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Technology and Management of Traffic
Review
U. D. C.: 65.02:681.3
Approved: May 2, 2005
Accepted: Sep. 6, 2005

MODERN INFORMATION COMMUNICATION TECHNOLOGIES AND TOOLS FOR SUPPLY CHAIN MANAGEMENT

ABSTRACT

The paper presents the most important supply chain technologies, including the latest applications and software tools used by companies that operate in the transportation and logistics fields. The primary goals of these technologies are information exchanges within and between organizations and/or managing supply chain related data and activities. New electronic logistics applications are increasingly being moved off proprietary systems and private networks onto the internet. With the e-commerce market exploding, portals are becoming a key element in bringing together an enterprise's employees, business partners, and customers – the principle actors of every supply chain - through one interface, accessible via the internet. Because of this capacity they are sometimes called e-supply chain mega portals.

KEY WORDS

supply chain, supply chain management, information and communication technology, software systems

1. INFORMATION TECHNOLOGY IN THE SUPPLY CHAIN

Transport and logistics are typical fields of business in which the cooperation between organizations represents a key factor for their solid and effective functioning. Supply chains, or clusters, connect the key players of this business, and information technology represents the means for their cooperation and the glue that binds them together. A Supply chain is a network of companies (vendors, producers, carriers, retailers, service providers, and customers) interacting to deliver a product or service to an end customer, linking flows from raw material supply to final delivery. The processes involved extend far beyond the domain of one company or decision maker, so a collaborative system is essential to ensure that all interests are realized, sustained, and/or improved.

In all branches of business we face the trend of increased global competition, which forces companies to improve their efficiency. Reduction of costs, improvement of operations and improvement of relationships with customers, suppliers and partners were always the main reasons for the adoption of new technologies. One of the measures for the improvement of efficiency and one of the greatest benefits of use of and investment in information communication technology is supply chain management. *Supply chain management* focuses on the inter-organizational management of goods flows between independent organizations in a supply chain, such as raw material suppliers, component manufacturers, finished product manufacturers, wholesalers and retailers. Global Supply Chain Forum [4] has defined supply chain management as the integration of key business processes from end users through original suppliers that provide products, services, and information that add value for customers and other stakeholders. This integrative approach to planning, control and monitoring of product flows, from suppliers to end users, aims at improved customer service at reduced overall costs, and leads to the development of important relationships with logistics providers, suppliers, and customers in order to enhance information exchange and the coordination of business activities, the key advantages of an integrated supply chain. The coordination of the management processes and activities in a supply chain requires efficient information exchange between the organizations in the supply chain.

The benefits of an integrated supply chain are numerous, but on the other side the implementation of such a chain is very costly, time consuming and represents a great challenge not only for the individual company but also for all its partners in the supply chain. The partners have to make up a common strategy; there must be a high level of confidence among them. To achieve greater information exchange, successful supply chain management requires effective management of strategic alliances, extensive data management capabilities and advanced inter-organizational information systems. Information communi-

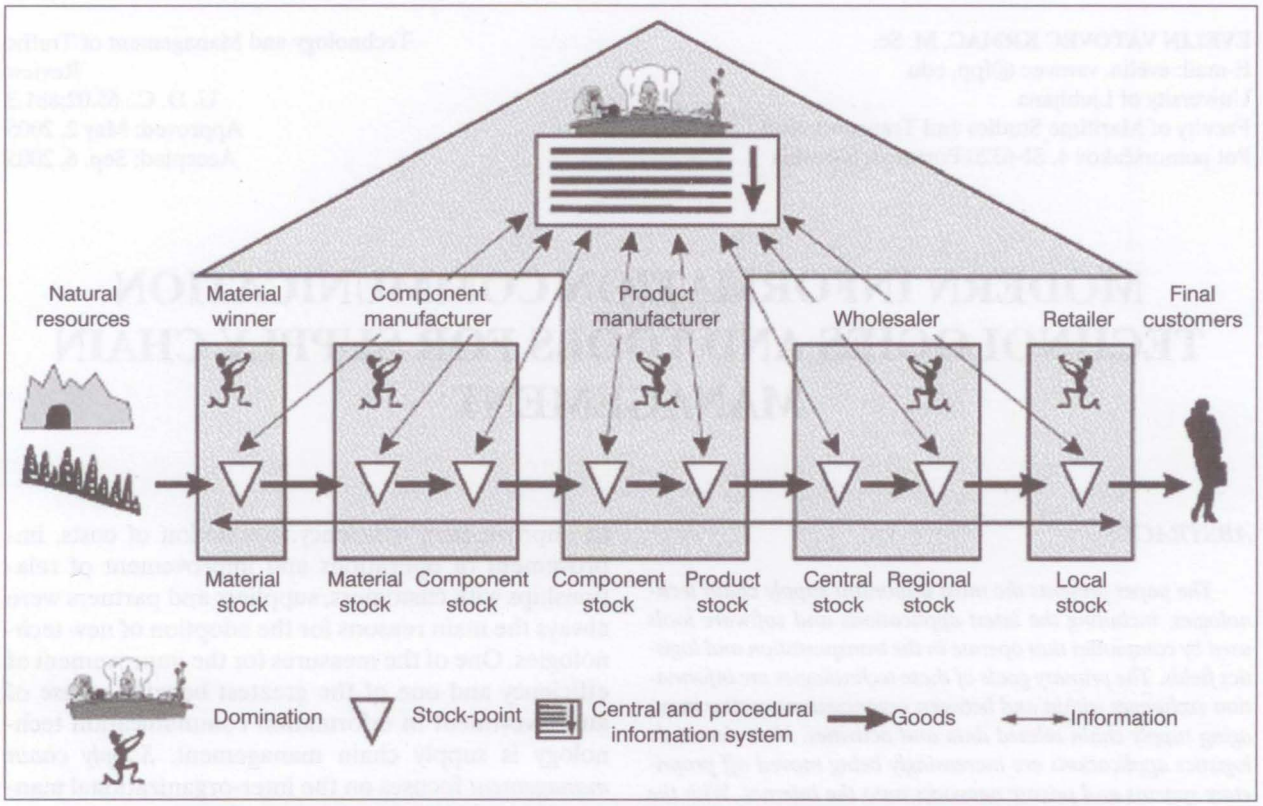

Figure 1 - Classic supply chain management (by domination of one organisation over others).

Source: Verwijmeren [10].

cation technologies facilitate the transfer of more accurate and up-to-date information, which results in better visibility of demand and inventory throughout the supply chain, and are essential in the use of international supply chains and e-commerce.

Information communication technology includes the application of hardware, software and networks to enhance information flow and facilitate the decision-making. It is one of the few aspects of logistics that simultaneously offers both improved performance and lower cost. It enables firms to maintain key information in an accessible format, process requirements, and make operational and planning decisions. The adoption and successful implementation of important hardware, software and network technology is a prerequisite for logistics success. The logistics information capability that facilitates a seamless flow of information is a very important element in further enhancing the efficiency of logistics activities and in potentially reducing the demand on the transport infrastructure itself.

2. OVERVIEW OF CURRENT SUPPLY CHAIN TECHNOLOGIES

An overview of the supply chain ICT includes technologies that primarily deal with managing and controlling supply chain related data and activities, including information exchange within and between organizations. They range from mature and widely used technologies, such as bar-coding technology, to relatively new application systems, such as supply management planning systems, supply chain event management systems, electronic commerce technologies, portals, geo-coded tracking systems, and others.

As regards the purpose or usage of a particular technology, they can be divided into two main groups – functional technologies and integrative technologies. Functional technologies, which are internally focused, include systems that are used to accomplish a particular function or are used in a particular functional area, such as warehouse and transportation management systems. Integrative technologies, which are externally focused, coordinate and integrate information flow and activities within and/or between companies, such as enterprise resource planning systems and supply chain planning systems.

2.1. Functional technologies

Browsing web sites and studying the literature in the field of transport and logistics we can discover a lot of different functional technologies or systems used to support and manage supply chains. Aside from bar-coding systems, warehouse management systems,

computer-aided design, electronic commerce technologies, internet-based logistics systems, radio frequency systems, transportation management systems and geo-coded tracking systems there are also demand forecasting management systems, customer relationships management systems, product data management systems, manufacturing execution systems, automated quality control systems and supply chain event management systems. They are briefly presented in the following sections in alphabetical order.

Automated quality control systems: Automatic quality monitoring and inspection devices observe the quality of in-process work pieces in automated manufacturing systems, and are essential for effective production. They are used to determine the acceptance or rejection of a work piece or a specific production long before work pieces are advanced to the next process. They are also used to monitor the calibration of fixtures and the conditions of cutting tools, and can be integrated into a feedback control system to directly influence the manufacturing processes.

Bar-coding technology: is one of the most commonly used methods of electronic auto-identification. It is a low-risk technology consisting of systems or products that are used in conjunction with many of the other technology systems to produce or use bar codes. Bar-coding technology increases efficiency through reduction in labour costs, increases inventory accuracy, makes turnaround for delivery of products faster, and eliminates the need for physical inventorying of products.

Computer-aided design (CAD) systems: CAD systems are generally stand-alone design tools that are used to design everything from parts to tools and fixtures.

Customer relationships management (CRM) systems: CRM systems are computer-based applications used to improve the selling and revenue generation process of an organization. They are particularly concerned with the relationship of the organization with its customers. They provide support for the provision of a service to a customer by collecting customer data and providing information and knowledge about customers and their behaviour. They help organizations to become more customer-oriented in the face of increased global competition.

Demand forecasting management (DFM) systems: Given the variety of forecast information needs in large organizations, a centralized forecast system capable of satisfying all of a user's information requirements is an important information system, which represents an integrated part within the framework of enterprise resource planning systems. The DFM system has the ability of providing forecast information for numerous users, improves forecast accuracy and enhances decision-making. Today's demand forecasting management systems are part of collaborative planning, forecasting, and replenishment (CFRP) systems, which are web-based tools for coordinating the various supply chain management activities, including production and purchase planning, demand forecasting, and inventory replenishment between supply chain trading partners.

Electronic commerce technology: provides the means for more efficient communication between buyer and supplier, and more accurate transmission of orders by enabling computer-based business transactions via private, proprietary networks such as electronic data interchange (EDI) or the publicly accessible internet.

Electronic commerce can reduce the costs of closely integrating buyers and suppliers and through electronic networks; organizations can achieve an integration effect by tightly coupling processes at the interfaces between stages of the value chain. [6] Electronic commerce technologies include interactive web sites, electronic mail, extranets (to promote electronic ordering with suppliers), intranets (to facilitate internal knowledge sharing) and EDI.

EDI is the most common form of an inter-organizational information system, an electronic commerce technology that improves customer service and lowers costs by facilitating communication and document exchange between supply chain partners, and has a positive impact on inventory levels and inventory management. Local systems linked by EDI support the flexibility of networked organizations, but EDI interfaces just focus on data exchange, and therefore exclude the decision rules required for supply chain management.

Internet-based logistics systems: are replacing electronic data interchange (EDI) systems. They can handle everything from order management and scheduling to delivery, and are designed to help companies cut costs by automating the processes of booking shipments, keeping customers informed, and making sure goods arrive on time. E-logistics applications make it easier to manage customers' requirements for on-time shipments at a lower cost. Supply chain management has been literally reinvented by the internet and other networked technologies and the practices they facilitate; i. e., e-procurement, e-logistics, collaborative commerce, real-time demand forecasting, inventory management, true just-in-time production, customer interface, web-based package tracking, etc.

Manufacturing execution systems (MES): known also as "shop-floor-control systems", provide a single, flexible platform for managing production, quality, inventory, and process controls. These systems also enable real-time visibility and control of manufacturing operations and help businesses to respond effectively to unexpected customer requirement changes. They are seen as a strategic tool for manufacturers to pro-

vide customer-specific, innovative, and cost-effective products in the increasingly competitive environment that is the result of globalization. MES is a dynamic information system that drives effective execution of manufacturing operations. Using current and accurate data, MES guides, triggers, and reports on plant activities as a result of various events. It also manages production operations from point of order release into manufacturing to point of product delivery into finished goods. MES also provides critical information about production activities to others across the organization and supply chain via bi-directional communication. [9] Some of the major benefits of implementing the MES system are higher productivity, higher revenue/square foot, higher value-add/employee, higher sales/employee, higher process capability, larger yield gains, reduced scrap and rework costs, reduced manufacturing cycle times and order-to-ship cycle times, stronger agility for handling JIT deliveries, etc. MES aims to provide an interface between an ERP system and shop floor controllers by supporting various execution activities such as scheduling, order release, quality control, and data acquisition. Adoption costs of manufacturing execution systems are high, and integration with other systems is very complex.

Product data management (PDM) systems: serves as the catalyst of a process of re-engineering and optimizing an organization's processes, to improve competitiveness through greater speed and responsiveness [7]. A major benefit of PDM is the reduction of lead-time or time to market, achieved by gaining control of the product introduction process, which also results in reduction of product introduction costs. Such systems remove barriers to information flow and allow critical information to be accessed by the relevant people, and improve communication and consistency within organizations because everyone has access to the same information. So PDM systems are important tools for gaining control of information, and consequently obtaining greater control of a business.

Radio frequency (RF) technologies: RFID (Radio Frequency Identification) has only recently been introduced to the consumer goods supply chain. RFID requires the creation and adoption of industry-wide standards, integration with internal business systems, and a significant investment in RFID tagging and reading equipment as well as supporting technology infrastructure. Initial costs of RF technologies are significantly higher than bar-coding costs.

RF technologies use radio waves to transfer detailed information from tags, programmed with a unique number and attached to items, cases, or pallets, to a company's information system. RF tags are superior to bar-coded labels in that they allow significantly more information to be stored and have the capacity to easily update or alter information at any point along the supply chain without having to change the tag. Another advantage over bar-coded labels is its capacity to reliably operate in harsh and dusty environments; but current RFID tags are not always reliable and will not work with some products or in certain situations. The main advantage and the greater potential of RFID is its possibility to trace products, collect and access the information about products via RFID tags during each step of the logistics chain.

Supply chain event management (SCEM) systems: is a relatively new supply chain application that improves a company's ability to share information across departments or company boundaries and encompasses event management, workflow management, enhanced information capabilities and business analyses. It enables a company to access supply chain information in real time and immediately respond to unplanned events.

Tracking systems: service-tracking systems provide customers with a means to realize the status of their requests and to anticipate and plan actions. For a manufacturer downstream in a supply chain, this service provides real-time information that enhances the effectiveness of raw material planning and scheduling. Service tracking systems provide the order and delivery status of the products and services; users of the system can make decisions based on the actual status. The internet-based techniques offer users easy access to real-time status information via web-based tracking systems, which have the advantage that information exchange and transmission are not geographically restricted. The geo-coded tracking system is a newer technology for tracking transport vehicles, formed of satellite or cellular tracking devices most commonly used in trucks or trailers to ascertain position and feed the information to ancillary systems such as transportation management systems or warehouse management systems and via internet to customers, who can track their goods on-line.

Transportation management systems (TMS): offer sophisticated algorithms for transport booking, monitoring and planning. They are intended to achieve enterprise-wide cargo control centres to address the complex transportation requirements between channel partners. The transportation management system is one of the primary systems used by logistics service providers, forwarders and carriers.

Warehouse management systems (WMS) or inventory tracking system: provide the software to track and control the movement of inventory, from receiving to shipping, through the warehouse, managing the utilization of warehouse resources such as space, personnel, and material handling equipment to improve productivity and efficiency. They are developed to support decision makers by providing consistent, timely,

subject-oriented information at the required level of detail. [11] Three main benefits of these technologies are reduction of shipping errors, increase in productivity, and inventory tracking ability. Logistics service providers and wholesalers are the primary users of these systems.

2.2. Integrative technologies

Integrative technologies are information systems used to coordinate and integrate information flows and activities within and between company boundaries to allow the company to effectively manage procurement activities to rapidly meet customer needs. These tools provide excellent algorithmic and technological features to support management decisions, allowing customized planning procedures and optimization algorithms. The goal of both types of systems is the same: to be able to enter information from any source into the computer system only once and have the information made available for all. Two widely known supply chain integrative technologies are enterprise resource planning (ERP) systems and supply chain planning (SCP) systems.

Enterprise resource planning (ERP) systems: offer a centralized information control system to integrate all company departments and functions and provide integration for supply chain management. It is an integrated set of application software modules or packages (capacity planning, customer service, cost and accounting, sales order processing and distribution, manufacturing, material procurement, production management, quality management, inventory, human resources, distribution, logistics, and finance), which work together as an integrated unit by bringing the visibility of real-time information to all departments and thereby focusing on the business as a whole. ERP software is the dominant strategic platform for supporting enterprise-wide business processes. [5] One of the important modules of the ERP system is the inventory management module, which provides functions to calculate safety stock and the reorder point for each item contained in the database based on the item's demand history. Thus, it provides ways to analyze the demand history, make forecasting recommendations, and suggest safety stock levels. [8]

Supply chain planning (SCP) systems: deal with long-term strategic issues between collaborating partners by coordinating material and capacity resources across networks of facilities, suppliers, customers, and trading partners. These systems integrate diverse applications and functions such as demand planning, sales and operations planning, supply and forecast planning, scheduling, distribution and transportation. One of these systems is the CPFR system, which is used to replace the approach of electronic data interchange (EDI). The objective of the CPFR system is to exchange the selected internal information on a shared web server in order to provide for reliable, longer term future views of demand in the supply chain. [1] This leads to benefits such as increased sales, faster order response times, lower product inventories, higher order fill rates, direct material flows, improved forecast accuracy and lower systems expenses.

The distinction between ERP and SCP systems is somewhat blurry. ERP generally covers the full range of manufacturing, sales and accounting software, sufficient to perform virtually all of the information technology transactions required by an enterprise, and provide information and decision support for most of the core processes as well. SCP, on the other hand, is more oriented toward specific logistics functions with specialized systems devoted to demand forecasting, production, transportation, delivery and distribution.

The typical progression for companies would be to implement ERP, electronically integrating company activities, and then adopt SCP to integrate with partners. So, in the next step this integrating system will enable suppliers, partners, distributors, and even consumers' real-time access to the ERP system via an extranet. The evolution of these systems will permit an automatic transference of supply chain partner demand forecasts into vendor production schedules, accounting, human resource requirements, and supply chain planning applications, such as the warehousing and inventory control application of ERP systems. Further, these systems will evolve into inter-organizational integration of various ERP system planning activities.

The integrative technologies provide extra intelligence for coordination between partners and greater flexibility, which is needed for this cooperation between networked organizations. They have to provide basic communication between the systems and users in the supply chain (data communication, message conversion, flow control, etc.), transparent information (stock visibility, track and trace and report), and advanced management throughout the systems and among the users in the supply chain (inventory management, production management and distribution management). [10]

Yet, there remains one non-technical condition that must be fulfilled in order to achieve all the benefits that modern tools for management of intelligent supply chain actors offer; this is the need for sharing common databases with partners, or the so called "trust factor", which could be the primary factor delineating failure or success. Shared information is the key to assuring that build and move decisions can be made as soon as demand is realized. And this is the first step toward achieving the global goal of modern supply chain management tools and systems, which is improved customer service.

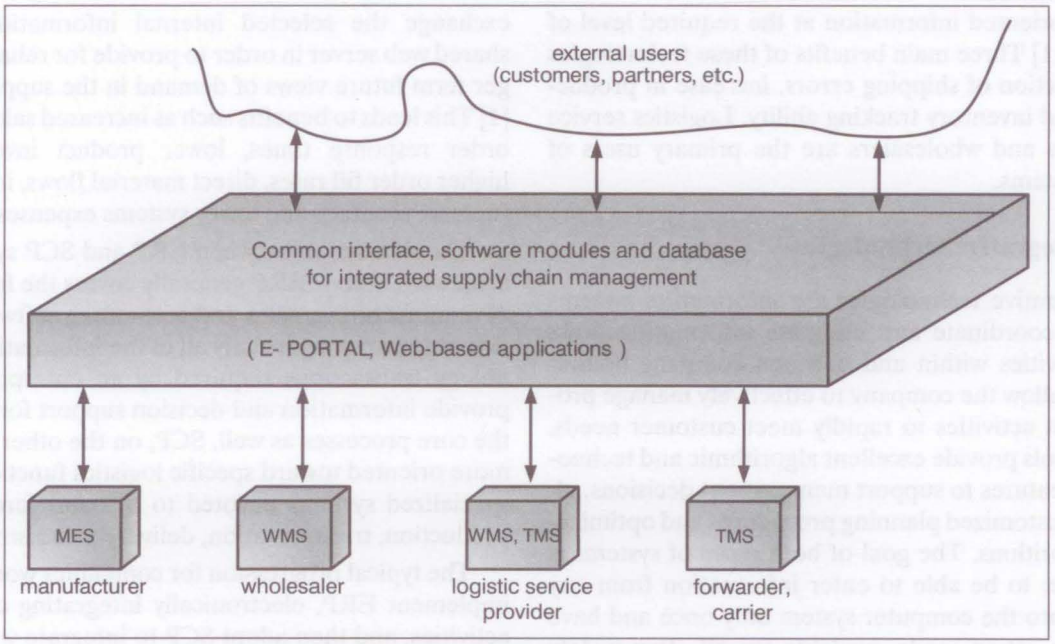

Figure 2 - Modern integrated supply chain management

3. BENEFITS OF INFORMATION TECHNOLOGY ADOPTION

One of the primary purposes of adopting and implementing new technologies in any specific functional area is to reduce overall operational costs. The next is improvement of operational performance, including improvement in shipment accuracy (reduction of shipping errors), increased accuracy through the automation of redundant tasks, removing the human error factor, and the improvement of customer satisfaction. Another mover of the supply chain technology is the expectation of reduced inventory levels, measured in improvement in inventory turnovers and the reduction of lead time. Information technology also reduces administrative and purchase order costs.

Another very important impact of information technology is the increase in the degree of integration between supply chain relationships, which can be expressed in improvements in information sharing, coordinating of logistics activities, trust between partners, and commitment to supply chain relationships.

One of the most important positive impacts of information technology is on the performance of the entire supply chain. The key advantage of electronic integration is the speed and proficiency of exchanging information with partners in order to better control inventory throughout the supply chain.

Today's electronic logistics applications or internet based systems deserve special attention, because the key driver behind the adoption of the latest e-logistic software and service offerings is customer satisfaction.

4. SUPPLY CHAIN TECHNOLOGIES OF THE FUTURE

In the field of information communication technologies every prediction as to how the development of technologies will proceed is tenuous. The main reasons are the velocity of changes in doing business, in information technology development itself, and the impact of globalisation and other economic factors that drive or have direct impact on the development of ICT. But there are some points we can emphasize with confidence. There is the daily phenomenon of the internet developing a greater and more powerful role in doing business, all kinds of electronic commerce technologies, including e-portals or e-supply chain portals as technologies that truly facilitate e-processes and change business processes by giving customers access to information they would otherwise be calling around for, and the streamlining of business processes by reducing the transaction costs of carrying them out. The goal of the e-portal is to consolidate all information in a single, browser-based dashboard, aggregating related applications and data, offering to a company the possibility of managing its operations in real time.

Every day there is a greater need for cooperation, linkage and collaboration of business partners, who form the supply chain or cluster, and dictate an even more rapid development and adoption of technologies that integrate the entire supply chain or support cooperation between members of transport logistics clusters, such as supply chain planning systems.

The common denominator of all of these technologies is that they electronically link members or partners of supply chains or clusters and provide end-to-

-end electronic communication and automatic data capture and transmission technologies. They offer to customers a cheap, fast and easy way to make their orders, track ordered products on the transportation logistics path from producer-supplier to them, and make all financial transactions related to these products. These are the main benefits of modern supply chain management tools and systems.

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POVZETEK

SODOBNE INFORMACIJSKO KOMUNIKACIJSKE TEHNOLOGIJE IN ORODJA ZA UPRAVLJANJE OSKRBNIH VERIG

V članku so predstavljene najpomembnejše tehnologije, ki se uporabljajo pri upravljanju oskrbnih verig, vključno z najsodobnejšimi programskimi orodji in sistemi, ki se uporabljajo na področju transporta in logistike. Osnovni namen teh tehnologij je izmenjava informacij med sodelujočimi organizacijami v oskrbni verigi ter upravljanje podatkov in aktivnosti znotraj nje. V zadnjem času smo priča vse večjemu odpiranju lastniških, zaprtih programskih sistemov preko interneta. V naraščajočem e-poslovanju zasedajo pomembno mesto portali, ki predstavljajo skupni vmesnik ali stično točko med zaposlenimi, poslovnimi partnerji in strankami, torej glavnimi akterji v oskrbni verigi, do katere je mogoče dostopati preko spleta.

KLJUČNE BESEDE

oskrbna veriga, upravljanje oskrbne verige, informacijsko komunikacijska tehnologija, programski sistemi

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