Contextual QR Codes

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***Abstract*— QR Codes (2D barcodes) are used to encode and decode data at a rapid rate. Using camera phones to read two dimensional barcodes for various purposes is currently a popular topic in both research and in practical applications. But until now, the information provided by QR Codes was solely static. What you see is exactly what was encoded. This paper proposes the notion of contextual QR Codes that merge a public QR Code and private information, in order to provide data related to a particular context. For example, a public tag <Hello> will be decoded and translated into "Good evening John Smith" or "Bonjour Jean Dupond", if the system is able to obtain data such as the name of the user, the language used on the machine (English or French for instance) and the moment when the interaction takes place.**

***Keywords*— QR Codes, Two-Dimensional barcode, Context-aware, Pervasive system, Ubiquitous computing, Ambient intelligence.**

I. INTRODUCTION

Computers are widespread and many everyday-objects come equipped with computer technology. Mobile phones are equipped with high-resolution color displays, wireless access to the Internet, and respectable processing power and memory. Nowadays, different kinds of codes are used in order to store, retrieve and manage information. Mark Weiser's vision of Ubiquitous Computing underlines the need of seamlessly unifying computers and humans around the notion of rich environment. He explained: "The most profound technologies are those that disappear." [26], [27]. Indeed, with the purpose of being minimally intrusive, pervasive systems have to deal with interaction issues in context-aware intelligent environments. This can be achieved through seamless interaction of environment and user, application and service adaptation according to user preferences and expectations, and efficient utilization of available resources [16].

My work is part of an exploratory project on adaptative services and usages for human learning in the context of pervasive communications, called P-LearNet (Pervasive Learning Networks). The aim of this paper is to present contextual QR Codes: instead of always exposing the same information to everybody, a contextualized QR Code is computed in order to provide specific information depending on a particular context.

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This document is structured as follows: Section two presents related work and explains the background and motivation of this project. Section three gives an overview of QR Codes covering technology, usage, and development approaches. Section four describes the notion of context used in section five in order to present contextual QR Codes. Applications scenarios are given in section six before a conclusion with a roadmap for future work.

II. RELATED WORK

In the domain of object identification, RFID[1] and NFC[2] technologies are considered as the latest generation, but, barcodes are still regarded as an interesting option, because of the basic technology and simplicity of the concept. Indeed, any inexpensive printer may be used, but creating an RFID requires a special dedicated device [7]. Previous studies show the relevance of using barcodes with phones equipped with a camera. Prototypical applications hyperlinking the real world were studied: allergy-assistant, country of origin of a given product, price comparison, instant eBay-auctions, etc. The Allergy-Check application [1], for instance, is based on the recognition of one-dimensional (1D) barcodes. *Once the user defines a profile that contains all substances he or she is allergic to, holding the mobile phone in front of a product's barcode gives the user a simple answer to the question Is that product compatible with my allergies?* [2].

With this approach, one can access data related to billions of products carrying EAN-13 barcodes (ISO/IEC 15420:2000) [12], if available in online specialized databases (Amazon, Wiki food, SINFOS…). Classical 1D barcodes are widely popular and universally recognized because of their reading speed, accuracy, and functional characteristics. However, the need to store more information in codes printed on small spaces leads to the emergence of two-dimensional barcodes (2D Codes). They can be used to access data and services like bus time tables, product information, etc. Figure 1 shows the same information encoded in a QR Code (left) and in a EAN-13 (European Article Numbering) barcode (right).

[1] Radio-Frequency IDentification (RFID) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders.

[2] Near Field Communication (NFC) is a new standard for mobile phones that allows them to both act as an RFID reader and be read by other RFID readers.

Figure 1: QR Code (2D) and EAN-13 (1D) barcodes encoding the same data (3254565174110).

There is a wide variety of 2D code representations available and specifically designed to simplify camera-based recognition. Some of them are open standards while others are proprietary such as Semacodes, Spotcodes, Rohs' VisualCodes, ColorCode, CyberCode, MobileTag, VeriCode, ShotCode, eZcode, HotScan, Codablock F, Aztec, FP Code (Fine Picture Code - Fujitsu) and BeeTagg (ConnVision). PDF417 (Portable Data File) and MaxiCode are used under AIM International ISO Standardization. The two most well known 2D barcode standards are DataMatrix (ISO/IEC 16022:2000)[13] and QR Code (ISO/IEC 18004:2000)[14]. There is no license fee to be paid to use neither DataMatrix nor QR Codes.

Even though a study comparing them [4] quoted by [7] explained the superiority of DataMatrix (excepted for Japanese Kanji symbols encoding), QR Codes are most common in Asia and particularly popular in Japan.

III. QR Codes

A QR Code is a two-dimensional barcode introduced by the Japanese company Denso-Wave in 1994. This kind of barcode was initially used for tracking inventory in vehicle parts manufacturing and is now used in a variety of industries. QR stands for "Quick Response" as the creator intended the code to allow its contents to be decoded at high speed.

A. Technology

A QR Code is a matrix code developed and released primarily to be a symbol that is easily interpreted by scanner equipment. It contains information in both vertical and horizontal directions, whereas a classical barcode has only one direction of data (usually the vertical one). Compared to a 1D barcode, a QR Code can hold a considerably greater volume of information: 7,089 characters for numeric only, 4,296 characters for alphanumeric data, 2,953 bytes of binary (8 bits) and 1,817 characters of Japanese Kanji/Kana symbols. QR Code also has error correction capability. Data can be restored even when substantial parts of the code are distorted or damaged.

In the QR Code standard, corners are marked and estimated so that the inside-code can be scanned [18]. The barcode recognition process has 5 steps: (1) edge detection, (2) shape detection, (3) identification of barcode control bar, (4) identification of the barcode orientation, dimensions and bit density using the control bar, and (5) calculating the value of the barcode [21].

B. Usage

Without a machine, it's impossible for a human to manually decode QR Codes but they are easily processed by scanning equipment. In Japan, many cellular phones are now natively equipped with a QR Code-reading software. Users photograph QR Codes and the software integrated into their phones decodes the messages and displays, manipulates, or stores the information on their mobile devices. Depending on the type of data recognized and the nature of the application, alternative actions can follow the decoding stage: a phone number can be automatically dialed, a short text message can be sent, a web page corresponding to the decoded URL (Uniform Resource Locator) can be displayed in a mobile browser, or a definite application can be executed.

QR Codes are part of daily life in Japan, Korea, Taiwan, Hong Kong and China. A study published in January 2005 by MRI showed that out of 2053 Japanese mobile phone users, 90% have recognized a QR Code. McDonalds uses codes to inform users about the nutritious value of its burgers. Apple advertised the new i-Pod on billboards with QR codes. QR Codes used in a Nike advertising campaign allows direct access to a dedicated mobile site[3]. In Japan, some teachers are using QR codes to distribute resources to learners [9]. QR codes now appear in magazines, advertisements, product wrappings, T-shirts, passports, business cards and on subway billboards in Japan. But, at a consumer market level, QR Codes are virtually unknown outside of Asia. It is believed that usage of QR Codes in the rest of the world will not gain momentum until mobile telephone operators begin pre-installing QR Code-reading software on mobile phones. Today, in Europe few phones come the software installed. Nevertheless, several companies, mainly in France, the UK, and Switzerland are starting to use QR codes to promote goods or services such as in Swiss online newspaper, or to inform customers about daily rates, for instance (European Central Bank).

C. Development (DIY)

Users can scan existing QR Codes or they can generate their own. Creating QR Codes online is very easy and many web sites (Kaywa, Snapmaze, Activeprint…) can be used to encode and print out such codes.

For camera phones and PDAs (Personal Digital Assistant) that are not equipped with QR Code readers, there are some add-on tools that decode QR Codes simply by positioning the device in front of the code. This is done automatically within the streaming flow and the user doesn't have to take a picture of the QR Code. QuickMark [19] and I-nigma [11] readers are good examples of free tools using this technique that are available for many manufactured models and devices. QuickMark provides extension functionalities to QR Codes, by allowing partial or entire encryption of codes.

[3] http://mobile.nikefootball.com/qrcode.jsp

Another interesting feature is the “Magic Jigsaw”: this option encodes binary data (a picture for example) as a chain of QR Codes that the user can scan to retrieve the original content.

Developers that want to use QR Codes in their applications have to first decide whether the computation of the code will be made locally or not. Obviously, a network connection is required when the treatment is done remotely, through a web service for example, such as those provided by Richard Jones [15]. Another option is to send an E-mail to r@qry.jp [20] with the picture of the QR Code as an attachment. The system will instantly send back the converted data.

Alternatively, if no network connection is needed or available, the code management will have to be done by the mobile device, in an autonomous way. If the final user only needs to scan codes and see the result messages, the softwares mentioned above are sufficient. But for developers who have to manage QR Codes, some SDKs (Software Development Kit) are announced and some are already available.

Microsoft Windows Live Barcode project, OpenNETCF QRCode Library for .NET Compact Framework and Google ZXing (Zebra Crossing) project will be available soon. Twit88 [24] provides an open source project on QR codes. We tried this solution and also some commercial other tools, like Tasman [23] (Tasman.Bars Java and .Net SDK).

Figure 2 presents the mobile application that we have developed in our laboratory. It was written in C# language and runs, with Tasman library, on a smartphone HTC TyTN II (Kaiser) supporting Windows Mobile 6. As the user clicks on the bottom left button the camera manager is invoked. Then, according to the selected representation (QR Code, for instance on Figure 2), the decoded information is presented to the user. Obviously, this is the classical and minimal management that our prototype is able to do. We will see in the following, how this application can become context aware by using various information.

IV. Context awareness

Current literature shows a growing interest in the creation of context-aware systems, but there is no consensus on the definition of context. However some definitions are quoted several times and become de facto standard [3]. For example, Anind Dey's definition, is one such standard: *A context-aware system is a computing system using context to provide relevant information and/or services to the user, where relevancy depends on the user’s tasks.* [5].

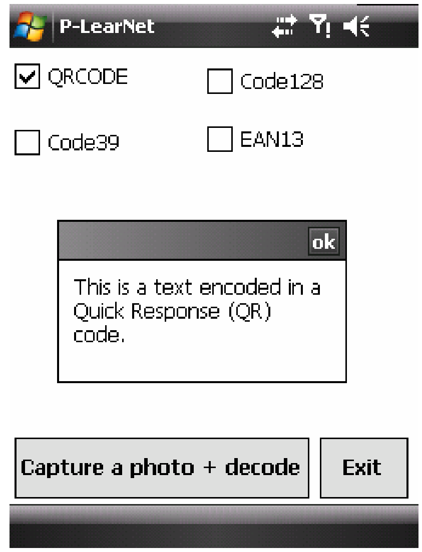

Figure 2: Our mobile application decoding QR Codes

Indeed, one of the main goals of ubiquitous computing is to provide relevant information, at the right time and place and under the right form. Context-aware systems should help filter information. This allows users to concentrate on the task rather than the technology.

Our current works is inspired by the AMULETS project, in which researchers used metadata and particularly location-based data (GPS coordinates) embedded in semacode URL, in order to determine the location of the device scanning the barcode that the students used [22], [17]. With this method, some parameters are passed in the URL that is generated dynamically.

V. Using QR Codes in context

Recently, some researchers introduced the notion of “contextual bookmark” which is a “*combination of a snapshot of a physical object taken with a mobile device and meta information about the content related to this physical object*” [10]. Our definition of a contextual QR Code is close to this one and is the following: it’s the result of a fusion between a public part of information (QR Code) and a private part of information (the context) provided by the device that scanned the code.

Figure 3 shows the public and private parts of a contextual QR Code. The private part can be one or more information among the subsequent: user’s profile, current task, device used, location, time and environment of the interaction. The machine decodes the QR Code and merges it with private data obtained during the interaction. Then, the XML (Extensible Markup Language) resulting file is sent to a web service (created in our laboratory) that computes the code and returns personalized messages. This web service was developed in C# .Net and is able to retrieve, according to particular tags, the right module to invoke (for example “Hello World” or “Meeting” Applications).

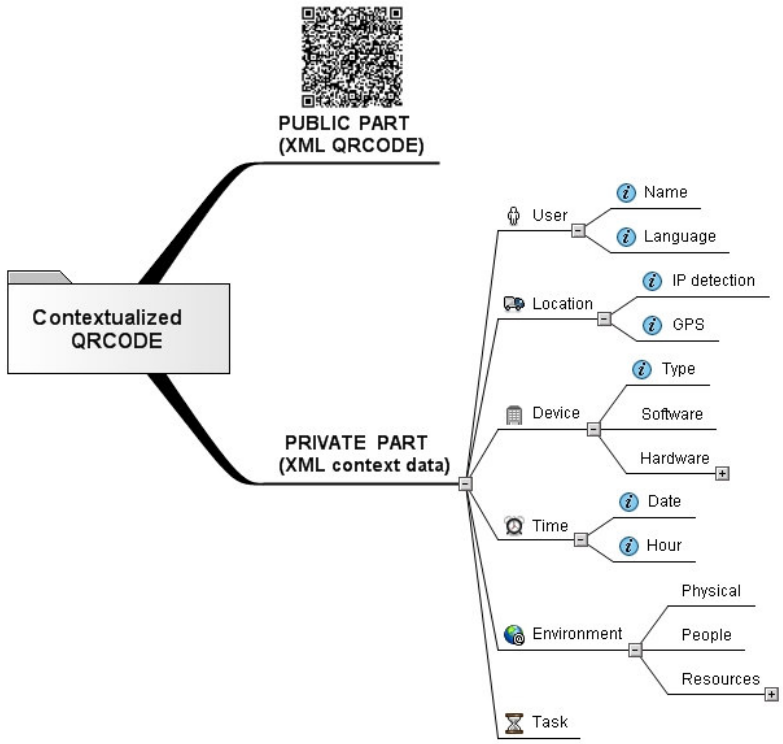

Figure 3: Pubic and private parts of a contextual QR Code

VI. APPLICATION SCENARIOS

At present, we use a HTC smartphone for our tests. To illustrate our approach, we developed a prototype able to run basic scenarios. In those scenarios, a QR Code represents data formatted in XML language and corresponds to the public part of the message. The second part of the message is generated when the user takes a picture of the QR Code, taking into account private information.

The functional decomposition of the program is the following: the "capture photo" module and "decode data" module are used in order to obtain a public XML message. Then, the "retrieve private data" and "create private XML message" modules are called. In a third time, the "merge private and public XML" module is used just before the "call Web services" and "display results" modules are invoked.

A. *Hello World example*

The first scenario is the venerable "Hello World" greeting. Imagine that the following message is encoded in a QR Code: <public> <tag> Hello </tag> </public>. If a user tries to scan this QR Code with a traditional reader (say Quickmark [19] or I-nigma [11] for instance), she will discover exactly this message on her mobile screen. Now, if she uses our contextual QR Code application, she will see a personal greeting message on her screen.

For example, if she scans the code at 8 o'clock A.M., connected with the IP address 209.9.235.121, the message will be, for example: "Good morning Jenifer Diaz from Pompano beach, Florida, USA.".

This is possible with IP detection [25] and thanks to an "ip to location" web service [8]. The name of the user is automatically detected in the mobile registry (ControlPanel\Owner).

It will take around 5 seconds to complete this task. Less than 2 seconds are dedicated to the decoding operation (this is almost the same time as this needed by QuickMark and I-Nigma) and 3 to 5 seconds are needed to reach the different web services used by our application. Of course that time will be dependent on the amount of encoded information and the network's speed.

B. *Meeting example*

The second proposed scenario is the meeting example. We often use a classical sheet of paper to write down our name and affiliation during a meeting. Sometimes, this is also used as a proof of presence of a person to a meeting or a brainstorming. Of course, a paper can't be used simultaneously by different people that have to sign it. But, a paper containing a QR Code can be scanned by many users, and even in different orientation. The exact time is not mentioned on the paper, because, it's to long and boring to do.

We think that the idea to use a QR Code that can be scanned during a meeting could be interesting if the users are correctly equipped with devices supporting the kind of task. Figure 4 represents an example of an XML file. The first part of the document concerns public information in relation to a meeting, and the second part, captured at the runtime, is about personal information of the user than scanned the QR Code.

```
<public>
        <meeting>
        <id>1234</id>
        <title>P-LearNet Brainstorming</title>
        <date>10/02/08</date>
        <room>326</room>
        </meeting>
 </public>
 <private>
        <device_owner>Alex Harasymczuk
        </device_owner>
        <date>   <day>10</day>
          <month>10</month>
          <year>2008</year>
        </date>
        <time>
           <hour>17</hour>
          <minute>39</minute>
          <second>27</second>
        </time>
        <language>english</language>
 </private>
```

Figure 4: Public and private parts of an XML file sent to a web service for treatment

The QR Code can be printed on a sheet of paper and/or can be generated on a digital screen, in order to be scanned at a relatively long distance. Figure 5 shows the result obtained by this user (Alex) after he scanned the code. Additionnal features have been added to our prototype: a picture of each person identified is displayed on the screen of the meeting. An automatic report is generated with the name of each participants and the time of their registration, etc.

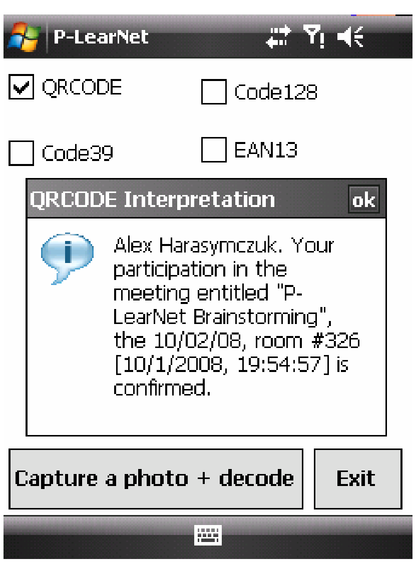

Figure 5 : Contextual QR Code interpretation

VII. Conclusion

We have presented in this paper the technology, usage and way of programming two-dimensional barcodes, called QR Codes. They offer an interesting way to capture and distribute a tremendous amount of information in a simple, quick and efficient manner. There are plenty of potential uses for this technology, but we think that future usages will surely be based on context-aware features.

We have proposed the notion of contextual QR Codes, which merges a public QR Code and some private information, in order to provide data related to a particular context. In the first example, the user scans a QR Code that contains a generic "Hello World" XML message, and obtains a personalized and contextual message. In the second example, users are invited to scan a QR Code that contains public information about a meeting (title, date, hour, room, etc.). The fusion of those data with the ones given during the interaction (such as the name of the person, the location, the language used) is then sent to a web service able to manage the provided information. Finally, the user receives on his mobile appliance the result of the interpretation of the contextualized QR Code.

We think that contextual QR Codes can be easily integrated into pervasive and ubiquitous applications and we believe that the power of Quick Response Codes coupled with context-aware information will provide an important impact on Human Computer Interaction.

Further works will lead us to work with other parameters of the context not yet used in our prototype. As we mentioned in Figure 3, the private part of the message could be related to user, location and time, but also to device, environment and task. We used the first three parameters in our prototype, but not the three last. In future version of our prototype, we will certainly add the possibility to personalize the responses according to the kind of device detected, the environment (light, noise, etc.) and user's task, in order to become more and more context-aware. Of course, some evaluations will be done to know how to improve the concept and the software in order to satisfy user's needs.

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References

[1] Adelmann, R., Langheinrich, M., Floerkemeier, C., A Toolkit for Bar-Code-Recognition and -Resolving on Camera Phones – Jump Starting the Internet of Things. Proceedings of the workshop on Mobile and Embedded Interactive Systems (MEIS'06) at Informatik 2006. GI

Lecture Notes in Informatics Series (LNI). Dresden, Germany, 2006.

[2] Adelmann, R., Langheinrich, M., Rapid Prototyping Platform for Mobile Phone Based Services on Retail Products., Demo at the International Symposium on Ubiquitous Computing Systems (UCS 2007), Akihabara, Tokyo, Japan, 2007.

[3] Clerckx, T., Model-based development of context-aware interactive applications in ambient intelligence environments, Ph.D thesis, Hasselt University, 2007.

[4] Consumer Electronics Association, Comparison of Data Matrix and QR Code. Technical report, 2001.

[5] Dey. A., Providing architectural support for building context-aware applications. Ph.D thesis, College of computing, Georgia institute of technology, 2000.

[6] Denso Wave QR Code and QR Code features, online document. Retrieved March 2008 from http://www.denso-wave.com/qrcode/qrfeature-e.html and http://www.denso-wave.com/qrcode/aboutqr-e.html

[7] Falas, T., Kashani, H., Two-Dimensional Bar-Code Decoding with Camera-Equipped Mobile Phones, Fifth Annual IEEE International Conference Pervasive Computing and Communications Workshops (PerCom), pp. 597 – 600, 2007.

[8] Fraudlabs tools. Retrieved March 2008 from: http://www.fraudlabs.com/ip2location.aspx

[9] Fujimura, N., Doi, M., Collecting students' degree of comprehension with mobile phones, Proceedings of the 34th annual ACM SIGUCCS conference on User services table of contents, Edmonton, Alberta, Canada pp. 123 – 127, ISBN:1-59593-438-3, 2006.

[10] Henze, N., Lim, M., Lorenz, A., Mueller, M., Righetti, X., Rukzio, E., Zimmermann, A., Magnenat-Thalmann, N., Boll, S., Thalmann, D., Contextual bookmarks, Joint Workshop Mobile Interaction with the Real World, MIRW 2007 and the 5th Workshop on "HCI in Mobile Guides", MGuides 2007, Singapore, pp. 51-54, 2007.

[11] I-Nigma : Retrieved March 2008 from: http://www.i-nigma.com/

[12] ISO/IEC 15420:2000 - Information Technology – Automatic Identification and Data Capture Techniques - Bar Code Symbology - EAN/UPC, 2000.

[13] ISO/IEC 16022:2000 - Information Technology – International Symbology Specification - Data Matrix, 2000.

[14] ISO/IEC 18004:2000 - Information Technology – Automatic Identification and Data Capture Techniques - Bar Code Symbology - QR Code, 2000.

[15] Jones, R., QR Code web service, Retrieved March 2008 from: http://www.binaryrefinery.com/qrweb/webservice.asmx (User and password need to be both set to br0wncow! for now).

[16] Khan, M.T., Zia, K., Daudpota, N. Hussain, S.A, Taimoor, N., Integrating Context-aware Pervasive Environments, IEEE International Conference on Emerging Technologies, ICET 2006, Peshawar, Pakistan, 2006.

[17] Kurti, A., Milrad, M., Alserin, F., & Gustafsson, J., Designing and Implementing Ubiquitous Learning Activities Supported by Mobile and Positioning Technologies. Proceedings of the IASTED CATE 2006 Conference held in Lima, Peru, pp 193-199, 2006.

[18] Ohbuchi, E., Hanaizumi., H., Hock, L.A, Barcode Readers using the Camera Device in Mobile Phones, in Proc. of 2004 International Conference on Cyberworlds, pp. 260-265, 2004

[19] Quickmark. Retrieved March 2008 from: http://www.quickmark.com.tw/

[20] QRY. Retrieved March 2008 from: http://qry.jp/

[21] Reilly, D., Smolyn, G. and Chen, H., Toward fluid, mobile, and ubiquitous interaction with paper using recursive 2D barcodes. Pervasive Mobile Interaction Devices 2007 (PerMID 2007), workshop at Pervasive 2007, Toronto, Canada, 2007.

[22] Svensson, M., Pettersson, O., Case study: Extending content metadata by appending user context, Växjö University, Faculty of Mathematics/Science/Technology, School of Mathematics and Systems Engineering, 2006.

[23] Tasman SDK.. Retrieved March 2008 from: http://www.tasman.co.uk/

[24] Twit88. Retrieved March 2008 from: http://www.twit88.com/home/opensource/qrcode

[25] What is my IP : Retrieved March 2008 from: http://wimip.fr/

[26] Weiser, M., The Computer for the 21st Century, Scientific American 265, No. 3, 94-104, 1991.

[27] Weiser, M., Some Computer Science Problems in Ubiquitous Computing, Communications of the ACM 36, No. 7, 74-83, 1993.