



Faculty of Information Technology

SMART HOME SYSTEM (SHS)

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Declaration

No portion of the work referred to in this report has been submitted in support of an application for another degree or qualification of this or any other university or institution of higher learning.

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Abstract

Smart home is the version of home suitable for today's needs. It should be ultimately convenient and secure to its residents. The basic idea is to equip the house with automation functions and security system. Nowadays, smart home concept included communication network, which wired the residents to the outside world. Some of it includes networks of entertainment.

Although smart home had reached our shore, it is new to most Malaysian. Most technology and devices used in local smart home systems are imported. Thus, on the whole the price is too high for Malaysian with average income. Moreover, its functionalities may not tailor to our need. For example, the system is not designed according to our standard.

Furthermore, almost all smart home systems are designed in such a way, that users cannot reset or modify it. Instead, technician's help is required. One of the reasons is over relied on the hardware. Hardware is hard to be reprogrammed (required high understanding in hardcode, assembly language or C) and its capability is very limited (due to the size of its memory).

Smart Home Project aimed to provide an alternative. Smart Home System uses program to replace all the possible functions of the hardware such as storing data and timing. Thus, increase the system's functionalities, yet cut down the cost. As all software (Programming languages and database) used by Smart Home Project is open-source, it will not trouble the user concerning license issue.

Smart Home Project is object-oriented based. Thus, any modification on the system to suit the users' need or to abide the standard set by government should not be cumbersome tasks. Furthermore, further enhancement of the system is not an issue.

Abstrak

Rumah pintar (Smart Home) merupakan versi rumah yang sesuai untuk kehidupan masa kini. Ia seharusnya memudahkan kehidupan seharian penduduk. Idea asas rumah pintar adalah melengkapi rumah dengan pelbagai fungsi automasi dan sistem keselamatan. Pada hari ini, rumah pintar semestinya juga dilengkapi dengan rangkaian komunikasi, yang menghubungkan penduduknya dengan dunia luar.

Walaupun, rumah pintar telah diperkenalkan di Malaysia, kebanyakan masyarakat masih tidak mengenali rumah pintar. Kebanyakan teknologi dan kelengkapan yang digunakan dalam sistem rumah pintar tempatan masih diimport dari luar negara. Justeru itu, sistem rumah pintar adalah terlalu mahal bagi masyarakat Malaysia. Selain itu, sesetengah fungsinya tidak sesuai untuk kegunaan masyarakat Malaysia. Sesetengah sistem tidak memenuhi standard yang ditetapkan oleh negara kita. Pengubahsuaian tambahan pula memerlukan kos yang terlalu tinggi. Sesetengah pengubahsuaian memerlukan perkakasan komputer tambahan, manakala yang lain pula memerlukan pendawaian semula.

Tambahan pula, hampir semua rumah pintar adalah direka sebegini rupa, di mana pengguna tidak dapat mengubah semula atau melakukan perubahan terhadap sistem. Segala perubahan memerlukan kepakaran juruteknik. Bagi senario sebegini, salah satu faktor utama adalah system tersebut terlalu bergantung kepada perkakasan komputer. perkakasan komputer adalah sukar diprogramkan semula (memerlukan ilmu dalam C, hardcode dan assembly language) dan keupayaannya adalah terhad (disebabkan memori yang terhad).

Projek Rumah Pintar (Smart Home Project) bertujuan memberi satu alternatif kepada pengguna. Sistem Rumah Pintar (Smart Home System) adalah direka sedemikian, ia menggunakan program sebagai pengganti kepada perkakasan komputer. Contoh fungsi-fungsi yang diambilalih oleh program adalah keupayaan menyimpan data dan menentukan masa. Jadi, ini dapat meningkatkan keupayaan sistem dan mengurangkan kos. Semua perisian yang dipakai dalam Projek Rumah Pintar adalah percuma, jadi pengguna tidak dibebankan oleh isu lesen.

Projek Rumah Pintar adalah berorientasikan objek. Jadi, sebarang pengubahsuaian dalam fungsi disebabkan keperluan pengguna atau pertukaran standard bukan merupakan satu kerja yang sukar. Tambahan pula, pengubahsuaian pada masa kelak bukanlah merupakan satu isu yang membimbangkan.

Chapter 1: Overview

1.1 Introduction

Maintaining and enhancing the quality of life of peoples involves facilitating independent living, increasing quality of care and technical assistance (Allen et al., 2001). At this point, technology plays an important role. Smart home technology is one of the technologies that is often being mentioned in this context.

Basically, the degree of smart home technology application in everyday life is exercised is variable, depending on functions, cost, individual wishes, and the type of building into which the technology is to be installed.

There is a lot of confusion about the overall concept of smart homes. The following definition was therefore formulated in the European funded project Domotics Integration Project (DIP) (Allen et al., 2001).

Smart home technology is the integration of services and technologies, applied to homes, flats, apartments, houses and small buildings with the purpose of automating them and obtaining an increase in:

- Safety and security
- Comfort
- Communication
- Technical management

1.2 Problem Statements

Malaysian's with average salary cannot afford most of the home automation systems. As most of the home automation systems are imported, currency exchange and transportation costs will increase the price. Basically, a home automation system with basic functionalities like I-Home System costs above RM 2000 excludes the renovation and rewiring costs. Thus, only those people with higher salary can usually afford to own a smart home.

Today, most of the oversea home automation systems provided online service to the user. But, online service may still a rare phenomenon in locally made home automation systems. For example, I-Home system does not provided such functionality to the user, which allows the user control the home appliances through the web site.

As the smart home technology mostly originated from western countries, some of the functionality may not suit the Malaysian lifestyles. For example, the functionality of the heater is well received by the user in western countries. But this functionality is not such useful in Malaysia.

1.3 Purpose of Study

Smart Home System (SHS) is designed with necessary functions to suit Malaysian lifestyles. For example, for the countries that have four seasons, smart home technology may be programmed to turn the heater on at nighttime during winter. However, such function is not suitable for Malaysian user.

SHS is also designed toward software-oriented to keep the cost as low as possible. Thus, open-source software that is free is used. Hence, we can download the coding from the Internet and modified it. Functionality such as timing and scheduling is controlled. Less memory is required of microprocessor. Thus, cheaper components can be used.

The security of the residents in a smart home is SHS's priority. Door automation feature will provide some protection before help arrive. In the other words, smart home technology can help to prevent burglary. For example, the user can locked the door through Smart Home Web Module (SHWM) if he/she forgets to lock the door after they left their home.

The residents could also enjoy the comfort and benefit from the energy saving of a smart home. For example, SHS have been designed which can switch off a fan or lamp that had been left on through Internet. Besides that, SHS helps by providing easy access to various home appliances without moving around.

1.4 Scope Of Project

The project's scope will focus on building two modules, which are Smart Home Web Module (SHWM) and Smart Home Control System (SHCS). These two modules are used to control the appliances inside the house.

SHCS is a PC-based home automation module for SHS. But for the SHWM, it is a web-based home automation module for SHS.

Besides the two modules, the scope includes building a microcontroller and model home to demonstrate the functionalities of SHS.

In term of system functionalities, SHS should demonstrate the following features:

- Switch on/off lamp or fan or an appliances
- Check appliance's status
- Open/Lock doors
- Scheduling, for example, the user can set the schedule to ask the SHCS or SHWM to perform the certain task.

In term of the interface, SHCS and SHWM will have a graphical visualization interface for higher degree of usability.

1.5 Project Significance

With our SHS, Malaysian's people can afford to own a smart home system. For this SHS, both software and hardware components are relatively cheaper than those currently available in the market. In particular, SHS is presented as open source software. The hardware components used are readily available in the local market. Thus, the owner does not have to use imported or foreign components, which are more expensive.

Smart Home project consists of SHWM the allowed the user to access the home appliances through web site. Such online service provides a lot of flexibility and safety features to the user. Thus, the user can control or monitor the home appliances such as lock the door, switch on/off the light at anytime and anywhere.

SHS project is worth conducted because it is designed to suit the Malaysian lifestyles. For example, most of the Malaysian today seek ease and comfort lifestyles. Thus, through the smart home technology, they could enjoy the convenience by easy access to the home appliances no matter inside or outside the home.

1.6 Project Plan/Schedule

SHS is a project completed in two semesters (about 8 - 9 months). The first semester is focused on documentation that covers from Chapter 1 (Overview) to Chapter 5 (Object-oriented Design). The remaining tasks which include development of the real system and writing documentation from Chapter 6 (Implementation) to Chapter 8 (Future Works) are carry out on the next semester. The overview of SHS project plan is enclosed at Appendix A

1.7 Outline of Project Report

In Chapter 1, overview of the project is stated. Besides, the problem statements of this project as well as the purpose of study are brought into discussion. Next, scope of the project is defined and the significance of this project is also brought into attention.

Chapter 2 is focused on the history of home automation system. Other topic of interested is the different type of home automation system available. A few of these systems are reviewed and comparison is done to get a clearer picture of current trend in home automation system.

In Chapter 3, an overview of the methodology used to develop SHS is discussed. Basically, this chapter emphasizes on the SHS work flow and the characteristics and tasks to be achieved in each phase of SHS development.

In Chapter 4, the analysis phase is looked into. Project requirements such as user requirements, software requirements and hardware requirements are stated. Besides that, use case diagram, activity diagrams and sequence diagrams are also constructed.

Chapter 5 emphasizes on SHS designs. In this chapter, class diagram is constructed to show the static structure of the system. Based on these diagrams, development could be carried out.

In Chapter 6, development tools that are used are discussed. In addition, the implementation of software and hardware are also discussed.

Chapter 7 covers all of the stages in the testing process that are conducted to validate and verify the system. Besides that, usability testing is carried out to check that user can use the system and like it.

In Chapter 8, the achievements of the system are stated. Further enhancement and improvement are included in future works.

Chapter 2: Literature Review

2.1 Introduction

Nowadays, the market is crowded with various type of the home automation system. However, none of them are the same. In this chapter, a few home automation systems are reviewed and compared.

2.2 History of Home Automation System

Introduction of microprocessor in the late 1970's (Josephs, 1999) gave birth to embedded system. "Embedded systems are the applications that fuel some of the microprocessors" (History of the Internet, 1999), they paved the path for the Home Automation Systems.

One of the earliest smart home systems ever recorded is "Electronic Computing Home Operator" (ECHO IV) in 1966 (Spicer, 2000). ECHO IV was "hand-crafted with surplus electronic parts and enclosed in oiled-walnut wooden cabinetry" (Spicer, 2000). Among the features in ECHO IV are "automated" family finances computation, recipes storage, shopping lists computation, family inventory tracking, temperature control, appliances automation, weather predicting and family message center (Spicer, 2000).

1969 marked one of the earliest attempts of commercial home automation system, "Kitchen Computer" by Neimann-Marcus (Spicer, 2000). Its main breakthrough functionality was its capability to suggest dishes given certain amount of ingredients. The system setbacks were lacks of means of input and output, troublesome access to the built-in recipe files. Users must be able to program using BACK (a type of programming language) and price tag of over \$10,000. However, none of the Kitchen Computer was ever sold (Spicer, 2000).

Despite their pioneer catastrophic attempt, home automation systems survived and flourished. Thirty years after the Kitchen Computer, the market is crowded with various type of home automation systems, varied in term of user domain, features and technologies used.

Next, a "66,000 square foot lodge, located on the shore of Lake Washington, near Seattle" (ISAT, 2001) is bought into attention, as it is not only a part of smart home history, but its future as well.

That lodge is actually the home of the Bill and Melinda Gates. Its construction is completed on September 1997, three months behind the schedule (Bill Gates Home, 1997). Since then, it is the holder of the Guinness World Record for the "most intelligent house" ever built (ISAT, 2001). Gates' residence is the symbolic figure for the modern smart home, and perhaps a vision of what future home hold.

2.3 Reviewing the Existing Systems

Among all the existing system, only a few were chosen for reviewing. In order to obtain a much clearer picture of the current home automation systems, following criteria are taken into consideration:

- User domain
- State-of-the art technology

Besides, reviewed existing systems are further divided into two categories:

- International companies
- Local (Malaysia-based) companies

The purpose of the categorization is to compare the technology gap between local systems and the international systems. In Malaysia, home automation system and smart home concept is relatively new compared to developed countries. Currently, local companies are lagging behind international companies in term of technology.

2.3.1 Reviewing the Existing International Systems

The following international existing systems are reviewed:

- Gates' Residence
- ALLSMART Solutions Inc. (ALLSMART): ALLSMART System
- Multimedia Design Inc. (MD): Multimedia Max
- Wisebox Telecom Technology Co. (WTT): Wisebox Voice System

It is not possible to review all the home automation systems. Thus, these home automation systems are chosen because they can give an overall overview of the existing systems in term of functionalities and technologies used.

Most of the home automation systems are similar in term of functionalities and technologies used. Thus, it is possible to categorise home automation systems. However, a clear defined categorisation cannot be outlined because most systems come in various commercial package to suit the need of different domain of users. Most of these system are designed in such a way that every module or components can functions on their own or become a a part of a much complete home automation system.

Gate's residence is chosen because it is the most advance smart home existed. Multimedia Max is designed for the handicapped person with special needs.

2.3.1.1 Overview of Gate's Residence

Gates' Residence is a state-of-the-art smart home. Its construction had taken seven years (ISAT, 2001) and cost \$97 million (Sargent, 2001). It is currently regarded as the most advanced and the most intelligent smart home ever built.

Gates' residence is designed in such that embedded Artificial Intelligence (AI) system and pre-programmed algorithms tailored to suit Gates' lifestyle.

In fact, chores are done by the time Gates need it to be done. For example, when a car approaches, the entry gate senses and fully opened by the time of arrival (Bill Gates Home, 1997), and bathtub is automatically filled to Gates' desired temperature and depth as he drives home from work (Sargent, 2001).

Generally, Gates' residence (ISAT, 2001, Sargent, 2001, Bill Gates Home, 1997) consists of following functionalities:

- Sensors, networked by miles of cable are implemented throughout the house: tracking the movement of guests via microchip that they wear. Thus, enable computerised adjustment of light and music to each visitor's pre-programmed preference.
- Walls-mounded high-resolution video screens that display pictures from Gates' digital art collection. These images also change according to the individual taste of each person in a room.
- Computers remember each guest's preferences from previous visits, allowing the house to be progressively tailored to each visitor's whims.
- A vast network of surveillance cameras and sensors with accuracy of within six inches.
- The floor is heated everywhere includes the driveway and exterior walkways.
- Melinda's clothes are accessed on a mechanized system, similar to that in a dry cleaner.
- The underground garage converts into a basketball court electronically.
- Both automated and personnel security system. Hidden cameras everywhere including interior stonewalls. System is monitored at the Microsoft campus.
- Theater is the most state-of-the-art theater in the world.
- Personal favorite music can be set to follow an individual throughout the house, even the bottom of the pool.

2.3.1.2 Overview of AllSMART: AllSMART System

As AllSMART home automation system is not given a specific name, it will be referred as AllSMART System for easy reference.

AllSMART divided AllSMART System into three solutions, Home Computer Networking, Total Home Systems Control and Home Theater & Entertainment System (AllSMART: 3.Total Home Control (AllSMART: THC), 2001).

Home Computer Networking is designed to form Internet connectivity with the home (AllSMART: THC, 2001).

Total Home Systems Control solution is the main system, incorporated various kinds of automation, whole house audio, communications, security, and environmental control features (AllSMART: THC, 2001).

Home Theater & Entertainment System consisted of a customer-customized home theater (AllSMART: 4 Home Theater and Entertainment System, 2001).

Generally, AllSMART system(AllSMART: THC, 2001, AllSMART: Two Way Satellite, n.d) consists of following functionalities:

- "Security and surveillance cameras, which includes basement, glass break, wells, entry's smoke, carbon monoxide, and motion detection".
- "Computer controlled lighting for 15 zones, scheduled, timed and scene control dimming of selected lights within home".
- "4 zone package control display of all temperature functions, programmable, remotely accessible, system zoning via balancing, offers energy savings and improved air quality".
- "Multi-channel stereo amplifier with various input sources controllable from each designated room. Includes choice of in-ceiling or wall mount stereo speakers and control system".
- "A pre-amp option to whole house audio. Requires no central station, voice response latching. Any number of stations. Wiring and 8 rooms and 2 door modules included".
- Use high-speed bidirectional satellite for internet access and TV viewing.

2.3.1.3 Overview of MD: Multimedia Max

MD is a USA company, winner of the 1996 Home Automation Association's Award of Excellence (Multimedia Max, 1998). Unlike most home automation system, Multimedia Max is a computer system helping people with disabilities (Multimedia Max, 1998).

Multimedia Max uses special input devices, such as voice recognition software and alternative keyboard input and HeadMouse (Multimedia Max, 1998).

Generally, Multimedia Max (Multimedia Max, 1998) consists of following functionalities:

- Appliance automation through a voice-activated computer system using Dragon Dictate.
- Appliance automation through PC using HeadMouse.
- Automatic phone dialing.
- PC-based wireless remote camera with voice command access.
- Built in temperature control for RCS thermostats.
- Start various computer programs such as Internet browser through voice command.
- Voice access to bill paying and other Internet services.

2.3.1.4 Overview of WTT: WiseBox Voice System

Wisebox Telecom Technology Co. specialized in Voice Home Automation, Telecommunication Equipment and Software Development (WTT: About Us, 2000).

Wisebox Voice system used a very different approach compared to other home automation system reviewed. It is one of the very few company that apply voice recognition technology, its commitment in level up Speech Recognition Rate (over 99%) had put it in a class of its own (WTT: Business, 2000).

Currently, Wisebox Telecom Technology Co.'s smart home successfully penetrated markets in each and every continent (WTT: Business, 2000).

Generally, Wisebox Voice System (WTT: Products and Feature, 2000) consists of following functionalities:

- Appliance Automation through natural voice commands.
- Appliance Automation through telephone and mobile phone.
- Appliance Automation through Internet.
- Appliances Automation through natural voice commands for appliances that use remote control.

Wisebox system consists of noise cancellation function (WTT: FAQ, 2000) providing the system with greater degree of reliability. However, purchase of the system would take at least 2-month time.

2.3.2 Reviewing Existing Local Systems

The following local existing systems are reviewed:

- I-Home Sdn. Bhd.: I-Home system
- Intelligent Automation System Sdn. Bhd.(IAS): Intelligent Automation System

2.3.2.1 I-Home Sdn. Bhd: I-Home System

I-Home Sdn. Bhd is the member of I Berhad Group (I-Home Brochure, 2002). It is one of the few home automation system development companies in Malaysia. It franchises is throughout the whole Malaysia. One of its franchises in Kuching is Oditech Global Sdn. Bhd.

Relatively, I-Home system is more naïve. It consisted of basic home automation features and securities without implementing state-of-the-art technology.

Generally, I-Home system (Kiu, 2002) consists of the following functionalities:

- Automated Light and Home appliances. However, home appliances are not fully automated. As the system capable of switching on/off the source of power, the speed of the fan is adjusted manually. Other appliances suffered from the same setback as well.
- Magnetic sensor to detect the status of doors or windows (whether it is open or closed). However, they must be locked manually. In cases of burglary, the system will call the owners' hand phone.
- A doorbell will trigger the phone once the bell is pressed. The resident can talk to the visitor through the phone.
- The system consisted of several modes, namely night mode, day mode and away mode. Each mode is pre-programmed. For example, the night mode will notify the user the doors and windows, which have been left on.

I-Home system does not required heavy rewiring. However, some renovation is still required.

The main setback of a wireless system is the signal (Kiu, 2002). As the system use the infrared signal, reflection of the signal caused other irrelevant appliance to be turned on/off. For example, if the user decides to turn on air condition A, other air conditions may be turned on/off due to the reflection of the signal.

I-Home system does not provide a medium of communication between both Internet module and Local Area Network (LAN) module. Thus, it is impossible for the Internet user to know whether there is anyone in the house.

2.3.2.2 IAS: Intelligent Automation System

Compared to I-Home, IAS is relatively new company. Based in Kuching and specializes in home automation system and security system. Besides smart home designing and installation, IAS conducts various kind of automation, which includes door access control system, building and industrial automation.

Generally, Intelligent Automation System (Chong, 2002) consists of the following functionalities:

- Automated Light and Home appliances. However, home appliances are not fully automated. As the system capable of switching on/off the socket, the speed of the fan is adjusted manually. Other appliances suffered from the same setback as well
- Gate automation. Gate automation can be access using remote control or wall-mounted switch. However, the system cannot provide feedback to the user. For example, if the gate failed to be closed, the user would not be informed.
- Door automation. Smart card is used for access. Password is required as the additional security feature.
- Pre-programmed automation can handle various kinds of tasks. Moreover, it is unlimited. The main setback is that only technician could reset it.
- Voice automation. Recognized keyword only.

Intelligent Automation System needs heavy rewiring. In fact, even the ordinary switches had to be changed. It used ST5000 BASEStation by Sierra Technology (Chong, 2002). The main setback is that it required advanced programming skill in C to reprogram the setting. PC used only during installation. Thus, it decreased system's usability. The technologies used are more sophisticated compared to I-Home. Its main setback is its price. Intelligent Automation System is ten times more expensive than I-Home System. For example, for a condominium, intelligent Automation System price range from RM10,000.00-RM30,000.00 (Goh, 2002), while I-Home system price estimated at RM2,308.00 (I-Home Boucher 2002). Besides technologies factor, over reliance on hardware jeopardized its price competitiveness (Chong, 2002).