10. E-KUBU: Smart Home Automation System for Housing Energy Management

By I Nyoman Dita Pahang Putra

E-KUBU: Smart Home Automation System for Housing Energy Management

Gusti Ayu Mayani Kristina Dewi
Faculty of Animal Husbandry
Udayana University
Bali-Indonesia
Email: kristinadewi@unud.ac.id

NMAED Wirastuti *Department of Electrical Engineering Faculty of Engineering*
Udayana University
Bali, Indonesia
Email: dewi.wirastuti@unud.ac.id

A.A. Istri Ngurah Eka Karyawati
Department of Computer Science
Faculty of Math and Science
Udayana University
Bali-Indonesia
Email: eka.karyawati@cs.unud.ac.id

I Ketut Gede Suhartana
Department of Computer Science
Faculty of Math and Science
Udayana University
Bali-Indonesia
Email: Ikg.suhartana@gmail.com

I Wayan Santiyasa *Department of Computer Science Faculty of Math and Science Udayana University*
Bali-Indonesia
Email: santiyasa@cs.unud.ac.id

I Komang Ari Mogi *Department of Computer Science Faculty of Math and Science Udayana University*
Bali-Indonesia
Email: arimogi@cs.unud.ac.id

I Gede Arta Wibawa *Department of Computer Science Faculty of Math and Science Udayana University*
Bali-Indonesia
Email: artawibawa@cs.unud.ac.id

Ida Bagus Gede Dwidasmara
Department of Computer Science
Faculty of Math and Science
Udayana University
Bali-Indonesia
Email: dwidasmara@cs.unud.ac.id

Nyoman Dita Pahang Putra
Department of Civil Engineering
Faculty of Engineering
UPN Veteran
Jawa Timur-Indonesia
Email: putra_indp.ts@upnjatim.unud.ac.id

Abstract— This study proposes an energy management mechanism through smart home automation concepts. The concept of smart home that was applied in this study was named Elektronic-Kubu abbreviated as E-Kubu. The system needed to connect to the Internet. The monitoring of the system was in real time through the device. The applications embedded in the device used to monitor and control the household appliances, remotely, such as turn on/turn off, such as lights, televisions or others appliances. The device used might have an Android, IOS, or Windows operating system. The results showed that the system reduced the use of PLN resources with electricity efficiency 19.6% (reduce from 138.80 KWh to 118.5 KWh or 13.8 KWh).

Keywords— Internet of Things, Smart Home, Electricity, monitoring, automatic

I. Introduction

Currently, energy crisis is the biggest problem faced by every country. The most felt energy crisis is electricity. In Indonesia, in 2016, several regions experienced an electricity crisis. Starting from Sumatra, Java, to eastern Indonesia with rotating blackouts [1]. The east of Indonesian had entered an emergency electricity such as Nusa Tenggara, Maluku and Papua. Research in [2] argued in Indonesian territory often a power outage. This is because Indonesia's electricity reserves are only 10%. Indonesia Electricity Company (PLN) through socialization in various media trying to appeal to and increase public awareness in electricity savings, but energy waste is still happening. To help improve the efficiency of electricity consumption, the development of technology can be used to reduce the use of electrical energy.

Many researches have studied Internet of Things (IoT) in energy management. In [3], the home energy management built using multiple low-cost microprocessor to increase its feasibility that contains smart meter, smart plug and smart home energy-saving system. In other research, [4] described one smart energy management cloud platform integrated with an open-source IoT platform called Iotivity. It implemented the mapping and Iotivity-In-snergy bridge modules to increase the interoperability.

In this study, an energy management mechanism was designed belonging to the Smart Home automation that is intended for housing in rural areas with security automation and electricity efficiency. The concept of smart home that was applied in this study was named Elektronic-Kubu abbreviated as E-Kubu. Kubu in Balinese means home. In this case, the house uses a combination of electronics and information systems management. E-Kubu used the decision-making system approach for automatically manage the devices used in a home. For example, the lights were automatically set. System recognized the state of the room then decide to keep the lights on as long as there is activity in the room, and will turn off the lights if the room is no activity. With this system, it is expected to be able increase the efficiency of electricity uses and be able to overcome the electricity crisis.

II. Study Literature

A. Internet of Things

Internet of Things (IoT) can be explained as a set of things connected to each other via the internet. Things here can be tags, sensors, humans etc. IoT functions to collect data and information from the physical environment, these data will then processed so that the meaning can be understood. The ability of IoT to communicate with each other makes IoT possible applied in all fields. In the health sector [5], IoT sensors can be used to monitor the patient's condition, so that the patient's condition remains monitored for 24 hours. In agriculture, IoT can be used as a sensor to monitor soil conditions, temperature and humidity that are important for plants. In the field of smart building, IoT can be used to monitor electricity usage each building [6]. Besides that, IoT can also be used in fields automation, transportation, smart grid and others.

According to [7], technology in IoT is divided into several architectures layer. The first layer is the Perception layer, this layer functions to read collect information from the physical environment. Then, data will be sent to the network layer. Finally the data will be used in the layer application. The Perception Layer is responsible for converting data to signals sent over the network to be read by the application layer. As for example, the use of barcodes by a minimarket. Inside the barcode is found data such as name, price and stock of goods. When information has been obtained, then the network layer will be responsible for sending data from one host to the host another. There are various types of wireless communication protocols used like ZigBee, WIFI, WPAN, etc. While the application layer works for process information that has been obtained for use according to its needs.

B. *Smart Home*

Research in [8] explains that smart home is a concept of integration from several services in the house using the same communication system. It still guarantees security and comfort with the high intelligence function. Research in [9] explained that smart home is a home or workplace, which has the technology to run the device and system automatically. According to [10] smart home is a concept technology that runs in a house by integrating an automation systems that have been designed to assist activities as well as routines house owner. This integrity can be done through hardware and software to control a number of equipment in the home environment, for example electrical appliances in the kitchen (microwave, toaster, etc.), street lighting, air conditioner, and others equipment. These equipment are controlled in a centralized control unit module sensor as an input and actuator as an output to respond on orders given by the control unit. On smart home system development, input command for the smart home control unit is based on the sensor. Research in [11] the latest, smart home is a combination of communication network that is connected to home devices and allows for controlled, monitored and accessed remotely.

In general, the E-Kubu requires three conditions to be called smart, i.e.

1. Internal Network: In the form of cable or wireless;
2. Intelligent Control: It is a gateway for managing the system;
3. Home Automation: Arrange and manage.

Tools to support the function of the smart home is divided into three terms that based on research focus and requirements of researchers. Three categories, i.e. comfort, healthcare and security. Comfort and healthcare can run remotely or locally in the house. In addition, security focus on user and device authentications.

1. Comfort
   One of the main functions of E-Kubu is being able to provide comfort to the occupants. There are two methods used, the first method, E-Kubu will function by recognizing the occupant's activities and then automation functions for appliances at home. The second method, using remote household appliances from a great distance.
2. Healthcare
   E-Kubu is able to replace the function of nurses and household assistants to the householder. The healthcare function can be in the form of monitoring reports occupant health that can be accessed by residents of homes and medicals or not monitoring the condition of residents.
3. Security
   Houses that have technology in, it will certainly be vulnerable to security attack. The most common security problem is caused weaknesses of the occupants themselves and authentication methods that are easily broken through.

C. *SDLC (Systems Development Life Cycle)*

SDLC (Systems Development Life Cycle), Development Life Cycle System) or Systems Life Cycle, in system and software engineering, is the process of creating and changing systems as well the models and methodologies used to develop systems. This concept generally refers to computer systems or information. SDLC is also a pattern taken to develop device systems software, which consists of stages: planning, analysis, design, implementation, testing and management (maintenance). In software engineering, the SDLC concept underlies various type of software development methodology. These methodologies form a framework for planning and manufacturing control information system, namely the software development process. There are 3 types the most widely used system life cycle method, namely: traditional system life cycle, life cycle using prototyping, and object-oriented system life cycle.

The main purpose of SDLC is to accommodate several needs. These needs usually come from end-user needs and also fixes a number of problems related to software development. All of these are summarized, SDLC process can be in the form of adding new features, both modular and process new installation. From the SDLC process, it also can be estimated how long is the life of a software which can be measured or adjusted accordingly support policy from related software developers.

III. METHODOLOGY

A. *System Design*

The schematic design of the overall system can be seen in Figure 1.

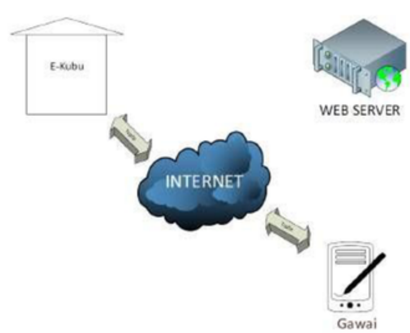

Fig. 1. The system overviews

E-Kubu is connected to the internet. The monitoring of the system can be done real time through the device. The applications that are embedded in the device can monitor and also control the device remotely, such as extinguishing equipment or turning on equipment, such as lights, televisions or devices others. The device used can have an Android, IOS, or Windows operating system.

The E-Kubu system design can be seen in Figure 2.

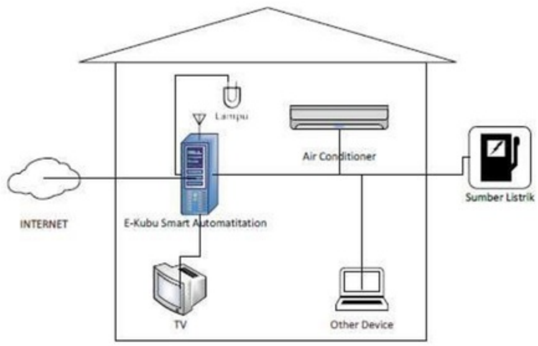

Fig. 2. E-Kubu system design

There is one core of the system which is a combination of sensors, microcontroller and microprocessor from a single computer board. The system received input from sensors that spread throughout the house. Sensors used include infrared sensors, temperature sensor, and light sensor. Data will be processed in the computer board and become the input of the artificial intelligence (AI) system. The AI system regulated the use of installed electrical equipment.

Furthermore, the system was also communicated with a web server and monitoring the use of electrical energy. Then the monitoring data stored in a stored database system on the web server. This web server has a function to store data from system monitoring which is embedded at home. The web server also manages communication with the device (home appliance/household devices) or device used to monitor. Data stored in this server, can be used to monitor electricity usage and also can used to support decision making.

B. *Analysis of System Functional*

The requirements of analysis of system functional as the following Table 1.

Table 1. System functional requirements

No.	System functional needs
1	The system can detect any motion that will be processed by Raspberry and notification will be sent to the telegram automatically
2	The system can turn on and turn off the lights automatically
3	The system can record the home state automatically and send it to telegram automatically with the recording duration a few seconds
4	The system can receive commands from the telegram in the form of detecting motion, turn on/off the lights, record and monitor the condition of the house

In terms of hardware, it was taken several electronics devices with minimum specifications as follows:

a. Raspberry Pi
b. PIR sensor
c. Camera Xiaomi Yi
d. Lamp
e. Modem
f. Laptop to support research

In terms of software, the operating system was used to building this system is Windows 10.

IV. Results and Discussion

A. *Hardware Design*

The hardware design of the system can be seen in Figure 3.

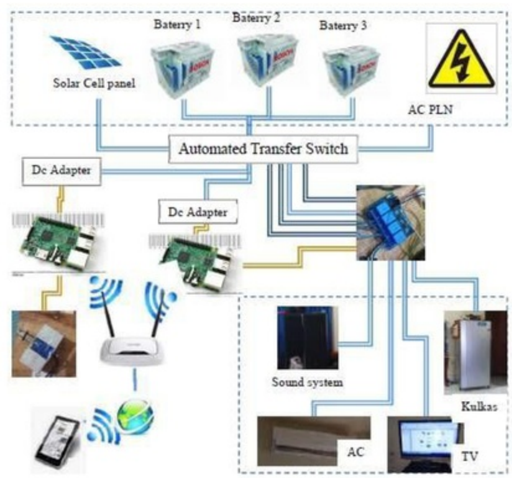

Fig. 3. Hardware design

From Figure 3, it can be seen electricity resources was used which were PLN and Solar Cell. Automated Transfer Switch (ATS) functions to distribute current to devices and accommodate electric current into the battery. Other functions from ATS is to determine the current to be used. If the current from PLN drop then the current used comes from the battery.

Two Raspberries are used to break and flowing current into the home appliances. Raspberry works on DC voltage so that it requires a DC adapter. Door lock works using 5 Volt DC voltage so that it can be directly connected to the pin out of Raspberry and can be controlled remotely using network media or Internet. The protocol used is IP TCP so that it can be accessed through Internet. Home appliances use AC currents. To be able to control AC current is used relay which is controlled by Raspberry Pi and can be accessed via the internet. If the relay gets 1 input from Raspberry then the current will flow and if enter is 0 then the current will be interrupted. Drainage mechanism and current input by the relay works mechanically similar with the workings of a solenoid which produces static electricity to connect and break the current.

B. Databases

The database consists of several functioning tables to manage household appliances through internet media. The table used were User Data Tables and Devices that can be seen in Table 2, 3, 4. Table UserData was used to authenticate users so only users that are divided in the user table are allowed to use the system. User ID and password was used for user authentication. If idUser and the password is correct then the system can be used properly, accordingly with rights access contained in the Access field of the user in question.

Table 2. Table UserData

Field	Tipe Data	Description
IdUser	Varchar (25)	Primary key
Nama_user	Varchar (25)	
Password	Varchar (25)	
Akses	Varchar (25)	
Phone	Varchar (16)	

Table Device is used to record device and device status. The status was the last status which was in on or off state. Device name contains the device naming rules. The device records the code of the name device registered or contained in the system.

Table 3. Table Device

Field	Tipe Data	Description
IdPerangkat	Varchar (25)	**Primary key**
Nama_Perangkat	Varchar (25)	
Status	Varchar (50)	

The device log table records any changes that occur whether automatic changes from the system or from the user. Automatic changes occur when the power is suddenly disconnected and or the power is distributed due to electricity resources has returned to normal.

Table 4. Table Device Log

Field	Tipe Data	Description
No	Number	Primary Key
IdPerangkat	Varchar (25)	Foreign key
Waktu	Date Time	Waktu perubahan status
Keterangan	Varchar (50)	Penyebab perubahan status

The relationships between tables can be seen in Figure 4.

Fig. 4. Relationship between tables

C. Testing scenario for E-Kubu system

In the framework of the E-Kubu system testing, the testing scenario and position of E-Kubu household appliances can be seen in Figure 5.

Fig. 5. Testing scenario map

From Figure 5 can be seen variety of household equipment. Household appliances that are subject to the trial of the application of E-Kubu such as AC, doors, sound systems, lights and electric stoves. This equipment was monitored and controlled through E-Kubu services.

D. Software Design and Implementation

1) Login interface

The main page of E-Kubu system is shown in Figure 6. On this page, it requires users to enter valid user data. After user data valid, login button goes to the main page. That consists of two menus, the current status and the device log. The main page default is the current status form.

Fig. 6. Login interface

2) E-Kubu Plan Form

After logging in, the user enters into the floor plan E-Kubu. An example display is shown in Figure 7. Users can view the status of each room by clicking in the intended room. In Figure 4.10. indicate the status of the room 2. When it is hovered, the room change color the background.

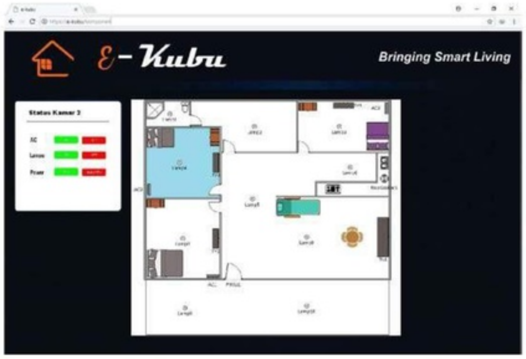

Fig. 7. Hover in room 2 with status device on/off

3) Status Details Form

The status detail form shows the condition of the device in a room. Each device is shown the latest state according to the condition. An example form of status details is shown in Figure 8.

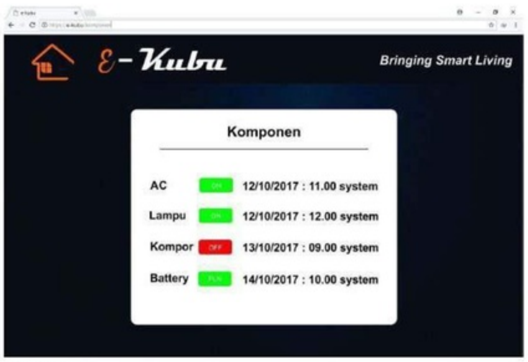

Fig. 8. Status form

4) Device control in a room

The equipment in each room can be controlled through the E-Kubu system website. Figure 9 shows control form of a room that has an AC, a lamp and a power socket for television.

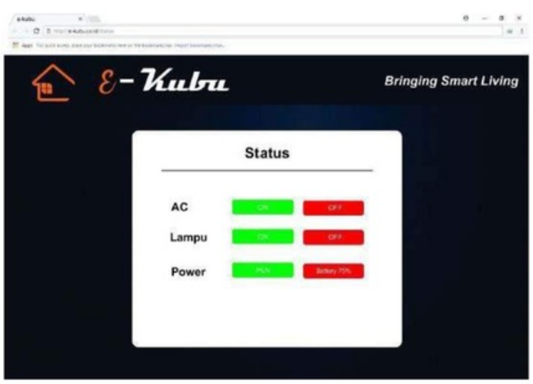

Fig. 9. Room device control

5) E-Kubu Application Evaluation

The evaluation was used black box test for knowing the efficiency and effectiveness of E-Kubu application design against user needs such as:

1. Functions that are incorrect or non-existent.
2. Interface errors (interface errors).
3. Errors in data structures and database access.
4. Performance errors (performance errors).
5. Initialization and termination errors

The successful test results are shown in table 2.

Table 2. Testing results

Description	Results
E-Kubu system turns AC on	Succeed
E-Kubu system turns AC off	Succeed
E-Kubu system controls AC temperature from device	Succeed
E-Kubu system open the door	Succeed
E-Kubu system close the door	Succeed
E-Kubu system turns stove on	Succeed
E-Kubu system turns stove off	Succeed
E-Kubu system detects stove gas leak	Succeed
E-Kubu system turns light on	Succeed
E-Kubu system turns light off	Succeed
E-Kubu system controlled via device	Succeed
E-Kubu system switches electrical resources (solar panel and PLN)	Succeed

The evaluation of E-Kubu system was done by comparing the electrical usage (PLN) of household appliances efficiency, before and after using the system. This was monitored in one month in each room. The results of measuring efficiency level of PLN resources with and without the E-Kubu system can be seen in Table 3.

Table 3. Efficiency level of PLN usage with and without E-Kubu System

Device tested	Without E-Kubu	With E-Kubu
Main Bedroom (AC, Light, TV)	40.4 KWh	35.3 KWh
Bedroom I (Light)	30.3 KWh	27.2 KWh
Bedroom II (Light)	32.4 KWh	27.3 KWh
Kitchen & Bathroom (Light, Water Pump)	21.3 KWh	19.2 KWh
Guest Room and Terrace (Light, TV)	12.4 KWh	9.5 KWh
Total	138.80 KWh	118.5 KWh

There was a decrease in the use of electricity sources for the main Bedroom was 5.1 KWh or 14.45%, Bed room I was 3.10 KWh or 11.40%, Bedroom II was 5.10 KWh or 18.68%, Kitchen and Bathrooms was 2.1 KWh or 10.94% and Guest Rooms and Terrace was 2.9 KWh or 30.53%. Overall, the degradation of using E-Kubu system was 18.30 KWh or equal to 15.44%.

V. Conclusions

We have proposed the E-Kubu system for housing energy management. It has worked to regulate the use of household appliances. It proven reduced the use of PLN resources with electricity efficiency 19.6% (138.80 KWh to 118.5 KWh or 13.8 KWh). The E-Kubu system enhanced the convenience of users in monitoring the use of household appliances through the device.

REFERENCES

[1] Dewi SN., Halim F. 2016. Indonesia Timur Darurat Listrik, Sering Padam. bisnis.news.viva.co.id. Jakarta. Downloded 22 March 2017. Time 05.00.

[2] Annisa, AA. 2015. JK: Cadangan Listrik Indonesia Masih Kurang.ekonomi.metrotvnews.com. Jakarta. Downloaded 21 March 2017. Time 20.00.

[3] Ming-Tang Chen, and Che-Min Lin. 2016. "Development of A Smart Home Energy Saving System Combining Multiple Smart Devices," in 2016 IEEE International Conference on Consumer Electronics - Taiwan (ICCE-TW), pp. 1-2.

[4] Chao-Hsien Lee, and Ying Hsun Lai. 2016. "Design and Implementation of a Universal Smart Energy Management Gateway based on the Internet of Things Platform," in IEEE International Conference on Consumer Electronics (ICCE), pp. 67-68.

[5] Lopez P, Fernandez D, Jara A, Skarmeta A.F. 2013. Survey of internet of things technologies for clinical environments. Advanced Information Networking and Applications Workshops (WAINA).

[6] Chen W. 2011. Application of internet of things for electric fire control. Electrical and Control Engineering (ICECE). p. 4741–4743

[7] Tan, J., and Koo, S. G. M. 2014. A Survey of Technologies in Internet of Things. IEEE International Conference on Distributed Computing in Sensor Systems, p. 269–274.

[8] Lutolf R. 1992. Smart Home concept and the integration of energy meters into a home-based system, in Proc. 7th Int. Conf. Metering Apparatus Tariffs Electr. Supply, p. 277–278

[9] Berlo A. V, Bob A, Jan E,Klaus F, Maik H, &Charles W. 1999. Design Guidelines on Smart Homes, A COST 219bis Guidebook. Brussels, Belgium: Eur. Commission.

[10] Sanchez. M-Tercero, R. 2010. Smart Home Technologies: Uses and Abuses. In Proc. Of Nint Mexican International Conference on Artificial Intelligence. p. 97-102.

[11] Setiawan A., Mustika IW., Adji TB. 2016. Perancangan Context-Aware Smart Home Dengan Menggunakan Internet of Things. Seminar Nasional Teknologi Informasi dan Komunikasi 2016 (SENTIKA). Yogyakarta. 18 – 19 March 2016. p. 455-459.

10. E-KUBU: Smart Home Automation System for Housing Energy Management

ORIGINALITY REPORT

12%

SIMILARITY INDEX

PRIMARY SOURCES

1	C.M. Lin, M.T. Chen. "Design and implementation of a smart home energy saving system with active loading feature identification and power management", 2017 IEEE 3rd International Future Energy Electronics Conference and ECCE Asia (IFEEC 2017 - ECCE Asia), 2017 Crossref	87 words — 2%
2	fti.uajy.ac.id Internet	72 words — 2%
3	Communications in Computer and Information Science, 2015. Crossref	50 words — 1%
4	www.ijirset.com Internet	46 words — 1%
5	K Joni, Haryanto, D F Rohim. "Smart Garbage Based on Internet of Things (IoT)", Journal of Physics: Conference Series, 2018 Crossref	37 words — 1%
6	A. A. I. N. Eka Karyawati, Azhari, Edi Winarko, Agus Harjoko. "Ontology-based sentence extraction for answering why-question", 2017 4th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), 2017 Crossref	34 words — 1%
7	research-repository.griffith.edu.au Internet	22 words — 1%

8	nyomanchandra.blogspot.ca Internet	18 words — 1%
9	Rosa Delima -, Febrian Galih -, Argo Wibowo -. "DEVELOPMENT OF CROP AND FARMER ACTIVITY INFORMATION SYSTEM", Researchers World : Journal of Arts, Science and Commerce, 2017 Crossref	15 words — < 1%
10	ilhamajji.blogspot.com Internet	13 words — < 1%
11	www.researchgate.net Internet	12 words — < 1%
12	corpgov.crew.ee Internet	10 words — < 1%
13	Jasper Tan, Simon G.M. Koo. "A Survey of Technologies in Internet of Things", 2014 IEEE International Conference on Distributed Computing in Sensor Systems, 2014 Crossref	10 words — < 1%
14	"Database Systems for Advanced Applications", Springer Nature America, Inc, 2014 Crossref	8 words — < 1%
15	"Computational Vision and Bio Inspired Computing", Springer Nature, 2018 Crossref	6 words — < 1%

EXCLUDE QUOTES	OFF	EXCLUDE MATCHES	OFF
EXCLUDE BIBLIOGRAPHY	OFF		