Development of Smart Home System to Controlling and Monitoring Electronic Devices using Microcontroller

H Maulana* and M R Al-Jabari

Department of Informatics Engineering and Computer Science – Universitas Komputer Indonesia, Jl. Dipatiukur no 112-114, Bandung 40134, Indonesia

*hanhan@email.unikom.ac.id

Abstract. The purpose of this study was to build Smart Home system using a microcontroller for controlling and monitoring electronic devices. There are 4 stages of building the system, it starts from Information gathering to generate user specification requirements, followed by assembling hardware, developing software, and system testing using blackbox testing and user acceptance test. The built system utilizes Microcontroller that equipped with Wifi module so the user can use the system to monitor usage of electronic devices that exist in their home and also can control the electrical appliance via the internet. Based on the results of system testing, Smart home system to control and monitor electronic devices using the microcontroller. More than 80% of user agreed that this system can reduce the power consumption and save time used by homeowners to check electronic devices before doing an activity outside the home. With this system users no longer feel worried about the status of their electronic Devices while doing activities outside the home.

1. Introduction

Electronic devices have become a part of our daily lives. In the use of electronic devices requires a relatively large resource depending on the electrical power of the electronic devices used.

Based on the results of interviews to the peoples in Bandung related these problems, 86% people say have a problem on electricity bills caused by forgetting to turn off electronic devices such as water pumps and air conditioner when they will go to work. The level of activities outside is also another reason why people forget to turn off the electricity. Another problem is their worried about accidents such as fires from certain electronic devices such as electric irons or electric stoves when people are unsure whether the Devices is turned on or turned off. Microcontroller is a computer system in a chip where there are a processor, memory and input Devices and Output Devices [1]. Many previous studies have explained the development of smart home to control electronic devices, especially lamps, and other electronic devices but in the study only used to control one electronic device only [2-10]. In those studies it only controls one electronic device, by using a microcontroller homeowners can manage the cost of electricity [11-14].

Based on the problems that have been described, it is necessary to build smart home system in controlling and monitoring electronic devices using the microcontroller. So that homeowners can control and monitoring of electronic device from a distance. With this system, it can save user’s time to check the status of electronic devices and can save the cost of the electric bill, because it can be monitored properly.
2. Research methodology
This research has 4 stages. Each step has a systematic and logical method so it can support the implementation of research. The research methodology used is described in Figure 1 below:

![Research Methodology Diagram]

Figure 1. Research methodology.

2.1. Information gathering
Observational field study is used to see and learn what users actually do in their own environment, office, or home in a range of contexts for a period of time. Interview and questionnaires also used in this research so that user could focus on the planned topic. The last method of gathering information is prototyping. This method used to present to users for gathering their comments concerning functionality and to clarify requirements and to uncover user interface issues and problems.

2.2. Hardware designing
At this stage, hardware is used as research instrument. The system is built by utilizing Android devices to control the sensors that are connected to the microcontroller.

2.3. Software development
Software used as a front-end application. Front end application displays the status of electronic devices and provided a feature to control electronic devices.

2.4. Research testing
The method used to perform system testing are black box and user acceptance test. Blackbox testing is used to test the system from developer view and the user acceptance test using a questionnaire to determine the level of user’s satisfaction with the system.

3. Results and discussion
3.1. System architecture analysis
The System to be built is android based that connected with the tools through web service. Figure 2 uses to describe of the architecture of the system to be built.
3.2. Software specification requirement

The software specification of the system to be built is divided into 2, SKPL-NF (Non-Functional Requirement Specification) and SKPL-F (Functional Specification Requirement).

Table 1 gives an explanation of Non-Functional Requirement Specification of the system to be built.

| Code      | Specification Requirement                                           |
|-----------|--------------------------------------------------------------------|
| SKPL-NF-01| System Requires Hardware For controlling and Monitoring electronic devices |
| SKPL-NF-02| System Requires Software For controlling and Monitoring electronic devices |

Table 2 gives an explanation of Non-Functional Requirement Specification of the system to be built.

| Code      | Specification Requirement                                           |
|-----------|--------------------------------------------------------------------|
| SKPL-F-01 | The system can perform Controlling electronic devices.             |
| SKPL-F-02 | The system can monitor the cost of Electricity expenditure.        |
| SKPL-F-03 | The system can monitor the status of electronic devices.           |
| SKPL-F-04 | The system can perform notification settings.                      |

3.3. Use case diagram

Use case diagram is used to describe a number of external actors with use cases contained in the system. Use case diagram can illustrate how the User interacts with any system and behavior that the system does. Figure 3 describes Use case Diagram of the system to be built.
3.4. Implementation system

Implementation is the stage to translate the design based on the results of an analysis that has been done into a real system. The purpose of implementation is to confirm the program has been designed to be used by the user.

3.4.1. Hardware implementation. The hardware specifications that used in the implementation of to be built systems are explained in table 3:

| No | Hardware          | Specification       |
|----|-------------------|---------------------|
| 1  | Processor         | Dual Core           |
| 2  | RAM               | 2 GB                |
| 3  | Harddisk          | Free space 200 MB   |
| 4  | Microcontroller   | MR Q7               |
| 5  | ESP Module        | Esp 8266 Esp-07     |
| 6  | Relay Module      | 4 Chanel 5V dan 50 mA |
| 7  | ACS Module        | ACS 217             |
| 8  | Electrical Power  | 220V                |

3.4.2. Software implementation. The Software specification installed on the devices used in implementing System must have an android operating system.

3.4.3. Class implementations. The class implementation describes the file structure that contains classes in the system are explained in table 4:
3.4.4. Interface implementation. Interface implementation describe display existing display on the system are explained in Table 5:

| No | User Interface Name | File Name | Description                        |
|----|---------------------|-----------|------------------------------------|
| 1  | Main                | main.bal  | Pages that display the main menu.  |
| 2  | MenuKontrol         | Menukontrol.bal | Pages that display Control Devices Menu |
| 3  | Menu2               | Tampilan2.bal | Pages that display Monitor Devices Menu |

3.5. Testing system
Testing the system is the most important thing that aims to find errors and deficiencies in software. System testing used to know the software that is made already meet the criteria in accordance with the purpose of designing the software. This software test uses black box testing and User acceptance test using questionnaires.

3.5.1. Blackbox testing. Black box testing focusing on the functional requirements of the system. scenario and result from black box testing are followed:

• Blackbox testing scenario
  This step is done by testing every functionality or process on the use case diagram and possible errors that occur during each process. Blackbox Testing Scenario is explained in Table 6:

| NO | Testing Component | Testing Details                           |
|----|-------------------|-------------------------------------------|
| 1  | The system has a function of controlling electronic devices | The system can Turn On and Turn Off the electronic device |
| 2  | The system has a function to monitoring electronic devices | Display the electricity bills |
| 3  | The system has a function to monitoring bill of electronic devices | Display the status of electronic devices |
| 4  | The system has a function to setting notification | Display menu for setting notification of system |

• Blackbox test result
  Based on the results of black box testing that has been done can be drawn the conclusion that the built-in system functionality, it can produce the expected output. All functionality is running well and there are no errors in the built system.

3.5.2. Acceptance test with questionnaire. This was done in the user environment by providing questions related to the system. Based on the questionnaire, it can be concluded that the smart home
system to control and monitor electronic devices using microcontroller allows people in monitoring and control electronic devices that exist in their home from a distance using smartphone android. And can facilitate homeowners to monitor the cost of electricity outages from electronic devices at home. Based on the results of Software Testing, it can be concluded that the results of this research are better than the previous research, in previous research, microcontroller is only used to control the lamp by connecting Microcontroller to the lamp, while in this research Relay Module installed between terminal block and Microcontroller. Interestingly the new system can control not only the lamp but also all electronic devices which is connected to the Terminal Block. The ACS Module on the system provides information about how much electrical power the electronic devices use when it is “ON”. This new Smart Home System also help the user to save the user monthly power consumption. This result is supported by previous research, that by turning off the switches of electronic devices will save electricity costs. The New system provides a notification to “TURN OFF” the electronic device when not in use. With this features no more electronic device in “ON” State but not in used, it make easier to manage the cost of electricity.

4. Conclusion
Based on the results of tests that have been done on the smart home system to control and monitor electronic devices using microcontroller it can be concluded that the system is built to facilitate the user to controlling Electronic Devices at home from a distance. Monitoring future that exist in the system can facilitate homeowners to monitor the cost of electricity expenditure from electronic devices at home.

Acknowledgments
Authors acknowledged Department of Informatics Engineering and Computer Science – Universitas Komputer Indonesia and people in Bandung City for supporting this research.

References
[1] Khadir A 2013 Panduan praktis Mempelajari Aplikasi Mikrokontroller dan Pemogramannya Menggunakan Arduino (Yogyakarta: Andi Publisher).
[2] Awal M 2015 "Pembangunan sistem home automation menggunakan arduino berbasis android terhadap lighting control," Skripsi, September 2015. [Online]. http://elib.unikom.ac.id/
[3] Muhammad A D 2015 "SMART HOME SYSTEM MEMANFAATKAN INFRASTRUKTUR WEB," Skripsi, September 2015. [Online]. http://elib.unikom.ac.id/
[4] Muhammad S 2013 Panduan Mudah Simulas dan Praktek Mikrokontroler Arduino (Yogyakarta: ANDI Yogyakarta).
[5] Rajeev P 2013 "Internet of Things: Ubiquitous Home Control and Monitoring," International Journal Of Internet of Things 2 (1) 5-11.
[6] Piyare R 2013 “Internet of things: ubiquitous home control and monitoring system using android based smartphone,” International Journal of Internet of Things 2 (1) 5-11.
[7] Kumar S 2014 Ubiquitous smart home system using android application (arXiv preprint).
[8] Kumar S and Lee S R 2014 “Android-based smart home system with control via Bluetooth and internet connectivity,” In Consumer Electronics (ISCE 2014), The 18th IEEE International Symposium on (pp. 1-2). IEEE.
[9] Mowad M A E L, Fathy A and Hafez A 2014 “Smart home automated control system using android application and microcontroller,” International Journal of Scientific & Engineering Research 5 (5) 935-939.
[10] Richard N C 2014 "Internet Of Things Dan Embedded System," pp. 10-13.
[11] Han D M and Lim J H 2010 “Design and implementation of smart home energy management systems based on Zigbee,” IEEE Transactions on Consumer Electronics 56 (3).
[12] Man S, Yang H X, Peng Y and Wang X S 2010 “Design of embedded wireless smart home gateway based on ARM 9,” Jisuanji Yingyong/ Journal of Computer Applications 30 (9) 2541-2544.
[13] Kelly S D T, Suryadevara N K and Mukhopadhyay S C 2013 “Towards the implementation of IoT for environmental condition monitoring in homes,” IEEE Sensors Journal 13 (10) 3846-3853.

[14] Santoso F K and Vun N C 2015 “Securing IoT for smart home system,” In Consumer Electronics (ISCE), 2015 IEEE International Symposium on (pp. 1-2).