Terminal Applications | Multifunction | Safe and Secure

Technology Reports

Special Articles on Technology toward Further Diversification of Life-Style Mobile

Terminal Applications Technology for More Comfortable Life-Style Mobile

For mobile phones, the migration to Third-Generation systems means more than just higher capacity and speed. They are coming to be truly multifunctional devices featuring diverse communication functions through Internet connectivity, engaging entertainment functions such as music playback, and life-infrastructure functions including the well-known "Osaifu-Keitai" (mobile wallet). This article introduces terminal applications technology for achieving multifunctional mobile phones.

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1. Introduction

In the beginning, mobile phone services were essentially communication services centered about the telephone function (voice communications). They later came to include data communications such as e-mail and information retrieval from information providers via Internet connections. Then, as the appearance of camera-equipped mobile terminals enabled users to transmit pictures, mobile phone services began to evolve from communications-related functions to information processing. Next, it became possible to play games on a mobile phone through the i-appli service, purchase products using e-money systems like "Osaifu-Keitai," and download and play music and watch television (One Seg broadcasts) thanks to the evolution of Audio-Visual (AV) functions. Mobile phone services have therefore evolved from information-processing services to entertainment-oriented services, and the mobile terminal itself has become an indispensible tool within the infrastructure of daily life. We can expect the mobile terminal to continue to evolve in this capacity.

Against this background, mobile terminals are equipped with various types of applications that play the role of centralized functions for achieving such evolutionarily advanced mobile phone services.

From among the software loaded on a mobile terminal, we here focus on applications that behave as application software for specific functions such as mobile Internet access and on middleware technology that provides software for using these applications in common. We describe the evolution to date and future development of the "Internet access function," "mail function," "application download and execution environment," "AV function," and "safe and secure functions."

2. Evolution of the Internet Access Function

The Internet access function first appeared in the mova 501i series in the form of a browser as part of the i-mode service. It has gone through a variety of changes since then. The following describes the evolution of the browser function and future developments.

2.1 Evolution of Browser Analysis/Processing Functions

The launch of the i-mode service on the mova 501i series included support for HyperText Markup Language (HTML) and Graphic Interchange Format (GIF)[*1] as a browser function. But the use of HTML, not all functions (elements/attributes) could be supported, and only those deemed essential for the purpose at hand were incorporated in the beginning thereby limiting the browser's power of expression. The hardware capabilities needed to increase expressive power were also limited at that time with the result that screen displays consisted mostly of text information.

Hardware performance eventually improved, however, and software functions continued to evolve from year to year.

After one year the mova 502i series featured a color liquid crystal supporting the display of Joint Photographic Experts Group (JPEG) images.

Then, with the aim of expanding content services, the types of downloadable content increased enabling users to download music files, video files and i-appli files. In addition, the FOMA 900i series was equipped with a FLASH® Player[*2] thereby expanding the rich content, and the FOMA 901iS series was equipped with a full browser[*3] and a Portable Document Format (PDF) Viewer[*4] enabling the same level of functions as a PC browser to be supported and Internet-based information directed at PCs to be accessed.

In particular, the support of a full browser expanded the range of supported functions providing full support of HTML elements and attributes and catching up with PC-based browsers by incorporating functions such as Cascading Style Sheets (CSS)[*5], Script[*6] and Document Object Model (DOM)[*7] enabled, for example, the expression of dynamic content. In this way, browser analysis and processing functions on mobile terminals evolved rapidly. **Figure 1** shows the evolution of the browser function and **Table 1** compares i-mode browser and full-browser functions.

2.2 Toward High-Speed and High-Capacity Terminals

The higher transmission speeds made possible by the introduction of W-CDMA and the increase in terminal memory enabled the browser function to handle even more data. For mova terminals, data size jumped from several kilobytes to 100 kB at one stroke. This was expanded to 300-500 kB with the full browser enabling the provision of impressive content.

The introduction of High Speed Downlink Packet Access (HSDPA)[*8] in 2006 raised transmission speed dramatically, and the speed of the transmission protocol of the full browser was increased by taking full advantage of this high-speed transmission network. In the HTTP request pipeline function, for example, this enhancement enabled multiple request data to be sent simultaneously and

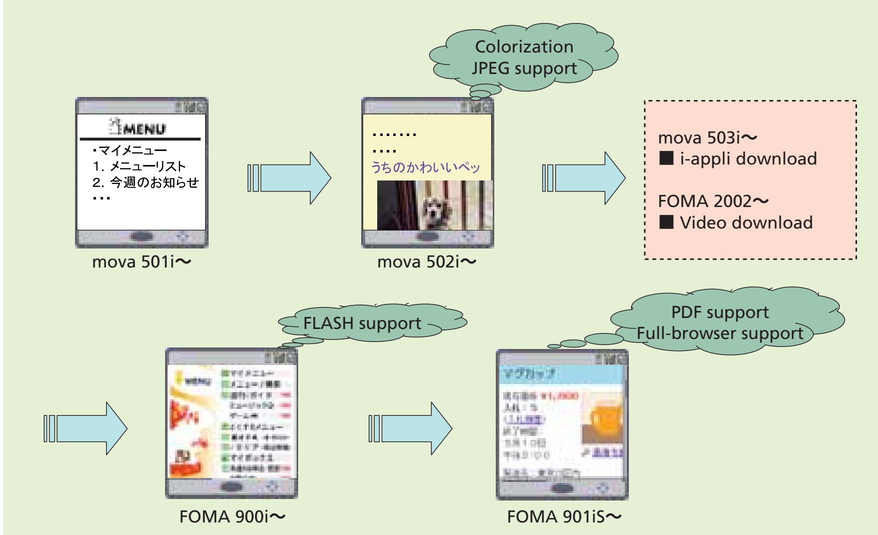

Figure 1 Evolution of the browser function

*1 **GIF**: An image file format featuring up to 256 colors.

*2 **FLASH® Player**: A vector-image playback environment.
FLASH is a registered trademark of Adobe Systems Inc.

*3 **Full browser**: A browser enabling PC-oriented Websites to be viewed on mobile terminals.

*4 **PDF Viewer**: A document format used in a PC environment.

*5 **CSS**: Specifications describing methods for expressing (displaying) elements; used in HTML, XML and other markup languages.

*6 **Script**: A simple programming language.

*7 **DOM**: Interface specifications for accessing and manipulating a document (information) in HTML.

all corresponding response data to be received in a continuous fashion. Introduction of this technology improved display speeds by about 40%.

2.3 Future Developments

The "browser" of today has become quite diversified in the way it is used. In recent years, for example, it has become a tool for displaying digital terrestrial broadcasts using the One Seg data-broadcast function installed in mobile terminals as well as a means of communication. In this way, the traditional style of watching TV is beginning to change as users come to watch program-related content. Development efforts are moving forward with the aim of converging broadcasting and communications such as by linking One Seg and i-appli, by enabling the downloading of ToruCa[*9] in conjunction with the FeliCa®[*10] service and by linking the browser with NTT DoCoMo services.

In the last few years, in addition to expanding the function set of the browser itself, other applications have come to be incorporated in the browser in the form of Plug-ins and the browser has come to be used as a means of communicating with those applications. From here on, the browser will continue to expand as a vital tool inside the Life-Style Mobile.

3. Evolution of the Mail Function

Mail has become an indispensible service in mobile phones, and it has grown to include a wide range of services from simple text sending/ receiving to Deco-mail[*11]. The following describes the evolution of the mail function.

3.1 Diversification of Mail Services

Figure 2 shows the evolution of the mail function.

The mail function installed as an i-mode service in the mova 501i series was initially capable of sending/ receiving text messages up to 250 full-width (two-byte) characters in size. Up to then, mail services were generally of the "short

Table 1 i-mode browser and full-browser functions

Supported Function	i-mode Browser	Full Browser
HTML4.01	△	○
CSS	△ (style attribute)	○
Script	×	○
DOM	×	○
Cookie	×	○
Supported media (still pictures)	JPEG, GIF	JPEG, GIF, BMP, PNG
SSL	SSL2.0/3.0	SSL2.0/3.0, TLS1.0
File upload	×	○
1-page max. size	100 kB	300 kB
Cache size	500 kB	1 MB
Frame page	×	○
Multi-window	×	○ (up to 5 windows)

BMP: windows Bitmap Image
PNG: Portable Network Graphics
TLS: Transport Layer Security

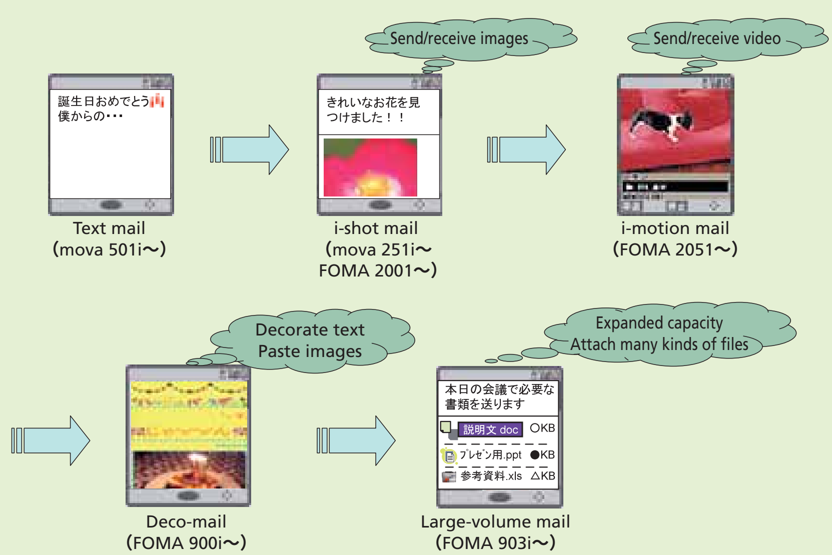

Figure 2 Evolution of the mail function

*8 **HSDPA**: A high-speed downlink packet transmission system based on W-CDMA. Used by NTT DoCoMo in the "FOMA High-Speed" service.

*9 **ToruCa**: A service for storing digital restaurant cards and coupons in a mobile terminal.

*10 **FeliCa®**: A contactless IC card technology developed by Sony Corp. A registered trademark of Sony Corp.

*11 **Deco-mail**: HTML-based mail service for mobile terminals.

mail" type that could send/ receive only 50 full-width characters. Consequently, the equipping of mobile terminals with i-mode mail that included the addition of pictograms for i-mode use plus significant changes in the transmit/receive system represented a major evolutionary step at that time.

This development was followed by the addition of the Chaku-melo service in the mova 502i series and a function for sending melodies to other mobile terminals. Then, with the appearance of the mova 503i series, to support users who felt that 250 characters was not sufficient for writing messages, a server function was adopted to divide up mail having more than 250 characters so that messages up to 2,000 full-width characters in size could be sent and received.

Next, with the spread of camera-equipped mobile terminals, a function for transmitting images such as photographs taken with the mobile terminal itself was incorporated in the mova 251i series. Around this time, a FOMA mail function was being developed in parallel, and considering the insufficient capacity of text messages in mova terminals and the need to achieve compatibility with PC mailers, the maximum size of mail to be transmitted was hiked up to 10 kB (5,000 full-width characters). Mail service that also allowed the sending of mail to multiple addresses and the attachments of files (GIF, JPEG, Standard MIDI File (SMF)) began with the FOMA 2001 and 2101V terminals.

In the following year, with the provision of video services in the FOMA 2051 series, support was provided for the attachment of video files up to 100 kB in size. And in parallel with the mova i-shot service, it also became possible to attach a JPEG file up to 100 kB in size.

Then, with the aim of upgrading the existing text-based mail service, the FOMA 900i series came installed with Deco-mail. Using HTML elements and attributes, this function enables character color, size and display position to be specified and images and photographs to be attached in mail. As a result, the Deco-mail function has found widespread use as a service for expressing the feelings on the mail-sending side in a more enriching manner. It has become the de facto standard for mail service in mobile phones in Japan.

3.2 Future Developments

Compared with its initial version in the FOMA 900i series, Deco-mail has expanded maximum mail size by about 10 times and has added more pictograms making the sending of mail all the more convenient for users. The mail function on the whole has developed in parallel with Deco-mail enabling the attachment of all kinds of files and expanding transmit/ receive size to 2 MB. The aim here is to provide mail services that even PC users would find easy to use.

From here on, as the mobile terminal becomes a Life-Style Mobile interlinked with various devices and services, we can expect the mail function to evolve steadily as a communication tool for expressing feelings and conveying information.

4. Evolution of Application Download/Execute Environment

The application download/execute environment supported by i-mode terminals is commonly referred to as "i-appli." The i-appli service enables a user to download software programmed in the Java®*12 language to the user's mobile terminal for execution. This service was launched when a Java execution environment was first installed in the mova 503i series that went on sale in 2001. Since then, functions have been added and performance improved so that services provided by i-appli have come to range from entertainment services like Mega Games (high-quality games) and Chokkan Games (interactive intuitive games) to services for daily life like e-money and credit. The following describes the evolution to date of the i-appli service and future developments.

4.1 Overview of i-appli Execution Environment

Figure 3 shows the i-appli execution environment installed in mobile terminals. This configuration consists of the K Virtual Machine (KVM), the Connected Limited Device Configuration (CLDC) Java standard class library, the DoCoMo Java (DoJa)*13 Java class library specific to NTT DoCoMo services and the Java

*12 **Java®**: A registered trademark of Sun Microsystems, Inc. in the United States.
*13 **DoJa**: A group of functions used by i-appli assembled as a group of Java program components.

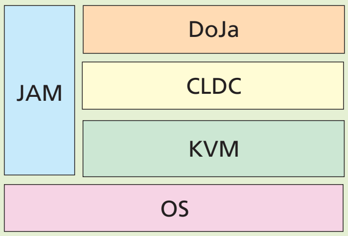

Figure 3 Configuration of i-appli execution environment

Application Manager (JAM) that controls i-appli startup. The KVM and CLDC adopt standard specifications to ensure compatibility, while DoJa was developed to achieve NTT DoCoMo original services. The spread of services based on i-appli is therefore heavily dependent on function development in DoJa.

4.2 DoJa Functions and Their Expansion

Table 2 shows the package configuration of DoJa and **Figure 4** shows the overview of DoJa. Here, DoJa is divided into i-appli base classes, function classes used by i-appli, and a scratch pad used as data storage. The base classes correspond to templates for i-appli programs; the programmer must program an i-appli inheriting a base class. A function class is called by the i-appli via an Application Programming Interface (API). The scratch pad may also be accessed by the i-appli via API to read and write data.

The distinctive feature of an i-appli base class is that it specifies an i-appli's life cycle (execution, suspension, resumption and termination) in a form that conceals from the i-appli creator interruptions characteristic of mobile terminals like incoming calls or mail. For example, in the event of an incoming call, the i-appli will automatically suspend processing, and on completion of that call, the i-appli will resume processing. The program template is such that the i-appli creator need not worry about processing like the releasing of resources during i-appli suspension. It is sufficient for the developer to program just the processing on the i-appli side at the time of resumption.

Table 2 DoJa package configuration

Package Name	Description
com.nttdocomo.ui	Contains application base classes and classes for user-interface functions and graphic functions
com.nttdocmo.device	Contains classes for controlling devices such as cameras, FeliCa and infrared
com.nttdocomo.io	Contains classes for handling communications and data input/output
com.nttdocomo.lang	Contains base classes for accessing memory control functions and those of original NTT DoCoMo objects
com.nttdocomo.net	Contains classes related to character-string processing during network communications
com.nttdocomo.security	Contains classes that handle digital signatures, ciphers, etc.
com.nttdocomo.util	Contains utility classes for phone functions, timers, etc.
com.nttdocomo.system	Contains classes for using native functions such as phonebook and mail
com.nttdocomo.fs	Contains classes related to file systems on storage devices when dealing with such devices

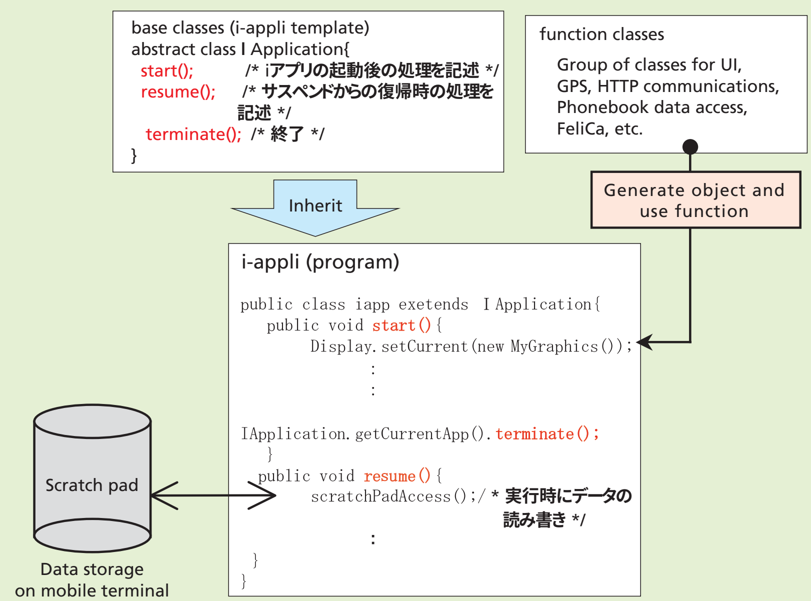

Figure 4 DoJa overview

The scratch pad is virtual data storage formed in memory; it is used for storing images and data.

During the period from the launch of the mova 503i series in 2001 to the launch of the FOMA 905i series in November 2007, DoJa underwent five major and three minor version upgrades including the addition of new functions and the expansion of i-appli and scratch pad size. **Table 3** shows major DoJa versions and corresponding terminal models, functions, i-appli size, and scratch pad size.

The expansion of i-appli and scratch pad size to the values shown was based on trends in content and the amount of memory that could be mounted in mobile terminals.

The development of DoJa functions progressed along three directions. Up to DoJa3.0, function expansion occurred mainly in the use of mobile-terminal native software (browser, mail, phone book, etc.) based on i-appli.

Here, there was a need to access the data handled by this native software in a secure manner, and this led to the development of the trusted function[*14]. Then, from DoJa4.0, function development occurred chiefly in the use of devices (Secure Digital (SD) memory cards, Global Positioning System (GPS), Bluetooth®[*15], etc.) installed in mobile terminals, and from DoJa5.0, function development was centered on recognition technology that could be applied to user interfaces as seen in Chokkan Games (movement/speech recognition).

These developments reflect three turning points in the expansion of the i-appli service: implementation of the trusted function, use of FeliCa, and use of SD-Binding and OpenGraphics Library for Embedded Systems (OpenGL ES). Implementation of the trusted function provided a mechanism whereby only i-appli programs that had been granted authorization could access mobile terminal functions,

Table 3 DoJa versions and corresponding models, functions and data capacities

DoJa main versions	Models	Functions and data capacities
DoJa1.0	mova 503i/503iS FOMA 2101/2001	i-appli size: 10 kB
		Scratch pad size: 10 kB
		Main functions: HTTP/HTTPS communications, UI functions
DoJa2.0/2.1	mova 504i/504iS FOMA 2102/2051/2701	i-appli size: 30 kB
		Scratch pad size: 100 kB
		Main added functions: standby i-appli functions, infrared communications, browser linking, camera/code recognition functions
DoJa3.0	mova 505i/505iS 506i/506iC/506iS	i-appli size: 30 kB
		Scratch pad size: 200 kB
		Main added functions: trusted function (i-appli DX), FeliCa function
DoJa3.5	FOMA 900i	i-appli size: 100 kB
		Scratch pad size: 400 kB
DoJa4.0	FOMA 901i/901iS	i-appli size: 100 kB
		Scratch pad size: 400 kB
		Main added functions: 3D graphics function, 3D sound function
DoJa4.1	FOMA 902i/902iS	i-appli size: 100 kB
		Scratch pad size: 400 kB
		Main added functions: SD-Binding function, digital TV function
DoJa5.0	FOMA 903i/904i	i-appli/scratch pad size: 1 MB total
		Main added functions: GPS, Bluetooth, OpenGL ES, movement recognition, accelerator sensor
DoJa5.1	FOMA 905i	i-appli/scratch pad size: 1 MB total
		Main added functions: speech recognition

*14 **Trusted function**: A function that grants usage rights only to authorized i-appli programs.

*15 **Bluetooth®**: A registered trademark of Bluetooth SIG Inc. in the United States.

and it enabled a significant increase in the types of data and devices that could be handled by i-appli programs. This, in turn, enabled the expansion of practical services such as navigation applications using maps. The use of FeliCa enabled the development of applications such as e-money and credit for the Life-Style Mobile and the use of SD-Binding and OpenGL ES enabled the provision of high-performance game applications. In particular, SD-Binding made it possible to store several tens of megabytes of game images in SD memory instead of the more difficult task of storing such data in mobile terminal memory. The use of OpenGL ES, meanwhile, gave i-appli programs direct access to a Graphics Processing Unit (GPU) making it possible to achieve realistic 3 Dimensional Computer Graphics (3DCG) on par with dedicated game machines.

4.3 Improving Performance of i-appli Execution Environment

In enhancing DoJa, efforts were made not just to develop functions but to improve performance as well. This was because of the need for high processing performance in games (especially for high-speed drawing). It was recognized that approaching the level of demanded performance would enable more games to be provided for NTT DoCoMo terminals and would increase the number of choices for users. Accordingly, with the aim of raising the level of processing performance in mobile terminals, measurement items were selected, benchmark content was prepared, measurements taken, and tuning performed for mobile terminals under development. Improvements were also made in the CPU installed in mobile terminals. For example, drawing performance improved by about three times in the FOMA P905i terminal compared with the earlier FOMA P902i model.

Efforts were also made to shorten i-appli startup time in addition to simply improving performance. This was in response to the call by many users for faster boot times. The startup of an i-appli program consists of the launching of the i-appli execution environment (KVM boot, i-appli load, execution of start () method by KVM) and the beginning of processing by the i-appli itself (after execution of start () method). Considering that the beginning of processing by the i-appli itself depends on the i-appli creator, the efforts made here to shorten startup time focused on shortening the launch time of the i-appli execution environment. To this end, the boot time of the i-appli execution environment from the selection of the i-appli by JAM was measured and the factors governing the prolonging of launch time were analyzed so that appropriate tuning could be performed. As a result, a launch time of one second or longer in the FOMA N900i, for example, was reduced to about one fourth of that in the N902i terminal.

4.4 Future Developments

Another point of concern in addition to adding functions and raising performance in a timely manner is improving the ease of access to i-appli programs themselves. One reason for expanding the i-appli service is to get more users to use i-appli programs. Efforts are therefore being made to develop means of access that take usability into account in addition to the current means of access (access by menus or by depressing the i-mode button).

5. Evolution of the AV Function

Figure 5 shows the evolution of the AV function in FOMA terminals. The AV function has a wide range of application starting with a videophone service and extending to an AV content playback service and a User Interface (UI) enhancement service. The following describes specific functions making up the AV function that we here divide into the areas of communication, AV content playback, and UI enhancement.

5.1 Communication

The FOMA series was first put on sale in October 2001, and it was only fitting of a Third-Generation mobile phone that a videophone service was launched at the same time as a means of communication. There were, however, a number of issues that had to be addressed if this videophone service was to find widespread use such as the securing of connection destinations and the increase in terminals equipped with this service. In

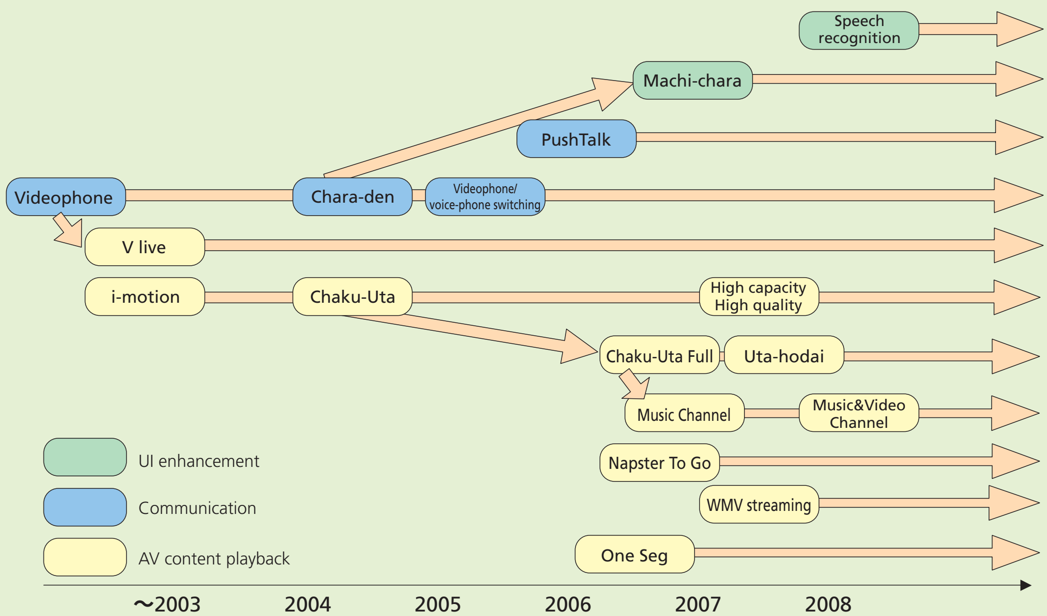

Figure 5 Evolution of the AV function

response to these issues, we adopted the 3G-324M[*16] standard specification for videophones using circuit-switching networks. Also, to ensure an acceptable level of quality even on low-bit-rate and high-error-rate wireless channels, we adopted the Moving Picture Experts Group phase 4 (MPEG-4)[*17] and Adaptive Multi-Rate (AMR)[*18] codecs known for their superior compression rate and error resistance for the video and audio codecs, respectively. Then, with the aim of providing users with more opportunities to use the videophone service, we developed the Chara-den animated avatar function incorporating 3D graphics technology and a function for switching between the videophone and regular voice phone while a call is in progress.

In November 2005, NTT DoCoMo launched its "PushTalk" service enabling 1-to-many communication in contrast to 1-to-1 communication used in its voice-phone and videophone services. PushTalk is a packet-switching best-effort type of service in contrast to circuit switching. It adopts communication protocols used on IP-based networks such as Session Initiation Protocol (SIP)[*19] for call control and user-participation-status notification, Real-time Transport Protocol (RTP) for voice transmission, and RTP Control Protocol (RTCP) for speaker's authority control.

5.2 AV Content Playback

Thanks to higher speeds on wireless channels made possible by the introduction of W-CDMA, NTT DoCoMo launched its i-motion video clip distribution service in October 2002 based on a file format specified by the 3rd Generation Partnership Project (3GPP) that produces standard specifications for Third-Generation mobile phones. In 2004, it became possible to set an i-motion clip to a ring tone to provide a service corresponding to the ChakuUta service.

In June 2004, NTT DoCoMo introduced its data packet flat-rate system, and in March 2006, it became possible to use this system in all billing plans. In technical terms, too, the year 2006 marked dramatic changes in the AV content distribution service in mobile phones due to the raising of processing capability in mobile terminals, the implementation of SD-Binding technology enabling the use of external memory instead of internal memory, the incorporation of High-Efficiency

*16 **3G-324M**: Circuit-switching videophone standard for Third-Generation mobile communication.
*17 **MPEG-4**: A coding system for moving-picture data used for delivering video over relatively slow communication circuits as in mobile terminals.
*18 **AMR**: A speech coding scheme for Third-Generation mobile communication defined by 3GPP. It allows flexible variation of the transmission rate according the type and condition of networks.
*19 **SIP**: A call-control protocol that can be used in videoconferencing and other applications in addition to VoIP.

Advanced Audio Coding (HE-AAC) and a high-coding-efficiency video codec (H.264[*20]), and support of a high-speed packet communications function based on HSDPA.

Specifically, this period saw the launch of the Chaku-Uta Full service enabling the download of audio files up to 5 MB in size, the Uta-hodai service that enables the use of Chaku-Uta Full for a fixed monthly rate, the 10 MB i-motion service enabling the download of video content up to 10 MB in size, and the Music&Video Channel service that can deliver content up to 25 MB in size making use of overnight delivery. The common element running through these services is that, despite the use of formats and codecs oriented to mobile phones, they correspond to content for listening and viewing purposes such as individual songs and video clips much like those delivered to PCs.

In addition, support of the Windows Media®[*21] Video (WMV) service when using a full browser as well as the Napster To Go®[*22] service and One Seg function meant that the same kind of content that can be enjoyed on home appliances, portable AV players, and PCs could now be enjoyed on mobile terminals.

5.3 UI Enhancement

Along with performance improvements in the mobile-terminal's CPU and hardware accelerator, the AV function has come to be used for more than just a dedicated player. Its range of application has expanded to the area of UI enhancement such as by the Machi-chara function that provides the user with a friendly UI through the use of 3D characters. In 2007, a speech-recognition function came to be supported enabling the activation of i-appli programs by voice-input signals thereby enabling users to use voice input for a purpose other than communication.

5.4 Future Developments

Looking to the future, we plan to continue our development efforts at improving the mobile terminal as a player of content as well as improving the usability of the mobile terminal together with various types of applications and devices and enhancing communications.

6. Safe and Secure Functions

NTT DoCoMo feels that it has a social responsibility to provide users with "safe and secure services." The following describes several functions that NTT DoCoMo has achieved to this end.

6.1 Secure Communications through Electronic Authentication

The provision of diverse applications for mobile phones has expanded the way in which the mobile Internet is used as reflected by Internet shopping and stock trading. It has consequently become even more important to ensure a high level of security through personal authentication.

From the beginning, FOMA terminals have been equipped with a function for authenticating servers from the mobile terminal on an end-to-end basis. This function uses Secure Socket Layer (SSL)[*23], the most widely used type of secure communications[*24] protocol.

FOMA terminals have also been equipped with the FirstPass SSL client authentication service as a means of authenticating a mobile terminal from the server. FirstPass was launched in June 2003 as the first commercial service in Japan using a client authentication function based on Public Key Infrastructure (PKI) technology.

6.2 Personal Data Storage Service

The advances made in mobile terminal functions and value-added services have also increased the variety and volume of user data. The risk of data loss due to a damaged or lost terminal has consequently increased and the protection of user data has become increasingly important. At the launch of FOMA services, it was assumed that users would take it upon themselves to back up data on their FOMA terminals using external storage media such as SD memory. At the same time, the development of increasingly sophisticated mobile terminals with higher added value has made the loss of data due to damaged or lost terminals a problem that can have a major social impact as well. With this in mind, the Personal Data Storage Service was launched in June 2006 as one service for achieving "safety

*20 **H.264**: An ITU-T standard that significantly improves upon MPEG-4 (see *17) quality and compression rate. Also called MPEG-4 AVC.
*21 **Windows Media®**: A registered trademark of Microsoft Corporation in the United States.
*22 **Napster To Go®**: A registered trademark of Napster, LLC.
*23 **SSL**: A protocol for encrypted communications.
*24 **Secure communication**: A safe way to communicate using encrypted communications and client/server authentication.

and security in times of emergency." The Personal Data Storage Service safely stores user data such as phonebook, images, and mail stored on the user's mobile terminal on a NTT DoCoMo server. It allows the user to retrieve that data at any time whenever needed. This service is based on the Open Mobile Alliance-Data Synchronization (OMA-DS)*25 international standard for data synchronization as a system for synchronizing and updating data between the mobile terminal and server.

6.3 Security Scan

Computer viruses first appeared in PCs with the intention of destroying data via an external storage medium like a floppy disk. Then, with the spread of the Internet, this mode of attack was followed by worms that would self-propagate over the network via e-mail or other means and infect computers in an explosive manner creating a genuine social problem. In June 2004, the "Cabir" virus appeared targeting mobile phones for the first time in the world.

Against this background, the targeting of mobile phones for attacks could be envisioned, and as a countermeasure, it was decided to equip terminals with the Security Scan function beginning in December 2004. To protect the mobile terminal, this function prevents the use of data at risk of generating bugs and prevents access to content or sites that could initiate a malicious attack to the detriment of the user.

This function is loaded on a mobile terminal by downsizing scan-engine software that has become basic to virus-detection technology on PCs. Pattern data used to protect the mobile terminal is prepared once a risk to mobile-terminal software is discovered and it is automatically downloaded to the mobile terminal. This process can deal effectively with new risk and enhance mobile-terminal security quickly and appropriately.

6.4 Future Developments

We introduced several applications and middleware functions as safe and secure services on FOMA terminals. In addition to providing services for achieving safe and secure mobile phones, NTT DoCoMo provides many functions for dealing with faulty, stolen and lost mobile terminal, for limiting access to harmful sites, and for dealing with natural disasters.

NTT DoCoMo plans to expand its services for safe and secure use of mobile terminals and to support the evolution of related applications and middleware through ongoing development efforts.

7. Conclusion

In this article, we described the evolution to date and the future development of the "Internet access function," "mail function," "application download and execution environment," "AV function," and "safe and secure functions" as application and middleware technology installed in mobile terminals. We can expect application technology to continue to evolve as mobile terminals become increasingly sophisticated in functionality, complexity, and performance. With the aim of expanding FOMA services, we plan to develop diverse applications in an efficient and timely manner to achieve compelling services and functions and make the use of mobile phones safer and more secure.

*25 **OMA-DS**: OMA standard specifying a data synchronization method between client and server.