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碩士論文

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以 Metadata 為基礎之下一代行動網路資訊服務平台

Metadata-based Mobile Service Platform for Next-Generation Heterogeneous Networks

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誌謝

本篇論文的完成，首先感謝我的父母親的栽培與支持，讓我接受教育到大學以及研究所，使我有更好的條件踏入未來的道路。誠摯感謝我的指導教授呂芳懌老師兩年來辛苦、耐心的教導，使我在研究所的過程中非常充實，在專業領域之外，更培養了更重要的自我學習和獨立思考的能力。也感謝諸位資料庫實驗室的同學、學長、學弟的照顧及督促，讓我可以平安的在實驗室度過每個漫長夜晚。此外，更要感謝從大學到研究所一路照顧關心我的磐頂教會許多的弟兄姐妹給我的扶持，讓我在信仰上更加成長，在生活上豐盛有餘。最後，我要感謝親愛的上帝總是與我同在，感謝祂在我的生命當中做了許多美好的工。

摘要

現今的 3G 行動系統提供了充分的頻寬給行動使用者接收多媒體影音資訊。因此，對於通訊業者來說，如何和現有的資訊提供者合作並提供大量的資訊服務，是 3G 和未來 4G 能否成功推展的一個重要關鍵。本文提出了一個建構於 3GPP IP Multimedia Subsystem (IMS)，並適用於現行的 3G 或未來的 4G 異質性行動網路的資訊服務平台稱為 Metadata-based Multimedia Service Platform (MMSP)。透過 MMSP，3G/4G 行動通信業者可以與 3rd party 服務內容提供者合作，共同服務行動通訊使用者。而服務內容提供者只需傳送所欲提供內容的 Metadata 至服務平台，由平台匯整與組織後，提供給使用者瀏覽。當使用者要求服務內容時，平台才將該要求轉送至服務內容提供者，直接將內容傳送給使用者。個人化資訊服務是另一個探討重點，我們利用 subscribe-notify 機制讓使用者訂閱他們有興趣的資訊，當平台收到更新資訊時，則立即通知訂閱的使用者。另外，使用者可以透過 receiving policy 的機制去自訂適合接收資訊的狀態，讓使用者可以更加個人化地方式去接收訂閱資訊。如能以上述之行動資訊服務平台放置於現今的 3G 或是未來的 4G 架構下，將能產生更多的商業利益，並且這個通訊業者和資訊內容提供者利益共享的架構，更可為行動通訊使用者帶來更便利的資訊服務。

關鍵字: 3G，4G，IP Multimedia Subsystem (IMS)，行動資訊服務，個人化資訊服務。

Abstract

Current 3G networks have provided sufficient bandwidth to enable users to receive multimedia services. For 3G and future 4G operators, the key issue to success is how to cooperate with existing content service providers (CSPs) to provide a large amount of multimedia services for users. This thesis proposes a service platform named Metadata-based Multimedia Service Platform (MMSP) that deploys 3GPP IP Multimedia Subsystem (IMS) as the basis in order to enable lightweight service cooperation between 3G/4G operators and 3rd party CSPs to participate mobile information provision. MMSP collects metadata of value-added contents that CSPs intend to provide so as to play as a service broker promoting mobile users to browse service contents. When users commit to receive contents, 3rd party CSPs deliver the contents directly. Besides, MMSP adopts subscribe-notify interactive model to keep users interested contents up-to-date, and to serve mobile users in a more personalized way by setting receiving policies. We present different service delivery schemes, application examples and implementations to demonstrate MMSP.

Keyword: 3G, 4G, IP Multimedia Subsystem (IMS), Mobile Information Service, Personalized Information Service.

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Chapter 1. Introduction

Communication evolution is now on its way toward third-generation (3G) mobile systems, which provide broadband communication connectivity to deliver multimedia services to mobile users, substantially improving the limitation of 2G/2.5G mobile systems that carry only voice and low bit-rate data. According to International Mobile Telecommunications-2000 (IMT-2000) standardized by International Telecommunication Union (ITU), 3G networks require to offer up to 2Mbps peak data rate for stationary, 384Kbps for pedestrian and 144Kbps for vehicular users. 3G mobile networks feature an all-IP architecture in which each device is identified by an IPv6 address. Most worldwide 3G mobile networks follow two standards: Universal Mobile Telecommunication System (UMTS, also referred to as wcdma) and cdma2000, with which communication industries have specified two system specifications, called third generation partnership project (3GPP) and 3GPP2.

4G also named Beyond 3G (B3G) [1-4] is expected to extend current situation, offering higher data rate for mobile communication, e.g., the peak rate should be more than 100 Mbps, 20 Mbps for moving users. 4G characterized as heterogeneous networks aims to cooperate with various wired/wireless technologies, ranging from personal, local to global, such as, WLAN, UMTS/cdma2000, and satellite networks. Since numerous wireless technologies have been designed independently to provide different service features, data bandwidth, and access range to meet a variety of user requirements, 4G should reserve the best features and eliminate limitations of each integrated network. For example, researchers and industries recently focus on the integration of WLAN and UMTS (or cdma2000) as a preliminary step toward 4G. Generally UMTS networks take care of wider coverage for general mobile users, while WLAN hotspots (54Mbps for 802.11a/g) are often accessible where UMTS radio spectrum is unable to reach. Also WLAN provided wider bandwidth than UMTS thus suitable for data-intensive services. Salkintzis [5] and Honkasalo et al [6] pointed out 3G and WLAN are mutually complementary and their combination will be a trend.

Communication community has made efforts on 4G technologies to compromise network heterogeneities. Always Best Connected (ABC) technologies [7] envision best network selection issues based on user’s service needs, radio coverage and data transmission considerations. Multi-input multi-output (MIMO) [8, 9] addresses bandwidth enhancement. Smart antenna [10] provides comprehensive radio interfaces on a single antenna. In addition, an elaborated system standard and specification are

required to outline the 4G system.

Besides the technical challenges, applications are equally important in 3G/4G networks [11, 12]. In commercial perspective, current 3G and future 4G communication operators should provide multimedia and our daily life related services to users. Value-added service contents and their access availability are the main drivers to attract mobile users to migrate from 2G/2.5G to 3G/4G networks. From current 3G operators viewpoint, creating value-added applications and services that users have never experienced in 2G/2.5G is a challenge, also an opportunity. Therefore, it would be better to cooperate with 3rd party content service providers (CSPs) to provide mobile information services, e.g., Internet webs offer countless value-added service contents, local restaurants and movie theaters provide their daily business information. Nevertheless, how operators can efficiently collaborate with 3rd party CSPs is one of the key issues to success.

Many people argue that killer application is also a critical issue in urging communication evolution. Ahonen [13] provided a good answer: killer application is personalized. User's interests and demands are dissimilar. Only providing plenty of personalized services can strongly attract users' attention. However, mobile users require a feasible way to manage their interested services. How operators can efficiently handle service-related information is also another issue.

This research aims to create a metadata-based service environment named Metadata-based Mobile Service Platform (MMSP) which is developed on 3GPP IP Multimedia Subsystem (IMS) for next generation heterogeneous networks to collect metadata of value-added contents rather than full contents from 3rd party CSPs. Moreover, the value of a service not only pending on service content itself, but also depends on the degree of personalized convenience that service personalization brings to users. Hence, a feasible mechanism to handle user-interested information so as to achieve personalized mobile services is also proposed.

The rest of this thesis is organized as follows. Chapter 2 categorizes the types of content services and CSPs that may involve in this research. Chapter 3 describes the entities of MMSP. Chapter 4 details the service provision, service delivery and management mechanisms. The business models concerning commercial opportunities rolled out by MMSP are discussed and system implementations are described both in chapter 5. Chapter 6 concludes this article and specifies our future work.

Chapter 2. 3rd Party Content Service Providers and Categories of Contents

We classify 3rd party CSPs that may cooperate with MMSP into Internet, local and individual CSPs, and the contents provided to users into live, on-demand and downloadable multimedia contents. “Content” refers to video, music, news or rich text which can be further categorized as personal entertainment, business information and location-based information.

2.1 Content Service Providers

2.1.1 Internet CSP

Worldwide Web (WWW) has been so far a dominant application on Internet. Currently, millions of Internet CSPs have gained revenue from offering value-added services via their webs, such as IP-based multimedia broadcasting, on-demand multimedia services, downloading services and so on. However, if they want to expand their service domain to mobile networks, integrating with 3G/4G operators is a vital step. Although pure mobile Internet accesses provide mobile users a straight way to retrieve services by browsing webs, frequently tracking current trends and availability of concerned information on users’ small-screen mobile devices are troublesomely infeasible. Therefore, services integration is required to make Internet information accessible to mobile users, and keep user’s interested information up-to-date.

2.1.2 Local CSP

For traveling users, location-based information is practically useful and required especially when they arrive at an unfamiliar city or town. Global Positioning System (GPS) only tells them current geographical position, lacking business information details, e.g., menu of a restaurant and room prices of a hotel in that area. Mobile network is a feasible environment to provide local CSPs a service platform to promote their business information. When detecting some mobile devices enter local area, the

platform can actively or on users' demands deliver location related business information to those traveling users.

2.1.3 Individual CSP

MMSP allows mobile users acting as content providers. Current 3G and forthcoming 4G networks offer sufficient bandwidth for individual users to conveniently transmit their own created contents, e.g., music ring tone and image wallpaper, through networks. Mobile users can subsequently browse and download these contents.

2.2 Categories of Contents

2.2.1 Live Multimedia Contents

Live contents such as Internet TV, radio, ballgame broadcasting over IP network are popular value-added services on Internet. Most of them are streaming based, CSPs deliver them though real-time protocol/real-time streaming protocol (RTP/RTSP) with the limitations of un-rewindable and un-forwardable just like watching TV at home. IP-based broadcasting services are also applicable for mobile users when they are currently in a foreign area where their interested programs are not available in local TV broadcasting network.

2.2.2 On Demand Multimedia Contents

Some entertainment services such as Movie-on-Demand (MOD), Video-on-Demand (MOD) and online music service are file-based. serving users with on demand approach. These contents are often transported over RTP/RTSP. Users are allowed to rewind and forward the contents. Some CSPs provide live broadcasting real time and on demand service for the same program afterward.

2.2.3 Downloadable Multimedia Contents

Location-based information, like restaurant daily menu, daily sale of mall and movie schedule, can be offered by local CSPs. The information is often composed of text and images, called rich texts, which are always tiny in size and suitable for replicated to MMSP and can be downloaded by users. The similar services such as

downloading music, pictures, phone rings, even movies are commonly provided by current Internet CSPs and individual CSPs.

Chapter 3. IMS-based Service Platform

3.1 IP Multimedia Subsystem

IMS [14] is a part of 3GPP specification release 5 [15, 16] specifying an overlay architecture above 3GPP packet switched core network to provide multimedia services, manage customer profiles and control call/media sessions in UMTS networks. Through Packet Data Gateway (PDG), internal UMTS Terrestrial Radio Network (UTRAN) endpoints can communicate with external IP networks. We deploy IMS and extend some of its functions to construct MMSP in order to interwork with CSPs of heterogeneous networks. Figure 3.1 illustrates the simplified IMS architecture that connects heterogeneous networks.

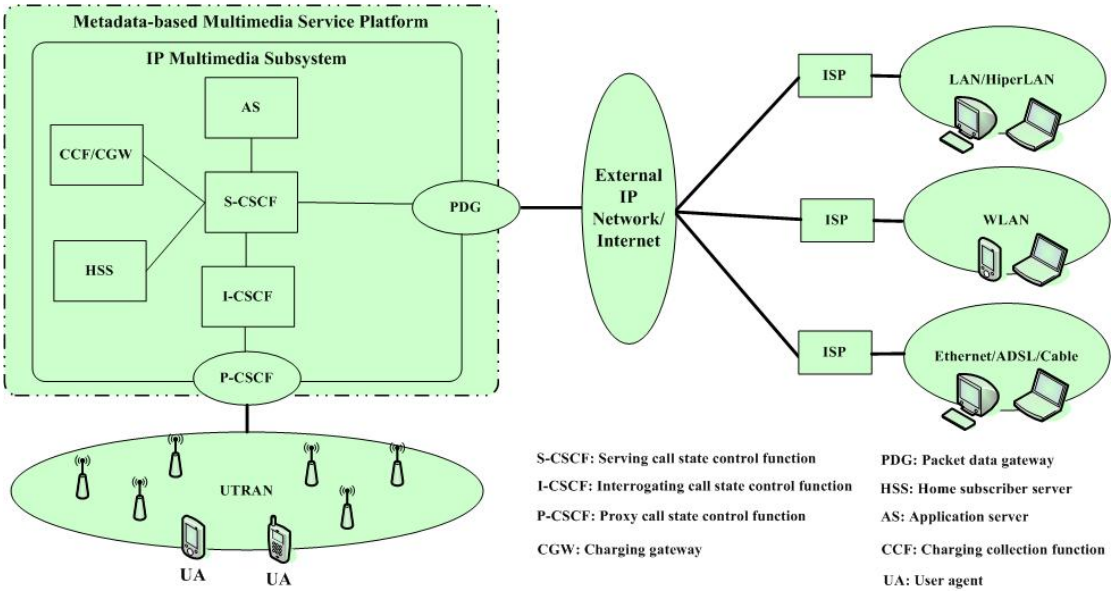


Figure 3.1 Simplified IMS architecture

(1). Serving Call State Control Function (S-CSCF): S-CSCF, the centralized control point of IMS, is equipped with complex logics and policies to process user requests by involving predefined algorithms and collaboratively communicating with others entities. Its other functions include session control, service provisioning and user registration.

(2). Proxy Call State Function (P-CSCF): P-CSCF, the contact point for endpoints

within UTRAN including home users and roaming users, acts as a proxy accepting packets from users and forwarding them to I-CSCF for further processing.

(3). Interrogating Call State Control Function (I-CSCF): I-CSCF identifies a mobile user's home network and forwards requests to S-CSCF, or assigns appropriate home S-CSCF for roaming users to perform SIP registration.

(4). Home Subscriber Server (HSS): HSS, a central database maintaining home user profiles recording their basic information, status, location, terminal information and service-related information, is responsible for managing Authentication, Authorization and Accounting (AAA) for each user and storing his/her service subscriptions.

(5). Charging Collection Function (CCF)/ Charging Gateway (CGW): When mobile users consume services or establish call sessions, CCF/CGW keeps track session status for future charging, thus expected to provide various charging options for different content services, such as flat rate or charging per service invocation.

(6). Application Server (AS): Originally AS is responsible for storing and provisioning services. In MMSP, we extend AS to extract and maintain content service items (metadata) provided by CSPs, to monitor metadata of schduled programs and to notify S-CSCF the upcoming scheduled programs.

(7). User Agent (UA): UA, a client application installed in user devices to bridge users and IMS, is distributed by communication operators as a GUI interface to assist mobile users to process service provision and requisition, consequently transforming user inputs into XML format and sending the data to S-CSCF, or vice versa. Various versions of UAs are then required to meet a variety of hardware and software requirements.

3.2 Protocols

Session Initiation Protocol (SIP) and Diameter, defined by IETF [17, 18], are adopted by IMS as the signalling protocol to establish, modify, terminate multimedia sessions for mobile systems. Some SIP methods listed in Table 3.1 are created for session manipulation. As deployed by Voice-over-IP (VoIP), SIP works in conjuction with Session Description Protocol (SDP) [19] of which data is embedded in SIP payload to describe media sessions. Each SIP user is identified by a logical address called SIP Uniform Resource Identifier (URI) which formatted like an email address

(e.g., user@mobile.com), makes user mobility possible.

Diameter [20, 21], an improved version of an earlier AAA protocol RADIUS, is adopted by 3GPP to perform AAA related funtionalities for IMS, as the interface between HSS and S-CSCF, also between AS and HSS.

Table 3.1 SIP methods used in IMS

SIP Method	Description
INVITE	To initiate a session and convey service request
SUBSCRIBE	To subscribe a specific event
NOTIFY	To notify user with information of subscribed service
REGISTER	To perform an application level registration
REFER	To forward request message
ACK	To confirm session establishment, usally conveyed in SDP payload
BYE	To terminate a session

Chapter 4. Service Adoption and Management

4.1 Service Item

MMSP may receive a variety and a large amount of registered services. Hence efficiently managing these data is one of its key issues. In order to prevent replicating all contents from CSPs to MMSP, we proposed “Service items”, the metadata manually extracted from service contents, as intermediary between CSPs and mobile users. Table 4.1 lists the primary fields of a service item. A few of them are extracted as the brief information to makeup Service List which acts like a menu. Users can browse Service List to request required service. MMSP forwards the request to the corresponding CSP for service content provision. During service registration, CSPs upload metadata rather than their capacity-consumed contents to lightweight MMSP.

Table 4.1 Parameters contained in a service item

Item Parameter	Description
Operation	Create /Update/Discard a service item
Title	Title of service
Provider	Title of CSP
SIPURI	SIP URI of CSP
Descrp	A brief description of the service item
Type	Type of service item (scheduled, intermediate, full content)
Category	Media type of the content (Video, Audio, Text)
Res	Resolution of the video, image, audio
Size	The file size of the content
Loc	The geographical location that the content is available
Exp	Item expired date/time
Start	Expected start time of the content (live only)
End	Expected end time of the content (live only)
Runtime	The runtime of on demand/live content
Chg	Charge per service access or access duration
Access_URL	Static or dynamic link to service content itself

QoS	QoS requirement of the service
Item ID	An unique Item ID
Sub ID	Subitems' IDs

4.1.1 Service Item Registration

Figure 4.1 shows the registration process. A CSP transmits service item via UA to MMSP. S-CSCF classifies the item to an appropriate category, generates a unique Item ID as the service identification and passes the item to AS.

UA records all Item IDs having previously registered, thus allowing its CSP to directly send requests to modify, update or discard those items if needed. Considering user mobility and system flexibility, MMSP also records the users' subscriptions in HSS and updates user profiles when necessary, e.g., users register with their new mobile devices.

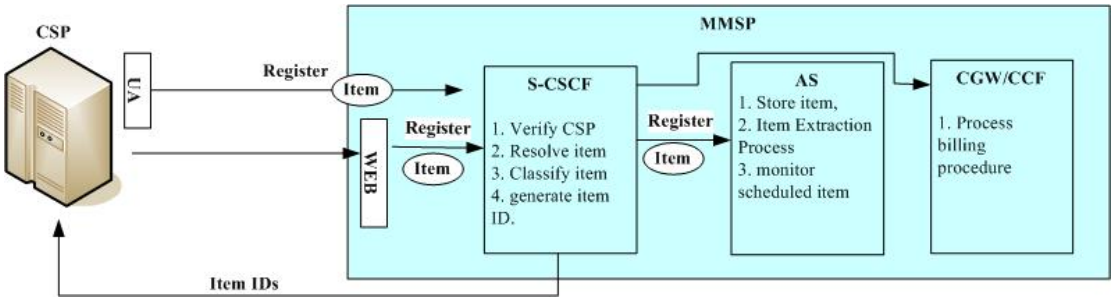


Figure 4.1 The process of service registration

4.1.2 Service List and List Browsing

Showing too much information on a mobile device is infeasible due to limited screen resolution. The brief information of a service item including Item ID, title, provider, charge and Sub ID is retrieved by Item Extraction Process as shown in Figure 4.2. When user browses Service List, an interactive session is initiated. S-CSCF dynamically accesses the concerned portion from AS and then sends to the user.

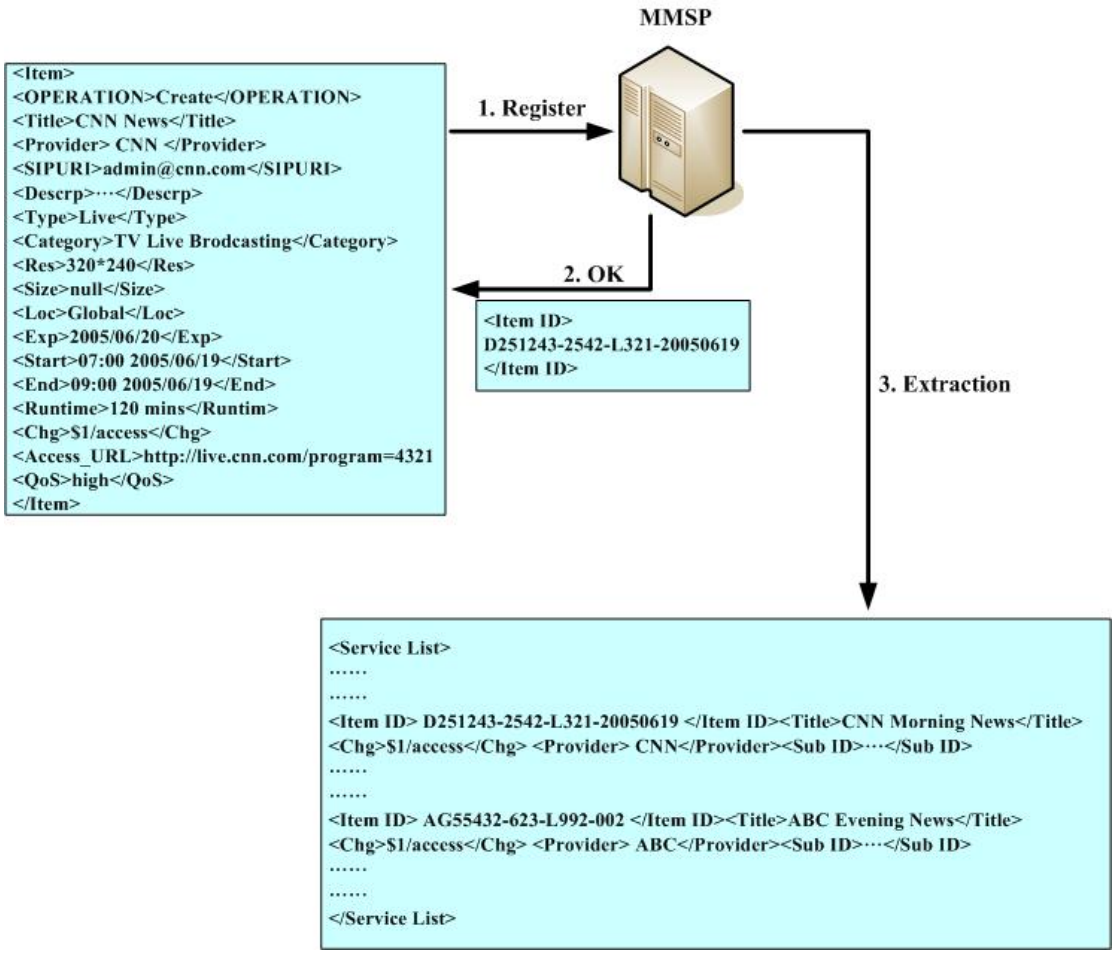


Figure 4.2 Process of item extraction for Service List

4.1.3 Types of Service Item

Metadata in MMSP can be classified into two types, intermediate and scheduled. The former contains links, dynamic or static, to the contents resided in CSPs. AS is responsible for maintaining Service List to correctly link to the corresponding CSPs and contents. The latter represents scheduled programs such as IP TV and ball game broadcasting programs. Once a scheduled item is triggered, AS informs S-CSCF to notify subscribers.

4.1.4 Service Item Identification

We separate Item ID, which is unique, into four fields including CSP, category, content and index IDs, as shown in Figure 4.3.

1. **CSP ID** stands for UID, a field of a user profile representing a CSP.
2. **Category ID** indicates service category depicted in Category field of a service item. AS maintains a table to record categories and their corresponding IDs.

3. **Content/Group ID** shows two significances. Content ID uniquely represents a single or regular service. A content has a unique content ID. Regular program, such as episodes of a series drama or daily morning news of the same Internet TV CSP, is given same content ID. Group ID is generated to represent a group of related contents, e.g., a group ID 20050501_20050507 represents a weekly schedule of an Internet TV CSP, while 20050506 stands for a daily schedule. Group ID is only for linking its subitems in AS and Service List, not for accessing service contents themselves.
4. **Index ID** is assigned to differentiate a program from a group of services of the same content ID, e.g., a series drama. Two naming schemes are proposed. The first, designating an incremental number to each episode of a series of programs, is suitable for a series drama. The second, giving a date as the name to each regular program (e.g., 20050417), is appropriate for daily/weekly programs and ball game broadcasting since they are often identified by date.

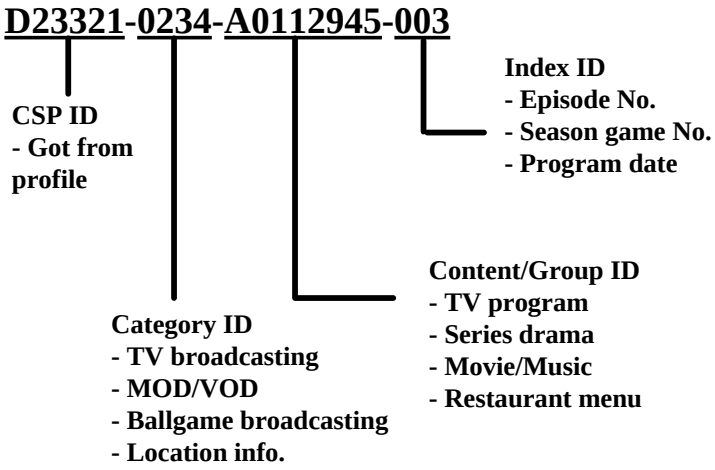
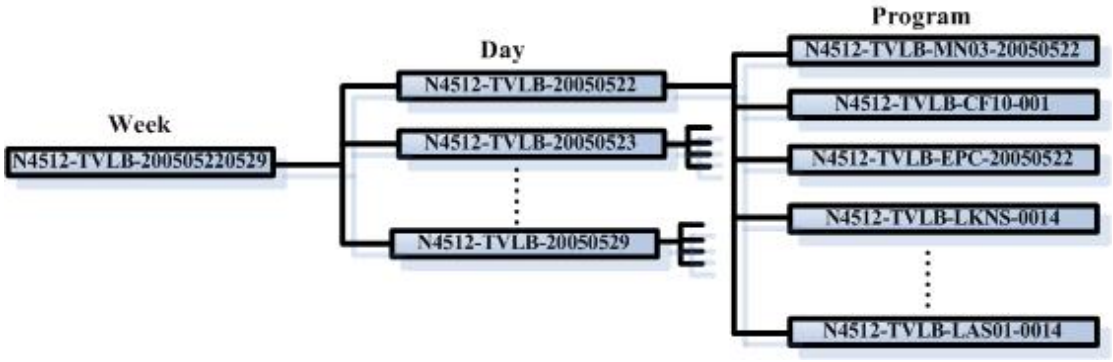


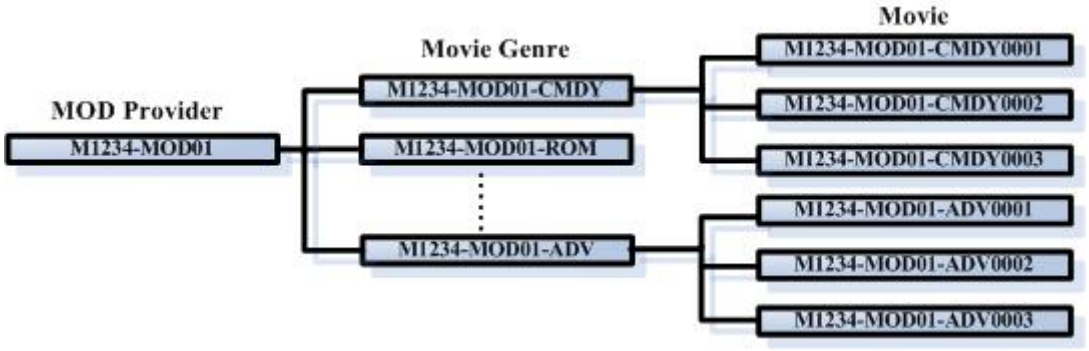
Figure 4.3 Composition of an Item ID

4.1.5 Item Organization

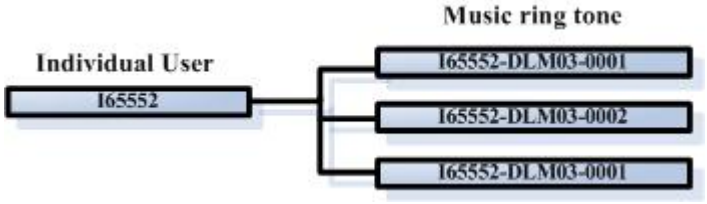
Service items are organized as a hierarchical structure to improve AS's access efficiency. The same structure is also applied to Service List. The field SUB ID records subitems. Figure 4.4(a) shows a weekly TV schedule linking to its seven daily schedules, each is a subitem of the week. In turn, each program, a subitem of a daily schedule, links to the corresponding content itself. User can click a program to request his/her service.



(a) Weekly TV program schedule



(b) Movie-on-Demand Service List



(c) Downloadable Service List

Figure 4.4 Hierarchical structures of service items and Service List

4.2 User Profile Management

How to manage and deploy profile servers and their possible implementation scenarios for 4G heterogeneous networks have been discussed by Bongant et al [22]. Generally, managing user profiles can achieve service personalization. Besides network level registration, e.g., IP acquisition, application level registration e.g., to declare user's current condition, is also needed. MMSP classifies the information conveyed on user profile into four types including basic, terminal, service-related and CSP information as listed in Table 4.2. Basic keeps user AAA, current status and location. Terminal depicts the device parameters user currently holds. Service-related is clearly self-explained. CSP information is for CSP as the published information.

Wherever connecting to mobile network, users have to submit login name (e.g.,

SIP URI) and password for authentication. UA automatically retrieves implicit information such as IP address, device model, current access network (Net), and current registration location (UserLoc) to update user profiles. UserLoc, an essential parameter for service personalization, can be identified via various detecting methods or other innovative methods [23, 24].

Table 4.2 Parameters in a user profile

Type of information	Parameter	Description
Basic information	SIPURI	SIP URI of registered user
	Username	User name for registration
	UserLoc	Current registration location
	Status	Online/Busy/Meeting status set by user
	UID	An unique ID used in service provisioning
	PWD	Login password
Terminal information	Dev	Model of device
	IP	IP of the registered device
	Net	Current access network
	OS	Device operating system
Service-related information	Unsent Notification	Pending notification when the user is offline
	SubsrbID	Item ID the user has subscribed
CSP information	Title	Public CSP name
	SIPURI	CSP's SIP URI
	Descrp	Brief description of CSP
	ServCat	The service category CSP may provide
	Addr	Address information
	Tel	Telephone number
	Web	Web page of CSP

4.2.1 User Subscription and Notification

Subscribe-notify interactive model [25, 26] is also one of the key mechanisms to achieve service personalization. A user subscription consists of subscribed

information and/or receiving policy. The former is to order services, while the latter specifies the policy user likes to receive his/her services. Table 4.3 lists the parameters. While a scheduled item of a upcoming program is triggered, S-CSCF searches the candidate subscriptions to find out users whose receiving policies are verified. Notifications are then issued. Figure 4.5 illustrates the policy verification algorithm

For example, a user subscribes broadcasting service of a series drama and sets a policy that notification is only delivered when he/she holds a PDA phone (SUBDevice: PDAPhone) within 9 am to 6 pm (SUBTime: 0900-1800) from Monday to Friday (SUBDayofWeek: Mon-Fri). UA sends these data in XML format to MMSP as a subscription. Accordingly, the user using his desktop PC or in the weekend will not receive notification of this service.

A user can select any episode of his/her desired drama, e.g., Item ID: N4512-TVLB-CF10-006, and subscribe it. UA then substitutes its index ID (006) with X as the Subscription ID (N4512-TVLB-CF10-X) to identify the subscription. When AS triggers N4512-TVLB-CF10-007, S-CSCF searches HSS for N4512-TVLB-CF10-X. Verified subscribers will be notified.

Table 4.3 Parameters in the subscription and notification

Subscription Parameter	**Description**
SubsrbID	Subscription ID
SUBTime	Notify user only during the specified time in a day
SUBDayofWeek	Notify user only in specified days of week
SUBDevice	Notify user only when he/she uses specified device
SUBNet	Notify user only when he/she is in specified network
SUBLocaion	Notify user when he/she is in specified location
EXPCount	Define the times service can be invoked, null indicates always valid
EXPDate	Define expired date of subscribed service, null indicates always valid
Notification Parameter	**Description**
ItemID	ID of notified item
ItemTitle	Name of notified item
ItemDescrp	Description of the notified service
Media Type	Video/Audio/Text
Access_URL	Links to CSP for direct media streaming service
Attachment	Attached file, e.g., image or ring tone

Input :
usr.dev, usr.net, usr.loc : current device, network, location of subscriber
sub.dev, sub.net, sub.loc : preferred device, network, location set in the receiving policy
sub.day_of_week, sub.time : preferred day, time set in the receving policy
EXPDate : expired date of the subscription
trigger.date, trigger.day_of_week, trigger.time : date, day of a week, and time to trigger scheduled service

Variable :
notify : to determine notifying user or not

Algorithm :
notify = true
do search candidate subscription
for each candidate
if {(*EXPDate* > *trigger.date*) ||
(*usr.dev* ⊄ *sub.dev)* ||
(*usr.net* ⊄ *sub.net)* ||
(*usr.loc* ⊄ *sub.loc)* ||
(*trigger.day_of_week* ⊄ *sub.day_of_week)*||
(*trigger.time* ⊄ *sub.time))*
return *notify* = false

if *notify* = true
S-CSCF sends notification to the candidate
endif }

Figure 4.5 Subscription verifying algorithm

Chapter 5. Service Delivery Scheme and Implementation

In the following, we propose service delivery schemes for live, on-demand and downloadable contents. Application examples and implementation are also addressed.

5.1 Live Multimedia Contents Delivery Scheme

Live multimedia contents must be synchronously delivered to mobile users. Accessing media stream through pure mobile Internet is not what mobile users want. Subscribe-notify interactive model can ensure serving users without missing their interested programs.

During service registration, live broadcasting CSPs should send weekly or monthly schedules as metadata to MMSP. Figure 5.1 shows an example. The field Access_URL of service item is a hyperlink (e.g., mms:// or rtsp://) for accessing media stream. Different media types for the same content may be provided. Mobile users may due to some reason want to listen or read text instead of watching. Therefore, media type should be selected before service starts.

Once committed, S-CSCF refers to the CSP to directly deliver the multimedia stream. Figure 5.2 illustrates the delivery scheme. MMSP establishes media sessions, recording the start and end time for billing procedure.

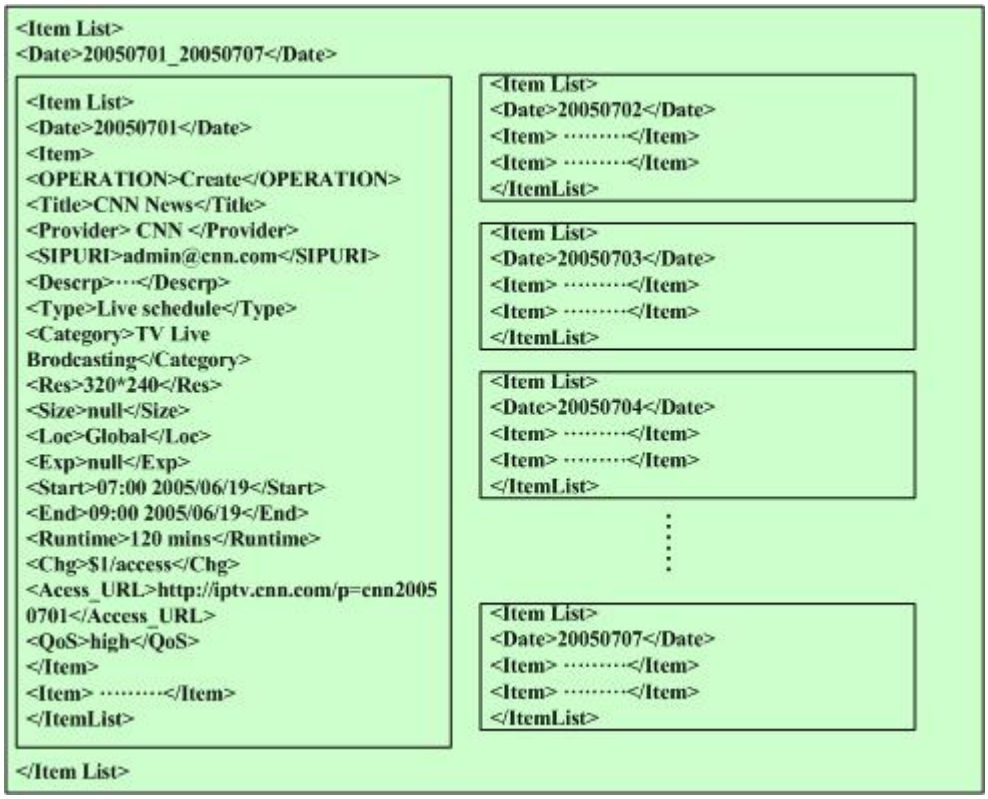


Figure 5.1 Registering weekly programs

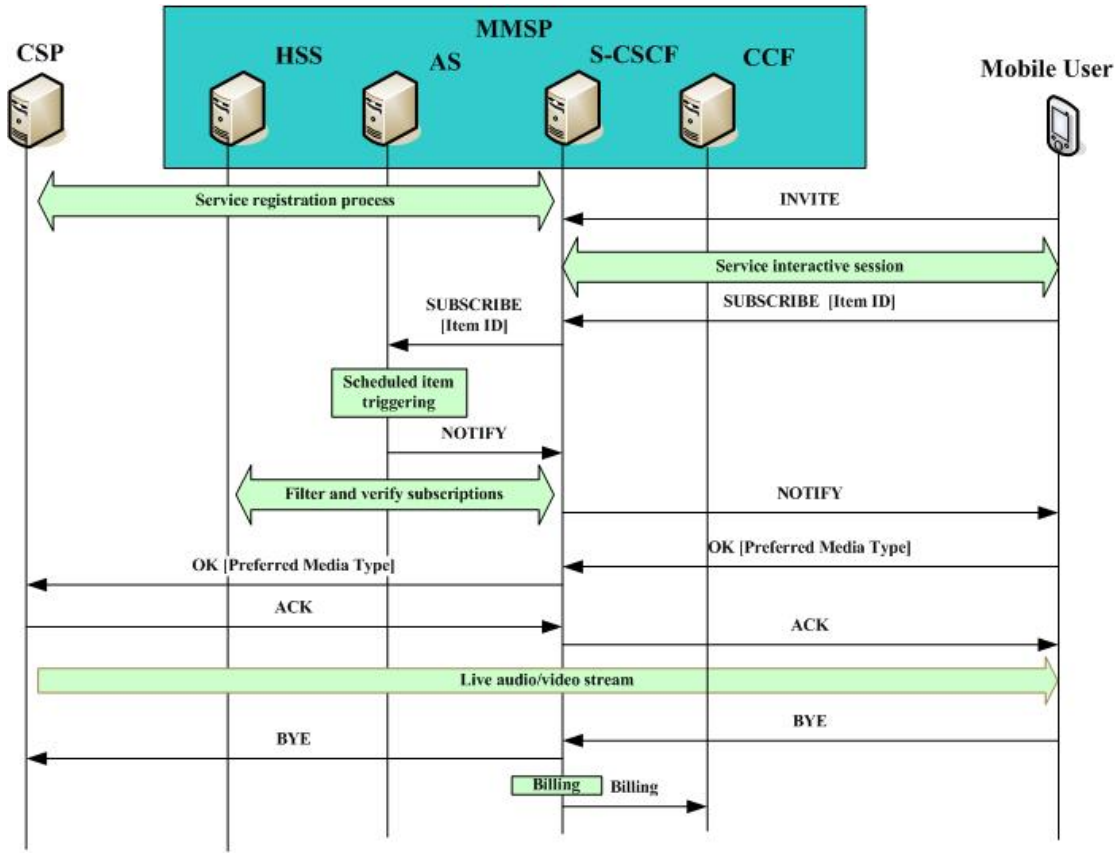


Figure 5.2 Live multimedia contents delivery scheme

5.2 On demand Multimedia Content Delivery Scheme

On demand contents are generally stored in CSPs' databases. Figure 5.3 illustrates the delivery scheme. Like live, only metadata is sent to MMSP. Once a series selected, MMSP does the same as live. Mobile users can subscribe their interested on demand programs and freely rewind and forward the programs within media session.

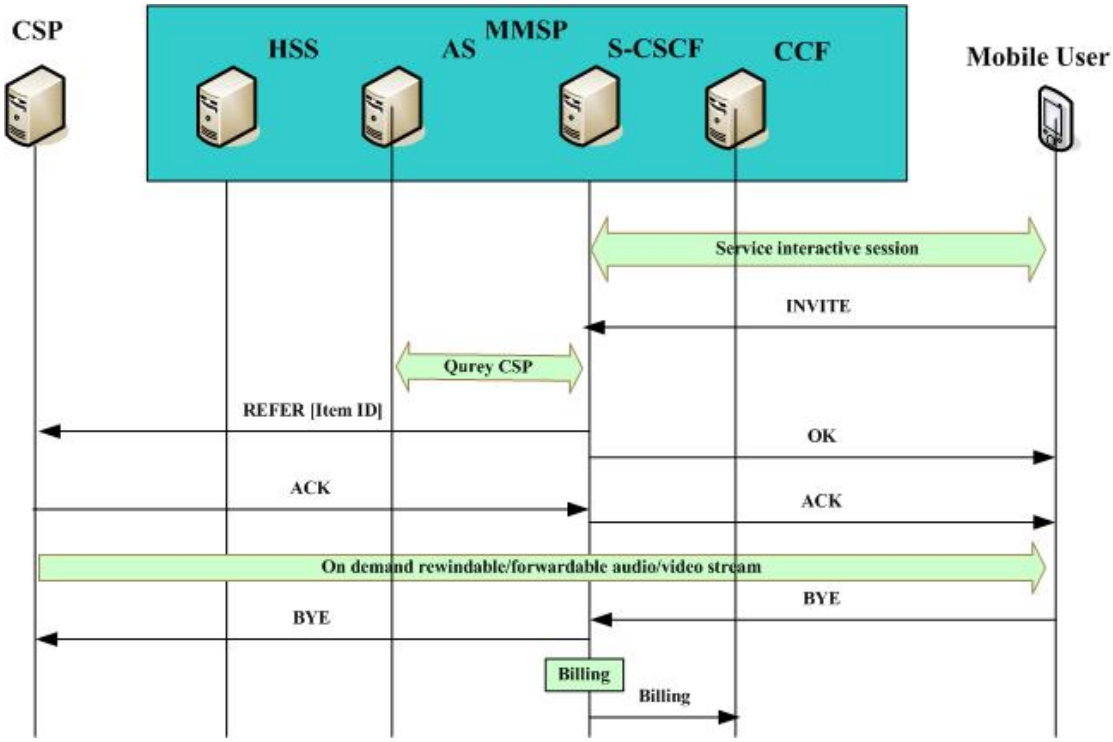


Figure 5.3 On demand content delivery scheme

5.3 Downloadable Multimedia Contents Delivery Scheme

Downloadable contents, generally tiny in size, are often represented in text and image. Figure 5.4 shows the delivery scheme. MMSP directly stores contents in AS as data objects. Once retrieved, they can be shown on UA without any transformation.

When a user enters local area, 3G/4G communication network may deliver location-based information to him/her who may then subscribe to receive the latest business information from local CSP.

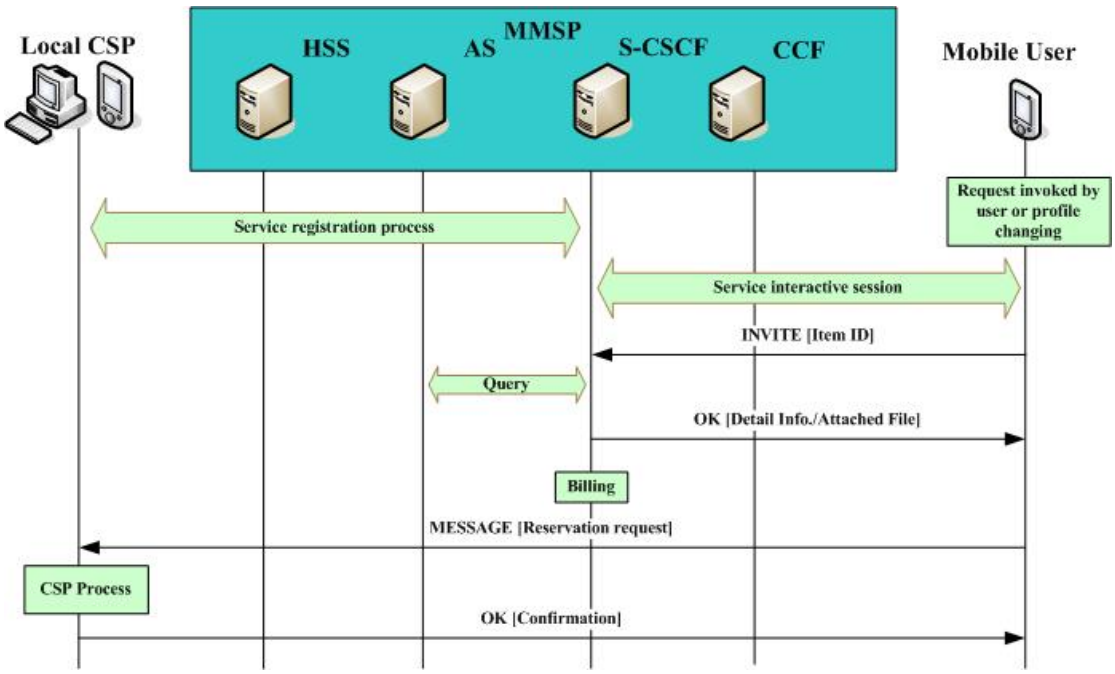


Figure 5.4 Downloadable content delivery scheme

5.4 Application Examples

Three applications, including Internet TV broadcasting, MOD/VOD and location-based services are performed as aollows.

5.4.1 Internet TV Broadcasting

The first application concerning Internet TV broadcasting is shown in Figure 5.5. Bob's UA sends an INVITE request to initiate a service interactive session, consequently receiving service category information and detailed metadata. After browsing Service List, Bob subscribes a program "Channel 8 evening news" which lives at 7 pm everyday. Additionally, Bob sets a receiving policy indicating he likes to watch this program only in the weekdays. MMSP keeps the subscription in HSS. When 7 pm approaches, AS triggers the upcoming scheduled item "Channel 8 evening news" and notifies S-CSCF to search HSS. S-CSCF finds out Bob's subscription, verifies its receiving policy and notifies Bob if today is a weekday.

Bob can decide to commit the service or not. If yes, he clicks the hyperlink contained in the notification as a confirmation. S-CSCF forwards the response to the Ch.8 TV streaming server which then sends an ACK through S-CSCF to Bob requesting him to declare the preferred media type, thus delivering the media stream to Bob's PDA which invokes an appropriate media player to play the stream. Wishing

to terminate the program, Bob closes the media player. UA sends a BYE message to the streaming server via S-CSCF which records the session status for charging reference.

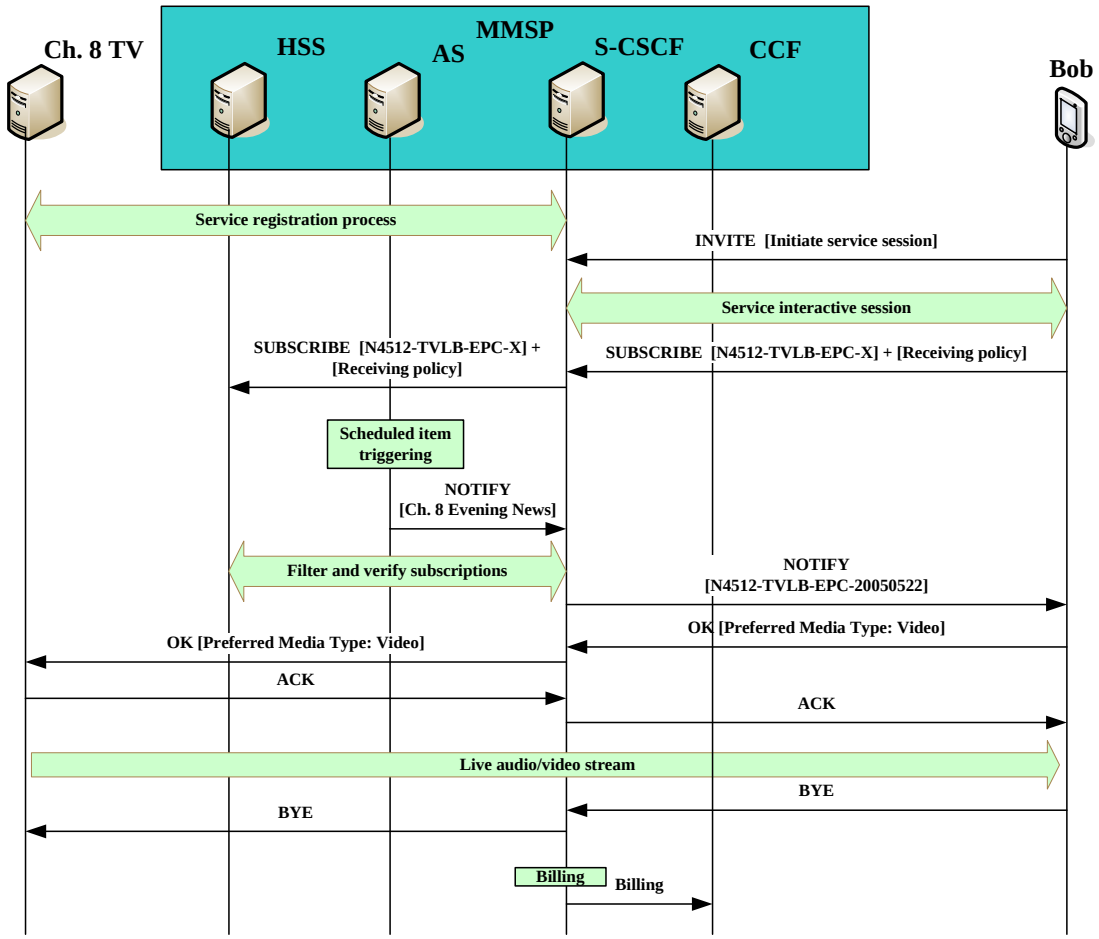


Figure 5.5 Application example of Internet TV broadcasting

5.4.2 Movie-on-Demand/Video-on-Demand Service

The second application concerning MOD/VOD service is shown in Figure 5.6. Now, Bob initiates another interactive session to browse MOD part of Service List. His UA sends an INVITE request including Item ID of the desired movie to MMSP. S-CSCF sends a REFER request to the corresponding MOD CSP with the Item ID. As acknowledged, S-CSCF sends an ACK to Bob to confirm forthcoming media session through which video stream is transported to Bob.

After watching the movie, Bob is interested in series drama “Star trek” of which new episodes is added per week. He subscribes it. After that, each time VOD CSP

registers the newest episode, S-CSCF will notify Bob.

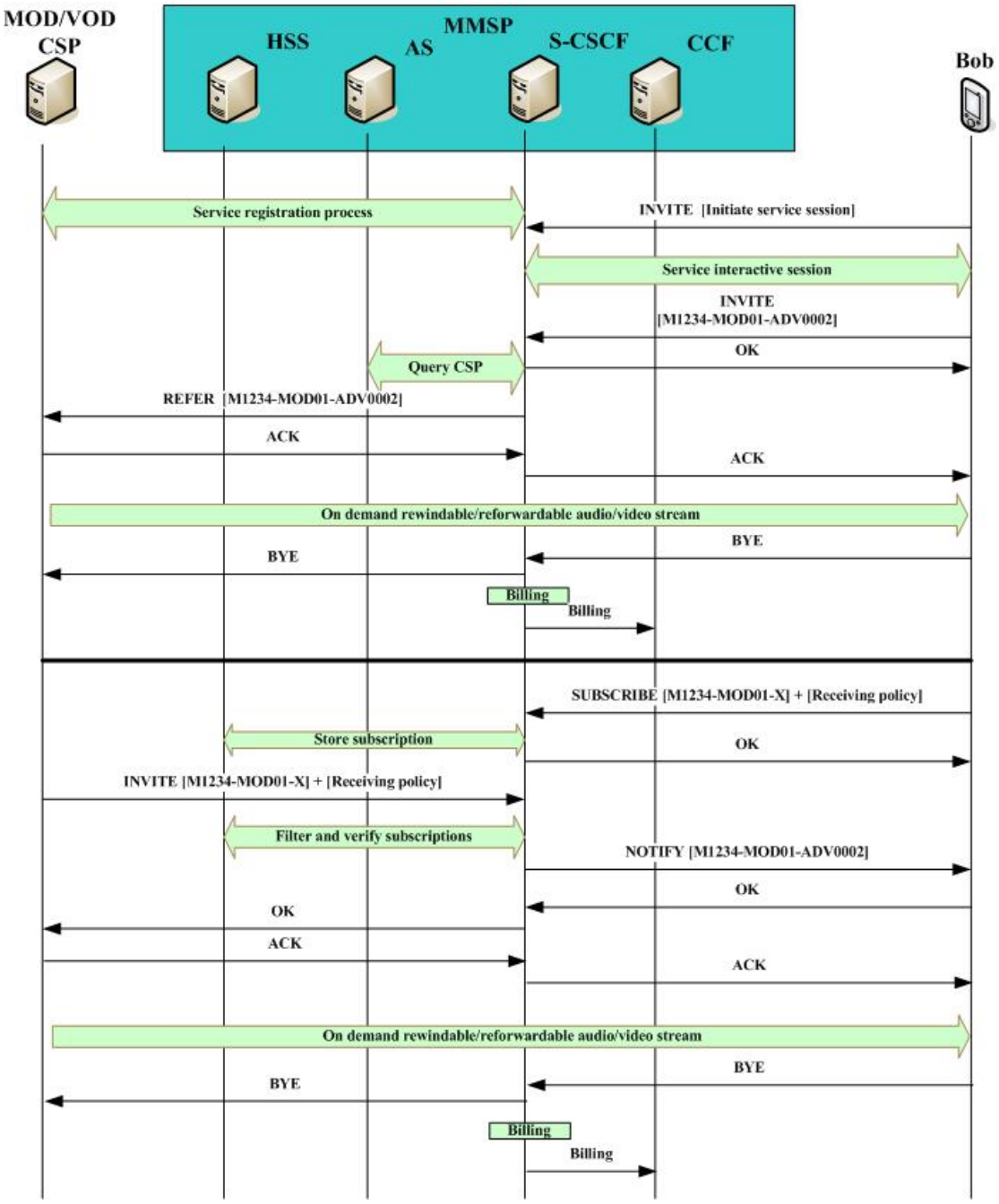


Figure 5.6 Application example of MOD/VOD

5.4.3 Location based information Service

The third application concerning location-based information service is shown in Figure 5.7. Now, Bob likes to retrieve local information of his living area, e.g., select a restaurant near both of his office and house. As selecting an Italian restaurant close to his office, he further retrieves its regular and daily special menu by sending an

INVITE request. Bob is also allowed to send a SUBSCRIBE request to receive its newest menu. Each time the restaurant updates its menu, MMSP sends a NOTIFY with the newest menu to Bob. If Bob likes to go, a MESSAGE for seat reservation will be sent directly. As committing the request, restaurant staff replies an OK via UA.

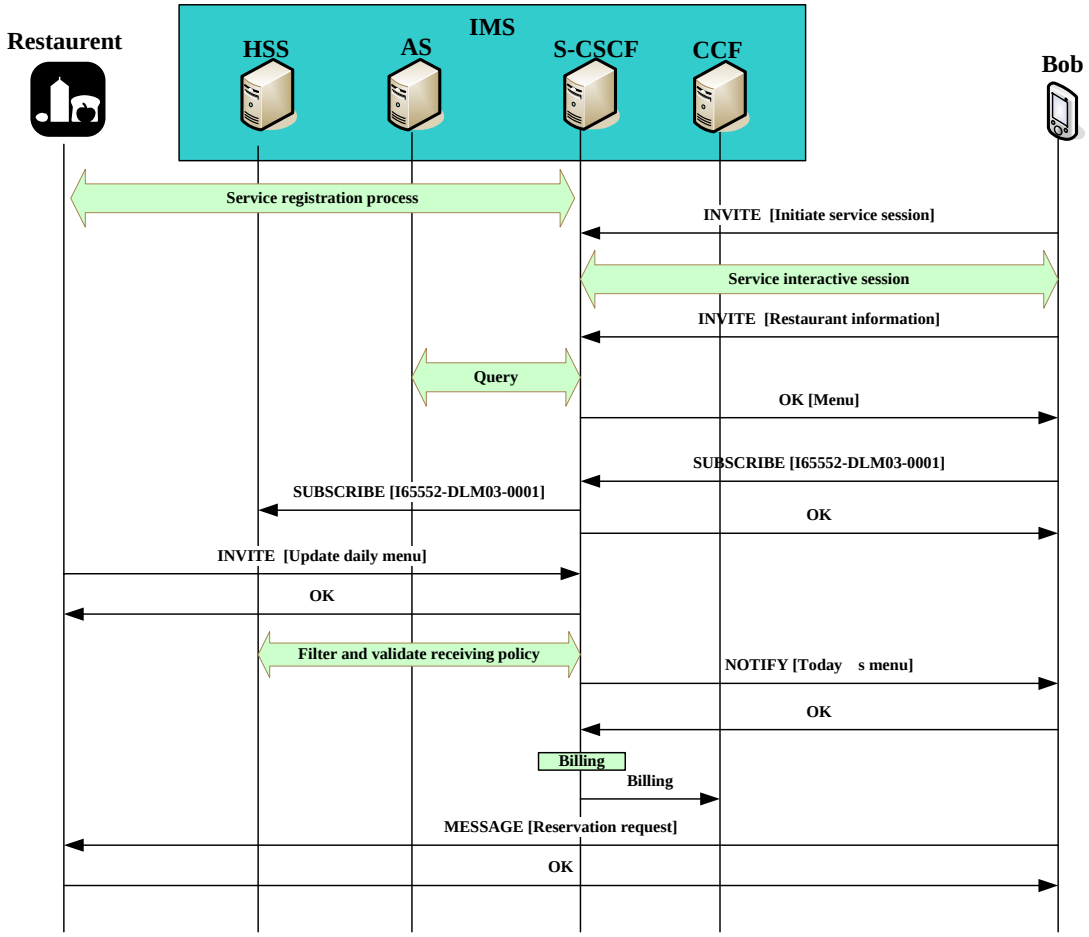


Figure 5.7 Application example of location based information

5.5 Implementation

The prototype of MMSP is implemented with Java language to exploit its cross-platform features. The implemented UA is given three functions, service browsing, subscribing and accessing. The service category user requests is listed on Service Category window as shown in Figure 5.8. While users select a category item, e.g., daily schedule and movie genre, UA further requests MMSP for the corresponding portion of Service List which is shown on Available Service window. Figure 5.8 and Figure 5.9 demonstrate the screenshots of requesting Internet TV broadcasting and MOD respectively. Description window briefly specifies the

selected item. The data comes from its Decrp field.

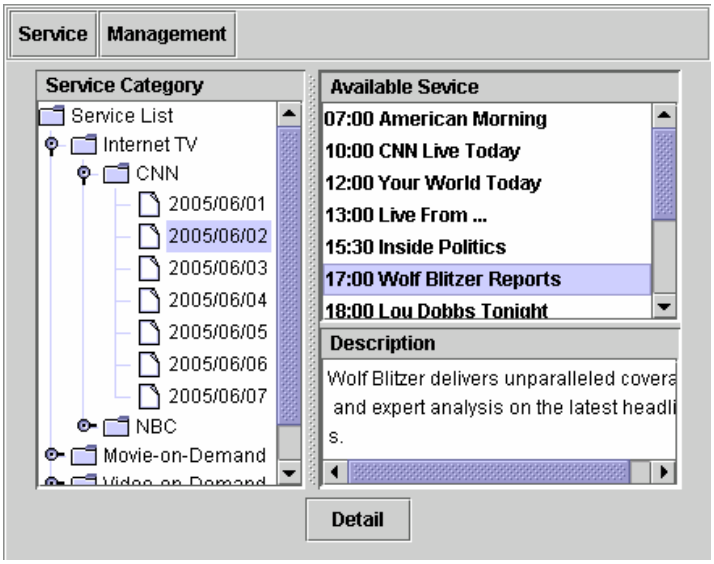


Figure 5.8 Service browsing on live multimedia items

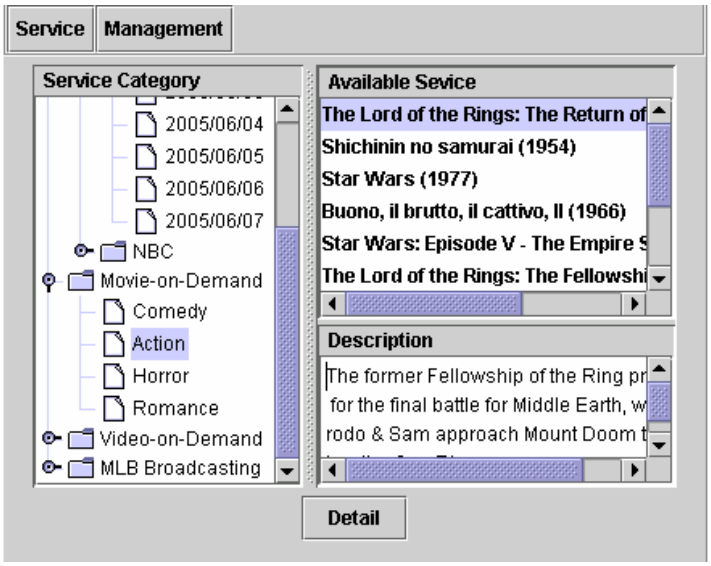


Figure 5.9 Service browsing on demand multimedia items

Figure 5.10 is the screenshot of subscribing a scheduled program of which the receiving policy dialog is shown in Figure 5.11. User may check and choose the desired constraints for receiving future notifications. Figure 5.12 is the screenshot of requesting on-demand service. Figure 5.13 reveals UA has received a notification, which is shown on Notification Message window. By clicking the attached hyperlink, the user can receive the media directly from CSP. Figure 5.14 presents the screenshot of playing a live program.

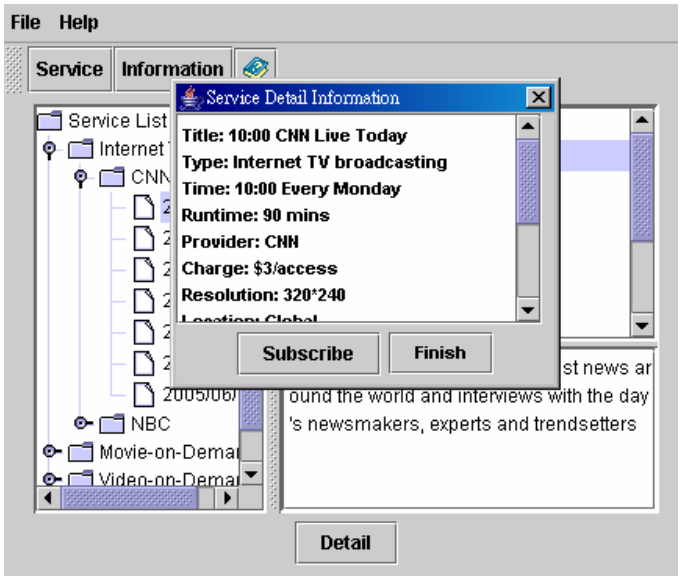


Figure 5.10 Subscribing a TV program

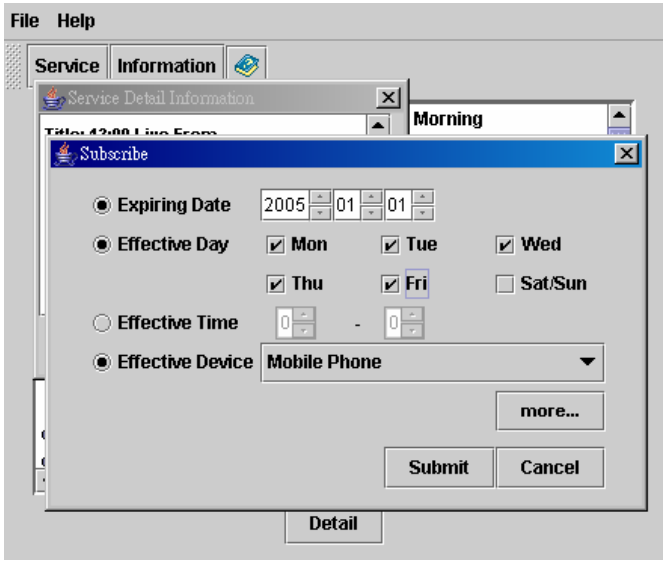


Figure 5.11 Setting a receiving policy

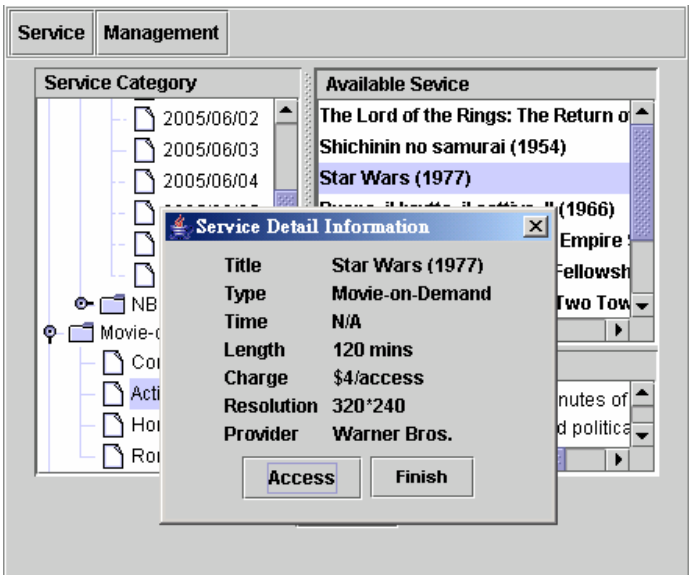


Figure 5.12 Requesting an on-demand program

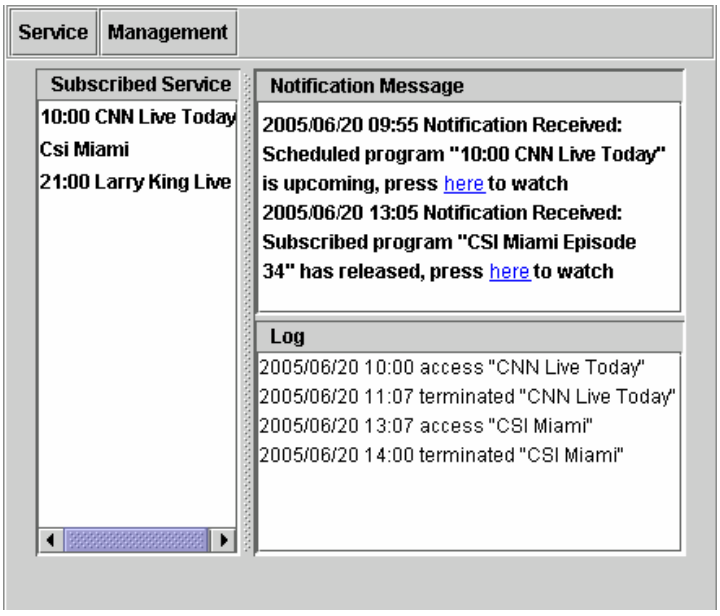


Figure 5.13 Notification messages in UA

Figure 5.14 Playing a schedule broadcasting program

Chapter 6. Conclusion and Future Work

This article proposes a mobile information service platform MMSP for 3G/4G heterogeneous networks. MMSP deploys 3GPP IMS to provide multimedia services to mobile users by cooperating with 3rd party CSPs. The major contributions are two-fold, lightweight service cooperation and service personalization. During service registration, CSPs send metadata instead of replicating capability-consumed contents to MMSP, which in turn organizes metadata into Service List as intermediary. But tiny-sized downloadable contents are fully duplicated to MMSP. Mobile users can browse Service List to acquire services. MMSP helps to establish a media session for CSPs to directly deliver contents to users with one of the three proposed delivery schemes. Furthermore, MMSP monitors session status to collect information for billing procedure. Owing to user mobility, we apply subscribe-notify interactive model to ensure users not missing any interested programs to achieve service personalization. Users can set up their receiving policies. Hence MMSP is able to notify them the upcoming or the newest subscribed contents in their preferred time, location and devices.

As comparing to the situation of duplicating full program to MMSP which instead of CSPs delivers contents to users, our brokering processes of live and on demand services, including resolving metadata for acquired contents, forwarding requests to corresponding CSPs and establishing a media session, consume additional time, which however is relatively shorter than the time required to deliver contents. That is why downloadable is stored in and delivered by MMSP, otherwise the cost is relative high. Moreover, MMSP of our scheme reserves less storage resources and spends less time for services since content delivery is distributively handled by CSPs.

Our future work will focus on migrating others existing Internet applications to MMSP, such as real-time financial information and personalized web page notification. Furthermore, a systematic coding mean for Item ID is also required to improve consistency and efficiency of service management.

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