The Role of Internet of Things on the Development of Ports as a Holder in the Supply Chain

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Abstract

The new technology greatly affects the way of production, consumption, communication, service delivery and ultimately on the entire supply chain. All stakeholders in the business process must invest in new knowledge and develop new business models to adapt to the changing business environment. Connecting devices over internet (Internet of things) and stakeholders' synergy open up opportunities for new market achievements as well as for the improvement of business processes both in the supply chain and in ports. The development of information technologies has an impact on the reduction of errors, costs, time of information transfer and transport, inventory reduction and thus on better customization. There should be no weak links in the supply chain, which is especially related to the port and port processes that are the basis of the supply chain network. The port is the core of all activities of the supply chain and is also a place where supply and demand meet.

Key words: supply chain, internet technologies, internet of things, ports

1. Introduction

Trade itself has its own characteristics which are expressed in a way that certain products are promoted and presented to customers. The term *supply chain* is the result of attempts to simplify the problem which arises during the flow of materials, money and information management. Today's competitive business environment has changed the role of the supply chain and the functions of management. The paper explores basic features of cooperation and the impact of IT (*information technologies*) on the entire supply chain, supply chain characteristics, with a special review of the influence of information technologies on the development of the supply chain in maritime industry.

In the supply chain, ports are the most important meeting points and represent the meeting point of supply and demand. That is why this paper gives an example of the use of IT technology in ports. Ports, considering the nature of their business, are the integration between supply and demand, the relationship between the supplier and the manufacturer or the relations between the logistics companies. The exchange of information between all participants in the supply chain in ports presents the basis of an efficient process as well as the basis of its improvement. The development of information technology that enables efficient data exchange contributes to the optimization of business information systems both in the business world and in ports. Successful implementation of IoT (*Internet of Things*) in port processes requires strong connectivity and participation of all stakeholders and also of competitive companies of the supply chain for joint investments in IoT infrastructure.

2. Concept and development of the supply chain network

The supply chain presents a network of facilities and distribution options that perform functions of material supply, their transformation and the function of mediation in the delivery of the final product to the customer [1, 2]. The supply chain can also be defined as more participants (suppliers, manufacturers, carriers, sellers, etc.) that are involved directly or indirectly toward satisfying the end-consumer.

2.1. Concept of the supply chain network

The aim of each supply chain is to extract the entire, maximum value, while the value of the supply chain is achieved by the difference between the final product and its value and the customer's satisfaction in normal proportions and possibilities according to his requirements [3].

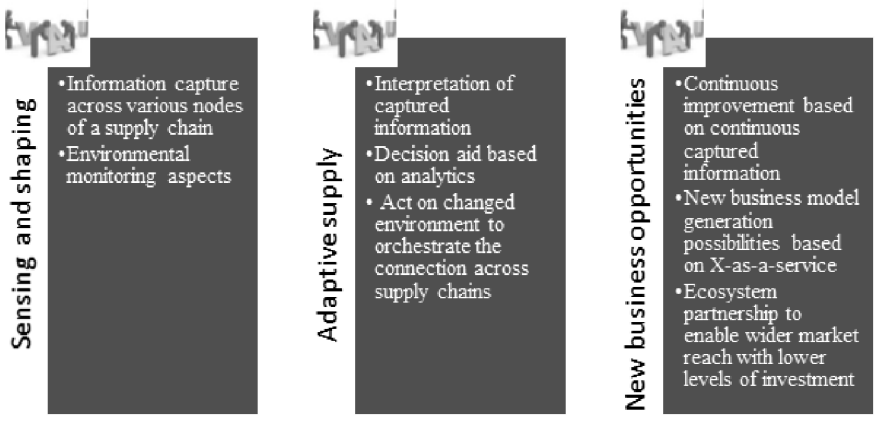

Figure 1 - Logistics IoT (Internet of things) framework, adopted from [4]

Figure 1 shows the potential for value creation by using an IoT application. The potential for value creation corresponds well with the scope of an IoT application. Business needs such as sensing the environment require little new value creation and, as a result, can be accomplished with relatively narrow-scope IoT applications. Similarly, to adapt an entire supply chain or distribution network to change requires more value creation and a wider scope of IoT application. Finally, to enable new business models and generate new revenue requires integrating customers into a product ecosystem, the widest of all IoT applications [4].

The quality of the supply chain is recognized through good connection between all the subjects (as seen in Figure 2: manufacturers, retailers, warehouses, distributor resellers) and executors (agents, shippers, providers etc.), which includes coordination of all information between suppliers, manufacturers and customers.

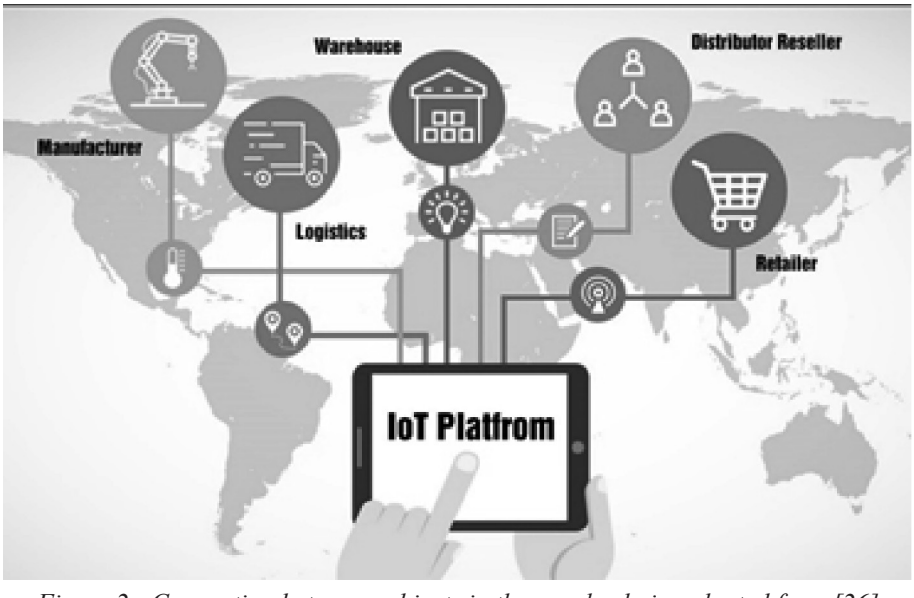

Figure 2 - Connection between subjects in the supply chain, adopted from [26]

The supply chain management is defined as the process of planning, implementation and monitoring of daily operations in the supply chain and also includes the process of colligation of the availability of required materials, their production process and the distribution of the final product [5]. The aim of the entire process is customer satisfaction and profit as well as the growth of the company. By increasing the complexity of the supply chain management, the supply chain management must be prepared by better organization and communication with new partners who are involved in the entire process of the supply chain [6]. The supply chain must be organized in a way to make

each sequence of materials or services directed toward their customers and to make each process more efficient and better performed. Every company has its own function that is different and distinctive in relation to others who participate in the business process and who contribute to the optimization of the supply chain. To make the supply chain more efficient, it should be as short as possible, as to enable all links that make up the chain to synchronously send goods to the end customer based on prompt information [7].

2.2. Development of the supply chain network

The entire supply chain configuration depends on sales of the final product and on the price the customer is prepared to pay for it and time to wait until the product reaches him. There are various models of delivery such as direct delivery from the manufacturer, direct delivery through a transit centre, mail delivery over a distributor to a customer, direct delivery from a distributor to a customer and customer pickup from a distributor/manufacturer [8]. The supply chain network design is the practice of locating and rationalizing the facilities within the supply chain, determining the capacity of these facilities, determining how to source demand through the network and selecting modes of transportation in a manner that provides the required level of customer service at the lowest cost [9].

2.3. Cooperation and exchange of information in the supply chain network

The supply chain cannot function as an independent company but comprises more entities which are part of it. Companies as independent subjects have seen business opportunities in amalgamation with other subjects in order to achieve business objectives. This way of amalgamation can be called network and is divided into two concepts i.e. ways of action. The first way is the interaction based on communication and exchange of relations, and the second way is the free flow of goods between individuals, sale. The access to the business process between participants is expected in a long term relationship. Combined planning and exchange of information in a longer period can result in the creation of innovative products and a new way of providing services [10].

Communication between partners is important for a successful supply chain process. The exchange of information refers to the extent the company shares any relevant, accurate, complete and confidential information in the right time with its partners in the supply chain. The exchange of information is conceptualized based on two dimensions: business planning and monitoring of the supply chain. On one hand, the exchange of information provides a common basis for partners and activates the flow of products, services, capital and feedback between partners. On the other hand, common information provides visibility to the supply chain, which refers to flows of basic materials for final products and services, and the view on the exchange of

information in the supply chain with accurate information from one entity to another [11].

The synchronization of decisions refers to the process whereby, together with the partners in the supply chain, activities are coordinated in the planning of the supply chain and of operations to optimize the supply chain. Decisions about the supply chain include the combining of information and plans, the solving of risks and conflicts, the establishment of procedures, rules and routines. With combined planning, it is necessary to harmonize business and capacities of each common partner [11].

The problem of synchronization of decisions is that each partner of the supply chain has its own right to decide about their supply chain and business process planning. The level of synchronization of decisions can be seen as a key element of the cooperation in the supply chain and as a way of building and maintaining mutual partnerships. Information technologies, as a system for decision support, can be used for the implementation of effective harmonization, but the best answer to successful synchronization of decisions is customer satisfaction [10].

3. Possibilities of *IT* application in the maritime industry

The development and improvement of information technologies in the entire logistical process creates pressure on port systems, requiring continuous development and technological progress at an adequate level. The primary goal of IT in the shipping industry and IT development in the port system are: to prevent unforeseen breaks in transport, to increase energy efficiency and to reduce maintenance costs. IT technology allows constant cargo monitoring (*smart containers*), the exact time of ship arrival at a port, handling automation at port terminals by using IoT, in a way that data are collected through various sensors in big data (*humidity, temperature, location*) where they serve for further processing. In case of unforeseen situations (bad weather, delays in port, damage to containers), intelligent devices provided with software components in themselves are able to diagnose a specific fault. Thus responsible persons can immediately react and try to solve the problem. The data that are stored in the Big Data through sensors serve for further data analysis that is crucial in making certain business decisions for the future (lack of a specific technology, improvement). With this mode of working ship operators and ship owners will benefit most, as can be seen in Figure 4.

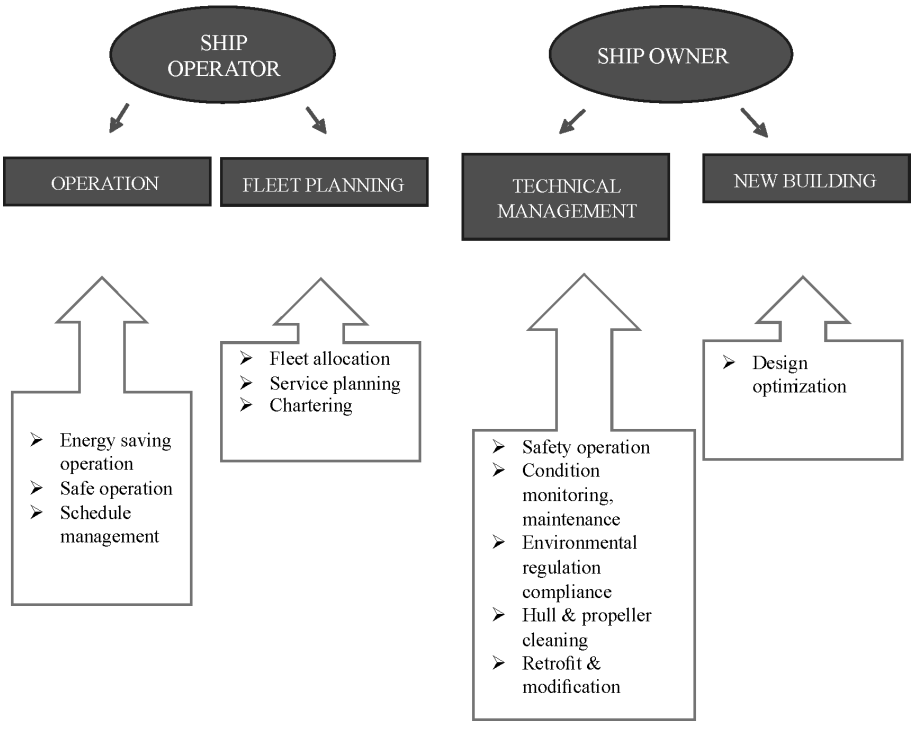

Figure 4 - Benefits of using IT applications (e.g. by ship operator and ship owner), adopted from [24]

The development of technology that has been used today and has enabled the optimization of business processes and business operations would not be possible without the use of the Big Data Analysis. Data which are collected and stored in the data warehouse (Big Data Warehouse) are used for further analysis (Big Data Analysis), whereafter decisions in the business process can be made on time and thus optimize and accelerate the operation of all business processes. The impact of the Big Data Analysis on business processes is shown in Figure 5 [24].

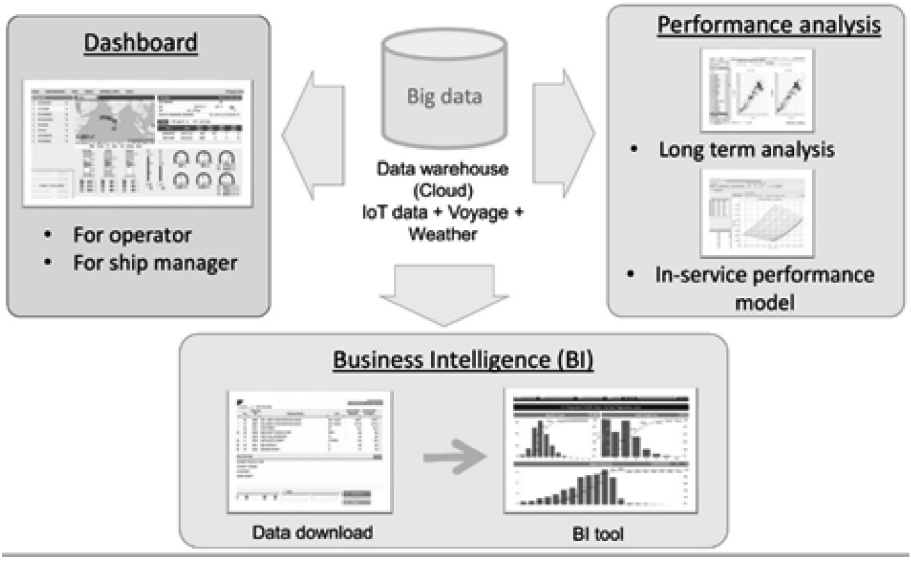

Figure 5 - Toolbox of using Big data, adopted from [24]

Analytics helps optimization of key processes, functions and roles. It can be leveraged to aggregate both internal and external data. It enables organizations to meet any stakeholder reporting demands, manage massive data volumes, create market advantages, manage risk, improve controls and, ultimately, enhance their organizational performance by turning information into intelligence [25].

The exchange of information in the port system is achieved through the communication between the activity holder and the central database. The process of information system designing should be subordinated to system users, to their needs and requirements. Therefore, the accuracy and availability of information in each situation and the flexibility and connectivity within the system as well as the possibility of an efficient information exchange with potential users can be stressed out as key determinants of the functional efficiency of the port information system [13].

4. Influence of IoT in port processes

Internet of things is a technology which enables integration of devices over the Internet and their mutual communication as well as interaction with various applications. Communication takes place in relations between things and people, as well as between devices themselves.

4.1. The scope and range of IoT

Devices with embedded sensors generate information through the communication structure and provide insight into processes, secure a functional environment from attacks, raise the productivity of people and property and provide profitability by identifying new business opportunities. Challenges of IoT technologies include the way of collecting, transmitting, securing and storing such data. The scope and range of the Internet of things dictates the use of open, expandable and massive solutions across these areas, and its responses to any set challenges will enable capitalization of exceptional possibilities of the industrial IoT market [16].

Internet gives us great opportunities. It facilitates and accelerates the flow of information, allows communication with everyone in the world – the medium for the first time allowing communication with everybody [13]. It is a simplifying means that can improve the lifestyle of humans in many ways, but can also threaten it. An individual, associated with the Internet, becomes the leading medium today and the producer of technology. Internet culture is a culture of creation and creators are at the same time its first users and users form societies called virtual societies. Certainly, the information technology has been progressing and creating new possibilities for progress, yet it is necessary to keep in mind that this technology represents several risks.

4.2. Framework of Internet of Things in Smart Ports

Successful implementation of IoT port processes requires strong connectivity and participation of all stakeholders and also of competitive companies of the supply chain for joint investments in IoT infrastructure. Thus, it is necessary to invest in models M2M (Machine to Machine) and V2V (Vehicle to Vehicle). M2M refers to the communication between two devices with built-in processors, smart sensors, drivers and mobile devices. The precondition for the functioning of these two models is communication over the Internet in a single, common, intelligent IoT network [19]. The use of M2M communication has been growing faster and faster. The aim is to automate and increase the efficiency of individual processes, systems or complex devices. The basis of this model is the collection of data, transmission of data through the communication network, data processing and response to appropriate information. In this way, the availability of information is ensured in the right place for those users who need them most in order to make optimal decisions. This model will certainly affect the production process, the communication, and the exchange of goods, both at the local and global level [19].

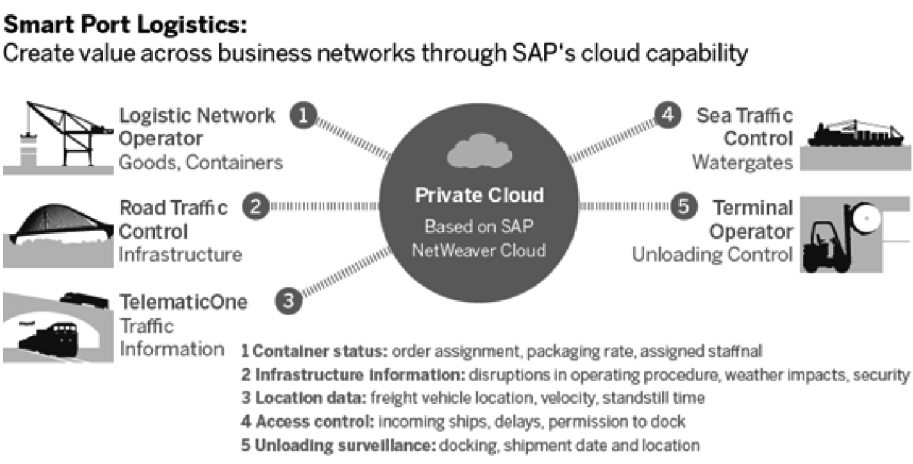

Figure 3 - The framework of IoT in a "Smart Port", adopted from [27]

A framework of using IoT in a port is shown in Figure 3. It is an example of the way the use of IoT can contribute to the port development and the whole supply chain.

The options with IoT in Ports and Shipping are the following [20]:
- Fully-automated port terminal,
- Drastically lower operating costs/labour,
- Autonomous cranes to load/unload containers,
- Autonomous vehicles to transport containers,
- GPS tracking and management of cargo,
- Better asset protection of expensive freight,
- Communicate with other vehicles in supply chain (i.e. trucks, freight rail cars, etc),
- Live video surveillance of port/docks,
- Enable mobile apps for port workers to boost productivity and improve operations,
- Meet strict regulations of shipping industry.

It provides real-time monitoring of the vehicle, the container, the cargo, the ship, and the clearance process, and ultimately the possibility to form a whole-process intelligently, and visually by the visualization monitoring system. Firstly, the unified data standardization system and data exchange system are built to do business carding and data needs analysis. Taking IoT technology as a basic infrastructure, by using such technologies as RFID, sensors, WSN, wireless communication, cloud computing, 3D virtual reality, fast automatic supervision, acquisition and tracking of containers, transport vehicles and goods can be achieved, in order to enable information networking and real-time data exchange in ports, yards, warehousing, customs, freights, and to form the intelligent management of traffic flow, logistics and information flow [21].

The second model that is closely related to M2M is V2V. V2V is a new concept that still requires a lot of research. In this case, vehicles act as a node in the network and communicate among themselves by using sensors which are connected in ad-hoc networks. This is a relatively new network technology whereby vehicles are constantly sending data about their current location, speed and direction of movement. In this way efforts are made to significantly lower the possibility of traffic accidents. The V2V standard is based on a protocol which is very much like the Wi-Fi network, GPS technology and sensors insight cars that detect any turning, breaking and other vehicle movements [22]. The V2V network infrastructure is quite complicated and has no fixed topology that must be followed in order for vehicles to move from one place to another. The application of such network can be divided into four wide categories, i.e. safety and avoiding of collisions, management of traffic infrastructure, telematics and entertainment services, and Internet connection. There are two kinds of communication: the communication between two vehicles and the communication between a vehicle and the communication center. As far as the development of the *Supply Chain Network* is concerned, special importance is given to the communication between the vehicle and the communication center, which would save the delivery time and find new distributional solutions [23].

5. Conclusion

The supply chain represents an organization system of people, technologies, activities, information and resources, which are together involved in the flow of cargo or services, from supplier to end customer. The supply chain implies complex processes inside and outside the business entity and carries the quality management risk within the supply chain.

The port is the core of all activities within the supply chain and is also a place where supply and demand meet. Information exchange between all stakeholders of the supply chain is the basis for an efficient business process. The flow of information within the supply chain needs to be fast, efficient and timely, for the entire process to be efficient and to ultimately satisfy the end user – customer.

The use of information technologies in all segments of the supply chain, i.e. the introduction of information technologies in the business of other stakeholders in the supply chain allows the flow and dissemination of information in a simple way. A synergistic effect is created by connecting all stakeholders of the business process in a unified entirety which results in a reduction of errors. Processes within the supply chain thus become more efficient, costs are reduced, the time of delivery shortened and the service quality raised.

The use of IoT technology in ports and the development of various applications that improve port operations as well as the entire supply chain process have only positive effects. If ports want to keep their users and acquire an outstanding position

on the market, they have to invest in information technologies and strive to optimize business processes concerning both the port and other supply chain stakeholders. The greatest potential for using information technologies is seen in the freight transport. It can be said with certainty that the development of new technologies will enable faster, more accurate, clearer and much safer cargo monitoring.

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Uloga Internet stvari na razvoj luka kao nositelja dobavnog lanca

Sažetak

Nova tehnologija značajno utječe na način proizvodnje, potrošnje, komunikaciju, uslugu isporuke i naposljetku na cijeli dobavni lanac. Svi dionici poslovnih procesa moraju ulagati u nova znanja i razvijati nove poslovne modele kako bi se prilagodili promjenjivom poslovnom okruženju. Povezivanje uređaja putem interneta (Internet of Things) i sinergija dionika otvara mogućnosti za nova tržišna postignuća, kao i za poboljšanje poslovnih procesa kako u dobavnom lancu tako i u lukama. Razvoj informacijskih tehnologija utječe na smanjivanje grešaka, troškova, vremena prijenosa informacija i prijevoza, smanjenje zaliha i samim time bolja prilagodba kupcu. U dobavnom lancu ne bi smjelo biti slabih karika, što je osobito vezano za luke i lučke procese koji su osnova mreže dobavnog lanca. Luka je jezgra svih aktivnosti dobavnog lanca te je također mjesto susreta ponude i potražnje.

Ključne riječi: opskrbni lanac, internetske tehnologije, internet stvari, luke