iHome: Low-Cost Domotic for Residential Houses

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***Abstract*—Domotic is a system that, through Information Technology, interactively regulating electrical devices within the building in order to increase comfort, energy efficiency, and security. There are some problems that need to be addressed in current domotic system. They are hardware and software interoperability, and affordability.**

This study will design a domotic system that has interoperable characteristic while maintaining cost relatively low. The system is aimed for monitoring and controlling residential houses. A gateway as a communication bridge between heterogeneous protocols is developed. Service Oriented Architecture is utilized to enhance the software interoperability. To reduce retrofitting cost, wireless sensor network is used.

Domotic; gateway; SOA, wireless sensor network (key words)

I. INTRODUCTION

Domotic (integration of *domos* [house] and informatics) is a system that is used to regulate interactively electrical devices within the building so that it will increase the comfort, energy efficiency, and security.

One example of domotic scenarios: couples that will return home from work get stuck in a traffic jam. Using a laptop or mobile phone connected to the domotic services, they can monitor the condition of the house with IP cameras and turn on lights and air conditioning remotely. That way, they can ensure that the condition of the home (including family members) is fine and also ensure convenient conditions are created as soon as they arrive.

Some companies, such as Konnex [1] and BTICINO MyHome [2], already offers building automation products that allow above scenario can be realized. The existing product mostly comprises as complete system of hardware and software. The product is generally a vertical system so that the integration with other standards very difficult. In general, this eventually resulted in very low adoption rate of domotic, especially in developing countries.

Domotic components that can be arranged independently by the end user (DIY-Do it yourself) are also available [3]. This solution is intended to allow user to be independent from commercial companies for its implementation. However, the success of this model depends on the technological craftiness of the user. Additionally DIY components generally consist of diverse hardware and software platforms, so interoperability is still an issue.

Some standards require cabling to connect between controller and controlled devices. This will lead to substantial costs if it is applied to the existing building. Costs incurred may reach 50-90% of the total cost of installing home automation. In US, a complete domotic system will easily cost the customer more than $50,000.

There are some problems that need to be addressed to realize the domotic scenarios previously mentioned. Existing problems are hardware and software interoperability and affordability. This study will design a domotic system that has interoperable characteristic while maintaining cost relatively low.

Realizing that diverse hardware protocols already exist, forcing one and all encompassing protocol might not be an ideal solution. This study chooses to develop a gateway as a communication bridge between heterogeneous protocols. Service Oriented Architecture (SOA) is utilized to enhance the software interoperability. To reduce or eliminate retrofitting cost, this study opts to use wireless sensor network (often also named as wireless sensor and actuator network).

II. SYSTEM ARCHITECTURE

Architecture of the domotic system can be seen in Figure **1**. The system is given a code name “iHome”. The architecture shows the system component: the customer, iHome Server and the customer-premise domotic system.

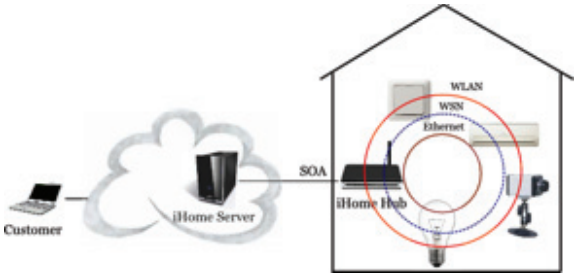

Figure 1. iHome Architecture

iHome Server is a web-based application where user can log-in and manage their domotic system. It might also provide authentication, authorization and accounting service for domotic service provider.

iHome Hub is a gateway that ensure hardware and software interoperability within the domotic system. It can interface with several standard such as WLAN, WSN and Ethernet. iHome Hub and Server will connect to each other through Service Oriented Architecture (SOA) framework.

The domotic system will be use both for monitoring and controlling. The monitoring will be performed using IP cameras. A couple of light will be controlled through WSN-based actuator.

III. DOMOTIC COMPONENT

A. *iHome Server*

A number of system components have been developed for the iHome system. The iHome Server is a web-based server that is used for business process management and home monitoring applications. This website is designed using the programming language PHP, Javascript and uses jQuery 1.4.4 library. MySQL is used for the database server. The prototype can be seen at http://pervasive.te.ugm.ac.id/home/. Figure **2** shows the screen shoot of the iHome Server accessed from the client.

Figure 2. Home screen of iHome Server

B. *iHome Hub/Gateway*

In the customer-premise domotic system, a number of components have been developed. One of the components is a gateway. Gateway is needed because it will function as a bridge between different protocols. In the iHome system protocol such as TCP/IP and WSN are used. Both of them are not interoperable, therefore a gateway is needed.

Figure **3** shows the gateway of the domotic. It uses off-the-shelf WLAN Access Point to minimize the cost while also maintaining interoperability with the IEEE802.11 and Ethernet standard. Interface to the Wireless Sensor Network (WSN) is added to the gateway via serial to USB interface. An open source firmware (OpenWrt[1]) is used for the operating system.

A TP-Link TL-MR3420 is selected for the gateway. The selection is based on several considerations. First, the price is relatively low ($40) and the offered performance is good. Second, its features meet the requirement needs for testing. For example, the AP already has a USB port, four Ethernet ports, and a port to connect to the WAN (wide area network).

Figure 3. iHome Hub Hardware

C. *Wireless Sensor Network*

Wireless Sensor Network is used as one of the communication platform in the domotic house. This wireless solution is chosen to minimize retrofitting cost.

The WSN communication channel mostly will be in the un-licensed frequency bands. Non-licensed bands will differ between countries (for example in European Union, there are 433 MHz, 866MHz, 2.5 GHz). Those frequencies are often used for connecting actuator, sensor, equipment, remote controller etc.

Standard protocol exists for low-power communication utilizing the un-licensed band, e.g.: Zigbee [4]. However, Zigbee standard has disadvantage for trying to be a universal solution for many application, therefore it often become a heavy protocol and difficult for implementation [5].

This study used proprietary technology named IQRF node[2]. The technology was chosen because it relatively cheap ($15 per node) and it has a lightweight protocol. Figure **4** shows an IQRF node with its programming board.

[1] http://openwrt.org
[2] http://iqrf.org

Figure 4. IQRF node and its programming board

D. *Service Oriented Architecture*

In this study, SOA is implemented as a web service connecting iHome server and gateway. At the gateway, a web service that is deployed as a server listening on port 8080. Clients make requests to the server via HTTP protocol GET or POST. This request will be accepted by the server and then forwarded to the WSN. Subsequently, the WSN perform data acquisition or actuation in accordance with what is required by the client. The outcome data acquisition or actuation will be processed by the server and encapsulated into a SOAP XML standard form. At the end, the XML data will be sent to the client via HTTP Response.

IV. MONITORING AND CONTROLLING

The iHome system is design for monitoring and controlling a residential house. For monitoring function, IP cameras are used. Since it is already an IP-based device, the integration is seamlessly achieved. The video stream required high-bandwidth channel, therefore TCP/IP based communication channel is used for the monitoring. The network used both WLAN and wired LAN for delivering the image to the server.

This study experimented by deploying 4 IP camera in an office building. Figure **5** shows the screenshot of the video image of the monitoring system.

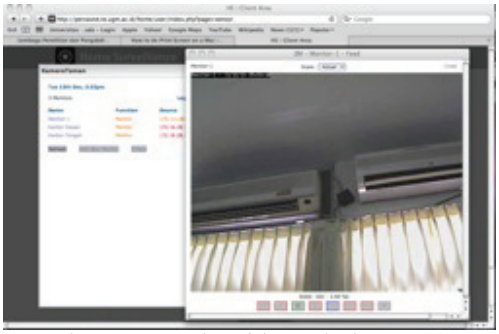

Figure 5. Screenshot of the monitoring system

The controlling component of the iHome is used for managing lights (on/off). We create a prototype of wireless relay that can be seen in Figure **6**.

Figure 6. WSN actuator for the light

V. RESULT AND FUTURE WORKS

An experimental test-bed has been developed at the Department of Electrical Engineering and Information Technology, Gadjah Mada University. Four IP cameras, a gateway and iHome Server has been installed in the three-floor building. The software in the server and web service also has been deployed.

The monitoring system has been deployed for the last 4 months and performs well. It also has a novel motion detection feature that is reported in [6].

The WSN-based actuator has been tested to control 5 lights in a laboratory environment. The communication channel has been successfully tested based on mesh topology.

Future work includes testing the controlling feature in a multi-floor setting. The software part of the iHome system will also be integrated further.

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