About Adopting Event Processing in Manufacturing

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Today's manufacturing enterprises are facing increasing pressure due to globalization, uncertainties, and strict regulations, among others. To cope with aforesaid challenges, manufacturing enterprises need to enhance their monitoring and control of enterprise processes (i.e., business processes and associated manufacturing processes) within and across different enterprise levels. This results in achieving higher degree of transparency, flexibility and adaptability. Enterprise integration (EI) within and across different enterprise levels can be considered as a building block towards realizing the aforementioned goals. Further, this building block can be exploited in realizing a real-time enterprise (RTE), which is based on the introduction of sense-and-respond and learn-and-adapt concepts into enterprise processes [1]. Lately, event processing and event-driven architectures (EDA) are gaining more attention especially related to business processes to accomplish sense-and-respond [2]. For instance, fraud detection during billing process [3] and fraud mobile call detection [4]. Similarly, research has carried out work in the area of business activity monitoring (BAM) based on event processing [5].

In contrast to financial sector, event processing is far away from adoption in manufacturing enterprises. However, it could be vital to incorporate manufacturing processes along with the corresponding business processes to reap the rich benefits of event processing. Now, attempts are been made to realize event processing in manufacturing. For example, a stream processing solution named public infrastructure for processing and exploring streams (PIPES) has been integrated with a manufacturing execution system (MES) named i-Plant [6]. The solution exploits continuous query processing in factory automation.

In the context of manufacturing enterprises, research has been carried out at Information Systems Institute for enabling EI, and enhancing online monitoring and control of enterprise processes [7], [8]. A framework based on an EDA has been developed constituting various components as illustrated in Figure 1. Data collection engine is employed for acquisition of real-time process data from physical resources available on shop floor. A level above, data aggregation engine is in charge of integrating real-time process data with corresponding transactional data from enterprise applications (e.g., ERP system). In addition, integrated data is utilized to create and administer online tracking objects by tracking object manager of data aggregation engine [9]. IEC 62265-3 regards tracking as an "activity of recording attributes of resources and products through all steps of instantiation, use, changes

and disposition". Tracking objects can be created and managed for numerous enterprise entity types (e.g., product, resource, order, batch). Each tracking object is characterized by a set of tracking object items (e.g., pressure, temperature) and references to other tracking objects (e.g., product tracking object will have reference to batch and order tracking objects). Tracking objects will be forwarded by tracking object manager to process visualization clients for displaying real-time information. Further, process visualization clients provide interfaces for forward and backward traceability of enterprise processes and their entities. Apart from process visualization clients, tracking objects are also forwarded to complex event processing (CEP) engine for recognition of certain situations. On detection of a certain situation, CEP engine dispatches online control objects to an online control object analyzer of data aggregation engine.

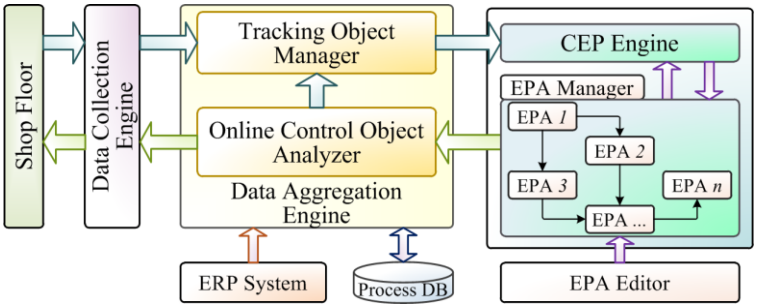

Figure 1. Schematic overview of EI and event processing in manufacturing

Event processing encompasses following components: (i) event producers, (ii) (complex) event processing, and (iii) event consumers [10]. In case of the aforementioned framework, tracking object manager can be seen as a dedicated event producer publishing tracking objects to all the subscribed clients (e.g., process visualization clients, CEP engine). In contrast to simple events, tracking objects can be interpreted as complex events which are composed of numerous simple events (i.e., tracking object items). Event processing engine is responsible for detecting certain situations occurred during execution of manufacturing processes from received streams of tracking objects and invoking appropriate reactions. Therefore, event processing engine employs event processing agents (EPAs) to identify situations and invoke suitable reactions.

An EPA manager deals with the lifecycle of EPAs. Besides managerial properties (e.g., unique EPA name), an EPA is composed of an event processing statement as well as an abstract definition of an online control object. An EPA can be used for a combination of tasks. First, execute an operation (e.g., transformation, creation, aggregation, filtering and deletion) on the tracking object streams. Several EPAs can be interlinked to form an event processing network (EPN) using the aforesaid operations. Second, detect certain situations by employing event processing statements on the incoming tracking object stream. Finally, invoke an appropriate (re-)action intended to be performed based on an identified situation (e.g., manipulation of shop floor resources). Further, EPA manager instantiates an online control object based on the abstract definition of online control object associated with the

appropriate EPA. In addition, EPA manager also incorporates the event context while instantiating the online control object. This control object is forwarded to online control object analyzer which can be seen as a certain event consumer. Online control object analyzer performs necessary actions utilizing services of data aggregation engine. EPAs can be defined dynamically by an enterprise member using an EPA editor and with the assistance of EPA templates. For simplified definition of event processing statements, an object model representing an event processing statement has been implemented. Enterprise member can define the (re-)actions within a certain EPA employing an abstraction mechanism.

Manufacturing enterprises are coping with increasing pressure to maintain its competitive advantages. This necessitates enterprise to enhance their monitoring and control of enterprise processes. In this regard, a framework is envisaged with two-fold objectives. First, integration of various enterprise levels which is a prerequisite. Second, employing event processing for enhancing online monitoring and control of enterprise processes based on the integrated enterprise. Aforementioned framework including event processing has been successfully realized in sand casting enterprise.

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