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Felix Piazolo
Michael Felderer *Editors*

Novel Methods and Technologies for Enterprise Information Systems

ERP Future 2013 Conference, Vienna, Austria, November 2013, Revised Papers

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ERP Future 2013

Felix Piazolo and Michael Felderer

Abstract This is the introduction of the ERP Future 2013 Research Conference proceedings. It provides a short motivation and an overview of the topics covered by the conference.

Keywords Enterprise resource planning · Business processes · Business management · Business intelligence · Enterprise information systems · Software engineering · Innovation of enterprise information systems

It becomes more and more apparent that enterprise information systems are strategic key resources to enable organizations to handle their end-to-end business processes efficiently. Especially enterprise resource planning (ERP) systems are known to significantly increase the profitability, productivity and competitiveness of private organizations by avoiding barriers sharing information between functional areas and managing processes. In public organizations and public administration itself a similar effect can be recognized regarding the effectiveness and transparency of public services, leading to an increased output and outcome. Still one has to keep in mind that the business process definitions and designs are the basis for further sustainable success. Information technology (IT) in general and enterprise information systems in particular are enablers to realize successful business and service models and to improve existing ones.

Looking at modern ERP systems, as an example of highly integrated enterprise information systems, and their promoted ability to orchestrate business processes from end-to-end within a distinct value chain in an integrated, consistent and highly effective manner brings up diverse challenges. Existing ERP solutions will become more and more complex the longer they are on the market and the

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technical environment including new technical possibilities in general is steadily expanding and growing. Innovative novel methods and technologies for enterprise information systems have to be developed to counteract the challenges that derive by the permanent growing complexity and technical environment as well as to secure a sustainable profit from the benefits of ERP systems and enterprise information systems in general. Nevertheless it is given by the mature customers respectively end-users that business models, technological environments, integration and interoperability possibilities and functionalities of enterprise information systems and bundles of solutions will change in the future according to their requirements and expected benefits.

Actual trends regarding enterprise informations systems still include without limitation software as a service (SaaS), cloud services in general, big data, mobile solutions, specific solutions for small and medium sized enterprises (SME), open source and freeware solutions, e-learning, innovative end-user training, social media integration, efficient and effective quality management and planning methods as well as techniques and criteria for the selection and evaluation process. How to take these trends individually into account depends on the role of each market player, their visions, strategies and business models. Scientifically evaluated studies support the decision making and have to consider business as well as IT aspects.

The ERP Future 2013 Research conference is a scientific platform for research on enterprise information systems in general and specifically on core topics like business process management (BPM), business intelligence (BI) and enterprise resource planning (ERP) systems. Besides the scientific community the event also addresses businesses developing, implementing and intensively using enterprise information systems. To master the challenges of enterprise information systems comprehensively, the ERP Future 2013 Research conference accepted contributions with a business as well as an IT focus to consider enterprise information systems from various viewpoints. This combination of business and IT aspects is a unique characteristic of the conference that resulted in several valuable contributions with high theoretical as well as practical impact. Revised versions of these conference contributions are collected in the present proceedings of the ERP Future 2013 Research conference entitled ‘Novel Methods and Technologies for Enterprise Information Systems’.

Methods and features that allow to over come boundaries in the sales process are addressed by the initial keynote speakers. An alternative approach based on native ERP integration of most common e-invoice scenarios is presented [1] as well as an overview on the evolution and the future of the sales process and active customer involvement [2].

Looking at actual trends in distributed computing and quality assurance one contribution addresses fact based modeling in the cloud [3] and another gives an overview on how lean management tools are supported by ERP systems [4].

Business process models provide the basis for the design, documentation and clear understanding of business processes which are prerequisites for successful enterprise information system implementations and operations. Three papers

address this meta topic. First, a refinement of the business process model and notation (BPMN) gateway activation concept for non-event-based gateways [5] is presented, second, the trade-off between flexibility and extensionality in the decomposition of business process models is discussed [6] and third, needs, concepts and models of business process management for knowledge work is critically looked at [7].

Due to ever evolving technologies and requirements, efficient development and adaptation of ERP software demands specific software engineering techniques and strategies. Several contributions address this topic from different viewpoints. To improve requirements engineering for ERP, one contribution provides a collaborative requirements engineering tool for ERP product customization [8]. Providing guidelines for testing in ERP projects is the aim of a comprehensive questionnaire whose design is presented in another contribution [9].

Open source has been a trend over many years and starts playing a major role in enterprise information systems and general IT architecture. One contribution discusses the conception of a novel open source environmental management information system design to assess the availability of resources [10]. Another one analyzes how open source business solutions in the field of enterprise resource planning, business intelligence, customer relationship management and data management systems match with the requirements of SMEs and vice versa how SMEs can select adequate solutions according to their specific needs [11].

End-user training is considered a critical success factor regarding the implementation and operation of ERP systems. Therefore it is relevant to investigate on what the user should focus looking at end-user training via e-learning [12] and to analyze if there is an impact of the learners behavior on the quality of the acquired skills [13].

The current trend of mobility in business applications is addressed by two contributions. On the one hand, the impact of private smartphone experience on satisfaction with business applications is investigated [14]. On the other hand, an end-user development tool for mobile ERP applications is presented [15].

Cultural issues regarding the utilization of ERP systems will become more and more relevant due to the advancing globalization. Besides global players also SMEs are confronted with this challenge. A company-based perspective is covering this topic [16].

How social software features like discussion forums could be weaved into ERP systems is also addressed [17]. Additionally, a generic model for ERP implementation strategies is defined [18] and specific implementation aspects of a campus portal are discussed [19].

Finally, the organizational outcome of a business intelligence based budget information system in the context of a federal ministry is evaluated [20].

We thank all authors for their valuable contributions and we hope that the collection is interesting for the individual reader and enriching for the scientific community as well as for the industrial and business application.

Special thanks go to Alfred Taudes of the Vienna University of Economics and Business, and his team for their commitment and cooperativeness to host the ERP

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Part I
Keynotes

Crossing the Boundaries: e-Invoicing/ e-Procurement as Native ERP Features

Christian Huemer, Marco Zapletal and Philipp Liegl

Abstract Electronic Invoicing has attracted a lot of attention by being a cornerstone of the Digital Agenda for Europe, Europe's 2020 Strategy. This agenda mandates a "think small first" principle in order to enable e-invoicing for companies of any size. The electronic invoice should be exchanged between the ERP systems of business partners. Traditional approaches based on electronic data interchange failed to attract SMEs. Due to the high costs, they only use e-invoicing if forced by their larger business partners. In this paper, we present an alternative approach that is based on native ERP integration of most common e-invoice scenarios. This approach was successfully implemented in a research project resulting in a university spin-off.

Keywords Electronic invoicing · Enterprise resource planning · Electronic data interchange · Inter-organizational systems

1 Motivation

The Digital Agenda for Europe [1] is one of the seven flagship initiatives of the Europe 2020 Strategy. Its overall aim is to "deliver sustainable economic and social benefits from a digital single market based on fast and ultra-fast internet and interoperable applications". The communication of the European Commission on

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"Reaping the Benefits of Electronic Invoicing for Europe" [2] underpins the importance of e-invoicing as part of the Digital Agenda. Accordingly, the European Commission wants to see e-invoicing become the predominant method of invoicing by 2020 in Europe, because it is expected to save around EUR 240 billion over a 6 year period and to decrease CO_2 emissions of 1 million tons per year by reducing paper consumption and energy costs for transportation.

Nevertheless, e-invoicing is a challenging goal since the communication also mentions that—according to a Eurostat Report on Enterprises Sending and/or Receiving e-Invoices [3]—the adoption rate of e-invoicing is 42 % by large companies and 22 % by SMEs, leading to a rather low penetration rate of e-Invoices estimated at about 5 % of all invoices. These low numbers are surprising, since e-invoicing offers significant benefits compared to paper invoicing. Most of these benefits do not arise from savings in printing and postage costs (which are only achieved by the sender), but rather from full process automation. In this context, one should note that invoices represent just a single step in an overall sales/procurement process. Thus, it is important to incorporate e-invoicing in a series of business document exchanges resulting in the full electronic support of inter-organizational business processes. A straight-through processing of all business document exchanges will result in the following benefits: elimination of re-keying redundant data, fewer errors, faster transaction times, less inventory cost, shorter payment delays, less interest charges, better planning capabilities, etc.

Although these benefits are commonly known, the communication of the commission concludes that e-invoicing is still too complex and costly, in particular for SMEs, which hampers its widespread adoption. Traditional Electronic Data Interchange Standards (EDI), such as UN/EDIFACT [4], which are used by many multinational companies are impractical for adoption by SMEs. With the appearance of XML new business document standards were introduced [5]. Although the markup-based XML document standards may provide advantages over a delimiter-based EDI syntax, the principal approach to develop business document standards did not change. As we outline in Sect. 2, this approach results in significant drawbacks for SMEs. However, the Small Business Act [6] committed the EU to the "Think Small First" principle, or in other words, to focus in particular on the needs of SMEs. Thus, the EU communication on "Reaping the Benefits of Electronic Invoicing for Europe" [2] stresses the importance that e-invoicing service providers develop services and solutions that require a low investment in infrastructure and skills for SMEs.

2 The Failure of Traditional Approaches

Exchanging business documents, such as electronic invoices, between ERP systems is not new at all. In particular, large corporations have been implementing so-called electronic data interchange (EDI) [7, 8] solutions for more than 30 years. EDI leads to a cross-organizational business document exchange between ERP

systems of two business partners without human intervention. Usually, EDI systems are based on business document standards. Still most common are solutions based on the delimiter-based UN/EDIFACT standard [4]. However, we recognize a move towards XML-based standards, such as UBL [9], even if this move takes place much slower than expected.

When referring to a "standard" one would expect that an enterprise that supports a certain standard, e.g. UN/EDIFACT, may send an invoice to any other enterprise that also supports this particular standard and that the receiving enterprise is able to process the invoice without any problems. However, this is not the case for the dominant business document standards (both UN/EDIFACT and XML ones). This is due to the fact that these business document standards are more or less designed as a reference document that has to be customized for partner-specific implementations. The "standard" covers the union of all elements that may be required by any enterprise in any industry in any geopolitical region. This reference model of the "standard" is than restricted by a so-called message implementation guide (MIG) to the specific needs of a particular supply chain. This subset usually covers only 3–5 % of the "standard" reference model. By following this approach one may implement supply chains with a high performance, such as the just-in-time (JIT) implementations in the automotive industry. Large corporations use their economic power to enforce a particular MIG on their smaller partners along the supply chain. This results in a closed user group, i.e. an extranet, along the supply chain which supports a certain "dialect" of a standard.

Evidently, it is a prerequisite to implement a dedicated interface for a specific MIG in order to participate in an extranet. It is quite common that a new interface to the ERP system goes hand in hand with a customization of the ERP system itself. Accordingly, the implementation of a new MIG does not only require a lot of technical skills and know-how, but it is also quite cost-intensive. Thus, SMEs are rather reluctant in implementing EDI and are usually only willing to implement EDI when being forced by a more powerful business partner. This leads to the economic paradoxon that most commonly larger corporations can stick to a single MIG implementation, but smaller ones trading with multiple larger corporations have to suffer from the costs of multiple implementations. This is due to the fact that different dialects, i.e. different MIGs of different extranets are not compatible with each other. When participating in another extranet one has to bear the costs of another implementation of a MIG even if it is based on the same "standard".

3 An Open e-Invoicing Platform

Already in 2005, we have proposed a theoretical framework for the types of systems that are used by companies of different size, which has been recognized by the e-Business W@tch of the European Commission [10]. The main idea can be outlined as follows: Only larger companies have in-house application developers or can afford hiring external consultants that are able to customize the interfaces to

their ERP systems in order to participate in EDI/XML-based business document exchanges. Smaller companies prefer to buy commercial off-the-shelf (COTS) systems and are rather reluctant to spend plenty of money on external consultants to extend their systems, if not absolutely needed or not forced to by business partners. Thus, they have to rely on the functionality provided by these systems. According to the "Think Small First" principle, it follows that ERP vendors should implement common B2B scenarios in their products.

Following this basic EDI our group at the Vienna University of Technology joined forces with three Austrian software providers (BMD Business Software, Mesonic and Blue Monkeys) to conduct the research project ERPEL [11] to deliver a prototype implementation for the Austrian market. The results of the ERPEL project were convincing to start a university spin-off offering an open platform to conduct business document exchanges between ERP systems on the fly. The main characteristics of the ERPEL platform are outlined in the following subsections.

3.1 Enabling B2B Communication as a Native Feature of ERP Systems

Today, the exchange of structured business documents is usually not a native feature of ERP systems. Such B2B communication is realized by external functionality, implementing enterprise application integration (EAI) features. Due to the high variability in document standards, message implementation guidelines and underlying communication protocols, these extensions require a high effort in customizing the solution to the individual needs. If not forced by larger business partners, SMEs are not willing to bear these costs. In contrary, ERPEL implements the B2B communication as a native feature of ERP systems. This results in a direct GUI integration eliminating the boundaries between ERP features and B2B communication. Thereby, sending a business document becomes as easy as printing a document. A document received via ERPEL is seamlessly "absorbed" by the ERP system without human interaction. In order to realize native ERPEL interfaces in ERP systems, we have special demands on the business document formats and the exchange protocol, detailed below.

3.2 Providing a Document Exchange Protocol Enabling Full Trace of Exchanged Documents

Usually, it is of interest to the sender of a business document to immediately know the status of the document, i.e., what happened to the document after transmission: Has the document been accepted by the platform? Was the document successfully delivered to the inbox of the recipient? Has the recipient picked up the document

from the inbox? Was the recipient's system able to process the document? Am I still able to revoke the document (in case it has not yet been picked up)? Answers to these questions are given in the GUI of the ERP system, once the users opens up the corresponding business case. It follows that these requirements demand a business document exchange protocol on top of well-established network protocols, reflecting the status of the document delivery. The ERPEL document exchange protocol supports these requirements by means of business signals. Our protocol guarantees the necessary level of trust in electronic document exchange that conventional protocols (e.g., e-Mail/SMTP) are not able to provide.

3.3 Permitting Business Document Exchanges Without the Need for Prior Technical Agreements

Shortly after the first UN/EDIFACT implementations, the major roadblock for its widespread adoption became apparent. The initial high costs of establishing a partnership may be justified only for long term partnerships and between a limited number of partners. According to the Open-edi reference model [12], these initial costs arise mainly due to the fact that business partners have to agree on a message implementation guideline (MIG), which requires a customized implementation for each of these partnerships. Open-edi suggests "introducing standard business scenarios and the necessary services to support them. Once a business scenario is agreed upon, and the implementations conform to the Open-edi standards, there is no need for prior agreement among trading partners other than the decision to engage in the Open-edi transaction in compliance with the business scenario". So far Open-edi remains a theoretical concept without any implementations. Nevertheless, we pick-up the Open-edi idea and provide a set of procurement business document types, whereby each of them is based on a core set of elements. A participant on the ERPEL platform may decide whether or not to support a specific document type. If a document is supported, the entire core set has to be understood. Thus, a simple lookup in the ERPEL registry ensures that a partner is capable of processing a certain business document type. This approach, which is in contrary to traditional ones, has been proven in Austria by the successful ebInterface initiative, which refers to invoices only.

3.4 Developing a Simple Extension Mechanism for Advanced Business Document Requirements Avoiding a Proliferation of Individual Solutions

As mentioned before, the core business documents of ERPEL reflect the most important requirements requested by all business domains. In order to cope with the challenge of business domain-specific requirements that go beyond the core,

ERPEL foresees a dedicated extension mechanism for the six core business documents. In order to avoid a proliferation of extensions caused by numerous bilateral agreements leading to an extension, the goal of ERPEL is to maintain a controlled set of extensions that have a well-defined hook in the core documents. ERPEL cooperates with the Austrian Economic Chamber on domain-specific extensions. Nevertheless, we still follow the Open-edi idea: If a company supports a specific extension, this information is declared in the ERPEL registry. Again, a simple lookup in the ERPEL registry ensures that a partner is capable of processing a certain document extension. This simple lookup replaces a complex technical agreement as used in traditional EDI systems.

3.5 Focusing on an Open Platform Approach

Even if the concept of exchanging documents via a platform has been implemented before, these solutions are limited by a closed world approach. In other words, traditional platforms offer only the functionality, which has been implemented by the platform provider and third parties are hardly able to provide additional services on the platform. However, B2B interactions require a multitude of specialized and dedicated services, which are already offered by other service providers. In order to make use of these dedicated services, they should be seamlessly integrated into the document exchange platform. Consequently, ERPEL follows an open platform approach. This means on the one hand that ERPEL provides the basic functionality of a document exchange and on the other hand that ERPEL provisions additional services, offered by third parties. Accordingly, ERPEL realizes the concept of a B2B app store for these additional services, which are further referred to as B2B apps. Third party providers may integrate their B2B apps on the platform and register them in the B2B app store. Users of these B2B apps are able to subscribe to them and utilize their functionality to meet their demands.

3.6 Additional B2B Services Leading to a Fully-Fledged B2B Solution

As outlined above, companies may require additional services that go beyond the exchange of business documents. These services include for example digital signing of business documents and archiving of documents. Another type of offered service may cover business performance analysis by providing statistics on the document exchanges to the involved parties. Additionally, we also envision B2B apps realizing business functionality that is important for establishing new partnerships such as checks of creditworthiness, VAT numbers, and correct addresses. However, especially SMEs are unlikely to implement such solutions on

their own or integrate different software packages to achieve the desired functionality. They want fully-fledged and out-of-the-box solutions involving no or only limited customization. ERPEL meets these needs by demands of its app store.

3.7 Lookup of Customer and Product Information in the ERPEL Registry

A central feature of the ERPEL infrastructure is a business registry. As mentioned above, the provision of registry functionality is key to enable the Open-edi vision of exchanging documents without prior technical agreements between the different partners. Accordingly, the registry covers the information which partner is capable of processing which documents and which extensions. In addition, the registry covers semantically enriched information about products and services offered by the ERPEL participants. Following the ERPEL approach, the product information is taken directly from the ERP systems of the business partners. Thereby, the ERPEL registry supports the information and selection phase of a business transaction enabling the search for potential business partners offering a desired product or service. Once a business partner has been found in the registry, the business transaction is conducted by exchanging business documents via ERPEL.

4 Conclusion

Following reports from the European Commission [2], it is envisioned that e-invoicing is becoming the predominant way of issuing invoiced by 2020. In order to reach a critical mass it is a necessity to deliver an inexpensive solution for SMEs that does not require any expert know-how. Traditional EDI standards and current XML-based standards fail in delivering such a solution for SMEs. Thus, we propose an integration of the business document exchange functionality in the ERP system itself. In the research project ERPEL we have implemented a prototype for the Austrian market in collaboration with three Austrian business solution providers. The ERPEL prototype is now extended by a university spin-off "ecosio" which offers a platform with the following characteristics:

- It is a *platform for exchanging business documents* of a procurement process, such as electronic invoices, without the need to prior agreements and partner-specific customizations.
- It is a solution that is *directly integrated into ERP systems* enabling ERP to ERP exchanges without any human intervention.
- It is a *ready-to-use* system where ERP vendors integrate a dedicated module into their ERP software.

- It comes *without any initial costs*, since the solution is part of the ERP system.
- It is *easy to use*, since the solution is integrated into the native user interface of the ERP system.
- It is a solution for companies of any size following the "Think Small First Principle" which does not require specific know-how nor high costs.
- It is *reliable*, since the business documents are exchanged as "registered letter". Users are able to fully trace the exchanges and are informed when the business document is delivered to the partner and when it is picked up by the partner.
- It is *secure* by building up on state-of-the-art authentication and authorization mechanisms.
- It is *inexpensive* and does not cost more than exchanging business documents by snail mail.
- It is fast since business documents are transferred from one ERP system into the other within seconds.

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Returning Lost Elements in the Sales Process: Manum Dare

Richard Mayr

Abstract The art of selling has undergone tremendous change throughout the years. Information and technology have made sales more efficient but have also negatively affected the customer-salesman relationship. Much of this can be attributed to the barriers built through digitization and the laptop. The tablet brings a new form to present products and share data. The flat surface removes those barriers and facilitates an exchange between customer and seller which has not been easily achieved since the move to laptops. The sense of touch is returning to the sales process after a long hiatus. Future advances in technology should further entice the senses and aim to improve the relationship between customer and salesman.

Keywords Sales relationship · Sales process · Effects of technological advances in sales · Increasing information in sales · Tablets in sales · 3D printers

1 Buying Experience of Yesteryear

How did our forefathers sell and what was the buying experience? As the salesman arrived, he picked a product from his cart, offered the product to the potential customer and that customer used their senses to decide the value of the good. There was always a relationship. That relationship was built together. Only two parties took part in the transaction. Once the sale was concluded, the customer was handed the product and off they went: a quality experience.

This physical interaction with the product was hugely important. By handling the product, the form and size of the product could be measured, giving a concrete

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feeling if the product could accomplish the task for which it would be purchased. The potential buyer could assess the craftsmanship with the sense of sight, touch and smell. If there was a deficiency in quality, that deficiency could be judged before the sale. If the buyer had concerns about what the seller was proposing, those concerns could be alleviated or confirmed by simply taking the product and deciding if it was worth the price.

The use of senses granted greater confidence when making the decision of whether to complete the purchase. The product and relationship remained center-stage and the process did not interfere. The salesman did not need to call into the warehouse to check if inventory was available and give a forecasted delivery date. The item was on-hand.

Throughout the years, the sales process has slowly moved away from this model [7]. Some aspects have become more efficient but also impersonal. There are evermore actors in the sales process and much of the salesman-customer relationship is controlled by the back office. Unfortunately, this quest for efficiency affects the relationship between salesman and customer and removes some the freedom to adapt the sales pitch to match the customer [5]. The efficient process also builds barriers.

2 Evolutions in Sales

Two evolutions have fundamentally changed the sales relationship and the interaction between salesman and customer: information and technology.

2.1 Information

2.1.1 Payment in Goods to Paper Currency

With a payment in goods, both salesman and customer had the perception of full information. Both could see the quality/value of the goods. They could touch and feel both items. Their sense of value determined whether the trade was made or not.

Paper currencies created an abstract sense of value. No longer could both parties determine the value of each product, work together to find the fair exchange. The sense of smell, touch and sight was removed from half of the transaction. One real item is now traded for an abstract representation of another.

Payment in currency also created a need to understand prices.

2.1.2 Market Prices and Segmentation

Market prices create transparency, but only for those who know the current market prices. Additional information can be a huge advantage. Trust, which is essential in any transaction, breaks down, when one party does not feel adequately informed.

Market segmentation gives further advantages to the informed party in a sale. Greater market segmentation can either be a success or failure and much depends on the salesman [2]. Pricing differences based on quality or other variations creates additional information which may not be readily available. This is not only true for natural resources but also for finished goods. Asymmetrical information becomes more commonplace and information becomes power.

The salesman-customer relationship is strained. There becomes a certain degree of mistrust and creates a level playing field only when both parties have the necessary information.

2.1.3 The Internet

The Customer has the ability to check prices and competitor's offers before and after the sales meeting. A more confident customer and a greater degree of transparency result. This, in turn, can reduce the mistrust built up through earlier forms of limited information [1]. The customer no longer needs to sit and wonder whether the salesperson's figures are correct. Those figures may be cross-examined after the conclusion of the meeting.

There are disadvantages to this from both the salesperson and customer's point of view. The information is gathered individually and not together. This requires additional preparation on the customer's side prior to the meeting. Time that could be spent thinking about what problems are faced and how these could be alleviated would be spent searching for pricing and other information, which is not always conducive to finding a solution.

If online reviews are available, numerous, positive reviews have been shown to have a significant impact on new product sales [3]. This impact does not always assist the salesperson when the customer enters a sales meeting with a product in mind that does not coincide with the salesperson's proposal.

In gathering information online, there is no teamwork involved. Each party enters the sales meeting with their own figures. If the two parties have conflicting figures, time may be spent comparing and ascertaining the source of differences. Hence, the relationship is not improved and the salesperson loses the ability to steer the discussion to follow the sales pitch. A more combative environment can also result.

The customer's desire to recheck the gathered information may also result in a delay in the decision to purchase. If the required information was not available during the sales meeting but is necessary, in the customer's point of view, the

information will need to be gathered after the sales meeting. Delaying the decision until a time in which the salesperson is not present cannot be seen as a positive and generally hinder the conclusion of the sale.

2.2 Technology

2.2.1 Oral to Written Communication

Written communication creates a barrier, where those who write and read control the contract and orders. A written record removes part of the element of trust established between buyer and seller.

2.2.2 Telephone Orders

Orders are called in by the traveling salesman after the meeting. This often takes place during the evening. Customers are no longer involved in the order. They are left only to hope the order is placed correctly.

Customer becomes a spectator instead of an active participant in the sales process.

2.2.3 Digitization

Command line programs cause customer to be illiterate in the language of managing sales. Programs are used with key combinations which take years to learn. These esoteric commands force the salesman to completely remove the customer from the ordering and inventory management process.

With the next step in digitization, even more is conducted behind the scenes than before. ERP, CMS and CRM programs provide further esoteric languages and complex interactions. While CRM usage has demonstrated a positive impact on sales performance and sales process effectiveness [4], not only is the customer but also the salesforce removed from some aspects the process.

Digitization breaks down the teamwork during the sales meeting. The salesman has additional information but this information is not always passed on to the customer. Often, the customer's ability to review the order is hindered by the complex programs governing the sales process.

2.2.4 Laptops and the Wall

Laptops build the ultimate physical and psychological wall. Instead of quickly jotting down notes on an order form, the salesman types away at the keyboard. Eye contact is lost. Connection is lost. Focus is lost.

Social interaction is greatly reduced. When entering data or searching for an item, the salesman is not fully engaged in the conversation. The salesman interacts primarily with the computer during those moments. Taking breaks to allow for data entry disrupts the flow of the meeting.

One solution is to share the laptop but sharing the laptop breaches the comfort-zone of the two parties. Instead of sitting next across from each other, the two parties sit awkwardly next to each other. Even reviewing the order can become an uncomfortable affair.

Handing over the laptop removes the salesman's ability control that magic moment, when the customer's interest is piqued, to take back the item and seal the deal. That time-tested trick of our forefathers cannot be utilized and the art of selling suffers.

3 Why Have Some Leading Companies Renounced This Last Advance in Technology?

3.1 How Have They Done So?

Printed catalogs are still used. Pen and paper are used during the sales meeting and those orders are either sent in by fax or entered into the system after the sales. This is certainly inefficient but the relationship may be better.

Brick and mortar stores present another alternative. A car buyer sits in the car, takes a test drive, feels the acceleration, comfort and thinks about the look before buying. A bed salesman invites a customer to lie down on the bed, giving the customer a feeling for if the bed fulfills their requirements. At the Apple Store, the MacBooks are slightly closed, forcing the customer to touch the MacBook before looking at it. This forces them to first feel the quality of the aluminum housing before the display turns on and keyboard light up.

3.2 What are the Disadvantages?

Printed catalogs are extremely costly to produce. These catalogs are created using computers and then printed. Huge efficiencies are lost when transferring from digital to printed form. The catalog is obsolete immediately after the print. Any price changes, inventory troubles or new items will not be included in the catalog. As printing is so costly, updates to the main catalogs are not feasible.

Printed catalogs also give a different feeling. The hand flips pages, but the eye does not see only the items it searches. Concentration is lost when scanning for the correct page numbers where a particular item may be located. Sensory overload is bound to occur when too many unwanted items are examined.

Traditional stores are expensive to operate and maintain. Often, the stationary store cannot serve all the customers needed to be reached, as not all customers will live within close proximity to the store. For many industries, the traveling, dynamic sales team is the only solution.

4 Rebuilding the Relationship

4.1 Informed Customers

Customers are capable of gathering pricing information before and after sales meeting. Why not hand them with the data during?

Hide unnecessary details but have them available when questions arise. There is no need to show a long list of technical details to each and every customer, for each and every product. That is a pronounced weakness of printed catalogs. Keeping that information only a button push away, the tablet allows the customer to see all the information necessary to make a decision but not the information which would only cloud their judgment and deviate from the salesman's pitch.

Have real-time information about prices, inventory and expected delivery dates at the tip of your fingers. Shift that information to the customer.

Build that relationship through teamwork and learn something together.

4.2 Tear Down That Wall

Remove the physical and psychological barriers between the salesman and customer. Do not speak esoteric languages, write secret codes, or use technologies that can only benefit and be interpreted by one party. Communicate visually with pictures instead of text. Let the customer zoom into view greater details of the product.

The addition of related articles to the tablet's screen can better catch the customer's attention and increase sales. Allow the customer's eye to be caught by a picture of a product they may not have considered buying before. Group products logically based on the customer. Facilitate discovery together instead of only suggesting what the customer may need.

Visual communication gives the customer a chance to rethink their decision without being distracted by the ordering process. With minimal distractions, the customer is also able to view the items again and their attention span has not been fully spent, thus, allowing for the discovery of new products.

Instead of leaving the customer with empty hands, haptic feedback plays a significant role again. Laptops have created a situation where the user is the only actor in the sales meeting who involves their hands. All others sit are forced to sit and passively listen as the user enters data, searches for information and reviews orders. With tablets, there is constant exchange. Both the customer and salesman are involved in gathering information, reviewing orders can involve teamwork and data entry is minimal. No longer does the customer need to bring an additional laptop to the sales meeting, just to keep hands busy.

Make the order together. Search for items in the digital catalog, providing the customer with the ideal starting point to launch the sales pitch. When an item is found and the customer's mind is made up, allow them select the item. Let them review the order. Let them push the confirm button.

Turn salesmanship back into a business of relationships and give the salesman the opportunity to sell solutions, instead of focusing on typing in his orders. Providing solutions to customer's most urgent problems, providing valuable information during the sale and accomplishing all of this in a timely manner should build a strong relationship [6].

Regain eye contact. Speak freely. Shake hands without reaching around/over a computer screen!

5 Future of the Buying Experience

5.1 2D to 3D

Tablets have broken down barriers by providing a flat surface. The next step would be to have a 3D image, projected above the tablet. Turning and rotating would bring back the missing aspects of having the item in hand. If the projected object could be displayed in its actual size, the ability to sense whether its size and form fulfill requirements would also return. Less would rely to the customer's ability to correctly image the product. Additional senses would be utilized, thus, facilitating an even more natural and efficient sales meeting.

5.2 Instantaneous Delivery

3D printers would return the satisfaction of purchasing and owning the item as soon as the sale concludes. The traveling salesman comes full circle and possesses everything he needs for the sale, albeit in a much smaller and more dynamic package.

6 Full Circle

6.1 Immediate Fulfillment

Immediate delivery offers much more important than merely saving shipping costs. The feeling a buyer derives from taking the purchase in their hands cannot be underestimated. Delaying that moment until delivery only weakens joy of buying. It gives the buyer time to think over their decision, question, rethink and possibly cancel their order before receiving it. Taking the product in hand grants a more concrete and realistic impression of what the product offers. Witnessing the production would then involve the customer in an additional step in the sales process. The sense of touch would be utilized in the every step of the sale.

6.2 Virtually Back to Our Starting Point

After a long process and many technological advances, we will be back to a buying experience where customers once again entice their senses, touch, feel and gain a more concrete image of what is on offer. The salesman will be able to offer his products, find the right moment to seal the deal and then allow the buyer to walk away with product in hand. Using all the methods developed by our forefathers, the salesman would have a full arsenal of techniques to build relationships, find the best solution and offer a great range of service. All in a much smaller package. Sharing the technology, working together.

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Part II
Future Tools

Fact Based Modeling in the Cloud

Peter Bollen

Abstract Service-oriented computing (SOC) allows organizations to tailor their business processes to web-based service-providers (in the 'Cloud'). In order to find those service-providers that provide the organizations with the best value, it is paramount that the service-requesting organization (SRO) has a precise description of the service it wants to have delivered by the service delivering organization (SDO). In this paper we will extend the fact-based family of conceptual modeling approaches with modeling constructs that allow us to conceptually model the services that are needed by the focal (SRO) and that should be delivered by a SDO using a well-established service oriented architecture (SOA) that contains a service broker (or repository service) as a third agent.

Keywords Service orientation · Fact-based modeling · Conceptual modeling

1 Introduction

In the *service-oriented architecture* (SOA) paradigm, a *service requesting organization* (SRO) basically outsources one or more organizational activities or even complete business processes to one or more *service delivering organizations* (SDOs). The way this is done currently, is that the SRO 'outsources' a given business service to a 'third-party' SDO for a relative long period of time (1 month, a quarter, a year). The selection and contracting activities are performed by managers responsible for the business processes in which the service(s) is (are)

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contained. Most of the current SDO's provide 'cloud substitutes' or 'internet substitutes' [1] for functions that used to be performed by an (integrated) SRO's enterprise system, implying that the SRO's that use these process services are shielded from the intrinsic complexities of these 'substituted' functionalities [2, 3].

The problem with current approaches for web services is that they cannot handle the semantic and ontological complexities caused by flexible participants having flexible cooperation processes. Semantic operability between participants (i.e. broker, SROs and SDOs) can only be achieved if the conceptual schema of the content, e.g. its ontology can be expressed totally and explicitly [4, 5].

In most business organizations the function that is responsible for information and knowledge management will have some kind of repository, schema or knowledge map that (ideally) defines the business concepts (business repository or business ontology) and the semantic relationships between these business concepts (conceptual schema or a data description language (DDL) of some sort). In the best case (large) companies have a business glossary in which business concepts are defined precisely. When it comes to processes we must conclude that at best descriptions of procedural knowledge might be documented in some type of flow-chart or other process description logic (e.g. BPMN [6]). In most practical situations, however, the process logic is embedded in software code and an explicit semantic description of the business process(es) is lacking.

The application of the service-oriented paradigm that will lead to the most benefits for the SRO will be embedded in a semantic-web environment in which the 'outsourcing' decision in principle, can be made in real-time every time a service is requested [7]. This real-time level of decision making implies that the service-processes that are requested should be defined in such a way that the negotiation, contracting and execution of the service can take place in 'run-time' without 'design time' human intervention. In fact-based terminology a process can be considered a fact-generating activity [8].

There currently exist a number of generic standards for expressing web ontologies, e.g. OWL [9] and for modeling web service ontologies, e.g. WSML [10] and web services execution, e.g. WFSL 1.0 [11] and BPEL4WS [12].

In this paper we will illustrate how the concepts from the application's process base (or program base, see [12]) using the fact-based conceptual modeling language (e.g. as documented in several variations in [13–17]) will enable businesses to define their platform independent models for their service-oriented requirement.

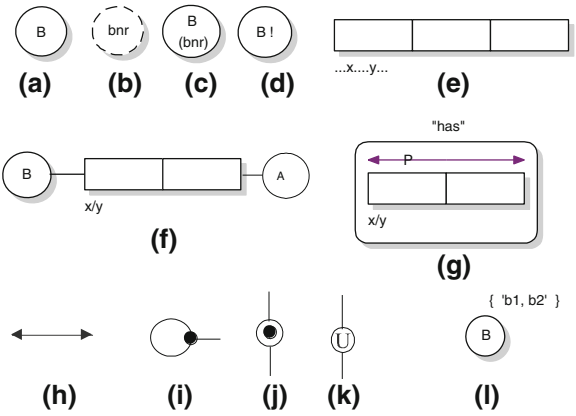

Fig. 1 Main symbols in object-role modeling (ORM)

2 Related Work

2.1 The Fact-Based Knowledge Reference Model

The (extended) fact-oriented approach structures verbalizable knowledge into the following elements [18]:

1. Knowledge domain sentences
2. Concept definitions and naming conventions for concepts used in domain sentences
3. Fact types
4. Fact type readings for the fact types
5. Population state (transition) constraints for the knowledge domain
6. Derivation rules that specify *how* specific domain sentences can be derived from other domain sentences.
7. Exchange rules that specify *what* fact instances can be inserted, updated or deleted.
8. Event rules that specify *when* a fact is derived from other facts or when (a) fact (s) must be inserted, updated or deleted.

A legend of the ORM-(I) [16] notation used in this article is provided in the following. The 'role-based' ORM notation makes it easy to define static constraints on the data structure and it enables the modeler to populate ORM schemas with example sentence instances for constraint validation purposes. In ORM (and other fact oriented approaches) the fact construct is used for encoding all semantic connections between entities. Figure 1 summarizes the symbols in the ORM modeling language that we have used in this paper.

Atomic *entities* (Fig. 1a) or *data values* (Fig. 1b) are expressed in ORM as simple (hyphenated) circles. Instances of an entity type furthermore can exist independently (e.g. they are not enforced to participate in any relationship), which is shown by adding an exclamation point after the entity type's name (Fig. 1d).

Simple reference schemes in ORM are abbreviated by putting the *value type* or *label type* in parenthesis beneath the name of the entity type (Fig. 1c). Semantic connections between entities are depicted as combinations of boxes (Fig. 1e) and are called *facts* or *fact types* in ORM. Each box represents a role and must be connected to either an *entity type*, a *value type* or a *nested object type* (see Fig. 1f). A fact type can consist of one or more roles. The number of roles in a fact type is called the fact type arity. The semantics of the fact type are put in the *fact predicate* (this is the text string …x…y… in Fig. 1e). A *nested object type* (see Fig. 1g) is a non-atomic entity type that is connected to a fact type that specifies what the constituting entity types and/or values types are for the nested object type. Figure 1h through Fig. 1l illustrate the diagramming conventions for a number of *static population constraint(s) (types)* in ORM. A double-arrowed line (Fig. 1h) that covers one or more 'boxes' of a fact type is the symbol for *an internal uniqueness constraint*. The symbol in Fig. 1k stands for an *external uniqueness constraint*. A(n) uniqueness constraint restricts the number of identical instances of a role combination 'under' the uniqueness constraint to *one*. A *mandatory role constraint* (Fig. 1i) can be added to a role. It specifies that each possible instance of such an object type must play that designated role at *all* times. A *disjunctive mandatory role constraint* (Fig. 1j) is defined on two or more roles and specifies that each possible instance of the object type connected to these roles must *at least* play *one* of these roles at *any* time. In Fig. 1l an example of a value constraint is given that enforces that each instance of the object type B either has the value b1 or b2.

2.2 Related Work on Service-Orientated Architectures

In [19] a service oriented architecture (SOA) is provided. The basic elements from this service-oriented approach to distributed software design is given in Fig. 2.

In the SOA from Fig. 2, service delivering organizations (SDOs) or service providers use the registry service (or broker [5] or service repository [21]) to publish their identity and a description of services that they provide. When a service requesting organization (SRO), service requestor [21] or service client, needs a service, it queries the lookup service (service discovery [22]) which will initiate the communication between SRO and SDO to establish a commitment regarding the service delivery [22].

We will take the SOA architecture from Fig. 2 as a basis for our further application of conceptual modeling on the SOA domain. We will thereby, explicitly distinguish three universes of discourse (UoD's): the client (SRO), the service provider (SDO) and the broker (or registry and look-up service).

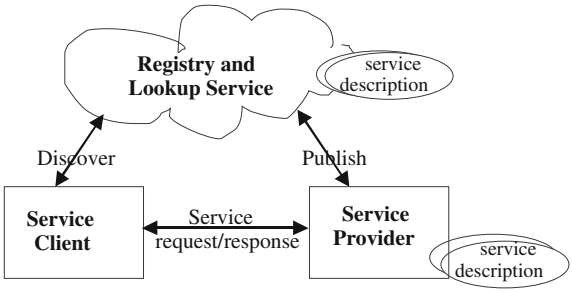

Fig. 2 SOA architecture as given in [19] and [20]

3 Fact-Based Conceptual Modeling of the SRO

We will extend the current modeling capabilities of the fact-based approach with modeling constructs for the modeling of business services in the context of the service-oriented paradigm by extending the concepts definitions and derivation/exchange rule modeling constructs [23] to cater for 'business services' that can be provided by either the SRO itself or by one or more (external) SDO(s).

In order to use the semantic web for selecting and contracting SDO's for any business function that needs to be outsourced, business organizations need conceptual modeling tools that define these functions or (parts of) business processes. The commonly used process modeling approaches lack the capabilities to be used for this purpose [24]. Therefore, we will extend the fact-based conceptual modeling approach to cater for the definition of business functions (or parts of business processes) during design time in such a way that in a semantic web environment in which SRO and SDO's can interchange their domain ontologies and thereby in run-time can decide which of the relevant SDO's will be partner to deliver the requested service for a given business transaction.

We will present the elements from the fact-based knowledge reference model (KRM) and see how they can be applied in the situation in which SDOs are involved in (interorganizational) business processes. We will use as a running example for the UoD of the SRO, the (fictitious) ABC company, and focus on the carrier selection process for customer shipments.

3.1 The SRO UoD: The ABC Company's Carrier Selection Process

ABC is a business that operates a number of 'brick-and-mortar' stores. Although the company does have an internet retail-website, it sometimes receives order request for deliveries via mail, e-mail or fax, outside the sales region it serves and in some cases even outside the country it operates in, and sometimes it receives 'overseas' order requests. Especially for the latter order category, ABC can make

an additional profit by shipping the order using the cheapest carrier at any given point in time. The customer has the choice between a standard shipping fee and an express shipping fee. The ABC company, has a logistics department in which one person is responsible for the shipment of continental and overseas orders. Since this person, has also other logistics responsibilities, he/she cannot afford to spend too much time trying to search for the best transportation deals. It might be beneficial for ABC, to 'outsource' the carrier selection process to a third-party, in this case a service delivery organization (SDO).

3.2 Element 1: Knowledge Domains Sentences

If we apply the KRM on the ABC case study we can conclude that the fact types that concern the customer, order, destination, shipment conditions and carrier do not change in the new 'service-oriented' situation. On the other hand the design-time specification of SDO selection can be considered a new UoD, in which following (types of) domain sentences are relevant:

'The order with ordercode 23456 of service requesting organization having organization code 34567 has a cargo dimension having a size for which the width is 3 m, the length is 1 m and the height is 2 m'.

'The order with ordercode 23456 of service requesting organization having organization code 34567 has a volume of 6 m^3'.

'The delivery type with delivery type code *large* is carried out by service delivery organization having organization code 873895 having a potential contract base with contract base code *weekly renewal*'.

'The order with ordercode 23456 of service requesting organization having organization code 34567 is shipped by the carrier having carrier code *DHL*'.

'The order with ordercode 23456 of service requesting organization having organization code 34567 has an ultimate delivery date having date code 2008-31-01'.

3.3 Element 2: Concept Definitions and Naming Conventions

We will now take this set of 'explicit' verbalizations and abstract them into a set of concept definitions and fact type readings in a fact type diagram.

In some of the fact-based dialects a list of structured concept definitions [25, 26] is an essential part of the business model. So far this list of structured concept definitions should facilitate the comprehension of knowledge domain sentences and comprise the business domain ontology [27].

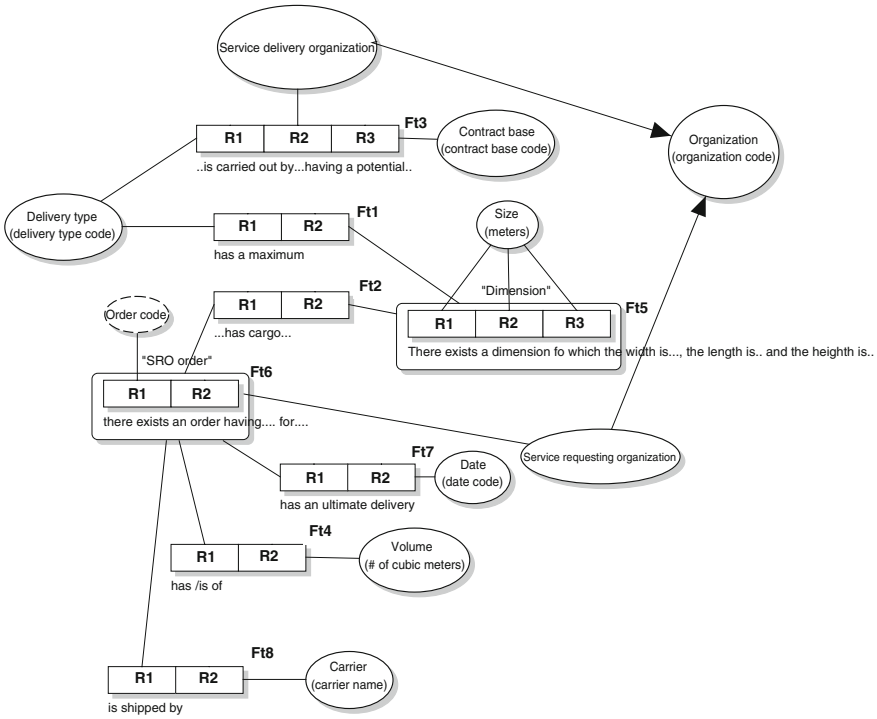

Fig. 3 Example fact types and fact type readings model

3.4 Elements 3 and 4: Fact Types and Fact Type Readings

The domain sentences from the former sections can be abstracted and will lead to fact types and associated fact type readings. In Fig. 3 an example is given of the fact types and fact readings that have been abstracted from these example domain sentences. In Fig. 3 we have depicted a small fact based modeling (FBM) fact type diagram for the example communication UoD for the SRO. The fact type diagram can be used as a starting point for the application of elements 5, 6, 7 and 8 of the KRM.

3.5 Element 5: Population State (Transition) Constraints

In case a standard between the SDO's and SRO's and service broker has been implemented, in which it is agreed upon that*: for any* (*predefined*) *delivery type at most one maximum dimension can exist*, we can show this as a uniqueness constraint of fact type Ft1 that covers the role R1. A further formalization of the

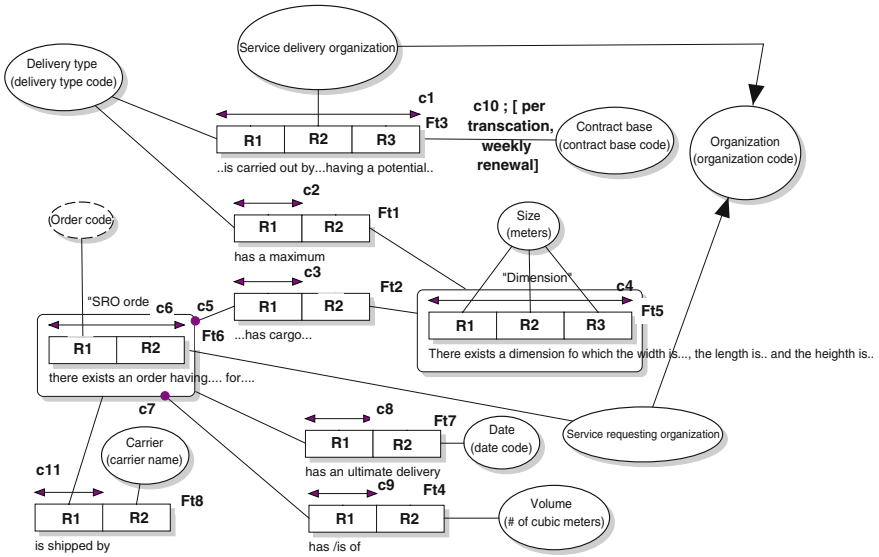

Fig. 4 Complete conceptual schema for SRO (in combination with Table 1). *Define* Order has volume (cubic meters). *As* Order has cargo Dimension *and* There exist a dimension for which the width is $Size_1$ and the length is $Size_2$ and the height is $Size_3$ *and* Volume = $Size_1$ * $Size_2$ * $Size_3$

allowed communication within the SRO's UoD's is the convention that *a given order by a given SRO must have exactly one dimension*. The latter business rule is encoded in the fact based modeling (FBM) fact type model in Fig. 4 as a uniqueness constraint spanning role R1 of fact type Ft2 in combination with a mandatory role on the nested entity type SRO-order. Finally, in role R3 of fact type Ft3 we can define a value constraint in which the allowed and enumerable set of values can be listed.

3.6 Elements 6, 7 and 8: Derivation Rules, Exchange- and Event Rules

In addition to the business rules that can be expressed as population state (transition) constraints, we can add business rules that can derive 'new' fact instances from 'old' fact instances. An example of such a derivation rule can be applied for fact type *Ft4*. We assume that *a* volume *is the multiplication of the three dimensions* figures that are modeled in fact type *Ft2/Ft5*. This derivation rule can be modeled as derivation rule *dr1* in Fig. 4 in which formula: Ft4.R2 = Ft5.r1 * Ft5.r2 * Ft5.r3 is contained. We note that in a service oriented architecture, derivation rules play an important role (next to exchange rules, see next section) because SRO's 'outsource' the execution and management of these rules

to SDO's. It's therefore, paramount to incorporate the semantic definition of these derivation- and exchange processes into the list of concept definitions. The addition to the list of concept definitions together with the fact type diagram and the fact type readings and the business rules (instances of elements 5, 6, 7 and 8 of the KRM) that are defined on the fact type structure are given in Fig. 4.

The last two elements in the KRM are the exchange rules and the event rules. For those fact types for which no derivation rules are given, we can in principle define an exchange process that states that a fact can be added or removed to/from the information base unconditionally or under some condition [28]. In the latter case we will give an event rule that specifies under what condition the exchange (addition or deletion) of a fact instance takes place. In case a number of instances of one or more fact types will be added and/or deleted under (possibly different) conditions on the information base in one ore more event rules, it is recommended to add the definition of such a 'transaction' into the list of concept definitions. If we inspect the conceptual schema for our example SRO we see that the process *calculate* volume is implemented within the sphere of influence of the organization itself. The process is made explicit in the form of derivation rule: *Define order has* volume (cubic meters), that is listed at the bottom of Fig. 4. The process determine carrier for order, however is outsourced to some SDO. We remark, that the definition of the process (or service description) as an imperative, in the case that SDO's who provide such a web-service are selected in run-time on a per transaction base.

Process: calculate volume	A process that has a result: a rough indicator of the cubic [volume] of a package which is determined by multiplying its width, height and length ⟨*Create*(*s*) *instance*(*s*) *of Ft4*⟩
Process: add order	A transaction in which the [order] and the [dimension] and [delivery date] of the [order] are added to the information system ⟨*Create*(*s*) *instance*(*s*) *of Ft2 and Ft7*⟩
Process: determine carrier for order	This process leads to the selection of a specific [SDO] for the shipment of an [order] under the best possible conditions for [delivery time] and [shipment price] ⟨*Create*(*s*) *instance*(*s*) *of Ft8*⟩

Adding the semantic definition of a (business) process to the list of concept definitions is a pragmatic extension of the current definition of the list of definitions, which normally contains definitions for concepts in the ontology. From a theoretically point of view, however, if we consider a process base [29] as part of our UoD, then a semantic definition of a process type should per definition be contained in the list of concept definitions.

4 Fact-Based Conceptual Modeling of the SDO

In this section we will look at the universe of discourse of a web-service that provides carrier selection services for SRO's. One of the main processes within this UoD's is the up-to-date acquisition of carrier data regarding latest offers, in terms of shipment conditions, and prices for each delivery type and possibly delivery (sub)-types depending upon each individual carrier. This web-service organization has as objective to match SRO's with carriers normally for a small fee per transaction. We will see that ontological commitments need to be established between SRO's and SDO's on a 'design'-time level. This means that key concepts for web-based service transactions will be harmonized (as can be checked for example in the list of concept definitions in Tables 1 and 2, for the concept *delivery type* and *carrier*). On the other hand, promotional concepts and other rating schemes can be introduced on the fly, at any time by a carrier. For many of these promotional campaigns and or new tariff schemes, it will not be feasible to establish ontology harmonization between the SDO and these carriers at all times. To cater for this, we need modeling constructs that allow us to deal with the runtime changes in domain concepts as used by SDO's in their carrier selection processes on behalf of their SRO customers. We will show now in our example list of definitions and conceptual schema for the UoD of the SDO can be modeled for these short-term runtime definitions of domain concepts. We note that a 'snapshot' of delivery types for every carrier that that is considered by a carrier-selection SDO will be modeled as a populations of fact type Ft1 in the conceptual schema of the carrier selection SDO in Fig. 5. The domain sentences that will be communicated will contain (amongst others) the following sentences:

'The carrier having carrier code *DHL* provides deliveries of local delivery type with local delivery type code *DHL express*. This carrier delivery type has a maximum dimension having a size for which the width is 3 m, the length is 3 m and the height is 3 m'.

'The carrier having carrier code *DHL* provides deliveries of local delivery type with local delivery type code *DHL express*. This carrier delivery type has a maximum delivery period length in days of 14'.

'The carrier having carrier code *DHL* provides deliveries of local delivery type with local delivery type code *DHL express*. This carrier delivery type has a standard price per kg which is the money amount of 12 dollars.

'The carrier having carrier code *DHL* provides deliveries of local delivery type with local delivery type code *DHL express*. This carrier delivery type has a promotional price per kg which is the money amount of 12 dollars in week 12 of the year 2008 A.D.'

'The carrier having carrier code *DHL* provides deliveries of local delivery type with local delivery type code *DHL express*. This carrier delivery type is classified as delivery type *large*.'

We now see that the carrier selection broker service not only provides the best deal for a service requesting organization, but also performs the role of

Table 1 List of concept definitions for SRO (based on sentences in Sect. 3.2)

Concept	Definition
Organization	A business entity that delivers services and/or goods to customers and/or other business entities
Organization code	A name from the *organization code* name class that can be used to identify an [organization] among the set of [organization]s
Service requesting organization (SRO)	An [organization] that potentially can request a service from a third party organization
Service delivery organization (SDO)	A [service delivery organization] that delivers a service to a [SRO]
Cargo	A product shipment from a [SRO] to a customer
Dimension	Size of [cargo] as length * width * height
Dimension code	A name from the *dimension code* name class that can be used to identify a [dimension] among the set of [dimension]s
Size	Depicts the extent in meters of any of the three elements of a [dimension]
# of meters	A name from the two-decimal number name class that can be used to identify a [size] among the set of [size]s
Volume	Depicts the extent in cubic meters of a three- [dimension]-al package
# of cubic meters	A name from the two-decimal number name class that can be used to identify a [volume] among the set of [volume]s
Delivery type	A generally agreed upon type of delivery by a [service requesting organization] and a service registry organization or broker that is characterized by a maximum [dimension]
Delivery type code	A name from the delivery type code name class that can be used to identify a [delivery type] among the set of [delivery type]s
Contract base	Type of commitment between a [service delivery organization] and a [SRO]
Contract base code	A name from the *contract base code* name class that can be used to identify a [contract base] among the set of [contract base]s
'Per transaction' contract base	A specific value for a [contract base code] that means that a contract between a [SDO] and a [SRO] change per transaction on the discretion of a [SRO]
'Weekly renewal' contract base	A specific value for a [contract base code] that means that a contract between a [SDO] and a [SRO] can change per week on the discretion of a [SRO]
Is shipped by	Depicts that a package is transported from an originator's door to a receiver's door
Order	A request to ship a package to a customer
Order code	A name from the *order code* name class that can be used to identify a [order code] among the set of [order code]s
Carrier	A third party logistics organization that ships packages for an [order] from a [SRO] to a client of the [SRO]
Carrier name	A name from the *carrier name* name class that can be used to identify a [carrier] among the set of [carriers]s that exist in the world
Date	Depicts a specific day
Date code	A name from the *date code* name class that can be used to identify a [date] among the set of [date]s

Table 2 List of concept definitions for SDO

Concept	Definition
Carrier	A third party logistics organization that ships packages for an [order] from a [SRO] to a client of the [SRO]
Carrier name	A name from the *carrier name* name class that can be used to identify a [carrier] among the set of [carriers]s that exist in the world
Dimension	Size of [cargo] as length * width * height
Size	Depicts the extent in meters of any of the three elements of a [dimension]
Delivery type	A generally agreed upon type of delivery by a [service requesting organization] and a service registry organization or broker that is characterized by a maximum [dimension]
Local delivery type	A label to refer to a specific type of service provided by a specific [carrier]
Carrier delivery type	A [local delivery type] that is offered by a [carrier]
Period length in days	A period or slice in time having a duration
Natural number	A name from the *natural number* name class that can be used to identify a [period length in days] among the set of [period length in days]
Money amount	A specific quantity of money
Dollars	A name from the *dollar* name class that can be used to identify a [money amount] among the set of [money amount]s
Promotional price	A price that is charged per kg for a delivery service during a number of [week]s in a promotional period
Standard price	A price that is charged in a [week] for which no [promotional price] is charged
Maximum dimension	The maximum [size] for length * the maximum [size] for width * the maximum [size] for height of an [order] for which a given [delivery type] is still valid
Maximum delivery period	The maximum value for [Period length in days] it takes to deliver a package to a client of a [SRO]
Year	A period or slice in time consisting of 365 days according to the Roman calendar
A.D.	A name from the A.D. name class that can be used to identify a [year] among the set of [years] in the roman calendar
Week	A period or slice of time consisting of 7 days
Weekcode	A name that can be used to identify a [week] within a given [year]
Process: classify service offering	A process that has a result a classification for a [local delivery type] offered by a [carrier] in terms of an instance [delivery type] that has been defined by a [SRO] and [SDO] ⟨Create(s) instance(s) of Ft108⟩
Process: add service offering delivery length	A process that has a result that a maximum delivery length for a [carrier delivery type] is entered into the information base ⟨Create(s) instance(s) of Ft106⟩
Process: add service offering standard price	A process that has a result that a [standard price] for a [carrier delivery type] is entered into the information base ⟨Create(s) instance(s) of Ft101⟩

(continued)

Table 2 (continued)

Concept	Definition
Process: add service offering promotional price	A process that has a result that a [promotional price] during one or more [weeks] for a [carrier delivery type] is entered into the information base ⟨Create(s) instance(s) of Ft102 and Ft107⟩

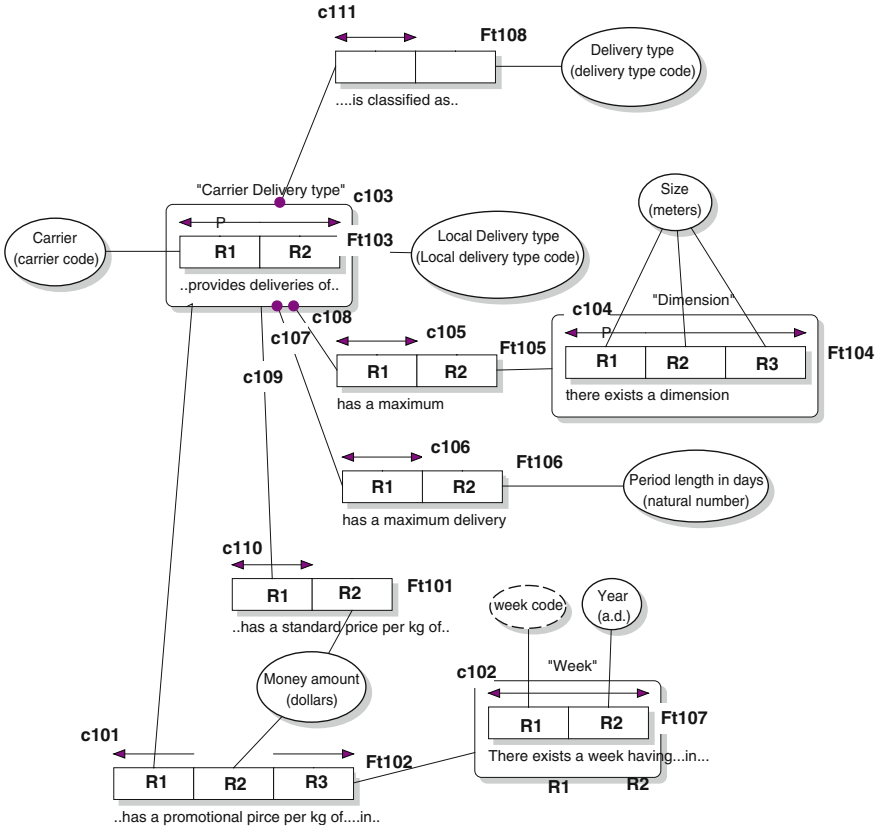

Fig. 5 Conceptual schema for SDO (in combination with Table 2)

'ontological harmonizer' between the SRO's and the carriers by introducing and defining the concepts of *local delivery type* and *carrier delivery type*.

In Table 2 we have provided the extended list of concept definitions for this example UoD of a service delivery organization in which the definitions of the fact generating processes are incorporated. In Fig. 5 we have given the complete conceptual schema for the example carrier selection process within the UoD of the SDO.

So, if we inspect the conceptual schema for our example SDO in Fig. 5, we can say that one of the 'core business processes' for the SDO, is establishing ontological harmonization in 'run-time'. This means that the SDO will populate fact type Ft108 in Fig. 5, by continuously scanning for recent service offerings provided by existing and new carriers. This business process mainly scans and interprets these service offerings, and as a result will 'label' these offerings and subsequently classify them, in the terminology, that was established between the SRO's and SDO's, via a broker or registry service.

5 Conclusion

In this article we have given additional modeling concepts for fact based modeling (FBM) to cater for the explicit modeling of an application domain's ontology. The new modeling constructs allow us to capture the definitions of the fact-generating business processes. The practical relevance of the list of concept definitions is in the 'networked' society and business-world in which a traditional conceptual schema has to be 'upgraded' to cater for communication of the definition of business processes with potential external agents, e.g. customers, suppliers, web-service brokers, whose identity is not yet known to us at design time.

In line with semantic web developments, the conceptual schema needs a communication part that contains 'definition' instances to be shared with the potential agents in order for them to be able to communicate effectively and efficiently with a ('web-based') business application in which the 'traditional' allowed communication patterns and their state (transition) constraints will not be violated. This will significantly increase the perceived quality and ease-of-use of such a (web-based) application, since it has established a semantic bridge with the potential external users, allowing them to communicate in a direct way with the business application, by preventing semantic ambiguities from occurring in the first place. Another advantage of applying FBM for capturing an application or a (relatively complex) domain's ontology is in its flexibility to use it even to model communication between agents in which (explicit) ontological harmonization at a type or schema level is not possible or desirable. By adding 'run-time' concepts as populations of (typed) concepts for which an ontological harmonization already has been established.

Another advantage of using (extended) fact-based modeling languages is that a business organization is not forced to remodel the application or domain ontology every time a new 'implementation' standard has been defined. Business organizations can capitalize on the 'FBM conceptual modeling investment, for the foreseeable future by applying the appropriate mappings between fact-based application ontology and the implementation standard of the time.

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How Lean Management Tools are Supported by ERP-Systems: An Overview

Martin Adam, Stephan Schäffler and Anna Braun

Abstract An increasing number of ERP providers offer support of Lean Management in their software. As part of a larger research project this article gives an insight into which elements of Lean Management are already covered by ERP-systems. More than 150 different functionalities within the ERP-systems that support Lean Management were identified. Not surprisingly production planning, scheduling and pull principles are supported by most of the functionalities, followed by performance and visual management. A detailed analysis of a selection of five ERP-systems showed that they have more than 50 % of the functionalities in common. But they are less realized in the basic system but in up to 13 different modules with the focus in production.

Keywords ERP-system · Lean management · Lean ERP · Toyota production system · SAP

1 Introduction

This paper is part of a larger research project that has been outlined by Adam et al. [1]. Its main goal is to foster research in Lean ERP—that is how ERP-systems support Lean principles. The paper mentioned above gives a reasoning of the research and an overview of the market situation. It shows that Lean ERP is a

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niche market regarding to customer demand. But there is a high number of ERP providers who offer Lean functionalities in their software.

The intention of this paper is to find out which Lean tools are supported by which modules of the ERP-system and to see if there is a difference between the vendors. In order to accomplish this goal an overview of Lean tools is given. In a next step, 10 ERP-systems were selected and functionalities were identified that support the Lean tools. Five ERP-systems were then been analyzed in order to see if the functionalities are covered by all vendors.

The evaluation is based on interviews and freely accessible information from the ERP providers. It turned out that the vendors didn't use Lean terminology consistently. Some even introduced their own terms. So linking new terms to the common Lean terminology opens space for misinterpretation. As in most cases the interview partners could not oversee all modules and there might be material that was not available for the research team, the result is biased and does not claim completeness.

2 Overview of Lean Tools

2.1 Origin

"Lean Management" as a term was introduced by Womack et al. at the MIT in Boston after having studied the Toyota Production System [2]. The TPS consists of a number of techniques that, historically, were developed over a period of more than 50 years. Each tool was an answer to specific problems that occurred to Toyota whereas the overall goal always was to raise efficiency and reduce costs. This led to the permanent focus on waste reduction. Techniques to identify value add and non-value add activities were developed. Keeping cost of poor quality low was another important element in saving money. Tools like Standard Operation Procedures (SOP), Total Production Maintenance (MTM) helped to raise reliability in the output of man and machine. Error-proof methods, also called Poke-Yoke were installed to keep rework low. After stability of the process was reached, flexibility was another topic. Due to the small automotive market in post-war Japan, batch sizes had to be small and quick responding to customer wishes was essential. Change over times had to be reduced and techniques like Single Minute Exchange of Dies (SMED) were introduced. Motivated by Henry Ford, Taiichi Ohno introduced flow production. But contrary to Ford, Ohno raised flexibility by reducing batch sizes until the ideal of a single piece flow. Another instrument to reduce costs that were caused by excessive inventory was the use of supermarkets and Kanban. Downstream processes withdraw material when they need it and in the right quantity just-in-time by using Kanban cards. No management effort is needed. Apart from all the new tools one main goal was to enable people to make their own work environment more efficient e.g. by Kaizen events [3, 4].

Table 1 Overview of lean tools on two levels

Lean tool—level 0	Related functionalities—level 1
Value stream analysis	Modeling capability
Waste analysis	Documentation of rework activities
Total productive maintenance (TPM)	Documentation of preventive activities
Standard operation procedures (SOP)	Documentation of operational method sheets
Quality at the source (Poka Yoke)	Documentation of mistake proofing efforts
Performance management	Tracking and reporting functions
Visual management	Visual controls (Dashboards, cockpits)
	Andon line
	Kanban visualization (Track Kanban)
	Exception alerts
Single minute exchange of dies (SMED)	Tracking functions
Production planning	Demand calculation
	Takt time calculation
	Safety and buffer planning (Inventory/supermarket)
	Production strategies
	Material resource planning (ABC, XYZ analysis)
	Celluarization (plant design, line design, cell design)
Production scheduling	Mixed production scheduling/Sequencing (Heijunka)
	Pacemaker planning
	Capacity balancing of line
	Batch size optimization
	Back flushing capabilities
	Production simulation capabilities
Continuous flow	Standardization
	JIT
Generic pull system (Kanban)	Pull signal creation
	Pull signal distribution (e.g. Electronic Kanban)
	External Kanban
Continuous improvement	Kaizen

2.2 Lean Tools

Although the evolution of the TPS was the answer to specific problems, the implementation of the tools followed certain logic. Identify customer requirements stands at the beginning and is followed by permanent waste reduction. Error-free and stable processes are prerequisites to gain flexibility. Whereas the implementation of Kanban requires stability and flow first in order to work properly. This logic is covered by the five Lean principles of Womack and Jones that guide implementation: Value → Value Stream → Flow → Pull → Perfection [2].

Based on Ohno, Shingo and Womack an overview of Lean tools was developed, in order to assess ERP support. The list follows the logic of the five principles (see Table 1).

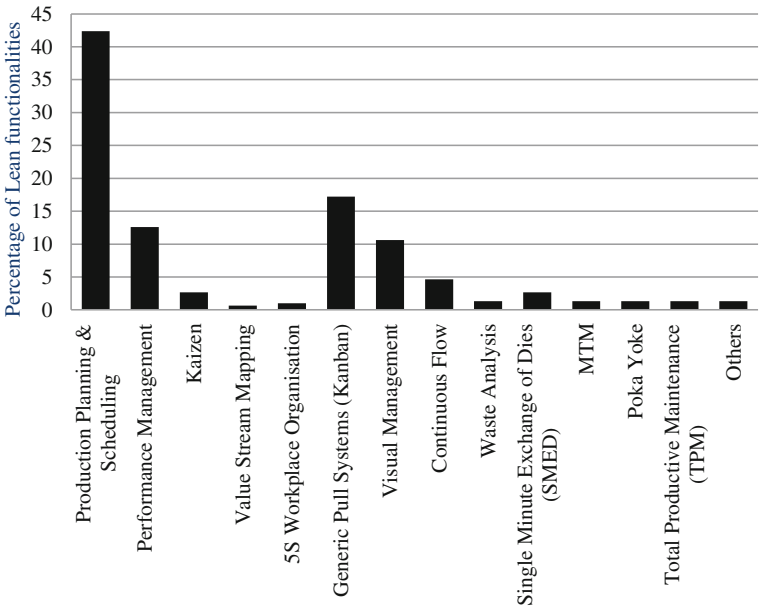

Fig. 1 Percentage of lean ERP functionalities that support certain lean tools

3 Assessment of ERP-Systems

3.1 Lean Tool Support by ERP-Systems

In the next step a selected number of ERP-systems was assessed against the list of tools in order to augment the related functionalities to a third level. The goal was to find out, which functions were already realized in ERP-systems. Therefore a broad range of ERP-systems was analyzed, from niche products to market leader. One criterion was that the vendor announced a support of Lean Management and that information was available for public. The following vendors were in focus: SAP, IFS, Microsoft AX, Infor, Plex, QAD, Seradex, Ultriva, SSL WinMan, IQMS.

In the end, more than 150 distinct functionalities were identified that support the Lean tools. The list of tools could be extended with these functions to a third level. Not surprisingly, more than 40 % of the 150 functions support Production Planning and Scheduling. Already far behind are functions that support Kanban, Performance and Visual Management. They contribute to the 150 functions with around 10 % each (see Fig. 1).

These findings were compared with a survey about the usage of Lean tools in 80 large and mid-size companies in Switzerland. Among the most frequently applied tools are Kaizen, Value Stream Analysis, 5S and Kanban (see Fig. 2) [5].

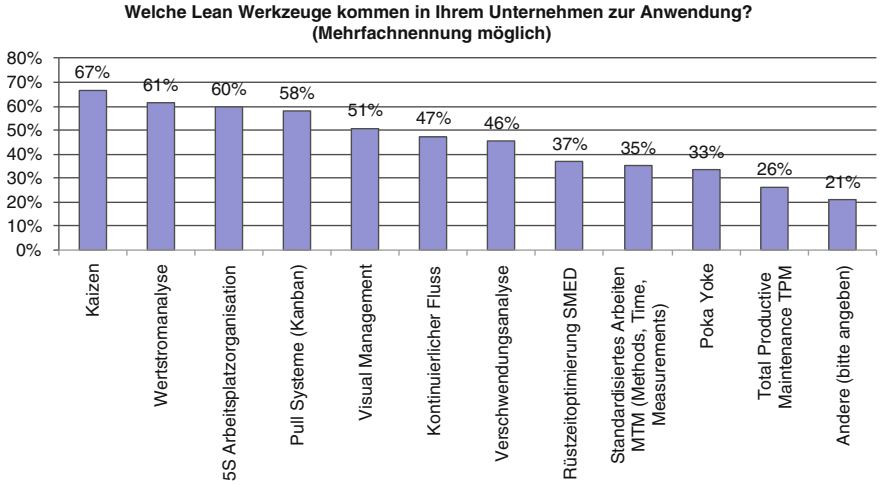

Fig. 2 Usage of lean tools in Swiss large and mid-size companies

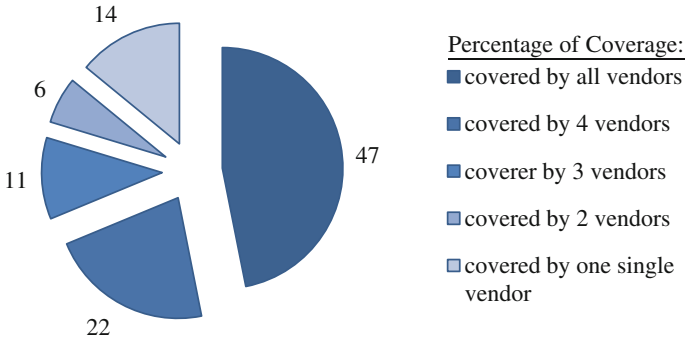

Fig. 3 Coverage of lean functionality by SAP, IFS, AX, Plex, QAD

If we compare the results of the two studies we see that e.g. for Kaizen, which is the most frequently used tool, hardly any support functions are developed in the ERP-systems. Similar results are for Value Stream Analysis and 5S. Another finding shows that from Kanban onwards in Fig. 2, the usage of the tools correlates with the number of support functions realized in the ERP-systems. That might lead to the interpretation that the software has been developed according to customer demand.

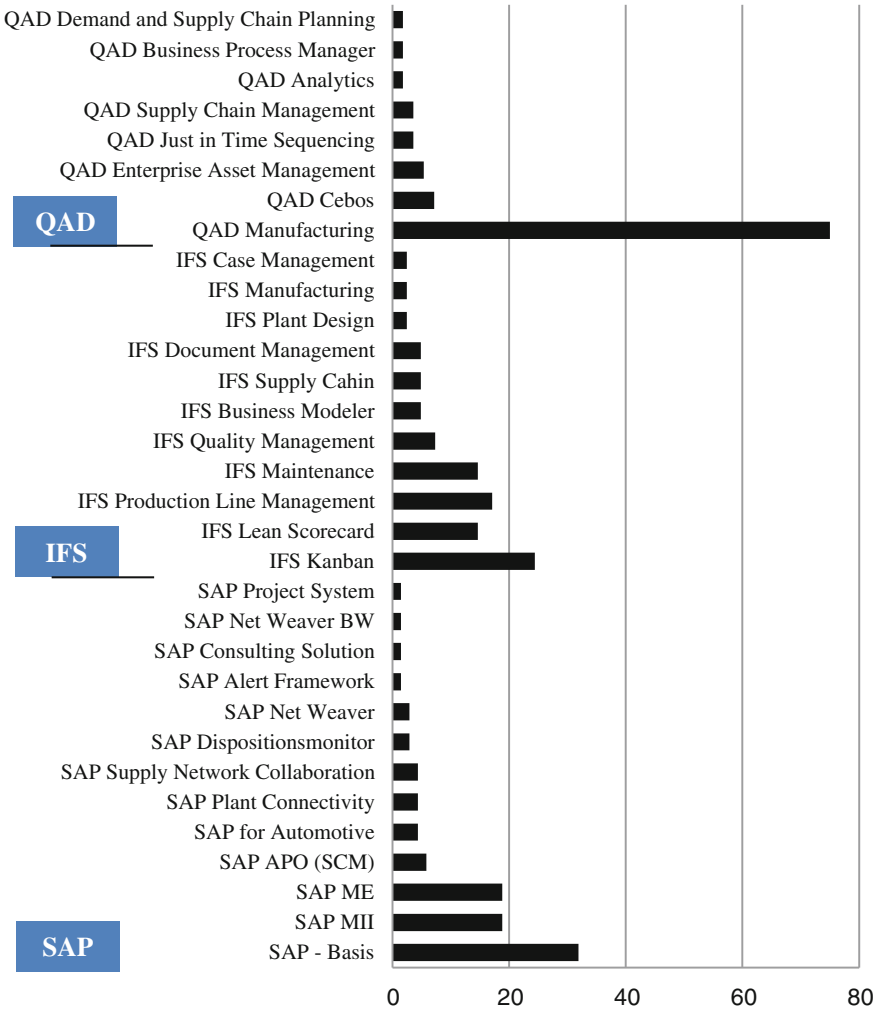

Fig. 4 Modules of SAP, IFS, QAD that cover ERP support functionalities (%)

3.2 Comparison of ERP-Tools

After having identified 150 functionalities in the ERP-systems that support Lean tools, the next question to ask was, are there any differences between the systems. Five systems out of the ten have been assessed in detail: SAP, Microsoft AX, IFS, Plex, QAD. The selection was based on the intention to cover the entire range: established vendors and new ones, large and small ones, those with a broad set of functionalities and specialized ones.

The result shows that the functionalities realized in the systems are quite similar. Although using different terms, SAP, IFS, Plex and QAD covered most of the 150 Lean functionalities, whereas Microsoft AX was following closely. Comparing the functions that are supported we see that the five vendors have nearly 50 % of the functions in common. Among the 14 % that are only covered by one vendor are certain types of Kaizen support and Value Stream Analysis. This goes in line with Fig. 1 where Kaizen and Value Stream Analysis is among the ones with less support in the ERP-systems (see Fig. 3).

In most of the cases the functions don‘t sit in the basic ERP-system but are spread over many modules. For SAP more than 13 different modules and linked products were found that support Lean. The main ones are SAP Manufacturing Integration and Intelligence and Manufacturing Execution. A similar situation is given in the example of IFS. More than 11 modules contain the Lean support, mainly the ones for manufacturing. This shows that in the case of SAP and IFS the original ERP-system was either augmented by Lean functions, like pull production, or new modules have been developed, like the IFS Kanban. This was done either internally or by acquiring external companies. A different situation is the one of QAD as QAD was already developed as a Lean ERP system. Therefore the majority of the Lean functions sit in one single module (see Fig. 4).

4 Conclusion and Further Research

Beside the fact that the results are biased due to company-specific terminology and lack of access to all relevant product information, the research showed the astonishing number of more than 150 functionalities that support Lean tools in ERP-systems. It also found out that they mostly support production planning and scheduling followed by Kanban and Visual Management. A detailed analysis of five ERP-systems showed that they realized quite the same functions. But that these are spread over up to more than 13 different modules. This is especially the case if the ERP-system is augmented by Lean functionalities and not build as a Lean ERP system from the beginning. Further research should drill into one ERP-system and cope with topics like modification in case of introduction of Lean Management and the development of an implementation roadmap.

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Part III
Business Process Models

Refinement of BPMN 2.0 Inclusive and Complex Gateway Activation Concept Towards Process Engine

Jan Kubovy and Josef Küng

Abstract This paper presents a possible refinement of Business Process Model and Notation (BPMN) Gateway activation concept for non-event-based gateways. The core refinement is the concrete formal definition of upstream token concept and calculation of the enabledness of an inclusive gateways (or also Or-Join) using modified Dijkstra's algorithm. The introduced algorithm for upstream token calculation considers also situations where two or more gateways are mutually dependent.

Keywords Bpmn · Inclusive gateway · Complex gateway · Activation · Process engine · Asm method · Refinement

1 Introduction

The Business Process Model and Notation (BPMN), currently in version 2.0 [1], is a well known and popular process modeling standard by the Object Management Group (OMG). The one, non-primitive, *Or-Join* activation concept of converging inclusive and complex gateways present in [1] is explored in Sect. 2. We use the BPMN Core Modeling Concepts [2] as a starting point for our refinements and define an algorithm for the computation of upstream tokens [2] for a particular gateway. We also demonstrate a proper function of the introduced algorithm in cases where two or more gateways mutually depend on each other (also called vicious circle), except some special cases, e.g., symmetric vicious circle shown in Fig. 1.

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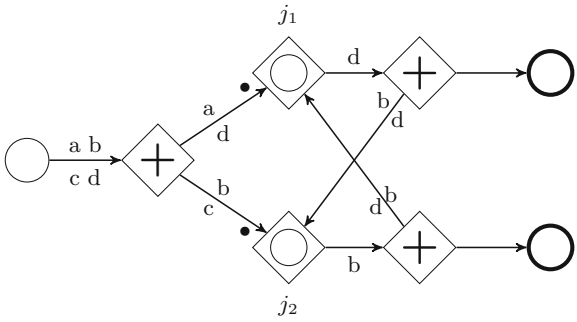

Fig. 1 A symmetric vicious circle [5]

For formalization the Abstract State Machine (ASM) method [3] was chosen, since this method is also used in the original work [2, 4] and this chapter is also part of a long-term ongoing work, which aims to formalize and enhance the BPMN 2.0 standard and is also using the ASM method.

In Sect. 2 we approach the upstream token concept using graph coloring algorithm, describe the work of this algorithm and show the enableness test for inclusive and complex gateways using the proposed algorithm. Next, in Sect. 3 we demonstrate the correctness of the algorithm, even in cases when some gateways may be mutually dependent on each other and identify exceptions when the proposed algorithm will not work.

2 Upstream Token

An upstream token of a flow node is a token in any Sequence Flow if there is a path starting with that Sequence Flow and reaching that flow node and if such Sequence Flow is not directly connected to that flow node. Upstream tokens are needed for flow node such as inclusive and complex gateways. This is defined using inhibiting and anti-inhibiting path [5] as a token which has an inhibiting path but no anti-inhibiting path to the corresponding flow node. Such upstream tokens are used as activation condition of an inclusive gateway [1, Table 13.3], or as a reset condition of a complex gateway [1, Table 13.5] and also as an `UpstreamToken → Set →` [2].

In this section we propose an algorithm as a refinement of the `Upstream-Token → Set →` [2, 4], which will for any given flow node in a process diagram identify all relevant Sequence Flow and color them based on their directly incoming sequence flow to the chosen flow node. This computation and coloring is made on an oriented cyclic graph represented by an ordered pair $\mathcal{G}(\mathcal{N}, \mathcal{E})$. The $\mathcal{G}(\mathcal{N}, \mathcal{E})$ can be obtained by converting all flow node of the process diagram to nodes $\mathcal{N}$ of $\mathcal{G}$ and all sequence flow to oriented edges $\mathcal{E}$ with opposite orientation than the original sequence flow of the process diagram.

Definition 1 (*Graph transformation*). Let $\mathcal{G}_d(\mathcal{N}, \mathcal{E}_{sf})$ be a process diagram, $\mathcal{N}$ be a set of all flow node in $\mathcal{G}_d$ and $\mathcal{E}_{sf}$ be set of all sequence flow is in $\mathcal{G}_d$. We construct an oriented graph $\mathcal{G}(\mathcal{N}, \mathcal{E})$ where $\forall e \in \mathcal{E} \exists! e_{sf} \in \mathcal{E}_{sf}(e = \{(n_0, n_1) \in \mathcal{N}\} \wedge e_{sf} = \{(n_1, n_0) \in \mathcal{N}\})$.

The next step is to color the edges of the graph $\mathcal{G}$ for every flow node that requires such coloring for its activation, e.g., inclusive or complex gateways, using the modified Dijkstra's algorithm [6] shown in Listing 1.

Definition 2 (*Colored graph*). A colored graph is a tuple $\mathcal{G}_\kappa = (\mathcal{N}, \mathcal{E}, \kappa, \delta, \mathcal{C}_\mathcal{N}, \mathcal{C}_\mathcal{E})$, where:

- $\mathcal{N}$ is a set of nodes same as in $\mathcal{G}_d$ or $\mathcal{G}$,
- $\mathcal{E} : \mathcal{N} \times \mathcal{N}$ is a set of edges after transforming $\mathcal{G}_d$ to $\mathcal{G}$, where the 1st parameter represents a node the edge is outgoing from and the 2nd parameter represents the a node the edge is incoming into,[1]
- $\kappa : \mathcal{N} \times \mathcal{N} \rightarrow$ *Boolean* is a function capturing closeness of the node related to a node a color calculation is done for,
- $\delta : \mathcal{N} \times \mathcal{N} \rightarrow$ *Integer* is a function capturing the distance between two nodes,
- $\mathcal{C}_\mathcal{N} : \mathcal{N} \times \mathcal{N} \rightarrow$ *Color* is a function capturing a node color related to a node a color calculation is done for,
- $\mathcal{C}_\mathcal{E} : \mathcal{N} \times \mathcal{E} \rightarrow$ *Color* is a function capturing a edge color related to a node a color calculation is done for.

The 1st node parameter of functions κ, δ, $\mathcal{C}_\mathcal{N}$ and $\mathcal{C}_\mathcal{E}$ represents the node a color calculation is done for. The 2nd parameter of those functions represents the relevant node or edge on the incoming inhibiting or anti-inhibiting path of the node passed to those functions in the 1st parameter.

3 Work of the Algorithm

The rule `ColorProcessGraph : N` shown in Listing 1 finds a shortest path from the `root` node of $\mathcal{G}_\kappa$ (representing an inclusive or complex gateway in $\mathcal{G}_d$) given as the only parameter to any reachable node in the directed graph $\mathcal{G}_\kappa$ in the way the original Dijkstra's algorithm [6] was designed. Additionally the algorithm colors visited nodes and tested edges, even those tested edges which are not further used for the search (i.e. incoming edges of closed nodes `n` $\in \mathcal{N}$ indicated by κ (`root, n`) = T). The algorithm starts with coloring each of the directly outgoing edges from the `root` node with a distinct color. Those colors are then

[1] Note that the direction of edges $e \in \mathcal{E}$ is opposite to the direction of sequence flow $s \in \mathcal{E}_{sf}$.

populated through $\mathcal{G}_\kappa$ till its leafs (usually representing start events in $\mathcal{G}_d$). If the algorithm visits a node, which has more than one incoming edge in $\mathcal{G}_\kappa$ (representing a splitting gateway in $\mathcal{G}_d$) for the first time (i.e. such node $\texttt{n} \in \mathcal{N}$ is not closed yet: κ (`root, n`) $= \perp$) it will additionally color this node with a distinct `limpid` color. Such `limpid` color will be further populated with the other colors such node will be colored with. A color calculation for a `root` node (represented by a `run` of rule `ColorProcessGraph: N`) will never color two nodes in $\mathcal{G}_\kappa$ having more than one incoming edge with the same `limpid` color. A `limpid` color is an indicator for other alternative path of the concrete node to populate their own `non-limpid` colors. Every time such node will be tested by the algorithm again (i.e. such node is already closed) all `non-limpid` colors of the tested Alternative Pathalternative edge will be populated to all nodes and edges in $\mathcal{G}_\kappa$ which are colored with the `limpid` color of the tested node.

All `limpid` colors are only visible locally inside the run of the `ColorProcessGraph`. The resulting set of colors obtained from both color functions ($\mathcal{C}_\mathcal{N}$, $\mathcal{C}_\mathcal{E}$) will not contain any `limpid` colors.

3.1 Enableness Test

The enableness of an inclusive gateway is defined as:

Theorem 1 (Enableness of inclusive gateway). *The Inclusive Gateway is enabled if* [1, 2, 5]:

- At least one incoming sequence flow has at least one token and
- there are no Upstream Token for that gateway, meaning:
  - a Token that has an inhibiting path,
  - but no anti-unhibiting path to the gateway

Based on the colored graph $\mathcal{G}_\kappa$ an upstream token for a concrete flow node is defined in Definition 2.2 and shown in Listing 2.

```
rule ColorProcessGraph(root)
  ∀ n ∈ 𝒩 do
    κ(root, n) ←⊥
    δ(root, n) ←∞
    𝒞𝒩(root, n) ←∅

  ∀ e ∈ ℰ do 𝒞ℰ(root, e) ←∅
  δ(root, root) ←0;
  set ← {root}

  while |set| > 0 do
    min ←∞
    node ← undef

    ∀ n ∈ set do
      if δ(root, n) <min then
        min ← δ(root, n)
        node ← n

    remove node from set
    κ(root, node) ←⊤

    ∀ next ∈ 𝒩 (edge(node, next) ∈ ℰ ∧ next ≠ root) do

      if δ(root, node) +1 < δ(root, next)
          ∧ ¬κ(root, next) then

        δ(root, next) ←δ(root, node) +1
        add next to set

        if ∃ n ∈ 𝒩 (edge(n, next) ∈ ℰ ∧ n ≠ node) then
          add nextLimpid to 𝒞𝒩(desc)

      if node = root then
        color ← nextColor
        add color to 𝒞𝒩(next)
        add color to 𝒞ℰ(root, edge(node, next))
      else
        ∀ color ∈ 𝒞𝒩(node) do
          if (∄ c ∈ 𝒞𝒩(next) (isLimpid(c))
              ∨ ¬ isLimpid(color)) then
            add color to 𝒞𝒩(next)
          add color to 𝒞ℰ(root, edge(node, next))

          ∀ limpid ∈ 𝒞𝒩(next) (isLimpid(limpid)) do
            ∀ n ∈ 𝒩 (limpid ∈ 𝒞𝒩(n)) add color to 𝒞𝒩(n)
            ∀ e ∈ ℰ (limpid ∈ 𝒞ℰ(root, e) do
              add color to 𝒞ℰ(root, e)
```

Definition 3 (*Upstream token*). A flow node represented by $n \in \mathcal{N}$ *in* $\mathcal{G}_\kappa$ has an upstream token if:

- there is a token in a relevant (for that node n colored with one or more colors) edge $e \in \mathcal{E}$, which has a token
- and there is no directly outgoing edge from node n, which has a token and is colored with one of the colors the edge e is also colored with

Listing 2. UpstreamToken : N → Set

```
UpstreamToken(node) =
  ignore ← { c ∈ C_E(node, e) | source(e) =node ∧ token(e) }
  relevant ← { e ∈ E | C_E(node, e) ≠ ∅ }

  return { t | t = token(e) with e ∈ relevant
      ∧ (C_E(node, e) \ ignore) ≠ ∅ }
```

4 Cyclic Workflow Graphs

In this section we show that the algorithm proposed in Sect. 2 works for use-cases including cyclic workflow graphs except some special cases, for which a reasonable semantics is not clear and can be sorted out by static analysis (e.g. Fig. 1) [5].

The process depicted in Fig. 1 was colored by `ColorProcessGraph` during the deployment of the process and the resulting coloring is indicated by small latin letters beside the sequence flow they color. Colors `a` and `b` are relevant for the inclusive gateway j_1 and colors `c` and `d` are relevant for the inclusive gateway j_2. Token are represented by a dot "•" next to the sequence flow they are contained in.

In the current state depicted in Fig. 1 we can see that for j_1 a directly incoming sequence flow colored with the color `a` contains a token and therefore all other sequence flow colored with the color `a` can be ignored. On the other hand, the second directly incoming sequence flow to j_1 colored with the color `b` does not contain a token but there is a sequence flow in the process colored with `b` and not with a containing a token which makes such token be an upstream token of the inclusive gateway j_1. The gateway j_1 has to wait for that token, hence for the activation of the gateway j_2.

Similarly for the inclusive gateway j_2 and its relevant colors `c` and `d`. In this case sequence flow colored with the color `c` can be ignored for the activation of j_2 since a directly incoming sequence flow of j_2 colored with the color `c` has a token. Sequence flows containing a token and colored with the color `d` and not with the color `c` block the activation of j_2. Hence j_2 has to wait for the activation of j_1. This symmetric dependency is considered as design error with unclear underlying semantics and may be detected using static analysis.

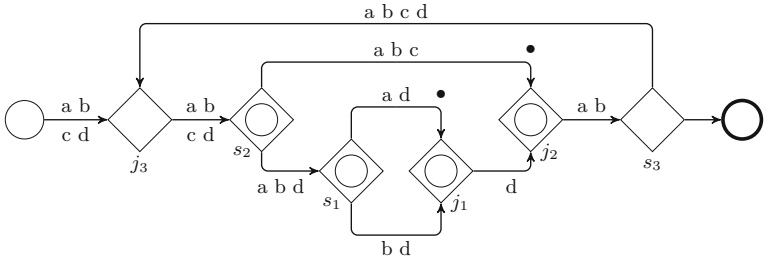

Fig. 2 A vicious circle in well-structured Process [5]

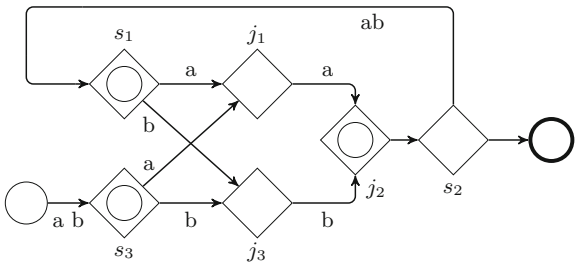

Fig. 3 A non-separable process [5]

4.1 Well-Structured Processes

The coloring of the process for each inclusive or complex gateway simulates the concept of inhibiting and anti-Inhibiting path and so coincide with the *Q-semantics* [5].

In the example of well-structured process depicted in Fig. 2 the coloring for both merging inclusive gateway (j_1, j_2) is shown. Similarly as in Fig. 1 the colors `a` and `b` are relevant for the gateway j_1 and the colors `c` and `d` are relevant for the gateway j_2. It can be observed that the gateway j_1 blocks activation of gateway j_2 but not vice versa. There is an edge in the graph colored the color `d` but not `c`, relevant for the gateway j_2, and having a token. And there is no edge in the graph colored with the color `b` but not a, relevant for the gateway j_1, and having a token.

4.2 Non-separable Processes

To complete our examples we also show that the proposed algorithm works correctly on non-separable process workflows. The example shown in Fig. 3 [5] is showing process colored with colors `a` and `b` relevant to the only iinclusive join j_2. For the sake of brevity we do not color incoming paths of inclusive gateways with only one incoming sequence flow (splits s_1 and s_3).

It can be observed that in all of those cases no two inclusive gateways are mutually blocking each other or themselves.

5 Summary

We have presented a possible refinement of the non-primitive activation concept of inclusive and complex gateways of a BPMN ground model [2, 4]. Our solution is based on a modified Dijkstra's algorithm [6] which colors the sequence flow of a process. Such coloring may be computed during deployment of a process into a process engine for every flow node, which may need it and so speedup the execution of Instance of such process. Emphasis was placed on brevity, simplicity and reusability of the algorithm shown in Listing 1.

We demonstrated correct work of the algorithm and also identified cases, where the proposed algorithm will not work, such as *Symmetric Vicious Circles* [5]. We agree that such cases may be considered as design errors where the underlying semantics is unclear and may be ruled out during development or deployment of an process by static analysis [7].

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On the Trade-Off Between Flexibility and Extensionality in the Decomposition of Business Process Models

Dirk Draheim

Abstract The decomposition of business processes and related artifacts is a necessary concept in conceptual modeling as well as in the definition of executable workflows. Decomposition is supported by almost all business process modeling notations and execution engines. Thereby the design of the interfaces and the semantics of these are an important factor to concern with impact, e.g., on a common understanding of the involved stakeholders. In this paper we analyze the flexibility and expressiveness of business process specifications with respect to hierarchical structure in a modeling language independent manner. The semantics of how instances of process capsules are initially and intermediately triggered via their interfaces turns out to be crucial for the discussion. We aim at clarifying the situation by characterizing and comparing a kind of intensional, so-called open, and a kind of extensional, so-called closed semantics for business process capsules.

Keywords Business process management · Business process modeling · Task modeling · Workflow management · Enterprise information systems · Enterprise resource planning · IT governance

1 Introduction

In this paper we analyze the flexibility and expressiveness of business process hierarchies. A comparative analysis of existing notations like event-driven process chains (EPCs) [24] or BPMN [18] is not sufficient. Rather, we want to understand the crucial modeling alternatives independent from concrete notations. And we

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want to analyze advantages and disadvantages of the crucial modeling alternatives beyond their mere notation and definition. Of course, the findings has been drawn from modeling projects with concrete notations and we hope that they are useful to compare, select or refine concrete notations and notational style guides in modeling projects in practice.

A crucial point in the flexibility and expressiveness of business process specifications with respect to hierarchical structure is the question of whether a business process can have only unique or multiple entries and exits and furthermore the semantics of how instances of processes are initially and intermediately started triggered via their interface events. This is the main observation of this paper and forms the background against of our discussion.

In the plethora of artifacts that are needed in the construction and maintenance of a today's typical very large enterprise information system, there are those that are directly executable [1] over those that are rather related to the executable artifacts [4] to those that embody pure business know-how. The more a modeling activity is business-oriented, the more it is about communicating ideas. The more a modeling activity is technology-oriented, the more it is about definite semantics, which is executable semantics eventually. The findings of this paper are of particular relevance for the sphere of business and IT governance [10] stakeholders, but there are also very important for bridging the gap between business-related and technology-related viewpoints on enterprise information systems.

Section 2 sets the stage by introducing hierarchies of business process models as leveled data flow diagrams. In Sect. 3 we distinguish between capsules with single and multiple interface points and identify two different semantics for processes with multiple start events which is crucial for the discussion in the sequel. In Sects. 4, 5 and 6 we conceptually develop the pragmatic differences in using the several modeling alternatives for building process hierarchies. We delve into the frictions between business process modeling and enterprise application modeling in Sect. 7. We report on related work in Sect. 8 and finish this paper with a conclusion in Sect. 9.

2 Hierarchies of Business Process Models

Basically, business process models are dataflow diagrams [5, 17, 21]. They do not merely specify the control flow between activities but also what data is produced by an activity and sent to another for subsequent consumption. We consider the approach of decomposing control flow and data flow in synch that has been followed by practitioners for two decades against the background of business process specification and workflow definition.

Figure 1 shows an example of a business process model with annotated data flow. The data items that flow along transitions are labeled with small Greek letters. The data is specified somewhere else, e.g., in a data dictionary, ER model, UML class diagram or the like. Furthermore, roles are attached to the activities in

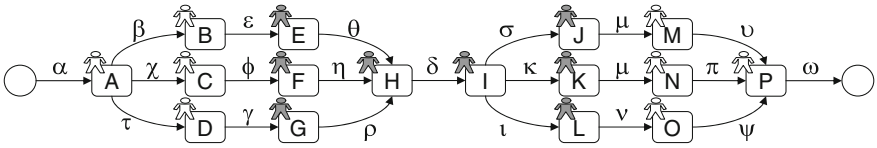

Fig. 1 A business process model with data flow and role specifications

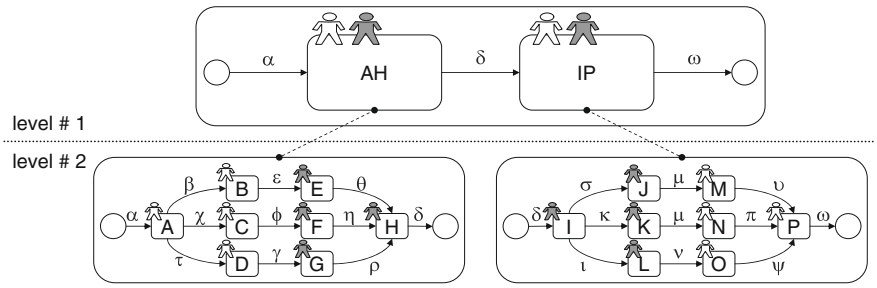

Fig. 2 Example for decomposition with unique start and exit points

the model in Fig. 1. Figure 2 shows a decomposition of the flat diagram in Fig. 1. The flat diagram is cut into two pieces that become stand-alone process definitions, each with an own start and end state. Start states are also called entries, entry points, start events, initial states etc. End states are also called exits, exit points, end events etc. We choose the term interface points as the generalization of entry points and exit points. Both the start states and the end states are depicted by unfilled circles in Fig. 2.

The decomposition results in a process hierarchy with two levels. An activity at the higher level refers to a business process specification it stands for at the lower level. This relationship is given by a dashed line in Fig. 2. If an activity at the higher level is triggered by an ingoing transition, it activates the start node of the business process specification it stands for. The roles assigned to the basic activities of a business process specification at the lower level are merged together and assigned to the corresponding composed activity at the higher level. The initial transition and the final transition from Fig. 1 and the transition at the cut point can be found at the higher level of the process hierarchy in Fig. 2 together with the respective data flow annotations. Actually, the original data flow α-transition from the start state to the A-transition in Fig. 1 is now represented in Fig. 2 by two transitions, i.e., an α-transition from the start state to the high-level state AH plus an α-transition from the start state to the basic A-state in the lower-level diagram. Similarly, the δ-transition, i.e., the cut point, is represented by three δ-transitions in the business process hierarchy—one in the higher process level and two in lower level. And so on for the ω-transition.

3 Forming Capsules of Business Processes

In Fig. 2 we have used only process specifications with a unique start and a unique exit point in the concrete decomposition and hierarchy of the diagram Fig. 1. The problem is that the chosen cut point, i.e., the δ-transition, is actually the only option to decompose the flat diagram in Fig. 1 as long as we do not allow for auxiliary modeling concepts like the usage of multiple interface points or multiple paintings of a modeling element. The problem is that the chosen partition in Fig. 2 might not be the desired or most natural one. Decomposing in order to get complexity under control is usually not just about arbitrary partitioning of a diagram with the target that the specification that one has to deal with becomes smaller and therefore better to handle. It is good if the parts that result from the decomposition express a feature or notion of the real world. This means that the decomposition is usually driven by some kind of conceptual cohesion of the entities.

3.1 Analyzing the Decomposition Step

The diagram in Fig. 1 visualizes a good example for a potential driving force in the composition of a business process specification, i.e., the orientation towards roles. The diagram in Fig. 1 has three natural regions with respect to the two roles. A first one consisting of the activities A through D, which all have the white role assigned to them, a second middle region with the activities E through L, which all have the gray role assigned to them, and a last region consisting of the remaining activities M through P, which again all have a white role assigned to them. A modeler might want to turn exactly these regions into part specifications and eventually into process abstractions. With the restriction to unique interface points he can not do this simply. Figure 3 shows the solution with the usage of multiple interface points. For example, if you are playing the role of a project manager and you want to divide work on the basis of the process description in Fig. 3 you assign work in terms of the higher-level activities and you are done. The two persons that you have assigned the activities to can then figure out what to do by delving into the more detailed process description of their assigned activities at the lower level. Each person can do this without coordination with the other person, because the person's tasks are clearly separated from each other by the decomposition structure. The same is not true for the specification in Fig. 2. As a project manager you now assign all of the tasks to both of the persons. The persons together delve into the details of all activities. The problem is that each of the persons can now see details of the process that he is not actually concerned with, which is a violation of the information hiding principle.

If the restriction to unique interface points is dropped, an identification of interface points must be introduced in order to distinguish them. Therefore, in Fig. 3 all the interface points are uniquely labeled. We delve into the semantics of

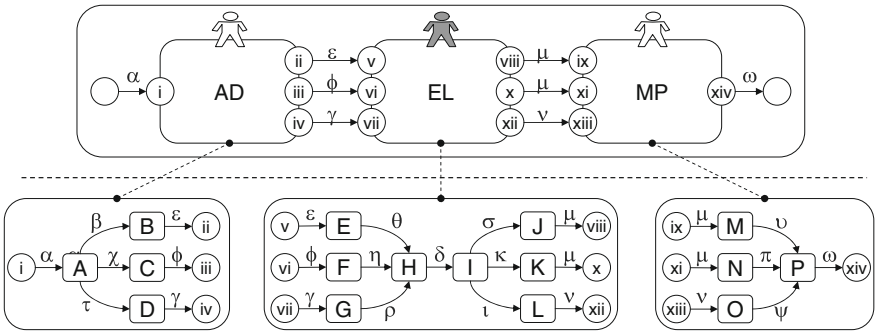

Fig. 3 Example for decomposition with multiple start and exit points

multiple interface events, i.e., into the semantics of business process specifications having multiple interface points in Sect. 3.2.

3.2 The Semantics of Multiple Start Events

The semantics of multiple interface points is not easy. Synchronization phenomena have an impact on possible semantics. A crucial problem is the semantics of start states and in terms of the enactment of process instances. For a business process with multiple start states, which is an activity at a higher level in a hierarchy, e.g., the process and activity EL in Fig. 3, it is, basically, possible to fix two kinds of semantics with respect to multiple start events:

- Closed semantics, extensional-like semantics. A process instance is created whenever a start event is triggered. The start of a process instance disables any further triggers to start events in the realm of the execution of the current process instance. This semantics is a self-explaining, i.e., self-contained from the viewpoint of the single business process.
- Open semantics, intensional-like semantics. After the start of a process instance all start events remain enabled, they are gateways to the dynamically evolving context of the process instance. The behavior of a process instance cannot be understood without the context it lives in.

The definitions of open and closed semantics of business process specifications are tight with respect to how events have to be understood during the execution of a business process instance. The further parts of the definition and the arguments based on them are weaker, in particular, for the closed semantics. The behavior of a business process with what we call closed semantics is actually not really self-contained, i.e., it is not really self-explaining, because the semantics of a business process has to be understood always in the context of the system's state, for example, in the context of the data of an information system. This means, in

particular, that an open semantics with further events beyond the ones directly modeled in the business process can be simulated within a business process specification with closed semantics. Exactly for this reason we have also used extensional-like instead of merely extensional for the closed semantics and intensional-like instead of intensional for the open semantics. The terminology of extensional versus intensional stems from logics, where the meanings of statements of an extensional apparatus are not influenced by the usage of statements, whereas, the statement of an intensional apparatus can, in general, only be understood as parts of their usage.

4 On Building Hierarchies with Closed Semantics

Each start event can be triggered independently from the outside. If we fix an extensional semantics this means, that once a business process instance is created, all of the start events are disabled for the lifetime of the process instance. This also means that the start of a process instance preempts all regions that are reachable via start events other than the initially triggered. For example, if the activity EL in Fig. 2 is started via the interface point (vi) it is sure that the activities E and G will not be executed during the lifetime of the started business process instance and, furthermore, the activity F is executed exactly one time during the lifetime of the business process instance, because also the interface point (vi) is disabled henceforth.

If the business process specifications of a modeling language or methodology are given a closed semantics in the above sense, this means that not all decompositions and abstractions are possible any more. This means that there may be hierarchies built on top of a given flat diagram that do not conserve the semantics of this flat diagram. As an example, please have a look at the flat business process specification in Fig. 1 and the concrete decomposition and abstraction of this business process model in Fig. 3. With a closed semantics of business process specifications the hierarchy in Fig. 3 is a valid one only under certain assumptions concerning the control flow that is still ambiguous in Fig. 1. Consider Fig. 4, in which we have given three alternatives of further control flow specification for a sub diagram in Fig. 1.

In Fig. 4a the next activity after execution of the A-activity is uniquely determined by a case distinction gateway. In Fig. 4b, a parallel gateway forks both a B-, C and D-activity after completion of the A-activity. The strands of execution forked by the parallel gateway in Fig. 4b are not synchronized before the execution of the H-activity. This means that each strand of execution starts its own copy of the H-activity which is indicated by the joining ‘or’-gateway. This is not so for the business process given by Fig. 4c. Here, a synchronizing ‘and’-gateway is used instead of the nonsynchronizing ‘or’-statements. This means that the three strands of execution initiated after the execution of the A-activity are re-joined by the ‘and’- gateway and a single instance of the H-activity is started.

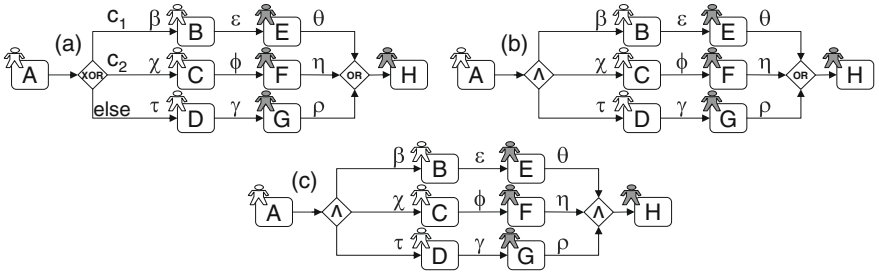

Fig. 4 Alternative control flows for a sub business process from Fig. 1

The hierarchy in Fig. 3 is based on a cut through the ε-, ϕ-, and γ-edges in Fig. 1. This cut is a valid cut if the business process in Fig. 1 behaves like Fig. 4a with respect to the sub diagram specified in Fig. 4. So, let us assume that the business process behaves like Fig. 4a. If an EL-activity is started it is guaranteed that no further events (v), (vi) or (vii) that are relevant for the behavior of the process instance will occur henceforth, because the case distinction was unique after the A-activity. Therefore, it is possible to disable the entry points immediately after the start of the process instance. In the overall system further events (v) through (vii) can occur in parallel to the current execution of the started EL-activity. These events can stem from further processes that have been initially started by the very entry point (i) of the business process specific cations. However, these further events (v) through (vii) are not relevant to the currently considered EL-activity. On the contrary, each of these events is meant to create a fresh instance of the EL-activity which again can have a closed semantics.

Now, let us assume that the business process in Fig. 1 behaves like Fig. 4c, i.e., parallel executions are forked and synchronized later. Then the cut through the ε-, ϕ-, and γ-edges in Figs. 1 and 3 is not valid any more for a closed semantics. If a EL-activity has been created, the input interface points cannot be considered disabled any more, because they are relevant to the behavior of the started subprocess instance.

Now, let us assume that the business process in Fig. 1 behaves like Fig. 4b, i.e., parallel executions are forked but not synchronized before the execution of the H-activity. The answer to the question whether the cut through the ε-, ϕ, and γ-edge is valid or not depends. The rest of the diagram has to be analyzed to answer the question, because it is possible that the initiated strands of execution need synchronization later, i.e., after the execution of the H-activity. If the rest of the diagram, i.e., the part started by the I-activity and ended with the P-activity also behaves like one of the patterns of Fig. 4a or b, it is a valid cut, otherwise it is not. This means, that, in general, parallel forks do not harm as long as the started process instances are not synchronized.

With an analysis of the whole diagram and its decomposition following the lines of the above discussion it can be decided whether a given hierarchy with closed semantics is valid with respect to a given flat diagram.

5 On Building Hierarchies with Open Semantics

If a business process specification with multiple start events has open semantics this means, that a business process accepts further events via its interface point after it has been started. The concrete behavior of a business process with open semantics can only be understood by looking at and analyzing the whole flat diagram. If you want to understand the behavior of an activity at a higher level of a model hierarchy, in general—or let us say better—in the worst case, you have to recursively unfold all activities of the given level via all lower level down to the lowest level and reconstruct the flat diagram from these unfolded diagrams first. Then, you can analyze the resulting diagram and can understand the behavior of the considered abstract entity as its footprint sub diagram in the whole flat diagram.

With an open semantics the modeler has an unrestricted flexibility in building hierarchies. The abstractions made are merely viewports onto a diagram at a lower level of the hierarchy. With a closed semantics only those hierarchies can be built that do not contradict the behavior of the underlying flat diagram. A business process with a closed semantics is a capsule. Once it is started, its behavior is not influenced by events from the context. In that sense its behavior is easier to understand than the behavior of a business process with open semantics. With a closed semantics you can define and execute a meaningful simulation of the system at each level of the hierarchy, i.e., a simulation in terms of the activities and transition from the given level.

Business processes with only one start event are special cases of business processes with multiple start events. Business process specifications that have only a single unique start event do not automatically have a closed semantics. Once a process with a single start event is started, in general, a further event may drop in through the entry point. However, if you have a modeling language with unique start events in practice, you usually assume a closed semantics for it. In Fig. 3 we have seen a decomposition of the business process in Fig. 1 that allows for multiple start and end states of the abstractions that result from the decomposition.

The usage of multiple start and end states reveals more flexibility for decomposing to the developers. In the example in Fig. 3 this extra flexibility was exploited for a role orientation in decomposing the system. A role is a feature. Orientation towards roles is an instance of what we have called feature-orientation [8] in the decomposition of a system. Formally a feature is an arbitrary subset of a system specification. In particular if you are modeling in the hierarchy in a bottom-up fashion, orientation towards features is a common pattern. Here, in business process modeling, we do not have to stick to the feature terminology and do not have to discuss and justify it, because we have the notion of business process at hand. Conceptually, a business process is a net of activities that together achieve a business goal [26].

Orientation towards business goals can give guidance in the decomposition of a business process diagram. The activities of the overall large business process are

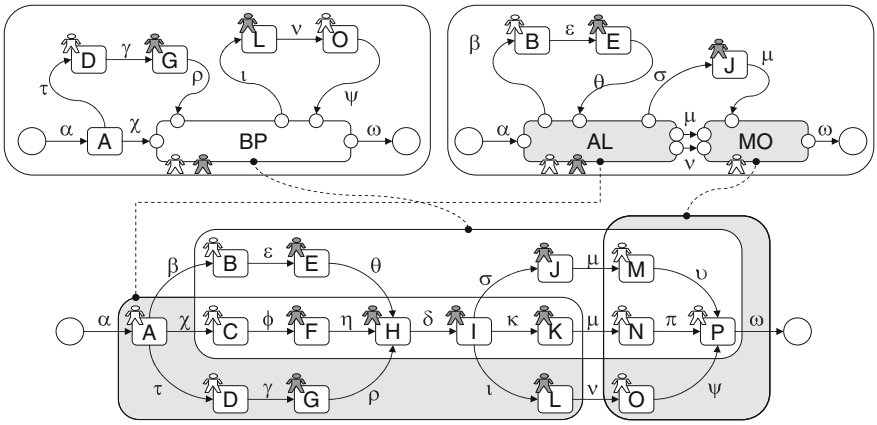

Fig. 5 Decomposing a business process according to business goals

there for together achieving an overall business goal. The question is whether it is possible to naturally identify and define sub goals of this overall business goal. Then, the diagram can be divided into those sub business processes that are necessary to achieve each of the sub goals.

Figure 5 shows a division of the business process model given in Fig. 1 into parts—or let us say—business sub goals or features. The resulting parts can be exploited in building a next level of a hierarchy. This creation of a next level is not unique. Furthermore, there is the problem that you cannot exploit all parts from a set of overlapping parts. The strict orientation towards business goals allows for full flexibility of identifying meaningful sub parts of a business process. The problem of such freedom in finding sub parts is that the found sub parts may overlap. And so it is in the example in Fig. 5. There are three sub-processes in Fig. 5, i.e., BP, AL and MO. BP overlaps both AL and MO, whereas AL and MO do not overlap each other. Two possible alternatives of next levels built on the basis of the three identified sub-processes are shown in Fig. 5. The left one exploits the sub-process BP and the right one exploits the sub-processes AL and MO. In both of the alternatives we have used not only abstractions of subprocesses from the lower level at the higher level but also some of the activities of the lower level. The two alternative higher level business process diagrams in Fig. 5 are possible with an open semantics of business process specifications that we have described in Sect. 3.2. In general, it is not possible to exploit the process BP in Fig. 5 together with one of its overlapping subprocesses AL or MO without further explanation. For example, let us assume that the business process shows a parallel control flow after the completion of the A-activity, i.e., that we have to deal with a situation as given by Fig. 4c. Then, if both sub-process BP and sub-process AL together occur in a diagram at a higher level you have a problem in modeling. You somehow need to model a parallel trigger of BP and AL and without further care and comment this would mean that too many instances of those activities that belong to the overlapping region of BP and AL are created.

6 On Building Hierarchies with Unique Interface Points

You might ask why one should restrict oneself to the usage of unique entries and exits for business process specification at all and why it is worth looking at this restriction. A straightforward answer is the semantic difficulties of multiple interface points.

Actually, in concrete projects in practice we often see explicit guidelines that restrict entries and exits to being unique for a business process specification. Even without explicit guidelines there is often a tacit understanding of business process modeling that entries and exits, or at least entries should be unique. For example, the concrete UML tutorial [15] states that a UML activity diagram may have only one start state. As an example for an academic publication, the paper [9], which aims at formalization of UML activity diagrams, gives a definition for activity diagrams that allows for a single start state and a single end state only. Section 9.3.2 of the specification of the Business Process Modeling Notation (BPMN) [18] warns the reader that a process specification with multiple start events may be harder to understand. The specification also strongly recommends the reader to use multiple start events only sparingly and advises him that he should be aware of the potential difficulties of other modelers in understanding the intent of a diagram with multiple start events.

So what are the reasons for the deprecation of multiple start states? One obvious reason may be that modelers want to avoid the extra effort to fix further notation and semantics for dealing with multiple entries and exits of a business process specification, in particular, with respect to the interplay between several business process specifications in a hierarchy. Actually, as we have seen in Sect. 3.2, significant effort is needed to fix extra notation and semantics for multiple start states; and in practice this effort remains a hurdle.

Another reason might be that business process specification and in particular also their visual presentations, i.e., the business process diagrams, might appear more structured to many modelers and therefore have a more systematic appeal. This argument has two facets, i.e., a local one and a global one. The local one is about the single business process specification with its start and exit point. The global one is about the interconnection of several business process specifications at a higher level in the specification hierarchy. From the local viewpoint a business process specification with one entry and one exit point is immediately understandable as a functional transformation. The data that is given to the process instance at the time of its creation is eventually transformed into data that leaves the process instance via the single exit point. If a process has multiple entry states and multiple exit states it is slightly more difficult to understand it as a functional transform. In case of a single entry point the input type of the functional transformation can be immediately understood as the type of the data item that is annotated to the incoming transition of the process specification. The same applies for the output type in case of a single exit point.

7 Seamless Enterprise Application Modeling

In projects that introduce IT support for business processes, there are typical two kinds of overlapping system specification, one kind that models the business processes from a business perspective, and another kind that models the enterprise IT systems from a technological viewpoint. The following situation is a typical one for a business software vendor. Typically, there are to group of experts in a software vendor company, one group of software engineers responsible for the development of the system, and one group of business experts responsible for selling the software and conducting projects in which the services are adapted to customer needs and introduced at the customer site. In a typical software introduction project a business expert conducts requirement elicitation efforts with the user because the existing software product does not fit totally. Then, the business experts communicate change requests or requests for entirely new functionality to the software development team.

7.1 Mitigating Frictions Between Process and System Models

Have a look at Fig. 6a. There is only one system, with one undebatable, observable behavior of the system—made of the system dialogues provided by the service applications to the user. However, the problem is that business experts and software engineers have a different view on this system. The business experts model a functional hierarchy that is oriented towards sales and communicating of how the system supports business tasks at the user side. The developers decompose the system dialogues into a component hierarchy in order to deal with complexity, i.e., they map the activities of the dialogues to software entities and decompose those software entities further. However, they not only decompose. Like the business people they also compose dialogues to hierarchies, however, sometimes with a different result, because their efforts are driven by technical issues.

Furthermore, the different groups usually use different tools and notations due to their different background as show in Fig. 6b. The business experts might use, for example, event-driven process chains (EPCs) [23], function trees and task models as notations and Visio, MindMap, and Word as tools. The software developers might use, for example, UML statecharts and class diagrams but partly also EPCs as notation and MagicDraw and Word as tools. In this way, models of the same system evolve in separated notations and in separated tools. As a result there can be a huge gap when looking at all models as a whole, a gap that is located in Fig. 6a, exactly there, were the system dialogues are visualized in the box in the middle. Try to understand the problem from the perspective of traceability. If a developer changes some code in some module, he could indeed derive the impact on business processes, but only in terms of the software developer models. However, for the business experts it is not so easy to understand a code change in terms of their business models. Furthermore, there is an overlap in specified

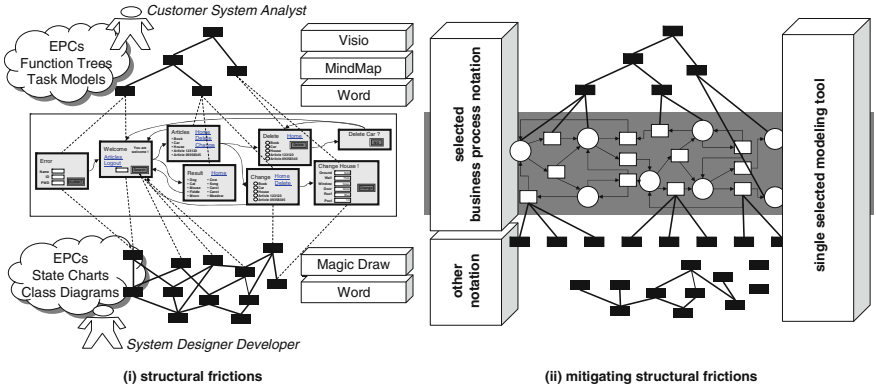

Fig. 6 Typical **a** structural frictions in a combined business process and system model and **b** their mitigation

phenomena exactly there, where the two worlds meet, at the level of business processes and beyond, i.e., there where also the software developers compose hierarchies bottom-up. Often the same piece of business process is modeled as an EPC by one expert and as a UML statechart by another. This situation can give rise to inconsistencies and communication problems between the two groups.

So, the problem is often not quality of the models and system descriptions—often, these are high both in the business expert and the software developer group. Typically, the problems are the notational heterogeneity and tool heterogeneity. How to approach these problems? As a first step you can select a canonical set of modeling notations, in particular, a single business process notation, and select a single integrating tool for all models and system descriptions—see Fig. 6b. Selecting notations and tools sounds easy, but it is not, because in selecting you must respect the stakeholders' expectations and attitudes. For the notation of the business processes Business Process Modeling Notation (BPMN) [18] might be a good choice, because the notational element set of BPMN very much resembles EPCs that many business experts are used to. Furthermore, BPMN is maintained by the Object Management Group (OMG) which guarantees a certain sustainability of the notation and therefore might convince the software developing team. As a next step you can fix a style guide for seamless modeling, so that the gap described above disappears. We propose to exploit the workflow charts that are elaborated in [1, 6] as a basis for developing such a style guide.

7.2 Variants in Software Service Provider Scenarios

Getting a variety of models under control is a concrete and severe problem in lot of software engineering and maintenance projects that is worth discussing here. Actually, it is an issue that is orthogonal to the main discussion strand of this book,

but the problem is sometimes so pervasive in projects and finding a smart solution to this problem is such a central question in these projects that it is sometimes overlooked that the management of many varieties is an extra problem independent from the need for frictionless modeling. Therefore the targeted discussion of this topic in this book can help to keep these two important issues separate and this can help to keep considerations on the design of a frictionless modeling approach focused. This is not a minor issue, because, in real-world projects we observe that people that are under pressure to deal with the complexity of system variants introduce ad-hoc concepts to deal with the problem. As a result, these ad-hoc concepts are actually redundant to existing concepts in the existing project's modeling apparatus, introducing new frictions in places where a disciplined, e.g., simply glossary-based introduction of new terms or viewpoints on the basis of existing concepts would be sufficient and efficient. And this is a pitfall not only for ad-hoc notations in real-world projects this is a pitfall, but also for the designer of a standard notation.

The need for a systematic approach to modeling variants of a system typically arises in what we call software service support scenarios in this book. This means that there is a software vendor that sells some software product to a customer. However, though the product is a standard product in the product portfolio of the vendor, selling the product to the customer is not enough. The vendor cares also for the deployment and maintenance of the software product and, most importantly, for the adaptation of the product to concrete customer needs. This adaptation involves requirement elicitation activities with the customer, in particular, an analysis of existing and future business processes. If the necessary customer processes are not fully supported, new functionality has to be implemented. Often, existing functionality must be changed, so that the necessary processes are supported. Eventually, a new version of the product, i.e., a customer version, results. The choice to name the described scenario a software service support scenario is a particular good one, because it is very close to the problems addressed by the IT Infrastructure Library (ITIL) [13, 14] service support process. Actually, the standardization of this scenario by a defined process is also an important issue for the software vendor. However, it is a different issue from the one discussed here and must not be mingled into this discussion.

For the described scenario, it is not important whether the resulting customer version is actually deployed at the customer site or is run by the data centre of the vendor, i.e., it is not important whether the vendor is a software service provider. Similarly, it is not important whether the vendor is an independent software vendor (ISV) or a full-service commercial-off-the-shelf (COTS) software house. An independent software vendor is a software house that offers development of individual software solutions on an individual project basis. Actually, successful ISVs are often specialized in a certain sector. Then they usually have a proven code base for the solutions they develop. Often, there is no exact means to distinguish such a code base from a COTS product and sometimes it may be only a question of the vendor's marketing strategy whether to mention this code base as an asset or not, and if so, whether to sell it as a framework solution or as a COTS product.

The variant problem is indeed also an issue for classical COTS vendors. This might puzzle the reader, because it is common sense that one of the disadvantages

of COTS software is the assumption that it completely rules the business processes of the customer that deploys that software—as if there is no room for an adjustment of the COTS product. Actually, the converse is true. Part of the business model of a COTS software house is to sell the COTS product, but for some COTS software houses the services offered on basis of the COTS product has become the more important part of the business model, and so is the adjustment of the COTS product to the customer's needs.

8 Related Work

In [7] we have investigated in how far a structured approach can be applied to business process modeling against the background of established results in the decomposition of flow charts [3, 16]. The paper [12] analyzes the tradeoffs in modeling variants of models as a family of harmonized models [20] versus a standardized single large model [22]. The contribution in [2] exploits functional role-based decomposition in the definition of process design rationales. A particularly mature analysis of and fully elaborated approach to decomposition mechanisms for executable business process specification is provided by [19]. The authors of [11] are interested in the quality of resulting business process model decompositions and take a software artifact viewpoint [25] to approach this facet.

9 Conclusion

In this paper we have identified two different semantics of business processes with multiple start and end events, i.e., a closed, self-contained semantics and an open, context-embedded semantics. We have explained that the selection of a self-contained semantics has an impact on the flexibility in building hierarchies and tried to explain why a self-contained semantics seems often to be preferred in practice. Based on that, we could, e.g., identify the reasons why methodology stakeholders stuck to the guideline of single entry or exit points for business process specifications.

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Business Process Management for Knowledge Work: Considerations on Current Needs, Basic Concepts and Models

Dagmar Auer, Stefan Hinterholzer, Jan Kubovy and Josef Küng

Abstract The portion of knowledge work is steadily increasing in today's working environments in western societies. This needs to be respected in the supporting IT systems. Starting with the characteristics of knowledge work and the resulting needs of knowledge workers, we present and compare two current standardization efforts in area of Business Process Management (BPM) by the OMG—the Business Process Model and Notation (BPMN) and the Case Management Model and Notation (CMMN). We argue that a hybrid approach will not suffice in the future, but that there is rather a strong need for full integration.

Keywords Business process management · Knowledge work(er) · Case management · Activity-centric · Data-centric · Business process model and notation (BPMN) · Case management model and notation (CMMN)

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1 Introduction

Western countries today are no longer primarily industrial societies but have developed towards knowledge societies. This has deep impact on the working environment, resulting in a high increase of knowledge work [1, 2]. Thus, not only approaches of how to organize work, but also the supporting IT systems have to take this into account. No longer, only well-structured, highly repetitive tasks, typically performed by administrative staff, have to be considered, but especially unpredictable, collaborative processes.

Managing work has been an important area of research and implementation within the last decades. Approaches based on the assembly line principle introduced in manufacturing by F. W. Taylor in the late 19th century have already been applied with office automation during the 1970s, adapted with Workflow Management (WfM) in the 1990s and are now main stream with Business Process Management (BPM). Mathias Weske [3] defines a business process as "… a set of activities that are performed in coordination in an organizational and technical environment. These activities jointly realize a business goal. Each business process is enacted by a single organization, but it may interact with business processes performed by other organizations." Thus, a business process can be well-structured, fully specified or dynamic, loosely specified, there is no constraint concerning these characteristics. However, BPM is often associated with well-structured, highly predictable, thus, predefinable processes. Such processes have a high number of repetitions, as they have already been considered with automation and are much easier to deal with than highly flexible ones. A contrasting approach concerning work management has been proposed by Peter Drucker, who introduced the term knowledge worker in 1959 [4]. Knowledge work and knowledge worker respectively, have gained much interest since then, e.g., by Thomas Davenport [2]. A knowledge worker typically does not deal with routine tasks but rather organizes his knowledge-intensive, unpredictable work to achieve a certain goal. The question is whether and how it is possible to obtain approximate productivity gains as they are evident in manual work. Drucker [5] states that improving the knowledge worker's productivity is the most important challenge for management in the 21st century. Companies will be increasingly measured by what extent they succeed in managing knowledge work. Nowadays they are more and more regarded as living organisms rather than machines. Therefore some productivity metrics won't work anymore. Case Management Systems (CMS) have been developed to support knowledge workers, i.e., providing tools to plan, control, improve working on a special case (cp. Sect. 3.2), including the information needed.

The Object Management Group (OMG) proposes two different standards to support these quite opposed types of business processes, the Business Process Model and Notation (BPMN) and the Case Management Model and Notation (CMMN). But reality is neither black nor white. On the one hand flexibility requirements are heavily increasing with traditional BPM [6], on the other hand

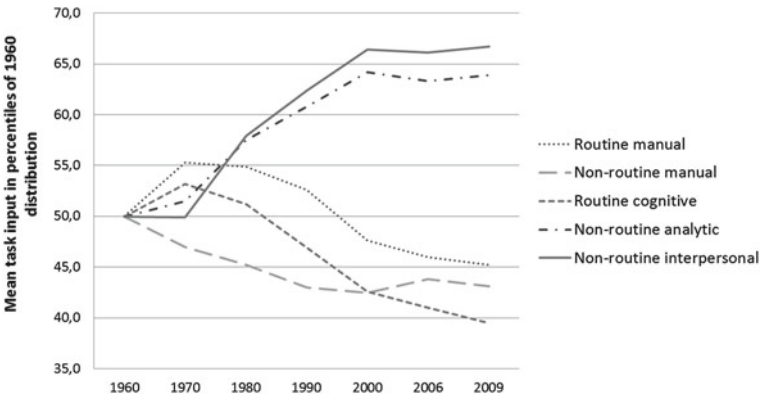

Fig. 1 Trends in routine and non-routine work in U.S. from 1960–2009 based on [8]

best practices, business rules, etc. are used to support knowledge work. Thus, the proposed hybrid approach does not seem to be adequate, especially when taking into account the strong trend towards knowledge work.

2 Knowledge Work and Knowledge Worker

A widely accepted definition of the term "Business Process implicates an organized group of related activities that together create a result of value to customers" [7]. Starting from this general approach it is evident, that process orientation could be a promising way to improve business. And it did—especially when BPM is being considered as identifying, describing and improving well-structured, highly predictable, thus, predefinable processes with a high number of repetitions.

This way of thinking has brought huge benefits to—for instance—manufacturing processes. F. W. Taylor on the one and Henry Ford on the other hand created the scientific foundations and first implementations of this understanding of managing processes. Briefly speaking it is evident that this kind of thinking influenced to a large extent the 50-fold increase of productivity within the past century [5].

But it soon became clear, that work in this manner covers only a part of business. In 1959 Peter Drucker distinguished Manual Workers from Knowledge Workers [4]. Since then, many of his books have run commentaries on the development of knowledge work and the knowledge worker. In recent years e.g., by Thomas Davenport who defines Knowledge Work as "… workers whose main capital is knowledge". Typical examples may include software engineers, architects, engineers, scientists and lawyers, because they are "thinking for a living" [2].

According to some empirical studies this work type is going to play the leading role in tomorrow's work as can be seen from Fig. 1 showing the development of routine and non-routine tasks in the U.S. during the last decades.

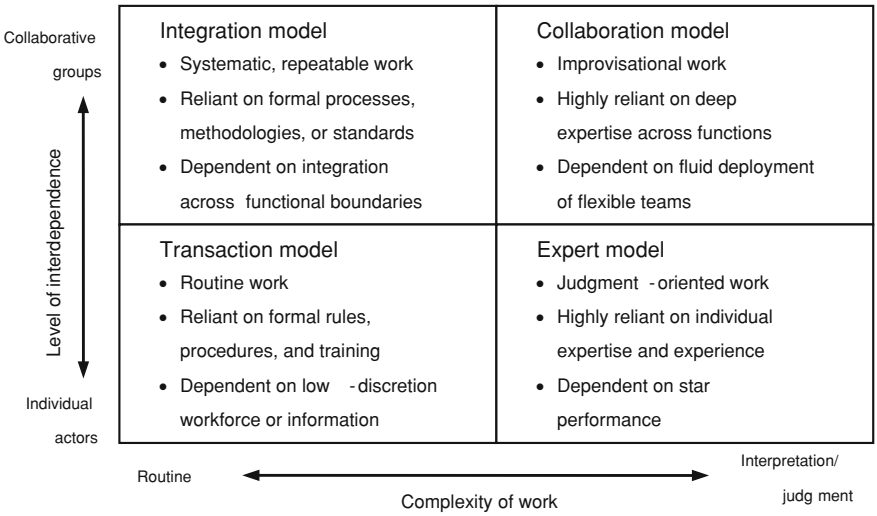

Fig. 2 A classification structure for knowledge-intensive processes [2]

It is clearly visible that the share of the workers employed in occupations that made intensive use of non-routine analytic and non-routine interactive tasks increased dramatically during the last four decades. In contrast job losses concerned clerks, assembly-line workers, low-level accountants, customer service representatives—jobs in the lower middle of the earnings distribution that where replaced by rules-based processing of information and robotics. Savage [9] describes a knowledge-focus as the third wave (after Agricultural and Industrial Age) of human socio-economic development. In the Knowledge Age, wealth is based upon the ownership of knowledge and the ability to use it to create or improve goods and services. The point is that the future potentials to create and increase value can be achieved (mainly) within this type of work [10].

This requires a closer look at the distinction among knowledge workers. Although it is rather difficult because of a broad variety of dimensions which have an impact on knowledge work, Davenport [2] reduces them to two dimensions (see Fig. 2). The matrix uses the level of work complexity (the degree of interpretation and judgment required in the process) and the level of collaboration which influences the extent of computer mediation that's possible in a particular job [2]. On some closer inspection it is obvious that knowledge work in a stricter sense dominates the right part of this matrix, whereas the left side can be considered as "knowledge-based" or "knowledge-applying" work [11]. This distinction is useful because this type of work can be automated or outsourced (to low wage countries, customers, suppliers, etc.) more easily.

Interpreting this term narrowly, "pure" knowledge workers have to develop something new in almost every activity in which solution and solution methods are not exactly known. They have to trust their tacit knowledge and learn (rather informally) with every attempt. To a large extent this work is strongly connected

with seeking, acquiring, capturing, analyzing, disseminating, sharing, and organizing information [12, 13]. In this context Reinhardt et al. [14] worked out role-models of typical knowledge workers like controller, learner, linker, networker, organizer, retriever, etc. However these role-models usually involve various types of work in varying degrees. So even supposed pure knowledge work typically contains some routine elements. This differentiated point of view influences significantly the way in which knowledge work is being modeled and supported by IT (cp. Sect. 4).

3 Basic Paradigms in Business Process Management

In the early 1990s process orientation in enterprise modeling, e.g., value chains, business process reengineering started to get high interest in business. This heavily influenced not only the way people think about their business, but also the supporting IT systems. Vast improvements in the whole IT sector not only quickened the development of such systems, but also stimulated the research communities. Over the years many different approaches and technologies were developed [3, 6], many of them still influencing the discussion on BPM and the supporting systems.

BPM does not imply a certain level of process structure per se. For a long time the focus has been on activity-centric approaches for predefined processes, as they are easier to understand and automate by IT systems than unpredictable, flexible, rarely structured ones. In the following we will discuss two occurrences of BPM—Traditional BPM and Case Management (CM). In this context we will discuss two modeling standards, developed by the Object Management Group (OMG), an international, non-profit standards consortium in the area of computer science, also well-known for the Unified Modeling Language (UML) or CORBA. The standards relevant in our context are the Business Process Model and Notation (BPMN) in version 2.0 [15] and the Case Management Model and Notation (CMMN) in version 1.0 Beta 1 [16].

3.1 Traditional Business Process Management

Traditional BPM emerged based on the paradigm used with highly structured manufacturing processes. The intention of this formal structure was to enable improvements, such as performance throughout the whole business process, and clarification of work for business and IT people in the sense that the whole business process gets visible through explicit modeling of the process type, monitoring of the process instances, and analyzing the process runs to optimize the model.

Traditional BPM Systems have a strong focus on routine work, supporting fully specified, repeatable routine processes. The model formally predefines the sequence of activities with decisions (conditions, gateways) to direct the sequence flow

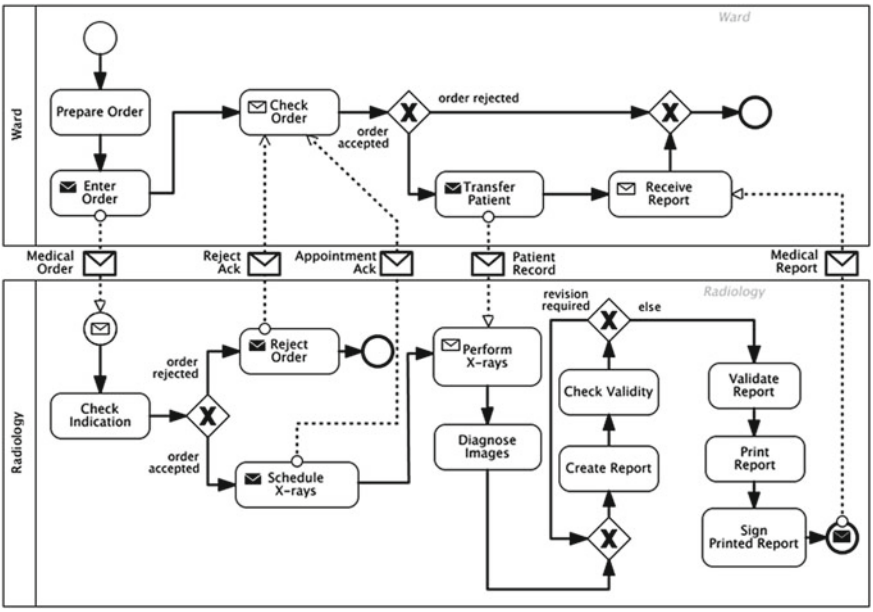

Fig. 3 BPMN collaboration diagram for medical order handling and result reporting (cp. [6])

(alternative, parallel, iterative routing) when describing the model during design time. At runtime a process instance is created based on the process model. Activities are enabled, i.e., available for dealing with, based on their position within the model. An activity can only be enabled after the previous activity has been finished, i.e., activity-centric execution strategy, where the focus is routing ("what should be done") instead of "what can be done", offering discretion to the users (cp. [17]). By using the work list paradigm, users (i.e., human actors) take over tasks by selecting from a list offered to them by the system [6]. Within the process instance only data needed to control the process execution is available, thus the context for the process instance is not directly available. van der Aalst et al. [17] describe this situation often resulting in errors and inefficiencies as "context tunneling".

There are many approaches, which try to implement BPM. One of those is the OMG standard Business Process Model and Notation (BPMN) currently in version 2.0 [15]. This popular meta-model and graphical notation provides a way to specify business processes based on flowcharting technique, thus activity-centric, similar to Unified Modeling Language (UML) Activity Diagrams (AD). BPMN offers to model work as a process [15] to introduce structure, improve performance, identify its start, end and intermediate steps [18], clarify participants and their roles, measure the execution of such a process, etc.

The following BPMN 2.0 diagram in Fig. 3 originating from [6] is an example for a collaborative process, describing the communication between two public processes, just to give a rough idea, of what BPMN stands for.

Concerning the collaboration diagram in Fig. 1, each process is represented in its own pool (Ward and Radiology). The processes have a clear structure—beginning with a start event (circle with a single thin line) and finishing with an end event (circle with a single thick line). The sequence of the tasks (rectangles with rounded corners) is defined by the sequence flow indicated by arrows with continuous lines. The sequence flow can be controlled with gateways. Figure 3 shows simple examples of how to control sequence flow such as a simple sequence with the tasks "Validate Report", "Print Report" and "Sign Printed Report". A loop can be found between the two gateways surrounding the tasks "Create Report" and "Check Validity".

BPMN provides many more specialized gateways and additional modeling elements so describe more sophisticated processes. The example here not only describes a single process but also the communication between two processes, which is represented by messages (dotted line with envelope icon). The example defines a clear structure, using different means to describe the possible routings. Dynamically reacting to changes, e.g., in the environment is not considered. This is why knowledge workers often deny BPM as it tends to be a limiting factor to their inconsistent, unique and creative work. As BPM has been widely accepted, there are also considerations and progress towards supporting processes which ask for more flexibility. This can be done by reducing the level of detail of the model or by using specific modeling constructs such as ad hoc subprocesses with BPMN. Still, the flexibility needed with many knowledge work scenarios cannot be satisfactorily achieved by this.

3.2 Case Management

In 2005 van der Aalst et al. [17] introduced CM as a new paradigm in BPM for supporting flexible, knowledge-intensive business processes. Since then, CM has gained much interest also in the scientific communities, resulting in different approaches. The goal is to improve the management of these processes, which are of high importance to the success of an organization. A big problem with knowledge-intensive processes is that they often only rely on the people working on them, which can be a great risk for the organization. Thus identifying best practices, guidelines, rules, providing the right information at the right time, etc. is important for knowledge transfer within the organization. Furthermore better planning, controlling, and supporting collaboration can highly increase quality, reduce working time and risk.

To specify the terms case and CM, we consider the following definitions by van der Aalst et al. [17], the Case Management Society of America [19], Forrester Consulting [20], and the CMMN development team [16].

A case describes the problem to be solved, the whole work to be done, e.g., a policy to be written, a product to be manufactured, a legal case to be handled, or a patient to be treated. The case holds all information necessary to handle the case.

Thus, the information, i.e., structured and semi-structured data, documents, collaboration and communication artifacts, policies, and rules, is available throughout the whole process. The key driver for the case is not a sequence of tasks to be executed like with traditional BPM, but data needed to achieve a goal.

CM is a "… semi-structured, but also collaborative, dynamic, information-intensive process …" [20], where the case is the central concept [16]. The focus is on what can be done to achieve a business goal. CM is widely spread in the area of health care, dealing with the management of medical cases. But CM is not restricted to this single domain, it is characterized by certain criteria, such as high degree of flexibility, no predefined process structures, but knowledge intensive human decisions and task. Thus, often also the term Adaptive Case Management (ACM) is found. The proceeding of the case is typically not predefined by a sequence of activities but is human-driven, i.e., it evolves during run-time due to user decisions. The tasks are enabled based on data. Furthermore, there are means to define relationships between those tasks, controlling the enabling of activities. Examples for CM processes are [16, 20] patient care and medical diagnostics in health care, legal cases in jurisdiction, claim processing in insurance, problem resolution in call centers, or mortgage processing in banking. The benefits of CM are not only the improvements in visibility (tracking of the whole process including run-time changes) and control over previously manual processes, but also the availability of all information including its history throughout working on the case.

Even though purists like Keith Swenson, vice president of research and development at Fujitsu America Inc., and chief software architect for the Interstage Product Family [21] claimed cases to be non-deterministic, unpredictable, unrepeatable individual occurrences, the need for certain modeling at design-time, providing best practices and responses to common problems, thus supporting organizational learning, has been widely accepted by the community [16, 19, 20, 22] and is also incorporated within the emerging CMMN standard.

As many CM approaches and tools have been developed, the need for a standard like BPMN supporting traditional BPM arose. Thus, the OMG launched a request for proposal, the Case Management Process Modeling (CMPM) in 2009 [23]. In January 2013 OMG published the Beta 1 version of the CMMN [16]. Besides OMG big players like IBM, Oracle, SAP and TIBCO are involved in the standardization process. CMMN defines the meta-model and notation to represent cases, and an interchange format for the models. The building blocks of the standard are comparable with BPMN 2.0. The standard is developed on the basis of common elements in current CM products and on current research results [17, 19, 24]. We will concentrate on CMMN for the following considerations concerning CM. Managing a case consists of two phases—design-time and run-time (see Fig. 4).

During the design the case model is defined by a case manager. Figure 4 shows plan items, which are part of the initial plan for the case instance too, and discretionary items, which build the pool of items, the case worker can select from (in his/her the discretion) when planning at run-time. Thus, the case worker can adapt

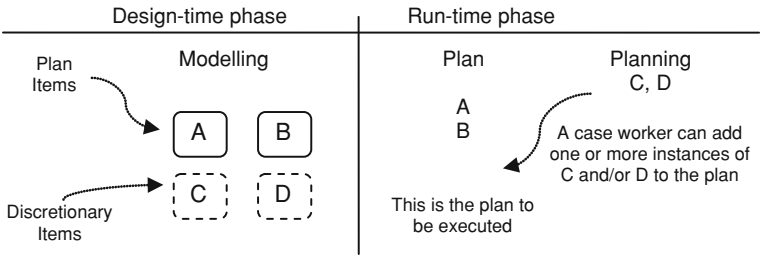

Fig. 4 Design-time phase modeling and run-time phase planning (cp. [16])

the case plan to support evolving situations and take ad hoc decisions. Each case instance is represented in its case file, containing all information. Updates to the context of the case, i.e., its case file, can be made throughout the whole case handling process. When repeatable patterns, best practices can be identified, they can be integrated into the case model to improve the future outcome [16].

Thus, CMMN case models can be much more formalized than the idea of pure CM, i.e., unique cases, unpredictability, implies. However the overall case cannot be orchestrated by a predefined sequence of tasks.

In the following we outline the essential aspects of CMMN based on [16], disclaiming many details and simplifying when possible without losing essence.

A CMMN model basically contains an information model (caseFileModel), a behavior model (casePlanModel), and a set of case-specific roles. The case file holds all information about the case context, necessary for evaluating expressions, raising events and case parameter handling. It is a logical model, containing case file items, which can be defined with any information modeling language (e.g., UML, XML, CMIS). In the further we will concentrate on the behavior model. The main building blocks of a case plan model are tasks, stages, events and milestones. There are special tasks like human tasks that can be used to describe manual work, process tasks used to define calling e.g., a BPMN process instance or case task to trigger the creation of another case with its own context (case file). A stage is used as a building block with case instances, containing other plan items such as tasks, milestones or stages and their associated sentries (for event handling). Thus, stages are means to build hierarchical structures. Events are used to describe anything relevant that happens (internal or external) during the course of a case, be it transitions in CMMN-defined lifecycles, such as enabling, activation or termination of a stage or task, achieving a milestone, a timer or user event. Events are handled in a uniform way via sentries. Milestones are used to identify the progress of a case at run-time. They can be either defined by the completion of a set of tasks or by the availability of key deliverables.

Sequential constraints on handling a case can be defined via criteria for enabling (entry) and terminating (exit) plan items. These criteria are represented by sentries. A sentry is a combination of an event (on) and/or a condition (if). Thus, not only events, but also constraints are defined with sentries.

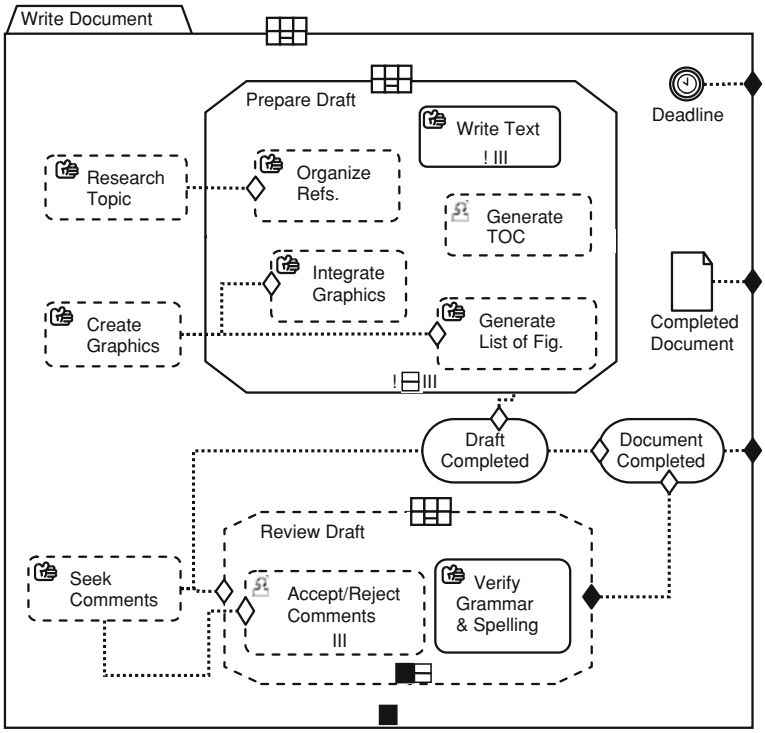

Fig. 5 Example case plan model for writing a document incl. reviewing tasks (cp. [16])

Furthermore applicability rules can be specified with CMMN (based on conditions) to evaluate based on the case context described in its case file, if items are applicable in the current situation.

The example in Fig. 5 illustrates some of the most important aspects of a CMMN case plan model. Write Document shows several tasks, most of them are discretionary (marked by dashed line). Furthermore several tasks have one entry criteria sentry marked by a shallow diamond shape. The dotted line between the tasks indicates a dependency. The stage Review Draft additionally has an exit criteria, which is connected to the entry criteria of the milestone Document Completed.

As can be recognized, there are quite a lot of commonalities between BPMN and CMMN, one would probably not anticipated when reflecting traditional BPM and CM. In the Sect. 4 we will compare the two approaches with special respect to knowledge work support.

Table 1 Comparing traditional BPM with CM with respect to the OMG standards BPMN 2.0 and CMMN 1.0 Beta 1 (the opposite pol view)

	Traditional BPM	Case management
Complexity of work		
Predictable	Highly	Hardly (if ever)
Routine	Yes	No, knowledge-intensive
Level of interdependency		
Level	Individual and group	Individual and group
Interface	Predefined	Predefined but can be changed at run-time
Flexibility		
Activation	Activity-centric	Data-centric, user-centric
Data updates	Within tasks only	As long as case has not been closed
Knowledge work		
When?	Focus on design	Design-time and run-time
Run-time roles	Execute	Planning and performing

4 Comparison and Interaction of BPMN and CMMN in the Context of Knowledge Work

In the previous section we have discussed two approaches in the area of BPM often characterized as opposite pols including standardization efforts. In the following the two approaches will be compared with special emphasis on their ability to support knowledge work. We will concentrate on the aspects discussed in Chap. "Crossing the Boundaries: e-Invoicing /e-Procurement as native ERP features": complexity of work, level of interdependency, flexibility, and how knowledge is used within the planning and execution phases. Table 1 gives a brief overview of the aspects and their characteristics in the two approaches.

Complexity of work Highly predictable processes, i.e., highly structured and repeatable, like the ones typically implemented in traditional ERP systems, have been implicitly used to communicate best practice comparable to automatic assembly line between workers. Compared to CM, traditional BPM not only communicates the intended goal but also defines the path of how to achieve it. Both, the goal and the path are typically fixed as soon as the process is instantiated. Tasks inside the process (e.g., described in BPMN) are executed by artificial or human actors. The focus of the traditional BPM approach is on managing the lifecycle of clearly predefined processes based on a transparent structure, business rules, event handling and allowing for analytics to improve the process model. In contrast CM has its focus on supporting knowledge-centric, human-driven processes, which are hardly predictable and have rare repetitions and little common ground.

Level of interdependency Traditional BPM as well as CM cope with individual actors as well as collaborative groups. While interfaces between the actors are predefined with the traditional approach (e.g., hand-over of work in BPMN from one lane to another), CM leaves space for run-time changes.

Flexibility Another fundamental difference is the driver for the proceeding of the business process. With traditional BPM the sequence is predefined by the model (i.e., on type level). An activity can only be started after the previous one (defined in the process model) has finished. With a case, the business process is data- and human-driven, i.e., it proceeds based on user decisions at run-time on the basis of the relevant information. Information is available throughout the whole process execution, avoiding context tunneling [17]. Thus, it is not the position of the activity in the process model, but the data values that reflect progress of the process instance [6].

Theoretically BPMN models could contain all decision options by using data-based gateways. But the complexity of the resulting model would be enormous. Even in simple models a gateway will not be able to capture all possible options to respect human decisions. Not to mention that all options may not be known during design.

Besides executable models, BPMN supports the explicit definition of knowledge obtained by experience, so called best practices, in models that are usually not executable (do not claim Process Execution or BPEL Process Execution Conformance but only Process Modeling Conformance [15]). Such BPMN models could be a complement to CM models for inexperienced workers to guide them through a CM process until they acquire the required knowledge and maturity.

As the need for flexibility heavily grows [6], constructs such as ad hoc sub-processes have been introduced into BPMN to provide some level of run-time flexibility. But still these means are far more limited than within the CM approach.

To cope with the challenge of measuring progress in a data-centric system, CMMN introduces milestones, which can either be achieved by providing certain data or by finishing certain tasks [16]. Thus, the milestone concept introduced with CMMN is not only data-driven.

Flexibility also concerns data. In contrast to traditional BPM, CM allows to change data associated to the case, as long as the case has not been closed (cp. CMMN [23]).

Knowledge work An additional important difference between traditional BPM and CM is which part of the work to characterize as knowledge work. With traditional BPM knowledge work is typically involved in developing the process models while working on the process instances is routine work. With CM building the model (on type level) as well as planning the concrete process instance and working on it are knowledge work. Thus knowledge has a much broader and deeper impact with CM than with traditional BPM. Furthermore with CM not only data used with the case is captured in the case file but also the activities planned, changed, performed or omitted at run-time. This asks for a more sophisticated role concept with CM. While traditional BPM only cares about the execution of activities, CM also considers planning activities, resulting in role types to provide more flexibility at run-time.

When discussing the differences, we already recognized that few processes are either completely predictable (i.e., can be fully structured and predefined) or completely unpredictable (i.e., need to by highly dynamic). It is more a broad spectrum with different appearances in between.

In the Sect. 5 we describe our considerations of how to deal with this broad spectrum of process characteristics, with special focus on individual and organizational learning, which has not been considered in the discussion so far.

5 BPM for Knowledge Workers

BPM for knowledge workers needs to take a broad spectrum of process characteristics into account, dealing with predictable, well-defined processes as well as unpredictable, rarely-structured ones, which need a high degree of flexibility.

The OMG argues for a hybrid approach already in its request for standard in 2009 [23] and adhere to it with the CMMN standard [16]. The idea is to combine traditional business processes (e.g., expressed as BPMN diagrams) with case models (e.g., a CMMN model) to introduce more flexibility into pre-specified processes on the one hand and more structure to cases on the other. However a hybrid approach is not really suitable, especially when considering knowledge work. In the following we reveal why an integrated approach is essential.

Conceptual gap Following a hybrid approach leads to a conceptual gap whenever shifting from one paradigm to the other. The different paradigms intrinsic in BPMN and CMMN have deep impact on the way modelers think about processes. Traditional BPM focuses on a predefined sequence of activities, i.e., the control flow, where each activity has to be finished before the next one can start. CMMN in contrast follows a data-centric approach, which means to keep the focus on information and behavior in an integrated manner. This allows for data-driven activation of tasks, leading to completely different run-time behavior. E.g., someone can still be working on task A, having already supplied the data (precondition) to start with task B. Thus, someone can already start working on B. The conceptual gap is not only perceptible by the modelers but especially by the users of the resulting IT system. With traditional BPM tasks are offered to users via the work list paradigm, i.e., a list of available tasks is offered by the system. Data-centric systems allow the user to search for tasks, leaving space to take personal strengths, interests, etc. into account.

Knowledge workers typically ask for flexible and predefined parts of the process model, as well. Thus, following a hybrid approach results in conceptual gaps, harming the user experience throughout the system, leading to the problems discussed above.

We consider an integrated model, based on a data-centric approach as an appropriate way to provide the needed flexibility and to allow for guidance through prespecified sequence flows, as activity-centric activation of tasks can also be built with data-centric systems (cp. [25]).

Organizational Learning Up to now we have been discussing the approaches with focus on the snap-shot perspective, i.e., the process model describes a certain situation, not taking changes into account. When considering organizational learning, changes of the process models, representing key knowledge assets within

an organization, are self-evident. Especially changes in the level of predictability are relevant. On the one hand working within a new domain or on a new problem can start with completely unpredictable processes and enhance towards well-structured ones, while on the other hand changes in methodology, technology and/or working staff (knowledge, people) require more process flexibility. For both directions, fast response to the changing environment is often crucial for business success [20].

Dealing with these constant changes in a hybrid way, especially concerning the level of predictability, would even intensify the already discussed problems concerning the conceptual gap. Not only that there are gaps in the initial model, but they are steadily changing. This results in a challenging task for the modelers, but an even unsustainable situation for the users. User interaction has to follow the basic paradigm and thus would be steadily changing. However a consistent interaction design is crucial for the success of an IT system.

Therefore, with our integrated model, we aim to provide a consistent user interaction paradigm, which allows the users to feel comfortable when using the system, even though the system is changing dynamically in other aspects such as available forms, form details, or query parameters.

Besides organizational learning also the individuals and their learning curve have to be taken into account.

Individual learning and heterogenous staff We did not consider the individuals so far. Rarely each member of a team working in the same area has the same qualification, experience, and other individual characteristics relevant for successful work. Thus, different levels of support are needed, e.g., via predefined processes, but also the information available (at once) should be adjustable to the people. Therefore the basic concept needs to be able to support processes that shift dynamically between more or less specified borders, depending on the user's roles. This also means that it needs to be possible for an expert user to assist a novice using additional information sources, ignoring the predefined process, etc. When working on the same process instance. So the solution of some hybrid products to start a subprocess either in a BPMN engine or to continue with a sub-case within the same engine is too restrictive.

We try to overcome this restriction by integrating process, information and users, respectively their roles. The big challenge is to provide the needed flexibility without making the whole system too complicated, to be manageable, i.e., to describe, understand, or validate it.

Monitoring and analysis To support working on flexible processes and to steadily improve them, monitoring and analysis are crucial. Monitoring of process instances allows for observing progress. While activity-centric approaches can provide information about the execution states of the activities handled so far, this information will not be sufficient with data-centric approaches. Furthermore CMMN introduces the concept of milestones. How do we then specify progress for the whole process instance? Even though a hybrid solution is conceivable, we do not regard it to be recommendable, as too many different concepts need to be combined to estimate the progress. Especially concerning analysis of the overall process, it is

much harder to determine improvement suggestions, as they will not only concern one system, but several systems with potentially changing intersection points.

With our integrated model, we base on the data-centric paradigm, but also consider the milestone extension integrated into CMMN, which already integrates activity-centric and data-centric properties. However we did not consider many things common to activity-centric solutions so far.

Thus, many questions are still open. We will continue our work with a more detailed review of the requirements identified so far, and existing approaches, before going into more details concerning our integrated model. CMMN 1.0 Beta 1 needs further investigation, especially as no case studies using this approach in real world scenarios are available for so far. Furthermore Manfred Reichert and his team provide an interesting advancement of the data-centric approach, the so-called object-aware approach (cp. [6]). They are having a very similar focus as we have, concerning the integration of data, process and roles, and also take aspects such as fine-grained control of data access into account, including progress. This approach thus, needs to be studied in more details.

Furthermore the demand for business-side control, i.e., not the IT but the business staff cares for the process models (types) and instances to be adapted, is increasing. Forrester Consulting [20] shows in 2010 that with CM systems IT still leads the change process also in aspects such as business rules, integrating new data, tailoring of screens, analytics or model change, and that changes typically need between 40 to 50 days to be realized. An agile environment needs shorter reaction times. Is the planning role proposed with CMMN sufficient, or how does it need to be designed.

So far we did not explicitly deal with the implementation model. It is obvious that also the implementation model has to support our integrated vision.

6 Summary

After a short characterization of knowledge work and knowledge workers we presented an overview of the two OMG standards dealing with BPM—BPMN version 2.0 and CMMN version 1.0 Beta 1, and compared the two standards, with special emphasis on knowledge worker support. We then argued that it is necessary to provide a consistent, integrated business process model to support well-structured and highly flexible processes as well. A hybrid approach as proposed by the OMG is not suitable to support the smooth transition within the spectrum from highly predefined to highly flexible processes without paradigm shifts. Furthermore a couple of additional requirements, e.g., necessary for supporting different levels of knowledge workers on the same process (instance), asks for additional flexibility not yet available with the existing approaches.

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Part IV
Requirements Engineering and Testing of ERP Systems

Towards Collaborative Requirements Engineering Tool for ERP Product Customization

Boban Celebic, Ruth Breu, Michael Felderer and Florian Häser

Abstract Requirements Engineering (RE) is the foundation for efficient software quality management. It is a cumbersome and complex task, particularly in the context of complex software products such as ERP systems, since it has to deal with numerous and specific challenges and large number of requirements to develop successful product, and therefore requires a systematic and collaborative approach. Tools which support RE in general are numerous nowadays; however, the task of providing a tool that specializes in RE for dynamic, customizable service-centric systems has been addressed seldom. In this sense, the result of our effort to provide such a tool—a support tool for collaborative requirements engineering and software artifacts linking (traceability), with focus on ERP product development and customization—is presented in this short paper. This tool was developed based on results of an analysis of challenges for RE in a highly dynamic ERP environment—these challenges were identified by performing survey of literature and through intensive discussion with our industry partner.

Keywords Collaborative requirements engineering · Enterprise resource planning (ERP) · SME · Product customization · Stakeholder collaboration

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1 Introduction

An Enterprise Resource Planning (ERP) system is a business management software that enables enterprises to bind all common data, practices, organizational units and activities across an enterprise into a single unified system, in order to achieve better performance and smooth workflow and to produce, process and access information in a real-time environment. ERP implementation is the customization, configuration and integration of an ERP system into an enterprise (company, organization).

Nowadays, ERP systems, in essence, represent highly complex networks of components and services. Aligning these services to specific needs of customer is crucial for the overall success of the system implementation. Unfortunately, implementing an ERP system into several enterprises can result with a complex history of product releases, industry-specific solutions or configurations specific to individual customers. This makes requirements engineering an even more troublesome process and demanding task than usual; yet, it is still essential for efficient quality management and successful ERP implementation [1].

On the other side, most Requirements engineering and management tools available nowadays, in addition to being decoupled from the development process, do not stimulate actively involvement and interaction among stakeholders. There are numerous such RE tools, both commercial and non-commercial, currently available on the market, but, based on our literature and online market research, very few of those focus on RE in the context of customizable ERP systems. In addition, most of these tools have other drawbacks as well. For example, difficult learning curve is one similar trait of most tools. Some require installation on client side. Of all the tools that we have reviewed, the most similar approach to ours is the WinWin methodology and support tool [2]. WinWin is a collaborative system requirements elaboration and negotiation tool. It integrates the group productivity techniques and some collaborative tools. It has support for stakeholder cooperation, requirements prioritization, issues management; glossary of terms is included as well, which is similar to our own tool. However, the training/learning curve is rather difficult for average stakeholder and requires additional effort, which undermines the collaborative aspect of this tool. Authors had to develop a lightweight version of their tool to ease the difficult learning process: EasyWinWin. Another difference from our tool is that WinWin doesn't have such strong support for collaboration with external systems (issue trackers, tests suites), which also undermines the collaborative aspect of the tool and makes the product customization process more difficult.

As a result of previous observations, our research addressed, distinctively, collaborative aspects of several different success-critical *stakeholders* involved; their roles will be explained in more detail in following sections.

In short, this short paper aims at advancing the field of requirements engineering for dynamic service-centric systems (ERP systems particularly) by sketching a novel approach and support tool which focus on project development

and, more specifically, *product customization* management and linking, traceability and visualization of software artifacts. The framework and its tool, developed on the basis of these ideas, are our main contribution to this field of research.

The rest of the paper is organized as follows. Section 2 gives a brief introduction to specific problems of requirements engineering in the context of customizable ERP systems, with focus on the collaborative aspect of requirements knowledge management process. Section 3 gives a sketch of the tool and solution framework and then reports the feedback from an ERP expert of our industry partner. Finally, we conclude and present future work.

2 Challenges for Requirements Engineering in the Context of Customizable Software (ERP) Products

Unfortunately, the ERP implementations failure rate keeps high [3]. Thus, numerous studies have been conducted in order to find and categorize all the challenges that ERP system implementation projects face. In this section we address the challenges to the requirements engineering in the context of (ERP) product customization and implementation, with additional focus on collaborative aspect of various involved stakeholders—namely: *business analyst* (often called *consultant*), the representative of the ERP vendor who discusses requirements for customized product with the customer and has to identify the collection of requirements which both satisfy the needs of the customer and makes the implementation efficient (thus, business analyst is usually a requirements engineer); *product manager*, who is responsible for development of the software product and plans its releases; *project manager*, who is responsible for the implementation of the customized product; *customer*, who purchases the ERP system implementation; *developer*, who develops the system and sometimes customizes it to specific needs of the customer; and finally *tester*, who develops test cases with aim to check the functionality and proper alignment of the product to specific needs and requirements. These challenges are result of our extensive literature review, and were additionally filtered through intensive discussions with our industry partner. We have identified some of these challenges in an earlier paper [1] and took them into strict consideration while designing our approach and framework.

- Collaborative requirements knowledge management

One of the challenges for RE is to bring various forms and representations of knowledge about requirements into conformance. On one hand, information about requirements can be held in more or less (un)structured textual form, like office documents; such documents are usually result of requirements negotiation between business analyst and customer. On the other hand, project and product managers, as well as developers and testers, need more concise and formal representation of

requirements and knowledge about software product (e.g. in form of models or class diagrams), in order to perform their tasks in satisfying manner.

- Software artifacts traceability and Change management

For achieving successful product customization and implementation, as well as efficient quality management/control, stakeholders need the ability to trace changes in requirements and their manifold interdependencies with other software artifacts (issues and customer requests, tests, risks), as well as their realization (e.g. release, branch-specific product) and state (implemented, under development, deprecated). This tracing ability is also a cornerstone for effective change management, since it helps with tracking changes (e.g. in standard product, requirements, other artifacts) and propagating them further (e.g. change of requirement needs to be reflected in the product implementation) in order to maintain actuality of requirements.

- Quality of requirements

Besides the consistency of product functionality with requirements, mentioned in previous challenge, quality attributes (e.g. completeness, stability, verifiability, comprehensibility) are also crucial for efficient requirements reuse. Only when these quality attributes are met, the requirements quality will be sufficient for successful requirements knowledge management. There are several approaches to model quality assessment which can be used to assess the quality of requirements (e.g. [4] for model-based requirements and [5] for textual requirements).

- Problems related to products and services

New challenges are emerging lately as a result of introduction of services in the cloud, increasing the need for the flexibility of the customization process. Similarly, customer-specific services demand for more flexible composition as well. These services may have many variants (e.g. for different industries) or are even customer-specific, which makes the requirements management an even more complicated task.

3 Tool Implementation

As stated before, we have developed a novel framework for Requirements Engineering in the context of customizable service-centric systems. In this section we sketch our framework and support tool, which is addressing the challenges mentioned in preceding sections. In the following paragraphs, we explain the framework in more detail.

The framework has been conceptualized in lively discussion with experts from our industry partner in this project. Our primary focus was to support collaboration of various stakeholders—our framework, thus, provides a front-end for these stakeholders to create and manage requirements artifacts. We took into account

that a product like an enterprise resource management system today is a complex network of services. These services may have many branch- or industry-oriented versions (variants) or are even customer-specific.

Typical scenarios we decided to consider are:

- Consultants authoring customer-specific requirements, looking for similar requirements having been implemented for other customers.
- Product managers planning releases and variants on the basis of various internal and external requests.

After thorough discussion and literature research our concept has comprised the following aspects:

- A Requirements Knowledge Base describing a business oriented view of the product as a base of interrelated requirements
- Support for traceability among artifacts related with product requirements like issues (e.g. customer requests, bugs), test cases and the product components
- A change-driven lifecycle model where every data element (like a requirement, a product component or an issue) has an associated lifecycle state which may change over time (e.g. a requirement being productive or deprecated)
- An evaluation-controlled process by systematic assessment of data elements (e.g. attaching requirements, test cases and product components with risk categories and risk values)
- To provide each stakeholder with the appropriate view on the Requirements Knowledge Base to support the stakeholders tasks (following the principles of view-based software engineering); this e.g. means that consultants are provided with interfaces where text can be easily edited, product managers get graphical charts to bundle and abstract requirements, whereas developers interact based on textually described models
- To support users of the system by recommendations derived from the central Requirements Knowledge Base (e.g. proposing links between artifacts).

In the following we describe the current status of the tool prototype, followed by an outlook on next steps.

3.1 Meta Model

The (initial) meta model of the framework is illustrated in Fig. 1. The meta model for conceptualizing requirements has been defined to comprise business process definitions, use-cases, and non-functional requirements. Each artifact can be tagged and categorized to support its reusability. Based on the content of requirements artifacts and its tagging, recommendations for the reuse of requirements are provided. Additionally, the requirements artifacts have states and assigned requests. The requests represent requests from customers but also development requests which are linked to product artifacts like components they have

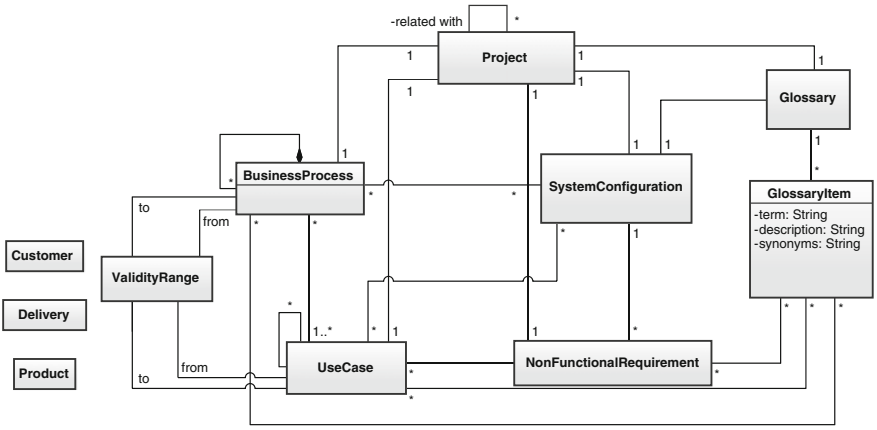

Fig. 1 Tool meta model

implemented or adapted. Support requests are also a valuable interface for Product Managers to plan future releases. If similar requirements occur several times in customizations then their functionality is a candidate to be included into a future release of the core product itself. Due to the internal linkage of the requirements artifacts to model elements representing the logical structure of the software product, change management, collaboration as well as the quality of the requirements can be guaranteed. Concerning the product, the project team has decided that product components are represented at the most abstract level by service hierarchies implementing specific product features. The data aspect is addressed through the concept of glossaries—collections of terms and their descriptions related to each other as homonym or synonym. Requirements may be attached with data imported from other systems. A bundling of requirements is supported by the concept of Owner representing a specific customer. In order to facilitate the collaboration between stakeholders, glossaries are attached to products.

3.2 Tool Functionality

The functionality of the current prototype can be shortly summarized as follows:

- Change-driven refinement process guiding the requirements engineer through the engineering phase, as well as involving various stakeholders into the process of ERP product customization. This allows flexible alignment with the dynamic business, architectural and technical requirements put in front of the specific ERP implementation.
- Support for creation and description of use cases, business processes, requirements and services, in web forms supporting both structured data in the

background (e.g. use cases attached with external files) and informal, unstructured, wiki-kind text editing facilities.
- Enhanced stakeholder collaboration (different types of stakeholders, their improved involvement and faster and more efficient interaction among them).
- Framework is optimized for processing large numbers of requirements.
- Support for all kinds of software artifacts and linking among them (linking among all types of artifacts in a repeatable process)—it provides tight coupling of requirements and other artifacts.
- Suitable/customized visualizations (trees, graphs, tables, diagrams, charts, matrices) of requirements and their prioritization, traceability links, tests results, risks and change impact—in order to support analysis, decision/strategy making and tracking of evolutionary change aspect.
- Support for issues—capability for importing issues from external Issue tracker systems and linking them to requirements.
- Support for test cases—capability for importing tests from external Test suites and linking them to requirements.
- Risk assessment support—with implemented risk assessment model.
- Portability—the tool can easily be adapted to various platforms (e.g. different operating systems, different RDBMS) by doing simple modifications.

3.3 Architecture

In order to enable easy collaboration among stakeholders, we decided to develop a web-based tool prototype; the tool can be accessed by any stakeholder through a web browser. The application allows multi-user access and is protected through role-based access control. Tool architecture is depicted in the following Fig. 2.

3.4 Outlook

The tool development and related research (e.g. comparison with tools available on the market, literature study) showed us the huge potential of the concept. In the subsequent iteration which is under current development we decided to extend our approach in the following way:

- Support of a flexible meta model through a model-driven approach

E.g. use case templates in the web forms may be easily extended by new text fields the web form is generated from the meta model;

- Extension by support for the definition of test cases;
- Strengthening of the view-based approach

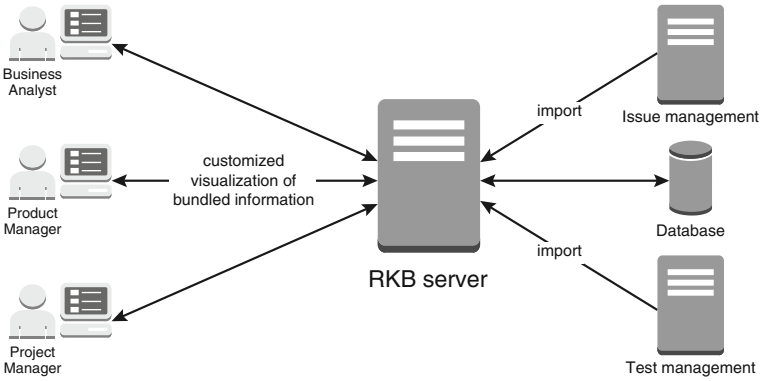

Fig. 2 Tool architecture. Requirements Knowledge Base (RKB) is the application server (application's logic)

Simultaneous work in different views, e.g. the framework supports language-oriented specification of test cases by the test engineer synchronized with text-editor like description of requirements by the business analyst/consultant;

- Flexible view generation with user-friendly interfaces

E.g. generating a matrix view relating selected requirements with selected product components; this requires the development of user-friendly view definition languages;

- Materialization of a generic assessment model

E.g. attaching requirements and product components with risk factors allowing tests to be prioritized; some risk values may be computed in an automated way, e.g. through call of runtime sensors or evaluation of static code metrics.

Opinion of an ERP expert As mentioned earlier, our research was done in cooperation with large European E-service provider which specializes in ERP systems for SMEs. The expert from our industry partner, in charge of the overall cooperation with our team, expressed satisfaction with our results and the framework itself, particularly with the web-based user interface, as well as with the strong portability potential. Some improvements were proposed; these proposals for improvement will certainly be taken into careful consideration during advanced phases of the tool development.

The prototype is available online for demo purpose (http://lr.q-e.at, access details are available on demand).

4 Conclusion and Future Work

This paper sketched challenges and our approach—RE support tool—to collaborative requirements engineering in the environment of customizable service-centric systems and ERP systems. Our framework supports the collaboration of various success-critical stakeholders: requirements engineers, project and product managers, business analysts, customers, etc., in the context of ERP system development and, particularly, product customization. This solution framework and support tool have been developed in collaboration with an ERP system vendor for small and medium-sized enterprises. The implementation phase will be followed by evaluation activities and further improvements of the framework.

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Design of a Questionnaire on Testing in ERP Projects

Michael Felderer and Johannes Keckeis

Abstract In this paper we present the design of a questionnaire on testing in ERP projects in the German-speaking area. The questionnaire is designed on the basis of a literature search on testing in ERP projects and a comparable survey on software testing in general. We describe the design process and the structure of the resulting questionnaire which is the basis for future work presented as well.

Keywords Enterprise resource planning · Quality assurance · Software testing · Questionnaire · Survey

1 Introduction

ERP systems have become an essential and also critical part of the infrastructure of many organizations [1]. As a consequence, implementation faults are often disastrous and result in dramatic cost and schedule overruns in ERP projects [2]. Effective and efficient testing, which helps to identify faults before the system is deployed and provides information on the system quality necessary to decide on deployment, is therefore one of the most critical success factors in ERP projects [3]. Since most projects are large scale and highly business-critical, the testing component is substantial—approaching 50 % of the total project budget [4]. Although the importance of testing in ERP projects is high, only few best practices and research results are available [4]. These could support practitioners to perform testing in a more structured way improving the effectiveness and efficiency of testing as well as the quality of the deployed ERP system.

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Our overall aim is to collect the body of knowledge of testing in ERP projects to provide guidelines for practitioners on how to perform testing in an effective and efficient way as well as for researchers which yet unsolved problems to address. As a first step in this direction, we perform a questionnaire on testing in ERP projects. In this short paper we present the design process as well as the structure of this questionnaire and preview the further research steps. In our questionnaire we address testing in *ERP customer projects* like introduction, migration or implementation of an ERP system. But we do not address testing during the standard ERP product development itself at the ERP vendor side as this is classical software product testing for which many best practices and a body of knowledge is already available [5]. The questionnaire is performed in the *German-speaking area*, the so called DACH region, including Germany, Austria and Switzerland. To enable comparison to testing in general and to assure quality, our questionnaire is based on the "Software Testing in Practice" survey performed in the DACH region in 2011 [6]. The questionnaire underlying this survey is aligned with the definitions and the standard test process of the International Software Testing Qualifications Board (ISTQB) [5] and in our questionnaire extended by questions specific to testing in ERP projects.

In this paper we present the design of a questionnaire on testing in ERP projects to perform this questionnaire and to derive guidelines for ERP testing as future work. According to this aim, this paper is structured as follows. In Sect. 2 we present analyze the available literature on testing ERP projects and testing surveys in general forming the basis to design our questionnaire. In Sect. 3 we present the design process to create the questionnaire. In Sect. 4 we present the structure of the resulting questionnaire. In Sect. 5 we give an outlook on our future work sketching the body of knowledge for ERP projects testing we intend to derive. Finally, in Sect. 6 we summarize the paper.

2 Literature on Testing in ERP Projects and Surveys on Testing

In this section we present and analyze the available research literature on testing in ERP projects and on testing surveys which provides the input to design the questionnaire in Sect. 3.

Most work published on testing in the context of ERP systems focuses almost exclusively on testing tools and practices for specific ERP systems ([8, 9]).

For testing ERP projects, Al-Mashari et al. [7] highlight that on the one hand it is important to ensure that the software *works technically* and that on the other hand the *business process configurations* are practical. When business processes are up and running, an important test is of whether the processes described and represented in the application system actually match with the processes taking place in the organization.

Several approaches ([4, 10, 11]) indicate the importance of *risk-, benefits- and coverage-based approaches* for testing in ERP projects. Gerrard [4] highlights the importance of risk-based testing in ERP projects and presents the concept of managing projects with intelligence. This concept of project intelligence (PI) states that ERP projects require *risk analyses* as input to testing, the information generated as testing proceeds to *measure progress* and support decision making, and finally *test reports* indicating whether the delivered system is acceptable. Keckeis et al. [10] provide a *cost-benefit analysis of automated testing* of ERP GUIs. Ramler et al. [11] present an approach for *value-based coverage measurement* that can be used to align the testing effort in ERP projects with the achievable benefit of testing, i.e., the detection and elimination of defects that threaten the business value associated with the ERP system's requirements.

Al-Hossan and Al-Mudimigh [3] review some work performed in ERP testing and highlight challenges as well as guidelines for successful ERP testing. The identified challenges and guidelines are related to the consideration of *testing levels* and *objectives*, test *automation*, test *prioritization* and *selection*, testing of *service-oriented architecture* based enterprise systems, as well as *test data provision* and *management*.

Finally, Felderer et al. [12] highlight the importance of high quality request data, which especially includes defect data, for the acceptance and success of an ERP system.

Several surveys have been conducted on the subject of software testing practices in different countries and scales. Garousi and Zhi [13] performed a literature search and identified 17 surveys on the subject of software testing practices. On the basis of a review of these surveys they designed a questionnaire to investigate the software testing techniques in Canada. Besides the respondents profile and demographic data, their questionnaire contains questions in seven categories: (1) *test levels*, (2) *test techniques*, (3) *test automation and test tools*, (4) *test metrics*, (5) *test management*, (6) *test training*, and (7) *research and interaction with academia*.

In the German-speaking area a comprehensive survey on "Software Testing in Practice" (STIP) has been performed in 2011 [6]. The survey was performed as anonymous online questionnaire in which different groups of people, i.e., developers, testers and managers, were asked about various aspects of testing. The respondents represent a wide mix of organization sizes and industries providing a sound data basis to derive general statements about the actual state of software testing in practice. Besides general questions referring to organizational and qualification aspects, the survey is comprehensive covering all aspects of testing, is well-founded on other questionnaires on testing in the German-speaking area [14] and the concepts of the ISTQB, and field-tested. As already mentioned in the introduction, we therefore design our questionnaire on the basis of the STIP questionnaire considering specific testing issues of testing in ERP projects.

Although our literature search showed that several surveys on testing processes, techniques and tools have been performed, none of these focused on testing in ERP

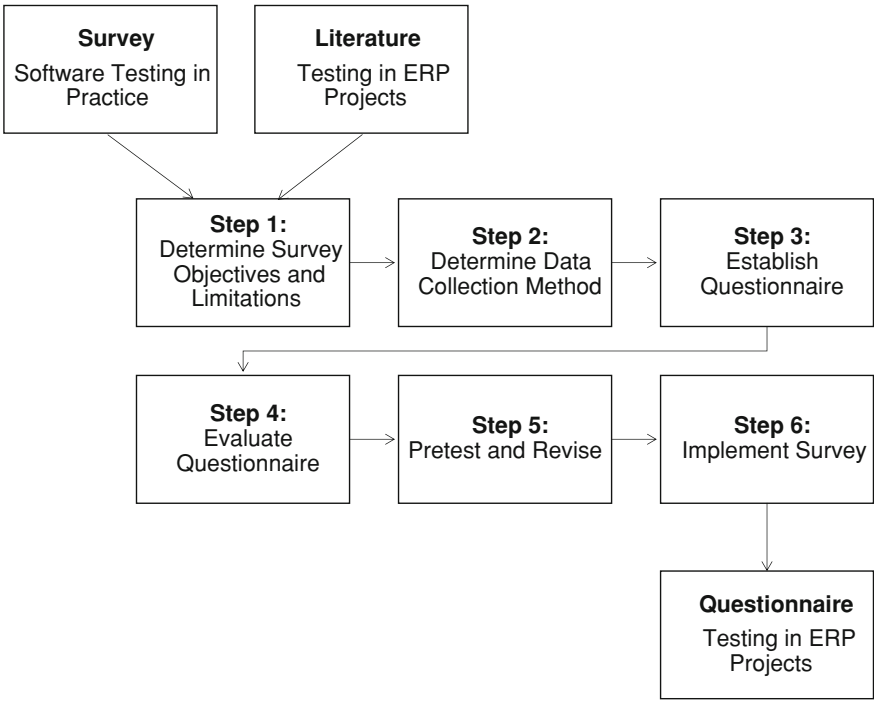

Fig. 1 Questionnaire design process

projects. Due to the business criticality of ERP systems and their testing, we take this as a motivation to construct a questionnaire on testing in ERP projects on the basis of the literature collected in this section.

3 Questionnaire Design Process

In this section we discuss all steps of the design process for our questionnaire on testing in ERP projects. The process steps as well as its input and output are shown in Fig. 1. Input are the survey "Software Testing in Practice" as well as the analyzed literature on testing in ERP projects. The design process itself consists of the steps (1) Determine survey objectives, resources and constraints, (2) Determine data collection method, (3) Establish questionnaire, (4) Evaluate questionnaire, (5) Pretest and revise, as well as (6) Implement survey, and is influenced by best practices from marketing research [15]. Output from this process is the questionnaire on testing in ERP projects whose structure is presented in Sect. 4. In the following paragraphs each design step is discussed in more detail.

Step 1: **Determine survey objectives and limitations**

Although the importance of testing in ERP projects is high, only few best practices and research results are available [4]. With this survey we want to shed light on testing in ERP projects and identify the state of the art and actual trends. Therefore this survey has several objectives:

1. Collection of the state of the art of testing and quality assurance applied in ERP projects.
2. Investigation which trends in the area of quality assurance and testing like test-driven development, exploratory testing or agile methods are also used in ERP projects.
3. Identification whether and how the challenges derived from the literature search on testing in ERP projects are addressed in practice.
4. Comparison of testing in general to testing in ERP projects.

From the results of the survey we will derive guidelines for practitioners on how to perform testing in an effective and efficient way as well as for researchers which yet unsolved problems to address.

The survey has several intended limitations. First, it only addresses testing in ERP projects but not testing during the standard ERP product development itself at the ERP vendor side as this is classical software product testing for which many best practices and a body of knowledge is already available [5]. Second, the questionnaire is performed only in the German-speaking area to perform the survey in a homogenous region and to enable a comparison to testing in general. This comparison is possible because our survey is based on the software test in practice survey performed in the German-speaking area [6] as well.

Step 2: **Determine data collection method**

The survey is conducted as an *anonymous online questionnaire* in the German-speaking area. As nearly every company has an ERP system today and is available online we think that this is the best way to reach a representative sample of the population. In addition, online questionnaires are easy and cheap to perform. As additional measure to attract many participants, we give away prizes and provide the results of the questionnaire if interested. Due to an online questionnaire it is also possible to address different target groups, namely developers, testers and managers.

Step 3: **Establish questionnaire**

As mentioned before the questionnaire is based on the "Software Testing in Practice" questionnaire [6]. It reuses many of its questions and extends the questionnaire to address the objectives defined before. As the STIP questionnaire is well evaluated and applied in practice, we reused its question and wording scheme when adding or adapting questions. The survey contains eleven main parts

(further explained in Sect. 4) as well as a welcome and closing text. The questionnaire contains a control flow to adapt it to the respective target groups and to skip specific dependent questions if general ones cannot be answered.

Step 4: **Evaluate questionnaire**

To evaluate the questionnaire, expert interviews were performed. The experts were asked to provide comments to all questions as well as to the correctness, completeness, reliability, validity and its comprehensibility. The experts were carefully selected to get feedback on all aspects of the questionnaire.

- First expert: Quality Assurance Responsible at an ERP-software vendor. Their product is designed or SME's.
- Second Expert: Quality Assurance Responsible at a big sized ERP customer. This ERP-customer is developing, modifying, and deploying their ERP worldwide in over 40 countries for over 30,000 employees by their self.
- Third Expert: ERP and Quality Assurance Responsible at a medium sized ERP Customer. This ERP Customer with subsidiaries in 13 countries is using different ERP systems within their group. Process- and ERP Quality Assurance especially within intercompany processes are very important and mainly achieved by interfaces. The pre-test and revise phase was also supported by these experts. Finally, the questionnaire was implemented and set online.

We interviewed the experts on the basis of a first online version of the questionnaire. On the basis of their answers the questionnaire was revised to be correct, complete, reliable, valid and comprehensible.

Step 5: **Pretest and revise**

The version of the questionnaire resulting from the evaluation phase was tested online and revised. A special focus of the pretest was on the control flow. The questionnaire was tested intensively by the three creators, the three experts who validated the questionnaire as well as by an experienced consultant. In addition, the control flow was tested on the basis of a systematic test plan.

Step 6: **Implement survey**

The questionnaire was implemented in the online survey tool LimeSurvey.[1] In our process the implementation of the questionnaire already started during the establishment of the questionnaire. Then, the welcome and closing text was added. The closing text enabled the participants to leave their email address to participate in the prize draw and to receive the results of the questionnaire. Finally, the questionnaire will be activated online for 1 month.

[1] LimeSurvey is available at https://www.limesurvey.org.

4 Structure of the Questionnaire

The structure of the survey follows the structure of the STIP questionnaire and considers challenges of testing in ERP projects. The questionnaire contains twelve parts.

First general information about the person, his/her field of work and the organization are asked.

In the second part on the one hand general information about the ERP system and on the other hand information about the implementation method, customizing settings and modification are determined.

The third part asks for challenges of testing in ERP projects.

The fourth part of the questionnaire is focused on in-house ERP-software development and deployment. It is assumed that a company with an in-house ERP-software development has different requirements to ERP testing. So within this part information about the ERP software development process model are requested.

In the fifth part, information about the test organization is asked.

Within the sixth part of the questionnaire information about risk management in the ERP context is gathered. Within this part it is asked, how and why risks in the ERP context are analyzed and managed.

ERP quality measures are determined in part seven. The used test types and methods are asked.

Information about invest in time and budget in the ERP testing domain are asked in part eight of the questionnaire. This part focuses together with the risk management part the profitability and cost/benefit aspects in the domain of ERP testing.

ERP test techniques are determined in the next part (part nine) and points out the operationalization of ERP testing. Test techniques often affect the testing architecture (part ten) and the settings within the architecture. This part focuses on the preparation (incl. Test-Master-Data) and the execution of test cases and its specifications.

It is assumed that the used test architecture and test techniques have an impact on the used ERP-test tools. The used test tools are as assumed determined in part eleven of the questionnaire.

The last part of the questionnaire focuses the ERP test evaluation and its reporting. The impact of the ERP-test results is determined within this part.

Answering each of the parts three to eleven is optional depending on the knowledge of the questioned person.

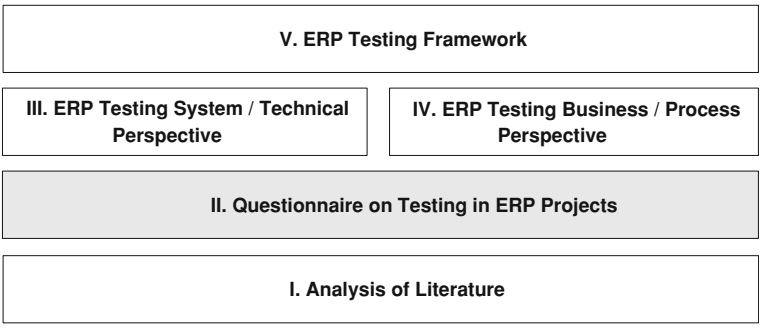

Fig. 2 ERP-testing stage-model

5 Future Work

In this paper, we presented the design of a questionnaire on testing in ERP projects. As shown in Fig. 2, this is an intermediate step towards an ERP testing framework providing testing guidelines for practitioners and open problems for researchers from a technical as well as a process perspective.

The questionnaire reflects a state of the art analysis and identifies testing challenges. On its basis two aspects in ERP testing will be investigated. On the one hand, the system and technical perspective, and on the other hand the business perspective of ERP testing. By integrating and combing these perspectives an ERP testing framework will be developed. This framework should deliver guidelines for ERP testing in context of the challenges collected in Sect. 2. In addition, we will also compare testing in ERP projects to testing in general on the basis of our survey results and the "Software Testing in Practice" survey to further refine the ERP testing framework.

6 Summary

In this short paper we described the design of a questionnaire on testing in ERP projects. The questionnaire is designed on the basis of existing surveys and challenges of testing in ERP projects which are extracted from a literature search. The questionnaire is designed in 6 steps, i.e. (1) determine survey objectives, resources and constraints, (2) determine data collection method, (3) establish questionnaire, (4) evaluate questionnaire, (5) pretest and revise, as well as (6) implement survey. The resulting questionnaire consists of eleven parts on the basis of the software testing in practice survey as well as the identified challenges. Finally, future work is sketched on the basis of an ERP testing stage model.

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Part V
Open Source

Conception of a Novel Open Source Environmental Management Information System Design to Assess the Availability of Resources: Status Quo and Directions for Future Research

Stefan Bensch, Ralph Andris, Dennis Stindt and Axel Tuma

Abstract Resources for new technologies are vitally important and limited in their availability. The reasons for the limited availability are political tension, supply concentrations or restricted potential for substitution and recycling. The consideration of information on the availability requires the mapping of this information in business information systems. Science and practice lack holistic and integrated solutions whose use supports the availability and evaluation of sustainable developments. Taking account of open source software, a concept of environmental management information systems is under development, in order to measure sustainable availability. The integration of existing IT systems and data sources provides an improved assessment of risks. The article shows a concept of IT architecture which can be used as open source software in the regulatory framework of environmental management information systems in order to evaluate the availability of resources and course of action.

Keywords EMIS design · Theoretical foundations · Resource availability

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1 Introduction

Technology companies in particular face the problem of the medium term to long term shortage of crucial resources. Functional assembly groups, like implemented in control devices, drive systems and electronic devices, may contain up to 40 critical resources [1]. The concept of 'criticality' sums up holistic descriptions of ecologic, economic and availability risks. The relevant factors are identified, too, and an aggregation is conducted with the goal of an overall assessment [2, 3]. A shortage of single resources may cause distinct economic and operational disruptions [4, 5]. Despite this awareness, there is a lack of authoritative information about the criticality of resources which are contained in assembly groups. Small and medium-sized enterprises (SME) in particular face the additional problem of electronic availability of this information. For that purpose open source enterprise resource planning (ERP) systems may be seen as a chance particularly for SME [6]. Nevertheless there is a lack of general concepts of how to map this information about the criticality in business information systems.

The problem of information availability is typical in research about environmental management information systems (EMIS), as an "organizational and technical system for the systematical gathering, processing and provision of environmentally relevant information in a company" [7]. Thus, an automated processing of life-cycle assessment data is only conditionally realizable, despite standardized approaches in the context of business information systems. This problem can be traced back to a semantic gap, a form of the provided data, which is neither structured consistently nor explicitly interpretable [8]. The limited availability of key resources is influenced by the high complexity of the object of investigation and its framework. The pluralism of methods of involved science disciplines (material, natural, (business) computer science, etc.) on the one hand and the functional areas involved in practical use (especially in the procurement function and product development) on the other hand have influence on the design of required systems. An open source software concept for measuring the availability of raw materials which supports companies especially in the procurement function and product development is important for science and companies. Sustainable development approaches exist for procurement and for the product development department. The procurement function faces the challenge of responding to the particular supply situation with hedge purchases and closed-loop supply chains. With scarce availability of resources the product and development departments face the special challenges of function substitution, the development of new components and redesign.

Meanwhile the use of EMIS is controversial since it is confronted with high tangible and intangible expenses [9]. Furthermore there is a lack of standardization. However, the idea of designing an open source EMIS concept widely exists for a large number of companies involved in the information and communication system industry (ICT).

A systematic examination of EMIS and open source software is supposed to identify future potentials and fields of action for the design of high-capacity EMIS platforms supporting the procurement function and product development. For this purpose two core issues exist for this article, which are fundamentally investigated in consideration of the design science paradigm for construct-oriented research as a recognized method of information system research [10, 11]:

- How is an open-source EMIS concept designed to assess the availability of crucial resources?
- How can current requirements be met and which questions of research, which are new or have not sufficiently been dealt with, can be identified from the approach?

This is supposed to demonstrate whether the design of EMIS approaches with open source software is advantageous and whether the provision of services for established and future EMIS technologies is suitable to meet the technical and organizational challenges in the procurement market and product development. Chapter "ERP Future 2013" explains the necessity of an investigation of an open source EMIS concept. In Chap. "Crossing the Boundaries: e-Invoicing/e-Procurement as Native ERP Features" the current state of research on EMIS is shown systematically with reference to used open source solutions. Furthermore, tasks and concepts of an EMIS are outlined. The procedure is documented in Chap. "Returning Lost Elements in the Sales Process: Manum Dare". Chapter "Fact Based Modeling in the Cloud" introduces an EMIS concept to assess the availability of key raw materials as an open source solution. Against this background conclusions for practice and research are derived in Chap. "How Lean Management Tools are Supported by ERP-Systems: An Overview", before the article ends with a summary and presentation of future research needs (Chap. "Refinement of BPMN 2.0 Inclusive and Complex Gateway Activation Concept Towards Process Engine").

2 Current State of Research: Evolution of Environmental Management Information Systems

In science and practice there are approaches for EMIS, for both a holistic and inter-company reporting and for the preparation of an environmental information management [12]. An EMIS can be assigned to three different categories [12]. *Reporting and information systems* are used for external reporting. *ECO-Controlling Systems* are used for internal company decision making processes. *Production-related EMIS* provide information for the design of eco-efficient production processes.

For business application systems it is a challenge to integrate functionalities of corporate environmental information systems. This integration is motivated by the fact that decisions in enterprises are based on the measures provided by ERP

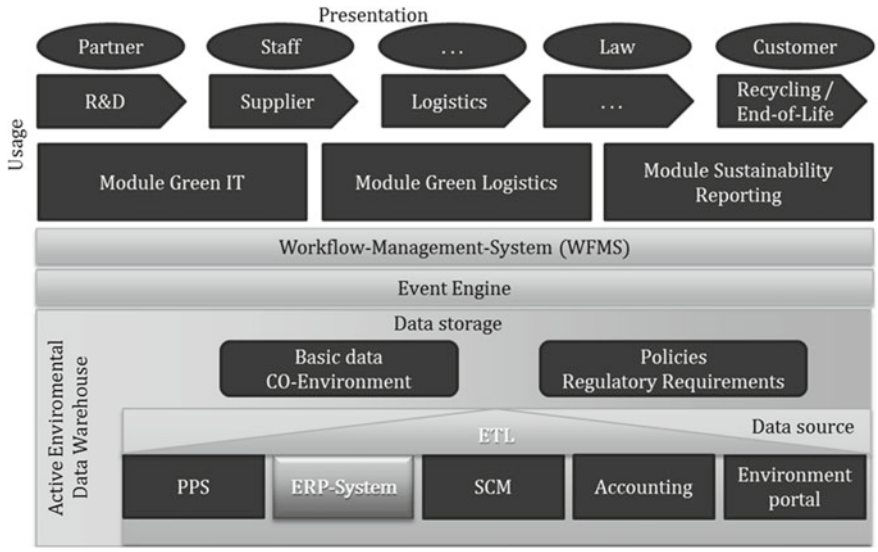

Fig. 1 Architecture of an EMIS 2.0 [12] inspired by [13]

systems [12]. In a literature analysis Teuteberg and Straßenburg [13] have essentially found out that existing solutions are not integrated and detected a lack of functional coverage. To the problem of obtaining hard available raw materials and the consideration of these in production and product development process, yet no concept of in-house preparation of decisions in the knowledge base could be identified.

2.1 Environmental Management Information Systems

The concept of corporate environmental information systems is based on the classic data warehouse architecture. Architecture stages are distinguished in four levels. Economically administrative systems (also known as operating systems), provide the features and functionalities with which business transactions can be conducted within organizations. These and other systems also referred as *source systems* (data providers) are the data sources for operational decisions in strategic information systems. On the *data management level* alongside both relevant environmental data and relevant regulatory data are mapped. The *modules* at the application level support the concept of value creation processes as a whole. The *presentation layer* provides reporting solutions. Figure 1 shows the concept of corporate environmental information systems. An event engine can automatically generate reports as soon as environmental requirements have been infringed. The workflow management includes corresponding reactive business processes.

Teuteberg also recommends preventive measure to protect companies from imminent compliance violations.

For the procurement of hard available raw materials the reference model provides no concept. The adaptation of the reference architecture can draw upon the procedure for mapping the evaluation task in the EMIS concept systematically.

2.2 *Open Source Environmental Management Information Systems*

The use of open source software in enterprises allows taking full advantage of manifold potentials. Today already, there can be seen a change on the software market, which is a clear and concise statement for the meaning of open source software in business environments. The expectations regarding this kind of software licensing mainly affect the adaptability and extensibility, next to reducing license costs. Concerning business information systems there are even more factors that are important, like open standards for the communication of systems and the independence of software suppliers [14].

Like ERP systems, Business Intelligence systems (BI systems) were a long time considered as expensive, complex, commercial products which were hard to establish. This prevented the diffusion of integrated planning systems, especially in SME. By the diffuse of the first open source solutions, many cost problems and the "black box"-problem were solved. With this, important business decisions were no longer taken by the software vendor but directly in the enterprises by customizing the software in regard to the business perspective [15].

Based on the initial findings outlined above, the scientific state of the art of the technology for open source and environmental business information systems shall be surveyed. Therefore, published scientific articles about EMIS in the open source market were collected with a systematic review of literature. The investigation was performed by keywords in the established online libraries EbscoHost, ACM Portal, AIS Digital Library, IEEE Xplore and the Internet in March 2013. In the online databases the search strings were like [(environmental management information systems) AND (open source)] in singular and plural (inflectional), in German and English language in abbreviated and full form, scans with and without hyphen in the title and the abstract. The Internet search has been made with the search engine Google Scholar.

It is striking that only a few scientific articles have been published in this subject area. The articles examine the economic *organizational perspective* on the one hand and the conceptual composition of EMIS on the other hand. Thereby the focus is on the conceptual development of generic categorized values.

The area of open source BI systems is characterized by significant progresses in the last years [16]. There are already various products covering nearly the full spectrum of BI tools. In addition, those systems are able to support the whole BI process, from data modeling through data loading to the generation of analytic

reports by the use of queries, online analytical processing (OLAP) and data mining approaches [GCD08]. The best known representatives of open source BI tools are SpagoBI, OpenI, Pentaho, JasperSoft, Palo and Vanila [17]. SpagoBI offers the largest future set and follows precisely the ideal-typical BI analysis stack [18]. Even though open source BI systems currently find more and more their way into enterprises, many authors of the publications stress that commercial closed source systems are still more widespread in enterprises [19]. They also mention that the representation of different parts of the systems (like database management systems (DBMS), extraction transformation load-tools (ETL-tools), OLAP clients and OLAP servers) also varies a lot. DBMS systems, e.g., are commonly more widespread than ETL tools [19].

Nevertheless, it is hard to find publications dealing with open source BI systems if the search is combined with issues like the sustainable acting in the fields of ecologic, economic and social sustainability. It gets obvious that there are only few scientific publications regarding these matters. Most of those articles come from the German scientific environment and are quite young, so is the first article describing the issue from 2004. All those articles conclude that there is a high need for action on the way to a greater diffusion on such systems [20–22]. Obviously, there are various approaches for environmental business information systems already today. However, they often stand in their own way because of the lack of documentation, open standards and expandability.

From a functional perspective there were already identified criteria for the selection and evaluation of open source systems in SME [6]. From a technical perspective we can find mechanisms from various enterprise information system architectures. Moreover, architectures, core components and technologies for virtualization are discussed to reach better performances, availability and a high scalability of technologies and defend risks of data storage [23].

The results clearly point out that an EMIS concept within the scope of open source BI systems is feasible, workable and suitable for all business environments.

3 Research Design

The work at hand follows the approach of design-oriented research, as a recognized method for information systems research [24, 25]. In practice, the contribution is based on the seven research guidelines following Hevner et al. [10]. The method is characterized as an iterative process with alternating phases of construction and evaluation (“build and evaluate”) [10]. Peffers et al. described in accordance with existing approaches to design-oriented research, a structured process in order to a nominal model that includes six steps for implementing design-oriented research with four possible entry points. Also as a mental model the approach supports situational action steps in the sense of a minimum common understanding of the presentation and evaluation of design-oriented research [11]. For the problem—the pursued objective is the nominal legitimated approach

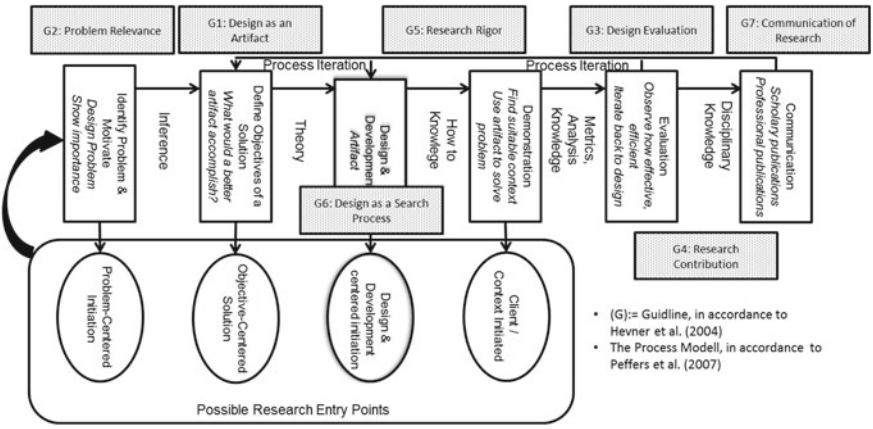

Fig. 2 Research design

applied systematically and progressively according to these research guidelines. Figure 2 shows this recommended and applied approach. Due to the complexity of EMIS processes challenged by open source systems, a continuous process in accordance to Peffers et al. and Hevner et al. is promising. In the following the assumed methodology is described, based on seven design guidelines (G) in regard to Hevner et al., starting from the entry point (Design and Development Centered Initiation) in reference to Peffers et al. The four nominal groups are a projection of determinants, also the projection of elements of the entry point category "Design and Development Centered Initiation".

The development process is centered on the design and evaluation process. The focus is on the design and evaluation of the EMIS. This is developed gradually in several iterations in accordance with the guideline "Design as a Search Process" (G6). For this purpose recursive design alternatives are tested against requirements and restrictions (requirements/constraints) [11]. As an entry point, the design-centered approach is chosen, that results from the existence of an artifact and its transfer to the open source domain. The requirements of the research guidelines "Design as an Artifact" (G1) and "Problem Relevance" (G2) are described in Chaps. "ERP Future 2013" and "Crossing the Boundaries: e-Invoicing/e-Procurement as Native ERP Features". As an artifact a system model with open source systems is designed (G1). The identification of data sources for the EMIS especially in context of structural change in information and communication industry (ICT) is significant (G2). The evaluation follows the procedure according to the methods of descriptive evaluation in regard to Hevner et al. [10]. The implementation concept is checked for plausibility in an argumentatively manner on methodological potentials (G3). The EMIS system model contributes to the expansion and structuring of the current state of knowledge, thus making it a "Research Contribution" (G4). The directive "Research Rigor" examines the application of proven approaches to strategic information systems and assessments to provide measuring raw materials in strategic

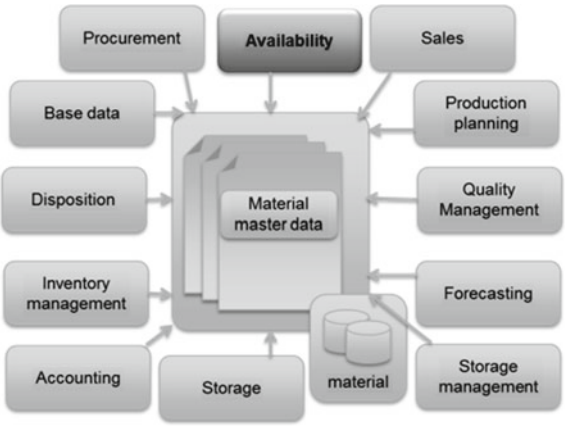

Fig. 3 Extension of material master data regarding availability assessment inspired by [26, 27]

procurement and product development (G5). To the directive, "Communication of Research", further publications of the model and further discussions with domain experts from business and scientific groups are planned (G7).

4 Analysis and Design of an EMIS Reference Architecture for the Evaluation of Raw Materials

4.1 Analysis of Relevant Data Sources for the Evaluation of Raw Materials

Enterprise Information Systems store master data as well as transactional data of procurement processes. Crucial information for decision makers comprises the assessment of the availability of certain materials and components. For this purpose we propose the specification of a dedicated material master data sight (views) that summarizes all relevant information regarding the procurement and development of innovative products. Currently, such information is not available in operative information systems. An overview of available sights (views) is given in Fig. 3 that is based on the leading, proprietary solution SAP ERP 6.0 [26, 27].

Here, no information is available that enable decision makers to conduct a holistic assessment of materials availability in the mid- and long-term.

Enterprises face two major challenges in the context of scarce resources. On one hand, the material composition of components is not transparent which necessitates an analysis of used materials in components. On the other hand an evaluation of identified materials regarding their availability has to be conducted.

SMEs in particular face uncertainties regarding the composition of procured components. In that case, availability risks are hardly transparent. For procured components two options for composition analysis are available:

Table 1 Evaluation of raw material

Source	Focused material	Application	Perspective
[3]	Cadmium, cobalt, gallium, indium, etc.	Technological products	National economy
[28]	Copper, iron, nickel, tin, silver, gold, tantalum, etc.	Mobile phones	Management
[4]	Energy- (oil, gas, cole), metal- (iron, steel, copper), non-metal-resources (salts, stones)	Generic	National economy
[2]	Generic	Generic	Global, national economy, management
[5]	Rare earth, cer, indium, lanthanum, tellurium, etc.	Technologies for renewable energies (wind turbines, photovoltaik, etc.)	National economy

1. The procured component is a *standard product*. Particularly, the electro- and electronics industry uses standard components. The ERP system commonly provides information as specification, material number and further supplier information. Here, the main challenge is about the automatized identification of composition from manifold sources, like life-cycle databases.
2. The procured component is *not a standard product* that is individually manufactured. Here, more effort to identify the composition is needed. For instance, publicly available databases are not providing any useful information.

Based on these observations, the uttermost task within an EMIS dealing with assessment of the products availability is to identify the materials that are used in components and to provide this information for the purpose of further analysis. Generally, potential information gaps can be closed by either an automatized interface to lifecycle or material information data bases (LC- and mat.-inf.-DB, e.g., EcoInvent, US Life Cycle Inventory Database, International Material Data System), interdisciplinary expert panels, value chain analysis or laboratory analyses. The necessary effort to identify the composition decreases with the degree of standardization of a component. Information on highly standardized components may be sourced automatically. For instance, information on such components (e.g. capacitors) is available in LC- and mat.-inf.-DBs. Detailed data on composition of components used in the German automotive industry are provided by the International Material Data System. More complex approaches, like laboratory analysis, have to be used in case of individually manufactured components.

After all materials are identified, these materials are assessed. A number of studies deal with the issue of material availability which is often termed as criticality. Criticality is a concept that assesses the availability of elements based on biophysical, technical, economic and social factors. The studies are either generic or material specific. A selection of those studies is presented in Table 1.

As mentioned above, the criticality is impacted by several factors. The selection of relevant factors, their measurement, the weighting between factors as well as the aggregation of factors is thoroughly discussed in academia. Against this background a decision support system has to be transparent and flexible in order to consider the preferences of the decision maker.

Although there are several differences among the studies, it seems there is some consensus regarding most of the relevant factors. Regularly named factors are geopolitical concentration of production locations (e.g., mines or processing companies), substitutability and recyclability of material or factors like political stability of producing countries. Less common are ecological or societal impacts. The dependency on a certain material (e.g., the percentage of sales that is generated with products that use the focal material) has to be considered from a corporate perspective.

Sources for compiling the relevant information for each factor have to be identified and, eventually, integrated automatically into the EMIS. The characteristics of the information cause a high degree of complexity and urge for a support by means of an IS. The information characteristics range from qualitative to quantitative data that also comprise several uncertainties. Furthermore, most of the data show a certain degree of dynamic. The integration of accordingly structured data from databases and unstructured data is a major challenge. For instance, data concerning the concentration of production as well as the amount of supply and demand can be sourced at the United States Geological Service (USGS).

The identification and assessment of used materials enables companies and national economies to analyze decision alternatives in order to derive adequate measures. Potential alternatives are substitution of material or function, large-scale storaging, hedging, recycling or vertical integration.

4.2 Open Source EMIS to Assess the Availability of Critical Raw Materials

Architecture planning is a decisive part of an open source project. The planning allows statements about the number of participating systems and their interaction. Data flows are analyzed in regard to their technical and business perspective. Big data, global availability and a great amount of users [29] require this planning to be made in a holistic way. This section provides an overall view of the EMIS architecture with open source software.

Central modules of an open source system for the strategic support of procurement functions may be built upon the basis of the architecture of an EMIS 2.0, following [12]. After the identification and the evaluation of raw materials it gets possible for enterprises to define various courses of action regarding the procurement and development of products. Following this approach, it is necessary to design an EMIS that allows the evaluation of raw materials. Therefore methods of

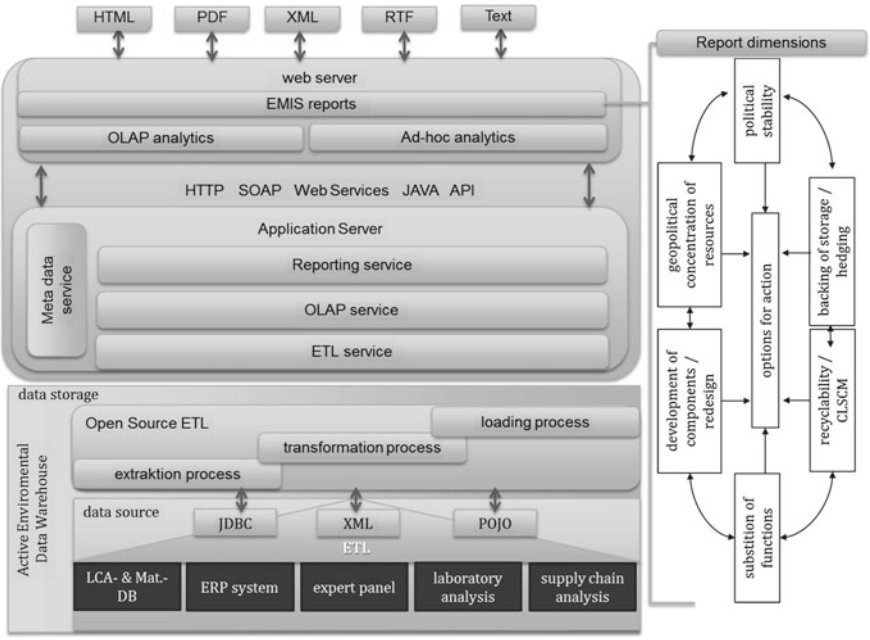

Fig. 4 Open source EMIS platform for the evaluation of raw materials

a multidimensional data modeling can be used to reach a technical implementation originated from a business concept.

The identification of important raw materials relies on both an analysis of business data (material master data, parts list, development information) and inter-company data. Lifecycle- and material databases, expert panels and laboratory investigation are tools to complement material master data for the purpose of a further analysis. The necessary data can be extracted from upstream systems. After the identification of hardly available raw materials, those have to be evaluated in regard to sustainable development approaches.

The access to source systems can be obtained by the help of free communication interfaces. For the modeling of those tasks there is a wide range of open source BI platforms (like SpagoBI, Pentaho or JasperSoft). Data extraction is possible from databases by using connectors like the Java Database Connectivity (JDBC) or any other interface for relational databases, or by using XML-based data extraction for web services. In many cases third party tools support the extraction of data, e.g., JasperETL, Pentaho Data Integration or Talend Open Studio. Those are tools that explicitly support the extraction of data into BI platforms [16]. Figure 3 constitutes the classic layer levels of a data warehouse architecture and regarding the evaluation of important data sources for raw materials and introduced report dimensions, how they can be integrated into the concept of EMIS. It reveals a 1-to-1 assignment of the technology stack support (Fig. 4).

A scientific key issue is the selection of evaluation criteria. In principle the evaluation follows economic and ecologic criteria. The economic evaluation is based upon price risks and the evaluation of the supply risks. Ecologic risks include all risks on every stage of value creation, beginning with the excavation of raw materials, going over treatment and use and ending with the dissipation of the materials.

5 Conclusion for Research and Application

5.1 Practice Contribution

It is important for the application layer to note that the provided services, responsibilities and host structures are to be determined systematically. Within the consolidation of offered services there will be an attempt to highlight overlaps and convergences between the overall offers. For this purpose documented features can be extracted from services, compared, and examined under a coverage analysis of divergence, convergence and completeness. Identified services and gaps in offerings are derived as artifact from the coverage analysis. Services and core functions are to be designed as interoperable as possible with the open source EMIS approach. A technical infrastructure is required to ensure the service. Basic services are provided by the operating enterprise IT infrastructure. To ensure the EMIS offering the semantic gap is to be closed, which refers to a non-uniform structured form of data. The "vocabulary" is to unify, so the technical communication can take place smoothly [8]. The structure can for example be based on data sheets for the raw materials.

On a case-by-case basis it is necessary to investigate how from a technical point of view IT services could be offered for small and medium sized companies. Use of the technology is determined by the reflection of the service, based on the higher layers (BI integration and presentation).

5.2 Perspective on Research

EMIS offers are often classified on the level on which the individual services are provided. Typical levels therefore are systematized and presented based on literature. Furthermore, explicit data sources and EMIS architecture components are described in a systematic manner. The view of EMIS systems has been extended by the addition of LC- and material database and supply chain management software towards an open source EMIS solution. Hence, the following requirements for research and application areas can be derived.

From the technical point of view it has to be considered in the next steps how established and future EMIS services can be provided in the open source enterprise concept. Previous publications in this regard considered the feasibility and proposed first concepts.

The current research efforts in the criticality exhibit some significant methodological flaws and lack of transparency regarding information providing and information aggregation. The illustrated EMIS concept supports academic as well as practical users to identify the sources for obtaining information clearly and to transparently define the aggregation logic as part of the recommended open source EMIS.

From a technical point of view the next tasks are to consider how established and future EMIS can provide services in the context of open source software. Research about the technological use of EMIS in context of open source is still not well understood, until today. Related approaches to service-oriented architectures and BI concepts already exist, which may be transferred to open source EMIS.

Contributions to EMIS can advance the acquisition of knowledge in the context of this work. A comparison of these approaches and transferability are still due. A key aspect here is the transfer of more opportunities, resources and responsibilities to small and medium-sized companies. This and other circumstances can be taken as an indication of the maturity lack in the available approaches.

6 Summary and Outlook

In this contribution EMIS and open source concepts were analyzed in order to develop a suggestion for the evaluation of raw materials with open source approaches on the basis of a reference architecture. The use of open source based EMIS in the analyzed area for the evaluation of courses of action holds significant benefits compared to the traditional use of EMIS and beyond that is able to supply more than reducing the costs. The derived potentials and requirements constitute a federate basis just for those medium-sized enterprises that so far had problems with the use and operation of EMIS, the evaluation of courses of action and moreover the creation and provision of content. The suggested integration solution enables effects of bundling in the design of courses of action. In many scenarios such requirements are the so far missing basis for a seamless use of decisive technologies in the operative use of environmental information.

In EMIS services for the evaluation of raw materials can technically be migrated to complex BI integration platforms to comply with the requirements of the chosen decision space. Thereby the different levels involve the infrastructure including the source systems for operating EMIS applications and services. The architectural layers provide the capability to assemble EMIS platforms within the meaning of environmental information management out of a composition of services.

Regarding current and future research the next step would contain an investigation about how the semantic gap for developing the data model and expanding

the material master data can be closed. A study in an interdisciplinary research team that consists of material scientists, physicists, purchasing agents, developers and computer scientists would lend itself for such kind of research in order to enable an algorithmic converting of these data. To facilitate the knowledge basis to link material master data and operative environmental data, the use of new domain specific ontologies would lend itself to this. With the aid of these intelligent and net-based data structures the spread, heterogeneous and complex information could be integrated [30, 31].

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Integration of Open Source Systems for SME

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Abstract To support the enterprise requirements in the case of enterprise resource planning, customer requirements management, document management systems and business intelligence proprietary but also open source software can be used. This paper focus on the open source branch and shows on a model which fields should be considered in selecting the best bundle for integration of these open source products. Therefore, a market analysis was done to identify the small and medium enterprise requirements and in an ongoing process the best open source systems fitting together has been chosen and proved by some case studies. The rating criteria's are license, the activity of the community and the proposed interfaces.

Keywords Open source software · Enterprise resource planning · Customer relationship management · Business intelligence · Document management · Small and medium enterprises

1 Introduction

Different studies focusing on satisfaction of Enterprise Resource Planning (ERP) systems show, that users of ERP systems aren't fully satisfied with their current products. Especially the integration of additional modules, the customizing and the ratio of cost benefit to satisfaction is low [1]. There are also the most of the studies on of ERP usage and satisfaction are made for companies with a number of employees larger than 50 [2]. This fact leads to the question, how much small

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companies with less than 50 employees are satisfied with their products and if they are using ERP systems, Customer Relationship Management (CRM) systems, Business Intelligence (BI) systems and Document Management Systems (DMS) or if they use individual software.

Therefore, a survey for asking the small and medium enterprises has been carried out. The return of 540 SMEs within Tyrol, Vorarlberg, Salzburg and Upper Austria is about 5 % of the sample size. The analysis of this survey will provide information about the use of ERP, CRM, BI and DMS, the satisfaction with the current system and the willingness to change from their current system to a more integrated system.

On the side of the system providers a lot of different ERP, CRM, BI and DMS systems in the proprietary sector can be found in the Gartner quadrants [3–6]. Also a few open source systems can be encountered in these quadrants. But even if the Gartner Quadrant doesn't show lots of open source systems, the quality of the software is high enough to compete in this market [7].

Still a challenge with the current business software systems is the ability to exchange data between the different systems [2]. The combination of these facts leads to the question, which products in the open source ERP, CRM, BI and DMS sector could possibly be used best in an integrated system. Therefore, different criteria's will be investigated and finally a case study will show which products could be used in a certain branch within SMEs.

2 Related Works

Besides the studies about user satisfaction, there also exist different studies evaluating the product functionality itself. One of the focuses of evaluating an open source system is, to evaluate the activity of the respective community. The activity can for example be measured by collecting data from the source code repositories and further consequence calculated by different formulas [8]. The second was used in this survey was the qualitatively analyse of community activity by asking experts [9].

All the different parameters will be combined in one model used in the different methods. All the different parameters have been ranked by their importance as a result of a qualitative survey. The most important parameters will be used in a framework to analyse the open source community activity by value benefit analysis as one of three parts of the product analysis.

3 Proposed Approach

To fit the needed requirements of SMEs best, this paper is divided into two parts. First of all a market research should analyse the demand side of integrated business software solutions. The analysis was done by an online survey where 540

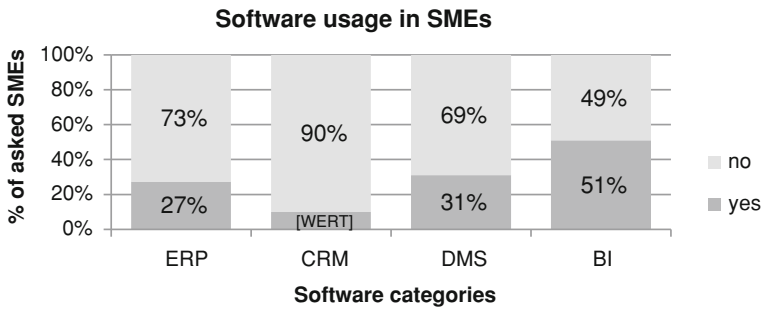

Fig. 1 The software uses in SMEs

companies in the category SME took part. From the basic population of about 31.000 SME companies 10,000 companies have been selected randomly and so the result of 540 answers can be seen as valuable [10]. When talking about SMEs, its always relates to these specific populations. Section 3.1 will show how satisfied SMEs are with their current solutions and if they are using ERP, CRM, BI or DMS.

The second part is made up of various software producing companies. To evaluate such software products and their communities, it will be described a way to evaluate open source systems by three main criteria. A case study at the end of this paper will discuss the combination of the two parts.

3.1 Market Research Results

The results of the market research illustrate, that the most SMEs doesn't use integrated enterprise systems. Figure 1 shows that only 30 % of the SMEs use an ERP system. The CRM system is identified as the worst used within the four categories. BI systems are the most widely used enterprise systems among SMEs. The reason might be the missing knowledge of what are typically BI systems are for. The percentage of SMEs which use all four systems is of course even lower, only about 4 % of SMEs use all four systems. The satisfaction of SMEs with their current systems is very similar between all sizes of companies within SMEs. Meaning that there is no big difference between a company with one to nine employees and a company with 20–49.

As shown in Fig. 2, about 80 % of the SMEs are completely or at least very satisfied with the processes covered by their software. In comparison only between 40 and 60 % are completely or very satisfied with the integration or combination of their current business software supporting their business cases. The general conclusion would be that the SMEs uses software for their business processes but only average satisfied.

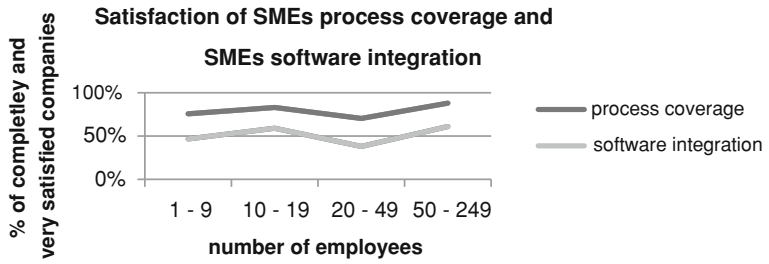

Fig. 2 Comparison of completely and very satisfied companies

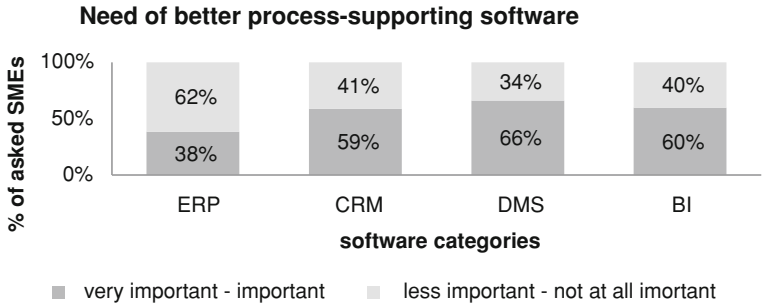

Fig. 3 Need of better support of certain software system

SMEs were also asked about the need to improve process support by these enterprise systems and approximately 38 % of the SMEs determined a need to implement ERP systems in the sense of integrated systems for their primary business processes. There is a higher need for better or different software solutions in the CRM, DMS and BI sector. As shown in Fig. 3, about 60 % of the SMEs would like to improve one of these systems. The combination of this need and the earlier mentioned satisfaction shows that SMEs are not fully satisfied with their software solutions and would eventually change to a more or best case fully integrated system.

The result of the survey shows that about 40 % of the SMEs would consider changing to an integrated business software solution. Transferred to the investigated total population it means that about 12.400 SME's would possibly change to such a system. This survey shows that the SME's ask for such an integrated business software solution.

To provide the information about a future changes in this field, SMEs were asked within what period they would change their system. The result shows that 71 % plan to change within the next 1–3 years.

3.2 Product Analysis Results

In order to analyse open source software, the license is one important point to be considered. Since there are lots of different open source licenses and the integrated system should be free of costs and remain the same license, only the strong copyleft [11] licenses will be taken into account by the product analysis [12, 13]. In total the six most important strong copyleft licenses were taken and been so accepted by the open source products [12, 14].

Besides the licenses, also the community is important for the quality of an open source system. After collecting different parameters out of related works and research papers, these parameters have been rated by analysing interviews of open source experts. The results of the qualitative surveys show that there three categories are important to measure. The categories are the code, amount of bugs/features and tools supporting the development process. Within every category concrete parameters, like lines of code, amount of commits or usage of a wiki system, were chosen to use for the activity analysis.

The last parts analyses the interfaces and architecture of the open source systems. Literature shows that services are common to connect different software systems [15]. A service can be realized e.g. by using CORBA [16] or web services [17]. Since CORBA is not widely allocated [18] web services will be the postulated interface to be used for integrate the different systems.

The product analysis was realized by a value benefit analysis, where every item got a different amount of points. The items are all equally weighted. Table 1 shows the best three products in each category with the highest amounts of points. These products will be used in a more detailed analysis.

It has to be mentioned, that the licenses strong copyleft in this analysis was a must criteria which influences the result the most. This means that well fitting system with a good rating in all the other categories are dismissed in case of the wrong licence. Therefore, the ranking would be different when only measuring the activity and the interfaces. In comparison, Table 2 shows the ranking only for the community activity and the interfaces. Only the CRM sector would completely remain the same.

Without taking the license into consideration, it would also be possible to create an integrated system with these products, but in this paper the license was defined as must criteria.

3.3 Case Study Summary

To check how the best products would fit into a certain SME target group a case study was made. This case study took SMEs with one to nine employees in the Tyrol in the crafts and trades affiliate as a target group. The case study came up with two results. First of all, a detailed look into each product shows, that certain

Table 1 Top 3 products in each category

Rank	ERP	CRM	BI	DMS
1	OpenERP	CiviCPM	Jaspersoft	Agorum
2	Dolibarr	X2CRM	KNIME	OpenKm
3	Adempiere	SugarCRM	BIRT	OpenDocMan

Table 2 Top 3 ranking without licensing

Rank	ERP	CRM	BI	DMS
1	OpenERP	CiviCRM	Jaspersoft	LogicalDOC
2	Dolibarr	X2CRM	KNIME	Agorum
3	OpenBravo	SugarCRM	SpagoBI suite	Alfresco

Fig. 4 Highly sophisticated case study scenario

products aren't made for this sector. For example in the CRM category, CiviCRM is specialized on Non Governmental Organisations (NGOs) and only shows functionality required in this field. The second result showed that depending on a company preference, different scenarios are feasible.

Depending on the use of CRM and BI, these two components can be covered by the ERP functionality or by one of the products chosen in the certain category. Figure 4 shows the result of the scenario in the most sophisticated version, meaning every category is covered by a specialized product.

4 Conclusion and Outlook

This short paper shows by considering different parameters how the best open source products of ERP, CRM, BI and DMS can be identified. These open source software products are the best by having a look on their type of license, the activity of the community and the supported interfaces. A combination of these open source products support the SMEs business processes and are the base requirements for a future integration of them. The currently used systems and the future requirements of SMEs have been analysed by an online survey among SMEs from different branches. The results show that SMEs with less than 10 employees have a

need for better process support by computer systems as well as the willingness to change to an integrated system. This confirms the requirement of an integrated solution where the best ERP, CRM, DMS and BI have been selected for a SMEs solution.

The second part of the paper defined three main criteria how to analyse open source products for SMEs suitability. The criteria licensing, community activity and interfaces have been used in a value benefit analysis to compare the different open source systems. The result was a ranking of the most useful open source systems in each of the four categories. An interesting aspect has been investigated within the type of license—here strong Copyleft. The licence strongly influences the ranking of systems so the decision of the license has to be well prepared by considering the strategic goals of the company. Open source software in the context of DMS seems to be driven by companies putting their knowledge in the redevelopment of the open source software and sell their software e.g. enterprise licenses.

Finally, the case studies built from the analysis data of the online SME survey showed that the ranked open source systems to fit their requirements for supporting SMEs business processes. Here has to be mentioned that this survey has its limitation in the amount of the investigated companies in the four provinces. So this is a limited view on the population of handcraft companies and also the structure of SMEs with one to nine employees has its limitations.

For further research the focus would be on a more representative group of investigating SMEs by expanding the survey to the DACH country's as well as considering more different types of industries. Also the more detailed analysis of the already-used software systems in SMEs can help to improve the results for the best software solution supporting the business processes.

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Part VI
ERP Training

ERP-End-User Training Through E-Learning: What Should the User Focus On?

Lukas Paa and Felix Piazolo

Abstract End-user training (EUT) plays an important role in enterprise resource planning (ERP) implementations and successful operations. Nowadays, most EUT is conducted with the support of digital media. In this study we investigated the impact of the amount of time spent by learners on different content types, namely media enriched text and video screenings, on acquired factual and conceptual knowledge as well as acquired skills concerning the ERP system. Findings show that more is not categorically better.

Keywords End-user training · Learning objective · Learning content · Successful training · E-learning

1 Introduction

Rapid changes in technological development require organizations to increase the knowledge level among their workforce to be able to keep up with competitors and, ultimately, to survive. To succeed among the competition, organizations have to invest in training. Recent studies show that firms with the highest deployed IT capabilities in their peer groups have been best able to profitably grow their revenues. This finding has been true for both large enterprises and midsized businesses [1].

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As reported by the American Society for Training and Development, the average U.S. company is training more of its employees than ever before, with the largest share going to technical skills training. The high need for technical skill training is for one part caused by the high number of implementations of enterprise resource planning (ERP) systems in companies around the world who require skilled end-users to efficiently and effectively operate them [2, 3]. According to Konradin, more than 92 % of all German industrial enterprises use ERP systems. In relation to total spending for ERP systems in German enterprises with more than 50 employees, 17.1 % were used for training of IT departments and end users, compared to 14.9 % in 2009 [3].

An increase in the requirements for continuous learning and the declining cost of online devices encouraged many organizations to move towards technology-enhanced, or e-learning, if they had not done so already. The use of e-learning technologies for the delivery of training grew constantly up to 50.4 % for small companies and even 62.4 % for large companies in the US of which a total of 70 % use video in some way [4].

On average, end-user training costs account for up to 30 % of the total ERP implementation budget, but organizations that spend less than 15 % are likely to have insufficiently trained employees. For successful implementation and maximization of the potential benefits of ERP systems, knowledgeable and skilled users are inevitable [5, 6]. ERP end-user trainings are most efficient in regard to learning outcome when taught on a live ERP system (hands-on) [7, 8]. End-user training (EUT), not only in the area of ERP systems, is one of the most pervasive methods for enhancing the productivity of individuals. EUT deals with teaching skills to effectively use software and applications. Today most EUT is done through computer-based training or e-learning initiatives [9].

E-learning with the purpose of teaching skills on software usually contains at least screenshots of the software interface, or even video screenings. Earlier studies showed that high quality multimedia content plays an important role in learner satisfaction and learning outcome [10]. As those require significantly more resources (time, money, as well as skills) this study focuses on the impact of different content types in e-learning on acquired skills and knowledge by participants [11].

2 Object of Investigation

A mandatory course for students of the Bachelor of Business Administration degree at the University of Innsbruck served as the object of investigation. During one semester students of this course are taught basic knowledge and skills concerning an ERP system like *purchase, sales, warehousing* and *production* through a learning management system (LMS) and a web-based live ERP system. The students are studying the mentioned units via the LMS by themselves prior to face-to-face lessons with an instructor.

All relevant theoretical knowledge and skills are taught through e-learning, which uses two main content types: video screenings (video) and media enriched text (text). Additionally, a support forum via which students can communicate with other students and tutors is provided. The course is portioned in four chapters. After every e-learning chapter participants have to solve a task (working package; WP) on the ERP system and a theoretical assessment. The data gathered consists of time spent on every single e-learning item by every student as well as the scores in each test, both practical (WP) and theoretical (e-assessment).

For the completion of every e-learning session, in a 2 week frequency, students have to solve a WP, in which they have to simulate a given process in the live ERP system, e.g. create a contractor and order a certain amount of a specific item. Learners can practice those tasks as often as they want during a 2 week period. At the end of each e-learning session, students have to submit their solutions for the WP through an upload feature on the LMS. After every e-learning session an attendance session with 25–30 students per class is held, in which the lecturer explains solutions to frequent mistakes and challenges by the students, and answers questions concerning the topic of the prior e-learning session. At the end of each instructor led session, a theoretical test in form of an online assessment (e-assessment) is conducted on the LMS, which controls factual and conceptual knowledge of learners. The WP and the e-assessment build an assignment package (AP) of which a total of four have to be completed during the semester. At the last attendance session, a final test has to be passed in class in which students have to solve a task similar to one of the working packages on the ERP system.

Student samples are frequently used in the literature and seem to be especially appropriate for training-related research. Although our sample is younger than average workers, it forms a reasonably representation of people undergoing ERP training in organizations (Fig. 1).

2.1 Types of Content

E-learning allows for a broad variety of content. The most basic type of content to create and display is plain text. It brings along the advantage of small file sizes, easy deliverability and is easy to consume with any device. It also builds the base for other content types in the form of a script for voice-overs or an outline for a video. Audio builds the next higher level of sophistication, where a script is converted into spoken words, which means more effort to create but allows for an easier consumption for learners on mobile devices or on the go. The next level is visuals, where static and moving images can be differentiated. In the category of static images, photos of real settings or screenshots of software displays can be summarized. More sophisticated ones would be illustrations, charts and graphs which usually include more information. Moving pictures include videos and animations, which again can contain real settings or screenings of software, or

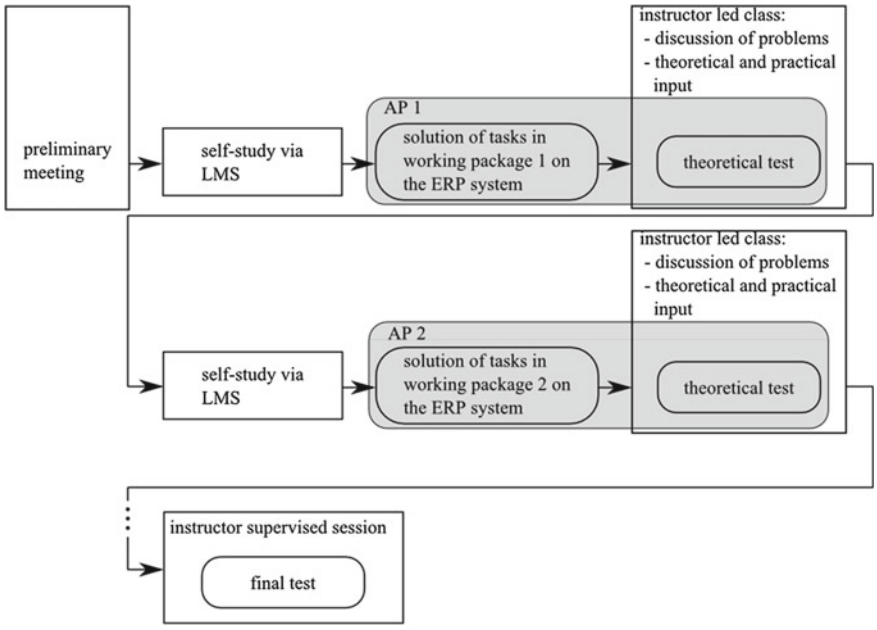

Fig. 1 Course cycle

consist of animated drawings. Moving pictures are the highest level of content, both in creation and ease of consumption.

On the investigated LMS two types of content can be differentiated: text enriched with illustrations, charts, graphs and screenshots (further referred to as 'text'), and video screenings of the ERP system (further referred to as 'video'). Video screenings recorded real actions on the ERP system, which were later enriched by short explanations (written comments in the video) but without audio (except for the sound of clicking and typing). All theoretical background knowledge concerning business processes, basic facts about ERP systems, and basic business terms and facts, were covered in the text parts. Required knowledge about how to use the ERP system were partly explained in the text content as well, but the demonstration on how and where to exactly execute commands were illustrated in the video screenings.

The entire e-learning content of the investigated course consists of 256 single items of which 62 are video screenings with an average duration of 1 min and 40 s. To browse through all content at 'average' reading speed and watching every video screening once, a participant would spend a total of 5.5 h, of which 1 h and 40 min are to be spent on video. The whole course content is partitioned in four chapters. The beginning of each chapter consists of theoretical explanations, which at the end of the chapter are illustrated by video screenings.

According to Blooms taxonomy of educational objectives [12, 13], the text items in the investigated course provide the materials for factual knowledge.

Table 1 RECAP model according to Imrie, 1995

	Learning objective in RECAP	Intermediate goals as in Krathwohl [13]	Method of assessment
Level 1	Recall Comprehension Application	Factual knowledge Conceptual knowledge	Specific question, multiple choice, short-text-insertions
Level 2	Problem solving skills	Procedural knowledge	Tasks, team work, projects

Factual knowledge describes the basic elements that learners must know to be acquainted with a discipline in order to be able to solve problems in it, for example specific terminology relating to a subject and specific details and elements important for the understanding of interrelations in a field.

Actual interrelationships among the basic elements within a larger structure, such as classifications, principles and generalizations, are part of the conceptual knowledge as well as theories, models and structures. The latter are also covered in the text items of the LMS. Procedural knowledge in the investigated course is mainly transmitted through video. Here, subject specific skills, techniques, and methods are demonstrated to the learners. Criteria for determining when to use appropriate procedures are also a learning objective of the video.

2.2 Types of Assessments

With the determination of the learning objectives according to [13] in mind, we will now describe how they were assessed during the investigated course.

In order to test knowledge, learners usually have to answer specific questions in a written or oral way, or solve a task, which are then evaluated by course administrators [14]. In order to assess the factual and conceptual knowledge, participants have to show that they are able to recall, comprehend, and apply the knowledge that was required to learn. By asking specific questions which proof the availability of the terminology and the interrelationships among them, it is possible to assess so-called 'level 1' knowledge by written or oral exams, like multiple choice tests or interrogations.

To test for procedural knowledge, participants have to prove their problem solving skills by solving certain tasks in which both the results and the approach will be evaluated.

Table 1 shows the RECAP model by Imrie [15] and its relation to Krathwohl's [13] learning subcategories which again base on Bloom [12]. RECAP stands for "REcall, Comprehension, Application, Problem solving".

Three different types of assessment are used in the investigated course. Four interim tests, which consist of a working package (WP) and an online assessment, as well as a final skill test. The different types of assessment will be explained in further detail.

Table 2 Types of question in the e-assessment

	AP1	AP2	AP3	AP4	Method
True /false	36	39	24	24	Verification of statements
Single choice (1 out of 4)	37	30	15	16	Selecting 1 correct answer
Multiple choice (1–4 out of 4)	31	35	31	23	Selecting between 1 and 4 correct answers
Mapping	14	13	21	7	Classification of items, order in processes
Indication on screenshot	36	36	10	12	Indication of functionalities and options to enter information on screenshots
Total	154	153	101	82	

E-assessment The online assessment was created to evaluate the knowledge and comprehension of the relevant content. The test is accessible through the LMS but has to be taken during the instructor led class, as no textbooks are allowed. It consists of 10 randomly selected questions for each participant, which have to be answered in 5 min. Given answers can be changed during the 5 min period. The test is mandatory and can only be taken once.

Table 2 shows the five different question types applied and in which quantity they exist.

Working Packages (WP) contain a certain task referring to the e-learning content and can be solved at home without a time limit but with a due date. Working packages include clear instructions on what participants have to achieve on the live ERP system. To solve the required task, the participants need factual, conceptual, and procedural knowledge. The required information and skills are covered in the LMS, which can be consulted during the solution of the working package.

For each of the WPs, participants have a time frame of 6 days to solve and hand it in. Actual required time to finish a WP after working through the referring e-learning content should be between 30 min and 1 h. As WPs are homework, students are allowed to work on it together and assist each other.

Skill Test. At the end of the course, every participant has to pass a final skill test on the ERP system. The skill test is very similar to the WPs but is conducted in the classroom, without any help and within 25 min. The Skill test covers one specific part of the entire course content. There are six different topics in total and each lector chooses one for his students.

3 Research

With this study we want to find out if there exists a relation between the amount of time learners spend with the e-learning content and the acquired knowledge and skills concerning the ERP system.

According to the common sense we assume that spending more time with learning objects results in higher skills.

H1.1: Spending more time on the video content results in higher ERP skills.
H1.2: Spending more time on the text content results in higher ERP skills.

The same is assumed for factual and conceptual knowledge.

H2.1: Spending more time on the text content results in higher theoretical knowledge.
H2.2: Spending more time on the video content results in higher theoretical knowledge.

H1 and H2 implicated that more time spent on both content types has a positive impact on overall test results, which leads to:

H3: Spending more time on both content types results in higher overall test results.

As the text content mainly covers factual and conceptual knowledge, which are assessed in the e-assessment, we assume that time spent on text content has a bigger impact on e-assessment scores than time spent on video content.

H4.1: Time spent on video content has a bigger influence on ERP skills than time spent on text.
H4.2: Time spent on text content has a bigger influence on theoretical knowledge than time spent on video.

3.1 Data Gathering and Analysis

Over two terms we collected data from 600 participants of the mentioned course teaching ERP end-user skills and knowledge. We collected all test results, from the theoretical test and the practical test for each of the four phases of the course as well as the final skill test.

In order to complete the whole course content students had to work their way through the LMS. The LMS automatically tracked every session of a participant and also allocated with which item he was interacting. If a participant would navigate to an item a second time, the total time would just be accumulated. As a result, at the end of each term we had a detailed (by the second) report on how long each student interacted with each item. As limitation we have to state that students were allowed to prepare for tests together and it might have occurred that two or more students were reading from the same screen at some time, in which case only the times for the student who logged in could be tracked. Additionally, the LMS can only track which item is displayed, but not if there is not another tab or even program hiding this item from the visible screen. Also, if the user was actually engaged with the content is not trackable.

With that in mind, we had to clean the data, as there were several logs of more than 10 h with just a single half page item, which we interpreted as measurement error. We analysed every single item concerning the average required time to read or watch (in case of video screenings) it. We are aware that reading speed and absorbing capacity vary widely between individuals, but there is no possibility to account for that with our test settings. We took our stated average times as basis and concluded that if a participant spent more than eight times the required time on one item, it was treated as a measurement artefact, and the maximum was set at eight times the required time. Concerning the video screenings, we took the duration of the video itself and allowed ten additional seconds to open the player and load the video and set this time as average.

3.2 Analysis

During the entire 2 semesters we have collected interaction times by learners with 256 content items as well as test results from 4 APs (one WP and one eAss each) and the final skill test. The mean duration of student engagement with the content was 46:44 h with huge variations in the total time spent on the LMS as indicated by a standard deviation of 22. The mean time spent on text content is 22:13 h with a standard deviation of 18 in comparison to mean time spent on video items of 24:31 h and a standard deviation of 9.

In order to get an overview of time spent by learners on the LMS, we categorized the time spent on single items based on the time required to read it once according to the following pattern:

- Category 1: Less than 31 % of the required time spent on the item:
- click through without proper reading
- Category 2: Between 31 and 90 % of the required time spent on the item:
- browsing
- Category 3: Between 91 and 150 % of the required time spent on the item:
- reading
- Category 4: Between 151 and 400 % of the required time spent on the item:
- learning
- Category 5: Between 401 and 800 % of the required time spent on the item:
- intense engagement
- Category 6: More than 800 % of the required time spent on the item:
- very intense engagement

The categorization bases on our estimations as well as the observed times of participants spent on items.

In a first step we observed the test scores of learners grouped for their average time spent on (a) text content and (b) video content. We calculated mean test results for each group, for example all who spent an average time on video content referring to category 3. Figure 2 shows the scored test results (WP, skill test and e-

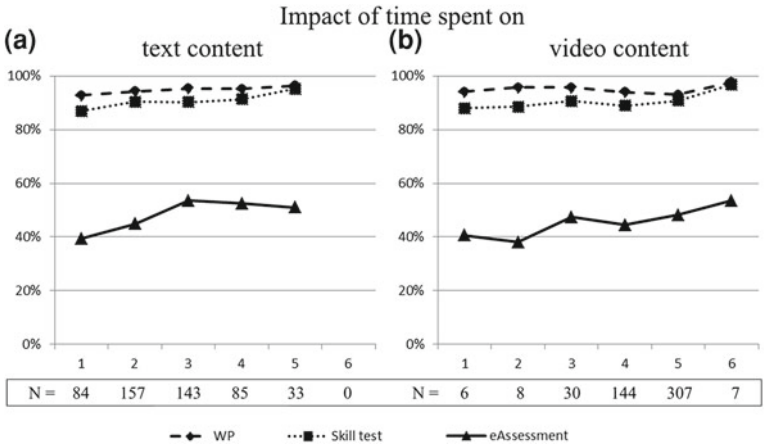

Fig. 2 Impact of time on different test scores

assessment) as percentage values of the maximum achievable points. All are dependent on the time a participant engaged with the different content types (text and video). One can read the graph like this: If a participant was intensely engaging with the text content (category 5) over the whole term, he or she was likely to score about 4.9 % points higher on the final skill test than someone only reading the content (category 3).

This basic calculation allows for the conclusion that participants, who spend more time with the provided content, achieve better results in general, even if there are some exceptions. Especially regarding the e-assessment scores one can see, that for both investigations (text and video) the highest results were achieved in category 3, with disregard of category 6 in graph b, which only has 7 observations. While analysing this graph, one has to keep in mind the amount of observation in each group (stated as N on the bottom of the graph). For example, concerning the time spent on video content (graph b), the categories 1, 2 and 6 are underrepresented.

Surprisingly, learners who spent more time than the average required time (category 3) to watch all videos on the video content, scored worse in the final skill test as well as in the overall achieved points unless they spent considerably more time on the videos (category 6). A possible explanation would be the affinity or aversion of some users to software. The ones who feel comfortable from the beginning operating a software might be likely to be more successful by just watching the video once than students with a general aversion to software who watched the video two to four times. Bandura refers to this phenomenon as computer related self-efficacy, which describes the belive in ones abilities to cope with computers and software [16, 17].

Another aspect might be the degree of focus. Learners solely focussing on the video are likely to absorb more of the content than someone running the video in the background.

To get a clearer understanding, we went back to the primary data consisting of times, not categories. We summarized the times spent on the two content types (text and video) per student per chapter and conducted a regression analysis to the achieved test scores in the WP as well as in the e-assessment. Results can be found in Table 3. As one can see, the degree of explanation of e-assessment scores is quite low. However, the time spent on the text content referring to the recent test shows highly significant and considerable large values, except for AP1. In terms of the WPs, the values of R^2 are considerably higher, and, with the exception of AP3, a strong impact on the times spent on the video content on WP test scores can be noticed. However, the negative correlations of time spent on text items in chapter two to four on WP test scores are confusing. This would mean that learners spending more time on text content were likely to score better on the e-assessment but worse on the WP, independent of the time spent on the video content.

In the next step we tested for two-way interactions (often thought of as a relationship between an independent variable and dependent variable, moderated by a third variable). Following Aiken and West [18], to increase interpretability of the interactions we first centred the independent variables by subtracting the mean score from each value. Then we created the interaction term by multiplying the centred independent variables. With those new created values, we conducted a linear regression in PSAW in two steps: First by using only the centred variables as independent variables, and in the second step by including the interaction term.

As we can see in Table 4, by including the interaction term we can raise the level of explanation (R^2) of the test scores considerably for all four tests.

The following graphs illustrate the meaning of this calculation. In all four settings the independent variable and the moderator compensate each other if one of the values is low. This means that if a learner is spending little time on the text items but more time on the videos, he or she is likely to achieve good test scores and vice versa. However, if the independent variable is high, and the moderator shows high values as well, test scores tend to be negatively influenced. This means that participants spending a lot of time on both text and videos, tend to score worse than participants focusing on only one.

According to Aiken and West [18], we calculated f^2 in order to show the proportion of systematic variance accounted for by the interaction relative to the unexplained variance in the criterion by following formula (1)

$$f^2 = \frac{r^2_{Y.AI} - r^2_{Y.A}}{1 - r^2_{Y.AI}} \tag{1}$$

$r^2_{Y.AI}$: Squared multiple correlation resulting from combined prediction of Y (AP test scores) by the additive set of predictors (A; time spent on both content types) and their interaction (I) (= full model)

$r^2_{Y.A}$: Squared multiple correlation resulting from prediction by set A only (= model without interaction term)

Table 3 Regression of content types on test scores

	AP1		AP2		AP3		AP4	
	WP	eAss	WP	eAss	WP	eAss	WP	eAss
R^2	0.138	0.071	0.257	0.087	0.290	0.122	0.346	0.151
Chap. 1 text	0.061+	0.262***	0.127**	0.190***	0.142***	0.240***	0.130**	0.229***
Chap. 1 VS	0.316***	0.137**	0.320***	0.140***	0.328***	0.173***	0.348***	0.167***
Chap. 2 text			–0.178***	0.228***	–0.139***	0.254***	–0.132**	0.288***
Chap. 2 VS			0.229***	0.259***	0.275***	0.227***	0.288***	–214***
Chap. 3 text					–0.222***	0.318***	–0.201***	0.269***
Chap. 3 VS					0.020	0.195***	0.037	0.196***
Chap. 4 text							–0.277***	0.363***
Chap. 4 VS							0.248***	0.229***

+ $p < 0.10$, * $p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 4 Comparison of R^2 for regression with and without interaction term

	R^2	R^2 with interaction	Sig.
AP1	0.133	0.249	0.000
AP2	0.112	0.196	0.000
AP3	0.041	0.272	0.000
AP4	0.155	0.272	0.000

Table 5 Effect size of interaction terms

	f^2	Effect size
AP1	0.104	Small/medium
AP2	0.154	Medium
AP3	0.317	Large
AP4	0.160	Medium

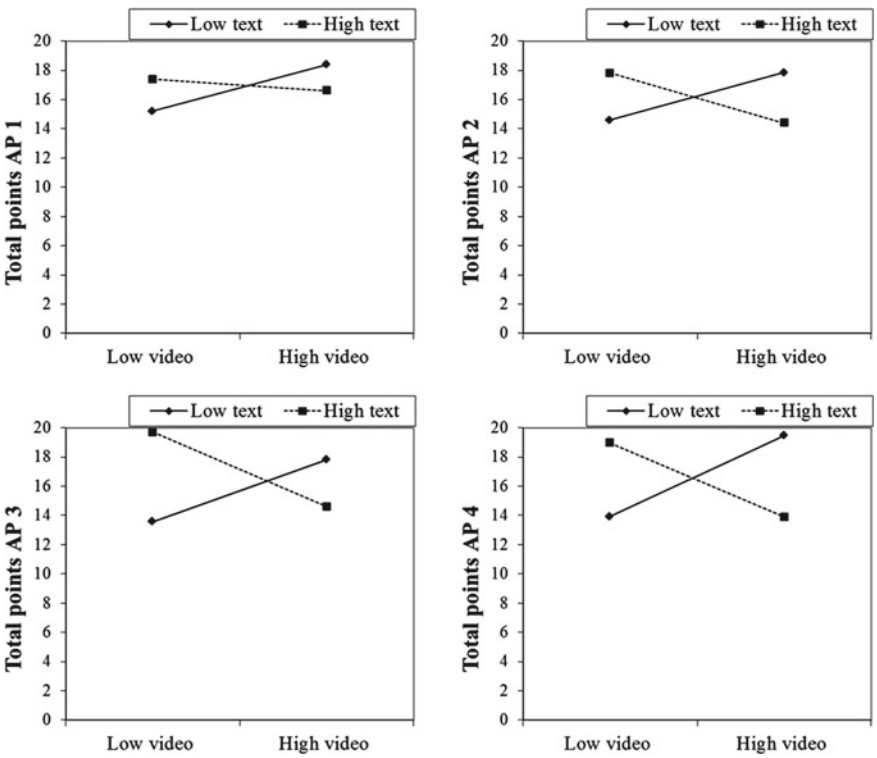

Fig. 3 Two-way interaction plots

According to Cohen [19], the effect size of including the interaction is considerably high for all four APs.

A possible explanation for the negative effect of high values for both of the independent variable through all fours tests would be the limited receptivity of learners (Table 5).

4 Conclusion

In general we can conclude that spending more time on the content type associated to the learning objective that is later tested in the assessment, has a positive impact on test results, which is both true for text and e-assessments as well as video and WPs. This is demonstrated in Fig. 2 as well as the regression analysis in Table 3. H1.1 and H2.1 can thereby be accepted. As the regression analysis shows, there is a significantly negative impact of time spent on text to scores in WPs, which results in a clear rejection of H1.2. However, this is not true for H2.2, as there exists a positive relation between time spent on video content and the associated e-assessment. This leads to the conclusion that spending more time on video content, which mainly covers procedural knowledge has a positive impact on e-assessment scores, which mainly tests for factual and conceptual knowledge. But spending more time with text content which mainly covers factual and conceptual knowledge has a negative impact on tests that assess mainly procedural knowledge.

Figure 3 surprisingly points out that if learners spend a lot of time on one content type, high time on the other content type has a negative impact on test results. Therefore H3 is rejected. We assume that this results in the limited reciprocity of learners or in different favoured learning habits.

H4.1 can be accepted as regressions in Table 3 show higher impact in all four WPs for video content compared to text content. The same occurs for the impact of text content compared to video content for three out of four e-assessments, which lets us accept H4.2.

In general, further research in this field should be undertaken to provide a broader basic data basis to underline or negate the first findings presented in this paper. Additionally it should be investigated if the kind of LMS and ERP system used is significantly influencing the results of our research.

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Is There an Impact of ERP Learners Training Behavior on Acquired Skills

Lukas Paa, Kurt Promberger and Felix Piazolo

Abstract End-user training forms a highly relevant factor for successful ERP implementations. As training is both time and cost consuming the most efficient way to train users is most organisations ambition. By investigating the activities of a student sample of ERP learners concerning time spent on an ERP system, amount of sessions and session durations we could gain insights in training patterns and learning behaviour. Provided findings are helpful to plan training schedules and system capacity.

Keywords ERP system · End user training (EUT) · Hands-on ERP · Training efficiency · Training habits · ERP implementation

1 Introduction

Experts agree that companies have the biggest benefit from ERP software when users, their employees, become accepting, comfortable, and proficient performing the business processes the software supports [1–4]. Stated differently, the success of a highly cost consuming ERP implementation depends on the people using the system for day-to-day work [5]. Apart from the acceptance of users, the training of

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those plays a very important role in order to have a working and reasonable utilized ERP system.

It is widely accepted that training on a live ERP system yields for the highest learning success compared to simulations and pure theoretical training [6, 7]. In this study we are investigating the impact of engagement with an ERP system on acquired skills and knowledge concerning the system.

2 Object of Investigation

A mandatory course for students of the bachelor of business administration degree at the University of Innsbruck served as the object of investigation. Participants get trained on basic knowledge and skills concerning an ERP system like *purchase, sales, warehousing* and *production* through a learning management system (LMS) and a web-based live ERP system.

The necessary theoretical knowledge and skills are taught through e-learning, which consists of media enriched text and video screenings. A support forum on which students can communicate with each other as well as tutors is optionally available. The course is portioned in four chapters which are each terminated by a test. Each chapter starts with the publication of the learning content for this session via the LMS. Students can start to engage with the content and also train the covered topics on the ERP system. During the entire term students can access the ERP system as long and as often as they wish. Seven days prior the end of each learning chapter a working package (WP) is published on the LMS. Students have to solve this WP in which they have to simulate a given process in the live ERP system. For example create a contractor and order a certain amount of an item. Participants can practice those tasks as often as they want. At the end of the learning session they have to hand in their solution which gets rated. At the end of each chapter there is one attendance class in which common problems are covered. At the end of this class a theoretical online assessment (e-assessment) on the LMS, which controls factual and conceptual knowledge of learners [8], has to be passed.

To assess acquired skills and knowledge three different types of assessment have to be completed. Four interim tests called assignment package (AP), which consist of a WP and an online assessment as well as a final skill test. The different types of assessment will be explained in further detail.

WP contain a certain task referring to the e-learning content and can be solved at home within a time frame of seven days. Actual required time to finish a WP after working through the referring e-learning content would be between 30 min and 1 h. As WPs are homework, students are allowed to work on it together and help each other out.

e-assessment The online assessment was created to evaluate the knowledge and comprehension of the relevant content. It consists of 10 randomly selected questions for each participant which have to be answered in 5 min.

Skill test At the end of the course every participant has to pass a final skill test on the ERP-system. The skill test is very similar to the WPs but has to be done in the classroom, without any help and within 25 min. The skill test covers one specific part of the entire course content.

3 Research

Aim of this study is to find out, whether or not there is an observable impact of the amount of log-ins, the total duration of time spent on the ERP system and the average session duration (SD) on acquired skills and knowledge.

For the entire semester, over 21 weeks, the activities on the ERP system by 269 learners were logged. This data collection formed a naturalistic enquiry, a paradigm describing a situation where data is collected in the background unnoticed by the learner [9].

The data gathered consists of every log-in as well as the corresponding SD. Due to unknown technical problems some single sessions could not be logged. Those cases were excluded from the analysis. Which tasks users executed could not be logged, so we know that users were logged on to the system but not what they did in detail. An automated log off did not exist in the utilized ERP system. In case the user closed the browser through which he accessed the ERP system the session was automatically terminated after 10 min. As long as the tab was open and the internet connection active the session continued independent of the user's activity.

We defined a session as the time starting with the log in until the log off, no matter if manually or automatically. Average SD is calculated by the sum of all SD during a certain period divided by the amount of log-ins during that period.

There were 5901 sessions documented during the whole semester. The mean amount of sessions was 21.9 per student, however, there were huge variations in the number of accesses as indicated by a standard deviation of 15.9. The lowest number of sessions was one and the highest was 82. Average SD was 71 min also with a high standard deviation of 90.

To determine the level of acquired skills and knowledge the scores in each test, both practical (WP and skill test) and theoretical (e-assessment) are used.

At first we analysed activities of learners in general on the ERP system. We could clearly see that only during the time they had to solve the WPs and approximately 10 days before the final test there was a considerable amount of log-ins. For that reason in Fig. 1 times between those periods are excluded. At first glance the rise of activity, both in overall SD as well as amount of sessions, as we get closer to the due date to hand in the WPs is observable. We can also see that during classes only a very small portion of students actually used the system. The decrease of activity towards WP4 shows that learners become more proficient and less anxious handling the system and solving the task during the term. The level of difficulty remained the same during all four WPs. Also during the preparation phase for the final test we can observe highest activity towards the end. Stated

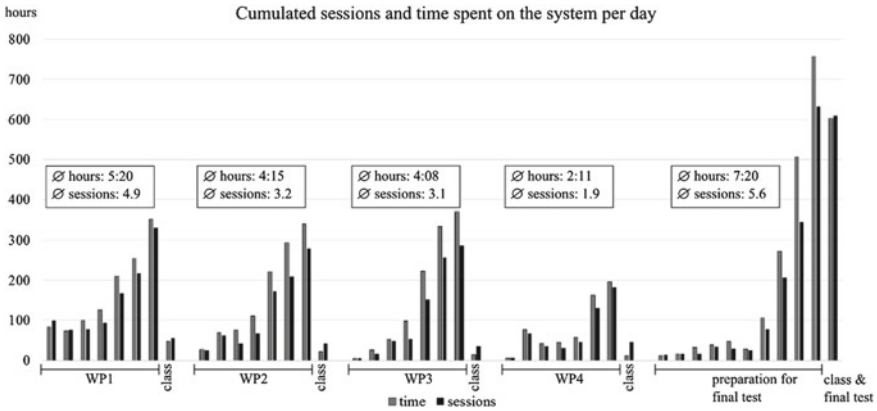

Fig. 1 Cumulated sessions and time spent on the system per day

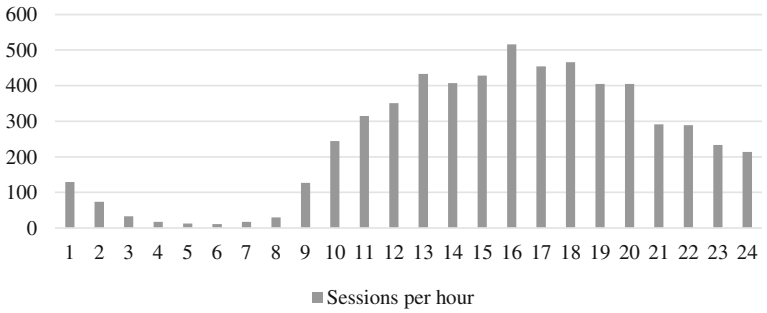

Fig. 2 Accumulated sessions per hour during the entire semester

average total time spent on the system (*Ø hours*) and average amount of sessions (*Ø sessions*) in the boxes relates to the entire week during which the WP had to be solved and the preparation time for the final test respectively. For WP1 for example, learners on average spent 5:20 h on the ERP system with 4.9 log-ins. This time is not necessary to solve one WP, but accumulates preparation and solution, for which a total of 2 weeks were available.

Figure 2 shows the distribution of log-ins by students accumulated for the entire semester. We can observe highest activity during the afternoon and early evening. The pattern of sessions throughout the day shows that the site was accessed continually throughout the day, even late at night.

The distribution of sessions over the course of a week is graphed in Fig. 3. This shows that the students accessed the system every day of the week including the weekend. Due date for WPs to submit was Wednesday at 23:59 which explains the high activity on Wednesday and the days before.

To find out if time spent on the system, amount of sessions and average SD have an impact on acquired skills and knowledge we conducted a regression

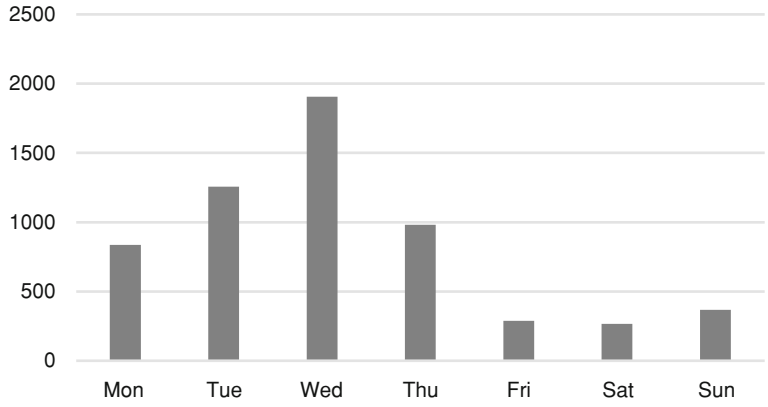

Fig. 3 Accumulated sessions per weekday during the entire semester

analysis, which didn't show a reasonable level of explanation. We assume that this results from the rather complex influences on information system learners. According to the literature the ability to learn the handling and use of an information system is strongly anchored to general attitude about computers (computer self-efficacy), which is influenced by the reluctance to use computers in general caused by the fear of making mistakes (computer anxiety), prior experience, engagement as well as demographics [10–12]. As we don't have any linked data for those influences a general conclusion is not possible at that point.

In the next step build categories of the average SD of learners in 30 min intervals (0–30 min → category 1; 31–60 min category 2; …; > 180 min → category 7) over the entire duration of the semester. Overall login times per learner were divided by the amount of logins. These were allocated to the corresponding category with which we compared means of different test scores. As demonstrated in Fig. 4, except for eAssessment scores we can conclude that an average SD of 30–90 min yields for highest ERP skills. An impact on factual and conceptual knowledge, measured in the eAssessment, cannot be observed.

In order to gain deeper insight we analysed the impact of SDs per learner in further detail. First we categorized every session by every user in the same 30 min intervals. Then we counted the amount of sessions in each category for every user. In order to know with which SD a user spent the most time on the system we set the amount of sessions per category in relation to the corresponding duration. The category a user spent the most time in was set in relation to the mean test scores (in the final test as well as in total). Results demonstrated in Fig. 5 show percentage of achievable points scored by users in each category. We can see that users who spent most of their time on the system in sessions between 121 and 150 min had the highest overall test scores (all WPs plus final test). SD of more than 3 h (category 7) appear to have a negative impact on skill and knowledge acquisition. Observing impacts on final test scores we can see that both very short SDs of 30 min and less as well as SD from 91–150 min yield for highest results.

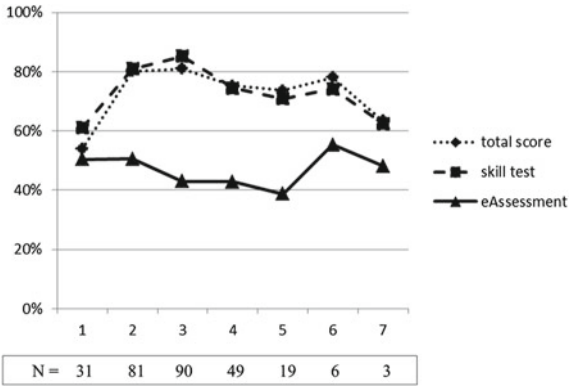

Fig. 4 Impact of ERP session duration on test scores

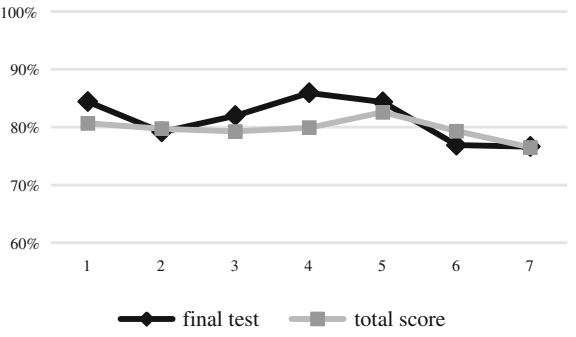

Fig. 5 Impact of session duration on test scores

In the next step we aim to find out if the behaviour of the best performing learners differs from the worst performing ones. First we compared the amount of session and overall time spent on the system in different periods for the highest achieving ten percent of participants of each WP with the lowest achieving ten. We aligned log-ins with the schedule of the course: training period, solution of the WP and day of attendance class. This cycle repeats four times and is followed by the preparation period for the final test and the final test itself. In the next step we aggregated all sessions by each student during each period and categorized the time per period according to following classification:

- Less than 30 min: category 1
- Between 30 and less than 90 min: category 2
- Between 90 and less than 150 min: category 3
- Between 150 and less than 210 min: category 4
- Between 210 and less than 270 min: category 5
- Between 270 and less than 330 min: category 6
- Between 330 and less than 390 min: category 7

Table 1 Comparison of best and worst performing learners

		Best	Worst	N
WP1	Logged in time	4	5	25 each
	Amount of sessions	4	3	25 each
WP2	Logged in time	3	6	25 each
	Amount of sessions	2	3	25 each
WP3	Logged in time	5	6	25 each
	Amount of sessions	3	2	25 each
WP4	Logged in time	3	3	25 each
	Amount of sessions	1	1	25 each
Final	Logged in time	4	3	49 each
	Amount of sessions	4	3	49 each
	Total time (in min)	1437	1506	49 each
	Total amount of sessions	19	16	49 each
	Average session duration (in min)	70	82	49 each

- Between 390 and less than 450 min: category 8
- Between 450 and less than 510 min: category 9
- 510 min and more: category 10

As students spend a lot time more preparing for the final skill test we doubled the time limits for the categorization of SDs for the period of preparation for the final test. Additionally we had to adjust the number of observations for the final test as 49 participants achieved the maximum amount of points. The amount of sessions stated represents the median of the actual amount of times participants logged onto the system.

Stated times and log-ins for WP1—WP4 are referring to the period between the publication of the WP and the due date for handing it in (solution of the WP). The prior period in which participants could have trained the covered content without knowing the actual WP were excluded as only a very small part of learners logged on during those periods.

Table 1 shows the median of logged in times according to categories and the median of amount of session for the best and worst performing participants of each WP. In relation to the final test we analysed the mean total time spent on the system during the whole term as well as the median of total amount of sessions.

We can see that the students with the highest test scores in general had a higher amount of log-ins for most periods as well as during the total period of the course. Worst performing ones in general spent more time on the system. Observed higher amounts of log-ins while having similar or slightly lower durations result in the conclusion that the average SD for best performing participants was lower compared to worst performing ones. This is also supported by the evidence of the original, non-categorized data.

4 Conclusion

Student samples are common for training related research. Although our sample is younger than average people undergoing ERP end-user training, it provides a reasonable representation of ERP learners in companies. If we look at the information gained from analysing student interactions with the ERP system, some learning behaviour could be determined by observing their use of the system, providing information that is difficult to obtain by other methods. The log-ins and corresponding SDs gave insights into student work patterns on a daily and weekly basis, and over the course of the semester. This information can be useful for trainers planning the schedule of the training and to estimate the necessary system and server capacity.

Our analysis of ERP learners in a university framework showed that due to the high complexity of the information system learning concept it is not easily possible to derive ideal SDs and amount of sessions for highest skill and knowledge acquisition. Nevertheless we could show that too long SDs have a negative impact on acquired skills and knowledge. Furthermore we can conclude that learners with the highest learning success on average spent a lower amount of time on the ERP system but with higher amount of session and shorter average SDs. This result might be influenced by the computer self-efficacy of learners, which will be investigated in the near future.

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Part VII
Mobility for Business Applications

Positive Impacts of Private Smartphone Experience on Satisfaction with Business Applications: A Counter-Evidence

Corinna Fohrholz, Christian Lambeck and Norbert Gronau

Abstract The high dissemination of smartphones in our everyday life has also influenced the use of business applications such as Enterprise Resource Planning (ERP) systems. In particular, the intuitive interaction of mobile devices and their innovative visualization concepts allow for a high joy-of-use. Whereas mobile business applications are already present today, the impact of private Smartphone usage on the user assessment of business applications, such as ERP, is rarely discussed. This paper addresses this research question by investigating the impact of private Smartphone usage on ERP user satisfaction. The authors hypothesize that users with lot of experience in mobile usage are also evaluating their ERP system more critical, as they also expect to have these intuitive interaction concepts in their business environment. The findings presented in this paper are based on a survey with 184 participants from small and medium-sized enterprises in Germany.

Keywords ERP · Mobile device · Usability · User satisfaction

1 Introduction

Enterprise Resource Planning (ERP) systems consist of numerous modules with rich functionality and are therefore complex applications that prevail to be hard to use [1, 2]. This complexity often hampers the system usage in terms of efficiency

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and user satisfaction, which are both essential usability aspects as declared in ISO 9241, part 11 [3]. Several user studies in the literature examined critical deficiencies in the use of ERP systems [4, 5]. The shortcomings comprised the identification of functionality, the support in error situations and the overall system complexity, to state only a few. These usability problems have an impact on a user's perceived usefulness of the ERP system, leading to a decreased user satisfaction [6].

In general, research in the field of ERP has primarily focused on technologies and algorithms to keep up with a steadily increasing complexity of business processes and volatile market needs. However, this research did rarely involve the explicit human–computer interaction, which is obviously less considered. The role of the graphical user interface (GUI) is currently underestimated, although it represents the user's elementary entry point to a variety of business functionality and information. The authors assume that improvements in the GUI of ERP systems also enhance the perceived interface complexity and therefore ease the system usage.

In recent years, the increasing number of mobile devices, such as smartphones or tablet PCs, also promoted the availability of mobile applications in the enterprise domain. This phenomena is also known as "bring your own device". This success today is not least based on easy-to-use and intuitive interfaces [7]. Seeking for the availability of mobile devices also in the enterprise domain, concepts and devices from the private sector are increasingly converging with business applications [7]. Due to restrictions in terms of size and interaction, the accessible scope of mobile enterprise functionality is often reserved to essential features [8]. In contrast to the high amount and detail of information in previous desktop ERP UIs, mobile solutions rely on a reduced set of functionality. This reduction in the content, extended by playful interaction concepts (e.g. multi-touch), might additionally encourage the high dissemination of mobile ERP applications. In 2005, Terrenghi stated that the usability of touch-enabled smartphone applications is better than those from stationary applications with established mouse and keyboard interaction [9].

Hence, the authors hypothesize that users with experience in private smartphone usage evaluate the usability of their ERP system more critical. While being used to positive effects in private life, such as a higher joy-of-use by interacting with visually rich interfaces, users encounter quite complex enterprise interfaces in contrast. This contradiction between the possibilities from private life devices on the one hand, and the current state of desktop ERP interfaces on the other, could become apparent by examining user groups with and without private smartphone experience. The authors assume that users with private smartphone experience are also requesting these intuitive concepts in their ERP system. This paper addresses these hypotheses and answers the following two research questions:

- Do users with smartphone experience assess their ERP system in a different way than users without such an experience?

- Do users with smartphone experience assess potential interface enhancements in a different way than users without such an experience?

To answer these research questions, the authors conducted a survey on the basis of a standardized questionnaire comprising 184 participants in Germany.

2 Related Work

2.1 User Satisfaction

User satisfaction is an essential part of many usability definitions. DIN EN ISO 9241 part 11 declares usability as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use [3].

A user's intention towards using a technology is basically determined by two factors: perceived ease of use and the perceived usefulness [10]. The Technology Acceptance Model (TAM) is often used to examine this user acceptance based on a research model approach. It declares that users, who consider a technology to be useful and easy-to-use, are also more likely to accept and use it. The TAM is often found in the research literature on user satisfaction in the field of IT systems [6, 11]. Furthermore, DeLone and others claim that user satisfaction is a significant indicator/instrument to measure IT success [12].

The assessment of perceived ease of use and the perceived usefulness is different between user groups. Several studies indicates these connection through TAM model [6, 11, 13]. The findings revealed that perceived usefulness and learnability have a significant impact on ERP user satisfaction [13, 14]. In addition, user satisfaction is also affected by a user's age, gender/sex and experience [15].

2.2 Problems in ERP Usage

The related work presented above is primarily focused on factors influencing user satisfaction. However, it is not focusing on usability problems of the ERP systems themselves. Parks stated that most of this research, whether focused on system, organizational or human aspects, measured "attitudes rather than use of the ERP" [16]. As a consequence, concrete user tests in addition to the well-established and model-based approaches are suggested. Her results, achieved in an exemplary inventory using a case with 38 participants, indicated "complexity was a significant variable only for time spent working on the task, not success" [16]. Several years ago, Topi et al. interviewed ERP users to identify critical deficiencies in their system usage [17]. Major difficulties existed in the identification of and the access to the right functionality, support in transaction execution, system output

limitations, terminology, and finally the overall system complexity. With the aim of identifying heuristics for assessing ERP usability, Singh and Wesson summarized and classified many of the common usability criteria found in research literature. Five major heuristics resulted, comprising navigation, learnability, task support, presentation, and customization [18]. The potentials of qualitative studies in usability research on ERP are part of the work of Scholtz et al. The work is based on the five ERP heuristics as introduced by Singh and Wesson [19]. A complementary, three-part approach was used, comprising a case study, an interview, and a diary. These techniques were applied to validate the results from Singh and Wesson in a quantitative manner and to obtain more information about the user's behavior.

2.3 *Benefits and Barriers of Mobile ERP Applications*

On the one hand, mobile ERP applications allow for efficient business processes and enable an enterprise to enter new markets [20]. Furthermore, several positive effects have been observed, such as decreased transaction costs and error rates as well as higher user satisfaction [21]. Following the classification schema from Nah et al. benefits of mobile ERP usage can be distinguished into the categories: effectiveness, efficiency, user satisfaction, security, (financial) costs and employee acceptance [22]. Examples for effectiveness and efficiency are the prevention of redundant tasks, shorter coordination times and additional communication channels (e.g. between field staff and the headquarters) [23]. Next to customer satisfaction in terms of flexibility and usability [24], mobile ERP applications are also able to increase internal employee satisfaction [8].

On the other hand, several shortcomings exist, which might affect a user's satisfaction in a negative manner. Zhang and Adipat specified six crucial factors that should be taken into account when using mobile ERP applications [5]:

- Mobile context
- Connectivity
- Small screen size
- Different display resolutions
- Limited processing capability and power
- Data entry methods

While using a mobile device when moving outdoors, environmental incidents might impair the user experience resulting in a higher cognitive workload [25]. The quality of the data link/data connection is an aspect, which influences the application's performance and finally, also the usability. The probably highest restriction is caused by the limited screen size. The quantities of functional items, that can be displayed simultaneously, as well as the possibilities to enter data, are also restricted [26]. In addition, mobile data input techniques differ from the established techniques in desktop applications. In particular, the distinction

between upper and lower case, or the keying of masses of text, remain elementary challenges in mobile applications [27]. Finally, mobile devices have limited capabilities in treating multiple applications simultaneously (e.g. using several applications in parallel) leading to the necessity to switch between them [28, 29].

2.4 Hypothesis

The preceding sections presented current problems in the usage of ERP systems, whereas shortcomings primarily exist in terms of navigation and identification [17, 30]. Furthermore, the visual information presentation and the menu structure do not often meet the user's definition of a user-friendly ERP system [31]. Bishu et al. pointed out that "From a user viewpoint […] the system itself is a maze of screens navigable through a series of hierarchical menus" [32]. In contrast, mobile interface concepts mediate new paradigms to interact with menus and to navigate through business information intuitively. These paradigms also address the limited screen dimensions by being as simple as possible [29]. To ensure a fluent system usage, filter mechanism ease the comprehension of presented information. User studies identified that mobile interaction concepts are considered to be easy-to-use [33, 34].

In spite of the decencies in mobile ERP usage, several benefits emerge that go beyond the enterprise and which also affect the user himself. In case studies from Burke et al. an increasing productivity and efficiency of employees has been observed, when using mobile enterprise applications [28]. Additionally, users tended to accept mobile business applications, if they are already familiar with mobile devices from private life. In their complementary investigation, Gebauer [23] and Wiredu [35] emphasize that this implication also exists vice versa from the working environment to private life. However, recent trends in the information technology/society (e.g. mobile products from Apple) encouraged the mobile dissemination in the private sector prior to business contexts [7]. Due to the high usage experience, users begin to demand these innovative concepts also in their business domain [36]. This implicit comparison between private and enterprise domain increases the requirements for mobile business applications concerning visually-rich and easy-to-use interfaces.

Based on these findings, the authors hypothesize that users with mobile computing experience (i.e. smartphones) evaluate their ERP system usability more critical than users without mobile experience. This hypothesis is based on the conclusion that mobile applications offer an improved usability (see Sect. 2.3), which will be used as an implicit reference for ERP system assessment. Therefore, the first hypothesis H1 is posed as follows:

H1: Users with smartphone experience in private and working life assess the usability of their ERP system worse than users without mobile experience.

Intuitive navigation and interaction concepts for the presentation and selection of business information are concepts that users of mobile ERP applications are

already familiar with. Such concepts are already applied to mobile business applications.

Therefore, the authors hypothesize that mobile users will also prefer these concepts to mitigate existing ERP usability problems. In contrast, non-mobile users might not be able to estimate the benefits of these paradigms for their business work. This assumption leads to the subsequent hypotheses H2 and H3:

H2: Mobile smartphone users assess the possibility to adjust the amount and the level of detail of the presented business information better than users without mobile smartphone experience.

H3: Mobile smartphone users assess the possibility to have up-to-date menus better than users without mobile smartphone experience.

For the investigation of these three hypotheses, the authors conducted a standardized survey with ERP users in Germany. The following sections present the survey methodology and the findings in more detail.

3 Methodology

Aiming for a broad survey sample and a variety of research questions, this survey investigated concrete causes of the usability problems and is explicitly focused on UI aspects. The survey was conceived as an online questionnaire, comprising small and medium- sized enterprises across Germany in a period of 10 weeks (from March to May 2013). The initial data acquisition for the identification and contacting of potential participants was based on an official enterprise information database service. The companies have been selected on the basis of the company size (micro, small, and medium-sized enterprises), branch (manufacturing; wholesale and retail trade; transportation and storage; information and communication; financial and insurance activities; professional, scientific and technical activities; administrative and support service activities; other service activities), country, and availability of a contact option. Due to the resulting high number of 523,095 enterprises, a random sample of 5,000 companies was selected for each group of company size. Based on this subset, we conducted 2,500 phone calls during the period requesting participation and asking for a valid mail address, leading to 1,080 invitations via the online service. This procedure was complemented by invitations via newsletters and newsgroups of the target audience. A reminder was sent 1 week after the initial invitation. Finally, 277 responses could be used for the subsequent analysis. The structure of the questionnaire comprised four sections to gather information about the company, the ERP system, the usability, and finally the participant. The user's path through the online survey got adapted according to the position in the company, the availability of an ERP system, and the use of supplementary software. User paths ranged from 14 questions (no ERP system and no additional software present, employee user) to 24 questions (ERP system and additional software present, CEO/CIO user) with an

average execution time of 11 min. This broad scope of research questions implies several methodological shortcomings, by nature. For instance, the length of the questionnaire constitutes a limiting factor as users should not have to spend more than 15 min on answering the questions to minimize the abortion rate. As a consequence, the authors decided to rely on only one item per construct. This certainly poses a risk for the reliability of the results, but allows for the investigation of several aspects simultaneously. Most of the assessment questions are using a fivepoint Likert scale. For the evaluation of statements which require a clear positioning of the user in means of agreement or denial, a six-point Likert scale was used. All questions also contained a "I don't know" option to avoid incorrect answers (i.e. misuse of the mid-value in five-point scales).

4 Results

4.1 User Satisfaction with ERP

From the total set of 277 companies providing answers, 66.43 % are using an ERP system (184), which is the basis for subsequent analysis. 70.86 % of them are medium-sized enterprises (50–250 employees), 24.57 % are small enterprises (10–49 employees) and only 4.57 % are micro-sized enterprises (less than 10 employees). The most frequently stated branches are production (52.30 %), wholesale and retail trade (16.67 %) and information and communication services (10.92 %). The average age of the ERP systems is 8.6 years and varies between one and 23 years. A broad range of ERP vendors can be found, whereas SAP is the most prevalent system with 28.26 %. ERP systems are used by participants holding different positions in their companies ranging from employees (38.51 %) to department managers (42.53 %) and CEOs or CIOs (18.97 %).

The participants were asked to evaluate the five statements shown in Table 1 on a six-point, decentralized Likert scale ranging from "1—I totally agree" to "6—I totally disagree". The results indicate that users are facing only medium to minor problems in all of the criteria considered (see Table 3). In contrast to our prediction derived from the related work, overall system complexity (see Table 3, no. 2) seems not to be a major concern as it is rated with 4.01 on average. However, system complexity is significantly related to the perceived abundance of information and its level of detail (Table 3, no. 3) ($r = 0.632$, $p < 0.001$). Moreover, the availability of numerous and useful visualizations (Table 3, no. 4) improves the user rating of system complexity ($r = -0.312$, $p < 0.001$). The presence of multiple application windows, which are simultaneously opened (item no. 5), is not a serious barrier for most users, as it is rated with 4.42 on average. However, it positively correlates with the users' assessment of ERP system complexity ($r = 0.300$, $p < 0.001$). The availability of useful and numerous visualizations

Table 1 User assessment of ERP usability criteria (n = 123)

Statement	Polarity	Mean value	Standard deviation
1. My ERP system offers a wide range of support functionality to deal with problems (e.g., explain causes, offer solutions and assistance)	+	3.36	1.36
2. My ERP system is very complex, which often makes me feel lost	–	3.97	1.39
3. The amount of information and given details is way too high for my needs	–	4.18	1.31
4. My ERP system offers numerous and useful visualizations, which I can choose myself (e.g., tables, diagrams, dashboards, organigrams…)	+	3.70	1.48
5. When having opened many application windows simultaneously, I feel hindered or overstrained	–	4.40	1.29

(Table 3, no. 4) is rated with 3.86 and requires further improvements—especially as this item has an impact on system complexity. The following section is dedicated to the use of mobile devices in private and business context.

4.2 Use of Mobile Devices

The inquired participants stated to use 1.5 mobile devices on average to access their enterprise information. Laptops are still the most commonly used type of device (80.0 %), followed by smartphones (27.4 %) and tablet PCs (25.3 %). The utilization of mobile applications has been observed in several enterprise divisions. In particular, users from sales and distribution departments often stated to employ such devices, probably due to its ubiquitous and versatile use. Project management, logistics and production scenarios are also present. In contrast, the use of mobile applications in highly centralized divisions, such as administration, seems to be less popular.

The private use of mobile devices, but also desktop PCs, could be found quite often. The leading activity is information retrieval and browsing (94.9 %), followed by multimedia applications (music, video, images) with 82.6 % and social media and chat with 52.2 %. PC and online games are only used by 25.4 % of the participants (Table 2).

The survey indicated that users possess more mobile device types in their private domain than in their business context. The participants stated to have 2.4 device types in/on average, whereas the highest differentiation appeared in the use of smartphones. 30 % of the users stated to use them in an enterprise context compared to 81 % using a smartphone in their private life. The analysis identified

Table 2 Dissemination of mobile devices in business and private context

	Business context (%)	Private context (%)
Laptop	80.3	84.5
Smartphone	27.5	81.0
Tablet	25.4	49.3
Netbook	10.6	15.5
PDA/Handheld	9.9	9.2
Others	3.6	0.0
None	16.2	4.2

Table 3 User assessment of ERP usability criteria depending on smartphone usage (Likert scale ranging from "1—I totally agree" to "6—I totally disagree")

	No smartphone			Smartphone		
	N	M	SD	N	M	SD
Statement 1: My ERP system offers a wide range of support functionality to deal with problems	72	3.35	1.41	57	3.37	1.33
Statement 2: My ERP system is very complex, which often makes me feel lost	72	4.01	1.40	57	4.00	1.32
Statement 3: The amount of information and given details is way too high for my needs	72	4.26	1.28	57	4.11	1.38
Statement 4: My ERP system offers numerous and useful visualizations, which I can choose myself	72	3.57	1.60	57	3.91	1.34
Statement 5: When having opened many application windows simultaneously, I feel hindered or overstrained	72	4.35	1.24	57	4.44	1.40

a significant correlation between private and business use. Participants employing a mobile device in their business context are also using it in their sparse time ($r = 0.335$, $p < 0.001$, $n = 142$).

4.3 Impact of Private Mobile Use on Satisfaction

In Sect. 4.1, the participants evaluated their ERP system with the help of five statements to investigate their particular satisfaction (see Table 1). The results illustrated a moderate assessment of the system's usability in all of the criteria. In Sect. 3 the hypothesis *H1* has been stated, claiming that the use of smartphones has an impact on this assessment of the ERP system.

Table 4 Strategies and concepts for usability improvement (Likert scale ranging from "1—I totally agree" to "6—I totally disagree")

	No smartphone			Smartphone		
	N	M	SD	N	M	SD
Adaptable level of detail	47	2.51	0.882	47	2.49	1.23
Adaptable amount of information	47	2.40	0.925	47	2.574	1.17
Availability of up-to-date visualizations and views	47	2.83	1.20	47	2.447	1.43
Visual, haptic or auditory feedback	47	2.87	1.03	47	2.574	1.10
Workflow guidance and assistance	47	2.38	1.13	47	2.128	1.11
Up-to-date menus	47	2.34	0.962	47	2.404	1.06
Multi-touch devices	47	3.51	1.35	47	3.638	1.39
Improved search functions	47	2.40	1.06	47	2.489	1.30

A first comparison of the mean values of ERP system assessment from private smartphone users and those from non-smartphone users revealed no observable difference. Both user groups evaluated their ERP system likewise. Only the rating of statement no. 4 (see Table 3) is slightly higher for smartphone users than for non-users, indicating that they are less satisfied with the given visualizations in their ERP system. The authors conducted an ANOVA analysis to investigate the significance of this observation, revealing no significant correlation ($F(1.127) = 0.242$, $p = 0.624$). In addition, none of the individual analyses of the user ratings identified a significant correlation between both user groups (all $p > 0.19$). Thus, the hypothesis *H1: Users with smartphone experience in private and working life assess the usability of their ERP system worse than users without mobile experience* has to be rejected. It can be concluded that a user's experience in mobile interaction does not affect the user's ERP system assessment in the considered usability criteria.

Mobile navigation and interaction concepts are often straightforward and follow intuitive principles. Menus have simplified and clear structures and are therefore fluently to use. Hence, the authors hypothesize that users with Smartphone experience would also appreciate these concepts in their ERP system. This might lead to a better user assessment of these approaches to overcome current usability problems. In one part of the survey, the participants got presented eight statements dealing with potential approaches to mitigate current usability problems. They were asked to assess these statements on a six-valued scale ranging from 1—very good to 6—very bad.

Table 4 presents these approaches and the mean values of the ratings of the user group without Smartphone experience ("no Smartphone") and the user group with Smartphone experience ("Smartphone"). The results indicate that the concept of "multi-touch devices" was rated even worse in the user group with Smartphone experience in average. In general, the results could not identify a clear difference between the ratings of both user groups ($F(1.92) = 0.147$, $p = 0.702$). An additional ANOVA analysis could also not reveal a significant difference between the individual ratings of these strategies between users and non-users of Smartphones (all $p > 0.16$). Therefore, the hypotheses H2 and H3 have to be rejected, too.

5 Conclusion

This paper investigated the research question, if private use of mobile devices (in particular Smartphones) has an impact on the assessment of ERP systems used in working life. The authors analyzed this correlation, conducting a user survey comprising 184 participants from Germany with an ERP system in use. Although more than 80 % of the participants stated to use Smartphones in their private life, the analysis could not identify a correlation between this private utilization and the user satisfaction with the ERP system. This finding is contradictory to those from the related work, which stated that users would implicitly transfer the private, mobile experience to their business domain [7, 36]. The findings of this survey allow for the assumption that the current trend of consumeration has not been adapted to enterprise applications so far. In particular, the worse rating of multi-touch devices as an approach to ease the ERP system usage highlights this assumption.

However, this effect might also appear due to the unawareness of the term itself (high abstention), that users are unable to imagine concrete potentials of this technology in their domain (high abstention and low rating) or that they know the technology, but are sure to have no benefits out of it (low rating).

For a further explanation of the findings in this study, the demographic user information has been additionally considered. More than half of the participants stated to be employed in their company since more than 10 years. About 70 % assessed their personal experience in the use of ERP systems as good or very good. Although this indicates a high qualification of the participants, the analysis could not reveal a significant correlation between the user's ERP assessment and their experience nor the years of employment in the company.

In our future considerations, also the impact of the user's position/role in the company will be investigated. The user groups in our study ranged from employees to department managers and CEOs, whereas more than 50 % of the participants can be assigned to the medium or higher level. This participant structure and its impact on the ERP and mobile assessment have to be investigated in more detail for a better interpretation of the results. Finally, also the age of the ERP systems should be taken into account. The authors assume, that the longer users work with an ERP system, the more they are already familiar with its deficiencies resulting in a moderate system assessment.

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Towards an End-User Development Tool for Mobile ERP Applications

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Abstract Aim of this paper is to identify requirements on a software tool supporting end-user development of mobile ERP applications and to design an appropriate software architecture meeting the identified requirements. The paper introduces a prominent development tool for mobile ERP applications, demonstrating its weaknesses regarding the purpose of end-user development (EUD). A multi-method requirements analysis is used to identify requirements of a suitable EUD tool for mobile ERP applications. The results of the requirements analysis reveal that an EUD tool is suitable for implementing standard functions such as data display and entry functionalities. These functions could be implemented by using a set of configurable application components. These components could be used by end-users to compose individual applications. Additionally, the results indicate that a form-based interaction technique seems to be a suitable option for end-users to develop mobile ERP applications. Finally, a prototypic implementation of a web-based EUD-tool demonstrates the feasibility of the presented software architecture.

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1 Introduction

The increasing flexibility and mobility of working environments requires a more ubiquitous access to the company's information systems, beyond the traditional stationary workplace. This trend is further reinforced by the rapid improvements in the area of ubiquitous technology [1]. Mobile enterprise applications enable anywhere and anytime access to the company's information systems, resulting in accelerated and more flexible business processes [2]. One important type of information system are Enterprise Resource Planning (ERP) systems [3, 4]. However, the development of mobile ERP applications is challenging due to a number of reasons. On the one hand, different platforms must be supported, like iOS, Android or Windows Phone, which use different programming languages and programming libraries. On the other hand, mobile devices usually have different screen sizes, different screen resolutions, and different interaction styles (e.g. keypad or touch screen). This situation leads to a high software development effort [5].

The goal behind End-User Development (EUD) is to empower users of software applications with no professional software development skills (so-called end-users), to create, modify or extend software artifacts [6]. Typical end-users in the domain of ERP systems are experts in business areas like finance, human resources or warehouse logistics [7, 8]. Due to their lack of knowledge in software development and limited time and motivation to gain the necessary skills, they are not able to adapt ERP systems to their needs. Instead, they have to delegate their requirements to software development professionals, resulting in long and costly adaption processes [9]. This is also true for the development of mobile ERP applications, especially because of the various used technologies and required domain knowledge [10].

Another reason why EUD is still no common practice in the ERP area could be that an extension or adaption of business functionalities of ERP systems by end-users is risky. However, mobile ERP applications use existing business functionalities of ERP systems [10]. Thus, there is only little risk because the development aspect is focused on accessing existing functionalities and the implementation of the corresponding user interface. Therefore, EUD could find greater support for mobile applications as previous EUD research in the ERP area. Aim of this research endeavor is to identify requirements of an EUD-tool for mobile ERP applications. Furthermore, the identified requirements are used to propose a possible software architecture for an EUD-tool. In order to demonstrate the feasibility of the proposed architecture a prototype of the tool is implemented.

The paper is structured as follows: After an introduction to end-user development, guidelines for an EUD tool are derived from literature. Afterwards, a prominent development tool for mobile ERP applications is evaluated regarding these guidelines. Moreover, requirements for an EUD tool for mobile ERP applications are identified from semi-structured interviews with professional software developers and a computer-based test with ERP experts. Using the

resulting requirements, a software architecture of a EUD tool for mobile ERP applications is proposed in the next step. Finally, a prototypical implementation of the proposed tool is demonstrated. The paper ends with a short summary and potential next research steps.

2 End-User Development

As computers and software applications play an important role in our everyday lives, most people are familiar with their general usage. The users of software applications, so-called end-users, perceive existing software applications often as not flexible enough to support their tasks in a convenient fashion as well as difficult to learn [6]. This is particularly true for ERP-applications, where end-users experience difficulties to retrieve their desired data or have to execute several cumbersome steps within the ERP-user interface in order to get the needed information [8, 9]. In addition to that, they perceive the mapping of their tasks within the ERP-application not as their desired way of working [8].

The development of software applications generally requires a professional training in software development [6], in which software design methods and programming languages are learned. However, end-users usually have their expertise in other domains. They use software applications to cope with their daily working tasks and expect a better or faster task execution by using software applications [11]. Examples within the area of ERP are employees working in the human resources or the finance department. They use specific ERP applications, e.g. for data management or data analysis. Due to their lack of knowledge in software development, they are usually not able to implement own software applications or adapt existing ones to their needs. Additionally, they often do not have the time to deal with software development topics [6]. In addition, the number of available, professional software developers is limited and the coordination effort between software developers and domain experts in traditional software development projects is high and costly [6].

One possible solution for the described problem is to qualify domain-experts to develop their desired applications themselves. For research endeavors that deal with related topics, the research field End-User Development (EUD) has been established [12]. One important research topic in EUD is the design and development of easy-to-use software development tools [11]. Easy-to-use in this context means that no programming skills are required to use the developments tools. Thus, the main challenge is to find ways to compensate the lack of programming skills through a suitable tool [11]. Successful examples of EUD-tools in practice are spreadsheets, the creation and configuration of email-filters as well as statistics- or computer aided design (CAD) tools [6, 13].

2.1 EUD Discussion and Guidelines

EUD has the potential to improve the implementation of end-user requirements [6]. This results from avoiding the difficult communication process and potential misinterpretations between end-users and professional software developers in traditional software development cycles [14]. As a result, an improved implementation of end-user requirements could lead to more efficient and effective business processes [8]. In addition to that, the potential of end-users is better utilized and the bottleneck of available professional software developers is avoided [6].

The challenge in EUD is to identify and implement the mental model of the end-users as good as possible [15, 16]. This is necessary because end-users usually do not think in terms of programming constructs. Furthermore, a suitable level of complexity of the development tool has to be identified that corresponds to the skills and knowledge of the end-user on the one hand, and the intended results on the other hand [12]. Moreover, the architecture and the building blocks used in the development tool must be flexible and modular enough to fulfill the end-user requirements [17].

In order to cope with these challenges a set of guidelines has been identified in EUD research:

- **Domain-focus**: EUD tools should be focused on a specific domain. This is necessary because there cannot be one universal EUD tool for all possible application contexts [18]. However, general purpose programming languages are not suitable for end-users [12]. As a consequence, a domain-focus is recommended. It allows to build higher-level building blocks that meet the corresponding professional terminology and mental model of the end-users [6, 12].
- **Avoid traditional programming constructs**: EUD tools should avoid traditional programming constructs like variables, conditions or loops, because end-users are usually not familiar with these constructs [11].
- **Gentle developing slope**: EUD tools should offer a range of different development levels with increasing complexity and power of expression [18]. This means that developing simple artifacts should be simple, while developing more complicated artifacts can involve a proportional increase in complexity [6]. This property is referred to as ‘gentle slope’ of development [19].
- **Avoid syntactic errors**: Syntactic errors in the development activities quickly lead to anxiety and uncertainty. Thus, a good EUD tool should avoid the possibility of syntactic errors whenever possible [18].
- **Extension possibilities**: EUD tools should offer the possibility to add new building blocks to extend the functionality of the tool [20].

2.2 EUD Interaction Techniques

An important aspect of an EUD tool is its user interface. While traditional programming languages focus on writing textual statements within a source code editor, different interaction techniques are used in EUD tools, like visual programming, programming by example or form-based development [13].

Visual programming generally refers to the use of visual programming languages for implementing a software application [21]. The program logic is defined by graphical elements in a two- or multi-dimensional fashion. The graphic elements represent interactively configurable software components [22]. The use of visual elements should improve the comprehensibility of the programming logic and simplify the programming process [22]. Many visual programming languages are based on the dataflow concept, which defines the execution order of the used elements. An often cited example of a visual programming language is "G" of the visual programming environment LabView[1] that is specialized on the implementation of software applications for measuring instruments [23]. In order to define a new visual programming language, the available visual elements and their associated reusable software components have to be defined and implemented. In addition, rules for composing these software components must be defined and enforced by the visual programming environment. Furthermore, a visual editor for the program design as well as a corresponding transformation tool to generate the final program is necessary. Depending on the number of available components and corresponding composition possibilities, the flexibility of a visual programming language can be quite high. However, the end-user has to learn a new language and get used to a new programming environment [13, 22].

Another interaction technique for EUD is Programming by Example (PbE). It represents an approach where a computer system should identify the program logic based on specific data sets [21, 24]. The end-user is executing a sequence of steps within a software application to fulfill a working task. The step sequence is recorded and program code is generated out of these recordings. Examples are the so-called macros in office applications. Depending on the complexity of the PbE approach, the variety of possibilities ranges from simple play backs of the recording to attempts that try to derive more generic program logic from the demonstrated steps [21]. The advantage of PbE is that end-users do not have to learn a new programming language and get used to a new programming environment. The disadvantage is that the use of PbE is limited to recurring activities in already existing software applications [13, 22].

Form-based programming represents an interaction technique where end-users create programs by choosing options and assigning values to predefined parameters [25]. Examples are so-called wizards in existing software applications that guide the end-user during the fulfillment of a specific task. The advantage is that

[1] http:// www.ni.com/labview, Accessed at 27th August, 2013.

syntactic errors can be reduced due to providing predefined options. However, the flexibility of form-based programming is limited to the provided set of options and possible attribute values [13].

3 Existing Development Tools for Mobile ERP Applications

According to the used technology three types of mobile ERP applications can be distinguished: native-, web- and hybrid applications [10]. Native applications are developed with the supported programming language and programming libraries of the corresponding operating system. These applications are able to access a wide range of features, but are limited to a single operating system. On the contrary, web applications run within web browsers and are thus able to run on different operating system. However, their possibilities to utilize device features are limited. They are implemented with usual web technologies like HTML, CSS and JavaScript. Hybrid applications run within a native application, which acts as a runtime environment. Hybrid applications are usually implemented with web technologies and access device features through a provided programming interface of the runtime environment application. Therefore, hybrid applications are an attempt to combine the advantages of native- and web application. However, the runtime environment application has to be implemented for each supported operating system.

Depending on the application type, different development environments are used. Native applications are usually implemented with specialized development environments for the corresponding operating system. Examples are XCode from Apple or the Android Developer Kit. In order to implement web applications, available web editors can be used. For the implementation of hybrid applications, so-called mobile enterprise application platforms (MEAPs) [26] are often used. MEAPs offer a middleware server to control the access of mobile applications to the backend systems of companies as well as a corresponding development environment. In addition to hybrid applications, the middleware servers usually also offer support for native applications. Examples of MEAPs are IBM Worklight or SAP Mobile Platform. In the following, one prominent development environment for developing mobile ERP applications, the SAP Mobile Workspace, is introduced and examined against the listed EUD tool guidelines in Sect. 2.1.

The SAP Mobile WorkSpace is the development environment of the mentioned MEAP SAP Mobile Platform. It is based on the popular development platform Eclipse. The development process using the SAP Mobile WorkSpace is divided into two phases: (1) developing the mobile data model and (2) designing the user interface of the mobile application. Developing the mobile data model is done by developing the so-called mobile business objects (MBOs). MBOs represent data connections to various backend systems, like databases, webservices or SAP

business application programming interfaces (BAPIs). In the second phase, either a native user interface is developed within the respective native development environment, or a hybrid application user interface with the SAP Mobile WorkSpace flow- and screen design tool. The flow- and screen design tool use a visual programming language to specify the flow logic of the hybrid application as well as the design of each screen. In the following, the SAP Mobile WorkSpace is investigated regarding the EUD tool guidelines listed in Sect. 2.1:

- **Domain-focus**: The Unwired WorkSpace is designed for cross-domain usage. Mobile applications from different domains that receive data from different backend data sources can be developed. Because of its generic orientation, universal terminology like *mobile business objects* or *flow logic* is used. However, in order to view data from backend systems or utilize user input, so-called *keys* must be used. Keys have a data type and are therefore similar to variables in traditional programming languages. By using keys, the occurrence of errors is possible, which could lead to incorrect results or program errors.
- **Gentle developing slope**: The creation of a simple data access functionality and a corresponding user interface is relatively simple and easy to learn. In addition to that, the SAP Mobile Workspace offers a range of further possibilities to implement more complex requirements. For example, the generated source code of the hybrid application user interface can be viewed and also adjusted. Moreover, it is possible to insert own JavaScript code at selected locations to react on certain events.
- **Avoid syntactic errors**: The creation of data queries to backend systems or the creation of rudimentary user interfaces is supported by a set of wizards. In addition, there are often opportunities to validate the entered statements before storing and executing. However, the occurrence of some specific kinds of errors is also possible, which are difficult to identify and fix. Examples are the incorrect assignment of keys to user interface control elements, or a misconfiguration of MBO operation calls.
- **Extension possibilities**: The SAP Mobile WorkSpace is based on the open development environment Eclipse.[2] Thus, it is possible to extend the functionality by using available Eclipse plug-ins. However, it is not possible to extend the Mobile Workspace plug-ins, e.g. to add new, reusable user interface controls.

The analysis of the SAP Mobile WorkSpace has shown that it has a rather generic orientation and supports the development of mobile applications from different domains. Thus, no ERP specific terminology is used. Therefore, end-users have to learn concepts like MBOs or cash- and sync-groups before using the tool. Regarding the used interaction techniques the emphasis is set on visual programming. In specific situations, this is supported by form-based programming. Overall, the entry obstacle using the tool is considered to be pretty high because

[2] http://www.eclipse.org, Accessed at August 29th, 2013.

end-users have to get used to the development environment and the used concepts. Due to the relatively high design latitudes, syntactic errors are possible and considered to be difficult to fix by end-users.

4 Related Work

Due to the different aspects of this research topic, the related work is grouped into different section. First, existing research on mobile ERP applications is analyzed. This is followed by EUD tools for desktop ERP applications. Finally, available EUD tools for mobile applications are investigated.

4.1 Research on Mobile ERP Applications

In general, little research can be found that deals with mobile ERP applications. Kurbel et al. [27] suggest a multi-tier architecture for mobile ERP applications. They describe that ERP data is generally stored in databases and the business logic is implemented on a corresponding application server. They mention that some ERP systems provide functionalities through specific programming interfaces, because the ERP data models are usually pretty complex and direct access to the database is sometimes prohibited. Their architectural proposal consists of a so-called content access engine as well as a content-extraction engine. The content access engine queries data from the ERP system and converts the results into an XML document. This XML-document is transformed via a XSLT (extensible stylesheet language transformation) processor into a device-optimized markup, e.g. based on HTML.

The research of Kurbel et al. [28] deals with the adaption of ERP content for mobile devices the authors argue that the focus of mobile ERP applications is to display selected data sets from the ERP system on a mobile device. In the ERP environment described in their paper, the ERP content is provided by Webservices. In order to adapt the results of the Webservice calls, unnecessary content is removed (content adaption), the layout and style is adapted for the mobile device screen (adaption of style and layout) and the navigation structure is adjusted (structural adaption). An example of the latter is splitting the content into several pieces in a way that each peace fits on a mobile device screen.

Homann et al. [29] analyze existing mobile ERP applications. They identify a number of recurring functionalities and acknowledge their similar user interface implementation. Based on these findings, they propose a catalogue of user interface patterns for mobile ERP applications. Additionally, they postulate the potential of implementing and using reusable building blocks for the development of mobile ERP applications based on their presented user interface patterns.

4.2 EUD Research on Desktop ERP Applications

Spahn and Wulf [8] propose an prototypic EUD tool that enables ERP users without programming skills to create small, interactive applications, named enterprise widgets, for displaying ERP data. The authors conducted a series of semi-structured interviews with ERP users of three German midsized companies. The interviews revealed that the end-users usually create custom spreadsheets and rely on getting relevant business data from the ERP system, but face some challenges when creating the required queries for their individual information needs. Additionally, the end-users have to access the same data sets within the user interface of the ERP system over and over again and are not able to create custom applications that better meet their individual working tasks. The authors implemented a visual design tool that provides building blocks that offer access to specific data sets of an ERP system. Theses building blocks can be combined in order to create interactive applications. Additionally, the authors implemented a middleware application platform with a specific query language, enabling experienced end-users to create new buildings blocks with individual data sets of the ERP system.

4.3 EUD Research on Mobile Applications

Cappiello et al. [30] introduce a Web-based EUD tool named MobiMash that enables end-users to create contents of a native Android application through composing different data services and corresponding visual templates. The EUD tool itself runs within a web browser on a desktop computer. In order to create content for their mobile application, end-users have to select a data-service and map it to a visual template. Both elements can be chosen from a set of available data services and visual templates. The development activities are supported by a preview function of the resulting user interfaces. MobiMash is restricted to the development of a specific mobile application that represents a composition of available data services.

Danado and Paternó [31] propose a visual-based EUD environment for smartphone applications on touch-screens. Their approach differentiates from other research efforts in the area of EUD for mobile applications in the fact that their EUD tool itself is running on a smartphone and not on a desktop computer. Thus, the authors faced the limitations of smartphones, in particular the smaller screen size. To cope with these challenges, the authors used the jigsaw-metaphor. They offered reusable functionality as jigsaw-pieces, which can be combined to build mobile applications. The prototype was implemented with web technologies in order to create cross-platform application.

5 Identifying Requirements

This section explains the steps conducted to identify the requirements for the aimed EUD tool and the respective findings. For this purpose, current challenges regarding the development of mobile ERP applications were identified through semi-structured interview with professional software developers. The assumption behind this step is that the challenges faced by professional software developers should be handled by the EUD tool and hidden from the end-user. In addition to that, requirements are identified by a computer-based test with potential end-users and supplemented by a subsequent questionnaire.

5.1 Challenges Faced by Professional Mobile ERP Developers

In order to identify current challenges in the development of mobile ERP applications, semi-structured interviews were conducted with professional software developers. The research method of semi-structured interviews following Gläser and Laudel [32] was chosen, because of the exploratory nature of the research goal. Before conducting the interviews, an interview guide was created to structure the interviews. The interviews were recorded and transcribed afterwards. The results were analyzed using a qualitative content analysis [32].

A total of seven interviews were conducted. All interviewees have several years' experience in developing mobile applications in general, and also experience with developing mobile ERP applications in particular. Three interviewees are working for IT-consulting companies; two in the mobile application area of an ERP vendor; one for an insurance company and one for a car manufacturer. The interviews were structured into three sections guided by the following research questions:

(1) How is the development of mobile ERP applications currently done?
(2) What are the current challenges in developing mobile ERP applications?
(3) What are suitable use cases for EUD in the area of mobile ERP applications?

The analysis of the responses shows that currently there is a strong focus on the mobile application development for the two operating systems, Android and iOS. Other operating systems for mobile devices are of minor importance. Accordingly, the two development environments XCode for iOS applications and the Android Development Kit for Android applications are mainly used. However, the experts mentioned that the focus on mobile web applications is increasing. Current problems are the high dynamics in the mobile device market and the constantly changing operating system programming interfaces and development environments. Moreover, a lack of standards to access ERP data was claimed. Additionally, all experts mentioned that they have difficulties to find the correct

programming interface and correct parameters to call ERP programming interfaces. They also stated that the development tools in the mobile area are constantly enhanced and adapted at the moment. This requires a continual process of acquainting oneself with new technologies, frameworks and programming techniques. Moreover, a lack of standardized data access protocols for ERP systems was claimed. For example SAP ERP systems use a proprietary protocol called RFC (remote function call), but offer also support for using SOAP and RESTful-Webservices. It was also found that the discovery and correct parameterization of the necessary ERP programming interfaces is challenging. For this purpose, the interviewed developers are often dependent on the specifications of the ERP experts. Moreover model-driven development environments are considered critical. It was claimed that these tools often produce program code that is not extensible. One interviewee mentioned that he sometimes uses these tools to produce a first prototype for discussions with customers. However, as soon as the requirements are identified, he uses a native development environment to implement the final application.

Regarding potential use cases for EUD in the area of mobile ERP applications there was a general agreement of the interviewed developers that two types of applications should be distinguished to answer this question. The first type are mobile ERP applications, which use sophisticated user interface controls or interaction techniques, like electronic signatures on tablet PCs to confirm ERP transaction. In the opinion of the interviewees this application type is not suitable for EUD, because EUD has to rely on standard elements. The second application type comprises mobile ERP applications, which use standard elements. Corresponding applications often focus on displaying or capturing ERP data sets. The interviewed developers stated that they have been often involved in development projects of the first application type. However, they generally see a huge potential for EUD for the second application type.

In summary, it can be concluded that a EUD tool for mobile ERP applications should focus on standardized building blocks that can be combined in order to develop a final application. Moreover, the EUD tool should hide the complexities of accessing the ERP programming interfaces from the end-user. In order to avoid problems with changing programming interfaces of mobile operating systems and to consider the growing importance of mobile Web applications, the EUD tool should focus on Web technologies.

5.2 Requirements of Potential End-Users

In order to identify the requirements of potential end-users, a computer-based test was conducted. Two low-fidelity mock-ups were developed for this purpose and demonstrated to the test participants before the experiment. For the first one, a form-based interaction technique was used and for the second a XML-based textual interaction technique. The test subjects were given the task to think about a

desired mobile ERP application before the experiment. During the experiment, their task was to develop this application with each presented mock-up. Following the thinking aloud method [33], the test subjects were instructed to speak about their thoughts during the experiment. They were also allowed to ask experiment leader questions. After the experiment, the test subjects were asked to fill out a paper-based questionnaire to evaluate the corresponding mock-ups and suggest potential improvements.

A total of nine potential end-users participated in the experiment. All participants had several years of experience in the area of ERP systems. No participant had experience in the area of mobile application development. The results revealed that the form-based interaction technique is generally understood quickly. However, some participants had difficulties to use the XML-based textual interaction technique. Although both mock-up tools had the same expression power, the XML-based mock-up tool was considered as more powerful. The good overview within the XML-based mock-up was mentioned as advantage. In both cases a preview functionality in order to get an impression of the current development effort was suggested. It has been shown that the satisfaction with the demonstrated mock-ups is strongly dependent on the chosen desired mobile application. Participants with the requirement of more complex functionalities, such as interactive data analysis through charts, were generally dissatisfied with the demonstrated mock-ups. However, participants with more simple requirements like data display and entry functionality, evaluated the demonstrated mock-ups generally as sufficient to fulfill their requirements.

In summary, the test results implied that an EUD tool for developing mobile ERP applications should focus on standardized data entry and display use cases. This is consistent with the recommendation of the software development professionals in the previous section. In addition, the form-based approach has proven to be suitable for the implementation of this application type. Potential improvements of a form-based EUD tool are an overview- and preview functionality.

6 Possible Software Architecture and Prototypic Implementation of the EUD Tool

In order to meet the identified requirements a software architecture based on an XML-based format to specify mobile ERP applications is proposed. The proposed architecture differentiates between data services and user interface templates. A data services template specifies the necessary parameters for calling the ERP programming interface. The UI templates are based on the proposed user interfaces patterns presented in [34]. They represent parts of the final user interface of the generated mobile ERP application.

An end-user specifies a desired mobile ERP application through a composition of predefined data services. A form-based interaction technique is used to specify

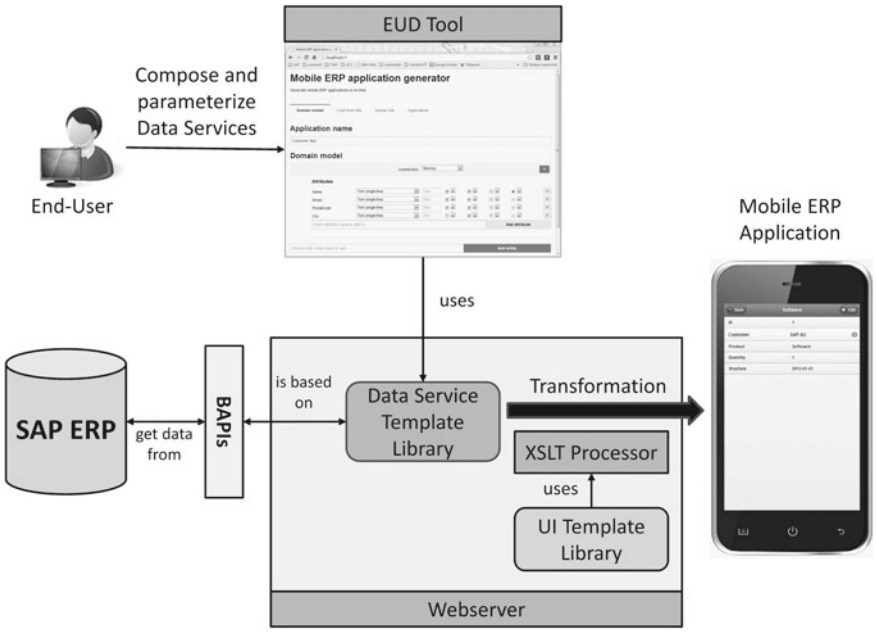

Fig. 1 High-level software architecture of the EUD-tool

the parameters of the underlying ERP programming interface. Additionally, each data service is linked to one or more user interface template. The linked user interface templates are used during the final generation of the mobile ERP application to specify its layout. Thus, the end-user does not have to deal with mapping data elements to user interface elements. The user interface templates are implemented as XSLT (Extensible Stylesheet Language Transformation). These stylesheets contain rules on how associated HTML5 user interfaces are built based on the specifications of the data service. Die final specification of the mobile ERP application is input for an XSLT-processor. The XSLT-processor generates the final HTML5 application based on the mobile ERP application specification and the associated user interface templates. Finally, the generated mobile ERP application is accessible through a unique Uniform Resource Locator (URL). Figure 1 outlines the described concept including the involved architectural components.

The current prototypic EUD tool implementation is based on an Apache Web server using the server-side programming language PHP. A SAP ERP system is used to provide the necessary ERP data. The data from the SAP ERP system is received through so-called business application programming interfaces (BAPIs), which represent the standard programming interfaces for SAP ERP systems. In the current prototypical implementation, only parts of the user interface patterns presented in [34] are available. Therefore, only a limited set of mobile ERP applications is supported at the moment. Examples of already available user interface patterns are the object view- and detail view pattern. In order to meet the

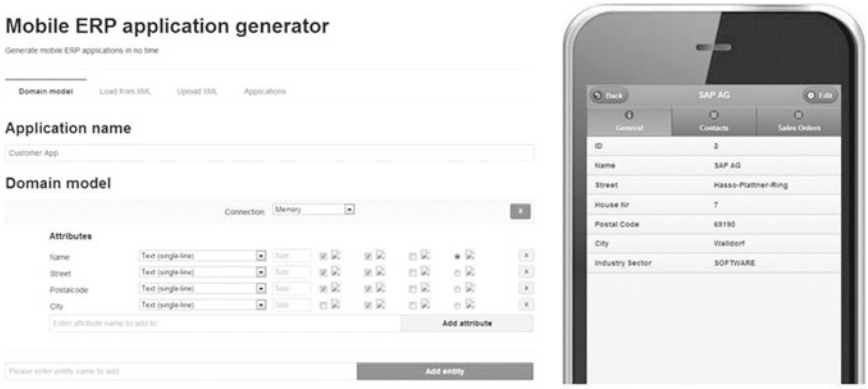

Fig. 2 EUD-tool screenshot with preview functionality

identified requirement of preview functionality, the current state of the application can be viewed within a browser-based iPhone screen (see Fig. 2). Therefore, the same generation process is used as for the final generation process. Due to the manageable scope of the mobile ERP applications, the generation process is relatively fast.

7 Summary and Conclusion

In this paper requirement for an EUD tool for developing mobile ERP applications have been identified. An evaluation of an existing development tool revealed that the tool is difficult to learn and error prone, mainly due to its large degrees of freedom using a visual programming language. Therefore, a form-based interaction technique was proposed in which end-users only have to choose their desired data services and corresponding parameters. The corresponding user interface is implemented based on commonly used user interface patterns for mobile ERP applications [34]. These patterns were implemented as XSLT-stylesheets.

Only a part of the user interfaces patterns proposed in [34] are currently supported in the existing prototype. This limits the number of possible mobile ERP applications and their usability. Another limitation of the current implementation is that data changes within the previewed mobile ERP application are also propagated to the corresponding ERP system. A sandbox environment would be useful to limit possible risks during the development process.

According to our current experience the presented concept is suitable for creating standardized mobile ERP applications quickly and without programming skills. Using this concept, different mobile ERP applications can be developed. Only for novel and more complex requirements the suggested concept seems to be not suitable. The proposed architecture based on an XML description of the mobile

ERP application specification in combination with an XSLT generation process has proven to be fast and extensible. Currently, the variety of possible mobile ERP applications is restricted to the available data services within the provided library. A possible next research step could be to find ways for the creation of new data services by advanced end-users.

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Part VIII
Cultural Issues in ERP Systems

Considering Cultural Issues of ERP System Utilization: A Company-Based Perspective

Kayo Iizuka, Yoshitaka Taguchi and Chihiro Suematsu

Abstract Some data show that the effect of investment in Enterprise Information System (EIS) is not high enough in Japan compared with the levels in the United States and other Western countries. Moreover, Japan is facing major changes in the business and IT environments. With global business expansion, improving operational efficiency at the global level using information technology (IT) has become one of the most important issues for companies. The Enterprise Resource Planning (ERP) packaged system, or ERP system is one of the options used for re-engineering global information systems in many countries. In this paper, the authors present results concerning the effect of implementation of ERP system. The analyses focused on the context of the global expansion of companies and the effects of customization of packaged software functions. Business Process Re-engineering (BPR) issues when implementing ERP systems are also discussed in this paper, regarding cultural issues specific to Japanese companies.

Keywords Enterprise resource planning (ERP) system · Enterprise information system (EIS) · Business process re-engineering (BPR) · Management style · Cultural issues

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1 Introduction

The importance of information technology (IT), especially for Enterprise Information Systems (EIS), is increasing because its role in supporting the achievement of business effectiveness is also increasing. The purposes of IT investment for enterprise information systems cover a broad range, such as enforcing information utilization, improving operational efficiency, supporting accurate decision making, and enhancing information security management. Improving operational effectiveness is one of the most important of these. However, survey results have shown that the satisfaction level of top management is not high enough. 46.9 % of top management personnel said "rather dissatisfied" and 14.0 % answered "definitely dissatisfied" to a question (4-point scale) about the satisfaction with the information system of their companies in Japan [1]. This means about 60 % of top management are unhappy with the information systems of their companies. It has been said that companies in Japan tend towards using custom-made software, and are more cautious regarding the installation of packaged software, compared to the United States or other Western countries [2–5]. Motohashi mentioned that Japanese companies tend to use custom-made software more than necessary, which is the reason why packaged software were rarely implemented and IT systems are not very cost-effective [3]. Although the percentage of enterprise resource planning (ERP) system implementation has increased to 52.0 % of the total, only limited modules are implemented in most cases (e.g. finance modules: 43.1 %, sales modules: 25.7 %, purchasing modules: 24.3 % [1]). Not a few companies that had unsuccessful results with their ERP implementation projects tended to focus on their As-is process (the process of current business execution), and believed that their new business process (To-be process) should be enhanced based on the As-is process [6], even though business process re-engineering (BPR) which is a drastic change (include management system, organization structure, performance measurements) proposed by Hammer and Champy [7] has been one of the hot topics in IT utilization for decades. However, many Japanese companies have to change their business drastically due to global business extension caused by transfers of plant activity overseas. In this paper, the authors present results on the effects of implementation of ERP systems among enterprise information systems. The analyses focused on the context of the global expansion of companies and the effects of customization of package software functions of ERP systems. BPR issues when implementing ERP systems are also discussed in this paper, regarding cultural issues specific to Japanese firms.

2 Related Works

2.1 Business Process Re-Engineering (BPR) Related Works

Related works concerning the BPR effect induced by IT implementation or IT operation could be classified into certain categories. Based on BPR theory presented by Hammer and Champy [7], researchers have conducted studies from various perspectives. Grover [8] focused on the implementation problem, Earl [9] analyzed the relationship between BPR and strategic planning, and Attaran [10] explored the relationship between IT and BPR based on the capabilities and barriers to effective implementation. Kadono [11] focused on the mechanism of how IT creates business value, particularly from the IT management perspective. Chikara [12] attempted to adapt the customer satisfaction method to an information system as part of the information system audit measurement.

2.2 ERP Implementation Related Works and Trend of ERP Implementation Research

Related works of ERP implementation can be classified into certain categories, such as Critical Success Factors (CSF) [13, 14], software selection process [15, 16], ERP education [17, 18], and various others. As for works about ERP implementation success factors, countries for research focus seem to move to economic developing countries from western countries. Works that focus Japan is less common, because most of the Japanese companies have been choose custom development of EIS.

Takei, Okuda, and Iizuka analyzed the literature about trends in CSF of implementing ERP systems [19]. Literature for the survey was extracted from Google Scholar. The exact keywords were "ERP," "ERP implementation success," "Enterprise," and "CSF." This kind of extraction method has often been used in literature reviews recently [20, 21]. By using this method, 76 articles were extracted and used for the review. The key items used for analyses were the date of publication, country, and the research trend by regions. In total, about 50 articles on CSF were reviewed and the CSF described in those articles were categorized. The most common CSF extracted from the literature were top management support, management style, goals and objectives, project management, project team, organizational fit, interdepartmental cooperation, user training, cultural effect, and various others. Overall, 86 % of the reviewed articles about ERP systems focused on success factors. From the extracted articles, those focusing on particular countries were used for analysis. Regarding the amount of literature about different regions, the levels for the Americas (North and South America) and Europe are decreasing, but the levels for the Middle East, Africa, and the Pacific are increasing (Fig. 1). From these results, it can be assumed that ERP systems have

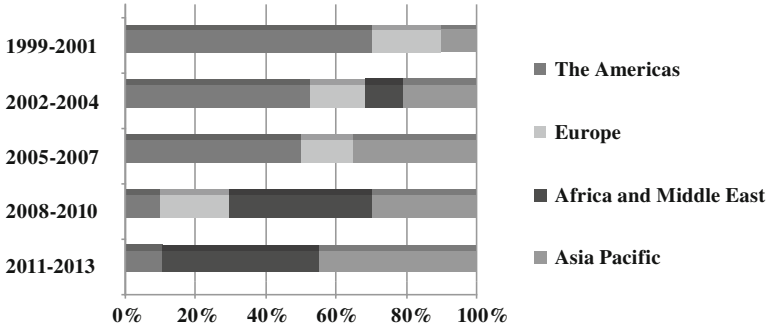


Fig. 1 Trend analysis of publications in the ERP literature (Takei et al. [19])

been more fully implemented in Western countries than in developing countries. In developing countries, firms need to develop their business at rapid speed, so ERP systems might meet their requirements. The differences in CSF by region can be explained as follows:

- Common factors among countries
  As mentioned in previous articles, there are common CSF between countries [21].
- Difference in BPR importance by regions

BPR used to be considered as an important CSF [22, 23]. However, some recent research results shows that BPR is not always important [24, 25]. This trend is shown in countries in the regions of the Middle East and south Asia.

Although some of the articles mention that BPR is not always important aspects of CSF for developing countries, a number of articles, mostly old articles focusing on Western countries insist that BPR is important. As for Western countries, it can be considered that CSF are rather established compared with the level in developing countries, and BPR used to be important, but is it is rather established currently. This may be one of the reasons why the numbers of articles not increasing in this region. In Western countries, topics of CSF are moving to focus from general CSF to CSF of specific industries or CSF using new technologies. On the other hand, most of the companies in developing countries can be considered to be at the stage of ERP implementation, which coincides with the business development stage, and their business process might be developing stage rather than re-engineering stage. As for Japan, although ERP implementation is not widespread compared with the level in Western countries, there are a numbers of companies with a long history of it in Japan [26].

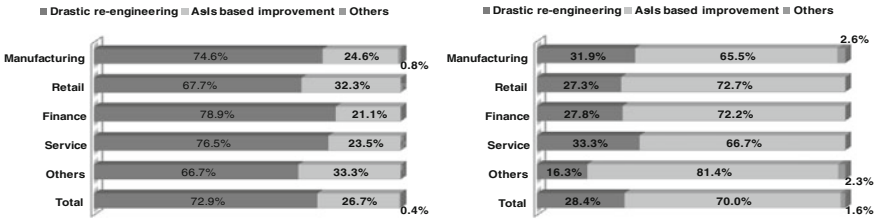


Fig. 2 Business process re-engineering/improvement policy (planned and actual) (Business strategy and IT research project, Senshu University)

Fig. 3 IT investment budget ratio by objective (Higano [27])

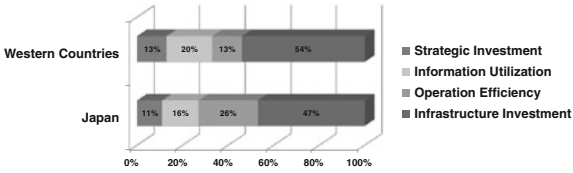
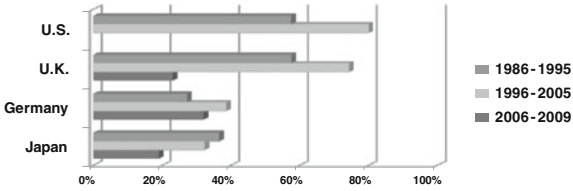


Fig. 4 Contribution of ICT capital services to value-added growth (*Variable data source* KLMSDB [28]) (Data on U.S. 2006–2009 have not in EU KOMS DB in 2013)



3 Analysis of ERP Implementation Effect Regarding ERP Utilization and Software Customization

3.1 BPR Implementation Status in Japan

It is often stated that some companies avoid choosing ERP because there are large gaps between the As-is business processes and the ERP functions, although it may be possible for such gaps to be reduced. For some years, many Japanese companies conducted As-is process-based improvement. Data from the survey conducted by the authors show that 72.9 % of the respondents (managers of information systems, business planning, or internal audit divisions) stated that the policy of their BPR was "drastic BPR," but only 28.4 % had attained it (Fig. 2). It is needed to find out the way to transform their business to achieve IT investment effect. Data from the survey conducted by the authors show that 72.9 % of the respondents (managers of information systems, business planning, or internal audit divisions) stated that the policy of their BPR was "drastic BPR," but only 28.4 % had attained it [6]. Figure 3 shows that Japanese companies tend to spend a lot more cost for improving business operational efficiency, however, the result seems to be effective enough (Fig. 4).

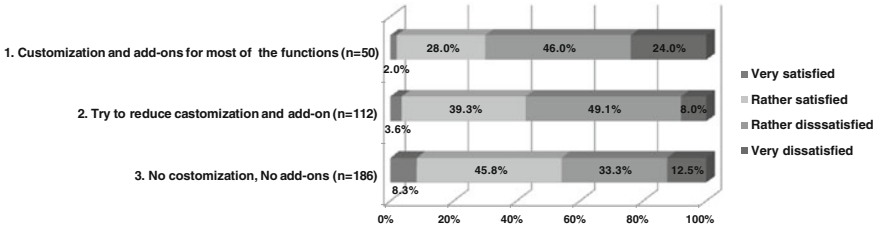


Fig. 5 Relationship between customization policy and effectiveness

3.2 Influence of Software Customization

As mentioned in the previous section, it has been stated that companies in Japan tend to use custom-made software. In addition, it has also been asserted that, in the case of implementing packaged software, they tend to customize the packages. Generally, reducing the amount of customization is said to be favorable for using packaged software because it not only reduces cost, but also facilitates software maintenance. However, some have pointed out that avoiding customization may cause inefficiency in business processes. Figure 5 show the relationship between customization and effectiveness. This survey was conducted by the ERP Forum in Japan and Impress Japan Ltd in 2013. The ERP forum is an Non-Profit Organization, founded in 1996 and now with 200 member companies; system integrators, consultants, ERP vendors, and major Japanese practitioner companies (or IT user companies). Impress Japan Ltd is one of the major publishers dealing with IT and the media. The survey was conducted in the form of a web questionnaire, and respondents were solicited via an e-mail magazine sent to readers of IT Leaders. The fact that these readers were targeted may be important since the respondents concerned are individuals with awareness of IT issues. (In this work, "customize" means to change packaged software functions by changing the program source codes, or adding source codes on original program. For some ERP packages, the vendor uses the word "customize" to refer to parameter setting, but this definition is not used for these questionnaire items).

The customization policy was investigated in terms of three types: 1. customization and add-on development for most of the functions; 2. try to reduce customization and add-on development; and 3. no customization or add-ons. Questionnaires for items about the effectiveness of enterprise information systems were prepared with responses in terms of satisfaction with business operations, information system operations, and other factors. Responses were marked on a four-point scale in terms of overall satisfaction. Satisfaction degree is used in order to measure effectiveness in this analysis. The analysis results show that less customization was associated with greater effectiveness of IT (Fig. 5).

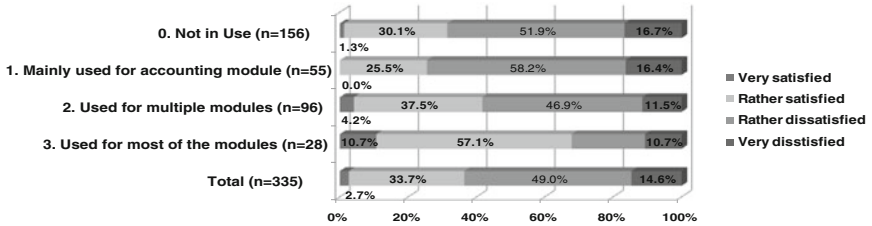


Fig. 6 Relationship between ERP utilization stage and overall satisfaction with EIS

3.3 Influence of ERP Utilization Stage

Figure 6 shows the relationship between ERP utilization stage and overall satisfaction with EIS. The ERP utilization stage was investigated in terms of four types: 3. used for most of the modules; 2. used for multiple modules; 1. used mainly for accounting modules; and 0. not in use. The wider the range of ERP modules, the higher the apparent degree of satisfaction (Fig. 6). The respondents who answered "rather satisfied" represented only 25.5 % of the companies in which an ERP system was "mainly used for accounting modules", which was less than half the figure for "used for most of the modules" and actually less than the figure for "not in use" (referring to the ERP system).

Figure 7 shows the relationship between ERP utilization stage and overall satisfaction with ERP software. The ERP utilization stage ("1. Mainly used for accounting modules," "2. Used for multiple modules," and "Used for most of the modules") was as same as Fig. 6 satisfaction item is not the whole enterprise system, but ERP package (Fig. 7). The number of the companies who "use plural modules" surpassed the companies who used "mainly for account module" in the survey conducted in 2013, However, many Japanese firms had used to be use mainly for accounting modules.

Another factor that can be considered to influence the effects of IT investment is the scope of information system integration [29]. Figure 8 shows the result of a survey about the IT implementation stage conducted by the Ministry of Economy, Trade and Industry (METI) in Japan [29]. The "IT utilization stage" is defined as follows:

Stage 1: The information system is implemented.
Stage 2: The information system is optimally utilized within a department or section within a firm.
Stage 3: The information system is optimally utilized within an enterprise (expanded beyond departments or sections).
Stage 4: The information system is optimally utilized among enterprises, (including suppliers or customers).

The fact that about 70 % of the firms are in stage 1 or stage 2 can be considered one of the reasons for the difficulty in implementing ERP systems in Japan, and the

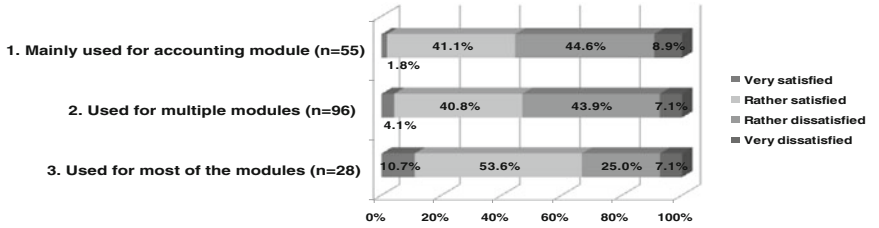


Fig. 7 Relationship between ERP utilization stage and overall satisfaction with ERP package software

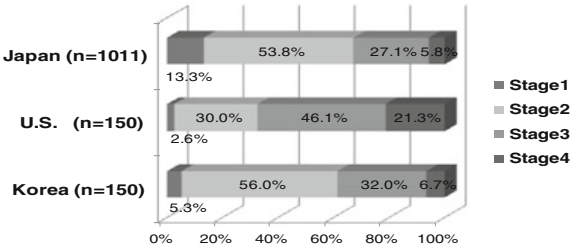


Fig. 8 IT utilization stage status (METI [29])

low effectiveness of IT investment in the country. There is the culture of called *Tatewari* in Japan. In the *Tatewari* type of organization, each section does not interfere with other departments, and everyone works hard and make effective mostly within the organization to which they belong. The scope of information system optimization is also one of the important factors determining whether ERPs are implemented or not.

3.4 ERP Utilization Stage Regarding Global Business Expansion

According to data from a survey conducted in 2013, 46.0 % of the firms in Japan have expanded their business overseas, and 10.1 % of firms state that they are going to expand their business in the near future [1]. Table 1 shows the relationship between the global expansion IT management stage and the ERP utilization stage. Variable data source is the same as used in 3.2.

The ERP utilization stage was investigated in terms of three types:

1. Region-based original management (use system by region, decentralized management)
2. Distributed standard management type (use a standard system, decentralized management)
3. Central standard management type (use a standard system, centralized management)

Table 1 Relationship between global expansion IT management stage and ERP utilization stage (Average score of 5-point-scale)

Global expansion IT management stage	ERP utilization stage	n	Q1.4a	Q1.4b	Q1.4c	Q1.4d	Q1.4e	Q1.4f	Q1.4g	Q1.4h	Q1.4i	Overall satisfaction (Q1.4j)
1. Use system by region, Decentralized management	0. Not in use	39	2.38	2.20	2.31	2.36	1.67	1.88	2.07	2.17	1.91	2.27
1. Use system by region, Decentralized management	1. Mainly accounting module	21	2.48	2.20	2.24	2.43	2.07	2.00	2.11	2.19	2.05	2.19
1. Use system by region, Decentralized management	2. Use plural modules	29	2.44	2.48	2.46	2.70	2.04	2.17	2.15	2.36	2.29	2.36
1. Use system by region, Decentralized management	3. Use most of the modules	10	2.60	1.83	2.60	2.60	2.17	2.00	1.67	1.90	2.11	2.40
2. Use standard system, Decentralized management	0. Not in use	14	2.41	2.30	2.27	2.45	2.17	2.27	2.06	2.14	2.08	2.29
2. Use standard system, Decentralized management	1. Mainly accounting module	6	2.50	2.50	2.33	2.33	2.33	2.33	1.67	2.00	2.00	2.17
2. Use standard system, Decentralized management	2. Use plural modules	16	2.44	2.56	2.50	2.75	2.00	2.40	2.07	2.13	2.20	2.38
2. Use standard system, Decentralized management	3. Use most of the modules	8	2.75	2.75	2.75	3.13	2.88	2.86	2.13	2.13	2.13	2.63
3. Use standard system, Centralized management	0. Not in use	18	2.13	2.07	1.94	2.38	2.13	1.92	1.81	1.88	1.88	2.00
3. Use standard system, Centralized management	1. Mainly accounting module	3	2.41	2.30	2.27	2.45	2.17	2.27	2.06	2.14	2.08	2.29
3. Use standard system, Centralized management	2. Use plural modules	11	2.73	2.38	2.55	2.73	2.55	2.78	2.30	2.36	2.45	2.55
3. Use standard system, Centralized management	3. Use most of the modules	6	3.50	3.25	3.33	3.33	3.60	3.50	2.60	3.17	3.33	3.33

Q1.4a: Satisfaction of information utilization
Q1.4b: Satisfaction of SCM (e.g. Inventory reduction)
Q1.4c: Satisfaction of information gathering of situation of divisions
Q1.4d: Satisfaction of shorten the accounting closing process
Q1.4e: Satisfaction of globalization of enterprise information system
Q1.4f: Satisfaction of International Financial Reporting Standards (IFRS) support
Q1.4g: Satisfaction of improve customer satisfaction
Q1.4h: Satisfaction of cost reduction by improving operation efficiency
Q1.4i: Satisfaction of supporting business process re-engineering (BPR) by using IT
Q1.4j: Overall satisfaction of EIS

The items for the ERP utilization stage are the same as in the previous section ("1. Mainly used for accounting modules," "2. Used for multiple modules," and "Used for most of the modules"). From these data, for the central standard management type, there is greater difference in satisfaction according to the ERP utilization stage. Even if the global management type is advanced, if the ERP utilization stage is less mature, the level of satisfaction tends to be low.

3.5 Discussion

- Influence of ERP package customization
  Package customization used to be considered necessary to fill in the gap between ERP functions and business processes of Japanese companies. Less customization was believed to result in better system operation and implementation project completion of package software. However, the analysis result shows that less customization has positive effect to overall effectiveness of enterprise information system.
- Influence of ERP utilization stage
  As mentioned in the prior section, most companies have used ERP systems in limited modules. Using limited modules of an ERP package system can achieve passably satisfaction as package software but, not for total enterprise information systems, because the scope of enterprise information system is not limited to the function of software, but including role of supporting business process.
- Regarding global IT management maturity and information infrastructure maturity
  It has been said that enterprise information systems in Japan are realizing partial optimization rather than total optimization throughout the entire company, and data presented by METI support this view. Many of firms in Japan are in the early stage of utilization of enterprise information systems, though technological information systems such as Computer-aided Design (CAD) or Factory Automation (FA) are fairly widely utilized in Japan.

Generally speaking, the more the firm is realizing a total optimization scheme, the greater the effect of IT investment will be. However, the situation in which "IT utilization is high" refers not only to the standardization of the system or realizing centralized management. From the analysis result the authors presented in 3.3, even if the global management type is advanced, if the ERP utilization stage is less mature, the level of satisfaction tends to be low, rather than the case that both global management type and the ERP utilization stage are less mature. It can be considered that the balance and alignment of global IT management maturity and information infrastructure integrated maturity is important, and ERP utilization is effective for improving information infrastructure integrated maturity, because ERP systems have capability to improve information infrastructure integrated maturity.

ERP systems have the capability to improve total optimization by standardizing information and business process among sections of companies (sections of different functions such as “accounting” and “sales”, or sections of different business such as “camera” and “computer”), though adopting an ERP system as an enterprise information system is not the only way to benefit from IT investment. However, in order to achieve effectiveness by ERP implementation, arrange for aligning management and IT would be necessary.

4 Considering Cultural Issues and Management Style

One of the major reasons why ERP implementation or the application of business process re-engineering methods developed in Western countries is often difficult for some Japanese companies is the difference of organizational culture between Western countries and Japan. However, for Japanese companies to maintain the same approach as in the past would be difficult because of environmental changes (e.g., a decrease in sales due to shrinking of the domestic market requires companies to make efforts to reduce costs in order to maintain profits; some companies have had to transfer production overseas in order to reduce labor costs.) As such, the optimal way to achieve effective ERP systems by dealing with these differences in culture and management style should be identified. In order to realize the effective utilization of ERP in Japan, it is necessary to consider what has been referred to as “Japanese-style management” and its characteristics.

4.1 “Soui-Kufu (創意工夫)”

The “lifetime employment system” and “labor participation in management” are some of the major characteristics of Japanese-style management. Quality circle (QC) activities have been carried out on these conditions (jobs of employees are sufficient to provide a stable income, under lifetime employment), and they contribute to improving the quality of Japanese products [30]. Not only to improve the quality of products, but each employee also observes the business processes, and keeps making improvements where possible. Business process improvement used to be done in a bottom-up rather than a top-down style. “soui-kufuu (創意工夫 in Japanese)” is one of the main keywords when discussing business process improvement in Japan [31]. This word is often heard in end-user interviews, especially in small and medium-sized enterprises (SME) including firms that have world level technologies. It means “creative originality and ingenuity”. Each motivated and skilled employee in the production lines or back-offices keeps improving the business process in their own way to make it more efficient. The

accumulation of Soui-Kufuu results have become a kind of intellectual property. These are the reasons why Japanese companies tend to execute As-is based improvement, even when they have planned to execute drastic business process re-engineering. Employees in the production lines or back-offices are involved in determining new business processes. To-be business process is determined using the non-hierarchical business process modeling method (the viewpoint of this method is that of employees on the production line or back office, rather than top management) has been preferred [32]. By using that kind of chart, employees can share process flow information with each other. Also, recognition of ingenuity can be considered one of the reasons that they tend to prefer custom-made software.

4.2 "Suriawase (摺り合わせ)"

From the survey results analyzed by the authors about process defining decisions, it is possible to assume that attempts to adjust and align an appropriate decision with understandings of the difficulty impacts on the effect (satisfaction) with implemented information systems in their companies [32]. As for the adjustment process, what is called "suriawase (摺り合わせ in Japanese)" is often thought to be important in Japan. The meaning of "suriawase" is close to "sync up". "Sync up" is a way to try to achieve mutual understanding and compromise among people or in organizations, but without any decision-making process. Okui showed the difference between the United States and Japan in the decision-making schemes of professional baseball teams. He mentioned that managers of Japanese professional baseball team have to make appropriate use of both commands and requests (and are torn between conflicting demands) with the general manager and players. Compared to this situation, the decision-making scheme in U.S. professional baseball teams is a rather simple top-down type, and the decision-making scheme in companies is similar to the pattern of baseball teams [33]. In the suriawase (sync up) type organizations, decisions are made using a bottom-up style, and discussions tend to take the form of exchanged equivocal opinions, the conduct code is "prioritize employees' experience", and the evaluation method is horizontal evaluation.

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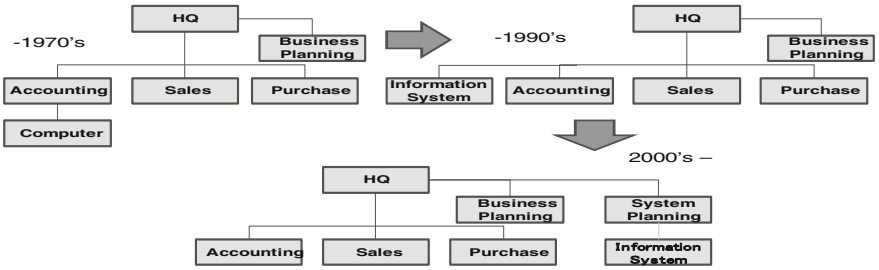

Fig. 9 Sample of change in organizational structure

scheme in U.S. professional baseball teams is a rather simple top-down type, and the decision-making scheme in companies is similar to the pattern of baseball teams. In the suriawase (sync up) type organizations, decisions are made using a bottom-up style, and discussions tend to take the form of exchanging equivocal opinions, the conduct code is "prioritize employees' experience," and the evaluation method is horizontal evaluation [32].

4.3 "Soron sansei, Kakuron hantai (総論賛成各論反対)"

The meaning of "*soron sansei, kakuron hantai*" is to agree with the plan in general, but not to compromise on the details. Japanese may agree with an abstract principle, but in a specific situation, the general idea is ignored when it contradicts what the context seems to call for [34]. In some cases, from the interview, most employees had agreed to drastic re-engineering to improve operational efficiency overall; however, they tended to resist drastic changes in business processes related to their own particular sphere of work.

4.4 Organizational Issues

In this section, the authors discuss about the analysis result of the survey for the objectives listed as follows:

- Recognizing differences in the formative factors of effectiveness using IT by organization division, and optimizing effectiveness on a company level.
- Recognizing difference in the formative factors of effectiveness using IT by organizational structure.

Organizational structure has changed and is varied in Japan (Fig. 9). Searching the best type of organizations might be one of the options, however, finding various solutions corresponding to some (but not all) organization type.

From the survey conducted by Iizuka et al. [35], the organization type in which the system planning section and the business planning section have a close relationship tended to achieve good results from BPR. However, for cases in which the firms settled on a numeric target (e.g. specific numbers regarding cost reduction, improved speed of operation, etc.), many of the firms could achieve good results from BPR even when these firms had an organization type in which the system planning department and the business planning department were more independent [35]. The reason for this is that the organization infrastructure compensates by setting specific numerical targets. In other words, the setting of numerical targets may enable compensation of an organization-based communication type in some way.

5 Conclusion

The purpose of this paper is to discuss ERP system utilization from the viewpoint of situations of the companies and cultural issues. At first, the authors reviewed the result of analysis of literature on ERP implementation trends, and mentioned common critical success factors (CSF) that differed by region. The quantity of literature on CSF of ERP is decreasing in percentage in Western countries because simply searching for success factors is considered to be not as necessary as before. On the other hand, literature on CSF of ERP is increasing in the Developing countries. These countries are presently in the development stage of both business and IT. However, the situation of Japanese companies is different. An ERP system is one of the options used for re-engineering global information systems in many countries. However, it has been said that firms in Japan tend towards using custom-made software, and are more cautious regarding the installation of packaged software, compared with other countries. There are companies with a long history, some of which have not been able to change their business processes drastically, though they had planned to do so. Moreover, Japan is facing major changes in the business and IT environments. With global business expansion, improving operational efficiency at the global level using IT has become one of the most important issues for companies. To address these issues, analyzing the Japanese situation by applying the existing analysis framework used in Western countries seems to be inadequate. Therefore, the authors analyzed the situation of Japanese companies, focusing on issues of customization of ERP package functions and global IT management. The analysis result show that companies with less customization tend to achieve higher scores for overall satisfaction with the enterprise information system, even though it has been said that functions of ERP systems are difficult to fit into Japanese business processes. Alignment of the IT management style and information infrastructure is also important. Even if the global management style is advanced, poor alignment with the information infrastructure tends to cause poor effect. Business process re-engineering (BPR) issues when implementing ERP are also discussed in this paper regarding cultural issues

specific to Japanese firms, because it can be considered that these issues represent some of the reasons why Japanese companies tend to use custom-made software. For future research, the authors will take up the challenge of developing a tool for effective adjustment process modeling [31]. It is hoped the tool will contribute to the adjustment of new business processes among different organizations, and the adjustment of top management perspectives and employees. Also, we will conduct a new survey to determine in detail the factors that contribute to achieving effectiveness of enterprise information systems under the organizational environment that Japanese companies are facing.

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Part IX
Implementations Strategies and Concepts

Weaving Social Software Features into Enterprise Resource Planning Systems

Dirk Draheim, Michael Felderer and Viktor Pekar

Abstract In this paper we present the Social Weaver platform that enables end users to weave snippets of social software features into the workflows of existing enterprise applications. We discuss the underlying vision from a technological viewpoint, i.e., an end-user development viewpoint, and an organizational viewpoint which is about a certain ubiquitous understanding of enterprise application integration. We present the system's requirements, architecture and realization. The concrete platform is based on the standard web technology stack, which makes sense because the web is the current natural host for enterprise applications, at least for new ones. However, the approach presented in this article is technological-independent with the concrete platform as a concrete instance proving the approach as doable. Conceptually, the realized platform is a key to analyze the current situation and possible future of today's enterprise application landscapes which oscillate between emerging social software metaphors and an ever increasing degree of process automation found in today's organizations.

Keywords Social software · Web 2.0 · Enterprise content management · Wikis · Enterprise resource planning · Business process technology · Workflow management · Big data · Aspect-orientation

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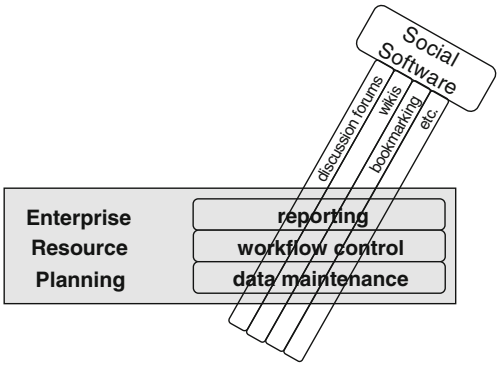

Fig. 1 Weaving social software features into ERP systems

1 Introduction

Currently, we see that new social software technologies gain ground in organizations. They come along with new agile and equal approaches to work organization. At the same time, classical enterprise resource planning (ERP) systems are still and always ever growing, simply in terms of the number of processes they support. Many larger organizations still have their own software development departments for realizing process-based applications and it seems that the demand for more and more process automation cannot be satisfied adequately. The two major technological strands of computer-supported cooperative work (CSCW) [20] on the one hand side and process-based automation [10] on the other hand side co-exist in organization with little to no integration. The same is even truer for the third strand of IT which is about individual office automation and individual ad-hoc IT support. This situation is also the driver for the current big data debate, which is an analytical a posteriori approach that massively targets the data facet of this scenario. Here is where the technological and organizational vision of our work starts. We present the Social Weaver platform ([29], https://github.com/vikpek/SocialWeaver) that enables end users to weave snippets of social software features into the workflows of existing enterprise applications as illustrated by Fig. 1. The technology allows the end-user to enrich existing ERP systems by features of existing social software applications at the level of user dialogs.

The approach presented in this article is technological-independent. As a concrete instance proving the approach as doable, the current Social Weaver platform is based on the standard web technology stack. This makes sense because the web is the current natural host for enterprise applications, at least for new ones. The developed platform exists as a stable, working version and has recently been launched as an open source software development project:

https://github.com/vikpek/SocialWeaver

The overall vision of this work can be explained in two strands, i.e., a technological and an organizational one, that represent two facets of the same story.

We delve into the technological vision in Sect. 2 that starts very concrete with the description of example ERP use cases for the targeted technology. We proceed with an explanation of the organizational vision that in Sect. 3 that is justified by and at the same time transcends the technological vision of Sect. 2. The architecture and implementation of the realized Social Weaver technology are explained conceptually in Sect. 4 and by means of a walkthrough through a concrete example case study based on the Google calendar application in Sect. 5. We report on further work and related work in Sects. 6 and 7, respectively. Finally, we finish this chapter with a conclusion in Sect. 8.

2 The Technological Vision

The technological vision of this work is about *end-user application weaving*. Imagine an arbitrary staff-related approval process in an enterprise, e.g., business trip planning, request for leave, or a request in the personnel disposition system. Now, we have that a certain change in the relevant employment law applies and a change to the workflows is needed. Before on the final solution is decided and the appropriate changes to the supporting ERP system is implemented, the chief personnel manager wants to communicate certain hints and orders to the staff that must be obeyed as a workaround to the eventual solution when working with the current processes. Because this phase is temporary, let us say 2–3 weeks, the personnel manager wants to communicate this hints in a lightweight yet robust manner. One option would be to write an Email to the staff. This has certain drawbacks. First, the email will also reach many employees that are not currently interested in, because the relevant workflows do not apply to them in the temporary phase. Second, there is the risk that the important information is overlooked or forgotten once the concrete workflow steps are performed. The same disadvantages apply if the information is posted in an enterprise-wide news system, e.g., based on a social software initiative or the more established enterprise content management system technology. Here, the risk that the information is overlooked might even be higher.

The desirable solution would be to post the necessary hints and orders directly in the relevant ERP system workflow steps. The crucial problem in current settings is that this will result in a change request to the software development department or the extern software service provider which needs to be considered a way too heavyweight solution. The technology realized by the current work offers way out of the dilemma. With our technology the personnel manager or its secretary can immediately drop the necessary hints as comments to the relevant workflow steps. Only minimal to no training is needed to use the technology which is largely self-explanatory. This means our technology follows an end-user development approach in terms of HCI (human–computer interaction) [24], and, actually, a very high-level end-user development approach.

With the current implementation of Social Weaver it is exactly possible to drop a comment via a comment box as an annotation to each element of a web site. The system has an extendable architecture and in principle it is possible to drop any social software feature to a workflow step in our technological concept. Web 2.0 frameworks and portal servers like Alfresco or Liferay offer many ready-to-use features and plugins. For instance, the personnel manager in our little example could enrich a workflow step by a means of gathering feedback from the employee, e.g., by a poll feature or a small feedback form. This way he could gather further information that is needed in the workaround to the new approval workflows.

It is important to realize that our approach does not answer the problem of data integration for the information that emerges by such added features. The entered data will be accessible in the social software application that is intertwined with the ERP system. A certain amount of data integration can be achieved if the social software application feature replays the information if the workflow step is re-visited or displays the information in another workflow step. However, we do not elaborate the pattern for such integration and it depends on the cleverness of the end-user to exploit the social software feature in such a way. Our approach intertwines and integrates application only at the level of user dialogs, the data tiers of the application remain separated silos. However, the approach is a crucial step forward in the direction of rapid, end-user enabled application integration. We wanted to create somehow a sweet spot between usability and rapidness versus design robustness and maturity. Therefore, the current example of a temporary process workaround is very typical. We feel that the usefulness of such approach is quite evident.

Have a look at a second example in Fig. 2 that we have taken from [9]. In this example a complete discussion forum from a social software framework is woven into the order process of an ERP system. The motivation is a continual improvement process for workflows and their supporting IT systems. We deal with an example of a truly high-repetitive process, i.e., the inspection of orders that is the main tasks of the respective specialized clerks. One of the employees has entered the discussion forum by linking it directly to the workflow steps he wants to discuss. Other employees will find this entry to the discussion forum exactly when they enter this workflow step. The discussion forum is itself a complex application with structured data and some kinds of processes. The example gives an impression of how two complex applications can be linked on the level of their dialogs. Again the integration is shallow, i.e., the data facet is not addressed. It will be further work to elaborate a concept for end-user data integration and our belief it that the way is via eventually solving and overcoming a fundamental problem of the current state-of-the-art in software development and operations, i.e., the lack of deep standardizations of applications and systems as described in [2].

Given these two examples as starting point, we can also identify a wide range of interesting concrete application areas in the software engineering life cycle: software testing [18], software quality improvement [19], legacy system refactoring and so forth. For example, in legacy system refactoring it appears natural

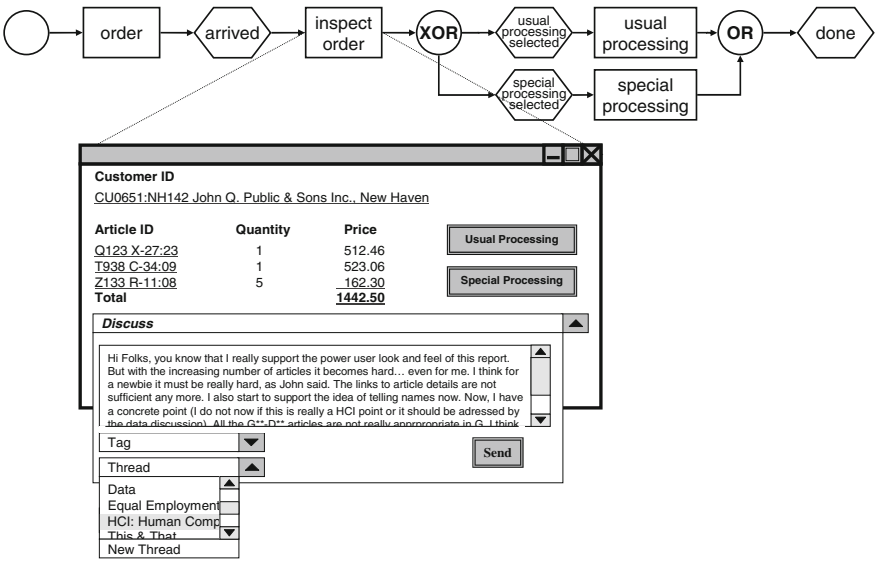

Fig. 2 Example for weaving of a complete discussion forum into a workflow step

that the team that re-engineers the software requirements of the legacy system discusses and documents the system along the lines of its dialogs. Again, we feel that the approach is immediately promising but at the same time shows crucial limitations with respect to the data integration facet, in particular, if holistic and integrated viewpoints on software engineering toll support [2, 5] are taken. Here, the problem of loose coupling of the data can be re-phrased in terms of the concept of traceability, which is a well-understood concept in the CASE tool community.

Taken all the examples of this section together, it can be stated that, overall, the proposed platform lays in the realms of enterprise knowledge management [26, 28] and enterprise application integration [21] which will be the topic of the next section.

3 The Organizational Vision

The organizational vision of this work is about *ubiquitous enterprise application integration*.

ERP systems form a center pillar of IT in today's organizations. Their role is not merely some work support that is only justified by some speed-up of work. Their role is crucial, i.e., mission critical in the way they formalize, document and guide work. ERP systems encapsulate major chunks of the enterprises know-how. However, not all kinds of work are amenable for a process-based approach. Some tasks are particularly well-suited for process automation. They are typically highly

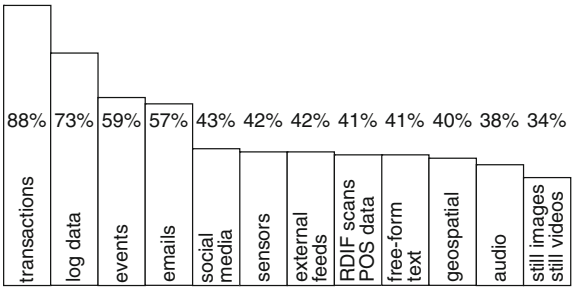

Fig. 3 Current exploitation of data sources in organizational big data initiatives—IBM poll [30] with approx. 500 respondents

repetitive and form major chunks of work of often specialized work forces in daily operations. For other tasks, e.g., in the areas of organization, planning, project work or team work, it might be more difficult to analyze their activities and to support them with classic ERP systems. ERP systems are based on structured data and formal processes. In the field of unstructured and semi-structured data and more ad-hoc processes another class of tool emerged over the decades that can be loosely classified as groupware or computer-supported cooperative work (CSCW) tools. A plethora of unstructured data and semi-structured data emerges from individual work and it has been the field of enterprise content management (ECM) [4] to gain control over these data.

There exist strands of informal work in enterprises. Sometimes, it is not rational to formalize certain kind of work, sometimes work arises and is not yet understood well enough to be formalized. In any case, IT support should seek for the sweet spot of bringing some structure into any kind of work found in enterprises. At least, a reasonable versioning and access control management for the artifacts emerging in work always helps. For collaborative work on artifacts, tools for rapid editing have early been proposed, e.g., ZOG [27], and recently gained wide acceptance by the Wiki wave [6]. The usefulness of Wikis to support team work is immediately evident, simply by the features they offer and independent of the equal work philosophy that comes along with their encyclopedic work metaphor. Today's social software products [16] now combine features from enterprise content management systems and collaborative editing tools which seems to be a natural step against the background of an analysis of the needs of organizational IT support. And this is how social software is currently actually exploited in enterprises, the usefulness for the extra genuinely social software features that come along with new products is not yet fully understood. By the way, an early representative of combining ECM with collaborative editing are Hyper-G and its successor Hyperwave [1].

The current big data debate [17], as long as it concerns enterprise data, also shows this duality in structured and semi-structured work and data. The survey in [30], see Fig. 3, shows which data sources are exploited in systematic data analysis efforts in today's organizations.

In our *ubiquitous enterprise application integration* vision we think of all the data in the enterprise as one single huge externalized knowledge basis [28] that is

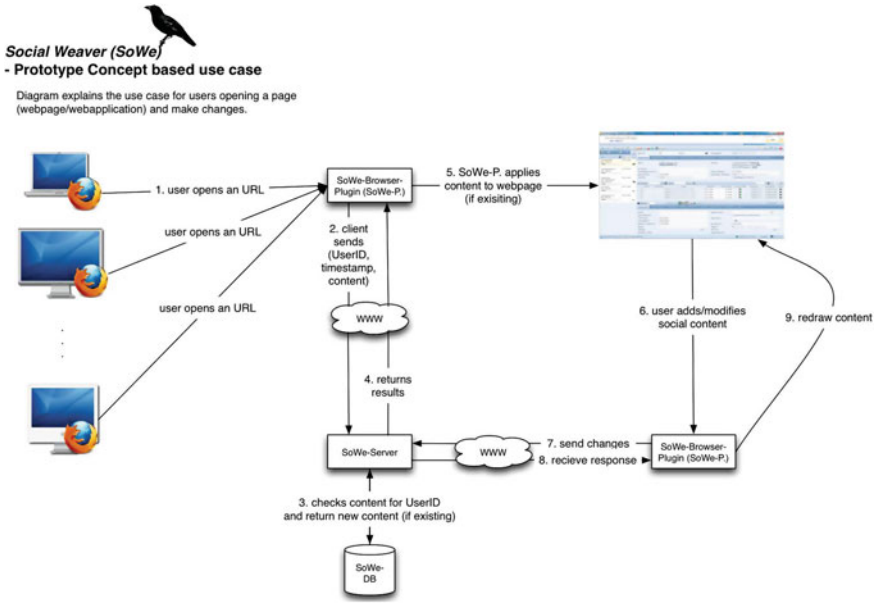

Fig. 4 Social weaver prototype use case

exploited by all processes and work activities in the enterprise. In [10] we have discussed this ideal as industrial information integration backbone (IIIB). Whereas a technical realization of such an information and process design currently seems nigh on impossible, it helped us in concrete enterprise application projects [3, 7, 8, 11, 23, 25] to find an optimal solution. Therefore, we think it is the correct metaphor for the case of integrating ERP systems with emerging social software technology.

4 Architecture of the Social Weaver Platform

The realized system functionality is described best by a generic use case of a user opening a web application and modifying content—see Fig. 4. First, the user opens a web application. Then, the Social Weaver plugin sends a notification to the server with all necessary information like user identifier, time stamp and payload. After the server has received the plugin message, it synchronizes with its current content in the database. The server application responses to the plugin client with content data if such data exist. Then, the plugin uses the content information from the server to insert all social web elements. Now, the user decides to make some changes to the social web content, e.g., adding a comment or creating a new comment box. Again, a notification is sent to the server containing changes. On

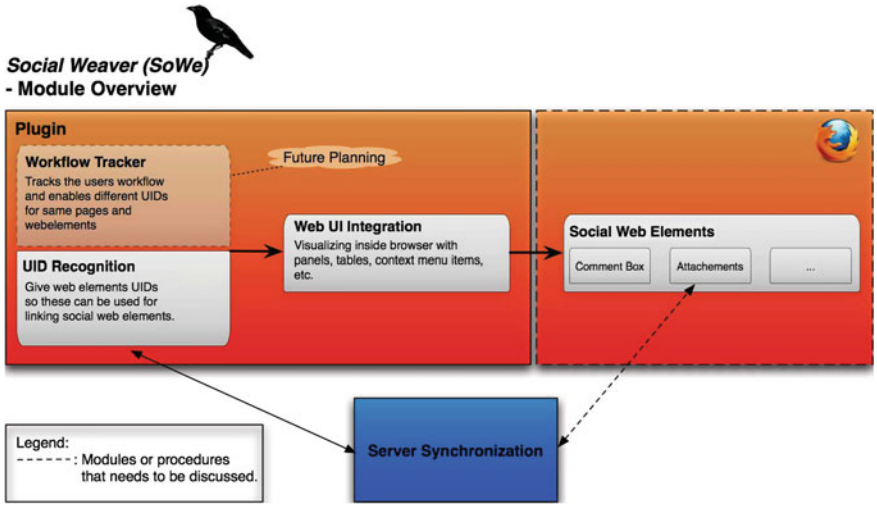

Fig. 5 Social weaver module overview

behalf of that, the server synchronizes the updates and responses. Finally, the plugin redraws the synchronized content.

The system consists of a web tier and a server tier. The basic architecture is shown in Fig. 5. The plugin takes control of one or multiple user sessions and draws the additional content into the browser view. The server application synchronizes with each plugin and distributes updates between several clients.

Social Weaver is designed in a modular way, so that it is possible to add more social media features, support multiple platforms and more web applications. In the current implementation, weaving of comment boxes is supported. The realized user experience is that browser displays comment boxes that are related to specific web elements. For example, in an online calendar a user can add a comment box related to an appointment that he wants to discuss in detail. Because it should be possible to add multiple comment boxes to any web element, we cannot just drop a box inside the user view, overlapping other interesting parts of the web application. Hence, we have the requirement to make additional content visible to the user, without interfering with the view on the original content. Possibilities would be fold/unfold-windows or just using small icons as references in the original view and outsource additional social content in external windows.

Social Weaver—The Plugin Of course, the plugin needs to be able to communicate to the server application as well. First of all the plugin needs to receive data that it prints to the screen. Secondly, changes made by the user have to be reported to the server. Because we are distributing the information between several users, there is also a need for synchronization. User updates may not overwrite updates made by other users etc. Social weaver exploits a parser framework containing application programming interfaces that creates and parses the content of our tuples. For instance, it is this way easier to add plugins for other browsers.

The data in the content-part of our tuple should have a uniform format no matter what web application or browser is in use. The server application does not need to be aware about the environment the plugin runs in—it manages the social web content independently.

Another important point is the interaction with the web application. Most such sites are dynamic and there exists no static and referable URLs. In addition, it is not certain that the same element that two users refer to in their independent sessions has a comparable identifier. This issue definitely needs to be handled specifically for any web application. The good news is that this only affects the plugin. The server application just needs clearly defined identifiers. As a solution for the plugin, we need the possibility to use scripts for identifying elements. This requirement is probably the vastly problematic one because it prevents a general usage of Social Weaver.

Social Weaver—The Server Application The server application's primary task is to synchronize different user sessions on one or multiple web applications. A user session is defined within the plugin, which does not mean a plugin can manage only one session. The server receives messages from different sessions, synchronizes them and distributes the most current state to all sessions. To establish a loss less synchronization every message contains a time stamp. We are assuming that every message contains a user identifier, a time stamp and an unique identifier for an element within the web application. This Anchor is the unique identifier for a single user action. For example, if a user adds a comment to an already existing comment box that is related to an appointment in a calendar, the server receives the users identifier, the time stamp for the modification and an identifier for the appointment in the calendar. With this information, the server can check its database for the comment box and add the new comment. It is important to realize that the server only uses the received data as identifier. All actions are completely independent to the web application.

In addition, we may assume that the received message have the same anchor form as discussed for the plugin. The content part from the anchor needs to be in a uniform format that has been generated by the plugin. So even the browser type does not matter to the server. The server has to be able to parse the content package and to create a new one that can be parsed by our plugins.

Social Weaver—Script Support The support for external scripts is essential for a generic usage of Social Weaver. The reason why script support is extracted into its own section is that it should be decoupled from the server and plugin that were discussed before. The underlying problem is the problematic identification of elements of a web view. There is simply no generic way of identifying elements in the users view across all web sites and applications. For that reason we need an extendable method to support more websites and applications. This could even mean that third parties could support their own systems by just adding the script without the need to modify Social Weaver directly. Let us consider the Google calendar application as example—see also Sect. 5. Assume a case where we want to match the same appointment field across different user sessions, which brings the problem that there is no identifier for the element itself. To the user it is

obvious to identify it because of the appointment name, date and time. And those parameters could be just the information we need to extract into our script.

The usage of scripts should be related to one or a set of URLs. This affects mostly the root URL of a server. However, it might be used for sub parts of a web page or application. A set of URLs could be used for scripts that are applicable for many websites. The workflow for using a script when the default matching procedure that comes with the plugin is quite straightforward. Whenever opening a new URL then the plugin should check whether there is a script for that case and depending on the search results proceed with the script or default matching procedure.

5 Case Study Example

This section leads us through a real example where Social Weaver is being used. It is explained which components are used in what situations and how they interact with each other. We use Google Calendar as basis for the scenario. Google Calendar (GCal) (http://google.com/calendar/) is free service for time management or in other words an electronic calendar. In the following context, GCal describes the web application that is accessible with any browser. The particular reason why we use GCal as testing scenario is that it is a freely available web application with shared data across user sessions. Such data can be a single appointment or a entirely shared calendar. Even though the HTML code differs for such data, the equality is clear to the user. The challenges with GCal are the differing HTML code for equal elements across user sessions.

The following explanations are based on a scenario with two users, i.e., Alice and Bob, who both are running the Social Weaver plugin in Firefox and are connected to the same Web Service, which means they share the same Social Weaver session. Additionally they obviously need a shared Google calendar. For accessing the calendar, they use the default web service provided by Google and no alternative client.

The scenario consists of the following steps. First, Alice weaves a comment box to an appointment in the shared calendar. Then, Alice uses the comment box to leaves a reminder. Now, Bob logs in and comments Alice's reminder. Now, we manually destroy the anchor directly in the database. Then, Alice recognizes this failure and re-links the comment box.

In the following two sub-procedures, update and matching, are explained. The reason why we handle those separately is that we use them more frequently in the whole process. That way we can just refer to them and keep the focus on the actual workflow.

Update Procedure The synchronization for Social Weaver is quite simple. On start up or whenever it is asked, the plugin sends two parameters in a JSON array to the web service using an authenticated POST request. Those parameters are the current URL and the time stamp of the last update. The web service uses that information to determine whether there are new and relevant anchors or not. In the

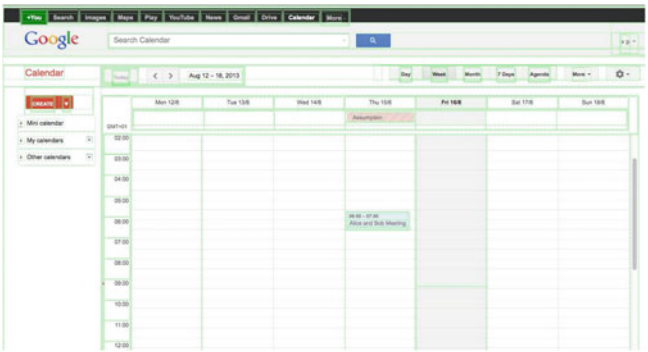

Fig. 6 Activated marking mode

positive case the anchors are returned. In Alice's case, nothing is returned since we have no marked elements.

What happens at the server with those data in detail? We use the time stamp of the last update and the current URL to create a query that receives only the corresponding anchors. Through a simple HTTP header authentication we know which user is getting access to the anchor data. It would be more an issue when having multiple users in different session in one Social Weaver context. However, such scenarios aren't covered in this thesis.

Matching Procedure When we use the term matching procedure it means that existing anchors are visualized to the user. Before every matching procedure, we assume that an update is triggered to ensure that the newest data is being used. Beyond the update procedure there is no need communicate with the server. When the user opens a new URL, it triggers the matching procedure. The plugin searches its local content whether there are some anchors for this URL. In a positive case the content is visualized to the browser view. At this point Alice would receive nothing from the plugin since no anchors exist for www.cal.google.com. The way in which anchors are retrieved from the plugin is quite similar how it is done at the back end. The major difference is that we do not use any time stamps at this time. There is no need for that since we assume everything is up to date after the update procedure.

Scenario Execution Now that we learned about the two sub-procedures, we are able to start with the actual scenario. First step is going to be that Alice weaves a comment box to an appointment. Alice enters www.cal.google.com which first of all triggers an update. Afterwards potentially new anchors would be displayed in the browser—which is not the case right now. Now Alice is able to mark an appointment—see Fig. 6. By clicking an element, she appends a comment box. In the background, the plugin runs the script or scripts that are related to the URL to define an identifier for the element. Using this identifier, the content-data for the comment box and the current URL the plugin creates a message in JSON format and passes it to the server.

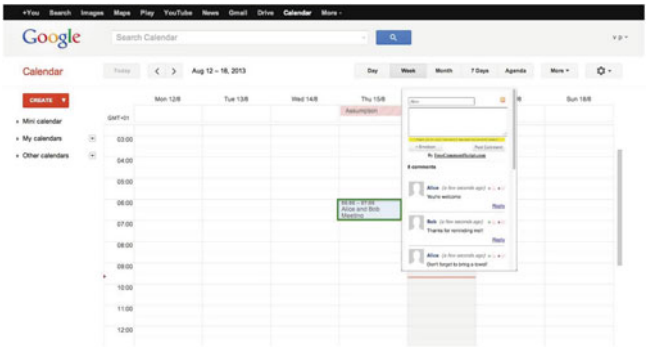

Fig. 7 Comment box woven into Google Calendar

The content for the comment box in this case is just a link. We use an external comment system that is injected as HTML code. The message is passed as an authenticated POST REST request. The web service performs some checks before the anchor is persisted. For instance, it could be the case that there is already an anchor for exactly this element (because another user created one in the meantime or the element identifier is not unique in this context). In our scene, everything works out fine and the web service stores the new anchor in the PostgreSQL database. The web service returns a positive status code to the plugin. This again triggers the previously discussed update and matching procedure. Alice sees her comment box attached to the appointment after it is persisted on the server. It is not possible that the plugin creates locally new anchors that do not exist on the server. Finally, it is possible for Alice to use the comment box. This step is very simple. As we already mentioned the comment box is an external service that is only injected by a link into our system. Therefore, Alice can add a comment without any consequences to our system at all.

Now it is Bobs turn. This process is quite similar and partially redundant to what happened when Alice created the anchor. For that reason we do not go into detail like we did for the first step. Bob opens the Google Calendar website, which triggers the update and matching procedure for this URL. Since there is an existing anchor now—Bob's plugin receives the data for displaying the comment box entered by Alice—see Fig. 7.

The last two steps are getting more interesting again. We simulate a evolution of a website that destroys our anchor mechanism. That can happen very easily depending on the type of script we are using or how fast the webpage evolves. What we do is to modify the element identifier directly in the database. This way it becomes impossible to match this anchor for the given URL. So Alice visits her calendar to check whether Bob has reacted to her reminder. Again an update and matching procedure is started. The update works seamlessly, but an error occurs while the matching progresses. The plugin runs the script to determine the element that belongs to the element id—but with no success.

For that case, the plugin enables Alice to re-link the content to the correct element or as in this case-appointment. The plugin performs the two following steps. First, a new anchor element is created which is basically a copy to the old one but with a correct element-id. This step is identical to the above-described procedure when Alice weaved the comment box into an appointment the first time. Then, we need to remove the broken anchor from the server. This is done by sending a remove REST request to the server including the old element identifier. After these steps are finished, it is necessary to run the update and matching procedures again. Now Alice and Bob are able once again to use the comment box. Re-linking an anchor does not necessarily has to be due to an error or web page evolution. For instance, if Bob changed the time of the appointment—the anchor would not work either. In this case, a re-link would solve the problem as well.

6 Further Work

Social Weaving can be extended with a workflow support. Since some problems with user interfaces appear only in certain situations that depend on the workflow context it would be a helpful feature to keep track about this information. Our intended approach is to reuse the code of the capture-and-replay component of an open-source test tool for this purpose. In addition, it would be interesting to go deeper into the idea of an automatic script generator. Instead of the user thinking about the architecture of the web environment, it is be possible to determine the needed information automatically. This would be a great acquisition, since no manual configuration for new environments would be necessary.

7 Related Work

Aspect-oriented programming [22] is about maintaining crosscutting concerns as capsules and weaving them into otherwise existing code. Our weaving of software feature directly corresponds to weaving aspects in aspect-oriented programming. In our approach, the features are distributed by the end-user, not the programmer, because we follow an end-user approach.

The reverse engineering tool Revangie [12, 14] inspects the website generated code, i.e., it is source code independent. Furthermore, not only static web sites are maintained but also dynamic ones. Revangie has a complex way of analyzing web sites. It is using the form-oriented user interface model [13], which is a graph that contains all information about the pages and additionally relationships between server-side actions and pages. Revangie addresses many problems that Social Weaving has to deal with as well, e.g., issues like screen classification or targets identification. The main difference to Social Weaving is that the whole web site code is analyzed.

The platform Platform for Education of Actual Software Engineering (PEASE) [15] is a domain-specific example of an application design that thoroughly combines process automation with social software features.

8 Conclusion

We have presented an approach of enterprise application integration by means of a concrete technological vision. The presented technology, the Social Weaver platform, enables the end-user to weave social software features into existing ERP system at the outermost tier of user dialogs. This way the technology yields a yet missing piece in the enterprise application integration puzzle. We have explained the architecture and realization of the platform and have discussed its usefulness in terms of concrete use cases.

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A Generic Model for Selecting an ERP Implementation Strategy

Enzo F. Berger

Abstract The different ERP implementation strategies are presented and examined to see whether they meet the criteria for an ERP implementation strategy. Factors, which affect the selection of an ERP implementation strategy, were introduced. The factors were grouped into classes according to their effect. Finally, the influencing factors were combined to a generic model on the basis of their effect on the selection of ERP implementation strategies.

Keywords ERP implementation strategies · Big bang · Step-by-step · ERP rollout · ERP implementation planning

1 Introduction

Due to the high complexity of Enterprise Resource Planning (ERP) systems, the failure rate of ERP implementation projects ranges between 40 and 60 % [1]. Hence, successful ERP implementation is an imperative issue in the field of ERP systems. There are many articles in which ERP implementations are discussed, but to be aware of these implementation strategies and to choose the most convenient one is difficult. Therefore, in this article, a generic model is presented which combines the most common ERP implementation strategies. Based on the factors that influence the selection of an ERP implementation strategy, this should simplify the correct selection of an ERP implementation strategy for future projects. It also should further help ERP implementers to create a better understanding and to find the right ERP implementation strategy for each project.

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Table 1 Criteria for ERP implementation strategies

Influencing factors of strategies in its original meaning	Criteria for ERP implementation strategies
Selection of the battlefield	ERP system selection
Estimation of own strength	Estimation of own resources
Estimating the opponent's strength	Project scope or Project complexity
Recognizing the opponent's options	Best practice in ERP system
Recognizing one's own opportunities	Possibilities of tailoring

This article discusses and defines the terms necessary for this work based on existing definitions. The different ERP implementation strategies were introduced and examined to see whether they met the criteria for an ERP implementation strategy or not. Factors, which affected the selection of the right ERP implementation strategy, were introduced. The factors were grouped into classes according to their effect. Subsequently, the influencing factors were combined to a generic model on the basis of their impact on the selection of ERP implementation strategies.

Much of this work is based on literature and logical conclusions. The most common ERP implementation strategies were investigated and examined using scientific methods. In addition, a model was created based on the existing correlations. The missing correlations were supplemented through an executed online survey.

2 Principles

2.1 Terms and Definitions

In the following sections, the terms "strategy" and "generic" are discussed in detail and defined for this work based on existing definitions. The definitions were extended when the existing definitions were ambiguous or inadequate.

2.1.1 Strategy

The term strategy has its origins from ancient Greece and is composed of the two words "stratos" = army and "agein" = guide together [2]. Due to the complex development of the concept of strategy, it is no longer possible to capture a clear definition [3]. Therefore, its definition has been based on the initial target - to conduct an army in a battle. In this case, five factors have been found which affect the selection of a strategy in its original meaning, shown in Table 1. These five factors were subsequently transferred to the introduction of an ERP system and

therefore, equivalent ERP factors were found for these five factors. Table 1 shows the strategy factors and their ERP equivalents.

The criteria shown in Table 1, was used in the first step to verify or falsify each ERP implementation strategy. It has to be mentioned, that the criteria in Table 1, which was derived from the original meaning of strategy, was later confirmed through the different findings from literature as influencing factors.

2.1.2 Generic

The term "generic" comes from the Latin word "genus", which means origin, ancestry, sex, or family [4]. In this sense, "generic" describes not only the properties of a single object, but it also refers to a family or class of similar objects [5]. It points to a higher category or hierarchy level of each of the derived objects.

In the specific case of this work, the term "generic" is used in connection with the term "strategy". A generic strategy therefore means a strategy which is the origin of all sorts of strategies or rather includes all these strategies.

2.2 The ERP Implementation Strategies

When implementing a new ERP system, the right implementation strategy is as important as the selection of an appropriate system [6]. An ERP implementation strategy defines how a system is implemented. Different companies may implement an ERP system in many different ways [7]. In literature, there are several different fundamental approaches to an ERP implementation strategy. A short introduction of the most common strategies is as follows:

1. Bancroft and Welti [8, 9] viewed the ERP implementation from a roll-out perspective and found five different strategies as follows:
   - The Big Bang approach installs all modules of the ERP system across the entire organization all at once.
   - The Step-by-Step or phased approach, implements one practical element at a time, in chronological order.
   - The parallel approach keeps both the inheritance system and the new ERP system active concurrently for a length of time.
   - The process line transition strategy breaks the implementation strategy so it is able to handle similar business process flows or product lines.
   - The hybrid approach is a combination of any of the implementation strategies such as the process line, phasing and parallel implementation strategies.
2. Dolmetsch et al. [10] in contrast, considered the implementation strategy from the perspective of Business Process Re-Engineering (BPR) and the integration

of Best Practice (BP) and found a process and information-system oriented approach. It has to be mentioned, that Dolmetsch et al. saw the information-system as a system with integrated functions and hence this approach can also be called the functional-oriented approach.

3. Hesseler and Goertz [11] tried to combine Welti's and Dolmetsch's approaches. In fact, they just added the functional-oriented and the process-oriented approaches to the Step-by-Step approach.
4. For Parr and Shanks [12] in turn, it seemed to be useful to categorize the ERP implementations. They found three categories, which depended more or less on the projects complexity.

   - Comprehensive: This category represents the most ambitious implementation approach. Typically, it involves a multi-national company which decides to implement an ERP in multiple sites often across national boundaries.
   - Middle-road: This category, as the name suggests, is mid-way between a Comprehensive and a Vanilla implementation.
   - Vanilla: This is the least ambitious and least risky implementation approach. Typically, the implementation is on one site only and the number of prospective system users is small (less than 100).

5. Finally, Rebstock and Selig [13] also used the perspective of BPR like Dolmetsch et al. did and hence, this can be seen as a refinement of the process-oriented approach. They found the following three strategies in their study of international ERP implementations.

   - De-centralized (local) analysis, modeling and implementation of country-specific business processes.
   - Centralized (global) analysis, modeling and implementation of country-specific business processes.
   - Coordinated analysis, harmonized modeling and implementation of country-specific business processes.

The ERP implementation strategies of the above featured authors were verified on the basis of the definition of strategy and examined to see whether they met the criteria of a full ERP implementation strategy or not. Ultimately, it was found that only the Big Bang and the Step-by-Step approaches met these criteria. The parallel implementation could only be verified as a security or mandatory option. The process line approach turned out to be a combination of the Step-by-Step and Big Bang approaches. The process-oriented approach and the information system oriented approach as well as the de-centralized, centralized and coordinated approaches, were all identified as part of a business strategy, as is explained in the next chapter. The categorization by Parr and Shanks and the strategy combinations of Hesseler and Goertz, could not be confirmed as strategies.

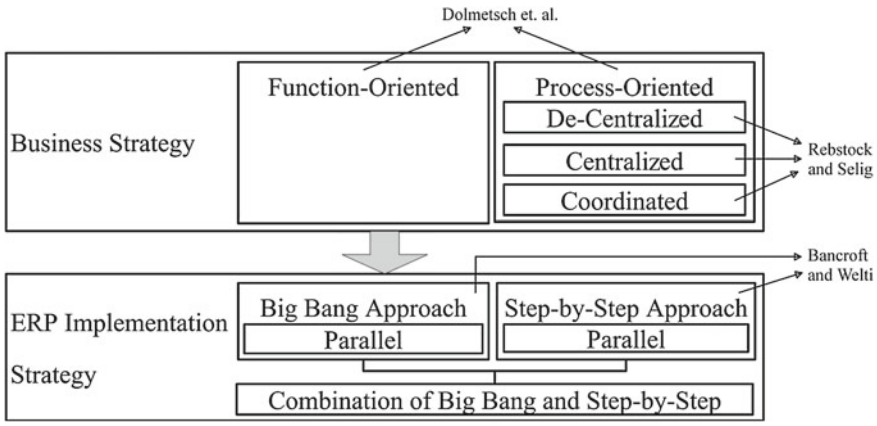

Fig. 1 Hierarchy of business and ERP implementation strategy

2.2.1 Hierarchy of Strategies

In the 1920s, when some of the largest firms in the US started pursuing a strategy of diversification, the hierarchical view of strategies emerged [14]. Hofer and Schendel propose four hierarchical levels of strategy. At the top, is the enterprise strategy followed in descending order by corporate, business and functional strategies [15]. It is important to realize that each level of strategy is constrained by the one above. It turned out that the ERP implementation strategy can also be seen as a subordinated strategy of a business strategy. This means that the motivation for an ERP implementation arises from a business strategy level and therefore a decision needs to be made at business strategy level whether a company wants to have a fast implementation with ready-made processes or to improve their processes with BPR. This decision usually goes hand-in-hand with the selection of an ERP system.

Figure 1 shows the business strategy with the function-oriented and the process-oriented approach according to Dolmetsch et al. and the distinction found by Rebstock and Selig.

The constraints of the business strategy on the ERP implementation strategy is symbolized by the arrow. The two ERP implementation strategies with the parallel sub-strategies were also summarized. As part of the strategy or option, the parallel approach was subordinate to both the Big Bang and the Step-by-Step strategies. Finally, the possibility of a combination of a Big Bang and a Step-by-Step strategy was depicted as a sub-strategy.

Table 2 Influencing factors on ERP implementation strategy

Direct-acting	Indirect-acting
Company size	
IS/IT strategy	
ERP system selection	
Resources (time, budget and HR)	Tailoring (BP, BPR und customizing)
Complexity (quality, PB, system integration)	System integration
	Tailoring (BP, BPR and customizing)
Risk (project risk, risk tolerance and budget)	Company growth → via Risk Tolerance
	Budget (financial risks)

2.3 Influencing Factors and Their Action

In the light of the definition of strategy, it is necessary to elicit the relevant influencing factors which influence the selection of an ERP implementation strategy. A distinction was made between direct-acting and indirect-acting factors. Indirect acting factors are those that act indirectly through other factors in the selection of the ERP implementation strategy.

Table 2 shows the influencing factors ranked according to their effect. The influencing factors of time, budget and human resources (HR) were combined together to form a class called Resources. The same was done with BP, BPR and Customizing.

2.4 Action and Interaction of Influencing Factors and Classes

The influencing factors were further investigated in terms of their interaction within each class and with other classes. A tension triangle was used to represent the interaction of the different factors within a class as shown in Fig. 2. The interaction of the factors in the resource class was represented by the time, cost and quality triangle of Elzer [16]. HR was substituted with time and budget because a lack of HR can be filled to a certain degree with time or budget. The tension triangles were connected by factors that are shared mutually.

3 The Generic Model

Subsequently, the Hierarchy of Business and ERP Implementation Strategy (Fig. 1) was used and expanded by using the interaction of influencing factors (Fig. 2), as shown in Fig. 3.

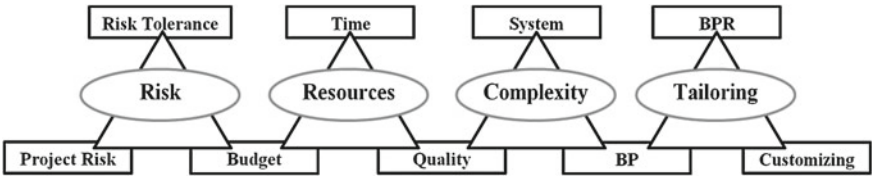

Fig. 2 Interaction of influencing factors

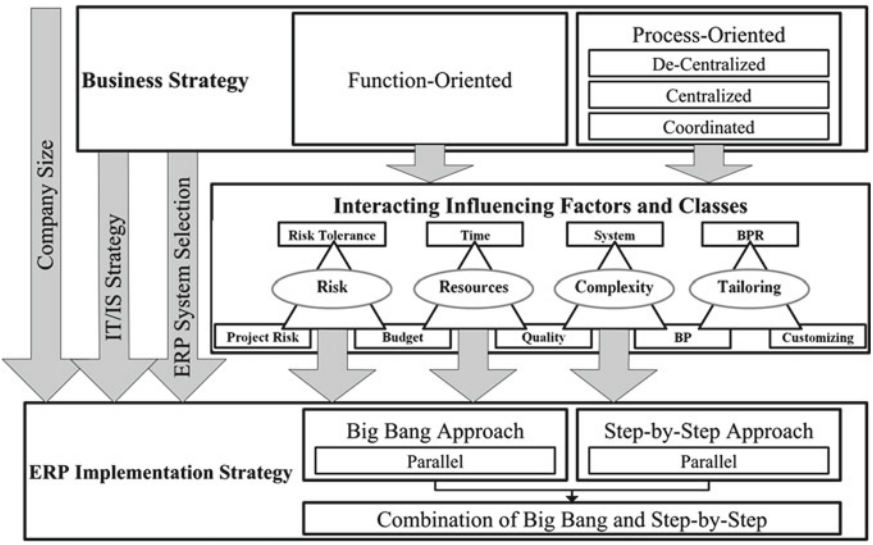

Fig. 3 The generic model

This new model now consists of the overall business strategy which is composed of function-oriented and process-oriented business strategies. This in turn, influences the information technology/information system (IT/IS) strategy, the ERP system selection and the influencing factors. While the IT/IS strategy and the ERP system selection act directly with the ERP implementation strategies, the remaining factors act via the influencing classes. Company size is an exception as it is neither affected by the business strategy nor by the influencing classes and acts directly with the ERP implementation strategies.

A generic strategy has been defined as a strategy which includes any strategy. In relation to ERP implementation, the model in Fig. 3, includes only the most common ERP implementation strategies and is therefore, still a proposal for a generic ERP implementation strategy model.

4 Conclusion

The most common ERP implementation strategies were presented and examined to see whether they met the demands of an ERP implementation strategy or not. The ERP implementation strategies were separated from the larger business strategies. As a result, a generic model was created that moved the function-oriented and process-oriented approaches from the ERP implementation strategy to the business strategy. The ERP implementation strategies were associated with the Big Bang and Step-by-Step strategies. The parallel implementation was classified as a subordinate strategy. Strategies such as the process line approach or hybrid approach were included as a combination of the Big Bang and Step-by-Step strategies. The influencing factors found, were ranked according to their combined effects, interaction and improved clarity in terms of the influencing classes of risk, resources, complexity and tailoring. Finally, the hierarchy of business and ERP implementation strategy was extended based on the influencing factors and influencing classes. The result is a generic model which can help find the right strategy for future ERP implementations.

4.1 Limits of this Work

A large part of this work was based on literature and logical conclusions. The most common ERP implementation strategies which were based on scientific methods were investigated and examined. In addition, a model was created based on the correlations found. An online survey supplemented missing information or correlations. However, there was no possibility to evaluate the featured model using empirical values. Therefore this remains open for future research.

4.2 Issues for Future Research

- Use of the model in a real-world scenario.
- Analysis of weaknesses of the proposed model.
- Factors from BPR that could influence the selection of ERP implementation strategies.
- Quantify the individual factors of the generic model.
- Demonstrate the usefulness of the model in a simulation.

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Integrated Campus Portal

Martin Plümicke

Abstract In this paper we describe the campus-portal which is established at the Baden-Wuerttemberg Cooperative State University. The bases of the portal is MS-SharePoint. In the portal all central administrating systems, as student administration, evaluation, customer relationship, alumni-management, eLearning and reporting will be integrated soon. Furthermore we will describe a process-management, which will be realized by the workflow-component of SharePoint using functions of different central systems in one process.

Keywords IT-strategy of universities · Portal · MS-sharepoint

1 Introduction

The Baden-Wuerttemberg Cooperative State University (DHBW) was founded in 2009 and accrued from eight educational-facilities, which were called Berufsakademie. In the year 2009 they were converted into one university.

As there are many different structures, especially IT-structures, it is a challenge to harmonize them.

At the moment there are three central software systems. There is one integrated system, named DUALIS,[1] to administrate the basic claims data of the students, the lecturers and the companies,[2] the resource planning of lecturers and premises, the

[1] Campusnet, Datenlotsen Hamburg.

[2] At the DHBW all students are additionally members of a company, where they make their internships.

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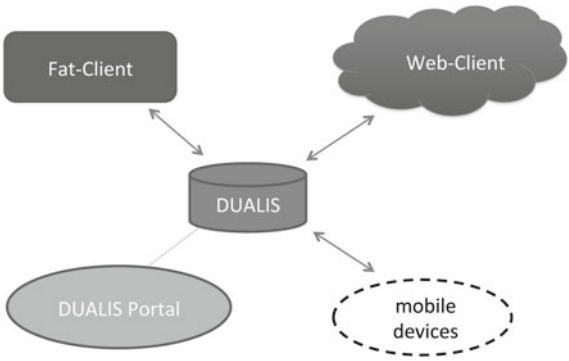


Fig. 1 DUALIS architecture

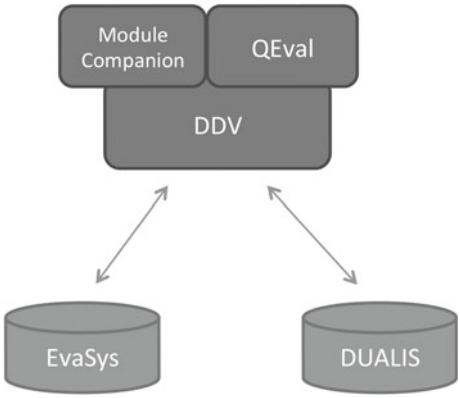


Fig. 2 Dualis Data Visualizer

timetable planning, the administration of all exams and the credentials. DUALIS has a rich-client, which allows to use all functions of the system. This client is only in a few parts configurable for different groups of staff. Additionally, there is a web-client for some self-service functions for students and lecturers. In Fig. 1 the architecture of DUALIS is presented. Beside the rich-client and the web-client there is a *portal-client*. This client is in development and should integrate DUALIS into the SharePoint (cp. Sect. 5.1).

A further system EvaSys[3] is used for the student evaluation. The client of EvaSys is a web-client.

For the reporting an in-house development tool is used, which is called **D**ualis **D**ata **V**isualizer (DDV). The tool bases on jreport.[4] At the moment reports of the DUALIS database and the EvaSys database could be used by DDV. The client of DDV is a Java rich-client. For the DDV-architecture compare Fig. 2. There are two applications, which use DDV. On the web-site of the university the module

[3] Electric Paper Evaluationssysteme GmbH.

[4] Jinfonet Software.

companion is presented, where the data base is in DUALIS. Additionally an application *QEval* uses the data from DUALIS and EvaSys to generate automatically evaluation reports.

Two additional central systems are prepared to be introduced soon. On the one hand a CRM-system MS-Dynamics will be introduced. In the CRM-system three groups of customers will be administrated: potential companies for the student's internships, potential part-time lecturers and student applicants. The client of MS-Dynamics is also a web-client.

On the other hand an alumni-tool will be introduced. The university decided to use the alumni-tool of the company Datenlotsen, which is implemented as a part of MS-SharePoint.

In the future some more central software systems should be launched. At the moment an e-learning strategy is developed. Probably, Moodle[5] will be selected as the standard e-learning tool for the DHBW. Then a central instance of Moodle will be implemented. Moodle has also a web-client.

Finally, a central email-tool will be established. The tool will be MS-Outlook as the client and MS-Exchange as the server. Microsoft offers two different clients. There is a rich-client and a web-client.

Additional MS-SharePoint is introduced as the software for the DHBW-portal. At the moment only the communication functions of SharePoint are used. The central intranet and intranets for all locations are implemented on the SharePoint platform. Additionally there is a interchange platform for all central boards and some informations as laws and contact persons are presented.

The paper is structured as follows. In the second part the portal strategy is described, the Sect. 3 is about identity management in a shared organisation for central systems. After that we give the different possibilities which offers SharePoint to integrate other web-clients. In the Sect. 5 we describe our integrated systems and in the Sect. 6 we present the process-management using different systems. We close by a summary.

2 The Portal Strategy

The main goal of our strategy is that the user from the university can reach all central IT-systems from one account on one platform. For this all presented central application should be integrated to the portal. In Fig. 3 the DHBW campus-portal with a central login is presented. On the right side the standard functions of SharePoint are realized. The blue colored parts show the applications that are being integrated in 2014 and 2015. The reporting system should be realized in 2015 too, Moodle and Outlook will follow.

[5] eLeDia—E-Learning im Dialog GmbH, Berlin.

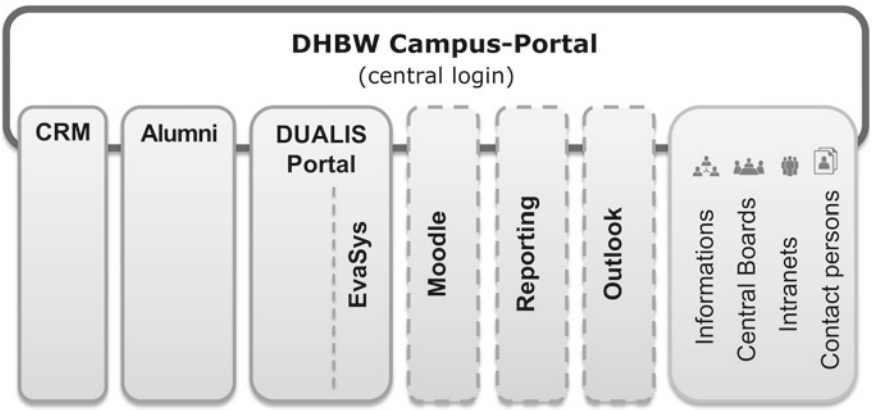


Fig. 3 DHBW Portal

3 Identity Management

Identity management describes the management of user data and defines the authentication and authorization to the systems. Normally each identity is mapped to exact one person, but a person can have several identities. More and more organisations tries to reach a one-to-one relation user to identity. This means that the user has only one password for all systems and in all systems the attributes of them are the same.

In the case of DHBW all 12 campus are responsible for their identity management. Therefore it is a challenge to guarantee authentication and authorization for the central systems. This is a typical situation for universities. In our context the locations are the de-central organisation-units, while faculties are comparable the de-central organisation-units for other universities.

3.1 Active Directory Federation Service (ADFS)

In [1] the ADFS is described in general and the integration with SharePoint technologies: *ADFS provides an identity federation solution for organizations looking to share identity information with their partners in a secure manner.* In our situation not the partners, but the locations share identity information. ADFS works like this: If a user of the organisation-unit **B** wants to login to a web-application of the organisation-unit **A** the ADFS of **A** sends a request to the ADFS of **B** to authenticate the user.

Furthermore ADFS allows single sign-on, which means, that a user needs not to authenticate them multiple for using different web-applications.

4 Possibilities of SharePoint Integration

In Jose Barreto's Blog [2] nine different kinds of integrating SharePoint with other web-applications are presented. We will look in detail on three of them, which are used in our portal.

4.1 Link

A simple way to integrate one web-application to another is providing a link. In combination with the single sign-on of ADFS this could be a an integration, where the user do not feel leaving one applications and entering another application. The realizisation is very simple.

4.2 IFrame-Integration

An IFrame is a HTML-element which allows to display a web-site in another web-site. IFrame-integration in combination with single sign-on via ADFS allows to present multiple web-applications in one web-site. Adversely, often the screens are too small to present the complete application and the look and feel of the systems differs often.

4.3 Web-Services

The W3C consortium describes a web-service 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 web-service 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* [3].

Another approach are the REST(ful) web-services. REST (Representational State Transfer) is no standard itself. It is an architecture style, which uses URI's (Uniform Resource Identifier) to identify the resources and the methods of http to send messages.

In the framework of SharePoint web-services could be used to call functions of different applications.

In combination with the workflow features this becomes a powerful tool. We will call this the *Workflow-integration*.

4.4 Workflow-Integration

As functions of different applications can be called by web-services, in SharePoint workflows can be modelled with functions of different applications. This means that it is possible to define workflows over different systems, such that the user knows only the process, but not the concrete system, which is used.

5 Integration of Different Systems into the Campus-Portal

In the following we will describe the integration of our central systems into the portal. This means for the users that they can use all system in one framework.

5.1 Integration of DUALIS and EvaSys

The standard web-client for students and lecturers (cp. Fig. 1) is integrated into SharePoint by an IFrame-integration. It is offered by the company Datenlotsen as the so called Portal+-license. This is the base of the DUALIS integration into SharePoint.

Additionally, an integration of the most important processes of studies und teaching into the portal will be done. The integration is done as a workflow integration. For this all processes of studies und teaching are modelled in a process companion [4]. In the appendix a cutout of the process "*planning of lessons*", is presented. Altogether 52 processes are identified.

Ten process groups are selected to integrate them into the portal:

No.	Process	User
1	Planning courses	Head of department, secretary
2	Course evaluation (with EvaSys)	Head of department
3	Students enrollment, exmatriculate and grant students leave absence	Secretary
4	Relations administrating (students ⇔ companies)	Secretary
5	Fees administrating	Administration
6	Remission fees	Administration
7	Recoveries of amounts verifying	Administration
8	Salaries und contracts accounting	Administration
9	Grates typing and unblocking	Lecturers, secretary, head of department
10	Transcript of records, credentials providing	Secretary

These processes will be implemented as SharePoint workflows. The basis of this implementation is the process modelling in [4]. The important benefit in comparison to the rich-client is that the SharePoint-client offers a workflow driving. This means that the staff need not to know the correct sequence of the process steps. They are driven by the system.

5.2 Integration of CRM

The CRM-tool MS-Dynamics has a web-client. Therefore we will realize a standard integration as an IFrame-integration. This means, that all functions of MS-Dynamics can be used in the portal and the look and feel is the same as in MS-Dynamics itself. For the start of CRM no additional authentification is necessary as CRM is integrated by ADFS into SharePoint.

Additionally, three CRM-processes will be integrated by workflow-integration.

No.	Process	User
11	Administration and acquisition of partner companies	Head of department
12	Administration of lecturers	Head of department secretary
13	Students recruitment (exchange platform)	Head of department partner companies

Furthermore, will look more detailed into the process 13: *Students recruitment (exchange platform)*. As at the DHBW a student is selected by the company, where the student makes his internships, and not by the university, we will offer an exchange platform to bring students and companies in contact. If a study contract come about between Student and company the data are automatically copied to the system DUALIS. This automatical process brings a great benefit for the university administration.

5.3 Integration of Alumni

The company Datenlotsen offers an alumni-tool as an extension of DUALIS. We decided to use this tools. The great benefit is that the process of exmatriculate a student is extended to the transfer process to become an alumni. For this some protection of data privacy must be considered.

The implementation of the alumni-tool is done in SharePoint, such that no technical integration is necessary.

5.4 Integration of Reporting

Our in-house development tool DDV should also be integrated into the portal, as many processes include the generating of different reports.

In the specification of DDV the requirement was given, that all functions has to be callable as a web-service. Therefore the integration of DDV could be done in an easy way.

5.5 Integration of Moodle and Email

Similar as the CRM integration Moodle and MS-Exchange will be integrated as I Frames, as there are standard web-clients, respectively. For some processes also a workflow-integration is planed. Especially for the interaction of CRM and Exchange it is very interesting to use a workflow-integration, e.g. for the recruiting processes, which includes email-campaigns.

6 Workflows Using Functions of Different Systems

In the final step the portal Should offer workflows of functions of different systems. This means that the user does not know exactly, which is the used system.

As an example we consider again the process of *course planning*. The process ends by the function *make course public* (Lehrveranstaltung veröffentlichen). If EvaSys and Moodle are integrated two things should be done, additionally. First the course in EvaSys should be generated. This means that an evaluation for the course could be done by the students. Additionally a moodle course room should be activated. As in our university normally presence courses are offered, the lecturer should be asked, if a moodle course room should be activated. If the lecturer answers *yes*, the workflow activates the moodle course room and registers the corresponding students, automatically.

The greatest benefit of the portal integration of different systems is, that the user needs to register only once and then the user can work process-oriented. He does not know which system is necessary to do a step of the process. The workflow engine drives the user through the process and the user do not notice which system is used.

7 Lessons Learned

It is very important especially for large universities to have a strategy for the central IT–systems. As nearly all central system *campus management*, *evaluation*, *e-learning*, *intranet* and *alumni management* have shared datas, the corresponding systems should be adjusted. Besides the common data management, the integration of the clients has a great benefit for the users.

At universities often different systems are introduced at the different faculties. It is a great challenge to harmonize these systems, as the users are accustomed to use theirs own systems and every new system has beside many advantages also disadvantages in comparison to the old one. It is important to assure users in processes of change. If this is disobeyed, often the IT-projects fail.

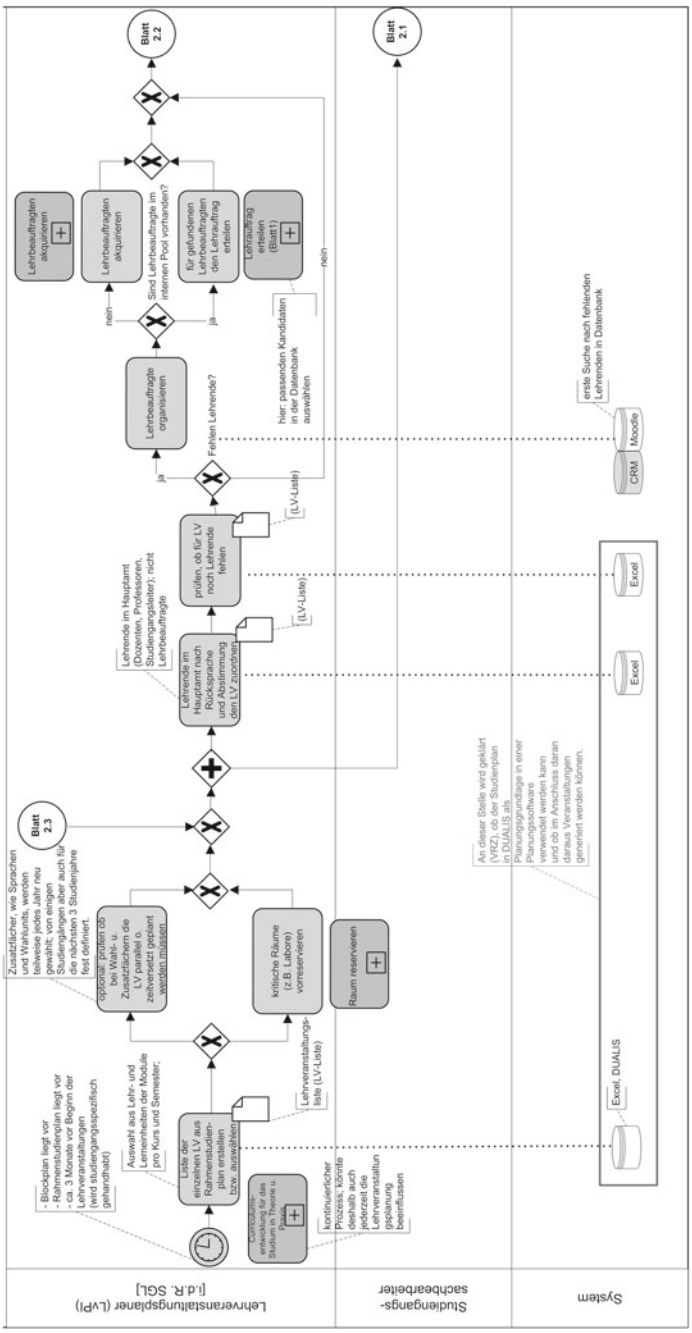
8 Summary

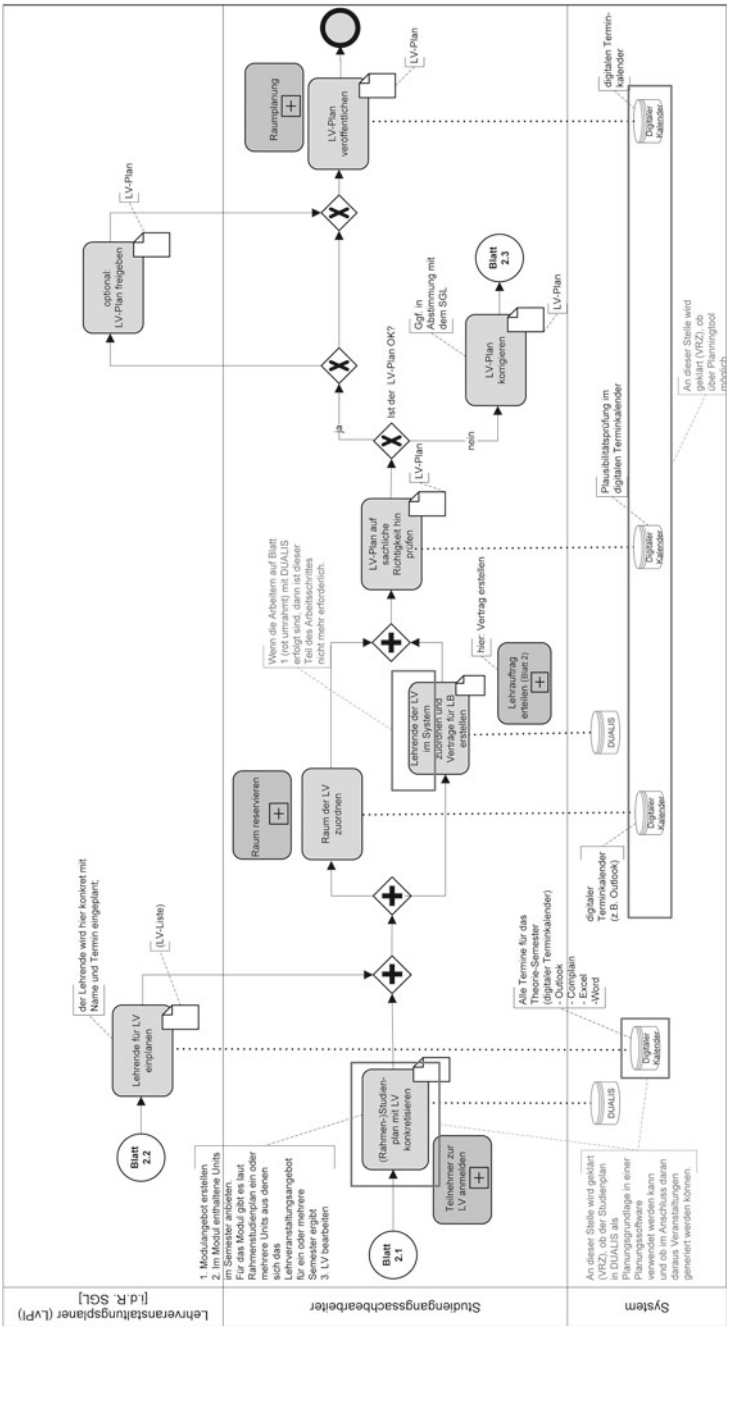
In this paper we presented a campus-portal on the bases of SharePoint. All central systems for the university administration, as student administration, evaluation, customer relationship, alumni-management, eLearning and reporting are integrated into the portal. For the staff this is a great benefit as they need only one application to use all systems.

Additionally we described the implementation of some workflows, which uses different system. This means that the staff can work process-oriented and not system-oriented.

Appendix

Processdocumentation: Planning courses


Lehrveranstaltungsplaner (LVPl) [i.d.R. SGL]
Studiengangs-sachbearbeiter
System
Blatt 2.3
Blatt 2.2
Blatt 2.1
Zusätzlicher, wie Sprachen und Wahlunits, werden teilweise jedes Jahr neu gewählt, von einigen Studiengängen aber auch für die nächsten 3 Studienjahre fest definiert.
- Blockplan liegt vor
- Rahmenstudienplan liegt vor
- o.ä. Konzept für Lehrveranstaltungen (wird studiengangsspezifisch gehandhabt)
Auswahl aus Lehr- und Lernenheiten der Module pro Kurs und Semester;
Liste der einzelnen LV aus Rahmenstudien-plan erstellen bzw. auswählen
Lehrveranstaltungs-liste (LV-Liste)
Konzeption entwicklung für das Studium in Theorie u. Praxis
kontinuierlicher Prozess; könnte deshalb auch parallel zur Lehrveranstaltun gsplanung beeinflussen
optional: prüfen ob bei Wahl- u. Zusatzfächern die LV parallel o. zeitversetzt geplant werden müssen
kritische Räume (z.B. Labore) vorreservieren
Raum reservieren
An dieser Stelle wird geklärt (VRZ), ob der Studienplan in DUALIS als Planungsgrundlage in einer Planungsversion verwendet werden kann und ob im Anschluss daran daraus Veranstaltungen generiert werden können.
Excel, DUALIS
Excel
Excel
Lehrende im Hauptamt (Dozenten, Professoren, Studiengangsleiter); nicht Lehrbeauftragte
Lehrende im Hauptamt nach Reihenfolge und Absimmung den LV zuordnen
(LV-Liste)
prüfen, ob für LV noch Lehrende fehlen
(LV-Liste)
Fehlen Lehrende?
ja
Lehrbeauftragte organisieren
hier passenden Kanddaten in der Datenbank auswählen
nein
Sind Lehrbeauftragte im internen Pool vorhanden?
nein
ja
Lehrbeauftragten akquirieren
Lehrbeauftragten akquirieren
für gefundenen Lehrbeauftragten den Lehrauftrag erteilen
Lehrauftrag erteilen (Blatt1)
erste Suche nach fehlenden Lehrenden in Datenbank
CRM
Moodle


Lehrveranstaltungsplaner (LVPl) [i.d.R. SGL]
Studiengangsachbearbeiter
System
1. Modulangebot erstellen
2. Im Modul enthaltene Units im Semester anbieten. Für das Modul gibt es laut Rahmen-Studienplan ein oder mehrere Units aus denen sich das Lehrveranstaltungsangebot für ein oder mehrere Semester ergibt
3. LV bearbeiten
Blatt 2.1
(Rahmen-)Studien-plan mit LV konkretisieren
Teilnehmer zur LV anmelden
Alle Termine für das Theorie-Semester (digitaler Terminkalender) exportieren
- Comma
- Excel
- Word
Digitaler Kalender
DUALIS
An dieser Stelle wird geklärt in DUALIS ob Studienplan in DUALIS als Planungsgrundlage in einer Planungssoftware verwendet werden kann und ob im Anschluss daran daraus Veranstaltungen generiert werden können.
Blatt 2.2
der Lehrende wird hier konkret mit Name und Termin eingeplant:
Lehrende für LV einplanen
(LV-Liste)
Raum reservieren
Raum der LV zuordnen
Lehrende der LV im System zuordnen und Verträge für LB erstellen
Wenn die Arbeitem auf Blatt 1 (rot umrahmt) mit DUALIS erfolgt sind, dann ist dieser Teil des Arbeitsschrittes nicht mehr erforderlich.
hier: Vertrag erstellen
Lehrauftrag erteilen (Blatt 2)
LV-Plan auf sachliche Richtigkeit hin prüfen
LV-Plan
digitaler Terminkalender (z.B. Outlook)
Plausibilitätsprüfung im digitalen Terminkalender
Ist der LV-Plan OK?
ja
nein
LV-Plan korrigieren
Ggf. in Abstimmung mit dem SGL
Blatt 2.3
LV-Plan veröffentlichen
Raumplanung
optional: LV-Plan freigeben
digitalen Termin-kalender
An dieser Stelle wird ggfs. der LV-Plan über Planningtool möglich.

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Part X
Public Sector

Public Sector Performance Management: Evaluating the Organisational Outcome of a Business Intelligence Based Budget Information System in the Context of a Federal Ministry

Philipp Otto and Norbert Schlager-Weidinger

Abstract The implementation of Business Intelligence (BI) systems is often seen primarily from the technical point of view. The target outcome often only comprises reports and performance indicators, without considering organisational impacts. This case study has the aim to expose the additional value of implementing a BI-system by considering technical and organisational structures in the present as well as future implications. The implementation of a Business Intelligence based budget information system in Austria's Federal Ministry of Science and Research induced, beside the technical results, an organisational change of budget planning and controlling as well as a new way of thinking was introduced.

Keywords Data warehouse · Budget planning · Intelligence based budget information system · Federal organic budget act · Budget component · Budget planning and controlling · Public sector · Business intelligence based budget

1 Introduction and Background

Regarding its activities and budget planning, public administration is often said to be input-driven, as well as backward-oriented and good governance seems to be impeded by volatile politics. To prove that matters can also be handled differently, Austria's Federal Ministry of Science and Research (FMSR) started a process of re-inventing its procedures and structures of budget and activity planning to meet

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DOI: 10.1007/978-3-319-07055-1_21,

the prerequisite of New Public Management and achieve a leading position among the Austrian ministries.

1.1 Demand for New Mindset

Before the implementation of the Budget Information system (BIS) within the FMSR took place there had been many unverified processing steps, with a lot of feedback-loops during the budgeting. Knowledge sharing was difficult because the data was stored decentralized. Long-established procedures were rather rethought and even less improved due to non-transparency.[1]

The efforts for improvement were supported by the Austrian Federal Budget Reform (AFBR).[2] The action is influenced by the notions of New Public Management, introducing several deep changes in the way federal budgets are planned, controlled and managed. The new principle "Every minister his/her own finance ministry" with more flexibility for the line ministries[3] forms the background for the BIS-project.

This re-evaluation of the ministry's goals and how they are intended to be reached are not only a matter of reacting to a diminishing budgetary scope. This also intends to deal with the challenges of a stronger outcome-orientation, which is also an implication of the Federal Budget Reform.[4] Due to the targeted outcome-orientation there has to be a clear definition of the organisation's objectives and actions. The need to answer the questions about the latter as well as to relate financial inputs with outcomes is another relevant factor for the project in order to define a clearer specification of the input-outcome-relations.

One of the biggest challenges emerged from the enacting of the Federal Financial Framework Act, which brought along the need for a 4 year medium-term expenditure framework.[5] As the budgetary needs in the field of scientific research are very often volatile and 1 year's plan can differ extremely from the next year's needs, there had to be a smart and software-supported solution for these special circumstances.

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[1] Meszarits, V., Seiwald, J. [3], p. 61 ff (for further information).

[2] Federal Organic Budget Act 2013—BHG 2013, Federal Ministry of Finance [2], (BGBl. I No. 139/2009).

[3] Steger [5], p. 155.

[4] Steger [4], p. 11.

[5] BHG 2013, Federal Ministry of Finance [2], Sec. 12 ff.

1.2 Demand for Transparency

Another precondition to be met was the creation of better transparency for all hierarchy levels. As the budgets are usually displayed in line items, there is often little understanding of the meaning of line items and budget allocation in the higher ranks. Due to this problem a new approach for planning and for the whole controlling cycle had to be found: the budget component as a new and understandable granularity for planning, controlling and forecasting, for the specialty departments can define their budgetary structure themselves, enforcing a huge democratisation of knowledge. Furthermore, a modern reporting scheme for spreading the information about budgets had to be implemented, now using state-of-the-art technology and an updated way of financial reporting. Before BIS was implemented, reporting used to be an ad-hoc matter.

1.3 Demand for a Smart Solution in a Cold Economic Climate

As the general economic climate has become rather rough these days and public budgets are constrained in many ways, there is the pressing need to tackle this issue in two ways: 1st, smart, concise and standardised processes for fast and transparent planning, controlling and forecasting of the budgets have to be implemented. 2nd, a new mindset about how budgets are spent, even about how to pave the way for a fundamental task review has to be created. This implies that creating a basis for discussion on strategic and operational planning, and going even beyond the needs for budgeting, became a second objective of the project.

1.4 Demand for Democratisation of Knowledge

Apart from the pressing issues introduced by the Federal Budget Reform there are some other needs entailed to be addressed by the BIS. Aside from the evident benefits of standardised, fast and transparent processes (especially for budgetary planning) there is the idea of a far-reaching decentralisation of information. Budgets are often seen simply as "given from above", so the identification with the budgets and the understanding of budgetary processes were affected, which is not the best precondition for a modern administration.

Furthermore, a need to improve the cost and activity accounting was recognised which should enable the delivery of proper management-relevant information. In this project, those fields of activity were dealt with and solutions could be found, bringing the cost and activity accounting much closer to the field of effective decision-making and turning budgeting into a major task for the specialty

departments. This clearly improves the quality of planning and forecasting and reduces budgetary inadequateness.

The underlying philosophy of the BIS is to enable the management level to use budgeting as a comprehensive tool with a control-function, not only with regard to monetary and other inputs, but primarily with regard to outputs and outcome relating to money spent in order to define clear processes of budgetary planning. Due to the speaking names of the budget components, a much more direct link between the resources spent and the impact on the system can be made visible.

2 Implementation

The implementation of the BIS represents a revolutionary approach within the Austrian public sector as, at the FMSR, a state-of-the-art standard software system was established, which allows a transparent, consistent and efficient high quality budget planning.

There were several success factors for the implementation. First of all, at an early project stage, the involvement of the whole IT department as well as key users of the BIS helped to design a novel system, which supports the needs of the ministry extensively. During the process the FMSR was enabled to increase in-house knowledge as well as to maintain and adapt the BIS for the future. So the autonomy of the ministry was supported and pecuniary resources can be saved in the long run.

Moreover, the open communication structure, which evolved from the integration of all key users and the implementation of training sessions, helped to improve problem-solving and ensures the efficient use of resources in this harsh economic situation. The project team implemented a perfectly fitting solution for the FMSR.

3 System-Architecture

In addition to classical Business Intelligence products for data analysis, the solution for FMSR is supplemented with significant data acquisition functionalities (see Fig. 1). The regularly performed data exchange between all components ensures the necessary data up-to-dateness. The master and transaction data is imported from three sources:

- SAP-HIS
- SAP-HV, includes all accounting information
- Additional data which is not available via the two previous systems is provided by Excel spreadsheets.

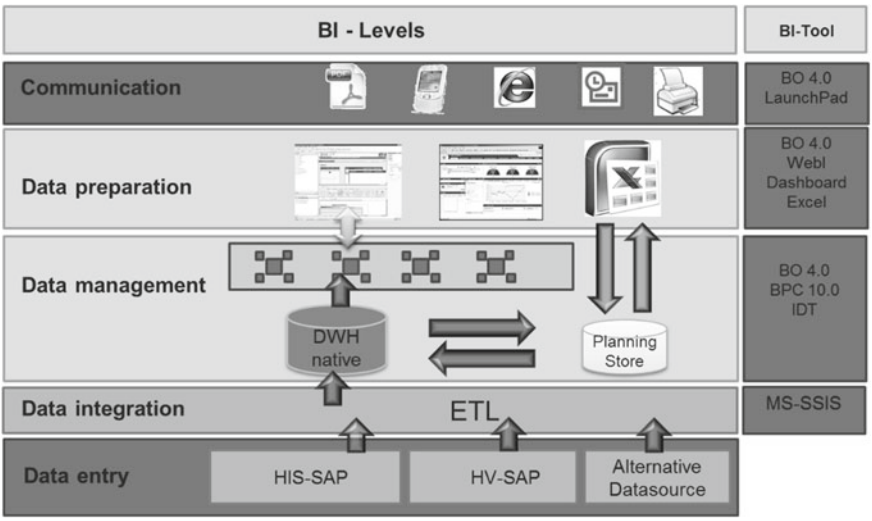

Fig. 1 BI layer model

The ETL process (Extract-Load-Transform) has been developed using Microsoft SQL Server Integration Services (MS-SSIS). It provides predefined processes for data integration, processes different data sources represented in the data warehouse (DWH) and forms the core of the data preparation.

The data management layer of the DWH is composed through a ROLAP technology. By means of the ETL processes, data from different sources is integrated into the DWH in a consolidated format to facilitate uniform data access. The Enterprise Performance Management tool (EPM 10.0) is the means to gather decentralised budget measures and descriptions from all departments. The EPM data exchange between the native DWH and the Planning Store is realised via MS-SSIS. Finally, the Information Design Tool (IDT) forms the underlying tables to a consolidated snowflake schema and guarantees consistent query-handling. The resulting object is called Business Object Universe and enforces the authorisation concept as well. Additionally, historical dataset-views are managed by the IDT.

The presentation layer consists of Business Objects analysis tools and MS-Excel with an EPM-plug-in. The latter is used during the budgeting process, whereas the former toolset is designed for complex reports. Web Intelligence (WebI) reports are used for standard and ad-hoc reports with detailed information. With the use of Dashboard Designer, clearly represented cockpits in Hichert notation can be achieved. Both tools have direct access to the DWH by using the Business Objects Universe (Fig. 2).

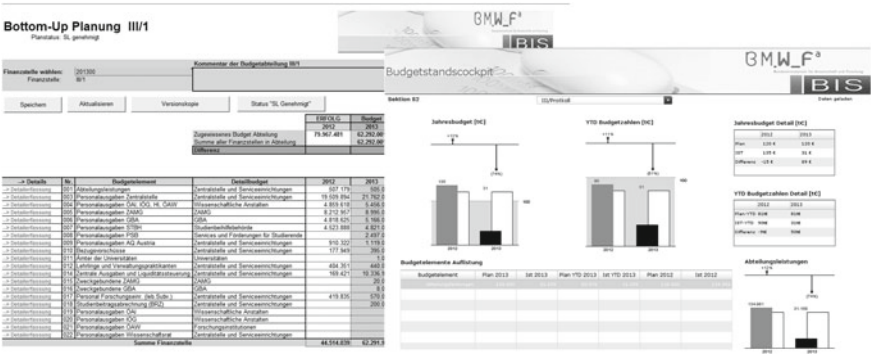

Fig. 2 Screenshots frontend

4 Results and Outcome

Listing measurable, quantifiable results of the project is challenging as a huge amount of, often also qualitative, outcomes were achieved through BIS.[6] However, the most important outcomes for the FMSR are listed in this section.

4.1 Improved Organisation

The biggest achievement was the implementation of a standardised process, which turned the previously complex budgeting process into a concise, decentralised and collaborative one.

Now it is possible to control the whole process through a centralised management process. This makes it easy to collect and spread data without much additional effort and reduces the necessary throughput time. Besides, the often countless loops of adjustments are reduced to just three transparent steps in planning, and completely new processes with focus on controlling and forecasting were introduced, which now deliver better data for steering the organization. Moreover, the system allows a contextual adaptation to fulfil future requirements (Fig. 3).

[6] Cf. Boselli et al. [1], p. 8.

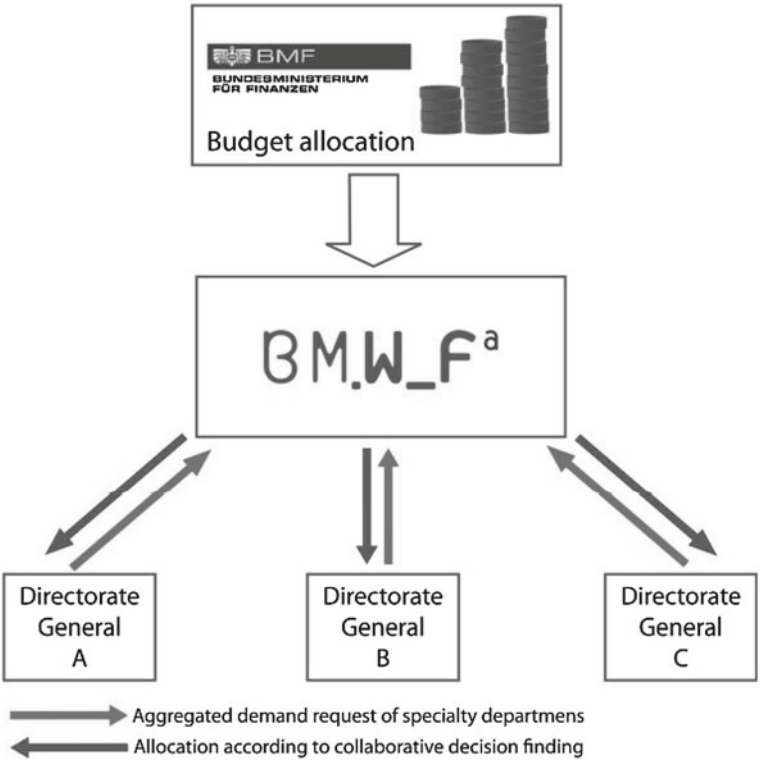

Fig. 3 Centralised management process

4.2 Increased Budget Quality

Due to the improved granularity of planning and the possibility of a business performance management the following advantages can be identified: The staff is much more involved in every phase of the budgetary cycle than before. The budgets become understandable even for people who are not familiar with budgetary law. This newly created understanding for budget makes it possible to unify the specialty departments' expertise on projects and tasks with the budgeting departments' specialised knowledge. Moreover, it enables an effective, efficient and outcome-oriented budget planning and leads to a new culture of participation with increased self-management.

The accuracy of planning has improved enormously, as the line items, which were hard to understand, have been transformed into well-known projects or programmes (the budget components). This brings planning closer to the relevant specialty departments as the substantial structure is disentangled from the fiscal structure. The budget components allow an innovative and fine-grained display of

the budget. This enables the FMSR, inter alia, to outline gender-specific programmes or projects and their pecuniary resources. Finally, the FMSR meets the requirements of the AFBR.

4.3 Increased Knowledge

Generally, there has been a boost in the interest in budgetary matters. Due to the project there are now standardised online-reports on planning and controlling. There is at least one report addressee in every specialty department receiving, inter alia, a monthly controlling report. Financial reporting is not the only result of the BIS-project. Also a new, wiki-based platform for several budgetary matters including contents like Federal Budgetary Law or outcome-orientation is implemented to strengthen and promote the intra-organisational knowledge not only about the project but also beyond that.

So the BIS strengthens the employees' skills by implementing an unprecedented culture of participation and an intra-organizational knowledge transfer.[7] Additionally, the personal responsibility in budgetary matters and identification with the own budgetary resources was generated.

4.4 Modern Technologies in Use

The implementation of a cutting-edge DWH as a Single Point of Truth with a planning and reporting tool allows business performance management and real-time fiscal surveillance. All the processes, the data model and the applications were designed in a way that neither the ministry's IT nor an external consultant has to be assigned to administrate the system or to implement new features—the solution can be operated independently by the budget department, which leads to reduced future costs and enhances the possibility of innovation.

4.5 Ensured Sustainability

With the BIS the FMSR implemented a state-of-the-art system, which makes adaptations easy in order to meet future requirements without changing the recently created standardised budget planning process. Due to the huge training efforts during the implementation the staff of FMSR is able to maintain and develop the system in-house. As a consequence of the continuity and accuracy of

[7] Cf. Boselli et al. [1], p. 6.

budget planning the FMSR gets independent from daily politics and cannot be influenced by individuals.

The BIS offers a unique solution in budget planning and controlling. Thus, the FMSR holds a pioneering role within Austria as it is a transferable system and can be seen as a best-practice solution for the whole public sector. Many quests of other ministries prove this idea and confirm that innovative solutions are possible—even in sensitive parts with a high public interest, like science and tertiary education.

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