IDEA GROUP PUBLISHING
701 E. Chocolate Avenue, Suite 200, Hershey PA 17033-1240, USA
Tel: 717/533-8845; Fax 717/533-8661; URL-http://www.idea-group.com

ITB12656

This paper appears in the book, *Emerging Trends and Challenges in Information Technology Management, Volume 1 and Volume 2* edited by Mehdi Khosrow-Pour © 2006, Idea Group Inc.

Redundancy Reduction Utilizing XML, Web-Services and 2-D Bar Codes

Greg Koniecek, University of Liverpool, Laureate Online Education, Laureate Online Education B.V., Arena Boluevard 61-75, 1011 DL Amsterdam Z.O., The Netherlands, greg@koniecek.com

Paul Darbyshire, School of Information Systems, Victoria University, PO Box 14428, Melbourne City MC, Victoria 8001, Australia, Paul.Darbyshire@vu.edu.au

ABSTRACT

By combining 2D symbol technology, XML syntax for data description and Web Services communication channels, it may be possible to lower the cost of processing and reduce data redundancy inherent in many data processing systems. Having an on-demand access to the information by way of Web Services will provide a way to reduce the amount of the data being stored between trading partners. This paper investigates the use of 2-D bar codes to import data directly into a trading partners receiving computer system. The research investigates directly importing the data via 2-D bar codes, as well as their utilization to automatically gain access to Web services. In the latter case, all needed connection information can be contained inside a separate 2-D symbol allowing an automatic connection to an external data repository.

INTRODUCTION

Although trading partners have computerized systems, they cannot connect easily to exchange important data. Thus, data has to be processed twice, then retained at both ends of the transaction. Today's market creates constant pressure on companies to lower their costs and overheads, in order to gain a competitive edge over their competition. The use of 2D bar codes helps us to encode portable databases, and facilitate keyless entry. Two dimensional bar codes are being considered for new and emerging applications where data is being required to physically accompany goods in transit (Villan 2005). However, current 2D bar code standards do not offer enough storage capacity for many of the new applications. If we combine the use of 2D bar codes with emerging Web technologies like Web services, the 2D bar codes can be used to deliver a payload which is a parameter to a Web service, that will return associated data. Having an on demand access to such information via a standard Web Service interface, could provide a way to reduce the amount of the data being stored between trading partners.

This paper discusses a proof of concept system developed that combines standard 2D symbols technology with Web technologies such as XML and Web Services. The system uses 2D bar codes to deliver a payload which is then used as a parameter to a web service. The Web service delivers an XML based data stream used as the ultimate exchange of data between the two systems.

BRIEF BACKGROUND

There are a number of emerging technologies such as 2D bar codes, Web Services, and XML, used as building components of applications, allowing easy exchange of business data between trading partners. These technologies, applied differently, could provide additional benefits leading to cost reduction.

Barcoding

Bar codes are recognized as a reliable way of carrying and presenting machine-readable data, however, readability of bar codes is fully dependent on good standardization and controlled development. "This is achieved through consensus agreements between national delegations representing all the economic stakeholders concerned - suppliers, users, government regulators and other interest groups, such as consumers" (International Organization for Standardization, 2004).

Figure 1. 2D bar code samples

Almost all coding symbologies have their ISO specifications. Just to list few, EAN/UPC has full specification in ISO 15420, PDF417 has an ISO 15438, and Data Matrix is specified in an ISO 16022. In the presentation, for the Department of Defense (DoD) Logistics Automatic Identification Technology (AIT) Office (Spitz, 2004) concluded that the "ISO 15415 is a well-defined conformance test for two dimensional Data Matrix Symbols". As such, it can be concluded, that between ISO standardization and usage of bar coding in areas of low tolerance for mistakes, bar coding is no longer an interesting experiment but a mature technology ready for wide spread usage.

There are many symbologies available but only few are in common usage. Most common used symbologies according to Bruce Philpot (2001) include the PDF417 and Data matrix standards. There are shown below in Figure 1.

PDF417 is a stacked bar code symbology, consisting of individual bar codes, arranged in rows and columns, thus allowing large amounts of data to be encoded in a single bar code. This standard utilizes Reed-Solomon error correction routines, enabling damaged symbols to be reconstructed accurately. These symbols are capable of encoding 2725 data characters in a single bar code. The Data Matrix standard comprises a two-dimensional matrix symbology consisting of black and white square modules arranged in either a square or rectangular pattern. While these capacities are significant compared to original bar code standards, they are still not enough to fully cater for trading partner data exchanges. However, if the 2D bar code is used to store a URL, an online system can utilize web services with the URL an input.

Web Services

In situations where users need an URL addressable set of functionalities, Web Services components should be considered as the first choice. "Web Services are loosely coupled contracted components that communicate via XML-based interfaces" (Schmelzer, 2002). Being loosely coupled, makes them independent of invoking a program, as well as creating platform independence. Their contracted nature makes their input-output parameters as well as binding requirements, publicly known. This is a very good starting point for any building blocks of a bigger application. In general, the Web Services architecture is implemented

as layers of several types of technologies. The organizations of these technologies are as a number of layers that build upon one another (Kulchenko 2002).

Interoperability and platform independence for Web Services are very important. In order to guarantee the same behavior between different applications, the World Wide Web Consortium (W3C) is designing the infrastructure, and defining the architecture and the core technologies for Web Services. "The goal of the Web Services Activity is to design a number of technologies that fit in the Web's architecture, in order to lead Web Services to their full potential" (Haas, 2005). Developers can write Web Services in any language.

UTILIZING THE TECHNOLOGIES

This research proposes a way to reduce the amount of the data being retained on both sides of the transaction. The concept is not new, as there are products providing the data sharing option already, but the proposed solution uses the globally adopted XML language for data exchange fully accessible over the Internet via Web Services. The concept of how to leverage the above technologies seems simple enough: create documents that contain both human-readable texts as well as machine-readable bar codes. There will be no need to retype the information from paper to computer. The only required action would be to point at the 2D bar code and scan the entire document or gain information from where the document could be accessed and transferred to the local system. The concept of document's online accessibility is based on the premise of 2D bar codes having more than enough capacity to provide an exact address to the Web Service. In other words, 2D bar code could contain an XML document providing the data directly or describing the location where the user could access the data.

Figure 2. Simple exchange scenario between companies

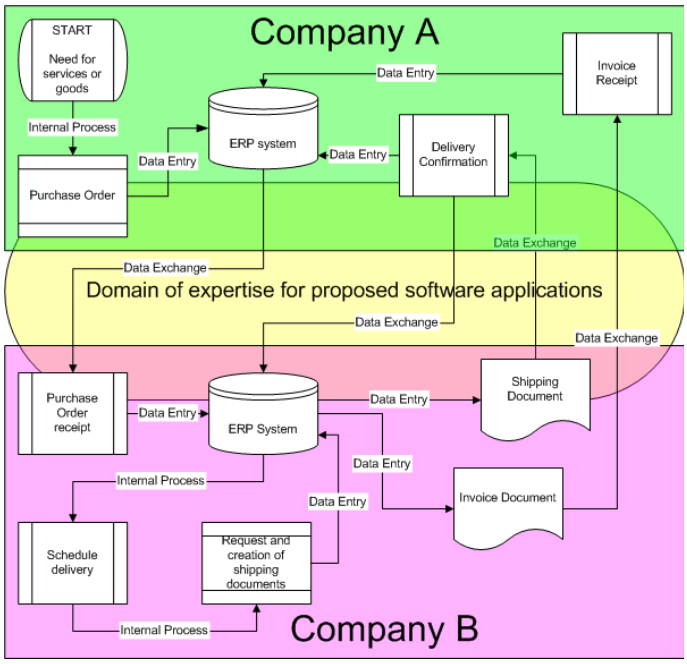
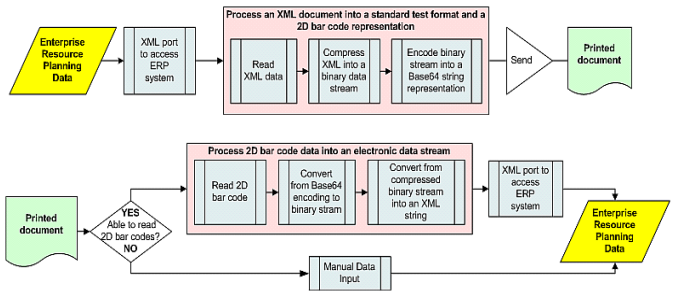


Figure 3. Sending and receiving data through 2D barcodes



EXPERIMENTAL DESIGN

The *proof of concept* system which was developed is linked to the service oriented business domain. Processes running the exchange of goods and services are derived from the needs and regulations governing inter-company relations. In many instances, companies cannot reach higher performance levels because of integration and automation costs. Most popular systems providing electronic data interchange cost a fortune to implement. As a side benefit, this research shows that it is possible to create a new, more economical way to exchange information between companies. This new way will allow company of any size to join global market of data and service exchange.

A typical case scenario is shown below in Figure 2. The implementation of the system enhances data entry process operating between the two endpoints shown.

The experimental system provides a unique way of processing the data. There is no specific data dependency on any software or hardware. The solution converts textural data in an XML format, into a graphical 2D symbol on the sending endpoint, and then reads a 2D symbol using a 2D bar code reader and converts it back to the textural form on the receiving endpoint as an XML document. This is shown in Figure 3.

This research implements the Data Matrix two-dimensional bar code symbology. Data Matrix is absence-presence symbology, which allows the system to read any type of character and uses the ECC200 standard for error correction. The strength of error correction algorithms allows the recognition of bar codes that are up to 60% damaged. The primary benefit of Web Services is the focus on protocol-based software integration. The system as developed utilized a Web Service, which allows requesting specific documents over the Internet.

RESULTS

The task of evaluating the influence of error-correction and image sizing parameters, on the quality and readability of the data, was conducted in a form of prearranged experiments. These experiments involved the printout of 2D symbols and scanning them with a hand held 2D scanner as well as desktop scanner and ClearImage (bar code reading software). The purpose of ClearImage is to read the picture taken with a standard desktop scanner and translate it into a text format. Some results on the experimental trials conducted in an industrial environment are shown in the the tables below.

Experiment description	Parameter	Handheld 2D scanner	Desktop scanner + ClearImage software
Image density (amount of data) influence on scanner's ability to read the image	500 bytes	Correct reading from multiple angles and distances	This scanner has no mobility and image must be placed flat on the scanning surface
	750 bytes	Correct reading from small angles and smaller distances.	The same
	1000 bytes	Problems with the reading performance. About one scan in five was read successfully.	The same
	1500 bytes	Scanner is not able to read bar codes from any distance nor angle.	The same
Lightning conditions	Day light	Good image recognition. The direct exposure to sun light caused glare on the printed media causing intermediate problems with image recognition.	The is no influence as desktop scanner has its own source light.

Lightning conditions	Artificial lightning	Good image recognition. No problems observed.	The same
	Darkness	Good image recognition. No problems observed. Tested 2D bar code has its own infrared light source working reliably in dark conditions.	The same
Error-correction  **Original Image**		Confidence : 100% Correction : Done	Confidence : 100% Correction : Done
		Confidence : 100% Correction : Done	Confidence : 100% Correction : Done
		Confidence : 100% Correction : Done	Confidence : 100% Correction : Done
		Confidence : 100% Correction : Done	Confidence : 100% Correction : Done
		Confidence : 0% Correction : Failed	Confidence : 0% Correction : Failed

Data Capacity

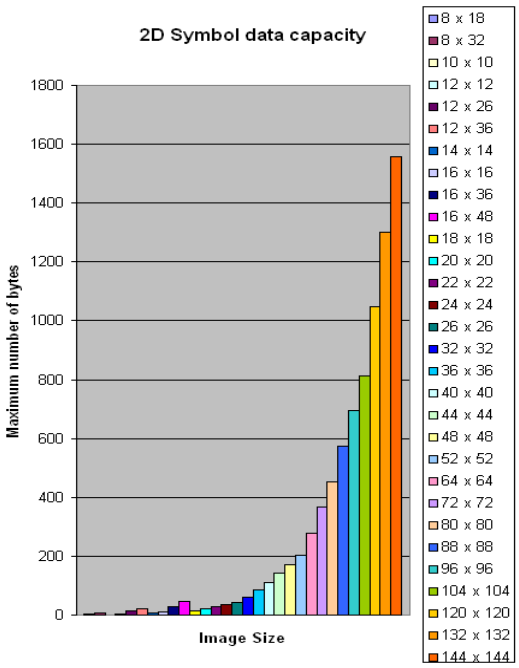
The ability of 2D bar codes to store enough information is critical to the proposed solution. Tests were conducted to find the maximum amount of data that can be carried by 2D Data Matrix symbols. The tests started at 3 characters encoded into the image sized at 8x18 mils and went progressively to 1556 characters encoded into the image sized at 144x144 mils. The capacity of the data inside the 2D symbol is proportional to its size. In order to support this claim tests were conducted probing the maximum data capacity in relation to the image size. Test results were compiled into a two-dimensional graph presenting the maximum number of bytes in relation to the 2D symbol size (Figure 4).

CONCLUSION

The experiments pointed out certain weaknesses of both, hand held bar code readers as well as stationary desktop scanners. Hand held devices are more prone to readability issues, but desktop scanners cannot be used in a warehouse environment where products have to be scanned in multiple locations. Alternatively, quality and reliability of bar code reads is much better with stationary scanners. A bonus with dedicated 2D scanners is the fact that decoding software is built directly into the units themselves and so there is no need for a third party solutions.

The research presented in this paper demonstrates that 2D symbology combined with XML technology creates a feasible solution to exchange information effectively between trading partners. The proposed solution is clearly less expensive than existing solutions, as any computer savvy user can implement it. By designing and deploying strong demonstration software it was demonstrated that such a system is a viable solution and technically possible. Deploying the system on an inexpensive hardware with popular software, proved that there is a clear financial advantage in implementing this new technology.

Figure 4. 2D graph representing bytes in 2D symbol size



ACKNOWLEDGEMENT

This research project was undertaken as part of a Master of Science degree with University of Liverpool and Laureate Online Education.

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