Real-Time Data Sharing in Production Logistics: Exploring Use Cases by an Industrial Study

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Abstract. Production logistics systems consist often of a number of low value-added activities combined with a high degree of manual work. Therefore, increasing effectivity and responsiveness has always been a target for production logistics systems. Sharing data in real-time may have a considerable potential to increase effectivity and responsiveness. The first step to realise real-time data sharing is to have a clear understanding of current state of PL systems and their requirements. This work is performed an 'as-is' situation analysis of an industrial case aiming at identifying which areas and applications would benefit most from real-time data sharing. The findings take a step closer to have a better understanding of CPS and Industry 4.0.

Keywords: Production logistics · Real-time data · Efficiency

1 Introduction

Production logistics (PL) systems comprises often a number of low value-added activities combined with a high degree of manual work [1]. To improve this situation, automating the operations and streamlining the processes is put on the agenda for companies [1]. This transition may often be stepwise, and thus it is not unusual that companies have inhomogeneous technologies within logistics systems, which again may reduce the overall effect of the implementation of the technology component. Typically, problems arising are incompatibility and lack of interoperability across the system leading to low information visibility causing long response time and low efficiency in PL systems [2]. High information visibility allows an improved decision making process and is therefore an important factor for improving the value of PL systems for stakeholders [3]. Furthermore, it can mitigate information sharing challenges caused by implementing inhomogeneous technologies. One of the main items facilitating effective information sharing is real-time data sharing [4]. Defining real-time information is a matter of conflict but Brahim et al. [3] defined it as "information that constantly allows action on the system in order to react rapidly and in suitable ways with respect to environment dynamics". In line with this definition, it is argued that the system is considered real-time when the information is still valid and relevant

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after collection and processing [3]. Reviewing the literature shows that using information flow in real-time has some benefits for PL systems in terms of integrated end-to-end delivery planning, more accurate material delivery and increased flexibility [5]. Real-time data enables the PL systems to have agile and swift reaction toward changes and unplanned events and can help to improve aligned decision-making among different stakeholders [6, 7]. Access to real-time data contributes to a reduction of bullwhip effects, reduction of misplacement and theft, reduction of identification errors, better replenishment policies, better scheduling, securing dangerous goods and temperature collected goods, improved traceability of products in the routing and improved the distribution planning are some other examples of these benefits [3]. Besides all these, real-time data is an imperative for any CPS (cyber-physical system) and Industry 4.0 concept [4, 8]. So far, researches have tried to clarify these concepts and their applications for PL systems. For example, Kagermann et al. [4] have depicted a stepwise digitalisation model for companies where collecting data in real-time is necessary for successful transition toward Industry 4.0. Qu et al. [9] have discussed AUTOM infrastructure, which facilitates real-time communication and helps to have a better resource management in production logistics. AUTOM infrastructure explains a general process of creating Radio Frequency Identification (RFID enabled shop floor. Lee et al. [10] have proposed 5C architecture for CPS implementation, which ensures real-time data circulation between physical world and cyber space. Tu et al. [11] have developed an emulation testbed in order to evaluate the effects of implementing IoT based CPS on PL activities. Most of the activates in their testbed are heavily depend on the real-time data, collects by mean of IoT technologies. Means of implementation are different but some examples can be categorized as IoT technologies like RFID, Real-time Locating System (RTLS) and Wireless Sensor Networks (WSN) [12]. Besides, cloud computing plays an important role to use IoT technologies more efficient in order to create CPS systems [13].

PL systems are complex and have high dynamics [1, 3] and introducing new concepts and technologies that enable real-time data sharing require clear understanding of their existing situation. Authors have found out most of the existing researches in this area, are still on conceptual level and there are less empirical study. To be able to realise these concepts in real PL systems, first it is essential to understand what areas and processes in PL systems need more attention and can benefit most from real-time data sharing. Therefore, the aim of this paper is to identify real-time data sharing use cases in PL systems by analysing the current state of a case study in production logistics. At the end, some suggestions regarding enabling technologies are shortly discussed.

2 Research Methodology and Approach

According to Yin [14] case study has the potential to investigate a phenomenon in its context. It seems the number of empirical researches in this area is rather scarce [15], and it is still needed to find out solutions on individual level. Besides, because of the complex nature of this phenomenon, case study can be an appropriate method to shed a light on some specific problems. This might even help to address more generic solutions based on this case study. The case company has been visited several times, and experts are interviewed to provide the current state regarding PL processes as well as describing the company's vision regarding PL. In addition, a group of managers in the case company has been participated in some meetings with the authors in order to clarify and confirm the case company's current and future plans. Some other data regarding logistical routines and procedures are reviewed by the authors to find a more detailed picture.

3 Case Study

AstraZeneca is an international producer of highly advance pharmaceutical, has almost 61100 employees in 18 production sites and supplies to over 100 different markets. They pay enormous attention to product and process quality in all parts of their supply chain. AstraZeneca has recognized that their logistics processes can be improved, that there is a low degree of information transparency and that they have inhomogeneous technologies in terms of both interoperability and maturity. Therefore, AstraZeneca is a good representative of an industry in digital transition facing the problems described above, and thus very suitable as a case study. One of the major production sites located in Sweden consists of central warehouse, high-bay, fixed bearing, cold chain and picking storages for warehousing system. Today in average, each item needs 20 touches to be able to be transported from initial stages to the end of process. AstraZeneca envision an "one-touch" strategy in order to have more efficient and responsive process flow within its production logistics with inhomogeneous level of automation and interconnectivity. The research presented here is partly carried out within the project 'DIGILOG' [16] and partly as a practical case study for undergraduate students at KTH University. The next section will first present the AS-IS analysis including an analysis of current problems, real-time data sharing use cases and some possible technical solutions to overcome the challenges.

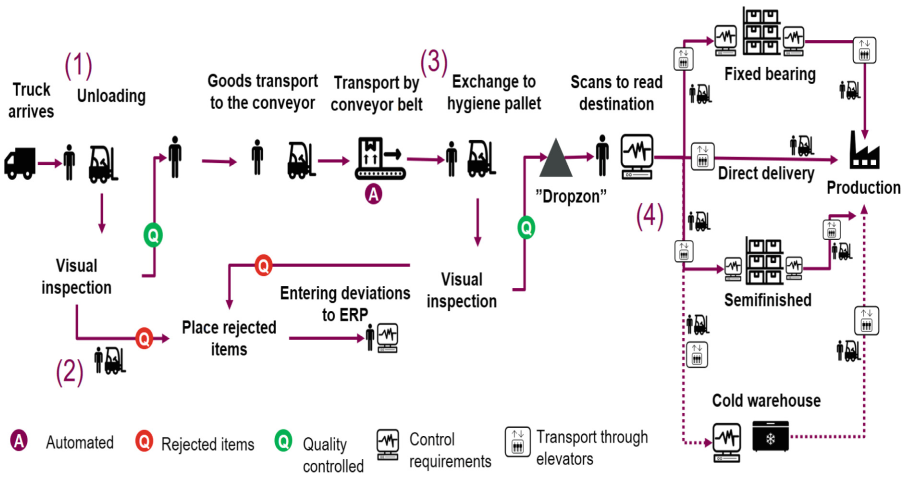

Fig. 1. Schematic flow of production logistics-AstraZeneca

3.1 Production Logistics at AstraZeneca

The focus of the study is the analysis of the two areas ‘Goods receiving’ and ‘internal material handling’ at AstraZeneca. Figure 1 shows the material flow in the case company. The figure is numbered 1 to 4 for sake of easier read. Each number represents one sub-process and contains relevant activities. For internal logistics, after unloading from trucks (1), the pallets go through quality control (2). Then, after barcode scanning, they will be transferred to pallet exchange zone since some of the wooden pallets need to be changed to hygiene pallets (3). Next, the pallets will be send to the transit hall to be shipped to ‘fixed bearing’ storage, semi-finished storage, cold storage or directly to the production area (4). Material movement happens in several floors by means of trucks and by using elevators. Before and after storing the items as well as quality control, the ERP (Enterprise Resource Planning) system must be updated by the operators.

3.2 Real-Time Data Sharing Use Cases at AstraZeneca

AstraZeneca’s strategy to automate some of the PL processes as well as existing issues in PL, are two major forces motivate real-time data sharing in order to meet one-touch vision objectives. Issues mentioned here are those that are somehow affected by data sharing among different stakeholders. This is reflected in Fig. 2. Each of these driving forces are more discussed in the next step, which lead to find use cases for each of these categories.

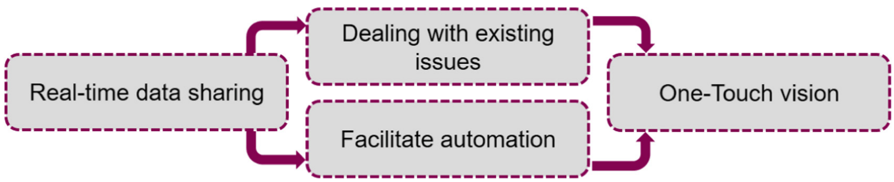

Fig. 2. Real-time data sharing in the context of production logistics at AstraZeneca

A. Use cases to address existing issues. After reviewing the PL process, interviewing experts at AstraZeneca and analysing the results of student projects, following issues are identified.

1. For goods receiving, there is no information regarding the arrival time, type of items and the exact quantity of the ordered items from the central warehouse. Logistics personnel become aware when trucks arrive to the loading docks.
2. Similar issue exist when parts are shipped from transit hall to the production areas, which do not receive information regarding type, quantity and arrival time. Logistics personnel act based on their experience to collect received items.

3. Transportation of wastes is logistics duty. Logistics personnel move around regularly and remove waste bins. Sometimes there is no waste to be removed and it has already caused unnecessary movement for the personnel because of lack of information.
4. Destinations information are stored in barcodes, labeled on each of the pallets. Operators use laser scanners to read the tags on the pallets making sure items are delivering to the right destination. Sometimes labels have poor condition for scanning. The information visibility is rather low and manual scanning can be considered as low values-added activity.
5. Storing of materials into picking storage has no specific order and there are no information on what is the exact address of each pallet and can be placed in any available storage position. After placement, the storage address is updated in the ERP system for later retrieval.
6. Transporting pallets trough elevators handled by trucks. Since there is no information regarding the availability of the elevators, sometimes truck drivers have to wait to access an available elevator or even deal with unavailable elevators. In general, the elevators have no means of connection and information sharing with the world around.
7. The ERP system needs to be updated in several stages like storing the items, retrieval of the items and registering quality inspection results. All of these happens manually creating low value-added activities for the operators.

B. Use cases cause by planned automation. AstraZeneca wishes to automate some of the existing processes. Following describes what information is required to have effective implementation of automation.

1. Automated material transportation – vertically and horizontally. In this case, these data should be shared in real-time: location, estimated travel time, operational status and destination. To be able to use elevators: elevators position, operational data, maintenance data, estimated travel time and capacity of the elevator should be shared in real-time with the automated transportation system.
2. Automated visual quality inspection. Quality inspection does not only concern finding defects but also identifying the correct item. Identification data, quantity of items and picking location needs to be shared in real-time with both transportation system and the ERP system.
3. Automated storing and retrieval of parts from picking storage. Inventory level of each item needs to be shared with the ERP system in real-time. To be able to make the automated storing and retrieval system effective: location, estimated travel time, operational status and destination needs to be shared among the system agents. This enables the system to plan and schedule dynamically and avoid any probable collision.
4. Automated communication between conveyor and transportation system. Data regarding the location and positioning of items placed on the conveyor belts need to be communicated with both the conveyor system and the transportation system.

3.3 Real-Time Data Sharing and Enabling Technologies

Based upon the analysis of which information required to overcome the challenges identified in Sect. 3.2 it can be summarized that the following information needs to be provided in real-time: (1) Location and position; (2) Operational data (Type of mission, availability for the next mission); (3) Time (estimated arrival time); (4) Items identification (type and quantity of the data); (5) Maintenance data (service time, service appointment etc.); (6) Quality inspection results (Ok, not Ok); (7) Speed (to be used for fleet management); (8) Parts temperature. Next step therefore is a suggestion to map what technologies exist that can ensure real-time data sharing for AstraZeneca. Table 1 listed these technologies what data they should share in real-time to support PL processes in AstraZeneca. Part of this work has been carried out by KTH students at ML1136 in January and February 2018.

Table 1. Technologies ensuring real-time data sharing in AstraZeneca PL processes.

Technology	Data	Process
AGV fleet management (Automated Guided Vehicle)	Location, Operational data, Time, Maintenance data, Speed	– Unloading from the trucks – MM (Material movement) between quality zone and the conveyer system – MM from and to the drop-zone – MM through the elevators – MM from the warehouse to the production
RTLS (Real-time Locating System)	Location	– MM between quality zone and the conveyer system – MM from and to the drop-zone – MM through the elevators – MM from the warehouse to the production
RFID (Radio Frequency Identification)	Items identification	– Unloading from the trucks – Updating the ERP system – Visual quality control
Automated vision inspection system	Quality inspection results	– Visual quality control
WSN (Wireless sensor networks)	Operational data, Temperature	– Visual quality control – MM through the elevators – Drop-zone
AS/RS (Automated storage and retrieval system)	Location, Operational data, Time, Maintenance data, Speed, Items identification	– Storage and retrieval from the picking storage – Updating the ERP system

In the next step, a brief explanation regarding available technologies and their use in PL processes is presented. Types and numbers of existing technologies in this area varies. To decide what technology might be suitable, communication capability, flexibility, technology maturity and spatial constraints considered. However, some other criteria such as cost and AstraZeneca's competence to embrace these technologies have not been considered either because there were no information available or because it could severely limit the study. Means for truck unloading can varies from using AGV's, conveyor belt or crane system. Even though a more detailed study is needed to find the correct technology for implementation, but considering flexibility, implementation effort and compatibility with other technologies, using AGV seems more reasonable at this stage. Types, variations, and navigation techniques can be different: some follow magnets on the floor while some of the other types use radio waves or lasers. 'Toyota' [17] and 'Rocla' [18] are two examples of AGVs that use laser for navigation [19]. Another example is 'MIR', which scan the area and then use camera for navigation. The advantage of the solutions similar to MIR is the 'fleet management system', which enables the logistics system to plan and schedule multiple transportation simultaneously [20]. Besides, WSN can support material delivery to and from the conveyor belt system to identify when items should be delivered and identify any probable stoppage in the line. For pallet exchanging, automated pallet exchange machines or automated load transfer systems can be used. An example can be load transfer system from "Cherry's Industrial Equipment" [21]. To make material movement through elevators more efficient, connecting WSN and RTLS with AGV fleet management can ensure that items will be transported vertically fully automated with possibly shorter delivery time. Types of sensors, interconnection methods need further analysis. Regarding the quality control process, in addition to using RFID and industrial cameras, using dimension-measuring technologies might be necessary. An example can be VIPAC D3 [22] uses infrared laser scanners. AS/RS solutions such as Autostore [23] can be considered for automating the process. Implementing AS/RS system needs heavy investment, which makes this suggestion not critical for the first step.

4 Discussion and Conclusion

This paper has identifies use cases for real-time data sharing in PL by investigating an industrial case study at AstraZeneca. Finding shows, PL systems should have access to data within a specific time farm to make the PL system effective and responsive. Otherwise, data might only have value for historical analysis and not for immediate use of other stakeholders such as production line units. Goods receiving, delivery to production lines, waste transportation, storing and retrieval from storages, transportation through elevators and updating ERP system will benefit most from sharing data in real-time. Findings of this case study reveals that two major issues exist in the case company. The first issue is lack of logistical data such as arrival time, shipments quantity, shipments location and transportation equipment position. The second issue is the difficulty to retrieve the data such as difficulty in reading barcodes, difficulty to find storage address and difficulty to update the ERP system in several occasions. In order to deal with these issues, sharing data in real-time is demanded. At first, some of the processes need to be automated not only to facilitate real-time data sharing but also to increase effectivity and make the system less vulnerable against problems causes by human factors. Some automation suggestions are presented in Sect. 3. It should be noted that automation create some new requirements for data sharing which are discussed in the form of use cases in Sect. 3. Further research can focus on evaluating the results of real-time data sharing considering enabling technologies.

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