i-mode FeliCa

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In July 2004, our services took a dramatic leap forward with the introduction of i-mode FeliCa.
With conventional contactless IC cards, users could not directly read the information within the cards, and data storage was only allowed under specific circumstances. With i-mode FeliCa, however, it is possible to read the internal information directly on the display of a mobile terminal as well as enjoy a wide range of services at any time, taking advantage of the collaboration with various i-mode services.

1. Introduction

i-mode FeliCa[*1] aims to strengthen the collaboration with i-mode services to further the concept of "mobile terminals that can be used as part of the everyday infrastructure." By building the i-mode FeliCa platform, it becomes possible to roll out seamless services that link virtual i-mode stores on the Internet with actual stores.

This article provides an overview of the i-mode FeliCa services and explains the mobile terminals that constitute the platform and the server technologies involved.

2. Services Overview

i-mode FeliCa allows storing information requiring high-level security measures such as electronic money in mobile terminals, through the collaboration among a mobile terminal equipped with a mobile FeliCa IC chip (hereinafter referred to as a FeliCa chip), the i-mode network, and various FeliCa Platform Servers that manage the FeliCa chips. Moreover, stored information can be used in both virtual i-mode stores on the Internet and actual stores.

Figure 1 shows some application examples of i-mode FeliCa.

The main specific feature is that all services provided by the
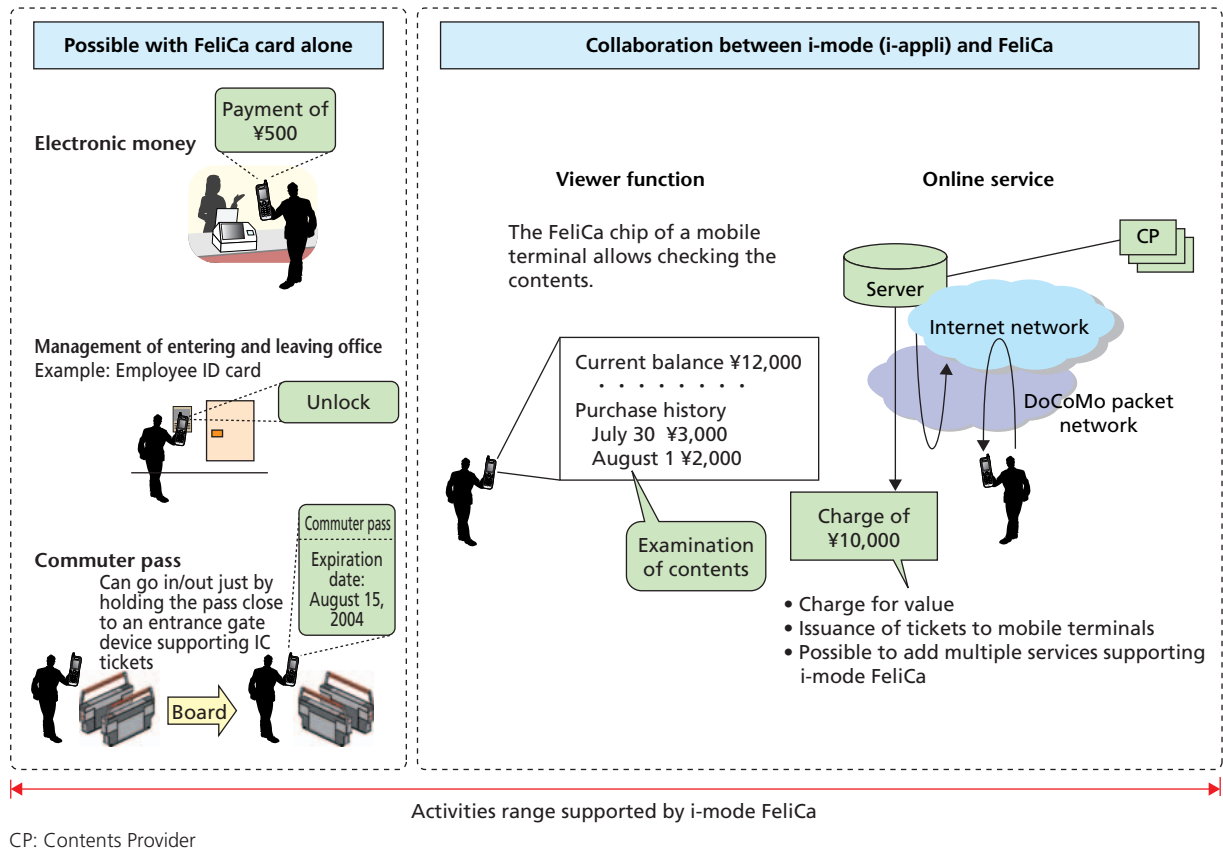
Development Reports

Figure 1 Examples of i-mode FeliCa compatible services

FeliCa cards, such as electronic money, electronic tickets, transportation tickets (commuter passes), membership cards (point cards), employee ID cards, electronic keys, credit cards and coupon tickets, can be used in i-mode FeliCa. This allows providing more sophisticated services than ever before.

Specific features of i-mode FeliCa can be summarized as below:

- Online tickets issuance service and value charge to FeliCa chips
- Viewing data within the FeliCa chip by access via an i-appli
- Supporting multiple i-mode FeliCa services with one FeliCa chip
- After setting up services for the FeliCa chip, it is possible to use the i-mode FeliCa services by simply holding the mobile terminal against the reader/writer (hereinafter referred to as R/W) without activating i-appli.

3. Features of the i-mode FeliCa Chip

The FeliCa chip implemented in an i-mode FeliCa compatible mobile terminal sets two areas, a common area and a free area, as shown in **Figure 2**.

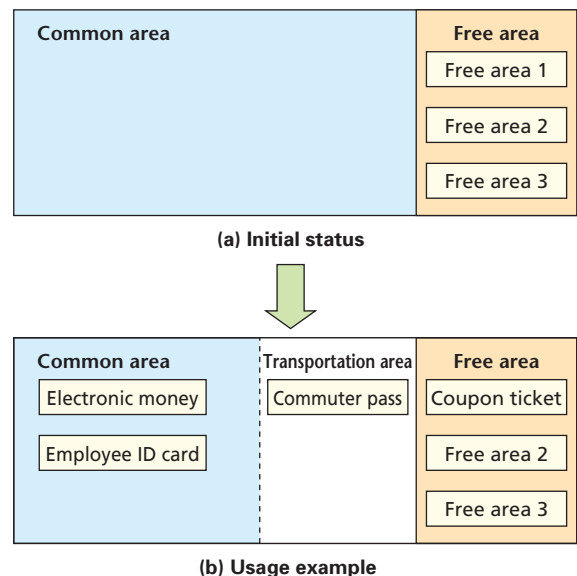(a) Initial status

(b) Usage example

Figure 2 Conceptual diagram of the FeliCa chip areas

The common area is operated and managed by FeliCa Networks, Inc. This area is used when service providers need to provide highly secure and flexible services. Note that when an i-appli accesses this area, it is necessary to use an IC-appli utilizing the i-appli DX mechanism. The IC-appli can be used by reg-

istering the information of this function in an i-mode server after applying to DoCoMo.

The free area is used by services that utilize the FeliCa chip simply as an external interface and data storage area without emphasizing security; it is frequently used for such as coupon ticket services. This area can be used freely by normal i-applis and is provided to users in a status where three equal-sized free areas are registered. Password authentication using a Personal Identity Number (PIN) code maintain a certain level of security.

In the future, the FeliCa chip is assumed to manage transportation ticket services, which are currently provided by FeliCa cards, allowing the users to divide the common area by themselves.

Figure 3 shows the flow of using the i-mode FeliCa services. The FeliCa chip in a mobile terminal does not have any preset services when purchased; the users cannot use the i-mode FeliCa services as it is. The users must acquire applications according to the following procedure, before they use the services.

1) The user downloads an i-appli to access the FeliCa chip from the service provider server. For an IC-appli, the application is downloaded via the DoCoMo i-mode server.

2) After activating the i-appli, the associated services are registered in the FeliCa chip through communication with FeliCa Platform Servers belonging to service providers.

3) The services within the FeliCa chip become available and the data within the chip becomes possible to read and write by communicating with the service providers' servers via

the i-appli. The mobile terminal can also be used as a FeliCa card by simply holding it against the R/W.

4. i-mode FeliCa Compatible Mobile Terminals

4.1 Overview

i-mode FeliCa compatible mobile terminal can receive the same services as FeliCa cards, but in addition they can also access the FeliCa chip from the i-appli and perform remote access to the FeliCa chip via communication with a FeliCa Platform Server. **Photo 1** shows the i-mode FeliCa compatible mobile terminal, which we developed this time.

4.2 Card Functions

The card functions have the ability to perform contactless communication conforming to the FeliCa technology system just by holding the mobile terminal against an R/W in the same way as for electronic money FeliCa cards and transportation FeliCa cards, which are already popular on the market. FeliCa cards run with current induced by carrier from the R/W, but the mobile terminals also supply a small amount of power to the FeliCa chips implemented in them to allow stable operations. If the remaining battery is enough for the card functions to operate, they will operate regardless of whether the power supply from the mobile terminal is on or off.

i-mode FeliCa compatible mobile terminal are mounted with a loop antenna for contactless communication to execute the card function. This makes it possible to use the card whenever
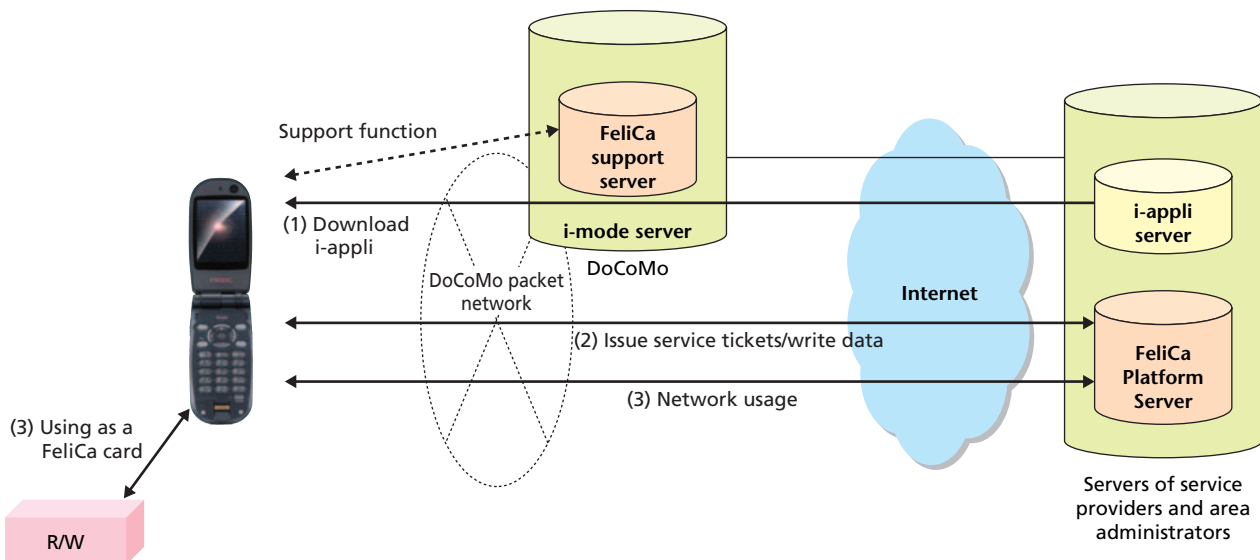

Figure 3 Flow of using i-mode FeliCa compatible services

| SO506iC | SH506iC | P506iC | F900iC |

Photo 1 i-mode FeliCa compatible mobile terminal

the mobile terminal can detect carrier by holding it close to the R/W. **Table 1** lists the specifications used in the contactless communication conforming to the FeliCa technology system.

As discussed above, multiple service providers can share a FeliCa chip, and the types of R/W used are considered to vary greatly. For this reason, we selected multiple R/Ws that can be used as standards and defined communication performance specifications that can support these R/Ws. Note that the communication performance is affected not only by the characteristics on the R/W side, but also by many other factors on the mobile terminals side such as the position where the antenna is mounted, the opening area, the presence of metal parts inside the terminal. Sufficient communication performance is secured by taking the design and downsizing into consideration.

4.3 Function for Collaborating with i-appli

To access from a mobile terminal to a FeliCa chip, we adopted a method to obtain access via i-applis, where a wide range of services expansion are expected.

Figure 4 shows the system configuration of this method. A mobile terminal is constituted of K Virtual Machine (KVM), the Java[*2] runtime environment required to operate previously implemented i-applis, the Connected Limited Device Configuration (CLDC) of the Application Programming Interfaces (API) for embedded devices, the DoCoMo Java (Doja) extension library for i-appli, the HyperText Transfer Protocol (HTTP) communication function, which handles

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*2 Java is an object-oriented development environment for networks promoted by Sun Microsystems, USA.

Table 1 Specifications of contactless communication

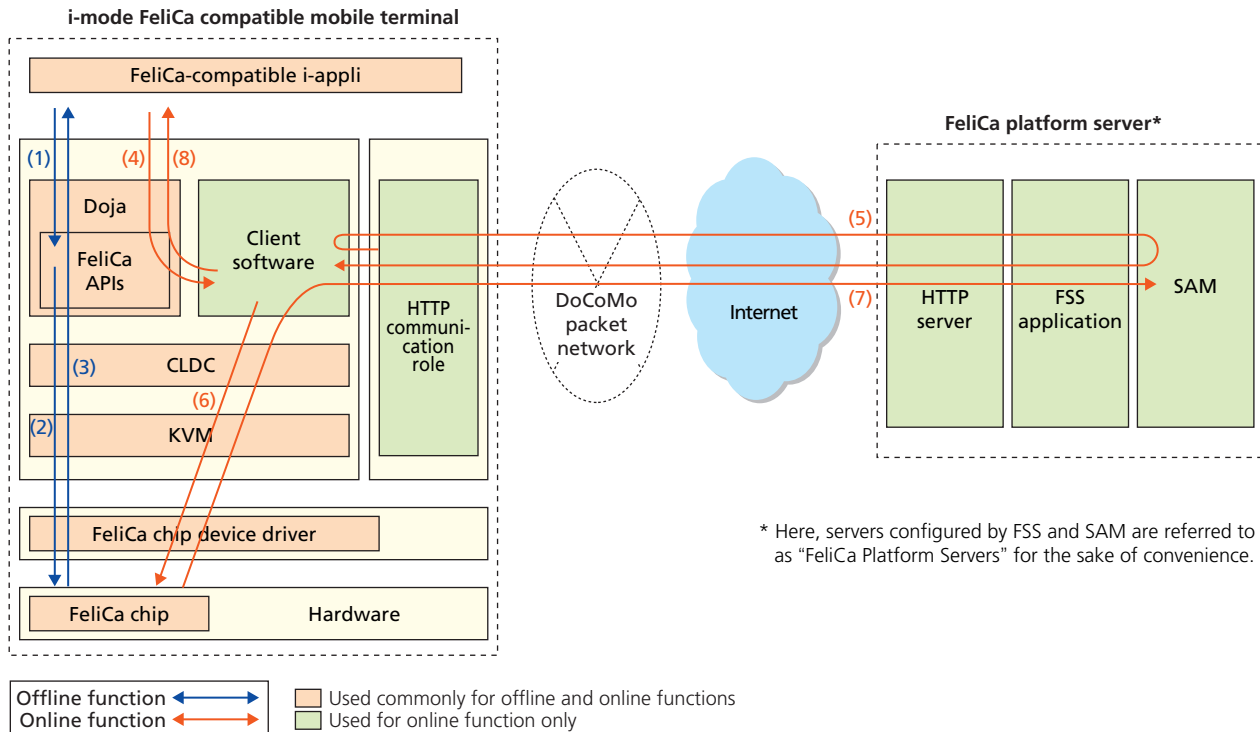| Fundamental frequency	13.56MHz
Modulation method	ASK
Bit coding	Manchester coding
Data transmission rate	212kbit/s

ASK : Amplitude Shift Keying

HTTP communication from i-applis as well as a group of FeliCa APIs expanded for FeliCa, client software for relaying communication with FeliCa Platform Servers, FeliCa chip device drivers for accessing FeliCa chips, and a FeliCa chip. FeliCa Platform Servers are configured by the HTTP servers and the FeliCa Secure Servers (FSS), which are web applications for communicating with FeliCa chips and the Secure Application Module (SAM), which handles cryptographic processing.

1) Offline Function

This function allows reading/writing data within the FeliCa chip directly from an i-appli. It is used for the viewer that allows displaying data within the FeliCa chip offline for instance. The data that can be read/written using the offline function is limited to the services in the FeliCa chip that do not require authentication with FeliCa Platform Servers.

Access to the FeliCa chip is initiated by invoking the FeliCa API from an i-appli (Fig. 4 (1)). Information required to execute a function in the FeliCa chip is passed to the FeliCa chip device driver via the invoked API, and a command is sent from the FeliCa chip device driver to the FeliCa chip, enabling reading/writing data within the FeliCa chip (Fig. 4 (2)). When the execution is completed, the result of execution is returned to

i-mode FeliCa compatible mobile terminal

FeliCa-compatible i-appli

FeliCa platform server*

(1) (4) (8)

Doja

FeliCa APIs

Client software

HTTP communi-cation role

DoCoMo packet network

Internet

(5)

(7)

HTTP server

FSS application

SAM

(3) CLDC

(6)

(2) KVM

FeliCa chip device driver

FeliCa chip   Hardware

* Here, servers configured by FSS and SAM are referred to as "FeliCa Platform Servers" for the sake of convenience.

Offline function ←——→
Online function ←——→

☐ Used commonly for offline and online functions
☐ Used for online function only

Figure 4 Architecture structure

the i-appli via the reverse route (Fig. 4 (3)).

2) Online Function

Triggered by an API call from an i-appli, this function initiates communication between the FeliCa chip and a FeliCa Platform Server, and allows reading/writing data within the FeliCa chip from the FeliCa Platform Server. It is used for reading and writing data requiring a high level of security, such as service registrations and value charges.

The i-appli initiates access to the FeliCa Platform Server by invoking the FeliCa API for initiating server communication (Fig. 4 (4)). Communication with the FeliCa Platform Server is performed via HTTP. The HTTP communication is carried out between the HTTP communication function of the mobile terminal and the HTTP server. FeliCa communication information is exchanged between the client software and FSS via HTTP, while cryptographic processing of the FeliCa communication information is performed in the SAM (Fig. 4 (5)). Whenever required, commands are sent to the FeliCa chip from the client software via the FeliCa device driver, reading/writing the relevant data (Fig. 4 (6)). Afterward, the execution result is returned to the FeliCa Platform Server via the reverse route (Fig. 4 (7)). When the communication with the server is completed, the client software notifies the i-appli that the communication has ended, and the online processing is completed (Fig. 4 (8)).

4.4 Activating i-appli from R/W

Some models are equipped with a function that automatically activates an i-appli specified by the R/W when the mobile terminals are held close to the R/W. In order to use this function, it is necessary to download the relevant i-appli in advance. The R/W sends i-appli startup information and parameters to be passed to the i-appli. If the corresponding i-appli is found within the mobile terminal, the i-appli is automatically activated and the received parameters can be read on the i-appli side. This function can be used for example when it is desired to notify some information from the R/W to the user. So far this function only supports automatic activation of i-applis, but will be made compatible with browser and email software by adding rules of data format sent from the R/W to the mobile terminal in the future.

4.5 FeliCa Lock Function

Some models are equipped with a function that disables the FeliCa functions via settings by terminal operations and a remote lock operation (FeliCa lock function) in order to strengthen the security. With this function, even if a user loses his/her mobile terminal, unauthorized use by third parties can be prevented as it is possible to set the FeliCa lock remotely.

5. FeliCa Support Server

5.1 Overview

In addition to the FeliCa Platform Servers operated by FeliCa Networks, Inc. and other service providers, DoCoMo also provides a FeliCa Platform Server (hereinafter referred to as FeliCa support server). The FeliCa support server is positioned as an integrated part of the i-mode servers. It has various support functions for providing the i-mode FeliCa services to users in a stable manner.

5.2 Functions

The FeliCa support server provides functions for "traffic area division," "FeliCa chip full-format" and "free-area PIN initialization" for each area of the FeliCa chip. It also provides functions for "collaboration with i-appli" and "support for various FeliCa chip formats."

These five functions are as follows.

1) Traffic Area Division Function

This function logically divides the common area within the FeliCa chip to create a common area and traffic area. By creating a traffic area, it becomes possible to use traffic system services. **Figure 5** shows an overview of the traffic area division.
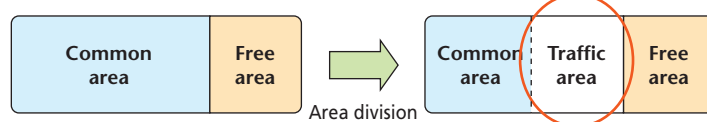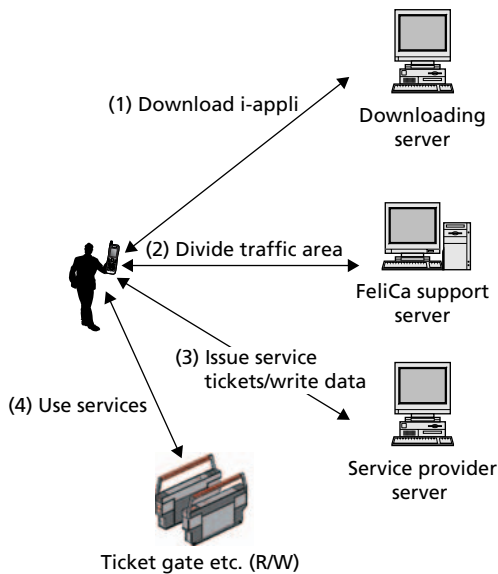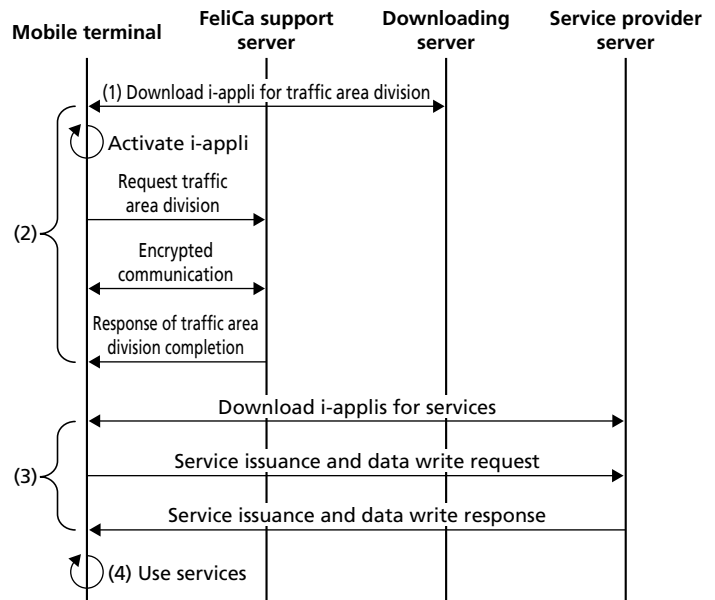
First, the user downloads the i-appli for traffic area division to the mobile terminal (1). Next, the user accesses the FeliCa support server using the downloaded i-appli for traffic area division and separates the traffic area from the common area within the FeliCa chip (2). After creating the traffic area, the user can download i-applis for necessary services from a server of a service provider and perform service issuance and data registration, thus making the FeliCa chip in the i-mode FeliCa compatible mobile terminal available for the services (3). Traffic system services can now be used via the i-mode FeliCa compatible mobile terminal, whose service application was enabled (4).

2) FeliCa Chip Full-format Function

This function deletes all data within the FeliCa chip (values and points of electronic money etc.) and returns the chip to the status it had at the time of purchase. This function can for instance be used when transferring a mobile terminal to a new user, when handing a mobile terminal in to DoCoMo for troubleshooting etc.

Figure 6 shows an overview of the full-format function of the FeliCa chip.

First, the user downloads the i-appli for full-format to the mobile terminal (1). Next, the user accesses the FeliCa support server using the downloaded i-appli for full-format, and per-

Figure 5 Overview of traffic area division

forms full format by deleting all data in the FeliCa chip (2).

3) Free-area PIN Initialization Function

This function forcefully returns the PIN code protecting the free area to the default PIN from the server side. If the PIN of a service registered in the free area has been changed for some reasons, the corresponding service may no longer be available. The service can be made available again by initializing the PIN using this function.

Figure 7 shows an overview of PIN initialization of the free area.

First, the user downloads the i-appli for PIN initialization to the mobile terminal (1). Next, the user accesses the FeliCa support server using the downloaded i-appli for PIN initialization, and initializes the PIN value protecting the free area (2). The service becomes available again by initializing the PIN (3).

4) Function for Collaborating with i-appli

As shown in **Figure 8**, the FeliCa chip updates and deletes values; it is necessary to maintain a high level of security. For this reason, i-applis that are permitted to access the FeliCa chip are registered in advance in the FeliCa support server, thereby restricting access to the high-security common area to services used by registered i-applis and preventing access from unregis-
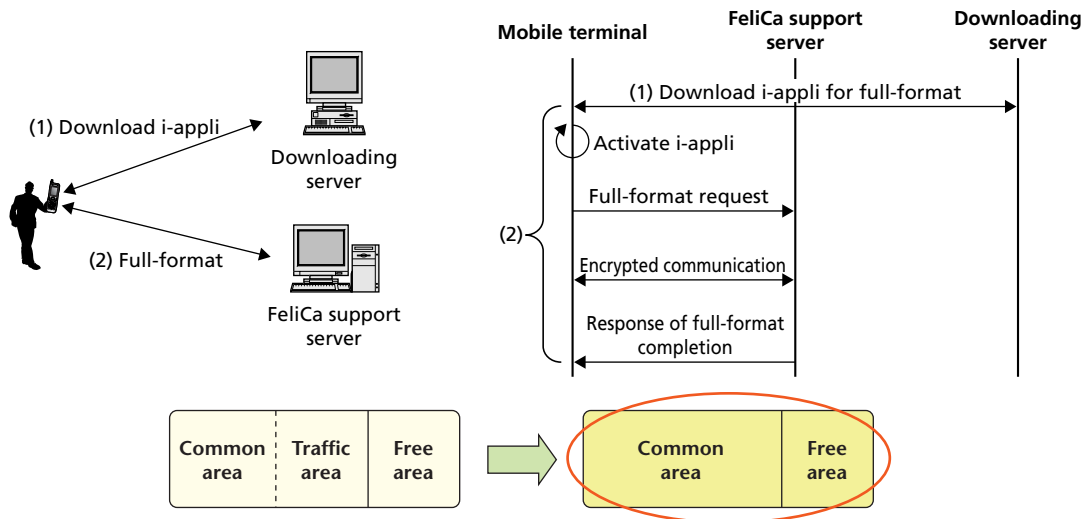

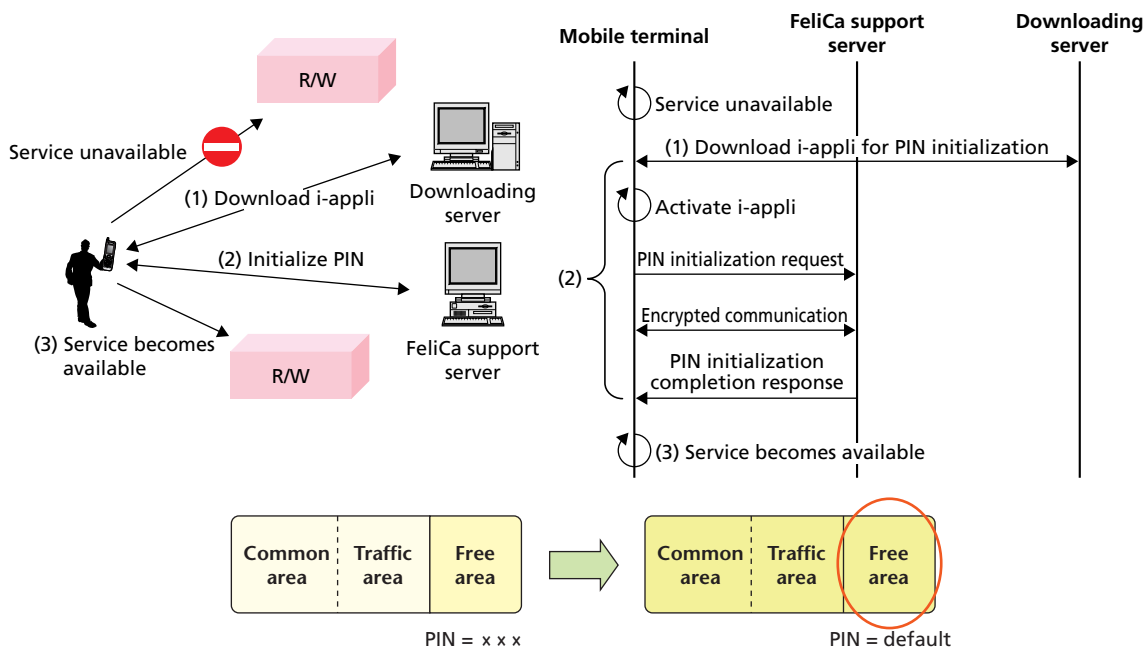Figure 6 Overview of FeliCa chip full-format
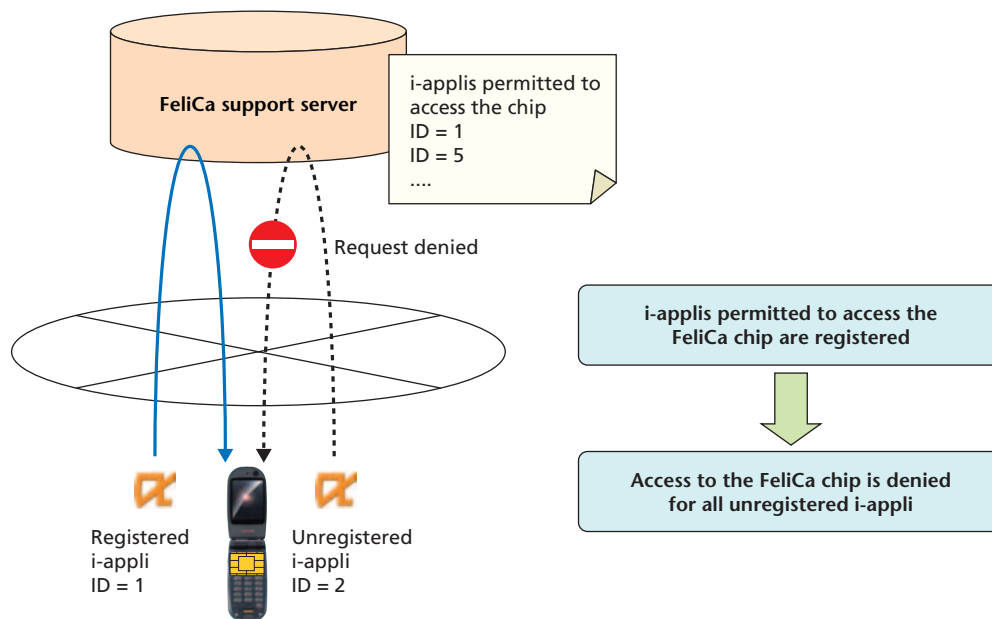

Figure 7 Overview of free area PIN initialization

Figure 8 Collaboration with i-appli

tered i-applis.

5) Functions to Support Multiple FeliCa Chip Formats

The FeliCa support server can support multiple FeliCa chip formats. For example, it can support FeliCa chips equipped in both 504iC and 506iC. Likewise, it provides expandability in case where there will be multiple FeliCa chip formats in the future.

As discussed so far, the FeliCa support server provides functions to support various types of users while maintaining the required level of security by performing encrypted communication with mobile terminals.

6. Conclusion

This article presented an overview of the services provided through i-mode FeliCa and mobile terminal/server technologies. In the future, we expect further development of real services using i-mode FeliCa and intend to examine services and develop technologies to create a new market.

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ABBREVIATIONS

API: Application Programming Interface
ASK: Amplitude Shift Keying
CLDC: Connected Limited Device Configuration
CP: Contents Provider
Doja: DoCoMo Java
FSS: FeliCa Secure Server
HTTP: HyperText Transfer Protocol
KVM: K Virtual Machine
PIN: Personal Identity Number
SAM: Secure Application Module

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