Building a smart-home system for a one-story house in Vietnam

Duong Quoc Hoang[1], Trinh Hoang Hon[2]

[1](Student at Ho Chi Minh City University of Technology)

[2](Lecturer at Ho Chi Minh City University of Technology)

Abstract – This article presents the construction of a smart-home system for a one-story house in Vietnam. This system employs control devices such as relays, buttons, sensors, and even devices to measure voltage, current and power. The resulting system is capable of controlling various devices from multiple locations while maintaining safety. According to simulation results, the smart-home system is safer, more technically advanced, and aesthetically pleasing compared to traditional homes. Though it may be relatively more expensive, it is still economically justifiable.

Keyword – smart-home system, smart-device, embedded system, smart-home device.

I. Introduction

In the era of rapidly developing information technology, the application of technology in daily life and industry has become increasingly popular, and many such systems have been developed. SCADA system [1] is used for Control and Data Acquisition in the industry. BMS (Building Management System [2]) is a system for managing the environment and facilities in a building. Smart home is an automation system that monitors and manages devices in a home through the internet. However, SCADA is suitable for industry, BMS is suitable for large buildings, and most current homes have not been widely adopted in Vietnam.

There are many famous brands in the world such as Xiaomi, Tuya, Lutron, Leviton, etc. [9] In Vietnam, there are also many famous names such as Xiaomi, Lumi, BKAV, etc. [10] Although these brands are very popular, they have not yet become popular in Vietnam households.

This article provides a general description of some devices, communication between devices, how devices communicate with the outside through the internet, and communication between users and the system to control devices. This Zig-bee standard smart-home system is built based on the above elements to create a system suitable for a one-story house in Vietnam.

II. Main

1. Overview

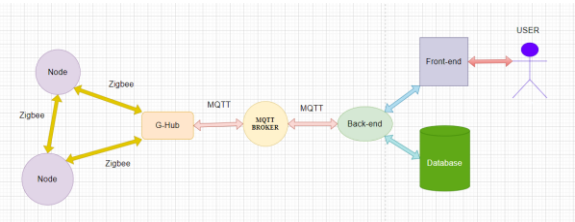

Figure 1. Overview

In this system, Zigbee network is used for communication between devices within the house and MQTT [6] protocol for devices to communicate with the outside world. Users interact with the system through a website,

the back end is responsible for coordinating data, the front-end displays information for users, and the database stores data.

2. Design system

a. Module Zigbee

Module Zigbee sz1v5 CC2530 2.4G:

- 2.4Ghz IEEE802.15.4 RF transceiver compatible
- Data transmission rate: 250Kbps
- Flash memory: 256KB
- RAM: 8KB
- Supports UART communication.

Figure 2. Module Zigbee sz1v5

Zigbee module is used to communicate between the G-Hub and Nodes.

b. G-hub

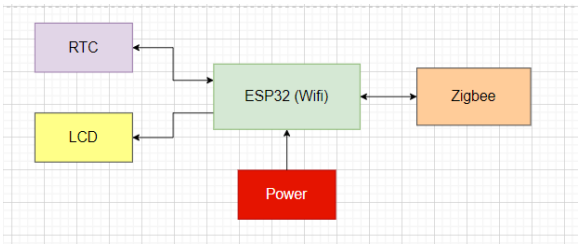

Figure 3. G-Hub

The main controller used is ESP32 [4] which communicates with Zigbee via UART, with additional RTC for real-time clock and LCD for displaying information.

RTOS is used in G-Hub to divide into tasks to efficiently operate.

Realtime operating system (RTOS) [12] is an operating system for real-time applications that process data and events with rigid time limits.

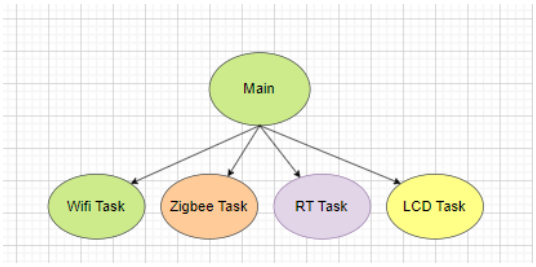

Figure 5. G-Hub Task

In this G-Hub, Freertos [3] is used which is a Realtime operating system for small-scale microcontrollers.

Tasks:

- Wi-Fi: Communicate via MQTT
- Zigbee: Communicate with other devices.
- RTC: manage time.
- LCD: Display information.

c. Node Sensor

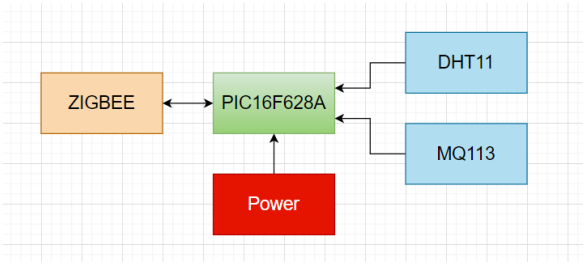

Figure 6. Node sensor

Main controller: Pic16F628A [8]

DHT11: Temperature and humidity sensor.

MQ113: Smoker sensor

Figure 4. DHT11

Figure 7. MQ113

Node sensor is responsible for reading temperature, humidity and air quality data and sending it to G-Hub for data storage and displaying information to the user.

d. Node relay

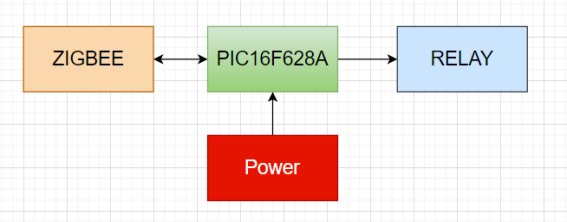

Figure 8. Node Relay

The main controller: Pic16f628a [8].

Relay is also used to turn devices on/off.

Figure 10. Relay SRD-05 VDC-SL-C

The main task of the Node relay is to switch the state of the relay on/off to control devices in the house such as lights, fans, etc.

e. Node button

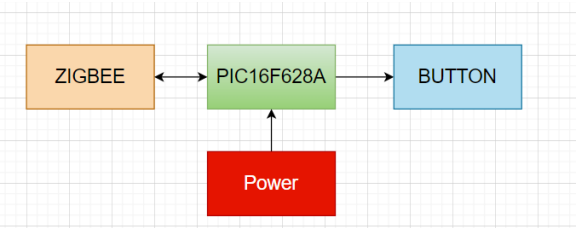

Figure 11. Node Button

The main controller: Pic16F628a[8].

A button is also used.

Node button is linked by users to a relay and pressing it controls the linked relay.

Figure 12. Button 6x6x8mm

f. Node relay Ade

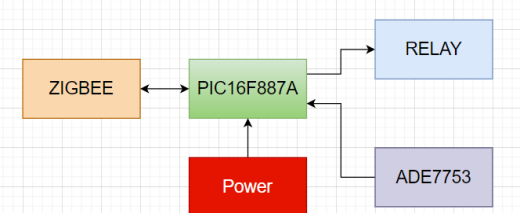

Figure 13. Node Relay Ade

The main controller: Pic16F887[8]

Relay is used for turning devices on/off.

ADE7753 [5] is used to calculate the electrical parameters of a device. ADE7753 includes ic ade7753 and current transfer circuit, voltage transfer circuit.

Figure 9. IC Ade7753

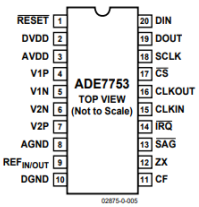

Figure 14. Pinout ade7753

Node Relay Ade is used to control the device and calculate its electrical parameters.

g. Zigbee

Zigbee [11] is a communication protocol developed based on the IEEE 802.15.4 wireless communication standard. This protocol was created to serve applications that require low cost and low power consumption but must be flexible in a wide range.

h. MQTT

MQTT [4] is a publish/subscribe mechanism protocol, where the client machine can publish or receive messages. It facilitates easy communication between multiple devices.

i. Web

The front-end uses the React framework [13].

The back end uses Node.js [14].

The database uses MongoDB [7].

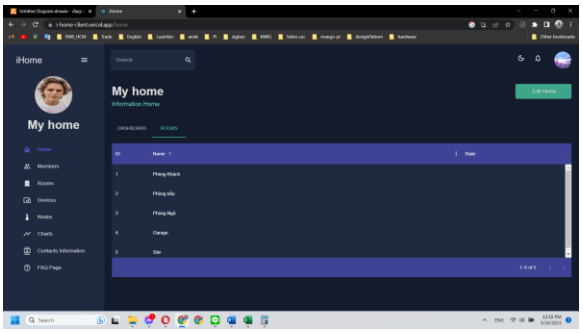

Figure 15. website

More details about website can be found at: https://i-home-client.vercel.app

3. Build a room use smart home system

This article proposed a method for designing the installation location of nodes to make it the most convenient and reasonable for users.

Design of device installation for a bedroom of two people, with a height from the floor to the ceiling is 3m.

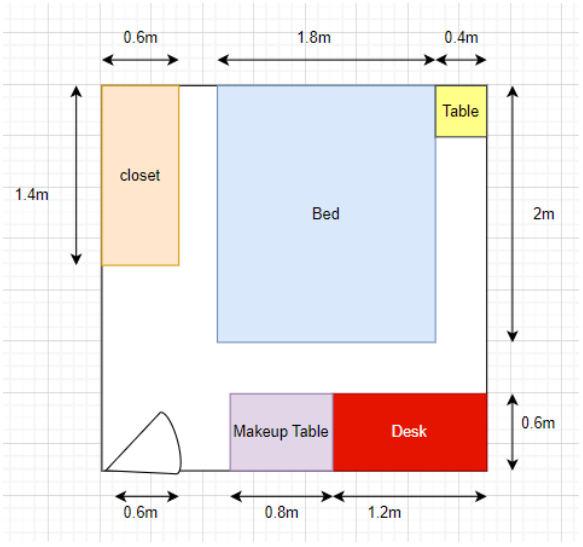

Figure 16. bedroom design

Devices in the room:

Device	wattage	Quantity
Light bulb for lighting	40W	1
Bedside lamps	12w	2
Work lamps	6w	1
Vanity table lamp	9w	1
Power socket	200w	1
Fan	47w	1

Table 1: All devices

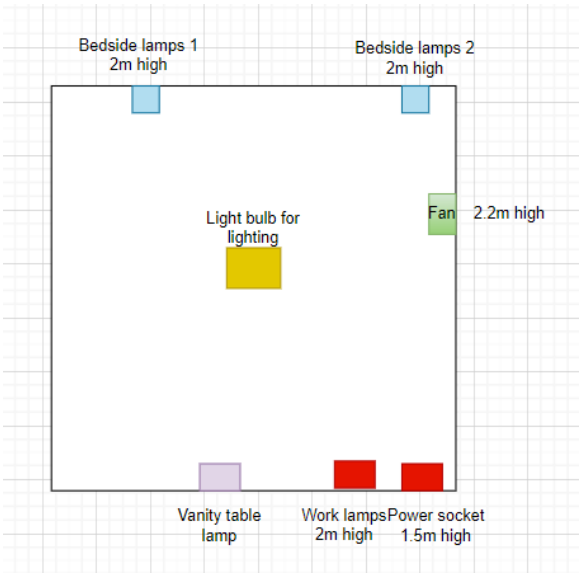

Figure 17. Equipment installation location

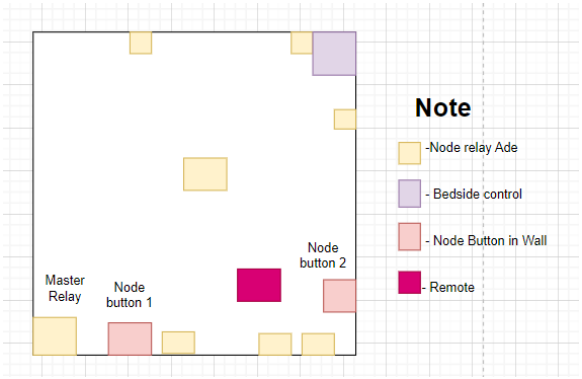

Figure 18. Installation location of nodes

- Bedside control: controls all devices in the room and some devices outside the room (bathroom light, outdoor, etc.).

- Remote: controls all devices in the room but integrated on a remote and can be taken away.

- Node Relay Ade is attached right at the location of the device.

- Wall-mounted Node Button: controls nearby devices.

- Node Button 1: controls the light bulb, fan, and Vanity table light bulb.

- Node Button 2: controls the light bulb and socket at the working table.

In the above design, a device can be controlled at many locations, from the wall-mounted Node Button, Bedside control, remote control, and can also be controlled via phone or computer through the website.

To better understand the design above this article will compare it with the traditional design that Vietnam households are currently using.

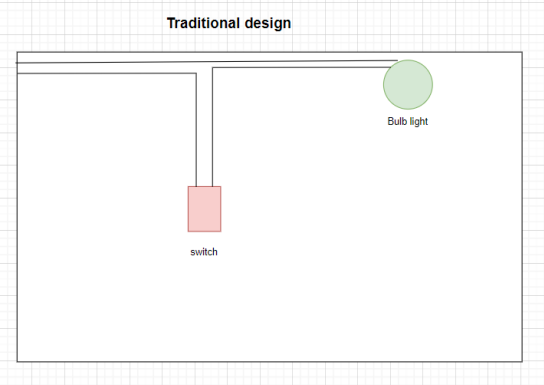

Figure 19. Traditional design

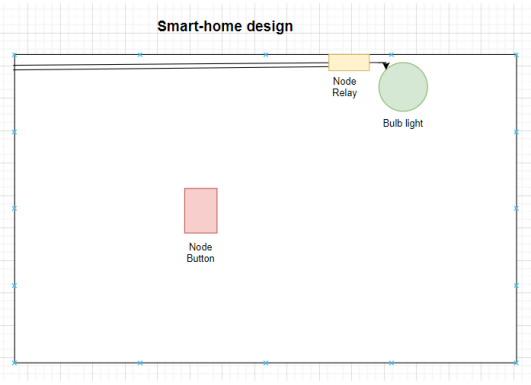

Figure 20. smart home design

a. Safety

In the traditional design, users still must come into contact with the 220Vpower network when turning on and off devices via switches, which can pose a danger to human life. In contrast, in the above design, users only come into contact with 5V electricity which does not affect human life. Therefore, the above design has a safer aspect compared to traditional design.

b. Technicality

In the traditional design, it is difficult to control a device in many places, while in the above design, it is easy to control a device in many places. Thus, the above design enhances the convenience of controlling devices.

c. Economy

Economic feasibility for a bedroom with wiring for two types of design.

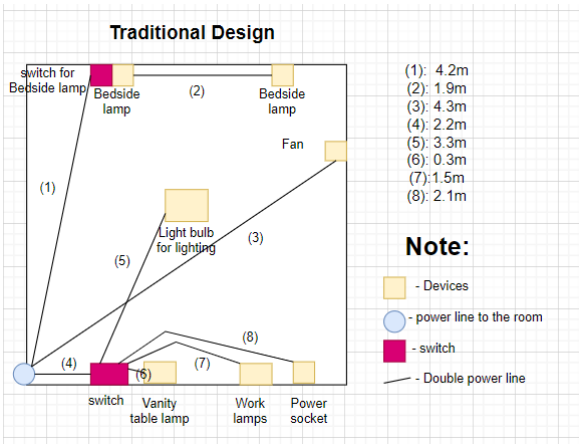

Figure 21. Traditional Design

For the traditional house:

- Total wire length: 20m

- All selected Cadivi VCM1 wire: 4.290 VND/meter

-> Wire cost: 20x2x4290 = 171.600 VND

- 3 switch set: 49.000 VND
- Single switch: 26.900 VND

Total cost: 247.500 VND

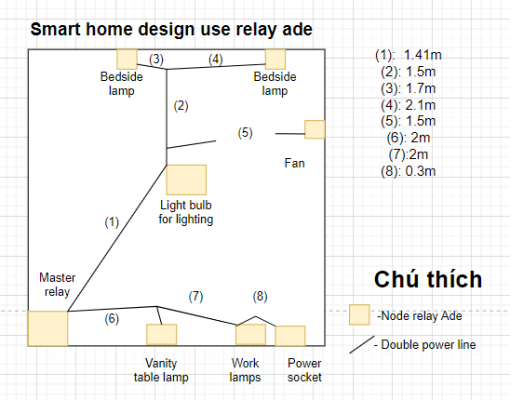

Figure 22. smart home design use relay Ade

For the smart-home design:

- Total wire length: 13m

-> Wire cost: 13x2x4290 = 111.540 VND

- ADE relay nodes: 8x300.000 = 2.400.000 VND
- Button nodes: 3x150.000 = 450.000 VND

Total cost: 2.961.540 VND

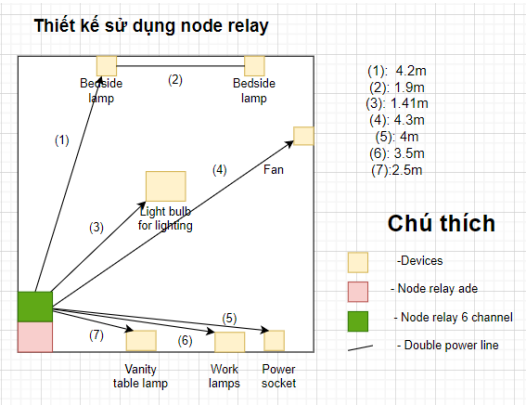

Figure 23. smart homes design use relay node

- Total wire length: 22m

-> Wire cost: 22x2x4290 = 188.760 VND

- ADE relay nodes: 300.000 VND
- Relay nodes: 175.000 VND
- Button nodes: 3x150.000 = 450.000 VND

Total cost: 1.113.760 VND

For a smart home, the number of devices for a household can be adjusted depending on cost. Overall, the cost of smart homes will be higher than traditional homes but still acceptable.

d. Aesthetics

In the traditional design, wiring needs to go down to the switch before reaching the light bulb, so measures need to be taken to wire (digging wall, etc.). In contrast, in the above design, electricity only needs to go straight from the source through a node relay placed anywhere and then to the device. Therefore, there is no need to search for measures to wire.

III. Proposed

From the data of devices in the house, a model can be built to search for the optimal way to use the device that saves the most electricity or can predict how close the device is to malfunctioning. It is also possible to detect warnings when there is an increase in electricity consumption of a particular device.

Develop more smart home devices to combine with existing devices. For example, node human sensor detects people in conjunction with relay.

IV. Conclusion

Figure 24. Test models

Smart homes provide more design solutions to increase safety for users, making the design look more aesthetic and technical. As for the economy, smart homes have higher costs than traditional homes but are still acceptable.

References

[1] Mr.Rohit Kadam, Mr.Pranav Mahamuni, Mr.Yash Parikh “smart home system”, January 2015.

[2] A.Daneels and W.Salter “WHAT IS SCADA?” , International Conference on Accelerator and Large Experimental Physics Control Systems, 1999, Trieste, Italy

[3] freertos, [online]. Available: https://www.freertos.org

[4] espressif, [online]. Available: https://docs.espressif.com

[5] Analog Devices, [online]. Available: https://www.analog.com/en/index.html

[6] hivemq, [online]. Available: https://www.hivemq.com/tags/mqtt-essentials

[7] mongodb, [online]. Available: https://www.mongodb.com

[8] Microchip Technology, [online].

Available: https://www.microchip.com

[9] iottechtrends, [online]. Available: https://www.iottechtrends.com/biggest-smart-home-companies

[10] smart-home, [online]. Available:

https://vneconomy.vn/thuong-hieu-smarthome-nao-dang-dan-dau-thi-phan-tai-viet-nam.htm

[11] Sinem Coleri Ergen “ZigBee/IEEE 802.15.4 Summary” September 10, 2004.

[12] John A.Stankovic, R.Rajkumar “Realtime operating system”

[13] reactjs, [online]. Available: https://legacy.reactjs.org

[14] nodejs, [online]. Available: https://nodejs.org/en/docs