JAIST Repository
https://dspace.jaist.ac.jp/

Title	Requirements of User Interface (UI) for home network system
Author(s)	Le, Loc
Citation	
Issue Date	2012-09
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/10759
Rights	
Description	Supervisor:Professor Yasuo Tan, 情報科学研究科, 修士

JAIST
JAPAN
ADVANCED INSTITUTE OF
SCIENCE AND TECHNOLOGY

Japan Advanced Institute of Science and Technology

Requirements of User Interface (UI) for home network system

By Le Loc Xuan

A thesis submitted to
School of Information Science,
Japan Advanced Institute of Science and Technology,
in partial fulfillment of the requirements
for the degree of
Master of Information Science
Graduate Program in Information Science

Written under the direction of
Professor Yasuo Tan

September, 2012

Requirements of User Interface (UI) for home network system

By Le Loc Xuan (1010228)

A thesis submitted to
School of Information Science,
Japan Advanced Institute of Science and Technology,
in partial fulfillment of the requirements
for the degree of
Master of Information Science
Graduate Program in Information Science

Written under the direction of
Professor Yasuo Tan

and approved by
Professor Yasuo Tan
Associate Professor Azman Osman Lim
Professor Yoichi Shinoda

August, 2012 (Submitted)

Copyright © 2012 by Le Loc Xuan

Acknowledgements

Firstly and foremost, I am very proud to be able to join Tan Laboratory as a master student. I specially thank Professor Yasuo Tan for being my supervisor. As my supervisor, he is an erudite and kindness teacher who had no hesitance in accepting my requests for research devices. Without his support and guidelines, I believe I could not do my research.

Secondly, I would like to thank Associate Professor Azman Osman Lim for his valuable comments and encouragement.

Next, I also would like to thank Mr. Marios Sioutis who supported me a lots in the role of my tutor, without him, I could not make acquainted with the life in JAIST quickly and focus on studying.

Finally, I would like to say many thanks personnel of FIVE-JAIST program. Without the program I would not be able to come to Japan to study.

Contents

1 Introduction **5**
- 1.1 Home network system . . . 5
- 1.2 Human interface . . . 5
- 1.3 Research objective . . . 6

2 Background **7**
- 2.1 Purposes of home network GUI . . . 7
  - 2.1.1 Existed smart home solutions . . . 7
- 2.2 Physical control user interfaces . . . 11
- 2.3 Proposed UI components . . . 13

3 System Architecture and Implementation **15**
- 3.1 HomeControl GUI Design . . . 15
- 3.2 Application architecture . . . 18
  - 3.2.1 Modal View Controller (MVC) [6] . . . 18
  - 3.2.2 UPnP architecture . . . 19

4 Experiments and results **21**
- 4.1 Test cases . . . 21
  - 4.1.1 Single device controlling . . . 21
  - 4.1.2 Multi devices controlling . . . 22
- 4.2 Data collection methods . . . 22
  - 4.2.1 User activity and device operation status logging . . . 23
  - 4.2.2 Questionnaire . . . 23
- 4.3 Evaluation characteristics . . . 23
- 4.4 Experiment results . . . 24
  - 4.4.1 Analysis from logged data . . . 24

5 Conclusion **27**

A Screenshots of the survey **29**

B Survey results **34**

Bibliography **40**

List of Figures

2.1 The GUI of Lutron Home Control 7
2.2 The GUI of iControlAV2 8
2.3 The control GUI of Samsung WF457 9
2.4 The GUI of FrontPoint Security 9
2.5 The GUI of HAI OmniTouch 10

3.1 HomeControl main view 16
3.2 HomeControl - light's detail view 16
3.3 HomeControl - air conditioner's detail view 17
3.4 HomeControl's scripts view 17
3.5 HomeControl architecture 18
3.6 Model View Controller design pattern of iOS Cocoa Touch [6] 18
3.7 UPnP protocol stack [7] 19

4.1 Result chart of Scenario 1. 24
4.2 Result chart of Scenario 2. 26

List of Tables

2.1 Required UI functions for the purposes 10
2.2 Home appliances and their functions 11
2.3 Proposed UI components for required UI functions and 13

3.1 Home device and operation status icons 15

4.1 Results of the single device controlling scenario 4.1.1 24
4.2 Results of the multiple devices controlling scenario 4.1.1 26

Chapter 1

Introduction

1.1 Home network system

A new network era is here, devices, which have connectivity function grown rapidly and become a very good and useful source of communication among the people and all the technologies of present time. There is time when most families could not afford to have more than one computer, but then, laptop, smart phone, tablet appeared sequentially. These network devices give birth to home network as a simply method to allow them to communicate with each other. After that, the home network has continuously evolved beyond connection and communication between the computational devices to connection and communication between all appliances, devices, and systems in a home. Through the integration of network functionality with the home appliances, nowadays home network system allows smart home to be more real than ever.

At the moment, the home network has abilities to assist all of our activities in the home include: working, entertaining, appliances controlling, communicating, etc. Moreover, many researchers in the world have given, and are giving their efforts to improve the life quality of people through the home network. Therefore, it will become a thing that cannot be missed in every family in a near future.

1.2 Human interface

A user interface is the system by which people (users) interact with machines. Human - machine interactions as well as the user interface involves such disciplines as ergonomics and psychology. The user interface is of paramount importance to a system: whereas a badly designed UI will complicate and hinder the use of a perfectly capable underlying system and negatively impact the user experience, a well-designed UI can help the user control and operate devices effectively. Furthermore, it provides feedback necessary in making operational decisions, thus simplifying the control of devices and improving user experience. In case of the home network system, the user interface can referrer as the graphical user interface (GUI) when it is used on a computer, a smart phone or a tablet PC. And for this case, the GUI has to be considered more carefully than ever because it

relates to the UIs of different control systems of home appliances.

1.3 Research objective

In our research, we discuss requirements for the Graphical User Interface for the control of a home network system. What we considered is how the GUI of the home network system should be when it aims to provide centralized control of the devices, connection management, be user-friendly and intuitive as well as provide support for scripting/programming device behaviour (e.g. timers). More precisely, we proposed required user interface functions which the home network should have after doing survey on different smart home solutions. Then we examine each of these functions and proposed the required GUI components.

Our approach is included considering physical forms of home appliances, categorize them according to their functionality. Next, we proposed required GUI components for each UI function and each type of home device functions. Based on this insight, we designed and implemented an application which satisfied all the required UI functions on an iPad. The implemented application was employed in experiments to evaluate efficient of the proposed UI functions. In the end, conclusions for requirements of GUI for home network system were given base on experiment results.

Chapter 2

Background

2.1 Purposes of home network GUI

2.1.1 Existed smart home solutions

Currently, there are many smart home applications on the market. They cover every aspects of people's life at their home which are: security, entertainment, communication, controlling home environment, doing housework, etc. We decided to choose five famous solutions which each of them concentrated on different aspects of the home network system to do a survey about their functions in order to find out what are common purposes of them.

The first application is *Lutron Home Control* [1] which is on the home environment controlling aspect. It has these following functions:

- light, shade, temperature, ventilation remote controlling.
- saving energy
- device scheduling.

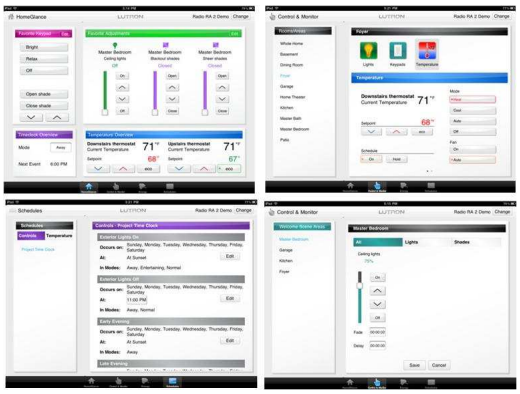


Figure 2.1: The GUI of Lutron Home Control

The second application is *iControlAV2* [2] which focus on the entertaining aspect and has functions that include:

- Home theatre components controlling.
- Input source selection (include Blu-ray Disc player, DVD player, Video deck, TV/SAT. Home Media Gallery, iPod and USB)
- Listen modes selection
- Detail system information displaying

Figure 2.2: The GUI of iControlAV2

Next we considered *Samsung WF457 Wi-Fi washer and dryer* [3] which related to doing houseworks. It has the following functions:

- Allow users to stay connected to the washer without having to manually control it at the machine.
- monitor cycle selections, remaining time and finishing alerts
- remotely start or pause the washer.

The fourth application is *FrontPoint Security* [4] in home security field. It can support user to:

- Arm and disarm security system.
- View system status.
- Control thermostat, door locks and lights.
- Wireless video surveillance.
- Immediately send panic signal to a police or medical

Figure 2.3: The control GUI of Samsung WF457

Figure 2.4: The GUI of FrontPoint Security

- Notify user with instant security alerts (by text message and emails)

The last one is *HAI OmniTouch* [5] which is used for in-house communication. This solution support user by the following functions:

- Display live video feeds to see the guest at front door.
- Manual accept/reject incoming messages
- Auto-answer, do-not-disturb modes
- Control intercom volume levels (voice and ring)
- The display shows where the message originated (front door, guest bedroom, etc.)

After considering the abilities and functions of the above mentioned elegant GUIs, we conceived that their purposes comprise:

- To help user easily select and get information of them
- To support user control through the GUI
- To reduce user effort when they control multi devices

Figure 2.5: The GUI of HAI OmniTouch

For these above purposes, the required functions of the home network GUI system can be described generally as:

Table 2.1: Required UI functions for the purposes

Required UI functions	**Purposes**
Centralized visualization of home devices	To help user easily select and get information of them
Device remote controlling	To support user control through the GUI
Device scripting/programming	To reduce user's effort when they control multiple devices

To proceed further, we investigated deeper into the presented general required UI functions for more details requirements which are:

- Centralized visualization of home devices
  - Show device location
  - Show device type
  - Show device current status
- Device remote controlling
  - Show "appropriate" UI functions for practical functions of the devices
- Device scripting/programming
  - Create a script
  - Edit an existed script
  - Execute a script

As it can be seen from the fancy detail requirement of "Device remote controlling" function, we suggested a survey on conventional physical control user interfaces to clarify what type of practical functions can appear in the GUI of home network system in next section .

2.2 Physical control user interfaces

In this section, we will discuss about classifying physical control user interfaces of electronic devices which are familiar to every one of us. The examined devices encompassed a wide range of home appliances as the following table 2.2:

Table 2.2: Home appliances and their functions

Home device	**Functions**
Light	• Turn On/Off • Set light intensity
Refrigerator	• Turn On/Off • Set cooling temperature
Kitchen stove	• Turn On/Off • Set heating temperature
Microwave oven	• Turn On/Off • Set heating mode • Set heating time
Washing machine	• Turn On/Off • Set washing modes
Clothes dryer	• Turn On/Off • Set drying modes
Water heater	• Turn On/Off • Set desired water temperature
Telephones	• Make a call • End a call • Set up phone number for calling

Electric shutter, curtains	• Open/Close
Air conditioner	• Turn On/Off • Set desired temperature • Set operation mode
Television	• Turn On/Off • Set channel number • Change TV channel • Set volume number

As can be seen from the table 2.2 above, we can categorize the functions of home devices into three categories:

- Command functions: these functions are used by the users to initiate an immediate action. For example: turn a device on/off, open/close an electric door/curtain/window, make a call, stop a call, play a song/movie, etc.
- Setting continuous values functions: this category includes setting desired temperature, setting light intensity, setting sound volume, etc. They are functions that allow user to set defined and contiguous values.
- Setting discrete values functions: The inputs of these functions are not contiguous values, they are functional specific values such as: air conditioner's operation modes, washing modes, etc. Users use them to set up the device by choosing one option from a set of mutually exclusive choices.

Now, the requirements of the GUI for the home network system can be described in details as the followings:

- Centralized visualization of home devices
  - Show device location
  - Show device type
  - Show device current status
- Device remote controlling
  - Show "appropriate" UI components for practical command functions of the devices

  - Show "appropriate" UI components for practical setting continuous values functions of the devices
  - Show "appropriate" UI components for practical setting discrete values functions of the devices

- Device scripting/programming
  - Create a script
  - Edit an existed script
  - Execute a script

2.3 Proposed UI components

In order to design an effective GUI, we proposed what user interface components are suitable for each identified required UI function base on these following Human Interface design guidelines from iOS developer library:

- Minimize the effort required for user input because it takes time and attention for user to input information.
- Use metaphors: Virtual objects should be metaphors for real world objects to help users quickly understand how to use the function.

Followed the above guidelines, we proposed that a useful GUI of home network system should have GUI components as in table 2.3 below:

Table 2.3: Proposed UI components for required UI functions and

UI functions	**UI components**
Centralized visualization of home devices	
• Show device location	• A map for each floor in the house • Icons represent physical devices at exactly the same location on the floor maps
• Show device type	• Different appropriate icons for different types of device

• Show device current status	• Different icon for different operation statuses of device
Device remote controlling	
• command functions	• a GUI button or a GUI switch
• setting continuous values functions	• a a slider, a stepper
• setting discrete values functions	• segmented control, list, combo box
Device scripting/programming	
• Create a script	• a record button to create scripts by recording users' controlling activities on the GUI
• Edit a script	• A script view to modify recorded scripts and assign scripts to script buttons
• Execute a script	• Customizable script buttons for quickly executing scripts on the main view

Chapter 3

System Architecture and Implementation

3.1 HomeControl GUI Design

Based on available devices in the experimental environment, we propose the following operation status icons as in table 3.1 for each type of device in order to help user quickly get the current information of devices

Table 3.1: Home device and operation status icons

Device type	**Operation status icons**	
Light	On	Off
Door	Opened	Closed
Air conditioner	On	Off
Electric Window/Curtain/Awning	Opened	Closed

In order to support all required user interface functions, the HomeControl GUI is composed of three UI views which are: a main view is the first showed up view when the application was started.

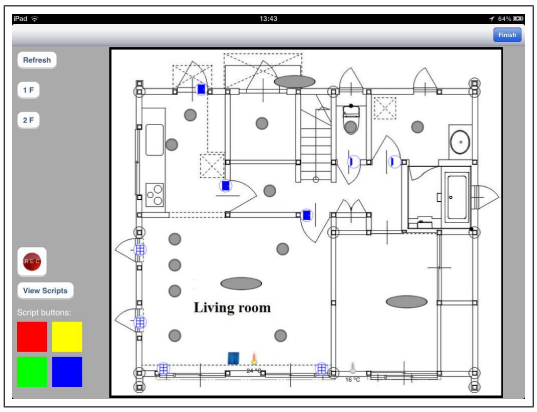


Figure 3.1: HomeControl main view

The main view in the figure 3.1 above included a map of the current house floor and icons present for devices at the same locations on the map. On the left side of the view, there are "REC" button for recording user activities to create device script and four coloured buttons to execute assigned script.

The second view of the application is detail view of a device that user can access by double tap the device icon.

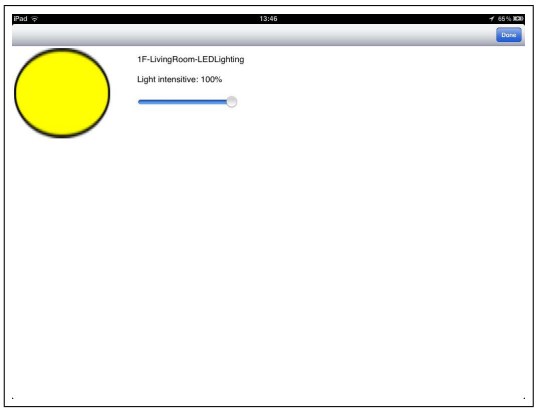


Figure 3.2: HomeControl - light's detail view

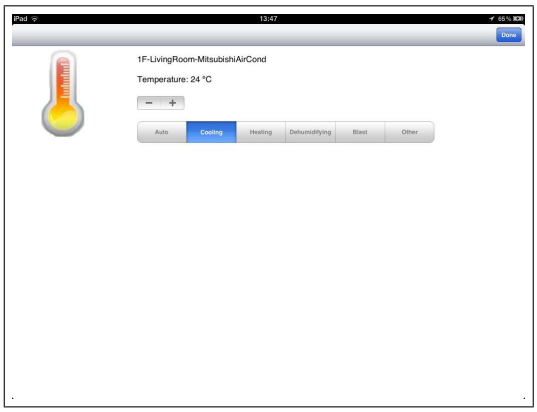


Figure 3.3: HomeControl - air conditioner's detail view

The last view of HomeControl application is scripts view which can be accessed from the main view by "Script view" button.

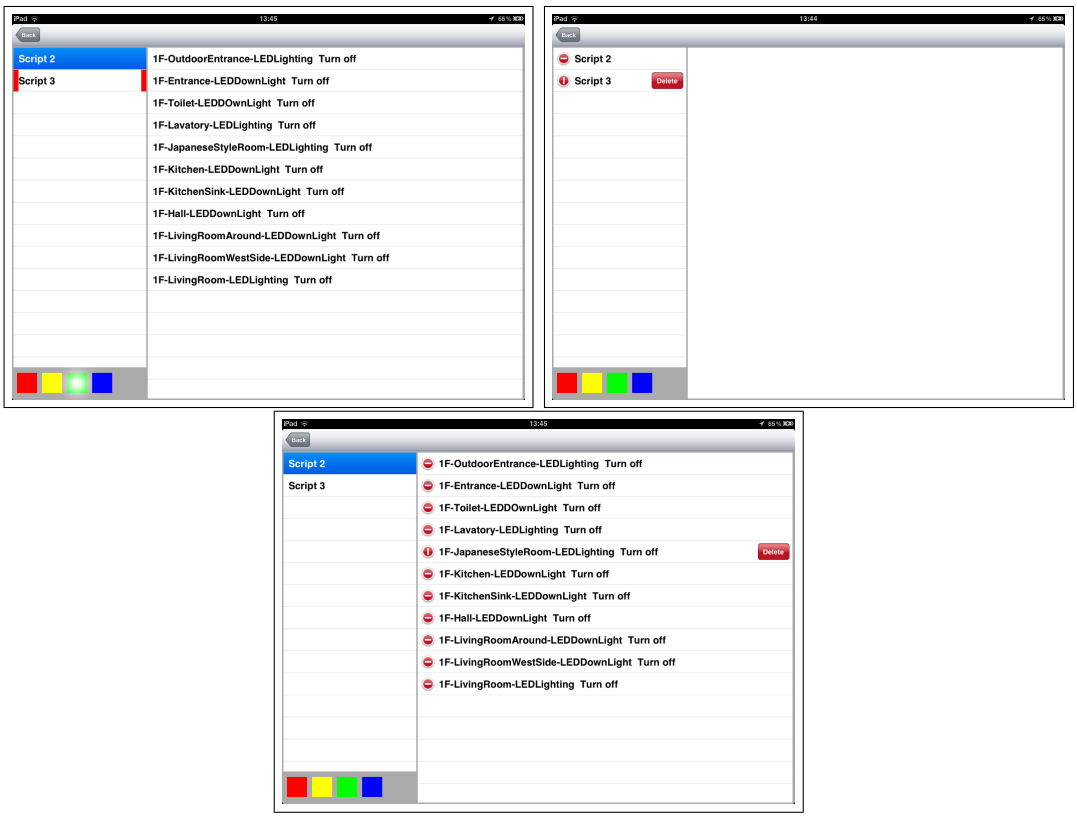


Figure 3.4: HomeControl's scripts view

In the scripts view as we can see in figure 3.4, user can enter editing mode by long touch (touch and hold) to edit a recorded script by select and delete the unwanted command on a device. Also in this view, user can assign scripts to the four coloured buttons.

3.2 Application architecture

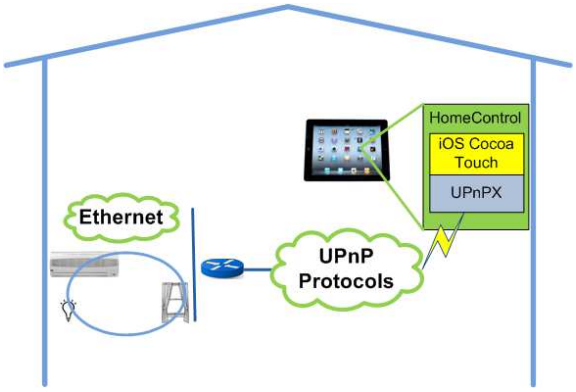


Figure 3.5: HomeControl architecture

3.2.1 Modal View Controller (MVC) [6]

MVC is the central design pattern of iOS Cocoa Touch platform. Therefore, there are three types of objects which create the GUI of HomeControl application. Not only the roles of the objects but also the way they communicated with each other are defined by the pattern.

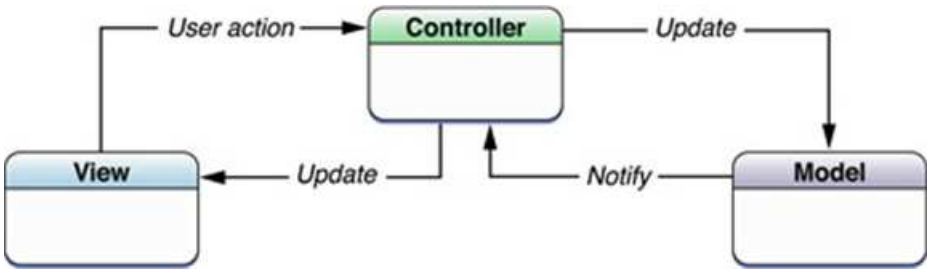


Figure 3.6: Model View Controller design pattern of iOS Cocoa Touch [6]

Model objects The data specific to the application and the logic and computation that manipulate and process that data are encapsulated in the model objects.

View objects Display data from the application's model object is the main purpose of view objects. They are what user can see and interact with on the application.

Controllers objects A controller object has role as an intermediary between the application's model objects and view objects. View objects know about changes of model objects through controller objects and on the contrary.

3.2.2 UPnP architecture

Universal Plug and Play (UPnP) is a set of networking protocol that defines an architecture for peer-to-peer network connectivity of smart appliances, wireless devices, and PCs. These protocols are depicted in the following figure 3.7:

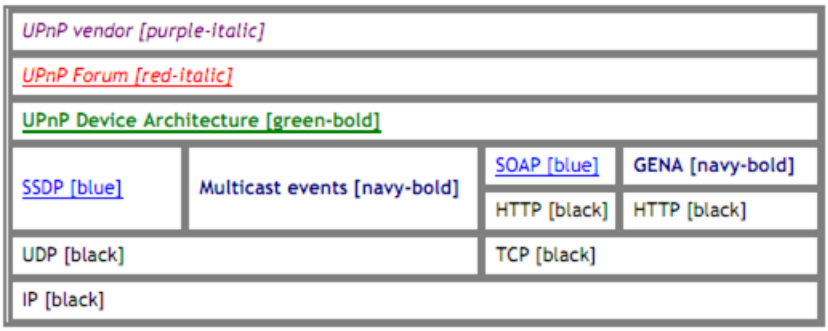


Figure 3.7: UPnP protocol stack [7]

Begin from the highest layer, only UPnP vendor-specific information about their devices is contained in messages. Going to lower layers, information defined by UPnP Forum working committees complement vendor content attached in the messages. At the fourth layer, they are hosted in UPnP-specific protocols such as the Simple Service Discovery Protocol (SSDP), General Event Notification Architecture (GENA) and multicast event protocol. SSDP is delivered via either multicast or unicast UDP. Multicast events are delivered via multicast UDP. GENA is delivered via HTTP. In the end, all messages above are sent over IP.

The core idea of UPnP is two universal categorizations of devices are given definitions as: controlled devices (or merely "devices"), and control points. A controlled device takes the role of a server, responding to requests from control points. Both control points and controlled devices can be implemented on a variety of platforms including personal computers and embedded systems. Multiple devices, control points, or both may be operational on the same network endpoint simultaneously.

There are six steps in a UPnP networking session:

Step 0 - Addressing Each device has to get an IP address from DHCP server or by assigning itself an address.

Step 1 - Discovery After given an IP address, the UPnP discovery protocol known as SSDP allows the device to broadcast its service to control points on the network. Correspondingly, the discovery protocol supports a control point to search for interesting devices on the network when it join the network.

Step 2 - Description UPnP specifications: "For the control point to learn more about the device and its capabilities, or to interact with the device, the control point MUST retrieve a description of the device and its capabilities from the URL provided by the device in the discovery message."

Step 3 - Control UPnP specifications: "Through control, control points invoke actions on devices and poll for values."

Step 4 - Eventing or *event notification*, this protocol in UPnP Device architecture is defined as General Event Notification (GENA). A UPnP description for a service includes a list of actions the service responds to and a list of variables that model the state of the service at run time. Update events are published when these variables change, and a control point may subscribe to receive this information. At first, the service publishes updates by sending event messages which contain the names of one or more state variables and the current value of those variables. These messages are also expressed in XML. A special initial event message is sent when a control point first subscribes; this event message contains the names and values for all evented variables and allows the subscriber to initialize its model of the state of the service.

Step 5 - Presentation This is the final step in UPnP architecture. If there is a URL for presentation of a UPnP device then a control point can retrieve a web page from this URL then use a web browser to show the page and allow users to control the device or view device status base on the capabilities of the page.

Chapter 4

Experiments and results

We evaluated the proposed required UI functions implemented in HomeControl application by setting up practical use cases and inviting users to use this application to control home devices in the home network system.

The environment where the experiments have taken place was the first floor of an experimental house. We have 15 lights, 1 electronic curtain, 4 electronic awnings/windows and an air conditioner that accompanied with the test cases.

4.1 Test cases

4.1.1 Single device controlling

In this scenario, we assumed user doing discrete tasks which control only single device at a time when staying in a room and this is the first time he use the application.

Scenario instructions

- Task 1: Turn on only the big light in the center of the living room
- Task 2: Set the center light's intensity to the highest
- Task 3: Open curtain in the living room
- Task 4: Turn on the air conditioner in the living room
- Task 5: Set the air condition in the living room to "Auto" operation mode

Purposes

- Compute learning time of user when using 3 types of device functions for the first time and later:
  - Command function: task 1, task 3, task 4

  - Setting continuous value function: task 2
  - Setting discrete value function: task 5

- Calculate how long it takes a user to select devices to control in order to evaluate how the visualization of devices' information affect the user

4.1.2 Multi devices controlling

For this test cases, it is assumed that user got used with the HomeControl application and he wanted to control multiple devices in the home with the least effort as possible. There are many realistic situations correlated to this scenario such as: user wants to turn off any lights in the house before he goes to bed, turn on air conditioner and close every windows in the room in the shortest time as possible, etc.

Scenario instructions

- Sequence 1: Turn on all the lights at the 1st floor
- Sequence 2: Turn off all the lights at the 1st floor while using recording function to create a script which will turn off all lights at the 1st floor.
- Sequence 3: Turn on all the lights at the 1st floor without using the tablet
- Sequence 4: Turn off all the lights at the 1st floor by using the recorded script on the tablet.

Purposes

To compare multiple devices controlling in various ways:

- by selecting the devices one by one
- by not using the application
- by using the script function

4.2 Data collection methods

Control activities of the participants in the experiments and operation statuses of home devices were logged through the experiments. After they finish 2 scenarios above, the participants were asked to answer a survey.

4.2.1 User activity and device operation status logging

4.2.2 Questionnaire

The Google Form service was used to create the online questionnaire, which is shown in Appendix A.

Format

It takes users from 5 to 10 minutes to answer the designed questionnaire. The short time required for completing this survey is an encouragement for participants to fill in more carefully, but meant that the questions had to be condensed and kept to a minimum without jeopardising the quality and range of information which was required. There were 3 sections in the survey for the respondent.

Demographic questions

The first two questions were to obtain basic demographic information of the respondent about their experiments with touch devices and smart home solutions. This information helped us ensure to get further understanding of differences between users with different technical backgrounds.

UI functional questions

They are the core questions of the survey, most of them were based on the Likert scale with possible answers: 'Definitely', 'Probaly', 'Not sure', 'Probaly not' and 'Definitely not'. The other questions were established on the time scale of events and open-ended question type which ask the respondent to explicate his own answer.

Overview questions

After filling the demographic and UI functional questions, respondent was asked about his overall feelings after using the HomeControl application. With 2 Linker scale questions and 3 open-ended questions, we focused on the ideas of the participants in order to achieve the users' viewpoints about the solution.

4.3 Evaluation characteristics

Based on the collected data from the logged files and the survey results, these following characteristics were considered as the metrics to evaluate the usability of required UI functions in the application:

- **Learning curve** How much time it takes user to recognize how to use the GUI
- **Operation time** The time a task requires

  - **T**ime for user to execute a task on a single device
  - **T**otal time for user to control multi devices
- **Success rate** percentage of tasks that users complete correctly.
- **User's subjective satisfaction**

4.4 Experiment results

4.4.1 Analysis from logged data

Table 4.1: Results of the single device controlling scenario 4.1.1

	Task 1		Task 2		Task 3		Task 4		Task 5	
	S	C	S	C	S	C	S	C	S	C
User 1	0:01	0:02	0:22	0:07	fail	fail	0:06	0:02	0:31	0:03
User 2	0:13	0:01	0:05	0:02	0:05	0:01	0:08	0:02	0:17	0:02
User 3	1:36	0:02	2:11	0:03	0:14	0:02	1:03	0:03	0:11	0:02
User 4	0:02	0:01	0:19	0:04	1:00	0:01	0:42	0:02	0:08	0:03
User 5	0:04	0:01	0:12	0:03	2:01	0:01	0:50	0:01	0:14	0:05
User 6	0:12	0:01	0:04	0:02	0:41	0:01	0:28	0:03	0:05	0:06
User 7	0:36	0:01	0:55	0:09	0:49	0:01	1:16	0:03	0:23	0:06
User 8	1:34	0:04	1:12	0:05	3:37	0:01	2:23	0:03	1:02	0:02
Avg.	0:21	0:01	0:40	0:04	1:12	0:01	0:52	0:02	0:21	0:04
Min	0:01	0:01	0:04	0:02	0:05	0:01	0:06	0:01	0:05	0:02
Max	1:36	0:04	2:11	0:09	3:37	0:02	2:23	0:03	1:02	0:06

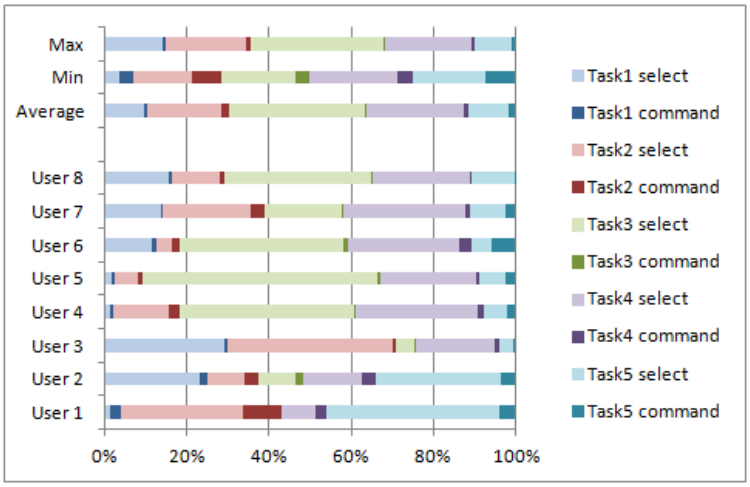


Figure 4.1: Result chart of Scenario 1.

In the table 4.1, for each single task, we examined device selection time and device controlling time which are signed sequentially as **S** and **C**

Comments The results from table 4.1 immediately clear that the learning curve of the user greatly depend on the device selection time, when the GUI components of the required functionality are showed up, users quickly figured it out how to control the device. For more details, what we can say from the table 4.1 are:

- Task 1: Turn on only the big light in the center of the living room
  - It took average 21 seconds for a user to select a light device when the time for user to turn on the light is only 1-2 seconds.
- Task 2: Set the center light's intensity to the highest
  - It took average 32 seconds to figure out how to enter detail view of the light when the time for user to set the light's intensity is only 2-7 seconds.
- Task 3: Open curtain in the living room
  - There are users who cannot recognize the icon for the curtain and they fail to complete this task.
- Task 4: Turn on the air conditioner in the living room
  - It took average 33 seconds for a user to recognize an air conditioner icon. The simple turn on function only took users 1-3 seconds to execute.
- Task 5: Set the air condition in the living room to "Auto" operation mode
  - After knowing that they can access the detail view of a device by double tap the device icon, the average time for a user to select and enter detail view of a device is reduced to 14 seconds.

In the second scenario, purposes of the experiments are comparing multiple devices controlling in various ways:

- Control by selecting the devices one by one.
- Control by not using the application.
- Control by using the script function.

Table 4.2: Results of the multiple devices controlling scenario 4.1.1

	Task 1	Task 2	Task 3	Task 4
User 1	0:48	0:38	0:25	0:25
User 2	0:22	0:28	0:52	0:29
User 3	0:44	0:47	1:14	0:39
User 4	1:08	0:54	0:24	0:48
User 5	1:08	2:32	1:28	0:41
User 6	0:47	0:27	0:44	0:57
User 7	0:22	1:12	0:56	1:24
Avg.	0:46	1:00	0:52	0:46
Min	0:22	0:27	0:24	0:25
Max	1:08	2:32	1:28	1:24

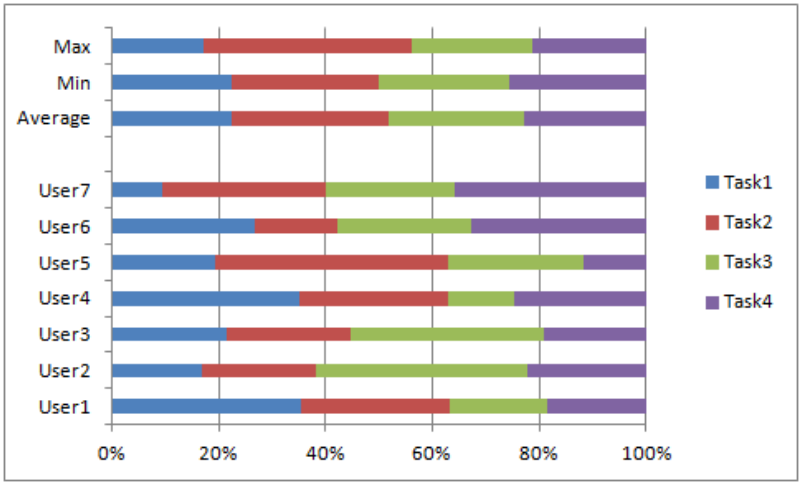


Figure 4.2: Result chart of Scenario 2.

Chapter 5

Conclusion

In this work, firstly we proposed the requirements as necessary UI functions of GUI for the home network system after doing survey on current smart home solutions and physical control interface of home devices. Then, the implemented HomeControl application which covered all the proposed requirements has been used in the realistic experimental environment. At the end, from the logged events and survey results, we can see that in the GUI for home network system, the visualization of device information has a greater effect on the user than the controlling of devices.

For controlling single device, it took users more time and effort to select devices than to control them by graphical functions for the first time. We can see that the proposed UI components that represent physical functions really helped users quickly understand the functions of devices. Moreover, from the results, we can say that recognizability of device icons decides the success of the task. If users cannot recognize the device icon, some of them will not be able to distinguish the icon with the map. On the other hand, in practical contexts, the nearest devices to the user are the most required targets to control because of their limited areas of effect. This leads to another approach for home device controlling where the target device is automatic selected by the home network system and whether the GUI still be appropriate for this situation needs more researches.

Next, controlling multiple devices by selecting device icons one by one on the house map has no significant improvement compared to not using the application. On the other hand, the time for user to create a script is greater than the time of the other two controlling methods. In general, it takes more time for users to use the script functions to control multiple devices at the first time when they create a script.

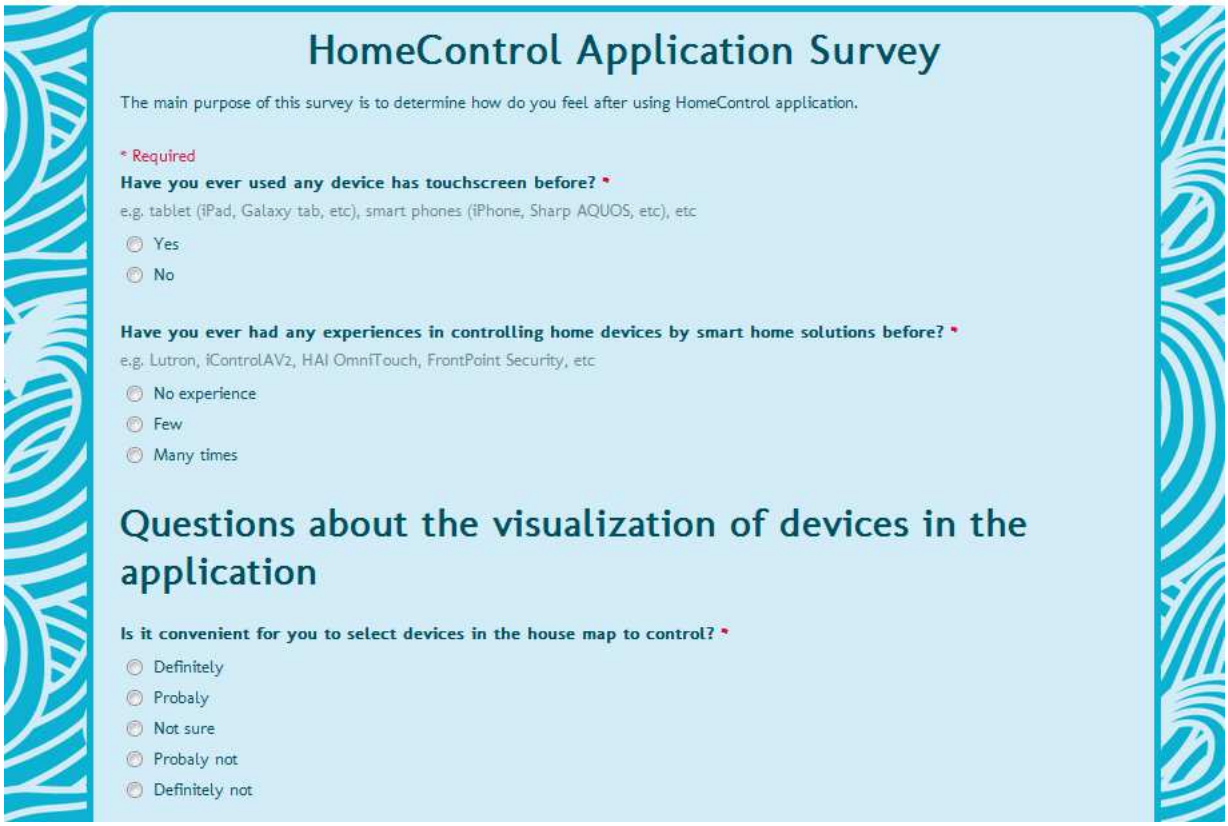
In conclusion, we believe the proposed UI functions and components are required for a friendly UI for the home network system. The positive feedbacks of the users in the questionnaire's results also guarantee for acceptances of users of a home network UI which followed the requirements. Comparing to the original controllers, we achieve those following improvements:

- User doesn't need to point the controller to the device.
- User doesn't need to hold many different controllers.

- User can recognize operation status of the devices to control even they couldn't see them in their view.
- User can just stay at one place to control the devices and didn't need to move around the house.

Appendix A

Screenshots of the survey



HomeControl Application Survey

The main purpose of this survey is to determine how do you feel after using HomeControl application.

* Required

Have you ever used any device has touchscreen before? *

e.g. tablet (iPad, Galaxy tab, etc), smart phones (iPhone, Sharp AQUOS, etc), etc

- Yes
- No

Have you ever had any experiences in controlling home devices by smart home solutions before? *

e.g. Lutron, iControlAV2, HAI OmniTouch, FrontPoint Security, etc

- No experience
- Few
- Many times

Questions about the visualization of devices in the application

Is it convenient for you to select devices in the house map to control? *

- Definitely
- Probaly
- Not sure
- Probaly not
- Definitely not

Is it easy for you to find devices that you want control in the house map of the application? *

- Definitely
- Probaly
- Not sure
- Probaly not
- Definitely not

How important do you think the following types of information are for helping you to control home devices? *

	Definitely	Probaly	Not sure	Probaly not	Definitely not
Device location					
Current device status					
Device name					

With the house map and device icons, could you locate the physical devices in the room? *

- Definitely
- Probaly
- Not sure
- Probaly not
- Definitely not

Questions about device controlling by the application

How long it took you to figure out how to turn on/off a light by yourself? *

- Before seeing the function
- After seeing the function
- After trying to use the function
- I couldn't, I need assistance

Do you think that you would like to use this application to turn on/off lights in your house frequently? *

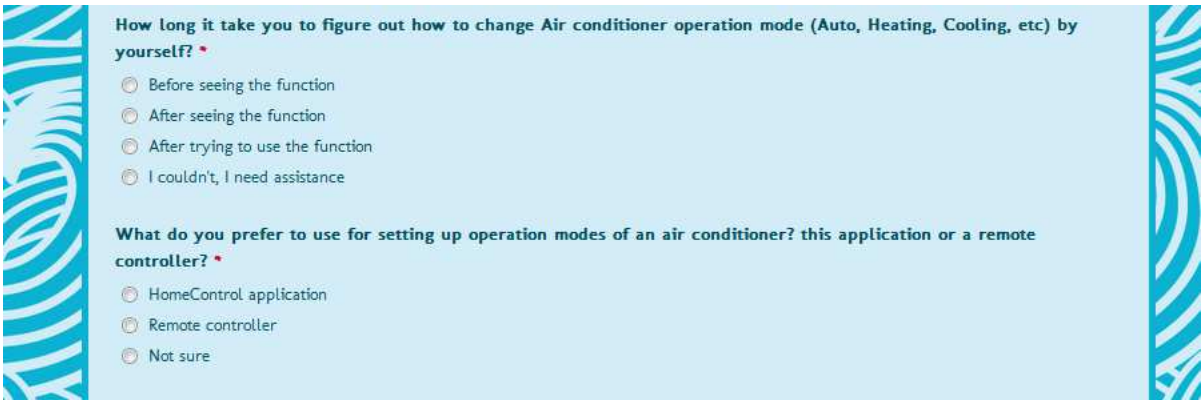
- Definitely
- Probaly
- Not sure
- Probaly not
- Definitely not

How long it take you to figure out how to set light intensity by yourself? *

- Before seeing the function
- After seeing the function
- After trying to use the function
- I couldn't, I need assistance

Do you think that you would like to use this application to set light intensity in your house frequently? *

- Definitely
- Probaly
- Not sure
- Probaly not
- Definitely not

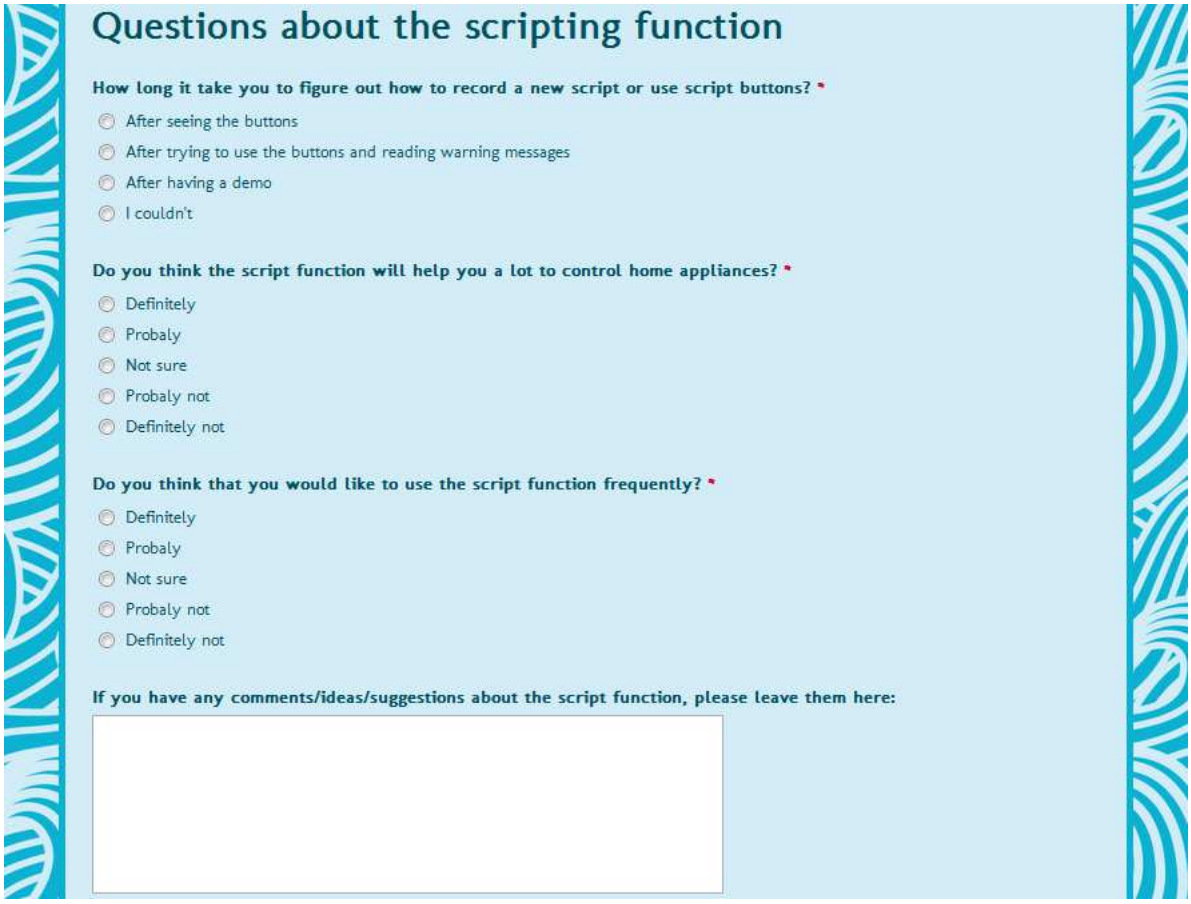


How long it take you to figure out how to change Air conditioner operation mode (Auto, Heating, Cooling, etc) by yourself? *

- Before seeing the function
- After seeing the function
- After trying to use the function
- I couldn't, I need assistance

What do you prefer to use for setting up operation modes of an air conditioner? this application or a remote controller? *

- HomeControl application
- Remote controller
- Not sure



Questions about the scripting function

How long it take you to figure out how to record a new script or use script buttons? *

- After seeing the buttons
- After trying to use the buttons and reading warning messages
- After having a demo
- I couldn't

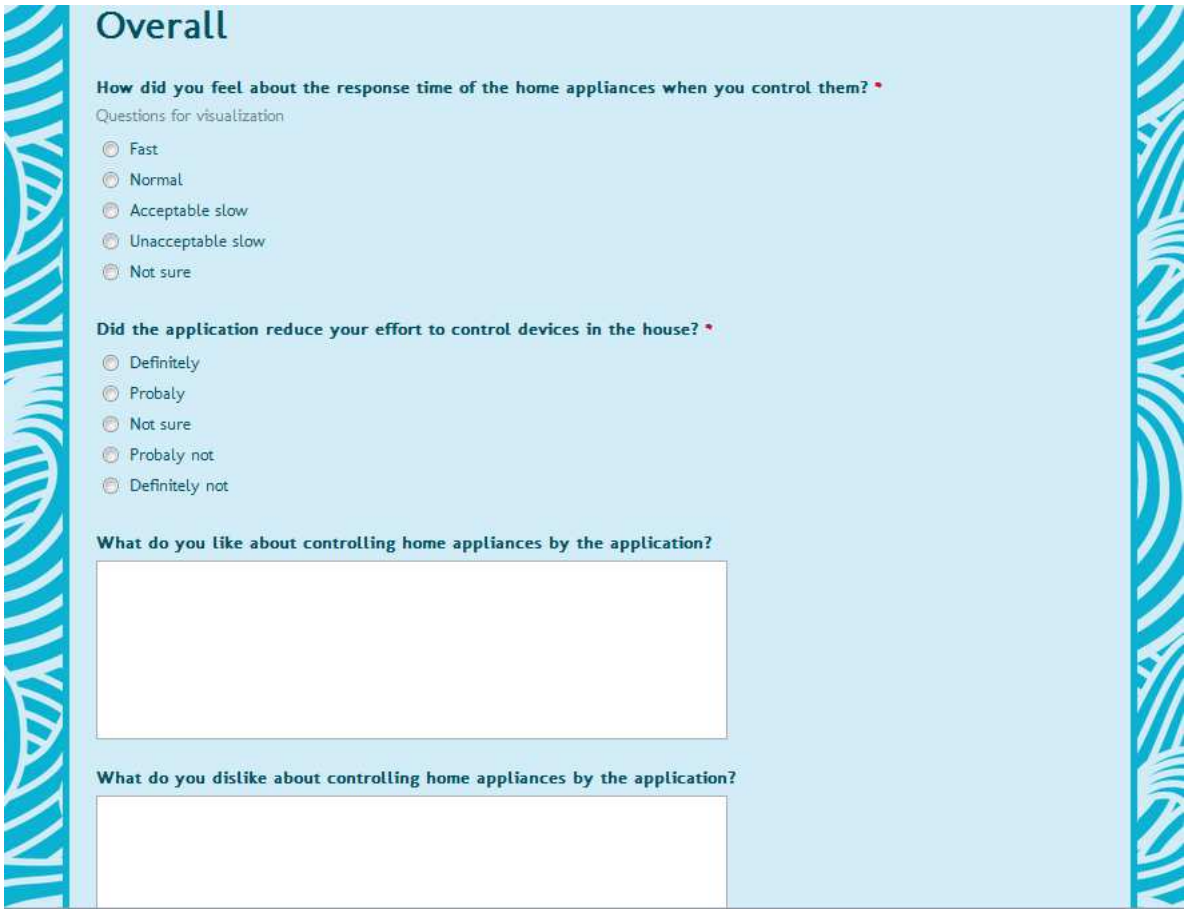
Do you think the script function will help you a lot to control home appliances? *

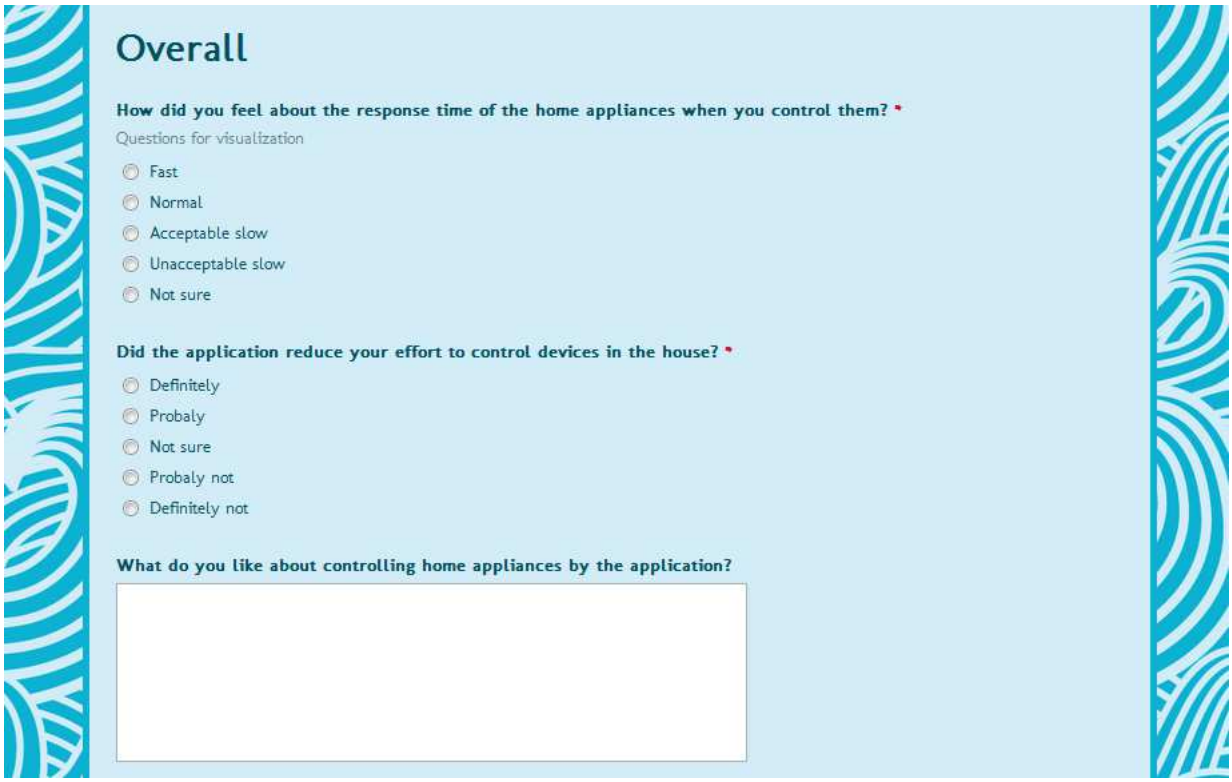
- Definitely
- Probaly
- Not sure
- Probaly not
- Definitely not

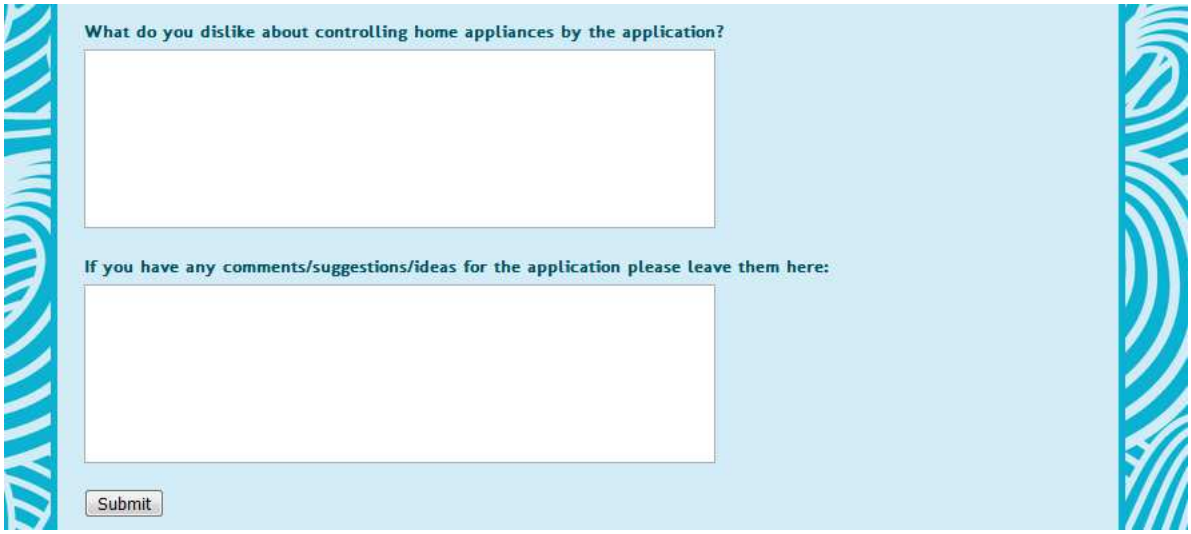
Do you think that you would like to use the script function frequently? *

- Definitely
- Probaly
- Not sure
- Probaly not
- Definitely not

If you have any comments/ideas/suggestions about the script function, please leave them here:


Overall
How did you feel about the response time of the home appliances when you control them? *
Questions for visualization
Fast
Normal
Acceptable slow
Unacceptable slow
Not sure
Did the application reduce your effort to control devices in the house? *
Definitely
Probaly
Not sure
Probaly not
Definitely not
What do you like about controlling home appliances by the application?
What do you dislike about controlling home appliances by the application?

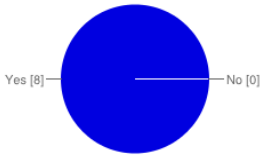

Overall
How did you feel about the response time of the home appliances when you control them? *
Questions for visualization
Fast
Normal
Acceptable slow
Unacceptable slow
Not sure
Did the application reduce your effort to control devices in the house? *
Definitely
Probaly
Not sure
Probaly not
Definitely not
What do you like about controlling home appliances by the application?


What do you dislike about controlling home appliances by the application?
If you have any comments/suggestions/ideas for the application please leave them here:
Submit

Appendix B

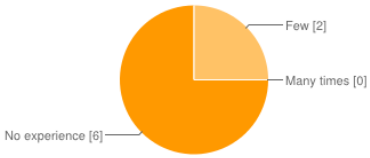
Survey results

Have you ever used any device has touchscreen before?



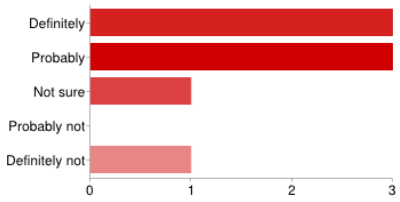
Yes	8	100%
No	0	0%

Have you ever had any experiences in controlling home devices by smart home solutions before?



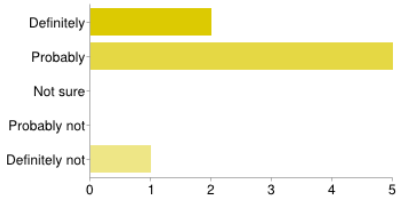
No experience	6	75%
Few	2	25%
Many times	0	0%

Is it convenient for you to select devices in the house map to control?



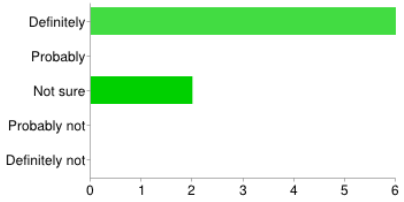
Definitely	3	38%
Probably	3	38%
Not sure	1	13%
Probably not	0	0%
Definitely not	1	13%

Is it easy for you to find devices that you want control in the house map of the application?



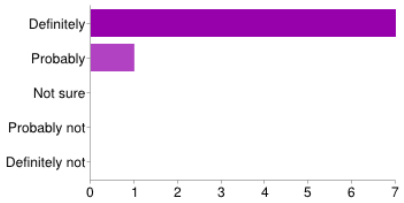
Definitely	2	25%
Probably	5	63%
Not sure	0	0%
Probably not	0	0%
Definitely not	1	13%

How important do you think the following types of information are for helping you to control home devices? - Device location



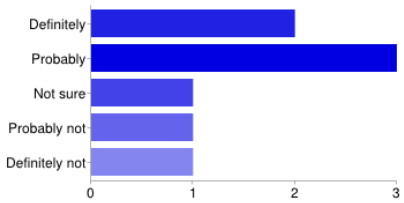
Definitely	6	75%
Probably	0	0%
Not sure	2	25%
Probably not	0	0%
Definitely not	0	0%

How important do you think the following types of information are for helping you to control home devices? - Current device status



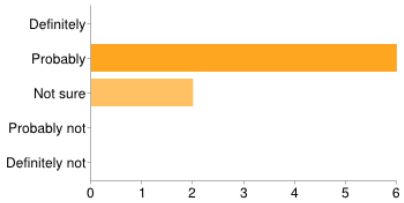
Definitely	7	88%
Probably	1	13%
Not sure	0	0%
Probably not	0	0%
Definitely not	0	0%

How important do you think the following types of information are for helping you to control home devices? - Device name



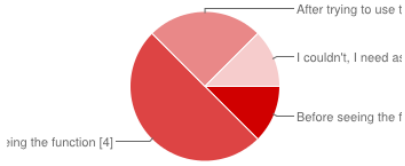
Definitely	2	25%
Probably	3	38%
Not sure	1	13%
Probably not	1	13%
Definitely not	1	13%

With the house map and device icons, could you locate the physical devices in the room?



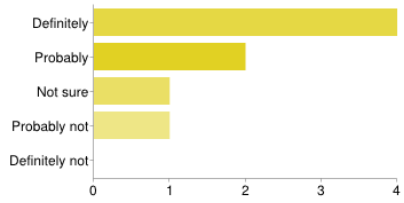
Definitely	0	0%
Probably	6	75%
Not sure	2	25%
Probably not	0	0%
Definitely not	0	0%

How long it took you to figure out how to turn on/off a light by yourself?



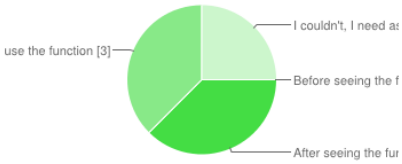
Before seeing the function	1	13%
After seeing the function	4	50%
After trying to use the function	2	25%
I couldn't, I need assistance	1	13%

Do you think that you would like to use this application to turn on/off lights in your house frequently?



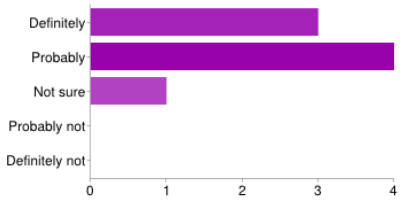
Definitely	4	50%
Probably	2	25%
Not sure	1	13%
Probably not	1	13%
Definitely not	0	0%

How long it take you to figure out how to set light intensity by yourself?



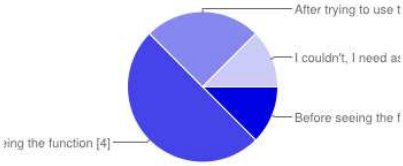
Before seeing the function	0	0%
After seeing the function	3	38%
After trying to use the function	3	38%
I couldn't, I need assistance	2	25%

Do you think that you would like to use this application to set light intensity in your house frequently?



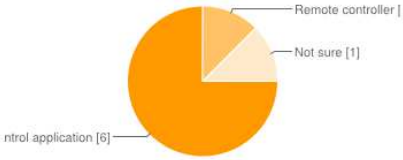
Definitely	3	38%
Probably	4	50%
Not sure	1	13%
Probably not	0	0%
Definitely not	0	0%

How long it take you to figure out how to change Air conditioner operation mode (Auto, Heating, Cooling, etc) by yourself?



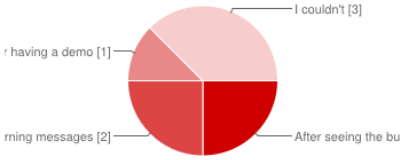
Before seeing the function	1	13%
After seeing the function	4	50%
After trying to use the function	2	25%
I couldn't, I need assistance	1	13%

What do you prefer to use for setting up operation modes of an air conditioner? this application or a remote controller?



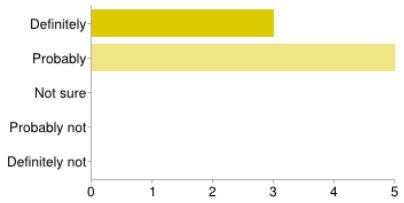
HomeControl application	6	75%
Remote controller	1	13%
Not sure	1	13%

How long it take you to figure out how to record a new script or use script buttons?



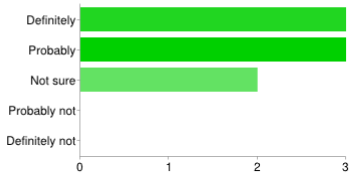
After seeing the buttons	2	25%
After trying to use the buttons and reading warning messages	2	25%
After having a demo	1	13%
I couldn't	3	38%

Do you think the script function will help you a lot to control home appliances?



Definitely	3	38%
Probably	5	63%
Not sure	0	0%
Probably not	0	0%
Definitely not	0	0%

Do you think that you would like to use the script function frequently?

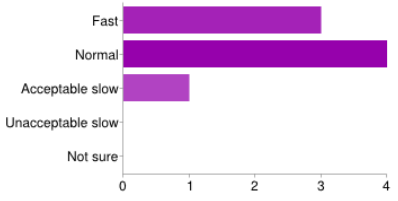


Definitely	3	38%
Probably	3	38%
Not sure	2	25%
Probably not	0	0%
Definitely not	0	0%

If you have any comments/ideas/suggestions about the script function, please leave them here:

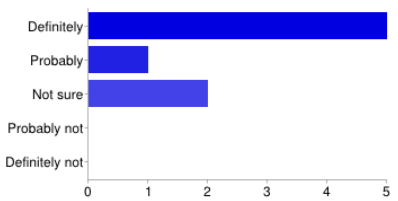
Better to have an instruction the way to use | Change the word script to suitable word because script is a technical word. It quit hard for home user to understand what script is. | | Now the maximum number of scripts is only 4. More scripts would be nice | | Overall working and handling of devices from tablet is interesting.the GUI is attractive but a bit confusing so before starting there should be some demo for some seconds to be familiar with working.overall the application is good and fascinating.

How did you feel about the response time of the home appliances when you control them?



Fast	3	38%
Normal	4	50%
Acceptable slow	1	13%
Unacceptable slow	0	0%
Not sure	0	0%

Did the application reduce your effort to control devices in the house?



Definitely	5	63%
Probably	1	13%
Not sure	2	25%
Probably not	0	0%
Definitely not	0	0%

What do you like about controlling home appliances by the application?

Can control with one touch. It is very comfortable to do the continuous activity. For example, user watching tv in the living room, and want to sleep in next five minute. The user can use this application for opening the air condition in the bedroom to make the bedroom's temperature cool. The visualization of states of all appliances looks very helpful. I can sit at one place and control everything without having to stand up and go directly to the appliances Convenient for users as we can control remotely many home appliances in house anywhere. Less human efforts

What do you dislike about controlling home appliances by the application?

Should show the loading or waiting time. It is quit hard to understand how to control device more specific detail such as adjust the light's intensity. And the light symbol is quite strange. I don't want to bring a tablet pc in my house. No instructions at all Users are not motivate. Less user friendly

If you have any comments/suggestions/ideas for the application please leave them here:

Please add on the loading status bar and intruction or user manual or help in the menu bar. 1. Change the light symbol. 2. Make the instruction for the user, such as help button. (I means in last version) 3. Change the word "script". I cannot understand at all what the script means, and what the script can do. 4. You should make the scenario more realistic. Then ask the tester test two time: with tablet, and without tablet 5. It's quit hard to understand your GUI, especially the color button in the left hand side. To get more user friendly, you should Put more figures and application that u ...

Bibliography

[1] Lutron home control, "Home Page", http://www.lutron.com, visited on 16/03/2012.

[2] iControlAV2, "Pioneer Corporation Home Page", http://www.pioneerelectronics.com/PUSA/Home/AV-Receivers/iControlAV2, visited on 16/03/2012.

[3] Samsung WF457 Washing Machine with Smart Control, "Product's features page", http://www.samsung.com/us/appliances/washers-dryers/WF457ARGSWR/AA-features, visited on 16/03/2012.

[4] FrontPoint Security, "Home Page", http://www.frontpointsecurity.com, visited on 16/03/2012.

[5] HAI OmniTouch 5.7 Touchscreen, "Home Page", http://www.homeauto.com, visited on 16/03/2012.

[6] Apple Inc., "Cocoa Fundamentals Guide", pp. 197-198, 2010.

[7] Contributing Members of the UPnP Forum, "UPn Device Architecture 1.1", pp. 9, 2008.