INTRODUCTION

Streaming digital video over the IP core and access platforms, with various networking mechanisms, has come to be called mobile IPTV. This streaming technology considers the possible service transfer from wire to wireless/from wireless to wire that is in place to ensure quality of service/quality of experience (QoS/QoE). Mobile IPTV service can be deployed to meet several advanced challenges such as mobility, adaptability, ubiquitousness, and so on.

Mobility is the most critical factor in dynamically changing access points without an obstacle in order to adapt to the next generation network (NGN) environment. Also, different applications and services should be available with high quality in the fixed/mobile convergence environment and on the devices. We derive a novel architecture that is a multiprotocol label switching (MPLS)-based NGN architecture for QoS-guaranteed and efficient IP mobility management across fixed and mobile access networks. Optimizing the user-perceived QoE of the streaming media application through heterogeneous networks and on heterogeneous terminals represents a challenging issue in terms of the application level.

We provide the technique of video source coding that is based on the network resource awareness of the terminal capability processing methods for mobile IPTV service. Also, we propose a new display scheme for the display of a specific target scene, which considers the context-aware viewer’s visual sight to provide viewer-centric mobile IPTV service.

NETWORK LEVEL CHALLENGES AND ISSUES FOR MOBILE IPTV SERVICE

QoS SUPPORT FOR MOBILE NETWORKS

The NGN services such as data, voice, and video will be delivered through a common infrastructure. This infrastructure is based on the fixed/mobile convergence concept and has been evolving to a packet-based architecture utilizing IP protocols to improve the efficiency and support of IP applications [1, 2].

From the network provider’s point of view, the NGN is designed to support network operation and maintenance by guaranteeing acceptable QoS classes and satisfying the various service-level agreements (SLAs) negotiated with customers. To meet the requirements over NGN mobile services, the end-to-end performance first must be manageable and predictable regardless of whether the end nodes are moving or not. Second, for the IP mobility service, the functions of mobile agents are positioned after the consideration of architectural consequences. Third, the...
existing and future transport technologies must
be able to support a future mobile world [3].

Recommendation Y.1281 [3], “Mobile IP Se-

m Services over MPLS,” describes the service de-
finition, requirements, and application procedures
to support mobile IP [4] services over the MPLS
network. There is a strong interest in the MPLS-
based mobility control and transport for the
NGN. MPLS [5] provides signaling and trans-
port mechanisms to support QoS, traffic engi-
neering, virtual private networks (VPNs), and so
on. Most mobile networks have been evolving to
use IP transport, and most IP routers support
MPLS capabilities. Mobility requirements, such
as QoS, traffic engineering, and VPN could be
better satisfied by using the MPLS than in pure
fixed/wireless networks.

MOBILE IPTV SERVICE SCENARIO ACROSS
FIXED AND MOBILE ACCESS NETWORKS

According to the QoS negotiation, mobile IPTV
services support differentiated QoS classes. The
QoS class between a mobile node (MN) and a
service provider can be initialized at subscription
time. The QoS class is dynamically changed by
on-demand requests. As shown in Fig. 1, when
the MN chooses to connect one of the networks
or moves to another network, the MN requests
the mobile or fixed network information (e.g.,
bandwidth availability, time delay, and packet-
loss ratio of wired or wireless channel) to select
one of the detected networks (e.g., wireless local
access network [WLAN], wireless broadband
[WiBro], code division multiple access [CDMA]).
Upon receiving a solicitation from the MN, an
information server provides the mobile or fixed
network information related to the decision of
the handover or access. After it is connected, the
MN tracks the temporal properties (e.g., time
delay, packet-loss ratio, etc.) of the traffic stream
against the agreed QoS classes. For example,
when the MN detects that the QoS class has
gone down, it can handover the service to a new
network instantly [2].

It is expected that the MN can define the
access and handover policies to use its services.
After detecting the presence of a mobile network,
the MN can choose one of the networks to
obtain service, which is based on the QoS
class required for a particular mobile IPTV ser-
vice.

MPLS-BASED NGNs WITH
FIXED AND MOBILE CONVERGENCE

BACKGROUND ON THE
MPLS-BASED MOBILITY SUPPORT

The MPLS [5] backbone network can build the
large-scale mobile IPTV network. The label
edge router (LER) is capable of forwarding IP
packets by encapsulating them. The label encap-
sulating packet travels a particular route through
the MPLS network. The label is used to represent
the explicit route and is encoded by relevant
classification according to QoS. Unlike normal
routers, the MPLS label-switching routers
(LSRs) establish a path between the endpoints
of a connection in a network and send the pack-

ets across that path, called a label-switched path
(LSP), which is a virtual connection, sharing the
bandwidth of the physical circuit.

In contrast to connectionless routing, the
LSRs can define the parameters of the virtual
connection, including the allowable speed and
priority. This is crucial to the ability of the LSR
to manage bandwidth and the QoS. The MPLS
label achieves the original goals of the flow iden-
tification. The MPLS enables the precedence or
class of service to be fully, or partially, inferred
from the label.

To support mobile service, the MPLS net-
work must accommodate the mobile agents. By
combining or merging functions of the mobile
agents into the MPLS node, the MPLS network
is capable of handling the MN. The mobile
agents can be located in the MPLS nodes. The
two MPLS signaling protocols — Constraint-
Based Routing Label Distribution Protocol (CR-
LDP) and Resource Reservation Protocol with
Traffic Engineering Extensions (RSVP-TE) —
can be used to set up the LSP tunnel between
the mobile agents through the MPLS network.

NETWORK ARCHITECTURE FOR MOBILE IPTV

We derive a novel architecture for efficient IP
mobility management from these investigations.
The proposed architecture, called access inde-
dependent mobile service (AIMS), is composed of
two major features. The first feature is the actu-
al separation of the control channels from data
channels by using MPLS LSP. The second is
direct data forwarding between the MN and the
correspondent node (CN).

Figure 2 shows the proposed network archi-
tecture. The access networks positioned at the
edge of the IP/MPLS core network have some
points of attachment (PoA) such as access points
(APs) or base stations (BSs). The IP/MPLS-
Based core network has a control plane for supporting mobility that is separated from the transport plane. The control plane has local mobile agents (LMAs) and a global mobile agent (GMA). The GMA is connected to the LMAs, and an LMA is connected to a LER in the MPLS-base network. The LMA is connected to a resource and admission controller (RAC) and can exchange information related to the resource and connection admission for supporting mobility. Both the GMA and the LMA are used for supporting mobility.

In this architecture, mobility signaling messages are sent via control LSPs between the GMA and the LMAs for fast and reliable transmission. In addition, the control LSPs for the signaling messages are handled with a higher priority than the data LSPs used to transmit data packets in the IP/MPLS network.

In this architecture, the LMA manages mobility within an access network (AN). Once a MN is moving into an AN, both the MN and the LMA perform a registration or location update, such as a binding update in the mobile IP (MIP). The LMA performs a registration or location update of the MN with the GMA and maintains the information (e.g., the IP address in the visited AN) related to mobility management. The LMA can be used for a registration or location update by using link-layer information for fast mobility. It also can exchange information with the RAC for resource and admission control in accordance with the movement of the MNs. The LMA includes the location management function (LMF) and handover management function (HMF) to support mobility [6].

The GMA supports mobility between LMAs and performs registration or location updates through an LMA. To support fast mobility, the GMA can use the information of the link layer by means of a close relation with the LMA. Information can be exchanged with different GMAs for supporting the inter-core network mobility. It can include the LMF and HMF for supporting mobility.

A RAC can be centralized or distributed in networks. If it is distributed, it can be implemented in the LER. The RAC contains resource and admission control functions (RACFs) and executes resource management and connection admission for supporting mobility [7]. For example, the RACF is responsible for resource allocation and connection admission if the MN requests connection by executing a handover.

An information server (IS) can store mobile or fixed network information for MNs such as bandwidth availability, time delay, and the packet-loss ratio of a wired or wireless channel. When a MN chooses to connect with one of the networks or moves to another network, the MN can request that the mobile or fixed network information select one of the detected networks so the stored information can be used.

The mobile service control system (MSCS) can be deployed in a centralized or distributed form. If it is distributed, the MSCS can be located in the GMA and LMAs. The MSCS is responsible for signaling, authentication and authorization, session control, user profile, and so on. These are all required by the MN when it performs mobility.

**Main Features of MPLS-Based NGN Architecture**

If an MN performs a handover, the IP address of the MN may be changed. In this case, the MPLS capabilities can support the change of the IP address. The MPLS capabilities also support regional mobility management. If an MN changes its location, the sub-system covering both the old and new location of the region is responsible for the mobility but not for the whole mobility management system [2].
The MPLS capabilities can cooperate with the handover management functions for maintaining session continuity during the movement. It supports a fast handover to cater to seamless non-real-time and real-time service requirements.

The LSP used for the session-based services can be established either on demand or by management procedures. Session parameters (e.g., bandwidth availability, time delay, packet loss ratio, etc.) for Session Initiation Protocol (SIP)-based or Session initiation Protocol (SIP) based application services could be applicable to establish the transport sessions.

The QoS commitments (e.g., jitter, loss, bandwidth, delay, etc.) for application services can be supported. Different types of QoS classes for application services are supported although network resources are limited. For efficient packet transmission, direct data forwarding is possible between the CN and the MN.

**APPLICATION-LEVEL CHALLENGES AND ISSUES FOR MOBILE IPTV SERVICE**

**USER-, TERMINAL-, AND NETWORK-AWARE QOE-GUARANTEED VIDEO SERVICE TRANSFER**

Mobile communications over a wide area have become more and more popular because of the emerging wireless IP networks and services. However, multimedia transmission and streaming services suffer from an unreliable connection and heterogeneous bandwidth to the different receivers. The multimedia streaming service, which is aware of the network resource, is still a critical topic for user-perceived QoE-guaranteed service. For example, if a user wishes to watch a fast moving video with content such as sports or dance, a much higher bit rate is required than for a user watching a slow-moving video. The bandwidth allocation in the distribution network will be very different for these two users to ensure that both users receive the same QoE. The bit rate required for the delivery of content at a fixed quality varies. Therefore, the priority of an individual video stream must be allowed to vary correspondingly both over time and from one stream to another.

Also, the personal mobile IPTV broadcasting service considers that the QoE-guaranteed video contents are transferred seamlessly between heterogeneous devices based on each user profile. The user currently has various handheld devices. It is always possible to buy an additional new device and use more than one at the same time. In this case, to maintain a high QoE-guaranteed video service for the specific devices that a user owns, all of the terminal capability information is associated with each user subscription profile on the home subscription server (HSS) system. The HSS function is defined as one of the subscriber functions of an IP multimedia subsystem (IMS) service network that is contained in the initial filter criteria.

Access to the supporting terminal capability and user profile information must be coordinated so that the context of the desired service can be received from the originating device to the target client device. This service involves seamlessly transferring QoE-guaranteed video and displaying it between different devices based on user profiles. To display the proper scene, the HSS, application server (AS), and softswitch (SSW) systems are composed to provide video streams seamlessly for the heterogeneous devices environment. These systems consider both the terminal capability and the user profile for personal mobile IPTV broadcasting service as shown in Fig. 3. The HSS system controls and matches all of the profile information in terms of service providers, users, and devices. A call session control function (CSCF) can either play the role of a proxy (P)-, interrogating (I)-, or serving (S)-CSCF for seamless session controls.

The personal mobile IPTV broadcasting service is more suited for transferring real-time sessions. Basically, it supports the capture of the session control information from the originating terminal device and transferring it to the target terminal device. This is done by a session control function that enables a user to have heterogeneous mobile devices. For the scenarios to provide a personal mobile IPTV broadcasting service, the provider would first find an available network resource for streaming (e.g., bandwidth, multicast address). Then, it would give this information to a content providing end-user that is controlled by the HSS. This example is shown in Fig. 3 as illustrated at a football stadium. Second, the content providing end-user sends an extracting video stream by first considering the liquid crystal display (LCD) panel sizes of heterogeneous devices. It also considers an actual broadcasting video stream with multicast or multiple unicasts by using the information in the AS. Third, the receiving client in the mobile environment may be able to select a specific content. This will be based on user profile and terminal capability with logical source information provided by content search results. In this process, service control functions may participate in session routing information gathered by the SSW. This message contains actual content address and session information for receiving it. Fourth, the receiving client devices in the mobile environment can request a content delivery function to join the session. The receiving client devices obtain the content from the content delivery function that is designed and located in the AS. Together, the providing functions in the HSS, SSW, and AS control all of the service providers, end-users, and terminal capability.

The IPTV contents provider provides a video stream on several heterogeneous devices, for example, a cellular phone, PDA, computer, or HDTV (IPTV), and so on. These devices have various LCD panel sizes and different resolutions from small to large, as these are heterogeneous networks (e.g., WLAN, WiBro, CDMA). The viewer can feel very uncomfortable if the multimedia content transfers from a widescreened LCD panel to a small-sized LCD panel without considering the resolution and aspect ratios. The user may not recognize the scene that appears on the device in the mobile IPTV service environment. Quality degradation due to down-sampling, up-sampling, encoding, and so on in the delivery channel can occur for a mobile IPTV service.
The term resolution is often expressed as a pixel count and as the spatial dimension in digital imaging that is captured and displayed on a device. The resolution is defined by three cases: low resolution (LR), high resolution (HR), or super resolution (SR). Consider the following case: an LR image captured by a mobile phone has a resolution of 128 * 128, but we would like to display it on a higher resolution screen of 1024 * 768. SR processing techniques are required so that the blurring effect can be reduced to improve user-perceived QoE. In this case, additional and complicated processing techniques are required to convert the LR image to a higher one. The aspect ratio of an image is defined as its width divided by its height. If an image is displayed on a device with an aspect ratio different from that of the image, modification is required, and it is an interesting issue for frame rate conversion.

Table 1. Frame resolution and aspect ratio comparison of heterogeneous devices.

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Aspect ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDTV</td>
<td>640 * 480</td>
</tr>
<tr>
<td>HDTV</td>
<td>1920*1080</td>
</tr>
<tr>
<td>Computer-VGA</td>
<td>640*480</td>
</tr>
<tr>
<td>Cellular phone</td>
<td>128*128</td>
</tr>
<tr>
<td>PDA</td>
<td>320<em>200/480</em>320</td>
</tr>
</tbody>
</table>

Figure 3. Configuration of personal mobile IPTV broadcasting service considering terminal capability and user profile.

The AS system extracts scalable-based multiple video streaming from the original video content that depends on the target terminal types and the allowable bandwidth of delivery channels. The AS system does this by using scalable video coding (SVC) technology for the heterogeneous devices that are aware of the mobile IPTV service. For non-scalable video content, the original video content should be prepared separately for the types of target user terminals and delivery channels. It is not desirable to maintain different versions of video bitstreams of the same content depending upon specific target device types and allowable bandwidth of the delivery networks.

To support a variety of user terminal devices and delivery channel capabilities, a joint standardization activity by the International Standards Organization/International Electrotechnical Commission (ISO/IEC), the Moving Picture Experts Group (MPEG), and the International Telecommunication Union-
Telecommunication (ITU-T) was developed. This SVC technology that targets flexible and efficient representation of scalable video streams uses a single bitstream to provide multiple spatial, temporal, and quality resolutions. SVC allows only for one-source-multiple-use by a single encoding; therefore, it produces flexible video bitstreams at different scalability layers with high coding efficiency on mobile IPTV systems. Figure 4 shows how the SVC encoder can produce scalable bitstreams at different scalability layers.

Each layer is encoded with separated encoders and the input video stream is spatially decimated to support multiple spatial resolutions. For each spatial layer (or signal to noise ratio [SNR] layer), the prediction comes from either a spatially up-sampled, lower layer picture or temporally neighboring pictures at the same layer. Because the information of different layers contains correlations, an interlayer prediction scheme reuses the texture, motion, and residue information of the lower layers to improve the coding efficiency at the enhancement layer [10]. The prediction module must interpolate when a layer is up-sampled to a different spatial resolution. SVC supports a non-dyadic spatial resolution ratio among spatial layers. Temporal prediction utilizes the hierarchical-B structure [11] to support multilevel temporal scalability.

Temporal scalability is a technique that enables a single bitstream to support multiple frame rates. It is typically supported with a predetermined temporal prediction structure as defined by the standard. In MPEG-2/4, temporal scalability is achieved by the well-known IBBP prediction structure. Up to three frame rates are supported by decoding only I-pictures, either I- and P-pictures, or all of the I-, P-, and B-pictures, respectively. The motion-compensated temporal filtering (MCTF) structure can be used as a preprocessing tool for better coding efficiency.

Although the SVC makes the scalable representation of video contents with high coding efficiency possible, the complexity of the SVC encoder is quite high so that currently, real-time encoding is very difficult to achieve. Thus, the optimization of the SVC encoder is very important to greatly improve the encoding speed. As well, the useful SVC rate control mechanism is being researched to produce the best possible visual quality of bitstreams for the heterogeneous network capability with bandwidth.

SVC addresses several technical issues in new ways as follows:

- A hierarchical-B structure is used to support multilevel temporal scalability.
- Intra-texture, motion, and residue predictions are used to exploit correlations among spatial and SNR coding layers.
- The enhancement layer information is used in the prediction loops to exploit temporal redundancy.
- The context adaptive entropy coding and the cyclic block coding result in improved coding efficiency.

Finally, SVC can be used for various applications such as multi-resolution content analysis, content adaptation, complexity adaptation, and bandwidth adaptation.

Despite the high complexity, SVC is an attractive technology for various applications due to its ability to efficiently represent scalable video streams.
To provide the QoE guaranteed service that satisfies the visual expectation of the viewer, the specific context-based extracting methodology should be applied to the contents on devices together with the considered LCD panel size of the targeted device.

**CONTEXT-AWARE QOE GUARANTEED VIDEO DISPLAY**

The display of a specific target scene that considers the context-aware viewer’s visual sight is one of the important factors in providing viewer-centric mobile IPTV service. When the original content for a large LCD panel is transferred to a small LCD panel, the video sequence captured for normal viewing on a standard IPTV may display an adverse effect. The viewer trying to view the image on the smaller display may have an unsatisfactory experience (Fig. 5a). To provide the QoE-guaranteed service that satisfies the visual expectation of the viewer, the specific context-based extracting methodology [12] should be applied to the contents on devices together with the considered LCD panel size of the targeted device.

The \( i \)-th frame of the \( n \)-th image for various LCD panel sizes of heterogeneous devices (HDs) that provide compatible scenes that consider the viewer’s visual sight is denoted as \( HD[i,n] \). According to the image classes in the video streaming and the viewer device capabilities in the HSS system for a personal mobile IPTV broadcasting service (Fig. 3), \( HD[i,n] \) may correspond to the entire display frame and determine image classes by the following procedures. For the procedure, if \( HD[i,n] \) equals to the original image, the image can be displayed as a whole frame. However, if \( HD[i,n] \) unequal and smaller than the original image, the image can be resized to \( HD[i,n] \), and the specific target scenes determination can also be used. If \( HD[i,n] \) unequal and bigger than the original image, the image is chosen again by the specific target scenes determination. For the previous processing case, a long distance image can be applied for the personal mobile IPTV broadcasting service at the same time. Video streaming services are broadcast and displayed on mobile devices such as a PDA, or mobile phone, and so on in any mobile environment. The methodology of pixel-based segmentation and any specific, target-image context detection is used for the case of a long distance image. In the case of an equal and non-long distance image, it is not necessary to determine. However, for cases of a long distance image, it absolutely must be determined and magnified to provide a more acceptable view of the specific target scenes (Fig. 5b). Each frame is classified into either \( HD[i,n] \) smaller than the original image or \( HD[i,n] \) bigger than the original image after the image class decision.

To display the target context for devices that have different LCD panel sizes, the simple method uses the location of a target context and applies the information to match at the center point of the screen size. However, it is not easy to determine which object is the specific target context in various LCD panel sizes in real time.

Usually objects from the video stream move unsystematically and are located at different positions. For the processing, a binary map is maintained, which is just an inverse of the scene(x,y) to detect the LCD panel size. If the scene(x,y) of the original image is bigger than the LCD panel size of the \( HD \), the binary map(x,y) is 0; otherwise, it is 1 in the first analysis. In this case, the scene(x,y) is computed by starting from the inter center and going to the outer block. After that, to extract each object in an image before extracting the specific target context, the minimum bounding rectangles (MBRs) are used. Each object has attributes, such as the MBR’s aspect ratio, average value, and number of pixels. According to these attributes, each object is categorized into a specific target context of viewer-targeting candidates. For extracting the target context, a simple and causal method must be used for real-time processing. Furthermore, the specific object-based acceleration scheme, using a decision tree, is applied to handle a case where a target context is moving very fast throughout the frames. First, the longest-tracked, specific target object candidate has the highest probability to be a target context. This strategy can minimize the influence of the object candidates. We maintain a candidates list and keep adding the newly found candidates to the decision tree. Each candidate has its own age. In the next frame, candidates are succeeded by the closest object in terms of both spatial distances and attributes. If a successor has an attribute of an object, it is kept on the list, and its age increases. In contrast, if a successor does not have a similar attribute to a target context, its age in the list is decreased. The oldest candidate is chosen as the most probable candidate. An object whose age is less than zero

![Context-aware QoE guaranteed video display for heterogeneous devices.](image)
is removed from the list. With this scheme, the specific target context can be extracted with high accuracy.

CONCLUSIONS AND FUTURE WORK

The demand on the guaranteed QoS/QoE of the flexible media content conversion through the heterogeneous networks and the display heterogeneous terminals will increase as much as the mobile IPTV service, which developed rapidly in residential and business communication markets.

The behavior of the mobile IPTV application in the business context is to request resources from a supporting heterogeneous network so that high quality is ensured; this includes mobility technology among the heterogeneous networks to maintain a high QoS and QoE. At the same time, the deployment of mobile IPTV service incorporates enormous challenges in each heterogeneous terminal that is aware of the multimedia stream-processing technology to provide a service that is associated with a high QoE by users.

In this article several related, active research issues for mobile IPTV service are highlighted, and some new research directions were indicated.

- Derivation of a novel QoS-guaranteed MPLS-based NGN architecture and technologies that enable end-to-end IPTV service in a mobile environment.
- Ability to correlate the impact of networking issues, terminal capability, and user profile at each of the video stream applications for mobile IPTV service.
- Overview of the SVC coding technologies with provision of the encoder structure of SVC in temporal and spatial scalability, as well as SNR layers for mobile IPTV service.
- Context-aware viewer-centric display procedure for mobile IPTV service.

Despite the promising advances in the research achieved by convergence of the network and multimedia in optimizing the QoS/QoE, there are still many specific challenges that must be addressed, such as the optimal resource allocation for large-scale multi-user systems and adaptable multimedia processing for triple-play mobile IPTV services.

REFERENCES


BIographies

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