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## Integrated Analysis Framework for Improving Production Processes in Software-Intensive Systems

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### Abstract

Software-intensive systems involve the using of software engineering that cooperate with other engineering fields to achieve common goals, e.g., to provide good quality products to the customers in the right time. In the production automation systems as examples of software-intensive systems, the projects managers want to observe the production processes, so they can check the conformance between the running systems and the planned systems, e.g., whether the systems provide the expected products in the right time, how much time needed to finish a sequence of jobs is. However, the observation of production processes in these systems is difficult because heterogeneous data models are used to represent data from business and production layers. We propose an integrated analysis framework for improving production process in the production automation systems. Current results show that the framework can help the project manager to plan and conduct production process data collection and analysis for improving the process quality.

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*Keywords:* software-intensive systems; production automation systems; analysis framework; process improvement

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## 1. Introduction

Software-intensive systems typically involve software engineering that support and cooperate with other engineering fields, e.g., mechanical engineering or electrical engineering, to achieve common goals, e.g., to provide good quality products to the customers in the right time. Production automation systems as example of software-intensive systems, are commonly used for producing manufacture products in mass production, fast finishing-time, and often changed configurations due to changes in customer orders.

Our research is dealing with production process management in the production automation systems, especially in observing and analyzing production process data for supporting the project managers' decisions on enhancing quality of the process and the products. In the production automation systems, the project managers observe and measure the quality of the running processes against the designed processes, to be able to take further decisions on improving the quality of processes and products, e.g., to change the configuration of layout due to users' requirements, to add more machines to the layout to finish the products faster.

However, the production process observation is difficult due to heterogeneity of tools and data models used by stakeholders from different engineering fields or layers. The manual process data collection from different engineering tools is error-prone and takes a lot of time, while the project managers' decisions are based on their experiences and expertise rather than based on the real process data. Hence, the systems are depending on the availability of the experts, which is scarce and limited.

To solve these problems, we propose to have an integrated analysis framework for production process data collection and analysis from the production automation systems. The current results show that the integrated analysis framework can support a more accurate project manager decision making. Also the using of automated approach for data collection and analysis make the work more efficient than by using the manual approach.

## 2. Related Work

This section summarizes related work on software-intensive systems, the production automation systems simulation and the production process observation approaches in the production automation domain.

### 2.1. *Software-Intensive Systems*

Software-intensive systems involve inclusion of software that essentially enhances the functionality of the systems [4]. The software-intensive systems have special characteristics, e.g. heterogeneity and multifunctionality, reactivity and timelines, human-machine interaction, complex hardware/software architectures, heterogeneous distribution, criticality, maintenance and long-term operation, and domain specificity. The verification of software-intensive systems is an important issue that is not covered in this paper yet.

Cruickshank et al proposed a validation metrics framework for safety-critical software-intensive systems [6]. By using Goal Question Metrics (GQM) and Goal Structuring Notation (GSN) approaches, they build the framework to be applied to safety-critical, software-intensive surface-to-air missile system. The application area is by now limited, but it is possible to be generalized in other specific areas.

### 2.2. *Production Automation Systems Simulation*

One of research directions in the production automation systems is designing and implementing simulation of production automation systems like Manufacturing Agent Simulation Tool (MAST) [14] to simulate the components and the behaviors of the systems by using multi-agent technology, so the reconfigurations of the real systems which is hard, risky and costly, can be reduced. Further extension of MAST, named Simulator of Assembly Workshops (SAW) [10], provides algorithms to handle certain class of failures and reschedule the business orders.

The benefit of using multi-agent simulation in the production automation systems is that we can simulate the new configurations of the systems before they are applied to the real systems. We can measure the effect improvements before and after some reconfigurations are applied as well. However, validation of simulation results to the real

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