

Using RFID Technology for Supporting Document Management

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Abstract. Integrating RFID and document management systems can provide a better awareness regarding the state of the enterprise context and, then, bring new benefits. The activity flow characterizing a business process depends on the moving of a definite sequence of paper documents from a given organization's office to another one. If the document circulation is monitored and managed by using RFID technology, additional data can be captured from the organization information system enriching the set of data produced by a traditional document management system. By extracting information from this data, an organization can improve its knowledge regarding its activity flows. As a result, less time for performing a business process is spent, capability to planning and make decision increases, evaluation errors decreases and economic advantages are obtained. This paper describes an RFID design, addressing this thesis.

1 Introduction

Current business process automation systems are focused on the activities of a business process rather than on the involved business entities, such as documents and persons. These entities are not monitored and the impact on the information system of the widespread mobility and traceability of the enterprise resources is not considered. Information does not always exist regarding their causal relations, topographical localization and movement in the surrounding space. Therefore, uncertainty exists regarding business processes. Planning and decisions making capability reduces and evaluation errors increase. Likewise, business process executors consume more time for performing their tasks and customer satisfaction decreases. Document management area is sensible to these drawbacks. Even if organizations have automated their business processes and provided them a global visibility, they continue to use paper documents often representing central business entities of the organization. A major control on their causal relations and circulation improves the organization's business.

Document management is emerging as an important IT issue for improving business processes. It represents an integral part of business continuity planning area and requires the integration and management of existing and new technologies in innovative solutions. A transition from traditional documents to digital ones is taking place, and standard ways for electronically managing documents are diffusing. XML or

PDF formats are examples. However, digitalization is not always suitable. Some documents having legal value must be recorded, kept and inventoried in the paper format, and cannot be completely replaced by digital documents. Technologies, such as bar codes, can be used. It supports recording and inventorying tasks, but it is not useful for documents tracking. Radio Frequency Identification (RFID) technology permits to overcome this limitation. Multiple RFID tags can be read once and they can be detected without passing each document on a scanner as for the bar code. In addition, an RFID tag can keep useful information in its on-board memory and be used for detecting and tracking the document.

The integration of RFID and document management systems brings the following new benefits to the organizations: (a) enrichment of the organization knowledge with information obtained from the tracking of RFID tagged documents; (b) enhancement of the global visibility of an organization, as remote authorized users can monitor the procedures involving RFID tagged documents; (c) new opportunities for RFID-based services and administrative e-services. An automatic ubiquitous system integrating the RFID technology has a certain intelligence level useful for supervising the activities carried out in the organization hosting it. It allows an authorized user to discover problems in the expected status of its requests in a business process, as documents are not anymore disconnected from the company information system. For instance, an employee can search a document and ask information regarding it without moving from his desk, even if the document has not been digitalized. Moreover, all the documents related to a specific topic or project can be quickly found. Periodic report can be generated for indicating outdated documents to be localized and cancelled from the company archives. Currently, RFID technology and document management are not widely integrated. Indeed, many organizations still have doubts regarding the real benefits and require evaluation, case studies with empirical evidence before adopting the RFID technology. This paper investigates the challenges RFID introduces for the document processing. In particular, this work aims at solving some malfunctions in the public administrations and at supporting the interest of the National Center for Computing in the Public Administration (CNIPA), in Italy, with reference to the adoption of the RFID technology [3]. With this in mind, an approach using the RFID technology for document management is proposed. In addition, a business case is proposed.

In the following, Section 2 considers drawbacks, benefits of the RFID technology. Section 3 introduces the business case, Section 4 describes the proposed RFID solution, Section 5 discusses its deployment. Conclusions are given in the last section.

2 Drawbacks and Benefits of RFID Technology

RFID technology supports a variety of application contexts. Its broad applicability favored an increasing interest, and provided benefits but also worries. In the following, an overview of the most common drawbacks and benefits is given.

Drawbacks

RFID affects applications, infrastructure, business processes and personnel. It is a part of IT. It is not simply another application [18], not a single, simple piece of technology, but it requires millions of tags containing standardized and coded data, and thousands of tags readers. The tags transmit relevant data to multiple software applications, including middleware, databases, legacy systems and new applications [15]. Malwares may also be transmitted and safe programming practices and techniques are needed for fighting database and web based attacks [14, 16]. Reading the properties of an RFID tag without authorization could violate users' privacy. Therefore, the use of antennas with high reception capability should be limited and/or blocker tags [12], or expensive techniques of cryptography within tags, or tags with short range of action for reducing their interception should be used. Implementing an RFID system is complex and expensive, as it required the acquisition of new components. Then, its adoption must be also motivated and a concrete business purpose and a market need are necessary for justifying its use.

Benefits

The RFID technology increases the ability of an organization of acquiring and storing in a database a vast array of data regarding the location and properties of any entities physically tagged and wirelessly scanned. It allows the tagged entities to become mobile, intelligent, communicating component of the organization's information infrastructure [10]. It realize the linkage between the physical world and the Information Technology (IT) and enables organizations to automatically monitor, decide, and take actions [2].

The Wal-Mart Stores were among the first practitioners to engage a real RFID experience. Their RFID system, implemented in January 2005, was applied to supply chain management. Afterward, many other enterprises (e.g., HP, Sun, IBM, Windows, Intel, ...) applied RFID in supply chain management. By using the RFID technology, the Wal-Mart Stores obtained an interesting Return On Investment (ROI) in terms of a decrease of the number of rejects of perishable goods and employees for checking them. Wall-Mart is continuing to consider RFID initiatives and encourage suppliers and partners to use this technology [17]. Ford Motor Co. uses the RFID for improving the efficiency of its supply chain. Ford had also an important impact on safety and security, as well as on product sales and inventory management [11].

Medical organizations are particularly interested in the impact of RFID usage for safety reasons [4]. They use RFID for tracking medical instruments, patients and hospital personnel. An hospital in Taiwan used RFID technology for a medical application [18], highlighting that RFID is a part of the IT infrastructure and its value is delivered only through its business applications.

The idea of a possible impact of the RFID technology on security, allowed NEC Corp. to obtain a contract with a Japanese bank for an RFID-based document management system in 2004. Bank of Nagoya Ltd. introduced the system in April 2005. Antennas attached to bookshelves and filing cabinets were used. They communicated data from RFID tags embedded in documents to a software system offered real-time document tracking. Moreover, it could be combined with the employees' identification systems. Bank of Nagoya is having evidence of RFID solution benefits in terms of cost reduction coming from the reduction of personnel [13].

3 The Business Case

The design of the business case regarded the following actors: the personnel of the selected organization working with sensitive documents, process analysts and experts in Ubiquitous Computing (UbiComp) technologies and methodologies. The cooperation among these actors allowed the determination of:

- short-term requirements, oriented to improve the staff's performances;
- long-term expectations, coming from the RFID use.

Short-Term Requirements

The personnel working with sensitive documents evidenced some inefficiencies of the current document management system, common to other organizations. Some of them could be overcome by the existent automated document management systems and use of electronic mails. Unfortunately, this is not enough, as:

- the accounting office is legally obliged to keep payment receipts, faxes, invoices and other documents some years. So, valuable staff time is spent for identifying them and eliminating them when the office is not obliged to keep them;
- staff's private information (e.g., curriculum, contracts) is stored in folders. They are often kept on shelves and guarantees for their secure access is required;
- legal offices often move their dossiers outside the organization and can lose them. In addition, a mechanism for rapidly finding them is needed;
- some administrative procedures have to follow a given bureaucratic course. Some written and signed orders have to cross various bureaus and managers, and a user could need to know the state of the procedures before taking his/her decisions.

The adoption of a document management system integrating RFID, could help to overcome these limitations, with the following requirements: reduction of labor time; increase of guarantees for security access; increase of capability of quickly locating documents; increase of project managers awareness and users' satisfaction. The same benefits cannot be obtained by adopting other technology like bar code, documents digitalization or documental workflow. Bar code technology allows to identify documents but not to trace their movements. The identification of a document is achieved by passing it on a scanner for reading its bar code and it cannot be remotely performed. Likewise, a digitalized document may be remotely consulted only if the document is indexed and an information retrieval system is used, but information are not provided regarding its physical location. The digitalization technology cannot provide information for monitoring a business process or obtaining quality measures from its execution. Analogously, the adoption of documental workflow can help to monitor a business process, but such system is static and is designed without pro-activeness. It is not able to autonomously capture illegal state changes in the workflow execution.

Then, in the business case, the application of RFID passive tags on documents was considered. Antennas placed in strategic points generate the magnetic field activating RFID tags. When a tag is activated, it sends information to or receives information from a reader. Passive tags have memory on board and are univocally identifiable by means of a factory defined Unique Identifier (UID). In particular, the RFID available memory was used for storing the name of the organization managing the document, email address and phone number of the office responsible for attaching the RFID tag

on the document. In this way, whoever, outside or inside the organization, finds a lost tagged document, could contact its responsible accessing an RFID antenna for reading the information written on the tag.

Long-terms RFID Expectations

A document can be linked to a variety of additional informative parameters such as: document description; office to which the document is destined; office responsible for its storage; beneficiary of the procedure; production date; expiration date; priority; access authorization; tags' UIDs referencing other documents; etc. This information can be kept into a database and those related to a document can be identified by means of the UID of its tag. The wealth of the database represent a key element of the success of RFID technology in the document management area. The database could allow obtaining the workflow history of the tagged documents. The information kept in the database could be linked to business intelligence tools, and/or UbiComp system for improving enterprise performances.

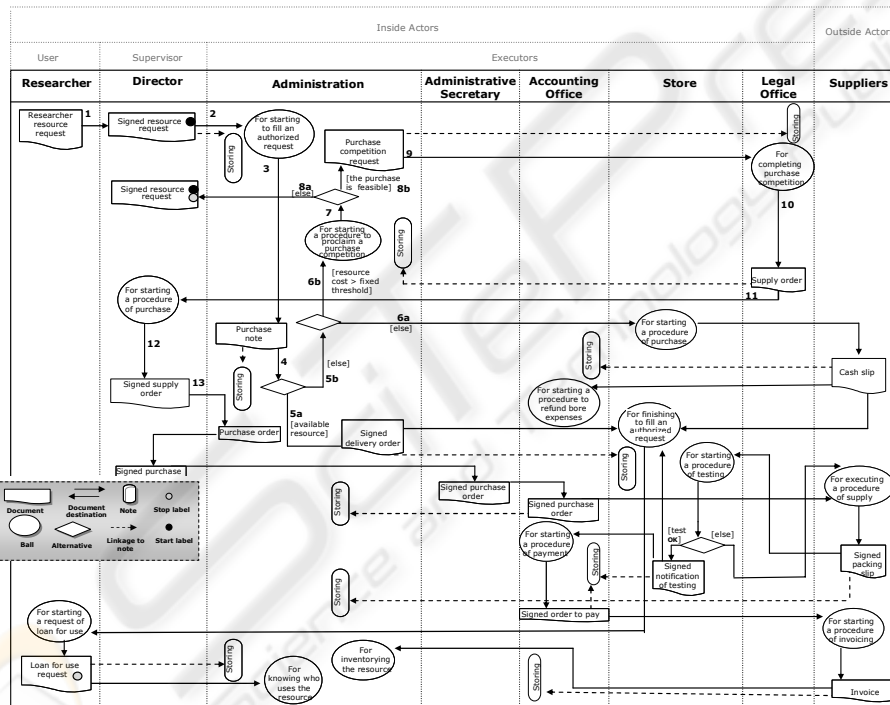


Fig. 1. Document diagram for the resource supply process.

4 The Pilot Experience

On the basis of interviews to the analyzed organization's personal and the exam of the existent Quality Manual conformed to the UNI EN ISO 9001:2000 standard the pilot process was chosen. The process regarded the resource supply and, in particular,

the filling of the orders for purchasing the resources needed for the organization activities. The documents produced during the selected business process are represented in the document diagram shown in Fig. 1. The following subsections provide a greater detail of the selected process, the designed RFID solution and the environment supporting it.

The Document Diagram

The document diagram in Fig. 1 highlights which documents open and close the business process through an attached symbol start and stop, represented by ● and ●, respectively. A ball in the diagram shown in Fig. 1 explains the function of the document in input and defines the starting of the activity flow characterizing a given procedure inside a given business process. The documents shown between two balls are the documents produced during the given procedure. The diagram in Fig. 1 does not explicitly show the complete activity flow of a procedure but focuses on the circulation of business entities and, specifically, the circulation of paper documents. It highlights how a document is related to other documents and when each document is moved between the offices of an organization.

The vertical lane to whom or which office a given document is assigned. In addition, the lanes allows highlighting that the office producing a document is not always responsible for its storage. Finally, the Suppliers lane is related to business process's procedures that are outside an organization as documents produced by suppliers, such as packing slip and invoices, are related to the start of internal procedures.

The Resource Supply Process

The pilot business process involves three main actors: researchers; Director (supervisor of the processes) and staff of the administration offices (executors of the procedures characterizing the selected business process). Four mutually exclusive paths characterize the process of filling a resource purchase order:

- a) the resource is available (see Fig. 1, path 1 2 3 4 5a ...) and the staff's Store can deliver immediately the required resource to the researcher;
- b) the resource is not available and has a value lower than a fixed threshold (see Fig. 1, path 1 2 3 4 5b 6a ...) and the Store staff starts a procedure for purchasing and delivering the requested resource;
- c) the resource is not available and has a value higher than a fixed threshold, its purchase is feasible (see Fig. 1, path 1 2 3 4 5b 6b 7 8b ...) and a request for starting a procedure to proclaim a purchase competition to legal office is sent. The procedure is activated from a supply order (see Fig. 1, path 1 2 3 4 5b 6b 7 8b 9 10) and not simply from the purchase note (see Fig. 1, path 1 2 3);
- d) the resource is not available and has a value higher than a fixed threshold, its purchase is not feasible (see Fig. 1, path 1 2 3 4 5b 6b 7 8a...) and a label of stop is applied on the signed resource request.

In short, the resource supply process finishes when the researcher resource request is rejected or when it is delivered. In particular, if the resource purchase has followed the c) path the resource supply process finishes when the filled invoice is also stored from the administration office.

The Designed Solution

The activities of each procedure in Fig.1 can start only when a given document is produced from an office and/or signed from a person in charge. Thus, a sequential order exists among these documents and a finite number of their chains is clearly identifiable. In particular, four potential chains of documents are present because four mutually exclusive paths exist for satisfying the researcher resource request.

A waste of time can happen in the procedure execution when, for instance, a document remains in an incorrect or long stack of other documents. The produced delay can be a unforeseen delay and result harmless, force the re-planning of the organization activities and be source of economic damages. If a team leader has planned research activities for when the required resources are delivered and the resources do not arrive on time as the purchase order (see Fig. 1, path 1 2 3 4 5b 6b 7 8b 9 10 11 12 13...) is lost, forgotten or delayed in the chain of signatures/authorizations: a) the team leader could be obliged to pay the researchers without they work because the required resources are not available and/or (b) could even lose the reserved funds because the purchase procedure has not been completed within the time limit.

RFID technology introduces a major control on documents by analyzing the chains of documents.

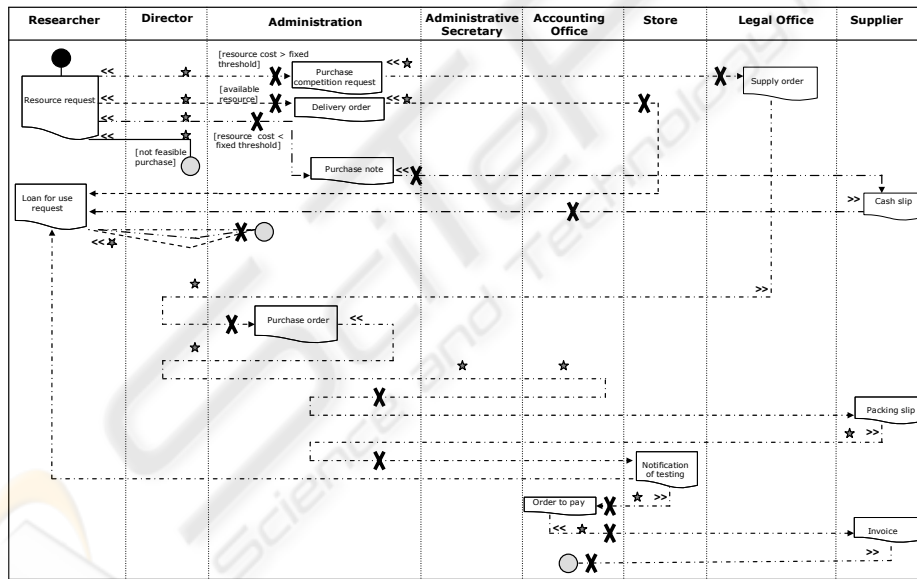


Fig. 2. Chains of potential tagged paper documents.

Fig. 2 shows the abstract of the document diagram shown in Fig. 1, depicted in terms of document chains. In particular, a different oriented temporal line, labeled with one or more of the following symbol, connects the documents of each chain: a signature mark “*” shows who signs a document; a storage mark “X” represents

where a document is stored; a creation mark “<<” indicates where a document is produced.

By automating the monitoring and management of the document chains, it is possible to obtain information regarding a document, such as who possesses it, if it is outside fixed boundaries, moved along a non-correct or unauthorized path or an interruption or delay happen along the path. By means of this information who manages, carries out and uses a business process can improve its knowledge regarding the activity flows that circulate within the organization and gain the advantages cited above.

In conclusion, an engine supporting the short-term requirements and addressing long-terms expectations from RFID use has been designed for:

- a) communicating with the readers of the antennas attached to the desks and in some strategic points for knowing if within a business process for each tagged document exists another tagged document referring it. When this condition is violated, the activities of the business process could be interrupted, an alert event can be launched and a timer activated. When a fixed interval of time is spent and the engine does not find a tagged document referring the tagged document in examination, an alarm can be launched to the office to which the last one is destined. In this way, the personal of this office can be pressed for resolving the cause of procedure interruption;
- b) controlling that all the used RFID tags are within the reading range of an available antenna. When an RFID tag is registered but it is not within the range of any antennas, an alert event can be launched and a timer activated. If the condition is again violated after a fixed interval of time and the related business process is open, an alarm can be launched to the receiver of the examined tagged document, or to the office responsible for its storage, if the related business process is closed. In this way the accidental lost of documents can be avoided;
- c) being on the alert that used RFID tags are not illegally destroyed. In this case, the designed engine can just send an alarm when it is not anymore able to monitor the related tagged document. Currently, there is still no strong guaranty that a RFID tag attached to document papers is not illegally removed from the document itself. Some work are done in the direction of being able to embed RFID tag directly inside the paper, like reducing the RFID tag size [7]
- d) controlling if there are tagged documents with an urgent priority. When this condition is verified, a message is sent to the receiver of the tagged document, so that the procedure managing the document is more quickly executed;
- e) communicating with the readers of the antennas attached to bookshelves and drawers for knowing if they store tagged documents that are expired and can be eliminated. Each time this condition is verified, message can be sent to the responsible for managing and inventorying the document, till when the tag is removed from the expired document and all the documents that it refers, and an expiration label is written in the database with reference to the UID of each disarmed tag;
- f) communicating with the readers of the antennas attached near the entry/exit to/from the considered organization and its offices for knowing if tagged documents are brought outside them or authorized boundaries. Each time that the designed engine verifies this condition, an alarm sending a vocal message can be launched, the luminosity of the area of entry/exit is lighted and a camera near the alarm point is turned on for filming who moves the document in an unauthorized area. This functionality can be realized only if a mechanism of topographical localization has been

designed. Topographical localization provides logistic information with reference to fixed geographical coordinates.

The Adopted UbiComp Platform

For addressing the short-term requirements and the long-term expectations discussed above, the engine to be implemented will be integrated as a service, named RFID Document Management (RDM) service, into an already existing extensible and ubiquitous platform [8, 9]. The services provided from this platform (a) has been concretely implemented; (b) are accessible from multiple types of user interfaces (e.g. Java/Java Web Start Application, Web browser, Jini browser); and (c) are used within a simulated real environment.

This platform was written in Java and designed as a general UbiComp common execution environment so that it is clearly reusable in different projects and for re-designing business processes using RFID technology. In particular, three services useful for the RDM service are included: INTELLIGENCE, RFID and LOCALIZATION. The INTELLIGENCE service allows the automatic creation of rules by using a learning system developed on the top of the WEKA tool [6]. These rules describe the relations between events and actions and are executed by the Jess rule engine [5]. RFID service works with active or passive RFID tags and LOCALIZATION service was implemented for locating people and objects.

5 The Deployment

The RFID technology can be introduced into the considered organization during deployment phase. However, technological support is needed for integrating it into business processes, as the technology is still not plug and play in existing applications.

The RDM service is designed for addressing this need and acting transversally to existent enterprise solutions with the aim of avoiding the modification of existing applications or architecture. In particular, the RDM service allows monitoring and managing the activated chains of documents for each defined business process using the required equipment for organization's offices and documents. The UbiComp experts defined the requirements: installation of the UbiComp environment on a PC connected to a network and connection of the RDM service to the database; attachment of passive RFID tags on the documents produced during the business process depicted on the considered diagram; antennas and readers installation in each office which is shown with a storage mark and in each entry/exit point to/from offices. Using the RFID service provided by the adopted UbiComp platform, the RDM service has the potentiality of showing a real time view of the state of the activated chain of RFID tagged documents for each business process allowing a lower level of errors, improving planning capability and taking more careful decisions.

6 Conclusions

This paper presented an RFID investigation for supporting RFID document management. It permitted to: (a) further confirm that formalizing business processes improves their comprehension; (b) verify the real extensibility of an existing UbiComp environment, and (c) obtain a further abstraction level of a business process with reference to the document management. The abstraction at document level aims at increasing the awareness on the state of a business process.

A clear understanding of individual business requirements and the presupposition of a quantifiable ROI are necessary conditions for winning the main difficulty of RFID technology and make convenient the implementation of a RFID system [1]. These conditions become also sufficient when RFID solution is justified from a business case. In particular, this idea is widely shared from many experts. Deloitte developed the methodology RFID evaluator, oriented to evaluate the feasibility of implementing a RFID project, in collaboration with Sun. While, IBM underlined that most companies are adopting some hybrid of two approaches to the RFID use [2]:

- top down approach that starts with the project of a business case, and passes through the preparation and execution of a pilot, since the deployment;
- learning by doing approach that starts with proofs or building of a simple trial, passing through a pilot or business case for deciding if advancing with the deployment.

This paper presented a business case by following the first approach. The top down RFID design in support of document management required the analysis of two roles: process analysts and experts in UbiComp technologies and methodologies. The process analysts had to depict the document diagrams for the selected business process by interviewing the organization staff and consulting the existent Quality Manual. The UbiComp experts have to obtain an abstract view of the depicted document diagrams and introduce an RDM service or customize an existing one. The integration of an RDM service in an UbiComp environment was analyzed and the steps to be executed during its deployment were defined by using the product abstract diagrams.

Future directions will regard improving the implementation aspects of the designed RDM service. In addition, its experimentation in various real contexts will be executed for obtaining an evaluation of its performances and the ROI improvement with the introduction of RFID in an organization.

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