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Mobile Applications for RFID Based B2B Systems

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1. Introduction

Business-to-business or "B2B" is a term commonly used to describe the transaction of goods or services between businesses, as opposed to that between business and other groups, such as transactions between business and individual consumers (B2C) or business to public administration (B2G) transactions [Turcu et al., 2007]. Given today's general interest in RFID (Radio Frequency Identification) technology, B2B systems are expected to allow for considerable extensions and improvements. It is expected that RFID technology will enable the building of complete and complex B2B solutions in areas such as industry and commerce where mobility is a key factor. In fact, the overall success of any RFID_B2B (Radio Frequency Identification - Business to Business) system is highly dependent upon this factor. The RFID_B2B system's mobility resides in the use of multiple PDA devices and RFID readers connected to them.

This chapter presents the principles governing the design and development of a mobile application, as well as various aspects regarding its integration into a more complex RFID_B2B system. The main goal of such application is to extend the applicability of generalized RFID_B2B systems. Mobile applications are generally expected to handle large amount of data, to operate in stand-alone mode and to allow their easy integration into complex RFID_B2B systems. All these aspects will be detailed presented in this chapter. The chapter also proposes new solutions and ideas regarding the design and development of a secure and very fast method for the communication and synchronization between different B2B servers and mobile applications running on various mobile devices.

2. RFID_B2B mobile applications

2.1 RFID

RFID (Radio-Frequency Identification) technology has been considered one of today's "hottest" technologies due to its specialized capacity to track and trace objects in real time. RFID technology is classified as a wireless Automatic Identification and Data Capture (AIDC) technology that uses electronic tags to store identification data and other specific information, and a reader to read and write tags. Tags are small chips with antenna. They ca be active (battery powered), passive (uses the reader signal to be activated) or semi-passive (battery-assisted, activated by a signal from the reader). RFID technology currently allows to identify, locate, track and monitor each and every item (product, box, pallet, etc.) and to

obtain continuous real-time information on these items from the factory, through shipping and warehousing, to the retail location [Finkenzeller, 2003]. Incorrect or outdated data used in invoices, bills of lading (a document from the carrier indicating the description of the goods being shipped) or purchase orders can result in product delivery errors and lost sales estimated at more than $50 billion annually [Lefebvre et al., 2006]. But RFID technology could prevent these costly data inaccuracies. Moreover, it is expected that RFID tags will replace conventional barcode labels due to their major benefits: high data storage capacity, read-write capability, read-speed rate, multiple entity identification, information updating, no line of sight scanning, durability, and environmental resistance [Turcu et al., 2006]. Also, it can be demonstrated that RFID enables more integrated and more collaborative business-to-business (B2B) ecommerce solutions.

2.2 RFID_B2B general presentation

The RFID_B2B system that integrates the mobile application is detailed described in [Turcu et al., 2007]; the generalized character of the system results from the fact that it can be easily implemented in various activity fields without any modifications in the structural level of software applications. Thus, the user can define the data format to be used for writing data into tags through an advanced template editor which allows user to establish necessary fields (e.g. acquisition date, location, current value) and their type (character, string, integer, real). [Turcu et al., 2007, Cerlinca et al., 2006]

The RFID_B2B system refers to the business relations in large enterprises, corporations and groups, as regards the control of the materials along their entire supply chain. The system proposes applying the RFID technology by using tags to identify materials and assemblies. Thus, based on the ID codes of the materials and assemblies, it is possible to control the content and the origin of any finite product, the content of assemblies and the origin of any constituent component, and so on, for each company which contributed to the creation of the finite product. By extending the system to the entire supply - chain - final producer, supplier, the manufacturer's suppliers, etc. - the customer can follow the course of materials included in the final product, up to the primary sources. In order to accomplish this, all the necessary tracking information will be comprised in the tags attached to the materials, assemblies and finite products. The RFID_B2B uses RFID technology by using passive 13.56 MHz tags for parts and finite products identification. The system also handles multiple PDA devices and PC servers and facilitates data sharing among these devices.

The general architecture of the RFID_B2B system is presented in figure 1 [Turcu et al., 2007]. Relating to this architecture we can note that the integrated RFID_ B2B system includes the following main components:

- one IBM-PC compatible computer which runs an OPC (OLE for Process Control) server with two main components: communication and data acquisition;
- one IBM-PC compatible computer which runs an OPC dedicated client. This computer can be the same as the first one;
- one network of different gates devices, each of them having attached an RFID reader, which provides local data processing;
- different PDA devices with RFID readers attached too;
- one IBM-PC compatible computer which runs a Local B2B server;
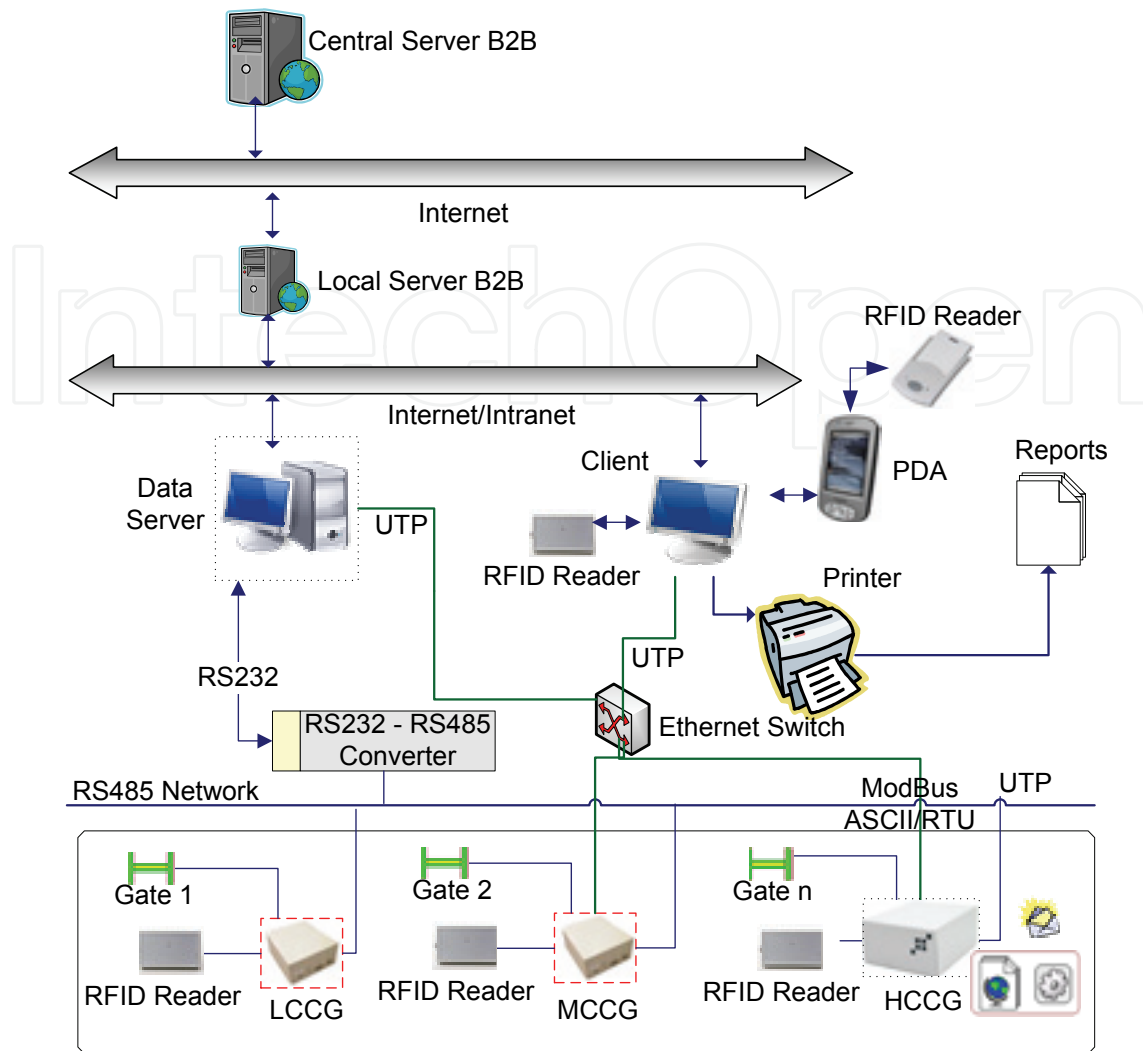- one IBM-PC compatible computer which runs the Central B2B server.

Fig. 1. The RFID_B2B system architecture

2.3 RFID_B2B mobile application facilities

Mobile applications present several interesting and complex challenges. Following our research, we have reached the conclusion that the software application that runs on such mobile devices and that is integrated into the complex RFID_B2B system should perform the following main functions [Cerlinca et al., 2008]:

- read and write RFID tags;
- work in stand-alone mode (independently of the main servers);
- store huge data;
- integrate and exchange information with complex RFID_B2B systems and other PDA mobile devices;
- ensure maximum security;
- employ a multi-user and user-friendly interface.

Within the mobile application integrated in the RFID_B2B system, the following main operations are facilitated:

- the bi-directional communication between the PC and PDA applications, allowing a total or a partial transfer of records within database tables from PC to PDA and in inverse order, for the update of the database from the PC and from the PDA;

- the communication between PDA and reader, enabling the reading of stored information into tags and the update of databases from the PDA, as well as the writing and updating of tags with database records and according to the settings performed by the user;
- enabling the system security, through system access control, as well as data encrypting from the database. These operations are performed both on the PC and the PDA;
- management of system registered users (users visualization, adding or deletion of certain users, profile modification, etc.);
- enabling the management of the database, which stores information related to tags;
- the configuration of the system in accordance with necessities;
- the visualization of the templates to be used for tag information storage;
- enabling the communication with other systems and allowing the connection with higher enterprise levels;
- the storage of all events and their administration (visualization, searching, filtering etc.);
- clock synchronization between the PDA and the PC;
- checking the connection state;
- basic file/directories based operations;

2.4 Specifications for implementation

There are many aspects to be discussed about the implementation of an RFID_B2B mobile application. However, this chapter will focus only on several most important aspects such as: data security, high degree of usage, communication/synchronization etc.

Needless to say, security is one of the most important aspects that should be taken into consideration when implementing an RFID_B2B system. Also, security is a major concern for mobile applications. Thus, wireless transmission, in a way, biases end-users to perceive mobile applications to be more vulnerable and unsecured. Our system provides several security enhancements and options to ensure the security of data and communication between applications:

- data encryption with the TripleDES algorithm for all important information such as user names, passwords, access rights, etc.;
- password-based access to all web services used for communication and synchronization between the PDA devices and the RFID_B2B systems;
- password-based access to the PDA's main application;
- support for different levels of access rights. This means that users are granted different rights to the application features. For example, some users will create new tags while others will only view the available database tags. The access rights are established at the PC level through a specialized application called User Management and transferred to the PDA through specialized web services.

Another important aspect we have focused upon in the implementation of the mobile application is the way in which a high level of generality can be provided. The application was designed in such a manner so that it can be used in different areas of activities. To insure the desired level of generality we took into consideration two important aspects. The first one is related to the use of tag templates to create specialized tags [Cerlinca et al., 2006, Cerlinca et al., 2008]. All templates are created at the PC level and then transferred to the PDA through specialized web services. The second aspect is related to the visual organization of the fields on a tag so that they can be read on the PDA display. Given our

experience in this respect [Cerlinca et al., 2006, Cerlinca et al., 2008], we consider that it is rather difficult to create/update a tag that has too many fields. Thus, the visual space on the PDA touch screen is far too small; the low display resolution and small display screen have inhibited information to be displayed completely and clearly. Also, it's difficult to manage information tag when the way that the template's fields were created and visual grouped may not correspond to the actual expectations of the user. That is why, an RIFD_B2B based application should allow users to define at the PC their own visual areas according to their needs and then group all tag fields. In general, each group will consist of several fields with the same purpose. All visual areas created at the PC level are then transferred to the PDA. Let's suppose that a company is selling Desktop PCs. Each PC that is sold to a customer will need to have an RDIF tag attached. As we already mentioned, a tag is created by using a specific template. A minimal Desktop PC template will have the following fields:

Field	Type	Size	Description
Location	CHAR	30	company location – e.g. **Bucharest**
Name	CHAR	50	product name – e.g. **DC X-Line Home X2 4200+**
Code	INT8	1	product code – e.g. **102**
Processor	CHAR	30	processor type – e.g. **AM2 Athlon 64 X2 4200+ BOX**
Motherboard	INT8(CODED)	1	motherboard type ID – e.g. **1 (nVidia nForce 630a/GeForce 7050PV**)
Memory	INT8(CODED)	1	memory capacity ID – e.g. **3 (4GB)**
Video	INT16(CODED)	1	video card ID – e.g. **0 (VGA GeForce 7050)**
HDD	INT16(CODED)	1	HDD type ID – e.g. **2 (250GB SEAGATE Barracuda 7200 7200rpm/SATAII/8M)**
TAG_DATE	DATE	1	Tag creation date – e.g. **20/11/2007**
EXPIRATION_DATE	DATE	1	product expiration date– e.g. **20/11/2009**
PRICE	REAL	1	product price – e.g. **590.47**
SHOP_ASSISTANT	INT8(CODED)	1	seller ID – e.g. **2 (John E.)**
CLIENT	CHAR	50	client name – e.g. **3 (Peter A.)**
PAYMENT_TYPE	INT8(CODED)	1	payment type – e.g. **1 (Credit card)**

Table 1. Desktop PC template

Note that all types in column 2 of table 1 are not built-in but application specific types. Figure 2 shows the tags editor window for the case when no visual group exists. Figures 3, 4 and 5 exemplify the visual organization of the fields on a tag.
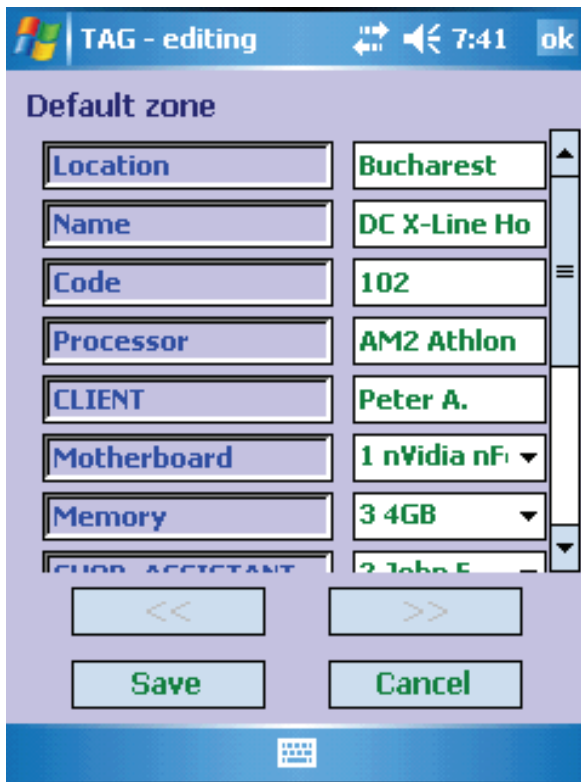
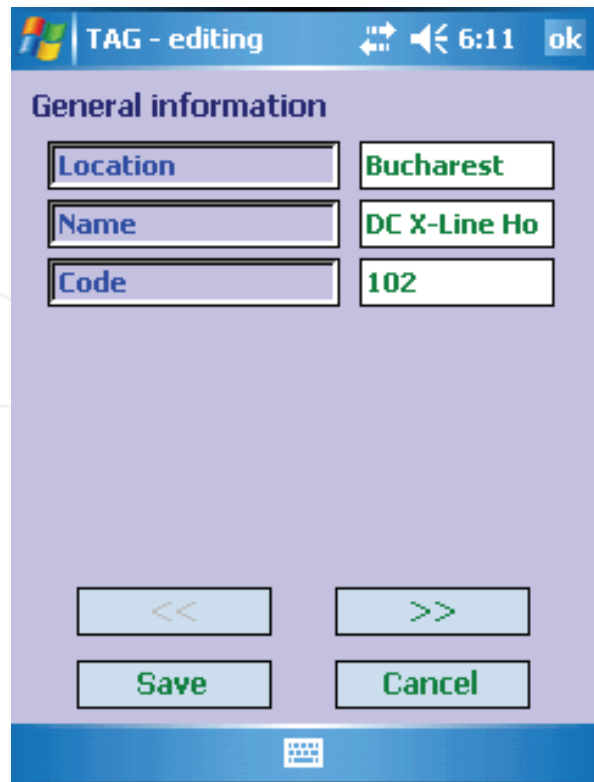Fig. 2. Tags editor window. No visual groups

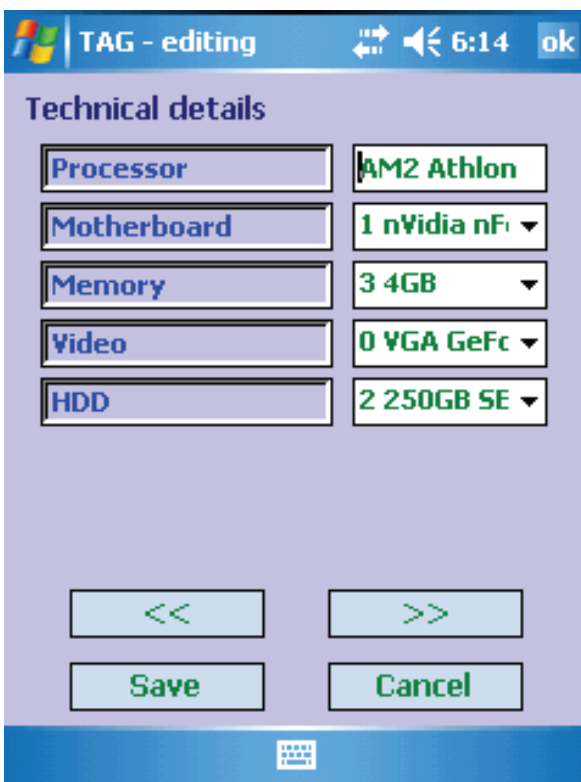Fig. 3. Visual organization of tag fields. First group

Fig. 4. Visual organization of tag fields. Second group

Fig. 5. Visual organization of tag fields. Third group

For the Desktop PC template, three visual groups were created. The mobile application also offers a 'visual groups' browser that allows user to browse through the visual groups and choose the one he wants to edit.

Perhaps the most important aspect in the design and development of RFID_B2B mobile applications is the one related to the communication and synchronization between mobile devices and different B2B servers and different mobile devices that run the same application. A powerful communication and synchronization component will provide the following facilities:

- the bi-directional communication between the PC and PDA applications, allowing a total or a partial transfer of records within database tables from PC to PDA and in inverse order, for the update of the database from the PC and from the PDA;
- support for multiple PDA devices/PC servers that could store different information about the same entities;
- support for intelligent updating of both PC and PDA databases;
- clock synchronization between the PDA and PC.

First of all, we should mention that a universal synchronization tool already exists and it is called Microsoft ActiveSync. In the following we will see what Microsoft ActiveSync is all about and why an RFID_B2B mobile application can't rely on it. Microsoft ActiveSync is a tool that allows users to create a synchronization relationship between a mobile device and a PC, by using a cable, cradle, Bluetooth, or infrared connection. Mainly, ActiveSync helps users to keep their information up-to-date on both mobile device and PC. If a change was made in one place, the next time when the user is synchronizing, the change will be automatically made to the corresponding information on the other computer. No matter where the user is viewing the information, he will know that it's up-to-date. ActiveSync can be used to synchronize Contacts, Calendar, E-mail, Tasks, Notes, Favorites and even files. When it comes to databases, ActiveSync can be successfully used to synchronize Pocket Access databases with Microsoft Access databases. But no RFID_B2B system can be built upon Pocket Access and Microsoft Access databases. Moreover, ActiveSync does not support record based synchronization. Only tables/databases synchronization is allowed. If we take into consideration the fact that different devices (PCs and PDAs) could store different information about the same entities and the database records must not be replaced but rather updated, then we can conclude that Microsoft ActiveSync is definitely not a viable solution for communication and synchronization in complex RFID_B2B systems.

In our RFID_B2B system, we used Sybase SQL Anywhere 10 for the PDA devices and Microsoft SQL Server 2005 for the PC Server. We consider Sybase SQL Anywhere 10 to be the best solution for PDA devices because:

- it is not just a database file but a real multi-user SQL server;
- supports stored procedures and user functions (using Watcom SQL, T-SQL, Java, or C/C++), triggers, referential integrity, row-level locking, replication (two technologies: SQL Remote, MobiLink), proxy tables (links to other databases), and events (both scheduled and in response to system events such as lack of free disk space) ;
- supports strong encryption of both database files and client-server communication.

The communication, which is a client-server process, is basically achieved through specialized password-based web services that are available on PC servers. While the RFID_B2B system supports the operation of several PC servers, the PDA must dynamically connect to any of these servers. This problem was solved at the PDA level by implementing

a specialized software component capable of reading the description of any web service and then connecting to it.

All data transferred between the PDAs and the PC servers is first converted from the database format into the XML format. There is still one important detail to be mentioned here: the amount of data to be stored on both the PC and the PDA can be huge, hence data transfer may take longer than one might expect. Furthermore, there is a lot of important data shared by the PDA devices and the PC servers that needn't be overwritten but perhaps only updated. Our communication component is intended to perform an intelligent update of both the PDA and the PC databases, by transferring and updating only the new/modified data that is explicitly marked as being transferable. The communication component is also able to handle multiple PDA devices. Taking into consideration the fact that different PDA devices could store different information about the same tag, we can conclude that this is not an easy task. The solution to this problem implies:

- the design and development of an UID server that will give a unique identifier to each PDA/PC in the system. The UID server has to be capable to handle security problems also (e.g. no PDA/PC with pirated/cloned application will ever receive an ID);
- the design of a table that will contain all the possible states that a database record can get into (Transferable to PDA, Transferred to PDA, Transferable to PC, Transferred to PC, Removed from PDA, Removed from PC etc);
- the design of a table that will contain the current states of each and every database entity that is involved in the communication/synchronization process. Al long as the RFID_B2B system can have more than one PDA device, this table can contain multiple records for the same entity (one record for each device). It is obvious that the state of some entity can differ from one PDA to another. In order to avoid huge computation time and disk space wastage, we do not consider any database record as an entity. For example, the tag's fields are not entities; only the tag is an entity. The RFID_B2B database was designed in such a manner that each table which contains entities (tags, templates etc) has a field called ModificationDateTime. Each time an entity is modified the ModificationDateTime field will be automatically updated.
- the design and development of a mechanism that will continuously update the above mentioned table in order to reflect the most recent changes of database entities.

Clock synchronization is also a very important component in the process of communication/synchronization. A successful process of communication will take place only when the PDA's clock is correctly synchronized with the PC's one.

Let us consider a simple test test-case that will demonstrate the efficiency of this communication/synchronization method. Let's suppose that we have an RFID_B2B system with 2 PDA devices and only one PC server. The table that contains the current states of all database entities is called tblEntitiesStates. At the PC level, the user creates one template (e.g. Desktop PC) and two different tags (e.g. Tag_PC1 and Tag_PC2). At this time, the tblEntitiesStates table will not contain any information related to DesktopPC_Template, Tag_PC1 and Tag_PC2. Next, the user is connecting the PDA1 to a computer that has an Internet connection and synchronizes the PDA's clock with the PC Server's one. Then he initializes a database transfer process by issuing a specific command to the communication web service. In the first step, the web service located on the PC server checks the current state of the following entities: DesktopPC_Template, Tag_PC1 and Tag_PC2. No information could be found for PDA1, which means that these entities were never transferred to PDA1. At this point, the web service will perform the following tasks:

- builds an XML string with all the information that must be transferred;
- sends the XML string to the PDA1;
- adds new records in the tblEntitiesStates table with the following information: entity's ID, PDA's id and state's ID (1 - Transferred to PDA)

In the next step, the user is modifying Tag_PC2, first at the PC level and then at the PDA level. The user is modifying Tag_PC1 also, but only at the PC level. The database records from tblEntitiesStates that are referring to Tag_PC1 and Tag_PC2 will be automatically updated, in order to change the current state from 'Transferred to PDA' to 'Transferable to PDA'. The user initializes a new database transfer process. Tag_PC1 and Tag_PC2 were marked as being transferable to PDA, but only Tag_PC1 will be transferred to PDA1, because the Tag_PC2 on PDA1 is newer than the same tag on PC. Next, the user is connecting the PDA2 to a computer that has an Internet connection and synchronizes the PDA's clock with the PC Server's one. Then he initializes a database transfer process. At this step, the web-service checks the current state of the following entities: DesktopPC_Template, Tag_PC1 and Tag_PC2. No information could be found for PDA2, which means that these entities were never transferred to PDA2. In this case, all the information related to these entities will be transferred to PDA2. The web-service will perform the same three tasks described above.

Now, let's perform a more complicated test. The user is performing some modifications in the following order: Tag_PC2 at the PC level, Tag_PC1 at the PDA1 level, Tag_PC1 and Tag_PC2 at the PDA2 level, Tag_PC2 at PDA1 level and Tag_PC1 at the PC level. Then he is transferring the database from PDA1 to PC. Tag_PC1 will not be transferred to PC because information on PC is newer. Tag_PC2 will be transferred to PC, because the last modifications were made at the PDA1 level. The database records from tblEntitiesStates that are referring to Tag_PC2 will be updated as follows:

- for PDA1, the state will be changed from 'Transferred to PDA' to 'Transferred to PC';
- for PDA2, the state will be changed from 'Transferred to PDA' to 'Transferable to PDA'.

In the last step, the user is transferring the database from PC to PDA2. The state of Tag_PC1 entity for PDA2 is 'Transferable to PDA' but the tag was modified both on PC and PDA2 levels. The most recent data is the one from PC, in which case, the tag will be transferred to PDA2. As for the Tag_PC2, the state is also 'Transferable to PDA', because the tag was transferred from PDA1 to PC. The most recent data is the one from PC, in which case, the tag will be transferred to PDA2.

As it can be seen from the test-case, the proposed method of communication/ synchronization ensures that the information is up-to-date on all RFID_B2B devices (PDAs or PCs) and no information will be mistakenly updated or replaced.

Another important aspect in the development of an RFID_B2B mobile application is related to the tags management. An RFID_B2B mobile application should perform at least the following main operations: the creation of new tags (see figure 6) and the read/write of RFID tags. Perhaps one of the most important facilities that an RFID_B2B mobile application should provide is the ability to read/write RFID tags. Figure 7 present the application's window that allows users to select the database tags that will be psychically written on RFID tags. The RFID reader is connected to the PDA through SD port. The ability to read/write RFID tags was achieved through a specialized software component that is performing the following main tasks:
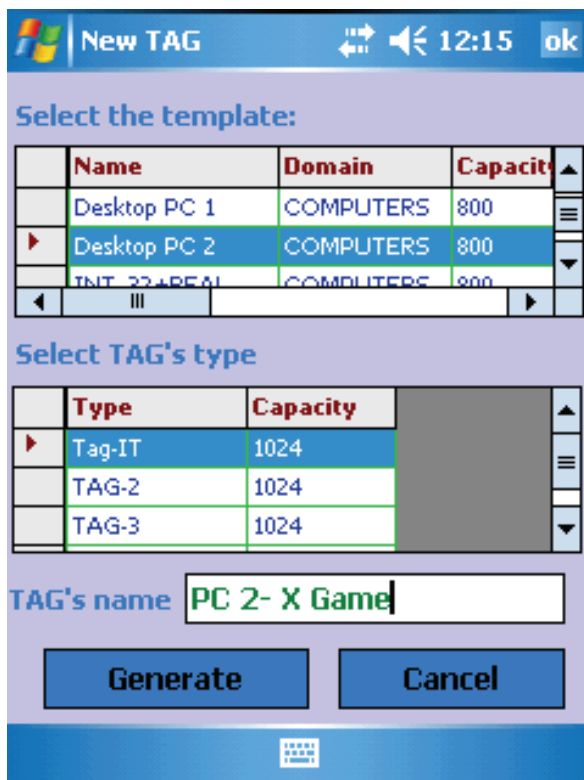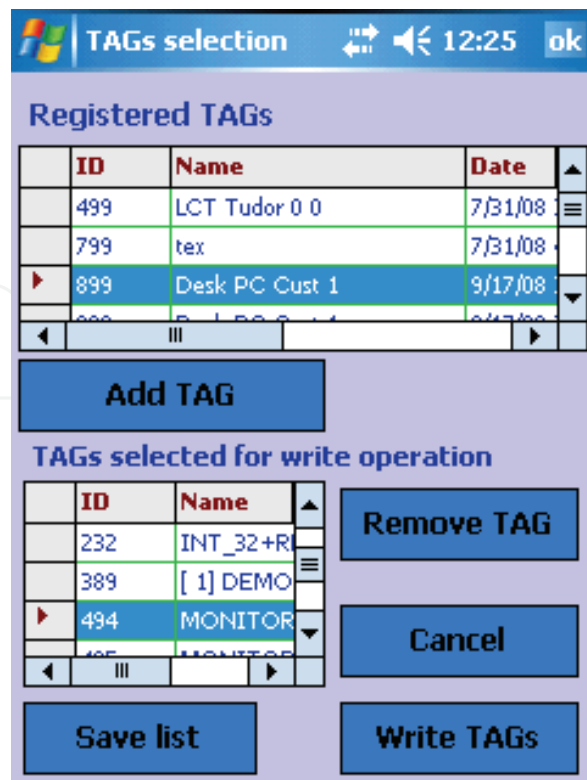
Fig. 6. Tags creation window   Fig. 7. Tags selection window

WRITE operation:
- establishing a connection with the RFID reader;
- getting the tag's data from the database;
- encoding the data to be written on the RFID tag;
- searching for an RFID tag in the proximity of the RFID reader;
- writing the encoded data to the RFID tag;
- closing the connection.

READ operation:
- establishing a connection with the RFID reader;
- searching for an RFID tag in the proximity of the RFID reader;
- reading all the data encoded in the RFID tag;
- decoding the data;
- updating the database;
- closing the connection.

Figure 8 presents the application's window that allows the reading/writing of RFID tags.

2.5 Advantages

The integration of the developed mobile application into the main RFID_B2B system has some considerable advantages:
- the PC-PDA communication component is fast and secure, allowing the use of several PDA devices within the same system and supporting an intelligent solution for updating data;
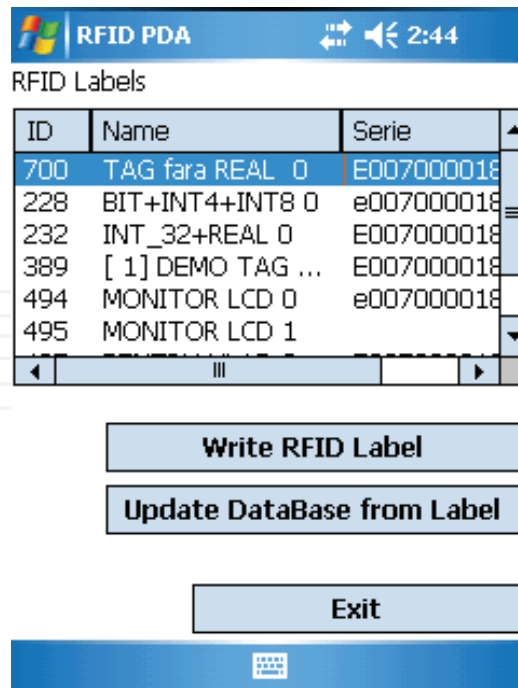- the generality of our application: one application – multiple purposes;

Fig. 8. RFID tags reading/writing

- the mobile application may be easily adjusted to users' requests, ensuring high performance and flexibility;
- the user graphics interface is simple to use and allows varied configurations depending on user preferences and necessities;
- the usage of the present system results in a considerable reduction of human errors;
- it promotes quality, security and ensures high-speed data processing.

Requiring no software modifications, the system is recommended for extremely varied activity fields.

3. Future directions for development

The following aspects might be taken into account as future directions for development:
- Application of agent technology, through the development of some intelligent agents, which allows the defining of the user's profile, simplifying, among others, the collecting of information and its filtering (considering the criteria chosen by users), etc;
- On-line processing of banking-financial-accounting transactions involved in B2B exchanges.

4. Conclusions

This chapter presents a PDA application that enables the development of complete and complex RFID_B2B solutions in industry and commerce. A tag will be attached to each material/ assembly, which will allow its identification based on an ID code. Thus, based on these ID codes attached to each product or assembly, it will be possible to check the constituents and origin of each finite product, the components of assemblies and the origin of the constituent components, and so on, for each company involved in the building process of the final product. By extending the system to the entire supply chain, the final

consumer will be able to track the origin of the materials included in the final product down to the primary sources.

The integration of the mobile application into the main RFID_B2B system has considerable advantages: the usage of several PDA devices within the same system; fast and secure PCPDA communication; a high degree of generality of the entire system; easily adjustment of mobile application to users' requests; a flexible user graphics interface; a high-speed and secure data processing; human errors reduction. Thus, the system is suitable for extremely varied activity fields without software modifications.

All in all, the implementation of our solutions has resulted in a high-performance multi-user mobile application, which can generate further improvements in RFID_B2B system. Companies have an excellent opportunity to improve their competitive advantage, using mobile technology to deliver important corporate information to employees, partners, and customers wherever they're located.

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Development and Implementation of RFID Technology

Edited by Cristina Turcu

The book generously covers a wide range of aspects and issues related to RFID systems, namely the design of RFID antennas, RFID readers and the variety of tags (e.g. UHF tags for sensing applications, surface acoustic wave RFID tags, smart RFID tags), complex RFID systems, security and privacy issues in RFID applications, as well as the selection of encryption algorithms. The book offers new insights, solutions and ideas for the design of efficient RFID architectures and applications. While not pretending to be comprehensive, its wide coverage may be appropriate not only for RFID novices but also for experienced technical professionals and RFID aficionados.

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