An intelligent bin system for decentrally controlled intralogistic systems in context of Industrie 4.0

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Abstract

Decreasing batch sizes in production in line with Industrie 4.0 will lead to tremendous changes of the control of logistic processes in future production systems. Intelligent bins are crucial enablers to establish decentrally controlled material flow systems in value chain networks as well as at the intralogistics level. These intelligent bins have to be integrated into an overall decentralized monitoring and control approach and have to interact with humans and other entities just like other cyber-physical systems (CPS) within the cyber-physical production system (CPPS). To realize a decentralized material supply following the overall aim of a decentralized control of all production and logistics processes, an intelligent bin system is currently developed at the ESB Logistics Learning Factory. This intelligent bin system will be integrated into the self-developed, cloud-based and event-oriented SES system (so-called “Self-Execution System”) which goes beyond the common functionalities and capabilities of traditional Manufacturing Execution Systems (MES).

To ensure a holistic integration of the intelligent bin for different material types into the SES framework, the required hard- and software components for the decentrally controlled bin system will be split into a common and an adaptable component. The common component represents the localization and network layer which is common for every bin, whereas the flexible component will be customizable to different requirements, like to the specific characteristics of the parts.

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1. Introduction

The future global market and manufacturing environment of the Industrie 4.0 will require changeable production and logistics processes to deal with highly customized products leading to small batch sizes which will have to be produced under the cost and performance conditions of today’s mass production. Particularly with regard to logistics, logistic networks have to keep pace with the emerging changeable production and value chain systems requiring autonomous and decentrally controlled networks of cyber-physical systems (CPS) which allow changeable logistical processes [1,2]. In line with this “fourth industrial revolution” logistics will further develop into a “cognitive logistics” which, based on the availability of a wide variety of information on all level of the logistic systems, is capable of adapting fast and flexible to volatile environments and can draw conclusions and optimize itself based on captured data. Also the tasks of logistics shift in times of decentralization and individualization of the production with the goal of low inventories more and more in the direction of a flexible and with respect to costs, time and use of resources optimized pathfinding. By doing this, logistics will also generate an added value in the future by providing customers the right products, at the right time, at the right location, in the right quantity and quality [3].

The cross-linking, automation and intelligent optimization of production and logistics processes will also lead to more efficient production of individualized products at economic reasonable conditions. Production and logistic equipment, raw materials, semi-finished and finished products will more and more communicate (semi-)autonomously with each other and independently optimize processes based on specific parameters of the respective partner, production and customer domain enabling tremendous efficiency gains. Also production and logistics networks can be adapted to the actual customer demands (instead of to the forecasted demands) in real-time. By a continuous optimization of the production program in combination with the use of additive manufacturing technologies, the production of customized products can be achieved under economically attractive conditions and at the same time logistics can be simplified e.g. by producing (spare) parts at the location where they are actually needed [4]. Intelligent bins are a major enable to realize these autonomous and decentrally controlled value chains by transferring major decision and control functions of the material flow to the bins in transport.

2. Decentralized control of intralogistics systems

Following highly dynamic market conditions and an increasing complexity of logistic networks efficient logistical processes are becoming more and more difficult to achieve with conventional planning and control methods. To achieve future flexible, adaptive and proactive logistic processes a decentralization and autonomy of the logistic decision-making processes is required. Based on new information and communication technologies intelligent logistical objects which are able to take over planning and control processes can be realized and transferred to the level of the physical material flow [5,6]. Today’s material flow systems in industry mainly rely on centralized material flow computers which are not capable of dealing with future challenges like individualized products, small batch sizes and volatile market conditions leading to the requirement of constant changes of the logistic system, like changing sources and sinks which have to be served. These centralized material flow systems are designed based on complex, centralized material flow controller architectures programmed based on predefined processes which would lead to a huge increase of complexity to transport these batch size 1 transport orders and a constant programming effort in changeable production systems [3,7,8]. The development and application of decentralized control methods for material flow systems combined with the approach of the Internet of Things bear a huge potential to solve the arising challenges within changeable production systems of Industrie 4.0 [3].
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