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UBIQUITOUS INFORMATION TRANSFER ACROSS DIFFERENT PLATFORMS BY QR CODES

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Since the notion of ambient intelligence was proposed in the 90s, many researchers and companies have developed devices, applications and systems based on the idea of an intelligence environment. Despite the obvious benefits of ambient intelligent environments there are few examples of real-world realizations. One reason is that systems are developed in isolation according to their particular purpose. In fact, there are many systems that serve similar and overlapping functions in different situations, but these systems cannot easily be merged into one intelligent system. For example, a museum guiding system allows tourists through handheld devices to browse exhibition contents including text, pictures, audio, video, etc. However, often tourists cannot easily share information with each other when they come across interesting items. In order to help simplify sharing, we present five information encoding types based on Quick Response Codes (QR Code) that facilitate the connection of independent systems implemented on different platform such as smart phones or Java phones. Two case studies illustrating the use of these encoding types are presented. The first system is a travel assistant system where the traveler can share information through QR Codes and a "Schedule Code" which provides references to specific sites. The second system, the Mobile Bird Information Searching System allows discovered multimedia to be shared across smart phones to Java phones via QR Codes.

Key words: User Interface, QR Code, Ubiquitous Computation.

1 Introduction

Ambient intelligent technology, such as museum guiding systems, provides relevant multimedia content to visitors. However, it is usually not straightforward for the visitors to share interesting contents as most implementations currently do not include mechanisms for sharing. This may be due to practical problems such as electromagnetic noise, power lines and cost. As a result, each system exists

in isolation without any means of device-to-device interaction. Even devices embedded in the same system may operate in isolation. We will refer to this as information gap. These information gaps are not only a result of the original architectures but also related to the cost and difficulty of deployment. Cost and deployment issues should therefore be considered when designing such systems. In this study we demonstrate that QR Code technology can provide a solution for narrowing the sharing gap because of its low cost, ease of deployment and development. Moreover, it can be easily annexed to existing systems.

A QR Code is a two-dimensional barcode which can be generated with QR Code creation software and be printed on paper, plastic, clothes and other surfaces. Several software and hardware decoders exist. QR Code images are reliant on cameras to be captured before decoding. However, camera phones have become inexpensive, commonplace and many manufactures release software decoders for their phones.

Much research has gone into developing robust recognition algorithms [2, 5-7, 9-11]. These endeavors include improvements of the decoding stage [2, 10], handling complex scenes [5], overcoming camera-shaking [6], detecting invisible barcodes [7], correction of distorted images [9], and managing non-uniform backgrounds [11]. These improvements have made it possible to realise many new application types [1, 3, 4, 8, 12-16] such as authenticity identification [8], information delivery for teachers and students [4], tagging of fishery products for food identification and tracing [15] and m-commerce [16]. Other avenues of research include combining QR Codes and watermarking technology by hiding watermarks into QR Code [13] and encoding QR Code images as watermarks into digital audio [14]. To overcome the QR Code storage size limitation, multiple QR Code images have been combined to improve security and reliability [1, 3, 12].

Our research is based on our previous work that focused on interactive search and recommendation models [17, 18]. The proposed system to be described in Section 3.1 and 3.2 is developed from the research results given in [19] and [20], respectively.

2 Encoding Types

Many systems are designed without thought for information sharing. It is therefore difficult for users to share information with others. However, information sharing is important in educational applications. For example, in museums, visitors like to look around on their own with a guiding system, but once they find interesting items it is difficult to share these with other members of their party without talking with them face-to-face. In this study we chose QR Code technology as the information sharing medium. In this section, we will introduce sharing paths between rich-resource device and limited-resource device. A smart phone is used to represent rich-resource devices and a Java phone is used for representing devices with limited-resources.

2.1 Smart Phone to Smart Phone

In order to support the exchange of different types of materials between smart phone platforms, we introduced three encoding types that serve six purposes including three types of advertisements, a coupon type and two types of guiding information. Each is represented by a unique encoding type listed in Table 1.

In Table 1, the active entries including types 1 and 3 are used for actively pushing information, such as television advertisements. The passive entries including types 2 and 3 are suitable for passively waiting for the user to make a selection, such as selecting a hyperlink on a web site. As listed above, the Index Tag (Type 3) can be used for both activities, but the type works on the premises that a preinstalled database is available. From a content representation viewpoint, the information column including types 1 and 2 can be used for providing active or passive information, respectively, including promotions or preinstalled guiding information. The multimedia entries including type 3 supports large multimedia contents such as audio and video. The main difference between these types is their respective sizes. Because multimedia files traditionally have been too large to be downloaded wirelessly on time, we usually preinstall such contents on the devices and use a database to store the identification of the requested content. The supported contents are listed in Table 2.

2.1.1 Encoding Type 1 – Text – Active / Information (Content: Text). Type 1 is the simplest means of sharing information between users. The information shows up actively when the user decodes the QR Code image. One advantage of this type is that users can directly receive information which the system or sender wants the receiver to know. The information may be a particular advertisement or short message. On the other hand, one disadvantage is that the QR Code image only can contain limited information. Sometimes, the information could be misunderstood by the receiver, because of its brevity. Consequently, this encoding type is only recommended for slogans, brief texts and advertisements.

More information can be provided by combining multi QR Code images [1, 3, 12]. This also allows multimedia content to be provided. Several QR Code images can be used to realize streaming media.

2.1.2 Encoding Type 2 – Hyperlink – Passive / Information (Content: Coupon promotion and Real-Time Guiding Information). In our implementation described in Section 3.1, bluetooth and QR Code are used to realize local advertisements. The QR Code used in the environment can be modified by a local franchise. Advertisements are used to attract the customers' attention. One has to overcome the QR Code storage limitation. One solution is to use a hyperlink allowing users to download the promotion multimedia. Although type 2 requires more steps and infrastructure to connect to the Internet, this type allows information to be gathered and mined by a server. Another advantage is that the QR Code size can be reduced.

A server is needed to provide the service, bridge promotions, and retrieve real time group behavior. The system responds immediately when the sender shares coupons or promotions to others.

2.1.3 Encoding Type 3 – Index Tag – Active / Multimedia (Content: Preinstalled Searching/Guiding Information). Some users prefer multimedia over textual information. However, a QR Code has limited storage capacity and is therefore unable to store rich multimedia. To overcome this problem multimedia and media file are preinstalled on the device and associated with an index tag. When users want to share such contents, the system automatically encodes the index tag into a QR Code image, to

Table 1 Smart Phone to Smart Phone – Encoding Types

		Representation Contents	
		Information	Multimedia
Activity	Active	Encoding Type (1): Text	Encoding Type (3): Index Tag
	Passive	Encoding Type (2): Hyperlink	Encoding Type (3): Index Tag

Table 2 Smart Phone to Smart Phone – Representation Contents

Encoding Types / Contents	Type (1): Text	Type (2): Hyperlink	Type (3): Index Tag
Information	Text	Coupon Promotion	Preinstalled Searching/Guiding Information
Multimedia	Streaming Media	Real-Time Guiding Information	Multimedia Information

be decoded by the receiver. After retrieving the index tag, the system identifies the local file location using the retrieved index, and then presents the related multimedia contents to the user.

2.1.4 Encoding Type 3 – Index Tag – Passive / Multimedia (Content: Multimedia Information). The proposed system described in Section 3.1 encodes a schedule code in the QR Code image to present a list of landmarks which may be of interest to the user. The user can pass on the image to friends for sharing the tour schedule. After the image is decoded, the system presents the schedule to the recipient, and waits for the recipient to select the landmarks of interest. After the selection, the related content can be downloaded. Two or more users can therefore immediately synchronize their schedules. Moreover, to increase the responsiveness of the system data mining can be used to mine which contents should be downloaded in the background a priori.

2.2 Smart/Java Phone to Java Phone

The previous sections described how information is exchanged between rich-resource devices. In this section, the information exchange from rich-resource to limited-resource devices is addressed. To simplify the transmission, the QR Code image is also used to provide the simplest transmission method. In such situations, the chief concern is that Java phones are more resource constrained than smart phones. Table 3 and 4 represent the encoding types and representation contents, respectively.

2.2.1 Encoding Type 4 – Text – Active / Information (Content: Coupon and Text Information). Because of the limited storage capacity provided by current Java phones, a hyperlink is needed to download the materials over a GPRS, or similar, network on demand. Only coupons and text are small enough to be directly encoded in the QR Code image. This encoding type is hampered by the same problems described in Section 2.1.1, i.e., that messages that are too short may lead to misunderstandings, and that it is impossible to modify an image already printed on paper. Although the solution has its limitation, the low cost means that the information can be published in many places. Pictures can be then shared using Multimedia Messaging Service (MMS).

2.2.2 Encoding Type 5 – Hyperlink – Passive / Information (Content: Large Document). Because most Java phones only have limited memory capacity unable to accommodate large files, large documents are delivered to Java Phone through hyperlinks. For example, users can share a novel comprising a full story with illustrations. The system will not know which paragraphs the users want to read and we cannot preinstall the entire novel on the Java phone. The novel is therefore downloaded in parts.

2.2.3 Encoding Type 5 – Hyperlink – Active / Multimedia (Content: Searching / Guiding Information). When the users want to share multimedia contents with others, an index with a website address is encoded into the QR Code image. The image can be shown to others directly or sent using MMS.

2.2.4 Encoding Type 5 – Hyperlink – Passive / Multimedia (Content: Searching / Guiding Information Collection). In order to guarantee system reliability, information searching /guiding systems usually have many preinstalled contents, such as maps, local information, textual introductions, audio and

Table 3 Smart/Java Phone to Java Phone – Encoding types

	Representation Contents	
Activity	Information	Multimedia
Active	Encoding Type (4): Text	Encoding Type (5): Hyperlink
Passive	Encoding Type (5): Hyperlink	Encoding Type (5): Hyperlink

Table 4. Smart/Java Phone to Java Phone - Representation contents

	Encoding Types	
Contents	Type (4): Text	Type (5): Hyperlink
Information	Coupon and Text Information	Large Document
Multimedia	None	Searching/Guiding Information

video. However, limited-resource device has insufficient memory to store such materials. Therefore, a list of hyperlinks is used. When sharing information, the system delivers the QR Code image which encodes a query code to users. After other users have decoded the image, the system retrieves the hyperlink result list via the network.

2.3 Limitations

In this section, different solutions based on smart phone to smart phone and smart/Java phone to Java phone were presented. The three encoding schemes text, hyperlink and index tag are handled differently on rich- and limited-resource devices. Java phones cannot exploit Type 3 (index tag). Moreover, smart phones can use multiple QR Code images to support streaming media. This is currently not possible with Java phones because they are unable to store an index database and the related materials. As we can see, when we want to transfer multimedia, different platforms have their own best encoding type. Smart phones use index tag but Java phones reply on hyperlink type. The other difference between these two scenarios is the application of using streaming media. Smart phones can use multiple QR Code images to generate streaming media but Java phones cannot. The main reason is that the combination of QR Code images needs more memory to store temporarily combined data. This limitation restricts the deployment to Java phones that normally have limited storage memory.

3. Implementations

This section introduces two example systems exploiting the proposed framework, namely the Traveler Assistant System (TAS) and the Bird Information Searching System (BIS). They also integrate Web technology to extend the services to other platforms.

TAS is implemented with a sharing mechanism where information is downloaded from a website to the handheld device. The system assists travelers with scheduling their journey and sharing this

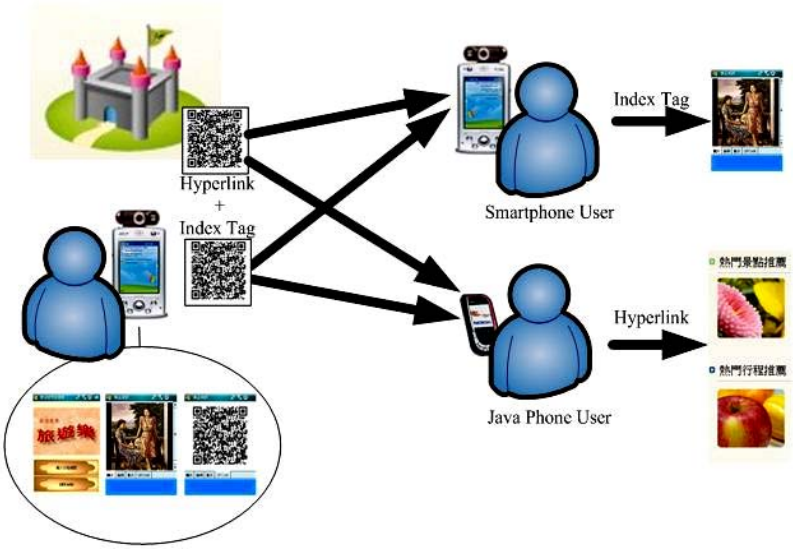

Figure 1 The traveler assistant system.

schedule with their party. The detailed mechanisms and architecture are described in Section 3.1. Next, BIS provides user interfaces for searching and browsing a wide range of bird information on both the smart phone and Java phone platforms. Users can search for specific bird information according to bird visual features, and then share the search results using a QR Code image. The image is decoded on the phone and the browser downloads the detailed contents from the Internet. Users can search information online using the Java phone browser. The system has been in use since 2005.

3.1 Traveler Assistant System

Recently, many mobile guiding systems have been proposed. Most of them are deployed at a particular local landmark or museums. Each system is tailored for one purpose. As a result, visitors must borrow different guiding systems from the service center when they visit different parts which are inconvenient. TAS provides an integrated platform for traveler assistance. Fig. 1 shows an overview of the proposed system.

3.1.1 Sharing. The system incorporates exhibitions sharing for museum touring and active publishing for local mobile advertisement. The system encodes the hyperlink or Index Tag Types into the QR Code image as follows:

http://bird.moja.com.tw/qrcode.php?Tag=1234
Service Web Entry Site Tag Number

The parameter Tag in the hyperlink indicates the index number. When the smart phone decoder decodes the image, the system treats the value of the Tag as the Index Tag. In the above example, the value is 1234. The system loads the materials according to the value recorded in the index database as described in Section 2.1.3. Alternatively, for Java phones, the hyperlinks are used to connect to the Website such that the contents can be downloaded.

When the smart phone receives the decoded data, the system may not know the content of an advertisement or exhibition information. Therefore, through a local advertising mechanism, described in 3.1.3, the user receives textual advertisements when entering the Bluetooth broadcast area. The format of the advertisement encoded in the QR Code image is as follows:

1234-Hello! Welcome to Sansia Old Street
Index Tag Texture Advertisement

If the multimedia contents of the advertisement are stored on the device, the system plays the media file directly according to the Index Tag, or else shows the textual advertisement. If the device can access the Internet, the system translates the Index Tag into a hyperlink and downloads the content directly. In the museum guiding system, the mechanism allows tourists to share information by a simple selection. After the selection, the TAS on the smart phone will jump into the interface shown in Fig. 2(i) to display the related-contents. A Java phone will then try to access the online contents. Fig. 2(f)-(j) shows the guiding information interfaces for TAS on a smart phone.

3.1.2 TAS Journey Schedule. Fig. 2(a) shows the main view in TAS. Users can select one of two functions to enter the views depicted in Fig. 2(b) and Fig. 2(l), respectively. Users can enter the Schedule Code though the interface shown in Fig. 2(b), and then the system will download the pre-scheduled landmark list on the screen. The list has two modes, namely List and Map Mode as shown in

Figure 2 The user interface.

Fig. 2(c) and (d), respectively. The red star in Fig. 2(d) indicates the particular landmark that the user selected. Users can click the button on the view in Fig. 2(c) or on the red star on the view in Fig. 2(d) to get the floor plan map shown in Fig. 2(e).

After the landmark is selected, the user can browse the exhibitions list by clicking the button below the floor plan. Fig. 2(f) shows the exhibitions list. Users can select the exhibition picture to enter the interface of the detailed contents shown in Fig. 2(g) to (i), i.e., pictures, text, audio and video. Fig. 2(j) shows the QR Code image used for sharing the information.

3.1.3 TAS Active Advertisement Interface. The TAS provides a Bluetooth broadcast service for local advertisement. When tourists walk through the store the blue bar below each interface will display the textual advertisement of that particular store. User can click on the advertisement for further details and access a list of advertisements (see Fig. 2(k)). When the user clicks on a particular button, the system jumps into the view shown in Fig. 2(g) to display the details of the advertisement.

3.1.4 Guide Web Entries. Users can adjust the schedule from the interface of the guide website after registering and logging into the site. After registering changes a schedule code is provided by the website. The journey schedule can then be downloaded to the TAS after the user provides this schedule code (see Fig. 2(b)).

Fig. 3(a) presents the homepage of the website. Users can reschedule the journey by logining to the website. A schedule code will be provided by the website following the adjustment of journey schedule. The schedule code can be downloaded to the TAS as shown in Fig. 2(l). Users can also upload different kinds of information to the website from the backend system as shown in Fig. 3(b).

Figure 3 Homepage and backend of the website.

3.2 Bird Information Searching System

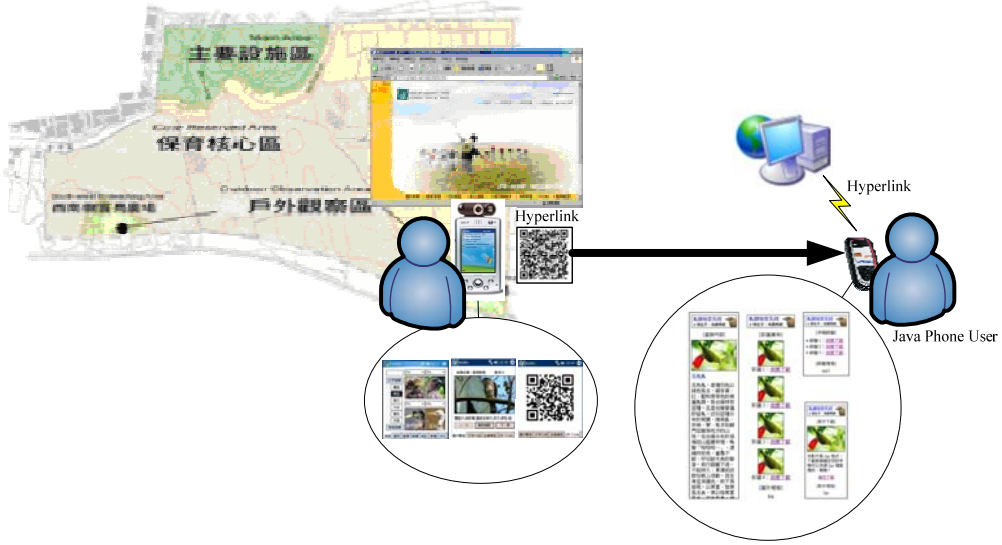

Figure 4 Bird information searching system overview.

The bird information searching system provides educational contents for tourists and students (see Fig. 4). BIS contains more than 100 entries and the collection is growing. The system embedded on smart phones contains rich materials about birds, including pictures, introductions, bird sounds and videos. The system also allows information to be shared using QR Code (see Section 3.1.2).

3.2.1 The BIS Visual Features Selection Interface (Smart Phone Version). The interface controls six visual features including body size, bird color, beak and foot shapes and flying and walking patterns. The system lists the search results according to the selected features.

Figure 5 The BIS search results interfaces.

3.2.2 BIS Search Results (Smart Phone Version). The search results are listed as shown in Fig. 5(a). The user can browse the bird information from Fig. 5(b) and (c), including pictures, bird sounds and introduction. Users also can write down observation notes using the Notes interface shown in Fig. 5(d), and also share the bird information with Java phones through QR Code images (see Fig. 5(e)).

3.2.3 BIS Visual Search and Note Interfaces (Java Phone Version). Fig. 5(f), (g) and (h) show the features selection, pictures and observation note interfaces. The detailed contents are downloaded immediately after selection.

3.2.4 BIS Search Results (Java Phone Version). As an alternative to the Java mobile application, which needs to be explicitly downloaded a priori, the BIS can also be accessed via a web-application for

mobile browsers. This system also provides a features selection and search result list. The contents include introductions, theme pictures, bird sound ringtone and a 3gp format video (see Fig. 5(i)-(m)).

4 Conclusions

We discussed three QR Code encoding schemes including text, hyperlinks and index tags. Text is used in basic scenarios that presents information directly to user after an image is decoded. Resource-limited devices, such as Java phones, can therefore access rich contents through hyperlinks and then the index tag provides a way to present various materials preinstalled on the device. Challenges include limited Internet access and limited device storage capacity. Hyperlinks require Internet access and the index tag needs an index database to record the location of related contents.

We also presented two systems that embedded sharing mechanisms. The Traveler Assistant System provides information to tourists for them to share with others. The sharing mechanism also works as a mobile local advertisement framework based on Bluetooth broadcasts. Stores can actively publish their product advertisements and users can share the coupons, activities and other advertisement with each other.

Moreover, we developed an educational Bird Information Searching System accessible on smart phones, Java phones and the Web. Smart phone users can share information encoded in a hyperlink with Java phone users. Even though the user did not install our Java BIS software, user can download the contents from the Internet by decoding the sharing QR Code.

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