

A Low-Cost Home Automation System Based-On Internet of Things

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Abstract—Internet of things (IoT) aims to merge human, physical object environments, and internet in one connection and package. This interconnectivity allows them to create a device that can monitor, analyze, control, and automate. Internet of things-based home automation system is applied to fulfill one of the ways to develop technology nowadays. In this paper, we presented the design of a low-cost home automation system by collaborating both Arduino UNO R3 and Jubito, which is the front-end of jaNET framework. All of the utilized tools and applications are open-source platforms, so the developers can develop more applications or projects. The boundaries of this work are how to switch lamps on or off, and how to open and close doors by applying servo motors. Home automation system, named as Homion, could be accessed through either local network or internet. The system had been implemented and tested on a house prototype.

Index Terms—Home Automation System; Internet of Things; Low-Cost.

I. INTRODUCTION

The internet of things (IoT) is a concept, which has the aim to make human and physical object environments as part of the internet connected to each other. Thus, it is possible to monitor, analyze, and automate anything and get the information quickly [1][2]. There is a wide range of IoT devices, including smart-phones, tablets, laptops, personal computers, digital cameras, sensors, and so on. The devices connected to another devices could bring smart processes and services to support all of the aspects in the basic needs, environments, systems, etc. Further, the implementation of IoT is suitable for optimizing the usage of technologies with smart objects and smart environments, which have a role in the development and interaction of machine-to-machine [3] and machine to environment [4].

A home is a part of an environments. A home automation system based-on IoT is a system that employs an electronics devices, such as personal computers (PC), gadgets and mobile devices to control basic functions. Further, some features of such home can be controlled automatically through internet anywhere, everywhere, and anytime. This system is usually called as a smart home system. The smart home system is meant to reduce the utilization of resources and human activities on its operation, making it is possible for client to operate systems from anywhere all over the world through internet access. The IoT is applied in the integration of several technologies for communication and performing some actions. In the previous years, the usage of IoT gadgets have increased significantly in the productions [5]. With the feature of these gadgets that uses many applications, it could be interesting to develop a controller that can access the internet [6][7][8]. The portability of a device could be a factor

to encourage researches to develop a device with integrated systems and technologies on its platform [9].

Due to the high cost of home automation systems, users are not interested to buy the device. However, the use of open-source device and application can help users to use low-cost home automation system than using any commercial products [10]. This system can be easily used to monitor and control home appliances using web-service anytime and anywhere, when it is still connected to the internet. This system has been built by implementing an Arduino UNO R3 board, connected to a controlled home appliances i.e. door locks and lamps. In addition, building a server computer applies a jaNET framework and Jubito as the front-end of the jaNET framework implementation. This system could be accessed by using local and internet networks. The internet network employed on a server computer is an IP public static. For the purpose of implementation and testing, a house prototype has been developed.

II. RELATED WORKS

An application programming interface, known as API, is an instruction set including functions and protocols that can be utilized by programmer when they are building an application software to be implemented on such operating systems. It allows a programmer to utilize a standard functions to interacting with the other operating system.

A web server is an application program functioned as a storage of web documents. So the web documents whether written using client side scripting or server side scripting stored in the main directory of it. The web server could be installed on a local computer or other computer wherein the internet or intranet functioned to serve web requests from the clients.

A. Jubito

Jubito is an implementation of thw front-end of open-source jaNET frameworks to interconnect and interaction between both hardware and software. Jubito provides an intuitively platform, for the user to interconnect the hardware and software objects and publish the user's projects online [11]. The Jubito can be downloaded at the site of <http://jubito.org/download.html>.

Jubito web server has the following features:

1. The jaNET framework terminal is deployed to execute or run API in jaNET frameworks
2. Instructions consist of Add New Launcher that functions to make a new API in jaNET frameworks; Add New Event Handler that functions to make an event to run one order or more in an event; Add New Evaluator that functions to evaluate an instruction;

Add New Web Service that functions to add a web-service within a response of XML/JSON; Add New Instruction Set that functions to make an instruction sets to be performed on the dashboard; and Remove that functions to delete Launcher, InstructionSet or EventHandler

3. Scheduler is functioned to make a schedule of instructions when the instructions will be executed by the system
4. Setting consists of web server which is functioned to configure of username, password, host, port, and authentic type required by the web server. Socket server is applied to configure socket server of data exchange communication or inter-program process whether on a machine or inter-machine. Serial port is utilized to configure a used serial port. Email is utilized to configure simple mail transfer protocol (SMTP) and post office protocol 3 (POP3). Short message service (SMS) is functioned to set an SMS-gateway to arbitrate sending of texts. While weather is applied to configure climate forecasting in around areas.

B. jaNET Framework

A jaNET frameworks are IoT frameworks that use open-source platform. This framework provides some built-in functions and application programming interface (API) which are capable to make an appropriate environment manipulating both hardware and software sources. This framework could run on the operating systems of the devices supporting .NET framework or mono-runtime e.g. Linux, Windows, and Mac.

A .NET framework is a software framework that provides a lot of numbers of computer programming libraries and supporting programming languages within a good interoperability. This feature causes the languages to function with each other in a system development. This is much different from the conventional application as the program written uses .NET Framework that runs on the software environments through common language runtime (CLR) and not directly on the hardware. This allows the applications built on the .NET framework could be run in the .NET framework supported hard-wares. It can be downloaded at the site of <http://www.microsoft.com/en-us/download>.

C. Arduino UNO R3 and Application

An Arduino UNO R3 is a physical computing and open source hardware platform. The Arduino UNO R3 is not only a development board, but also a hybrid of the hardware and programming language. The main feature of Arduino UNO R3 is its ability to interconnect with other computer, mini computer, or microcontroller. In addition, The Arduino UNO R3 requires an application to program into it. A used software of programming Arduino UNO R3 is Arduino integrated development environment (IDE). It is applied to programming Arduino UNO R3 which has the features of writing a program, compiling a program, and uploading program onto Arduino UNO device. This software is free of charge and can be downloaded at the website of <https://www.arduino.cc/en/Main/Software>.

The Arduino programming language is a C-programming language. The C-programming language is a multi-platform because it could be implemented in the operating systems of

Windows, Linux, Unix, Mac, or others without changing the source codes.

III. METHODOLOGY

In this section, we present the mechanisms and terms to build a home automation system. The home automation system is constructed by both hardware and software terms. The utilized devices to build this system are Arduino UNO and personal computer (PC) and some light emitting diodes (LEDs), servo-motors and supporting components. The universal serial bus (USB) is applicable to function the programming and communication between both Arduino UNO board and PC through USB port. The serial port baud-rate set into 9600 bps. In addition, .NET framework is deployed in the server computer to communicate and control using Jubito is the.

For the implementation, firstly we defined The Arduino UNO R3 pins. A declaration of the defined pins was bundled in the library. Pin of living room was set on pin 4, pin of dining room was set on pin 5, pin of bed room was set on pin 6, and pin of garage was set on pin 7. Variables of living room, dining room, bed room, and garage were configured into outputs. Further, functions for the front door and garage door were dedicated to pin 9 and 10 respectively. The function of string in the variables of the front door and the garage door was to declare the initial positions of front door servo motor at 85 degrees and garage door servo motor at 93 degrees.

A. Jubito Configuration on the PC

In order for the Jubito server to run, a server computer needs .NET Framework 4.5. This is because Windows 7 has been used as the operating system of the server computer. The .NET framework 4.5 is a requirement to run Jubito server and execute instructions on the jaNET framework.

Jubito server could run within the applied command of "judo server start" on the terminal of jaNET.exe (see Figure 1). After the Jubito server runs successfully, it must be tested by opening the web browser application to check Jubito whether server runs well. A default Jubito web-page is on the site address of <http://localhost:8080/www> when it is opened on the localhost. Before accessing the main page, there is an authentication of username and password. The default username and password of the Jubito is admin. Some modifications and configurations have been implemented on Jubito which exist on the web server and serial port. Weather and set of instructions would be stored in AppConfig.xml file.

Configuration done by the server computer is a network configuration. The configuration allows the server computer to access whether on local network or internet network. The server computer IP address is 192.168.1.10. Other configurations are subnet mask of 255.255.255.0, default gateway of 192.168.1.1 which is an IP address router, and DNS server of 192.168.113.254. The DNS server is applied to direct a router in network, which is communicated with router ISP. Configuration of the server computer IP address is shown in Figure 2.

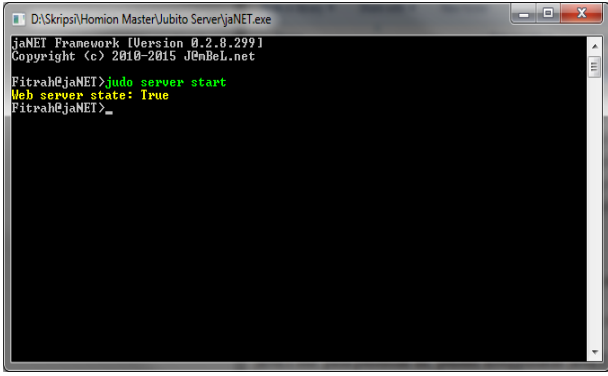


Figure 1: Jubito Server was run using Terminal

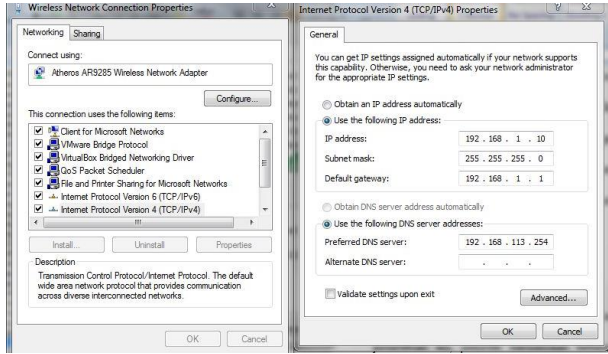


Figure 2: Server Computer IP Address Configurations

B. System Design

In this paper, we proposed a home automation system that could be accessed through internet or local network. When the client is addressing a uniform resource locator (URL) of web server, the client will enter the system of home automation system, called as homion. Before entering in the main page, it must enter an authentication of username and password. Thus, if it is valid, the client might have access to the system.

There are features, such as lamp and lock-door controls exist on the main page of homion. When the client wants to control lamp at such rooms, the client could choose any rooms which that could be switched on or off. After getting the input from the client, the server computer would read the input and instruct to the microcontroller to switch the lamp on or off. The client could also pick a door-lock control using the same way as switching a lamp on or off. The flowchart of the home automation system is shown in Figure 3.

On the main page, Homion displays some features to control and interact between client (human) and machine using a prototype of home appliances. In this case, represented as lamps and servo motors for locking door. When the client wants to control or switch the lamp on in a particular room, the client could choose which room in the display of the main page and thus switch the lamp on. A mapping design of home automation system is applied using a prototype that has two floors, which are the first floor and the second floor. The first floor consists of a garage, living room, and dining room, while the second floor consists of the bed room and the bath room (see Figure 4).

The principle of a home automation system based on IoT is shown in Figure 5. As a client, the web server could be accessed by gadgets or laptops connected to the internet. The homion website address must be written correctly, and thus username and password must be entered. Then, the main page would display some variables which would be chosen. A

variables of living room, dining room, bed room, and garage configured into outputs in the Arduino UNO R3 because LEDs are parts of the built system outputs and servo motors also. A global design of home automation system is shown in Figure 5.

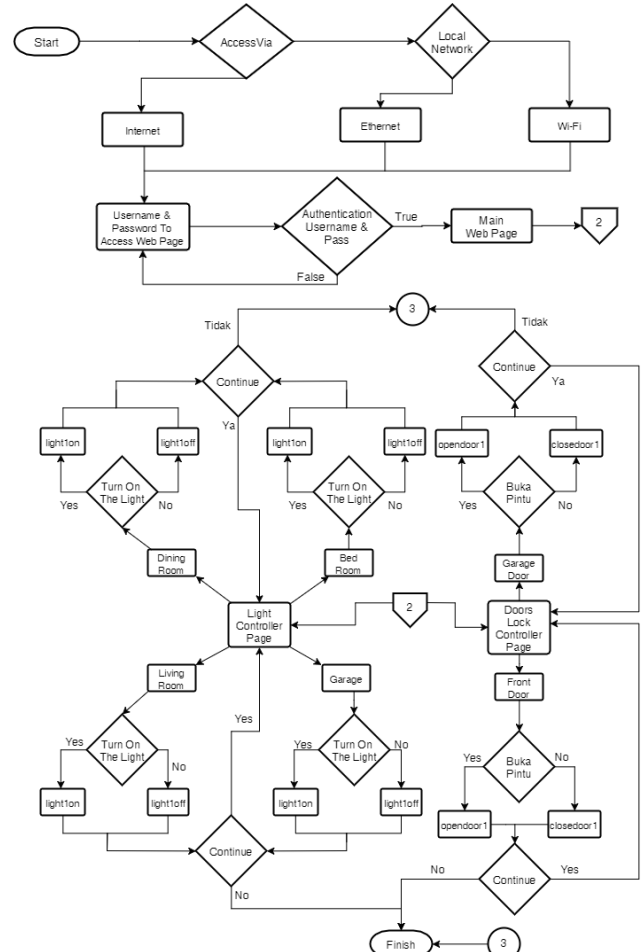


Figure 3: Flowchart of Home Automation System

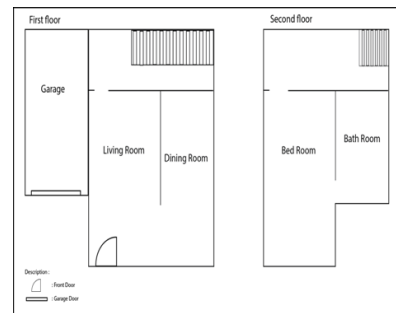


Figure 4: A Home Automation System Mapping

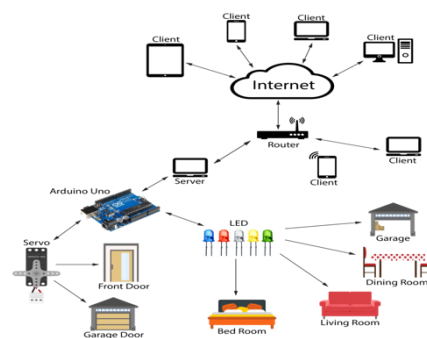


Figure 5: A Global Design of Home Automation System

IV. RESULTS AND DISCUSSION

The connection testing was done by pinging from client computer to server computer through local and internet networks. The opened system web-page which is on server computer could be accessed via client computer or smart-phone. The used client computer internet protocol (IP) address is 192.168.100.109 and the default gateway is 192.168.100.1. The pinging activity is shown in Figure 6.

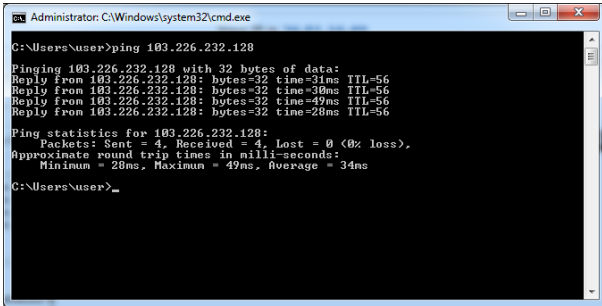


Figure 6: Connection Test using Local Network

Figure 6 shows that a pinging activity from client computer which was connecting to the server computer using server computer public IP address of 103.226.232.128 had been successfully done. This is shown that the system which is on the server computer could be accessed via internet network. The accessed results of the web page of homion, which is on the server computer is shown in Figure 7.

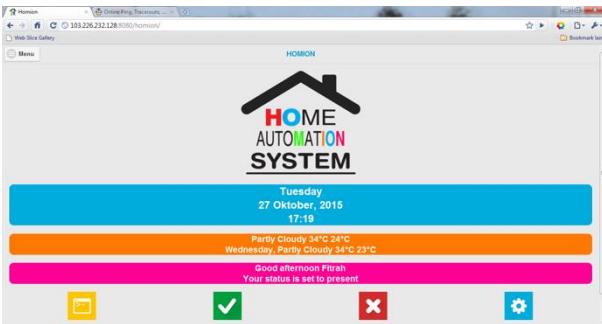


Figure 7: Main Page of Homion

The prototype of the home automation system has been built to match it to the actual condition of home, as shown on Figure 8. The lamps in each room applied LEDs as indicators, while for the opening doors, namely the garage and front door of the living room applied servo motors to move the doors.

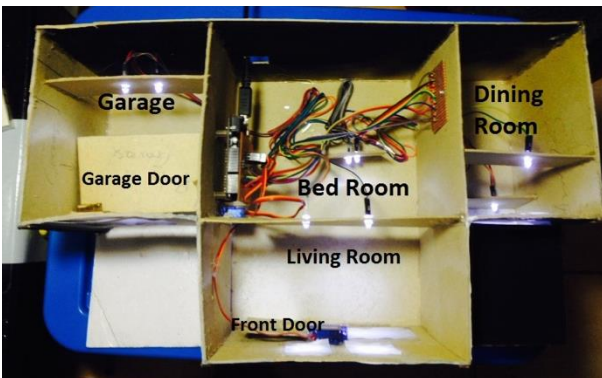


Figure 8: Prototype of Home Automation System

The test of the Room lamp control has been done via internet network to access the web page on the server. The functions of switching the room lamp is shown in Table 1.

Table 1
Room Lamp Control Test

No.	Function	Procedure	Success	
			Yes	No
1	Living Room Light On	User runs function of living room, light on at the web page on the category of light	✓	
2	Living Room Light Off	User runs function of living room, light off at the web page on the category of light	✓	
3	Dining Room Light On	User runs function of dining room, light on at the web page on the category of light	✓	
4	Dining Room Light Off	User runs function of dining room, light off at the web page on the category of light	✓	
5	Bed Room Light On	User runs function of bed room, light on at the web page on the category of light	✓	
6	Bed Room Light Off	User runs function of bed room, light off at the web page on the category of light	✓	
7	Garage Light On	User runs function of garage, light on at the web page on the category of light	✓	
8	Garage Light Off	User runs function of garage, light off at the web page on the category of light	✓	

A door-locking control test has been done via internet network to access the web page of homion located on the server. The functionalities of door locking is shown on Table 2.

Table 2
Locking-Door Control Test

No.	Function	Procedure	Success	
			Yes	No
1	Open Front Door	User runs function of open front door at the web page on the category of door lock	✓	
2	Close Front Door	User runs function of close front door at the web page on the category of door lock	✓	
3	Open Garage Door	User runs function of open garage door at the web page on the category of door lock	✓	
4	Close Garage Door	User runs function of close garage door at the web page on the category of door lock	✓	

V. CONCLUSION

A home automation system had been built and tested. The system implemented The Arduino Uno R3 board and a personal computer (PC) as a server to be accessed by the client. To be able to communicate with the server computer via internet, The Arduino Uno R3 must be programmed and

configured using a serial communication. Besides, the configuration of Jubito needs to be done in order to synchronize with the system that has been built. A set configurations, which include a configurations of web server, username, password, serial port, weather, event handler, launcher and instruction sets; and also configurations of server computer have been done using a configurations of IP address and router.

ACKNOWLEDGEMENT

The authors would like to acknowledge STMIK AMIKOM Yogyakarta for funding this paper in the presentation.

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