Chapter 6
Summary, Conclusions and Future Work

The necessity to (re-)act on internal and external events in (near) real-time has been formulated as part of the RTE vision. This vision requires an enterprise with fully integrated, automated and individualized value creation processes. With respect to manufacturing enterprises, the following problem areas could be identified in this research work: (i) standardization of shop floor interfaces to establish a vertically integrated enterprise; (ii) conceptualization of real-time monitoring and control concepts based on EDA and CEP; and (iii) their implementation in the realm of MES.

The seamless horizontal and vertical integration is a prerequisite for an immediate transfer of information from its POC to an appropriate POA. Further, the RTE requires measures to select and analyze relevant information, thus avoids an indiscriminant flood of data. Finally, a continual alignment of planned and actual process execution is envisioned by an RTE.

Overall, the realization of the aforementioned RTE in manufacturing requires the consideration of management, computer science, and engineering perspectives. The management community’s view of a manufacturing enterprise and its production management is focused on topmost enterprise levels (i.e., strategic and tactical enterprise levels). Further, from a management perspective, ERP is considered as a suitable approach for support of value creation processes.

However, a deeper and broader integration of the manufacturing level (i.e., shop floor) has been researched by the engineering community. Their research and development activities have led to various standards and implementations of MES. Recently, MES has been mentioned as a means to establish an RTE in manufacturing. In addition, control engineering has provided principles for the realization of multiple closed-loop controls (i.e., feedback controls). At this point, it is noteworthy that, for instance, cybernetics has been considered as a theoretical foundation and principle of the RTE. Nevertheless, major issues remain open with respect to the interface to shop floor resources.

The RTE was formulated by Gartner as a vision, thus does not explicitly define with which IT it has to be implemented. Nevertheless, the RTE’s behavior has been described as being event-driven. Therefore, EDA and CEP have been identified as enablers of an RTE. These paradigms enable IT systems, which adhere to the
following system requirements of an RTE to be built: (i) agility; (ii) timeliness; and (iii) availability of information. Unfortunately, so far, CEP has been employed only for financial and administrative processes within and across enterprises. Concepts and approaches for real-time monitoring and control of manufacturing processes that capitalize on CEP are rare. Also, the liaison of MES and CEP requires further attention in research.

A framework for the realization of an RTE in manufacturing has been conceptualized, implemented, and evaluated in this research work. This framework has been designed for manufacturing enterprises, which (i) produce tangible products; (ii) are SMEs; and (iii) are part of the German industry. Thus, the manufacturing enterprises and their manufacturing processes, which are supported by the developed framework, have been characterized. Thereby, the relevance of the manufacturing sector for the German economy has been discussed.

Before delving into the details of the developed framework, a related work on intelligent monitoring and control approaches, like MAS, HMS, and so forth, has been provided. Some ideas and concepts of these approaches could be transferred to the presented event-driven framework. The framework consists of two parts: (i) a process model that describes the methodology for the introduction of the IT architecture; and (ii) the design and implementation of the IT architecture for the realization of an RTE in manufacturing.

The process model entails (i) analysis and (re-) design of business and manufacturing processes; (ii) design of an enterprise data model and modeling of data flows between (IT) systems; (iii) identification of control-related knowledge employing, for instance, a KDD process and interviews with domain experts; and (iv) the use of this knowledge for monitoring and control of manufacturing processes.

The last two steps of the process model assume the existence of integrated process data, event-driven monitoring and control mechanisms. Therefore, an IT architecture has been developed that capitalizes on EDA and CEP. Process data is acquired from manufacturing resources and integrated with transactional data from enterprise applications. This functionality can be used to realize backward and forward traceability. Further, a real-time tracking of enterprise entities, like production orders, products, batches, and so forth, has been developed.

The stream of tracking objects can be interpreted as an event stream. This event stream is analyzed by a CEP engine to detect critical process situations and deduce appropriate (re-) actions. Noteworthy, the tracking objects contain actual process data as well as planned data from enterprise systems (e.g., ERP system). Therefore, the established control approach is based on an integrated enterprise, which is demanded by an RTE. Also, the remaining RTE principles, i.e., automation of decision-making processes and the immediate availability of information at the POA, are fulfilled by the developed IT architecture.

The process model and the event-driven framework have been implemented for a foundry. The framework is employed to monitor and control highly automated aluminum sand casting processes of the Ohm & Häner Metallwerk GmbH, Olpe, Germany, in their new plant in Drolshagen, Germany. The current release of the