A Practical Experiment on Mobile Data Broadcasting

Network-linked services and location-aware services

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Abstract— This paper describes an experiment that evaluated the feasibility and advantages of mobile data broadcasting services that will be launched in Japan in 2006. Network-linked services and location-aware services are distinct applications of the mobile broadcasting services. The network-linked services will enable users to obtain content data from broadcast and communication networks, while the location-aware services provide each user with location-based information. The experiment was performed with the prototype receivers receiving actual broadcast waves and data from the mobile Internet. The trial service contents and the prototype broadcast system were also developed. We discuss the appropriate distribution of broadcast and network content.

Keywords— Digital TV; Mobile Applications; Service Composition; XML; Location-based Services

I. INTRODUCTION

Integrated Services Digital Broadcasting (ISDB) services were first implemented in Japan in 2000 in the form of ISDB-S (Satellite) systems. Terrestrial services, i.e. ISDB-T (Terrestrial), were initiated in December 2003. The ISDB-T system uses Band-Segmented Transmission-OFDM (BST-OFDM) modulation that enables not only high-quality digital HDTV and data service but also mobile reception of digital broadcasting. Services for mobile receivers are scheduled for launch at the beginning of 2006. Since these services mainly target cell phones with embedded Digital TV (DTV) tuners, broadcasters can provide information via not only broadcast channels but also via the communication network. Thus, network-linked data broadcasting services and location-aware data broadcasting services will be possible through mobile reception of digital broadcasting.

So far, we have been working on developing network-linked data broadcasting services that efficiently utilize the communication channel. Since the prototype mobile DTV receivers are beginning to be designed and tested, we carried out an experiment with prototype receivers in an environment comprising actual broadcast waves and Internet connectivity. We also developed a prototype broadcast system and the trial contents and evaluated the feasibility of the services delivering these contents.

The following section begins by explaining the ISDB-T system for mobile services. After that, the experiment we conducted is described and the operability and effectiveness of the network-linked and location-aware data broadcasting are discussed. We also consider what the most effective combination of broadcast and network content would be.

II. ISDB-T SYSTEM FOR MOBILE SERVICES

This section outlines Japanese mobile digital broadcasting services in terms of their modulation, transmission, protocol stacks and data broadcasting.

A. Modulation and Transmission System

BST-OFDM enables not only wide-band service for home receivers but also simultaneous high-error-tolerant reception for mobile receivers within the same radio channel. The 5.6-MHz band assigned to each broadcaster is divided into thirteen segments (Fig. 1). One of them has been assigned to mobile services that will start up in 2006 while the other 12 are now being used for high-bit-rate HDTV services that were initiated in 2003 for home receivers.

Since mobile reception services use a very robust modulation parameter, the mobile service has only a very limited bandwidth compared with HDTV services. Although the total transmission rate varies widely depending on the transmission parameters of OFDM, we currently believe that approximately 320 kbps can be achieved by assuming parameters appropriate for mobile reception.

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B. Protocol Stacks

Within such a narrow bandwidth, mobile service is provided using MPEG-2 systems, i.e. MPEG-2 Transport Stream (TS) containing MPEG-4 AVC video and MPEG-2 AAC audio streams. Fig. 2 illustrates the protocol stacks of ISDB-T’s mobile digital broadcasting service.

Data broadcasting is also available for mobile services, since the receivers are capable of browsing BML (Broadcast Mark-up Language) content. BML is a multimedia content mark-up language based on XHTML. The data broadcasting service enables broadcasters to provide text and graphics based information about TV programs as well as news and weather. Fig. 3 shows example screenshots of the mobile receivers.

C. BML (Broadcast Markup Language)

BML is an XML-based multimedia coding scheme, which is defined in ARIB STD-B24 [5]. Multimedia data services were started in Japan by using BML for fixed receivers in December 2000. Table I shows the composition of the BML specification. Some enhancements for broadcast use were made, for example, video stream synchronization and new APIs to invoke external functions.

D. Mobile Profile for BML

For mobile services, new functions that are specific to mobile services are being discussed and an additional BML profile for mobile receivers is bound to be specified by the final quarter of 2004. Although the fundamental structures are the same, the mobile profile specifies enhancements specific to mobile services as well as some restrictions on functions (tags, APIs, etc.) to fit the relatively low performance and small screen of mobile receivers.

Notable features of the mobile profile are functionalities for network access and acquiring the receiver’s location. Network access is realized by hyperlinking to network resources like the World Wide Web. Thus, content authors can compose the service by combining broadcast and network contents seamlessly. These network contents are also written in BML as parts of a broadcast service sequence. Location acquisition will also be possible through the ECMAScript API instructing the receiver’s resident functionality to acquire its geographical location (i.e. latitude and longitude).

III. EXPERIMENT

We performed an experiment to prove the feasibility and the advantages of the mobile data broadcasting services. We first describe the prototype network-linked and location-aware broadcasting service for the experiment. Then we describe the environment and conditions of the experiment and discuss the results.

A. Prototype Services for the Experiment

So far, we have proposed network-linked data broadcasting and location-aware data broadcasting as distinctive services for mobile broadcasting [1][2]. Network-linked data broadcasting enables viewers to obtain BML contents from both broadcast channels and network servers on the Internet. Usually, users start viewing contents from the top BML page on the broadcast-side, then they trace hyperlinks to other pages and at some point go to the server-side BML pages.

In location-aware data broadcasting, users can obtain location-specific information depending on where each user is. For example, a user can acquire the weather forecast for their exact location.

For the experiment, we developed a trial emergency broadcast information service for use in a major disaster like a large earthquake, assuming that this would be a most characteristic example of a network-linked and location-aware service. The trial service offered the three kinds of information listed below.

### TABLE I. Specifications in BML

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Specification</th>
<th>Standardization</th>
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<tbody>
<tr>
<td>Tagging rule</td>
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<tr>
<td>Base tagsets</td>
<td>XHTML 1.0</td>
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<td>Presentation</td>
<td>CSS level 1/2</td>
<td>W3C</td>
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<tr>
<td>Dynamic changing</td>
<td>DOM level 1/2</td>
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</tr>
<tr>
<td>Scripting language</td>
<td>ECMAScript</td>
<td>ECMA</td>
</tr>
<tr>
<td>TV service specific enhancements</td>
<td>ARIB STD B-24 part 2, etc.</td>
<td>ARIB</td>
</tr>
</tbody>
</table>
• Evacuation area information: By showing a map including a few evacuation sites close to a viewer depending on his/her location, even a stranger to an area can get the exact information on where the nearest evacuation sites are and how to get there.

• Health status registration: Viewers can register personal information such as health status, whether or not he/she had evacuated, where he/she is, and messages. The registered data is stored on the broadcaster’s database.

• Health status search: Viewers can query the status of a person by name. The search uses both broadcast data and network querying.

Through the experiment, besides proving the feasibility of the services, we wanted to learn the most effective distribution of broadcast and network contents.

B. Conditions and Environment

1) General Conditions
To evaluate the feasibility of the services, the experiment was carried out under close to actual operation conditions. For this, we developed a prototype broadcast system that could transmit actual test-broadcast waves and use an actual mobile network.

2) Prototype Receivers
The receiver was able to receive actual broadcast waves and connect to the mobile Internet at the same time. It also supported the protocol stacks for decoding of video, audio, and the mobile profile of BML. It also had a location acquisition capability.

Figure 4. Prototype mobile receivers – cell phone type (left) and handheld type (right)

Two different types of receiver were developed for the experiment. One was a cell phone with mobile DTV functionalities (Fig. 4, left), and the other was a stand-alone handheld mobile DTV receiver (Fig. 4, right) that had a larger screen and fewer buttons than the cell phone type. Both receivers were fitted with the capabilities described above.

3) Prototype Broadcast System
The prototype broadcast system (Fig. 5) could distribute contents via both broadcast channel and communication network. Broadcast video, audio and data were multiplexed into an MPEG-2 TS stream and transmitted by using OFDM modulation. The network server stored contents for Internet distribution and received viewers’ responses. The server could generate a dynamic response to a user’s request while the system could modify the broadcast content, dynamically.
reflecting the latest update of database in real time. Therefore, each element of this system had to be able to connect to and coordinate with each other.

4) Transmission Parameters

Table II shows the components of the service and the rate distribution used in the experiment. The total transmission rate derived from the modulation parameters was 312 kbps. The actual average total was approximately 300 kbps considering fluctuations in the video and audio streams. The rate of PSI/SI (service information such as synchronizing clock, multiplexing parameters, program name, etc.) was logically decided from the service composition. In general, a trade-off between video/audio quality and required data transmission speed determines the rate distribution for video, audio, and data. However, we used the MPEG-4 Simple Profile for the video encoding in the experiment because an MPEG-4 AVC decoder had not been implemented in the prototype receivers, and therefore, we could not evaluate the actual video quality of the mobile service. We assigned tentative values for video, audio and data by considering the existing encoding quality estimation and by satisfying the requirement for our trial service. Thus, 40 kbps was available for data broadcasting.

The total size of the data broadcast content was determined from the bit rate and transmission cycle of the data stream. The transmission cycle determines how soon data content is provided after a user tuned to the channel. We assumed that the waiting time should be less than 8 seconds, and thus set the maximum content size to 40 kBytes in the experiment. This means only 40 kBytes of data could be provided by broadcast at any one time and the rest of the data had to be provided via the Internet. We had to take this limit into account and select which data should be on the broadcast side and which should be on the server side.

C. Results and Considerations

1) Service Composition using Broadcast and Network

It is vital in composing network-linked broadcasting services to choose the appropriate distribution path for each content element according to their characteristics in order to maximize the advantages of each transmission path. Table III summarizes the broadcast and network characteristics.

Broadcasting has a great advantage in not having any transmission congestion. Therefore it is suitable for providing many people with general information such as nationwide news, weather information, entrance pages, etc. But broadcast data are sent using the MPEG2 data-carousel transmission scheme, in which the same data are sent repeatedly in a certain amount of time, and therefore, the amount of transmittable data is limited, especially for mobile services.

On the other hand, the advantages of a communication network are its capability of sending different contents to different users and generating contents dynamically in response to user requests. This feature enables personalized content to be offered by broadcasters. The weakness of any communication network is an innate congestion problem, but this can be dealt with to some extent. For example, it is effective, when composing the broadcast content, not to let many people access the server at the same time.

As shown in Table IV, we designed the trial content to use broadcast for most of the BML documents, small graphic images, all data on the evacuation site’s name and location, and as many number of registered safety status data as possible in 40 kBytes. The rest of the safety status data and dynamically generated contents were provided via the Internet.

We also demonstrated the effective use of broadcast and a communication network by composing the service as follows.
As for the evacuation area information service, table data that contained the name and location (latitude and longitude) of all evacuation areas inside the disaster area were sent via broadcast at any time. The receiver first obtained its own location (Fig. 6(i)), then calculated the distance to each evacuation site to find the nearest three (Fig. 6(ii)). This calculation process was done completely inside the receiver by using the ECMAScript API of BML. Therefore, the network connection was not necessary to provide this information. However, when the user wanted to see a map of his/her location and select one of the listed evacuation sites (Fig. 6(iii)), the receiver would connect to the broadcaster’s www server, passing its location as a parameter, and obtaining a map image generated by the server. (Fig. 6(iv))

The evacuation information service had two steps as follows. First, it provided limited information only by broadcast with no network congestion or server load. Then, only if the user requested, it provided personalized information for each user over the Internet. This methodology is important in composing network-linked data broadcasting service, in order to minimize congestion and also to provide the best possible service even when the network is unavailable. We applied the same strategy to the health status search service where only the most recent status data (for up to several hundred persons) are broadcast and the rest are provided via the Internet as requested. We also reduced the number of network connections of users accessing the registration service. This was done by holding the users’ input data inside the ECMAScript variables as long as possible during a sequence of user inputs through several pages and later sending all of them to the server at one time.

In this way, we could demonstrate the effective combination of broadcast and network in the experiment. Even though this experiment targeted particular emergency broadcast services and used only one set of transmission parameters, these methodologies should be effective for other services with other parameters.

2) Consideration on Location-Aware Service

Either of the two following methods can be used to implement location-aware services.

- Broadcast-only method: The receiver extracts location-specific information from the broadcast data by calculating the distances to where the information belongs. This entire process is done at the receiver side by using ECMAScript.
- Network-linked method: The receiver obtains location-specific information from the server on the network. The receiver sends location data to the server; then the receiver obtains a map generated by the server with the location data.

![Figure 6. Illustration of a sequence of evacuation information and how network-linked location-aware service works](image-url)
server calculates and sends back content with information about the nearest point.

The latter method requires an Internet connection for every transaction. However, more complicated information filtering can be done than with the receiver-side calculation of the first method. Therefore the broadcaster should choose the appropriate one depending on the service’s requirement. Although this methodology is similar to the two-step model above, the point is that even the broadcast-only model can realize a certain degree of personalization.

In the experiment, the most distinctive example of location-aware service is the personalized map provision service. These kinds of services are better suited to a network-linked model than to a broadcast-only model. If this service were to be achieved only by broadcasting, only a very limited map area could be drawn because of content size limits. Moreover, the receiver would have to support a map drawing functionality such as vector graphics, but this is not supported in the current ARIB specification. Therefore, it is reasonable to use a network for these services even if they generate network congestion. On the other hand, showing the name of the nearest three evacuation sites is an example of a broadcast-only location-aware service.

IV. CONCLUSION

We developed an experimental environment in which prototype receivers could receive actual broadcast waves and connect to the Internet. We proved the feasibility of a typical network-linked broadcasting service as well as determined an effective combination of broadcast and network contents, which makes the most of both the multi-client-serving advantage of broadcast and information personalizing advantage of networks. We also showed the advantage of location-aware broadcasting services for mobile receivers. We believe that the experimental results will help us to prepare practical broadcast systems and develop actual services. However, we still need to perform a simulation in consideration of network congestion and server load assuming a realistic number of users connecting to the server. Our future research will focus on the estimation and simulation of actual situations, enabling the design of a more feasible, detailed combination of broadcast and network contents.

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REFERENCES