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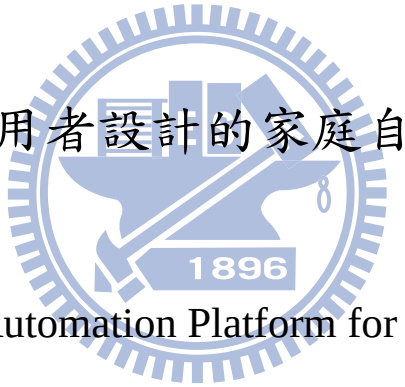

為 DIY 使用者設計的家庭自動化平台

A Home Automation Platform for DIY User

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中 華 民 國　九 十 八　年 七 月

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摘要

「為 DIY 使用者設計的家庭自動化平台」，這是我所研究的主題。不同的電子產品間往往有不同的廠商規格，彼此難以合作，但是本實驗室已完成的 MHAP(MOM-based Home Automation Platform)，則可以讓使用不同標準的產品間順暢地溝通。根據這樣良好的基礎，我希望能發展一套服務訂做系統，幫助使用者可以自由又快速的訂製想要的家庭或是辦公環境的自動化服務。透過建立一個服務的庫藏，利用服務的仲介者(Service Matcher)在了解使用者所擁有的設備環境後，自動產生適當的服務。並可以在設備環境有變化的時候，自動將服務變形成為可以運行的模式。

本研究之成果為一個以家庭裝置環境設定導向的家庭自動化平台設計，稱之為 MyHA(My Home Automation)。另透過問卷調查獲得受訪者對於家庭服務和智慧型產品的看法，參考此結果設計一套可供 MyHA 使用者取用的家庭服務範本。MyHA 中各種設定文件皆使用 XML 的格式，讓 MyHA 具有可攜性，並且讓使用者間可以交流彼此對家庭服務的想法與設計，以期能進一步促進家庭自動化的發展與普及。

A Home Automation Platform for DIY User

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Abstract

In this thesis I propose a home automation platform, which is design for Home Automation DIY users. As we all know, electronic devices produced by different manufacturers often operate under different specifications, as a result, it is difficult to make then work all together. Therefore, the DCSL has completed the MHAP (MOM-based Home Automation Platform), so that all the devices with different criteria would be able to communicate with one another seamlessly. Based on such a ideal foundation, I decided to develop a decision-making system, so that the users would be able to set up a desired home/office automation service efficiently.

In brief, after building up a treasury of services, a special service called the Service Matcher will be able to gather and analyze the information of the user's environment, and provide an ideal service automatically. Further more, the Service Matcher can transform the prior service into a new workable one. The main contribution of this research is design of a device-location oriented home automation platform, which is named as MyHA (My Home Automation.) Before I began to design this platform, I had survey a group of potential users about their opinions toward intelligent devices with my questionnaires. Besides, all the set-up documents of is written in XML format, so that MyHA is perfectly portable. The XML format also makes it possible for different users to exchange their opinion and idea of home automation, and ultimately contribute to the further development of smart homes.

Acknowledgements

The author is indebted to Dr. Shyan-Ming Yuan, his advisor, Mr. Chi-Huang Chiu, the candidates for Ph.D. of the Department of Computer Science, National Chiao-Tung University, Mr. Chun-Yuan Chen of Computer Science, National Chiao-Tung University, for their assistance and helpful comments in this research. The author especially thanks to Miss Ko-Chia, Chen for her assistance of the earlier drafts of the manuscript.

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Chapter 1 Introduction

1.1 Motivation

In the near future, there will be a lot cheep and smart home appliance in our home market. When customers need some new home appliance to replace their traditional stuffs, they can easily go into a shop store and bring some little digital controllable devices home. Surely they can online these new comers step by step follow instructions in the menu which comes along with the new comers and slowly try out all possible set up to let them cooperate with old smart guys, or we can provide some platform to make the whole process as easy as how customers pay for their new home servants.

Prior to my research, our lab has already established a platform called MHAP [1], which has made various kinds of electronic devices with different specifications able to communicate and work along with one another. Based on such a ideal foundation, I would like to build up a service-designing system, which can help its users to customize a desired home or office automation service. Briefly speaking, with a pre-built service library, the Service Matcher--which will be introduced thoroughly later in my thesis--will first detect what the devices in the specified environment are, and then it will automatically decide what the appropriate services are. Moreover, the Service Matcher will be able to detect the changes of the device environment and transform the service into a functional new service.

1.2 Objects and System Goals

As I started to consider about how to enforce a Home Automation for low-end

DIY user, I was wondering what kind of home services that people would really want and how do people think about intelligent equipment and home automation.

Since most people do not have the experience of DIY their home automation, I turn to give thought to a similar case: personal computer DIY users. The reasons that end users choose to make their home automated by themselves may list like fallows: 1. Enjoy fun process. 2. Hold their home control power in their hands. 3. Save some money from manufactories and seller [2]. Not only the reasons looks similar to the why people DIY their personal computer and the drawback or so call “sweet burden” are also alike – have to figure out what the real needed and take the responsibility of maintains and repair. In fact, due to the bigger scale and multi equipment involved, the job is harder. As all other DIY user would faced, they have to take care over every trouble which sometimes pop up with no alarm, figure out where the error started, then correct it or cover it…It’s a nightmare to anyone who does not have a leisure life.

I want to design a system that can help normal people to enjoy their interesting, modern, easy and light financial burden smart home environment.

1.2.1 Device-Location Oriental Service Template

To release the end user’s burden from making up services gradually, a home system should provide user some templates that have deferent purpose and still are modifiable.

The template not only describes how service work and what device and environment it needs.

1.2.2 Service Auto-Apply

With a database of templates can save a lot of time for DIY users, however, they

still have picked up services and decided what devices should work together for perform the job. A ideal system for DIY users give user a short cut to get what they want by ask some simple questions, like “if you want a light control service,” “how about a media control center?” or “Do you need whole package service for bedroom?” then select suitable services templates and turn them into real services.

1.2.3 Service Auto-Recovery

If some devices fail, the system will have the ability to fix the problem first without effecting the user’s daily life.

1.3 Problems

MHAP is a well-designed mom-based communication platform. Appliances of different protocols can communicate each other through the MHAP. It also implements an interface for users to make a rule-based service and it give home appliance a location-embedded identity. However, location information does not work more than as an identifier for service and users. The interface help users ordering a service, however, they still have to communicate appliances and start up the whole process by themselves.

1.4 Solution

Concern the problem that DIY users may face and the ability of MHAP, here are three ways to support the new system.

1.4.1 Device-Location Oriental Service Template

Review the design of the system descriptions in MHAP, especially the service

and rule description structure. By adjusting and adding some new attributes to descriptors to strengthen the influence of environmental factors in home service and improve the usability of home service.

1.4.2 Service Template Database

Provide a service template database to home system. These templates can give DIY users a foundation to start up a service and they are modifiable, user can change it into want they want. The database should be portable, and user can take it to where they go then rebuilt their home service by the templates.

1.4.3 Service Matcher and Auto-Apply

Provide a service matcher that recommend service template for DIY users. The service matcher evaluates the condition of both system and home environment, and proposes a list of service template. System then modified these services into user's requirement and put them on service.

Chapter 2 Background

2.1 Home Automation

The original Home Automation (HA) means the device or appliance within the homes connects and collaborates with each other and links to services and systems outside the home to facilitate the human life. The HA system also known as smart home, which focus on localized technology augmented environments where people perform everyday life activities. This system contains internal network, intelligent rule and devices in the home network for convenient or some special purpose [3-6]. Devices with automation services and various appliances being controlled or providing state information.Besides, the change of a device's state may also cause the change of another device's state or trigger some action of another device in a HA environment[1].

Increasingly, HA system should dynamically reconfigure their services at run-time in response to changing conditions in the user actions, and in the surrounding physical environment. Self-configuration has been mainly applied to servers or networks systems. These systems are required to work without interruption, maintaining a certain quality of service. In order to do so, the system manages its resources for prioritizing certain services and maximizing the number of supported users. However, it is believable that HA can also take advantage of the self-configuring benefits [5-8].

2.2 HAMP

In 2007, Chun-Yuan Chen proposes the MOM-based Home Automation Platform (MHAP), which accomplishes event-driven Home Automation in incompatible home networks. MHAP is independent of any home networking technology and integrates home networking technologies in home gateway. By involved Message Oriented Middleware (MOM) and Open Service Gateway Initiative (OSGi), MHAP provide reliable automatic operations, fault tolerant and reconfigurable Home Automation, which is also highly extensible. MHAP can team up appliances, other MHAP gateways and Internet services, for example, Web Services[1].

By constructed above HAMP, an application system can get rid off the trouble in physical level, such as device discovery, communicate with devices that belong to different protocols. We can ignore the device that bought by users are X10 [9], INSTEON [10], UPnP [11] or HAVi [12], and focus on solving users' problems.

2.3 XML Rule

Rules in the Web have become a mainstream topic since inference rules were marked up for E-Commerce and were identified as a Design Issue of the Semantic Web, and since transformation rules were put to practice for document generation from a central XML repository (as used here). Rule-based systems are a relatively simple model that can be adapted to any number of problems. Even as in other systems it has its limitations, rule keeps playing an important role in AI shells for knowledge-based or expert systems and in Intelligent Agents[13, 14].

2.3.1 RuleML

The Rule Markup Initiative has taken steps towards defining a shared Rule Markup Language (RuleML), permitting both forward (bottom-up) and backward

(top-down) rules in XML for deduction, rewriting, and further inferential-transformational tasks. The initiative was launched in the Internet in the winter of 2000. Complementary efforts consist of the development of (Java-based) rule engines such as jDREW and Mandarax RuleML, as well as XSB-RDF RuleML. RuleML's earlier design evolved into DTDs-Schemas for positional-slotted RuleML sublanguages including Object-Oriented RuleML (OO RuleML). Efforts also went into defining MOF-RuleML: The Abstract Syntax of RuleML as a MOF Model.

The goal of the Rule Markup Initiative is to develop RuleML as the canonical Web language for rules using XML markup, formal semantics, and efficient implementations.

RuleML covers the entire rule spectrum, from derivation rules to transformation rules to reaction rules. RuleML can thus specify queries and inferences in Web ontologies, mappings between Web ontologies, and dynamic Web behaviors of workflows, services, and agents[15].

I design a new rule schema, which defines the devices event/action procedures in HA services, by referencing RuleML and the original rule design in HMAP. The further discussions are in the fallowing chapters.

Chapter 3 Survey and System

3.1 Survey

To understand and ensure the users' thoughts of environment and equipment for Home Automatic, we ran a questionnaire, which focus on people's view on daily used smart equipment and automation environment, through internet and paper form in the fall of 2008. The survey comprised of three sets of questionnaires: concerning personal background, the use and perceptions of smart devices, and their opinion of possible Home Automation scenario.

This survey tried to ask people who would DIY their Home Automation in the future. Considering the case of personal computer DIY and the usual home decorating DIY, the most possible user should be the group who get used to the operating tools, target materials and feel interested with the topic. In our case, the tool is personal computer; the materials are the digital devices. So first, we focused on people who practiced computer operating, and then pondered that who might relish Home Automation. The DIY-able HA situation is coming but not now, the potential users are someone who are fond of new technology and going to have a controllable home area. Judging from these conditions, PTT Bulletin Board System, which is arguably the largest BBS in Taiwan, is a suitable platform to distribute questionary, due to its academic object and relatively young user groups [16-18].

The result is a collection of 136 people's complete feedback. 71.32% of them were simply students and 22.49% got a full time or part time job, and most of them use computer, mobile phone, digital camera, PDA daily, and heavily (93.38%).

82.35% (112 people) interviewees dominate over a private room or house. The background data shows the participants in my survey are relatively young and quite practiced to operating digital and intelligent devices. The participants of this survey are the main users of smart equipment in the near future. The questionnaire is attached in the end of this report.

Take a look of the results, even they are highly computer users, only 40.44% people owns smart equipment, which dose not include computer, mobile phone, etc, and no mater they have these devices or not, 69.85% of them don't use them frequently. The results may due to the occupation and economy status, they are students and would not pay a lot money on home equipments.

When the questions came to "Without money issue, will you want to have some smart electronic daily necessities?", 49.26% of them said "yes", and the other half people(47.79%) want to take into account other factors. The other factors include functional integrity, interface, appearance, etc. shows in Table1-1:

Table 3-1 The result of Intelligent home appliances purchase factors

Q: Will the removal of price factors, the following factors will affect whether you decide to have smart electronic daily necessities?		
Answer	Count	Percentage
Functional integrity	122	89.71%
Interface	104	76.47%
Appearance	84	61.76%
Durability	94	69.12%
Power Saving	66	48.53%
Product specifications	28	20.59%
Other	4	2.94%

Products' appearance is count on device manufactures, and to the others, a Home Automation platform can do some fixing and supporting. HA platform can provide a universal controller service and give users a new interface. The platform can also

integrate devices' functions, extend the life of devices, and saving power by controlling devices' behavior. Software can solve most users' concerns, this fact push us more forward on the way to design a HA platform for them.

Table 3-2 The result of the degree of interest in home services

Q: The following is a list of catalogs of different purposes of home automation services, please select the item you are interested in:		
Answer	Count	Percentage
Living in Living Room	90	66.18%
Long Vacation	116	85.29%
Home GYM	48	35.29%
Quick Morning	96	70.59%
Dinning Time	54	39.71%
Good Student	74	54.41%
Sweet Dream	120	88.24%
Bath Time	87	63.97%
Party Night	51	37.50%
None	2	1.47%

The question in Table 3-2 tried to understand what kinds of HA services are more interesting to users. Services in this question are catalog by purposes and scenarios not the type of involved device. These titles accompany with short descriptions can give interviewees a larger space to imagine what these services can bring to them. The result shows the most popular two are Sweet Dream and Long Vacation. Therefore, the flowing discussion will use these two as examples.

3.2 MyHA and MHAP

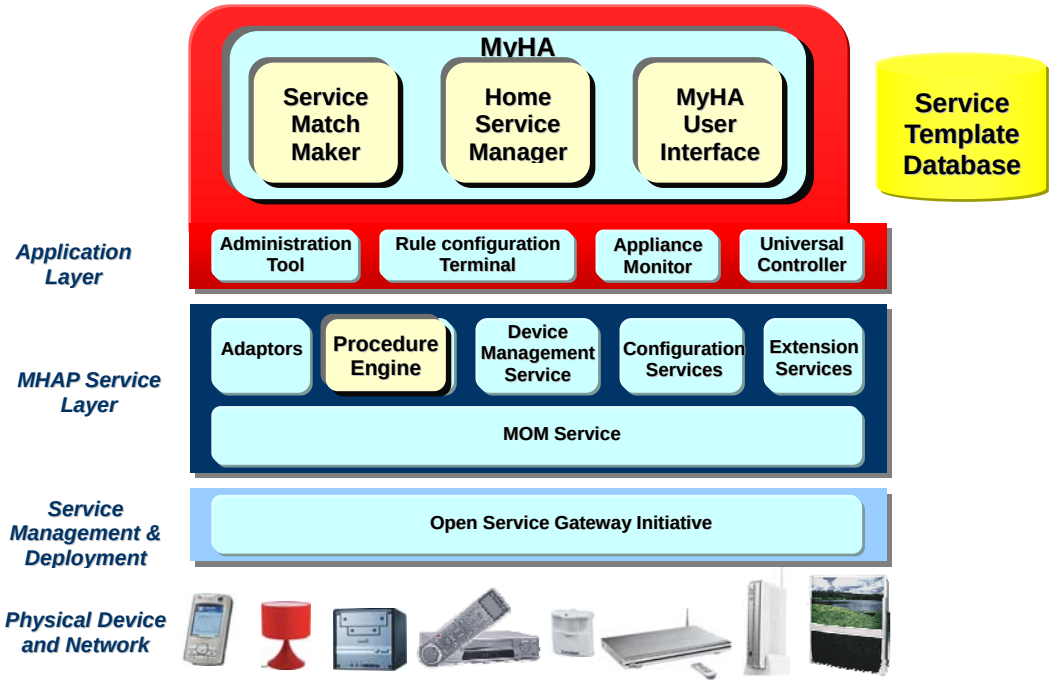


Figure 3-1 MyHA on MHAP Architecture

In Chapter 2, I have introduced the original system architecture of HAMP. To achieve the system's goal, I designed an application and named it "MyHA", which is short form of "My Home Automation". In figure3-1, you can see the modified architecture layer. MyHA lies in the application layer with its plus one—Service Template Database. Inside MyHA, there are the Service Matcher, Home Service Manager and an interface for end users to communicate with MyHA. The Service Matcher performs the most important function of MyHA, it connects the home environment and home service. Service Matcher also carries out the service Service Auto-Recovery by cooperates with the Device Management Service in MHAP Service Layer. The working detail of Service Matcher will be described in Chapter 4.

There is a little modification in MHAP Service Layer that the original Rule Engine has been changed to Procedure Engine. The reason for this change is the rules in MyHA or HHAP do not have the ability to conduct a new principle or results, they just point out what situation of devices' states would course some services asking

some specific device to perform some actions. Thus, device event/action procedures became the real service behavior descriptors.

3.3 MyHA System Scope

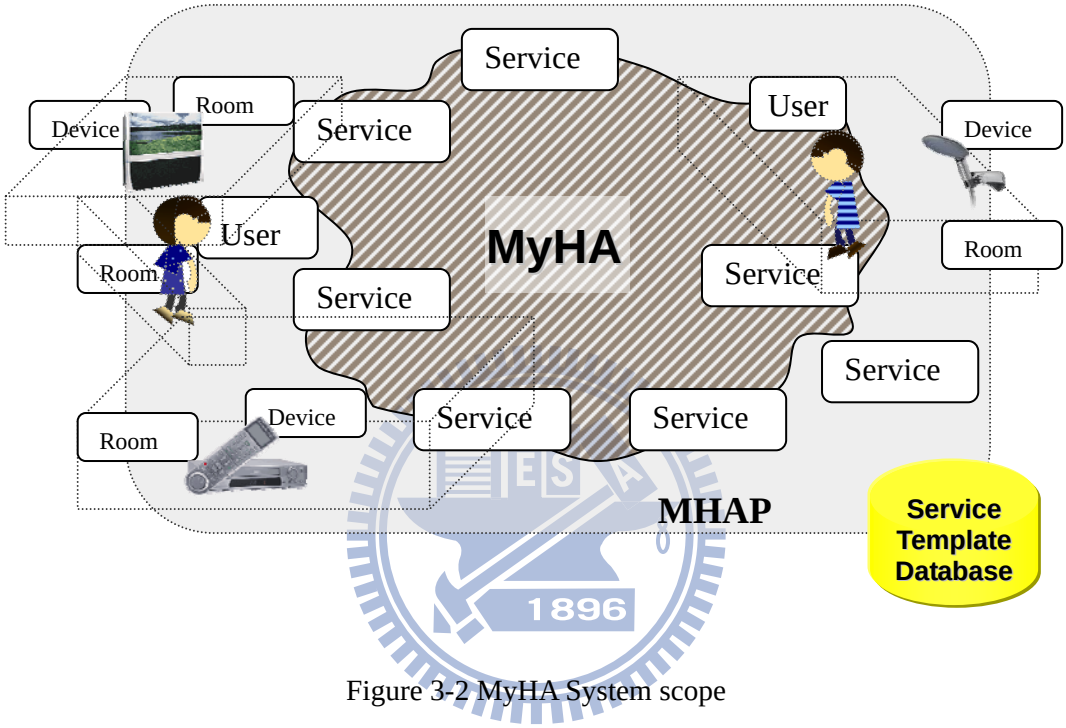


Figure 3-2 MyHA System scope

Figure 3-2 is the top-view of MyHA and the environment. The base is MHAP and the white area is MyHA.

First of all, let's see what entities are in this system, know what is performed in side this system and what should it to deal with. From the design view, we can define these entities as four categories: device, user, room and service.

In MyHA, users are service owner and more importantly, they are part of event creators. MyHA do not treat users as the central of the system as some other home automation system [19, 20], but the users' home environment plays the significant role. This frame of reference can delight the system burden and simplify system structure, and still can fit DIY users' requirements. As we abstract users as event

creators, the system can be more flexible and users can exchange home service more easily[21-23].

3.3.1 Home Device

In MyHA system, a device is a household appliance, which routines household tasks, using electricity or some other energy input. Many home networking technologies[24] have developed such as UPnP, HAVi, X10, INSTEON, Jini[25] and LonWorks[26], they give appliances connection ability.

3.3.2 Home User

A home user is someone who is involved in the Home Automation System. They can be a power user who apply their requirements to the system and define how Service will work or just enjoy the services.

I classify Users according to their authority and duty into four types:

1. Chef Manager: A chef manager manages and defines the whole system. Besides of the service made up, he/she also can set up the devices, person data, room information and the connection to the out side system.

2. Power User: They are end-user but own some privilege to make up their user-demanded services.

3. Bon Vivant (Normal User): some one who needn't worry about how the System works and just take the advantage from the Service. (A Bon Vivant can order some exist service in System.)

4. Guest: Sometimes a guest is our boss, sometimes we just don't want he/she get too close to our daily live. By using some simple identifier devices e.g. a finger print identifier, system can prevent a guest from crush into our bedroom but he/she can also use warm water in washing room in a cold cold wintertime.

Except for the Guest users, all users need ID/PW.

3.3.3 Room

Room is an area unit, the devices or services will work in it.

In the original HAMP design, system uses the room information as part of message topic and Region division to offer a Reliable Fault Tolerant Home Automation. I want to give room a more individual character, make the room data or we say the location information more useful for user demanded service.

3.3.4 Home Service

In the original design of MHAP, the service describes the functions that device can provide. In my design , the new service descriptors are divided into two kinds：1. Basic service descriptor; 2. Home service descriptor.

Home service performs a particular job. The service is provided according to the home users' demands or it is just an inner function using by the system and completed by a serial device works.

The following picture illustrates the life cycle of a service:

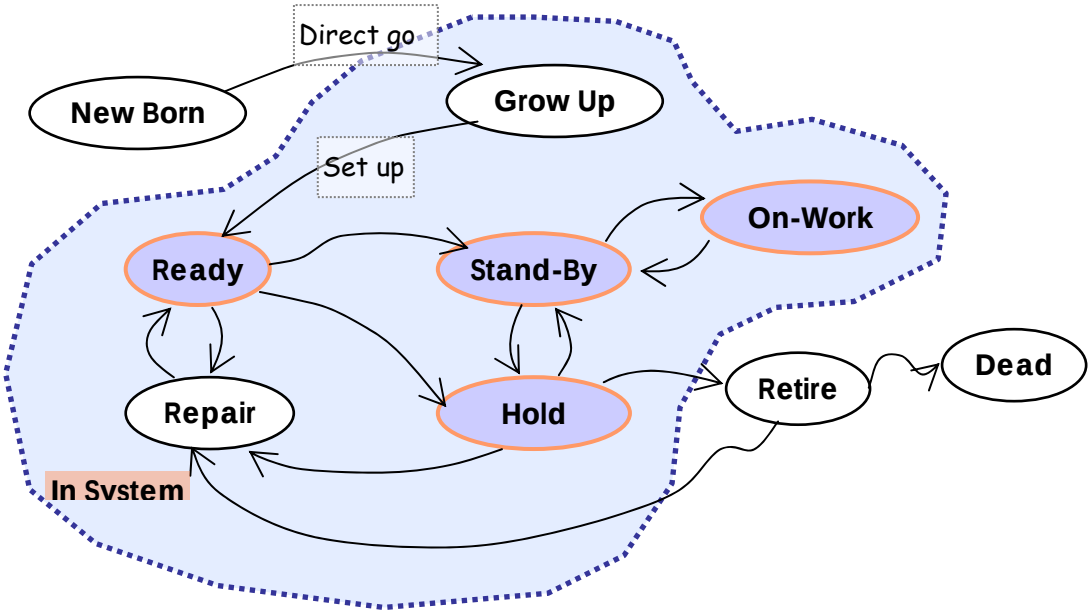


Figure 3-3 Reliability requirement of Home Automation System

A service will be given birth when an Appliance is plug on the system or a user want to create an on-demanded Service. At the first case, the Basic Service of that Appliance will be created by system automatically and immediately go through the Grow Up state to Ready .More over, by default setting, an On-Line Appliance its basic functions are also on-line, thus the Service is set to be on Stand-By state. When it comes to the second case, the Service will not change its state to Ready until the User completed the Set-up process

These states filled by gray are Mutual Services. A Mutual Service means that it has ability to work.

A Service at mutual state has fallowing attributes:

1. Application List

2. Event/Action procedure

3. User

Once a Service became a Ready Service, it will go to the Stand-by state or just be holding until the user call it up to Stand-by state. Even the Ready state looks like a

temporary state; only pass Ready state a service can start its career. A service on Hold state will not work, but it is still under system control, and Users and System can change and watch its content. If a user wants to change the setting of a service, or the system thinks a service need to be adjusted because of some devices or services in the system were changed and that may affect the Service working, the Service setting can be repaired and sent to Repair State. Once the repair is done, the Service goes to Ready state and moves to Stand-By or Hold state again.

A Service can retire when the System or users think it no longer usable. At this state, the System will not maintain the data of service. If users want some Services go back to working, those Services have to go Repair state first. Users can announce a Retire Service to be Dead state, and this service will be deleted form the System forever and ever.

3.3.5 Virtual Device

A Virtual Device is actually a Service. Two or more Appliances accomplish the Action part of this kind Service. Users can set a service, which is in mutual state, as a virtual device. A virtual device has a device descriptor as a real device.

When a service is in mutual state, users can define it as a virtual device and service will make a device descriptor for this virtual device。

One benefits of virtual device is that user can maintain this virtual device through universal device interface. Users can easily maintain their favorite Services. Further more, once a service became a virtual device, other services can operate it directly.

3.3.6 The Service Creation Flow

1. User proposes a Service demand.
2. Create the corresponding procedure.
3. Run down the Procedure Checker.
4. Subscribe the event(check out the correct express)
5. Mark up Time event.
6. Finish Service creation.

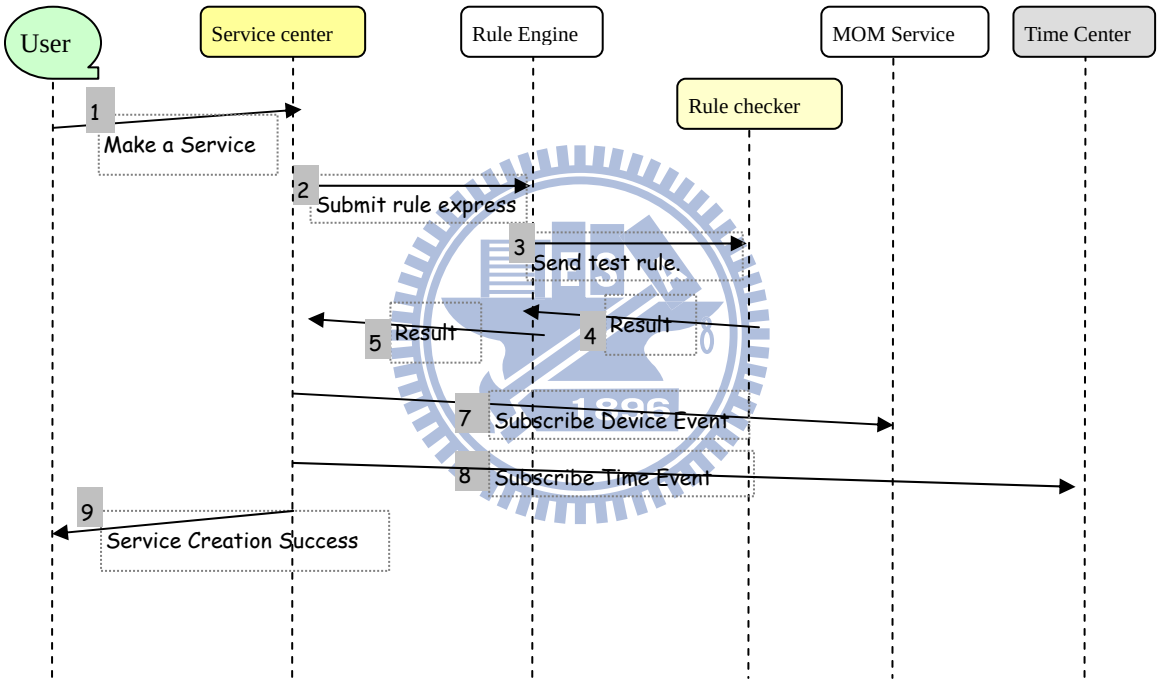


Figure 3-4 Reliability requirement of Home Automation System

3.4 Location Information

3.4.1 Floor Plans

The Floor Plan provides system the information of devices' location and, more importantly, describes room-device relation. Floor Plan is able to help the system to complete automatic information matching. By processing the location information provided by Floor Plan, we can set up the default service, which is mainly defined by the location of the room; it can also provide the grouping function. Besides, every time when a device or even an environment alteration occurred, we can use the prior Floor Plan as a base to maintain the consistence and continuity of the service. The further discussion is in Chapter 5.

A floor is simply a container. A floor contains all other kinds' elements of environment. User can set a floor "above" or "under" other floors.

Room corresponding to the physical room in users' home environment, is surrounding by walls or identified by how users use it, therefore, a large space, in the settings can be divided into several different rooms. This setting is set in accordance with the users' habits, so to a big dining room, which includes oven and cookers, can be set as one room or a dining room and a kitchen is up to users' free will. A room can own devices and other rooms. User's can set a room "next to" another room.

There are some default room models in system. For example, bedroom, toilet, living room, bathroom, hallway, etc. The followings are some special room type:

1. Entrance

An entrance, which contains a door, a gate or nothing but simply an open space, can be view as a room or a special pace in this home system. Entrance can own

devices, like electrical gate, drape, door ring, etc. It is differ from an ordinary room by the ability to connecting two independent rooms. If we view an entrance as a room, then the “next to” attribute represent where we can get by it. Since a room definition can tell the meaning of an entrance, an entrance can be set as a room.

2. Window

Window is similar to an entrance, thus I set windows as type of room.

3. Stair

Stair can also own some device, and it is a room, too. However, when it said a stair “next to” floors, it meant thst the stair is ascending or descending to these floors.

4. Open space

It is a room without walls and specifies the undefined area of house. For example, there are no doors or walls in between doorway and living room, then user can defined this blur space as an open space.

5. Out space: It defined the space out of users’ domain and it’s surrounding users’ other rooms. Rooms “next to” out space, tell system that they are in the edge of users’ home environment. Moreover, it is still a kind of rooms.

If users do not have a lot sensors in their home environment [27], Floor Plan can also set for completing environment information [28], basically, if users did not set down a quality relations room map, it will not affect the implementation of the system, but some default service that from service template database may not be able to apply. Total empty floor planes will constraints the functions of service automatically apply. User can manage appliances by room. The device procedures of services can be grouped by room. Room group can apply the procedure template.

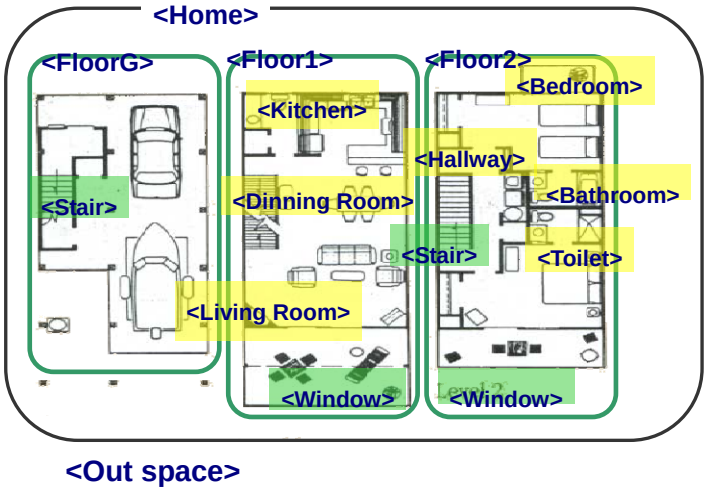


Figure 3-5 A Example of floor plan in graphic view

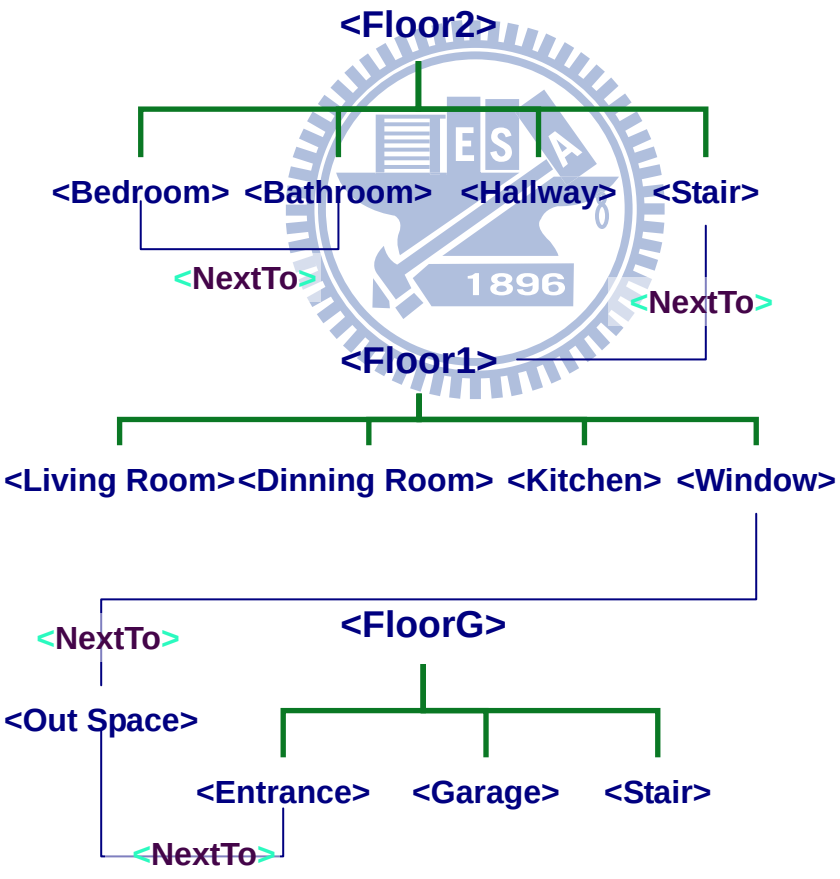


Figure 3-6 A Example of floor plan in tree structure

3.5 Service Manager and Procedure Engine

In the original version, Rule (procedure) Engine is the conductor for the device operation. One the miss part of the original MHAP is the Service management. Rule (procedure) engine charges the logical analyze and create logical command. However, it is Service Manager to provide the event problem and command words to Rule (procedure) Engine.

3.6 Home Service Templates

A service description with its procedure and uses dummy devices ID to represent unknown employee devices. In a service template, it allows no real device as action and event provider, but a real exist device spec. in the ID tag, using the device type code.

Users can create their own service templates, as home device manufactories and sales can provide service templates alone with their products.

3.7 Service Share Space

Build up service template database on internet. This database collections service templates witch provided by manufactories, home automation organizations, and home users.

3.8 System Parameters and System Service

Service Parameters are applicable system-wide parameters and give service some cognitive messages from users. For example, the cool / hot temperature, the wake up time, and the loud volume, etc.

Timer is a virtual device and service can use it as a normal device. This unit

keeps all required time event, include the time be notice and the name of the subscriber when the time comes up, it throws a time event with the subscriber data to MOM.

Some devices do not have timer themselves. By using a system service Timer, system approves time events of routine jobs. Timer maintains the system clock. It also keeps the time event from procedure.

Chapter 4 Descriptors

4.1 MyHA Descriptors Overview

MyHA uses the MHAP descriptors design as a foundation; descriptors provide profiles of the entities inside MyHA. The MHAP descriptors are the guideline of device abstract and protocol mapping. MyHA retained the original design of mapping descriptor and basic service descriptor, but added some additional and modified some descriptors.

MyHA promises users that they can carry their home service setup with them when they move or change their home environment. At the same time, MyHA want to encourage users to share their home automation set up with other MyHA users. For these reasons, all the descriptors in MyHA are made up in XML format.

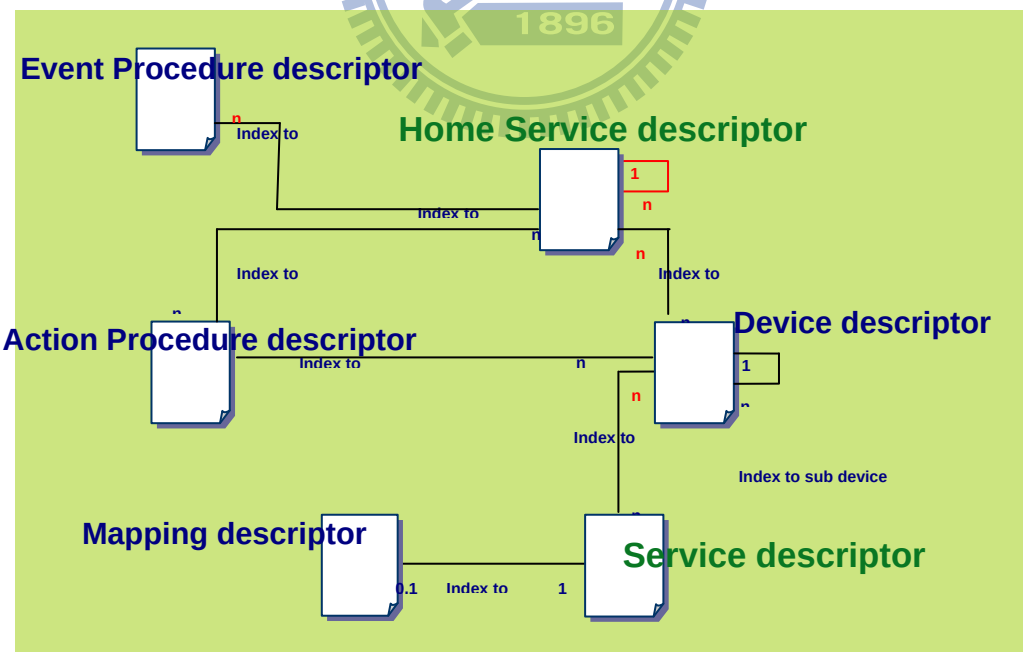


Figure 4-1 The XML-based MyHA descriptors relationship map

4.2 Root Descriptor

Describe the system environment. For each system, there is only one root.

```
<?xml version="1.0" ?>
<root>
            <specVersion>
            <major>1</major>
            <minor>0</minor>
            </specVersion>
            <systemID></SystemI>// systemID = the fixed IP address
            <friendlyName> </friendlyName>
            <userDescription></userDescription>
      <modelName>Home</modelName>
            <geoInformation>
              <lat></ lat>// Lat = latitude
              <lon></ lon>// Lon = longitude
            </geoInformation>

</root >
```

Figure 4-2 The XML-based MyHA descriptors relationship map

4.3 Device Descriptor

In the original system, each MHAP device has a root device descriptor which indexes to the sub devices and services. Therefore, the device can be two or more types of standard device simultaneously through the hierarchical architecture. In my design, the new schema will keep this structure.

The part of Action Mapping is also keep as the original design. My improvement is focus on the service contraction and the enhancement of the procedure expression.

```
<Device type="sigle">
    <specVersion>
        <major>1</major>
        <minor>0</minor>
        </specVersion>
        <deviceType>urn:schemas-UPnP-org:device:Timer:1</deviceType>
        <friendlyName>Home Timer</friendlyName>
        <manufacturer>Smarthome</manufacturer>
        <modelName>Timer</modelName>
        <serialNumber>9999999999</serialNumber>
        <UDN>uuid:Smarthome2001X10</UDN>
        <userDescription>Timer</userDescription>
        <room>0000</room><location>
        <coordinates><x></x><y></y>          </coordinates></location>
        <availableArea>          </availableArea>
        <geoInformation>          </geoInformation>
        <basicServiceList>
        <basicService>
            <serviceType>urn:schemas-UPnP-org:service:power:1</serviceType>
            <serviceId>urn:schemas-UPnP-org:serviceId:power:1</serviceId>
            <SCPDURL>/service/power/description.xml
    </SCPDURL>
        </basicService>
    </basicServiceList>
```

Figure 4-3 An example of the device descriptor

4.4 Room Model Descriptor

The room model descriptor gives end users a direction to contribute their own house

```
<RoomModels>
    <RoomModel>
        <RoomModelName>Home</RoomModelName>
        <RoomDescp>整個使用空間</RoomDescp>
        <DeviceList></DeviceList>
    </RoomModel>
    <RoomModel>
        <ParentOf>Bedroom</ParentOf>
        <RoomModelName>Room</RoomModelName>
        <RoomDescp>一般房間</RoomDescp>
        <DeviceList></DeviceList>
    </RoomModel>
        <RoomModel>
        <RoomModelName>Toilet</RoomModelName>
        <RoomDescp>廁所</RoomDescp>
        <DeviceList></DeviceList>
    </RoomModel>
    <RoomModel>
        <ChildOf>Room</ChildOf>
        <RoomModelName>Bedroom</RoomModelName>
        <RoomDescp>臥房</RoomDescp>
        <DeviceList></DeviceList>
    </RoomModel>
</RoomModels>
```

Figure 4-4 An example of the room model descriptor

4.5 Home Service Template Descriptor

The service descriptor play the role as the original design-- it describes those simple actions a device can perform without other devices. Home service descriptor contains the service that ordered by user. It can be as simple as the basic action but the most important function of this descriptor is to keep enough information about the user demanded service to ensure the system can running these complicated service as user expect.

```
<serviceModel>
  <serviceModelID>sm0003</serviceModelID>
  <friendlyName>Sweet Dream</friendlyName>
  <userDescription></userDescription>
  <serviceTag>0007</serviceTag>
  <userList/>
  <availableArea>
      <room> <roomCorrespondID>R0</roomCorrespondID><roomModel role="main">Bedroom</roomModel>
      </room>
      <room><roomCorrespondID>R1</roomCorrespondID>      <roomModel role="none">LivingRoom</roomModel>
      </room>
      <room>      <roomCorrespondID>R2</roomCorrespondID><roomModel role="none">Home</roomModel>
      </room>
  </availableArea>
  <eventDevices>
      <device type="single">
        <deviceModel>Light</deviceModel>    <room>R0</room>
        <device_ID role="leading" score="10" correspondID="A" deviceType=""></device_ID></device>
      <device type="single">
        <deviceModel>Timer</deviceModel>  <room>R2</room>
        <device_ID role="system" score="0" correspondID="D"> </device_ID>
      </device>
  </eventDevices>
  <actionDevices>
      <device type="single"><deviceModel>Light</deviceModel><room>R1</room>
      <device_ID role="leading" score="10" correspondID="B" >1234567891</device_ID></device>
     <device type="single"><deviceModel>Television</deviceModel><room>R0</room>
      <device_ID role="supporting" score="3" correspondID="C" >1234567895</device_ID></device>
  </actionDevices>
  <involved_rules>
      <eventRule role="leading">
                  <ruleID>er00010</ruleID>//if A off on off
                  <eventDevices>    <eventDevice ruleDeviceCode="A">A</eventDevice> </eventDevices>
      </eventRule>
      <eventRule role="leading">
                  <ruleID>er00009</ruleID>//if Time 23:00~6:00
                  <eventDevices>    <eventDevice ruleDeviceCode="A">D</eventDevice> </eventDevices>
            </eventRule>
            <actionRule role="leading" >
                  <ruleID>ar00002</ruleID>//turn A off
                  <actionDevices><actionDevice ruleDeviceCode="A">B</actionDevice></actionDevices>
            </actionRule>
  </involved_rules>
  <geoInformation> //globle </geoInformation>
</serviceModel>
```

Figure 4-5 An example of the home service template descriptor

HyMA classify home service by some service features, e.g. location, purpose, involved device, and uses these categories on service auto-apply .User can add these information by themselves.

I classified service by how they work and what function it controlled.

To insure the whole system be always available and not be influenced by some

devices crack, system keep some u-be choices. User can indicate substitute for event or action devices, if the main devices went out of work, system pick up the double.

Furthermore, user can set substitute procedure for services, if the devices failure caused the involved procedure totally disability, service can apply the appointed one to fill the vacant position.

More over, in service descriptions we give each event a role to show how these devices affect the service.

4.6 Event and Action Procedure Descriptor

What is procedure? For end users, they order Service, however, the communications between Appliances are through the system core-union -Service Engine, therefore all the entities outside core-union they use service-view and inside the core-union use procedures to describe Service and control Service acting.

Procedure s are Hieratical and the condition judgment in procedure should be time sensitive. Some services may ask events to happen in order or some services do not care about the happening sequence. This kind property should be show in the service procedure.

Procedure is just a form, and the Service will fill it. A procedure consists of event and action part. To enhance the reusability and flexibility, I decide to manage and store event and action parts separately.

By observation my daily life, I simplified what the actions a normal people would do to their home devices into the set in upper one; then I switch the on/off into up/down, higher/lower… or some specific functions like recording and deleting…then we get several similar procedures sets in the lower one:

1. Turn A's function A1's Parameter AP1 up
2. Turn A's function A1's Parameter AP1 down
3. Turn A's function A1's Parameter AP1 up, then turn off B's function B1's Parameter BP1 down
4. Turn A's function A1's Parameter AP1 up, then turn off B's function B1's Parameter BP1 up
5. Turn A's function A1's Parameter AP1 down, then turn off B's function B1's Parameter BP1 down
6. Turn A's function A1's Parameter AP1 down, then turn off B's function B1's Parameter BP1 up
7. It's the time, then …(1~6)

Figure 4-6 A draft of device's event/action procedure

Here I show how the basic procedure 4 looks like:

```
<event>
<if type="and"> <timesing waitingTime="30">0</timesing>
//the unit is second and 30 secs is the basic time zone
      <var>
            <targetID>A</targetID>
          <varName>Power</varName>
          <acceptList >
                <acceptValue type="Solic">true</acceptValue>
          </acceptList>
      </var>
   </if>
</event>
```

Figure 4-7 An example of the event procedure descriptor

```
<eventRule ID="er00010" NAME="IF_4">
<rulegroupID>rg0001</rulegroupID>
<ruleCapture>IF some device off on off</ruleCapture>
<event> //a rule has one event
  <if type="and">
    <timesing>1</timesing>
    <waitingTime>10</waitingTime>//the unit is second
     <var>
          <targetID>A</targetID>
        <varName>Power</varName>
        <acceptList >
              <acceptValue type="Solic">fail</acceptValue>
        </acceptList>
    </var>
     <var>
          <targetID>A</targetID>
        <varName>Power</varName>
        <acceptList >
              <acceptValue type="Solic">true</acceptValue>
        </acceptList>
    </var>
     <var>
          <targetID>A</targetID>
        <varName>Power</varName>
        <acceptList >
              <acceptValue type="Solic">off</acceptValue>
        </acceptList>
    </var>
  </if>
</event>
</eventRule>
```

Figure 4-8 An example of the event procedure descriptor for Sweet Dream service

```
<actionRule ID="ar00002" NAME="BasicControl_2">
<ruleCapture>A off</ruleCapture>
<action>
   <timesing>0</timesing>
   <reaction>
       <commandTarget>A</commandTarget>
            <BasicServiceName>Power</BasicServiceName>
             <actionName>Power</actionName>
            <argumentName>setPower</argumentName>
            <argumentValue>fall</argumentValue>
   </reaction>
</action>
</actionRule>
<actionRule ID="ar00005" NAME="Gate_1">
<ruleCapture> A</ruleCapture>
<action>
   <timesing>0</timesing>
    <reaction>
       <commandTarget>A</commandTarget>
            <BasicServiceName>Lock</BasicServiceName>
            <actionName>Lock</actionName>
            <argumentName>Lock</argumentName>
            <argumentValue>true</argumentValue>
   </reaction>
</action>
</actionRule>
```

Figure 4-9 An example of the action procedure descriptor for Sweet Dream service

This is a simple procedure has one event message and one action command. Each <var> is a query to a single device's single and I use <and> to capsulate the single event, and if the service needs more than one event message, <and> can capsulate these events. Surly, <or> can work for its situation too.

When there are multi event message, here comes a new problem—the timing control. Event messages are sent by devices and cause by human operating and the

different sequences may mean different intentions. For example, turn down the light in toilet then open one in the hallway, can indicate a move from toilet to hallway; a reverse sequence can not cause by the same move. On the other hand, the order can mean nothing but the time slot may do. Quick open and shut down the same light can be a signal of starting some services, same behavior but happened in 5 minutes may just means you leaved and came back to the same place.

Table 4-1 The time control tag description of event procedure

Event		
Tag	Description	
TIMESING= 0	The event does not care about the sequence and time range of event.	
TIMESING= 1	The fallowing Query responses have to be accepted in order; otherwise the action will not be triggered.	
TIMESING= 2	This event repeats in a time range.	
WAITINGTIME	if TIMESING= 1	How long the service can wait the next event happened. The time unit is second.
	if TIMESING= 2	The time range
TIMEORDER	if TIMESING = 1	indicate the sequence of the event.

Table 4-2 The time control tag description of action procedure

Tag	Description
Action	
TIMESING= 0	All the reactions occur at the same time and the order is not strict.
TIMESING= 1	Reactions perform in a particular sequence.

Chapter 5 Home Services and Auto-Apply

5.1 Home Service and Event/Action Procedure

In this chapter, I will explain the relationship of service and device procedure in the system.

We already know that device procedure is a guideline that tells us how things going, in tradition, device procedure describes the admit behavior of specific objects, it may under some circumstantial condition or not. In this home automation system, I try to separate the target object and the behavior into different parts. This graph shows the main idea:

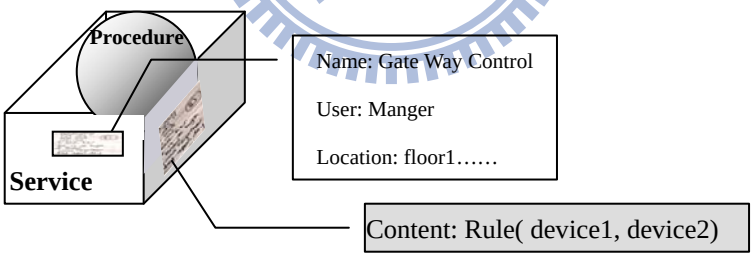


Figure 5-1 Service contains device procedure

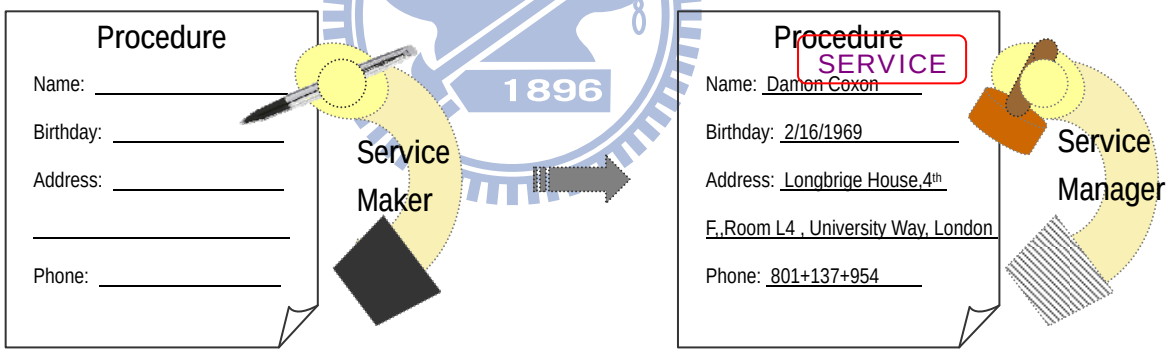
In this point of view, services are just like packages for procedure. Like all those productions we buy in the convenient stores, a package, here is the service, has to explain the name of this product, the inside compositions, and the notable situation, etc. Our service marks up information, such like its purposes, its target users, its suitable location, etc. In addition, the most important parts-- the involved procedure and those devices that the procedure hire.

The benefits gained from this layout including:

1. In home application, there are many cases that one service just performs a similar action under similar situation to some other services. The little differences between these services is where the location them occur or what devices perform the jobs.” When TV volume up, higher the door ring volume” is just the same kind operation as “When the sound system volume up then louder the phone ring tone” In fact, we can even separate event procedure and action procedure into different parts. This will discuss in next section.

2. Faster Service auto apply: In the very beginning of system setup, system already has some template procedure.

From the other point of view, the procedure is a form, a playbook for service, and a service is the one who knows which devices will play which position.



Procedure is an empty form. When user or system wants a new service, the service maker fills up the space in rule. After service maker finished its work, service manager registers the content as a new service.

Figure 5-2 The process to provide a new service by filling up a form of procedure

To fill up the form of a procedure correctly, a service needs efficient number of vent devices and action devices.

Now, consider the service- procedure index question. Service performs a serious and complicate action for user. Sometimes, there is no casual relation between those

actions and we still want them team as a service. In this case, a service should contain more than one procedure.

In addition, here is a different consideration: we want some back up procedure, in case some bad thing happened to the involved procedure. As we do to the devices in procedure, service involved extra one or more procedures as the substitute. Therefore, the main procedure and substitutes have similar behavior.

A service can contain more than one procedure:

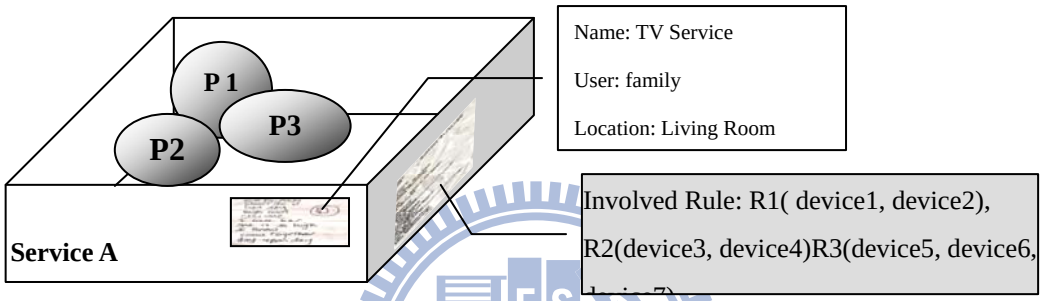


Figure 5-3 Service and procedure - direct packet

Alternatively, if I force every procedure to be wrapped by a service, the situation will be like this:

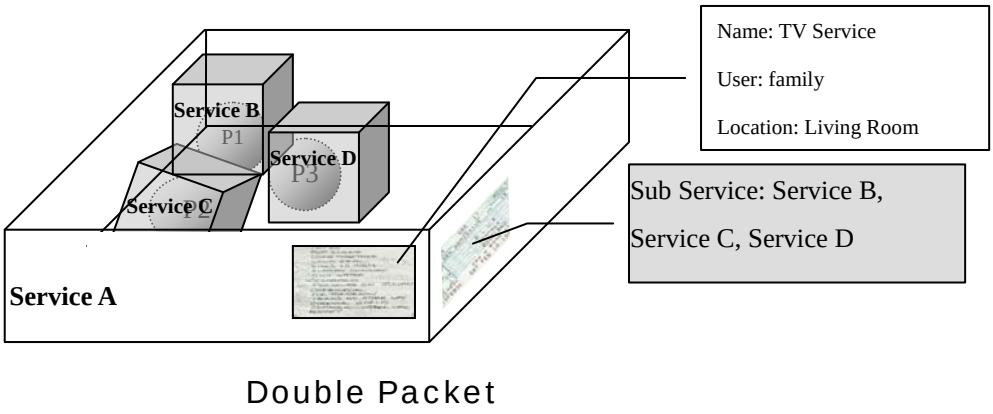


Figure 5-4 Service and procedure - double packet

It is easy to tell that the package is bigger than the first one. However, the service

information on service in double packet case is smaller in the second one.

To identify Service, System uses service ID and users use service name, and friendly description that are made by end user. However, the service ID and that information defined by user cannot quickly tell system what is the purpose of a service.

The role tag in <serviceType> of such service is noted as “container”.

The double packet structure can surly make the service description much simpler and clearer than the naked one.

Assume that I let the first one alive. Here comes the further problem: Can procedure act other procedure or just other service?

The goal of the system is to be as flexible as possible to carry every thing that user desire to come true in an easy way. Procedure design is the key point to realize this.

The first adaptation is to allow procedure s hiring existing procedure and other controllable object in the system. Controllable objects including devices, location data, user data, service and procedure.

Plan A: A procedure directly nominates other procedures, that means all the stuffs involved in every procedures are packaged by the only one service,

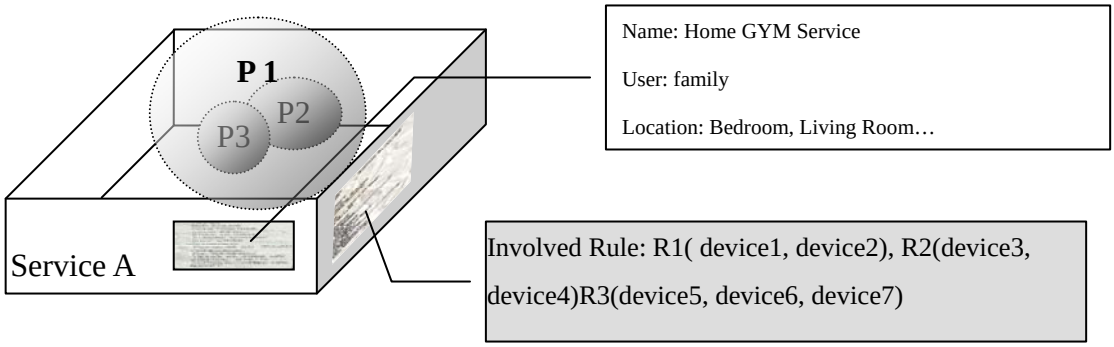


Figure 5-5 Procedures in side Service - direct packet

so all the materials contain in those stuffs have to be memo on the only one package, in the situation which is showed above, that would be service A to record all the devices used by R1, R2 and R3.

Plan B: A procedure cannot directly include procedure; procedure can only hire a service.

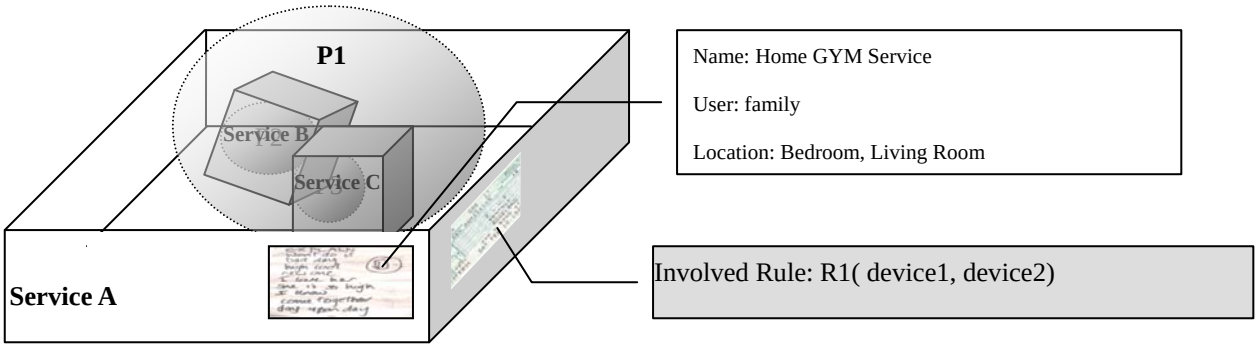


Figure 5-6 Procedure s in side Service – wrap by service

A service just keeps the information of devices for the procedure in the top level.

To know the information of devices in the inner service, the system digs deeper to look up the inner service descriptions. Both ways are available. I think the second way is more consistent with the basic design of the whole architecture.

5.2 Service Auto-Apply

Assume the system already has a rich service model database, the situation of MyHA is just like a baseball scouts or a model agent. There are punch talent player, who suit the team needs perfectly and can the team give the player a satisfactory treatment? A matchmaker can do this puzzle for you!

5.2.1 Scenario

When dose the Auto-apply work?

1. When you Move

You keep most home devices, and take them to your new house. At the same time, you throw some old equipments and some devices you just do not like or need them anymore. You also buy some new furniture and interesting toys. The layout of rooms in new house may different to before one, however, in general case, you may not change the composition of equipments in each rooms.

Thus, in your new bedroom, beside a bed, some closets, etc, you still have a nightstand, a sound system, wireless phone and a mosquito killer. Although, there is a little bit difference -- you got a brand new and powerful air conditioner, which can not only control air temperature, but also combine humidistat and ozone air cleaner, that replaces the traditional one in old house. At the same time, you still want to enjoy those comfortable services you have made when you lived in the old house; of course, plus some new fancy little trick. To have them from starting at the head is not a bad solution. It is fun. You can stew your brain and pop up some great idea than those old one you made in old house. However, moving is a hard job, adjust stuff to its right place is troubled and exhausted. Let MyHA carry your original idea to the new but still familiar environment.

2. When you buy a new toy

Tommy bought a new shower system this Friday afternoon. This new babe can make a babble bath and modulate spa pool, it with digital controller for water temperature and volume. Gina will be very happy about this surprise. After a crazy Friday night working in restaurant, she always says that she want a comfortable weekend spa with relaxing music and mild light effect. Tommy just set up the system when Gina came home. Can he finish the setting of the bath program ASAP to give Gina a surprise?

5.2.2 Service Matcher

Service Matcher is responsible for service auto-apply service. It is under the service manager. It picks out service templates for users and evaluates the capability of home environment, finally makes services and home devices work together. Service Matcher dose not just measure the services' capability, but also evaluate User's Home environment. That is the reason why the first step of Auto-apply process is called the Matching.

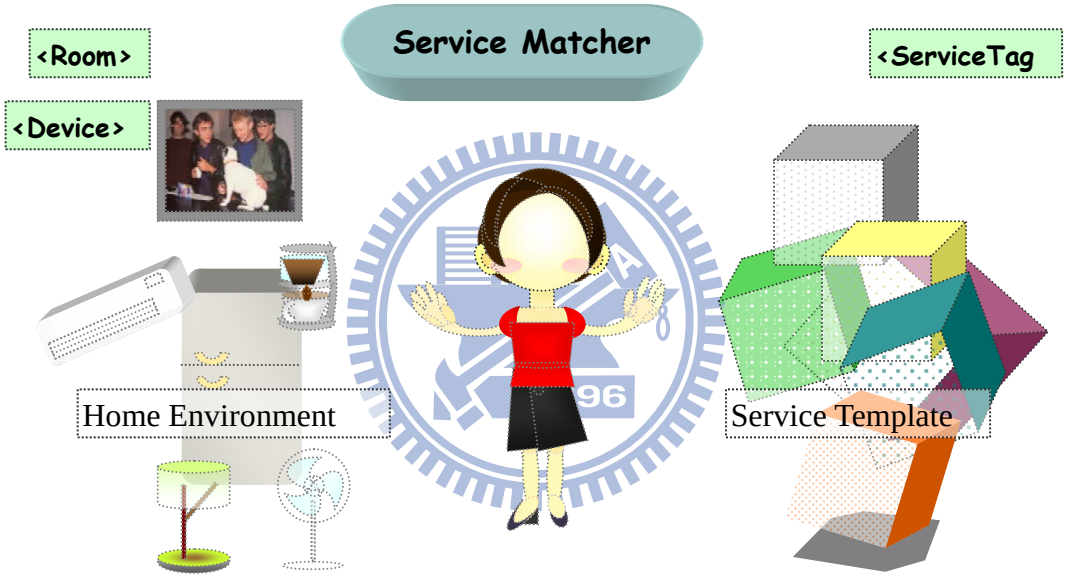


Figure 5-7 The concept of Service Matcher

Matching Service survey the condition of both side, then give a possible services and devices list to users. What gave out alone the list are some suggestions. Service Matcher will throw out the information, which would help user to decide service is more workable and what devices should be lunched.

1. **devices scanning**

Based on the discovery service of MHAP, system can capture device movement. When a new device is inserted or an old device is removed, Service Matcher will

search for services that contain the same kind of devices.

2. **choose Service**

System owns a service template database. Users can select several service template modules from service share spaces and put them into their home service modules database. This service module base is the foundation of auto applies procedure.

Here I discuss how the home system finds out a propriety service for user from the home-service-module databases.

At the very beginning, users provide the big direction of service. Chose the wanted service module is the first picking. This occurs at the install procedure and any other time users want to change the setup of their home database. The second time that users release their desire to system is now--when the home auto applies getting star, users can (or not) claim some purposes of new services. E.g. House keeping, light control, etc. Base on these conditions, system stars the picking.

3. **Pick up candidate service templates**

By using some system recognizable tabs and user readable descriptions (<serviceType>, <friendlyName> and <userDescription>) that stored in service descriptions as searching key, Service Matcher combs out some service templates as users desired services from service template database. These service templates are candidates of services. System evaluates the candidates by what devices type they need and where they work.

5.2.3 Home Environment prerequisite

The evaluation starts from location requirement to devices.

1. **Location prerequisite**

A service may perform in one room or distribute in several rooms in different floor, and service can specified these rooms have to be a bedroom, living room or it

does not care.

For example, one a light opened in living room can express different thing from another light lighting in a bathroom, so it is necessarily needed to mark up service room type.

Furthermore, in some cases of multiple room services, the relationship among rooms is the key factor of service performance, which gives service a significant reason to note the room relationship prerequisite.

To note the relationship between rooms, first, service has to mark up the room, which the main action or main event take placed. Using the main room as a base, service can describe the relationship between main room and other rooms .Here is the room-relationship tag list:

Table 5-1 The role table of room in service

Role	Description
<Main>	The Room contains the main event or action device. For each Service has only one main room.
<Next>	This room is next to the main room.
<Belong>	This room is contained by the main room.
<Up>	This room is in the upper floor and right above the main room.
<Down>	This room is in the lower floor and right under the main room.
<none>	Service does not care the relationship between this room and main room.

To make sure the services after applied are executable by home system, Service Matcher compares devices that already in the system and devices required by services.

Using those devices claimed by service template as searching key, searching through home environment. If no device fits the requirement, mark it as missing.

The perfect situation is all the devices fit the original presupposition. System already got every devices involved in the chosen service template, and all their types,

functionalities and locations satisfy the service's requirements.

2. Device Restriction

If some devices, in the found device set, are disqualifying in some criteria, Service Matcher evaluates if this situation would damage the service performance. Here I list the points that devices may loose their scores:

1) Location

Two X10 lamps, one is in the living room, and the other one is in study hall. They are definitely with different purposes. Thus Service Matcher has to make sure

2) Type

3) Functionality:

A similar but worse situation, if there are some absent devices, it absolutely made a set lose score. Even though, it doesn't mean this device set cannot work for user.

Now consider how Service Matcher evaluates found devices.

Even Service Matcher does want a perfect match, however, more frequently, it comes up some drawback and a restrict requirement would lead to nothing available. Therefore, when a device set is not perfect, Service Matcher will try to tolerate or fix it.

The main gate to decide if a service can be carry on is the importance of the problem devices. In every service description, Service Manager sticks a role tag and a weight attribute on each device, which involved in every service. A main actor is the most important device in a service. A main actor's responses or reactions will determine that whether a service is success or fall into failure.

A main event device is similar to main actor. If the event cannot send out from main event device, the service won't be trigger. Here is the device role list:

Table 5-2 The role table of device in service

Role	Point	Description

<Leading>	6	This is the main device of this service, without this device the service cannot work.
<Support>	3	This device is less important than main device, but still played a significant effort in the service.
<Entourage>	1	This is the least important device in the service.
<Substitute>	0	This device is a substitute for the Main/Support/Entourage device.
<System>	0	This device is a virtual devices provided by system, e.g. timer,

3. The Sub-service

As the discussion in chapter 4, service can contain sub-service, so if a service has sub-services, this service also need to manage its' sub-service as it does to devices. Since a service can be treated as a virtual device and reversely a device can be view as a service, service uses the same method that adopted to describe devices role to manage sub-services.

5.2.4 The Criteria

The full score is gain from .

full score of a required room: $\sum_{i=0}^{m} (Pd)_i$

Pd: the score gain by the device, according to the role of device, it is from 6(leading)-0(Substitute or System);

m: the number of devices required by this room.

score gain by a required room: $Rs = \sum_{i=0}^{m} \frac{(nd_r)_i}{(Nd_r)_i} \cdot (Pd)_i$

ndr : the number of qualified devices gain by the device role r;

Ndr : the number of devices required by the device role r;

m: the number of devices required by this room

For each required room, there could be more than one qualified room, Service Matcher uses the highest score one as The first priority of the candidates recommended. When we let service pick all the highest scored rooms and note the score of the highest score room as $R_{max,}$ the service will reach its maximum score too:

the max score the service can gain: $\frac{\sum_{j=0}^{k}(R_{\max})_j}{\sum_{j=0}^{k}\sum_{i=0}^{m}(Pr)_i}$

j: the number of room required by this service

In the end, if the score service gain is higher or equal to the threshold that user set up, Service Matcher will recommend this service to user.

When the problem device is a main actor or sent a significant event. When the device is just one member of a device set, for example a light which belong to a decorate light group, and it only performs same job as the other lights in that group. I call this kind of device a support device and the event they produce as a side event.

The device type hits but the function dose not. Check if there is a lower level function. A segment control may substitute a continually control. Play now disc may step for the play a music program.

5.2.5 Compromise

If Service Matcher cannot find out a fund device set which is good enough to carry on service duty even under losing some support devices, there are still two ways to save this deal:

1. Amend service procedure, drop event or delete action.

2. Find the potential device of home environment

5.3 Device Procedure checker

Device Procedure (rule) checker's duty is to check if there is any logical conflict or potential conflicts between any pair of procedures.

There are some problems that a rule-base automation system may encounter during numerous services working.

5.3.1 Time Trap

This is in order to avoid requiring a single device to execute two or more different order at the same time. If procedure a, b have time contraction: a. not allowing the procedure, user have to change the procedure design of one of them; b. allowing user to set the priority of the procedure s which applies when a conflict of procedure s occurs.

Avoid chain reaction: Device Procedure checker checks all the device of action part. If they are working for other procedure, we do not want a chain service reaction. If an event was caused by a action procedure, it should not be considered as an event of another procedure, unless user wants this to happen. Procedure engine should keep the action records. Thus, when here comes an event, procedure engine can recognize if this event is a just out action, then we can ignore it.

1. Service Action log

Time/ Service ID/ Action ID/Device ID/Variable ID/ Variable Value O/ Variable Value N

2. Service Reaction Chain

System can show the possible Service reaction chain on the Service Management UI. Users can decided if they want some reaction be available.

5.3.2 Logical Trap

Three kinds of Logical Trap might occur in this system. The first one is when the signal of the event and the action in the same service conflicts with each other. For instance, the action is “turn switch A off” when the event is “switch A is off.” The second one happens when there are logical conflicts in events or actions of the service. Finally, the third one happens when different services conflicts with on another.

Chapter 6 Results

6.1 Service Template

Here I list some service categories. Some of these templates are come from my imagination of a more easy way to live in daily life and the others are come from movies and novels. E.g. *Blade Runner*, *The Fifth Element*, *Minority Report*, *Iron Man*, *2001:* A *Space Odyssey*, etc.

Here I note the service template as this form:

[<Name>] (Event) {Action Set}.

6.1.1 Living Room

1. (DVD player on play), {turn off primary lighting; turn on secondary lighting}, {set stereo mute}, {close curtain}.
2. (TV on), (if stereo is not mute for five seconds), {set stereo mute}.
3. (massage chair operating)，(TV Of)，{set stereo on and play the default program}。

6.1.2 Kitchen Work

1. (First, the dish washer is on work) and (second, the main Light in kitchen is turned off) {turn on the [Light +Music] stereo in living room} ,{if the dish washer is off work},(the music volume will be turn down)

6.1.3 Home Secure

1. <a quick leave>**{turn all light off} {lock all door besides entrance}**

2. <intrude alert>{sent SMS to cell phone}{sent video to cell phone }

6.1.4 Home GIM

1. (treadmill on)，(TV Off)，{set stereo on and play the default program}{turn on the air conditioner}

6.1.5 Long Vocation

1. {Lock the front door turn on the highest home secure service}, {shut down the power supply of the appliance set}, {make air cleaner operate once a week} and {set some light to turn on at every night}.

6.1.6 Sweet Sleep

1. (turn off and immediately turn on the main light in bedroom two times), {close the door in bedroom}{play the Sleeping Music program for 90 minis}{close the curtain}
2. (the template is under the cold standard e.g. 12 ℃)(after the sleeping time e.g. 00a.m.){turn on the hitter in bedroom}{turn off the hitter when it comes to 6 a.m. }

6.1.7 Quick Morning

1. Alum rings, {making Coffee}, {pre-hit the oven}, {turn on the light in shower room}, {play the demand Music program}, and(after the door open and close){turn off the Music }

6.1.8 Party Night

1. <ice rock>(user set this service on),{turn on the ice maker},{music + light program on},{toilet auto flash },{air conditioner on},{lock room set }
2. (music volume up){Phone volume up}{door ring volume up},(music volume down){Phone volume down}{door ring volume down}
3. <KTV>
4. <yard party>
5. <pool party>

6.1.9 Good Student

1. <start study>(desk lamp on and off and on in 2 seconds),{phone ring tone down }
2. <sound control>(music volume up){Phone volume up}{door ring volume up},(music volume down){Phone volume down}{door ring volume down}<take rest>

6.1.10 Movie Time

1. (DVD player on),{mute the main light},{put the cabin down}
2. (music volume up){Phone volume up}{door ring volume up},(music volume down){Phone volume down}{door ring volume down}

6.1.11 Dinnertime

1. (Main light in dining room on and off and on),(it hotter than 27 ℃){ turn on the air conditioner when }
2. (tv is off)(sound system is off){turn on the sound system}{play the dinner

3. (tv is on)(sound system is on){turn of tv}{play the dinner program in sound system}

6.1.12 House Keeping

1. <cool housewife>(),(it hotter than 27 ℃){ turn on the air conditioner when }

6.2 User Interface

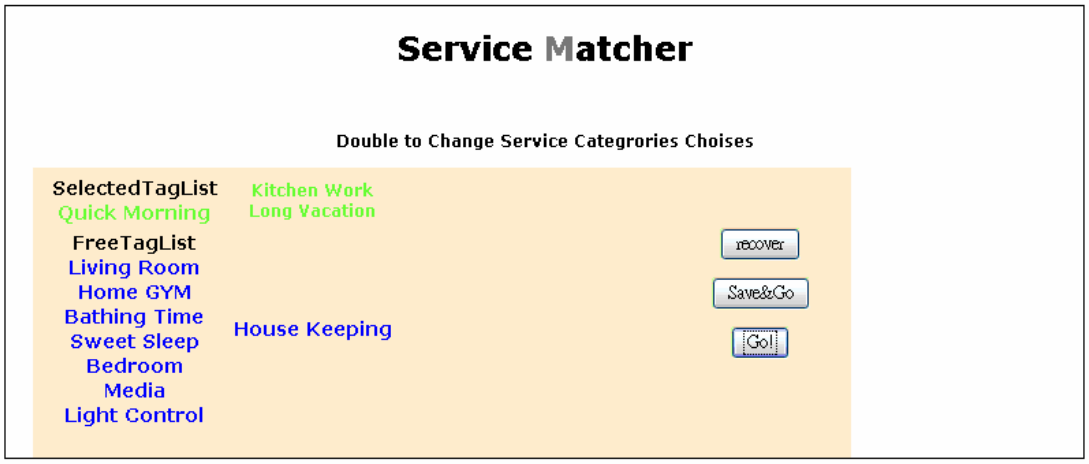


Figure 6-1 MyHA on MHAP Architecture

User choosing some home service description tags, which they feel interesting. They can save the set up as the Service Matcher's principle, or do not save it, thus let this selection as a one-time preference.

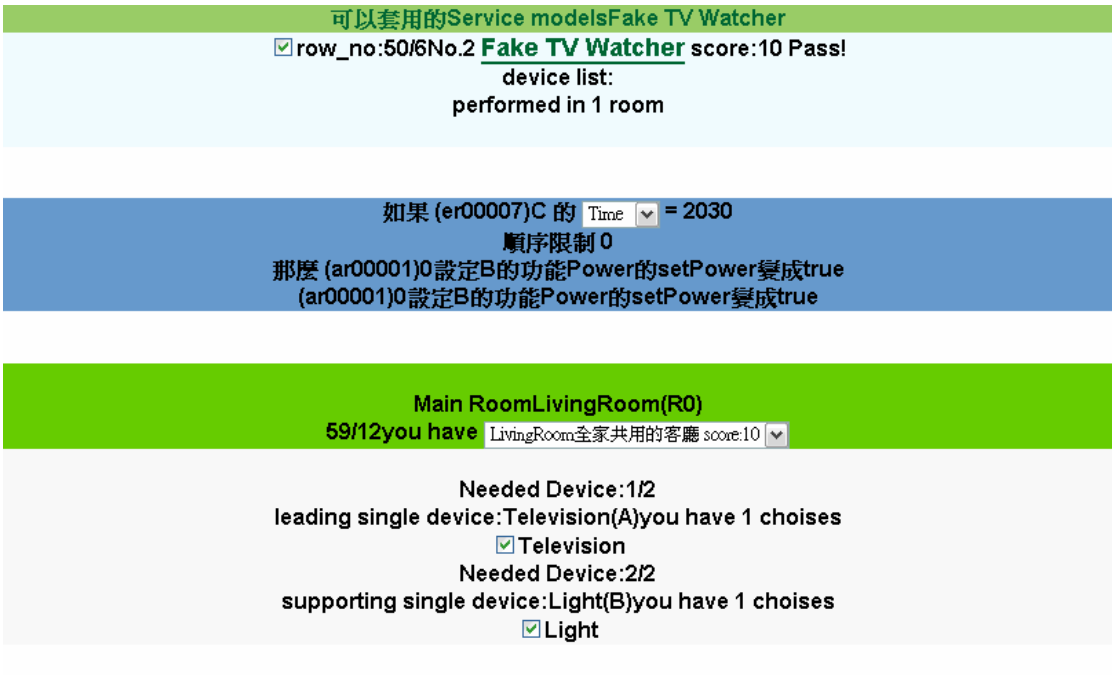


Figure 6-2 MyHA on MHAP Architecture

Figure 6-2 shows a example of the matchers work. It lists all the services that are already in-used or not fit the users' requirement. And give user the results of evaluation. Users can select qualified service or modify service design to create a new service to improve the score.

Chapter 7 Conclusion

7.1 Contributions

The system I proposed here enhance the deficiency part of MHA, providing a more end user friendly service structure, which achieve its' goal by a device located oriented service matcher service, and a service template database that has a potential to continued growth.

7.1.1 Cheep and quick solution for DIY user

Unlike building automation, most end users do not live in a new and well-designed house, which give them a great foundation to build up their home service, normal user want to enjoy an automation home environment have to pay a lot effort and that is what people always try to avoid. Without deploying plenty sensors or signal senders, MyHA use device-location oriented system can give user a simple, rapid and flexible home service solutions.

7.1.2 Enhance Home Service Capability

Refine the design of system descriptors. First, added a high-level home service, which is upon those basic device services, encapsulate the user requirement into a more manageable shape. The dividing structure of home services and device event/action procedures ensure the higher flexibility of HA system. Second, import time signal and sequence attributes into MyHA. Finally yet importantly, using home environment as the service based, emphasize the influence of room relationship and device location. The last two made the MyHA service become more accurate in

capture users demands.

7.1.3 Service templates

A set of home service template, it can be the foundation and reference for any one who want to set up her/his Home Automation.

7.2 Future Work

To understand the home/domestic environments, there are many different research approaches are being used. Such as ethnographic studies [29, 30], the development of technology models [31], the use of cultural probes [32], and patterns [33]. These studies all focus on an important issue: that the home is open to continual reconfiguration by those who inhabit it. More recently, researchers have started to develop domestic technologies “in the wild” by constructing and placing technologies within domestic settings in partnership with users. This includes ‘technology probes’ [34] where development takes place in partnership with a number of distributed families and the development and placement of lightweight media space technologies [35]. Not only has this work highlighted the importance of the inhabitants becoming involved in the design process it has confirmed the need for technology to be open to reconfiguration within the home [36]. Researchers have extended this work to consider ubiquitous computing and domestic technologies [37]. A key feature is the relationship between the technologies within the home and the underlying services needed to support them.

7.2.1 Device Function Management

In the current design, the home service matching and ordering are step in the device level. It is conform to the physical environment and intuitively correspond with

management and deployment process. Further observation of the user demand for services, the real demand is rooted in the functions of products. There are some research about component model for ubiquitous devices and Jigsaw Pieces. Try to fit this feature in DIY users' requirement can be the next step.

7.2.2 User Behavior Learner

Once MyHA services set on, system logs device action. The action list plus room information would form a map that contains a user's behavior patterns. Observing hoe user operating home devices for a few days, system can dig out the user's behavior patterns out, and then based on these patterns to make a service for user.

This could be an alternative way to provide service auto-apply to DIY users. No mater what method service used to build up service for user, the user behavior is a good assistant to revise the service setting.

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Appendix

您好，

我是交通大學資訊科學與工程研究所，分散式系統實驗室的學生，為了完成研究，希望獲得您的幫助，請您花一點時間幫我完成以下的問卷，非常的謝謝您。

離開房間就自動關閉電扇和音響，晚上休息的時候就自動鎖上前後門還要打開走廊的小夜燈，一個按鍵讓公寓進入宴會模式，持續的空調和音樂播放，配合環境中的分貝調整電話與門鈴音量，不受電話和燈光干擾的藍光電影時光……這些不論是電影或是現實生活中都已經是很容易達成的事情，為何還是離我們有點遙遠？難道只有高級住宅中透過專業家庭服務公司，購買昂貴的成套產品，才能有這些享受？或是必須具備撰寫代理人服務的程式能力，才能一點一滴慢慢打造想要的便利環境？能不能自由選擇想要的產品，又很快速的取得享受服務？

「為 DIY 使用者設計的家庭自動化平台」，這是我所研究的主題。藉由發展一套服務訂做系統，將幫助使用者自由又快速的訂製想要的家庭或是辦公室的自動化環境。

透過這份問卷，您將幫助我了解使用者對自動化家庭環境的想法，我會將這些資訊整合應用到系統介面的開發上，因此您的意見對我非常重要。

問卷完成後，您將受到一份問卷的統計結果。並且，如果您有興趣，也很希望您能幫助我完成下一階段的實驗與問卷：藉由實際的操作介面，測試系統是否能實現您所預想的自動化服務。

關於本研究和本實驗室相關訊息可以到 *http://dcsw3.cis.nctu.edu.tw* 查詢。

問卷完成請e-mail 給我 *knightgustav@gmail.com*；或是有相關問題也可以與我聯絡討論，謝謝。

本問卷共分成四大項目，大約會花您 15 分鐘的時間。 

第一大項：背景資料：

1) 請問您的職業是 1. 學生 2. 半工半讀 3. 就業中 4. 自由生活者 5. 其他

單選，請填寫數字或是補充文字_____

2) 請問您擁有自己的工作空間(例如：實驗室或辦公室座位或個人工作室與辦公室)？1. 是 2. 不，我沒有工作空間 3. 不，我和別人共用空間

單選，請填寫數字或是補充文字_____

3) 請問您擁有自己可以作主的生活空間(例如：自己的公寓，個人的房間，或是在您管理下的家庭環境)？1. 是 2. 不，我沒有可作主的個人空間

單選，請填寫數字或是補充文字_____

本大項結束，請至第二大項。

4) 請問您日常生活中是否經常使用電腦、手機、PDA 等電子資訊產品？ 1. 是，我天天使用 2. 是，我經常使用 3. 不，我只偶爾使用 4. 不，我很少使用這些產品

單選，請填寫數字或是補充文字_____

第二大項：智慧型產品觀感與使用情況

這裡所指的智慧型電子產品是指擁有操作介面，可依您的要求執行指定的任務的日常生活設備。例如：數位導航、電子刷卡機、數位恆溫裝置、數位冰箱等。

1) 請問您日常生活中是否經常使用除了電腦、手機和數位相機之外的其他智慧型電子產品？ 1. 是 2. 不，我只偶爾使用這些產品 3. 不，我從不使用這些產品

單選，請填寫數字或是補充文字_____

2) 請問您目前是否擁有的智慧型電子日常生活用品(例如：可以顯示內容的數位冰箱、自動清掃的吸塵器機器人、數位咖啡壺等)？ 1. 是 2. 不

單選，請填寫數字或是補充文字_____

選擇 1，請繼續回答本大項第 3)題，
選擇 2，請跳至本大項第 4)題

3) 請問您目前擁有的智慧型電子日常生活用品有那些？ 1. 家事類 2. 影

音視聽類 3. 安全管理類 4. 資訊類 5. 燈光系統 6. 衛浴系統 7. 健身活動 8. 其他

複選，請填寫數字與產品數量或品項(例如 1. 冰箱、咖啡壺 3. 居家監視、電子防盜鎖 5. 大燈) _____

_____

_____

4) 請問若不考慮價錢因素，你是否會想要擁有智慧型電子化的日常生活用品？ 1. 是，我會想要擁有這類產品 2. 是，我可能會想要這類產品，但要考慮其他因素 3. 不，我完全不想使用這類產品

單選，請填寫數字或是補充文字_____

選擇 1、2，請繼續回答本大項第 5)題，
選擇 3，請至第本大項第 7)題。

5) 請問除去價錢因素，以下那些因素會影響您決定是否擁有智慧型電子日常生活用品？ 1. 功能完整性 2. 操作介面 3. 外型 4. 耐用性 5. 省電 6. 產品規格(例如：X10 或 UPnP 等…) 7. 其他

複選，請填寫數字或是補充文字_____

6) 如果能滿足所有考慮因素，您會想要擁有哪些種類的智慧型電子日常生活用品？ 1. 家事類 2. 影音視聽類 3. 安全管理類 4. 資訊類 5. 燈光系統 6. 衛浴系統 7. 健身活動 8. 其他

複選，請填寫數字與產品數量或是補充文字_____

本大項結束，請至第三大項。

7) 請問您不想擁有智慧型電子日常生活用品的原因是？ 1. 操作複雜 2. 感覺不夠聰明 3. 耗費能源 4. 產品規格太多難選擇(例如：X10 或 UPnP 等…) 5. 就是不喜歡電子產品 6. 其他

複選，請填寫數字或是補充文字_____

8) 請問如果改善題 7)的因素，您會想要擁有智慧型電子日常生活用品嗎？ 1. 是，我會想要 2. 是，但還要再考慮 3. 不，還是不想要用

單選，請填寫數字或是補充文字_____

選擇 1、2，請跳至本大項第 5)題，

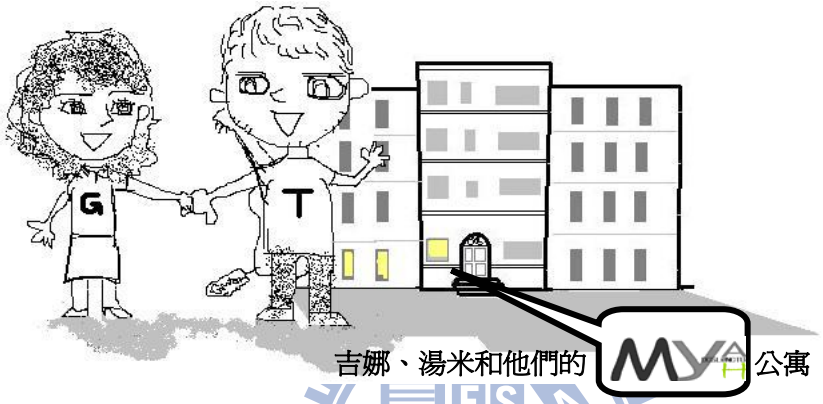
選擇 3，本大項結束，請至第三大項。

第三大項：智慧型自動化生活環境

MyHA是一個以幫助大家完成所需要的自動化環境爲目的的系統。

請閱讀以下情境：

湯米和吉娜擁有一間自己的公寓，他們工作很忙碌，雖然收入不多，但是他們喜歡讓家庭有些聰明的家電，讓他們可以兼顧工作和輕鬆有趣的生活品質。他們用家裡的電腦主機安裝了 MyHA，用來管理他們買的各式各樣的家電設備：



吉娜、湯米和他們的 公寓

1. 買了一個新產品：

吉娜在餐廳上班，週末的晚上下班總是很疲憊。湯米趁著假日的下午到家電賣場買了一個具有電子調節功能的衛浴組，配合家裡已經有的可調整亮度的燈具，還有音響設備，想讓吉娜一回家就可以享受燈光美氣氛佳還有好音樂的 SPA。好不容易裝好，門口已經傳來吉娜的鑰匙聲！

好險 MyHA 已經有自動設定服務，設備一裝好馬上套用適當的服務。於是湯米輕鬆坐在沙發上，只等吉娜打開新的蓮蓬頭，房間裡的音響馬上就響起了他們最愛的邦喬飛的音樂，還有舒適的燈光，以及吉娜驚喜的歡呼聲……

2. 東西壞掉：

原本設定了入睡之後，要將走廊的夜燈打開，但是今天晚上夜燈忽然壞了，是要不開燈，還是已經躺在床上了，還要爬起來，趕快把它修好，或是跑去客廳隨便開一盞差不多亮度的燈？

MyHA 可以自動察覺設備故障的情形，尋找可以替代的方案：MyHA 自動用開放空間的小燈暫時替代原本夜燈的工作，讓你還是可以悠閒的上床休息。夜燈被修復後，自動地重回工作崗位，不需要重新設定。

3. 搬家了：

湯米和吉娜要搬家了，淘汰了一些舊的設備，也買了一些新家電，同時變更了一些擺設方式。搬家已經很辛苦了，湯米真希望原本調整好的睡眠自動空調關燈服務，還有 SPA 設定可以馬上工作。

吉娜在新家重新啓動 MyHA，在確定的新家的房屋配置後，原有的服務就回來了，也因應家電的變更自動調整了內容。想到明天早上還是有自動開啓的咖啡壺、預熱的電子爐，還有回家前的自動空調……新家的第一夜也睡的非常安穩。

1) 請問您覺得這樣的情境有那些吸引人的地方？ 1. 很方便 2. 有趣 3. 感覺很帥 4. 有幫助 5. 很需要 6. 沒什麼吸引人的 7. 其他

(複選，請填寫數字或是補充文字_____

2) 請問這樣的功能吸引您嗎？ 1. 是，很我也想要有這種服務 2. 是，滿不錯的 3. 不，沒什麼感覺 4. 不，感覺很沒有意義。

(單選，請填寫數字或是補充文字_____

選擇 1、2，請到本大項第 4)題
選擇 3、4，請繼續回答本大項第 3)題

3) 請問不吸引您的原因爲？ 1. 沒有這種需要 2. 不必系統幫助也可以達成 3. 感覺沒有幫助 4.. 其他

複選，請填寫數字或是補充文字_____

4) MyHA可以提供各種類別的服務，請問以下的服務種類有哪些您會想要擁有？ 請在選項前打V：

___ **1. 客廳生活**：提供在客廳中會使用服務，例如在看電視的時候自動幫您把音樂系統的音響關掉或暫停；如果想坐在按摩椅上放鬆一下，可以自動幫您打開電視或是音響。

___ **2. 出遠門**：要離開家裡一陣子，除了必要的保全設定外，離開時自動關閉不必要的電器用品，還希望回到家中的時候家裡空氣清新，地板乾淨沒有灰塵，或是不希望鄰居發現家裡沒人?系統可以自動設定空調系統運轉，打掃機器人定時工作，偶而開關家裡的電燈等。

___ **3. 家庭健身房**：就算在家也要健身，可以用跑步機也可以在沙發上運動，運動的時候如果沒有開電視可以幫你播放合適的音樂，或是就是想看電視也可以幫你確定音樂關掉，並打開你喜歡的節目，同時調整空調溫度，設定電話自動轉接。

___ **4. 匆忙的早晨**：早上要醒來有人要靠咖啡，有人要音樂，也有人需要沖澡，也有人全部都要--設定早上鬧鐘一響或是浴室的燈一開，其他就通通準備好；出門的時候也幫你把該關的東西通通關好。

___ **5. 用餐時刻**：吃飯的時候飯菜讓人心頭和身體都熱呼呼，可以用餐廳的燈亮起代表用餐時間，替你打開空調和風扇，順便準備音樂或是電視。

___ **6. 用功的學生**：晚上要熬夜專心的話，手機跟電話還是轉到靜音或是留言好，咖啡也幫你準備好，然後訂時提醒你該離開桌子活動一下。

___ **7. 安心睡覺**：睡覺前除了基本的門戶安全外，總有一些小事要照顧？像是燈光的關閉，習慣留夜燈或是喜歡全黑？自動幫你關閉該關的電器、窗簾，空調也可以自動設定睡眠氣溫和濕度。

___ **8. 沐浴時間**：洗澡的時候電話可以自動轉到留言，洗完澡後室內氣溫的調節，浴室除濕；吹頭髮後，地上都是頭髮，讓機器人自動幫你清理；當然也照顧到你想要的音樂氣氛。

___ **9. 派對夜晚**：當個派對主人有很多事情要兼顧，人氣和食物要自己忙，但像是隨派對流程播送的音樂，分區域的燈光控制還有房門安全、空調控制，製冰器持續運轉，或是派對結束立即開始的清掃，都可以幫你照顧好。

5) 除了以上，您有什麼對智慧型生活環境的想像嗎？或是您很希望有一些瑣碎的事情，可以有自動化產品幫您完成？產品不一定要是真實存在的，例如可以是產品 A+B+C 的功能=新產品 D；或是您想要產品 E、F 和 G 可以一起配合幫您完成工作？ 請盡量根據您的想法填寫。

本大項結束，請至第四大項。

第四大項：建議與意願

1) 對於像 MyHA 這樣目的的系統您有什麼建議嗎？1.有的 2.沒什麼意見

單選，請填寫數字，並補充文字_____

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在系統測試介面完成後，我會需要您的幫助，測驗系統是否有達到目的，測試方式暫定爲透過網頁介面操作系統，並完成問卷。

2) 如果系統完成，您願意幫我測試 MyHA 是否可以幫助您達成對智慧型自動化環境的想法嗎？1. 好，我很願意 2. 不確定，要到時候再考慮 3.不，請不要找我測試

單選，請填寫數字_____

如果你願意幫助我從事軟體測試問卷，請留下您的聯絡方式(手機/e-amil 均可)：

_____

_____

3) 當問卷回收統計完成，您希望收到統計結果嗎? 1. 是，請寄給我結果 2. 不，請不必寄給我結果

單選，請填寫數字_____

如果你願意收到問卷結果，請留下您的聯絡方式(手機/e-amil 均可，已填寫者免填)：

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如您採用線上填寫，請寄回*knxxxxxtav@gmail.com*。

如果您使用的是紙本問卷，請交回給分發的人員，或傳真至 02-2xxx-3xxx。

本問卷結束，非常感謝您的耐心填寫。如有任何疑問也歡迎與我連絡。
非常感謝您的協助，希望您天天都過的很開心！