Design study of the U-City Home Network based on the CEaaS of Cloud computing

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Abstract. According to the recent advancement of wired and wireless communication network technology such as mobile communication and high-speed Internet, home network service based on Internet information appliance makes great strides. Particularly, the UPnP based technology that guarantees QoS (Quality of Service) for heterogeneous devices is now applied to the development of various home network services. UPnP is very difficult for individual user to find any service of appliance they need and it would take a lot of time. Hence, this paper defines a new paradigm as Consumer Electronic as a Service (CEaaS) using cloud computing for next-generation ubiquitous network environments and propose new U-City home network architecture.

Keywords: ubiquitous, home network, U-City, cloud computing, CloudSim.

1 Introduction

The value of the rapidly growing IT technology is highly appreciated, as it has become an integral key element in all areas of our society, from transportation to industry, economics and so forth. In recent years, ways to improve life quality and increase a city's competitiveness have been studied in the form of the U-City (ubiquitous-city), a fusion between IT and other technologies, such as ET (environmental technology), BT (bio technology), MNS (micro & nano system) etc.[1].

Particularly, the SaaS (software as a service), PaaS(platform as a service) and IaaS (infrastructure as a service) are provided by default in the currently used U-City home network system, while other services are included within the XaaS (Everything as a Service) framework.[2] However, the services provided by the current home network are shared between all users with system access privileges, making it very difficult and time consuming for individual users to find their desired device service.

In this paper, in order to solve such problems we have designed a web service for the U-City home network by applying the CEaaS (consumer electronic as a service) cloud computing technology used in the U-City home network to the UPnP.

The paper is organized as follows. Chapter 2 describes the main technologies used in cloud computing and UPnP's EaaS(Electronic as a service) standard technology. Chapter 3 explains the design of the CEaaS cloud service, as proposed in this paper. Chapter 4 explains the implementation of the proposed CEaaS cloud service and reveals the results of the network cloud service performance evaluation, tested using CloudSim. Finally, Chapter 5 presents the conclusions reached.

2 Related work

Cloud computing can be divided, based on the services it provides, into Software as a Service (SaaS), which rents the required software to the users, Platform as a Service (PaaS), which provides a professional system environment, and Infrastructure as a Service (IaaS), which provides the required hardware for CPU, memory, graphics, data storage and other computing over the network [3] - [5].

2.1 Introduction to the UPnP standard technology

The basic architecture of UPnP consists of three types of components (devices, services and control points) and undergoes the following work phases: Addressing, Discovery, Description, Control, Event and Presentation.

Figure 1 shows the structure of the existing UPnP middleware which provides the home network services. In this structure all the services provided by the home network are shared with all the users who have access privileges, but it is very difficult and time-consuming for individual users to find their desired device service. For example, assuming that there are two bedrooms with a TV set and that several appliances are installed in the rest of the home, when the user gives the middleware the command to turn off the TV in the small bedroom, the middleware will require a complex algorithm for determining which one of the devices it should shut down.

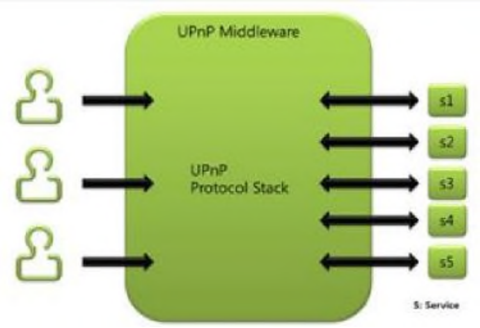

Fig. 1 Home network service architecture of UPnP middleware

3 Proposed home network system

To compensate for these disadvantages of the existing middleware a new CEaaS service concept was applied, as shown in Figure 2. In order to run the U-City service in the proposed middleware we made it possible for the inside platforms to interact with one another and, at the same time, designed a user interface for easy web management. Implementation details will be discussed in Chapters 3 and 4.

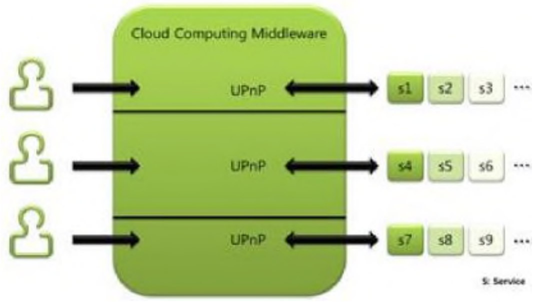

Fig. 2 Home network service architecture of cloud computing middleware

The proposed CEaaS (**Customer** Electronic as a **Service**) system means "cloud services optimized for home networks". Because the proposed CEaaS system processes the performance of the utilized resources at server level, independently from the user's PC, it can provide a consistent environment. Providing such an environment will be very important to the promotion of home network system construction.

It is a service that implements the server-level multi-tenant and can be defined as Cloud in Cloud, a term now used in Windows 8. As a method to compensate for the disadvantages of the existing UPnP, the CEaaS web service refers to the cloud manager system that ties users connected on various devices into one cloud group and provides a redistribution service.

The detailed description of the proposed CEaaS cloud service is as depicted in Table 1.

Table 1. Test bed system implementation

Section	Contents
Programming language	Java / JSP / PHP
Operating system	Ubuntu 9.04
Web server	Apache Httd2.2.17
Web application server	Tomcat6.0
Framework	CodeIgniter

4 Proposed CEaaS system

CloudSim is the only simulator that permits the simulation of service providers in the cloud computing environment. In order to analyze the capabilities of the CEaaS cloud system developed in this study we tested performance using the CloudSim cloud simulation tool. To test the availability of the cloud service we modeled the cloud computing network environment's service model using the Datacenter, Host, Virtual Machine and Cloudlet provided in CloudSim. Due to the presence of a queue that manages Cloudlet in the Virtual Machine, the system is a Virtual Machine from the queuing theory's point of view. As shown in Figure 3, if the "work request time" needed by the services in TO and the Data center resources are insufficient in the cloud service model, there is a T1 "waiting time" in the queue before the needed

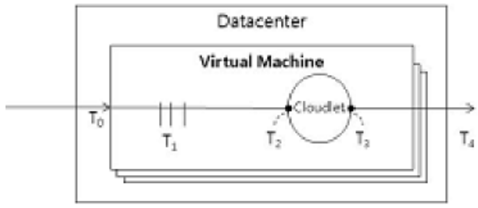

Fig.3. Service model for cloud

resources are allocated.

T0 : Cloudlet.SubmissionTime
T1 : Cloudlet.WaitingTime
T2 : Cloudlet.ExecutionStartTime
T3 : Cloudlet.FinishTime
T4 : Cloudlet.SuccessTime

The indicators used to assess the availability of cloud services are as follows:

- Average waiting time = E(T1)
- Average travel time = E(T4 - T0)
- Average queue length
- Work throughput
- Server utilization = XE(T3 - T2), Server utilization<1
- Server processing cost = Datacenter.costPerBW × Cloudlet.file_size + Datacenter.cost × Cloudlet.ExecuteTime + Datacenter.costPerBw × Cloudlet.ouput_size

- Data center cost = VM_Num × (Datacenter.costPerMem × VM.memory + Datacenter.costPerStorage × VM.size)

The user request is generated by the exponential distribution of random numbers, with the average waiting time being the waiting time in the queue, and the mean time, E (T4 - T0), being the average time it takes from the moment the service is requested by the user (T0) till the moment the service is provided (T4). Depending on the service request, the average queue length is a variation of the average queue lengths existing in the Virtual Machine. The throughput is the amount of processing work done by the server in a certain amount of time, while the server utilization rate refers to the total server running time percentage when processing the user's request generated at T0 by random exponential distribution (X).

The cost that occurs when using IT resources from CloudSim's Datacenter refers to the Datacenter_Debt (cost resulted when creating a Virtual Machine in the Datacenter) and the Processing Cost (cost for running Cloudlet). The former refers to the sum between the cost of the memory used by the Virtual Machine in the Datacenter (Datacenter.costPerMem × VM.memory) and the cost of the storage space (Datacenter.costPerStorage × VM.size) when physical resources are provided in the Datacenter. The latter refers to the costs incurred when running the Cloudlet, depending on the input and output sizes of the cloud service (Cloudlet.file_size, Cloudlet.output_size), namely the cost resulted in the Datacenter's bandwidth (Datacenter.costPerBW) and the Datacenter's cost (Datacenter.cost) while running the service (Cloudlet.ExecuteTime). Therefore, the cost of providing a service in the cloud computing environment is the sum of these two costs.

Figure 4 shows that when the number of services requested by the user becomes 120, the utilization rate is close to 100% and the server is used continuously. The higher the utilization rate, the higher the chances for overload to occur when providing the Cloudlet, even if resource wastage can be reduced, because all the IT resources in the Datacenter are being used. Therefore, the server's structure must be properly designed to prevent an overload by determining the server's utilization rate.

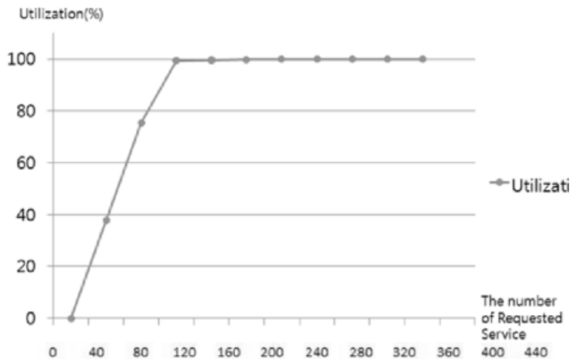

Fig 4. CEaaS cloud's resource use rate

Therefore, as shown in Figures 5 and 6, when the Virtual Machine processes more that 120 Cloudlets, it reaches the maximum throughput. Same as with the utilization rate, the operation throughput uses the Datacenter's IT resources appropriately, based on the throughput's increase. However, because the server's performance is fixed, the operation throughput is limited. Therefore, user requests should be limited to less than 100, in preparation for intensive requests to the Cloudlet. According to Figure 6, it is possible to provide users with appropriate services by using the Datacenter's resources effectively and considering the server utilization rate when the number of services is 120. Additionally, in terms of the operators' revenue, its income increases when the number of services is greater than 80.

Therefore, it is possible to say that an operator running a system of similar performance to that in Figure 11 can perform 80 to 120 services. These values can change according to the indicators pursued by each operator.

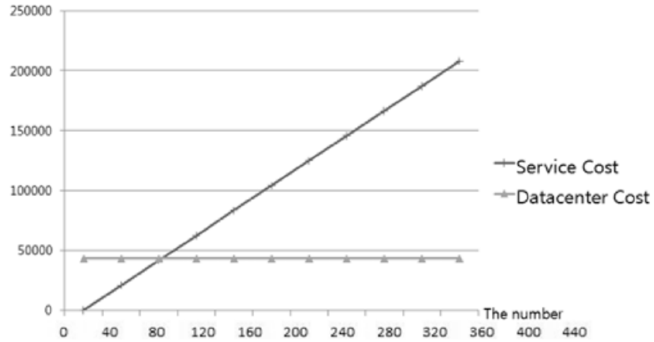

Fig.5. CEaaS cloud‘s throughput rate

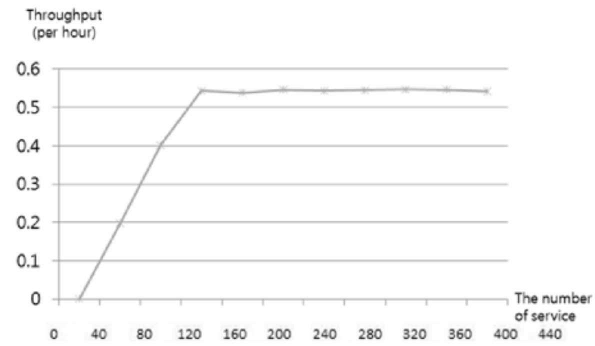

Fig.6. Datacenter and CEaaS service cost

5 Conclusion

The disadvantage of the existing UPnP middleware is that it is very difficult and time-consuming for individual users to find their desired device service when access privileges to the home network's services are shared with all the other users. In other words, multi-tenant is not viable. In order to solve this problem, the proposed CEaaS system was implemented as a new Cloud in Cloud service, by building a cloud authentication system server that can control the service in the front cloud and implement the server level's multi-tenant. The CEaaS system installs a virtual machine on the existing cloud server, builds the CEaaS server on the corresponding cloud's front server, and is set up to manage 4 user manager classes.

In this paper, in order to test the performance of the designed CEaaS system, we performed a simulation using CloudSim; not only did they obtained results indicate very good performance, but they also indicated the possibility of creating very high cost and revenue models when compared with similar existing systems. These results prove that users can get that same quality for the desired service, regardless of the performance of their device system, when connecting to the CEaaS cloud system.

In the future we will research ways to link external cloud computing platforms with the cloud computing platform for U-City home networks, largely through cloud computing methods such as the Private Cloud and the Public Cloud. In parallel, we will also research plug-ins for easily adding or removing services from the growing U-City services.

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