

Web Based Smart Home Automation Control System Design

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ABSTRACT

The development of technology provides and increases security as well as convenience for humans. The development of new technology directly affects the standard of life thanks to smart home automatic control systems. This paper describes a door control, automatic curtain, home security (CCTV, fire, gas, safe, etc.), home control (energy, light, ventilation, etc.) and web-based smart home automatic controller. It also describes the use of ARM (Advanced RISC Machines) for automatic control of home equipment, a Multi-Axes Servo Controller using FPGA (Field Programmable Gate Array) and PLC (programmable logic controller). Additionally, it describes the development of a HTML editor using web auto control software. The tab loading time (7 seconds) is faster when using ARM-based web browser software instead of Chrome and Firefox is used because the browser has a small memory footprint (300M). This system is realized by web auto controller language which controls and uses PLCs that are easier than existing devices. This smart home automatic control technology can control smart home equipment anywhere and anytime and provides a remote interface through mobile equipment.

Key words: Home Automation, Smart Home, Remote Control, ARM Processor.

1. INTRODUCTION

'Smart Home' concept is emerged in 1980s with starting to use the concept of 'Smart Building'. In this period, smart home designed only for user's convenient [1]. The development of technology directly and indirectly provides and increases security and convenient to human. This development of technology directly affects life standard by smart home system design. Smart phone or home network technology which continuously creates added value makes life standard all the more high [3]. Smart home should be designed to reflect resident's wants and needs which put part or every equipment and function together [4].

Every sort of automation technique (lightening, temperature control, door and window control, security system and etc.) of intelligent building can be applied to home automation. Smart home market of Korea has 28% of high average annual growth rate and with this pace of growth, it is predicted to reach about 11 Trillion Won in 2015 and about 18 trillion won in 2017.

Now we are entering the era of hyper connectivity which all things are connected to human through network [5], [6]. Especially, we can feel the big wave coming toward us that the Internet of Things will change the paradigm of information technology [7]. LG U Plus will show IoT service for pet raised

at home. Also it expands IoT service to Cuchen which is a specialized home appliances company, specialized smart home company Commax, furniture company Enex and other various areas [8].

Home network or ubiquitous home networking technology is the technology that various areas are united such as communication, broadcasting, home appliances, construction and content and etc. have a great ripple effect in industry and can create added value.

Smart home technology realizes, not just in home network connection, but house or building information technology while informationization is taking place in the everyday life and makes a better life standard by providing broader and more diverse information and service being free from place in house and equipment [3].

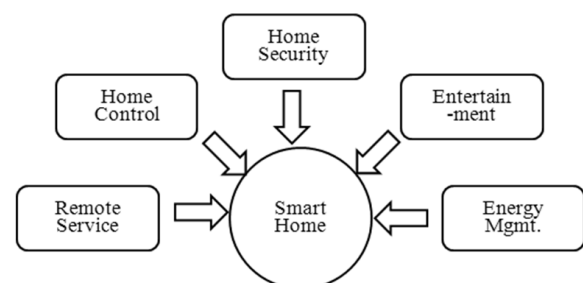


Fig. 1. Ubiquitous Technology for Smart Home

Smart home system realized in this paper is consisted of CAD-based editor, web touch screen, web order language in

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multiple performance, ARM imbedded module, remote PLC, smart home equipment operating automatically and home server control system. Home control equipment is composed of intrusion detection, gas valve control, door lock, automatic curtain, ventilator control and other on/off control module and those are controlled by home server. Home server provides user interface which can control by them and remote interface which can be controlled by smart phone so that they can control automatic control system at anywhere and anytime conveniently.

In the construction of the paper, chapter 2 mentions current state of smart home service and its domestic and foreign research. In chapter 3, it explains smart home whole composition designed in this paper, hardware system and software. Lastly, in chapter 4, it describes conclusion and content of future study.

2. SMART HOME CONTROL AND OUTLOOK

2.1 Current State of Smart Home Service

In recent years, 'Smart Home, or Home IoT' which is called as future source and core of the trend, take one part of Internet of things(IoT). With the spread of smartphones, personalization of IT has been expanded but entering upon an IoT era, personalization of IT is getting strengthened. And now, application of IoT is getting expanded to personal space like as car and home [9].

Domestic smart home market has 28% of high average annual growth in Fig 2. With this pace of growth, it is predicted to reach about 11 Trillion Won in 2015 and about 15 trillion won in 2016.

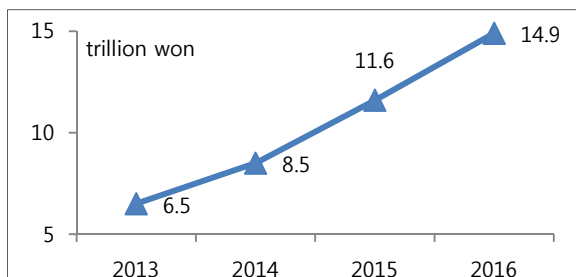


Fig. 2. Domestic Smart Home Market Outlook [10]

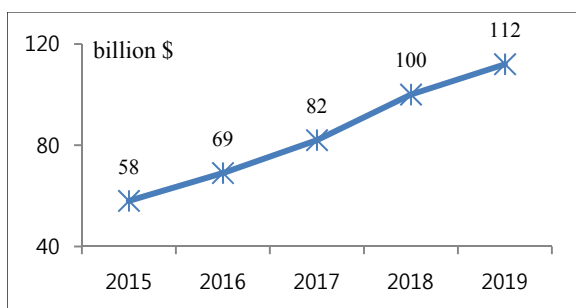


Fig. 3. International smart home market [11]

Smart home of domestic construction companies is provided the service focused on Wall Pad installed in the living

room. The main service is the phone call between inside and outside, door control, home security(CCTV, fire, has, safe and etc.), home control(energy, lightening, ventilation and etc.) and etc. but, it is not vitalized currently.

The current service level that communication companies provide is so weak that even CCTV is the all of it. Current state of three domestic communication companies and preparation plan of smart home is showed on table 1.

Table 1. Service state of three domestic communication companies

Item	Current services	Future services' plan
KT	• B Home CCTV	• Home IoT usage with 11 companies • Develop the open type IoT, platform 'mobius' & development of 'personalized plat form'
KT	• Olleh giga home fitness • USIM based doorlock service	• 'Smart home care' business plans with covey • 'Home IoT' field partnership with Nokia
LG U+	• U+ gas lock • U+ home CCTV momcar	• Home IoT service plans like 'Home manager', 'Magic mirror' with LG electronics

Most of home appliances of global leading home appliances company LG and Samsung Electronics are designed to connect to network and they have already provided this service. But because of smart home is not standardized, it has to be dealt with compatibility. Especially, LG Electronics participates in Allseen Alliance with Qualcomm, Microsoft and etc. as the platform standardization aspect. While, Samsung Electronics is planning to build 'OIC(Open Inter-connect Consortium)' with Intel and invest[9].

AT&T, US company launched its own platform 'Digital Life' which provides home security and automation service by affiliating with Linear, Cisco, Honeywell, Yale and etc. at 15 cities in April, 2013. They have 14 million(criteria of Sep, 2014) members now.

Orange, France Company launched 'Home Live' service in Oct, 2014. It controls and monitors home equipment through smart phone, tablet, PC by mobile application. Platform communicates through Z-Wave technology based on MiOS. They provided Motion sensor, door/window sensor and smoke detecting sensor with system manufacturing company Fibar group and they are planning to launch IP-based equipment as Philips(lightening), Netatmo weather station(automatic temperature control), health care, wearable and etc.

NTT Docomo, Japan Company launched 'Docomo Smart Home' service in Mar., 2013. They provided the service that people can enjoy content focused on home entertainment connecting to smart phone, tablet, TV and various home appliances so that they can use at anywhere and anytime at home, unlike AT&T, Orange Company which focused on home security and automation [12].

2.2 Study of Smart Home Automatic Control

According to the use of smart terminal became popular recently, the intention to use smart equipment about 'security, home appliances, health care and etc.' tends to increase which can interlock with smart terminal [13].

Zigbee is the representative technology of short-distance sensor network for the low power, low price, and easy use. In 'smart phone-based home automatic control system design and realization' [8], requested message typed by user and remote-controlled equipment translate the order through request analysis device and give back the result to user or create the packet for sensor control and deliver to sink node. Zigbee Communication controls each equipment by sending signal to each control module of intrusion detection, gas sensing, gas valve, TV, lamp, air conditioner, lightening, automatic curtain, door lock, ventilation and etc.

M2M(Machine to Machine) or IoT(Internet of Things) will use in earnest through popularization of smart sensor, expansion of wireless network, price decline of communication module and spread of supply on smart equipment in hyper-connectivity era which everything is connected to human by network for smart home automatic control.

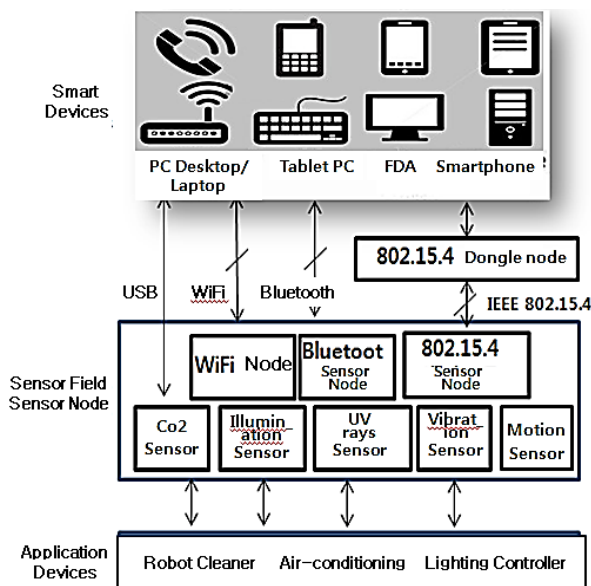


Fig. 4. Technology fusion and re-formation of external sensor equipment and smart equipment connected directly [7].

Instead of both sensor and smart equipment exchange information through internet, it is able to communicate through network interface equipped in smart equipment and sensor. This technology is highly important for IoT service [7]

In Fig 4, those technologies which are wire mode USB as a direct communication way, Bluetooth as wireless way, IEEE 802.15.4 (Zigbee), RFID/ NFC, WiFi could be applied. It has an advantage to be built independent and personalized safe network by avoiding the internet access for communication and at the same time, it is strengthened in security and free from other network state.

Various smart equipment already support diverse networking system, so it is available for small scale of networking system. In this system, although research that

provides sensor data processing framework is at an early stage, it is actively on a process.

In this hyper-connectivity era, all of the things are connected to human by network. McKinsey selected IoT as one of the technology that change a human life rapidly and expected that it will be applied to almost every industry fields [14].

In 'Web-based smart home automation: PLC control realization' [2], smart home should be considered by these 4 main part: 1) Physical structure of Building 2) System(safety, air conditioner, electronic control), 3) Service(internet, communication), 4) Management(energy, light).

In this study, smart home control is realized through PLC control of touch screen using computer, mobile device and internet. This application has two parts and it is composed of ARM(CPU)-based automatic control, web auto control RPL controlling hardware, touch monitor controlling by web screen and web browser(Firefox).

The broad usage and interest on ARM(Advanced RISC Machines) without high quality processor as PC level is expanded practically to all fields in electronic industry such as PDA, application processor of smart phone, MP3 player and mobile device.

For a single smart phone, lots of controller is used such as 1)AP core CPU, 2)Modem control usage, 3) Codec DSP usage in modem, 4)Sound Codec usage in AP, 5)USB controller usage, 6)Bluetooth controller usage, 7)Touch pad driver usage, 8)LCD

Controllers usage, 10)Electricity controller usage 11)Charge and discharge controller usage, 12) Ethernet controller usage and etc. [16].

3. SMART HOME AUTO-CONTROL SYSTEM

Smart home auto-controller system's block diagram realized in this thesis is like Fig. 5. The hardware and software component of smart home application are User Client, CAD based editor, touch screen, ARM imbedded module, and Remote PLC.

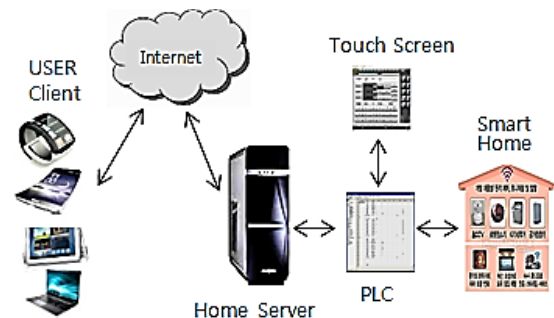


Fig. 5. Block diagram of the smart home system

Fig. 6 is the entire constitution picture of the smart home system. Users utilize wearable machines, smart phone, tablet, PC and they also use web browser (Firefox) for data receive & transmission. In order to make a choice between the 2 web browsers, Mozilla Firefox & Chrome, we do comparison analysis: 1) web browser execution speed, 2) tab loading time,

3) memory usage percentage, and 4) memory usage percentage with the browser plugins activated. Due to the fact that Firefox has superiorities on the faster simultaneous tab loading time (7sec), and on the smaller memory usage percentage, Firefox is more suitable for smart home auto-control web browser [16].

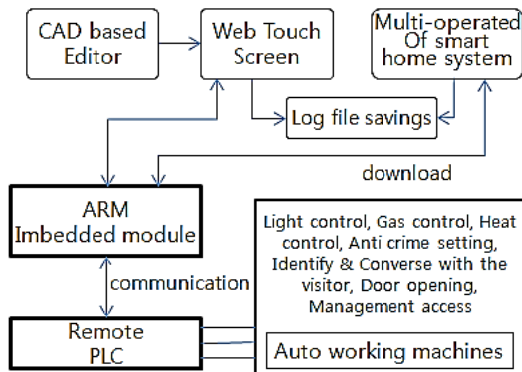
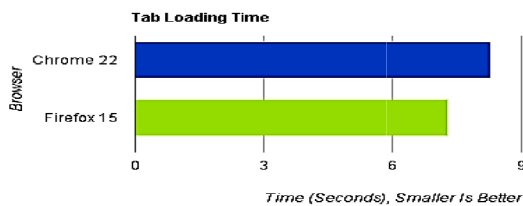


Fig. 6. Total composition of smart home system

► Tab loading time

When we opened the 9 tabs simultaneously during the running of the program, it took 7 seconds for Firefox to load all the tabs, and Chrome lasted more than 7.



► Memory usage percentile (Memory Usage with Nine Tabs Open)

When the 9 tabs were opened, we measured the memory that the browser used. And we found out that Firefox used 300MB memory, while Chrome used more than 500MB of memory.

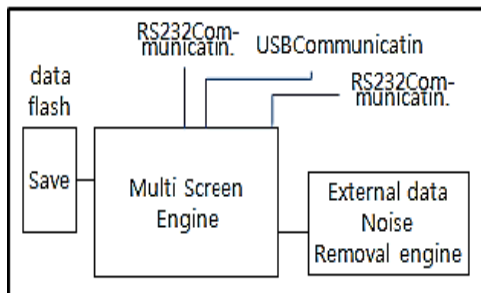
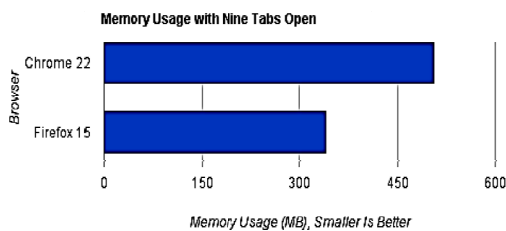


Fig. 7. ARM imbedded model

3.1 Hardware of smart home

In Fig. 7, 'ARM imbedded' consists of multi-screen engine, memory, engine used for eliminating the external data noise. And it is suitable for smart home's auto-control.

- Involves the Multi-axis Servo Controller and PLC function usable by utilizing ARM CPU and FPGA.
- Web auto controller, which controls hardware, is an internal controller working in an order, controlling PLC remotely between the existing PLC and the touch screen.
- Touch monitor controlled by web screen can be controlled in remote areas and A/S is possible, and also if the machine malfunctions, it tells us the place where the troubles come from.

We commonly use PLC to automatically control the machines in the house, and for the control language, we use ladder diagram. PLC has several inputs and outputs. It must be usable in the large range of temperature, and must be strong against the electronic noise or shocks. Program for the control is saved in the battery backup and the non-volatile memory.

3.2 Software of smart home

We generally use PLC for controlling automatically the home appliances equipment and we use control language as Ladder Diagram. PLC has many inputs and outputs. It has to operate in a broad temperature range, strong for the electronic noise, vibration and also shock. Program for controlling is saved in battery back-up and non-volatile memory. It has a real time handling ability to an input, so output has to react in time according to the input condition.

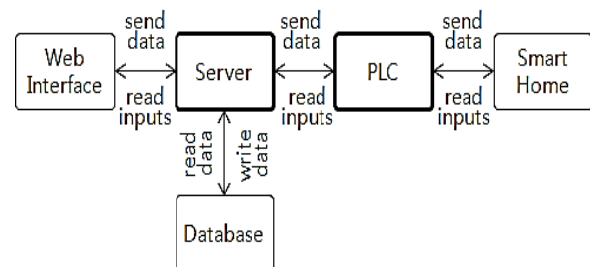


Fig. 8. Flow diagram of smart home system

Desired function is mainly operates by Ladder diagram. If the input signal goes in through switch, it handles in internal by operating technique of Ladder diagram and lastly output is showed to the output coil. The move of the controlled object that printed out will be controlling the whole system.

But the Ladder diagram is wanting in ability to control smart home by internet and mobile equipment automatically on smoothly.

In this study, web automatic control system language has been developed. It made to control Multi-Axis motion control and external output in easier way and those are the characteristics.

- According to the task order, it operates in sequence control so that anyone can understand easily and it is available for the separated work as process1, process2 and etc. because several programs works at that same

time for each functions.

- It shows current processing step by indicating program making and current processing step if machine stops.
- If machine's movement is abnormal, it tells why it stops so programing and debugging are convenient.
- It save every state of machine's movement as log file, so it is easy to do causal analysis when it stops.
- Program making editor is composed in advance as Excel so just select and put the data on order listed from left side, programming is completed.

[Example of Programming]

The content of execution operation is as following

- 1st: Operates start1 thread as a start order
- 2nd: Operates start2 thread as a start order
- 4th: Wait until external input of s/w 201 turn to 'on'
- 5th: out on 301, Turn on external output 301
- 6th: delay 100, delay one second
- 7th: Turn off external output 301 for out off 301
- 13th: jump start1, Jump to 3th
- 15th: wait on 202 5 is the order to handle the noise as 'wait more than 0.05 sec after the input of 202 S/W'

Table 2. Example of the web auto-control controller's language

No	#label	Command	X	y	z	w	>label	val
1		progstart					start1	
2		progstart					start2	
3	start1							
4		waiton	201	s/w	wait until the input of 201 s/w			
5		outon	301	Turn the 301 on				
6		delay	100	Delay 1 second				
7		outoff	301	Turn the 301 off				
8		delay	100	Delay 1 second				
9		outon	302	Turn the 302 on				
10		delay	100	Delay 1 second				
11		outoff	302	Turn the 302 off				
12		delay	100	Delay 1 second				
13		jump					start1	
14	start2							
15		wait	202	5	Wait more than 0.05 sec after the input of 202 s/w			
16		outon	303	Turn the 303 on				
17		delay	50	Delay 0.5 second				
18		outoff	303	Turn the 303 off				
19		delay	50	Delay 0.5 second				

About 50 sorts of the order for the automatic control as oncall, onjmp, switch, and, or, not, the four fundamental calculation and etc. is used.

3.3 Control program using web browser control (imbedded module control of html file)

Mutual exchange is available between C++ program and HTML-attribute ID value and working screen can handle with HTML java Script. Cad-based HTML edit screen is a CAD based editor and followings are advantages of it.



Fig. 9. CAD-based HTML menu screen of editor

- 1) Perfect WYSIWYG and Overlapped design is available using CSS4. We can print completed page as a size we want.
- 2) Modify is available by classifying necessary functions and saving and reuse as block and symbol. In case of necessary, modify is also available.
- 3) All functions are made at once by changing the attribution located on the function icon as positioned button.
- 4) After making a button, locating it and changing the attribution, homepage to automation control are automatically handled.

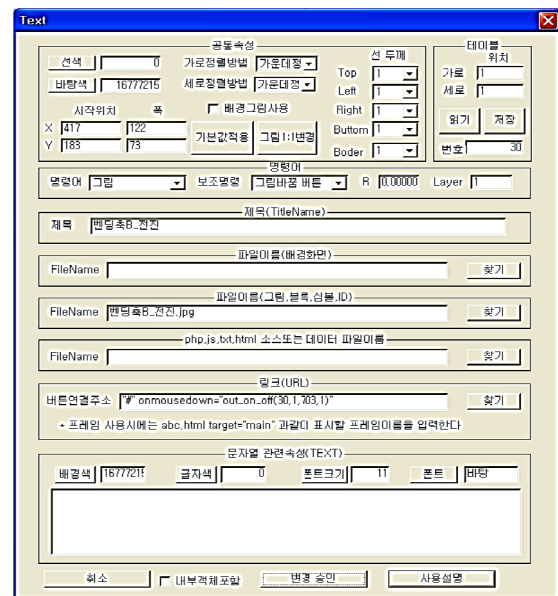


Fig. 10. Screen change the control Parameter button to properties

In Fig. 11, to control imbedded module, do programming → compile → download → monitored variable and debugging. To input the name in Korean instead of variable number is also fine.

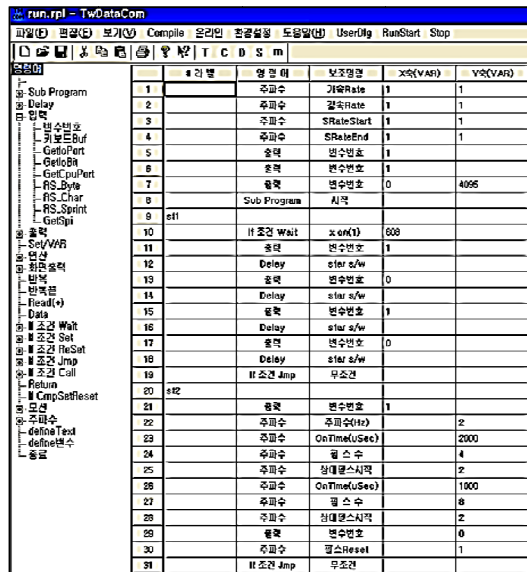


Fig. 11. Multi control language edit and compiler screen controlling imbedded module

3.4 Development Environment(Development language, usage system, Used Public SW and etc.)

- Web program development Cad Edit → Visual C++6.0
- Web program development Cad Edit → Visual C++6.0
- Touch environment → Visual C++6.0
- CPU : AT91SAM7S256, SAMSUNG 44B0
- Remote control PLC :k3p-07as
- Imbedded : Code Warrior for ARM Developer suite 1.2

3.5 Smart Home Temperature Controller

Smart home control system designed in this paper is the control program using web browser control, we can easily confirm each room's heating temperature by smart phone and control it both inside and outside. To make smart home control possible, web environment and smart control module home equipment gateway provide URL information for data communication to web browser of mobile device.

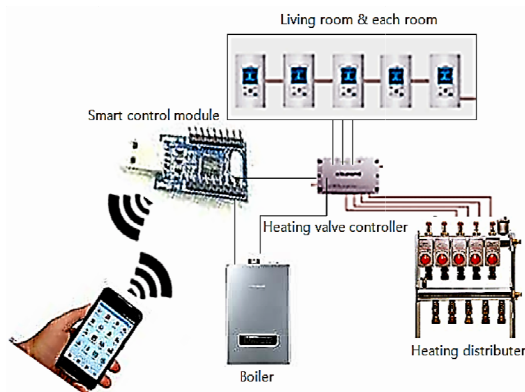


Fig. 12. Smart Home Temperature Controller

4. CONCLUSION

In this paper, for smart home automatic control, ARM-based smart control module, web automatic control system language controlling home equipment (CAD based HTML editor, multi control language controlling imbedded module) are developed and touch monitor controlling by web screen is developed as control and maintenance are able to do remotely. Design of web-based smart home automatic control system could provide the service to control and maintain various type of home appliances remotely such as door in home, lamp, temperature, refrigerator, curtain, power equipment and etc. by using various devices in outside like smart phone, laptop PC, tablet PC and etc. and web browser which operates in those devices.

It needs to be researched that ARM imbedded module designed from this study, study for home equipment realization by using multi control language and about access authority and security when access remotely to home equipment and be provided the service.

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