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INFORMATION AND COMMUNICATIONS TECHNOLOGY SUPPORTING INTERNAL TRANSPORT SYSTEMS MANAGEMENT

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Abstract

The article presents some aspects concerning the application of Information and Computer Technologies in logistics processes. In order to improve management processes the integrated informatics and communication systems, dedicated applications and hardware solutions are used increasingly. The market offers a variety of solutions developed strictly for Transport and Logistics consisting of a multitude modules and applications meeting standard and non-standard requirements of supply chains. Specified solutions are used in warehouses and other types of logistics facilities realizing internal transport. A useful tool for supporting management of warehousing processes in logistics facilities is Warehouse Management System with RFiD technology for information collection and advanced planning. The RFiD is identification technology using radio waves for reading and recording information about products, logistics units or equipment on electronic chip. Construction of RFID systems largely depends on the destination of the system. The special attention is paid to the use of RFID technology to manage transportation system in warehousing facilities. The main features of RFiD technology are discussed.

Keywords: *ICT, informatics systems in logistics, WMS, RFiD, warehouse management*

1. Introduction

The market economy forces constant improvement of logistics and transport processes and services offered to the clients to increase competitiveness and minimise costs. One method to increase the attractiveness of logistics business is improvement of informatics and communication solutions supporting implementation of business processes. This applies to all elements in the logistics chain, starting from origin points until the delivery of finished products to the final customer [8, 9, 11, 12, 16].

Modern logistics is not only a strategy of execution and synchronization of the supply and delivery of goods, but also a way to manage the material flows, adjusted for interference-free flow of goods from suppliers to customers with minimal stocks and on appropriate level of reliability. The main requirements for logistic are formulated as 7R rule. The primary goal of any supply chain system and logistics itself should be to get the *right product* to the *right place*, to the *right customer* at the *right time*, at the *right quality* and *right quantity*, and at the *right cost/price* [8]. In addition, an advanced inventory planning and replenishment engine within an integrated supply chain management system composing moderns ICT solutions for logistics would give the buyers the tools to make this happen.

In order to meet the requirements according to the assortment, quantity, place and time it is necessary to develop a correct network of connections and relationships between suppliers, medium elements of supply chains and. Therefore, it is important to control correctly material flows, particularly in the area of distribution, since its main task is to provide buyers desired products with attractive price and quality. The movement of goods from producers to consumers is performed by many actors (operators, freight forwarders, carriers, warehouses) who operate in either production, supply or transport and warehousing.

Development of science and technology, especially Information and Communication Technologies, gives a plenty of opportunities of progress in new products development, as well as in the distribution and offering services. Currently the dominant feature of economic relations is the increasing amount of goods exchanged on the market, and increasing international competition and the globalization of the world economy.

Companies strive to achieve the greatest market flexibility and productivity of invested funds. This involves the search for development strategies and innovative technological solutions to adapt business to market needs and expectations of buyers of logistics services and final beneficiaries of supply chains. This applies not only to the efficiency of the management system but also the storage and transport processes. Implementation of a new and modern technologies is a Process Innovation, which, according to the international definition [6, 21] means "… the implementation of a new or significantly improved production or delivery method (including significant changes in techniques, equipment and/or software). Minor changes or improvements, an increase in production or service capabilities through the addition of manufacturing or logistical systems which are very similar to those already in use, ceasing to use a process, simple capital replacement or extension, changes resulting purely from changes in factor prices, customisation, regular seasonal and other cyclical changes, trading of new or significantly improved products are not considered innovations".

2. Integrated information systems improving the implementation of transport processes in logistics facilities

In order to improve management processes, information technologies – especially integrated informatics management systems – are used on an increasing scale. The market offers a variety of solutions for different purposes dependent on business process, its aim and functional range. The most popular addition to the typical integrated solutions like ERP, MRP II, SCM, APS and WMS are freight exchanges, electronic maps, the tendering platforms, as well as route planners, GPS, inventory modules, human resources modules, engineering applications, account modules, applications for undertakings complex distribution and transport processes, systems for forwarding management or programs to carry out procurement procedures. The basic functions of logistics information systems are then:

– the acquisition of data: orders, proposals, production reports etc.,
– processes tracking,
– the sharing of data through the supply chain,
– the collection and archiving of logistics data,
– processing of data in order to give them the informative value,
– customer service,
– planning and control of production, distribution and inventory,
– coordination of the supply chains,
– advanced planning of logistics systems development.

On the other hand the data sources for logistics information systems are:

– processes: manufacturing, transportation, storage, distribution, transhipments,
– customer demand – real and realized,
– market analysis,
– logistics controlling and others.

The abilities of implemented software applications, as well as their functionalities should be the result of the functions of particular logistics or business process, necessary decision support and the nature of the logistics processes.

Information systems used in supply chains may be constructed as *integrated information systems* or narrow applications dedicated to specific logistics processes. Integrated information system is a system supporting management organized as a modular and complex way in all

management areas [20]. Integrated information system is an array of multiple information sets linked together in an organized way. It means that there is a well-defined plan for collecting and linking information sets. In the logistics facility or supply chain, an integrated information system would link information across different services and functional areas and would integrate information across cooperating entities to support material flows and fulfil the expectations of a clients. These are the most substantive and technologically advanced systems supporting management in enterprises and institutions. The main features of the system are functional complexity, integration of data and procedures, functional flexibility and structural, substantive and technological advancement and openness.

The implementation of supply chain is supported by standard classes of integrated information systems, including (definitions partly from [7]):

- MRP – Material Requirements Planning, a software system that helps businesses to forecast both inventory levels and purchases which must be made in order to produce and sell said inventory. This is mostly used in the manufacturing business planning and production.
- MRP II – Manufacturing Resource Planning, Successor to the MRP, it integrates planning of all aspects (not just production) of a manufacturing firm. MRP-II includes functions such as business planning, production planning and scheduling, capacity requirement planning, job costing, financial management and forecasting, order processing, shop floor control, time and attendance, performance measurement, and sales and operations planning.
- ERP – Enterprise Resource Planning, Accounting oriented, relational database based, multi-module but integrated, software system for identifying and planning the resource needs of an enterprise. ERP provides one user-interface for the entire organization to manage product planning, materials and parts purchasing, inventory control, distribution and logistics, production scheduling, capacity utilization, order tracking, as well as planning for finance and human resources. It is an extension of the MRP II.
- CRP – Capacity Requirements Planning, method of capacity planning in which the demand or load on each resource or work centre is added up, without regard to setup time. CRP is used usually to determine if a proposed master production schedule is practicable.
- DRP – distribution Requirements Planning, systematic process for determining which goods, in what quantity, at which location, and when are required in meeting anticipated demand. This inventory related information is then entered into a MRP as gross requirements for estimating input flows and production schedules.
- DRP II – Distribution Resource Planning, extended version of DRP process, which includes provision for key non-inventory resources such as labour, material handling facilities, and storage space. This information is then entered into a MRP II system as gross requirements for estimating input flows and production schedules.
- WMS – Warehouse Management System, a software application that supports the daily operations of a warehouse, allows for a system of centralized management of warehousing tasks including inventory control, tracking, and the location of stock items. WMS may work on their own as a single application or be an integrated part of a larger system. Current WMSs are capable of being highly complex and handle significant amounts of data many companies will allocate an entire staff to the operation of the software.
- APS – Advanced Planning and Scheduling, refers to a manufacturing management process by which raw materials and production capacity are allocated to meet demand. APS is especially well suited to environments where simpler planning methods cannot adequately address complex trade-offs between competing priorities.
- SCM – Supply Chain Management, management of material and information flow in a supply chain to provide the highest degree of customer satisfaction at the lowest possible cost. SCM requires the commitment of supply chain partners to work closely to coordinate order generation, order taking, and order fulfilment. They thereby create an extended enterprise spreading far beyond the producer's location.

– TMS – Transportation Management System is a subset of SCM concerning transportation operations and may be part of an ERP system.

The functionalities of these solutions overlap making difficult the selection of the solutions tailored to the needs and depends heavily on the type of business carried out by the operator. Entities grown on production will base their work on MRP II, ERP or even more far-reaching like ERP II solutions. Businesses grown on the distribution and commercial functions will base their activities on SCM, TMS or WMS.

The above-mentioned solutions usually cooperate, and dispose own modules controlling material and information flows (internal transport) in logistics objects such as warehouses or production facilities. A special type of integrated solution used in internal transport and warehousing is WMS.

Warehouse processes are crucial elements of supply chains. Warehouses buffer, direct and transform material flows due to client's orders. These transformations add value to handled products but must be managed and reported into superior systems. Warehouse Management Systems controls, monitors and archives material flows performed by internal transport system. It is built on a strength industrial relational database updated in real time from multiple sources simultaneously [4]. The typical physical structure of WMS in the logistics facility with additional elements is shown in Fig. 1.

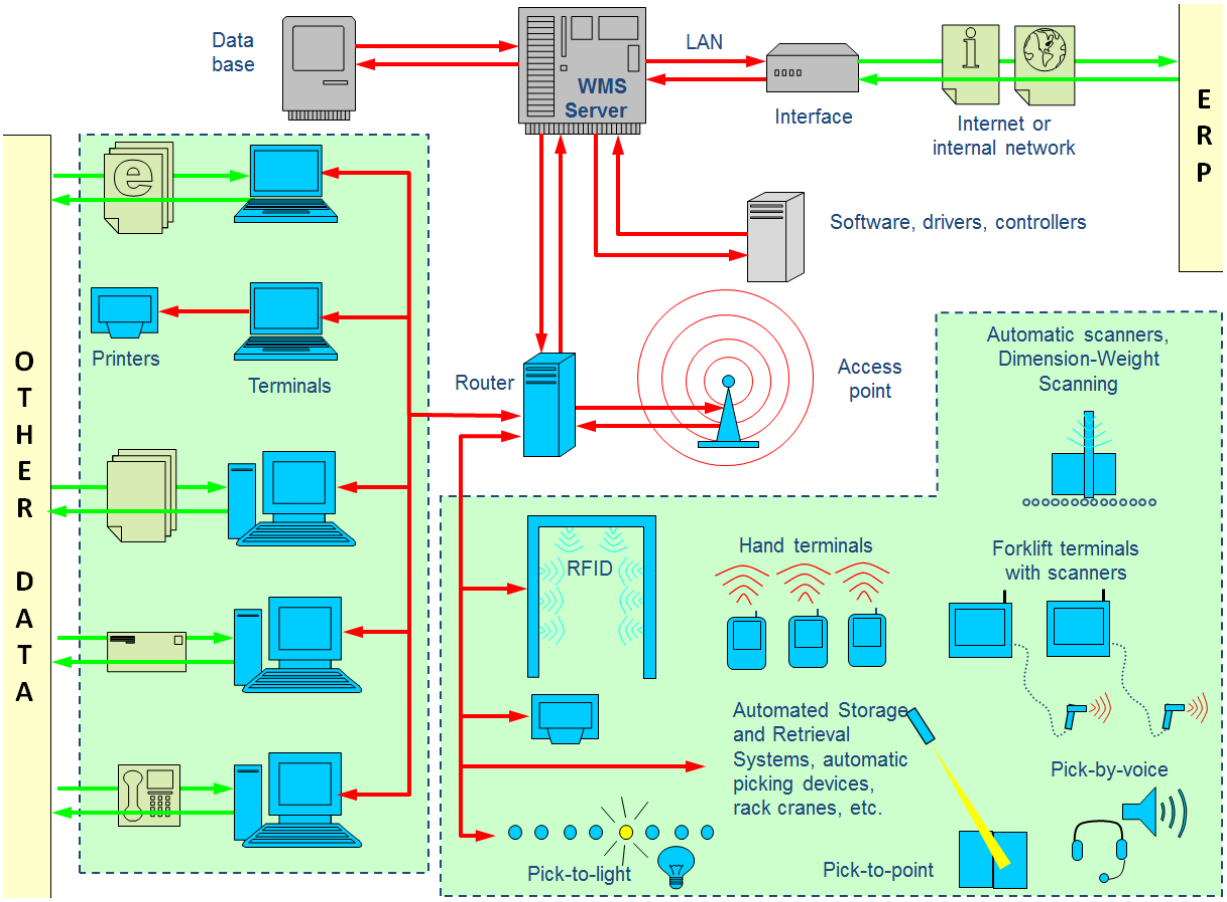

Fig. 1. The typical structure of WMS installation in logistics facility with supporting equipment.

Presented structure uses different automated data capture (ADC) devices for communication between the system and employees on the floor. An interesting type of device is RFiD system presented in next point.

Timely, effective and efficient operation of logistics facilities like warehouses, loading points, distribution and supply centres and other depends largely on types of informatics and commu-

nication systems and their functions. The typical functionalities of WMS in warehouse facilities embrace:

1. Processing client's orders and supply reports to release material flows.
2. Advanced implementation of FiFo, LiFo or FeFo rules integrated with receiving, allocation and picking procedures in a distribution facility.
3. Slotting materials in disposed space according to access ability and efficiency of internal transport.
4. Routing patterns, including composing of order-picking lists.
5. Implementing multiorder-picking, batch-picking, zone-picking and wave-picking mechanisms.
6. Advanced replenishment algorithms.
7. Stock locator system to monitor internal transport operations and warehouse locations.
8. Communication with equipment and employees (material flow control – MFC).

Other functionalities used in logistics facilities are:

9. Sequencing vehicles arriving and leaving the facility according to order of handling individual consignments to the different directions of shipping.
10. Managing cross-docking processes (compare [14] and [19])
11. Planning the spatial arrangement and equipment of the facility, including the course of internal transport routes and pedestrian routes and the size (dimensions) and loading areas (see [10]).
12. Determining equipment parameters including "safe speed" and traffic rules in terminals as a function of the conditions existing at the facility (see [2]).
13. Setting processing procedures for different categories of items (like priorities, delays, standard, strategic clients etc., compare [13]).

All presented functionalities aim in lowering labour consumption by shortening transport cycles, better utilization of storage space, minimizing operation costs and increasing safety of people and materials while quality and reliability of logistics processes is on a high level.

3. Improvements of internal transport organization with RFiD technology

The implementation of tasks numbered in previous section by WMS (or other solution) requires additional technologies for exchange of information among partners involved in supply chain and used to identify materials. In most cases Global Standard 1 (GS1) standards (or similar) are used for coding business and logistics information. The exchange of coded information is carried out in order to communicate business entities and to the implement internal logistics processes in the facilities. In the second case, the basic techniques used for data exchange are graphic codes (of various types, including barcodes) and electronic records (mainly supported by radio frequency RFiD).

Radio frequency identification (RFiD) technology is a highly sophisticated automated data capture (ADC) technology to helps the modern WMS. This method of identification uses radio waves to read and record information from electronic chip. Construction of RFiD systems largely depends on the destination of the system. The RFiD system generally consists of four basic elements (Fig. 2) [1, 15, 17, 19]: transponder (tag) placed on identified product, the reader to code or retrieve information, coupling element (antenna), software.

One of the most important elements of the RFiD is tag or transponder [3, 5, 12, 18]. It is a miniature form device placed as a labels or tags on individual products or packaging. Tag carries electronic information, which may be the address – a link to the database of manufacturer or distributor of a particular product. It is possible not only to store information about products in a chip, but also their replenishment and reading (Fig. 3).

Tag can be placed on the packaging in several possible configurations:

– Each package unit is equipped with a separate tag. Overpack may contain own tag. The advantages: ability to accurately identify all items. The disadvantage is the lack of direct (eye) contact with each element what can cause errors in the event of failure of any of the tags.

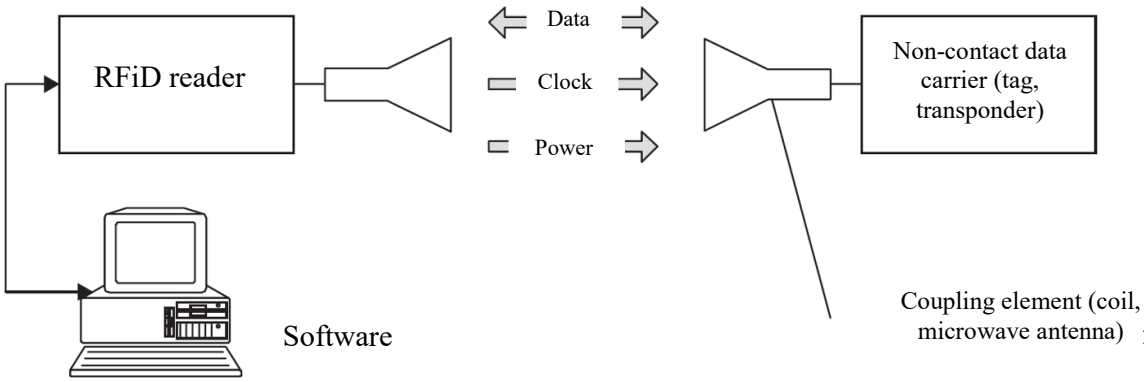

Fig. 2. The general structure of RFiD system (source [1])

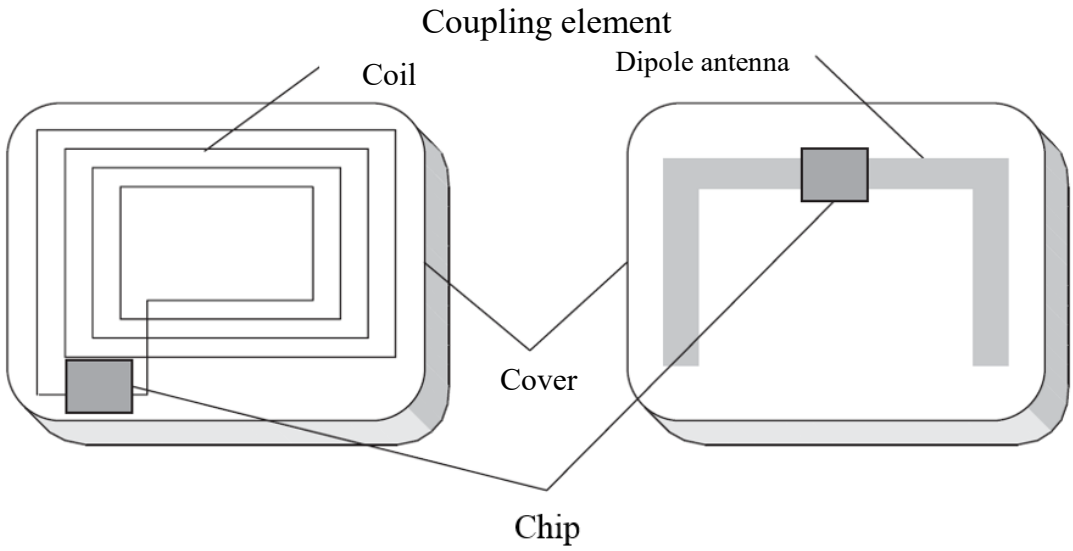

Fig. 3. The typical structure of RFiD tag (source [1])

– Individual packages bear only printed information. Overpack has only tag. Advantage: due to direct contact with the tag placed on the packaging identification will be carried out flawlessly. The disadvantage: no control over the content. Applying the tag on the outside is opposing the idea of RFiD.

RFiD can also be used to improve the management of transport equipment. Not only the materials and packaging units, but also transport equipment and devices can be marked. This makes possible constant monitoring the work of these devices and their position in workspace, which translates into the possibility of using complex algorithms for work management (routing) and directing the flow of materials in warehouses.

Implementation of sophisticated RFiD solutions allows companies to increase the competitiveness and increase the services quality. Improving logistics processes through the implementation of RFiD technology in particular allows for:

– Shortening the time of receiving and put-away of supplies to storage areas.
– Shortening the time to prepare shipments.
– Improving picking processes.
– Elimination of errors in picking process and thereby minimizing customer complaints.
– Improving productivity and enabling fast and effective training of employees.
– Accurate tracking and archiving inventory flows, which is the basis of current management and analysis enabling continuous optimization of flow processes.
– Improving production processes.
– Improving sales processes and customer services.

On the other hand, RFiD technologies imposed by stronger players (monopolies) can lower the efficiency and productivity of weaker participants of supply chains (compare the Walmart issue) forced to use the technology for which are not prepared.

These improvements result not only from possible automation of recognition and decision processes, but also from modern patterns of work organization, giving up some labour-intensive operations, reducing employment, and allowing for the system's support in emergency situations.

One of the important aspects of warehousing process is internal transport management. The use of RFiD technology allows for managing transport devices and workers by MFC modules controlled by single dispatcher. The dispatcher is able to trace in real-time, analyse and report about all flow processes.

On the basis of the data supplied by radio frequency controlled forklifts management system the dispatcher can decide about operations and give the disposition by computer terminal connected to transport devices. The dispatcher's decision is immediately transmitted by radio-terminals to the appropriate warehouse workers and devices. The command is send immediately, completely electronically without any paper, to the possibly best-located device or worker.

Considering above it is, clear that RFiD technology allows for total control of material flows and handling processes by the management system. Of course, before these tasks are executed they are approved by the dispatcher. The system transmits work-orders to the mobile radio terminals on warehouse floor and requires confirmation of their execution and accuracy. In this way verbal or paper instructions are replaced by a precise algorithm leading employee in a clear and unequivocal manner "step by step" through the execution of even the most difficult and complex material flow process.

When using RFiD the employee focuses each time only on work execution and confirming the correctness of the implementation. The work execution generates input data for optimization algorithms analysing in real-time incoming transport tasks taking into account: specificity, execution time, priorities, available work resources etc., and develops possibly good decision about the allocation of the tasks to specific resources (forklifts).

4. Identification of emergencies and addresses of warehouse locations using RFiD technology

As it was mentioned in previous section operators and workers perform transport task triggered by system assigned automatically and ordered by radio terminals. The system monitors and controls on-line the warehousing process. In case of emergency or error (like "occupied location", "withdrawal palette", "palette too high", etc.) system can take appropriate actions to counteract them. To control on interrupted transport task is taken by a special module.

In general, the handler of emergencies (usually integral part of the management system) has a catalogue of typical emergencies that may occur. For each of these situations the appropriate procedures are prepared. In case of a real emergency, the system automatically:

– transmits the instructions to appropriate transport device,
– if necessary, generates the appropriate inventory list and / or block sites occurring error.

Furthermore, in most cases the notification about the occurrence of an emergency is sent via email or SMS to the appropriate management level in a warehouse. This allows for flexible parameterization of rules and procedures counteracting mistakes.

The second quality factor in logistics services is managing stocks of materials. In order to avoid confusion when picking and depositing loading units in racking systems, the material flow control system uses RFiD for automatic control of storage location addresses. Most often storage locations are equipped with passive RFiD tags encoding unique address of location. Forklifts are equipped with RFiD antennas, readers and interfaces transmitting data to management system. In this manner, each collection or deposition of a loading unit from or to storage location is automatically notified and checked by management system. The management system controls on-line the

execution of transport tasks and checks whether the loading unit is placed in appropriate storage location. Any error is immediately reported to the forklift truck operator and to the dispatcher.

Conclusions

The modern telematic technics and systems are necessary tools supporting providing high quality and cheap logistics services, so are important for designers or analysts of logistics systems – especially efficient warehousing facilities. The particular significance of ICT is for the management of logistics processes in supply chains. The use of appropriate information systems significantly improves the quality of work and services provided by transport and warehousing systems.

RFiD is a modern technology effectively supporting logistics operations and complementing information and communication systems. It is a stable technology that brings proven business benefits. It should be taken into account whenever it is important to increase efficiency, reduce losses and improve the service, but the implementation must be well thought out and fitted to demand. RFiD technology still is considered as expensive and difficult in implementation.

Implementation of RFiD technology can bring to increased competitiveness of company and better quality of logistics services. Improving processes of material handling performed by internal transport systems can be done through rational implementation of RFiD. Good implementation will lead to reducing operation time's better space utilisation, lowered number of mistakes, increased safety and reliability.

A constant disadvantage of RFiD technology applied in logistics and transport is a price, particularly concerning tags. The design of the tags and their technological complexity make them significantly more expensive than printed barcodes. In many cases, this makes RFiD not profitable in use. Marking products with a relatively low unit price with RFID tags can lead to excessive increase in the unit price. This in turn makes this technology limited by itself, being uneconomical for mass products with low price.

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