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Simulation based Validation of Supply Chain Effects through ICT enabled Real-Time-Capability in ETO Production Planning

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Abstract

According to Industry 4.0, real-time information in production planning and control, shows a high potential for optimizing the whole supply chain. The paper considers the plant building industry, especially the off-site fabrication and on-site installation. Traditionally, production planning is centralized following a Master Schedule that rarely is up to date, ignoring deviations on-site. As a result, components are delivered in advance or too late, which create non-value adding activities and high inventory levels. The paper proposes an ICT-supported nearly real-time capable production planning approach, which by means of a simulation, shows a drastically reduction of the inventory level on-site.

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Keywords: Real-Time Capability, Production Planning, Digital Factory, Engineer-to-Order, Just-in-Time, Supply Chain Management, Industry 4.0

1. Introduction

With the introduction and development of ERP (Enterprise Resource Planning) systems, the foundation was laid for centrally managing data creating a common database for production companies. Advanced Planning and Scheduling (APS) systems develop solutions for complex planning and scheduling problems using optimization

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algorithms [1]. By intelligent and automated planning and control systems, future smart factories are able to provide real-time information throughout the entire supply chain [2]. The increasing trend towards digitalization allows a more accurate and reliable production planning and control through (nearly) real-time data. If information is always available in the entire supply chain and kept up-to-date at all times, a future demand driven value chain and factory becomes an achievable goal. In symbiosis with highly responsive, reconfigurable and time efficient production systems [2, 3] emerging trends towards mass customization [4, 5] can be managed. With the implementation of Cyber-Physical Systems (CPS) and Internet of Things (IoT) sensing enterprises become reality. Manufacturers can sense deviations from the production plan as soon as they appear and identify delays in the logistics network in real-time [7]. A central issue in the digital, sensing and smart factory of the future remains, how digital integration and real-time data monitoring can be realized in practice [6].

The plant building and construction industry is characterized by an off-site fabrication and on-site installation of components. Traditionally, fabrication is based according to a static Master Schedule, which rarely considers deviations on-site. As a result, components are delivered too early or too late to the site for installation, causing the following kinds of waste: 1) The overfilling of buffers on-site, inducing handling and searching activities and increasing the risk of damages. 2) Construction interruptions due to missing components causing waiting times and low productivity levels on-site.

The paper is structured as follows: First, new challenges and opportunities for production planning and control through the emerging trend of Industry 4.0 are described. In a short literature review, the actual state of the art in real-time capability in production planning and control is summarized. Next, the concept of a (nearly) real-time production planning approach for the ETO plant building and construction industry is presented. In this context, due to usually long lead times, real time has actually a slightly different meaning as in industrial series manufacturing. Thus, the exchange of management information is based on a weekly frequency but a true real time availability of management information (e.g. minutes or seconds) would be nonsense. Afterwards, the effects of the proposed approach will be validated through a simulation using the tool FlexSim.

2. Real-time capable production planning and control in the digital factory of the future – state of the art

2.1. Industry 4.0 – challenge and opportunity for production planning and control

After mechanization, electrification, and computerization of industrial production we are now in the Internet of Things (IoT) era or also called as the fourth industrial revolution (Industry 4.0). With the emerging trend of Industry 4.0, companies will connect and link their products, machines, storage/handling/transport systems, and other resources worldwide as CPS in the so-called ‘smart factories’ [8]. The term “Industry 4.0” is actually highly discussed as a vision in research and industry to revolutionize production management and the factory of the future. We are now at the beginning of a new epoch in production, where web technology and intelligent automation as well as digitalization support the development of CPS [9]. The concept of Industry 4.0 is strongly related to the term CPS [10]. The term emerged around 2006, coined by Helen Gill at the National Science Foundation in the United States [11]. CPS capture data of the real world via sensors, process them with software from embedded controllers, use the Internet and cloud computing for mutual communication between the connectors, and interact with real world by means of mechatronic actuators [12]. The desired benefits are evident: intelligent, networked objects and autonomous control systems are able to reflect customer demands in real-time [13].

Advances in production planning and control have focused on increasing the sophistication of the planning function [14]. CPS act as provider to change the principles in production planning, from centralized production concepts to decentralized manufacturing systems [15]. Many manufacturing companies are still at the very beginning of collecting and using data gathered during production processes, dealing with the problem that major parts of the collected data are outdated or biased and far away from real-time. Emerging Industry 4.0 technologies in data gathering of production management offer the opportunity to receive accurate information and precise feedback for a reliable production planning and control [16]. Production planning and control (PPC) should be able to provide feedback about disturbances directly when they occur and communicate this feedback to the factory-level PPC systems [14]. Therefore, information of all involved products, processes and resources are needed in real-time. However, stakeholders within production management had rarely access to this real-time information [17].