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## **Information and communication technologies (ICT) in construction and development of logistics systems**

### **Technologie informacyjno-komunikacyjne (ICT) w budowie i rozwoju systemów logistycznych**

**Abstract.** The higher and higher level of competitiveness of enterprises, the increasing expectations of customers or internalization of business are just a few examples of challenges that most of companies must face nowadays. None of these challenges may be faced, however, if the companies do not cope with logistics problems. The increasing number of problems, among others related to the necessity of diversification of products, of provision of frequent, fast and small deliveries, of ensuring reliability and flexibility in operation, of transfer of goods almost all over the world, can no longer be solved with application of traditional methods. Condition of success in contemporary logistics is implementation of modern technology. Companies without IT systems, without automatic identification of goods or electronic exchange of data have not chances for strong presence in today's supply chains or other modern forms of business. In this paper characteristics of selected information and communication technologies (ICT) were presented with reference to the operation of contemporary logistics systems. The introduction presents the role and substance of the information resources in logistics. Technological solutions concerning transfer of information were grouped and characterized according to the following types: family of electronic connections, corporate networks and information highways. In each group of the solutions main faults and benefits were presented, from the perspective of possibilities of application in logistics.

**Key words:** logistics, information and communication systems, logistics systems, technological solutions

**Synopsis.** Coraz wyższy poziom konkurencyjności przedsiębiorstw, rosnące oczekiwania klientów czy internalizacja biznesu to tylko nieliczne przykłady wyzwań, przed którymi stoi dziś większość firm. Żadnemu z tych wyzwań nie da się jednak sprostać, jeśli firmy nie poradzą sobie z problemami logistycznymi. Coraz więcej problemów m.in. związanych z koniecznością dywersyfikacji produktów, zapewnienia częstych, szybkich i jednostkowych dostaw, zapewnienia niezawodności i elastyczności działania, przesyłu towarów niemal na całym świecie nie może być już rozwiązane przy zastosowaniu tradycyjnych metod. Warunkiem sukcesu we współczesnej logistyce jest wdrażanie nowoczesnych technologii. Firmy bez systemów informatycznych, automatycznej identyfikacji towarów czy elektronicznej wymiany danych nie mają szans na silne uczestnictwo w dzisiejszych łańcu-

chach dostaw, czy innych nowoczesnych formach biznesu. W artykule przedstawiono charakterystykę wybranych technologii informacyjno-komunikacyjnych (ICT) w odniesieniu do działania współczesnych systemów logistycznych. We wprowadzeniu przedstawiono rolę i istotę zasobów informacyjnych w logistyce. Rozwiązania technologiczne dotyczące przesyłu informacji pogrupowano i scharakteryzowano według następujących typów: rodzina połączeń elektronicznych, sieci korporacyjne i autostrady informacyjne. W każdej grupie rozwiązań przedstawiono główne wady i korzyści z punktu widzenia możliwości zastosowania w logistyce.

**Słowa kluczowe:** logistyka, systemy informacyjno-komunikacyjne, systemy logistyczne, rozwiązania technologiczne

## Introduction

Information in logistics, understood as provision of suitable resources to all so-called basic processes [Chaberek 2002], constitutes the basis for all actions. According to this definition, information is also a subject of flow in time and space. Information is subject to purchase, processing, transfer, storage and sale. Information (information systems) is the basic element of logistics systems. Information transfer channels create channels of transfer of goods and services (logistics channels). They consolidate the modules of logistics system, such as: centers of supply, inventory, production and sale, creating specific organization structures (not always formalized, for instance virtual enterprises) [Boysen et al. 2015]. Flow and use of information must be monitored and controlled. The same is for lack or glut of materials, shortage or surplus of information – they may cause great problems in enterprise operation. Enterprises may measure value of their information resources by sharing information with recipients. Achieving competitive advantage depends on to what extent the enterprise is able to use the information, so that the information would not be used by the competition. So, on one hand a challenge for the enterprises is releasing the information, and maintaining strict control over how the information will be transferred and used. The aim of this paper is characteristics of selected information and communication technologies, and specification of their roles in operation of logistics systems, and also their systemization. Considering the fact that the subject of this paper remains within the field of economics and management science, so for methodology purposes herein attention was focused on humanistic methodological approach towards them. The humanistic methodological approach promotes application of hermeneutical methods of research<sup>1</sup>, which means analysis, explanation and interpretation of any written sources related to the subject of research<sup>2</sup>.

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<sup>1</sup> The very term hermeneutical comes from Greek *hermeneutikos* – referring to explanation. In hermeneutics we observe theories of “operations of understanding with reference to text interpretation”. See: [Wikipedia...].

<sup>2</sup> A characteristic feature of this model is emphasizing of a particular role attributed to the systems of values, source texts and their contexts, and also to the words through which qualitative research is conducted, being the core of this method of “doing” science. See: [Kuciński 2010].

## **Characteristics of selected technological solutions for information transfer**

To particular groups of information sources various channels of information transfer are applied with various techniques and technologies. Logistics systems, forming various formal and organizational structures, require different channels of information flow, applying various technologies of data transfer. These differences consider, for instance, the cost of implementation of particular technology, various speeds and infallibility of transfer, different level of data security, etc. The level (generation) of these techniques and channels determine abilities of development of information tasks – one of the main objective of logistics. Technological solutions within transfer of information may be classified according to the following types [Kisielnicki and Sroka 1999]:

- family of electronic connections,
- corporate networks,
- information highways.

The family of electronic connections is the whole range of technological solutions, providing a computer mode of communication between market partners (legal entities, natural persons) on various economic topics and issues [Długosz 2017]. Contemporary generation of these devices, characteristic structure of software, hardware and communication are oriented toward the application of large and centralized computing powers, whilst data access for users is provided by communication and terminal drivers. The main advantage of electronic connections is complete time coordination of the logistics process (and the basic processes, such as production, distribution, dispatch, customs clearance, etc.) with the cycle of documentation and settlement service. Technical possibilities, such as the electronic exchange of trade data between contracting partners (transfer of documentation), or electronic settlement of payments, create a new quality in shaping trade relations. Thus, the electronic connections, as the systemic channels of information transfer reflecting the logistics processes within the material sphere, constitute a significant factor of integration of the logistics environment.

Internal networks, the synonyms of which are the corporate information systems or company internal networks, are the software-hardware solutions serving for communication and group/team work in the dispersed environment [Niedzielska 1997]. Among such information systems one may distinguish three various models of transfer and processing information, which may be regarded as the corporate information systems. They are as follows: host centric, PC centric and network centric systems. The basis for differentiation of the abovementioned models of information provision are the procedures of gathering and sharing data, methods of data management and proportions between information services provided globally or/and locally to the systems' users. The basis for host centric model of processing is concentration of data and of managing of access to the data. This enables centralized coordination of the system of permissions and responsibilities within preparation and processing of data and planning, implementation and maintaining IT resources.

The main value of the host centric model of information provision is its usefulness in operations that support centralized management of settlements. Unquestionable benefits of the use of this type of solutions are obviously the possibility of electronic exchange

of data, electronic transfer of documents and payments, or electronic transmission of messages to and from interactive databases [Adamczewski 2001]. Apart from that, the centralized solutions are effective due to:

- high control of the system of data processing,
- possibility to gain the exact match of the information system services to the needs of users.

However, a disadvantage of centralized solution may be some lack of flexibility, following from:

- lack of openness of the centralized information system outside the sphere of one economic entity,
- stagnation of the centralized applications and processing resulting from supplementing the information system with target-oriented applications [Adamczewski 2001].

Information systems based on the PC centric model are most often applied in economic practice. Their development and universality of application are the result of commonness of PC use, access to proper software and also to supporting communication techniques. This model assumes spatial and functional distribution of information and existence of the system of connections (most often with the use of technologies of local computer networks), providing communication and sharing of the same resources. The objective of dispersion of data distribution is natural matching of the information system structure to the organization structure of a company, increase in productivity by acceleration of processing and its approximation to the place of data generation and application.

The network model is a sort of combination of the host centric and PC centric processing. It enables both preservation of the features of the host centric processing model, related to the supervision over data, and their effective use (in the PC centric model), at the same time allowing decrease the contributions on infrastructure and limitation of costs of administration and maintaining the IT system [Maffei and Meredith 1995].

Value of the network model follows from limitation of costs of the information system, with preservation of the ability to introduce changes fast, for instance in the response to the change of conditions of conducting activity supported by a particular system. Apart from that, the advantages of the network system of processing are:

- effectiveness of integrated, globally and locally dispersed computing services,
- openness to implementation of changes in applications and processes with a response to changes in the environment where the computer-aided activity is conducted.

The core of the network model of processing is a computer network, characterized by:

- an easy access for users to the data dispersed spatially and functionally,
- openness to effective and fast implementation of advanced applications and solutions,
- economic effectiveness related to both rational use of information resources and possibility of integration of various computer and communication platforms.

### **Corporate information systems as elements of logistics systems**

A relatively new quality in corporate information systems used in the sphere of management of supply chains is the intranet – that is the internal company network using (in place of deliberately tuned standards) WWW technology [Handfield and Nichols 1999].

This is the active data (information) search conducted by the user, replacing a traditional, target-oriented distribution of data (information). In place of the system based on the data distribution to all or/and selected recipients, determined by a particular application, there is an access by the data user possible from particular places, and in a current defined time. Introduction of the intranet as a corporate information system solution signifies among others, an implementation of such principles of organization:

- central data sharing (which means their coherence and lack of redundancy),
- supplementing and changing of local contents of the preserved collections of data,
- access to all employees in the network.

In the intranet network it is possible to organize segments with specific authorization solutions for access permission. The intranet requires application of central administration of search mechanism, allowing supervision of places and types of the stored data. A practical value and usefulness of the search mechanisms depend on the quality and integrity of data.

Progressive cooperation and globalization of economic activity have created the latest type of connections referred to as extranet. This subsystem of information channel is a part of the intranet that goes beyond corporation. It may be assumed that extranet is a nucleus of the corporate network that is most often defined as the web of local computer networks [Alam et al. 2015].

Sometimes corporate networks are referred to as the web connecting dispersed environments and functional resources, including collecting, preserving, distributing and processing of data with the aim to share them with users, regardless of their position in the corporation. The network of such type contains both elements owned by a corporation and also IT solutions supplied from outside by private or public operators. If companies cooperating with an entity that provides international logistics services and this entity performed integration of their external connections and information channels, they would obtain an information network able to serve the whole international distribution/production process.

## **Development of information systems applied in logistics**

Proper operation of logistics systems within regional operational systems depends on availability of the integrated information system [Kawa and Wiczerzycki 2006]. Both the integrated regional network and the operational one are usually characterized by cyclical cooperation of many small enterprises located within small distances. In such bodies, routine operations, sending company messages, guidelines, orders and technical or trade documentations often cause trouble. In a spatially dispersed environment, which at the same time is technologically integrated, the information of permanent nature (available all the time from any place, being “within sight”) have the bigger and bigger share in total resources [Huemer 2002].

Databases of companies providing logistics services must contain, among others, information about spare capacity of cooperating companies or characteristics of services provided by them. The data should be available to all cooperating companies within the chain of supplies. Many techniques of categorization of data enable their application and full use. The following solutions may serve as examples: SWOT (IT Supported System of

Trade in Goods), SIT (System of Goods Information) or Hannibal – IT system that helps to collect economic information about enterprises, their products and services, as well as proposals of international cooperation.

The wide web of corporations, tasks of which are now fulfilled by the widely-available Internet, may be perceived as the foundation of global information infrastructure for international business relations [Atzori et al. 2012]. Undoubtedly, the use of any techniques of information provision, applied in all disaggregated processes reflected in a model of virtual company, gives a wide range of opportunities. The increasing reliability, popularity and availability of telecommunication technologies and of electronic media, such as the Internet, give many organizations a chance to access almost unlimited range of partners. Operation of a virtual company bases on contacts by electronic means with application of highly advanced information technologies.

Within cooperation of networks of companies jointly creating a virtual company, frequently including international cooperation located on various continents, the field of IT seems to be the smallest problem, compared to such issues as: physical flow of goods, legal and administration aspects, etc. Most of applications of IT now supporting the logistics in Polish enterprises correspond to solutions with respect to technological advancement. The above state is influenced mostly by financial conditions, but also by awareness of the owners and managing teams. A short characteristic of domestic applications of IT was presented in Table 1.

Table 1. Features of present and proposed IT applications in Poland

Tabela 1. Cechy obecnych i proponowanych aplikacji informatycznych w Polsce

Present state	Required state
<ul style="list-style-type: none"> <li>– single domain-specific systems, most often: finance, HR, payroll, less often logistics,</li> <li>– partialness of solutions of many suppliers of system components,</li> <li>– functional inconsistency and lack of integrity,</li> <li>– dependence on one software platform,</li> <li>– weak support for management processes,</li> <li>– lack of management accounting and controlling of logistics processes high costs of acquisition and maintenance of system, limited possibilities.</li> </ul>	<ul style="list-style-type: none"> <li>– functional complexity, integration of data and procedures</li> <li>– one supplier – integration of solution</li> <li>– software-hardware independence</li> <li>– benefiting from EDI, intra and Internet and multimedia</li> <li>– full support for management processes within process orientation</li> <li>– lack of management accounting and controlling of logistics processes</li> </ul>

Source: own study based on [Kale 2001, Długosz 2009].

The Integrated Management Information Systems are at present the most advanced form of support provided for management and logistics processes. Development of information systems applied in logistics is presented in Figure 1.

Main features of the Integrated Management Information Systems [Bond et al. 2000]:

- functional complexity – a system comprises all fields of technical/economic activity of an economic entity (reflected within the functional sphere);

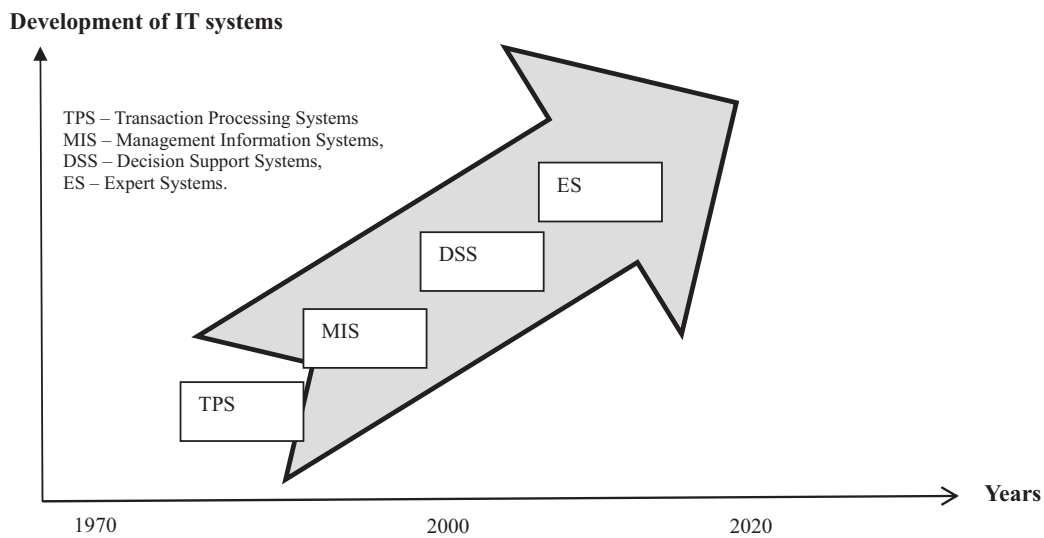


Figure 1. Development of information systems applied in logistics  
Rysunek 1. Rozwój systemów informatycznych stosowanych w logistyce  
Source: own study based on [Gamdzyk 1996].

- functional and structural flexibility – provides maximum adaptation of software and hardware solutions (within technical and functional structures) to the requirements of an object at the moment of installation and launching of the system, and also enables its dynamic adaptation when requirements and needs, generated by the environment, change;
- openness – guarantees ability to broaden the system by new modules, scalable architecture (usually: client-server) and creation of new connections with internal systems, such as systems of market partners;
- substantive advancement – provides full IT support for information and decision-making systems, with the use of mechanisms of free data aggregation, variance, optimization and forecasting, etc.,
- technological advancement – guarantees accordance with current standards for software and hardware, with a possibility of migration onto new platforms of hardware, operating systems, media and communication protocols;
- compliance with Polish regulations, for instance with the Accounting Act, with particular consideration for principles of bookkeeping with application of information technology, with principles of settlement and reporting financial results of economic entity, and principles of drawing up financial statements, etc.

Speaking of the roles of information and communication technologies in operation of the logistics systems we must still take into consideration the traditional techniques of communication, such as phone or facsimile machine, and we must not underestimate their importance. They are still bases of direct communication, especially in countries with low level of industrialization.

## Summary

Development of logistics in Poland and globally was and has been a result of changes taking place in the system of information supply. Specific information and communication technologies have created special environment for logistics of information, and thus for logistics industry as a whole. Only the new possibilities within the sphere of logistics of information gave rise to the development of idea, of concept and application of logistics on an unprecedented scale-service of economic processes within provision of suitable resources in proper place, in proper amount and at suitable costs. That gave rise to new opportunities within the field of logistic services and created a new quality of operation of economic systems.

This paper distinguishes three basic types of technological solutions, concerning transfer of information:

- family of electronic connections,
- corporate networks,
- information highways.

The main advantage of the first type of solution is complete time coordination of the logistics process (and the basic processes, such as production, distribution, dispatch, customs clearance, etc.) with the cycle of documentation and settlement service. Among the second type of solutions we may point out various models of systems of information transfer and processing: the host centric, the PC centric and the network centric systems. Undoubtedly, a benefit of such solution is a possibility of communication and group/team work in the dispersed environment. The pillar of global information infrastructure of the contemporary international economic relations is obviously the Internet. The Integrated Management Information Systems are at present the most advanced form of support provided for management, including the management of logistics processes.

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