MAINTENANCE PROCESSES OF THE RFID-BASED IT SYSTEM FOR DOCUMENT MANAGEMENT

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Abstract: The paper presents the approach to maintenance using RFID technology. The approach has been used for maintenance procedures preparation in RFID-based modern restricted access administrative office where individual documents can be identified by RFID tags. The main contribution of RFID is to act as a gateway linking different physical items and network together. By extending the concept to industrial maintenance domain, the integration of RFID with current mobile, wireless and internet technologies can effectively facilitate maintenance operations.

Keywords: RFID, Document Management System, Maintenance, IT System

1. Introduction

This paper presents maintenance processes of RFID devices in a modern restricted access administrative office.

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The basic functionalities of the system include:

- remote identification of unclassified and classified data storage devices labelled for real-time radio-reading at the storage and work location;
- automatic inventory of unclassified and classified documents arranged in piles and filed, including automatic detection of relocation;
- control of the movement of data storage devices as well as unclassified and classified documents across security zones, including access control of unclassified and classified documents;
- protection of data storage devices and documents against unauthorized relocation;
- automatic identification of data storage devices and documents not only at the storage location, but also at workstations;
- protection against repeated copying of unclassified and classified documents;
- control of printing of unclassified and classified documents with a copy limit;
- identification of the location of individual unclassified and classified documents with a pre-set accuracy of a file or volume location.

The science project – entitled "Electronic system for life-cycle management of documents with various level of confidentiality" – focuses on the use of the latest information and communication technologies related to Radio-Frequency Identification (RFID) and biometrics. The aim of completing this research project is to build and implement a prototype of a modern secret office designed to manage documents with various levels of confidentiality. The project covers all processes that take place in a secret office and use devices equipped with RFID transmitter / receiver modules. The focus of the

research concerns not only documents and data carriers, but also all secret office equipment (cabinets, desk, copying machines and entry/exit control devices) and the appropriate software.

The integration of all software and hardware components in a single system involves the need to establish strict rules for data exchange between them. In the following chapters an approach to maintenance of the RFID-based IT system for document management is described.

2. Classified Document Lifecycle Management System

The document lifecycle management, built on the basis of the Business Process Management System, is used by the personnel of the restricted access administrative office, where the system is to be implemented. The system co-operates with the following external systems: CrossTalkAppCenter and Cosmos. It is integrated via adequate programming interfaces (Web service). The document flow management system also has a graphic user interface (GUI) accessible from the Internet browser level. CrossTalkAppCenter and Cosmos also have user interfaces enabling their control and configuration (Figure 1.).

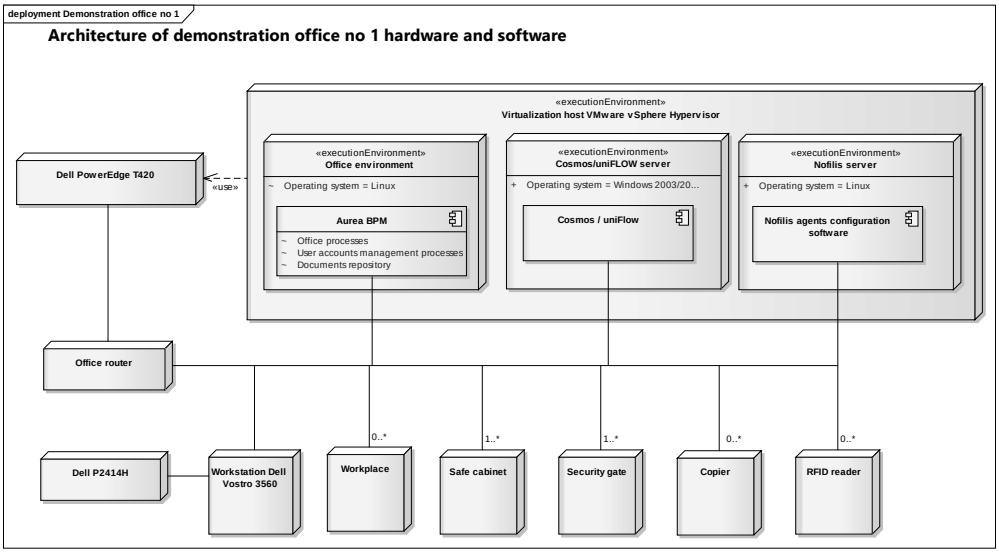

Fig. 1. Architecture of the classified document lifecycle management system

As a result of the analytical work, the following business processes of the secret office equipped with the RFID devices have been defined:

- acceptance of the document or documents with the RFID tags from a natural person,
- acceptance of a parcel with documents including the RFID tags, with traces of opening,
- performance of standard procedures when receiving the RFID tagged documents,
- registration of correspondence in the form of the RFID tagged documents,
- classification of the RFID tagged documents,
- registration of the created RFID tagged documents,

- processes related to the storage of the RFID tagged documents,
- preparation for dispatch of the RFID tagged documents,
- sending of the RFID tagged documents via a carrier,
- making the RFID tagged documents available,
- destruction of the RFID tagged documents.

To enter the secret office, it is necessary to go through a sluice (Fig. 2, left). The sluice is composed of the entrance door (outside), which allow to enter the secret office from its environment, and exit door (inside), which allow to exit the secret office to its environment.

It provides the functionality of RFID document detection as well as metal detection. All the information obtained during the scan may be used to initialize further archive procedures, such as limiting access to certain parts of the building, informing the security personnel and so forth.

The cabinet (Fig. 2, right) is an independent mechanically-electronic storage unit. It has been designed to automatically detect all documents stored within it. This is achieved with the HF RFID Mode 2 ISO 18000-3 tags.

The cabinet casing is made of coated wood or metal, depending on the model. A pair of sliding door is installed in each, with both a physical and a magnetic lock on it. Aside from the casing, the cabinet contains the RFID infrastructure (the reader and the internal antennas), as well as a control unit, a power supply unit, the main board and the electromagnetic lock which is unlocked with an identifier RFID tag.

Fig. 2. The entrance sluice / body scanner (on the left) and the cabinet (on the right)

The administrative office is also equipped with a copier (Fig. 3, left). This device is based on a Canon 4225 copier machine. It synchronizes the process of copying of the document with the RFID tag readout of both the document and the RFID identifier of the user.

Based on the information read from the tags the centralized archive system permits the copier to create physical copies of only those scanned documents for which the user is authorized.

The copier includes a purposefully designed RFID antenna, a RFID reader and a server station modified to interface with the centralized archive system.

The tray reader (Fig. 3, right)) was designed for the purpose of initial document registration. It automatically identifies, reads, writes and tracks the RFID-tagged documents. It is capable of reliable readout and writing of all RFID tags of the documents placed on the covered part of the tray.

Tightly packed stacks of overlapping or touching RFID tags are identified with 100% reliability. The reader operates instantly thanks to two reply channels and is capable of reliably identifying up to 60 documents placed in the tray.

Fig. 3. The RFID copier (on the left) and the tray reader (on the right)

The workstation for the restrictive access administrative office workers is equipped with desktop computer connected to all necessary peripheral devices including tray readers (Fig. 4). It is also equipped with appropriate software for document management and business processes execution (Fig. 5).

Fig. 4. The restrictive access administrative office workstation

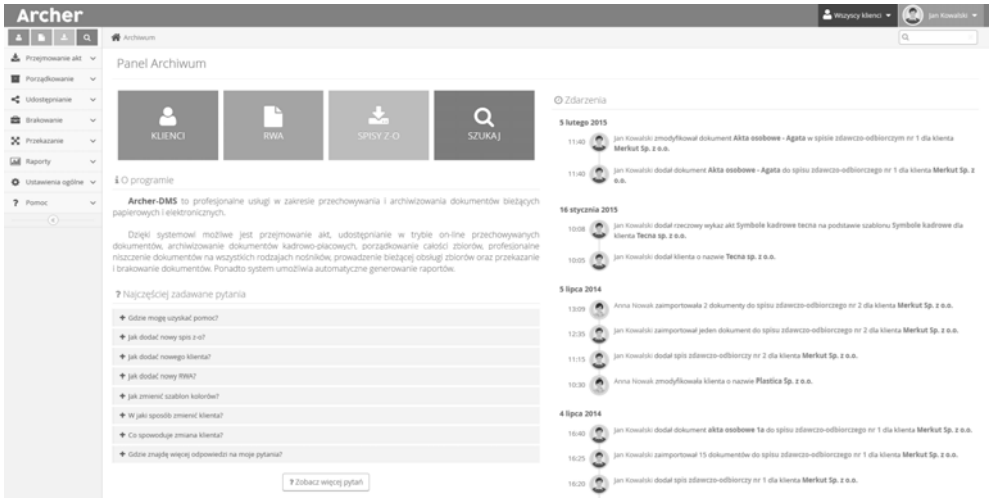

Fig. 5. The restrictive access administrative office management system

2. Maintenance management

As a consequence, of the implementation of advanced manufacturing technologies and just-in-time production systems, the nature of the production environment has changed during the last two decades. This has allowed companies to massively produce products in a customized way. But the increase in automation and the reduction in buffers of inventory in the plants clearly put more pressure on the maintenance system. Maintenance exists

because no matter in what industry a company operates and what products delivers or what resources have (technical objects - machinery, equipment, installations, etc.) that require keeping them in motion. Keeping them in motion, we want to make them implement the tasks set by the user. The term "maintenance" is defined in standard EN 13306 as the "Combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function (function or a combination of functions of an item which are considered necessary to provide a given service)."

Maintenance is set in an agreed business context to which it has to contribute and the maintenance function needs to cope with multiple forces and requirements within inside and outside the organization boundaries. The tasks of maintenance are complex, including a combination of management, technology, operations and logistics support elements. Kelly [1] gives the following generic expression for the maintenance objective: "...to achieve the agreed plant operating pattern, availability and product quality within the accepted plant condition (for longevity) and safety standards, and at minimum resource cost".

Márquez and Gupta [2] expresses that maintenance management must align with business activities at strategic, tactical, and operational levels. The awareness of maintenance as a strategic factor within a company is established in literature. In recent years, maintenance has been considered as an activity contributing efficiently to the companies' strategic objectives in profitability and competitiveness. Kans [3] has described maintenance management as activities in order to reach the goals of efficiency, effectiveness and cost-effectiveness in the maintenance area and where the overall goal is to contribute to company's profitability and competitiveness (Fig. 6).

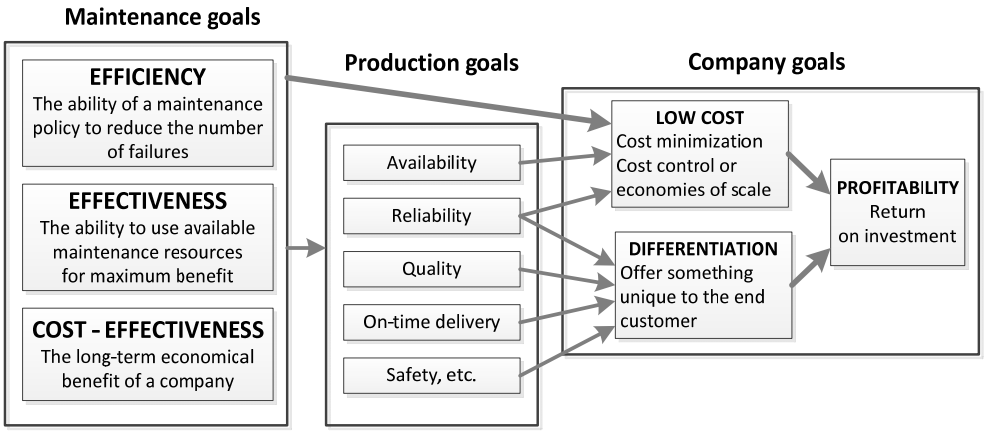

Fig. 6. Connection between maintenance and profitability [3]

Many maintenance strategies have been developed in the last decades and applied to a large array of industries. An extensive classification of maintenance policies is found in [4]. The author describes six policies for single-unit systems with several examples of each category: age-dependent, periodic, failure limit, sequential, repair limit and repairs counting. A quite different perspective on the term policy is found in [5]. The author describes, from his point of view, the traditional division of maintenance policies into following categories: technology oriented (Reliability Centered Maintenance, RCM), human factors oriented (Total Productive Maintenance, TPM) and monitoring and

inspection oriented (Condition-Based Maintenance, CBM). The strategies listed above are widely discussed in the literature. However, in the enterprises there are many "individualized maintenance strategies" that refer to "knowledge-based enterprise". The main objective of such methods is to use the immaterial resources of each organization in order to increase the economic benefit resulting from the construction of a maintenance strategy adapted to the requirements and resources of each organization [6].

The fulfilment of maintenance management objectives is highly dependent on the proper mix of resources and the development of good communication between all participant. Clearly, the choice of the structural elements of maintenance is not independent from the environment. Factors like the business context, society, legislation, outsourcing market, will be important. Furthermore new manufacturing trends, such as the Industry 4.0 context, will influence the current and future maintenance management enormously. A whole new era for maintenance is expected as communication barriers are bridged and coordination opportunities of maintenance service become more intense. Two factors—technology and people—are the keys to transforming maintenance processes, in the way enabling meeting requirements of the new management approach.

3. Radio-Frequency Identification (RFID)

According to Roy Want in [7], "Radio Frequency Identification Technology (RFID) has moved from obscurity into main stream applications that help speed the handling of manufactured goods and materials". This technology has emerged as Frederick Hertz found existence of radio frequency during his experiment in 1886 and developed for the purpose of defence during the Second World War. However, most of the scholars report that the first commercialization of RFID technology was done by Wal-Mart as they launched RFID based material identifying system in 2005. Table 1 describes a brief history of how RFID technology was developed and diffused.

Table 1 A brief history of RFID technology [8]

Date	**Event**
1886	The idea of using Radio Frequency to reflect waves from objects was started from Frederick Hertz's experiment.
1930–1940	American navy research laboratories developed a system known as IFF (Identify Friend or Foe).
1940–1950	The first application of RFID consisted of identifying allied or enemy planes during WW2 through the use of IFF system.
1973	Charles Walton, a former IBM researcher registered patent using RFID technology, a radio-operated door lock.
1980–1990	Many US and European companies started to manufacture RFID tags.
2003	The Auto-ID center for MIT became EPC global, an organization whose objective is to promote the use and adoption of RFID technology.
2005	Wal-Mart launched and RFID pilot.

RFID is the wireless technology which uses radiofrequency electromagnetic fields to gather data about a certain object without coming in contact with the data carrier. A radio frequency identification system includes three key components:

- a transponder (a word combining transmit and respond - RFID tags);

- a transceiver unit (a read-write device with integrated antenna - RFID readers);
- integration with servers and service and enterprise resource planning systems - RFID middleware).

Tag is a microchip to store the information of the object being tracked and this information is accessed via radio signal of RFID reader/transceiver. To allow wireless transmission of data to the reader tag consists of an antenna which is tuned to receive radio frequency waves emitted by a reader or transceiver. To acquire information from a tag, a reader must send a signal to the RFID tag, triggering the tag to transmit the information to the reader. The reader then reads the signal, converts it to a digital format, displays this information on a built-in screen or transmits it to a linked computer for data analysis and processing. RFID tags can be active, passive, or semi-passive tags, and are classified into five classes according to their capabilities and functionalities. The second key component is RFID reader. These emit low-powered RF signal to activate passive tags; identifying tags; and transferring in formation to and from a tag. here are a variety of RFID readers available on the market. USB and serial port type readers are usually used in PC system; otherwise, CF, SDIO and Bluetooth are selected for PDA's or mobile computers. Besides, RFID readers tend to be embedded into laptops, PDA's, cell phones and other embedded devices. The next key component is RFID middleware. Middleware refers to software or device that makes the connectivity between the RFID readers that read the data and the enterprise data base systems and is responsible for the quality, and therefore usability of the data. RFID middleware applies filtering, formatting and logic to tag data captured by a reader, and sends this processed data to backend applications [9]. Therefore, middleware applications are needed to manage the flow of data from readers and send them to backend management systems.

RFID effectiveness already proved its importance in military, security, healthcare, real time objects tracking. Similarly, RFID can improve railway processes in various ways such as automatic vehicle tracking and identification, operation and maintenance, asset management and others.

In industrial environments, RFID is commonly used to automatically route materials, identify containers and track equipment. Generally, RFID provides the highest value in situations when traceability through a process or item life cycle is required, where labor costs or data errors related to identification and handling are high, when there are time or labor constraints related to item identification, handling or replenishment, and any time business processes or software applications need more information about an object than bar codes or other forms of automated data capture technology provide.

The main contribution of RFID is act as a gateway to link different physical items (like goods and sensors) and networks (internet) together. By extending the concept to industrial maintenance domain, the integration of RFID with current mobile, wireless and internet technologies can effectively facilitate maintenance operations.

4. Maintenance process

Establishing an effective and efficient maintenance process is highly dependent on supporting ICT infrastructure for information system that facilitates maintenance decision support.. This IT system uses RFID readers via radio frequency tags and computers' information management technology to plan for routine maintenance and deal with unforeseen breakdowns to ensure that machinery are operational.

Two key factors are identifiably driving the adoption of RFID in maintenance [10]:

- Maintenance drivers (e.g. in transparency of maintenance processes, lack of information to determine a proper maintenance strategy, maintenance costs) and
- Information technology innovations (e.g. mobile terminals, tablet computers, wireless communication, component miniaturization, embedded systems with sensors).

Many industries today face the challenge of managing their maintenance resources as efficiently and cost effectively as possible. The opportunely coordination of different resources like personnel, spare parts, equipment, tools is the key factor to success. A web-based online computerized maintenance management system (CMMS) is a good option to allow field engineers accessing CMMS via local network and internet. However, the time-consuming for entering data, the problem in identifying items and the human mistake are not yet been solved. Barcode are one option for dealing with these problems, but they are easy-to-destroy, especially in an industrial environment, and usually related to the print quality. A crucial aspect of maintenance management for its various decisions depends on the availability of relevant, good quality as well as timely data that is captured by the ICTs. Hence, radio-frequency identification (RFID) is rapidly emerging as the replacement for the barcode. It can be combined with CMMS to establish a high speed, accurate and reliable wireless maintenance environment. Additionally, RFID contains embedded memory and supports updating of storage information. Based on that, field engineers can immediately and accurately identify items, manipulate storage information, such as machinery data, sensor identification, audit trails of maintenance activities, spare part information and use of maintenance tools.

5. Using RFID technology for maintenance

RFID technology is particularly suited for assets management, assets tracking and keeping maintenance information because it allows operators identifying tools, machine and spare parts accurately, easily and rapidly. Indeed, RFID is not only applied as the replacement of barcode, but also acting as a distributed memories storage device for keeping up-to-date maintenance information in RFID tags. Components of RFID system are displayed in Fig. 2 and shows that an RFID tag is implanted on each equipment of a factory. This RFID tag receives signal from reader and gives a return signal with identification number to the RFID reader which then reads the data and then RFID middleware applies filtering, formatting and logic to tag data captured by a reader, and sends this processed data to backend application server. This collected data is then acquired by factory e Maintenance cloud and then filtered, integrated, and analysed for cost effective maintenance planning and decision making (Fig. 7).

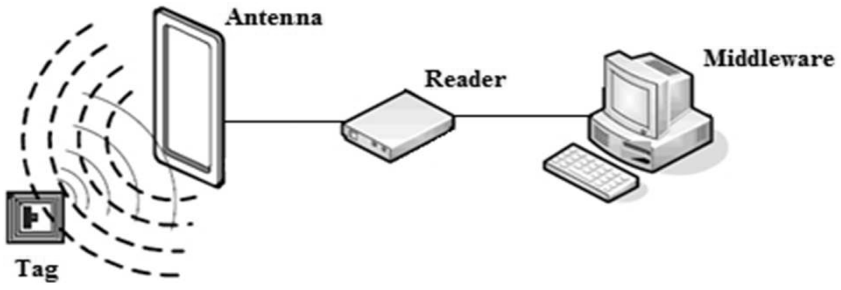

Fig. 7. Components of RFID system

There are numerous views of what e-Maintenance actually is, one important part is the application of information and communication technology (ICT) to achieve effective information system within the maintenance area. Therefore, an effective and efficient information system aims to provide just-in time information to the targeted users and optimization of the information process, i.e. making the right information available at the right time and at the right point of location. Therefore, the real time information is available to the e-Maintenance cloud for effective and efficient maintenance decision making. A proper e-Maintenance solution needs to be able to sense the context of the individual stakeholder in order to properly adapt the information to the stakeholder's current situation. E-Maintenance seeks to implement maintenance management, wherein maintenance operations, planning and decisions data and tools to process and act upon them become available anytime, anywhere and to anyone at multiple levels of operation outside and inside factory (Fig. 8).

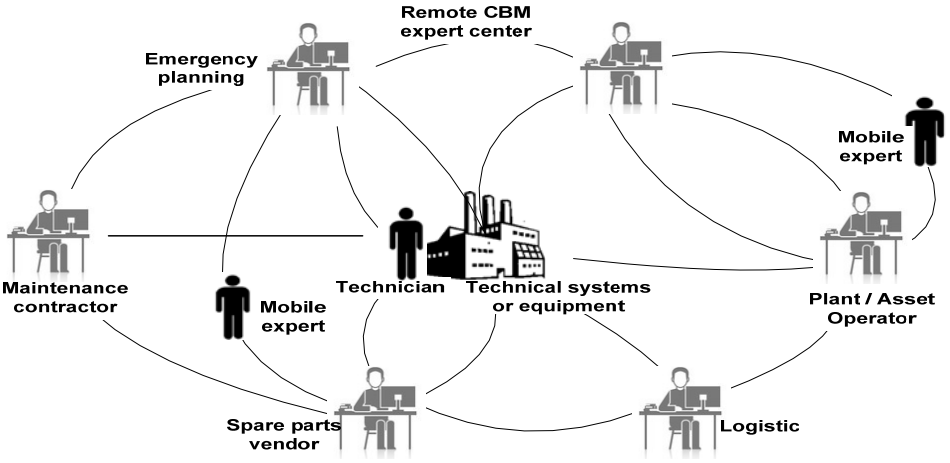

Fig. 8. e-Maintenance environment [11]

RFID technology helps to collect data for better analysis for the visualization of data depending upon the needs of different maintenance stakeholders. With the wide use of RFID technology in maintenance processes, the maintenance tasks are more effective and efficient in terms of time, because data is available in real time for analysis and visualization.

6. Conclusion

The new approach to maintenance using RFID technology described in the chapters above are to be used for maintenance procedures preparation in RFID-based modern restricted access administrative office, where individual documents can be identified by RFID tags. It has been shown that integration of RFID items with modern mobile, wireless and internet technologies can effectively facilitate maintenance operations.

The use of RFID tags and antenna readers allows you to maintain all the events that can occur during the completion of every-day work. These events, stored in the database, are a

very good source for further data analysis in terms of incidents detection. This approach can sufficiently reduce the cost of maintenance as well as the time of fault detection and repair.

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