

Situational Handling of Events for Industrial Production Environments

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Abstract.

Industrial production environments are complex, volatile and driven by uncertainties nowadays. Enterprises are striving for flexibility and adaptability to handle these challenges and remain competitive. Market requirements such as shortened product life cycles, increasing number of variants, and customized products lead to complexity in production systems. To be able to handle this complexity, digitalization like the vision of “Industrie 4.0” can offer different solutions. In such complex production settings, decision-making and real-time reactions to events occurring during production processes are one way to handle the challenges. The approach presented here includes a situational handling of events for a manufacturing environment. The exemplary implementation of the method will be carried out by means of a complex Cyber-Physical Production System (CPPS) at the Fraunhofer Research Institution for Casting, Composite and Processing Technology IGCV in Augsburg and demonstrated using an example of a mass production for CFRP components.

Keywords: Complex Event Processing, Rules, Production Processes

1 Introduction

Digitalization leads to increasing amounts of data describing the status of products and resources in an industrial production environment. On the basis of this data, in order to achieve a near real-time monitoring and control of production and logistics processes, an intelligent processing and analysis of data is required. As a result of this development, "complex event processing" (CEP) plays an important role for analyzing extensive data streams in near real-time. CEP are methods, techniques and tools to process events in real-time [1]. For example, fraud prevention systems in the financial world are based on CEP. Fraud detection in banking and credit card processing depends on analyzing events. This must be conducted in real-time to prevent losses before they occur. [2]

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CEP is both an industrial growth market and a research area. Despite the first successful projects in various fields such as banking, there is still a need for experience with adaptations of CEP to specific processes like the industrial production environment. [3]

For CEP applications a distinction can be made between complex events, whose patterns within the data streams are known a priori, and formerly unknown patterns, which have to be recognized for the first time. In the first case, special event query languages provide a convenient way to specify complex events and efficiently recognize them. In the second case, machine learning and data mining are applied to the data sets. [1]

The approach presented here focuses on the second case. Figure 1 shows a schematic procedure of a CEP engine [4].

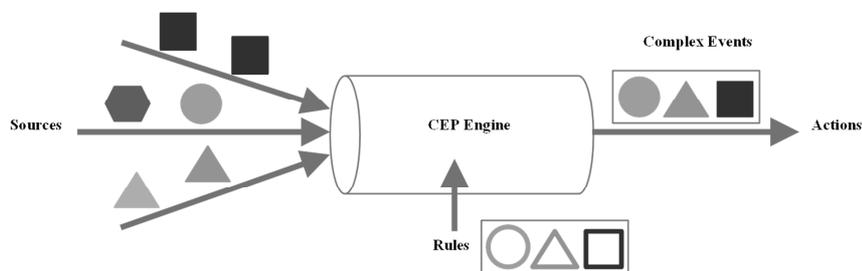


Fig. 1. CEP Engine

Multistage production processes with sequentially following process steps are characterized by complex relationships and interactions between the process parameters. Challenges for processing events in these production processes include the large amount and heterogeneity of the data, the high speed requirement of these events, and the partially insufficient data quality. Therefore, there is a need to process the occurring events automatically, systematically and promptly. For this to be achieved, the following objectives have to be fulfilled:

- agility,
- responsiveness and
- real-time capability.

This corresponds to the idea of the Real-Time Enterprise (RTE). The RTE stands for real-time in the business world. All necessary information should be available at the right time. [5]

RTE includes the electronic control of internal business processes as well as those that affect business partners and suppliers. The timely consideration comprises all projects and properties and their current states interacting in real time.

A higher flexibility is achieved in process management using the Real-Time Enterprise, whereby the company can respond more quickly. Other benefits include the cost savings, higher speed and better product quality.

In order to implement RTEs various intelligent and decentralized control approaches are possible [6]:

- Multi-Agent Systems
- Holonic Manufacturing Systems
- Bionic Manufacturing Systems
- Fractal Manufacturing Systems
- Reconfigurable Manufacturing Systems
- Agile Manufacturing Systems
- Flexible Manufacturing Systems
- Service-Oriented Architecture
- Event-Driven Architecture

When comparing the different management approaches by criteria such as flexibility, agility, real-time capability, responsiveness and realistic modeling, significant differences, especially with regard to the application areas and the practicality of the control approaches, show up.

The current research activities aim to introduce the SOA paradigms in all control levels of a manufacturing company. Business applications offer their functionalities as services in a Service-Oriented Architecture (SOA). The communication approach of SOA is based on request-reply communication.

Since RTE has to react to events in real-time, the implementation of publish-subscribe mechanism is needed for RTE [7]. An Event-Driven Architecture (EDA) supports the production, detection, consumption and reaction to events. Nevertheless, SOA and EDA are complementary concepts for achieving modularity, loose-coupling, and flexibility [8].

In addition, the systematic processing of events that are generated during the production is a promising approach for the implementation of RTE. Although CEP is a proven technology in the financial industry, the acquisition of real-time monitoring and control of manufacturing processes requires more attention.

Figure 2 provides an overview of the classification of CEP as a building block for the realization of a Real Time Enterprises. For this purpose, a distinction is made between control architectures and software technologies.

A Service-Oriented Architecture (SOA) in conjunction with an Event-Oriented Architecture (EDA) can build the basis for the implementation of a Real Time Enterprises. The combination of these two architectures is also called SOA 2.0 [9]. In this context CEP, Simple Event Processing and Event Stream Processing are software technologies for the implementation of Real Time Enterprises. Simple Event Processing means that simple events directly trigger specific results. In contrast, Event Stream Processing is a technology for processing continuous event streams.

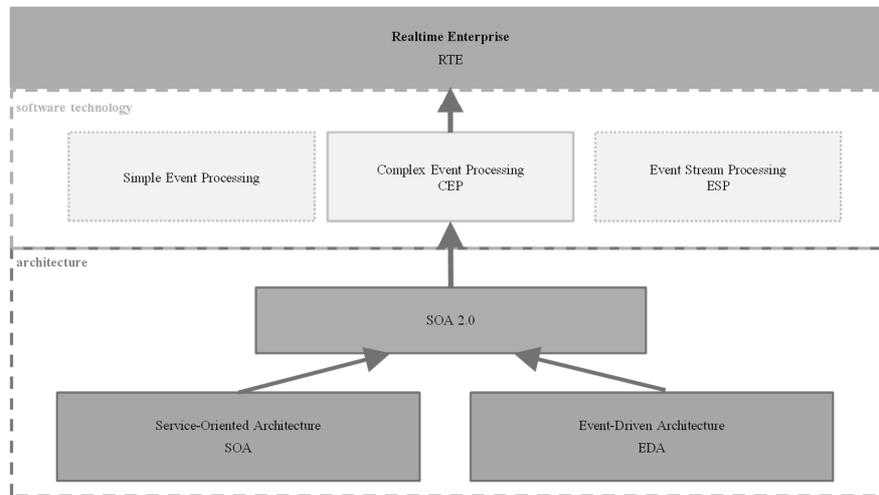


Fig. 2. Software Technology and Architecture

2 Research Question and Goal

In order to adapt CEP for applications in manufacturing environments, further research is necessary in the fields of knowledge representation, event modeling and event processing.

The goal of the approach represented here is to develop a situational event management. This situational event management should be based on the CEP technology. The focus lies on the development of a procedure for the deduction of rules for the CEP engine. Currently, experts have to design and understand event models that are representing the dependencies and relationships between event objects of the business processes [10]. Moreover, they have to understand the historical data and derive knowledge in order to implement declarative rules together with IT experts. Within this work a method that maximally systematizes and automatizes this proceeding should be developed.

The main research questions are:

- Which events are available and relevant for the real-time control of complex production processes?
- How can data of different sources be brought together in an event model?
- How can rules systematically and automatically be generated for event processing?
- Which actions are suitable for the situational event handling and control of the production processes?

3 Proposed Approach

The solution components for the realization of the event handling consist of the following three areas:

- event modeling,
- event processing and
- event reaction.

These three solution components build on one another strongly and influence each other. Since event processing is the central component of the event handling process, it is the focus of this work

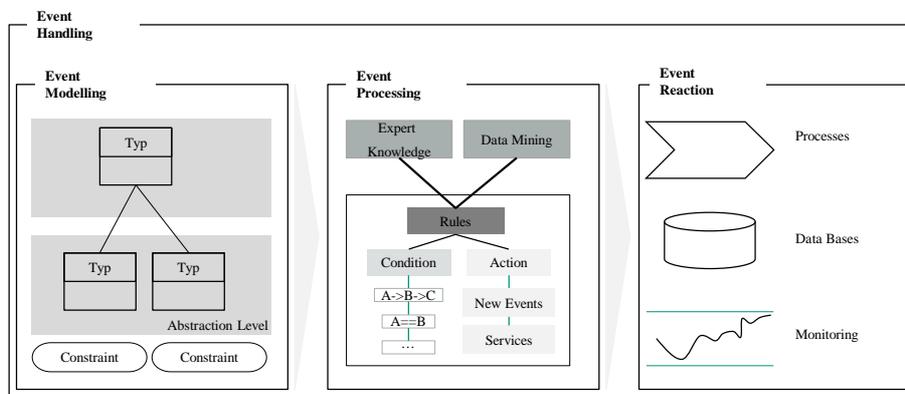


Fig. 3. Approach for Event Handling

3.1 Event Modeling

In order to formulate the rules for the CEP engine an event model has to be described to visualize the relations, constraint and abstraction levels. A modeling method for the description of the differences between the relevant events and dependencies has to be chosen. In addition, the relevant events for the real-time control of the production processes should be identified and be compared with standards and norms in the field of event definition. Moreover, alternative modeling methods and languages regarding event modeling should be compared.

However, first assessments have shown that the Unified Modeling Language (UML) is suitable for event modeling. Graphical event models and event constraints can be described by UML.

3.2 Event Processing

For this purpose, the area of rule languages and thus the evaluation and selection of possible software solutions has to be illuminated. The design of the rules should be based on expert knowledge and methods such as data mining. Alternative control languages and alternative event handling methods, like manual or automatic response to events, have to be elucidated. Different software solutions have to be considered for the realization of a CEP engine. The main focus of this part is the development of a methodology for the creation and adaption of rules for the CEP engine.

The methodology will be based on two pillars. One is the graphical user interface for domain experts and the other one is the establishment of rules by data-mining.

For the development of the rule system the requirements have to be collected, evaluated and analyzed. Important requirements are usability of the GUI and the reliability, flexibility and scalability of the system.

3.3 Event Reaction

Finally, the area of possible reactions to events has to be examined. The possible actions triggered by the event rules have to be defined and compared. Different output media such as tablet PCs, headsets and higher level IT system are suitable.

The main question will be: is a manual or an automatic response to events more appropriate for the field of production? Therefore, in an attempt to answer this question, a scientific study will be carried out in the context of the use cases explained in Chapter 4.

4 Use cases

The exemplary implementation of the method will be carried out by means of a complex Cyber-Physical Production System (CPPS) at the Fraunhofer Research Institution for Casting, Composite and Processing Technology IGCV in Augsburg and demonstrated using an example of a mass production for CFRP components.

The Learning factory for cyber-physical production systems (LVP) at Fraunhofer IGCV in Augsburg shows a modern production presented by the example of a gear-box.

The production scenario is based on the manufacturing and assembly of a gear box with a high number of different variants. The different parts of the gear box are produced on several machine tools. Subsequently, there is a quality assurance step before the variant specific parts are assembled on several stations. After this last step of the production process, the gear boxes can be delivered to the customers.

The demonstrator consists of two material stocks, a turning machine as a production resource, a quality assurance station and two manual assembly stations. In addition to these fixed resources, there is a mobile robot responsible for the material transport.

The goal of the prototypical implementation is the realization of an intelligent production control as a reaction to certain events during the manufacturing process of the

gear box. The handling of production information in smart products is realized by RFID tags. Several RFID antennas have been installed throughout the demonstrator to enable the reading and writing of information on important points during the production process.

Moreover, the situational event handling will be demonstrated using an example of a mass production for CFRP components. Within Carbon Fiber Reinforced Plastic (CFRP) production processes many events affect the quality and production planning and control. Through the interaction of the individual events, such as mold temperature, completion of required preforms, and so on, complex situations arise, which should be monitored and analyzed in real time. CEP is suitable for this application.

Challenges for the mass production of CFRP components include the high costs and the lack of transparency of the dependencies between the events that occur in the production process. In order to reduce the inventory, the transparency along the supply chain has to be reduced and manual operations have to be eliminated. This should lead to lower costs, increased responsiveness to changes during the production process and reduced efforts for rework.

The process costs can be reduced up to 40 % by the further optimization of the processes for the production of CFRP components. [11]

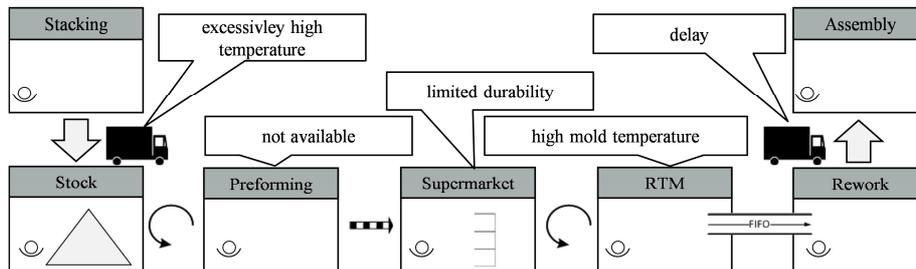


Fig. 4 CFRP Process and Events

5 Conclusion and future work

The use of the software technology "Complex Event Processing (CEP)" should be examined in more detail for the production area. A near real-time monitoring and control of production and logistics processes can be realized with the help of CEP.

For the present work this should be realized within a learning factory for digitalized production (LVP). The LVP shows the practical perceptibility of "Industry 4.0" for a richly varied gear production.

In addition, the feasibility will be shown for a real CFRP manufacturing process as part of a research project. The event processing will be developed for this use case, and thereby the procedure for developing a situational event handling will be validated.

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