

A Framework for Cloud-based Smart Home

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Abstract—Smart Home is one of emerging application domains of The Internet of things which following the computer and Internet. Although home automation technologies have been commercially available already, they are basically designed for signal-family smart homes with a high cost, and along with the constant growth of digital appliances in smart home, we merge smart home into smart-home-oriented Cloud to release the stress on the smart home system which mostly installs application software on their local computers. In this paper, we present a framework for Cloud-based smart home for enabling home automation, household mobility and interconnection which easy extensible and fit for future demands. Through subscribing services of the Cloud, smart home consumers can easily enjoy smart home services without purchasing computers which owns strong power and huge storage. We focus on the overall Smart Home framework, the features and architecture of the components of Smart Home, the interaction and cooperation between them in detail.

Keywords—Smart home; Cloud computing; Cloud services; Intelligent control.

I. INTRODUCTION

Smart Home is one of the emerging application domains of The Internet of things which is the third wave of the global Information Industry. The smart home is a concept of the pervasive computing, and it gradually becomes essential for the people living in information age^[1]. In order to provide more humanized services and make household life more comfortable, safer and energy-efficient, smart home applies to smart space environment built at digital home. However, existing smart homes cannot provide more home services with sustained growing digital home appliances.

Cloud computing has recently emerged as a new paradigm of ubiquitous computing that becomes significant for both private and public sectors^[2]. The ultimate principle of cloud computing is that the computing is "in the cloud". It can quickly adapt to changing load owing to its powerful computing capabilities and massive storage capacity^[3]. It deals with accessing applications or storing data in the "Cloud" via the Internet or a network and using associated services.

Due to the limited resources and difficulties of expanding the scope of application in smart home, we consider that smart home merge into the Clouds to be offered more home services and get more informations provided by the Clouds. Therefore, we present an easy extensible and useable framework for the overall smart home. In our design, the smart home, smart

home Cloud and the terminal user interconnect with each other seamlessly, stably, effectively, that makes smart home really "smart".

This paper is organized as follows. A overview of current applications for cloud computing and smart home is displayed in section 2. Section 3, 4 and 5 presents the design scenario for Smart Home, and components are respectively in detail. Finally, we will conclude the paper in section 6.

II. RELATED WORKS

A. Cloud computing

Cloud computing is a model for enabling convenient, on demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction^[4].

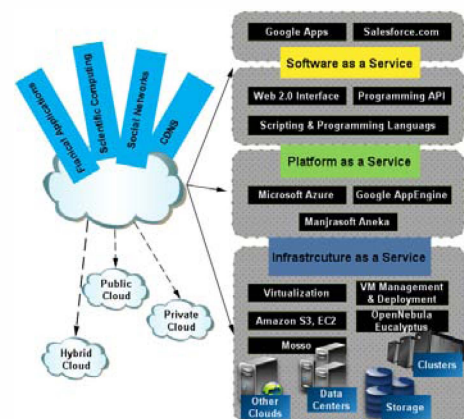


Figure 1. Cloud Computing Layers

Typical service models of a Cloud infrastructure mainly includes three categories^[5] shown in Figure1. SaaS (Software as a Service), its purpose is to supply customers with Web-based applications, e.g. Google, Amazon Elastic Compute Cloud. PaaS (Platform as a Service), offers customers an application development and deployment platform as a service, e.g. Google AppEngine, Microsoft Azure. IaaS (Infrastructure as a Service), various kinds of the underlying computing (e.g. Virtual machine) and storage resources as services are given to users, e.g. IBM's Blue Cloud^[6].

B. Smart Home

At present, there are several outstanding global companies that concern with intelligent household which specially design for high-grade residence or redecoration housing. A brief introduction of representative applications is as follows.

1) Honeywell Smart Home

In April this year, Honeywell smart home products in mainland China officially registered named MoMasTM. In digital technology and mobile control are becoming more mainstream today, in the intelligent life space created by MoMasTM Honeywell Smart Home^[7], people can enjoy a variety of stylish control terminal applications. Just use your fingertips to click mobile terminal devices supporting Wi-Fi such as iPhone, iPad, iPodtouch, digital photo frame and Netbook, you can easily manage and control lighting, curtain, air-conditioning, heating, visual intercom, anti-theft alarm, environmental monitoring, energy saving detector and other household equipment at anywhere at anytime, this realizes a variety of devices of a key linkage control.

2) Control4

Control4^[8] is a professional in home automation control products and solutions of development, production, marketing and services of world-reowned enterprise. Control4 based on IP technology is capable of combining more economic, better, faster and more fashion technologies within home automation surroundings. It adopts Zigbee (or Wi-Fi) wireless home automation technology to modify existing housing. Because of Control4, all appliances in home could perfectly be integrated together, and bring maximum benefit that home theatre, multi-room music, lighting, temperature control and security system all are in control in a unified platform.

III. FRAMEWORK OVERVIEW

Along with increasing amount of digital appliances in smart home space, numerous data storage and complex control or management become a much heavy burden on smart home system^[1]. Cloud computing represents an on-demand service model for delivering resources ranging from storage and data access via computation to software provisioning^[2], so it becomes an ideal alternative.

Thus, we consider that Smart Home can merge into the Clouds to provide more services and get more informations provided by the Clouds. A well-matching solution is proposed that deploy reusable services on the household service provider side, and let a variety of independent single-family smart homes access these services over the Internet, and finally to form an overall smart home. The said structure is shown in Figure2, in which we can see that it primarily consists of smart home, smart home Cloud and consumers.

Smart home represents a single-family intelligent household, consisting of a central control system and a number of extensible subsystems (home theatre, security system, Environmental control system, etc.). In smart home, each devices interconnecting with any others via the central control system, which also acting as a pipe which transfers data between the Cloud and devices in smart home. A number of smart homes form a smart home network, and all needed home

services are provided by a service provider named smart home Cloud which undertakes the storage and calculation tasks referring to management of appliances, storing, analysing and resolving data.

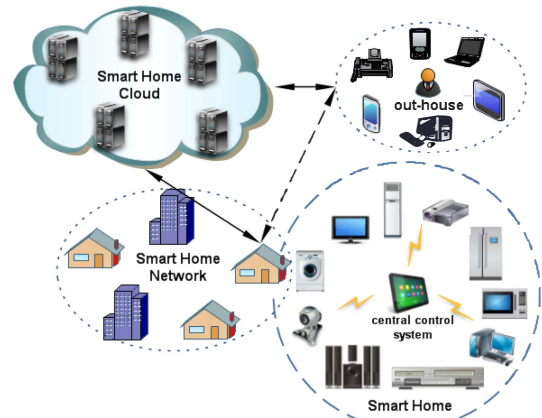


Figure 2. Structure of the overall Smart Home

For example, if there is a unusual situation (e.g. fire/smoke) occurs in home, environmental detectors will first check whether the parameters of surroundings is dangerous for house or not, then raise a alarm to the centralized system which immediately analyse and transmit a security service request to the Cloud which afterwards notice the home members this emergency after receiving and processing the request. On the other side, members chose to login theirs account to confirm the correction that forces the Cloud to order the surveillance camera in home turning on and sending the video back to they.

IV. CLOUD FOR SMART HOME

A. Cloud computing

The commercial Clouds and related Cloud-based researches have greatly promoted the development of Cloud computing. As previously mentioned, cloud computing^[9] is the delivery of computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a utility (like the electricity grid) over a network (typically the Internet). It describes a new supplement, consumption, and delivery model of IT services based on Internet protocols. Users can use web-based tools (Web browser) or applications that installed locally on their side to access the remote computing sites provided by the Internet. What the users enjoy after they access succeed is the Web services or Web applications supplied by cloud services providers.

B. Web service

Web service^[10] as a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specially Web Services Description Language, known by the acronym WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP (Simple Object Access Protocol) messages, typically conveyed using HTTP/HTTPS (Hyper Text Transport Protocol) with an XML

(Extensible Markup Language) serialization in conjunction with other Web-related standards.

C. Architecture of smart-home-oriented Cloud

In this paper, we propose a Cloud that not merely bases on present Cloud architecture but also expands service scope in order to offer special and efficient home services for digital appliances. Figure3 illustrates the layered design of smart-home-oriented Cloud computing architecture.

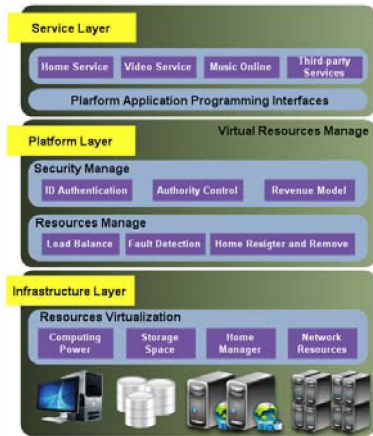


Figure 3. Cloud architecture diagram

1) Infrastructure Layer

Infrastructure Layer consists of massive physical resources^[11] and virtualized resources that are specifically designed for the delivery of Cloud services, which is the lowest level in Cloud architecture. These resources are managed by higher level virtualization component that the Cloud can control computing power, storage space, network resources.

2) Platform Layer

Platform Layer^[11] composed of resources manage module and security manage module is the Core Layer of the Cloud Mode. Resources manage module implements resource virtualization and management as well as system process status detection, such as registering or removing the virtualized smart home. Security manage module is responsible for ensuring the stability and protecting the Cloud security including certifications, data research and reconfigure, etc.

The platform layer and infrastructure layer constitutes the foundation of delivering PaaS for smart homes. If all the smart homes in Chongqing connect with a similar Cloud via a network, the Cloud based on PaaS could provide service providers a platform to deploy their tailored services for smart home consumers

3) Service Layer

The service layer has a face-to-face interaction with service providers and smart home users^[11], and concentrates on application services. The services providers create and deploy their services or applications through Application Programming Interface offered by the Cloud platform. The users use the services or applications that provided by smart home Cloud, enterprise public Cloud or other third party Cloud.

V. SCENARIOS OF SMART HOME

Smart Home, a dwelling incorporating a communications network that connects the key electrical appliances and services, and allows them to be accessed, monitored or remotely controlled^[12], is known as Home automation providing improved convenience, comfort, energy efficiency and security^[13].

A. Requirements

Smart home should meet three crucial requirements so that it could become really smart.

1) Internal network

Every digital appliance in smart home should be able to interconnect^[11] with any others so that forms a internal network. The way of connecting within the network can include wired and wireless, and the common network protocols^[13] are Bluetooth, Wi-Fi, ZigBee, IrDA, GPRS, USB, etc.

2) Intelligent control

We usually mention a significant feature of smart home is Remote Control^[11]. It means, whatever the requests from within the home or outside, appliances and services at smart home can be intelligently managed and controlled by a central controller who could be a single computer or television screen, or even from a smart phone^[12]. For instance, auto-discovery services, auto-detection devices, auto-transmission data and auto-switching tasks and so on^[11].

3) Home automation

It is automation of the home, housework or household activity^[12]. Considering that we let smart home merge into the Cloud, it aims at building a intelligent space that interconnected appliances within the home implement their functions via linking to services provided by smart-home-oriented Cloud or connecting with other devices outside the home.

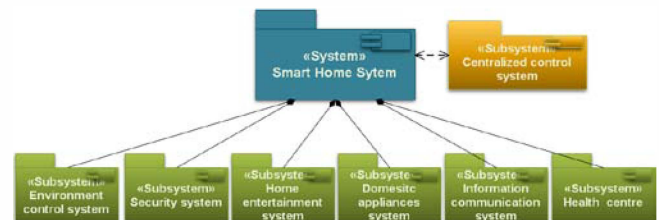


Figure 4. Block diagram of smart home system

B. Internal structure of smart home

The internal network of smart home is formed by various of interconnecting subsystems in the smart space. Except basic application systems (like security system, environment control system, home entertainment system), the centralized control system is the core that owns rights of managing and controlling the smart home. The design scenario of this system is appeared in Figure4.

Each subsystem refers to different applications and services that could bring us a colorful and convenient household life. Not all of the devices (lighting, air conditioning) in home

C. Home services

Figure 5. Application and services of smart home

1) *Environmental*

2) Security

3) *Home entertainment*

4) *Domestic appliances*

5) *Information and communication*

6) *Health*

Health monitors maintain vigilance at every "when you're indoor" moment and measure vital signs parameters at regular time, then gather infos to patient's records. Meanwhile, remind the patient to take medicine, get up and sleep on schedule.

VI. CONCLUSION

REFERENCES

- [1] Haijun Gu, Yufeng Diao, Wei Liu, Xueqian Zhang, "The Design of Smart Home Platform Based on Cloud Computing", International Conference on Electronic & Mechanical Engineering and Information Technology, 2011.
- [2] Mina Deng, Milan Petkovic, Marco Nalin and Ilaria Baroni, "A home healthcare system in the cloud – addressing security and privacy challenges", IEEE 4th International Conference on Cloud Computing, 2011.
- [3] Yu Hua Zhang, Jian Zhang, Wei Hua Zhang, "Discussion Of A Smart Home Solution basing Cloud Computing", International Conference on Communications and Intelligence Information Security, 2010.
- [4] <http://csrc.nist.gov/groups/SNS/cloud-computing/cloud-computing-v25.ppt>
- [5] Ashish Tanwer, Abhishek Tayal, Muzahid Hussain, Parminder Singh Reel, "Thin Apps store for smart phones based on private Cloud Infrastructure", ITU-T Kaleidoscope Academic Conference, 2010.
- [6] <http://csrc.nist.gov/groups/SNS/cloud-computing/cloud-computing-v26.ppt>
- [7] <http://www.honeywell-smarthome.com/main.aspx>
- [8] http://www.control4.com.cn/_d269862805.htm
- [9] http://en.wikipedia.org/wiki/Cloud_computing
- [10] http://en.wikipedia.org/wiki/Web_services
- [11] Yongquan Yang, Zhiqiang Wei, Dongning Jia, Yanping Cong, Ruobing Shan, "A Cloud Architecture Based on Smart Home", Second International Workshop on Education Technology and Computer Science, 2010.
- [12] <http://www.housingcare.org/information/detail-2545-smart%20home-a-definition.aspx>
- [13] http://en.wikipedia.org/wiki/Home_automation