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RFID technology based solution for classified document management system in government institutions

1. Introduction

This paper presents the concept of an innovative electronic system for managing confidential document tracking. The research results are part of an R&D project partially supported by the National Centre for Research and Development under grant no. DOBR-BIO4/006/13143/2013.

Both increasing the security level of documents and raising the security level associated with the persons authorized will improve the quality of the entire process of document flow. A tangible result of these actions will be a reduction (and eventually total elimination) of incidents related to the uncontrolled disclosure of classified documents and data. This has considerable importance with respect to the state safety, relevant even to today's terrorist threats. Poland, as a member of the European Union and NATO, has a duty to make particular efforts with regard to the protection of the processing of sensitive information.

An additional advantage of the proposed solutions, apart from providing better control over the storage and document sharing, will be the ability to trace the document flow between safety zones with the knowledge of authorized persons that have been using the documentation. Mapping of classified documents flow, in case of incident, will allow the effective investigation of the causes of its occurrence and will allow compiling a list of potential perpetrators.

The main users of the system will be units of state administration, including subordinate to the Ministry of National Defense and the Ministry of the Interior. An important field of application for the results of the project will also include the area of justice and health care institutions. Potential customers interested in deploying the results are the following institutions: Ministry of National Defense, Ministry of the Interior, Internal Security Agency, Foreign Intelligence Agency, National Police and Polish Border Guard.

In addition, hospitals, libraries, national archives, colleges and universities would also be interested in the project results.

2. Objectives

The main objective of the project is to develop a modern system for electronic and paper document traceability based on RFID tags. The specific objectives of the project are:
– development of a real-time remote identification system for RFID tagged sensitive and non-sensitive media in both the workplace and storage facilities,
– development of an automatic inventory system for classified and unclassified documents arranged in stacks and contained in binders, along with automatic detection of changes in their positions,
– development of a system to control the flow of media and classified and unclassified documents between the security zones, along with controlling document access permissions,
– development of an electronic system for protection against unauthorized document relocation,
– automatic identification of media and documents in the storage area as well as in the workplace,
– development of technology to protect against multiple copying of the classified document,
– identification of the location of a single classified and unclassified document to the particular individual folder or volume.

3. RFID Technology

RFID is a technology of radio frequency identification. The idea of such a system is to store a certain amount of data in transceiver devices (RFID tags). Then the data is automatically read, at a convenient time and place, to achieve the desired result in a given application.[1]

[1] K. Finkenzeller, *RFID Handbook: Fundamentals and Applications in Contactless Smart Cards and Identification*, Second Edition, John Wiley & Sons 2003; P.H. Cole, D.C. Ranasinghe, *Networked RFID Systems and Lightweight Cryptography*, Springer 2008.

The beginnings of radio frequency identification date back to the nineteen forties, when the device based on metal detectors appeared. The first shop anti-theft systems, based on the decoding of resonant circuit stickers or magnetoacoustic systems, which use magnetic shields, began to function from the nineteen sixties. Full radio identification appeared in the nineteen seventies, and the first system introduced on the market was a Texas Instruments TIRIS.[2]

Today, the technology is growing fast and creates many new possibilities for potential users. An RFID System consists of two components: a tag placed on the identified object and a reader whose role is to read the data from the tag. Depending on its construction, the system allows for reading tags from up to a few inches to a few feet from the reader. The positive aspect of this is that the transmission of the data does not require the tag to be visible.[3]

RFID tags are technologically advanced labels that contain an electronic memory chip and antenna through which the data is transmitted. RFID tags, depending on the nature of their application, are of different sizes and are made of various materials, mainly paper and plastic. Their construction depends on the requirements of the frequency range in which the device is to work.[4]

Tags can be classified according to their power source and memory type. Depending on the power source, tags can be divided into Passive, Semi-Passive and Active. Depending on the memory type, tags can be divided into Read Only and Read-Write.

RFID Readers can be classified according to their design and method of fixation. Depending on the design, readers can be divided into Read and Read-Write. The former can only read information from RFID tags, the latter can read from and write information on RFID tags. Depending on the method of fixation, readers can be divided into Fixed and Mobile. The device of the first type is fixed or attached at a fixed point; e.g. at the entrance gate. The second type device is mobile and can be carried and operated by the user regardless of their location.

The RFID reader sends radio energy to the tag and waits for the tag's response. Whereas the tag detects this radio energy and sends back a response containing relevant information. In simple systems, the reader's energy functions only as an on-off switch to trigger a response from tags. However, in more advanced systems, the reader's signal can actually contain commands for the tag and instructions to write memory on the tags.

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[2]   K. Finkenzeller, op.cit.

[3]   Ibidem.

[4]   Ibidem.
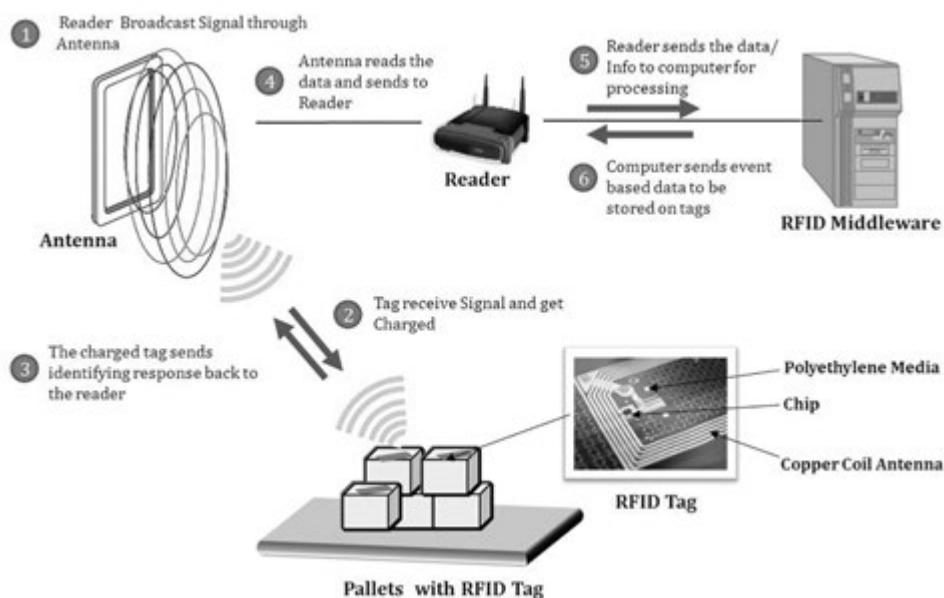
Figure 1. RFID technology

Due to the technical implementation of RFID (encoding type, tag memory size, transmission speed, the ability to read multiple tags within range of the reader, etc.), there is a wide variety of RFID standards: TIRIS, Unique, Q5, Hitag, Mifare, Icode, PJM.[5]

PJM (Phase Jitter Modulation) is a new form of encoding information in a radio wave through modulation of the phase. Although this technique has been developed recently, its essential possibilities allow achieving much better performance than any other previously known RFID standard. PJM technology enables efficient and error-free scanning of a large number of tags, what sets it apart from the currently used RFID solutions whose disadvantages do not allow using them effectively for archiving and supervision of documentation.[6]

PJM allows faster reading of a large number of tags in a shorter period of time, which plays a key role in identifying documents. Consequently, it was decided to use the PJM standard, which allows to read much larger amount of data stored in the tags and

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[5]   Y. Zhang, L. T. Yang, J. Chen, *RFID and Sensor Networks Architectures, Protocols, Security and Integrations*, CRC Press 2009; D. Paret, *RFID at Ultra and Super High Frequencies. Theory and application*, John Wiley & Sons 2009.

[6]   M. Bolic, D. Simplot-Ryl, I. Stojmenovic, *RFID Systems Research Trends and Challenges*, John Wiley & Sons 2010; S.B. Miles, S.E. Sarma, J.R. Williams, *RFID Technology and Applications*, Cambridge University Press 2008.

eliminates errors of identification in the case of signal interference caused by the large number of stacked tags. The use of PJM technology allows to fulfil the project's goals.

4. Software

A combination of modern RFID technology, enabling rapid identification of a large number of objects in a short period of time, along with the appropriate computer system that processes information collected by RFID devices, will allow to track and store documents automatically. This applies to individual copies, as well as collections of documents (stored in folders, binders, or other office equipment adapted for this purpose). The use of a document management system is necessary to ensure the implementation of the objectives of the project. The system will keep track of changes in the location of documents (within the zone located in the secret office). It will also provide information as to their current location and status.

In order to ensure communication between the designed document management system and RFID devices, it is necessary to use the appropriate system software developed along with the RFID technology, enabling the transmission of information from RFID devices to application software for the collection and processing of the data. The number of utility programs will be used to build the system. CrossTalk AppCenter, developed by noFilis, is a modern platform for track&trace applications. The integrated object and event repository takes care of any data operation without touching the database itself. Event listeners are able to handle messages from various AutoID systems like passive RFID, active and passive RTLS, Wi-Fi and GPS tags and many more. CrossTalk provides many adapters to exchange object and event data with backend or automation systems, including SAP (AII, IDoc, BAPI), WebServices, databases, file interfaces and many more.[7]

The workflow in the designed solution will be provide by the Aurea Business Process Management System. Aurea BPM is a multilingual and multifunctional tool for modelling, executing and optimizing business processes. It automates and improves dynamic, constantly changing business processes in heterogeneous, distributed, multilanguage environments.[8]

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[7]   noFilis "CrossTalk AppCenter 3.0 Installation and Administration Guide", Canon UniFLOW documentation – www.canon.com.
[8]   Aurea BPM system documentation – aurea-bpm.com.

In the designed electronic system for managing confidential document tracking, the JEE (Java Enterprise Edition) computing platform will be used for building an application layer. As a database, the Oracle Relational Database management System will be used. It provides safe and reliable data storage for the tracked documents.

The proposed system will allow the current and historical control and analysis of media and classified and unclassified documents flow within the security zone of the secret office as well as any changes resulting from a change of the zone (entry/exit). Any object relocation will be associated with a person who made this relocation. Depending on the permission of such persons, the appropriate response of the system will be issued. If the person has no access right to the document, an alert will be automatically generated. The system will also use biometric technology which will give the opportunity to "bind" the user with their record in the system. User permissions for the specific type of documents will be determined on the basis of the permissions management system.

In the case of unauthorized document relocation, depending on the assumptions, the system will respond automatically. In addition, the body scanner will be used for this purpose. It will be installed at the border zone (entry/exit) and will detect both metallic and non-metallic items, including RFID tags and other metallic items that could be used to hide tags in. The use of RFID tags and the quality readers for reading and automatic identification of users, will give a full view of the "movement" of the media or documents.

The project foresees also the use of the most advanced technology related to the use of RFID tags and appropriately adapted copying devices. All copiers used in the secret office will be equipped with an RFID reader, which will give them the ability to monitor and manage the creation of (classified and unclassified) documents photocopies. Depending on user permissions and the type of the document, the system will either allow or deny copying. All photocopies will be performed on a paper with assembled RFID tag, which will be automatically recorded in the system as a subsequent copy of the document. It will allow the system to manage all copies of the document.

5. System architecture

The use of RFID technology combined with a properly prepared workplaces allow full identification of media and documents not only at their storage locations, but also on all the user workstations. It is assumed that all workplaces in the security zone will be equipped with properly designed furniture (fitted with suitable reader for document identification). Figure 2 presents the prototype architecture of the secret office.
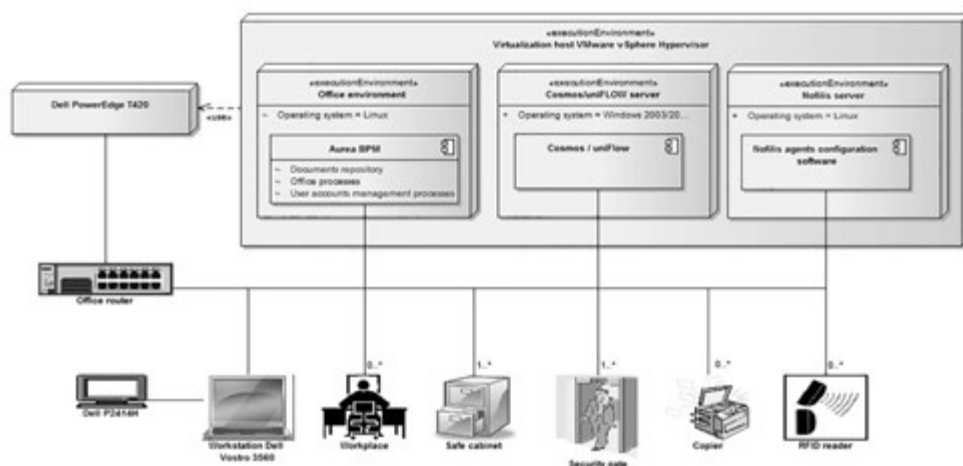
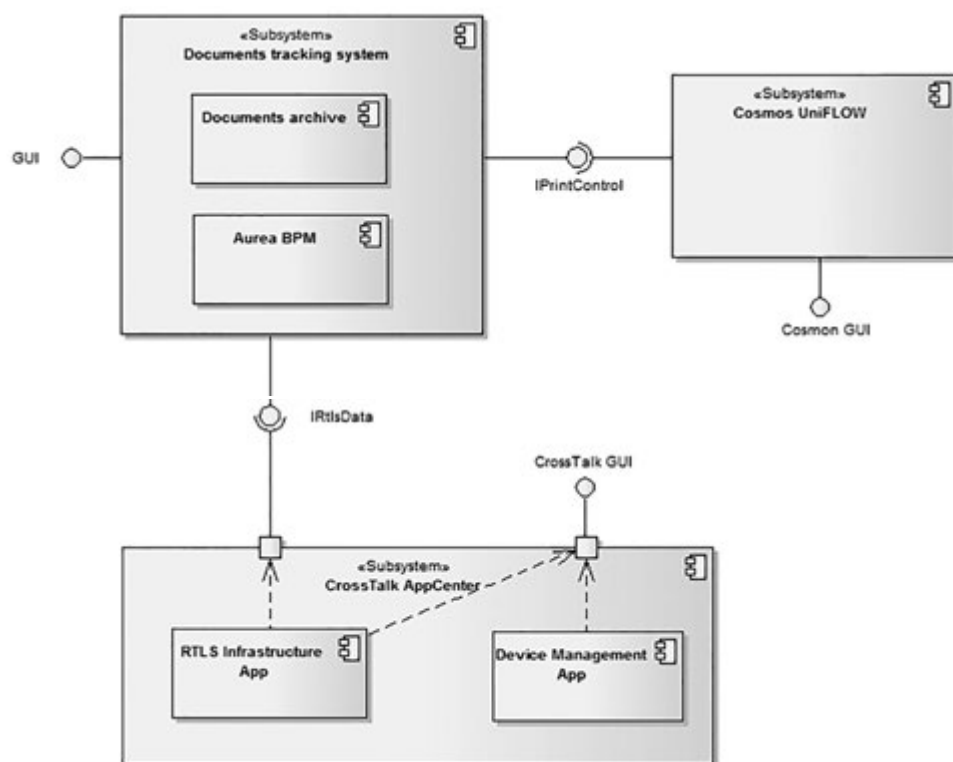**Figure 2. Architecture of the secret office**

Figure 3. System architecture

The logical architecture of the system is shown in Figure 3. The diagram shows the external interfaces of the document life-cycle management system, which will cooperate with CrossTalk's AppCenter and Cosmos UniFLOW. Communication will occur by the programming interfaces – Web services.[9] Document Management System will also be equipped with the graphical user interface (GUI), available from a Web browser.

The range of the data exchanged between the document life-cycle management system and other systems is shown in Figure 4.
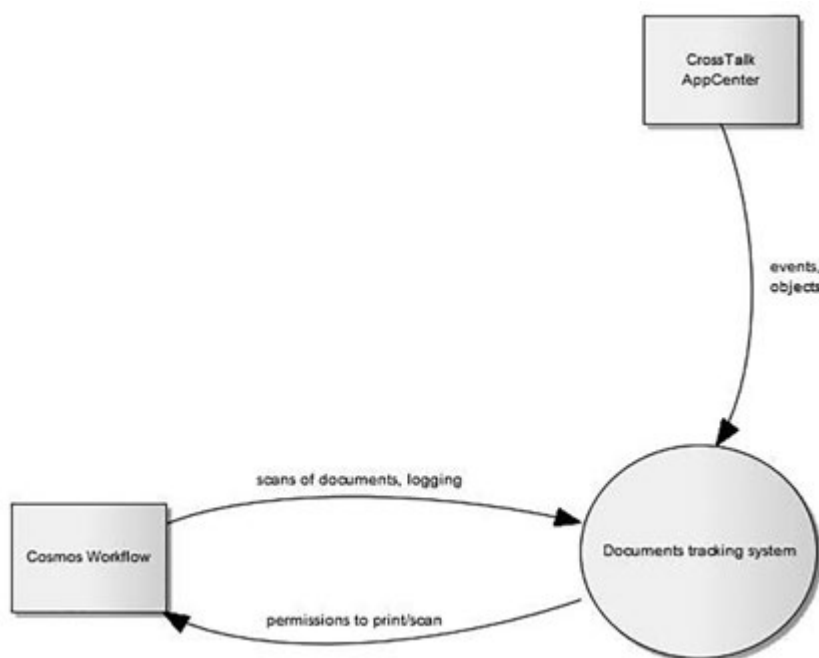

Figure 4. Data flow diagram between systems

6. Experimental evaluation of system reliability

Reliability model for the document management system in the environment located in one room and made up of many different types of elements, including RFID antennas,

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⁹ E.J. Braude, M.E. Bernstein, *Software engineering: modern approaches*, J. Wiley & Sons 2011; C. Larman, *Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and Iterative Development*, 3/e, Pearson Education India 2012.

metal and wooden cabinets with drawers, photocopiers, recording desks, locks, badges and a large number of documents marked with RFID identifiers will be developed. Each component will be classified in terms of their reliability. For most of them an individual reliability model will be developed.

Elements of this reliability model connected with the whole system will be as follows:
– elements of the remote identification of documents marked,
– elements of the remote identification of electronic media (external storage),
– elements of the remote registration of the position of the document marked or other media positions,
– procedures for inventory of documents and other media,
– models of change of position of papers and other media,
– procedures for sharing documents marked and other media,
– procedures for selective copying and printing of documents marked.

These procedures will be taken into account in the software document management system.

The level of reliability of the document and media management system is dependent on the efficiency of the system's hardware components state, including a set of RFID antennas, and the reliability of the system software. In the process of reliability investigation of the software, connected with document management system, the knowledge of the software component structure (modular structure) will be used. The indicator of system software reliability will be a function of this structure and values of the reliability of software components.

Reliability states of individual components of the system (hardware and software) will be defined and the same states for the whole system. Similarly, for individual documents and their packages suitable states will be defined. We will define relationships between different elements in the reliability model, and the whole system in the form of multidimensional reliability structural function of this system. It will be defined as a stochastic process associated with the transition of individual documents or packages between different reliability states. It will determine the characteristics of reliability for the system workflow. These characteristics will be the basis for developing a secure reliability plan required for modern technical systems. Within this secure reliability plan the following aspects will be developed:
– measurement reliability of the system and its separate elements,
– measurement of software reliability and its constituent components,
– levels of limit values for the reliability of the system and its separate elements,
– list of research necessary to investigate hardware, procedures and software components,

- methodology for testing various hardware components of the system,
- methodology for testing individual components of the system software,
- methodology for the study of individual procedures,
- the form of the final report of reliability tests.

The whole methodology will be a mature analysis of the reliability of the proposed document and media management system. It will provide a basis for testing reliability and testing efficiency in the subsequent steps of the project.

Reliability testing document and media (external memory) management system and a study of its subsystems are divided into two stages:

- examination of the system and its separate parts beyond the prototype of the office space,
- examination of the system and its separate parts in the prototype of the office space.

Using the previously developed methodologies and reliability characteristics of the study, it will be subject to:

- remote identification of documents and media, unclassified and classified, storage places and work in real time,
- procedures for automated inventory of documents and media, unclassified and classified, placed in stacks,
- automatic detection of changes in the position of marked documents and media,
- flow control of unclassified and classified documents and media between security zones,
- checking and control procedures of particular persons' authorization to access classified documents,
- system of electronic documents and media protection against unauthorized movement and identification of documents and media in the workplace,
- method to prevent making multiple copies of a document and to print a limited number of copies,
- identification of the position of a single document and media from the specified accuracy,
- proper functioning of the special entrance gate.

These studies will be carried out both in relation to the entire document management system and its individual parts. The result will be developed for each of the two test stages:

- final reliability values for system and its separate parts,
- final reliability values for software and its separate components,
- recommendations arising from the study of reliability of the system and its separate parts,
- final report of reliability tests.

The whole will be the result of experimental tests of reliability connected with the document management system and its separate parts.

7. Experimental evaluation of system efficiency

All relevant methods, procedures, techniques, etc. in the document management system must be examined in terms of the efficiency of their use. It is very important to examine the capacity of the system and its separate components. In this case, as in reliability studies of the document management system, we study the system and its separate subsystems efficiency in two stages:

- – examination of the system and its separate parts beyond the prototype of the office space,
- – examination of the system and its separate parts in the prototype of the office space.

Research related to the term 'efficiency of the system' may depend on a number of important factors affecting the efficiency of the system:

- – size of sets of documents and media marked by RFID in selected procedures of their circulation,
- – duration of set of documents and media marked by RFID identification in selected procedures of their circulation,
- – the significance of the impact of typical and random changes in system conditions to correct its work.

Characteristics related to the load of the system software will be examined as well.

8. Conclusions

In this paper, we have presented the concept of the implementation of a computer system using RFID technology for confidential documents tracking and lifecycle management. The documents have various levels of confidentiality and their management takes into account different levels of access for different groups of users.

As a result, the prototype of the secret office will be developed and all necessary rooms, equipment and software will be prepared to provide document management for different levels of confidentiality.

It is possible to use the results of the project in the area of defence and security of the State to provide better control over the storage and classified documents flow, as

well as ensure the traceability of media and documents. The practical use of the results of the project may also find application in the economic area, to be used in processes related to the archiving.

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System zarządzania dokumentami niejawnymi w instytucjach państwowych bazujący na wykorzystaniu technologii RFID

Streszczenie

W artykule przedstawiono koncepcję innowacyjnego systemu elektronicznego zarządzania kontrolą obiegu dokumentów niejawnych firm państwowych. Przedstawione rozwiązanie koncentruje się na zastosowaniu najnowszych technologii informacyjnych i komunikacyjnych związanych z wykorzystaniem znaczników identyfikacji radiowej (RFID) i danych biometrycznych. Przedmiot badań dotyczy nie tylko dokumentów i nośników danych, ale także wszystkich elementów obsługi biurowej kancelarii w instytucjach państwowych (szaf, biurek, maszyn kopiujących i urządzeń kontroli użytkowników).

Słowa kluczowe: RFID, system komputerowy, BPM, BPMS, zarządzanie procesami biznesowymi, możliwość śledzenia dokumentów, zarządzanie dokumentami, kancelaria tajna