# WEB BASED INTEGRATION OF MES AND OPERATIONAL BI

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Abstract: Internet and web-based technologies increase the informal networks within and across organizations. This implies an acceleration of changing basic conditions and forces the embracement of innovative technologies to achieve flexible business processes. However, current research indicates a lack of flexibility in enterprise applications with negative effects on customer satisfaction and service orientation. Hence, the paper's arguments build up on the hypothesis that a web service (WS) based integration approach is beneficial for a conjoint process oriented and flexible decision support oriented infrastructure. A combination of Manufacturing Execution Systems (MES) and Operational Business Intelligence (OpBI) is discussed, because both concepts are promising support of process flexibility. In result an architecture scheme demonstrates a WS oriented interaction of MES and OpBI functions. In conclusion the effort of information gathering can be reduced. The use of web-based technologies in context of operational decision making facilitates a comprehensive synchronization of business processes with flexibility-enhancing effects.

## 1 INTRODUCTION

The design and control of business processes based on coherent information is a determining competitive factor. Internet and web-based technologies influence the business processes of an organization as well as its relationships to customers and suppliers. These increasing informal networks accelerate the changing basic conditions. Companies are forced to embrace the emerging web technologies in order to keep their business processes flexible by corresponding adjustments. However, research indicates that organizations are not able to meet flexibility demands. According to a survey of the Aberdeen Group, 85 percent of companies do not provide an adequate flexibility within their applications (Rodriguez, 2007). This lack of flexibility implies high cost due to delayed decisions and low productivity associated with negative effects in terms of customer satisfaction and service orientation. With respect to the given issue, the position paper discusses whether a web service (WS) based integration approach is beneficial for a conjoint process oriented and flexible decision support oriented infrastructure.

The range of conformable concepts allowing efficient support is large and manifold. Recently, MES and OpBI came into the discussion promising both support of process flexibility. These concepts are integrative approaches for operational process control and analysis, but they come from different perspectives – the engineering and the decision support point of view. A combined approach of MES and OpBI facilitates overarching analyses to comprehensively coordinate and optimize processes so that organizations are able to react fast and flexible on business occurrences (Hänel and Felden, 2011). Considering the state-of-the-art, the integration potential of WS to combine MES and OpBI is not investigated, although especially service-oriented architectures (SOA) are beneficial to support flexibility (Erl, 2009). Therefore, we contribute to the research of WS and decision support by proposing a discussion about opportunities and potentials of a web-based integration regarding to engineering and economic driven systems.

Chapter 2 sheds light on the integration potential of OpBI and MES. Furthermore, the ability of WS and SOA in context of a flexible operational decision making is discussed. Chapter 3 joins the separately considered aspects and presents an architecture scheme for a web based integration of MES and OpBI. Finally, the paper is summarized to give conclusions and further research perspectives.

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## 2 STATUS QUO

The scope of OpBI and MES is the analysis of processes to recognize weak points, malfunctions or business interruptions to improve the management of business processes continuously and to generate overarching process information. This chapter explains the concepts of OpBI and MES as well as its potential of complementation. Thereafter, WS are put in context to the demonstrated decision support to support flexible architecture requirements.

### 2.1 OpBI and MES

OpBI is aiming for an integrated ensemble of analytical activities and operational processes (Eckerson, 2007). The main focus is on reducing times to collect, report, and analyze data as well as to take appropriate decisions (White, 2006). Information regarding the process states during progress is provided (Bauer and Schmid, 2009). Due to this reason, OpBI analyzes, controls, and improves organizational core processes in a fast and flexible manner (Cunningham, 2005). Thereby, a Corporate Performance Management is facilitated (Schwingel, 2010) considering the organization as closed-loop system, where strategic-tactical and operational management is interrelated (Golfarelli et al., 2004). Figure 1 comprises the functionality of OpBI.

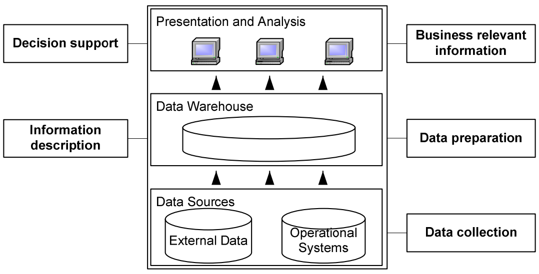


Figure 1: Functions of OpBI.

OpBI provides analytical capabilities in order to control the organizational value creation in favor of a continuous improvement of process design and execution. Thereby, it is a moderator between the analytical intention and the actual occurrence of a process. A timely adequate relation between process performance and states of target achievement get communicated to the corresponding audience.

A comparable approach to support the decision making on the shop-floor is the MES (Younus et al., 2010). It is placed between the layer of Enterprise Resource Planning (ERP) and the layer of process execution (ISA, 2000). A vertical integration by enabling task-oriented compaction, communication and access of data is realized (Kletti, 2007). The ERP-system responsible for order and resource planning communicates desired quantities to the MES executing a permanently target-performance comparison and a feedback to ERP. This is to be done over the full production cycle using real-time data (MESA, 1997). The MES-architecture consists of application layer, functional layer, and data interface layer (Fei, 2010). The data interface layer enables the access of MES-database on machines and plants to gather relevant data. The application layer presents the information generated out of a MES-database on several clients. Users are able to send requests and to get desired results. Therefore, MES are covering eight functions (VDI, 2007):

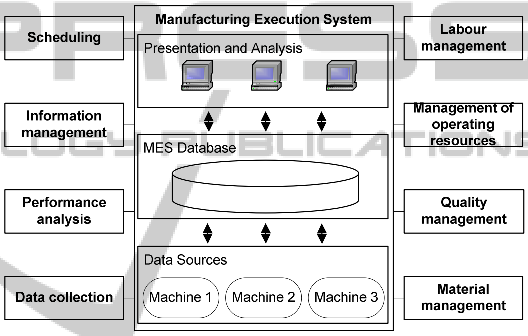


Figure 2: Functions and architecture of MES.

The functions of OpBI and MES consider an integrated provision of data as well as its purposive reporting and analysis. If the MES gets more complex by including a high number of operational processes, the similarity to OpBI will grow. This is associated with a performance lost and limitation of decision-making in real-time, because an increasing complexity requires a higher degree of interfaces (Saenz de Ugarte et al., 2009). Furthermore, the limited analysis capabilities of the MES (Alpar and Louis, 2007) question the benefits of such a strategy. OpBI also forces the decision-making in real-time, has comprehensive analysis capabilities and facilitates company-wide process control. But, this concept is seldom applied in manufacturing (Eckerson, 2007). A possible reason is that the MES covers more functions than operational BI, because it is especially designed for production environments (Meyer et al., 2009). Hence, OpBI cannot compensate a MES and vice versa, but they have beneficial intersections to support enterprise-wide decision making. Table 1 demonstrates this functional complementation potential.

Table 1: Overlapping and complementation possibilities for MES and OpBI.

| MES functions \ **OpBI functions** | Decision Support | Business relevant information | Data preparation | Data collection | Information description |
|---|---|---|---|---|---|
| Scheduling | **M** | **M** | | | |
| Quality management | **M** | **M** | | | |
| Labour Management | **M** | **M** | | | |
| Materials management | **M** | **M** | | | |
| Management of operating resources | **M** | **M** | | | |
| Data collection | | | | **O** | |
| Performance analysis | | | **O** | | **O** |
| Information management | | | **O** | | **O** |

An integration approach is required to provide a basis for a conjoint process oriented and flexible decision support oriented infrastructure using MES in combination with OpBI. Therefore, the presented monolithic driven and data warehouse oriented architecture of the concepts are contradictory. Flexibility and reduction of complexity is possible by modularization, which means to structure a system in semi-autonomous and straightforward subsystems (Aier and Dogan, 2005). To support such a modular design Section 2.2 discusses WS to gain a flexible information architecture.

## 2.2 Web Services in context of MES and OpBI

The technology of WS is commonly implemented in a SOA, representing the current state-of-the-art for flexible IT structures (Erl, 2009). A SOA can be understood as „ … a way of designing and implementing enterprise applications that deals with the intercommunication of loosely coupled, coarse grained (business level), reusable artifacts (services). Determining how to invoke these services should be through a platform independent service interface …" (Wilkes and Harby, 2004). It is possible to combine (orchestration) the existing components depending on flexibility requirements in consequence of the loosely coupled services. Thus, business functionalities are to be abstracted and assembled according to the process logic. This leads to new processes, which can be easily redefined or created. Especially, vendor independent specifications enable a consistent integration of heterogeneous systems and an open communication between various components. A SOA is understood as an abstract concept, supportable by WS (Erl, 2009). According to the W3C, a WS is defined as follows:

> A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the WS in a manner prescribed by its description using SOAP-messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards. (W3C, 2004)

Nowadays, SOAP and WS Description Language (WSDL) specifications are state-of-the-art based on Extensible Markup Language (XML) (Melzer, 2010). WSDL describes the WS-interface and specifies service functionalities, restrictions and conventions. Furthermore, it refers to an endpoint that corresponds to a software component. Those descriptions can be stored in a Universal, Description, Discovery and Integration (UDDI) repository. The UDDI is based on XML and serves as directory service that is responsible for WS publication and detection. SOAP allows as message exchange format the discovery, searching, finding and usage of WS. Thereby, the transport occurs by an underlying protocol like HTTP or FTP. In this context, a WS gets described by a WSDL document and published in a UDDI. A potential service-consumer will search through SOAP in the UDDI and retrieves the matching WSDL. Afterwards, the service consumer will start the communication to the service provider by the SOAP protocol.

The main concept of a SOA is the encapsulation of business functionalities. In this context, OpBI and MES functionalities have to be encapsulated into WS, so that they act either as service user or service provider. Performance analysis services provide analytical business logic and correspond to mature BI techniques (Martin, 2011). The data collection services provide the required operational, tactical and strategic data. They are divided into data access, transformation and infrastructure services, corresponding mainly to encapsulate extract, transform and load (ETL) functionalities (Dinter and Stroh, 2009). The data access service includes four basic operations, namely create, read, update and delete. They allow universal access to all connected systems and all systems to request demanded analyses (Vogt et al., 2008). Source and target exist likewise as service or database e.g. the DWH. If persistently storing is not required, the data get promptly accessed by a service from any operational system on demand and will be used for further analysis (Dittmar, 2007). Transformation services represent the encapsulated transformation phase of ETL. Thus, tasks like aggregation, encoding, filtering, conversion, join and mapping have be fulfilled by services. (Martin 2011; Dinter 2008) There are existing cross-cutting tasks in addition to the presented services that are realized through infrastructure services (Dinter and Stroh, 2009) including data security and data protection features as well as aspects of data quality, master-data, and meta-data management (Gordon et al., 2006). Furthermore, the data collection services provide all MES relevant data regarding to materials, operators, machines and processes in real time through specific decision support services. On this basis, the labour management service ensures that every shift is properly organized and recorded. The material management handles the need driven supply and disposal with material on schedule, as well as the management of work in process. Here, quality information, schedule and material status data are considered. In this context, the quality management services sustain the guarantee of the product quality and the capability of the process, by quality planning and inspection. The service for management of operating resources provides a demand-actuated availability on schedule and functionality of equipment (machines, operating utilities) in a historical, current and further view. The scheduling service plans operational sequences in manufacturing under consideration of available resources and capacities. (VDI, 2007)

# 3 WEB BASED INTEGRATION PLATFORM

The platform is divided into five components, which gets successively refined. The data storage component holds data sources and serves as fundament for further analyses. Here, process changes get noticed by the event engine and will be instantly inserted by orchestrated data collection services placing the target data into the data source. In addition, performance analysis and decision support services accessing the available data through the same services. The enterprise-wide consolidation of information exceeds in most of the cases the IT budget and the manageable complexity (Melzer, 2010). Therefore, it appears adversely to follow the traditional BI architecture concept, since a DWH exists no longer in a monolithic pillar, but rather in an embedded IT infrastructure (Martin, 2011). Thus, the DWH lose its role as central data storage component (Dittmar, 2007). The historical data stored by the DWH are combined and synchronized with real-time information from the operational processes. This provides an input flow for decision support and performance analysis services. There is the danger that redundant and distributed storage lead to individual application terminologies ending in inconsistencies and duplication. Due to this reason, a central meta data repository is required.

The service platform component reflects all encapsulated and presented functionalities of OpBI and MES. In this context, both have to be implemented in a WS oriented way. Here, OpBI and MES take the role as service provider or service consumer. This integrates analytical functions into processes and operational applications affecting the operational detailed planning. All services are event-driven and transfer real time data. Thereby, WS are endpoints, which react to or produce new events. (Vogt et al., 2008) In this context, a WS oriented platform promises the integration of OpBI services into MES processes and systems, avoids redundant implementations, enables an unproblematic integration, improves scalability, and allows an open communication between all components.

The integration component realizes the coordination of all services and events in the total system. The service repository (UDDI) manages and publishes all service descriptions, which are presented in form of WSDL. Furthermore, the service repository selects WS in cooperation with the orchestration engine. The selection is based on the service description, which makes the service available for the orchestration engine. The orchestration executes a service sequence that can be embedded in other systems or processes. In addition, the orchestration engine contains mechanisms that allow state management, logging and monitoring of sequences. The orchestration engine is requested by events that are triggered from the event engine. Here, the event engine is based on publish-and-subscribe. It receives and processes events from all components, which are sent to registered users. Furthermore, the event engine holds analytical operations.

The analysis is enriched by business process events (Vogt et al., 2008). Therefore, defined business rules are required, which are provided by the corresponding repository. This prevents a redundant implementation of business rules,

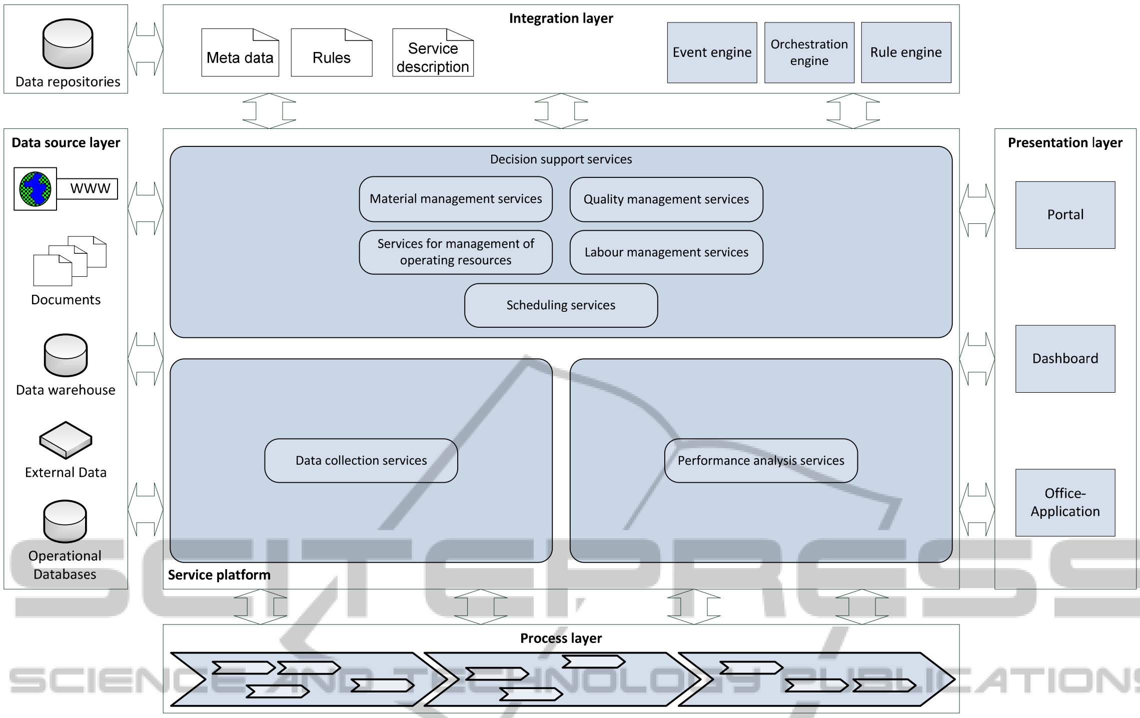


Figure 3: Web-based integration architecture for OpBI and MES.

increases their reusability and separates the process logic from the decision logic.

The core of the process component is the process. Here, the event engine analyzes continually business process events in real time. The required process states are received by data collection services and passed through decision support and performance analysis WS. Hereby, a timely adjustment of the manufacturing process in consequence of unpredictable circumstances can be established. Complex events or causal, temporal or spatial relationships are detected by the event engine and leading to defined reactions in process execution. Thus, decisions can be automated and done in shortest time. Consequently, the approach enables the monitoring of critical process key figures in MES, OpBI analyses and hereupon tailored events. A so called closed-loop can be established that provides reduced decision latency.

The top level is represented by the presentation component. This enables a flexible integration of different visualization options. The fundament is performance analysis and decision support services which allow graphical representations in portals, dashboards, or office applications. (Vogt et al., 2008) The user can be informed about circumstances by event or send its decision directly to the event engine.

# 4 CONCLUSIONS

The position paper discusses an integration platform to consolidate economic and engineering driven information across the whole value creation. The proposed architecture joins the concepts of MES and OpBI, while their domain specific functions are conserved. Thereby, during the paper`s discussion the advantages of WS are evident in favour of a flexible process oriented decision support. Process performance indices are enriched by information from all segments of the value chain as part of technical-economic analyses. This reduces the effort of information gathering and provides the ability for a comprehensive synchronization of business processes with flexibility-enhancing effects. Organizations are able to consider changing requirements of customers and suppliers contemporary to adjust their production, distribution and purchase processes. This implies an increased process transparency so that improvements and innovations are possible in fields of process and product design. Next to the introduction of completely new products, there are for example opportunities to improve quality characteristics of products or to tailor the use of resources according to business needs. Due to the knowledge about the process performance in all segments of the value creation, the necessity as well as technical and economic feasibility of innovation is assessable in detail. In order to realize the presented benefits of the integration platform, a practical validation of these arguments is required. Thereby, the discussed insights of this position paper serve as guidance and basis for further research.

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