SOA를 기반으로 한 스마트 홈 플랫폼

김진홍*, 김현호**

요약

스마트 홈은 유무선 네트워크에 연결된 기기들을 제어하여 안전, 보안, 편의 서비스 등을 제공할 수 있는 주거공간을 의미하며 플러그 앤 플레이, 스마트, 스크린과 함께 토탈 패키지로 제공하는 서비스를 말한다. 예를 들면, 리모콘의 사용을 통해 쓰이는 가정에서 조명의 조절은 가정 자동화로 할 수 있으며, 전자보안 시스템 뿐 만 아니라 음성 인식은 스마트 홈의 특징이다. 스마트 플랫폼 기반 홈 서비스의 구조는 일반적으로 서버 중심으로서, 이에 따른 많은 문제가 야기되고 있으며, 특히, 스마트 디바이스와 이를 위한 동적 서비스는 변화하는 환경에 따라 매우 어려운 상호 작용을 발생시킨다. 게다가, 효율적이고, 적절한 서비스를 제공하기 위한 방법은 스마트 홈을 위한 가장 중요한 이슈이기도 하다. 따라서, 일반적 환경에서 제공되는 문제들을 해결하기 위해, 스마트 홈을 위한 적절한 서비스를 제공하기 위해, 서비스 지향 아키텍쳐 기반 스마트 홈 플랫폼을 제안한다. 스마트 홈 플랫폼은 서비스 지향 메커니즘을 가지고 있으며, 스마트 네트워크 환경을 위한 스마트 홈 서비스를 위한 OSGi 플랫폼을 이용한 컴포넌트를 적용한다.

Smart Home Platform Based on SOA

Jin-Hong Kim*, Hyun-Ho Kim**

ABSTRACT

Smart Home is defined as a residential space in which wired and wireless devices provide safe, secure, and convenient services. It is a service that comes in a total package of plug and play, smart, and screen. For instance, lighting can be customized automatically for a resident with a remote controller. The characteristic of Smart Home is not only electric security system, but also voice recognition system. The structure of Smart Home Service Architecture with Smart Platform is usually server-centered and thus causes many problems especially in a dynamic environment, resulted in a very difficult interaction. In addition, the most important issue for Smart Home is how to provide efficient, appropriate services to its residents. In order to solve the problem in general environment and provide appropriate services to smart home platform, we propose Smart Home Platform that is based on SOA. Smart home platform has service-centric mechanism and applies a component that uses Open Services Gateway Initiative (OSGi) platform, which provides smart home service in smart network environment.

Key Words : Smart Home, Smart Home Service, Service Oriented Architecture (SOA), Open Services Gateway Initiative

* 한성대학교 정보통신공학과 (✉jinhkm@gmail.com)
** 명지전문대학 컴퓨터정보과
· 제1저자(First Author) : 김진홍 · 교신저자(Correspondent Author) : 김현호
· 접수일(2012년 1월 4일), 수정일(1차 : 2012년 2월 3일), 게재확정일(2012년 2월 6일)

Ⅰ. Introduction

As smart device and network become a change in every smart environment, a variety of traditional smart home is basically implemented under a centralized architecture, is connected to the home network, and controlled by the home gateway, which is the platform for service providers to provide services. In addition, they can be networked to exchange their information, their technology, bring a new future for how a home can serve users. Every thing in their homes will be connected and automatically controlled. However, today is just the dawn of home automation so that we have not had any standard technology yet. In the current view of home automation different vendors have been developing different technologies for different purposes. In most cases the system requires a central server, which is not only to control all other appliances but also to interconnect sub-systems of different technologies. This architecture is called Server Centralized Architecture and it has been known to have limited interoperability, scalability, and extensibility. In addition, because of tight coupling, a change in client side also requests for changing in server side. For these reasons, it is necessary to have a better architecture. Service Oriented Architecture, a software architecture evolved from Distributed System, is proposed to be applied in this area. Service Oriented Architecture can solve the problems we have with Server Centralized Architecture, promising a suitable architecture for the future home networks.

In this paper, we describe how Service Oriented Architecture can be applied for home networks to solve the problems that Server Centralized Architecture have. The paper also mentions the issues, which remain to be researched more, with Service Oriented Architecture. In order to develop a smart home, it is important to conform to open standards. Otherwise, a variety of proprietary systems will cause incompatibility, which can be harmful to the mass potential consumer market. In this regard, OSGi, which is an emerging open standard for deploying services to smart-home environments, appears to be a good choice.

By using the service-oriented approach, the system will have a flexible infrastructure, which can easily adapt to user requirements and Service Oriented Architecture completes our architecture. Service Oriented Architecture coordinates these platforms and treats every interaction among them as a service requesting/provision, thus playing the role of the middleware so that these platforms can communicate with one another. As a consequence, these OSGi platforms can access the system information, gather the environment status, and use services provided by others.

This paper is organized as follows. Section Ⅱ shows an overview of technologies; OSGi and Service Oriented Architecture for our related works. Section Ⅲ explains Service Oriented Architecture as an architecture model for Smart Home Platform. Section Ⅳ discusses the operation of smart home system, user authentication, and event management. Finally, we will conclude the our paper.

II. State-of-art technologies

2.1 OSGi Service Platform

The OSGi Service Platform is comprised of two parts: the OSGi framework and the OSGi standard services. For the purposes of this paper, the framework is the most important since it defines what a service is, whereas the standard services define specific services and their specified functionality. As such, the standard services, which include HTTP, logging, device access, and user management among others, are not discussed further. It is sufficient for the purposes of this paper to understand that services in OSGi are simply Java interface definitions that have precise and specified semantics; the semantics of a service interface are defined by the creator of the service interface and any object that implements a service interface is assumed to obey its contract.

The OSGi framework creates a host environment for managing bundles and the services they provide; a bundle is the physical unit of deployment in OSGi and is also a logical concept used by the framework for organizing its internal state. The state of active bundles is persistent across framework activations, meaning that active bundles are returned to the active state when the framework is shut down and subsequently restarted. The manifest file is simply a set of attribute-value pairs where some attributes are standardized by the OSGi specification.

2.2 Service Oriented Architecture (SOA)

Web services developments and standards in support of automated business integration have driven major technological advances in the integration software space, most notably, the service-oriented architecture. The purpose of this architecture is to address the requirements of loosely coupled, standards-based, and protocol-independent distributed computing, mapping enterprise information systems appropriately to the overall business process flow. In a Service Oriented Architecture, software resources are packaged as “services”, which are well defined, self-contained modules that provide standard business functionality, and are independent of the state or context of other services. Services are described in a standard definition language, have a published interface, and communicate with each other requesting execution of their operations in order to collectively support a common business task or process. A service in Service Oriented Architecture is an exposed piece of functionality with three essential properties. Firstly, an Service Oriented Architecture based service is self-contained, i.e., the service maintains its own state. Secondly, services are platform independent, implying that the interface contract to the service is limited to platform independent assertions. Lastly, the Service Oriented Architecture assumes that services can be dynamically located, invoked and combined or recombined. Logically, a service in an Service Oriented Architecture is a bound pair of a service interface and a service implementation. Service interface defines the identity of a service and its invocation logistics. Service implementation implements the work that the service is designated to do. Because interfaces are platform independent, a client from any communication device using any computational platform, operating system and any

programing language can use the service. These two facets of the service are designed and maintained as distinct items, though their existence is highly interrelated. Accordingly, for well defined and semantically unambiguous applications, an Service Oriented Architecture can serve as an enabler of just-in-time integration and interoperability of legacy

applications: a key consideration for enterprises that are seeking to deploy demand driven computing environments. Services in a Service Oriented Architecture exhibit the following main characteristics[1,2,3]. All functions in a Service Oriented Architecture are defined as services. These include pure business functions, business transactions composed of lower-level functions, and system service functions as well[4]. All services are autonomous. Their operation is perceived as opaque by external components. Service opaqueness guarantees that external components neither know nor care how services perform their function, but they merely anticipate that they return the expected result. The implementation and execution space of the application, providing the desired functionality, is encapsulated behind the service interface[5]. In the most general sense, the interfaces are invocable. This implies that it is irrelevant whether services are local or remote, the interconnect scheme or protocol to effect the invocation, or which infrastructure components are required to establish the connection.

III. Smart Home Platform based on SOA

3.1 Smart Home Architecture

Recently, many companies have already offered successful commercial Cloud services including SaaS, PaaS, and IaaS. But those services are all computer-based and designed for Web browsers. Currently there is no Cloud architecture whose purpose is to provide special services for digital appliances in smart home[6]. In their paper, they propose an additional Model, the smart home Cloud, which not only bases on the present Cloud architecture but also modifies the traditional Service layer to provide efficient and stable services for smart home. In contrast to the traditional Model, they try to bring Web service and Peer-to-Peer (P2P) technologies to the Cloud. Smart home nodes and Cloud server form a peer-to-peer network, which can help the Cloud server to reduce bandwidth pressure when transmitting higher quality audio/video signals. Smart home gateway describes its services in WSDL and registers it to the Cloud service directory so that other homes can search and consume the service[7,8,9]. Peers (smart home) are both suppliers and consumers of the services. In this research paper, more work need to be done, such as, implementing a model that simplifies the service interface so that smart home users can interact with Cloud without complex operations.

3.2 Smart Home Platform

As the vinculum that links Cloud and smart home, home gateway, which helps smart home merge into Cloud to provide more information services and access services provided by Cloud, plays a significant role in this architecture as shown <Fig. 1>. The model created in this paper is based on smart home which is divided into three parts: infrastructure layer, platform layer, and service layer.

The major issue in this research paper is basically coming from the fact that this architecture is purely a conceptual model and more work need to be done to implement and improve it. In addition to that, it is assumed that only one user will be taken into consideration, whereas in real life houses are concerned with more than one user.

3.3 Smart Home Service

Our SHS (Smart Home Service) provides how disparate and distributed devices are being connected quickly for purposeful co-ordination so that smart homes and buildings can be IT-enabled, satisfying the users to the fullest. Finally the evolving cloud technology can further boost next-generation homes and offices with a stunning array of proven and potential network services that can be aggregated adroitly to achieve sophisticated things, which ultimately leading to greener, leaner, cleaner, and smarter homes, hospitals and hotels. Scores of cloud-based simple and atomic services can be orchestrated to realize cognition-attached device ensembles that are community-centric, context -aware, autonomic, real-time, and dynamic. The currently dominating centralized and box-based approach has paved the way for much more distributed, decentralized, cloud-backed, creative, and catalytic method of establishing next generation homes. In SHS major issues will be the focus of this as followings:

1) Effective integration of cloud infra structure in smart home solutions.

2) Strong prediction algorithm to help anticipating users' actions.

3) Concurrent and parallel multi-user and multi-home environment.

For these reasons, we will concentrate on designing and implementing a novel model that tackles in somehow these issues. Several premises are important for the proposed architecture:

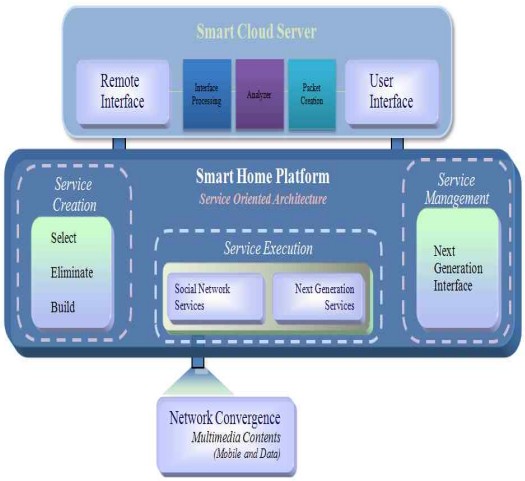

그림 1. 스마트 홈 플랫폼의 구조

Fig. 1 The Architecture of Smart Home Platform

1) The system must allow local control and also remote control of devices.

2) The system must allow the centralized administration of several independent houses, (probably) by different users.

3) The system must use open source technologies that are easily assimilated by the programming community. It must not require high costs of development and deployment.

Based on the above description, the proposed architecture requires a web server that centralizes control and provides the needed functionality to manage devices with remote access. It also requires a computer at home, connected with the desired controllable devices (lamps, HVAC, etc.).

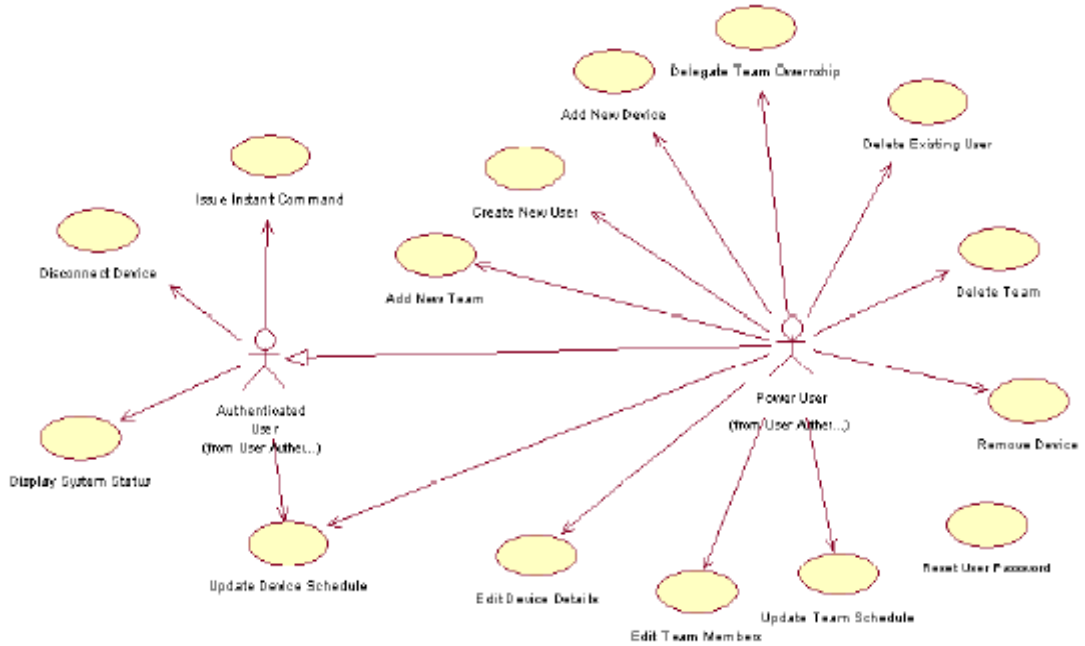

그림 2. 스마트 홈 시스템의 동작

Fig. 2 The operation of Smart Home System

For simplicity, the system does not require a fixed public IP number; therefore the home -located application will work exclusively as a client of the web server. Thus, the user does not need more than a classic domestic Internet access.

Ⅳ. Design of Smart Home Service

This paper will take the information outlined by the analysis and implement the actual design of the smart home system using the UML design methodology to represent the information required.

4.1 The operation of Smart Home System

The Use case diagram depicted in <Fig. 2> outlines the main tasks and the status device controlled by the system. It issues a command to change a status of a device through an Actuator. It also setups a schedule for future events and disconnects a device that can then be controlled manually.

In order to enhance the security, some of the system functionalities can be made not available to remote users.

4.2 User Authentication

Before users carry out a operation within the smart home system, they will need to be authenticated. Three categories of authenticated users are defined as follows: Authenticated Users, Remote Users who connect to the system remotely, and Power Users who will perform certain administration functions in the system.

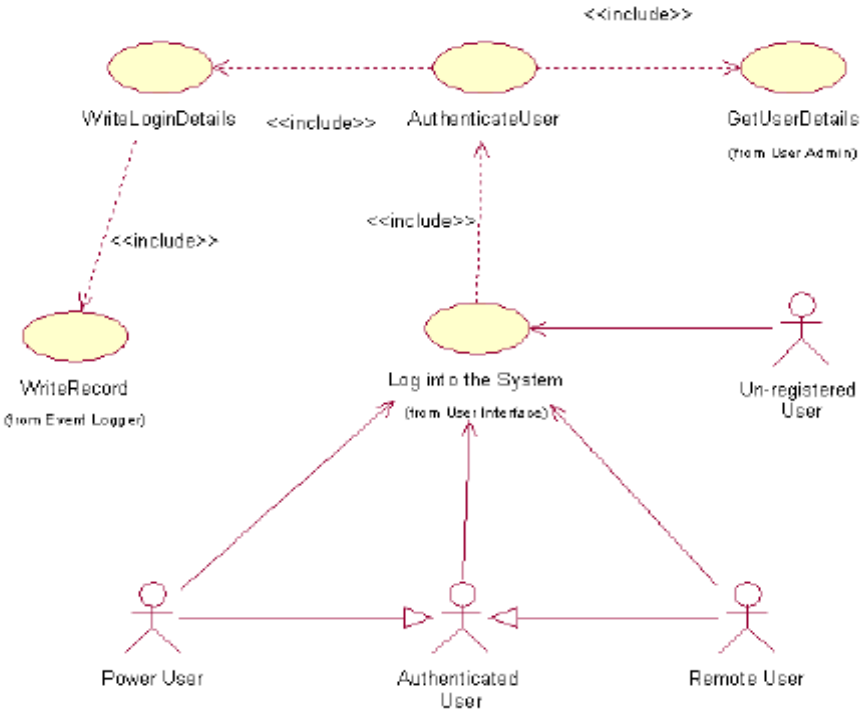

그림 3. 사용자 인증

Fig. 3 User Authentication

A time-stamped entry will be recorded into an event log for the reference. <Fig. 3> illustrates the scenario as a use case diagram.

4.3 Event Management

Events are provided by sensor communicating with the system, e.g. a thermometer or occupancy sensor. In order not to overburden the system with a constant stream of data, sensors will be sub-divided into two categories. The first category is for realtime sensors, which due to the sensitivity of the input provided a motion detector part of a the home security system.

The second category contains all the other sensors, such as a thermometer, which might not require immediate action. In this case, the input provided is simply stored in the system database and will be analyzed, perhaps in combination with other events, at the next scheduled cycle.

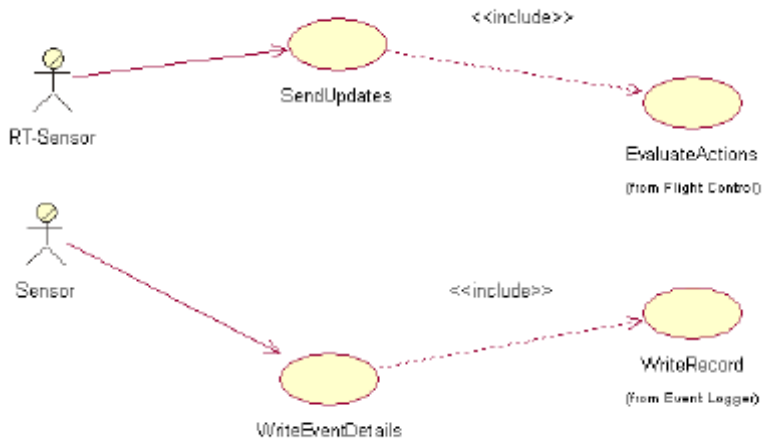

그림 4. 이벤트 관리

Fig. 4 Event Management

V. Conclusion

This paper has provided the Smart Home system, cloud computing, temporal reasoning, and sensor networks; it has investigated in more details about the basic blocks of a Smart Home system; it has provided the analysis which the system requirements and the main sub-system for the SOA based smart home system were outlined in details.

표. 1 스마트 홈 플랫폼과 기존 플랫폼의 성능차이

Table. 1 The Performance Difference between Smart Home Platform based on SOA and Other Platform

Scenario	Smart Home Platform based on SOA		Other Platform	
	Devices	Events	Devices	Events
System	99.7%	99.1%	85%	87%
UA	99.8%	99.8%	91%	93%
Telecom	100%	100%	88%	82%

From the <Table 1>, managed events for our smart home platform have an improvement about 10% higher than other platform with our service scenario. Moreover, it has dealt with the actual development of a smart home system which has expanded the analysis by documenting use case scenarios and integrating these into the identified sub-systems. Accordingly, we proposed operating system-aspect, user authentication- aspect, and service-aspect by smart home platform architecture.

In addition, we can provide more both excellent automation and fully service on smart home platform than ubiquitous city environment. Therefore, our research for smart home platform will be continuous to getting more and more. It also anticipate to improve domestic communication platform and different smart service especially.

References

[1] Choonhwa Lee, David Nordstedt, and Sumi Helal, "Enabling Smart Spaces with OSGi," *Pervasive Computing IEEE*, Vol. 2, No. 3, pp.89-94, 2003.

[2] R. Kawamura and H. Maeomichi, "Standardization Activity of OSGi Open Services Gateway Initiative," *NTT Technical Review*, Vol. 2, No. 1, pp.94-97, 2004.

[3] Li-Chen Fu, Chao-Lin Wu, and Chun-Feng Liao, "Service-Oriented Smart-Home Architecture Based on OSGi and Mobile-Agent Technology," *IEEE Transactions on System, Man, and Cybernetics, Part C: Applications and Reviews,* Vol. 37, No. 2, pp.193-205, 2007.

[4] Saito T., Tomoda I., Takabatake Y., Teramoto K., and Fujimoto K, "Gateway Technologies for Home Network and Their Implementations," *21st International Conference on Distributed Computing Systems Workshops*, pp.175-180, 2001.

[5] Wei Zhiqiang, Qin Shuwei, Jia Dongning, and Yang Yongquan, "Research and Design of Cloud Architecture for smart home," *Software Engineering and Service Sciences ICSESS 2010 IEEE International Conference*, pp.86-89, 2010.

[6] Yongquan Yang, Zhiqiang Wei, Dongning Jia, Yanping Cong, and Ruobing Shan, "A Cloud Architecture Based on Smart Home," *2010 Second International Workshop on Education Technology and Computer Science*, pp. 440-443, 2011.

[7] D. Valtchev and I. Frankov, "Service Gateway Architecture for a Smart Home," *IEEE Communications Magazine*, Vol. 40, No. 4, pp.126-132, 2002.

[8] B. Horowitz, N. Magnusson, and N. Klack, "Telia's Service Delivery Solution for the Home," *IEEE Communications Magazine*, Vol. 40, No. 4, pp.120- 125, 2002.

[9] D. Marples and P. Kriens, "The Open Services Gateway Initiative: an introductory overview," *IEEE Communications Magazine*, Vol. 39, No. 12, pp.110-114, 2001.

저자소개

김진홍(Jin-Hong Kim)

2006년 성균관대학교 컴퓨터공학과 박사
2009년 VODAFONE Co. Senior Researcher
2010 년 성균관대학교 정보통신공학과 연구조교수
2011년~현재 한성대학교 정보통신공학과 겸임교수
※ 관심분야 : 소프트웨어공학, 스마트 플랫폼

김현호(Hyun-Ho Kim)

1987년 성균관대학교 전자공학과(공학사)
1997년 연세대학교 전자계산전공(공학석사)
2006년 성균관대학교 컴퓨터공학(공학박사)
1988~2000 LG전자 컴퓨터사업부 SE
2003년 ~ 현재 명지전문대학 컴퓨터정보과 부교수
※ 관심분야 : 스마트 플랫폼, Mobile Computing, Ad-Hoc Networks