Leveraging Product-Service Systems by Implementing Service-oriented Architecture

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The efficient provision of integrated product-service bundles requires the cooperating partners’ information systems (IS) to be able to exchange production and customer master data. We reply to this problem by presenting a service-oriented architecture (SOA) based approach for connecting partners within product-service systems (PSS). The research question addressed in this paper is: Which are the distinctive information flows required to integrate production and service processes and how can these information flows be supported by the implementation of a SOA? We answer this question by providing a set of services that describe and explain the information flows between production and service processes in the case of the corrective maintenance process in machinery industry. Subsequently, we present the machine record concept which implements and thereby evaluates the provided services and information flows.

La mise à la disposition efficace des paquets produits – services intégrés requiert un système d'information (IS) des partenaires coopérants pour être capable d'échanger des données permanentes de fabrication et de client. Nous répondons à ce problème par présenter une approche basée sur une architecture orientée vers des services (SOA) pour associer des partenaires dans des systèmes produits-services (PSS). Dans ce dossier, la question de recherche est : Quels sont les flux d'information particuliers qui sont requis pour intégrer des procès de fabrication et de service et comment est-ce que ces flux d'information peuvent être soutenus par l'implémentation de SOA? Nous répondons à cette question en proposant un kit de services qui décrit et explique les flux d'information entre des procès de fabrication et de service au cas de procès de maintenance corrective dans l'industrie mécanique. Ensuite, on présente le brouillon d'enregistrement mécanique qui implémente et, à travers, exploite les services proposés et les flux d'information.

1. Introduction

Today, many economies are confronted with tertiarization, i.e. the evolution from a goods-based to a service-based economy. Consistently, customers increasingly demand integrated problem solutions that fit their individual needs instead of standardized physical products. To satisfy this demand, suppliers strive for providing integrated product-service bundles that comprise separately marketable physical products and related services (Hamilton; Koukova, 2007) instead of limiting their offer.
to physical products only. Integrated product-service bundles are able to create values for customers that are higher than the summed-up outcomes of their components (Schmitz, 2008). Distinguishing physical products and services becomes increasingly challenging (Fitzsimmons; Fitzsimmons, 2001; Teboul, 2006; Vargo; Lusch, 2004)

Results from empirical studies (Knackstedt et al., 2008) disclose the implications of tertiarization on the German mechanical engineering and electrical engineering industries. According to Stille (2003), turnover generated by services has doubled in the electrical engineering sector from 9.6% (1997) to 18.5% (2000), while significant gains from 16.8% (1997) to 22.5% (2000) could be identified in the mechanical engineering sector. Moreover, Mercer Management Consulting highlights, that half of the growth in German mechanical engineering in the years 1998-2003 can be accounted to exploiting the potential of services. Likewise, the margin of the service business (10%) is significantly higher than the margin of the product business (2.3%). Moreover, they state that margins could be even higher when looking at some leading edge services only, which gain margins up to 18% (Mercer, 2003). A further empirical study shows that companies attribute a high (38.1%) or very high (59.8%) impact on their revenues to their service business. Services are also seen as a good means for differentiation from competitors and customer retention. Consistently, 94.9% of the companies plan to grow their business by offering product-service bundles (Sturm et al., 2007).

On the one hand, product-service bundles can be provided by single companies meaning that e. g. manufacturing and service departments collaborate. On the other hand, traditional manufacturers have the possibility to cooperate with service firms in order to jointly offer integrated product-service bundles to customers. These intra- or inter-organizational cooperations are called product-service systems (PSS). The cooperative provision of product-service bundles by a PSS involves executing traditional manufacturing processes as well as service processes. These two kinds of processes differ substantially, as they require different management approaches (Sampson; Froehle, 2006) and apply different information systems (IS) for their planning and execution. Despite the differences inherent to the processes, the partners’ IS need to be able to exchange data like production data and customer master data (e. g. bills of material, orders, confirmations, appointments or instructions) in order to provide product-service bundles efficiently.

Moreover, PSS need to be flexible to a certain degree in order to allow for modifying the cooperation’s organizational structure as well as adapting to changing customer demands. As a consequence, the IS are also required to be versatile in order to ensure that shared processes and message exchange are and stay efficient and facilitate changes from a technical perspective. The recent trend to implement IS based on the principles of a service-oriented architecture (SOA) (Erl, 2005) is one attempt to achieve this flexibility.

Therefore, we present a SOA based approach for connecting partners within product-service systems (PSS). In three case studies, we investigated the distinctive information flows required to integrate production and service processes (cf. section 2) in order to support them by the implementation of service-oriented IS (cf. section 3). In this paper we focus on the machinery industry and provide a set of services that describe and explain the information flows between production and service processes in the case of the corrective maintenance process consisting of six areas of operation
(cf. section 4). In particular, we illustrate our approach by the shared machine record as one main concept of the execution area (cf. section 5). Thereby we implement and evaluate the presented services and information flows.

2. Methodology

Our research as illustrated here is basically made up from three explorative case studies (Yin, 2003) conducted by a team of six researchers and several teams of master degree students over a period of 20 months. The cases (cf. Table 1) tend to represent the entire life-cycle of an integrated product-service bundle consisting of physical components and related services (planning, operation, replacement).

<table>
<thead>
<tr>
<th>Life-cycle stage</th>
<th>Case Study 1</th>
<th>Case Study 2</th>
<th>Case Study 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Planning</td>
<td>Operation</td>
<td>Replacement</td>
</tr>
<tr>
<td>Industry sector</td>
<td>Mechanical engineering</td>
<td>Mechanical engineering</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Primary unit of analysis</td>
<td>Consulting company</td>
<td>Service unit of a global machine tools manufacturer</td>
<td>Reverse logistics and recycling service provider</td>
</tr>
<tr>
<td>Company size</td>
<td>Small</td>
<td>Large</td>
<td>Medium</td>
</tr>
<tr>
<td>Offered product-service bundle</td>
<td>Selection, integration and optimization of logistic systems</td>
<td>Mill centers and turning centers plus 60+ related business services</td>
<td>Reverse logistics, remarketing, and recycling of electronic equipment</td>
</tr>
<tr>
<td>Complexity of product-service bundle</td>
<td>High</td>
<td>Very high</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 1: Conducted case studies

Whereas the objective of the studies at large was to gain a comprehensive understanding of producer and service-provider interactions, here we especially refer to study no. 2, which focused on the operating stage. Within our research we analyzed four product-service bundles offered to customers by cooperating producing and service-providing business units within a global acting mechanical engineering group.

We conducted 23 semi-structured interviews, including the CIO, Head of Quality Management, Head of Engineering, Head of Service Engineering, Key Account Manager and Controlling Manager of the particular enterprise. Most of these interviews were conducted in the form of workshops and involved one or two researchers and one to three respondents each. Participating researchers were involved in analyzing
several product-service bundles (but not all), visited the companies as a research team, and consolidated findings with the other teams. Thus, insights gained from one case could be transferred to other cases and product-service bundles, but were also critically reviewed.

Each interview targeted a distinctive bundle consisting of physical goods and related services. After defining the nature and components of the joint product-service bundle the interviews focused on the underlying business processes (including information, organizations, people, and resources). The interviews were guided by the key questions and the analysis schema of the analysis method we developed (cf. section 3). Data gathered in the interviews focused on activities to be carried out on the manufacturing and service sides and the required information exchanges that were put in place or were desired to integrate the production and service sides.

All interviews were documented in semi-formal business process models. The final results were documented in case study reports which have consecutively been verified and approved by the industry partners. The here analyzed case 2 finally led to 23 business process models that grounded the information flow analysis.

Subsequently within an abstraction step we condensed our insights gained from the cases as well as from accompanying literature studies and expert interviews into an approach for an information system architecture supporting the provision of integrated value proposition by means of product-service bundles.

In the following we introduce the corrective maintenance process as one investigated business process consisting of activities employed by both producer and service provider. We illustrate required information flows between business partners (data oriented services) and present additional business functionality for coordinating the producer and service provider cooperation. Later on, we illustrate the machine record concept as a prototypical implementation that uses the specified infrastructure for evaluating the concept.

3. SOA in Product-Service Systems

The institutionalization of product-service systems imposes new challenges concerning versatility to the companies involved. In this context, versatility means that producers and service providers can adapt to new requirements efficiently and quickly (Andresen et al., 2005; Spath et al., 2001). Versatility refers to all aspects of a company, including strategy and culture as well as organization, processes and information systems (Gronau, 2006). Modularization is one basic strategy to increase the versatility of systems (Baldwin; Clark, 1997). This is achieved by assembling modules (subsystems) to systems, with each module encapsulating specific functions and communicating with other modules via well defined interfaces.

In the field of software engineering different approaches of modularization are discussed to increase the versatility and flexibility of information systems (McIlroy, 1968). In object-oriented programming (Lutz, 1997) functions are encapsulated on a rather detailed abstraction level and coupled closely due to mechanisms like inheritance and instantiation. The coordination of these interdependencies demands for the use of frameworks which are usually bounded by certain platforms or program-
ming languages. Component-based software engineering addresses these shortcomings by raising the level of abstraction. Software components are supposed to be non-context-specific and applicable for multiple-use (Frank, 1999; Turowski, 2001). However, component-based software engineering mainly focuses on the modularization of single application systems and thus disregards distributed IS architectures.

The service-oriented approach picks up the principles of object-oriented and component-based development and postulates the use of services which are specified and implemented using widely applied standards (vom Brocke, 2006) in order to design both intra- and inter-organizational information systems. The standardization of specifications allows for the efficient distribution and orchestration of services and thereby achieving versatile information systems. The concept of service-oriented architectures (SOA) has been intensively debated in recent years. A SOA is a multiple-layer, distributed information system (IS) architecture (Legner; Heutschi, 2007) consisting of services that encapsulate parts of the application logic. Services are abstract software elements and/or interfaces which provide other applications with stable, reusable software functionality at an application-oriented, business-related level of granularity using widely applied standards (e.g. SOAP, WSDL, BPEL, XML, HTTP). Services are invoked by means of message exchange. These messages usually represent electronic business documents and can be part of processes that transcend the boundaries of a single organization like the traditional manufacturer or service firm.

SOA itself is not a technology standard, meaning it does not depend on a single technical protocol like SOAP. It represents an architectural blueprint, which can incorporate many different technologies and does not require specific protocols or bridging technologies. The focus is on defining cleanly cut service contracts with a clear business orientation (Krafzig et al., 2004).

For this architectural blueprint, scientific literature outlines design-principles that can be subdivided into four categories: interface orientation, interoperability, autonomy and modularity, and requirements-orientation (Klose et al., 2007; Legner; Heutschi, 2007). In comparison to monolithic systems, it is these principles that allow for easier changes to information systems.

Design principles related to interface orientation demand the interfaces of services to be described explicitly and completely. Service consumers should not require any information above and beyond the service specification in order to be able to invoke them (Baskerville et al., 2005). Furthermore, the service interfaces must abstract from implementation details. Service interfaces in a SOA represent stable, binding contracts between service providers and users and are managed in a central repository (Klesse et al., 2005). Thus, functions encapsulated by services can be easily exchanged if e.g. the service company is substituted by another one without affecting further elements of the PSS. The key requirement is that the new partner is also able to interact with the same interfaces.

In order to guarantee such interoperability, components should be standardised from both a technical (e.g. transfer protocols, data formats) and conceptual perspective (e.g. clearly and uniformly specified terms, standardized data models, semantics on the functionality and parameters as well as quality characteristics) (Krafzig et al., 2004). These standards are regarded to be most useful when open, platform independent and widespread (Fritz, 2004). From the technical point of view, principles of
**Interoperability** are currently being addressed by web services technology and have led to standards like SOAP and WSDL. Regarding the conceptual perspective, there is a need for appropriate standardized web services in the field of PSS.

Principles concerning **modularity and autonomy** require the grouping of functionality and resources into a manageable number of partially autonomous subsystems, i.e. domains and services. In accordance with the principles of component-based software engineering, functions or resources with high interdependency (cohesion) are grouped together in such a way that their logical dependency on other subsystems (loose coupling) is as low as possible (Papazoglou; Yang, 2002; Vinoski, 2005). Encapsulated functions have to be autonomous to a certain degree and should as well be useable outside their original context. Thus, functions of the producer’s and the service provider’s information systems are should be reused in the joint provision of integrated product-service bundles.

Furthermore, loosely coupled communication reduces runtime dependencies. This can be achieved by means of dynamic service addressing via logical names (e.g. a uniform resource identifier, URI), asynchronous, message-based communication between service users and providers as well as stateless service interaction (Brown et al., 2002; Erl, 2005; Kossmann; Leymann, 2004; Legner; Heutschi, 2007).

Regarding **requirements-orientation**, the functionality provided by services should be derived from business processes or business objects following a top-down process. This approach ensures that findings correspond to the business requirements of the PSS. In this context the service granularity is one key decision. Fine-grained services are restricted to small units of functionality or data exchange. Regarding complex business scenarios in a distributed environment, services which exchange a larger quantity of data in one operation and support complete process activities are considered to be more appropriate (McGovern et al., 2003). Moreover services should also be sufficiently generic to allow for their reuse in several processes and/or by several partners (Newcomer; Lomow, 2004).

The identification of business functions to be provided as services is a basic precondition for a detailed specification and implementation of services in a service-oriented architecture (SOA). Currently, there is no predefined guidance for the implementation of a SOA and the design of messages to connect partners within a PSS. Accounting for this need, we developed and applied an analysis method drawing from the service blueprinting framework of Shostack (1981) and the front-stage/back-stage framework proposed by Teboul (2006). This method extends the idea of different lines (line of visibility, line of interaction) separating service providers (i.e. front-stage) from customers by including producers (i.e. back-stage) into the analysis. The basic idea is to vary these lines and hence to allow more or less visibility (i.e. information sharing) and interaction during the process of value co-creation. Functions were rated due to their outsourcing and visibility potential for stakeholders and were only planned for implementation as a service if both business potential and technical feasibility could be verified. We defined formal specifications that can be utilized in message exchange between producers and service providers, and thus can serve as building blocks of a SOA for PSS and. The analysis method itself is presented in detail in (Klose et al., 2007) and (Beverungen et al., 2008).
4. Corrective Maintenance Integration Scenario

Subsequently, integration requirements of the corrective maintenance process in machinery and equipment industry are presented. This process particularly refers to case study no. 2 which focused on the analysis of a global machine tools producer’s service unit. The machine tools producer produces complex products like milling and turning centers that may be in operation for several decades. On the one hand, parts and components are subject to planned maintenance during their operation. On the other hand, maintenance processes may also have to be conducted correctively. Mostly, this happens when the milling or turning center is malfunctioning causing a production stop at the customer’s plant. As this might lead to extensive amounts of money to be lost, the time-frame for corrective maintenance processes is very short, which makes monitoring machines, error identification, and best-practice repair procedures especially crucial.

The corrective maintenance process can be subdivided into six areas of operations. Within product specification the performance bundles sold to the customer and the business model selected by the customer are set. Within the resource planning the occurrence of unscheduled events is determined and referring service operations are planned. Within the execution the actual measures of the corrective maintenance are conducted. In context of the suggestion system the service provider transmits advices contributing to the construction and production processes. Profits and losses assigned to single contracts are shared proportionally amongst producer and service provider within the intra- or inter-organizational settlement. The quality of the PSS is assessed within the controlling.

4.1. Product Specification

For providing product-service bundles physical good components and service components have to be brought together and must be captured in a shared product specification (cf. Fig. 1, top) and calculations have to be made from both a customer and a provider perspective. For describing physical products and related services different description approaches have to be integrated. Whereas physical goods traditionally are described by sets of functional requirements, services tend to be described by a potential and result proposition. If combining physical good and service components, exclusion and inclusion relations have to be regarded, which also need to be respected by an information system for customer order processing. Here, the supplier has to determine, which of the variety of possible combinations he tends to provide while the customer has to select a certain combination from the remaining solution space. Depending on the business model followed, different aspects of the product specification are highlighted. Furthermore, service provision and production have to calculate costs for the shared value creation on the one hand and to estimate the customers’ willingness to pay for alternative product-service bundles (e.g. selling and financing of a certain machine type, guarantees on operational availability of a machine type, operation of the machine for the customer) on the other hand. Thus, customer prices for the offered bundles can be determined which form the basis for further analysis from a customer point of view like calculating the total cost of ownership for concurrent product-service bundles.
4.2. Resource Planning

In order to provide product-service bundles, the different planning levels of production and service provision have to be integrated for phasing capacities of both spheres (cf. Fig. 1, bottom). Planning is a complex task as the production of the physical good and the provision of the related services are carried out asynchronously. Based on certain machinery and equipment types it has to be assessed, which physical good components are requested in which business models, allowing for estimating the later demand of service capacities for the maintenance resp. the operation of the machine. Besides the adjustment of personal capacities, especially the provision of spare parts has to be regarded which requires not only sales estimations of machines, but also depends on the applied maintenance strategies. For realizing the estimated demand, the distribution schemes have to be chosen appropriately which might even result in having spare parts stocked directly at the location of service provision (e.g. at the service provider’s or the customer’s place). This also claims for an integration of both planning spheres.

Within the operative resource planning quick reactions to unscheduled malfunctions have to be aligned with scheduled maintenance activities. If so, planned preventive maintenance tasks have to be rescheduled due to unforeseen corrective maintenance demands. Furthermore, a common overview of spare part stocks is required. The operative resource planning for handling malfunction information and fault reports can be settled either at the producer’s or the service provider’s party. For the planning of service staff assignment information is needed from both producer (e.g. spare part availability at a certain time) and service provider (e.g. availability of service technicians at a certain time).

![Fig. 1: Integration requirements for Product Specification and Resource Planning](image)

4.3. Execution

The execution of a corrective maintenance activity is supported by (1) creating a common infrastructure for supporting the service technician and (2) setting up and updating a shared machine record, which contains service-related information provided by the producer (e.g. bills of material, maintenance schedules) and information about so far conducted service activities (including used spare parts).
(1) A common infrastructure (cf. Fig. 2, top) should support the service technicians at the machinery in solving the investigated problem as fast and cost-saving as possible. In the simplest case, the customer can call a telephone hotline, which assists him in problem identification and solving. Here, production and service provision require access to the scripts leading the hotline conversation in order to continuously improving them. Information used in this context is usually machine type specific and does not need to be adjusted to single machine instances. Here, production contributes knowledge about the machine itself, whereas the service provider knows about the process and restrictions of problem identification at the customer’s site. If the technicians can use mobile devices for retrieving machine-related information, production and service provision have to be involved as well (Thomas et al., 2007).

(2) For a certain machine (machine instance) the producer contributes information on physical good components (parts and spare parts). The service provider reports on conducted service operations. Service history and construction data together form the machine record (cf. Fig. 2, bottom) for a certain machine. Thereby service technicians can inform themselves in before on recurrent problems and variations from the delivery status of the machine. Multiple machine records of a machine type can be used for investigating improvement requirements to production and service processes. Service histories allow producer and service provider for the common provision of business models focusing on availability and performance. The data captured in the numerous machine records support e. g. TCO calculations of the underlying machine type for the sales department.

![Fig. 2: Integration requirements for Execution](image)

**4.4. Suggestion System**

Conducting the corrective maintenance activities provides valuable insights on how to advance the machines and how to improve the corrective maintenance process which are managed within the Suggestion System (cf. Fig. 3, top). If the production of the machines and the provision of the corrective maintenance services are conducted by autonomous institutions, such feedback frequently does not reach the producer. Providing integrated product-service bundles offers the chance to institutional-
ize feedback on causes of malfunctions and product improvements between service provision and production.

### 4.5. Settlement

The collaborative provision of business models focusing on availability and performance by independent producers and service providers requires that profits from providing the product-service bundle are shared among the partners (Fig. 3, center). Also in-house settlements are needed, if involved production and service units have turnover responsibility, e.g. as cost or profit centers. The settlement processes can be divided into three levels. On the planning level it is determined, which performances are contributed by which partner and what is the share on the total profit of each partner. By means of finance plans planned cash flows can be explained. For the cooperation being profitable for all partners, the additional accumulated value of providing the product-service bundle should be positive (Holten; Schultz, 2001). On the operations level, during provision of the product-service bundle, the actual operative payments have to be processed. On the control level the planning premises are checked against as-is data, allowing for learning from planning failures. By means of performance ratios the plans can be aggregated into certain meaningful values that e.g. inform on realized ratability.

### 4.6. Controlling

The cooperation of production and service provision should be accompanied by a continuous controlling (Fig. 3, bottom) process. As a common instrument a Balanced Scorecard can be used here. There already exist concepts that apply Balanced Scorecards to cooperation concepts like supply chain management which can be applied to PSS as well (Siepermann, 2008). Besides the popular perspectives of the Balanced Scorecard especially the evaluation of the cooperation itself is focused here, which can be expressed by the cooperation willingness and the cooperation ability of the involved partners.
5. Exemplary Implementation of the Machine Record

The identified information flows and outlined business functionality have subsequently been described as web services by their interfaces following the paradigm of a service-oriented architecture. Here, we present the case of a machine record (cf. Fig. 4) as a fragment of the entire platform that has been part of a prototypical implementation for evaluation purposes. This proof-of-concept has been conducted in cooperation with the service and production units of a global machine tools producer that also integrated the customer of the product-service bundle into the scenario and thereby extended the specification drafted in section 4.3.

In this scenario service provider, producer and customer share a common machine record. The machine record can be accessed by a web frontend. The machine record allows service provider and customer to retrieve machine-related manuals, bills of materials, work plans and machine-related safety advices for supporting the actual service provision. Table 2 shows a corresponding document structure describing the required information objects. The related information is mainly provided by the producer’s ERP system. Therefore the machine is referred to as the main outcome of the product-service bundle (cf. Table 2). The related outcome description in turn contains a reference to the required information objects that can be accessed using system specific connectors within the producers ERP system.
Apart from machine-related information various further receipts can be accessed via the web service. Those documents are referred to by the service using the position field (cf. Table 2). Cooperation partners can see service requests that have been demanded by customers. These requests have been submitted either using the service or manually (e.g. via telephone hotline) to one of the partners and are then shared in the PSS by the web service. Requests are followed up by offers and orders in case the service provision is not covered by guarantee (cf. Table 2, Field “guarantee duration”).

For each service provision conducted a protocol is generated which is also linked using the position field. Those protocols e.g. contain information on causes of malfunctions or spare part usage. They can be evaluated by other services of the specified architecture. Based on the activities described in that protocol, finally the provided service has to be settled and the related invoice is linked to machine record.

The web portal contains additional functionality that is provided by linked services which therefore should be named here only in brief: For monitoring purposes a schedule informs about upcoming maintenance and other service provisions for this specific machine. Performance indicators related to e.g. submitted utilization data of the machine can be captured and build a base for identifying preventive maintenance or machine replacement demand.

Finally, customers can submit feedback related either to physical components or services of the product-service bundle.
### Table 2: Document machine record

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record number</td>
<td>Unique identifier for the specific outcome instance (product-service bundle)</td>
</tr>
<tr>
<td>Date of creation</td>
<td>Date of creation of the outcome instance record</td>
</tr>
<tr>
<td>Main outcome instance number</td>
<td>Link to the outcome instance (product-service bundle) that the record is assigned to</td>
</tr>
<tr>
<td>Description</td>
<td>Description of the outcome type. Name and/or functionality can be stored as text.</td>
</tr>
<tr>
<td>Safety advice</td>
<td>A product related information for protecting persons and environment from potential accidents</td>
</tr>
<tr>
<td>Guarantee duration</td>
<td>Guarantee expiring date</td>
</tr>
<tr>
<td>Business partner ID</td>
<td>Link to the master data of the mater data owner. The “owns-relation” can also map previous owners.</td>
</tr>
<tr>
<td>_Position</td>
<td></td>
</tr>
<tr>
<td>_Position number</td>
<td>The outcome record contains multiple positions, for referencing all document related to the outcome (e. g. work plans, receipts or requests)</td>
</tr>
<tr>
<td>_Reference type</td>
<td>The reference type describes the type of the document the position number links to. That can be e. g. a work plan, a bill of material, feedback, a manual, a protocol, a receipt or a request.</td>
</tr>
<tr>
<td>_Reference number</td>
<td>Number of the document that the position refers to</td>
</tr>
</tbody>
</table>

### 6. Conclusion and Outlook

Producers and service providers increasingly cooperate in product-service systems to offer integrated and individual problem-service bundles to their customers. Regardless of such cooperation being intra- or inter-organizational, sharing information is crucial in order to provide product-service bundles efficiently. In order to enhance information sharing between cooperating producers and service providers we proposed the implementation of versatile information systems according to the service-oriented architecture paradigm. Our approach provides guidelines that can help to advance information systems for product-service systems, as current ERP systems often fall short of e.g. supporting resource planning in integrated service and production scenarios (Dietrich 2006).
Building on the analysis of three case studies, we derived a set of web services that can serve as building blocks for integrating service and production processes and thus for leveraging information sharing in PSS. We illustrated the need for efficient information sharing by a cooperation of production and service provision in the case of the corrective maintenance process in machinery in equipment industry which comprised six areas of operation. In particular, we presented the shared machine record as one main concept of the execution area. By specifying the information items on a data-field level and implementing a first prototype for the machine record concept, we showed that our information item specifications can be used for designing the interfaces of web services.

Regarding further research, additional evaluation of the presented web services and prototype is needed. An evaluation of the machine record concept is already planned in form of a case study with partners in the machinery industry. Furthermore, we currently discuss the data-field specifications in a committee of service researchers and practitioners in the course of several standardization workshops with the German Standardization Organization (DIN). We expect the committee’s feedback to help us in enhancing the specifications’ explanatory and theoretical strength as well as their value for practitioners.

Moreover, the standardization process will lead to a publicly available specification (PAS) on information items to be shared in PSS. This PAS will be designed to serve as guidance for the implementation of a SOA and the design of messages to connect partners within a PSS, thus advancing the adoption of our approach in practice.

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