The Use of RFID Technology in Intermodal Transport

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ABSTRACT

Intermodal transport is one of the most revolutionary and important phenomena in the 21st century regarding transport. This type of transport represents freight transport ″from door to door″ using at least two branches of transport without the change of freight unit. Recently in intermodal transport there is a greater use of radio-frequency identification – RFID technology that enables electronic monitoring of intermodal freight during the entire transport time, loading trucks or wagons with freight, loading ships with the same freight to the port of unloading and transport continuation to the destination. The results of its use for private companies are reflected on monitoring the flow of freight and the higher market delivery speed, higher productivity and efficiency (which inevitably causes production process improvement), while for the countries it is important to improve national security, reduce traffic congestion etc. With regard to given facts, this paper shows the importance of RFID technology for the development of intermodal transport and it answers some of the crucial questions regarding its application.

Key words: Intermodal transport, trucks, wagons, liners, radio-frequency identification, freight unit, fare reduction.

1. INTRODUCTION

Greater amount of goods that is transported daily in intermodal transport has doubled in the last few years. Two million containers are transported by sea daily, as key intermodal manipulative units, which proceed to the destination by the following means of transport: river, maritime, land and air transport. In the midst of the development, higher safety and capacity standards are being set as a challenge. It is noticeable that present ports, railway stations, truck terminals, concerning carrying capacity, or different means of transport, have reached their maximum or are going to reach it, so the main answer to the flow of goods acceleration lays in jo b optimization during freight manipulation. Although RFID technology is an ideal solution for every type of intermodal transport, today, in the 21st century, a traditional way of transport is still being used for transport supervision, which results in the fact that very often neither the sender nor the receiver knows where the shipment is at a certain time. This fact opens up the doors to many negative consequences – theft, smuggling, various forms of criminal activity. A logic question emerges – why does it represent a problem for world companies, in the century of progressive development, to introduce RFID technology in the business activities of a shipping company? There are numerous positive effects of RFID technology and only one negative, and there is a solution even to that problem. Namely, RFID presents a financial challenge in the beginning; it is very expensive, but it is also cost-effective over the long term, without the loss of goods and with no criminal activity. The purpose of this paper is to become familiar with basic elements and ways to apply RFID technology, as well as with problems that arise in intermodal freight unit transport. The paper consists of five parts. It describes the basic elements of intermodal transport system, intermodal unit development system and intermodal freight unit. Furthermore, it presents the overview of RFID technology together with the work frequency and the possibilities of applying the EPC (Electronic Product Code), possibilities of RFID implementation with sensors and basic implementation costs. It analyzes the influence of RFID on the automatization of the trans-shipment process in the port and, in the end, it gives an example of a company that tested RFID technology in real working conditions in intermodal transport.

2. BASIC ELEMENTS OF INTERMODAL TRANSPORT SYSTEM OVERVIEW

Intermodal transport is a complex system of the transport chain with the freight unit in its center that consists of smaller units connected in an entirety of certain dimensions that do not change during the transportation. Intermodal transport unit represents a container, a changeable truck chest and a semi-trailer. Its use enables transportation cost reduction, freight homogeneity and massiveness. In Figure 1 the flow of goods in intermodal transport is demonstrated.

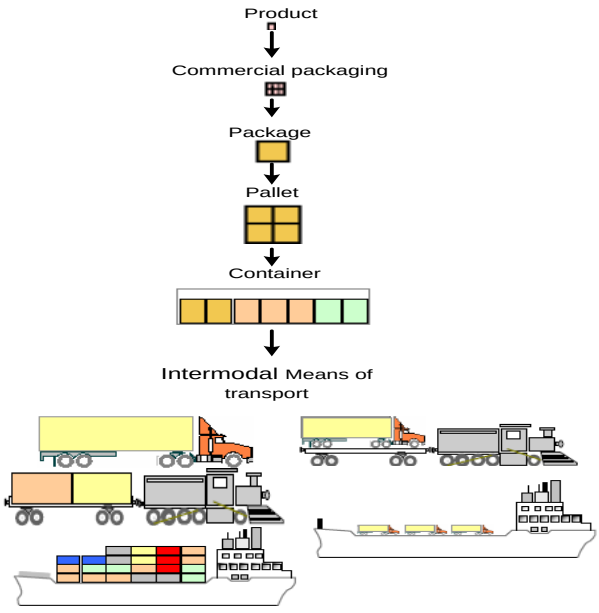

Figure 1: Flow of goods in intermodal transport

In Figure 2 the flow of the product in the development of the intermodal transport unit is presented.

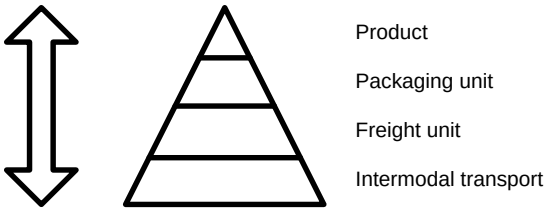

Figure 2: Intermodal unit development system

The most common means of transport in intermodal transport is surely the container ship, because ¾ of world trade is carried by sea. With the development of technology, container ship capacity grows as well, which is shown in the Table 1.

Table 1: Container ship characteristics through history

Generation	Year	Capacity (TEU)
I	1960 – 1970	750 – 1000
II	1970 – 1980	1000 – 1500
III	1980 – 1990	1500 – 3000
IV	1990 – 1995	3000 – 5000
V	1995 – 2000	5000 – 7000
VI	2000 – 2002	7000
VII	2002 – 2004	7000 – 8000
VIII	2004 – 2006	8000 – 10000
IX	2006 – 2008	10000 – 12000
X	2008 – 2009	12000 – 1400
XI	2009 -	15000-

3. RFID TECHNOLOGY

3.1. RFID technology overview

Radio-frequency identification is a method of automatic identification that enables storing and remotely retrieving data via radio waves using RFID transponders and readers. RFID transponder is a computer chip that enables the transportation of an identification number and each one is equipped with an antenna. Passive RFID transponder does not have its own power-supply, but receives energy from radio-frequency reader emission (smaller signal range, smaller resistance etc.). Semi-passive transponder has a battery that feeds the chip, but uses the reader energy for communication. Active transponder has its own battery; bigger resistance, bigger range (up to 100m), wider applicability. RFID reader also has an antenna that enables it to communicate (reading and writing data) with transponders in range. RFID-middleware represents a program interface that receives the data from the reader and then filters them by previously determined rules, sending them, if necessary, to the belonging information system (a company's database). Figure 3 demonstrates the mentioned structure.

The reading and data transfer speed is connected to the frequency. The higher the frequency is, the quicker the transfer. RFID frequencies together with application fields are presented in Table 2.

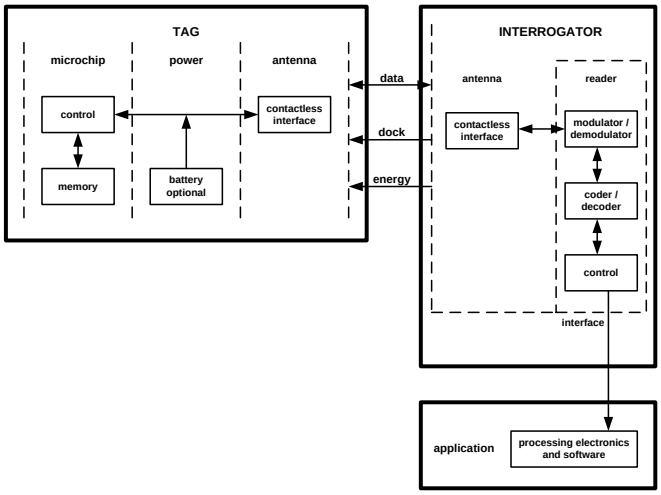

Figure 3: RFID system overview

Table 2: RFID frequencies

frequency band	system characteristics	example applications
Low (LF) 100–500 KHz (typically 125–134 KHz worldwide)	Short read range (to 18 inches) Low reading speed Relatively inexpensive Can read through liquids Works well near metal	Access control Animal identification Beer keg tracking Inventory control Automobile key/anti-theft systems
High (HF) (typically 13.56 MHz)	13.56 MHz frequency accepted worldwide Short to medium read range (3–10 feet) Medium reading speed Can read through liquids/works well in moist environment Does not work well near metal Moderate expense	Access control Smart cards Electronic article surveillance Library book tracking Pallet/container tracking Airline baggage tracking Apparel/laundry item tracking
Ultra High (UHF) 400–1,000 MHz (typically 850–950 MHz)	Long read range (10–30 feet) High reading speed Reduced likelihood of signal collision Difficulty reading through liquids Does not work well in moist environments Experiences interference from metals Relatively expensive	Item management Supply chain management
Microwave 2.4–6.0 GHz (typically 2.45 or 5.8 GHz)	Medium read range (10+ feet) Similar characteristics to UHF tags, but with faster read rates	Railroad car monitoring Toll collection systems

3.2. RFID technology in intermodal transport

Intermodal transport unit holds a unique identification number. Manually written numbers as well as their control during the transport are subject to errors. With the introduction of RFID technology, container identification number, as the main freight unit in intermodal transport, is stored on an RFID tag not leaving any room for error. The tag holds a unique identification numbers named Electronic Product Codes (EPC) - the code that resides on an RFID tag that is unique to each product. The code contains manufacturer and product information as well as an individualized serial number which is shown in figure 4. EPCs are maintained by EPC global.

Figure 4: EPC code example

When implementing RFID technology in each segment of intermodal transport, all manipulative devices have to be equipped with RFID readers, thus enabling automatic container identification as well as all manipulative activities performed with it. RFID readers can be placed on cranes, vehicles etc.

With the implementation of active transponders with sensors and GPS, instant supervision of key information in container transport is enabled. Sensors analyze given data boundaries and the change that is not within given boundaries can be automatically sent to authorized organization. Some of the basics magnitudes whose value is measured when implementing sensors in RFID technology are:

- Position – using the GPS system it is possible to determine the momentary position of the containers;
- Temperature – if measured, it can be discovered whether the container was opened, the presence of fire, electronic devices, person;
- Chemicals – the presence of poison, explosives and radioactive material is tested;
- Air pressure – in the case the container is hermetically closed, its damaged condition or opening are automatically discovered;
- Sound – whose measuring can reveal whether the device is used inside and is a person talking inside;
- Movement – if something is moving in the container etc.

3.3. Basic costs of RFID technology implementation

As it has already been mentioned, it is possible to implement more types of sensors in the container, i.e. intermodal unit; however, this raises the question of profitability. It is a fact that in transport of goods, there is no economic excuse for using more types of sensors. It is applicable only in transport of goods of extremely high value, transport of military equipment etc. The basic costs of RFID technology implementation is shown in Table 3. Components provided are divided into:

- passive tags,
- active tags,
- UHF readers, and
- Middleware.

Actual cost and what is cost dependency about is shown, respectively.

Table 3: Price of basic parts of RFID technology

Component	Actual cost	Cost depends on
Passive tags	20-40 cents (in more advanced versions, it can be up to several USD)	Antenna Frequency Memory size Packaging
Active tags	10-50 USD	Battery Chip Packaging
UHF readers	500-3,000 USD	Intelligence and frequency of the readers
Middleware	Depends on applied field	Depends on applied field

3.4. RFID technology architecture intermodal transport

In Figure 5, RFID technology architecture in intermodal transport in combination with GPS and sensors is shown. With a suitable way of implementing RFID technology in intermodal transport, an intermodal transport company is enabled to monitor the product in the entire transport chain, from its packaging in intermodal unit to its arrival to the destination. If damage, breaking in the container or any opening happens, data base will automatically be uploaded and each dysfunction that occurs will be pointed out. Except for the investment problems at the beginning, there is also the problem of piling data that constantly upload the server (data base), however this is solved by an advanced version of middleware which filtrate gathered data.

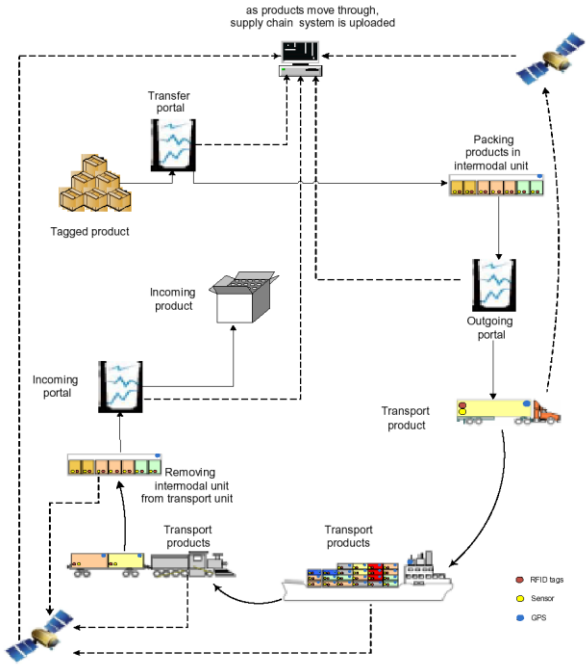

Figure 5: Architectural proposition of implemented RFID technology in intermodal transport

3.5. RFID influence on automatization of transport process in intermodal nodes

It is a fact that the longest possible freight hold-up or loss of time happens during loading/unloading of the ship or land vehicles (wagons or trucks), i.e. intermodal node (place where two branches of transport are intertwined or certain freight manipulative actions take place). In Figure 6. an intermodal node is shown.

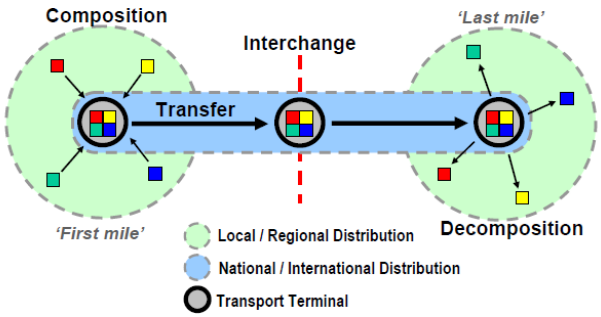

Figure 6: Intermodal node

Using RFID technology, we have the possibility to monitor the freight in ports or goods and port terminals and consequently the possibility to influence the delivery. Monitoring the flow of freight is significant in order to optimize port transport process for instance and, consequently, to ensure market supply in due time, i.e. planning the course of production process in production companies (e.g. car industry, shipyards etc.), especially organizations that deal with transport (different transporters). Introducing RFID technology to the mentioned freight processes, we have the possibility to directly influence trans-shipment time reduction in intermodal node with the following consequences: reduced cost, higher efficiency, bigger profit etc.

One of the most interesting intermodal nodes is surely the seaport. RFID technology enables the reduction of total amount of time of port occupancy. Total amount of time of port moorings occupancy can be demonstrated with the following equation:

$$T_{uvzv} = T_{var} + T_{vib} + T_{vpob} + T_{vni} \quad [\text{hours}] \qquad (1.)$$

where:

T_{uvzv} – total amount of time of moorings occupancy;
T_{var} – administrative action time upon ship´s arrival to the berth;
T_{vib} – time needed to unload the ship;
T_{vpob} – time needed to prepare the ship to leave the berth;
T_{vni} – time when there is no unloading.

In the previously mentioned relation, the use of RFID technology can directly influence the T_{vib} variable accelerating the time needed to unload the ship because of the automatic identification of the intermodal unit.

4. TESTING RFID IN ACTUAL WORKING CONDITIONS

One of the first world companies to introduce and test RFID technology in intermodal transport was the shipping company Horizon Lines in September 2006. The integration of RFID together with WEB management system enabled an incomparable visibility of the containers from the loading time until they reached the final destination. The test was performed during transport under extreme conditions in the area of Alaska on 40 degrees Celsius below zero. This experiment eliminated the fear that a certain company upon introducing this technology would become and has proven the functionality and cost effectiveness of RFID technology. With regard to the positive test results, in January 2007, the company introduced an active RFID solution, enabling their clients to monitor the freight movement in any transport phase. Precisely because of the investment in the research and development in intermodal transport and because of constant efforts to improve the technology, Horizon Lines, Inc. have successfully managed to reduce total costs when processing the transport data and have also become extremely popular and appreciated in their area of expertise. On March 7, 2008 they were selected in top 100 logistic IT providers.

"What we did was an ocean-container shipping industry first," said Ken Privratsky, vice president and general manager of Horizon Lines. "We've set a precedent, on a national and international level, for providing greater visibility of deliveries and more efficiency in supply-chain operations. Using RFID technology, we are enabling our clients to better utilize the assets that they have."

5. CONCLUSION

Dealing with the mentioned thematic, the following advantages of RFID system in intermodal transport have been noted:

- each intermodal manipulative unit has its own unique identification number;
- it enables to read and write data from a distance up to several meters;
- it is possible to simultaneously read more identification number tags;
- it is possible to encrypt data on a transponder;
- automatic use of RFID enables the acceleration of manipulative processes and the reduction of human action;
- transponder is resistant to light reflection and it is not disturbed by the complete lack of light;
- there are no negative environment consequences (detergents, water, paint, ice etc.) that put obstacles in the way of radio-wave communication;
- national security is improved;
- possibility of timely theft or freight damage detection;
- possibility of on-line monitoring of the momentary freight position etc.

Based on these facts, it is obvious that the benefits of using RFID technology in intermodal transport are numerous, in the private as well as the public sector because of the possibility to monitor the flow of freight (goods) to better organize the

working process in the ports, transport of goods and the technological production process. Introducing RFID technology in intermodal transport, the initial investment would be significantly high, but all the participants in the chain of transport would profit in the long term.

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