Low-cost & Smart Home-Control System in the Android-based Environment

Dedy Van Hauten
Human-Computer Interaction Department
Surya University
Tangerang, Indonesia
dedy.hauten14@student.surya.ac.id

Erwin Anggadjaja
Human-Computer Interaction Department
Surya University
Tangerang, Indonesia
erwin.anggadjaja@surya.ac.id

***Abstract*—This paper presents a design of smart home-control system based on Bluetooth connection in an android-based smartphone. Bluetooth technology is used to provide remote access from an android-based environment, i.e. tablet, smartphone. The system intended to control electrical appliances, with relatively low-cost design, user-friendly interface, and ease of installation. To demonstrate the feasibility and effectiveness of the system, external output devices are attached as indicators. End result shows that we found that our system is proven through simulations and experiments.**

Keywords—Android; Bluetooth; Low-cost; Smart Home;

I. BACKGROUND

Recently the idea of a smart home has emerged in many publications and home appliances companies. Also, the smart home concept in the system improves the standard living at home. Smart home automation system can be described as the introduction of technology in the home environment to provide convenience, comfort, safety and energy efficiency for the residents.

There are several technologies used in this emerging system such GSM, Wi-Fi, ZigBee, and Bluetooth. Among the most, Bluetooth become one of the most popular [2, 4-5]. In this paper we opt Bluetooth for its capability in the context of availability and compatibility with most android system. Android initially developed by Android, Inc., which Google bought in 2005 [8]. It's open source and have many features, it's make Android continues to grow until it became the number one smartphone in the world for most widely used smartphone. Because of this, we choose android platform for our GUI.

The proposed system can be seen in Fig. 1 Home appliances which are embedded in sensor are connected forming a smart system. Those modules are communicating each other using simple data collection unit (I/O or command) for connection between controller and appliances. A user (with their smartphone / tablet) can access the controller via Bluetooth connection which is attached to the home. In addition, appliances status will be shown at controller GUI on Smartphone. Taking into account the flexibility, the main controller is designed supporting any wireless connections, though in this paper we decided to use Bluetooth technology. From cost wise, the system is built using a low-cost microcontroller (Arduino-based) and Bluetooth module (HC-05) as the core.

The remaining of the paper is organized as follows. In Section II, we briefly discuss several work and research regarding home-automation system. Section III describes the system architecture and its features while Section IV outlines the implementation of the system. Finally, some conclusions are presented in section V.

II. RELATED WORK

There has been a significant–development of smart home-automation studies in recent years. Most of them are due to the higher affordability and advances in smart devices which provides a wide connectivity, yet much attention has been given in academic research. Various wireless technology that can support some form of long-distance data transfer, sensing and control such as Bluetooth, Wi-Fi, RFID, and mobile networks have been used to embed various levels of intelligence at home. Studies in [2, 4-5] have presented a Bluetooth-based home automation system using the Android smartphone.

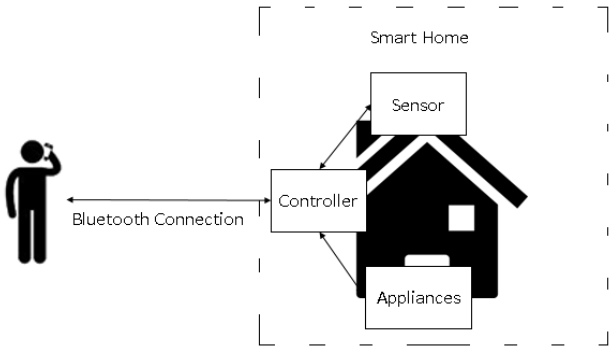

Fig. 1. Illustration of low-cost home e-control system

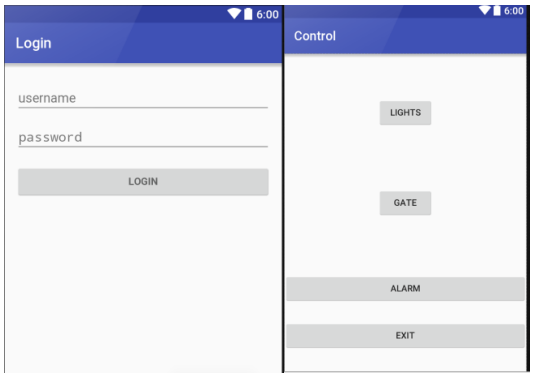

Fig. 2. Android's Main GUI

Systems mentioned above have made significant contributions to the design and development of home automation systems. For example, a work carried by [1,4-5] was designed using mobile phone to remote control system. The study from [3] showed a Smart Home System Based on Internet of Things Technology using remote control by phone. In addition, its design also implemented of Symbian operating system. This restrict the user to use the system because Symbian-based phones on the market today is very less. Also, a work by Kumar & Qadeer [6] does not specify the operating system of their device (mobile-phone), whilst [5] states control the mobile phone is designed in JAVA applications, and mention that it can be run at Android OS. Different OS will make a big different because amount of the user who use it.

III. Proposed System and Architecture

Fig. 1 illustrates the overall control function of the system. The Bluetooth connection enabled the system communicates with graphical user interface (GUI) on smartphone without cable. The controlled home appliances are managed by the main control board. We use Arduino Uno, Bluetooth HC-05, LED, Servo, buzzer and push button for this system.

The system also provides control by Android GUI installed in Smartphone. With this feature, the user can interact with the system via the screen of the Android device(s) to control the whole system (look Fig. 2)

A. Hardware design

This section discusses the hardware part of the main controller. We utilize an Arduino-based microcontroller, mainly due to its capability of performing both serial as well as USB features. Both these features are used to establish the Bluetooth and USB connection to the GUIs, respectively. For the communication, low-cost Bluetooth module HC05 is chosen due to its feature as a master-slave connection, besides as a hub between main controller and the android device(s).

To make the system more realistic, we design a prototype utilizing LED as light control, servo for gate control, and buzzer as the alarm, for external output devices. Please refer to Fig. 3 for the hardware system design.

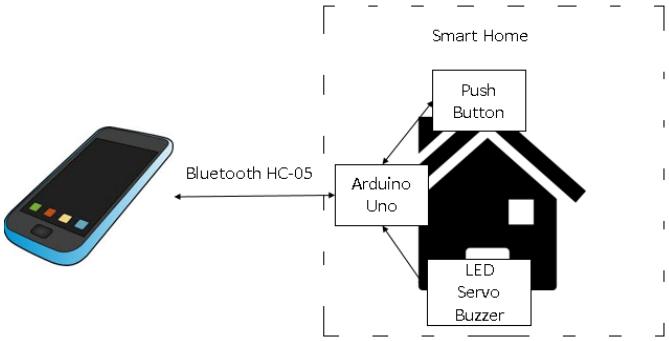

Fig. 3. Hardware System Design

In details, the control of the system is given as follows:

1) Gate control

For gate control, we use servo driven by motor to function as a gate. When the "Gate" button is pressed, the servo will drive the motor, after 1 minute, servo will automatically lock the gate.

2) Light control

For the light control, LED is used as the prototype replacing real light. When "Light" button is pressed, LED will automatically turn on, and vice versa.

3) Alert control

As for alert, we utilize a concept of usual alarm, with installation in two different places. First is outside the house, functioning as a neighborhood-warning system, while second installation is in the security office. When someone press the button at smartphone or push button. This will ring the alarm.

B. Software Design

This section explains the flow of the system in a high-layer perspective. The flow diagram of the software system design can be seen at Fig. 4. The application is designed in minimal Android version 4.0.3 Ice Cream Sandwich with API level 15. The application is designed in low API level so that the devices with higher version are compatible with it. Fig. 2 illustrate the Android GUI tested on smart phone with Version 6.0.1(Marshmallow).

IV. System Implementation

The implementation of the system, basically is divided into two parts: for the smart home and software in the android-device.

1) Smart Home Implementation

In this part, Bluetooth connection takes control of the controller. Once the connection has been initialized, it enters into an idle state until any command is received from the remote user. Upon successful reception of commands as strings from the Smartphone app, it's decoded and appropriate control action is taken. This can be seen in Fig 5.

2) Android Application and Features

Since most of the android device is supported by Java, we decided to develop and implement the application in JAVA programming language using the Android Software Development Kit (SDK) [7]. We use a smartphone with specification operating system Android OS

6.0.1(Marshmallow), RAM 1 GB and processor Quad-core Cortex-A7 1.3 GHz.

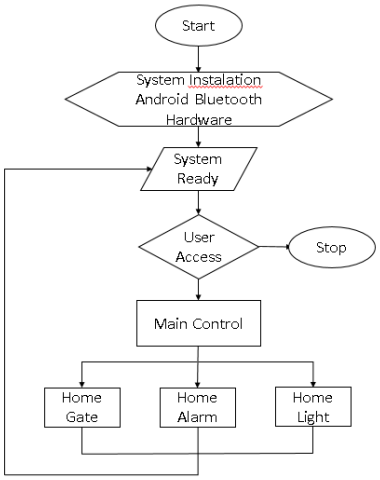

Fig. 4. Software System Design

This research work proudly offers a feature that the developed app is transparent from the user while allowing full interaction with the application. This will make the user feel comfortable yet ease of use. Additionally, by using the several software packages, we were able to customize the application to include a variety of user interface elements such as text boxes, lists and command buttons.

Fig. 4 illustrates the full design for the software system, with the functionalities of GUI mentioned above, as shown in Fig. 3. In details, as the first step of using the system, the user has to enter their username and password (Fig. 2), then connect to the Arduino controller (via Bluetooth connection). This is for the security of the system.

Internally, the apps will send the following string to the controller: "*lON", "lOFF", "dON", "dOFF", and "panic". "lON"* indicates that status of output port of Arduino for having the light ON, while *"lOFF"* indicates the other condition. *"dON"* indicates that status servo on the Arduino is 180 degrees (gate open), whilst *"dOFF"* indicates the closed gate. *"panic"* string indicates ring-ing process of the alarm/buzzer (Fig. 6)

From the GUI side, it also can inform the state of the appliances. The color of "LIGHT" and "GATE" buttons will change into green when the light is ON or gate is open. Meanwhile, when "PANIC" button is pressed the background of device will show red. The function this is to give a notification to user, so the user knows the status of their appliances see Fig. 7 for details.

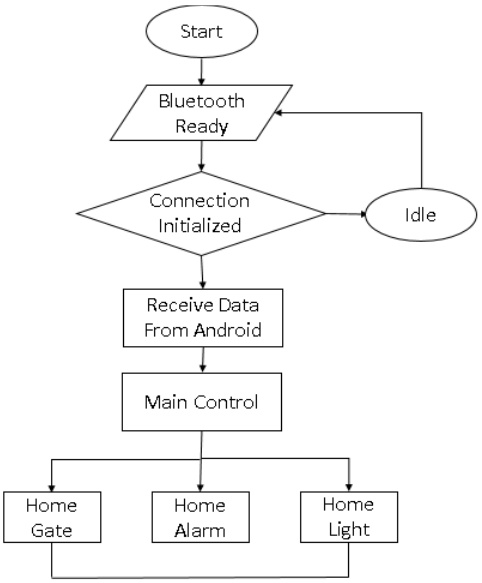

Fig. 5. Bluetooth System

V. CONCLUSION

To conclude we found that our system is proven through simulations and experiments. Low-cost controller such Arduino and Bluetooth module has been used effectively to design such smart-home system. Android-based smart phone provides assistance as a daily device carried by user(s), while the implementation of the wireless Bluetooth connection allows the system installation with a much simpler way. GUI display shows real-time status that is transparent to user, provides a user-friendly interface, simple, and easy control. For future implementation, we are considering to design such system in the Internet-of-Things manner, i.e. such wearables devices or technologies.

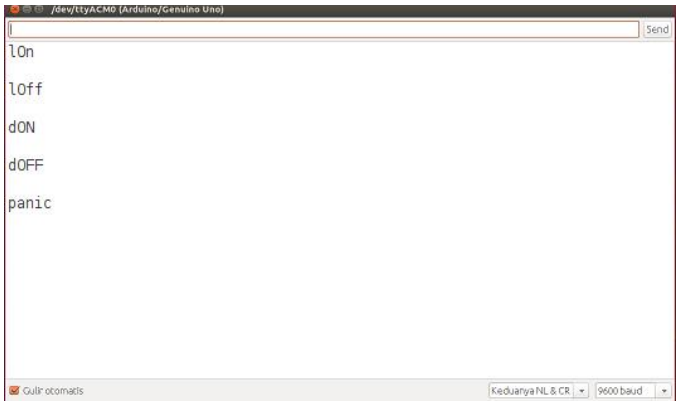

Fig. 6. String Received at Arduino

Fig. 7. Android's GUI before and after

REFERENCES

[1] C.-H. Chen, C.-C. Gao, and J.-J. Chen, "Intelligent Home Energy Conservation System Based On WSN," presented at the International Conference on Electrical, Electronics and Civil Engineering, Pattaya, 2011.

[2] R. Piyare and M. Tazil, "Bluetooth based home automation system using cell phone," in Consumer Electronics (ISCE), 2011 IEEE 15th International Symposium on, 2011, pp. 192-195.

[3] Y. Liu, "Study on Smart Home System Based on Internet of Things Technology," in Informatics and Management Science IV. vol. 207, W. Du, Ed., ed: Springer London, 2013, pp. 73-81.

[4] J. Potts and S. Sukittanon, "Exploiting Bluetooth on Android mobile devices for home security application," in Southeastcon, 2012 Proceedings of IEEE, 2012, pp. 1-4.

[5] R.A.Ramlee, M.H.Leong, R.S.S.Singh, M.M.Ismail, M.A.Othman, H.A.Sulaiman, et al., "Bluetooth Remote Home Automation System Using Android Application," The International Journal of Engineering And Science, vol. 2, pp. 149-153, 2013

[6] Sandeep Kumar & Mohammed A Qadeer, "Universal Digital Device Automation and Control", in IEEE, 2009, pp. 490-494

[7] "Download Android Studio and SDK Tools | Android Developers", *Developer.android.com*, 2016. [Online]. Available: http://developer.android.com/sdk/index.html. [Accessed: 14- Apr- 2016].

[8] Elgin, Ben (August 17, 2005). "Google Buys Android for Its Mobile Arsenal". Bloomberg Businessweek. Bloomberg. Archived from the original on February 24, 2011. Retrieved February 20, 2012. In what could be a key move in its nascent wireless strategy, Google (GOOG) has quietly acquired startup Android, Inc.,