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EMISA FORUM

Grußworte

Liebe Fachgruppenmitglieder,

Ich freue mich, Sie als Empfänger der neusten Ausgabe des EMISA Forums der Fachgruppe EMISA begrüßen zu dürfen. Der Höhepunkt in diesem Jahr war wieder das Fachgruppentreffen der EMISA, das am 24.-25. Mai 2018 in Rostock stattfand. Wir danken Michael Fellmann, Kurt Sandkuhl und Dirk Fahland, welche die Leitung übernommen und ein hervorragendes Programm zusammengestellt haben. Insgesamt wurden sechs PhD Proposals und elf Beiträge in der Kategorie Novel Research Directions vorgestellt. Zudem gab es weitere elf Vorträge über aktuelle Forschungsergebnisse. Unser Dank gilt auch Mathias Weske und Janis Stirna, die Keynotes beisteuerten.

Ein wichtiger Programmpunkt war in Rostock auch die Mitgliederversammlung, auf welcher ein neues Leitungsgremium gewählt wurde. Die vorgeschlagene Wahlliste wurde einstimmig angenommen. Somit wird das Leitungsgremium in den Jahren 2019-2021 aus folgenden Personen bestehen:

- Dr. Dirk Fahland (TU Eindhoven)
- Dr. Agnes Koschmider (KIT)
- Dr. Henrik Leopold (VU Amsterdam)
- Prof. Dr. Jan Mendling (WU Wien)
- Dr. Judith Michael (RWTH Aachen)
- Prof. Dr. Manfred Reichert (Uni Ulm)
- Prof. Dr. Ulrich Reimer (FH St. Gallen)
- Prof. Dr. Stefanie Rinderle-Ma (Uni Wien)
- Prof. Dr. Eric Proper (Luxembourg Institute of Science and Technology)
- Prof. Dr. Matthias Weidlich (Humboldt-Universität zu Berlin)

In die Riege der EMISA-Fachexperten rückt nach einstimmiger Wahl Hansjürgen Paul auf. Ich freue mich, dass ich weitere drei Jahre als Sprecher des Leitungsgremiums fungieren darf, und dass mir ab 3.1.2019 Agnes Koschmider als stellvertretende Sprecherin zur Seite steht. An dieser Stelle danken wir Stefanie Rinderle-Ma für Ihre Arbeit als stellvertretende Sprecherin in den vergangenen Jahren und Kristof Böhmer, mit dem sie gemeinsam das EMISA Forum betreut hat.

Im kommenden Jahr steht ein wichtiger Termin an: das 40-jährige Jubiläum der EMISA! Das nächste Fachgruppentreffen ist in Tutzing anberaumt. Es wird organisiert von Heinrich C. Mayr. Der Termin ist der 15.-17. Mai 2019. Bitte die Einreichungsfrist 15. Dezember 2018 vormerken. Weitere Infos sind bereits online unter https://ae-ainf.aau.at/EMISA2019/ abrufbar. Wir freuen uns auf ein tolles Geburtstagsfest in Tutzing!

Mit herzlichen Grüßen,

Jan Mendling
(EMISA-Sprecher)

EMISA'18 in Rostock

From May 24-25, the 9th International Workshop on Enterprise Modelling and Information Systems Architectures (EMISA'18) took place in Rostock/Germany. It was organized by Michael Fellmann and Kurt Sandkuhl (University of Rostock). An attractive full two-day programme was compiled comprising 28 presentations. Among them were two keynotes held by the renowned researchers Mathias Weske (HPI Potsdam) and Janis Stirna (Stockholm University). Whereas Mathias Weske addressed rethinking established BPM-concepts for case-oriented and decision-intense processes, Janis Stirna shared his experiences from facilitating and engaging participants in enterprise modelling initiatives. In addition, the program comprised 6 PhD research proposals, 11 novel direction talks as well as (again) 11 presentations of papers on existing research. Among the latter, the best paper from the BIS'18 was presented. Authors contributed from many countries, including Australia, Belgium, Netherlands, Austria, Sweden, Switzerland, Turkey and Germany.

Like in the previous year, the workshop attracted around 40 participants who contributed to lively discussions and fruitful exchange of ideas. Moreover, the participants also enjoyed two social events. The first took place as a get together in Rostock City before the first workshop day. The second took place at the end of the first workshop day and comprised a city tour combined with a walk to the restaurant near the city harbour. The dinner was sponsored by the EMISA expert group of the German Society for Computer Science and took place in a relaxed atmosphere in the restaurant “Zum alten Fritz”.

All in all, the organizers look back to another successful edition of the EMISA workshop. We would like to express our gratitude to all people that contributed to the successful event: The keynote speakers who contributed their insights, the presenters that shared their recent research and fresh ideas, Jan Mendling who supported the event from the side of the EMISA expert group and the local organizing committee for supporting us.

As an outlook to next year: The EMISA group will celebrate its 40th anniversary in 2019. For this reason, the EMISA 2019 conference will take place at the “Evangelische Akademie” in Tutzing, Germany (near Munich), the location of its inaugural meeting in 1979. We hope to see you all there!

Some Impressions from the EMISA-Workshop

Photos are kindly provided by Hansjürgen Paul.


EMSEA 2018
MAY 24–25

40 Years SIG EMISA: Digital Ecosystems of the Future: Methods, Techniques and Applications (EMISA 2019), Tutzing

https://ae-ainf.aau.at/EMISA2019

Call for Papers

For 40 years, the GI Special Interest Group on Design Methods for Information System (GI-SIG-EMISA) has been a platform for industry experts and academics to exchange and discuss the methodical aspects of planning, modeling, developing and running digital ecosystems. While terminology and buzzwords change, many of the questions raised when EMISA was founded still remain challenging, and many new questions came along over the years. The EMISA 2019 conference celebrates the 40 years anniversary of the EMISA conference series at the location of its inaugural meeting in 1979, the "Evangelische Akademie" in Tutzing, Germany (near Munich). Located beautifully right next to Lake Starnberg, the "Evangelische Akademie" links modern accommodation with a stunning scenery and features the fantastic "Rotunde" room which provokes lively and intensive discussions. The EMISA 2019 Conference Chairs invite original submissions not under review elsewhere: Full papers of a maximum length of 14 pages and short papers of 8 pages. In addition, we invite the research groups involved in GI-SIG-EMISA to present their current research and projects in an innovative exhibition. Short papers (max. 8 pages) of exhibitors will be published as well; a plenary "EMISA 2019 Madness" will allow each group for inviting the audience to its exhibition stand. The EMISA 2019 program will also feature keynotes by personalities who have substantially contributed to GI-SIG-EMISA in the past 40 years.

Topics

- Digital Ecosystem, Enterprise Architectures & Architectural Patterns
- Methods and Tools for designing and implementing Digital Ecosystems; Ontologies and Reference Models
- General Purpose and Domain-Specific Modeling Methods and Languages, Metamodeling; Method and Model Engineering

- Analysis, Evaluation and Quality of Modeling Methods, Models, Architectures, and Languages
- Model-Driven Development, Models@run-time, Model Centered Architecture
- Business Process Management and Enterprise Architecture Management
- Learning and Teaching Digital Ecosystem Design and Development and underlying Methods
- Applications and Best Practices
- Innovative Approaches to Digital Ecosystem Development

Important Dates

Submission Deadline	03 January, 2018
Notification	26 February, 2019
Final papers	17 March, 2019

Submission

All accepted contributions will be published in a volume of the Lecture Notes in Informatics (LNI) under a Creative Commons BY-SA 4.0 licence, see https://gi.de/service/publikationen/lni/. In addition, the EMISA 2019 Conference Chairs will recommend excellent submissions for fast-tracking to the open access journal, *Enterprise Modelling and Information Systems Architectures - The International Journal of Conceptual Modeling* (https://emisa-journal.org). Submissions have to comply with the LNI author guidelines described at https://gi.de/service/publikationen/lni/ and must be submitted via EasyChair: https://easychair.org/conferences/?conf=40yearssigemisa. Submissions exceeding the page limits or not complying with the author guidelines will not be not reviewed and desk rejected.

Chairs

Conference:	Heinrich C. Mayr, Stefanie Rinderle-Ma und Stefan Strecker
Panels:	Jan Mendling und Gottfried Vossen
Exhibition:	Agnes Koschmider und Matthias Weidlich

17th International Conference on Business Process Management (BPM 2019), Vienna, Austria

https://bpm2019.ai.wu.ac.at/

Call for Research Papers

The annual BPM conference is the premium forum for researchers and practitioners in business process manage-ment. BPM is a broad discipline, covering topics that range from formal methods in computer science, techniques in information systems engineering to management science methods. Therefore, not only different research topics are addressed, but also different research methods are employed that require different evaluation criteria in the peer reviewing process. To accommodate for this diversity, the BPM conference is structured into three tracks and the BPM Forum that cover not only different phenomena of interest and research methods but, consequently, also different evalu-ation criteria. Each track has a dedicated track chair and a dedicated program committee. The track chairs, together with a consolidation chair, are responsible for the scientific program. In this way, the breadth of the BPM community is represented and the BPM conference is positioned as a venue for all aspects of the broad BPM discipline.

Track I: Foundations

Track I invites papers that follow computer science research methods. This includes papers that investigate the underlying principles of BPM systems, computational theories, algorithms, semantics, and methods for modeling and analyzing business processes. This track also covers papers on novel languages, architectures, and other con-cepts underlying process aware information systems, as well as papers that use conceptual modeling techniques to investigate problems in the design and analysis of BPM systems. Papers in Track I are evaluated according to computer science standards, including sound formalization, convincing argumentation, and, where applicable, proof of

concept implementation, which shows that the concepts can be implemented as described. Since papers are not required to have an immediate application in concrete business environments, empirical evaluation is not required in Track I. Instead, papers will be evaluated on the basis of the soundness of the formalization and the degree to which the developed foundations permits new ways of modelling and/or analyzing BPM systems.

You should send your paper to Track I if:
• It provides foundational results about the underlying principles and concepts of BPM systems.
• It advances the state of the art in BPM through the investigation of formal methods and algorithms.
• It contributes to the definition of novel concepts, languages, and architectures for BPM systems.
• It tackles conceptual modelling issues of BPM systems and their environment.
• It investigates novel concepts of BPM systems through the development of proof-of-concept implementations.

Track II: Engineering
Track II invites papers that focus on engineering aspects of information systems research. The focus is on the investigation of artifacts and systems in business environments. Papers in this track are expected to have a strong empirical evaluation that critically tests criteria like usefulness or added value of the proposed artifact (for example by showing considerable performance improvements compared to past work). This track covers business process intelligence, including process mining techniques, and the use of process models for enactment, model-driven engineering, as well as interaction with services and deployment architectures like the Cloud. It also covers BPM systems in particular domains, such as digital health, smart mobility, or Internet of Things. Empirical evaluations are important to show the merits of the artifact introduced. Where applicable, artifacts should be compared to state-of-the-art in a reproducible manner. A self-critical discussion of threats to validity is expected. Formalization of problems and solutions should be used where they add clarity or are beneficial in other ways.

You should send your paper to Track II if:
• It has a significant engineering, systems or design contribution.
• Its results are empirically evaluated, preferably in a reproducible manner, e.g., using public datasets or public Cloud infrastructures.
• It reports on a system that you designed, with a maturity of at least a prototype, i.e., it can be evaluated in an application context.

Track III: Management

Track III invites papers that aim to advance our understanding of how BPM can deliver business value or competitive advantage, for instance by developing capabilities to improve, innovate, or transform organizations or to tackle the challenges and opportunities of digitalization. Papers that study process thinking, organizational routines, process innovation, and the application and impact of BPM methods and tools in use contexts based on empirical observation are highly welcome, too.

Areas of interest include a wide range of capability areas that are relevant for BPM, such as strategic alignment, governance, methods, information technology, and human aspects including people and culture. We seek contributions that advance our understanding on how organizations can develop such capabilities to achieve specific objectives in given (cross-) organizational contexts. Papers may use various strategies of inquiry, including case study research, action research, focus group research, big data analytics research, neuroscience research, econo-metric research, literature review research, survey research, or design science research. Papers will be evaluated according to management and information systems standards.

You should send your paper to Track III if:

- It tackles an organizational challenge/opportunity.
- It builds on and draws from real-world organizational endeavors in BPM.
- It extends the BPM body of knowledge to better contribute to strategy delivery.
- It advances our understanding and methodology of BPM to support digital innovation.
- It contributes to solving grand societal challenges through BPM.

Important Dates

Abstract submission:	1 March, 2019
Full paper submission:	8 March, 2019
Notification:	10 May, 2019

Remark: Deadlines correspond to anywhere on earth

Submission

Each paper will be submitted to exactly one track. Please use the track descriptions above to decide where to send your paper. Authors may contact track chairs for clarification. Papers must be formatted according to Springer's LNCS formatting guidelines. Submissions must be in English and must not exceed 16 pages. The title page must contain a short abstract clarifying the relation of the paper with the topics above. The paper must clearly state the

problem being addressed, the goal of the work, the results achieved, and the relation to other work. Student papers are treated as regular papers in the review process. Importantly, the contribution under-lying a student paper must be carried out mainly by the (PhD) student(s), but others (advisors, collaborators, etc.) can appear as authors as well. When submitting the paper, student papers must be clearly marked as such in the EasyChair system. To be eligible for the best student paper award, student papers have to be presented at the conference by a student author. Papers must be submitted electronically in PDF format via the BPM 2019 EasyChair submission site: https://easychair.org/conferences/?conf=bpm2019. Submissions must be original contributions that have neither been published previously nor submitted to other conferences or journals while being submitted to BPM 2019. Authors are encouraged to adhere to the best practices of Reproducible Research (RR), by making available data and software tools for reproducing the results reported in their papers. Accepted papers will be included in the conference proceedings published by Springer in the Lecture Notes in Computer Science series. For each accepted paper, at least one author must register for the conference and present the paper. Authors of selected papers will be invited to submit an extended version to special issues in Elsevier's Information Systems (Tracks I and II) and in Springer's Business & Information Systems Engineering (Track III). Innovative papers which has high potential of stimulating discussion at the conference but does not fully meet the quality criteria for the main conference will be invited for presentation at the BPM Forum. Those papers will be published in full length in a separate post-proceedings volume in the Lecture Notes in Business Information Processing series, as well as being presented during the main conference. There will not be short papers at the conference. First-time submitters to BPM may request to be considered for a pre-submission shepherding program in which a selected BPM PC member advises on the presentation and positioning of a shepherded paper. Interested candidates are encouraged to contact the PC Chairs (bpm2019@easychair.org) by February 1, 2019.

General Chairs
Jan Mendling, Stefanie Rinderle-Ma

WELCOME TO ZEUS 2019

11th ZEUS Workshop
February 14-15, 2019 in Bayreuth, Germany

http://zeus2019.org

ZEUS focuses on the discussion of fresh ideas, the presentation of work in progress, and the establishment of a scientific network between young researchers in the region.

1. Discuss fresh ideas

We offer a forum to discuss ideas at a level that is more work-in-progress than in a traditional conference. We thereby want to attract especially PhD students in the early phases of their work. Participants can get feedback from outside their group before a submission to a reviewed conference. This makes ZEUS an original opportunity to discuss ideas.

2. Practice scientific work

We see the ZEUS workshop as an opportunity to practice the whole range of scientific work. We do not take the sole focus on the submitted papers, but also on the presentations and the discussions during the workshop. To this end, we hand out a Best Presentation Award since 2010 at the end of the workshop to appreciate high quality presentations.

3. Establish contacts between young researchers in the region

We aim at bringing together young researchers who work in the same geographic and scientific region. This way, we would like to provide an opportunity for people to establish a scientific network that can be intensely used, including mutual visits at affordable costs. The workshop will serve as a platform to present current research ideas and research directions.

Topics

The topics of the ZEUS workshop are centered around service technologies, which includes a rich set of facets. The purpose of analysis, synthesis, or simulation of service technologies are as welcome as practical evaluations, use case-driven feasibility studies, or technology adoption models. ZEUS also calls for contributions in the field of Cloud Computing, RESTful services, and microservices.

Topics include, but are not limited to:

- Service lifecycle: analysis, specification, modelling, testing, deployment, execution, monitoring, adaptation
- Patterns, languages, reference models, and model extensions
- Multi-view and multi-perspective engineering (SOA, choreographies, collaborations, conversations, artifact-centric systems)
- Formal methods, models, simulation, and verification
- System architectures for service composition
- RESTful Web services (design aspects, hypermedia, linked data, mashups, conversations)
- Microservices and Nanoservices (architecture, lifecycle, deployment, composition)
- Workflows and business processes
- Complex event processing (correlation, aggregation, transformation, monitoring, extraction)
- Security, compliance, and non-functional requirements and properties
- Cloud-enabled applications, migration to/from the Cloud, Cloud Integration, Serverless Computing
- Composable Big Data Analytics Pipelines
- Applications, frameworks, methods, tool demonstrations, and case studies

Important Dates

Submission:	January 9, 2019
Notification:	January 28, 2019
Camera-ready (pre-proceedings) version:	February 4, 2019

Submission

We are looking forward to three types of contributions for ZEUS 2019. All papers must be submitted following the instructions at the ZEUS submission site handled by EasyChair: https://www.easychair.org/conferences/?conf=zeus2019

Results can be presented in talks or tool demonstrations. Submissions will be reviewed by at least three reviewers each in order to assure general fitness regarding content, readability and scope and to give first feedback to the authors. Depending on innovation, technical soundness and presentation clarity, papers may be rejected or accepted as position or workshop papers.

Workshop papers:

Workshop papers are regular contributions that describe original solutions in field of ZEUS. These papers must not exceed 6 pages (LNCS style). Workshop papers are reviewed according to the call for papers. Accepted papers shall be included in the proceedings and presented at the workshop.

Positions papers:

Position papers should draft a new idea and put it up for discussion at the workshop. Position papers should only be an extended abstract and must not exceed 3 pages (LNCS style). Position papers are briefly reviewed according to the call for papers. The main idea and the relation to existing work should be contained. Accepted papers shall be included in the proceedings. Position papers have been introduced based on the experiences gained from the last editions. They allow authors to get early feedback during the workshop, but should not disallow extending the paper to a full paper submitted to a first class conference - even if the position paper is referenced and the delta is explained properly.

Tools demonstrations:

ZEUS also offers a forum to demonstrate implementations of techniques and algorithms in the area of the aforementioned topics to get early feedback and provide interesting insights for the audience. Tool demonstrators are asked to submit a demo script of no more than 3 pages (LNCS style) which states how the tool is linked to the call for papers and what to expect during the demonstration.

Program Chair

Stefan Kolb, University of Bamberg

Local Organizer

Christian Sturm, University of Bayreuth

Research Group Software Construction | Prof. Dr. Horst Lichter

Qualitativer Vergleich von Pflegeprozessen für Unternehmensarchitekturmodelle

Liebe Fachgruppenmitglieder

Im Rahmen eines Forschungsprojekts an der RWTH Aachen führe ich eine vergleichende Umfrage zum Thema „Pflegeprozesse für Unternehmensarchitekturmodelle“ durch. Ziel dieser Studie ist es, verschiedene Pflegeprozesse anhand vorgegebener Qualitätskriterien miteinander zu vergleichen.

Teilnahme: Teilnehmen können Unternehmensarchitekten, Lösungs-architekten, Forscher und alle, die zur Pflege von Unternehmensarchitektur-modellen in irgendeiner Form beitragen.

Dauer: ca. 10-15 Minuten

Freiwilligkeit und Anonymität: Ihre Teilnahme an dieser Umfrage ist freiwillig. Es steht Ihnen zu jedem Zeitpunkt dieser Studie frei, Ihre Teilnahme abzubrechen. Ihre Daten sind selbstverständlich vertraulich, werden nur in anonymisierter Form ausgewertet und nicht an Dritte weitergegeben.

Nutzen der Studie: Mit Ihrer Teilnahme tragen Sie dazu bei, neue Erkenntnisse über die qualitative Wahrnehmung von Pflegeprozessen für Unternehmensarchitekturmodelle zu gewinnen. Wenn Sie es wünschen, können Sie am Ende der Umfrage Ihre E-Mail-Adresse angeben. Sie werden dann die Ergebnisse dieser Umfrage dann im Januar/Februar per E-Mail erhalten.

Spende: Für jeden verwertbaren Fragebogen werde ich 2€ an eine Hilfsorganisation spenden. Am Ende der Umfrage können Sie deshalb eine Hilfsorganisation auswählen.

Link: https://www.soscisurvey.de/EA_Model_Maintenance/

Für Ihre Teilnahme danke ich Ihnen im Voraus ganz herzlich.

Research Group Software Construction | Prof. Dr. Horst Lichter

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Research Assistant

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Towards a Method for Designing IT Self-Services from an IT Operations perspective

Current Research Talk Proposal

Florian Baer[1], Kurt Sandkuhl[1] and Michael Leyer[2]

Keywords: IT Self-Service, Service Blueprinting, Service Design, IT Operations.

IT self-services, such as automated software deployment and password reset, allow an organization's employees that are outside of the IT operations function to become actively involved in the process of producing IT services. In the recent years, IT self-services have been widely adopted by organizations' IT operations functions. Recent trends in software engineering like development and IT operations (DevOps) and site reliability engineering have intensified this adoption even more. IT operations strives for the reduction of the IT personnel's workload in IT self-services. However, the realization of this goal cannot be taken for granted as highlighted by the results of a multiple-case study that was conducted by us with five IT self-services. Therefore, the IT operations' decision makers must be guided in designing IT self-services whose implementations will reduce the IT personnel's workload. Our research goal is to develop a method for designing IT self-services from an IT operations perspective. We thereby address the following research question: *How can IT operations' decision makers be supported methodically in designing IT self-services, in which the IT personnel's workload is reduced compared to the corresponding full-services*? The design of the method follows the design science research paradigm.

IT services must be considered as processes that are sequences of services tasks, which allow to produce the IT service (i.e., the outcome of the service process). IT self-services are one extreme of IT services. In IT self-services the employees perform a portion of the service tasks, which otherwise would have been performed by IT operations, on their own and independently from the IT personnel. In our prior work, we present a framework including a set of equations to calculate the self-service intensity (i.e., the effort that the employees must spent performing the services tasks) of a service process. Service processes can be visualized in service blueprints.

We conducted a multiple-case study with five IT self-services to shed light on the problem that will be acknowledged by the IT operations' decision makers, if the IT

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personnel's workload is not reduced in the IT self-service and the solutions to it. The acknowledged problem manifests itself as a lack of service production control and is rooted in knowledge and skill gaps and a free IT self-service outcome. A lack of service production control is two-dimensional and includes a forbidden service production and an excessive service production. Two solutions were found to a lack of service production control. The two solutions comprise the adoption of five behavioural patterns: chargeback and limitation, standardization of the IT self-service, authorization of employee orders, showback, and training and support.

Based on the findings of our multiple-case study, we defined several specific functional and generic environmental requirements that must be satisfied by a method guiding IT operations' decision makers in designing IT self-services. To satisfy all these requirements the method must include a new notation for blueprinting IT self-services. The development of a new notation is required, because the existing service blueprinting approaches do not allow for an adequate specification of self-services, as highlighted by the results of the analysis of 47 service blueprinting approaches that we conducted.

We developed a meta-model that extends the meta-model underlying the service blueprinting approach. We add to the service blueprinting approach, among others, the possibilities to blueprint the category of the IT self-service, the resources that are exchanged in the IT self-service, the required capabilities of the service tasks and the capabilities possessed by the involved employees.

The phase structure of the designed method includes the following phases: determine devolvable IT services, determine full service, determine employees, and determine service task devolvement. These four phases comprise several method components: identification of IT service catalogue, identification of recurrent, routine service tasks, identification of service process, identification of service task requirements, identification of employee capabilities, grouping of employees, adoption of solution(s), and identification of employees' intentions to participate. The latter method component is required, because the employees' participation in the IT self-service is the prerequisite for IT operations to realize a reduction of the IT personnel's workload. We conducted a meta-analysis including 26 individual quantitative studies on self-service technology usage intention and identified 13 factors that have a direct influence on customers' intentions to use self-service technologies.

We plan to evaluate the overall method in four steps including ex ant and ex post evaluations in artificial and naturalistic settings. The method evaluation will include participant action research as well as case study research.

Semantic Consistency – Through Seamless Modelling and Execution Support (Extended Abstract)

Tomas Jonsson,[1] Håkan Enquist[2]

Abstract: Approaching semantic consistency between enterprise actors and their IT-based Information Systems is a socio-technical process matching organisational perception of reality to data structures provided by IT-based Information Systems. As a part of an effort to improve this process, a web-based model driven non-commercial information systems environment has been developed to facilitate communication between modellers and enterprise actors, where modellers modelling a semantic model (abstract view of data) can receive feedback from enterprise actors by executing the model as an information system (concrete view of data). The work summarised in this extended abstract has been published in [1]

Keywords: Semantic Consistency; Information Systems; Semantic Models; Model Driven Systems; Model Validation

1 Introduction

We regard Enterprise Information System (EIS) as socio-technical systems i.e. systems of enterprise actors, information and IT artefacts. Semantic consistency between enterprise actor perspectives of information and the IT artefacts is essential for efficient information management and usage in the EIS.

Conceptual models can be used to reflect relevant concepts and semantics of an enterprise and thus play an important role in communication between users, domain experts, modellers and system designers, in the life cycle management of IT based Information Systems (ITbIS). The EIS socio-technical system includes various enterprise actors with different semantic perspectives. The semantic modelling facility must therefore allow a combination of mainstream (ER type) model and semantic perspectives.

Semantic consistency between actors, model and ITbIS cannot be fully evaluated until a resulting ITbIS has been put in context of the socio-technical EIS. Thus a demonstration of a concrete view of data based on the Conceptual Models is fundamental to evaluation of semantic consistency and further, evaluation will only be relevant if the ITbIS presentation of data accurately corresponds to the semantic model.

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2 Semantic Triangle Consistency

The IS life cycle process, from conceptual model to target ITbIS, in mainstream approaches, involves several steps of manual transformations of what the conceptual model expresses. Each step involves several design choices and degrees of freedom for design and implementation, resulting in deviations from the statements of the conceptual model. However, with a semantic model driven ITbIS i.e. semantic model execution, Fig. 1, free from manual transformation processes, consistency between model and implementation can be guaranteed.

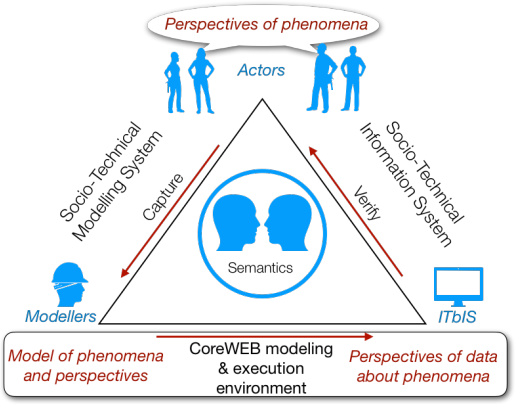

Fig. 1: Socio-technical context of CoreWEB modelling and execution environment.

3 Modelware as the New Level of Software in CoreWEB Environment

A concrete view of data based on Conceptual Models is fundamental for evaluation of semantic consistency. CoreWEB a (non commercial) modelling and execution WEB service (https://www.ameis.se/cml) based on Core Enterprise Architecture Framework (CoreEAF) has been developed. CoreEAF is a reference architecture and modelling method (phenomena oriented semantic modelling) for information systems, proven to be viable for large scale information systems [2]. CoreWEB is aimed at students and practitioners who want to develop and validate semantic models with multi-actor perspectives.

References

[1] Jonsson T., Enquist H. 2017: Semantic Consistency in Enterprise Models – Through Seamless Modelling and Execution Support. Forum and Demos at ER 2017, CEUR Workshop Proceedings Vol-1979, p356-359

[2] Jonsson T., Enquist H. 2015: CoreEAF – a Model Driven Approach to Information Systems. Proceedings of CAISE Forum 2015, p137-144

Blockchains for Business Process Management - Challenges and Opportunities (Extended Abstract)[1]

Jan Mendling[2], Ingo Weber[3]

Abstract: Blockchain technology offers a sizable promise to rethink the way inter-organizational business processes are managed because of its potential to realize execution without a central party serving as a single point of trust (and failure). To stimulate research on this promise and the limits thereof, in this paper we outline the challenges and opportunities of blockchain for Business Process Management (BPM). We structure our commentary alongside two established frameworks, namely the six BPM core capabilities and the BPM lifecycle, and detail seven research directions for investigating the application of blockchain technology to BPM.

Keywords: Blockchain, Business Process Management, Research Challenges.

1 Paper Synopsis

This extended abstract summarizes the key challenges identified in a recent research commentary on blockchains and business process management. Altogether, seven major research directions are identified at the intersection of both topic areas. These challenges relate to the BPM lifecycle and BPM-related different capability areas. The challenges include the following.

1. Understanding the impact of blockchain on strategy and governance, in particular regarding new business and governance models enabled by revolutionary innovation based on blockchain.
2. Devising new methods for analysis and engineering business processes based on blockchain technology.
3. Investigating the culture shift towards openness in the management and execution of business processes, and on hiring as well as upskilling people as needed.
4. Developing techniques for identifying, discovering, and analyzing relevant processes for their adoption of blockchain technology.

[1] This paper has been published as Jan Mendling, Ingo Weber, Wil M. P. van der Aalst, Jan vom Brocke, Cristina Cabanillas, Florian Daniel, Søren Debois, Claudio Di Ciccio, Marlon Dumas, Schahram Dustdar, Avigdor Gal, Luciano García-Bañuelos, Guido Governatori, Richard Hull, Marcello La Rosa, Henrik Leopold, Frank Leymann, Jan Recker, Manfred Reichert, Hajo A. Reijers, Stefanie Rinderle-Ma, Andreas Solti, Michael Rosemann, Stefan Schulte, Munindar P. Singh, Tijs Slaats, Mark Staples, Barbara Weber, Matthias Weidlich, Mathias Weske, Xiwei Xu, Liming Zhu: Blockchains for Business Process Management - Challenges and Opportunities. ACM Trans. Management Inf. Syst. 9(1): 4:1-4:16 (2018)

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5. Redesigning processes to leverage the opportunities granted by blockchain. Just like the move from paper files to digital files allowed streamlining processes, blockchain may allow re-imagining how processes can be done in collaboration with external stakeholders. The whole area of choreographies may be re-vitalized by this technology.
6. Developing a diverse set of execution and monitoring frameworks on blockchain.
7. Defining appropriate methods for evolution and adaptation.

The BPM community has a unique opportunity to help shape this fundamental shift towards a distributed, trustworthy infrastructure to promote inter-organizational processes. With this paper we aim to provide clarity, focus, and impetus for the research challenges that are upon us.

What we know and what we do not know about DMN (Extended Abstract)[1]

Kathrin Figl[2], Jan Mendling[3], Gul Tokdemir[4], Jan Vanthienen[5]

Abstract: The recent Decision Model and Notation (DMN) establishes business decisions as first-class citizens of executable business processes. This research note has two objectives: first, to describe DMN's technical and theoretical foundations; second, to identify research directions for investigating DMN's potential benefits on a technological, individual and organizational level. To this end, we integrate perspectives from management science, cognitive theory and information systems research.

Keywords: DMN, BPMN, Process Modeling.

1 Introduction

The Decision Model and Notation (DMN) is a recent standard of the Object Management Group. It complements the Business Process Model and Notation (BPMN) with a notation for modeling decision logic and dependencies between decisions and data elements. The specification formulates several goals, which can also be understood as hypothetical benefits: First, the notation should be readily understandable by both business users and technical developers. Second, it should be straight forward to transform it to artifacts that implement decision logic. Third, it should be easily usable together with BPMN. DMN enjoys an increasing uptake in industry and receives attention in academic research. However, empirical research on DMN is still scarce such that it is unclear to which degree the proclaimed benefits materialize. We review the literature and discuss a research agenda for investigating the potential benefits of DMN in the three categories: technology, individual and organization benefits.

2 Technology

The history of operational decision management and DMN finds its origin in decision table modeling, where rules for decision logic are represented in a structure of related tables, which map combinations of inputs to outcomes. DMN standardizes existing

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decision table formats (using a hit policy indicator), by elaborating the requirements diagram, and by introducing a standard expression language. Even though DMN standardizes and extends the modeling capabilities of decision requirements and decision logic (e. g. by adding FEEL), various results from previous research into decision tables can be readily adopted. These include works in the area of Verification & Validation including table networks, table simplification, code generation and decision mining.

3 Individual

In order to structure the discussion of DMN-related research problems on the individual level, we refer to a theoretical model that describes modeling as a process of knowledge construction. The outcome of this process is influenced by three major perspectives: First, the characteristics of model viewers in association with their tasks; second, the content that is captured in the model and third, the presentation format of this content. From a cognitive point of view, the content view relates to the inherent complexity of information that must be understood. While intrinsic cognitive load may not be easily altered without changing the decision situation, extraneous cognitive load can be decreased by how the decision model is presented and more cognitive effort can be devoted to schema construction (germane load). Challenges in this area include the understanding of novice-expert differences and skill differences for reading and creating models. An important reference theory is the physics of notations framework.

4 Organization

Decisions that are explicitly defined through DMN and not hardcoded inside organizational decision making processes will likely decrease complexity and hence ease the implementation of business rules and analytic technologies. In this way, DMN might contribute to improved efficiency and effectiveness of organizational decision making. From an organizational point of view, benefits might result from the integration of modeling notions that organizations utilize. From another perspective, it is also clear that decision execution efficiency is highly affected by the amount of input data that is required to be collected for business process decisions, which is likewise costly for organizations.

5 Conclusion

DMN will change the way how processes are specified and implemented. In this paper, we described its technical foundations of decision table research and its theoretical background of modeling research. We identified research directions for investigating its potential benefits on a technological, individual and organizational level, and in this way clarifying what we know and what we don’t know about DMN. Insights into the way how

programmed decisions are specified and implemented together with process will be a cornerstone of future research into information systems and BPM in the years to come.

An Empirical Review of the Connection between Model Viewer Characteristics and the Comprehension of Conceptual Process Models (Extended Abstract)[1]

Jan Mendling[2], Jan Recker[3], Hajo A. Reijers[4], Henrik Leopold[5]

Abstract: Understanding conceptual models of business domains is a key skill for practitioners tasked with systems analysis and design. Research in this field predominantly uses experiments with specific user proxy cohorts to examine factors that explain how well different types of conceptual models can be comprehended by model viewers. However, the results from these studies are difficult to compare. One key difficulty rests in the unsystematic and fluctuating consideration of model viewer characteristics (MVCs) to date. In this paper, we review MVCs used in prominent prior studies on conceptual model comprehension. We then design an empirical review of the influence of MVCs through a global, cross-sectional experimental study in which over 500 student and practitioner users were asked to answer comprehension questions about a prominent type of conceptual model - BPMN process models. As an experimental treatment, we used good versus bad layout in order to increase the variance of performance. Our results show MVC to be a multi-dimensional construct. Moreover, process model comprehension is related in different ways to different traits of the MVC construct. Based on these findings, we offer guidance for experimental designs in this area of research and provide implications for the study of MVCs..

Keywords: Conceptual Modeling, Process Models, Model Viewer Characteristics.

1 Introduction

The complexity of contemporary information systems draws much attention to how their analysis and design can be supported by appropriate methods and tools. Efforts are spent on new techniques that support the modeling of system requirements and, increasingly, on how these techniques actually aid the analysis and design process. Of special interest in this stream are studies that focus on conceptual models as an aid to facilitate the comprehension of certain domain facts that relate to an information system, which will contribute to better design decisions and eventually a better system. Therefore, investigating the factors that influence the way people make sense of conceptual models is instrumental in improving the analysis and design of information systems in terms of their effectiveness and efficiency. Not surprisingly, conceptual modeling remains an

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active field of study, with contributions regularly occurring in the field's main journals. Studies that discuss the comprehension of various modeling artifacts acknowledge model viewer characteristics (MVCs) as a factor of influence. Various aspects of MVCs have been discussed in the literature, partially relating to theoretical knowledge, duration of practice, education, or familiarity. We observe, however, that MVCs are hardly considered prominently in research on the comprehension of conceptual models.

2 Findings

To examine the role of MVCs and the measurement thereof in explaining how well users understand conceptual models, several options exist. Our specific objective was to evaluate measures of MVCs and their impact on individuals' understanding of conceptual models. To that end, an experiment appears to be the best choice, also because it is congruent to past research in this area.

We set out to empirically examine how modeling expertise relates to model comprehension performance and, based on the results, develop and explore a multi-dimensional profile of modeling expertise. We find that layout plays a significant role for both comprehension performance as well as completion time. The position of a participant (student versus practitioner), by contrast, can only explain differences in completion time. As for the five MVCs, we observe that Familiarity, Intensity, and Knowledge can be used to explain performance differences. Education as well as Duration were not significant in this context. With respect to completion time, none of the MVCs appears to be a good predictor.

Our results affirm our contention that experiments in conceptual modeling literature would benefit from a more developed understanding of which MVCs need to be included in experimental designs. Our research is a first empirical exploration of this area and we hope future studies will further extend these ideas. Two avenues are particularly important in this regard. First, the development of a more sound theoretical basis to conceptualize MVCs and ideally also other elements of conceptual modeling pragmatics - the study of the contexts in which conceptual models are used. Second, the execution of more rigorous and systematic measurement development work to operationalize MVC as the multi-dimensional construct we found it to be. Third, prior studies should be replicated with MVCs being explicitly integrated into the data analysis. We hope that other colleagues will join us in these endeavors.

Dynamic Skipping and Blocking and Dead Path Elimination for Cyclic Workflows (Extended Abstract))[3]

D. Fahland[1], Hagen Völzer[2]

Abstract: We propose and study dynamic versions of the classical flexibility constructs skip and block and motivate and define a formal semantics for them. We show that our semantics for dynamic blocking is a generalization of classical dead-path-elimination and solves the long-standing open problem to define dead-path elimination for cyclic workflows. This gives rise to a simple and fully local semantics for inclusive gateways. The work summarized in this extended abstract has been published in [FV16].

Keywords: Process modeling, process modeling languages, BPMN, process flexibility by design, dead path elimination, inclusive gateway semantics, skipping and blocking

1 Problem Description

One of the challenges in process management is striking a balance between the clarity of a process model on one hand and its ability to support a large variety of process flows on the other hand (also called process flexibility). A model can express flexibility in different ways: by design, by deviation, by underspecification, and by change [Ro17; RW12]. Flexibility *by design* faces the above challenge directly: including many different possible paths in a model tends to increase its complexity.

The classical concepts to *skip* tasks and to *block* a path can be used to express flexibility by design. They have been used predominantly for *static* flexibility, i.e., to remove tasks or paths from the model *before* deployment through process model configuration [Go08]. However, in many processes, skipping and blocking dynamically depend on user input or dynamically computed data. WS-BPEL uses *dynamic* skipping and blocking for *dead path elimination* [LA94], but is limited to acyclic control-flow graphs and merges deliberate task skipping (by process logic) with enforced task blocking (due to activity failure). This prevents the free combination of these concepts and can create unintended side effects [BK05].

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[3] This article summarizes problem, approach, and selected findings of a study published as *Dirk Fahland, Hagen Völzer: Dynamic Skipping and Blocking and Dead Path Elimination for Cyclic Workflows. BPM 2016: 234-251 (2016) doi:10.1007/978-3-319-45348-4_14* [FV16]

In this paper, we study freely combinable concepts for dynamic skipping and blocking in arbitrary process models in the context of BPMN.

2 Results

We define dynamic skipping and blocking for BPMN-like languages, each with a dedicated local semantics, such that they can be used independently from each other or freely combined. We define the semantics for general control-flow graphs, including cyclic graphs, and compare the semantics of static and dynamic skipping and blocking.

Our proposal for dynamic blocking includes a generalization of the Dead-Path-Elimination (DPE) concept [LA94] to general control flow, which so far was limited to acyclic control flow. We point out that dynamic blocking is closely related with the semantics of inclusive gateways (aka synchronizing merge pattern, OR-join semantics).

Our generalization of DPE to cyclic flow graphs gives rise to a purely local semantics for inclusive join behavior. As a result, our semantics does not entail semantic anomalies such as 'vicious cycles' (see, e.g. [Ki06]). In comparison with existing semantics, it can be enacted faster, i.e., in constant time, it is compositional for more models and therefore easier to understand and use, and it permits more refactoring operations for process models.

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Towards a Quality Framework for Enterprise Architecture Models

Simon Hacks[1] and Felix Timm[2]

Keywords: Enterprise Architecture, model quality, quality framework, EA modeling

Enterprise Architecture Management (EAM) addresses inter alia effective and efficient Business-IT-alignment [Ahl12]. One central artefact of EAM is the enterprise architecture (EA) model. It provides a holistic view on the enterprise with respect to its elements and dependencies that are required for value creation. In general, the EAM discipline is an extensively discussed research field [Sim13]. Nevertheless, to our knowledge no widely accepted approach exists, that enables stakeholders of EA to completely assess the EA model's quality. As we found out during our research, only a few articles address this research gap with the specification of EA quality attributes, but without providing a holistic framework how to actually use them in an EAM context. Therefore, we solely focus on the EA model and define the following research question (RQ): What aspects does a framework for assessing the quality of EA models have to contain?

To answer this research question, we created a first artifact following the means of design science research [Pef07] in [Tim17]. Therefore, we conducted a systematic literature using the combination of the terms "enterprise architecture", "model" and "quality" in abstracts of articles on the Scopus and AISeL databases from 2007 to the present and ended up with seven different articles relevant to our research. Those seven articles serve as input for our framework, which is based on the six principles for proper modelling of [Bec12].

Figure 1 depicts the Enterprise Architecture Model Quality Framework (EAQF). It is structured by three dimensions: (i) EA purpose, objective, stakeholders, (ii) EA model as a whole, and (iii) certain EA model views. Statements should be made regarding these dimensions. Thus, for each of these dimensions we identify quality attributes that can be related to the six principles from [Bec12] and provide measures how to assess these attributes based on the related literature.

We demonstrate and evaluate our framework by applying the proposed means to a single case study. This case study showed that EAQF supports a better EA development and helps uncovering quality flaws. This is grounded by the fact that it can be facilitated as a setting to guide through the development.

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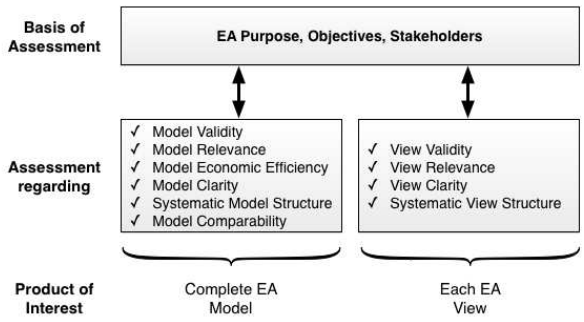

Fig. 1: The Enterprise Architecture Model Quality Framework (EAQF)

Our research still offers different improvement potentials. First, our conducted SLR covers limited number of search terms. Second, the external validity of EAQF needs further investigations. Third, a case study does not ensure that the quality attributes are sound and complete. Fourth, the maturity grade of the EAM unit may be an important point, since for organizations with a low grade other quality attributes can be interesting compared to those with a higher grade. Fifth, the framework should be configurationally as every organization has special demands towards EAM. Last, executing EAQF has shown that questions are interrelated with each other. Though, these relations are not made explicit. This should be explored in future work, since this can reduce the needed effort to execute EAQF significantly.

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The Concept of Knowledge Blockchains in Enterprise Modeling

Hans-Georg Fill[1], Felix Härer[2]

Abstract: In this talk we present the results of a paper that has recently been accepted for the HICSS conference and nominated for the best paper award. The main contribution is the application of blockchain technologies to enterprise modeling. This approach is denoted as *knowledge blockchains* and permits to apply so-called knowledge proofs to enterprise models. These knowledge proofs enable a. the transparent monitoring of knowledge evolution, b. the tracking the provenance, ownership, and relationships of knowledge in an organization, c. the establishment of delegation schemes for knowledge management, and d. the proof of existence of patterns in models via zero-knowledge proofs. The feasibility of the approach has been validated via a technical implementation on the ADOxx meta modeling platform and applied to an illustrative use case.

Keywords: Blockchain; Enterprise Modeling; Knowledge Management

1 Introduction

The upcoming of Bitcoin as one of the first virtual currencies has sparked interest in the underlying blockchain technologies and lead to various research initiatives for investigating the application of these technologies to other domains. In the paper published at the HICSS conference in January 2018 [FH18], we applied these technologies to the domain of knowledge management. In particular, we investigated how the core properties of blockchains such as tamper-resistance, decentralization, and the irrevocable storage of information could be applied to explicit organizational knowledge in the form of enterprise models.

For this purpose, we first derived extensions for enterprise modeling languages on the meta-meta level. These comprised in particular extensions for storing hash values of the information contained in enterprise model instances, which form the basis for generating Merkle trees and the corresponding Merkle root hash. Using such a root hash together with the Merkle tree, it becomes possible to track any changes in enterprise models without having to disclose the actual content of the models (zero-knowledge proofs). A further extension concerned the addition of a permission management and delegation scheme. This

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is required in our approach to authenticate parties who are entitled to conduct changes on the models stored in the knowledge blockchain. In addition, permitted modeling operations can be specified. Finally, by designing mining rules we covered also the aspect of ensuring the correctness of transactions in our blockchain approach.

2 Results

The research resulted in a prototype implemented on the ADOxx meta modeling platform [FK13]. Thereby, the technical feasibility of the approach could be positively evaluated. Furthermore, by applying it to a small, illustrative use case, we could show the use in a practical scenario and derive future research opportunities based on this approach. In this use case of a bank account registration – a model in BPMN notation – identities for two actors, and according permissions are secured by a transaction made to the knowledge blockchain. ADOxx handles the creation of a new block by calling a custom DLL for calculating SHA-256 hash values, building a Merkle tree through ADOscript, and signing the transaction using ECDSA cryptography and OpenSSL. In effect, model elements are recorded in a tamper-resistant way. Knowledge managed "on chain" is immutably stored and can be traced back to its provenance, enabling the knowledge proof applications mentioned.

3 Future Research

In our future research we are currently about to extend the approach and add in particular mechanisms to ensure the correct instantiation of enterprise models in the blockchain based on a given meta model. For ensuring the correctness of the approach, we plan to formalize the core parts of the approach and thus enable a more detailed description of its inner workings [BF14, FRK12].

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Towards Cognitive Assisted Living 3.0 (Extended Abstract)

Integration of non-smart resources into cognitive assistance systems

Claudia Steinberger[1], Judith Michael[2]

Abstract: The setup and running of cognitive assistance systems like HBMS, the Human Behavior and Support-System, is accompanied by two main challenges: considerable effort is needed to set up a user's context information and activity recognition results are still too coarse-grained for the intended user support. This paper presents a semantic markup approach, which helps to overcome these challenges by simplification of the construction of inhabitant's context model and by improvement of the system's activity recognition capability. Describing non-smart resources semantically enables to facilitate their flexible handling in a cognitive assistance system. Of course, such resources start to become interoperable with enclosed context models. Moreover, we show how personalized and adaptive HBMS user clients and the power of the HBMS environmental context model can be used to bridge an existing activity recognition gap. The work summarized in this extended abstract was published in the SmarterAAL workshop 2018 proceedings (at PERCOM 2018) by IEEE [SM18].

Keywords: Semantic Manual, Cognitive Assistance, Schema.org, User Context Model, Simulated Sensor Data, HBMS.

1 Motivation

With the cognitive assistance system HBMS (Human Behavior Monitoring and Support)[3] we aim to actively assist people e.g. in activities of daily living, using user's episodic knowledge (behavior) as well as information about user's environmental resources, social and personal situation and location [MM13][MS17]. Evaluating the HBMS-System we were faced with two problems:

(1) The user's context had to be modeled manually when setting up the HBMS-System. Particularly, considerable effort was needed to model the user's resources like domestic appliances to build up the user's environmental context model. Large parts of the user manuals have been reconstructed to enable the HBMS-System to assist the user.

(2) Existing activity recognition results were not sufficient for the intended user support especially for fine granular user interactions with environmental resources.

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In [SM18] we have presented an approach to overcome these challenges and to join the HBMS-System with the semantic web to simplify the construction of user's context model and to improve its activity recognition capability.

2 Approach

The detailed information contained in (online) manuals and the ability to semantically understand them is very valuable for active user assistance. A cognitive assistance system can support context sensitively how to use different resources and devices. The HBMS-System aims at deriving support services using integrated conceptual models of abilities, the environmental and spatial context and the episodic memory of the supported user building up the Human Cognitive Model (HCM) [MS17]. These models are described using the Domain Specific Modeling Language HCM-L.

While human readers understand the handling of a good manual mostly at a glance, an assistive system needs extra information to comprehend resources, their functionality and associated instructions semantically. Our approach shows how to represent this information in manuals semantically by reusing schema.org as far as possible and introducing some extensions, where needed. This makes them understandable for the HBMS- System (and others) and interoperable with its environmental context model.

These semantically enriched manuals can then be used to import resource domain knowledge into the HBMS-System. Semantic manual data is collected from the web, transformed and integrated into the HBMS-System data stores mapping tagged elements to HCM-L Resource Types, HCM-L Functions or Multimodal Instructions. The HCM-L Modeler enables to visualize the imported information and use it in the HBMS-support process. Additionally, an automated mapping from old to renewed devices is easily possible. Moreover, it is possible to recognize fine granular activities via personalized and adaptive user feedback. The HBMS-System simulates sensor data based on this user feedback and handles it in the related context middleware and the following components as if the data comes from a genuine sensor. This approach bridges the activity recognition gap.

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Clustering Event Logs based on Behavioral Similarity

Agnes Koschmider[1]

Abstract: This paper summarizes an approach for clustering of event logs based on the notion of behavioral similarity. Additionally, behavioral similarities between events are considered instead of a pure sequence of events allowing to identify homogeneous traces. Different to existing approaches this technique constructs a classification a-priori allowing to directly detecting changes in historical and real-time traces. The evaluation of our approach demonstrates efficiency in terms of change detection, performance time and the quality of clusters.

Keywords: Event logs, process mining, clustering, flexible processes

1 Motivation & Approach

The analysis of human behavior in the context of intelligent, connected environments is a challenging task. Humans behave according to best practices and a single behavioral model is typically not sufficient to represent them all. In fact, existing process mining algorithms reportedly generate spaghetti models from event logs of flexible processes, which are largely incomprehensible. One solution for event log structuring and analysis in such environments provides clustering techniques, which intend to split log files according to a notion of similarity or dissimilarity so that the same or similar tasks or processes are contained in each group and thus smaller and simpler process models can be mined. This paper summarizes a novel approach for clustering event logs by their behavioral similarity, rather than deriving a unique process model encompassing all traces. The clustering approach takes a process model as input but then iteratively constructs a-priori a classification and assigns traces to groups that are found most similar to them. The approach is depicted in Figure 1. The mandatory input of this approach is a to-be process model. Depending on the mining purpose, the to-be model could be a to-be process characteristic for a human with care level 2. Then the process is derived from documentation on care levels. Optionally, an as-is process model is taken as additional input. When the as-is state is not known, an empty trace is considered as as-is model. Based on this input a morphing is determined representing all valid and possible states from the as-is to the to-be process model. To determine the number of valid in-between states the process models are transformed in a textual representation of process trees, which we call a behavior-oriented trace (bt). An example bt would be [→a, x(b,c),d] meaning that a is executed in sequence, followed by b and c as alternatives and subsequently d follows sequentially. Then level recursion, deletion and insertion algorithms are applied to find possible clusters. In a nutshell, the level recursion

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algorithm decomposes behavior-oriented traces into array lists, attaches nesting depth to lists in order to improve indexing and intend to find n-gram items (at least 2-gram). The deletion and insertion algorithms delete or insert elements that are missing or unnecessary in *bt*s. In case that similarities or changes in event logs should be detected, then the Levenshtein distance in combination with a model-awareness notion are applied. The size of a cluster correlates with the group size (i.e., the more traces in a group, the larger the cluster). Our clustering approach can be evaluated based upon the "maximizing intra-cluster similarity and minimizing intercluster similarity" [WB13]. This means that a small distance between all elements within a cluster and a large distance between the groups should be produced. This is exactly the benefit of this clustering approach. All behavior-oriented traces on the root axis fulfill this requirement and thus make our clustering approach efficient. This clustering approach relies on the presentation of [Ko17]. The approach has been formalized and implemented in the meantime and performance analysis were conducted.

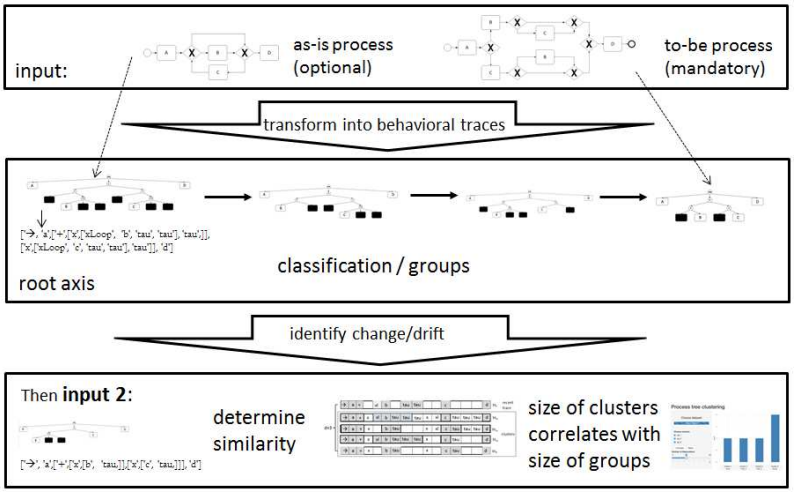

Fig. 1.: Clustering technique based on the notion of behavior similarity and the number of clusters is determined beforehand. The size of a cluster correlated with the group size.

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A Model Centered Perspective on Software-Intensive Systems

Heinrich C. Mayr[1], Judith Michael[2], Vladimir A. Shekhovtsov[1], Suneth Ranasinghe[1] and Claudia Steinberger[1]

Abstract: The aim of this paper contributing to resurrect research interest in conceptual modeling as a means for designing and producing software-intensive systems, as there is still no comprehensive and consistent use of conceptual modeling in practice. The idea is to see any software and information system as a construct consisting of model handlers (model consumers and/or producers). This leads to the paradigm of "Model Centered Architecture", which treats all processes, as well as the data they process, as instances of models. These models in turn are instances of metamodels, described using a particular domain specific modeling language (DSML), and represented using a corresponding domain specific representation language. Consequently, all system interfaces are defined through models (via an appropriate DSML) as well. The paper introduces the relevant MCA concepts and sketches open research questions in this field.

Keywords: Model Centered Architecture, Domain Specific Modeling, models@runtime, Language Hierarchies

1 Introduction

We start from the obvious fact, that any kind of data managed and/or processed within a software-intensive system, as well as the processes themselves, are instances of explicitly specified or implicitly underlying models and, clearly, are models again [ELP11]. We, therefore, see any software and information system as a construct consisting of model handlers (consumers and/or producers), which leads to the paradigm of "Model Centered Architecture (MCA)" [Ma17].

MCA can be seen as a generalization of Model Driven Architecture (MDA) [KWB03], Model Driven Software Development (MDSD) [Li11], and models@runtime [Be14]. MDA and MDSD deal with generating software through model transformation out of a (conceptual) requirements model. The Object Management Group (OMG) proposes to use the Unified Modeling Language (UML), the Meta Object Facility (MOF), the XML Metadata Interchange (XMI), and the Common Warehouse Meta-model (CWM) for this purpose. Models@runtime [Be14] uses models as artifacts at runtime with the goal to blur the boundaries between development time and runtime artifacts [BG10]. This allows for planning and executing maintenance and adaptation on model level [He15].

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Other initiatives focus on metaprogramming [SD12], domain specific modeling [KMM16], multilevel modeling [Fr14], and generative programming [CE00]. Metamodeling frameworks like ADOxx® [FK13] or language workbench and code generation frameworks like MontiCore [KRV10] support the definition of Domain Specific Modeling Languages (DSMLs) and the creation of related modeling tools. [Fr13] and [MM15] discuss the DSML creation as part of a comprehensive Domain Specific Modeling Method (DSMM).

Like multilevel modeling, MCA advocates, for any system aspect, the use of (possibly recursive) hierarchies of DSMLs, each embedded into a DSMM. I.e., MCA focuses on models (and their meta-models) in any development step up to the running system.

The aim of this paper is contributing to resurrect research interest in conceptual modeling as a powerful means for designing and producing software-intensive systems. For, despite of its power, there is still no comprehensive and consistent use of conceptual modeling in practice: for instance, in software development or business process management conceptual models mostly serve as prescriptive documents that, without synchronization with the developed artefact, stepwise diverge from reality.

The reasons for the restricted enthusiasm for modeling are manifold, so let's sketch only some of them: First, software developers generally seem to prefer working on the concrete and algorithms centered programming language level instead on the more abstract level of metamodels and models. This might be a consequence of insufficient and inadequate modeling education, in particular regarding domain specific modeling languages and their creation. Second, even when deploying generative approaches as cited above, mostly extensive manual interventions on the code level are necessary that not only jeopardize the accordance of models and code but also possible cost advantages. This carries even more, as these cost benefits are hard to anticipate due to the lack of appropriate assessment methods and therefore are considered as a risk.

With MCA, our long-term goal is to get rid of the need of such manual interventions so that system developers can concentrate on requirements analysis, metamodeling and modeling. This is why we want to attract attention to this field.

The paper's organization is as follows: Section 2 outlines the main MCA concepts. Section 3 discusses the variety of domain specific modeling and representation languages coming into play. Section 4 aims at drawing attention to some of the open issues.

Given the page limit, there will be no detailed discussion of related work beyond the already mentioned. However, when applicable, we will refer to work listed in section 5.

2 Model Centered Architecture

The basic idea of MCA is to treat all processes as well as the data they process (MOF level 0) as instances of models (MOF level 1). These models in turn are instances of meta-models (MOF level 2), described using a particular DSML, and represented using a corresponding domain specific representation language. Consequently, all system interfaces are defined through models (via an appropriate DSML) as well. This means, that the system components are seen as model handlers (producers and model consumers or both). Figure 1 shows the architectural patterns realizing such approach:

1. *Modeling tool pattern:* means for creating and managing models according to the given DSMLs; such tools are either custom built or generated using an existing meta-modeling framework like ADOxx (consumes meta-models and produces models).
2. *Model (and data) exchange interface pattern:* model transfer to runtime components.
3. *Model (and data) adapter pattern:* components transforming models/data into the format understood by the system, e.g., from an XML dialect to OWL.
4. *Model (and data) storage and storage manager patterns:* enable persistence.
5. *Model handler pattern:* use the adapted models to provide the functionality of the MCA-based system, which again leads to the production of models.

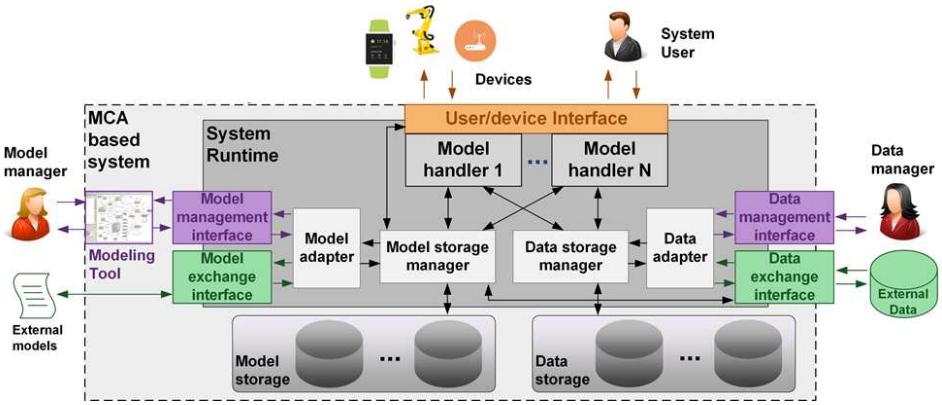

Fig. 1. Architecture of MCA-based systems

Figure 2 sketches the aspects conceptualized in the MOF hierarchy (for simplicity, we waive here the more complex view when using a multilevel modeling approach). (1) the application domain together with the application data exchange and user interfaces, each of them equipped with an appropriate DSML on level M2, and (2) the interfaces for model exchange (data on M0) and model management. The M2 interfaces allow for handling meta-models as MCA artifacts (meta-model management) and for integrating external meta-models (meta-model exchange). On the M1 (model) level the M2 meta-models are instantiated for a concrete application situation. On the M0 (instance) level, the application itself results from creating extensions of the M1 model elements.

If the application domain meta-model is comprehensive in the sense of providing concepts for structure, dynamics and functionality, the M0 extensions either form the models@runtime which might be handled by an interpreter (orchestrated by M2, visualized by the arrows from M2 to M0). Alternatively, when using a MDA tool, code may be generated from the M1 dynamic and function models. But even when following the conventional programming approach, effort may be saved by implementing the patterns as generic modules first and then reusing and adapting these for various projects.

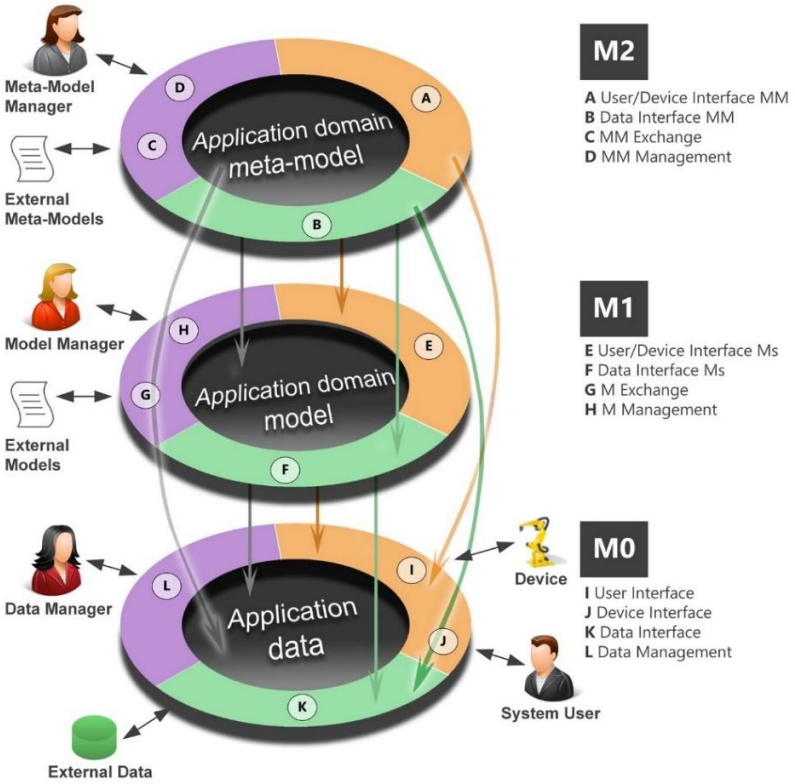

Fig. 2: MCA Model Hierarchy

Thus, MCA is a very flexible framework for creating complete software-intensive system by mere meta-modeling and modeling. For a proof of concept, we have successfully used and refined this approach in two large development projects: (1) QuASE [SM16], which provides flexible means for harmonizing stakeholder views and supports decisions in development and maintenance processes. (2) HBMS [Ma16], which provides ambient support services derived from integrated models of abilities, current context and episodic knowledge that an individual had or has, but has temporarily forgotten. The HBMS core, the Human Cognitive Model (HCM), preserves a person's episodic memory in the form

of comprehensive conceptual behavior models. The interfaces to activity recognition systems as well as multimodal user interfaces again are defined via DSMLs. In both projects we deployed ADOxx for DSML definition and modeling tool generation, and we reused model/data adapter and exchange module templates.

3 Language Hierarchies

The semantic concepts defined through the model hierarchy are to be represented by *syntactic constructs* of appropriate representation languages that again form a hierarchy as shown in Figure 3. We distinguish three levels in this language definition hierarchy:

The grammar definition level (top level of the hierarchy) contains the means of defining the language grammars. In our research, we use a specific version of EBNF, compatible with the ANTLR grammar definition language, for these means.

The language definition level defines grammars for the various representation languages (RL) related to the defined DSMLs: meta-meta-model RLs (not shown on Fig. 3 for brevity), meta-model RLs, model RLs and instance/data RLs.

The language usage level comprises the representations of the models of all levels.

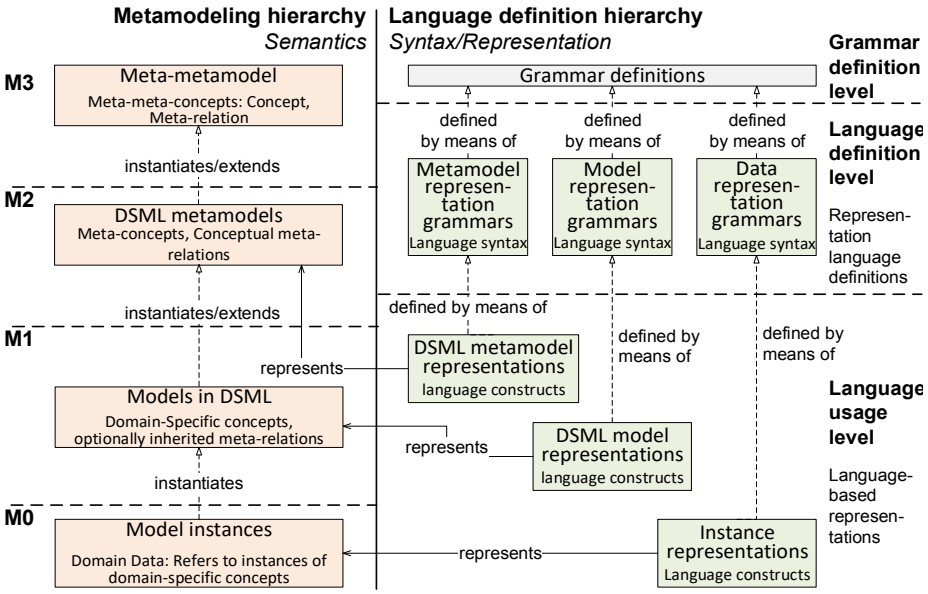

Fig. 3. Representation language definition hierarchy

This language definition hierarchy can also describe the ways of using existing languages for this purpose. For example, it is possible to use OWL 2 as a representation

language for interface or application concepts. In our projects, this proved to be very efficient, as it allowed us to reuse, among others, existing reasoning mechanisms for particular model handlers.

4 Research and Development Issues

While testing and refining the MCA approach in close linkage with the development of the aforementioned QuASE and HBMS systems, we identified a series of pending issues to be addressed by further research and development, among them:

1. Available metamodeling platforms and frameworks do not allow for handling several metamodels and DSMLs at the same time in the same production environment. This however, is essential for a smooth and integrated handling of various application domains, interfaces etc. to be supported by the same system under development.
2. For being comprehensive, such frameworks should be equipped by multi-model interpreting and/or code generating facilities.
3. For achieving acceptance in practice, a software process model as part of a MCA based development method has to be provided that, in particular, is aligned with Scrum to allow for agile modeling based [Ru17] development and flexible work division.
4. Similarly, an integrated method for cost assessment could help to alleviate the inhibitors in practice of changing to a model centered development paradigm.
5. Reusability of metamodel and language design might be fostered by extending MCA to the multi-level modeling paradigm [Fr14]. Within this context, a systematic analysis is needed which, and on which levels, concepts for covering quality, privacy and security issues should be provided by (meta-)models and languages. The same holds for concepts for interface modeling, as these are necessary for linking system parts in complex systems.
6. Ontological grounding on all levels might provide an even more stable semantic basis for development projects. The respective ontologies in turn, can be based on a common MCA foundational ontology. In addition, harmonization of views, notions and labels [LSM12] would enhance model understandability and quality.

We thank our reviewers for their valuable comments and advise, and we hope to initiate with this contribution a fruitful discussion on model centered system architecture.

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Cloud Service Billing and Service Level Agreement Monitoring based on Blockchain

Nils Neidhardt[1], Carsten Köhler[1] and Markus Nüttgens[1]

Abstract: In cloud computing, a customer sources parts or even his complete IT infrastructure out to a cloud service provider. This often results in a loss of control: Due to a lack of transparency, the verification of the billing process, as well as the provider's adherence to service level agreements (SLAs) can be difficult to track for the customer – which can diminish his trust in the service provider. As a solution therefore we propose a blockchain- and smart contract based concept, which implements the SLA monitoring-, as well as cloud billing services in a decentralized, transparent manner, thus reducing the need for the customer's trust in the provider. Hereby, tokens are exchanged between the customer, the provider, as well as external SLA monitoring services in order to timely document customer- and provider actions.

Keywords: Blockchain, Smart Contract, Cloud Service.

1 Introduction

1.1 Problem description

The outsourcing of IT infrastructure to a cloud service provider often results in a loss of control for a customer: This is because he loses visibility into his infrastructure and therefore depends on the information that he is given to by the provider. As a result, significant trust of the customer in the service provider is necessary: Hereby, the consumer relies on the correctness of the invoices that he receives, as well as on the fact that the service level agreements were uphold. If the customer suspects inconsistent or faulty behavior from the provider, his only option is typically limited to questioning them on an individual basis.

1.2 Motivation and prior work

Park [PHC13] and Sekar [SM11], who have recognized the aforementioned problem as well suggested a solution through a neutral "verifier", which monitors and controls transactions between the customer and the provider and settles in the event of a dispute. Zou, who has discussed this approach as part of her dissertation however argues that the verifier would require just as much trust and hence form the bottleneck of the process [Zo16]. As a possible alternative therefore, she suggests the blockchain technology: Due

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to its distributed structure and consensus mechanism, it allows participants to exchange transactions without the need to trust each other or a central party. Hence, a blockchain based solution may be able to address the trust problem between cloud service provider and consumer and as such forms the basis of our concept.

1.3 Research questions

The following research questions are proposed in this paper:

RQ1: Can blockchains improve the transparency of the billing process and SLA compliance of cloud service providers, and therefore reduce the need for a customer to trust the provider?

RQ2: How can the efficiency of the billing process improved via smart contracts?

RQ3: What are potential challenges for the use of blockchains in the context of cloud service provisioning?

2 Concept description

2.1 Blockchain selection process

In order to identify the most suitable blockchain platform for our purpose, we used an Analytical Hierarchy Process [Sa15] based on the following selection criteria: Metacoin capability (7), smart contract [Sz97] support (6), smart oracle support (5), size of the technical community (4), a private, public or consortium BC (6), transaction costs (4), performance (2). As a result of the selection process, we chose Ethereum [Bu14]: The main reasons were its smart contracting capabilities, which would allow us to issue custom tokens, as well as to query external data sources via so called smart oracles (see 2.3). Further, the size of the technical community and therefore the maturity of existing development tools played a decisive role.

2.2 Service initialisation and usage tracking

As a precondition for our concept, both the service provider, as well as the customer need to have an Ethereum wallet. Thereafter, the customer can book various services from the provider, such as hosting or backups. For each of those services, the provider then sends custom Service-Coins to the customer's wallet. Those coins could be different for each service in order to track them individually. The customer then sends the service coins back to the provider on a per-use basis – e.g. when requesting a backup. The used coins will then be billed for accordingly in the billing process (2.4), e.g. at the end of each month. This allows a transparent, granular invoicing to the customer.
At the same time, the costs of using the Ethereum network, or more specifically the Gas price, have to be considered. Gas has to be paid for each transaction - the relationship

between GAS and Ether is ETHER = STARTGAS * GASPRICE. STARTGAS is the amount of GAS that is required to perform a transaction, with the standard value being 21000. The GASPRICE is currently 4 GigaWei. For example, a normal transaction would cost 84,000 GigaWei or 0.000084 Ether. Converted in Euro it is 0.045 € (1 ETH = 540 EUR[2]). We take this price and calculate the costs for a billing period. Table 1 shows the cost calculation for the service usage and the quantity of various services of the customers. We assume that the service is used on 22 days a month as this is the average of monthly workdays.

Table 1: Transaction cost prognosis for service usage concept

No of services	Usage (22 d)	Cost per customer	100 customers
1	22	0,99 EUR	99,00 EUR
5	110	4,95 EUR	495,00 EUR

2.3 SLA monitoring

For the verification of the provider's adherence to the uptime SLA, we developed a smart contract. For each service offered by the provider, it hereby maintains a list of customers. Consequently, the Ethereum address of a new customer is added to the appropriate list after both parties signed the SLA. They further agree on a service checking interval that should be used by the smart contract, e.g. every 5 minutes. The customer will then receive SLA-coins whenever the smart contract determines that the service is unavailable.

At the end of a month, the SLA coins are counted and if the amount is higher than a certain threshold, the SLA is violated.

A main challenge for the smart contract is then to detect whether a monitored service was unavailable. Since a blockchain like Ethereum is naturally a closed system, external information (as in this case the service availability) has to be transferred into the blockchain so it could subsequently be processed by our smart contract.

This is typically achieved via so-called Oracles: These are external services, which actively push external data into the Ethereum blockchain. A potential shortcoming of Oracles is the fact that they have to be trusted, which could undermine the benefits of using a blockchain in the first place.

As a remediation we therefore used the "Oraclize" [Or16] oracle service, which enables verifiable honesty. This is accomplished via the integration of TLSnotary [TL14], a service which can intercept a TLS-connection and therefore attest that a certain server has sent certain data at a specific time. Furthermore, Oraclize can utilise multiple independent data sources and e.g. return the median value of their outputs to the blockchain, which mitigates the risk of having a corrupt Oracle.

[2] The price information is from coinmarketcap.com accessed on 1.5.2018

A potential alternative to Oraclize could be the service “Reality Keys”, which offers a mixed form of purely automatic and human driven Oracles [Re17].

The overall workflow of the SLA monitoring process is illustrated in Figure1: Hereby, the Oracle sends service availability information into the blockchain, which is then read by the SLA-monitoring smart contract. If a service is unavailable, the contract then sends SLA coins to a list of customers, who could then proof whether their promised SLA levels were uphold. Eventually, SLA coins could then be used by the billing smart contract to reimburse customers in case of an SLA breach.

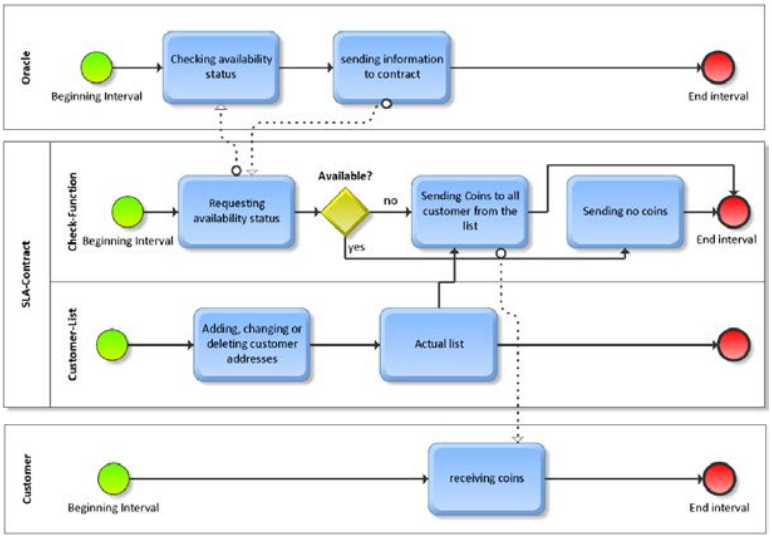

Figure 1: SLA Monitoring Process

2.4 Service billing

The service billing smart contract bills a customer based on the service coins that he used. Therefore, two options exist:
The customer could pay in fiat currency, which means that a price per service coin is agreed upon in advance.
Alternatively he could pay in Ether: This could either be done after receiving the bill, or by locking up Ether in advance, which would automatically be used by the smart contract. In this scenario the smart contract would act as a decentralised escrow party.
The price per SLA token could either be agreed upon in Ether, or in fiat currency. In the latter case, the smart contract would have to query the exchange rate from Ether to fiat from an oracle service.

3 Conclusion and further outlook

Our smart contract based concept and prototype implementation thereof has shown promise to improve the transparency of the billing process, as well as the SLA compliance of cloud service providers.
At the same time, several challenges still have to be overcome:
Managing cryptocurrency wallets and private keys adds complexity, which should be made as opaque as possible to the customer. Determining service prices in Ether may also be impractical due to the high volatility of the currency. This also makes the cost of transacting on the Ethereum blockchain difficult to predict, which poses a risk for the economic viability of the solution. This could be mitigated by choosing a different blockchain with smart contracting capabilities and lower transaction costs.
Lastly, the open nature of the blockchain may allow competitors to derive information about the business relationships of the cloud service provider, which could be addressed via the addition of recent cryptographic techniques such as ZK-SNARKs [Be14] .

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Empirical Insights into the Appraisal of Tool Support for Participative Enterprise Modeling

An Experimental Comparison between Whiteboard and Multi-Touch Table

Anne Gutschmidt[1]

Abstract: The paper presents an experiment about modeling tools in the context of enterprise modeling in teams. A goal modeling task was set where three teams of three persons worked with a whiteboard, and three teams of three persons worked with a multi-touch table. The participants' ratings of the tool were compared between both manipulation groups. Moreover, the participants explained their ratings in individual interviews. Results indicate that multi-touch tables can be expected to be equally accepted by modeling teams, and uncover further potentials of the tool.

Keywords: enterprise modeling; multi-touch table; group work; tool appraisal; TAM; experiment

1 Introduction

The idea of participative enterprise modeling is to involve domain experts in the modeling process [SPS07]. To support them in collaborative modeling, suitable tools are needed. This study compares a modern tool, the multi-touch table (MTT), to a conventional tool, the whiteboard, to gain more insight into users' needs in the context of participative modeling. A whiteboard is a low-cost modeling tool that is available almost anywhere in a company. It allows participation in the modeling process of every stakeholder. A MTT represents a more costly tool which, however, allows for saving models digitally in order to share and edit them later on. The question is whether the MTT is likely to be equally accepted by modelers as is a whiteboard, such that the use of MTTs could be recommended for collaborative modeling. According to the Technology Acceptance Model (TAM), the intention to use a technology and its actual use are influenced by perceived usefulness, perceived ease of use, and perceived enjoyment [VB08]. This paper presents an exploratory comparison between whiteboard and MTT for enterprise modeling in teams focusing on the following research question: Does the MTT reach similar or better rankings for perceived usefulness, ease of use and enjoyment than the whiteboard such that it can be expected to be equally accepted by users in the context of participative enterprise modeling? Secondly, determinants of these constructs are examined in order to gain concrete hints on how to support modelers.

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2 Background

According to the TAM, perceived usefulness and perceived ease of use are major predictors of the intention to use and the actual use of a technology where ease of use is an antecedent of usefulness [VB08, Da89]. While usefulness refers to the product created by using the technology, the process of using the technology is addressed by enjoyment. Thus, usefulness can be considered as extrinsic motivation whereas enjoyment represents intrinsic motivation [Da89]. The latter is an important determinant of ease of use [VB08]. Thus, all three constructs serve in predicting the acceptance of a technology such as MTT.
The advantages of MTTs have been shown in previous studies, especially in the educational domain [PH09, MH14], where they are appreciated by students for enabling easy sketching and changing. Although there have already been several studies on MTT, there is still a need for research, especially with regard to functionality (usefulness) and the design of user interfaces (ease of use) for different kinds of tasks. Modeling tasks can take quite different forms. [Ba13] examined teams who were modeling UML state charts either on MTT or PC. He observed that input via touch keyboard was more laborious and time-consuming. [LW11] compared the use of a MTT with structured interviews for assessing business processes involving domain experts. They found that using the MTT was more fun and brought more insights in process understanding although the ANOVA showed no significance. [Bu12] compared MTT with flipchart and pen-and-paper equipment on brainstorming tasks. All teams produced a similar amount of ideas, however the pen-and-paper equipment seemd better-suited for categorizing ideas. The authors claim that the users' assessment of a tool was dependent on the kind of task at hand, e.g., the MTT seemed best suited for mindmapping. Enterprise modeling comprises a variety of models, thus, it is probably connected with different kinds of tasks. The study presented here will focus on one of these models, questioning the suitability of a MTT for collaborative goal modeling by comparing it to a conventional tool, i.e. a whiteboard.

3 Method

Experimental Design and Data Evaluation Method: To examine the influence of the tool on the users' subjective appraisal the tool was manipulated as independent variable. The participants of the study were invited to a multimedia lab where they worked either with a MTT or a whiteboard, based on random choice. In a group of three persons, the participants had to draw a *goal model*, which is a very basic model of the 4EM method, for a *pizza delivery service*. Every team had 30 minutes time to create the model. Afterwards, individual interviews were conducted and the participants filled out a questionnaire to assess the dependent variables. Perceived usefulness and perceived ease of use were measured using scales by [Da89]. A scale by [DBW92] was used to measure enjoyment. The questionnaire also contained questions about demographics and experience with modeling and MTT. In the interviews, the participants were asked why they found the tool useful or not useful etc. This lead to a list of advantages and disadvantages of the respective medium. Since the

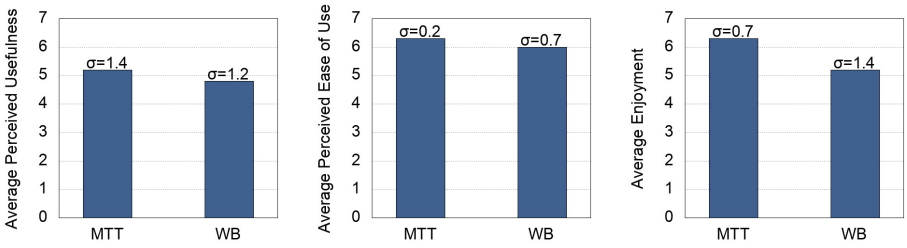

Fig. 1: Average values depicted as bars, and standard deviations of perceived usefulness, perceived ease of use and enjoyment (items rated on a 7-point scales with 1 = lowest), separated by tool, i.e. multi-touch table (MTT) and whiteboard (WB).

sample was too small for more sophisticated statistical analysis, only descriptive statistics were used to explore for a possible influence of the tool on the users' appraisal. To get overall values of perceived usefulness, perceived ease of use and enjoyment, mean values of all items of the respective scales were calculated. Afterwards, mean values of the respective constructs were determined for all whiteboard and all MTT users separately. Qualitative content analysis was applied to the interview transcriptions. To get a deeper understanding of the participants' appraisal of the tool, the interviews were scanned for statements on reasons for their appraisals of the tool they used in the modeling session. Subsequently, the text units were again categorized.

Sample: 18 persons took part in the study, three of them female. Three teams used the whiteboard and three teams used the MTT, with one gender-mixed team in each group. They were students of business information systems or computer science. In the whiteboard group, participants were 24.9 years old on average ($\sigma = 2.2, max = 28, min = 22$), in the MTT group, participants were 23.6 years old on average ($\sigma = 1.9, max = 28, min = 22$). The participants came from Russia, India and Germany. The level of experience of the 4EM notation, measured with a 5-point scale with 1 representing no experience, was at 2 on average for the MTT group ($\sigma = 1, max = 3, min = 1$) and at 3.7 on average for the whiteboard group ($\sigma = 0.6, max = 4, min = 3$). On a 5-point scale, the participants of the MTT group estimated their experience with MTTs at an average value of 1.7 with 1 representing no experience ($\sigma = 1.3, max = 5, min = 1$).

4 Results

Figure 4 shows the average values, represented as bars, of perceived usefulness, perceived ease of use and enjoyment, divided into MTT and whiteboard. Standard deviations can be found above the bars.
When asked to explain their judgement on usefulness, ease of use and enjoyment of the whiteboard or MTT, respectively, the participants named several advantages and disadvantages of the tools of which only the most frequently named will be listed here. With

regard to **advantages of the whiteboard**, six whiteboard users said that they appreciated that changes could be easily made at the whiteboard, e.g., *"What I like so much is that you can wipe off everything, can write again"* (5,1,1,63, translated from German).[2] Five whiteboard users mentioned that whiteboards were easy to handle, using them was intuitive and simple. Five persons said that with the witeboard they got a good overview. A major **disadvantage of a whiteboard** seems to be that with growing complexity models get more confusing, as stated by four whiteboard users. Three participants criticized that models cannot be saved. Moreover, three participants complained that changes would be hard to make to a model. Two participants said that the space on the whiteboard was restricted.
Concerning **advantages of the MTT**, six of the respective participants said that the MTT was easy to handle, e.g., *"it was a lot easy. Begin easily, drag here and there, set up the links. It was very friendly"* (3,2,1,75). Furthermore, five participants appreciated that changes could be made easily, such as deleting or moving content, with the software automatically adapting the model. Four participants said they especially liked the touch interface. They found it natural and easy, or they described themselves as used to it from smartphones. The possiblity of saving and thus being able to share models was mentioned by four participants. Three participants liked that the MTT enabled parallel working which may make the group faster. Two persons said the MTT let them get a good overview. Two participants said, with the MTT, one was able to build big models. Shortcomings of the software represented a major **point of criticism for the MTT**. Seven participants complained about problems with the software, e.g., when using the keyboard. This category also included missing functions, i.e. one team would have liked a zoom function. Two participants mentioned general problems using the MTT, e.g., *"Maybe I have to get used to using this, because my finger is so fat"* (1,2,2,2).

5 Discussion

The participants of the study judged whiteboard and MTT very similarly with regard to usefulness, ease of use and enjoyment. The MTT was very slightly rated higher. As far as can be derived from the interviews, most participants consider both tools as easy to handle. The touch interface seems to entail some attractiveness. Moreover, the opportunity of parallel working at the MTT seems to be appealing. Users are aware of typical advantages of the MTT, such as being able to share digital copies of models. The corresponding disadvantage of the whiteboard was named by whiteboard users. Space seems to be a challenge on both tools, however, MTT allow for intelligent software solutions that would possibly enable appropriate space management including zooming. The study has shown that users may be irritated or even frustrated if the software does not work properly or as expected. Thus, companies who want to apply enterprise modeling with MTT should care for usable and functional software that fits to their purposes as suggested by the TAM. All in all, users seemed to be equally comfortable with a MTT as with a whiteboard leading to the assumption that MTT will be equally accepted as a tool for participative modeling.

[2] Citations from interviews are given with number of trial, number of participant, page and paragraph.

The small sample size is one limitation of the study, however, it was considered as acceptable fo enabling an exploratory insight into tool support for collaborative modeling. Future studies should involve greater samples including different domains and less technophile persons. Additionally, further models and varying model complexity must be examined. The goal models in this study comprised at most 30 components. With growing complexity and size of models, more shortcomings of MTT might appear. That is why the software prototype used in this study will be improved and tested in future studies with particular focus on space management and supporting parallel working. MTTs offer advantages in terms of quick digitalization but they also have huge potentials with regard to participative enterprise modeling, enabling the creation of models based on the collaboration of several stakeholders. It might be useful if all stakeholders had a chance to participate in drawing, possibly resulting in increased satisfaction and commitment with the model as [LW11] already hypothesized. The connection between active participation and subjective appraisals such as commitment with the model will also be part of future studies.

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Model-Based Generation of Enterprise Information Systems

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Abstract:

Thick clients of client/server-information systems include increasingly more logic which leads to several challenges in the development process: Resulting from the separate development of front- and backend, the risk for inconsistencies between components on the one hand, and communication overhead between developers on the other hand are high. We present an approach which helps to overcome these challenges by using model-driven engineering for the development of data-intensive enterprise information systems. WebDEx was developed as a generator for the creation of such systems. It uses UML/P inspired modelling languages, as models (1) build the base for communication among project members and (2) are used as input for the code generator which ensures consistency by construction. This work relies on an infrastructure created by the language workbench and code generation framework MontiCore. Moreover, this paper presents the practical application of this approach for the agile development of a multi user, adaptable web-application to be used by more than 400 chairs of RWTH Aachen University.

Keywords: Data-Intensive Enterprise Information Systems · Model-Based Software Engineering · Model-Driven Information System Development · Multi-User Web Applications · WebDEx · Agile Development

1 Introduction

In the development of web-applications with classical thin clients, logic is defined on the server-side. In modern architectures, thick clients, also known as smart clients, assign a part of the functionality to the client-side. This type of software design is getting more in common in modern architectures [JW06]. Hence frontend and backend are implemented separately and often use different programming languages. Developers of both parts have to communicate intensively and have to adjust their implementation to the corresponding other side. Consequently, this increases the risk for communication overhead and inconsistencies.

Abstract models have proven to be a good approach to face these challenges. They can be used as a foundation to all parts of the implementation. These models provide a viable input for generators to create source code, which is consistent among various parts of the project

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(consistency by construction). Domain experts with modelling skills are able to develop and customize these models within their respective domain without being involved into details of the implementation or other domains (similar to [HMM18]). Models build the base for communication among project members. Moreover, changes of the models are easily passed on to the source code and decrease development time. This provides advantages for each of the three intended user groups: *The developer* needs only specific knowledge about the implementation e. g. of types, but not about the involved domains. *Domain experts* with modelling skills develop the models (data structure and GUI design) within their scope, and need no knowledge about implementation details. *The end user* benefits from fast handling of changes, easy adaptability to new guidelines and quick implementation of feature requests.

This work is based on the model-driven software engineering (MDSE) experiences of the SE group of RWTH Aachen university and the developed MontiCore (MC) language workbench and code generation framework [KRV10]. Models, created with UML/P [Ru16] inspired modelling languages, are used as input for this framework. The presented approach for the development of enterprise information systems (EIS) is grounded in preliminary work of the research group, e. g. several theses and the latest developed MontiCore Data Explorer (MontiDEx) code generator [MRR15]. MontiDEx processes models to generate data-centric applications in Java and Java Swing. The current approach includes the movement to a different technology stack (Angular as a framework for client applications). Thus, a new EIS generator called WebDEx was developed. There exist several approaches for the generation of web applications using different platforms, e.g., Bernardi et al. [Be12] integrate three meta-models based on a declarative language. Given the page limit, we refer the readers for further discussion of related work to `http://www.se-rwth.de` (publications and phdtheses).

The presented approach has a high proportion of generated code and shows its' practical application with a case study creating a data-intensive EIS within the MaCoCo project[3]. An important goal of the project was the agile development and adaptability of this multi-user web-application. Thus, lead users are involved actively in the development process, new features are delivered quickly and frequently and the project team reacts fast to changes with a focus on improving the quality of the EIS. MaCoCo will be used for financial and staff management of more than 400 chairs of the university. Moreover, the findings from building generic abstractions make our approach reuseable for other EIS development projects.

The paper is structured as follows: Section 2 specifies the general concept of the approach and its' main advantages. Section 3 presents the first practical realization of our approach in the MaCoCo project. The last section reviews the current progress and highlights further goals and next steps for our approach.

[3]The MaCoCo project is funded by the RWTH Aachen University and jointly realized by the chairs of Controlling and Software Engineering.

2 MDSE for data-intensive EIS

Our approach for the model-based generation of data-intensive EIS (Figure 1) consists of three major components: (1) A set of *models* describing the software that will be generated as input, (2) a powerful *generator*, including a set of parsers, capable of interpreting given models and (3) the *target*, where the generated sources will be built in (in this case realized as web-applications).

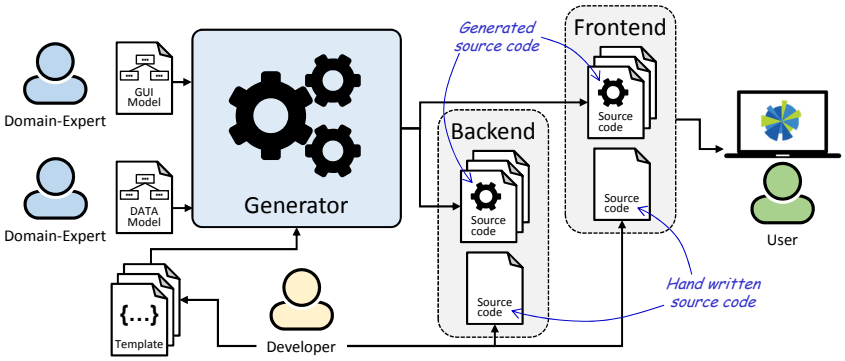

Fig. 1: Approach for the model-based generation of data-intensive EIS with the WebDEx generator

(1) Domain experts provide models in corresponding textual domain specific languages (DSLs): A GUI-designer provides a GUI-model (based on MontiViz [Re16]), whereas different domain-experts provide data-models, e. g. class diagrams (created with UML/P [Ru16] inspired modelling languages). These models describe different aspects and components of the software.

(2) The generator interprets the models with parsers (created with MontiCore[4]). In a next step, the generator detects conflicts between the given models, e. g. names are assigned twice, and applies standards which are defined at a global level, e. g. getters and setters for each data class or default parameters. Once the abstract representations of the models are processed, the generator uses platform specific *templates* to generate source code. Such a template is a blueprint for code fragments in a certain programming language, like method or attribute definitions (e. g. how to write a `toString()` method in Java code). They can be exchanged to generate source code in different programming languages, while using the same set of models.

(3) Depending on it's configuration, the generator will create code for both front- and backend. The generated code is easy to read and interpret, can be easily extended to include hand written code, and reacts well to model changes by domain experts.

[4]MontiCore provides parsers for textual DSLs if provided with a corresponding grammar. See `http://www.monticore.de/` for more information.

To sum up, the main advantages of using the generator are: it works iteratively and deals thus well with changes, it is responsive to existing hand written code and already provides extension points to enable the enhancement of the generated functionality by hand.

3 Practical Realization: MaCoCo

In academia research projects' *financial management* is becoming increasingly demanding: Different funding authorities, a variety of funding schemes and especially diverse requirements for accounting make it a challenging field for researchers and administration. Similar challenges occur for *staff management*, where different sorts of contracts and salary schemes, official restrictions for employments and changing assignments to projects keep administration busy. The more *projects* a chair has, the more researchers are hired and the more important it is to keep an overview.

Out of this need, the chairs for Controlling and Software Engineering started the MaCoCo (Management Cockpit for Controlling) project[5], which realizes a data-intensive EIS as web application. Supported features are extended financial and staff management as well as course administration for professors. MaCoCo is intended to replace and standardize existing management processes and is planned to be used by up to 400 chairs of RWTH Aachen University.

In a first realization step, a handwritten prototype has been realized to outline the project's scope. Based on this source code a generator was created to replace the handwritten parts step-by-step with generated code [Gr06]. Whereas it may seem quite unusual to develop a project like this, this first realization step was very useful to evaluate the initial concept and get more into the domain. Anyhow, here is no need to follow this way of realization in other projects: The generator can now be used to create a new application, without preceding handwritten implementations.

As readers can imagine, each chair has different requirements for such a system and they can change over time due to external influences. This means *agile development* for quick implementation of requests is a must. Using a model driven approach in combination with the generator makes it possible to react quickly to changes in the data model and still produce a consistent product. Changes of data types of existing attributes or adding new attributes in the model will result in a corresponding change in the generated application. Currently nearly two thirds of the dynamic parts of the application are generated. Runtime environments and services are currently hand written, but could be easily generated as well.

[5] See `https://git.rwth-aachen.de/macoco/extern/wikis/home` for further details.

4 Conclusion

To sum up the main contribution of this paper: The presented approach makes it possible to generate large parts of an EIS and to develop such systems in an agile manner. As a proof of concept we presented the practical application of the approach in a case study. It is possible to use multiple models as an input and to generate source code in two different programming languages (TypeScript, Java). The *most challenging aspect* was building abstractions of the existing hand written source code fragments. Generic parts had to be identified in order to efficiently create templates. Nevertheless, once these generic abstractions exist, they are reusable for other EIS development projects.

Up to now visualizations and SQL statements are not generated. Thus, *next steps* include the development of a generator for visualization models and the generation of SQL statements related with the visualization. Furthermore, we are interested in using additional models, e. g., state charts and sequence diagrams, as generator input to improve program logics.

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Dealing with Artifact-Centric Systems: a Process Mining Approach

Guangming Li[1] and Renata Medeiros de Carvalho[2]

Abstract: Process mining provides a series of techniques to analyze business processes based on execution data in enterprises. It has been successfully applied to classical processes on WFM/BPM systems, in which one process execution consists of events attached with the same case id. However, existing process mining techniques suffer from problems when dealing with artifact-centric systems, such as ERP and CRM, in which a business process involves a set of interacting artifacts and a case notion for the whole process is missing. Some typical problems are convergence and divergence in XES logs, and lost interactions between multiple instances in process models. Existing artifact-centric approaches try to address these problems, but have not yet solved them satisfactorily. For instance, one has to pick an instance notion in each artifact, the description of the end-to-end behavior is distributed over multiple diagrams, and the interactions between the data perspective and the behavioral perspective are not explicitly presented. This paper proposes a set of new techniques, such as a novel log format and a novel modeling language, to enable process mining for artifact-centric systems.

Keywords: Artifact-Centric Systems, Process Mining, Object-Centric, Event Logs, Process Models

1 Introduction

Nowadays, information systems are widely used in enterprises to support their daily business process executions. Such an information system is called *Process-Aware Information System (PAIS)*, since it needs to be aware of business processes [Du05]. A typical class of PAISs is formed by generic systems that are process-centric and driven by explicit process models, i.e., one process execution on these systems is constituted by a single case with a unique case identifier. Examples are Workflow Management (WFM) systems [vdAvH04] and Business Process Management (BPM) systems [We07]. Another class of PAISs consists of artifact-centric systems that do not have a unique case notion, which could be used to trace and isolate its executions. The entire process on these systems is seen as a set of interacting business entities called artifacts. Examples are Enterprise Resource Planning (ERP) systems (SAP, Oracle, etc.) and Customer Relationship Management (CRM) systems [O'00].

Process executions on PAISs generate various data, e.g., relational database tables and event logs, which can be analyzed to discover insights to reflect the "health"condition of

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enterprises. Process mining provides a set of techniques to analyze business processes from different angles. For instance, process discovery is a technique to automatically discover a process model from recorded process executions. Conformance checking detects the disagreement between the actual process executions and a reference process model. Performance analysis identifies the bottlenecks in business processes.

Process mining has been successfully applied to classical WFM/BPM systems, which assume a case notion for the whole process. However, one can easily see that this assumption is violated by real-life processes supported by ERP/CRM systems. These systems are artifact-centric and often have one-to-many and many-to-many relationships between data objects (e.g., customers, orders, invoices and payments). Existing process mining techniques need a case notion to correlate events both in event logs (MXML and XES) and process models (Petri nets, EPCs and BPMN). Therefore, they are doomed to fail on artifact-centric systems. In this paper, we propose new process mining techniques, which do not depend on case notions and are suited for artifact-centric systems.

2 Challenges

As mentioned above, artifact-centric systems do not assume case notions in their business processes. Therefore, existing process mining techniques suffer from the following problems when they are applied to these systems.

The XES log format harms the quality of original data. There often exist one-to-many and many-to-many relationships in the data generated by artifact-centric systems. Therefore, a case notion for the whole process is difficult to be identified. If we straightjacket such data into XES logs, it flattens multi-dimension data as separate traces, which leads to convergence and divergence problems. Besides, the XES format focuses more on the behavioral perspective (i.e., only considering events and information related to events), which may not present useful information on the data perspective.

Existing modeling languages are difficult to model interactions (i) between process instances and (ii) between the data perspective and the control-flow perspective. Existing process modeling languages (e.g., Petri nets, EPCs and BPMN) consider process instances in isolation. The interactions between instances cannot be described properly. Besides, they mainly focus on the control-flow perspective. Powerful constructs present in ER models [Ch88] and UML class models, which can easily deal with one-to-many and many-to-many relationships are not employed at all. Moreover, constraints on the data perspective must influence behavior, but this interaction is not described by existing languages .

Deviations are not totally detected. Some deviations on the behavioral perspective can only be detected by considering multiple instances and constraints in the class model. In this situation, the weak data perspective in existing models makes such deviations undetectable.

Performance analysis may not be reliable. Due to convergence and divergence problems, the performance analysis result may be imprecise (e.g., inaccurate frequencies). Besides, because of missing information on data perspective, useful insights for users on this perspective may not be provided by performance analysis.

3 Approaches

The problems discussed in Section 2 prevent the employment of "classic" process mining techniques on artifact-centric systems. In this section, we propose new process mining techniques to solve these problems, as shown in Figure 1. In general, the spectrum of our approaches are consistent with the lifecycle of "classic" process mining research, i.e., our new process mining techniques try to reach the same goals on artifact-centric systems, as the "classic" process mining approaches reach on WFM/BPM systems. More precisely, based on a novel log format and a new type of models, we propose new process mining approaches covering log extraction, model discovery, conformance checking and performance analysis, to enable process mining on artifact-centric systems.

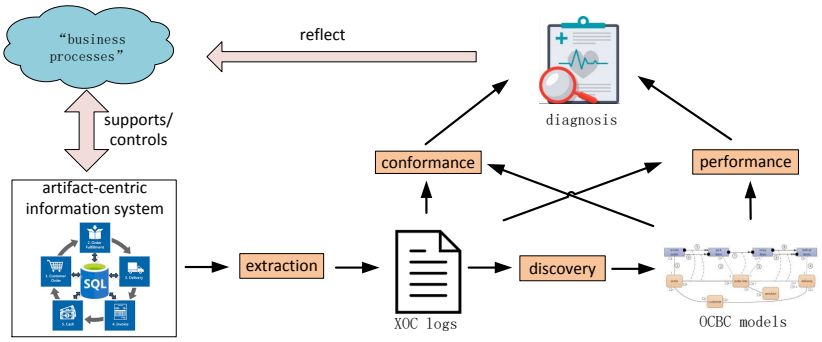

Fig. 1: The framework of our approaches.

eXtensible Object-Centric event logs. We propose a novel log format named eXtensible Object-Centric (XOC) to organize the data generated by artifact-centric systems [vdALM17]. Artifact-centric systems do not have a clear case notion for the whole process, but they follow an intuitive principle that each occurred event on the system changes the state of the system (i.e., adding, updating or deleting records in the underlying database). Triggered by this idea, a XOC log consists of a set of ordered events and each event corresponds to an object model representing the database, which provides an evolutionary view of the system. Note that an object model may represent only the tables involved in the target process when the database covers multiple processes.

Object-Centric Behavioral Constraint models. We propose a novel modeling language [vdALM17], that combines data modeling languages (ER, UML, or ORM) and declarative

languages (Declare, CMMN, or GSM), resulting in Object-Centric Behavioral Constraint (OCBC) models. More precisely, as shown in Figure 2, an OCBC model consists of a class model (presenting cardinality constraints between classes on the data perspective), a behavioral model (presenting declarative constraints between activities on the control-flow perspective), and relationships (① ∽ ④) which connect these two models by relating activities to classes. Unlike existing declarative languages, the scope of each behavioral constraint (e.g., ⑦) is identified by classes (e.g., “order line") rather than case notions.

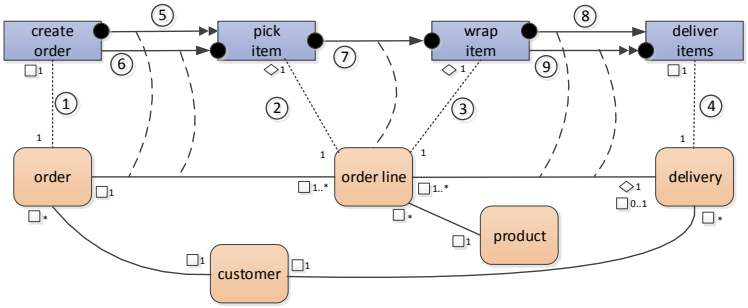

Fig. 2: A small Object-Centric Behavioral Constraint (OCBC) model.

Besides, we propose approaches to automatically extract XOC logs from relational databases of artifact-centric systems and discover OCBC models from XOC logs [LdCvdA]. Based on a XOC log and a reference OCBC model, a set of rules are defined to check the conformance between them [vdALM17]. In future, we also plan to analyze the performance based on the statistics of frequencies and time, which can be obtained by replaying a XOC log on an OCBC model. More precisely, various metrics can be defined to analyze the performance of business processes from different angles.

4 Related Work

The artifact-centric approaches [CH09] (including the earlier work on proclets [Aa01]) consider the entire process as a set of interacting artifacts. Each of these artifacts can be described by an information schema (called an artifact schema) and a non-trivial lifecycle (indicating how the artifact evolves through a process execution). However, these approaches suffer from the following problems: (i) within an artifact (proclet, or subprocess), one is forced to pick a single instance notion (although a case notion for the whole process is not required); (ii) the description of the end-to-end behavior needs to be distributed over multiple diagrams (e.g., one process model per artifact); (iii) the control-flow cannot be related to an overall data model (i.e., there is no explicit data model or it is separated from the control-flow); (iv) interactions between different entities are not visible or separated (because artifacts are distributed over multiple diagrams); and (v) cardinality constraints in the data model cannot be exploited while specifying the intended dynamic behavior.

Besides, colored (data-aware) Petri nets [Je96] add "color" on tokens to attach a data perspective on the behavioral perspective. BPMN [Gr10], Data flow chart and UML activity diagram [EP00] can describe behavioral perspective and its communication with data perspective by data objects and data stores. Concepts like lanes, pools, and message flows in conventional languages like BPMN can model interactions between process instances. In summary, these models mentioned above can describe the data perspective and interactions to some extent, but more powerful constructs present in ER models and UML class models are not employed at all in these models.

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Design and Development of a Process Modelling Environment for Business Process Utilization within Smart Glasses

Jannis Vogel[1], Sven Jannaber[1], Benedikt Zobel[1] and Oliver Thomas[1]

Abstract: Business process modelling languages do not yet allow a representation of mobile or wearable device functionality, such as gestures, audio and video recording or voice commands, within a process model. However, in the last decade novel technologies like Smart Glasses or Smart Watches have been further integrated into the execution and support of business processes, thus leading to new requirements for an appropriate business process modelling and their integration into information systems. Hence, the paper focuses on a novel research direction with the overall objective to assess a potential integration of mobile and wearable device functionality in business process models, which subsequently can be transformed, utilized and automatically executed on mobile and wearable devices. Based on a Smart Glasses-based exemplary business process, we demonstrate the usage of domain-specific modelling languages for a model-driven Smart Glasses-based information system.

Keywords: Domain-specific Modelling Language, Smart Glasses, Wearables, Model-driven IS

1 Introduction and Motivation

Process models have proven to be beneficial for businesses, especially if such models consider specific domain concepts and are used to enable the implementation of information systems [To07]. In addition, [Ho11] mentioned that ubiquitous computing and mobile devices will result in new research to allow flexible business processes and an easier integration. However, technological advances such as mobile or wearable devices are not yet considered by standard business process modelling languages such as the EPC and BPMN, although e.g. Smart Glasses have been frequently associated with mobile process support [Me17, NMT17]. To this end, more and more domain-specific extensions have arisen for business process modelling in the last decade [BPS14], which allow for the representation of a special domain within modelled processes and improve the model quality as a communication instrument between process experts and business users [Yo16]. Although many different BPMN extension for various domains exists [BE14], only a few address the technological integration of devices like the uBPMN by [Yo16].

Therefore, superordinate focus of the conducted research is a design-driven research

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project, which aims for a direct integration of mobile and wearable device functionality into business for process automation purposes. The research presented in this short-paper focuses explicitly on Smart Glasses as a new wearable device, due to its popularity in the context of mobile process support, e.g. in the field of technical customer service. Hence, the presented research addresses the following research question: *How can mobile and wearable device functionality be integrated within business process models that can be utilized and automated on Smart Glasses?*

To address the research question, we initiate a design-driven research project with the aim to integrate Smart Glasses functionality into a new domain-specific modelling language (DSML), whose models can be interpreted for the utilization and automation on Smart Glasses. The new procedure, explained in detail in section 3, should minimize implementation concerns like privacy, limited battery capacity and small screens that turn up with the use of Smart Glasses. This is realized by using a model-driven concept. A correct representation of the Smart Glasses functionality is achieved through a domain-specific language extension that is based on the BPMN. The paper is structured as follows. The next chapter outlines the research method, followed by the objectives of the solution and explanations behind the conceptual idea of model-driven information system demonstrated by a BPMN extension for Smart Glasses functionalities. Finally, the last section discusses the implications of the new research direction and gives an outlook.

2 Research Method

The research method towards a utilization and automation of Smart Glasses functionality is shown in Figure 1. The research project follows a problem-oriented Design Science Research Method in accordance to [Pe08]. The excerpts from the first two phases are presented in this paper (red border). In the first section, the problem is identified and motivated. A DSML for Smart Glasses representing functionalities should lead to a utilization and automation of the created process models within model-driven IS. In section three, we clarify the objectives of the solution. Not included in this paper, but in the outlook of the design-oriented research, is the design and development phase. It contains a definition of requirements for the DSML and the model-driven concept for a total model to IS transformation. The DSML for Smart Glasses will be developed. Moreover, we will implement a prototypical implementation of the generated model-driven IS. In the demonstration phase, the prototype is applied to real business processes from various domains. An evaluation will create new insights and evaluates the generated prototype against the real world. Lastly the results of a new model-driven concept will be communicated in the IS literature and through practical talks and exhibitions. Especially the rigorous definition of new concepts for a technological domain-specific modelling language is crucial for further usage. Therefore, further investigations have to be included regarding the development of technological domain-specific modelling languages for mobile devices and wearables. For the most popular

modelling languages such as EPC and BPMN, general approaches exist for development. For instance, [BS14] created the method for domain-oriented development of BPMN extensions. Other frameworks are more general, like the Framework for the Development of Domain-Specific Process Modelling Languages by [Ja17].

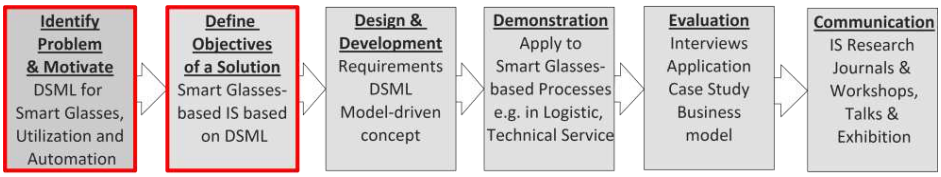

Fig. 1: Design Science Research Method [Pe08]

3 Integration of Smart Glasses Functionality within Business Process Models

The primary objective is an effective integration of business process models through a model-driven approach, which allows an automatic generation of a Smart Glasses-based IS. The model-driven concept is depicted in Figure 2. We build on an example process in the logistics domain based on a primary use case (15) identified by [Ni17]. We use the process receipt of goods, which is very common in the logistic domain. A possible BPMN extension for the Smart Glasses-based process domain or any other DSML is used for a model-driven approach (1). The user can trigger the process with a speech command, e.g. “process receipt”. After that, an identification of the palette is executed through a scan task. The user can then decide manually if the products are intact. If the products are damaged, the user should record the damage with the Smart Glasses camera and receives a damage classification as an information provision task in a list form. The other path results in an advanced communication task, which informs the receiving department that the delivery is satisfactory. Besides the graphical representation, further properties could exist for a precise Smart Glasses-based IS, such as the declaration of possible interactions functionalities such as speech, touch or gestures. The process model is then used as basis for the software development. Code generation and interpretation are two approaches (2) for the model-driven software development (MDSD). The main differentiation between both is the code binding. An interpreter allows the binding during runtime, while a generator binds the data during compilation. Therefore, further advantages could appear with the use of an interpreter. An interpreter is supposedly favourable, because changes at the model directly affect the behaviour of the software. Consequently, a developer and a business expert can change the model together iteratively until they created the desired information system [St07]. Especially in the Smart Glasses domain, the variable creation of Smart Glasses information systems is necessary, since Smart Glasses are used in a mobile environment where processes can change rapidly.

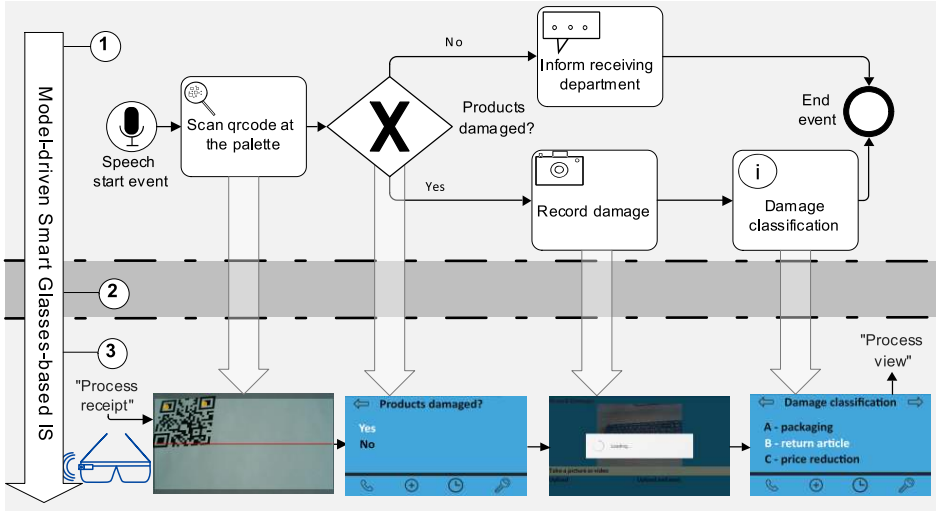

Fig. 2: Transformation of business process model to Smart Glasses-based IS

A model-driven concept realized with an interpreter aims at a 100% model to information system transformation. Therefore, no further steps are necessary for the directly generated Smart Glasses-based IS (3). Consequently, a mobile worker gains step-by-step guidance comparable to [Me17] and also generates process relevant data through the solution with speech commands, photos and interactions through the usage of the device during job tasks. The presented solution is similar regarding the usage of process models for mobile process support as in [Me17]. However, the concept in this paper extends the access to Smart Glasses functionalities through technical process models and focuses on the generation of Smart Glasses-based IS with a model-driven approach, which exceed visualisation purposes.

4 Conclusion and Outlook

The presented concept is a solution for the challenges that turn up with the implementation of Smart Glasses in businesses. A possible BPMN extension, which implements the missing Smart Glasses-based process concepts, allows the technical representation of Smart Glasses functionalities in a process model. Through the combination with a model-driven approach, many advantages regarding model quality, implementation speed and enhancement in the importance of process models can be gained. The presented challenges and potentials with the aid of a model-driven IS can be transferred to new existing and upcoming mobile devices and wearables. Further investigations have to be done besides the pure technological integration of the devices within process models, how internet of things components can be integrated into the presented research and how an overall context-aware information system can be realized.

Finally, a further question is how new cloud services for translation, computer vision or artificial intelligence can be integrated through a modular approach.

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Towards practical applicability of Service Engineering: A literature review as starting point for SE method design

Simon Hagen[1], Sven Jannaber[2] and Oliver Thomas[3]

Abstract: Several methods for developing services have been published in research, but only few find their way into practical application. In this study, which is also the first part of a superordinate DSR project, we conduct a literature review and analyze service engineering methods. The results will be used to derive practically tested methods and implement a supporting tool.

Keywords: Service Engineering Method, Design Science, Literature Review, Workshop

1 Introduction

Induced by the intensifying globalization and interconnectivity of markets and competition, especially small and medium sized enterprise (SME) strive for improving their business models to gain a sustainable competitive advantage [Kf18]. Since mechanical engineering is a leading industry in Germany, one strategy for product-centred offering is by integrating services to supply a solution-bundle instead of a physical product solely (often referred to as product-service system, PSS) [Lc16]. Offering services can imply significant opportunities for companies to stay competitive [Pl18]. Henceforth, the management and engineering of services has been a frequent subject of discussion in literature. Initial studies on the impact of services on economies can be found in scientific literature in the 1970s and 1980s [Co84] and developed over time to today's research discipline of Service Engineering (SE) [SM10]. According to [Pg09], SE strives for the "systematic development and design of services using suitable models, methods and tools as well as the management of service development processes" and many methods have been developed yet to support this process. However, only few SE methods are used in practice [Mt06], even though they support companies in improving their business, which questions the applicability of the SE methods developed so far.

Therefore, our superordinate research aims at enabling companies to apply systematic approaches to develop their service offerings by designing suitable SE methods and implementing appropriate supporting tools. As a starting point, we conducted a study (expert interviews) confirming the results from [Mt06] and revealing requirements on the usage of SE methods in German SME (currently in review) and performed an extensive literature review regarding the current state-of-the-art of SE methods, which will be described in this contribution. By doing so, we want to provide results for the superordinate research and answer the following research questions within this

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contribution: *(1) Which SE methods have been developed in science so far* and *(2) how do they perform when being assessed against practical applicability* (which resulted from the previous study interviewing experts)?

2 Research Method

For the paper at hand we conducted a structured literature review (LR) according to [WW02], examining 3,361 results from six databases (ACM, AISeL, EBSCOHost, ScienceDirect, Web of Science, SpringerLink). We applied the search term "Service Engineering" in combination with "Tool", "Method", "Model", "Framework", "Methodology", "Approach", "Design" and "Procedure" and limited the results to the years 2000 to 2018 since the term SE has primarily emerged after 2000. Furthermore, we have restricted our results to the original, first-time publication of each method. No further restrictions were made. Figure 1 shows the assessment of the publications found. The final 29 publications were transferred into a concept matrix and analysed in detail, by highlighting similarities within the applied components of each SE method (e.g. phases) and characteristics originating from previous studies with a similar scope (c.f. section 3).

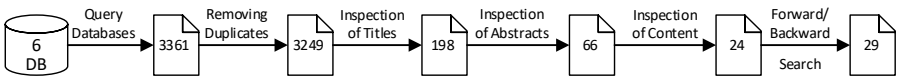

Figure 1: Literature review research approach

In combination with the interviews stated in the introduction, the presented research marks the first phase of a superordinate DSR project, illustrated in Figure 2. Based on the results of the LR, we will evaluate promising SE methods in distinct workshops with both researchers and practitioners, in order to assess whether a method is suited for an application in practice and how they have to be adapted or combined to provide most benefit (phase 2). The resulting SE method will then be implemented as a software tool (phase 3) which guides engineers through the service development process. In accordance to DSR, we will then evaluate and improve the prototype in the later phases. The dotted rectangle in the figure marks the scope of our current research.

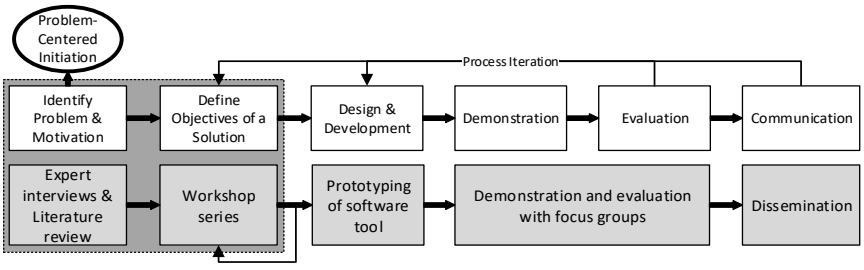

Figure 2: Research framework according to [Pk08]

3 Results of the Literature Review

To fit the scope and purpose of this research proposal, we demonstrate an excerpt of our LR, which in total consists of many more characteristics and analyzed publications (c.f. section 2). We therefore focus on the main findings related to practical applicability of SE methods which we derive from characteristics like *tested in practice (1)*, *concrete realization suggestions (2)*, *interfaces to other disciplines (3)* and *sufficient description (4)*. With respect to different phases of SE, we distinguish between: *(5a) strategy/planning*, *(5b) development*, *(5c) organizational aspects*, *(5d) reusable documentation* and *(5e) evaluation and adaption of the method*. The reduced concept matrix is given in Table 1, a partly-filled circle marks a characteristic which is partly-fulfilled by the corresponding method. All descriptions and conclusions of the results in this contribution refer to the matrix in Table 1, but also apply to the findings of the entire study.

Authors / Characteristics	(1)	(2)	(3)	(4)	(5a)	(5b)	(5c)	(5d)	(5e)
Alix, Vallespir (2010)	○	◐	○	○	x			x	x
Vasantha, Komoto, Hussain et.al (2013)	○	○	○	●	x				x
Berkovich, Leimeister et al. (2014)	○	○	◐	●	x	x		x	
Pezzotta, Cavalieri, Gaiardelli (2012)	◐	○	○	●		x		x	
Gangadharan, Luttighuis (2010)	◐	○	◐	●	x	x			
Kersten, Kern, Zink (2006)	○	○	○	○	x			x	
Kunau, Junginger, Herrmann et al. (2005)	○	○	○	●		x	x		x
Spath, Demuß (2006)	○	○	○	○		x	x		
Bullinger, Schreiner (2006)	○	○	○	○		x			
Scheuing, Johnson (1989)	◐	○	○	○		x			
Modell nach DIN (1998)	○	○	○	○	x	x			x
Kingman-Brundage, Shostack (1991)	○	○	○	○		x	x	x	x
Mont (2001)	◐	○	○	○	x	x	x		x

Table 1: Excerpt of the concept matrix of the literature review

In terms of the *practical evaluation (1)* of the examined SE methods, it becomes obvious that only few methods have been tested on use cases in practice. In addition, these evaluations usually neither take place in firms nor are they executed by practitioners, but are applied by scientist to known examples. However, one has to note that our assessment only involves first-time publications of the SE methods, rather than all succeeding submissions in which more detailed evaluations might have been conducted. Nevertheless, the findings imply that practical evaluation does not play a key role in SE method development, which is questionable considering the long-term objective to apply such methods in practice.

The second characteristic, *concrete realization suggestions (2)*, refers to descriptions or references to well-known and accepted methods or tools (e.g. BPMN for process modelling or business model canvas for business modelling), which are used in the context of the superior SE method. This is a valuable indicator for whether the method can be easily applied in practice, since one can use predefined methods to accomplish the

development of new services, rather than having a generic description of an approach and thus having to implement it by oneself. As the results show, only very few methods suggest concrete tools or artifacts to realize the proposed SE method. In addition, the suggestions often do not cover the complete method and only focus on several steps/phases. This result goes along with the *sufficient description (4)* of the phases, tasks and structures of the SE method if there is no reference to an external approach. If the SE method has its own approach for the different phases, they need to be described extensively and sufficiently, which does not hold is in most cases.

Interfaces to other disciplines (3) refers to the (intended) capabilities of a method to integrate (with) other engineering fields (e.g. software engineering). Due to the increasing integration of products, services and other fields (c.f. introduction), it is important that SE methods promote or support such interactions. Despite the importance, only few methods partly consider the integration to other engineering tools or methods to allow a seamless development of a solution offering. However, this link usually does not refer to specific methods but implies the adherences of the other disciplines (e.g. "Since multiple departments […] participate in the creation of the user requirements document […]" [Bm14]).

The last characteristic described in this excerpt is divided into several values. In general, the characteristics (*5a-5e)* indicate which priority or focus a method sets. This is important for the next step in our research and therefore for the practical applicability, since a method should be able to cover the whole cycle of SE development. Within this contribution, the characteristics *(5a-5e)* do not seek to exhaustively describe all aspects of a SE method, but seem to be the most important ones. We do not assume that for every project all phases are required. However, for a generic approach, which will be used as a basis for a prototype, an extensive view is important. The analysis shows that two core areas are covered in almost every SE method: *strategy and planning (5a)* as well as *development (5b)*. This seems consequential, due to the meaning of development procedures. Other facets however, like the consideration of *(5c) organizational aspects*, the *(5d) documentation of the results* or the *(5e) evaluation and potential adaption of the method*, are considered only scarcely.

4 Conclusion and Future Research

The results of the LR show that, from a scientific point of view, no SE method seems to be fully applicable in practice yet. However, one has to notice that the aim of scientific methods is not always to satisfy practitioner's needs, but in an application-oriented field of research, this aim should be implied. Therefore, based on the insights we gained from our previous study (expert interviews), the literature review shows that it is challenging for companies to find adequate and usable SE methods. Especially in rapidly changing times, a suitable method can be of big value for companies to continuously improve their business model. However, the study also reveals information regarding beneficial aspects

of the methods examined which we use to carry on our superordinate DSR project. Based on the results of the interviews from practice, requirements regarding service development, and the complete LR, we compile a comprehensive method for SE development, which especially fits the requirements of practitioners. Since this method already builds upon practical requirements, we expect it to already be more applicable in industry. However, to improve the new method even further, we will apply it to real-life use cases with practitioners and evaluate it accordingly. So far, an initial search regarding suitable workshop concepts has been carried out, which will be used to prepare a generic workshop concept. Subsequently, this allows for evaluating different SE methods. In a first step, we will test the workshop concept with a group of researchers (pre-test) from different disciplines to obtain information about the workshop concept in general and a first glance at the applicability of one SE method. The results will be used to finalize the concept and apply it in several workshops with practitioners (second step). In an iterative process, we evaluate SE methods and improve our newly designed method continuously. We have terminated the first workshops for May 2018. Finally, we want to implement a supporting tool which guides engineers through the process of the evaluated SE method and provides useful functionalities during the process.

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Towards a Modular Reference Architecture for Smart Glasses-based Systems in the Logistics Domain

Benedikt Zobel[1], Lisa Berkemeier[1], Sebastian Werning[2], Jannis Vogel[1], Ingmar Ickerott[2] and Oliver Thomas[1]

Abstract: While smart glasses-based systems have potential to support users through context-adaptive information provision, implementations are still scarce and limited to pilot and test projects. This lack of design and implementation experience as well as research hinders deployment of these devices in organizations. Through a comprehensive consortium research project, we defined a system architecture addressing various implementation issues. By presenting this architecture as reference model, we make this design knowledge accessible and support future projects, both in research and in practice.

Keywords: Smart Glasses, Domain-Specific Modelling Language, Information System Architecture, Logistics

1 Smart Glasses for Logistics Services Functions

Smart glasses have potential to support logistics service tasks along the whole value chain [Ni17]. With context-adaptive information provision in the user's field of view and hands-free navigation options, smart glasses are especially beneficial as a service support system for information intensive and bimanual tasks [EV15]. Implementations of smart glasses-based systems are still scarce and limited to pilot and test projects [Ca15]. Due to this lack of design and implementation knowledge, organizations face uncertainties how to deploy smart glasses. Implementation projects face technical and social risks. Smart glasses such as the Google Glass face adoption barriers because of a negative social impact [KKA15]. Smart glasses are equipped with sensor and camera technologies to gather data from the user's environment. The privacy invasive functions need to be considered in the system design from the beginning [Be17]. In terms of the technical realization, questions arise on how to implement system modules and how to integrate processes into the support system. The integration of processes into the guidance system has high resource costs as modelling experts and domain experts are both required to model the processes [Me16].

In the three-year consortium research project Glasshouse, we developed a system architecture addressing these implementation issues. We introduce a reference architecture to make this design knowledge accessible. Reference models aim to bring design knowledge of specific information models into a reusable form [Th06]. We argue that

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reference models for smart glasses require the integration of a modular implementation approach, privacy compliance aspects and process models. The reference architecture for smart glasses-based support systems ensures compliance with privacy regulations and provides guidance in the technical implementation.

Against this background, the questions that guide our research are: (RQ1) How can smart glasses be implemented in logistics services? and closely connected to the previous question: (RQ2) How can a reference architecture for smart glasses in logistics services be build? To address our research questions, we proceed as follows: In Section 2 we provide a concise overview on the consortium research project. In Section 3 the reference architecture for smart glasses-based support systems in logistics services is introduced. The discussion and an outlook are provided in Section 4.

2 From a Research Project to a Reference Architecture

In cooperation with a globally acting logistics service provider with a focus on contract logistics, a medium-sized logistics company with a focus on fashion logistics as well as a software implementation company, we defined potential use cases for smart glasses in logistics [Ni17]. The target of the project is the development of modular solutions to pilot a support system for smart glasses along the logistics supply chain. We target reliable processes, ergonomic workplaces, and we address technology acceptance of smart glasses. As part of the requirements engineering and prototyping process, we integrate the factors privacy, usability and acceptance from the beginning to guarantee usable and accepted smart glasses-based systems for real and practical applications [Be17, Be17b, Zo16].

Through the course of the project, we implemented three smart glasses prototypes from different application areas. They integrate process guidance and modelling aspects. Furthermore, we implemented a web application to model business processes for smart glasses. While creating first prototypes, requirements from software-, technology- and backend-side appear. We refined the requirements after each development phase. This leads to different prototypes based on the use cases and ending up with a clear need of a smart glasses-oriented software architecture addressing technological, software- and backend- requirements [Be17b].

3 Architecture

Technology adoption can be impeding once existent architectures or data have to be connected and integrated. Hence, careful and thorough planning of the technical architecture of a smart glasses system is essential. We conducted three focus groups with functional requirements from the logistics domain and the technological capabilities of smart glasses in mind. We decided on applying a microservices approach, garnering from

its small overhead and advantages in terms of modularization and code reusability. Furthermore, this approach enables the implementation of independent prototypes. We drafted and discussed a holistic architecture for a smart glasses-based system in the logistics domain, without restrictions of specific use cases or processes. The architecture (cf. Figure 1) resulting from the focus group discussions is based on two main parts, further being divided into six subsystems. The logistics worker, initially independent of his or her specific tasks, only has access to the frontend modules. These consist primarily of a visualization system on smart glasses guiding the users through their respective work processes. The devices display useful information directly into the user's field of view, or retrieve input. With the modelling system, selected business processes can be altered, corrected or added easily and quickly. Smart glasses and modelling tool are both connected to a cloud-based project system as the key hub of the architecture. This subsystem provides all processing modules of the potential functionality. Through outsourcing most of the functionality into the backend system, the mobile devices are primarily used as input and output periphery, increasing battery runtime and sparing the limited processing power in the frontend. To address privacy concerns of smart glasses, we added a privacy gate between the backend hub and the frontend application. By default, all privacy-invasive functionalities, such as camera access or voice recording, are deactivated. The authentication service unlocks the individually necessary functions. With this approach, we apply the two technical and organizational measures of *Privacy by Design* and *Privacy by Default* of Article 25 of the EU-GDPR. If needed, the system can further establish a connection to the internet via an external communication service, e.g. for using proprietary modules such as voice control. All data is stored in system-specific databases. Aspects outside of the system, which either are necessary for the information system (such as mobile data) or can lead to system advances (such as 5G connectivity) were modelled as part of the outside environment.

We tackle the previously noted challenge of integrating the system into other enterprise applications (e.g. warehouse management systems) by defining a client interface service, connecting to the backend system of the logistics company. Through modular information inquiries following a Software-oriented Architecture (SOA)-Approach, data can either be retrieved or uploaded from and into the client system. One important aspect of the system is the usage of technological domain-specific modelling languages (DSML) to request the defined microservices and their functionality in the architecture. Hence, we suggest a new desktop-based DSML for a model-driven IS development that allows for a flexible combination of the microservices and therefore a highly customizable smart glasses-based frontend application. The approach is similar to the usage of conceptual models (e.g. EPC or BPMN) for the design and execution of service-oriented information systems like in [TB10] and serves as a significant supplementation. Standard process modelling languages such as EPC or BPMN do not have the capability to represent all of these aspects adequately. Therefore, new DSML are necessary that allow for a representation of microservices, functionalities of a wearable device, definition of interfaces, the control of the data flow and the final representation on the wearable device. Such a DSML would have to be well-defined regarding new concepts and how this reflects to new notation elements and attributes. Further new desktop-based modelling tools are necessary to

represent the mentioned dimensions for one notation element in an efficient way. The presented architecture should serve as the enabler allowing a new DSML to steer the interlink of microservices and enabling model-driven information systems. The combination of this architecture with new technological DSML could increase the process modelling relevance within the IS research community and in practice, since it creates a novel implementation approach with potential business value.

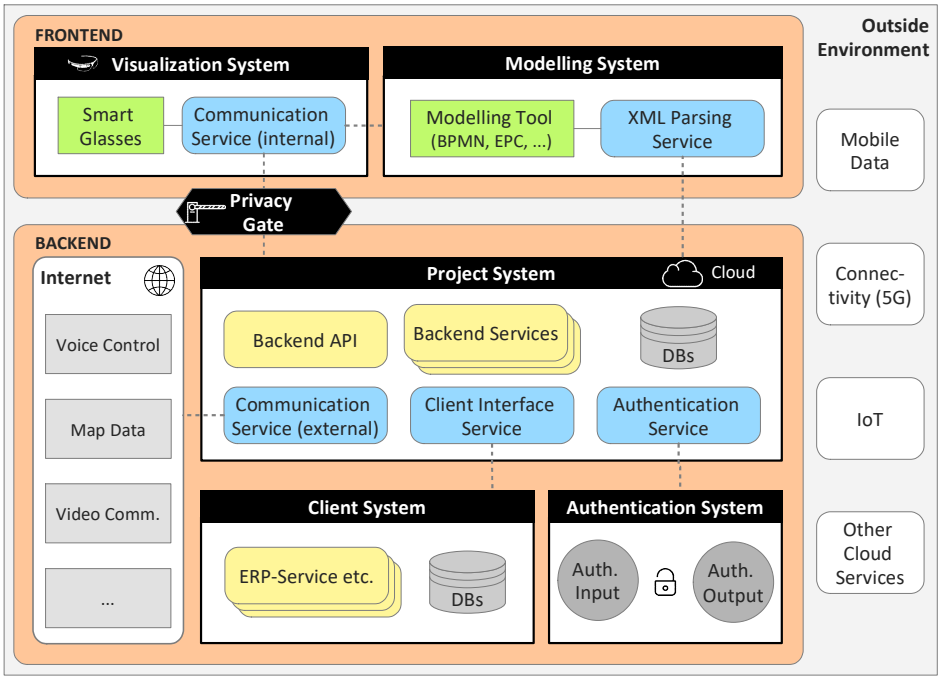

Figure 1: Reference architecture for smart glasses-based systems

4 Discussion and Outlook

Through focus groups and thorough planning, we deducted a reference architecture for smart glasses-based systems. The primary business domain of our architecture is the logistics sector, and as we started the creation process with specific requirements in mind, we present our architecture as a practice-oriented construct in need of further evaluation and validation. Through the ongoing evaluation of the already implemented and following systems, we work towards validating and maturing the proposed architecture. Despite these limitations, we expect that the approach can be generalized towards other domains building on procedural workflows with manual tasks. Through the strict separation of functionality on the frontend and the backend, durability of the devices' battery-life and a

controllable privacy aspect can be supported. Consequently, this approach intensifies the importance of technological interfaces, introducing potential for interface issues. This strengthens the strategic value of upfront planning and stakeholder involvement.

An ongoing development of IoT-possibilities and technologies enables everyday support of work processes. Through increasing connections and integrations of an information-provision device (smart glasses) with information-collecting hardware (smart sensors, IoT), the future of the workplace may lie in an always knowledgeable and informed user. Future research has to investigate the potentials of this rising interoperability and connection of different mobile systems.

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Towards Tool-supported Reflection of Sustainability in Business Models

Thorsten Schoormann[1] and Ralf Knackstedt[2]

Abstract: Sustainability has become increasingly important to business research and practice. Approaches that support fundamental changes in behaviour to act economically, ecologically and socially are required. Modelling and analysing business models can contribute to this, for example by generating new ideas as well as improving and evaluating current businesses. In this PhD Research Proposal, we report the current state and future perspectives of our research, which aims to derive design-relevant knowledge on how to reflect sustainability in business models on (1) a representation layer as well as (2) a tool-support layer.

Keywords: Sustainability, Business Modelling Language, Tool-support, Design Principles.

1 Introduction, Problem Awareness and Objectives

The rapid deterioration of the natural environment, concerns over wealth disparity and corporate social responsibility pose fundamental issues for our entire society [Br87]. In order to address these challenges, 'sustainability' has increasingly gained importance in business research and practice (e.g., [Me10, SRB13]). Approaches that support essential changes in behavior and practice (e.g., consumption or production) are required. Reflecting sustainable-oriented aspects in businesses is a challenging task, and thus, appropriate approaches and tools are needed.

Business modelling—here understood as the act of modelling the value-oriented essence of a business [Go00]—can be applied to visualize, innovate and evaluate business models [Ve14]. A business model "describes the rationale of how an organization creates, delivers, and captures value." [OP10, p. 14] For representing such models, modelling languages with graphic notations are usually used such as the 'Business Model Canvas' [OP10]. In order to contribute to sustainability, these languages should support the design of innovative businesses that, for example consider cleaner products and processes [Lu10]. However, there is a deficit of research and well-accepted guidelines of modelling languages that provide constructs for considering economic, ecological and social sustainability in an equal manner (*Gap 1*).

Moreover, to facilitate the applicability of such modelling languages, appropriate (software-)tools are required [Re12, Ve14]. Software-based tools—so-called Business Model Development Tools (BMDT)—allow to digitally represent, edit and analyse

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business models. They have enormous potential to promote certain actions (e.g., understanding, sharing and assessing) more efficiently than the 'pen & paper' versions [OPT05]. Although a number of BMDTs have been proposed in research and practice, to the best of our knowledge [Sz17], virtually no design-relevant knowledge exists concerning the functions that such tools should (*Gap 2*). Besides knowledge of BMDTs in general, there is also a lack of software features and principles for representing and evaluating business models in respect of sustainability (*Gap 3*). These lacks are problematic because they inhibit tool designers in their endeavour to (re-)design software tools and users to reflect and apply sustainable-oriented features.

In sum, the primary goal of this research project is to derive design relevant knowledge for (software) tools that allow for reflecting economic, ecological and social sustainability in an equality manner. Accordingly, this PhD proposal is guided by the following key questions that relate to the (1) representation and (2) tool-support:

- ***Q1.1****—How are current business modelling languages adopted in order to incorporate economic, ecological and social aspects? (Gap 1)*
- ***Q1.2****—What are research perspectives for business modelling languages contributing to sustainability and how can they be addressed? (Gap 1)*
- ***Q2.1****—What are functions of current software tools for business model development in general and in respect of sustainability? (Gap 2 and 3)*
- ***Q2.2****—Which functions should a software tool provide in order to support the visualization and reflection of sustainability in business models? (Gap 2 and 3)*

In order to achieve our overall goal, we aim to design artefacts that respect economic, ecological and social sustainability. According to [Ve14], Design Science Research (DSR) is an appropriate research paradigm for such issues. DSR is based on a problem-solving paradigm that aims to design purposeful artefacts like design principles [He07] that capture essential knowledge about instances of a class of artefacts, which is helpful for both technology oriented and management oriented audiences [Se17]. Following DSR [KV08], we suggest, develop and evaluate our main artefact—design principles for software tools—across several cycles (Fig. 1).

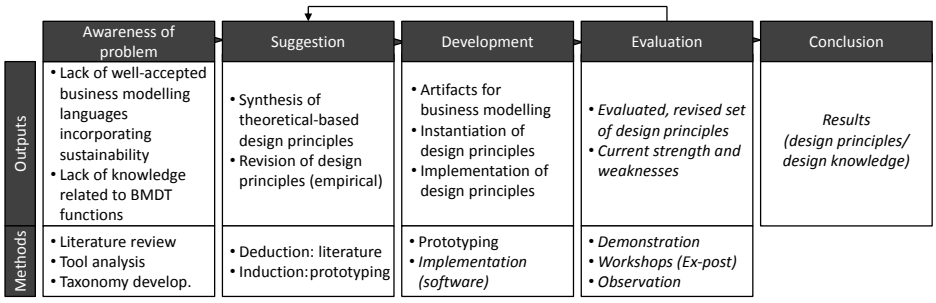

Fig. 1: Overview of the entire research design (future work = italic), according to [KV08]

2 Previous and Published Work

Our research focus on two major layers namely (1) 'representation' (e.g., modelling languages) and (2) 'tool-support' (e.g., business model development tools). Next, we outline and discuss selected results on each layer in more detail.

As a first step, on the representation layer (1), we aimed to analyse how current business modelling languages address economic, ecological and social issues (Q1.1). Based on an extensive literature review, we identified heterogeneous consideration in the state of the art studies, and thus, consolidated typical customizations of existing business model languages—mostly by adapting the Business Model Canvas [OP10]—in a typology. In total, we derived seven types that aim to respect sustainability by providing additional semantics or adjusting current semantics of such languages. Beside a lack of adequate evaluation of these notations, we suggested three perspectives in particular (Q1.2), which need further investigation: (a) domain-specific modelling (e.g., predefined elements to configure business models; patterns), (b) strategies for sustainability assessment, and (c) combination of different models or modelling languages [Sc16].

In following studies—up to now—, we researched (a) how established building-block-based modelling approaches can be adopted to standardize business models (e.g., used terms and abstraction level) as well as can serve as a configuration support (e.g., pre-defined and selectable elements; taxonomy). In order to demonstrate and evaluate our extension, we used the domain of Carsharing business models [SBK17a]. Regarding (c)—further models—, we developed a taxonomy of extensions that contribute to the representation of sustainability in business process models, and thus, can act as a detailed view on the key activities of an organisation [SBK17b].

On the tool-support layer (2), we analysed functionality that supports the design, representation and evaluation of sustainability in business models (Q2.1). To do so, we initially examined software tools and verified if and how the derived types from the literature review [Sc16] are supported. Because there are many deficits, we decided to take a broader perspective on this field and analysed functions of BMDTs in general. As a result, we lack design-relevant knowledge concerning the functions that such tools should possess. To contribute, (Q2.2) we analysed 24 BMDTs and build a taxonomy of functions, which is a necessary foundation for advanced research [Sz17].

3 Research-in-Progress and Outlook

Based on the findings, we derived an initial set of design principles (what a system should allow [Se17]). Following the DSR paradigm [He07], we run through several cycles of building and evaluating solutions—here, paper-prototyping sessions in an educational setting in particular—in order to complement the theoretical-grounded principles with empirical data. Currently, we are finalizing the implementation of the design principles in form of a software prototype. Afterwards, we plan to investigate the

applicability and usage of such a class of tools. We aim to evaluate the design principles in two stages: First, we will conduct an ex ante artificial evaluation [SB12] with master students who are knowledgeable in modelling business models. Moreover, we are targeting to apply the prototype to reflect sustainability in a real business case from an industry partner to contribute to the practical relevance. Second, we like to verify our artefact with 'real users' but have to acquire suitable participants as well as design a suitable workshop concept. Because the software tool incorporates different artefacts, whether evaluating the entire prototype or single functionality has still to be specified.

Furthermore, our findings related to the business modelling language as well as to the features that need to be provided, should be reflected against the common methodology of development business models with respect of sustainability. Accordingly, we plan to explore how and in what situations, a BMDT can be applied. For instance, is it used for analysing sustainability in existing business models or rather for constructing new ones?

4 Conclusion

Contributing to sustainability in business models is of great relevance, and we assume that providing design principles for a tool-support allows benefits for research and practice. For example, new IS theories can be derived [Gr06] (e.g., to explain how specific features affect the awareness of sustainability) and the proposed design knowledge can be applied to (re-)design new IT-artefacts such as software tools or single features. Nonetheless, different points need to addressed by future endeavor including sustainability-oriented assessment strategies, evaluation design knowledge, applicability of design knowledge and business model development methodology.

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A Flexible Event Handling Model for Using Events in Business Processes

Sankalita Mandal [1]

Abstract: Business process management (BPM) enables modeling, implementing and monitoring organizational processes to achieve certain business goals. As organizations continue to strive for agility, they have started taking advantage of the digitization and bring flexibility in their processes by several means. One of these is to integrate complex event processing (CEP) with business processes. Event handling specifies how a process communicates with its environment and how this environment influences the execution of the process. Though highly expressive and feature-rich languages like BPMN exist for process specification, they still lack an unambiguous semantics for event handling in different situations. In this work, an event handling model is proposed that take into account the possibilities of subscribing to an event at different point in time with respect to process execution. The model is grounded with formal semantics using Petri Nets and trace analysis to ensure correct execution of process behavior as well as the temporal dependencies among event subscription, event occurrence, event consumption and event unsubscription.

Keywords: Process execution; Event handling; Event subscription; BPMN

1 Introduction

Process model defines a set of activities to achieve certain business goals [We12] in an organizational context. These activities are connected with causal and temporal dependencies using control-flow. A process model also specifies how a process is supposed to interact with the environmental occurrences, represented as events [EN10]. Process engines subscribe to event sources and react to events emitted by these sources according to the process specification. Often, a complex event processing engine is used to abstract from the complexities of connecting to different event sources emitting events in different formats and aggregating them to receive the business level event [HMW13].

Business Process Model and Notation (BPMN) [OM11] is the industry standard for modeling and executing processes. BPMN includes explicit event constructs to depict the production and consumption of events, message flows to link external process participants, and control-flow routing based on events such as event-based gateways or boundary events. However, the event handling semantics in BPMN is pretty limited while it comes to specify when

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to subscribe to an event source or when to stop listening to an event stream [MWW17]. According to BPMN, when the control-flow reaches the event construct, the node is enabled and the process instance waits for the event occurrence. Once the event occurs, the control-flow is passed to downstream activities. The above semantics is a severe limitation as in a distributed setup, the event sources are mostly unaware of the process execution status and therefore the events can occur anytime irrespective of the process being ready to consume it.

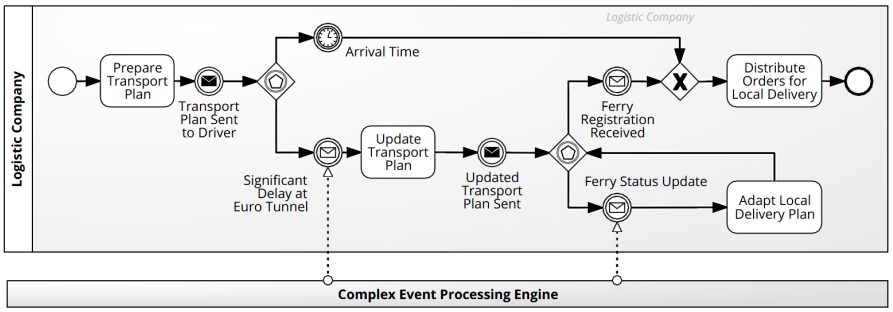

Fig. 1: Motivating example showing the need of flexible event subscription.

In Fig. 1, a process from logistics domain has been shown. The *Logistic Company* manages a process engine to control several transportation where trucks carry goods via Euro Tunnel following the transport plan sent by the company. However, when the truck is still driving (before `Arrival Time`), the engine gets notification if there is a `Significant Delay at Euro Tunnel`, e.g. caused by technical difficulty or traffic congestion. In this situation, the alternative route ferry is taken to cross the Strait of Dover. The ferry status update is considered periodically to adapt the local delivery plan at the destination and the orders are distributed once the ferry is taken. Now, Euro Tunnel or ferry do not know about the processes run by the logistic companies and publish the status update events whenever there is a change of situation which might not coincide with the time when the process is ready to receive the update. As a result, a process instance may not react to an event which occurred before its control-flow reached the respective event construct, even if the event is still relevant for process execution. The process execution might even get stuck waiting for an event which has already occurred. On the other hand, the process engine does not need to listen to an event stream if at certain point of process execution the event becomes irrelevant, e.g. Euro Tunnel updates become irrelevant after ferry is chosen.

So far, there is no clear semantics for all the possible scenarios supporting flexible event handling from a business process perspective. The work in this thesis proposal addresses these shortcomings of event handling semantics and aims to offer a flexible event handling model accommodating the possibilities of event-process interactions starting from the initiation of process engine, via process execution, to the engine termination. The next section discusses the steps followed so far as well as the future plans to achieve this.

2 Research Plan: Past, Current & Future Steps

The goal of the research is to build a flexible event handling model from the perspective of business process execution. The event handling semantics should be grounded formally and provide conceptual as well as technical analysis of using events in business processes. The rest of the section describes the steps required to reach the goal.

Integration of Real-World Events and Business Processes. The whole research is predominantly motivated considering the importance and advantages of using event information flexibly during process execution. There can be several applications (such as [Pu17]) of using event processing techniques that can improve process flexibility and efficiency. The first step was, therefore, to build an integrated architecture enabling event-process interaction. Though the current process engines have provisions for receiving events from external sources, there was no end-to-end framework considering the conceptual and technical challenges for integrating real-life events in processes. In our work associated with a project with industry partners [Be16], we explored the basic aspects to consider while integrating the two worlds of BPM and CEP [MHW17]. This framework identifies three requirements: 1) Separation of concerns between the logic of process execution and event processing, 2) Representation of event hierarchies to show the connection among event sources, low-level events generated from the sources and higher-level business events aggregated from them, and finally 3) Execution of event integration that deals with the technical challenges such as binding events, receiving events and reacting on events. Based on these requirements, a conceptual framework is provided. Also, an integrated architecture consisting of the process engine Chimera[2], the event processing platform Unicorn[3] and an extended version of Camunda process modeler[4] is implemented to realize the concepts.

Early Event Subscription and Event Buffering. The basic framework defines the concept and technicalities required to subscribe to an event, get notified when a matching event occurs and to react on the event according to process specification. However, in a distributed IT setup, the event sources might be unaware of the process execution status. Therefore, the BPMN assumption of event occurrence only when the process is ready to consume it seemed unrealistic and restricting. Hence, the notion of early event subscription using an explicit subscription task is introduced in later work [MWW17]. To accommodate early event occurrences, an event buffer is discussed in this context. The buffer comes with specific policies to store, retrieve and reuse the events.

Flexible Event Handling Model with Petri Net Mapping. The next step prescribes the formal semantics for handling events considering the fact *events can occur anytime – before, during or after the process is ready to consume it*. Based on the grounding semantics, we first

[2] https://bpt.hpi.uni-potsdam.de/Chimera
[3] https://bpt.hpi.uni-potsdam.de/UNICORN/WebHome
[4] http://bpmn.io/

analyze different possibilities of modeling an external event in a process flow, represented as intermediate catching message events. We assume that the subscription does not have any unresolved data dependency, i.e. the subscription is not dependent on any data that must be generated during process execution. The subscription, occurrence and consumption possibilities of events are considered based on a timeline starting from the initiation of process engine and ending at the engine shut down, as shown in Fig. 2.

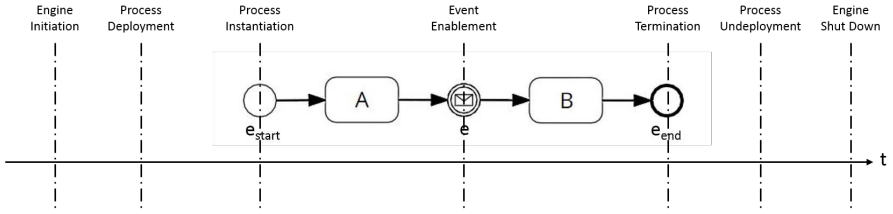

Fig. 2: Process execution timeline.

The CASU Framework proposed in [DM09] talks about (un)-subscription patterns with respect to process instantiation semantics whereas we focus on the environmental occurrences modeled as intermediate catching events. Fig. 3 is an extended version of the causality proposed by [BDG07] that said an event can only be consumed if there is a subscription for this event and the event has actually occurred. We proposed in [MWW17] that to make an event relevant for a process, the subscription should be done before the event occurrence. An unsubscription can be done only when a subscription exists, but it is independent of the event consumption, or even event occurrence, e.g. if at certain point of process execution, the event becomes irrelevant, unsubscription can be done. The dependencies show that along with maintaining the causality of process execution, the event subscription, occurrence, consumption and unsubscription should also follow certain temporal ordering. Currently we are working on mapping the concepts required for flexible event handling model to Petri Net modules in order to specify the implementation semantics and analyzing the traces to ensure correct execution.

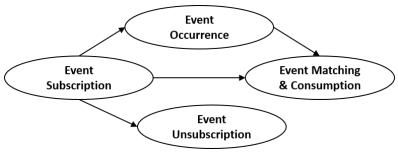

Fig. 3: Dependencies among event subscription, event occurrence, consumption, and unsubscription.

3 Conclusion

Event processing informs business processes about the environmental occurrences, such that the process can adapt to the changed environment as required. This improves process execution with respect to flexibility and efficiency. Hence, we presented a basic framework to realize the integration of event processing in business processes. Further, we developed the notion of early event subscription and event buffering to accommodate the need of flexible event-process communication in a distributed IT system. To this end, a formal event

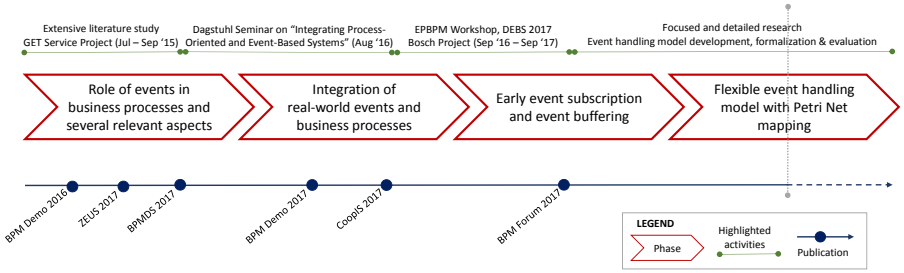

Fig. 4: Research progress and planned steps.

handling model is proposed that specifies the semantics for event subscription, occurrence, consumption and unsubscription taking into account the complete runtime of a process engine and several points in time when subscription for an intermediate event can be made. Next steps include correctness check of process specification in the light of the interactions with environmental events. Fig. 4 summarizes the research progress reflecting on the phases discussed, the associated publications for each phase and the activities that inspired further research directions.

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Smart Self-Management for Better Working

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Abstract: Work intensification and blurring boundaries between private and professional life constitute major challenges in today's society. High working pressure and imbalances between life domains can cause serious physical and mental health problems. Thus, personal self-management becomes increasingly important to cope with high work demands while considering personal resources. In recent years, sensor technology has become ubiquitous and enables new kinds of data collection. This PhD research proposal discusses how information technology can be used to support the enhancement of self-management competencies. The proposed approach considers a wide range of data from several sensors that will be analysed to provide the user with comprehensive feedback. By using smart devices, it will be possible to give situational feedback even in a mobile context.

Keywords: Self-Management, Sensors, Assistance, Work Organisation, Stress Prevention.

1 Introduction

Mobile devices such as smartphones or tablets are widely used and help us to work, learn, and manage our social relationships. All this can be done independently of location and time. While there are many benefits, the boundaries between life domains can become vague with a high flexibility. Furthermore, the increasing usage of information and communication technology can cause a high intensity of work. Resulting stress threatens motivation, performance, wellbeing, and health [LGC04, BS05]. Especially for the increasing proportion of knowledge-intense work [Ru17], these challenges are amplified greatly since this kind of work goes along with a high self-responsibility. Therefore, it is a major challenge to carefully deal with individual freedoms and resources in order to avoid overload. In this context, individual self-management becomes increasingly important. In a recent study, 55% of the respondents indicated a need to develop competencies in this field [Ru17]. Self-management comprises the willingness and ability to manage the own life responsibly and to shape it in such a way that productivity, motivation, well-being, and balance in life are promoted and maintained over the long term [Gr12]. As sensor technology and smart devices are increasingly integrated in everyday life, these technologies may serve as a remedy to support people in self-management. The aim of the presented PhD project is to develop a concept for an assistance system supporting the diverse aspects of self-management. The next section describes the key features of the proposed approach. Section 3 presents potential components of an assistance system and Section 4 describes the next steps.

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2 Proposed Approach

Enhancing self-management competencies may include the need to observe one's everyday behaviour, recognise necessary development steps, consequently drive the development through concrete actions, and perform progress checks. Performing all these actions may be challenging. The key research question for the described PhD project is, how the potential of sensors and smart devices can be used to assist individuals in their self-management. By using devices that are easy to integrate in daily life, a wide range of data can be collected continuously and at runtime. Collecting data over the long term and combining data from several sources will enable providing comprehensive feedback for self-management. Moreover, the use of smart and wearable devices allows to remind the user of taking actions or to intervene in certain situations unobtrusively even in a mobile context [MW15]. In summary, the proposed innovative approach for self-management assistance comprises the following central aspects:

- Consideration of several areas and individual factors of self-management
- Use of mobile and unobtrusive devices with built-in sensors
- Data collection at execution time
- Aggregation and analysis of data from multiple sources
- Feedback on development over time
- Situational guidance and interventions at execution time

3 Potential Components

A central point of the project is to bridge the gap between research in self-management and sensor-based assistance systems. As a first step, the literature was analysed to find features that are relevant for self-management and that can be supported by the use of technology. The development of the system concept follows the core idea that information systems essentially acquire or receive information, process it, and deliver relevant results to the user. Therefore, potential components for the steps data collection, data analysis, and feedback generation are identified and described in the following. At the current phase of the project, a prototypic implementation of data collection and storage is developed.

Data Collection. To assist users in everyday work, data needs to be collected mainly without user intervention and in an unobtrusive way. As *smartphones* and *personal computers* are already widespread and integrated in daily life, these devices easily lend itself to collect data. Furthermore, wearables such as *smartwatches* are unobtrusive, light-weight, and do not interfere the user in daily processes. Smartwatches have numerous built-in sensors [KMM17] and deliver more accurate physiological data than smartphones [Sh15]. To consider especially the wellbeing and health aspects of self-management, relevant data can comprise the *user's activity level* (e.g. walking vs. sitting) and *physiological data* (e.g. heart rate). To detect the environmental context, for example, if a user is currently in the office or in a public park, *outdoor positioning* (via GPS) and *indoor positioning* (e.g. via Wi-Fi, Bluetooth, or ultrasonic [Ly15]) can be used. Finally, it is

possible to identify *software-based work* and to monitor contents related to used applications via additional software running on the devices. The software could then run in the background and record all types of events. By doing so, information from digital calendars, mailing programs, writing tools, web browsers, or other tools can be retrieved. Such information shows, for example, if the user currently is in a meeting, works on a document, browses for information on the web or is engaged in organising and communication. Selected data will be stored in a database. As data shall be collected and analysed over time, the open source time series database InfluxDB[2] is chosen for implementation. It is then possible to efficiently analyse the time series data.

Data Analysis. The retrieved variety of data has to be aggregated and combined in order to provide the user comprehensive feedback. Therefore, complex data analysis will be necessary to detect patterns, to recognise the need for interventions, and to analyse developments over time. Four important components of complex information are identified yet. The first component is intended to analyse *time spent* on certain activities. Using the broad range of collected information such as location, appointments, and motion of a user, even activities where no operations on a device are performed could be monitored. The second component focuses on *workload*, because a high workload in the long-term can lead to decrements in performance, motivation, wellbeing and health [Ho97]. To determine the general workload, the amount of tasks, appointments, emails, opened files, and physical activity could be considered. In regard to individual workload, changes in a user's cognitive performance caused by mental workload can be estimated by considering heart rate variability [Ts17]. *Biological rhythms* as the third component considers the human's circadian rhythms that drive the patterns of cognitive, behavioural, and physiological processes (e.g. activity, sleep, and mood). Individual rhythms should be considered, because rhythm disruption can lead to negative effects like reduced motivation, performance, and health [FK14]. Biological rhythms could already be associated with patterns of smartphone app use [Mu16]. Thus, the data collected from background software on the personal computer and smartphone could be used for this component. Furthermore, physiological and activity data would add high further value in order to determine these rhythms or their disruption. The fourth component is conceived for analysing the *productivity status* with respect to individual resources. For example, if decreased cognitive performance is recognised, taking a break for recovery may be productive, but randomly surfing the internet when performance is high may be not. Therefore, information from time-consuming activities, workload, and biological rhythms could be combined in order to analyse productivity over the long term.

Feedback Generation. The system is envisioned to support the user in reflecting behaviour as well as in taking action for development. For the first, *information on development over time* that is delivered from data analysis will be presented to the user. Furthermore, users shall have the opportunity to define goals related to the information presented, for example, to work on high-leverage tasks at performance peaks. In order to encourage the user to take action for self-development, the system is envisioned to give

[2] https://www.influxdata.com/

situational feedback by providing recommendations on carrying out or omitting activities together with a reason for the certain recommendation. The feedback could be delivered by personal computers in a stationary context and by smartphones or smartwatches in a mobile context. In the following, possible recommendation features are described. The system could, for example, recognise a conflict of activities to a user defined goal and *remind to pursue the goal*. Furthermore, the assistance could *recommend a next task*, e.g. according to an urgent deadline recognised through an appointment. Similarly, the system could *intervene distracting actions* like randomly browsing the internet. Regarding wellbeing and health it is considered important to have *recommendations of breaks and relaxation*. Generating such feedback could depend on workload and biological rhythms. The system could recommend a break, e.g. if decreased cognitive performance is predicted. Finally, existing mechanisms of digital calendars that warn the user when appointments overlap could be extended to also regard workload and biological rhythms. The system could then *recommend a suitable date and time of an appointment* according to these factors, when the user is about to plan it.

4 Next Steps

The development of the system concept is seen as an iterative process by which relevant features are identified, selected components are implemented prototypically, and the concept is evaluated and possibly adjusted. Currently, a prototypical implementation of the identified data collection components is carried out for a first experimental run. In this process, an important step will be to develop an appropriate interaction of the proposed devices and technologies. Furthermore, the suitability of retrieved data has to be examined. Physiological data from current smartwatches, for example, may be more accurate in workload monitoring, if user activities are characterised by little movement [Bi16]. If higher accuracy will be required, approaches to filter misleading data could be used [Ra17]. Sensor data could additionally be contrasted against answers from psychology questionnaires. These can, for example, reflect a person's experiences of positive or negative moods [QKK09]. Considering not only measured data, but also subjective appraisal will have an impact on the quality of system feedback to enhance individual self-management skills. Next, the main focus of situational feedback will be specified in order to determine which analysis components actually will be part of the project. To this end, requirements will be determined from empirical studies. When components for data analysis are selected, their prototypical implementation will be arranged. After collecting first practical experiences, it will be possible to elaborate the system components.

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Patterns of Stability and Change in Business Processes

Using Process Mining to Capture Reality in Flight

Bastian Wurm[1]

Abstract: With the ubiquity of information systems in business and everyday life, people are increasingly leaving digital traces of their activities. Using this trace data alongside with other – more traditional – data collection techniques, such as interviews and document analysis, researchers can enhance their understanding of organizational processes and the different actors involved in these. In this Ph.D. research proposal, I outline an innovative approach that uses process mining techniques to capture "reality in flight". Additionally, information stored in process model repositories and derived through expert interviews help to complement this perspective and make sense how stability and change occur in organizational processes.

Keywords: Theory Development, Business Process Management, Process Mining, Business Process Change, Business Process Standardization, Trace Data Analysis, Grounded Theory Method.

1 Motivation and Related Work

Business process management (BPM) and organization science have both recognized the importance of studying organizational processes [Du13, LT17, BR10a, BR10b]. However, the perspectives these research streams take on processes as a unit of analysis vary greatly. In BPM processes are often implicitly treated as simplistic and deterministic [MP00]. Process design and improvement often follows a top-down approach, not considering how business processes emerge as organizational routines [Be14]. On the contrary, organizational science perceives processes as "perpetually in the making" [GJT08], they are under constant change and permanently renewing themselves.

While BPM leaves behavioral aspects and intentions of process participants aside, research on routines masks out the role design decisions and artifacts play when it comes to executing the process. This is problematic, because each of these perspectives is limited due to its particular focus leaving the interplay of routines and top-down business processes unconsidered [Be14]. In particular, there is a very limited understanding how changes in process design and changes in routines affect each other. To evolve into a true process science and to develop strong process theory [PRK17], both fields of research need to join their strengths.

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The purpose of this doctoral dissertation is thus to address this research gap by building strong process theory [LT17] that explains stability and change in business processes. Accordingly, the research question I pursue reads as follows:

How does change in business processes take place?

I aim to answer this research question using a combination of traditional grounded theory methodology and traditional computational theory development [BSS18]. On the one hand, I will use process mining algorithms [Aa11, AD12] to identify process variants [Ho15a] and evolutionary drifts in business processes [Ma17]. On the other hand, I will employ grounded theory methodology [SR09, ULM10] to complement the computational theory development process and make sense of the data by considering context information derived in interviews. With this work I expect to identify motors of change in business processes [VP95] that will be used to explain how process change takes place. Furthermore, a method will be developed that allows to use process mining techniques for organizational research.

The remainder of this Ph.D. research proposal is structured as follows. In the next section, I present an initial draft of the method I want to employ for analyzing business processes, i.e. a combination of automated and manual theory development [BSS18]. In particular, I elaborate on the different types of data I plan to use and how I intend to interpret them. Additionally, I show how process mining algorithms can be used to detect change in business processes. Finally, I provide a brief summary and outline the expected contribution of this work.

2 Method

In this Ph.D. research proposal, I suggest the complementary use of traditional grounded theory methodology [Ch96, SC94] and computational theory development [DLT07] to inductively develop strong process theory [PRK17]. In a recent article, Berente and associates [BSS18] outlined the advantages of such computationally-intensive theory development approaches that make use of the opportunities that the ubiquity of trace-data provides. Examples for studies that employed computationally-intensive theory development include, but are not limited to, Lindberg et al. [Li16], Vaast et al. [Va17], Miranda et al. [MKS15], and Pentland et al. [PRW17].

2.1 Data and Sense-making

For this research, three types of data will be used: Trace-data in form of log-files, qualitative interview data, and data on process documentation, i.e. process models, process guidelines and other documentation materials. Table 1 gives and overview over

the different types of data employed, how they will be analyzed, and what kind of information each of them provides for theory generation.

Type of Data	**Trace Data (event-logs)**	**Process Documentation**	**Interviews**
Type of analysis/ interpretation	Process Mining	Grounded Theory Method	Grounded Theory Method
Type of Information	Descriptive/ Ontological perspective – i.e. what is?	Teleological and normative perspective – i.e. what is the goal and how should it be?	Why is it as it is?

Table 1: Overview of Materials for Theory Generation

First, trace-data will be analyzed using process mining techniques. Employing variant analysis [Ho15a] and drift detection [Ma17] allows to compare different process variants and understand how a process evolves over time. At this stage, the main goal is to derive a descriptive overview of the relevant processes.

Second, process documentation, i.e. process models, process guidelines, and the like, are examined. Here, the main questions are of a teleological and normative nature. I.e. I want to collect information about the goals of a process and how the process should be performed according to its designated design. For example, different goals of a business process can be considered [BM18, BZS16].

Third, qualitative interviews with process experts and process managers provide contextual knowledge. The interviews will be interpreted using the grounded theory method [Ch96]. This knowledge further enriches the insights gained in the prior stages. In this stage, I focus in particular on explanations about why the process is executed as it is the case and why certain changes in the process occurred.

Independent of the exact sense-making strategies employed, sense-making ultimately remains a cognitive process [GW14], which requires inspiration and creativity by the researcher [La99].

2.2 Process Mining Techniques for Detecting Patterns of Stability and Change

Process mining is usually used for process discovery, conformance checking, and enhancement [Aa11]. However, more and more algorithms are developed that can be used to compare different variants of the same process [Ho15a, LS12] or detect changes in processes over time [Ho15b, LT15]. Both of these types of algorithms are fundamental when it comes to detecting and understanding change in business processes.

Figure 1 below presents an example for (concept) drift [Ho15b]. Instead of analyzing the whole log, the log is broken down in multiple parts, each of which is analyzed individually. For this reason, it is essential to detect the change point (t_c), i.e. the point in time when the change takes place, and accordingly divide the log-file [Bo11]. Based on this procedure, differences between different process versions can be mapped out.

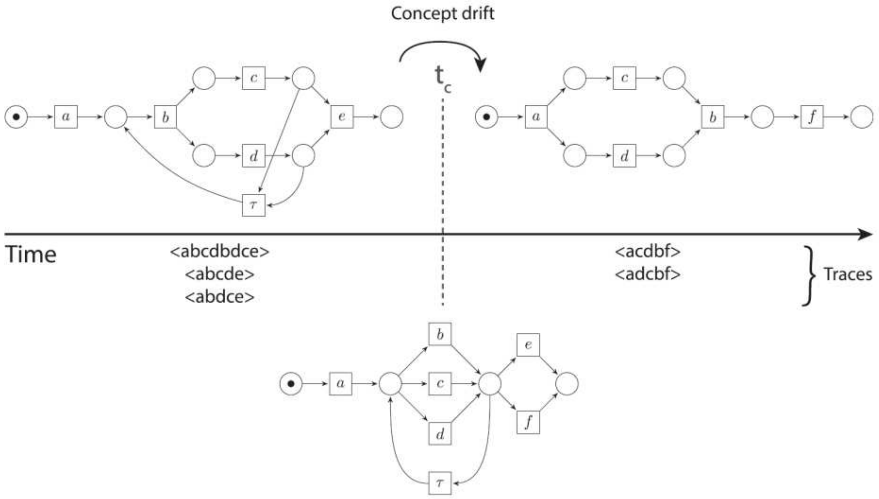

Figure 1: Example of process drift [Ho15b, p. 96].

Drifts, i.e. changes, in processes can either take place gradually or suddenly [Bo11, Ma17]. Sudden drifts are major changes that emerge at a particular point in time. They can be an indicator for major changes in the design of the business process, e.g. when a newly designed process version is introduced. Yet, there might be a time lag between the change of the business process' design and the change occurring in the actual log (i.e. the enactment of the process design by process participants). Having said that, gradual drifts are small changes that appear over a stretched period of time [Ma17]. They suggest a slight alteration to the process behavior. This change in process execution can be attributed to smaller design changes or to changes that can be attributed to process participants. In fact, gradual drifts can be a clue for the presence of positive deviance [Me16, Re15].

The presented algorithms give an example how process mining can enable insights about how change and stability in business processes occur. However, process mining alone can only determine that changes took place. Why changes occur, the exact dynamics behind these changes, and the motivation for these changes currently remain a black box. Together with interviews and process guidelines/ documentation, a sense-making

process can take place that gives reason to not only that changes happened, but provide additional knowledge how and why certain changes came about.

3 Expected Contribution

In this Ph.D. research proposal, I outlined the research background and design of my doctoral dissertation. I presented a synthesis of process mining techniques, qualitative interviews, and supplementary document analysis I want to employ. This combination of computational and traditional techniques for inductive theory development will be used in order to inductively generate theory that explains patterns of stability and change in business processes.

Based on the explicated methods, there are two main contributions as a result of the proposed dissertation.

The first main contribution is the derived method. Work on process mining is centered around the development of algorithms for process discovery, conformance checking, and enhancement. Only recently research has been gaining momentum that uses process mining and other data-centered techniques to investigate business processes from an organizational science lens. The method presents an alternative to ThreadNet [PRK17, PRW16], sequence approaches [Ga14], and network analysis [Bo09] and thus helps to view business processes and routines from a different perspective. Taking into consideration not only qualitative data (i.e. interviews), but also trace data using process mining allows for well-grounded inferences. Hence, the dissertation strives for an approach, which is not only novel but also very rich in terms of the different data types taken into account for theory generation. Even though such a method can help to systematically investigate business processes, theory development also requires the researcher's inspiration [La99].

The second contribution lies in the application of that method to identify motors of change [VP95] in business processes. Having those motors identified, future work can further theorize about business processes and organizational routines. In particular, future studies can investigate further conditions for each motor to occur and the exact mechanics how each motor operates. I hope that this Ph.D. research can contribute to pave the way towards a strong process science [PRK17] and more rigorous theorizing about business processes.

This work is relevant for practice as well. Practitioners can use the identified motors of change to anticipate how changes in process design affect changes in process execution and the underlying routines. This enables management to proactively accompany business process change within its organization.

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About the Selection of a Business Process Improvement Methodology

Towards the Development of a Supporting Meta-Methodology

Steven Gross[1]

Abstract: Organizations seek to change the design of their business processes in order to respond to a changing and challenging environment. A wide variety of business process improvement methodologies exist which aim to support practitioners in this effort. However, the selection of an appropriate approach is by no means trivial. Ideally, the characteristics of the methodology applied should fit the characteristics of the process improvement project in order to yield the best results. In this research proposal, we outline how the design science research methodology (DSRM) is adopted to develop, test, and evaluate a meta-methodology for the selection of an appropriate business process improvement methodology.

Keywords: business process improvement, process redesign, process innovation, methodology selection, methodology development, design science research

1 Introduction

The organic nature of organizations, the need to respond to increasing competitive pressure and customer expectations, and the ever changing organizational environment, to only mention a few, are challenges that call for a consideration how business processes are designed and carried out [Du13]. To respond to these challenges, practitioners use and rely on methodologies instead of chaotic "trial-and-error" approaches to systematically derive improved business processes [KTG97]. Business process reengineering as first introduced by Hammer [Ha90, HC93], and business process redesign as responded by Davenport and Short [DS90] are historically developed methodologies that aim to guide practitioners through the process of process improvement. Since then, a variety of new and refined business process improvement methodologies have been introduced.

The selection of an appropriate methodology plays a key role for the success of the improvement project [In02] and thus should be considered carefully. However, given the numerous methodologies on the market, this selection is not a trivial task. Several studies have undertaken the effort to merge different improvement approaches with the aim to combine their advantages [GKT93, LC01, HC04, PS10] or focused on customizing composite methodologies [KTG97, In02]. However, it has been shown that different

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methodologies are most appropriate for dealing each with a specific type of problem [JK84], so the usefulness of holistic improvement approaches can be questioned.

To the best of our knowledge, there is no systematic approach that guides practitioners through the selection of an appropriate business process improvement methodology that meets the improvement project's characteristics. Therefore, it is our intention to address this research gap accordingly and develop a meta-methodology which guides through the selection of an improvement methodology that meets the improvement project's needs. Against this background, the research question is

- How can organizations find a business process improvement methodology that supports their improvement project most appropriately?

In the following section the background and motivation will first be elaborated. In the consecutive method section, it will be outlined, how the research question is planned to be answered. This proposal ends with a description about the expected research contribution.

2 Background & Motivation

In the broad sense, a methodology can be defined as "any kind of advice given to analysts about how they should proceed to intervene in the real world" [JK84, p. 477]. More concrete, a methodology is a set of principles a user adopts to guide through the actions to improve a perceived real-world problem situation [Ch84]. The problem in this case is the discrepancy between the current and the potential state of a business process, in terms of fulfilling the specified improvement objective(s). A methodology in the context of process improvement guides through and limits the (potentially unlimited) solution space from all available- to a specific process design.

2.1 Improvement methodologies and their characteristics

There is a great number of improvement methodologies available on the market. In this context we use the term business process improvement generically: it entails all initiatives to change the design of a business process for the better, e.g. process redesign, -reengineering, -innovation, and -optimization. There exist specific methodologies for different kinds of processes (e.g. knowledge intense [MBI15] and supply chain processes [PNR14]) and methodologies for different sectors (e.g. for the public-, construction-, and education sector [KW05, KBW07, Ab11]). Methodologies also differ in their scope: From rather narrowly focusing on the act of redesigning the process itself [LC01], to a rather holistic approach [Po98]. Additionally, methodologies are more or less strict about the application of the steps and activities involved. For instance, [SB05] is purposely developed as a structured step-by-step approach, while [KW05] was designed with a minimum of procedural structure. Both are claiming that their specific methodological

design is beneficial for achieving the improvement goal. These and other characteristics lead practitioners to be confused by the choice of methodologies available [In02].

2.2 Improvement projects and their characteristics

A business process improvement project has distinct characteristics. Kettinger et al. [KTG97] for instance identified four characteristics, namely project radicalness, process structuredness, customer focus, and potential of IT enablement. Project radicalness and customer focus is what we label as the 'improvement intensions', the process structuredness is part of the 'business process' characteristic. We want to add improvement objectives to this list of characteristics, as these set out the direction of the improvement effort. The improvement objectives should be derived from the firm's strategic vision [DS90]. Typical objectives, to only mention a few, are cost reduction, time reduction, increased output quality, but also improved quality of work life, empowerment [DS90], flexibility [JR05] and innovation [In02], or a mix of these. Improvement projects are likely to have other characteristics that define them, which we intend to identify.

2.3 Finding an appropriate improvement methodology

As the work of Jackson and Keys [JK84] points out, a problem-solving methodology is likely to be of use for a specific type of problem and the problem's context. They specifically state that "no one methodology is likely to be of use in all circumstances" [JK84, p. 477]. It is thus crucial to analyze the problem context correctly as well as to identify the appropriate methodology for this problem [JK84]. In the context of business process improvement it has also been acknowledged, that specific characteristics of the improvement project call for different methodologies [KTG97].

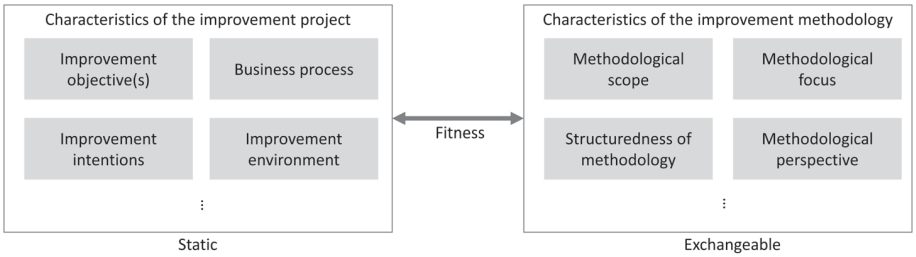

Fig. 1: Fitness between characteristics of the improvement project and improvement methodology

Thus, to increase the fitness between the characteristics of the improvement project and the corresponding methodology (Fig. 1), an appropriate methodology has to be selected [Ch97]. We define a methodology to be appropriate for an improvement project, if its characteristics match the characteristics of the improvement project, e.g. the methodological focus encompasses the type of business process to be improved. In this way it facilitates to achieve the improvement objectives and intensions for the kind of

business process to be improved. Taking into consideration the elaborated need to find an appropriate business process improvement methodology, it is the aim of this study to develop a meta-methodology that assists in finding an improvement methodology that best fits the characteristics of the improvement project.

3 Methods

To develop the meta-methodology, design science research methodology (DSRM) as introduced by Peffers et al. [Pe07] will be adopted. This methodology is extensively used for the development and evaluation of artefacts [Br11, DJ12, Sh14]. It consists of six activities, and in the following, the activities and how they are applied will be described.

The first activity 'problem identification and motivation' refers to the specific research problem and the value of the potential solution [Pe07]. As mentioned, characteristics of both, the improvement projects and the improvement methodologies have to be identified, since these determine the fitness between both. Hence, as a first step in this activity, a systematic literature review will be conducted as described in [Ki10] to get a comprehensive overview which methodologies for the improvement of business processes are actually available. The data collected through the literature review comprises for each methodology the following information (if applicable): Its goal and definition, the entailed steps and activities, the recommended area of application, the objectives followed, on which methodology it is built on, and which concepts it deploys. This data will then be used to find distinguishing characteristics in the improvement methodologies found. To determine characteristics that differentiate improvement projects, two sources of data will be used: First, the case studies that describe the application of methodologies found in the systematic literature review will be analyzed. To complement this data, practitioners will also be interviewed in the form of semi-structured in-depth interviews [RR12]. To analyze and interpret the data obtained in this interviews, the grounded theory method will be used as described in [SR09, ULM10]. These results are essential for the later development of the meta-methodology. Based on this, we will then justify how the characteristics of the methodology have to meet the characteristics of the improvement project and that the meta-methodology is of great use for practitioners.

In the second activity 'define the objectives for a solution', objectives of the solution are inferred, given the problem definition and general knowledge about what is possible and feasible [Pe07]. The desired features and functionality of the meta-methodology are closer described in this section, based on the results from the first activity and the research background.

In the third activity 'design and development' the methodology is created. This is done by using the theory and knowledge obtained in the first and the objectives defined in the second activity. The main task will be to find out how to match characteristics from a project systematically with characteristics of an appropriate methodology. Since it is

impractical to do this for every improvement methodology, methodologies with similar characteristics will be grouped.

The fourth activity is 'demonstration'. Here, the artifact, in this context the meta-methodology, will be used to solve one or more instances of the problem [Pe07]. We perform this step by conducting a case study, in which practitioners with an experience in the field are asked to use the meta-methodology to select an appropriate improvement methodology for fictional improvement projects. We will conduct semi-structured in-depth interviews [RR12] with the participants to get an insight about the perceived usefulness of the meta-methodology and use this feedback to modify it accordingly.

'Evaluation' is the fifth activity and aims to measure how well an artifact supports a solution to the problem [Pe07]. First, it will be assessed whether the developed methodology fulfills the objectives defined in the second activity of DSRM. Since to the best of our knowledge there is no other methodology that aims to guide through the selection of an improvement methodology, it cannot be evaluated against another approach. Therefore, we introduce usability, comprehensibility, and completeness as an initial set of measures, while acknowledging that these still need to be extended and refined. To evaluate this quality attributes it is planned to design and conduct a controlled experiments with students, which is one evaluation method proposed in [He04]. The meta-methodology should also produce the same output given the same project characteristics. To evaluate this consistency, different descriptions of fictional improvement projects with distinct characteristics will be created during the design of the experiment. A group of students will then be provided a random project description, with the aim to use the meta-methodology to select an improvement methodology. The results can then be used to asses the consistency of outputs for students with the same project descriptions.

The last activity 'communication' aims to disseminate the research results [Pe07].

4 Expected contribution

The main contribution of this work is the development of a meta-methodology for selecting a business process improvement methodology. This will be of great help for practitioners in the initial phase of an improvement project. No two improvement projects are alike [In02] and the use of the developed meta-methodology is expected to save time during the selection process and will ultimately lead to better improvement results through meeting the improvement project's characteristics.

The second contribution is the theoretical analysis of the characteristics of improvement methodologies, improvement projects and their interrelationship. For the further development of improvement methodologies, this theoretical basis can help to assess whether more targeted improvement methodologies for certain project characteristics still need to be developed.

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The Role of Process Representations in Business Process Redesign Projects

Isaac da Silva Torres[1]

Abstract: Markets and the desires of customers change. Thus, also organizations and their business processes need to change at certain points in time. To achieve this, organizations engage in different activities related to Business Process Redesign (BPR). BPR involves, among others, analysing business processes and identifying suitable possibilities to improve them. One of the key steps preceding any business process redesign project is to appropriately capture and represent the respective processes of an organization. Over the past years, particularly process models have been advocated as the most suitable artefact for doing so. However, to the present day, there is no empirical evidence that process models are indeed a superior representation format in the context of BPR. While theory confirms that creative problem-solving tasks are highly dependent on the type and format of information provided to the problem-solvers, the general superiority of process models in this context has not been demonstrated. Therefore, in this thesis I will study the role of process representations in the context of BPR. To this end, I will adopt a qualitative research approach and conduct multiple case studies in organizations that have conducted BPR projects in the past. My overall goal is to shed light on the role and importance of process representation formats in BPR projects.

Keywords: BPR, Process Representations, redesign project.

Introduction

There are many ways how to capture and represent knowledge about organizational procedures. Examples include flow charts [An05], textual documents [We17], state transition diagrams [MJ17], process models [Ko09], and checklists. Research has shown that organizations employ several of these representation formats. What they all have in common is that they often serve as a starting point for analysis and re-design initiatives [He09].

Many authors have investigated the advantages and disadvantages of these formats for different purposes [Ni98]. Some argue that graphical process representations and particularly process models are best suited for analysing and redesigning processes [Mo09]. This is also emphasized in [AJ05], where the authors argue business process models are useful for visualizing and analysing the flows and complex relationships among operations.

While process models are widely believed to be the superior choice for representing processes, there is no evidence that process models are really the best starting point in the context of redesign projects. Against this background, my main research question is:

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What is the role of process representation in BPR and how does the choice for a particular process representation affect process redesign efforts?

By answering this question, I aim to shed light on the importance of process models in the context of redesign and whether other representations formats are a suitable alternative. What is more, I will contribute to academic literature as well as industrial practice.

Context and Importance

In this section, I clarify the context and importance of my research. I first explain the goals of business process redesign (BPR). Then, I will review related work and highlight the research gap.

Business Process Redesign

Business Process Redesign is an important step within the Business Process lifecycle and the technical challenge of creating a new process design after its analysis [Ni98]. BPR was initially introduced as Business Process Reengineering as a radical approach for organizational change [HC93]. BPR has received different names throughout the years including "*business process improvement*" [Be09], "*business process re-engineering*" [DS90], "*core process redesign*" [Ja14], "*business restructuring*" [Pe17], "*continuous improvement process*" [Ze11]. Business Process Redesign represents an incremental and intended transformation of a business process [LR07]. The goal of BPR is to decrease the time required to handle a particular problem, lowering the execution-cost of the process, adding value to the quality of the service delivered, and increasing the flexibility of the business process to deal with changes that might occur over time.

Related Work on Business Process Redesign

Research on BPR has resulted in many contributions that discuss options to improve the quality, efficiency, and economic viability of business processes [Da94]. There is a lot of work on how BPR shall be executed. These so-called *methods* or *frameworks* typically define particular steps how to transform a given business process into an improved version [Ze11]. Many of the existing methods and frameworks differ with respect to their emphasis [Re17]. They can be distinguished based on their *impact* and *nature*. In this context *impact* refers to the efforts and the pace, and nature to how BPR is done in a more abstract way [LR07]. When categorizing *impact*, there are two types: Gradual and Radical. *Gradual* methods support the identification of problems or bottlenecks in a process and then help to resolve these in a cumulative way [Du13]. As such, these methods do not challenge the foundations of the existing process, but seeks to improve the overall process gradually, e.g. benchmarking, Six Sigma, Lean, etc. *Radical* approaches aim to transform drastically the way how it is done, change on a grand scale.

This type of methods contradict the fundamental assumptions and principles behind an existing process and try to radically overcome them [Du13], e.g. Business Process Reengineering, NESTT, Product-Based Design, etc.

Focusing on the *nature* of BPR methods, we can distinguish between analytical and creative methods. *Analytical* methods are generally based on mathematical or quantitative techniques. They are supported by tools and techniques, in particular to analyze process problems or to generate process improvement alternatives [Ko09]. *Creative* methods bring forth human creativity and awareness. Basically, it is created from group dynamics and its insights. People creativeness and subjectivisms take place to come up with new ideas on how to organize a business process, workshops and focal groups represent a great way for its implementation [RL05]. It is important to note that the choices along the methods can vary. A method, for example, could be *gradual* and *creative*, e.g. 7FE [Du13].

There are also a few tools available to structure the redesign phase. That is why many of the tools used in redesign are also process modeling tools. They support the use of a notation to capture a business process in a diagram or somehow represent it. There is a variety of tools to access business process models evaluation, generally focusing in simulation techniques [AJ05].

Despite all the contributions made through years in BPR there are still pending issues that still need better understanding, even with a widely targeted topic such as BPR. In this research our foremost concern will be process representations in BPR.

Proposed Research

Goal and Objectives

It is known that the preference for a representation format might not always correspond to performance in using it [Co94]. Research points out that the problem-solving phase (process analysis and process improvements implementation), in a BPR project, became easier when an appropriate representation was included in the redesigned process [Mo09]. These representations capture, in some graphical and/or textual notation, the activities, logs, states, business rules and possibly other information that is relevant to a business process [Re09], creating the opportunity for analysts to choose among them which format better represents their business processes [Wo10]. The importance of choosing the right representation approach is an important piece of the redesign process [KM01]. This research will look into this importance while addressing its real relevance and role throughout a BPR project. The main objective of this thesis is to determinate whether Process Representations play a role in BPR or not and how.

Methodology

I already conducted a literature review to better understand the topics of BPR and process representations. To this end, I used Google Scholar and ResearchGate, which can be considered as the most comprehensive search engines for academic literature at this point. The search terms were "*business process redesign*", "*business process redesign projects*", "*process representation formats*" and "*types of process representations*".

As a next step, I intend to conduct an Expert Panel with practitioners from different companies with experience in BPR projects. The goal is to obtain an overview of the role that process representations play in BPR projects in practice. Based on these insights, I will design and conduct an experiment to empirically test relevant hypotheses related to the role of process representations in BPR projects.

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Batching vs. Non-batching in Business Processes

Challenges with regards to Batch Activities in Business Processes

Luise Pufahl[1] and Niels Martin[2]

Abstract: A common phenomenon in operational business processes is batch processing. Batching is used to reduce cost or time by collectively executing several cases at specific activities in a business process. Recently, approaches were developed to explicitly design and execute batch activities in business process models, and to mine batch work from historic process execution logs. Process redesign suggests organizations to evaluate which activity should be designed in a case-based or batch-oriented fashion. However, it is not discussed how such an analysis should be conducted. This paper discusses current challenges on this topic. Further, it proposes a preliminary methodology for identifying beneficial batch activities and their configuration.

Keywords: process models; batch activity; process redesign

1 Introduction

For running a successful business, organizations strive for operation excellence in running their business processes to reduce costs, to improve productivity, as well as to increase customer satisfaction. Documenting, analyzing, improving, and automating business processes are key activities in this regards [Du13]. The main artifact in BPM (business process management) are process models which capture business processes with a process modeling language, e.g., BPMN (Business Process Model and Notation).

Batch processing is a common phenomenon in operational processes to reduce costs or processing time. Batching implies that several cases are collected at specific activities to process them as a group. For instance, in logistics, it is more cost-efficient to combine parcels to be sent to the same recipient instead of handling each one separately. Although batching of products or customers is well discussed in operations research [PK00, Me02], in BPM this concept is not well considered and discussed so far. The common assumption is that each process case "is assumed to have an independent existence and they typically execute without reference to each other"[Ru05].

Recently, approaches have been developed which enable modeling and executing batch activities in business processes [PMW14, Na15, PRM16]. Moreover, process mining

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techniques were proposed to identify batch activities from historic process execution information [Ma17b, We13]. Such approaches help to depict batch activities explicitly in process models and to identify them from historic logs. However, they do not discuss which batch activities are beneficial for a business process, and which are not. Process redesign literature suggests that it might be helpful for some processes to remove activities with batching, but in others it might be beneficial to introduce batching to improve the process flow time or cost [RM05]. Details on how to operationalize this recommendation are absent. In this paper, we discuss challenges in identifying beneficial batch activities and their configuration in Section 2. To this end, we highlight related work which can be leveraged and identify research gaps. Further, a preliminary methodology is sketched in Section 3.

2 Major Challenges in Identifying Batch Activities

This section discusses four challenges related to the identification existing or new batch activities (challenges 1 and 3), the evaluation of their benefits (challenge 2) and the identification of an optimal batch configuration (challenge 4).

Challenge 1 - Identification of existing batch activities. Process redesign usually starts with an as-is-analysis where the current process design is analyzed [Du13]. For discussing existing batch activities, recent approaches by Pufahl et al. [PMW14] or by Natschläger et al. [Na15] help to visualize them in a process model, also with their configuration.

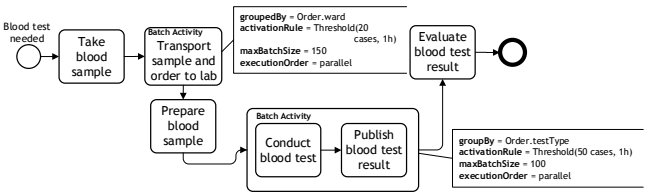

Fig. 1: Blood testing process with two batch activities.

For example, in Fig. 1 a healthcare process with two batch activities is visualized as a BPMN diagram. In this process, a blood sample is taken from a patient, if a blood test is needed. Then, the sample is brought to the laboratory where the blood sample is prepared for testing. The actual test is conducted by a blood analysis machine. After the test, the results are published in the central hospital information system, where they are accessible by the physicians for evaluation in the respecting ward. Within the given process, two batch activities are specified. As several blood test orders incur at a ward, the nurse will not bring each blood sample individually. Instead, she delivers several ones together to save transportation cost. This is captured by the batch activity *Transport sample and order to lab*. The second batch activity is the sub-process which consists of two activities and enables to collect multiple blood samples before a test run on a blood analysis machine is started. With the configuration parameters of a batch activity [PMW14], a process designer can specify the batch execution: which instances are grouped in a batch (*groupedBy*), when a batch is started (*activationRule*), how

many instances are allowed at maximum in a batch (*maxBatchSize*), and how the batch is executed, either parallel or sequential (*executionOrder*).

The first challenge relates to the identification of existing batch activities. Several complementary information sources can be used. Batch activities can be discovered together with process experts using interviews or workshops [Du13], or based on observations. However, in more flexible processes, extensive interviews or observations might be required. In this respect, techniques to automatically discover batching behavior from historic process execution data can be used [Ma17b, We13]. The insights retrieved using such techniques are determined by the level of granularity at which historic logs are recorded. Note that the expertise from process experts is still required to validate the findings from data.

Challenge 2 - Batching vs. no batching. After having identified existing batch activities, the benefit of batching needs to be determined. On the one hand, batch activities help to reduce costs or activity execution time by processing several cases collectively. In the blood testing process, machine costs can be saved. On the other hand, instances might experience increased cycle times as it requires certain time to fill a batch [PK00].

The challenge is to define performance indicators for batch activities with regards to the four performance dimensions cost, time, quality, and flexibility [Du13]. Examples are *activity costs*, *batch size*, *cycle time* detailed by the *turnaround time*[3] and *waiting time* at a batch activity [Pu18]. For each scenario, the appropriate performance indicators need to be identified. These ones then need to be measured, e.g., based on historical process execution data, and need to be interpreted to determine whether to continue with batching or not, and if yes, whether the current batch configuration should be improved (as is discussed in fourth challenge).

Challenge 3 - Hidden potential batch activities. Besides existing batch activities, potential new ones could also be identified. The challenge is how to identify beneficial candidates.

Two types of batch activities are distinguished: sequential and parallel ones. For parallel batch activities, where several items are processed simultaneously, a resource has to be able to process them at the same time. Thus, the resource perspective has to considered in such an analysis. For sequential batching, the resource still processes the cases individually, but setup times are reduced because the activity is executed on multiple cases one after the other. This requires a detailed analysis how much time during an activity execution is spent for getting familiar with the task or for setting it up and the actual execution. Potential new batch activity candidates need to be evaluated with regards to performance indicators as well. This can be supported by business process simulation. In [PWW17], an extensible BPMN process simulator was developed also supporting the simulation of batch activities.

Challenge 4 - Recommendations on batch activity configurations. Finally, after defining the batch activities for a business process, these also need an optimal configuration which

[3] Time an activity instance spends for batch execution, from waiting for it until its termination.

consists of a grouping parameter, an activation rule, a maximum batch size, and the execution order. While the latter two parameters are mainly dependent on the resource handling the batch activity, the grouping parameter depends on the type of cases being processed. The batch activation rule enables striking a balance between cost benefits and the influence of batching on process performance. While initial approaches have been developed to mine the current execution order and batch activation rule from process execution data [Ma17a], the recommendation of appropriate batch configuration parameters is still a challenge. This requires the development of simulation-optimization approaches or the usage of techniques from queuing theory [Me02] which might be supported by works on queuing mining [Se15].

3 Methodology for Integrating Batch Activities

Taking into account the challenges in Section 2, a preliminary methodology to integrate batch activities in business processes is proposed in Fig. 2.

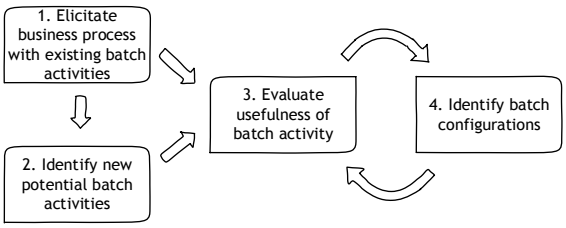

Fig. 2: Preliminary methodology for integrating batch activities.

If a business process is analyzed regarding its potential for batch activities, the business process should be first elicited with known process discovery techniques, such as evidence-based, interview-based, or workshop-based discovery [Du13]. Thereby, existing batch activities should be depicted in the process model, for instance, with the batch activity element presented in [PMW14]. Process mining techniques [vdA11, Ma17b] can support this step. Additionally, new potential batch activities can be identified in second step with the support of resource information, process execution data and expert knowledge. In the third step, the usefulness of the identified batch activities has to be evaluated. To this end, performance indicators for the batch activities have to be defined. Then, those are evaluated based on historic and/or simulated execution data. After having identified potentially useful batch activities, in the last step, their optimal batch configuration has to be determined. This step needs to be supported by simulation-optimization approaches.

4 Conclusion

In this paper, we motivated the necessity of batch activities in business process modeling. Moreover, we discussed the challenges of identifying existing batch activities and potential new ones, evaluating their benefit as well as configuring them correctly. Based on this, a

preliminary methodology was deduced for integrating batch activities in business processes. This will be developed further in future work by the authors.

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Relaxing Modeling Criteria to Produce Genuinely Flexible, Controllable, and Usable Enterprise Modeling Methods

Dominik Bork[1] and Steven Alter[2]

Abstract: Enterprise modeling (EM) applies abstraction in creating simplified representations of complex realities. Unfortunately, both the realities and the task of creating valid conceptual representations bring daunting challenges. Complexity is increasing, e.g. the transition of conventional production towards product-service systems operating in heterogeneous enterprise ecosystems. Simultaneously, modeling methods and tools tend to be formal and inflexible, and often are designed for automated model processing rather than for helping business professionals understand business situations. The result is the current, unsatisfying state of enterprise modeling, in which models can be developed and used directly only by modeling experts and are largely impenetrable to non-experts. This paper presents a set of principles that suggest directions for progress toward genuinely flexible, controllable, and usable enterprise models. The principles accept the relaxation of some expectations about enterprise modeling while trying to maintain rigor and completeness in models.

Keywords: Enterprise Modeling; Modeling Principles; Modeling Methods

1 Mismatch between Modeling Capabilities and Modeling Goals

Attention to rigor and completeness is a central tenet of systems analysis and design (SA&D), requirements engineering, enterprise modeling, and conceptual modeling in general. For example, Bork and Fill [BF14, p. 3400] speak of representing "static and dynamic phenomena of systems prior to their implementation," which typically requires formal models that are precise and complete. A long term vision of translating directly and automatically from conceptual models and requirements specifications to executable code has driven passionate IS research debates focusing on the completeness and general adequacy of ontologies, metamodels, and reference models.

The benefits of enterprise models often come at the cost of complexity and inflexibility due to formalization and rigor needs of modeling methods and supporting tools. In contrast, domain experts often perceive the business in imprecise ways and may or may not have the expertise to capture their knowledge in a conceptual model. Furthermore, modeling tools sometimes constrain intuitive specification of externalized knowledge by forcing users to express themselves in modeling languages that are unfamiliar or difficult to use.

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A position paper by Sandkuhl et al. [Sa18] encourages transforming EM from an elite discipline performed by experts towards a vision of "modeling for the masses". An important element of their future research agenda is *Softened Requirements to Completeness, Coherence and Rigor*. This paper builds on that goal by proposing a set of principles that might be incorporated in an EM approach for creating genuinely flexible, controllable, and usable models. Application of those principles probably would require softening some criteria for model quality that the EM community takes for granted. The question at hand is whether the proposed principles would generate desired benefits without sacrificing important values and goals of the EM community.

2 Principles for Relaxed Enterprise Modeling

Our proposed EM principles aim at a compromise between important but divergent approaches to EM. Emphasizing rigor and correctness of models and modeling methods, Karagiannis and Kühn [KK02] say that the foundations of formal modeling include the modeling language (comprising its semantics, syntax, and notation), modeling procedure, and mechanisms & algorithms. In contrast, Sandkuhl et al. [Sa18] argue for democratizing EM and seem willing to accomplish that through approaches such as consolidating semi-formal models produced by business professionals. This paper's compromise between those two directions maintains the idea of rigorous modeling but proposes principles that relax or even omit some built-in assumptions of current EM methods. We may find that most principles can co-exist while some of them prove mutually contradictory in practice.

Tab. 1: Principles for Relaxed Enterprise Modeling

Principle	**Rationale**
Abstraction	Models are abstractions of other things and therefore are not equivalent to those things. The structure and behavior of a model is not equivalent to the structure and behavior of whatever is being modeled. Increasing the level of detail and precision in a model will not generate something that is equivalent to whatever is being modeled.
Priorities	Details of models should be driven by the content being represented and the purposes of the model's users. Details of models should not be driven by a need to satisfy the requirements of a modeling technique or metamodel or by the expectations or preferences of the EM community.
Usability Principles	
Controll-ability	Users should be able to control a model and view it from different perspectives and at different levels of detail. Different users might have quite different goals ranging from attaining a basic understanding of a business situation through using simulation or other automated methods to predict how a system will behave.

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Principle	**Rationale**
Zoomability	As with online maps, it should be possible to visualize and explore the entire system under study and any part of it by changing the focus and level of detail, e.g., from highly aggregated to highly detailed. Using different zoom levels to slide between different levels of detail enables interactive exploration of models.
Cognitive manageability	Modeling methods, notations, and tools should not impose extraneous cognitive load [Sw94]. Modeling tools should help modelers focus on the content that they are concerned with and should minimize additional attention required to understand or use tools or notations for representing and displaying that content.
	Content Principles
Minimum critical specification	One of Cherns' [Ch87] sociotechnical principles says that designers and modelers should specify only what is necessary and should not specify unnecessary details. In a broader sense, over-specification is futile because the frequent occurrence of noncompliance and workarounds [Al14].
Design incompletion	Another of Cherns' sociotechnical principles says that the design of a sociotechnical system is always incomplete because sociotechnical systems (including processes, participants, goals, etc.) typically adapt in response to changes in the environment that surrounds it.
Completeness linked to purpose	Simulation and code generation require complete models. Incomplete models are adequate for representing vague or incomplete information [GP18], or for supporting communication among stakeholders.
Precision linked to purpose	Some aspects of a model or modeling language can be very precise while other aspects can be relatively vague. E.g., an imprecise model of a business process may be useful before filling in all intermediate events and task types.
	Modeling Principles
Domain specificity	A model's domain should be specified clearly. The domain of many models is somewhat unclear. For example, some models do not include the characteristics of human participants who produce a system's output.
Semantic clarity	Concepts in a model or modeling language should be defined clearly. That might seem obvious until one looks at models of service in which the concept of 'service' itself is not defined clearly.
Adaptable syntax	In contrast to established beliefs, it is possible for a model to be useful even if it does not have a formal syntax. In co-evolutionary contexts, syntactic concepts can be defined while modeling [CA13, WSG17].
Flexible notation	In certain scenarios, it is important for modelers to introduce specific notations while modeling [Bu18].

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Principle	**Rationale**
Imprecise semantics	Imprecision is almost inevitable when typical domain experts create conceptual models. Models should not try to be more precise than domain experts' imprecise knowledge about the system under study [GP18].
Flexible modeling procedures	It is possible to produce useful models without using a structured modeling procedure. Just as one might fill out a jigsaw puzzle by moving from the outside toward the center, it might also be possible to fill out the puzzle from the center to the outside.
Flexible Tooling	Controlled flexibility should be reflected in modeling tools, which should adapt to a user's objectives. Rigorously specified fixed metamodels and metamodel constraints are needed in some cases. In other cases, modelers' creativity and intuitions call for bypassing or augmenting fixed structures.
Modularity	Models should consist of modules whose interactions and internal elements can be named and described separately. Modularity makes it easier to describe the structure of a model and to set up the structure of a model before filling in the details.
Module-specific semantics	In a modular structure, concepts that are relevant to one module might not be relevant to another module. Therefore it should be possible for different modules to have different semantics.
Module-specific syntax	In a modular structure, any syntax that might be relevant to one module might not be relevant to another module. Therefore it should be possible for different modules to be modeled using different syntax.
Optional transparency	Modules are encapsulated but visibility to other modules or to users is optional, and ranges from glass box to black box.

3 Concluding Remarks

Research in conceptual modeling and EM focuses primarily on the precise and unambiguous representation of all relevant aspects of a system under study. Construction of these models is supported by modeling tools and methods that are not well suited to be used by domain experts and other stakeholders who lack modeling expertise. Thus, despite the wide adoption of EM and its strong contribution to the analysis and design of complex systems, its rigor and formality present obstacles to theory-driven and creativity-employing techniques of the IS discipline.

Each principle proposed by this paper presents a research challenge along a path toward enabling people who are not EM experts to participate fully in EM. Each principle can be used in describing or evaluating existing EM methods and in thinking about new EM methods, especially methods that might apply IS theories such as work system theory or

design thinking. Those and other practical approaches bring some degree of rigor while calling for relaxation of modeling constraints related to syntax, semantics, and notation that are built into existing EM methods and tools.

We intend to investigate practicalities of these principles in future research. We hope to focus special attention on tool-related implications of these principles within an overarching goal of maintaining a reasonable degree of rigor and formality while also allowing domain experts and other stakeholders to participate more fully in enterprise modeling.

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Same Same But Different – Federating Enterprise Modelling for the Digitalized and Data-driven Enterprise

Robert Winter[1] and Michael Blaschke[1]

Abstract: To the extent that digitalization and data-driven innovation change the way how organizations are managed, also enterprise modelling (EM) approaches need to be adapted. We argue that the once dominant process centric approach to EM needs to be increasingly accompanied by EM components which are value centred or decision centred. As EM is challenged by fragmentation and heterogeneous maturity as a consequence of a greater diversity of core concepts, we propose a two-dimensional framework which affords to better reflect EM coverage of multi-modal organizations, understand relations and dependencies between EM components, and guide IS evolution.

Keywords: Enterprise modelling, digitalization, data-driven innovation, multi-modal management, federated enterprise modelling, process modelling, value modelling, decision modelling.

1 Management Becomes Increasingly Multi-modal

In the early 1990s, organizational design and performance management were fundamentally re-shaped by shifting the focus from ***functional specialization*** (e.g., inventory vs. production vs. accounting vs. sales) to systematic control of ***output flow*** (e.g., order-to-cash). Process models and process-focused management since then allow to "manage the white space on the organization chart" [RB95]. This shift puts the **process concept** to the forefront which integrates secondary concepts like function, output, resource, organizational unit, and performance indicator.

Pervasive digitalization of organizational life, commonly referred to as digital convergence, has become the "new" reality in information systems (IS) [TLS10]. Digitalization applies "digitizing techniques to broader social and institutional contexts that render digital technologies infrastructural" [TLS10:749]. Consequently, organizational design and performance management have been challenged again by having to accommodate fast-changing, increasingly individualized, context-depending ***digital interactions.*** Managing this so-called ***front-stage*** [GT09] fundamentally differs from managing harmonized support processes (designated as ***back-stage*** [GT09]) [LP15]. This calls for a bi-modal management approach. Models for managing the increasingly important front stage usually put the **value concept** to the forefront (value proposition and appropriation) which integrates secondary concepts like customer journey, context, channel, and delivery process [Bl18].

For organizational design and performance management of both the organization's back

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and front stages, the exploitation perspective [BT03] is dominant. Conversely, the exploration perspective is dominant for innovation. Since the increasingly important ***data-centred exploration*** portion of the digitalized enterprise has both exploration and exploitation characteristics [Ha15], this calls for a third management mode. It would be too simplistic – and too implementation-oriented – to associate this management mode with data only. From a business perspective, managing data exploration does neither focus on output flows nor digital interactions, but on informed business decisions (or ***insights***), going far beyond was is traditionally understood as "data management". From a management perspective, it is organizational decision-making which needs to be designed, justified and steered. As an extension of early approaches to centre management tasks around decisions informed by multi-dimensional data ("business questions", cf. [Co98]), the **informed decision concept** integrates secondary concepts like data lineage and data quality [DD17], business purpose [FHS17], and context.

In summary, digitalization and data exploration increasingly call for a multi-modal, tripartite management approach [LP15]. As a consequence, process centricity is additionally accompanied by value centricity and informed decision centricity.

2 Differentiated Design Foci Need Federated Enterprise Modelling

Enterprise modelling (EM) refers to the abstract representation, description, and definition of the structure, processes, information, and resources of an organization. Due to the conceptual differences of the three outlined constituents of tripartite, multi-modal management, EM for the digitalized and data-driven organization needs to be federated:

1. **Back-stage EM**: For modelling the parts of the enterprise that are harmonized for performance (exploitation), **process** is the established core concept of this EM component. Traditionally (e.g., in SADT [RS77]), functions and data were core concepts for EM. With the shift towards a process-orientation, the Architecture for Integrated IS (ARIS) metamodel, for instance, supports **process**-centred performance management. Functions, data, outcomes, performance, and organizational units all become linked by the process concept [Sc87].
2. **Front-stage EM:** For modelling the parts of the enterprise that need to be customized, contextualized, and optimized to support customer journeys and service encounters, **value** increasingly becomes a core concept of this EM component. Early approaches to analysing and designing interactions at digital interfaces and IT-enabled interactions are often still process-oriented. E.g., service blueprinting [Pa11] is still focused on an interaction process. However, service is primarily about value-in-use and value-in-context [VL08] so that process is not the core concept any more [LN15; LVW08; VL04; VL08; VL16]. In service-dominant logic, **service** is the fundamental basis of economic exchange, which refers to "applying specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another actor

or the actor itself" [LN15:158]. Consequently, emergent front-stage IS analysis approaches support **value**-centred performance management beyond mere process considerations. In this notion, economic exchange is pervasively linked by value proposition/appropriation [Bl18].

3. **Data-centred exploration EM:** For modelling the parts of the enterprise where data exploration is important, we bring forward the **informed decision concept** to denote a powerful candidate for the prevailing core concept of this EM component. Pioneering approaches to modelling data-centred exploration were process oriented. For example, data exploration has been modelled by a supply-chain logic covering extraction, transformation, load, integration, enrichment, provision, and analysis in data warehousing and business intelligence contexts [SRS11]. We believe that, much more than by the data supply-chain process, data-centred exploration is characterized by the purpose-driven, flexible exploration of (re-)combination and reuse potentials of enriched data [Ch12; LP15]. Data is explored for two purposes: decision making and innovation [Ha15]. Consequently, informed decisions are a good candidate for a core concept. A conceptual model of informed decisions needs to link data sources (master, transaction, and derived data), enrichment processes (data lineage), relevant business questions, exploration purpose (including justification of its ethical and legal foundations), and context. A starting point could be a taxonomy of data exploration use case types.

Perspective	**Function-centred**	**Process-centred**	**Value-centred**	**Decision-centred**
Time	From 1970s	From 1990s	From ca. 2005	From ca. 2015
Managerial Focus	Manage performance of a complex network of functions which are linked by dataflows	Manage output flow per control objectives and quality specifications	Customize, contextualize, and optimize support of customer journeys and service encounters	Manage systematic data-driven decision making and innovation
Business Aspect	Functional organization	Back-stage (mainly exploitation)	Front-stage (mainly exploitation)	Data-centred exploration
Method	Structured Analysis	Business Processes Design / Engineering	Value Modelling / Design	No mainstream yet
Exemplary Techniques	SSD, SADT, SSADM	ARIS-based, BPML, BPMN, UML	Partial support only (e.g., e^3value, Value Proposition Canvas)	Partial support only (e.g., multi-dimensional modelling, business questions, analytical use case types)
Seminal References	[RS77]	[Sc87]	[VL04]	

Tab. 1: Chronology of complementing perspectives on enterprise modelling

Table 1 illustrates the complementary albeit heterogeneous character of the different EM components. As management approaches become increasingly multi-modal, Business Process Design and Engineering (BPD/E) can be expected to become less and less domi-

nant in EM. For increasingly important front-stage and data exploration parts of enterprises, "local" models/methods/techniques have been proposed or are under development, leading to more **methodological fragmentation** for both management and EM. While BPD/E has become a mature approach over the last 20 years, value modelling/design is nascent (only partial support, inconsistent approaches), and decision-centred modelling is in its infancy. In addition to fragmentation, another challenge for EM is therefore **heterogeneous maturity** of its components. This may however also be a learning potential: Nascent EM components should adapt well-developed models/methods/techniques for their respective domain. It is however widely unclear how the different components can be integrated.

3 An Architectural Vision for Federated Enterprise Modelling

We have outlined fragmentation and different maturity levels as key challenges that accrue from an increasing diversity within EM. To envision an architecture for federated EM, a modelling and a content dimension are differentiated in what follows.

1. The **modelling dimension** refers to federating hierarchically interrelated constituent EM **modelling concepts** on four layers. Iivari et al [IHK01] proposed to differentiate between paradigm, approach, method, and technique. These four layers are hierarchically interrelated. **EM paradigms** are concerned with a set of philosophical (paradigmatic) assumptions and believes that guide our interpretation of reality. **EM approaches** embody a set of related features (e.g., goals, guiding principles, and fundamental concepts) that drive interpretations and actions in EM. Therefore, different EM approaches can be distinguished by their distinct fundamental concepts such as processes, value, or decisions. **EM methods** are concerned with a set of activities, which are intended to guide the work and cooperation of various stakeholders involved in EM endeavours. **EM techniques** are concerned with the development of well-defined, reusable procedures to achieve specific types of well-defined outcomes.

2. The **content dimension** refers to federating EM **content integration** on different layers that structure the business-to-IT stack. Many EM approaches (e.g. [Wi11]) propose to differentiate models that **integrate** different aspects, models that **focus** on a specific aspect in more detail, and models that **align** other models.
   The main modelling purpose on the **integration layer** is to integrate fragmented aspects from separate, yet related EM components. To integrate heterogeneous aspects, modelling needs to be high-level to keep models comprehensible and manageable. For business-related concepts, the business model concept holds the power to integrate heterogeneous aspects on such a high-level [LP15; MTA17; Wi16]. An ontology- and taxonomy-based development (or integration) of a suitable meta-model serves as conceptual foundation interfacing between aspect models [FM07; Ve15].

The very successful Business Model Canvas [OPT05], for example, already integrates certain back-stage and front-stage aspects. Based on emerging principles for designing modelling concepts for collaborative design [Av18], also high-level aspects of data-centred exploration should be integrated.

For business-related concepts, the main modelling purpose of the **focus layer** is to represent one of the three EM components (process-centred, value-centred, and data exploration-centred), either holistically or partially, for 'local' analysis/documentation needs. As a consequence of the focused content, modelling on this layer can be more in-depth. While modelling concepts focusing on process-centred enterprise components have reached a high level of maturity, proposals focusing on value-centred enterprise components (e.g. [Bl18]) not only lack a serious proof of concept, but also mechanisms for cross-focus references. Modelling concepts focussing on data exploration are usually centred on data – which is an implementation rather than a business concept. Informed decisions have not been analysed from an ontological perspective sufficiently yet to serve as a sufficient conceptual base for appropriate modelling concepts. It is not even clear whether decision purpose, decision justification or decision context should be the leading concept for respective modelling concepts. As new conceptualizations will emerge, also mechanisms for cross-referencing front-stage and back-stage models need to be developed.

For implementation-related concepts, existing focus layer models for software, data and IT infrastructure are not directly impacted by increasingly multi-modal management.

The main purpose of the **alignment layer** is to provide of a basis for associating business-related and implementation-related models. Examples for association concepts modelled on this layer are capabilities, applications or domains [AW09]. As models on the alignment layer need to be more aggregate than the models they align (e.g. application landscape vs. process models and software platform models), additional EM components on the focus layer create no specific challenge here.

Finally, on the implementation layer the relevant IS design concepts (e.g., software services) are represented. Multi-model management

4 Implications

As EM is intended to support the "translation" of organizational design into the design of appropriate IS, recent trends in enterprise management serve as a starting point for this short paper. As enterprise management becomes increasingly multi-modal, the coverage of EM approaches needs to be extended to cover the specific concepts that are central to front-stage business and data-centred exploration. To avoid fragmentation and heterogeneous maturity of EM components, analysis and design principles of mature components

(back-stage EM and IT/business alignment models) should be used as blueprints to establish new (truly business oriented conceptualization of data-centred exploration) or to enhance existing (business modelling, front-stage business) EM components. Special emphasis should be put on the relationships between existing and new EM components because processes, value and informed decisions, while being subject to different management modes, still are closely related core concepts of any enterprise.

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