industry enable telemedicine services and remote health monitoring [3]-[5]. Several applications of microcontrollers in manufacturing allow automation, control, and monitoring of systems [6]-[8]. And several applications of microcontrollers in the hospitality industry enable smart restaurant and smart hotel [9]-[11]. In a microcontroller-based system, a microcontroller is usually used to monitor and control devices [12]-[17], Wi-Fi, internet, 4G, and GSM are used to connect devices [18]-[23] while a smartphone application or web application is used to manage and monitor system [24]-[26].

There hasn't been much research on the topic of smart hotels, especially smart budget hotels. Research on hotels, especially those related to the use of technology, mostly discusses the process of digitizing and automating hotel management systems [27]. In addition, there is also research related to electronic facilities that lead to automation to create smart green buildings [28]. In this kind of research, electronic facilities are controlled and automatically perform their functions for resource efficiency. In this research, where the subject is a budget hotel, electronic facilities are controlled with a different purpose, namely to give guests the opportunity to choose the electronic facilities they want to use in their rooms according to their needs and budget. With this facility, budget hotels will accommodate customers who only want certain services.

In this research, a smart system is developed to answer the needs of budget hotels in providing essential services to the guest by giving the opportunity to choose electronic facilities used in their rooms according to their needs and the funds they have. The contribution of the research lies in the development of a smart system that can control and monitor electronic facilities in budget hotel rooms so that guests can choose the electronic facilities they need. The built system can also be used to view device status, device service hours (duration), and device power consumption over a certain period of time. The system was developed using a microcontroller, sensor, radio frequency identification (RFID), device, database server, and web application.

2. METHOD

The system developed in this research is built according to the network topology that can be seen in Figure 1. From Figure 1, it can be seen that electronic devices are installed in three different rooms located on different floors. On each floor, there are managed switches and access points that wirelessly connect electronic devices in each room to the network on each floor. Managed switches on each floor are connected to Router B so that networks on each floor can connect to a public network switch that are connected to a database server located on the network managed by Router A. The client computer in the front office is connected to Router A via a managed switch, this allows the client computer to send all data entered by the front office staff to the database server.

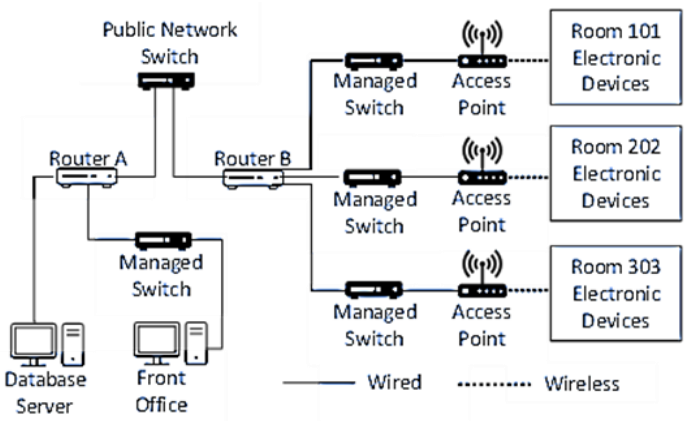


Figure 1. Network topology of the developed system

The block diagram of the electronics installed in each room can be seen in Figure 2. From the block diagram, it can be explained that the RFID card is read by the RFID reader and then the reader sends the card number of the RFID card to the database wirelessly via ESP 8266. The database will check the service ordered by the guest and send it back the information to ESP 8266. The information received by the ESP 8266 from the database is processed and then the result is sent to the 5 V Relay in the form of a signal. The information contained in the signal allows the system to activate the device according to the choice made by the guest. Arduino uno provides 5 V voltage to turn on relays and sensors so that they can carry out their functions. At the same time, Arduino uno also receives current data from the ACS712 sensor. All data received by Arduino uno from sensors is sent to the database server via ESP 8266. All sensor data received by the database is processed to measure service hours (duration) and power used by the lamps and devices. All devices are considered working if current value sent by ACS712 is above 0.44 A. The service hour (duration) of the device is measured from the time taken for the device from ON to OFF mode. The power value is measured from the average current value when the device was working multiplied by 220 volts as the standard voltage in Indonesia.

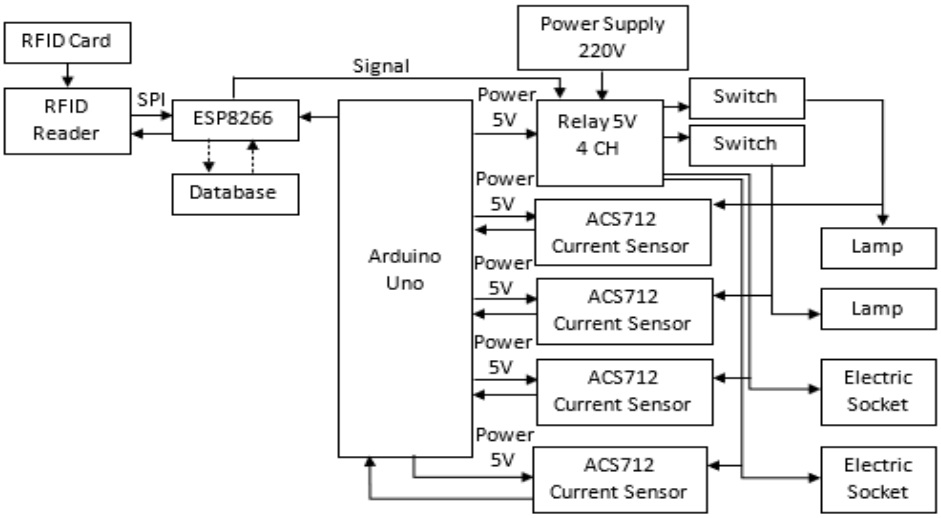


Figure 2. Block diagram of the electronic devices installed in the hotel room

The web application developed in this study can be seen in Figures 3-5. Figure 3 shows the the card data page that gives user access to information related to the RFID card used by the guest or the hotel staff. On this page, information provided is the RFID card number, ID number, name, status (guest or staff), room number, and the service chosen by guest or provided to staff. On this page there is a date picker box to filter the needed information. There is also a blue button at the bottom left of the page that serves to update RFID card data. The update card button on this page is a button to enter the update card data page that can be seen in Figure 4. The function of the update card data page is to update the card data to the database server (including the registration of a new card or deleting card information that has been used). The data entered to the database from this page are card number, ID number, name, status, room number, and the service selected by the guest or provided to the staff. A new RFID card can be automatically registered to the database by filling in all the fields on this page. From Figure 5 can be seen the device monitoring page, from this page users can access information about the date, card number, device, duration (service hours), and power consumed. This page serves to monitor devices' service hours and power consumed from certain devices in certain rooms and on certain days by using the filter function above the table.

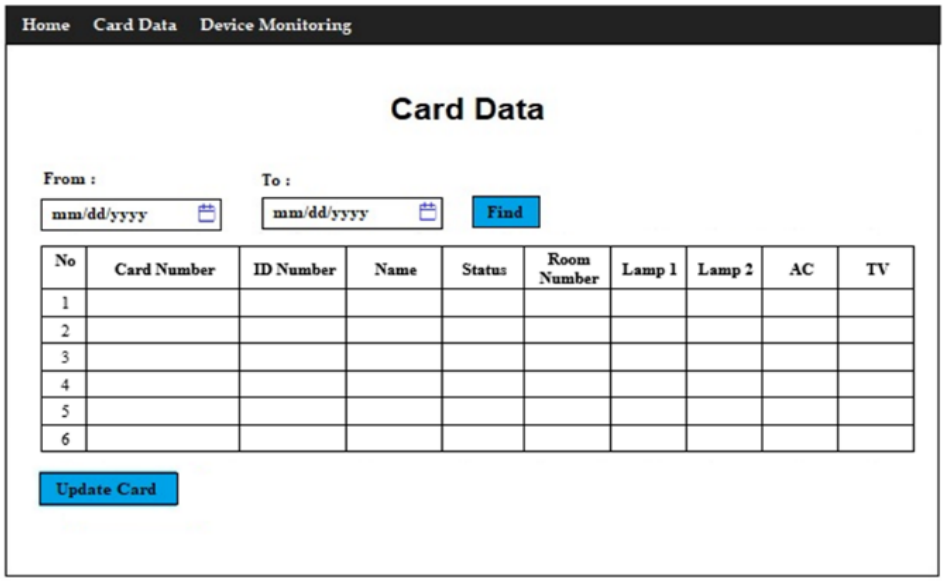


Figure 3. The page of card data

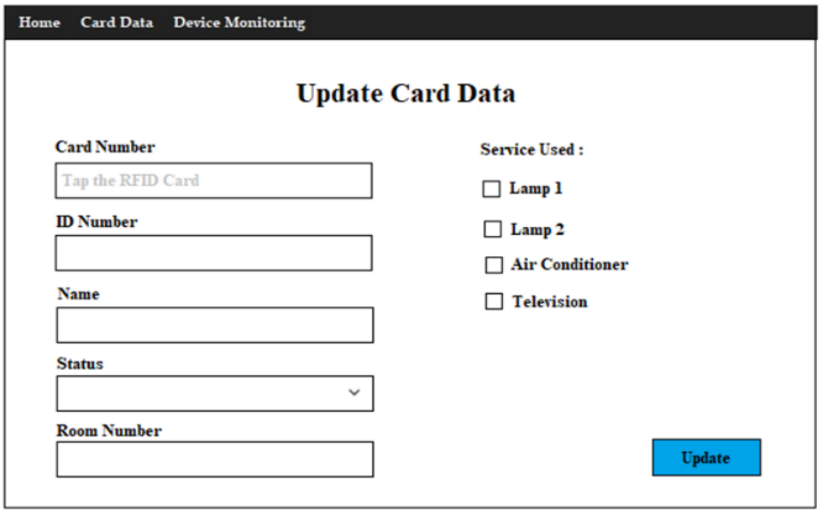


Figure 4. The page of update card data

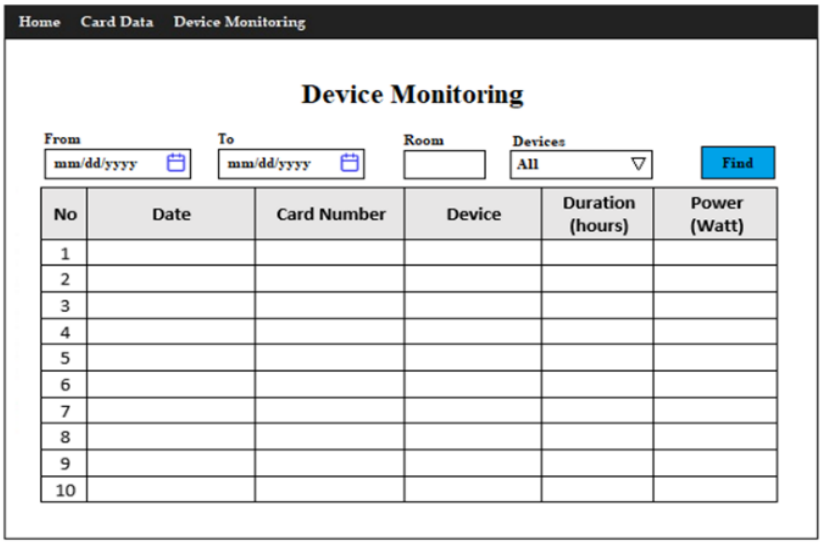


Figure 5. The page of device monitoring

3. RESULTS AND DISCUSSION

In this research, the first test was done to see the system update process. In this test there are three group of data that are input to the system via the update card page. The first group was entered one day earlier than the second group. The RFID card used in this test is brand new (never been registered). The data entered into system can be seen in the Table 1. The example of the data entered into the system via the update card page can be seen in Figure 6 while the results of updating the data can be seen in Figures 7-9. Figure 7 shows the results of the updating process on the first day while Figure 8 show the results of the updating process on the second day. To see the use of the RFID card from Day 1 to Day 2, it can be done by filtering the data as shown in Figure 9.

Table 1. The sample data used in system testing

No	Group	Card number	ID number	Name	Status	Room number	Lamp 1	Lamp 2	AC	TV
1	1	BA8B9815	1234567	Ahmad	Guest	101	on	off	on	on
2	1	3A59919	2135476	Budi	Guest	202	on	on	on	off
3	1	BB9C8962	3214675	Charli	Guest	303	on	on	off	on
4	2	3A59919	234765	Dani	Guest	202	on	off	off	off
5	2	BB9C8962	345321	Ella	Guest	303	off	on	on	off

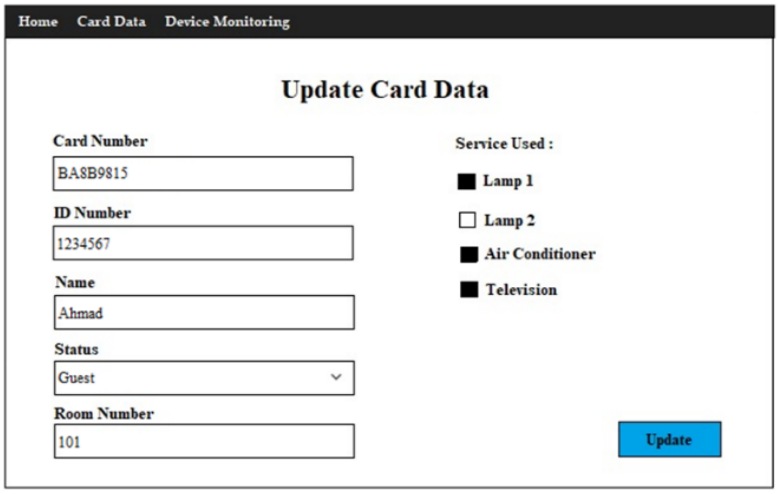
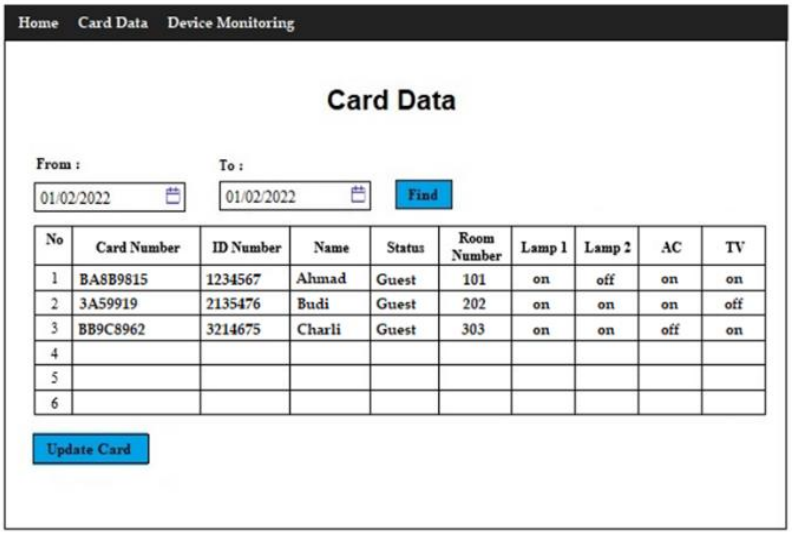
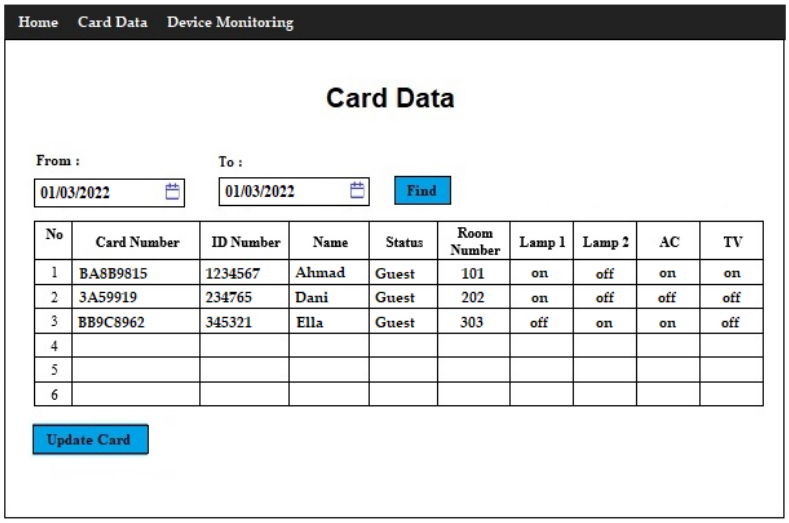


Figure 6. The example of data entered to the system



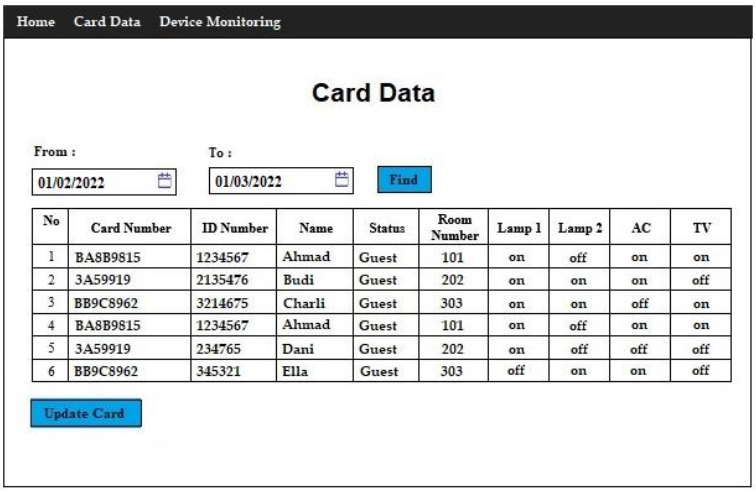
No	Card Number	ID Number	Name	Status	Room Number	Lamp 1	Lamp 2	AC	TV
1	BA8B9815	1234567	Ahmad	Guest	101	on	off	on	on
2	3A59919	2135476	Budi	Guest	202	on	on	on	off
3	BB9C8962	3214675	Charli	Guest	303	on	on	off	on
4									
5									
6									

Figure 7. The result of data updating on the 1st day



No	Card Number	ID Number	Name	Status	Room Number	Lamp 1	Lamp 2	AC	TV
1	BA8B9815	1234567	Ahmad	Guest	101	on	off	on	on
2	3A59919	234765	Dani	Guest	202	on	off	off	off
3	BB9C8962	345321	Ella	Guest	303	off	on	on	off
4									
5									
6									

Figure 8. The result of data updating on the 2nd day



No	Card Number	ID Number	Name	Status	Room Number	Lamp 1	Lamp 2	AC	TV
1	BA8B9815	1234567	Ahmad	Guest	101	on	off	on	on
2	3A59919	2135476	Budi	Guest	202	on	on	on	off
3	BB9C8962	3214675	Charli	Guest	303	on	on	off	on
4	BA8B9815	1234567	Ahmad	Guest	101	on	off	on	on
5	3A59919	234765	Dani	Guest	202	on	off	off	off
6	BB9C8962	345321	Ella	Guest	303	off	on	on	off

Figure 9. The use of RFID card from first to second day

From Figure 7 it can be seen that on the first day there were three guests who checked into the hotel and each guest was given an RFID card. From Figure 8 it can be seen that Ahmad was still staying at the hotel on the second day, but Budi and Charli had already checked out and their RFID cards were used for new guests (Dani and Ella). From Figure 9 can be seen a list of RFID cards used on the first day to the second day. From the discussion above, it can be concluded that the algorithm and database developed on the system have been running as expected so that the update process can run very well.

The second test is done to see the accuracy of the system. In this test the measurements obtained from the system are compared with the actual measurements. To measure the actual service hours, a timer is used, while the actual power value is obtained from the datasheet of each device. The results of the second test can be found in Tables 2 dan 3. From the two tables it can be seen that the accuracy of the system for measuring service hours (duration) is 99.1%, while the accuracy of the system for measuring the power used is 99.4%. The accuracy of the system developed is very good, but specifically for the accuracy of measuring service hours, it needs to be improved considering that a 0.9% measurement error will have an impact on the funds spent. Threshold 0.44 A as the ON and OFF conditions of the device can cause an error in the calculation of service hours by 0.9%.

Table 2. The accuracy of system to measure the service hours

No	Date	Card number	Room number	Device	Duration (System)	Duration (Actual)	% Accuracy
1	1/2/2022	BA8B9815	101	Lamp1	3	2.98	99.3%
2	1/2/2022	BA8B9815	101	AC	6.2	6.17	99.5%
3	1/2/2022	BA8B9815	101	TV	2.7	2.66	98.5%
4	1/3/2022	BA8B9815	101	Lamp1	2.6	2.58	99.2%
5	1/3/2022	BA8B9815	101	AC	5.3	5.26	99.2%
Average percentage of accuracy							99.1%

Table 3. The accuracy of system to measure the power consumption

No	Date	Card Number	Room Number	Device	Power (System)	Power (Actual)	% Accuracy
1	1/2/2022	BA8B9815	101	Lamp1	5	5	100.0%
2	1/2/2022	BA8B9815	101	AC	720	725	99.3%
3	1/2/2022	BA8B9815	101	TV	79	78	98.7%
4	1/3/2022	BA8B9815	101	Lamp1	5	5	100.0%
5	1/3/2022	BA8B9815	101	AC	718	725	99.0%
Average percentage of accuracy							99.4%

4. CONCLUSION

The developed system is able to answer the needs of budget hotels in providing essential services to the guests by giving the guests the opportunity to choose electronic facilities used in their rooms according to their needs and funds. This can be seen from the performance of the developed system in updating the database correctly, turning on and off the device due to guests selection, and providing complete information about the

RFID card data on the web application. The developed system is also able to provide information to hotel staff regarding working hours and the power used by the device selected by the guest through the web application. The accuracy of the system in providing information on working hours and the power used by the device per day reaches 99% for working hours and 99.6% for the power used by the device. With the development of this system, budget hotels can provide added value to guests in choosing the services they need. For the flexibility of hotel guests in choosing services, it is necessary to develop a smartphone application so that guests can easily add or change the services they need.

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BIOGRAPHIES OF AUTHORS

Daniel Patricko Hutabarat received the Bachelor Degree in telecommunication engineering from Telkom University, Indonesia, in 2021 and the Master Degree in electrical engineering from Trisakti University, Indonesia, in 2006. Currently, he is an Associate Professor at the Department of Computer Engineering, Bina Nusantara University. His research interests include internet of things, embedded system, distributed system, cloud technology, wireless sensor network, network security, secure and reliable system, and computer vision. He can be contacted at email: dhutabarat@binus.edu.

Robby Saleh received the Bachelor Degree in computer engineering from Bina Nusantara University, Indonesia, in 2020 and the Master Degree in electrical engineering from Indonesia University, Indonesia, in 2005. Currently, he is an Associate Professor at the Department of Computer Engineering, Bina Nusantara University. His research interests include internet of things, distributed system, cloud technology, wireless sensor network, ad hoc network, network security, secure and reliable system, and embedded and mobile system. He can be contacted at email: robby@binus.edu.

Lukas Sebastian received the Bachelor Degree in computer engineering from Bina Nusantara University, Indonesia, in 2022. Currently he is working in private industry. His research interests include electronics, applied network, and embedded system. He can be contacted at email: lukas.prabudi@binus.ac.id.

Jonathan received the Bachelor Degree in computer engineering from Bina Nusantara University, Indonesia, in 2022. His research interests include electronics, applied network, and embedded system. He can be contacted at email: jonathan003@binus.ac.id.

Senanayake Mudiyanselage Namal Arosha received the Master Degree in computer science and engineering from City University of Jose Antonio Echeverria, and the Doctoral Degrees in Artificial Intelligence from Johannes Kepler University of Linz. Currently, he is an Associate Professor at the Faculty of Science, University of Brunei. His research interests include intelligent healthcare assistive devices, wearable integrated sensor suit, soft tissue model, and real time biofeedback control. He can be contacted at email: aroshas@ieee.org.