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A Novel Model for Home Media Streaming Service in Cloud Computing Environment

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Abstract

Many people now receive various multimedia services through their personal devices via a home network. The rapid growth in multimedia content and smart devices means that multimedia services can encounter many problems in home networks. High volumes of storage capacity and processing resources are required manage these large amounts of media content. In addition, users may find it difficult to receive smooth streaming services in remote places because of limited remote access functions. To address these problems, we propose a model that uses cloud computing technology to store and manage large volumes of multimedia content. The proposed model provides remote access functions for receiving multimedia services in home networks and in wireless local area networks (WLANs). The model has four components, i.e., the Assistant Gateway, cloud server, remote controller, and media device renderer. The Assistant Gateway is an important component in the proposed model. It can access a cloud server to obtain multimedia content information before sending it to users in a home network. Thus, users can receive home media streaming services via the Assistant Gateway using a media device renderer. Based on this model, we implemented each component to support streaming service for users in remote areas.

Keywords: *cloud computing, remote access, media streaming services, UPnP, Assistant Gateway*

1. Introduction

Many different types of multimedia and smart devices now support universal Plug and Play (UPnP) and Digital Living Network Alliance (DLNA) functions that provide multimedia services in home networks. UPnP and DLNA are standards for sharing device functions and services. UPnP is an important protocol for home network technologies [13]. DLNA is an international standard for home media services that is supported by a consortium of major companies. These standard technologies are efficient for sharing and playing multimedia content using heterogeneous devices in a home network. However, a limitation of these technologies is that they only work in home networks. Remote access functions are not used efficiently and they have only been studied to a limited extent. Recently, many studies aimed at supplementing multimedia content sharing and playing technologies with remote access functions in UPnP were conducted to provide convenient home media services anytime and anywhere [1, 3, 6]. The rapidly increasing volume of multimedia content also means that the storage ability and processing power of a single computer are no longer sufficient to meet the processing demands of large amounts of multimedia content and

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provide efficient personalized multimedia services to users. To address this problem, we propose an efficient model that uses cloud computing technology [11] to store, process, analyze, and manage a large volume of multimedia content, as well as remote access functions to receive media services in a home network and in a wireless local area network (WLAN) [4, 5].

To provide ideal home media services, the proposed model is divided into four components, *i.e.*, the cloud server, Assistant Gateway, media device renderer, and remote controller. The cloud server stores and manages a large volume of multimedia content that is stored by users and it includes a multimedia content transcoding module to provide multimedia streaming services using heterogeneous devices. The Assistant Gateway is the most important component of the proposed model because it stores and manages user log information and receives multimedia content information from the cloud server. The Assistant Gateway then sends the multimedia content information to the remote controller, which is responsible for the user experience (UX). The Assistant Gateway also includes an automatic device−matching function that provides convenient multimedia streaming services to users. The media device renderer is a UPnP media player, which is located in a home network with the Assistant Gateway.

The remainder of this paper is organized as follows. Section 2 discusses related work to aid the understanding of the proposed model. Section 3 describes the proposed model and explains its main functions. Section 4 presents a service scenario using the proposed model. Section 5 explains how we implemented the proposed model. Finally, Section 6 concludes the paper.

2. Related Work

Nowadays, much research is being conducted on multimedia content sharing and communication among home networks. Mahdi *et al.*, a new service for multimedia sharing is proposed. This service provides content sharing among users within homes as well as remote access to content. The solution is based on the use of UPnP technology for multimedia sharing in a home network and the IP Multimedia Subsystem (IMS) for the session establishment and QoS management in the core network. Hu et al. proposed architecture to provide an efficient in-home media content distribution mechanism associated with the home gateway to enable local and P2P content sharing in home networks. This mechanism complies with UPnP conventions to support UPnP-compatible home applications and services [1, 8, 9].

2.1. Universal Plug and Play (UPnP)

UPnP is an internet protocol that provides mutual data sharing services. UPnP devices recognize each other without a separate installation in the home network. In addition, once the devices are automatically connected to the Internet via TCP/IP, they announce themselves to the Internet using the hypertext transfer protocol (HTTP). Through the Internet, UPnP devices share their services and control service functions simultaneously. Therefore, users receive the services of all UPnP devices by using just one of them.

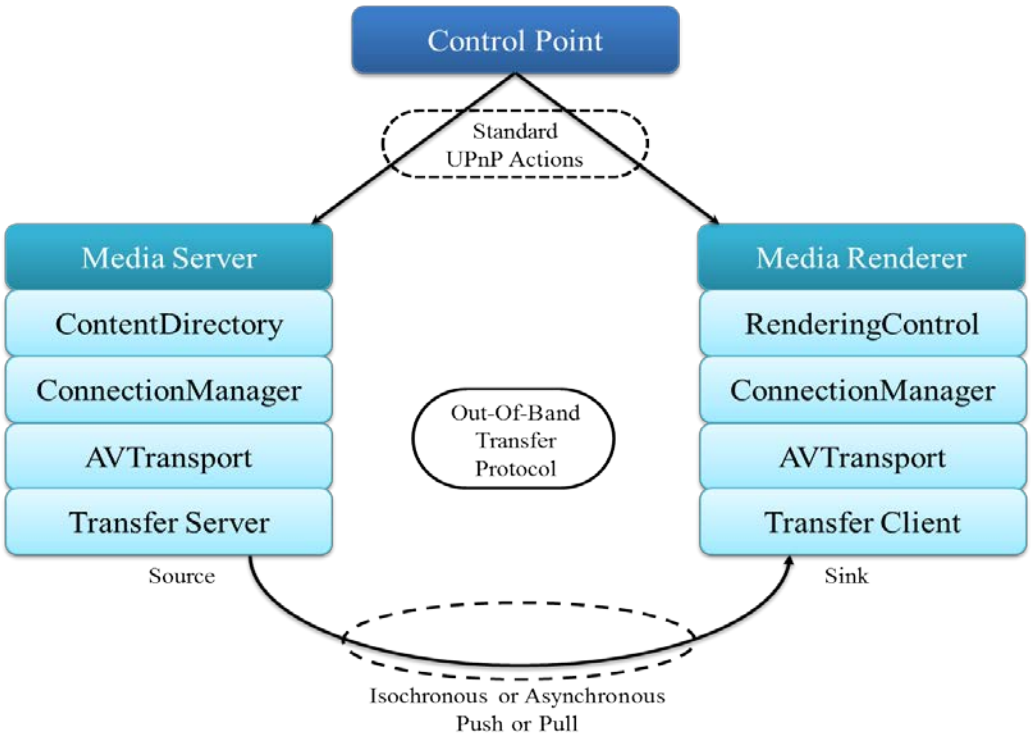


Figure 1. UPnP AV Architecture

2.1.1. UPnP AV Architecture: It is a multimedia service architecture that shares media content among heterogeneous devices. Further, it is designed on the basis of the UPnP device architecture and consists of three components, namely, Control Point (CP), Media Server (MS), and Media Renderer (MR). CP controls MS and MR, MS stores media content and provides media streaming services, and MR plays media content supported by MS [14]. Figure 1 is structure of UPnP AV architecture.

2.1.2. UPnP Remote Access (RA) Architecture: It is an application specification and extended function of UPnP that allows remote devices to access the appointed home network. Remote devices can communicate with UPnP devices that are in a home network and provides UX to UPnP devices. The UPnP RA architecture consists of a Remote Access Server (RAS) placed in a home network and a Remote Access Client (RAC), which is a remote device. RAS has a crucial role of connecting remote devices with UPnP devices and service information in a home network. RAC supports the functions of accessing to UPnP devices through RAS [15].

All the cited research related to home networks focus on the efficient transmission and sharing of multimedia content between home networks. However, the main drawback of the above–mentioned approaches is their inability to ensure scalability and safety for storing multimedia content in the proposed systems. In this paper, we propose a model to solve the above–mentioned problems.

3. Proposed Model for Home Media Service

The proposed model uses cloud for storing, processing, and managing a large amount of multimedia content, as well as UPnP technology to access UPnP devices in a home

network for sharing and playing multimedia content. The core of the proposed model is Assistant Gateway using the UPnP technique. Assistant Gateway provides stable multimedia services to users between a cloud server and a home network. Assistant Gateway takes multimedia content information from cloud server to remote controller and collects media device renderer information using UPnP. Remote controller displays multimedia content information to users. Users can select multimedia content according to their information. Remote controller sends the multimedia content information to Assistant Gateway let it selects a media device renderer using automatic device matching model. Figure 2 depicts the architecture of the proposed model.

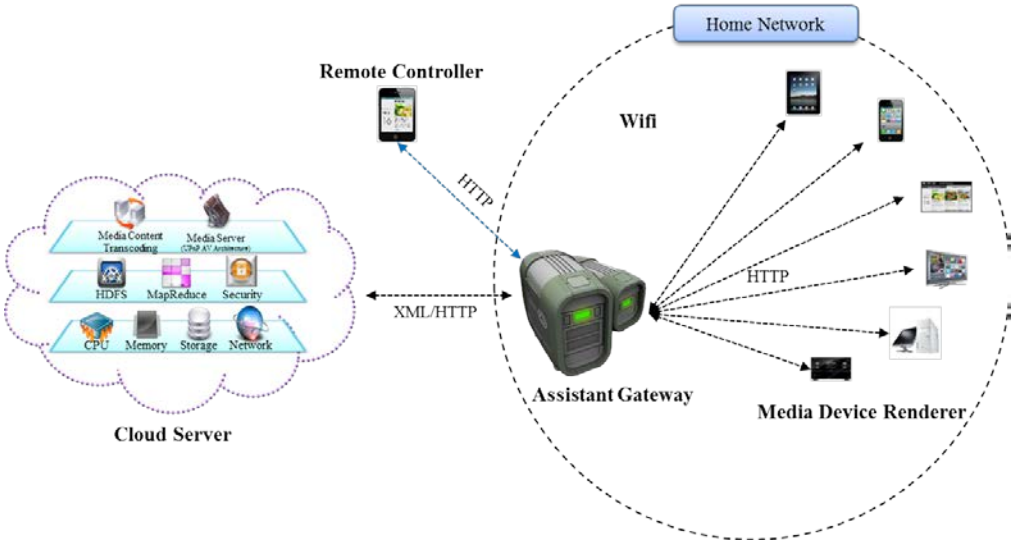


Figure 2. Architecture of the Proposed Model for Home Media Streaming Services

3.1. Assistant Gateway

Assistant Gateway manages user and multimedia information. For providing a safe personalized multimedia service, a login function is implemented in Assistant Gateway. Thus, users can receive safe personalized home media services anywhere. Furthermore, Assistant Gateway stores and manages the OAuth–based authentication-id generated by cloud server for users. Using the authentication-id, Assistant Gateway can freely access to cloud server and obtain multimedia content lists and metadata. All of the multimedia content is stored by users or shared by those related to these users. Assistant Gateway simultaneously obtains metadata with the multimedia content list for classifying the content. Multimedia metadata are composed of many attributes such as title, author, duration, resolution, date, size, and URL. They are efficiently stored and managed in a SQLite-based database that records multimedia content lists and metadata. Simultaneously, it stores and manages the multimedia seek time for providing gapless playback service to users. In addition, multimedia metadata are used for automatic device– matching functions.

Assistant Gateway uses the UPnP protocol for maintaining communication with media device renderer and providing multimedia content to users. To support multimedia services using UPnP, Assistant Gateway provides the functions of MS and RAS proposed by UPnP AV and RA architectures, respectively. Assistant Gateway

maintains the Content Discovery Service (CDS) and Connection Manager Service (CMS) of MS to support multimedia services. CDS manages the multimedia content list and metadata that are sent from the cloud server to users. CMS is used for maintaining connections between Assistant Gateway and other UPnP devices. RAS is designed for providing users with multimedia content. Assistant Gateway using RAS provides remote devices multimedia content and media device renderer information within a home network. Assistant Gateway includes an RA Transport Agent and an RA Discovery Agent for communicating with remote devices. Both are part of the RAS. The RA Transport Agent constructs a safe communication channel between Assistant Gateway and remote devices. The RA Discovery Agent can receive information from remote devices and verifies synchronization service data for communicating with them.

For providing convenient multimedia services and user-friendly functions, Assistant Gateway offers an automatic device–matching function [10] that uses the resolution of multimedia content for selecting an adaptable media device renderer. Although the UPnP protocol supports multimedia on demand services, users can receive convenient and efficient home media services because of the automatic device–matching function. Assistant Gateway executes a multimedia streaming service using the automatic device–matching function according to the result that is received from comparing multimedia content with the resolution of media device renderer. The automatic device–matching function is only supported in a home network and cannot be used for remote devices. Therefore, remote devices can use multimedia on demand services only. In addition, for supporting efficient multimedia services, Assistant Gateway provides a multimedia gapless playback function to users. Using this function, Assistant Gateway can record the ending time of multimedia content to a database that is based on SQLite. When users play multimedia content for which the ending time was recorded, Assistant Gateway obtains the stopping time from the database and sends it to media device renderer for playing multimedia content continuously. Figure 3 shows structure of Assistant Gateway.

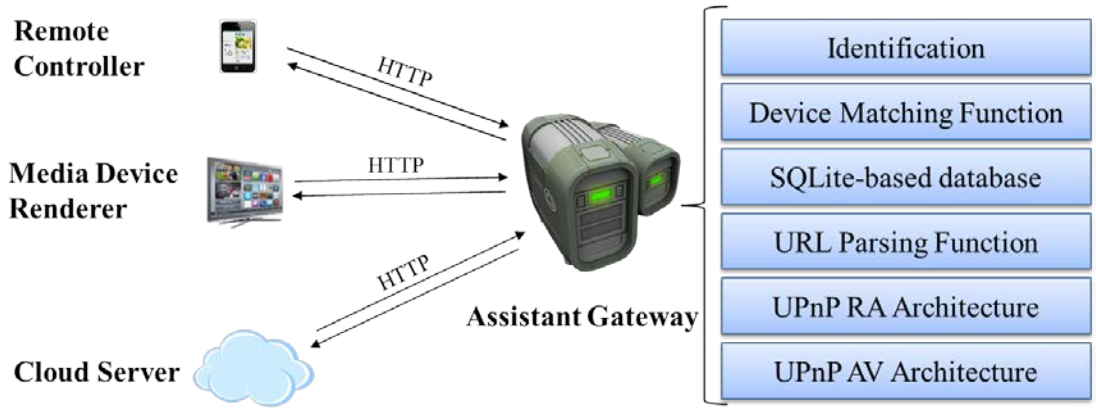


Figure 3. Structure of the Assistant Gateway

3.2. Cloud Server

Cloud server stores and manages a large amount of multimedia content stored and shared in a home network. For providing personalized management services, cloud server generates and issues each user an OAuth-based authentication-id that is managed by Assistant Gateway. For personalized services, cloud server creates virtual computing

resources and storage for each user using Xen technology in the cloud environment. The multimedia content of each user is stored in a private virtual space. For providing multimedia streaming services to heterogeneous devices, we designed a multimedia content transcoding module in cloud server.

The multimedia transcoding module is designed and implemented on the basis of MapReduce, which can efficiently process large amounts of data using the Hadoop Distributed File System (HDFS) [2, 5, 7]. The multimedia transcoding module is a multimedia content converter that converts multimedia formats to a uniform type for heterogeneous devices. Multimedia content is converted into an MPEG-4 format, which can be played in any kind of multimedia device including smart phone, tablet PC, and smart TV. For providing adaptable multimedia streaming services to a majority of multimedia devices, the resolution of the converted multimedia content is classified into three types, namely, 1024 × 760, 800 × 600 and 320 × 240.

The multimedia management module is implemented in cloud server for sending multimedia information to Assistant Gateway. The role of the multimedia management module is to provide Assistant Gateway with a multimedia content list and metadata through HTTP to supply content information to users. This module manages all multimedia content that has been converted by the multimedia transcoding module.

Users utilize the multimedia information supported by cloud server to select multimedia content through Assistant Gateway. Then users receive a multimedia streaming service from cloud server using the selected multimedia content. For providing the multimedia streaming service to users, a multimedia streaming server module is implemented in cloud server.

The multimedia streaming server module provides media streaming services to media device renderer using HTTP-based multimedia streaming technology [12]. Assistant Gateway search for multimedia content through CDS using the multimedia URL address received from media device renderer, and transmits it to the multimedia streaming module of cloud server. In cloud server, the multimedia streaming server module communicates with the related media device renderer and provides the multimedia streaming service to users.

3.3. Remote Controller

Remote controller is a mobile device that provides user interface function to verify the multimedia content list supported by Assistant Gateway and is able to control multimedia streaming and media device renderer remotely. It supports login function for registering users' information at Assistant Gateway. Remote controller provides CP and RAC functions of UPnP AV and RA architectures, respectively. A device with functions of UPnP/DLNA CP can access and control heterogeneous devices without an additional setting-up. Remote controller can also verify multimedia streaming ending times and sends them to Assistant Gateway. The ending point is stored in the database of Assistant Gateway.

3.4. Media Device Renderer

Media device renderer requests the multimedia streaming service from cloud server using a multimedia content URL that is selected by the user, and plays it. Media device renderer has MR functions of the UPnP AV architecture. Using media device renderer, users can easily receive multimedia streaming services because it provides AV Transport Service (AVT), Rendering Control Service (RCS), and Connection

Management Service (CMS) functions of MR. AVT is an important component for playing multimedia content. RCS provides functions for controlling sound, mute, and brightness. CMS is used for network communication with Assistant Gateway, cloud server, and remote controller. As a result, media device renderer is the only multimedia device for playing multimedia content using UPnP.

4. Home Media Service Scenario

In this section, we explain the correlation between each module through a service scenario using our model. Our service scenario is as follows.

The user uses remote controller to launch an application and login to Assistant Gateway.

Assistant Gateway verifies the login information and access to cloud server using an OAuth-based authentication-id for requesting multimedia information of the user.

Cloud server receives the request from Assistant Gateway, confirms the authentication-id, and sends the multimedia content list and metadata that belongs to that user.

Assistant Gateway receives the multimedia information from cloud server, inserts it into a database, and then sends the information to the user.

The user checks the multimedia information using remote controller and then selects multimedia content to play.

Assistant Gateway receives the multimedia information selected by the user and sends him/her a message to ask what kind of service he/she wants to use. The services include automatic device matching and on demand services.

The user selects the service using remote controller. If the user is not at home, Assistant Gateway cannot provide the automatic device–matching service to the user.

If the user wants to play multimedia content in remote controller, he/she presses the on demand service button, and Assistant Gateway sends the selected multimedia metadata to remote controller.

Remote controller requests the multimedia streaming service from cloud server using the URL of the multimedia content and plays the content.

The user stops the multimedia content, goes home, and then reselects the multimedia content in the home network.

Assistant Gateway asks the user about the services again.\ The user selects the automatic device–matching service.

Assistant Gateway compares the resolutions between the multimedia content and media device renderer, and then sends the multimedia metadata to the adaptable media device renderer for providing the multimedia streaming service to the user. Simultaneously, Assistant Gateway transmits data about the multimedia content stopping time to media device renderer.

Media device renderer selected by Assistant Gateway receives multimedia metadata and stopping time, and requests the multimedia streaming service to cloud server using the URL of the multimedia content.

Cloud server verifies the multimedia information and sends multimedia streaming data to media device renderer.

Media device renderer plays the multimedia content from the stopping time on wards.

When the multimedia streaming service is completed, the user uploads new multimedia content into Assistant Gateway.

Assistant Gateway automatically uploads multimedia content that has been stored by the user in cloud server; then, cloud server updates the multimedia information for the user.

5. Implementation

5.1. Environment used for the Implementation

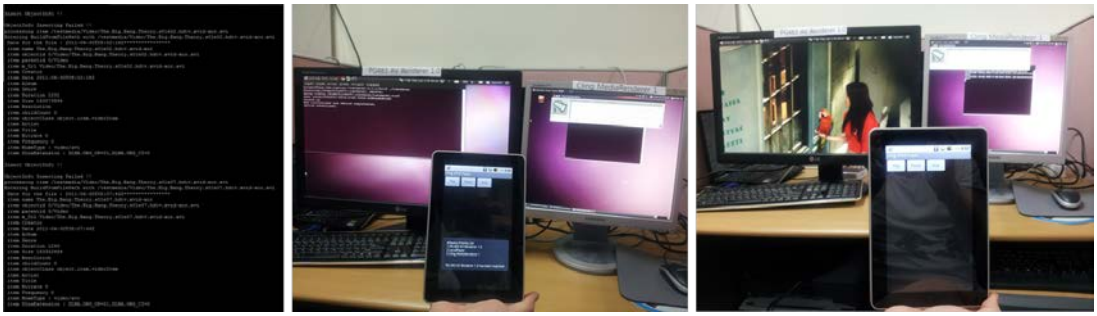
The functions of our proposed model were implemented on the basis of architecture described in this paper using open source. We used Platinum to implement the cloud server, which provides UPnP and streaming service functions. It is an open source library based on C++. The functions of the remote controller and media device renderer were implemented using the Cling library, which supports the UPnP functions of the PC and the Android platform. The Assistant Gateway is an important component for communicating among UPnP devices. It was implemented in Java. We used the Cling and OAuth libraries to produce the user identification and UPnP functions. All the components of the architecture of our proposed model communicated using HTTP. Table 1 shows the implementation environment.

Table 1. Environment used for the Implementation of our Proposed Model

Contents	Assistant Gateway	Cloud Server	Remote Controller	Media Device Renderer
OS	Ubuntu	Cent OS	Android	Android, Ubuntu
Library	Cling, OAuth	MapReduce, Platinum, OAuth	Cling	Cling, libupnp
Device	PC	Cluster Server	Android Device	Android Device, PC

5.2. Results

Figure 5 shows the screen after the proposed model was implemented in a home network. Figure 5(A) shows metadata extraction information after verifying the metadata of media files transferred from the cloud server by the Assistant Gateway. This information was sent to the remote controller by the Assistant Gateway so users could select their multimedia content. Figure 5(B) shows the result of the device matching module combining multimedia content and media device renderer metadata to provide an automatic device matching function, which supports a convenient media streaming service for users. Figure 5(C) is shows the media stream being played by the media device renderer, which automatically selected the device matching module of the Assistant Gateway. The URL of the media content selected by users was passed from the remote controller to the media device renderer via the Assistant Gateway. Using the related URL, the selected media device renderer requested media streaming from the cloud server and prepared the stream services. After the URL of the media content was verified and accepted by the cloud server, it transferred the streaming data to the media device renderer. Using the streaming data, the media device renderer played the media content. The remote controller could also be used to control the media stream.



A B C

Figure 5. Implementation of the Proposed Model

6. Conclusions

In this paper, we proposed a home media service model that provides extended multimedia service functions based on cloud computing technology to support home media streaming services anytime and anywhere. Based on cloud computing technology, the cloud server supported personalized multimedia services using many different functions. The Assistant Gateway provided home media services in a home network and in WLANs. In addition, the Assistant Gateway had a decisive role in home networks where it supported remote controlled multimedia content information so users could select multimedia content. It also selected an adaptable media device renderer, depending on the multimedia content selected by users. Using the proposed model, users could receive efficient and convenient home media services.

In the future, we plan to study algorithms and methods for providing effective multimedia streaming functions using cloud computing technology. To provide an active multimedia streaming service via the Assistant Gateway, we will evaluate the performance of the multimedia streaming service. In addition, we aim to develop an efficient algorithm for the accurate selection of a media device renderer in a home network.

Acknowledgements

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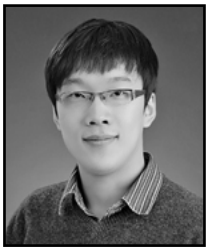

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