THE PRESENTATION OF PRODUCTION LINE AND WAREHOUSE MANAGEMENT BASED ON RFID TECHNOLOGY THROUGH 3D MODELLING AND ANIMATION

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The RFID technology is complex, combining a number of different computing and communications technologies to achieve desired objectives. This article primarily deals with the simulation of production line and warehouse management based on RFID technology, through 3D modelling and animation. It describes the various components of a RFID lab (a laboratory for the automatic identification of goods and services), which consist of a production line and a warehouse management system based on RFID technology.

This paper characterizes and describes the processes that take place in the laboratory as well as the technologies which are used. Moreover it describes production line processes and warehouse management. 3D models and animations created to capture the whole process in the laboratory are set up and described.

Keywords: RFID technology, 3D models, warehouse management, simulation

1. Introduction

RFID technology is complex, combining a number of different computing and communication technologies to achieve desired objectives. Each object, which has to be identified, has a small object called a RFID tag stuck to it. Each RFID tag has a unique identifier that enables additional information about each object to be stored. Devices known as RFID readers wirelessly communicate with RFID tags, with a view to identifying the attached RFID tags, as well as enabling information stored in the RFID label to be read and updated. Our department has focused on research in the field of automatic identification and data collection. The established RFID lab (laboratory for the automatic identification of goods and services), which consists of a production line and a warehouse management system based on RFID technology, acts as a model in the article, depicting the process of automatic identification in a conditions similar to operational conditions.

2. About the RFID Lab

RFID lab means laboratory for the automatic identification of goods and services. The core of the system for the identification of goods and services through RFID technology is known as SAP. It is therefore a real system that is used in practice and through logistics processes can be simulated in the laboratory. The data format conforms to GS1 standards. The formats in this specification are defined, and are available for use. Resolution of the data involves AI application identifiers, while tags are the format used by EPC – Electronic Product Code. An Electronic Product Code can be characterized as a number encoded in electronic form and stored in a storage medium such as a chip. EPC is an internationally standardized system that is used to identify objects and goods uniquely throughout the supply chain. The laboratory for the automatic identification of goods and services is designed to present RFID technology in various parts of distribution chain and provide a platform for partner companies to test applications for their customers. RFID lab is also intended to cooperate with universities to enable the project’s own research and development, as well as to create space for joint projects. As has been already mentioned above, the University of Zilina, Faculty of Operation and Economics of Transport and Communications is one of the partners of the laboratory and is represented by members of the Department of Communications.
The main goals of the laboratory are:

- to show the utilization of radio frequency identification in various parts of the supply chain (in manufacture, distribution, warehousing, retail). Laboratory demonstrates the advantages delivered by radio frequency identification, i.e. no line of sight scanning, multiple scanning etc.,
- to provide partner companies with an opportunity to test their applications for their clients. Laboratory enables its partners to use the installed equipment for developing pilot projects and applications,
- to cooperate with universities on solving projects of research and development as well as creating space for joint projects,
- to introduce the key standards of GS1, i.e. barcodes, eCom – electronic exchange of data and GDSN – global data synchronisation network on real examples.

Laboratory is divided into 5 sectors:
- design and verification of barcodes,
- manufacture,
- packaging and distribution,
- warehouse,
- retail outlet.

2.1. Description of the Processes and Equipment

In this section we characterize production line and warehouse management processes simulated through 3D models and animations.

The main objective of the laboratory for the automatic identification of goods and services is to present RFID technology in the following processes:

- Receipt of material – entered from SAP.
- Application of RFID labels to the desired material.
- Simulation of production (SAP applicator gate) and finished products.
- Labelling of pallets and crates through Smart Labels.
- Palletising and packaging.
- Warehousing.
- Simulation of the store with RFID support [1].

2.1.1. Entering the Production and Application of Labels

The process of the identification of goods begins with selecting the quantity and type of material from SAP. It is possible to enter:

- EAN product number (a product serial number will be generated from SAP ERP).
- Batch number.
- Number of boxes (representing products).

After all transactions are done, all information about content and label design is sent to be printed. This is done on the bottom side of the RFID tag. This has an adhesive surface. The upper side has a backup bar code and other necessary information.

Design ‘template’ label boxes include:

- in text form:
  - Product name (20 alphanumeric characters).
  - Batch Number (10 alphanumeric characters).
  - Date of manufacture (YYMMDD – 6 numeric characters).
  - Serial number of the box (four numeric characters).
- Bar code EAN13 (the product number assigned in SAP ERP) (the bar code must be in accordance with ISO/IEC 15420).
- RFID tag – EPC 96-bit format (GTIN (product number) + serial number) [1].
Before sending data to a ZEBRA printer, it is necessary to configure the parameters for RFID printing and set the printer for network printing. This allows the printer to print a label (the label) and encode the EPC number onto the tag. The conveyor belt is up and running. Figure 1. shows two conveyors, the applicator of labels produced on the Zebra printer and two RFID gates.

2.1.2. Presentation of Production, Entry into the Warehouse

Entry into production:
At the end of the first belt, on which there is the printer and the label applicator, is a RFID gate. This is tasked with reading all smart labels or RFID tags located on boxes. Scanned data from each unique tag is transferred to the SAP system by requesting a Web service, then taking the number and batch and comparing them with required number to be produced. The SAP report shows which product is in production.

Output of the production:
In the laboratory, the production process is not simulated. The actual process of production should be located in the same place as the two associated conveyors. At the beginning of the second conveyor is the next RFID gateway. This reads information about the product coming from the production line; in our case the box.

The finished products fall into a pallet fence, which is located at the end of the second belt. In this range, the tag is placed on pre-recorded data Datamax printer. This printer is not involved in the system, and the system knows which products (boxes) contain a tag.

Palletising:
Pallets containing finished products are hand-labelled with pallet tag numbers. A forklift truck is used to transport the goods to the warehouse through the door "KODYS / Vectra [2], where the contents are assigned to the pallet tag. A situation may arise in which the number of products scanned at the production exit gate (second gate) does not match to the number of products scanned at the KODYS / Vectra gate. If this happens we recommend turning on the puttee range and the gate area will try to read all tags. The process continues only with the number that was loaded by the gate. "Here we get the answer to the question: ‘Are there any products that get lost?’ [2]. In this way we obtain a unique identification needed for the storage of goods.

Figure 2 shows RFID gate and puttee [2].
2.1.3. Warehouse Management

This process occurs in the laboratory to simulate inventory control, warehouse management, automated storage management and unloading, inventory stocks, and orientation in the warehouse using RFID in conjunction with reading the barcode label on the shelves.

Figure 3 shows a mobile terminal being used in a RFID lab.

![Figure 3. Mobile terminal](image)

The mobile application was created with SAP ITS Mobile Technology. Operations in mobile applications are as follows:

**Storing:**
The terminal of storage operation is selected. Subsequently, the RFID sensor will load the number of pallets to be stored. At the destination site the bar codes will be scanned. The location of the pallets in the goods reception area will be controlled. The SAP ERP is based on data which has been entered. It creates a storage command and a menu with the goods which are stored in the new storage location.

**Bin transferring:**
The terminal selects the bin transfer operation. The RFID reader will load the number of the pallet intended for storing and warehousing, and at the destination site the bar code will be scanned. The SAP ERP is based on data which has been entered and creates a warehouse order together with a list of goods stored in the new storage location.

**Removal – issue of cost centre:**
The terminal selects the removal operation. Pallets are loaded via the RFID reader and then selected the number or type a number of cost centre. The SAP ERP is based on data which has been entered and creates a warehouse order and material evidence, the range of material on it is removed and the pallet in the system disappears [1].

3. RFID Technology

Identification processes that rely on AIDC technologies are significantly more reliable and less expensive than those that are not automated. The most common AIDC technology is bar code technology, which uses optical scanners to read labels. Most people have direct experience with bar codes because they have seen cashiers scan items at supermarkets and retail stores. Bar codes are an enormous improvement over ordinary text labels because personnel are no longer required to read numbers or letters on each label or manually enter data into an IT system; they just have to scan the label. The innovation of bar codes greatly improved the speed and accuracy of the identification process and facilitated better management of inventory and pricing when coupled with information systems.

Radio frequency identification is a wireless data collection technology that uses electronic tags which store data, and tag readers which remotely retrieve data. It is a method of identifying objects and transferring information about the object’s status via radio frequency waves to a host database. RFID is not necessarily a direct replacement for bar codes, but as the costs of RFID systems continue to decrease, the functional utility of RFID will greatly surpass that of bar codes [7].

RFID represents a significant technological advancement in AIDC because it offers advantages that are not available in other AIDC systems such as barcodes. RFID offers these advantages because it
relied on radio frequencies to transmit information rather than light, which is required for optical AIDC technologies.

Like bar codes in an earlier time, RFID is the next revolution in AIDC technology. Most of the advantages of RFID are derived from the reliance on radio frequencies rather than light (as is required in optical technology) to transmit information. This characteristic means that RFID communication can occur:

- Without optical line of sight, because radio waves can penetrate many opaque materials,
- At greater speeds, because many tags can be read quickly, whereas optical technology often requires time to manually reposition objects to make their bar codes visible, and
- Over greater distances, because many radio technologies can transmit and receive signals more effectively than optical technology under most operating conditions.

The ability of RFID technology to communicate without optical line of sight and over greater distances than other AIDC technology further reduces the need for human involvement in the identification process. For example, several retail firms have pilot RFID programs to determine the contents of a shopping cart without removing each item and placing it near a scanner, as is typical at most stores today. In this case, the ability to scan a cart without removing its contents could speed up the checkout process, thereby decreasing transaction costs for the retailers. This application of RFID also has the potential to significantly decrease checkout time for consumers.

3.1. Components of an RFID System

An RFID system is a set of components that work together to capture, integrate, and utilize data and information. This section describes some of them. The components are as follows:

- Sensors, Tags, Antennas, Readers.
- Connectors, Cables, Networks, Controllers.
- Data, Software, Information Services.

RFID systems can be very complex, and implementations vary greatly across industries and sectors. RFID system is composed of up to three subsystems:

- An RF subsystem, which performs identification and related transactions using wireless communication,
- An enterprise subsystem, which contains computers running specialized software that can store, process, and analyze data acquired from RF subsystem transactions to make the data useful to a supported business process, and
- An inter-enterprise subsystem, which connects enterprise subsystems when information needs to be shared across geographic or organizational boundaries.

Every RFID system contains an RF subsystem, and most RFID systems also contain an enterprise subsystem. An RFID systems supporting a supply chain is a common example of an RFID system with an inter-enterprise. In a supply chain application, a tagged product is tracked throughout its life cycle, from manufacture to final purchase, and sometimes even afterwards (e.g., to support service agreements or specialized user applications).

3.1.1. RFID Tags and Frequencies

An RFID tag is a small device that can be attached to an item, case, container, or pallet, so it can be identified and tracked. It is also called a transponder. The tag is composed of microchip and antenna. These elements are attached to a material called a substrate in order to create an inlay [8].

Tags are categorized into three types based on the power source for communication and other functionality.

- A passive tag uses the electromagnetic energy it receives from an interrogator’s transmission to reply to the interrogator. The reply signal from a passive tag, which is also known as the backscattered signal, has only a fraction of the power of the interrogator’s signal. This limited power significantly restricts the operating range of the tag. Since passive tags are low power devices, they can only support data processing of limited complexity. On the other hand,
passive tags typically are cheaper, smaller, and lighter than other types of tags, which are compelling advantages for many RFID applications.

- An active tag relies on an internal battery for power. The battery is used to communicate to the interrogator, to power on-board circuitry, and to perform other functions. Active tags can communicate over greater distance than other types of tags, but they have a finite battery life and are generally larger and more expensive. Since these tags have internal power, they can respond to lower power signals than passive tags.

- A semi-active tag is an active tag that remains dormant until it receives a signal from the interrogator to wake up. Then the tag can use its battery to communicate with the interrogator. Like active tags, semi-active tags can communicate over a longer distance than passive tags. Their main advantage relative to active tags is that they have a longer battery life. The waking process, however, sometimes causes an unacceptable time delay when tags pass interrogators very quickly or when many tags need to be read within a very short period of time.

- A semi-passive tag is a passive tag that uses a battery to power on-board circuitry, but not to produce return signals. When the battery is used to power a sensor, they are often called sensor tags. They typically are smaller and cheaper than active tags, but have greater functionality than passive tags because more power is available for other purposes. Some literature uses the terms “semi-passive” and “semi-active” interchangeably.

**Carrier frequencies**

Today, there are four carrier frequencies implemented for RFID that are popular globally: 125 KHz, 13.56 MHz, UHF ranging from 866 to 950 MHz depending on national radio regulations, and microwave frequencies of 2.45 GHz and 5.8 GHz. There is also the frequency range 430-440 MHz, which is allocated to amateur radio usage around the world. The ISM band 433.05-434.790 MHz is located near the middle of the amateur radio band. The amateur radio band has emerged as an RFID channel in a number of applications. The frequency range has been called the ‘optimal frequency for global use of Active RFID’.

**Functionality**

The primary function of a tag is to provide an identifier to an interrogator, but many types of tags support additional capabilities that are valuable for certain business processes. These include:

- Memory – memory enables data to be stored on tags and retrieved at a later time. Memory is either write once, read many (WORM) memory or re-writeable memory, which can be modified after initialisation. Memory enables more flexibility in the design of RFID systems because RFID data transactions can occur without concurrent access to data stored in an enterprise subsystem. However, adding memory to a tag increases its cost and power requirements.

- Environmental sensors. The integration of environmental sensors with tags is an example of the benefit of local memory. The sensors can record temperature, humidity, vibration, or other phenomena to the tag’s memory, which can later be retrieved by an interrogator. The integration of sensors significantly increases the cost and complexity of the tags. Moreover, while many tag operations can be powered using the electromagnetic energy from an interrogator, this approach is not workable for sensors, which must rely on battery power. Tags typically are only integrated with sensors for high-value, environmentally sensitive, or perishable objects worthy of the additional expense.

- Security functionality, such as password protection and cryptography. Tags with on-board memory are often coupled with security mechanisms to protect the data stored in that memory. For example, some tags support a lock command that, depending on its implementation, can prevent further modification of data in the tag’s memory or can prevent access to data in the tag’s memory. In some cases, the lock command is permanent and in other cases, an interrogator can “unlock” the memory. EPCglobal standards, International Organization for Standardization (ISO) standards, and many proprietary tag designs support this feature. Some RFID systems support advanced cryptographic algorithms that enable authentication
mechanisms and data confidentiality features, although these functions are most commonly found on RFID-based contactless smart cards and not tags used for item management. Some tags offer tamper protection as a physical security feature.

- Privacy protection mechanisms. EPC tags support a feature called the kill command that permanently disables the ability of the tag to respond to subsequent commands. Unlike the lock command, the kill command is irreversible. The kill command also prevents access to a tag’s identifier, in addition to any memory that may be on the tag. While the lock command provides security, the primary objective of the kill command is personal privacy. RFID tags could be used to track individuals that carry tagged items or wear tagged articles of clothing when the tags are no longer required for their intended use, such as to expedite checkout or inventory. The ability to disable a tag with the kill command provides a mechanism to prevent such tracking.

3.1.2. RFID Reader

The second component in a basic RFID system is the *interrogator* or reader (see Figure 4). Readers can have an integrated antenna, or the antenna can be separate. The antenna can be an integral part of the reader, or it can be a separate device. Handheld units are a combination reader/antenna, while larger systems usually separate the antennae from the readers. The reader retrieves the information from the RFID tag. The reader may be self-contained and record the information internally; however, it may also be a part of localized system such as a POS cash register, a large Local Area Network (LAN), or a Wide Area Network (WAN) [6].

There is also Middleware, software that controls the reader and the data coming from the tags and moves them to other database systems. It carries out basic functions, such as filtering, integration and control of the reader.

RFID systems work, if the reader antenna transmits radio signals. These signals are captured tag, which corresponds to the corresponding radio signal.

![Figure 4. Mobile Handheld Interrogator](image)

4. The Presentation of Production Line and Warehouse Management with RFID Technology through Multimedia Application

This chapter describes how the processes of the product line and warehouse management were presented in the laboratory for the automatic identification of goods and services through multimedia application.

Multimedia is a term frequently heard and discussed among educational technologists today. Unless clearly defined, the term can alternately mean a judicious mix of various mass media such as print, audio and video. Or it may mean the development of computer-based hardware and software packages produced on a mass scale and yet allow individualized use and learning. In essence, multimedia merges multiple levels of learning into an educational tool that allows for diversity in curricula presentation.

Multimedia is the exciting combination of computer hardware and software that allows you to integrate video, animation, audio, graphics, and test resources to develop effective presentations on an affordable desktop computer (Fenrich, 1997).

Multimedia is characterized by the presence of text, pictures, sound, animation and video; some or all of which are organized into some coherent program (Phillips, 1997).
Today's multimedia is a carefully woven combination of text, graphic art, sound, animation, and video elements. When you allow an end user, i.e. the viewer of a multimedia project, to control 'what' and 'when' and 'how' of the elements that are delivered and presented, it becomes interactive multimedia.

Why use multimedia at all? Of what use is multimedia in education? The answers to these questions could be sought through an understanding of the capabilities and limitations of the medium.

Besides being a powerful tool for making presentations, multimedia offers unique advantages in the field of education. For instance, text alone simply does not allow students to get a feel of any of Shakespeare's plays. In teaching biology, an instructor cannot make a killer whale come alive in a classroom. Multimedia enables us to provide a way by which learners can experience their subject in a vicarious manner. The key to providing this experience is having simultaneous graphic, video and audio, rather than in a sequential manner. The appeal of multimedia learning is best illustrated by the popularity of the video games currently available in the market. These are multimedia programs combining text, audio, video, and animated graphics in an easy-to-use fashion.

Moreover, under conditions of chronic under-funding, multimedia can provide an enhanced or augmented learning experience at a low cost per unit. It is here that the power of multimedia can be unleashed to provide long-term benefit to all. Multimedia enables learning through exploration, discovery, and experience. Technology does not necessarily drive education. That role belongs to the learning needs of students. With multimedia, the process of learning can become more goals oriented, more participatory, and flexible in time and space, unaffected by distances and tailored to individual learning styles, and increase collaboration between teacher sand students. Multimedia enables learning to become fun and friendly, without fear of inadequacies or failure.

As such multimedia can be defined as an integration of multiple media elements (audio, video, graphics, text, animation, etc.) into one synergetic and symbiotic whole that results in more benefits for the end user than any one of the media element can provide individually.

4.1. 3D Modelling and Animation

Due to the proximity of processes that are performed in the RFID lab, this application was accompanied by 3D animation. It is a process related to the transfer of data over a LAN, where a SAP SERVER communicates with other devices and equipment separate from the server.

4.1.1. Modelling

In order to animate the models it was necessary to create a final scene. This consists of a number of 3D models whose work is described in this subchapter through words and pictures [4].

Figure 5. Work Environment of the program Cinema 4D R10 at modelling RFID lab [2]
Figure 5 shows the preview of the work environment. Cinema 4D R10 was used to remodel likenesses of all the objects, and place them in the final scene. The Y axis of the building was moved for clarity in the picture. Preview the template of modelling, which is designed for modelling objects in the program Cinema 4D R10. Units of length used Cinema 4D R10 uses meters as units of length. Generated models were modelled in scale, the reality that the observed ratio of the various parts of models.

Conveyor belt number 1, modelled according to its design drawings contained in the instructions for its maintenance, together with the printer and Zebra RFID gate No 1, is shown on Figure 6.

![Figure 6. Model of the conveyor belt, printers and ZEBRA RFID Gate No. 1](image)

The following sections of individual processes were modelled in a similar way to the previous conveyor belt number 1. They are:
- Conveyor belt number 2.
- Zebra printer and label applicator.
- RFID Gate KODYS / VECTRA.
- Store.
- Server.
- Building.
- Wood pallets, boxes.
- Forklifts and pallet fence.
- FrontEnd.

4.1.2. Animation

When the scene was modelled the animation was made by technical parts of the scenario. All animated scenes were created with 25 images (frames) per second. Frames will be referred to below by letter. Animation took place in the layout window in the program Cinema 4D R10 by templates Animation. Here a timeline has been added to the standard view (Timeline) shown on Figure 7 [4].

![Figure 7. The time line window in the program Cinema 4D R10](image)
The following scenes of individual processes were animated:

- Goods Receipt – this part featured the animation motion model of a forklift truck, which carries a variety of materials for input into production.
- Data from the Frontend pass to the server and then to the printer ZEBRA – this animation was used because of representations from – where transmit data after entering production.
- Data from the RFID gate No.1 forwarded to the server – the animation showed the transition of data from RFID gate No. 1 to the server after reading an RFID tag placed on the box. First it was necessary to animate the movement patterns of boxes on the model conveyor belt.
- Data from the RFID gate No. 2 forwarded to the server.
- Data from the RFID gate KODYS / VECTRA forwarded to the server.
- Applied Ethics.
- Entering Warehouse.
- WiFi router and server [2].

Exporting of animation

Finally, it was necessary to export our animation (rendering of scenes). It is divided into set of rendering parameters and rendering using Net Render Cinema.

Set rendering parameters:

Export of video was the same after completion of each animation. They made two kinds of settings, export animation. The first was a video animation at 267x150 resolutions, due to faster rendering. This video served to check that everything was as requested.

The second set of exports was made up to suit the requirements of the animation, which was verified in a video with lower resolution. The second set of the exports was as follows: video resolution 1280 x 720 pixels with a size relative to the first the final format was 16 at the ninth were all selected frames. The number of frames per second (frame rate) was 25th AVI format was chosen for better picture and the possibility of creating a video with higher resolution.

Render using Net Render Cinema:

It was about two programs that allow the resulting animation rendering on multiple computers involved in the network. Condition was imposed as an animation project. The first program was Net Render Server. The running conditions were created at the beginning of rendering network.

5. Conclusions

RFID is a very useful and exciting technology. It seems that everywhere one looks there is some article about RFID and the huge benefits its technology promises. Moreover, there are many examples that demonstrate how this technology is fulfilling its potential. This article is intended to bring opportunities for implementing RFID technology in the storage and production lines. Through the use of RFID lab a specific model example has been realised. The results of the modelling and animation of each scene are applications that simulate the processes in the RFID lab. Through these applications it may be easier to understand warehousing operations based on RFID technology. This article is a part of the projects described below, which together with the afore-mentioned application will improve the learning process at the Department of Communications.

The given article was written to support the following projects:

1) AV: 4/2045/08 "Aplikácie technológie RFID pre vybrané poštové procesy na podmienky HSS".
2) KEGA 077-059ŽU-4/2010 "Implementácia nových technológií do vzdelávania (vytvorenie RFID laboratória ako podporného prvku pre vzdelávanie)".
3) KEGA 089-068ŽU-4/2010 "Aplikácia RFID pri sledovaní pohybu diplomových a bakalárskych prác v rámci univerzitného campusu".
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