

Special Article on Advanced i-mode Mobile Phones

Overview of Advanced i-mode Mobile Phones

*Hidetoshi Yazaki, Isao Hirakodama, Yuko Sasahara,
Madoka Tsutsumi and Kouji Chiba*

i-mode mobile phones are all-in-one mobile phone terminals in that they are equipped with a browser, e-mail and other general-purpose applications. This article reviews the technologies used in the Digital Mova 503i series, which has advanced functions like Java and SSL capabilities.

● New Technology Report ●

1. Introduction

The year 2001 is marked by the 9th anniversary of DoCoMo's mobile phones based on the Personal Digital Cellular (PDC) system, which was launched in April 1993. The mobile phones are evolving at a dramatic pace, from speech telephony to information services based on data communications. In January 2001, DoCoMo released i-mode mobile phone 503i series, which exploits the merits of data communications and advanced applications.

Since the launch of mobile communication services, ceaseless efforts have been made to add advanced features to DoCoMo mobile phones and to reduce their weight and size. The first standard-type mobile phone with i-mode support was the 209i series, which boasted 60 g in weight and 60 cc in size. Efforts to decrease the weight and size were also made for the 503i series, although miniaturization had not been the sole concern in the interests of its brand image as a high-end product with advanced functions based on the latest technologies. The 501i series [1] released in February 1999 was the first i-mode mobile phones with browsing and e-mail functions. It is fresh in our memory how quickly, to the world's astonishment, the 501i series penetrated the market after its release. This was followed by the 502i series, equipped with a color Liquid Crystal Display (LCD) and adapted to advanced entertainment services such as downloadable ringing melodies. The latest 503i series is adapt-

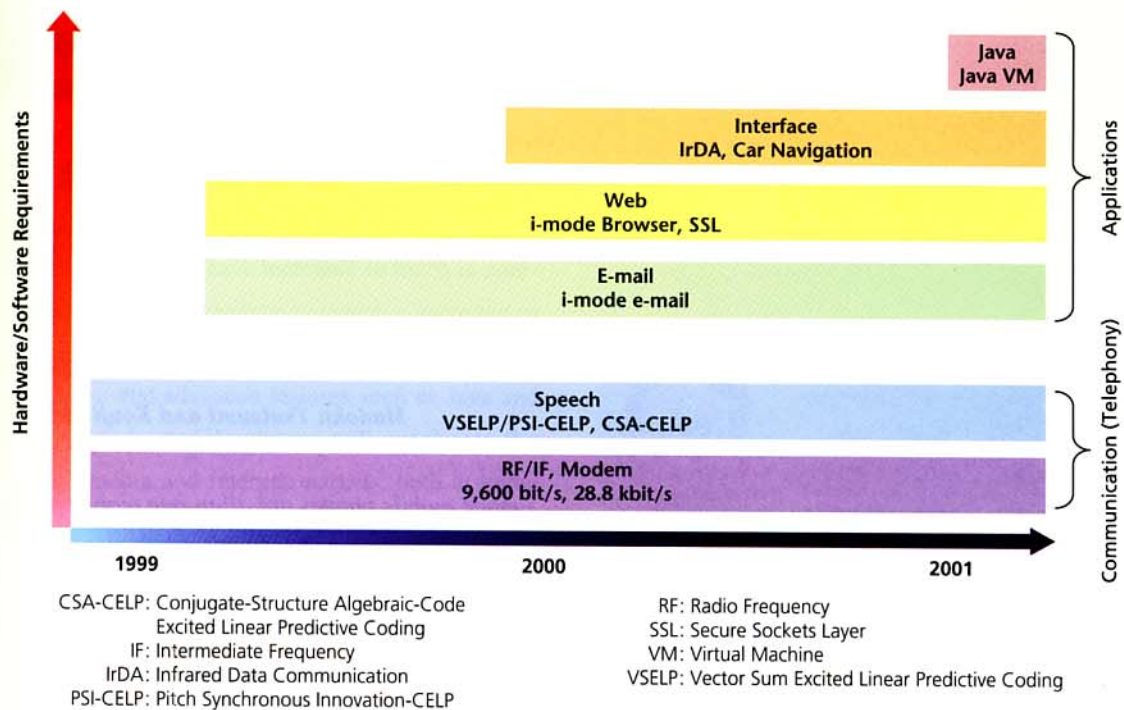


Figure 1 Introduction of Advanced Functions

ed to more advanced entertainment, agency and mobile commerce services, and adheres to an end-to-end security protocol which is essential for protecting confidential information. It should be noted that mobile communications markets worldwide are becoming increasingly inclined to services provided via Internet connection. It is no exaggeration to say that the key for future mobile phones lies in the development of applications geared to the Internet. **Figure 1** shows how the functions of i-mode mobile phones have become more advanced over the years.

2. Development of Advanced i-mode Mobile Phones

Conventional i-mode mobile phones were able to adapt to the steady expansion of browsing, e-mail and other services based on data processing systems. However, the limitations of data processing systems in achieving more advanced services drove DoCoMo to adopt a technology called Java,^{★1} aimed at providing more dynamic and flexible services. Java's core philosophy "Write Once, Run Anywhere" is a good description of DoCoMo's fundamental stance, which is, to provide services equally to all mobile phones. As Java generates applications that can run on any mobile phone regardless of the Operating System (OS), it is an extremely attractive technology, considering its ability to enhance and advance the functions of mobile

phones. In conjunction with the adoption of this technology to make services more convenient, DoCoMo adopted the Secure Sockets Layer (SSL)^{★2} to eliminate the risks of unauthorized access to personal information. SSL specifies the procedures for checking the authenticity of the party at the other end of communication, and makes end-to-end encrypted communication possible. The protocol creates a secure data connection environment for the user. Models in the latest Series are referred to as advanced i-mode mobile phones, because they are based on a wide range of new technologies that facilitate convenience, entertainment qualities and interoperability.

3. Hardware Configuration

The three main components in hardware development are as follows.

(1) Central Processing Unit (CPU)

Compared with the 502i series, the CPU of the 503i series faces greater computational complexity due to the authentication process and encrypted communication associated with SSL and the execution of commands from Java applications. 503i achieves greater speed performance by expanding the bus width, raising the clock frequency, increasing the cache memo-

★1 Java: An object-oriented programming language suited for use on networks, developed and advocated by Sun Microsystems in the U.S.

★2 SSL: Secure Sockets Layer, a protocol that creates a secure connection between a client and a server, developed and advocated by Netscape Communications in the U.S.

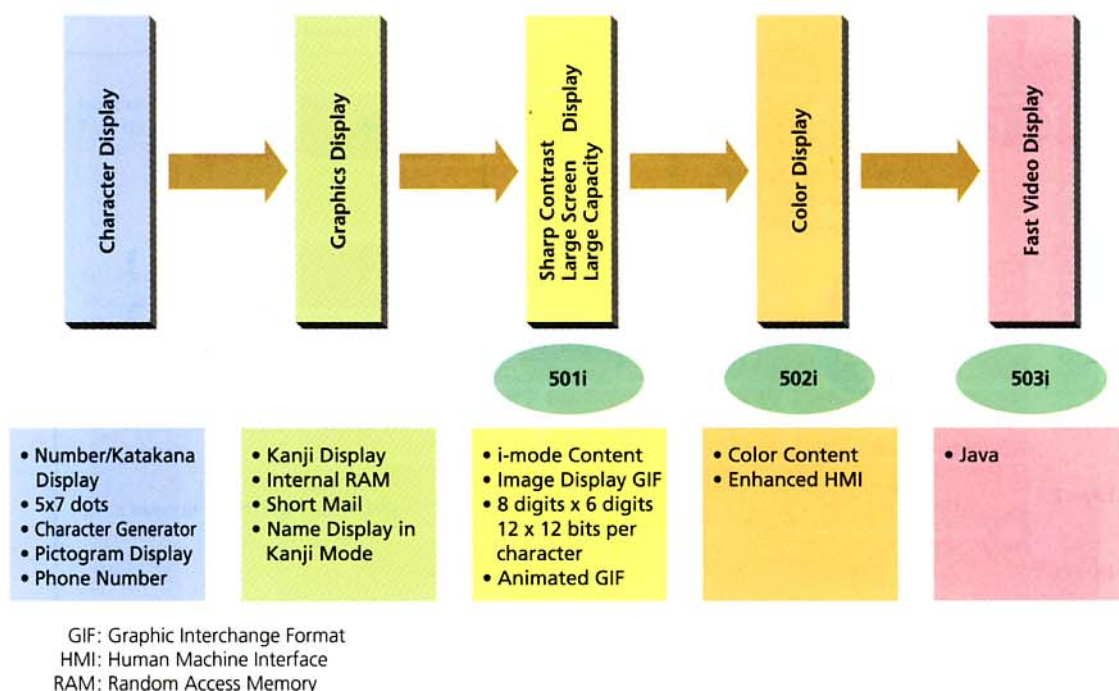


Figure 2 Changes in Objects Displayed by LCD

Table 1 Comparison of LCD Technologies

		TFT (Active)	TFD (Active)	STN (Passive)
Display	Number of Colors	65,536 colors	4,096 colors	256 colors
	Brightness	Reflectance: 30%		
	Contrast	15: 1	15: 1	10: 1
	Viewing Angle	80°		70°
Response Speed		Approx. 60 ms	Approx. 60 ms	Approx. 400 ms
Power consumption during standby-mode	Total Screen Display	3 mA	1 mA	0.4 mA
	Partial Screen Display	0.7 mA	0.4 mA	0.15 mA

STN: Super Twisted Nematic Liquid Crystal
 TFD: Thin Film Diode Liquid Crystal
 TFT: Thin Film Transistor Liquid Crystal

ry, adopting fast display LCD, and distributing the load of internal processing.

(2) Various Types of Memories

The 503i series has about twice the Random Access Memory (RAM) and Read Only Memory (ROM) compared to the 502i series, to cope with the increased size of contents designed for color LCD, the dramatic expansion of the user data region required to store Java applications, and the radical increase in the working memory needed to run Java applications.

(3) LCD Device

The 501i series was equipped with monochrome LCD, and some models in the 502i series were equipped with color LCD. In contrast, each and every model in the latest 503i series has a color LCD as a standard feature. Color LCD enables the mobile

phones to display exciting graphics in addition to conventional text, which facilitates the entertainment value of i-mode contents. Moreover, the 503i series has a larger screen and a higher resolution. The display area (number of characters and graphics displayed) has been enlarged and the visual performance has been improved without any noticeable increase in the overall size of the mobile phone and power consumption. **Figure 2** shows how the objects displayed on LCD have changed with models. **Table 1** compares and contrasts LCD technologies. In contrast with the earlier series, which adopted an LCD technology called Super Twisted Nematic Liquid Crystal (STN)^{*3}, some models in the 503i series rely on Thin Film Diode Liquid Crystal (TFD; 4,096 colors)^{*4} and Thin Film Transistor Liquid Crystal (TFT; 65,536 colors)^{*5}.

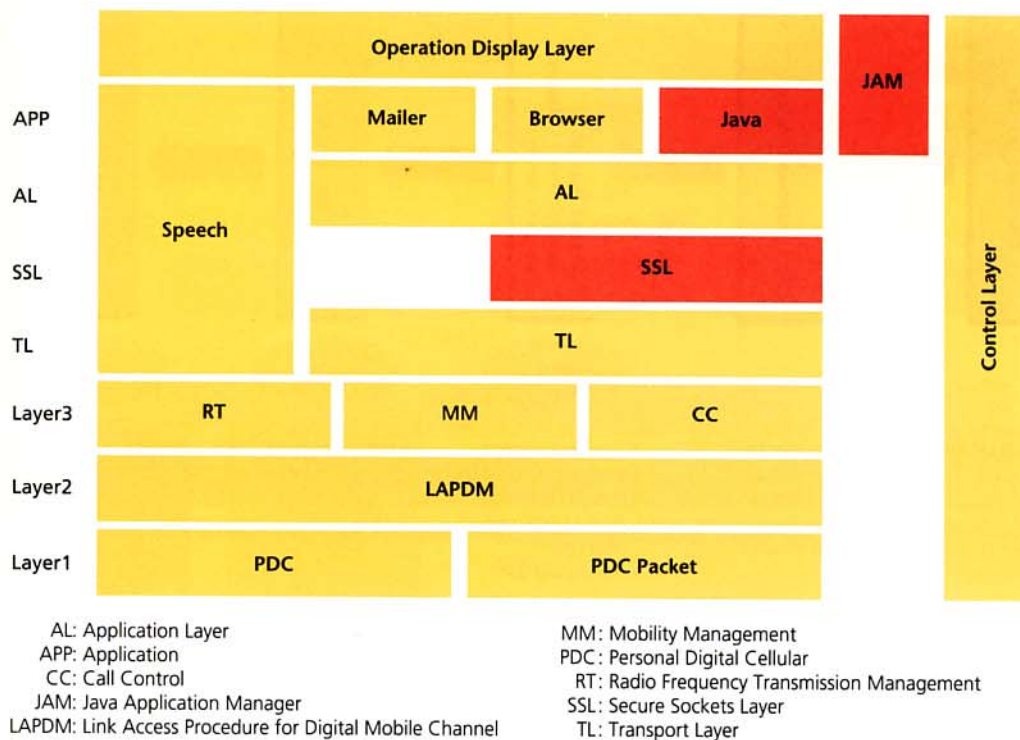


Figure 3 Protocol Stack

4. Protocol Stack

Figure 3 illustrates the protocol stack of the 503i series. Red-shaded areas represent the new components.

The Java Application Manager (JAM) in the Figure refers to the component which manages the operation of Java applications.

5. Overview of New Functions

The new functions of advanced i-mode mobile phone 503i series are outlined below.

(1) Java

In the 503i series, a new middleware has been installed for downloading and running Java applications. The middleware is a Virtual Machine (VM) that runs on the OS. The 503i series employs the K Virtual Machine (KVM), which is a VM subset developed for mobile phones and other embedded devices. KVM enables users to download and delete applications, and allows memory-constrained mobile phones to receive a wide range of services in an efficient manner at real time. It also

leaves much room for the enhancement of services.

Java makes the following services possible.

- Entertainment services: Games, karaoke, etc.
- Agency services: Stock quotes, etc.
- Mobile commerce services: Net transactions, etc.

(2) SSL

SSL is a security protocol that creates a secure end-to-end communication between i-mode mobile phones and i-mode servers. SSL not only encrypts the exchanged data, but it also checks the authenticity of the party at the other end of communication.

(3) i-mode Communication Protocol

i-mode uses a simple communication protocol, with minimal control information (e.g., header) and retransmission control, in order to establish communication under the resource constraints in mobile phones. The latest advanced i-mode mobile phones have improved transmission efficiency and quality, as well as an optimized interface between layers to ensure coherence with SSL.

(4) Browser

The browser is designed for a subset version of Hyper Text Markup Language (HTML). As the latest version has the capacity to display content up to 10 kbyte, in contrast with 5 kbyte in the earlier series, users can browse more elaborately-designed

★3 STN: Super Twisted Nematic. A passive matrix LCD, in which the transmittance and reflectance of light is controlled by twisting the liquid crystal molecules.

★4 TFD: Thin Film Diode. An active matrix LCD similar to TFT. TFD is reflective and consumes relatively little power.

★5 TFT: Thin Film Transistor. An active matrix LCD, in which a thin-film transistor is associated with each pixel. TFT displays have outstanding speed, contrast, and color saturation.

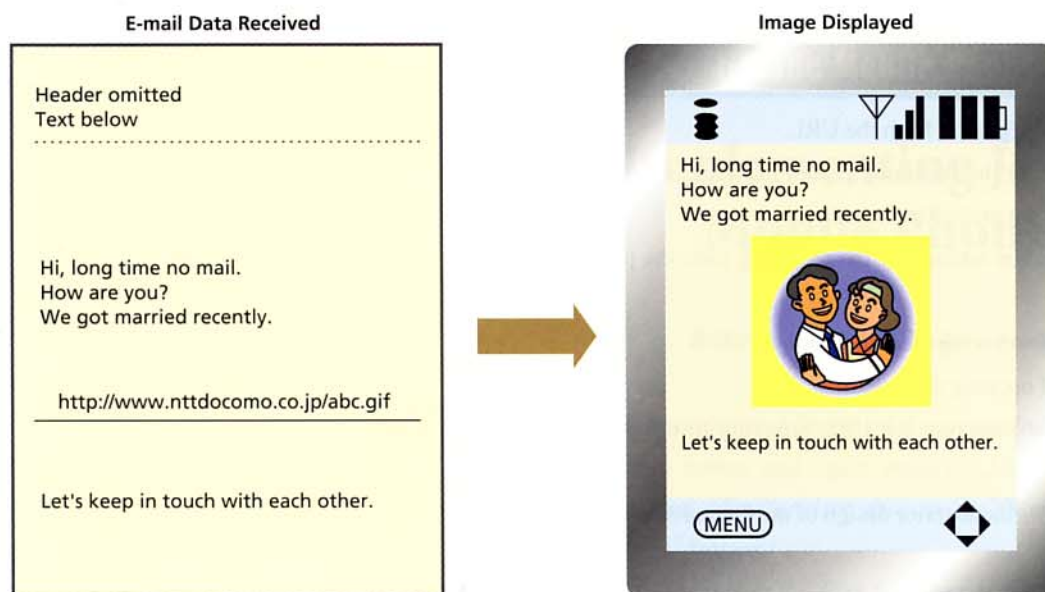


Figure 4 Picture E-mail

sites. The browser has the following new functions, aimed at improving the quality of the service.

- Making an outgoing call by using the Phone to function: The user can check the phone number on the screen to make a call.
- Directly registering phone numbers in the phonebook, to be used by the phone to function.

(5) External Interface

Models with infrared communication functions are in compliance with a data exchange and communication standard called Infrared Mobile Communication (IrMC),^{★6} which enables data exchange with other i-mode mobile phone models, Personal Digital Assistants (PDA), PCs and other devices. All models also have connectivity with i-navi link, which is a service interfaced to car navigation systems.

(6) 16 Melodic Chords

The 503i series can playback more sophisticated melodies than the 502i series, as it can generate more than 16 tones simultaneously, and 128 types of sounds in total, for signaling an incoming call with an original melody or i-melody. Also, the series allows users to attach uncopyrighted melodies up to 500 bytes to an e-mail message.



Photo 1 Exterior Design of Digital Mova 503i Series
From left: SO503i (Sony), N503i (NEC), D503i (Mitsubishi), P503i (Matsushita), and F503i (Fujitsu)

(7) Picture-attached E-mail

Picture-attached e-mail is a technology that enables pictures to be displayed in the text of an incoming e-mail message, as part of improving entertainment services. The mechanism of the technology is described in brief below, and illustrated in **Figure 4**.

- ① The user writes down the URL where the picture data (GIF file) is located, in the text of the e-mail message to be sent.

★6 IrMC: A data exchange protocol based on infrared communication standard IrDA1.0/1.1.

The user sends the e-mail.

- ② At the receiving end, the mobile phone identifies the string of characters referring to the URL after receiving the e-mail, and acquires the picture from the URL.
- ③ Upon displaying the incoming e-mail message, the mobile phone inserts the picture in the text.

Depending on the settings by the receiving user, the picture is acquired:

- At the time of receiving the e-mail;
- At the time of opening the e-mail; or
- At the time of selecting the URL referring to the picture data.

Photo 1 shows the exterior design of the Digital Mova 503i series.

6. Conclusion

This article overviewed the advanced i-mode mobile phones. Java is the most noteworthy function, as it enables the

easy enhancement of mobile phone functions at real time. More advanced services are likely to emerge in the future, based on the combination of Java and mobile phone resources (e.g., communication functions).

REFERENCES

- [1] K. Enoki et al: Special Article on i-mode Services, New Technology Report, Vol.1, No.1, pp.4-40, Oct.1999.

GLOSSARY

AL: Application Layer
 APP: Application
 CC: Call Control
 CP: Contents Provider
 CPU: Central Processing Unit
 CSA-CELP: Conjugate-Structure Algebraic-Code Excited Linear Predictive Coding
 GIF: Graphic Interchange Format
 HMI: Human Machine Interface
 HTML: Hyper Text Markup Language
 IF: Intermediate Frequency
 IrDA: Infrared Data Communication
 IrMC: Infrared Mobile Communication
 JAM: Java Application Manager
 KVM: K Virtual Machine
 LAPDM: Link Access Procedure for Digital Mobile Channel
 LCD: Liquid Crystal Display
 MM: Mobility Management
 OS: Operating System
 PDA: Personal Digital Assistant
 PDC: Personal Digital Cellular
 PSI-CELP: Pitch Synchronous Innovation-CELP
 RAM: Random Access Memory
 RF: Radio Frequency
 ROM: Read Only Memory
 RT: Radio Frequency Transmission Management
 SSL: Secure Sockets Layer
 STN: Super Twisted Nematic Liquid Crystal
 TFD: Thin Film Diode Liquid Crystal
 TFT: Thin Film Transistor Liquid Crystal
 TL: Transport Layer
 VM: Virtual Machine
 VSELP: Vector Sum Excited Linear Predictive Coding