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RFID IN SUPPLY CHAINS – POSSIBILITIES AND SOLUTIONS

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ABSTRACT:
Within the Interreg IIIC REGINS project framework the Department of Logistics and Forwarding at the Széchenyi István University in Győr, Hungary started a project with the title "Promotion of RFId (Radio Frequency Identification)". Our project screens the state of the art and the ongoing development of RFId technology and processes. Special focus is on the needs of SMEs and supply chains. This paper presents the state-of-the-art of RFId systems and the necessity of the introduction to supply chains. Emphasis is given to new technologies.

KEYWORDS:
RFID, chipless tag, supply chain management

1. INTRODUCTION

After a long gestation Radio Frequency Identification (RFId) technologies are finally reaching the market with components that could be effectively used for business applications. Early studies by MIT Auto-ID Center outlined seven main foreseeable applications of RFId technologies: inventory management, product or asset identification, logistics and transportation, healthcare, customer service, theft and waste prevention, personal and asset status.

It is clear that RFId technologies have a huge potential and provide more extensive flexibility than former barcode applications by offering, if standardization limits are overcome, "a common platform on which users could implement several applications simultaneously" [1]. Despite these premises, RFId technologies are far from being widely adopted [1]. In the short term, they seem to be a viable solution only for large companies. Moreover, the expensiveness of the tag is difficult to justify for low value products, whereas barcode could still be applied. SMEs will probably benefit from these technologies only as a "second tier" adopter, possibly forced by their supply chain leaders. Furthermore, the lack of industry and application standards is limiting RFId market expansion and diffusion. Some preliminary findings show that the total implementation cost is discouraging firms from adopting RFId solutions in their supply chains, confining tags to products batch and single warehouse internal automation. Costs seem to slow down RFId adoption in the field of platforms platform perspective. However, the diffusion of the technology itself can allow a decrease of the total platform investment in the costs of readers and tags.

This would enable a virtuous circle where lower costs will drive a wider adoption, even on products with a low value. This process, replied on a large scale, will lower tag prices. However, the costs of tags and readers and direct costs in general are just a part of the total investment required for RFId implementation [3]. System integration, training, reorganization and application implementation costs have a wider scope and are generally influenced by the company profile.

Moreover, given the limited number of RFId implementations, another problem is caused by the lack of information in three fields:

how all the information related to product ID will be managed by companies;
how it could be integrated with their existing systems;
which effects could this have on their supply chains.

Finally, the interorganizational dimension should not be underestimated. The possibility to track down the single product item along an entire supply chain generates relevant information flows and requires efficient data management among partners that should be supported by an adequate Interorganizational System (IOS). In particular, the evolution of information and communication technologies (ICT), and especially Internet-based ones, provides business networks with new opportunities to effectively support the collaboration and management of supply chain activities.

2. STATE OF THE ART OF RFID

Radio Frequency Identification (RFId) is an automatic identification method, relying on storing and remotely retrieving data using devices called RFId tags or transponders. An RFId tag is a small object that can be attached to or incorporated into a product, animal, or person. RFId tags contain chips and antennas to enable them to receive and respond to radio-frequency queries from an RFId transceiver. RFId tag integrated circuit is designed and manufactured using advanced and small geometry silicon processes. New advances in manufacturing process are making possible different approaches based on polymers, as a low cost alternative to the former chips. In terms of computational power, RFId tags are quite poor and contain only basic logic capable of decoding simple instructions. However, they are difficult to design, because of the challenges to manage very low power consumption, noisy RF signals or keep it operating within the strict emission regulations. When the tag enters the field generated by the antenna, it starts interacting with it and thus with the reader. The reader (mobile or fixed) emits an electromagnetic interrogation signal, which, if the tag is of passive type, charges components of transponder power supply. Following this request, tag sends to the reader its unique ID code and in case others data recorder in the memory chip. [4]

The communication can happen in two directions (reading or writing mode) and it use radio frequency signals. When the reader receives information from RFId tag, it can temporally store them, but usually as soon as impossible all data are transmitted to the host with wire or wireless infrastructure.

The most important constraint on the widespread use of RFId technologies is the cost of the tags. The most widely used tags are so called EAS tags, which cost between 1 and 6 US cents each. Over 6 billion of them are used annually. These EAS tags are a 1-bit tag and contain little or no information, merely indicating presence or absence. Passive tags with some data storage cost between 5 and 10 US cents each in large quantities (several million). High value items, cartons and pallets are being tagged and here costs may be up to US$100 per tag. At current prices it is not economic to incorporate tags into every retail item. Prices will fall as manufacturing

technologies improve and there is a prediction that 10 billion tags will be used annually by 2009 with 1 trillion being delivered in 2015. In the last 50 years only one billion RFId passive tags (other than EAS tags) and 500 million active tags have been sold. While the use of RFId technologies is predicted to grow significantly, it may take several years to get to the point where the majority of retail items are tagged. [1]

3. RFID AND INFORMATION SYSTEM IN SUPPLY CHAINS

RFId adoption could greatly impact on how information is managed within enterprises. The ability to track products at item level on the entire supply chain presents a great challenge for today's Information Systems. Existing solutions in terms of installed software and hardware are generally configured to operate on well-defined aggregation levels such as the batch, the order, the pallet or the container. The achievable finer granularity could impact the IS in its entirety, redefining information flows. Moreover, such an issue could not be overcome by simply choosing a different tagging level as certain benefits arise only when applied directly to products. Similarly, the tags' ability to store a relevant quantity of data, even those gathered by sensors during use, effectively enables the creation of heavily distributed IS.[5] Moreover, RFId technology is generally deployed in interorganizational supply chain processes; for this reason, system interoperability has to be granted. The success of RFId technology requires the solution of several issues linked to the IS:

- to obtain correct data from the transponder
- to integrate RFId applications in the current IS
- to exchange information based on RFId data among the partners' IS
- to exploit RFId data availability in terms of information and applications.

The entire RFId system is based on the data gathered from the tags. This information generates a very high data volume in a supply chain, which has to be treated (aggregated, verified, processed) before other applications can use it. Moreover, organizations generally present specialized applications supporting different business processes. In order to integrate radio frequency technology in the existing IS, the organization needs a flexible structure that allows the interoperability of legacy systems and current applications, such as the Warehouse Management System (WMS) or the Enterprise Resource Planning (ERP) system. The introduction of an intermediate level that makes the RFId information available to other business applications could safeguard the IT investment by providing a means for interoperability. Figure 1 illustrates how the IS can make use of the RFId devices thanks to a middleware application.

The complexity of this intermediate level, the middleware application, is variable and depends on the type of the organization and on the complexity of the IS. The introduction of middleware could contribute to the general trend of Enterprise Application Integration (EAI), reducing the change management effort, minimizing the risks associated with the new project (legacy systems maintain their configuration), and impacts in general. In certain cases, the development of middleware applications could consist of ad-hoc solutions specifically customized on the company's needs; therefore and even disregarding the opportunity of a make-or-buy for middleware development, customizations are generally expensive and could constitute a barrier to RFId adoption.

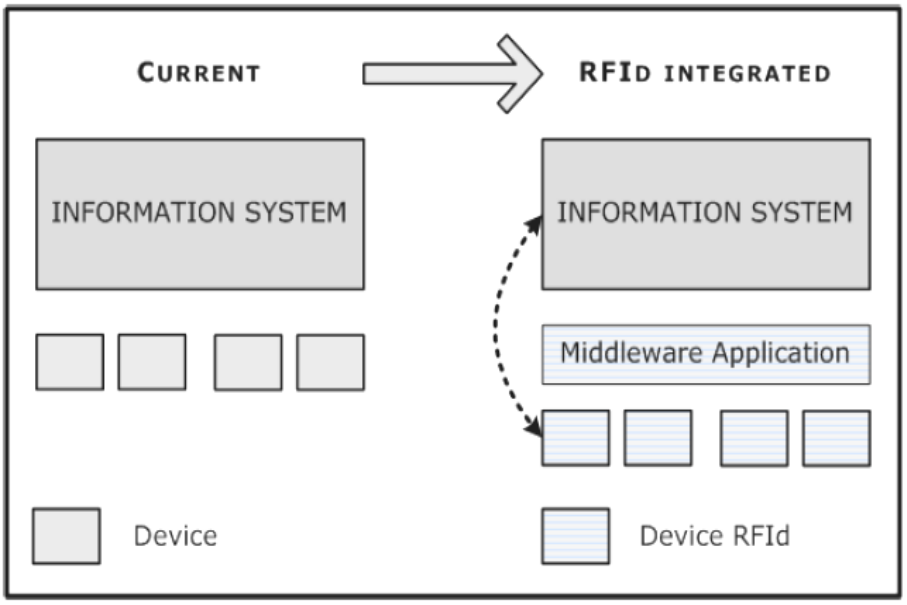

FIGURE 1. THE INTRODUCTION OF A MIDDLEWARE APPLICATION
(SOURCE: INTERREG IIIC REGINS-RFID: A GUIDELINE TO RFID APPLICATION IN SUPPLY CHAINS [2])

The severity of this issue has to be evaluated on a case-bycase basis, but companies that in recent years have already pursued an integrating policy should have developed open systems able to exchange data based on standard protocols. In this cases, and probably it will be common in future, the middleware layer will become very thin, requiring readers from the configuration and management only because a large part of its functions will be offered "on the shelves". Similarly, companies that already adopted major ERP suites will require that the RFId module is activated or bought to make their system directly accept readers' data. The "middleware commodization" will largely depend on the openness and standardization of the interfaces. EPC Savant architecture already consists of two interfaces, one connecting the readers and the other for communications with external application or services. The standardization of the external interface could be sufficient to grant the system's interoperability.

Finally, RFId applications have a very important inter-organizational dimension. A large part of the benefits from their adoption emerges only when the system involves multiple partners, like in full-scale supply chain applications [3].

As previously stated, companies adopt specialized applications to support business processes, and an RFId system needs to become integrated with them through middleware applications. Data volumes from scanned tags could require the management of multiple reading and data look-up in a corresponding database almost in real-time. Moreover, the inter-organizational nature of RFId deployment requires companies engaged in the system to share a certain amount of data and information, reproducing the EAI issue (IOIS support) on a larger scale. In this case, the interoperability should be granted by a secure network infrastructure, generally managed by the supply chain leader, whereas participants could be asked to open their own infrastructure and share information; problems on data ownership could arise. The infrastructure itself should be scalable and built basing on open standards and able to grant real-time information exchange both inside and outside the organizational boundaries.

The above considerations make the relevance of standardization in this context clear. Private network infrastructures could emerge at the supply chain or industry level, thus requiring other "interfaces" for the systems to be interoperable. The EPC proposals, on the contrary, exactly address these issues at their bases.

4. BOUNDARIES OF THE PRESENT TECHNOLOGY AND SOLUTIONS AT THE ENGINEERING SIDE

There are a wide variety of security concerns with RFId tags. One concern of interest is the ability to track the location of a person or asset by an unintended actor. While the RFId specifications generally deal with short ranges (a few inches to a few feet) between the readers and the tags, specialized equipment can pick up a signal from an RFId tag much farther away.

This is a similar problem to that with wireless LAN's. Normally a WLAN is only effective for a user within 100m or so. But an attacker with powerful antennas can be more than 10km away and still access the network. RFId tags fall prey to the same problem; an attacker can be two orders of magnitude farther away than intended and still read data. For instance, if an RFId tag is designed to be read at 30 cm, an attacker may be able to be 30 m away and still interact with it.

RFId tags typically only contain a unique number that is useless on its own. The idea is that the reader interfaces with some backend system and database for all transactions. The database stores the information that ties the unique ID to something of interest

Unfortunately, we cannot always assume that an attacker will not have access to the backend database. As the last decades of network security have demonstrated, backend systems are often all too easy a target for an attacker. And once the database tying the unique ID's to physical items has been compromised, it would be nearly impossible to retag all items in response. The vast majority of RFId tags on the market require no authentication to read the information on them. This allows anyone, an attacker or even just a competitor, to read the data on an RFId chip. Further, many tags have the capability to write information to the chip without authentication. This is especially troubling for enterprises relying on RFId for things like supply chain management. An attacker could theoretically overwrite values on the RFId tags used by the enterprise, thereby wreaking havoc with their RFId system.

Killing a tag is an other important security issue. One of the primary privacy concerns regarding RFId is the ability for a consumer to be tracked once they have bought an item that contains an RFId tag. To overcome this fear, vendors and enterprises have devised various ways to attempt to terminate the tag.

One method of terminating a tag used for retail sales is to simply change the info on the tag to random data when the item is sold. That way a store's security system knows the item has been sold and does not sound an alarm when the item leaves. Further, with random data, the idea is the RFId information can no longer be tied to a value in the database. The problem with this method is that there is still an RFId chip active in the item, even if the data on the chip is random. An attacker is still able to physically track the tag, and even store data on it if they so desired. So some tags also have the concept of a KILL command. When a tag receives a KILL command, it ceases to respond to requests from RFId readers. A KILL command actually terminates the RF capability of the chip. While this is good from a privacy perspective, it poses a massive security risk. The KILL command is protected by a password on the chip. Unfortunately, RFId chips are very primitive. So many enterprises have all their RFId chips created with the same KILL password. Further,

there is no capability to change the KILL password once a chip has been fabricated. An attacker with knowledge of an enterprise's KILL password can potentially terminate all the RFId's they are within range of. In a short period of time, an attacker can render hundreds of thousands of tags completely useless.

As RFId tags get cheaper, they will be integrated into more and more systems. While an incredible tool for supply chain management and asset tracking, RFId tags have more in common with 20 year old memory card technologies than contemporary wireless systems. Unlike old memory cards, RFId tags are accessible from a great distance given advanced wireless equipment. Attacks against RFId tags are trivial and privacy concerns are everywhere. To date, these concerns have not outweighed the advantages to businesses in need of RFId technology and the rate of adoption is accelerating. Until new standards and more advanced chips can be made, RFId tags will remain easy targets for attackers determined to cause havoc or commit crimes. [6]

5. FUTURE OF RFID – CHIPLESS TECHNOLOGY

Chipless tags are innovative transponders characterized by the absence of the silicon chip. Tag's logic is then replaced by a circuit laid with special ink or plastic film. Chipless tags promise to improve the physical limitations of radio frequency detection while potentially offering reduced costs due to the absence of integrated circuitry. The circuitry in fact can be directly printed on the product and packaging for a fraction of the cost of traditional tags (0.1 cents) [5].

Chipless tags can be more easily applied near metal and liquid or embedded in items like paper, thereby offering greater flexibility and functionality with their use.

They are much cheaper because their price is only limited to the cost of the materials used, which are in most cases basic and readily available in large quantities. The Chipless Tags selling forecast foresees a huge increase in the use of this kind of tag; in the future, in fact, 45% of the Tags in the market will be chipless. Three of the most important chipless technologies are the following: Surface Acoustic Wave (SAW), Thin Film Transistor Circuits (TFTC) and Printed conductive ink stripes or low cost plastic film.

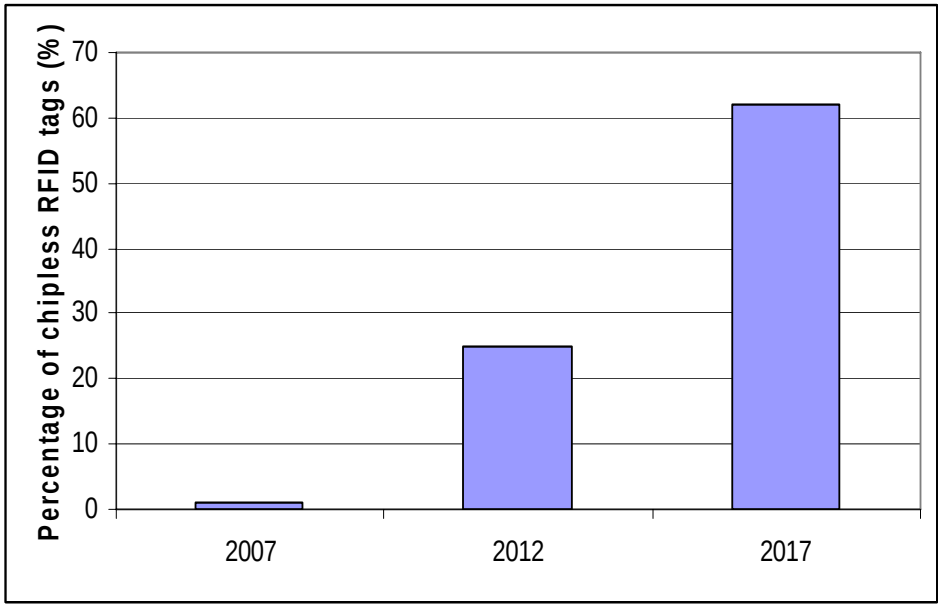

FIGURE 2. PERCENTAGE OF CHIPLESS RFID TAGS 2007-2017 (SOURCE: IDTECHEX [2])

The most innovative technology is SAW, based on acoustomagnetic laws. SAW technology is based on the conversion of an interrogating radio wave from the reader directly into a nano-scale surface acoustic wave on the SAW chip surface. The tag's antenna is directly connected to the IDT (inter-digital transducer) which uses the piezoelectric effect in the lithium niobate substrate material to efficiently convert between radio waves and surface acoustic waves. That acoustic wave then travels past an encoded set of wave reflectors which interact to produce a unique acoustic wave pulse train. These pulses are directly converted into an encoded radio wave reply signal that is sent back to the reader. (RFSAW "The global SAW tag") The main advantages of the SAW technology are:

- No threshold voltage so potentially better tolerance of interference and longer range than silicon
- Inherent temperature sensing
- Can do positioning using beams
- Lithographic process with fewer stages than silicon and less precision needed
- Hard against a full 10Mrad gamma sterilization
- Exceptional temperature range (e.g. minus 55C to plus 400C).

However, there are several disadvantages:

- Brittle crystal
- No read/write options
- Scale up to high volume.
- Ideal frequency of 2.45 GHz is busy and sensitive to water.

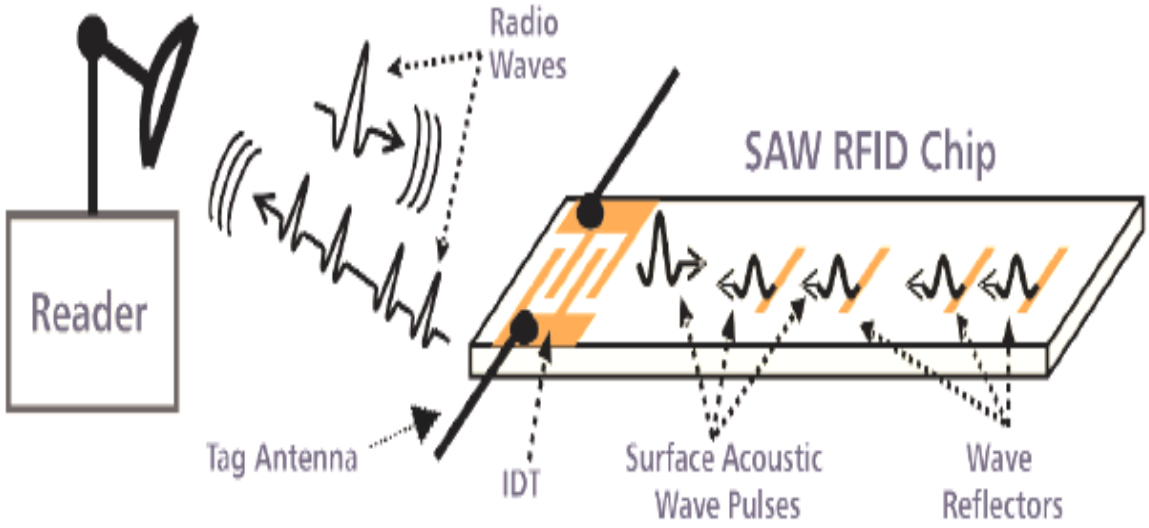

FIGURE 3. SAW CHIPLESS TAG [5]

6. CONCLUSIONS

RFId applications seem to provide companies with the opportunity to radically change the way logistics and supply chains are managed. The ability to track, at item level, material flows among partners until they reach the consumer is the perfect answer to the many issues inter-organizational coordination posed in the past. Benefits like a "crystal clear" supply chain, item identification, automated inbound and outbound logistics, real-time sales and inventory information or supply chain assets monitoring, just to cite some of the most common, are sufficient to consider RFId more in terms of when it will impact a company than if it will have effects on the market.

However, adoption is still slow and a lot of efforts have yet to be put in the development of basic RFId system building blocks like standards, protocols and operating frequencies. Thus, despite the increasing availability of successful experiences, RFId solutions are not going to be found "on the shelves": components, hardware or software are easily bought on the market, but putting an entire system together is generally an effort single companies can hardly face and especially for SMEs, which lack both competences and financial resources, this appears unviable.

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