Mobile Terminal Supporting Terrestrial Digital TV Broadcasting

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We developed "FOMA P901iTV," a mobile terminal equipped with functionality for receiving "one-seg" terrestrial digital TV broadcasting for cellular mobile terminals. While fusion of mobile communication and broadcast is rapidly becoming a mainstream concept, this mobile terminal distinguishes itself through the inclusion of a number of unique features such as linking data broadcast to i-mode communication.

Technology Reports

1. Introduction

On April 1, 2006, "one-seg" broadcast was commenced. "One-seg" broadcast uses one of the terrestrial digital TV broadcast (hereinafter referred to as "digital TV") segments for transmission of TV directly to mobile terminals and similar.

Generally speaking, in digital TV, physical channels[*1] 13 to 62 are designated in the Ultra High Frequency (UHF)[*2] domain, such that the broadcasting is provided at different frequencies and one channel in the range is assigned to each broadcaster. Each physical channel is assigned a remote control ID, which is associated with remote control key numbers 1 to 12, as we are used to in conventional analog TV and similar, and a service ID for identifying programs when multiple programs are broadcast using the same physical channel in the same time slot. These IDs are written in the Network Information Table (NIT), i.e., the control information included in the broadcast wave, and transmitted.

In the one-seg service, the control information is limited to the minimum amount required for broadcasting using one segment, which is obtained by dividing the aforementioned 6 MHz

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*1 Physical channels: According to the frequency assignment proposal announced based on the provisions of the Radio Law, 50 frequencies are assigned in 6 MHz intervals in the UHF band, as one of the frequency bands used for TV broadcast (terrestrial). A physical channel refers to a channel number assigned to one of these frequencies, and one channel is assigned to each broadcaster.

*2 UHF: The frequency band from 300 MHz to 3 GHz, also called the extremely high frequency wave.

frequency band per physical channel into 13 segments, such that the information is properly received even by mobile terminals and other terminals whose information processing capacity is relatively small. One of the features of this approach is that data broadcast, in addition to video and voice, can be received at the same time. By implementing the one-seg function in mobile terminals and linking data broadcast with i-mode communication, it is possible to acquire information related to programs, link to sites of broadcaster and so on, and the communication traffic can be expected to be increased further.

DoCoMo began examination of constituent technologies, including development of prototypes from April 2003, and has been preparing for the launch of broadcast services since then. FOMA P901iTV was developed for the purpose of launching mobile terminals supporting the one-seg service on the market prior to the service launch. During the development, we focused on the following points.

- One-seg reception functions focusing on coordination with communication
- User interface prioritizing ease of use
- Expansion of additional digital TV functions, including viewing reservation and recording
- Design supporting high-sensitivity reception and low-power-

consumption

This article describes the features of one-seg broadcast and provides an overview of the new functions developed for P901iTV.

2. Overview of P901iTV

Photo 1 shows the external view of P901iTV and **Table 1** shows the basic specifications. We aimed to make P901iTV a compact and light-weight mobile terminal by adding one-seg viewing functions to the FOMA basic functions. The main features in terms of appearance are as follows:

Photo 1 External view of P901iTV

Table 1 Basic specifications of P901iTV

	P901iTV	(Reference) P901i
Size	110 × 51 × 27 mm	102 × 49 × 22 mm (non-jacket style)
Weight	App. 150 g	App. 104 g (non-jacket style)
Continuous standby time	Stationary: App. 460 hours Moving: App. 350 hours	Stationary: App. 460 hours Moving: App. 350 hours
Continuous call hours	Voice communication: App. 140 minutes Videophone: App. 100 minutes	Voice communication: App. 140 minutes Videophone: App. 90 minutes
Continuous viewing hours	Digital TV: App. 3 hours Analog TV: App. 1 hour	
LCD	Main: App. 2.5 inch (240 × 320 pixels) Sub: App. 0.9 inch (96 × 25 pixels)	Main: App. 2.2 inch (240 × 320 pixels) Sub: App. 1.0 inch (96 × 64 pixels)
Camera	Main: 2,010,000 effective pixels (Maicovicon) Sub: 110,000 effective pixels (CMOS)	Main: 2,020,000 effective pixels (Maicovicon) Sub: 100,000 effective pixels (CMOS)
Other functions	Digital TV (one-seg) viewing functions Analog TV viewing functions FeliCa	Custom jacket

LCD: Liquid Crystal Display

- Support for diversified viewing styles with the rotating 2-axis structure
- Equipped with a retractable whip antenna whose angle can be adjusted
- Equipped with a large, wide viewing angle LCD screen

A new hardware platform supporting the following one-seg technologies is implemented on P901iTV.

1) Modulation Method

In one-seg broadcast, a broadcaster selects a digital modulation method, either Quadrature Phase Shift Keying (QPSK)[*3] or 16 Quadrature Amplitude Modulation (16QAM)[*4]. Orthogonal Frequency Division Multiplexing (OFDM)[*5] is adopted as the transmission channel encoding scheme. By distributing the transmission data among several frequencies, OFDM allows suppressing the influence on the entire system even if signals in a certain frequency band are lost. It is thus robust against inter-ference and suited for reception with mobile terminals.

2) Encoding Scheme

One-seg broadcast uses H.264[*6] as the video encoding scheme. The compression/decompression processing method of H.264 is based on the concept of motion compensation[*7] and transform encoding[*8] in the same way as for the conventional Moving Picture Experts Group phase 4 (MPEG-4)[*9] scheme. It is characterized by its adoption of motion prediction between frames: although it allows high-rate compression, it still requires a data processing amount approximately twice as large as MPEG-4. In order to support H.264, we used a dedicated hardware platform to keep the power consumption low and achieved high-speed processing performance; this is the first time that a dedicated hardware platform is used for FOMA terminals. In addition, MPEG-2[*10] Advanced Audio Coding (AAC)[*11] is used as the sound encoding scheme.

Table 2 shows an overview of the main parameters of one-seg broadcast.

Table 2 Overview of main parameters of one-seg broadcast

Item	Description
Broadcast method (operation standard)	ISDB-T (ARIB TR-B14)
Frequency	UHF channels 13 to 62 * UHF channels 20 to 28 are used in the Tokyo metropolitan area
Multiplexing method	OFDM
Modulation method	QPSK, 16QAM
Transmission speed	App. 312 kbit/s (modulation method: QPSK, encoding ratio: 1/2) App. 416 kbit/s (modulation method: QPSK, encoding ratio: 2/3) App. 624 kbit/s (modulation method: 16QAM, encoding ratio: 1/2)
Video encoding scheme	H.264/AVC (QVGA, 15fps)
Voice encoding scheme	MPEG-2 AAC + SBR
Data broadcast	BML profile C
Subtitling	Optional
Contents	Simultaneous broadcast

Integrated Services Digital Broadcasting-Terrestrial (ISDB-T): A Japanese terrestrial digital broadcast standard. This standard was formulated taking fixed reception at home as well as mobile reception by mobile terminals etc. into consideration.
Spectral Band Replication (SBR): Technology to improve the compression efficiency dramatically, primarily at low bit rates, by expanding the playback bands.
Simultaneous broadcast: Broadcasting the same program in two different channels at the same time. Here, this refers to "broadcasting the same program in the same time slot as terrestrial analog TV broadcast."

3. Overview of One-seg Viewing Functions
3.1 Channel Selection Function

In order to select a program while receiving one-seg broadcast, a physical channel is first specified and then the NIT included in the control data is acquired. After this, the corresponding service ID is selected among the information included in the NIT, and the desired program is acquired. With P901iTV, we strived to simplify the operations, such that the primary service[*12] can be specified simply by selecting a physical channel, i.e., without having to specify a service ID. Specifically, the following functions have been implemented.

1) Up/Down Channel Selection Function

With this method, a user can select channels registered in a channel list created by the user one by one sequentially in ascending or descending order by pressing the left/right keys of the cross-shaped key briefly while viewing one-seg broadcast.

2) One-touch Channel Selection Function

A user can select a channel registered in the channel list by pressing a numerical key and/or the "∗" and "#" keys of the

*3 QPSK: A digital modulation method that allows transmission of 2 bits of information at the same time by assigning one value to each of four phases.
*4 16QAM: A digital modulation method that allows transmission of 4 bits of information at the same time by assigning one value to each of 16 different combinations of amplitude and phase.
*5 OFDM: A digital modulation method where the information is divided into multiple orthogonal carrier waves and sent in parallel. It allows transmission at high frequency usage rates.

*6 H.264: A coding system for moving-picture data capable of high rates of compression compared to MPEG-2 (see *10) and MPEG-4 (see *9). It can support a wide range of applications such as high-definition broadcasting.
*7 Motion compensation: A method of compressing image data efficiently by taking the direction in which data moves in sequential frames into consideration.

mobile terminal while viewing one-seg broadcast. In order to improve the convenience at channel selection, P901iTV supports both entering a single digit of a channel number and specifying a channel by entering a 2-digit number sequentially.

3) Search and Select Channel Function

When the user presses the left/right key of the cross-shaped key while viewing one-seg broadcast, the function searches for the next physical channel in ascending or descending order along the frequency axis and selects a channel as soon as it identifies the NIT of a physical channel captured by the tuner.

4) Last Channel Selection Function

This function maintains the channel previously viewed as historical data and selects the channel automatically even if no channel selection operation is performed the next time the mobile terminal is used.

3.2 Channel Scan Function

Channel scan refers to a function for obtaining information for selecting a one-seg channel from broadcast waves. This function stores channel information that can be viewed in the form of a channel list within the mobile terminal. The channel list is created automatically when a user selects "Automatic Channel Setting" from the function menu.

The created channel list is different from those for household fix-channel TVs; taking into account the fact that mobile terminals can be used in various different locations, the function is designed to store multiple lists. This allows creating a channel list for each location if, for instance, the reception channels are different from those in the normal reception environment at the destinations of business trips etc., and viewing channels while switching among them.

The channel scan function first scans through UHF channels 13 to 62 in a channel-by-channel manner, obtaining reception level and service ID, service channel name[*13], remote control ID and other information for channels with which it was able to synchronize, and then creates a channel list. At this point, it assigns physical channels to channel numbers 1 to 62 according to the remote control IDs. Channel numbers 1 to 12 are assigned

to keys for one-touch channel selections, enabling users to choose these channels with simple operations.

In areas operated using Multi Frequency Networks (MFN)[*14], where the parent station and relay stations broadcast the same contents at different frequencies, it is possible to receive radio waves of both the parent and relay stations and the same service ID and same remote control ID may be detected for different physical channels. In this case, the function automatically registers the information of the channel with the highest reception level to the remote control ID.

Moreover, in case of terrestrial digital broadcast with different program data for each area, the same remote control ID may be detected from different physical channels and different service IDs in border regions between prefectures and similar overlapping areas where radio waves from multiple transmission stations can be received. In this case, it is necessary to register both channels in the channel list because the contents broadcast are different, but which service should be prioritized when registering the channel to the remote control ID poses a problem. P901iTV, in this case, displays area names based on region identification codes included in service IDs, enabling the user to choose a priority when assigning channel information by specifying the name of a region.

By adding these two types of processing, P901iTV allows creation of a channel list that can be optimized for a user's place of residence, improving the convenience for the user in selecting channels.

3.3 Viewing Reservation Function

P901iTV is equipped with a function for registering information of programs a user wants to see in the mobile terminal in advance. The function, then, makes a viewing start announcement at the reserved time and automatically launches the one-seg viewing functions.

There are two ways to perform reservation in advance, either by direct input or by linking with the TV program i-appli. Even in case of direct input, the trouble of key input is minimized by linking with the channel list to improve the operability.

3.4 Power Supply Management Function

Since the one-seg viewing functions consume a considerable amount of power, the battery is consumed relatively quickly in continuous viewing. In order to solve this problem, P901iTV prevents the battery from being consumed without the user's consent by notifying with an alarm when the battery capacity drops below a preset threshold value.

3.5 Vertical/Horizontal Screen Switching Function

The display is a large, wide viewing angle LCD screen (2.5 inch), which is constructed with a rotating 2-axis mechanism that allows changing the screen style horizontal or vertical at viewing. In normal vertical screen viewing style, the upper half of the display area displays TV images and the lower half displays data broadcast. In the large horizontal viewing style, the image contents are allowed to take up the entire screen area and can thus be displayed at an easy-to-see resolution of 320×180 dots. Furthermore, it is possible to switch the screen orientation while continuing to view TV simply by rotating the LCD display area. It is also possible to launch the one-seg function automatically by using the style-linked function. **Figure 1** shows an overview of these operations.
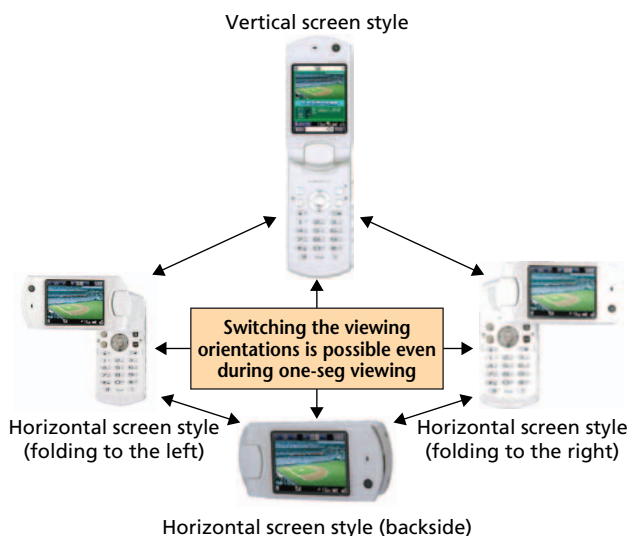
Vertical screen style

Switching the viewing orientations is possible even during one-seg viewing

Horizontal screen style (folding to the left)

Horizontal screen style (folding to the right)

Horizontal screen style (backside)

Figure 1 Overview of vertical/horizontal screen switching operation

3.6 Active Switching Function

The up/down and left/right keys built into mobile terminals did pose a problem when implementing the one-seg viewing operations (channel change and volume adjustment) and data broadcast operations (screen scroll and shift) simultaneously. For P901iTV, the problem was solved by implementing a function for switching modes, such that the user can select either the one-seg viewing functions or the data broadcast functions and then operate the keys accordingly. For example, the up/down key functions as volume control when the one-seg viewing functions are active and as screen scroll when the data broadcast functions are active. With this function, the operability of the limited number of keys was improved to address a variety of operations. **Figure 2** shows an overview of these operations.

3.7 Half/Full Screen Switching Screen

P901iTV is equipped with a half/full screen switching function that allows switching between full and half screen view mode during one-seg viewing. When viewing in the vertical screen style, the data broadcast screen image is displayed in the lower half, but by using this function, it is also possible to view data broadcast in full screen mode in the same way as for i-mode.

3.8 Recording Function

The recording function supports saving both still images and video. Note that, due to copyright protection considerations, functions for storing such contents in external memory, setting them as standby screen, or copying or editing them are not supported.
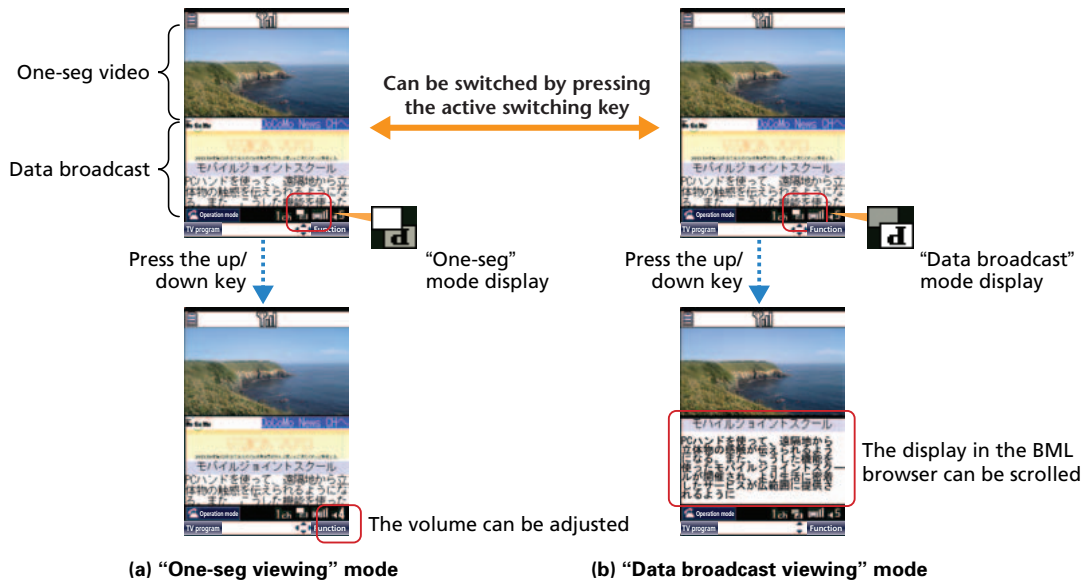
1) Still Images

This function saves an image displayed at the moment the recording button is pressed during one-seg viewing, in Joint Photographic Experts Group (JPEG)[*15] format. The storage size is 320×240 dots and up to approximately 100 images can be stored in the built-in memory of the terminal.

2) Video

This function allows recording video during one-seg view-

One-seg video

Data broadcast

Can be switched by pressing the active switching key

Press the up/ down key

"One-seg" mode display

Press the up/ down key

"Data broadcast" mode display

The display in the BML browser can be scrolled

The volume can be adjusted

(a) "One-seg viewing" mode

(b) "Data broadcast viewing" mode

*This function is provided only in Japanese at present.

Figure 2 Overview of active switching operation

ing. The image area is 320 × 240 dots, the frame rate is up to 15 frames per second and up to approximately 30 minutes worth of video can be recorded in the built-in memory. By using a format called Transport Stream (TS)[16] prescribed by MPEG-2 when saving, it is possible to reduce the amount of video processing to suppress CPU load at recording. Moreover, P901iTV utilizes the image/sound processing blocks of the one-seg viewing functions as is during playback for maximum efficiency of implementation.

3.9 Reception Level Display Function

P901iTV displays whether the reception level of broadcast waves is outside range, weak, or strong using pictograms to assist users by giving them visual feedback. **Figure 3** shows the pictogram designs for the one-seg reception levels.

It has been found that the reception states can be classified into the following three conditions due to characteristics of terrestrial digital broadcast, from analysis results of field tests and so on.

- Status where the frequency of bit errors in the received stream exceeds the threshold level for the data to be decod-
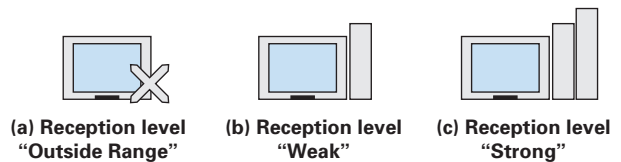

(a) Reception level "Outside Range"

(b) Reception level "Weak"

(c) Reception level "Strong"

Figure 3 Pictogram designs for one-seg reception levels

ed normally (Fig. 3 (a))

- Status where bit errors occur sporadically due to weak electric field, multi-pass phasing[17] etc., and the image and sound may be disturbed (Fig. 3 (b))
- Status where errors can be corrected sufficiently well, and data can be received normally (Fig. 3 (c))

The three reception levels are displayed by defining threshold value parameters according to these states.

3.10 High-Sensitivity Antennae

P901iTV adopts a retractable whip antenna and an antenna-embedded earphone to improve the reception sensitivity.

The main feature of the whip antenna is that the angle can be adjusted freely. The ability to change the antenna angle

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*16 Transport stream: A data sequence where image, sound and data contents in several programs are divided into individual packets and reassembled in order with information identifying programs added.

*17 Multi-pass phasing: A phenomenon where a radio wave is subjected to repeated reflection and diffraction due to geographical features and buildings, and thus reaches a receiver as multiple radio waves.

freely to suit the way the mobile terminal is held improves the antenna gain by approximately 3 dB compared to a mechanism allowing extension/contraction only. It is noted that, in the hinge mechanism[*18] area used for adjusting the antenna angle, the Product Liability (PL)[*19] Law is taken into consideration as well and all screws are flat with the surface. Furthermore, there is a risk of breaking the antenna if an external load is applied to the antenna while it is extended. The mechanism thus has a structure where the hinge area rotates if the bending force exceeds a certain level to reverse deflection of the antenna, thereby releasing the load in a single direction.

The antenna-embedded earphone hangs in a U-shape when used. It was found that the antenna gain fluctuates due to the shape and the distance from the body. For this reason, a structure that allows disconnecting the earplugs around halfway along the earphone cable was adopted, and a UHF-band antenna is placed in the half close to P901iTV while a Very High Frequency (VHF)[*20]-based antenna is placed in the half close to the user's ear. With this arrangement, it is possible to view one-seg broadcast with high reception sensitivity even if the user replaces the antenna-embedded earphone with commercially available head-phones, due to the presence of the remaining UHF-band antenna.

These two antennas allow automatic selection of the most sensitive antenna configuration at all times at one-seg viewing due to pseudo-diversity effects, achieving reception at higher quality.

4. Data Broadcast and BML Browser

4.1 Data Broadcast

In terms of data broadcast, P901iTV uses a Broadcast Markup Language (BML)[*21] browser to display text information as a supplement to image and sound contents of broadcast programs and provides services for accessing Websites via the Internet.

4.2 BML Browser

The BML browser is able to handle contents written in eXtensible Hyper Text Markup Language (XHTML), which primarily means text information, Cascading Style Sheets (CSS) that define font sizes, character ornamentation, line spacing and other layout characteristics, script functions for executing unique programs in the browser of the mobile terminal and BML contents consisting of groups of extended functions especially designed for broadcast.

In terms of graphics, it supports a broad range of functions for displaying objects, such as JPEG, Graphic Interchange Format (GIF)[*22] and Animation GIF[*23]. In addition, some of the functions extended for broadcast allows launching i-mode and initiating voice calls from the BML browser.

4.3 Linking with Mobile Communication via the BML Browser

The most significant feature of data broadcast in one-seg broadcast is the function to link with mobile communication.

This link is achieved by accessing a Website via a tag displayed in the BML browser on the data broadcast screen via i-mode (**Figure 4**). In case of a drama, for example, in addition to the image content, a hyperlink tag might link to a Website belonging to the broadcaster that introduces the profiles of the actors. If a user clicks the tag, communication is initiated and the mobile terminal is connected to the Website introducing the actors. Thereby, the user can acquire information about the actors while watching the drama.

Various services are being examined for data broadcast. It is anticipated that functions linking between communication and broadcast will be expanded further in the future.

5. Issues, Solutions and Effects in Linking Communication and Broadcast

5.1 Issues

Bi-directional communication functions involved in data broadcast have entered a new phase, where communication and broadcast are converging. However, in the examination of ARIB TR-B14, an operation standard for terrestrial digital broadcast, the following issues affecting existing communica-

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*18 Hinge mechanism: A structure that connects two parts together and allows opening and closing, just like a hinge. Also used in folding-type mobile terminals.
*19 Product Liability Law: Law allowing consumers to claim damage liability when damage arises due to product defects.
*20 VHF: The frequency band from 30 to 300 MHz, also called the very high frequency wave.

*21 BML: XML-based markup language for data broadcast.
*22 GIF: An image format.
*23 Animation GIF: An extension of GIF, an image format. The animation GIF format is equipped with a mechanism to display multiple images in single frame steps.

tion services and the security of mobile terminals were identified in the standard proposal prepared by broadcasters during the initial phases.

- All broadcasters can read and write information from/to Non Volatile RAM (NVRAM)[*24] areas within mobile terminals freely via data broadcast

*This function is provided only in Japanese at present.

Figure 4 Linking between BML browser and i-mode

using the features of the expanded functions for broadcast.

- Broadcasters can transmit information within mobile terminals to Uniform Resource Locators (URL) described in contents using the features of the expanded functions for broadcast.

- In general, permission prompts (reminders to users) can be displayed when communication is initiated according to instructions included in BML contents created by broadcasters.

5.2 Solutions

DoCoMo considered the following methods of restricting access in order to prevent leaking of personal information due to communication functions involved in data broadcast.

1) NVRAM Usage Requirements

An NVRAM area is assigned for each broadcaster affiliation within a mobile terminal by limiting the capacity for broadcast. An NVRAM area for reading and writing described in BML contents is matched with an affiliation ID indicating the affiliation of the broadcaster included in broadcast waves. The NVRAM area for broadcast can only be used by authorized affiliated broadcasters.

2) Restriction of Communication Destinations

The number of access destination domains that allow broadcasters to communicate by affiliation is limited to one per affiliation. A table of correspondence that defines affiliation IDs specifying broadcaster affiliations and domain names of communication destination servers allowing access by launching

functions via data broadcast is stored in advance in the mobile terminal as a domain table; this table is limited to represent a strict one-to-one correspondence. As a general rule, it is assumed that this domain table is not updated. When receiving broadcast, the mobile terminal reads the affiliation ID embedded in the broadcast contents. If it is attempted to launch communication via a function described in the BML contents, the mobile terminal checks the domain name against the domain table recorded, and only communicates with the server of the domain in case the domain is authorized. **Figure 5** shows the specific correspondences.

3) Display of Permission Prompts

Permission prompts are displayed on the mobile terminal when communication is initiated, regardless of the presence of instructions in BML contents.

5.3 Effects

In order to formulate technical requirements to communication based on the broadcast standard, DoCoMo proposed the aforementioned access restriction methods in forums of deliberation by broadcasters, manufacturers and communication carriers, and the methods were established as the ARIB operation standard. Hereby, the following effects can be expected.

- Reading and writing from/to the NVRAM area within a mobile terminal by data broadcast is uniquely determined to be performed by "the broadcaster carrying out the broad-

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*24 NVRAM: Semiconductor memory (nonvolatile memory) that allows maintaining stored contents even when the power supply is turned off.

cast." This allows clarifying which entities are responsible for managing personal information.

- There is no need to secure an NVRAM area that is sufficient for all broadcasters, thus allowing to save memory capacity.

- The communication destination is virtually limited to Websites of broadcasters. It is possible to avoid situations where a mobile terminal is directly connected to unspecified Websites, allowing the mobile terminal side to be in control.

- It becomes possible to remind users to the occasions where communication is initiated regardless of the presence of instructions in BML contents created by broadcasters, such that they can use their mobile terminals with security.
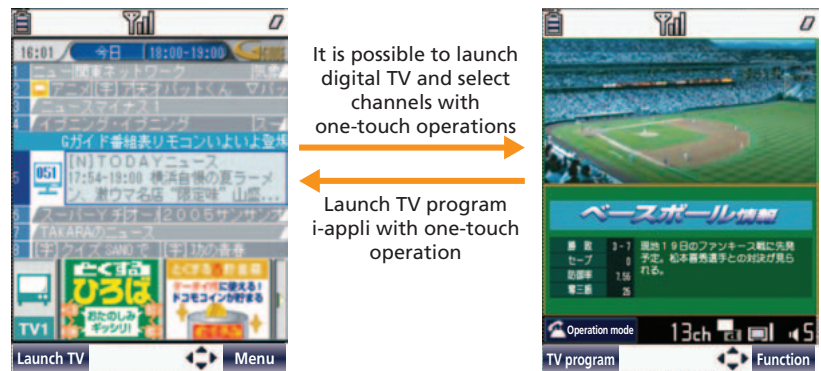
Furthermore, these methods allow broadcasters to perform the following operations.

- It is possible to ensure that the administrator of the parent domain (affiliation key station as a matter of practice) has the freedom to determine sub-domains at his/her own discretion and responsibilities and assign servers to all broadcasters belonging to the affiliation. It is also possible to accommodate expansion and relocation of servers in a flexible manner.

- It is possible for affiliated broadcasters to share information stored in the NVRAM area in a mobile terminal. Thus, when accumulating points by answering questions in a quiz program, for instance, the score may be stored in NVRAM and a user who usually watches the quiz program in Tokyo can continue to watch the program and accumulate points even if he has to go on a business trip to Nagoya.
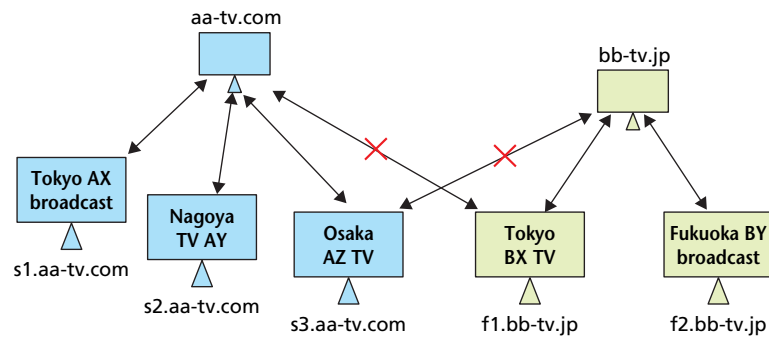
Broadcaster	Affiliation	Affiliation domain name	NVRAM	Destination domain
AX broadcast	aa affiliate	aa-tv.com	aa frame	aa-tv.com or s1.aa-tv.com
TV AY	aa affiliate	aa-tv.com	aa frame	aa-tv.com or s2.aa-tv.com
AZ TV	aa affiliate	aa-tv.com	aa frame	aa-tv.com or s3.aa-tv.com
BX TV	bb affiliate	bb-tv.jp	bb frame	bb-tv.jp or f1. bb-tv.jp
BY broadcast	bb affiliate	bb-tv.jp	bb frame	bb-tv.jp or f2. bb-tv.jp

Figure 5 Limitation of communication destinations in one-seg data broadcast

It is possible to launch digital TV and select channels with one-touch operations

Launch TV program i-appli with one-touch operation

*This function is provided only in Japanese at present.

Figure 6 Linking between TV program i-appli and one-seg launch

- If a sub-domain is specified as the transmission destination by BML contents, it is possible to limit the target to the server of the broadcaster operating the intended sub-domain. It is thus possible to address cases where it is desired to put information together in a specific server and similar.

6. TV Program i-appli Supporting Digital TV

P901iTV manages TV programs via i-appli. The TV program i-appli receives the TV program information via i-mode and can be operated during one-seg viewing, such that the user

can choose channels, make viewing reservations etc. using the TV program while watching TV.

In terrestrial digital broadcast, TV program information of each channel is transmitted multiplexed in broadcast waves; it is thus possible to generate a TV program purely based on broadcast waves. Normal one-seg broadcast contains only information of the program currently broadcast and the next program, however, and the insufficiency of information in creating TV programs thus posed a problem. For this reason, the TV program information is acquired via i-mode, thereby making it possible to acquire not only the currently broadcast program information, but also information that can be used for making future viewing reservations as well.

Furthermore, as the TV program i-appli was implemented, the Doja[*25] Application Program Interface (API)[*26] was extended in order to allow launching the one-seg viewing functions and registering viewing reservations from the TV program i-appli.

When launching the one-seg viewing functions from the TV program i-appli, it is possible to select a desired channel based on physical channel information and service ID. In particular, by setting a service ID assigned uniquely to the services of each broadcaster as a parameter, it was made possible to select a desired program according to the viewing location.

When registering viewing reservations in the TV program i-appli, the trouble of manual entry by users is minimized by setting program information such as information of channel selection (physical channel and service ID), program name and starting time automatically, thus simplifying the registration operation from the TV program i-appli as much as possible. **Figure 6** shows a linking image of the TV program i-appli and the one-seg viewing functions.

7. Other Functions

1) Terrestrial Analog TV Broadcast Viewing Function

P901iTV also supports analog TV and allows up to 60 minutes of continuous viewing. With this function, P901iTV also supports viewing analog TV channels, thus improving the marketability.

2) FeliCa Function

P901iTV is equipped with a FeliCa chip and supports the "Osaifu-Keitai" service.

8. Conclusion

Through our development of a mobile terminal supporting terrestrial digital TV broadcast, we have made a significant step toward "fusion of mobile communication and broadcast," which DoCoMo has set a goal of. In the future, we intend to carry forward examination of the user interface improvement, reduction of size and weight as well as extending the playing time by power saving.

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*25 Doja: Java[TM] extended library for i-appli.
Java and all the trademarks and logos related to Java are trademarks or registered trademarks of Sun Microsystems, Inc. in the US and other countries.
*26 API: An interface allowing upper-level software to use functions provided by the OS, middleware, etc.