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Design Study of the U-city Home Network Architecture 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 for heterogeneous devices is now applied to the development of various home network services, on the other hand, 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 Electronic as a Service using cloud computing for next-generation ubiquitous network environments and propose new U-City home network architecture. The system shows that ubiquitous services can be provided to users effectively in a Home network environment. The performance of the developed proposed system is observed by measuring the data processing time. The system shows that ubiquitous services can be provided to users effectively in a Home network environment.

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.

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Chapter 3 explains the design of the new concept EaaS cloud service, as proposed in this paper. Chapter 4 explains the implementation of the proposed new concept EaaS 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

As shown in Table 4, 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].

Table 1. Classification of Cloud Computing Services

Cloud Service	Explanation
Software as a Service (SaaS)	Offers renting application functionality from a service provider rather than buying, installing and running software yourself.
Platform as a Service (PaaS)	Provides a platform in the cloud, upon which applications can be developed and executed.
Infrastructure as a Service (IaaS)	Vendors offer computing power and storage space on demand.

The main cloud computing technologies are as follows.

① Virtualization

- Building a virtual hardware infrastructure that allows system operation beyond the boundaries of the physical hardware
- operating technology that allows a single computational resource to run like one, or vice versa

② Large-scale distributed processing

- Technology that allows for the distributed processing of large amounts of data in a large server environment (thousands of nodes)

③ Open Interface

- applied to feature changes and extensions to existing services in the cloud-based SaaS and PaaS

④ Service provisioning

- Business process automation from service application to providing resources, increased economics and the flexibility of cloud

⑤ Resource utility

- Technology for establishing a billing system based on collecting the amount of computational resources used

⑥ Service Level Management (SLA)

- A quantitative form of quality management is required, such as level of service technology

⑦ Security and Privacy

- Technology for the safe storage of sensitive security information on external computing resources

⑧ Multi-Sharing Model

- Model that uses a Single IT Resource Instance in the form of multiple separated user groups

2.1. Introduction to the UPnP Standard Technology

As shown in Figure 1, 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.

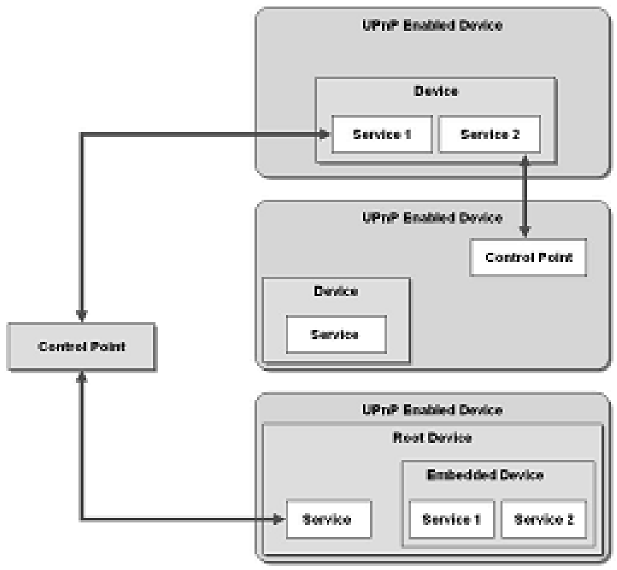


Figure 1. UPnP Architecture

Next we describe the behavior of each component in part. UPnP devices involve services and accessories. Other categories of UPnP devices can contain other services, such as groups or embedded devices. The small control unit of UPnP networks is a service. Services represent actions and model their own status through the use of state variables. The services provided by UPnP devices consist of the state table, the control server and the event server. The state table models the state of the service by using state variables, and updates it if there are any changes.

Figure 2 shows the UPnP protocol. The foundation for UPnP networking is the TCP / IP protocol and at the core of this protocol is addressing. Once a device is connected to the network, a proper address is specified and the search operation can proceed. The UPnP service manual includes a list of actions for service responses and a list of variables that model the service status at run-time. The control point, after securing the device description, performs operations essential for the device control [6-11].

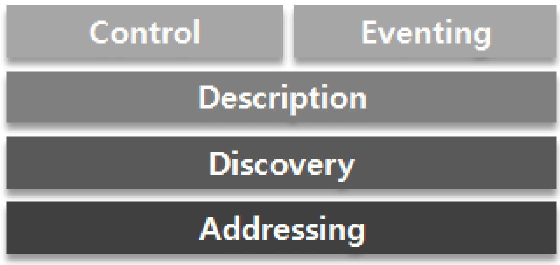


Figure 2. UPnP Protocol

2.2. Disadvantages of the Existing UPnP Technology

UPnP, a software technology that expands on the concept of Plug & Play which allows the connection of existing PC and peripherals, permits not only PCs, but also all other devices in the home to be installed and configured as a single network without any separate settings. That is to say UPnP devices participate dynamically in the network, are allocated an IP address and provide their services to the network. Additionally, they also receive services from other devices. Such a behavior is automatic, so satisfactory service is provided even if the user doesn't know the UPnP network structure and behavior.

Figure 3 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.

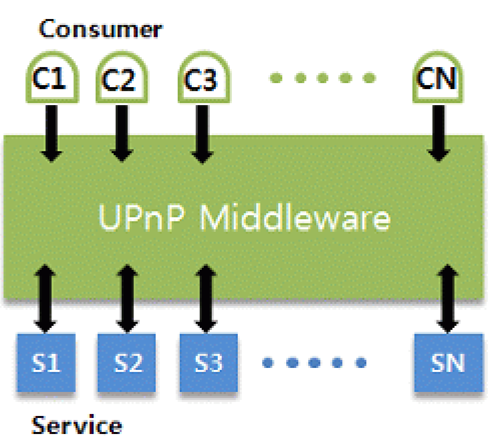


Figure 3 Home Network Service Architecture of UPnP Middleware

To compensate for these disadvantages of the existing middleware a new CEaaS service concept was applied, as shown in Figure 4. 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.

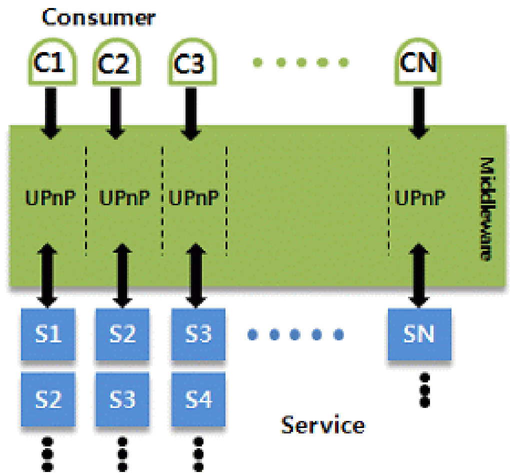


Figure 4. Home Network Service Architecture of Cloud Computing Middleware

3. Proposed Home Network System

The proposed New EaaS (Electronic as a **Service**) system means “cloud services optimized for home networks”. Because the proposed New EaaS 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.

The New EaaS cloud system is built in the cloud server on a number of home network managers that include VM, with every unit acting as a single PC and administering each user’s access independently through an authentication system performed in the front server. In other words, users obtain the same result by connecting to the cloud server and the home network manager deployed within the cloud server on a variety of devices. It is built as a system which users can access at any time, from any environment.

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 New EaaS 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 New EaaS cloud service is as depicted in Table 2.

Table 2.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

The module diagrams used to test the New EaaS are as shown in Figure 5. In addition, as shown in the Figure 4, Service Classes were defined in the New EaaS system which are called and used in the Sync Service Class through the Synchronization Manager. The Worker Thread is automatically generated within the manager by the Signal Interface.

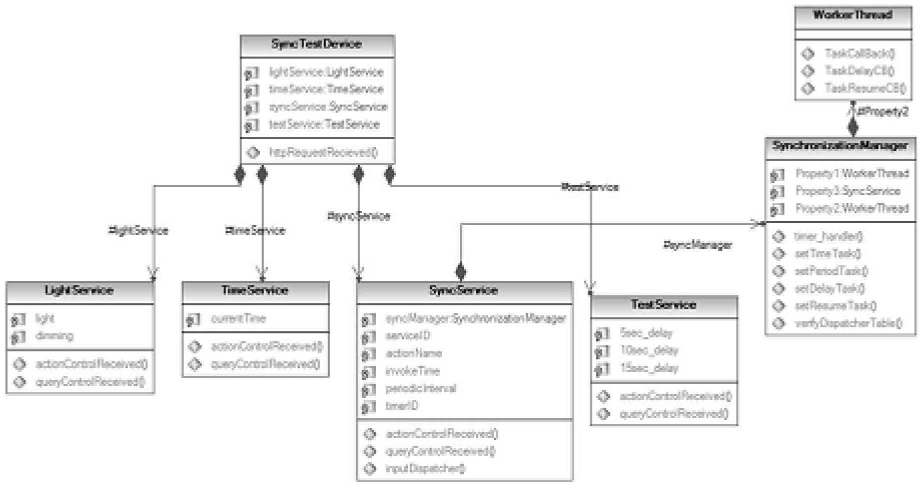
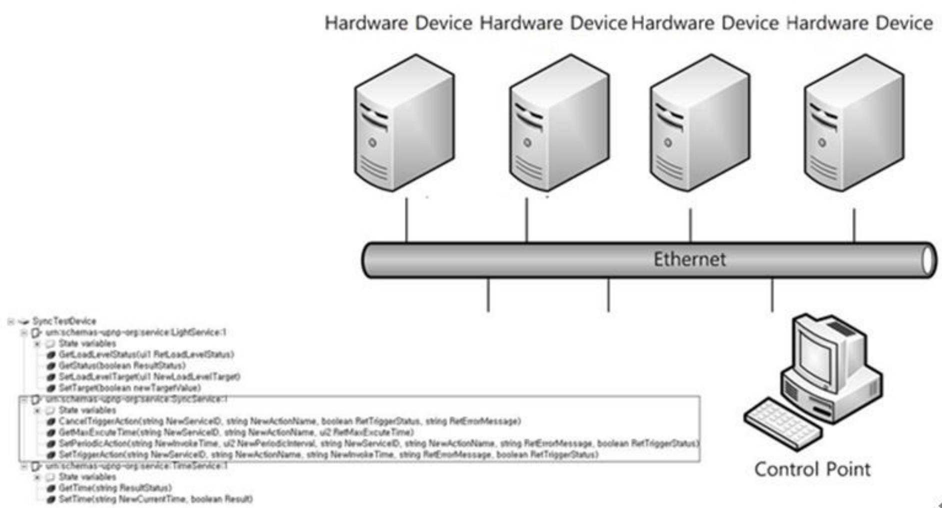
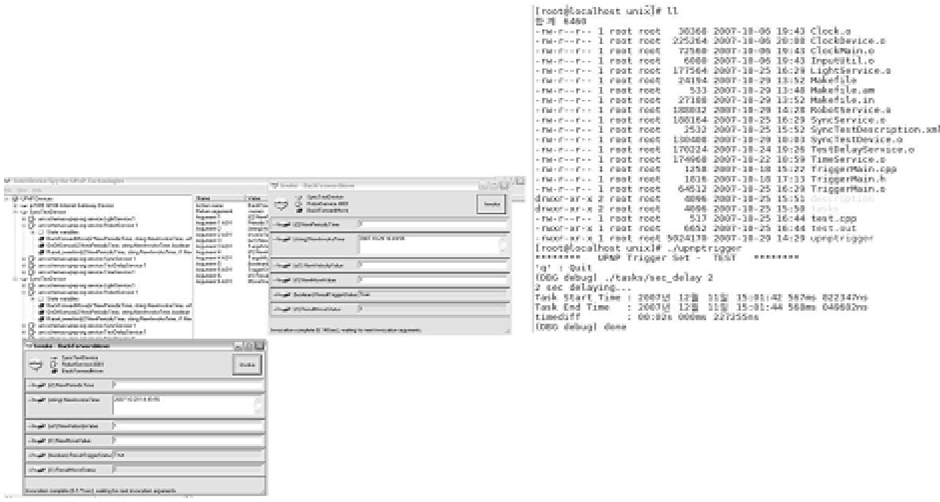


Figure 5. Class Diagram

And, as shown in Figure 6 (a), (b), a synchronization service was added on four computers.



(a)



(b)

Figure 6. Sync Service Operation Feature

4. Experiments and Evaluations

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 New EaaS 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. The queuing model can be applied to the operator that determines the system or processing order, to communication device processing etc. Several queuing models (M/M/1, M/M/c, M/G/1, G/M/11 *etc*.,) exist and each of them is modeled by the work request time (packet arrival time) / service time / server number. Thus, the Virtual Machine that provides the Host's resources as a service inside the Datacenter in Figure 8 is the multi-M/M/c model. As shown in Figure 8, 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 resources are allocated.

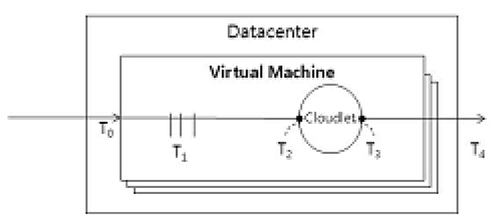


Figure 8. Service Model for Cloud

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

T0 was implemented to generate an exponential distribution from the distribution of operation requests in the physical network, requests which are generated by a random number. Service processing progresses in the order of requested operations and if there is no available PE (Processing Element) the operations are queued. When the requesting service is assigned the needed resources, the operation is executed at T2 and finalized at T4. T4 is the time when the user is provided with all the services.

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 = λE(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 (λ).

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.

An operator that holds a Datacenter maintains 10 Hosts, with each of them having a Virtual Machine whose performance was optimized for the said Host. The Datacenter's IT resources are managed by the FCFS (First-Come First-Served) policy; in order to provide IT resources as a service to the user, the operator uses virtualization technology, such as a Virtual Machine, who is then assigned Space Shared Allocation VM by the Host. The Virtual Machine provides the user with Cloudlet by using a space partitioning scheduler. Details on the performance values for each system are shown in Table 3.

As the Utilization of the Datacenter increases, the resources' efficiency also increases. Figure 9 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.

By looking at Figure 9, we can tell that the Cloudlet is provided in normal conditions when the user makes less than 120 requests. The Datacenter's Throughput increases with the server utilization rate.

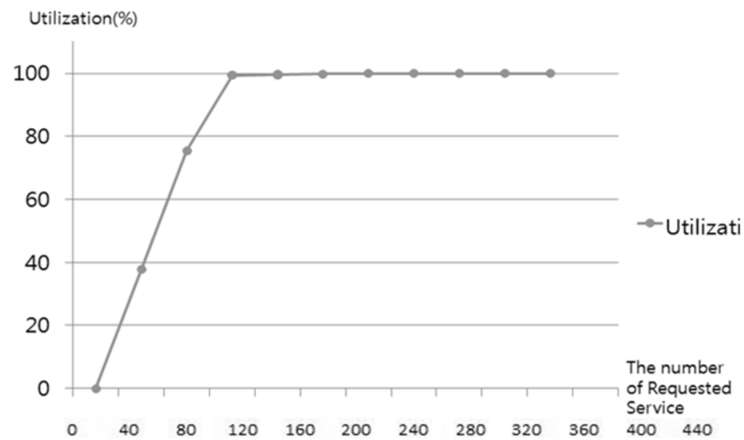


Figure 9. New EaaS cloud's Resource use Rate

Therefore, as shown in Figures 10 and 11, 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 11, 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.

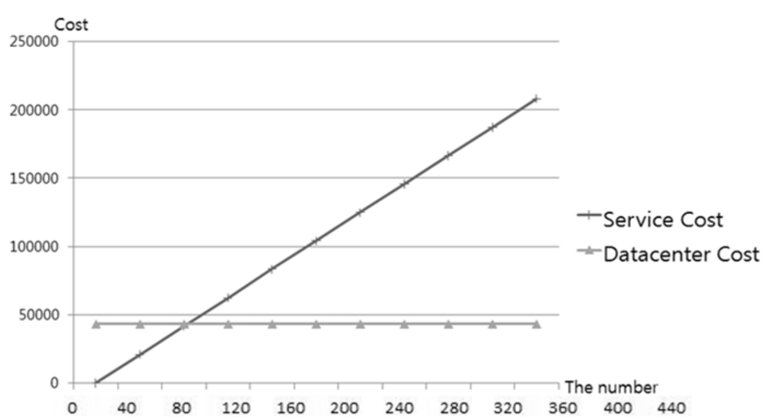


Figure 10. New EaaS cloud's Throughput Rate

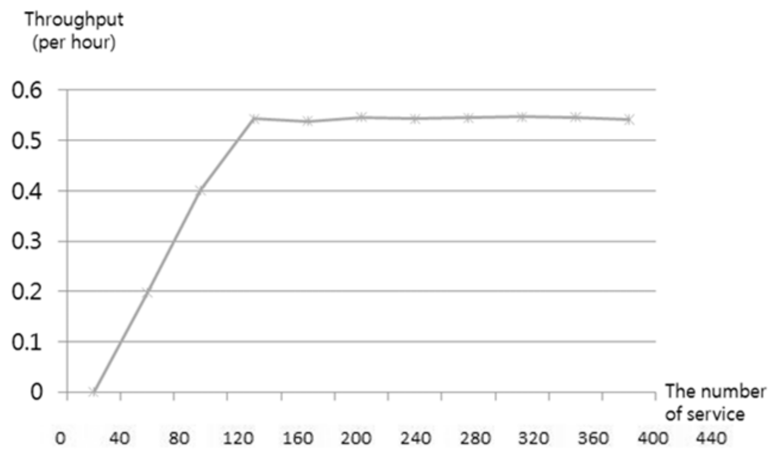


Figure 11. Datacenter and New EaaS Service Cost

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.

Table 3.Simulation Input Setting Value

Value name		value
Datacenter	Time_zone	8.0
	Cost	0.1
	Cost per Memory	0.05
	Cost per storage	0.02
	Cost per bandwith	0.1
	Bandwith speed	80
	Architecture	x86
	OS	Linux
	Quantity	1
	Policy	FCFS
Host	Memory	1024x4(MB)
	Bandwith	100(MB)
	The member of processing element	enterprise user * virtual machine
	Performance of PE	1000(MIPS)
	Storage	10(TB)
	Quantity	10
	Policy	SpaceSharedAllocationVM
VirtualMachine	Size	storage of Datacenter
	Bandwith	bandwith of Datacenter
	Memory	memory of Datacenter
	The member of core	1
	VMM	Xen
	Quantity	10
	Policy	SpaceSharescheduler
Cloudlet	Length	20000000
	file size(Input size)	400
	Output size	400

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 New EaaS 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 New EaaS system installs a virtual machine on the existing cloud server, builds the New EaaS 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 New EaaS 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 New EaaS 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.

References

[1] Y. G. Shin, H. B. Kim, S. P Lee, E. S Nahm and Y. H. Lee, "U-City Service Provisioning Based on Cloud computing", Korea Institute of Information Technology, vol. 7, no. 3, **(2009)**, pp. 142- 150.
[2] H. Min, Y. Kim and G. H. Nam, "Trends in Technology Of Cloud Computing", ETRI Electronics and Tele-communications Trends, vol. 24, no. 4, **(2009)**, pp. 1-13.
[3] L. Zhang and Q. Zhou, "CCOA: Cloud computing open architecture", IEEE International Conference on Web Services, IEEE computer Society, **(2009)** July, pp. 607-616.
[4] O. G. Min, H. Y. Kim and G. H. Nam, "Trends in technology of cloud computing", ETRI Electronics and Tele-communications Trends, vol. 24, no. 4, **(2009)**, pp. 1-13.
[5] Wikipedia, "Cloud computing", http://en.wikipedia. org/wiki/Cloud computing, **(2013)** February.
[6] Wikipedia, "UPnP", http://en.wikipedia.org/wiki/ UPnP, **(2010)** January.
[7] SJ/T 11316-2005 Home network system architecture and reference model.
[8] "UPnP(Universal Plug and Play) technology analysis", EIC, Korea, **(2003)**.
[9] UPnP Forum technical documentation, Universal Plug and play Devices Architecture, http://www.upnp.org.
[10] UPnP Forum technical documentation, Universal Plug and, http://www.upnp.org.
[11] D.-H. Bae, J.-H. Park, S.-J. Kang and K.-H. Choi, "Bridge Architecture for Interoperability between UPnP and LonWorks", KIISE, vol. 1, no. 30, **(2003)**.

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