Contributions to Enterprise Content Management and Qualitative and Quantitative Decision Support

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This thesis is dedicated to
those who supported and
inspired me. – Thank you.

I. Abstract

Decision-making is an important and yet also complex process. New technologies, increased interconnectedness, and digitalization provide access to tremendous amounts of data as input for decision making processes. Decision support is highly relevant in practice and in need of further research. Within this cumulative doctoral thesis, exemplary studies in the context of qualitative and quantitative decision support are presented and discussed based on the corresponding research papers. The thesis is thematically divided into three main parts. Part A revolves around qualitative data in form of enterprise content. To manage the huge amounts of particularly unstructured data, Enterprise Content Management (ECM) evolved as an integrated approach to Information Management (IM) on an enterprise-wide scale. In the context of several theory-induced and also practice-oriented research studies, it is indicated that ECM systems have the capabilities to support qualitative decision support and Knowledge Management (KM). Part B deals with expert opinions and survey-based decision support. Within two exemplary studies, information derived from qualitative and quantitative survey data, such as questionnaires and expert opinions, are used to promote decision support and making. Part C focusses on quantitative data and optimization-based decision support. Several real world applications are investigated and indicate that Decision Support Systems (DSS) allow complex decision making and problem solving based mostly on numeric and quantitative data. Decision support based on quantitative and also on qualitative data allows to prepare organizational decision making and can lead to better and effortless decisions. Due to the ever-increasing creation of massive amounts of data, the relevance of decision support to gain technology-based competitive advantage will further increase in the future.

Keywords: Enterprise Content Management (ECM), Decision Support, Decision Support System (DSS), Optimization, Car Sharing, Green IS, Reference Model, Survey Research, Nexus of Forces, IS Governance, Grounded Theory.

Zusammenfassung

Entscheidungsprozesse sind wichtige und gleichwohl auch komplexe Prozesse. Durch neue Technologien, erhöhte Vernetzung und Digitalisierung wird der Zugriff auf riesige Datenmengen ermöglicht, welche als Grundlage für Entscheidungsprozesse dienen können. Entscheidungsunterstützung ist in der Praxis äußerst relevant und erfordert weitere Forschung. In dieser kumulativen Doktorarbeit werden exemplarische Studien im Kontext von qualitativer und quantitativer Entscheidungsunterstützung präsentiert und auf Basis der entsprechenden Forschungspublikationen diskutiert. Die Arbeit ist thematisch in drei Abschnitte eingeteilt. Abschnitt A handelt von qualitativen Daten in Form von Enterprise Content. Um die riesigen, größtenteils unstrukturierten Datenmengen zu bewältigen, ist Enterprise Content Management (ECM) als integrierter Ansatz zum Informationsmanagement auf unternehmensweiter Ebene entstanden. Im Kontext von mehreren theorie-induzierten und auch praxisorientierten Forschungsstudien wird dargestellt, dass ECM Systeme das Potential haben qualitative Entscheidungsunterstützung und Wissensmanagement zu unterstützen. Abschnitt B beschäftigt sich mit Expertenmeinungen und umfragebasierter Entscheidungsunterstützung. In zwei exemplarischen Studien werden Informationen aus qualitativen und quantitativen Erhebungsdaten, wie Fragebögen und Experteninterviews, verwendet um Entscheidungsunterstützung zu befähigen. Abschnitt C fokussiert sich auf quantitative Daten und optimierungsbasierte Entscheidungsunterstützung. Verschiedene reale Anwendungsfälle werden untersucht und vermitteln, dass Entscheidungsunterstützungssysteme auf größtenteils numerischen und quantitativen Daten eine komplexe Entscheidungsfindung und Problemlösung ermöglichen. Entscheidungsunterstützung basierend auf quantitativen und auch qualitativen Daten erlaubt organisatorische Entscheidungsprozesse vorzubereiten und kann zu besseren und weniger aufwendigen Entscheidungen führen. Durch die ständig zunehmende Generierung riesiger Datenmengen wird die Relevanz von Entscheidungsunterstützung in Zukunft weiter steigen um technologiebasierte Wettbewerbsvorteile zu erlangen.

Schlagworte: Enterprise Content Management (ECM), Entscheidungsunterstützung, Entscheidungsunterstützungssystem, Optimierung, Car Sharing, Green IS, Referenzmodellierung, Umfrageforschung, Nexus of Forces, IS Governance, Grounded Theory.

II. Management Summary

Decision-making is an important task and essential for each of us on a daily basis. Good and timely decisions are to be prepared based on manifold kinds and huge amounts of data in order to find the best alternative. To make an important decision, rational decision makers gather all kinds of information from diverse sources to first prepare the decision and then select the best alternative based on the available information. New technologies, increased interconnectedness, and digitalization allow people to access tremendous amounts of data as input for decision making (Fichman et al., 2014; Herrera, 2007). The increasing amount of data is a gift, but also a curse since "information has gone from scare to superabundant" (The Economist, 2010).

Decision support based on qualitative and quantitative data is highly relevant in practice and in need of further research. Firms strive to analyze and make use of quantitative transactional data to improve decision making (Davenport et al., 2001). Qualitative and unquantifiable data is another important source of decision-relevant information and makes up the biggest part of the data since approximately 80% of the data in organizations is unstructured (Gartner Group as cited in O'Callaghan and Smits, 2005). In fact, enterprise content and unstructured documents are increasingly becoming a key business resource because it contains important, innovative, and decision-relevant information (Rickenberg et al., 2012a, 2012b). Qualitative information derived from subjective assessment of the complex and dynamic business environment belongs to the information needs of decision makers of modern organizations (Herrera, 2007). Expert opinions and know-how can be gathered e.g. by interviews and questionnaires within surveys and represents decisive qualitative and quantitative information.

Within this cumulative doctoral thesis, particular exemplary studies in the context of qualitative and quantitative decision support are presented and discussed based on the corresponding research papers. The thesis is thematically divided into three main parts: Part A revolves around qualitative data in form of enterprise content, Part B deals with expert opinions and survey-based decision support, and Part C focusses on quantitative data and optimization-based decision support. All research contributions can be consolidated under the umbrella of business decision aid and making.

PART A: To manage the huge amounts of unstructured data, Enterprise Content Management (ECM) evolved as an integrated approach to Information Management (Päivärinta and Munkvold, 2005). It enables the management of particularly unstructured content on an enterprise-wide scale (Rickenberg et al., 2012a). As it is highly relevant for practice, the market for software and consulting is booming (Andersen, 2008; Herbst et al., 2014; Wiltzius et al., 2014). In contrast to the significant attention from practitioners, ECM only received little consideration from scholars (Tyrväinen et al., 2006; Rickenberg et al., 2012a). As a relevant but emerging field in IS research, it has been largely ignored by the IS discipline (Simons and vom Brocke, 2014). Most authors state that few research has been conducted so far (Tyrväinen et al., 2006) and that scientific literature is very limited (Alalwan, 2012b; Grahlmann et al., 2012).

To set the basis for advancing knowledge and rigorous research, a systematic and coherent review of ECM literature in the IS domain is conducted which includes 68 articles in 2012 and an update of 58 articles in 2014 (chapter 2). Based on the framework for ECM research as introduced by Tyrväinen et al. (2006), the articles are reviewed, classified, and categorized and main topics were derived in a concept-centric way. The framework for ECM research is refined based on the reviewed literature and the application of coding techniques, see right hand side of Figure I. Implications for further research and practice are derived based on the reviewed literature and findings.

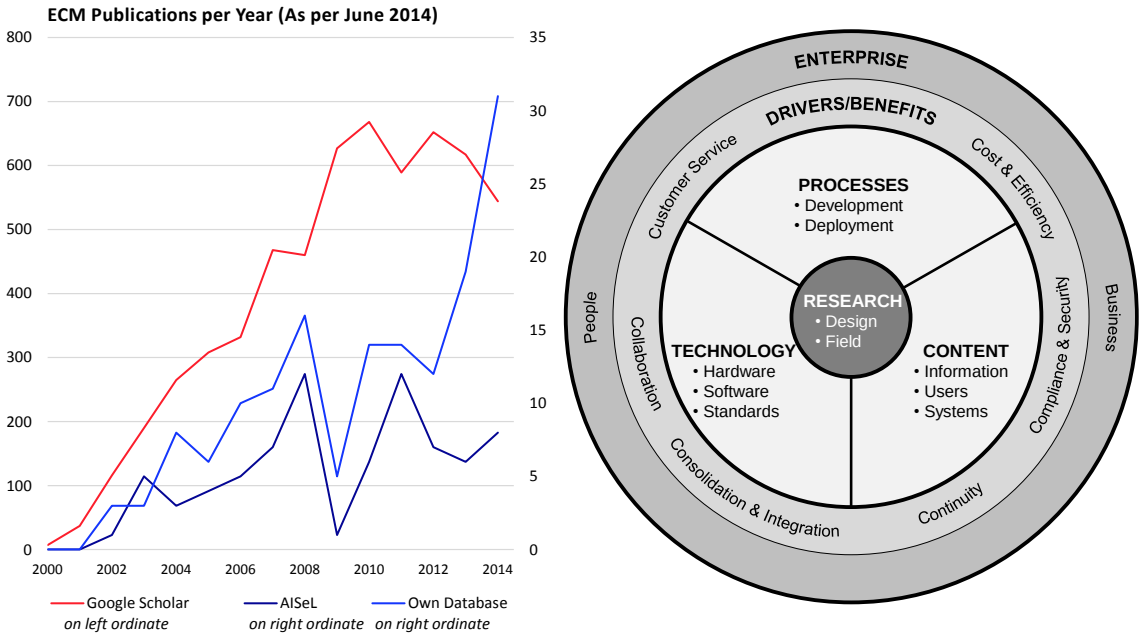

Figure I: **Number of ECM Publications and Extended Framework for ECM Research, Based on Rickenberg et al. (2012a).**

The comprehensive, in-depth review helps practitioners and scholars to get started with the complex and multifaceted topic of ECM. The body of literature of the emerging field is small but steadily growing, see the number of ECM publications per year on the left hand side of Figure I. The literature from the IS domain tends to be less technical than in the first years of research and focuses more on organizational aspects.

Companies still struggle with the identification, assessment, classification, and visualization of the huge amounts of content that are created at ever increasing rates each year. Towards these ends, a process-oriented approach that uses the business process structure as an entry point to enterprise content is presented (chapter 3). As shown in Figure II below, this comprises practical guidelines, the 7W Framework for content classification (left hand side), and different visual representations (right hand side) including a document map. The actual practical usefulness of a document map is shown by the assessment and use of it in an engineering company as per 2014. Based on this and in order to provide more business value, enterprise content can be assessed and classified based on the perspective of knowledge components to transform content into organizational knowledge. An approach is presented that applies a knowledge perspective on ECM in a knowledge-based framework for assessing, classifying, and managing enterprise content. The Knowledge-Based Content Management (KBCM) framework (chapter 4) consists of different research artifacts on different level of abstraction.

Category	Attribute	Attribute value
WHAT	Document Type Process Origin Destination Association Template	String: *GENERIC NAME* Classified: *PROCESS NUMBER/NAME* *Classified: *OWN CREATION, INTERN, EXTERN* *Classified: *OWN USE, INTERN, EXTERN* Classified: *ASSOCIATED WITH OTHER CONTENT*, no Classified: *EXISTING*, not existing
WORTH	Confidentiality Relevance	Classified: open, intern, confidential, (top) secret Classified: low, medium, high, very high
WHERE	Storage Location Archive Location	*Classified: *LOCAL, FILE SERVER, EMAIL, PAPER-BASED, INFORMATION SYSTEM (ERP, CRM, ETC,), OTHER* Classified: *KNOWN ARCHIVE*, unknown, none
WHICH FORMAT	Storage Format Archive Format Naming Convention Storage Convention	*Classified: .doc, .xls, .ppt, .pdf, image, plain text, paper, *OTHER* Classified: as storage format, *OTHER, none* Classified: *KNOWN*, unknown Classified: *KNOWN*, unknown
WHO	Owner Involvement	String: *PERSON* String: *PERSONS, DEPARTURES, COMPANIES*
WHEN	Creation Publication Archiving Deletion Creation Frequency Change Frequency Frequency of Use States	String: *GENERIC POINT OF TIME* Classified: *DATE KNOWN*, unknown Classified: *DATE KNOWN*, unknown Classified: *DATE KNOWN*, unknown Classified: low, medium, high Classified: low, medium, high Classified: low, medium, high Classified: in process, finished, approved, published, locked, active, inactive, *OTHER*, not appl.
WHY	Storage Reason Retention Period Audit-Proof Version Control	String: *GENERIC REASON* Classified: DURATION, none Classified: yes, no Classified: yes, no

SMALL CAPS: Further Specification needed/possible,
*: Multiple Choice, Underlined: Main Attribute

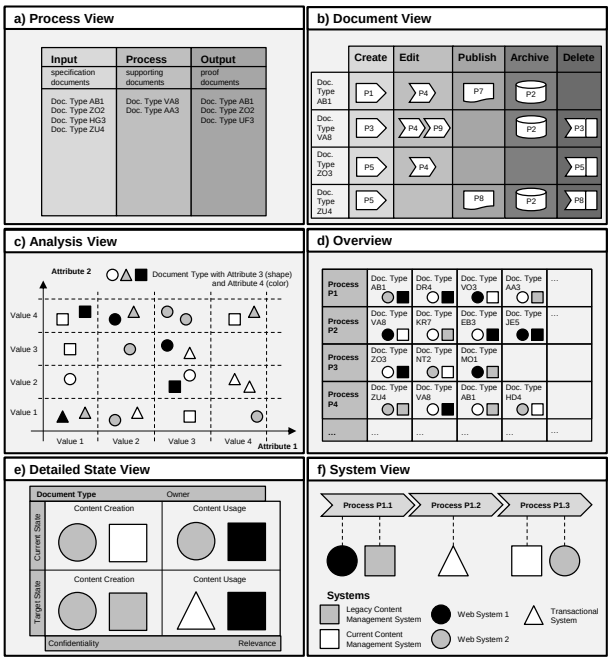

Figure II: 7W Framework and Visual Representations, Based on Rickenberg et al. (2012b).

From a theoretical point of view, the ECM research field and its current state are in need of thorough investigation, especially concerning its relevance, implications, and future development. Accordingly, the ECM research domain is analyzed, synthesized, and evaluated using grounded theory methodology to create theoretical foundations and investigate its status quo (chapter 5). An overview and formal description of the grounded theory is shown in the narrative framework for ECM research in Figure III.

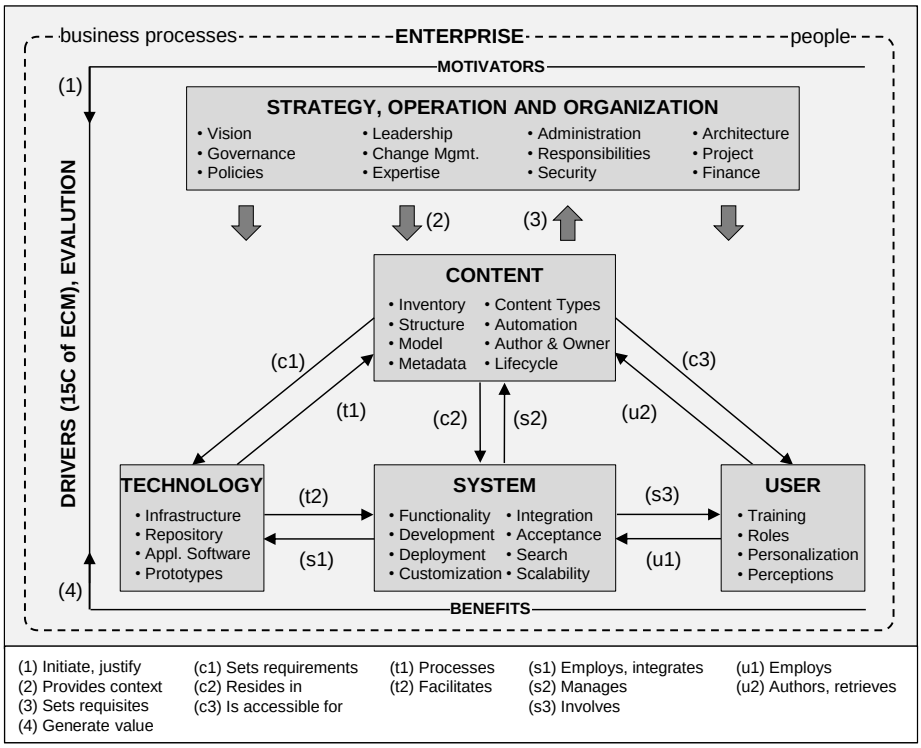

Figure III: Narrative Framework for ECM Research, Based on Rickenberg and Breitner (2014a).

ECM research is relevant but more rigorous research, further theory building, and discussions are necessary to increase its maturity and positively influence its future progress. Research topics need to be adjusted to address the enterprise-wide scope and the challenging, complex integration of preceding and related concepts into a holistic view, which represents a key characteristic and a main implication of ECM. To conclude Part A, ECM systems have the capabilities to support qualitative decision support, however, enterprise content is hardly used systematically to provide decision making information.

PART B: Deriving information from questionnaires and expert opinions, surveys are able to promote decision support and making. Survey research allows to gather information of a large group of people and is conducted to advance scientific knowledge (Pinsonneault and Kraemer, 1993). With varying degree of formalization and structuredness, both – qualitative and quantitative data from surveys – serve as an important input

for data analysis and synthesis, which then can enable survey-based decision support. Two examples are presented which focus on deriving information from survey data. The current era is shaped by the Nexus of Forces which comprises big data, social, mobile, and cloud computing as all-embracing trends. Based on qualitative survey methods employed in an iterative Delphi study, a reference model and initial insights are provided to address the challenges and influences that the interacting forces pose to organizations and governance structures (chapter 6). The IS governance reference model for the Nexus of Forces is shown in Figure IV. It encourages clear communication and provides IS researchers with a basis to develop specific models. Concerning IS practice, the model allows organizational decision makers to derive an effective IS governance implementation. As a result of consumerization pressure, corporate and IS governance structures need to be adjusted to increase the role of corporate governance regarding IS decisions. Hybrid governance approaches and federal archetypes are key areas for future research.

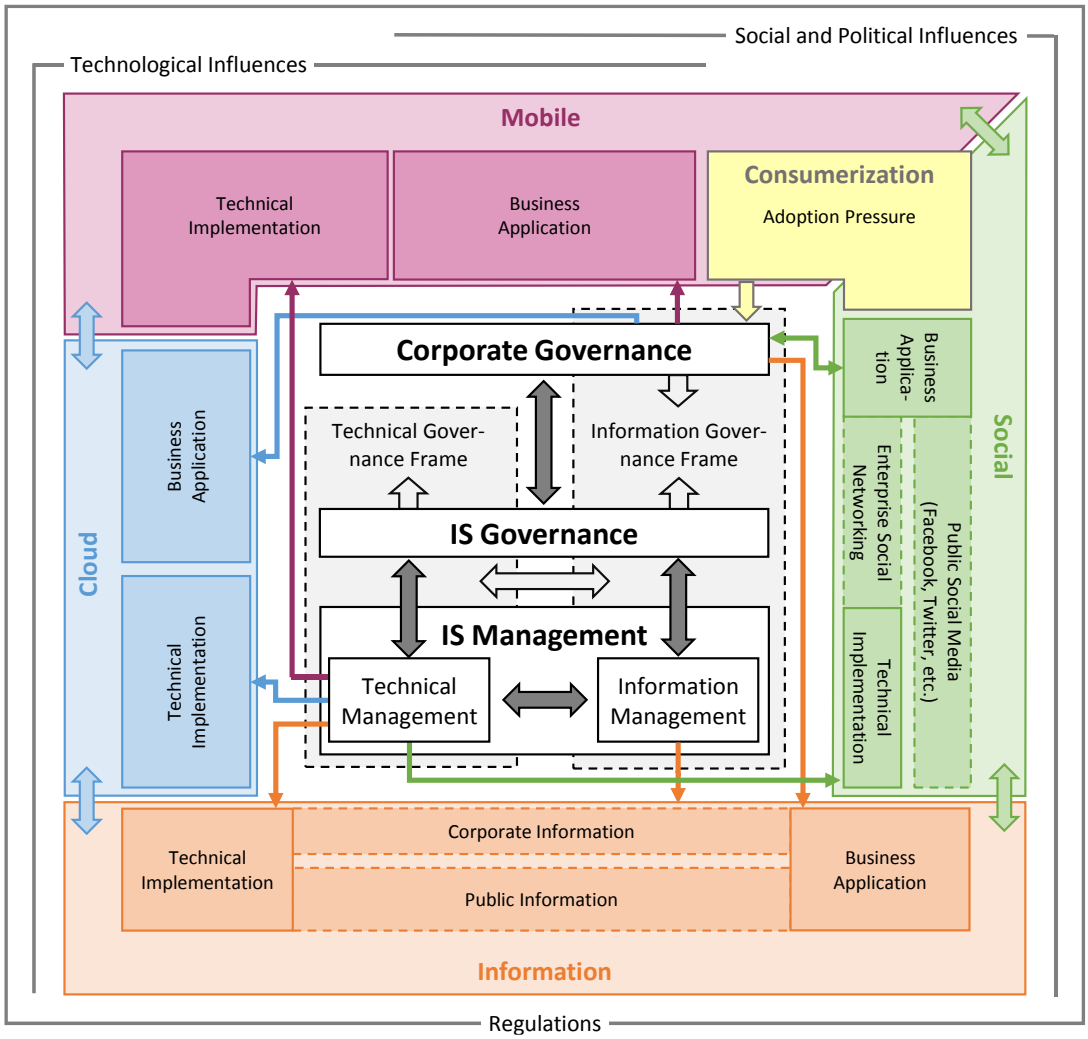

Figure IV: **IS Governance Reference Model for the Nexus of Forces, Based on Lebek et al. (2014).**

With regard to the abstract and high-level question of how IS can contribute to achieve the Millennium Development Goals (MDGs) and build a better world, decision support based on survey research methodology and a questionnaire is provided (chapter 7). Qualitative and quantitative survey data gathered from leading IS researchers indicates that with the right focus and alignment, IS practice and the underlying research domain has the potential to take on the big questions and can help to build a better world. Exemplary quantitative results concerning the MDGs are shown in Figure V.

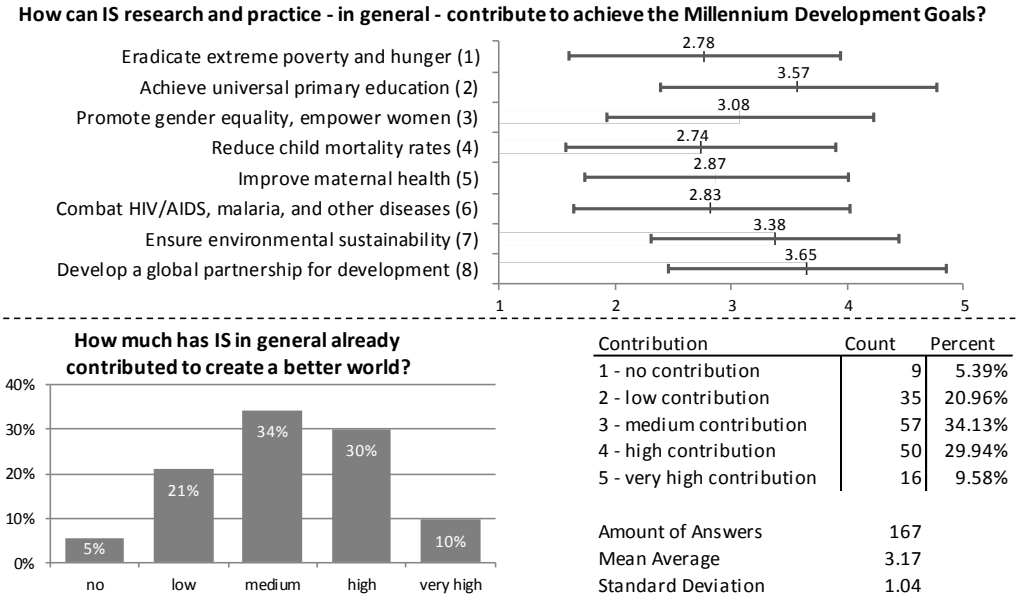

Figure V: Results of a Survey among IS Researchers on How to Build a Better World with IS, Based on Rickenberg et al. (2014).

The survey aims to provide a starting point, create awareness, and stimulate further discussions and research. Besides positive aspects, it also reveals challenges and critique concerning IS research. While IS research is currently mediocre at best, the IS community needs to step up and challenge established practices and habits to increase the relevance and impact. To conclude Part B, information derived from qualitative and quantitative survey data is able to contribute to decision support and decision making.

PART C: Focusing on mostly numeric data, Decision Support Systems (DSS) allow to analyze huge amounts of data and prepare organizational decision making (Huber, 1981), which can lead to better respectively less effortful decisions (Todd and Benbasat, 1992). DSS are “interactive computer-based systems that help people use computer communication, data, documents, knowledge, and models to solve problems and make decisions” (Power, 2002). Concerning optimization-based decision support with quantitative input data, several real-world examples of complex decision making and problem

solving are presented. These examples evolve from the application domains transportation and scheduling and are illustrated based on the implemented (prototype) DSS.

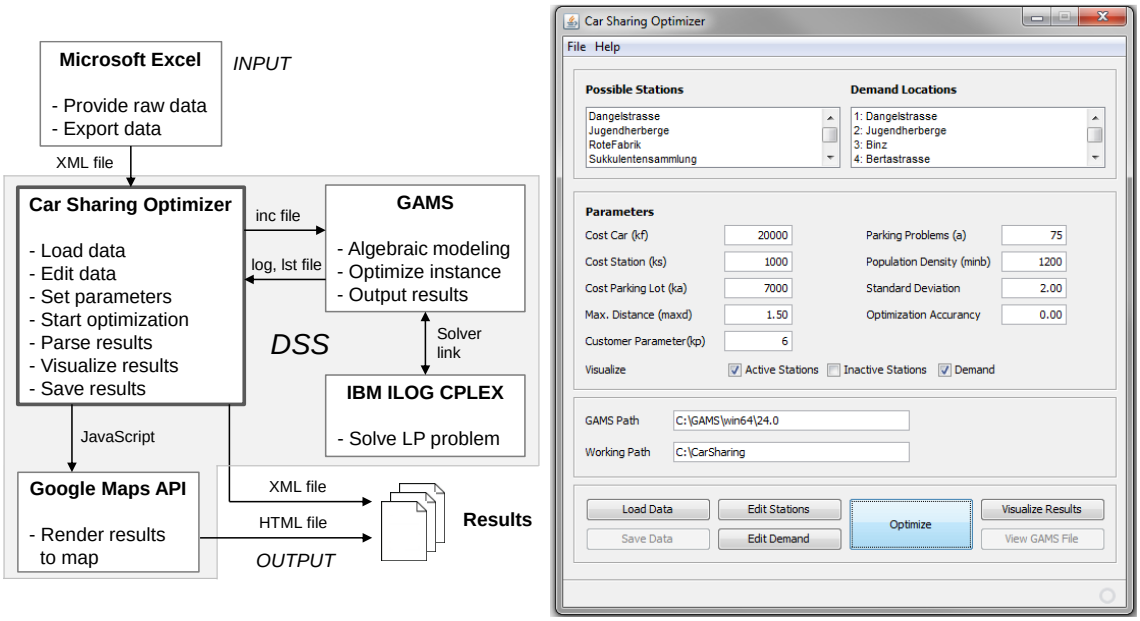

Figure VI: System Architecture and Data Flow and GUI with Data, Parameters, and Functions, Based on Rickenberg et al. (2013a) and Olivotti et al. (2014).

Car sharing is a sustainable mobility concept that allows urban individuals to share a car sequentially, but the positioning and sizing of stations is challenging. An optimization model is presented to determine the prime location and size of car sharing stations (chapter 8). To enable numerical solving and instant visualization, the model is integrated into the DSS OptCarShare 1.0, which is shown in Figure VI. Within two application examples with varying parameters, it is illustrated that the research artifacts provide decision support for planning car sharing stations and can thus contribute to environmental sustainability according to Green IS. Electric car sharing represents an approach to further increase the sustainability of car sharing, but its profitable operation still poses a problem. The existing optimization model and DSS are refined to match the specific characteristics and parameters of electric car sharing and further demonstrated and evaluated within an illustrative example (chapter 9). The benchmark results with the DSS OptECarShare 1.5 indicate that profitable operation of electric car sharing is possible nowadays. In the context of sustainable freight transport and scheduling of prototypes, further application examples and research questions about decision support by quantitative optimization are investigated briefly (chapter 10). To conclude Part C, DSS allow complex decision making and problem solving based mostly on quantitative data.

Based on the current trends of cloud, mobile, and social computing and the massive data streams, ECM will evolve in the future. Cloud and mobile ECM allow to access enterprise content from everywhere and at any time. Social computing aspects such as Enterprise Social Networking (ESN) enable social networking in the professional business context inside of organizations. A consolidation of ECM and ESN allows an integrative perspective on content, people, and processes. The Internet of Things, Industry 4.0, and sensor data will create even more massive data streams that can be analyzed, e.g. with big data approaches, to create information and additional value. All these trends coming from practice will be of growing importance within the next years and need to be analyzed from a theoretical point of view in further research. Innovating forces and technology waves, such as social computing, mobility, the cloud, and big data analytics impose dramatic changes to businesses, economies, societies (Goes, 2013). The Nexus of Forces which combines these four trends will have strong and broad impact on business organizations and all kinds of organizations, but also on people and societies in general.

Environmentally sustainable development and Green IS encompass important issues and are of increasing relevance for the IS research community. Efficient car sharing and especially electric car sharing networks can help to reduce emissions within cities and also decrease the total amount of cars in cities. Next to environmental issues, IS research should also put more emphasis on important contemporary societal issues and needs to take on the big questions and global challenges (Rickenberg et al., 2014). The promotion of social and sustainable goals and review metrics to measure the impact and contribution of IS research is needed. Thus, the IS research community can really take on humanity's grand challenges and strive to reach high level goals.

To conclude thematically, decision support based on quantitative and also on qualitative data allows to prepare organizational decision making and can lead to better and effortless decisions (Todd and Benbasat, 1992). Due to the ever-increasing creation of massive amounts of data, modern organizations, consultants, scientists, and academics have to direct their attention to "[…] the generation of knowledge and intelligence to support decision making and strategic objectives" (Goes, 2014). Along these lines and as motivated here, the relevance of qualitative and quantitative decision support to gain technology-based competitive advantage will further increase in the future.

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VI. List of Abbreviations

7WF	7W Framework
ADR	Action Design Research
AIIM	Association for Information and Image Management
AIS	Association for Information Systems
AMCIS	Americas Conference on Information Systems
BPM	Business Process Management
CSF	Critical Success Factor
DIKW	Data-Information-Knowledge-Wisdom
DM	Document Management
DSR	Design Science Research
DSS	Decision Support System
ECIS	European Conference on Information Systems
ECM	Enterprise Content Management
EDM	Electronic Document Management
EIM	Enterprise Information Management
ESN	Enterprise Social Networking
GAMS	General Algebraic Modeling System
GUI	Graphical User Interface
HICSS	Hawaii International Conference on System Science
ICIS	International Conference on Information Systems
IJeC	International Journal on e-Collaboration
IM	Information Management
IS	Information System
IWI	Institut für Wirtschaftsinformatik
KBCM	Knowledge-Based Content Management
KM	Knowledge Management
MDGs	Millennium Development Goals
OR	Operations Research
RM	Records management
RQ	Research Question
SME	Small and Medium-Sized Enterprises
UML	Unified Modeling Language
UN	United Nations
VHB	Verband für Hochschullehrer für Betriebswirtschaft
WCM	Web Content Management
WI	Wirtschafsinformatik
WKWI	Wissenschaftliche Kommission Wirtschaftsinformatik im Verband der Hochschullehrer für Betriebswirtschaft

VII. Overall View of Publications

A short chronological overview of the research publications that form the basis for this cumulative thesis is presented here. Published articles as well as submitted articles are shown in Table I. A more detailed classification of the publications according to the research topic and underlying methodology is given within the next section.

In total, 20 articles are included in the publication list from which 16 are published, one is forthcoming, and three are submitted to IS outlets. Especially the papers that were published or submitted to academic outlets which are – according to the WI/IS or JOURQUAL 2.1 ranking – categorized in category "A" or "B" set an important foundation for this thesis, see WKWI (2008) and Schrader and Hennig-Thurau (2009).

The above mentioned "A" and "B" papers (#5, 6, 7, 10, 14, 17, 19, 20) represent the cornerstones of this thesis and set the basis for the following thematic chapters. Concerning Part A of the thesis, chapter 2 bases on paper #6 from the Americas Conference on Information Systems (AMCIS); chapter 3 bases on paper #5 from the European Conference on Information Systems (ECIS); chapter 4 bases on paper #10 from the Hawaii International Conference on System Science (HICSS); and chapter 5 bases on paper #20, which was submitted to an IS journal. With regard to Part B, chapter 6 bases on paper #19, which was submitted to an IS journal; and chapter 7 bases on paper #14 from the International Conference on Information Systems (ICIS). Regarding Part C, chapter 8 bases on paper #7 from the ECIS; and chapter 9 bases on paper #17, which was submitted to an IS conference.

Additional papers (#2, 4, 8, 11, 12, 13, 15, 16) present preliminary or extended research results. Paper #11 from the Multikonferenz Wirtschaftsinformatik (MKWI) extends chapter 8 in a different city as application context; paper #12 from the MKWI extends chapter 3 with social networking aspects; and paper #16 refines chapter 4 and is published in the International Journal on e-Collaboration (IJeC). Paper #15 builds a basis for chapter 9 and was presented and is forthcoming at the International Conference on Operations Research (OR). Four papers are the foundation for chapter 10: papers #2, 8 are IWI discussion papers; paper #4 from the MKWI; and paper #13 was published in the journal Wirtschaftsinformatik & Management (WuM). Four IWI discussion publications (#1, 3, 9, 18) are thematically not further taken into account in this thesis.

Overall View of Publications

Table I: Chronological Overview of Publications.

#	Publication Date	Title	Authors	Outlet	VHB/WKWI	VHB/JQ2.1 (Score)	Type, Topic	Part-Chapter	Appendix
20	Submitted	Enterprise Content Management Research: Analysis, Synthesis, and Evaluation Using Grounded Theory Methodology	Rickenberg, T.A.; Breitner, M.H.	Submitted	A	A	Qualitative, ECM	A-5	Appendix 20
19	Submitted	Big Data, Social, Mobile, and Cloud Computing: Towards a Reference Model for IS Governance and the Nexus of Forces	Lebek, B.; Rickenberg, T.A.; Hohler, B.; Breitner, M.H.	Submitted	A	A	Qualitative, SURVEY	B-6	Appendix 19
18	11/2014	A Process Model to Integrate Data Warehouses and Enable Business Intelligence: An Applicability Check for the Airline Sector	Edwards, C.; Rickenberg, T.A.; Breitner, M.H.	IWI Discussion Paper #64, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, pp. 1-17.			Qualitative		Appendix 18
17	Submitted	Towards Profitable and Sustainable E-Car-Sharing: A Decision Support Systems to Optimize Station Location and Size	Kühne, K.; Sonneberg, M.; Rickenberg, T.A.; Breitner, M.H.	Submitted	A	B	Quantitative, DSS	C-9	Appendix 17
16	05/2015	Enterprise Content Management Systems as a Knowledge Infrastructure: The Knowledge-Based Content Management Framework	Le Dinh, T.; Rickenberg, T.A.; Fill, H.-G.; Breitner, M.H.	International Journal of e-Collaboration (IJeC), 11(3), pp. 49-70.			Qualitative, ECM	A-4	Appendix 16
15	Forthcoming	An Optimization Model and a Decision Support System to Optimize Car Sharing Stations with Electric Vehicles	Kühne, K.; Rickenberg, T.A.; Breitner, M.H.	Selected Papers of the International Conference on Operations Research 2014, Aachen, Germany.		E (4.87)	Quantitative, DSS	C-9	Appendix 15
14	12/2014	Building a Better World through Information Systems – An Explorative Survey among Leading IS Researchers	Rickenberg, T.A.; Koukal, A.; Breitner, T.A.	Proceedings of the International Conference on Information Systems (ICIS 2014), Auckland, New Zealand, pp. 1-19.	A	A (8.48)	Qualitative, SURVEY	B-7	Appendix 14
13	07/2014	Nachhaltigerer Gütertransport – Eine Machbarkeitsstudie mit Entscheidungsunterstützungssystem	Rickenberg, T.A.; Breitner, M.H.	Wirtschaftsinformatik und Management (WuM), 4|2014, pp. 52-60.			Quantitative, DSS	C-10.1	Appendix 13
12	02/2014	Anforderungsanalyse von Enterprise Social Networking Anwendungen – Eine Action Design Research Studie	Yücel, A.E; Rickenberg, T.A.; Breitner, M.H.; Schlüter, M.; Hohler, B.	Tagungsband der Multikonferenz Wirtschaftsinformatik (MKWI 2014), Paderborn, Deutschland, pp. 1707-1720.	C	D (5.44)	Qualitative, ESN/ECM	A-3	Appendix 12
11	02/2014	Car Sharing in Zürich – Optimization and Evaluation of Station Location and Size	Olivotti, D; Rickenberg, T.A.; Breitner, M.H.	Tagungsband der Multikonferenz Wirtschaftsinformatik (MKWI 2014), Paderborn, Deutschland, pp. 1500-1512.	C	D (5.44)	Quantitative, DSS	C-8	Appendix 11
10	01/2014	Towards a Knowledge-based Framework for Enterprise Content Management	Le Dinh, T.; Rickenberg, T.A.; Fill, H.-G.; Breitner, M.H.	Proceedings of the Hawaii International Conference on System Science (HICSS 2014), Big Island, USA, pp. 3543-3552.	B	C (6.44)	Qualitative, ECM	A-4	Appendix 10
9	12/2013	Innovation Management: How to Drive Innovation Through IT – A Conceptual Model	Edwards, C.; Rickenberg, T.A.; Breitner, M.H.	IWI Discussion Paper #62, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, pp. 1-40.			Qualitative		Appendix 9
8	08/2013	Design and Implementation of a Decision Support System for Complex Scheduling of Tests on Prototypes	Rickenberg, T.A.; von Mettenheim, H.J.; Breitner, M.H.	IWI Discussion Paper #57, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, pp. 1-11.			Quantitative, DSS	C-10.2	Appendix 8
7	06/2013	A Decision Support System for the Optimization of Car Sharing Stations	Rickenberg, T.A.; Gebhardt, A; Breitner, M.H.	Proceedings of the European Conference on Information Systems (ECIS 2013), Utrecht, The Netherlands, pp. 1-12.	A	B (7.37)	Quantitative, DSS	C-8	Appendix 7
6	08/2012	Enterprise Content Management – A Literature Review	Rickenberg, T.A.; Neumann, M; Hohler, B.; Breitner, M.H.	Proceedings of the Americas Conference on Information Systems (AMCIS 2012), Seattle, USA, pp. 2132-2144.	B	D (5.92)	Qualitative, ECM	A-2	Appendix 6
5	06/2012	Towards A Process-Oriented Approach To Assessing, Classifying And Visualizing Enterprise Content With Document Maps	Rickenberg, T.A.; Neumann, M; Hohler, B.; Breitner, M.H.	Proceedings of the European Conference on Information Systems (ECIS 2012), Barcelona, Spain, pp. 1-12.	A	B (7.37)	Qualitative, ECM	A-3	Appendix 5
4	03/2012	Green by IT – Nachhaltiger Gütertransport durch Entscheidungsunterstützungssysteme	Rickenberg, T.A.; von Mettenheim, H.J.; Breitner, M.H.	Tagungsband der Multikonferenz Wirtschaftsinformatik (MKWI 2012), Braunschweig, Deutschland, pp. 1487-1498.	C	D (5.44)	Quantitative, DSS	C-10.1	Appendix 4
3	02/2012	Beiträge zur Transformation des deutschen Energiesystems	Breitner, M.H.; Köpp, C.; Rickenberg, T.A.; et al.	IWI Discussion Paper #50, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, pp. 1-560.			Qualitative/ Quantitative		Appendix 3
2	01/2010	Plattformunabhängiges Softwareengineering eines Transportmodells zur ganzheitlichen Disposition von Strecken- und Flächenverkehren	Rickenberg, T.A.; von Mettenheim, H.J.; Breitner, M.H.	IWI Discussion Paper #38, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, pp. 1-38.			Quantitative, DSS	C-10.1	Appendix 2
1	01/2008	Komplexe Prozesse mit Personenerkennung und Zeiterfassung in Hotels	Rickenberg, T.A.; Wenzel, D.; Zinovsky, T.	In: Wohlers, G.; Breitner, M.H: RFID-Anwendungen - Einführung, Fallbeispiele und Szenarien in der Praxis, Shaker Verlag, pp. 67-116.			Qualitative		Appendix 1

1. Introduction

1.1 Motivation, Research Topics, and Research Questions

Decision-making is essential for each of us on a daily basis – whether in business or private life. To make an important decision, rational decision makers gather all kinds of information from diverse sources to first prepare the decision and then select the best alternative based on the available information. A typical decision making example from business is whether a company should invest in a new costly technology, for instance an Enterprise Content Management (ECM) system. The company has to gather manifold relevant information to decide whether it is useful to buy and implement a new ECM system plus further choose from different vendors. But even in private life, decisions are taken for which collecting and analyzing diverse data is sensible. *Is it better to buy or lease a car, and which brand should I choose? Can I rely on car sharing or even electric cars in everyday life?* Especially for far-reaching decisions, such as high investments, a structured decision making process supported by the right information is useful.

New technologies, increased interconnectedness, and digitalization allow people to access tremendous amounts of data as input for decision making, see Fichman et al. (2014) and Herrera (2007). In fact, 90% of the data in the world has been created in the last two years (IBM, 2014) which defines our decade as the age of big data. The increasing amount of data is a gift, but also a curse since it results in data and information overload (Sabeeh and Ismail, 2013; Zou and Webster, 2014). “Information has gone from scare to superabundant” is stated in an article in The Economist (2010) titled *Data, data everywhere*. Due to the plethora of data and information, there is often not too few but massive amounts or even too much data (Bharadwaj et al., 2013). So on the one hand, huge amounts of data are a great challenge for decision makers (Herrera, 2007). The right information needs to be retrieved at the right time from diverse sources and without forgetting or missing any important aspects or sources. But on the other hand, additional data is an opportunity since it can contribute valuable information to improve decisions (Davenport et al., 2001).

To enable good and timely decisions, there is need for decision support based on qualitative and quantitative data. “Decision makers strive to make the best decisions

using quantitative data […] in combination with qualitative information derived from a subjective assessment of the environment" (Herrera, 2007). Therefore, quantitative data, qualitative data in form of enterprise content, and also expert opinions via surveys are important types of input for decision processes. Quantitative business data as a source of decision-relevant data and information is usually stored in databases of business information systems (IS) and also structured documents (such as xml). Despite the availability of transactional data, few firms actually analyze and make use of it to improve decision making (Davenport et al., 2001; Alalwan, 2012b). Due to the fact that approximately 80% of the data in organizations is unstructured (Gartner Group as cited in O'Callaghan and Smits, 2005), qualitative and unquantifiable data is another important source of decision-relevant information. In fact, enterprise content and unstructured documents are increasingly becoming a key business resource because it contains important, innovative, and decision-relevant information (Rickenberg et al., 2012a, 2012b). Further, qualitative information derived from subjective assessment of the complex and dynamic business environment belongs to the information needs of decision makers of modern organizations (Herrera, 2007). Expert opinions and know-how that can be gathered e.g. by interviews and questionnaires within surveys represents decisive qualitative and quantitative information.

To manage these huge amounts of unstructured data and address content chaos in companies, ECM evolved as an integrated approach to IM (Päivärinta and Munkvold, 2005; vom Brocke et al., 2011b). It enables the management of particularly unstructured content on an enterprise-wide scale (Rickenberg et al., 2012a). As it is highly relevant for practice, the market for software and consulting is booming (Andersen, 2008; Herbst et al., 2014b; vom Brocke et al., 2011b, Wiltzius et al., 2014). In contrast to the significant attention from companies and practitioners, ECM only received little consideration from scholars (Tyrväinen et al., 2006; Rickenberg et al., 2012a) and has been largely ignored by the IS discipline (Simons and vom Brocke, 2014). It is a relevant but emerging field in IS research (Simons and vom Brocke, 2014), however, most authors state that few research has been conducted so far (Tyrväinen et al., 2006) and that scientific literature is very limited (Alalwan, 2012b; Grahlmann et al., 2012).

Next to gathering and managing the right data, it is crucial to aggregate, analyze, and use data to enable informed decisions that then lead to action and finally generate

business value (Davenport et al., 2001). As stated by Smith and McKeen (2003), the long-term vision for ECM includes improved decision making, however, most firms do not utilize ECM to analyze content in order to facilitate and improve decision making (Alalwan, 2012a,b; Smith and McKeen, 2003). Most recently, Alalwan (2012b) confirmed the decision support capability of ECM (e.g. increased decision quality and speed) and proved the strategic association between the management of enterprise content and decision support.

In this context, decision support systems (DSS) allow to analyze huge amounts of mostly numeric data, prepare organizational decision making (Huber, 1981), and can lead to better respectively less effortful decisions (Todd and Benbasat, 1992). DSS can be defined as "interactive computer-based systems that help people use computer communication, data, documents, knowledge, and models to solve problems and make decisions" (Power, 2002). However, they are not intended to replace human decision makers but support business decision making.

Against this backdrop, this thesis addresses qualitative and quantitative decision support, which provides the context and structure of the thesis. While the thesis revolves around decision support, the underlying research articles mainly address specific questions concerning ECM, survey research, or DSS. The individual research contributions are then consolidated under the umbrella of business decision aid and making. The thesis gives an overview of contributions addressing these issues and is thematically divided into three main parts: ECM in Part A, survey-based decision support in Part B, and DSS in Part C, see chapter 1.3 for more details. The underlying research papers of this cumulative thesis address the research questions (RQs) as shown in Table 1 on the following page. To address these questions, diverse research approaches were used, which mainly draw from design-oriented research and the design-science paradigm. In the following chapter 1.3, the research approaches and a methodological overview of the thesis and the underlying research papers are presented.

Table 1: Investigated Research Questions.

Part	Chapter	Central Research Questions
A Enterprise Content Management	2	What is the current state of ECM literature?
	3	How can enterprise content be identified, assessed and visualized from a process point of view?
	4	How can enterprise content be assessed and classified based on the perspective of knowledge components to transform content into organizational knowledge? (HICSS 2014) How can enterprise content management systems be enhanced to implement a knowledge infrastructure in knowledge-intensive organizations? (IJeC)
	5	RQ1: Is ECM research a relevant subfield of IS research? RQ2: What are the theoretical and practical implications of ECM research? RQ3: What are likely scenarios for future ECM research?
B Survey-based Decision Support	6	RQ1: How do the new challenges of big data, social, mobile, and cloud computing influence IS governance? RQ2: What key areas for future research are evolving concerning IS governance and the Nexus of Forces?
	7	How can IS research and practice contribute to build a better world?
C Decision Support Systems	8	How can the optimal location and size of car sharing stations be determined and decision support be provided? (ECIS 2013) How can the optimal location and size of car sharing stations be determined for the Swiss city of Zürich with varying parameters and further decision support be provided? (MKWI 2014)
	9	How can car sharing organizations provide profitable e-car sharing?
	10	*Diverse RQs about decision support for real world applications in the context of quantitative optimization.*

1.2 Research Approaches and Methodological Overview

As characterized by Hevner et al. (2004), two main, quite complementary paradigms dominate research in the IS domain: behavioral science and design science. While behavioral science strives to develop, verify, and justify theories to explain or predict human or organizational behavior, design science is rooted in engineering and aims to create new and innovative artifacts in order to extend the boundaries of human problem solving and organizational capabilities (Hevner et al., 2004; Nunamaker et al., 1991). Both paradigms co-exist and complement each other (Ayanso et al., 2011) as they are positioned "at the confluence of people, organizations, and technology" (Hevner et al., 2004). However, it is widely recognized that the Anglo-American IS research area is based on a behaviorist approach and that the European IS research community, in particular the German community, builds on design-oriented approaches and systems development research such as the design and implementation of innovative business solutions, see e.g. Österle et al. (2011), Wilde and Hess (2007), and Bichler (2006).

Since this thesis and the underlying research activities were largely conducted in cooperation with an IT service company as industrial partner, the goal was to provide utility for relevant problems through rigorous research. While behavioral science strives to achieve truth, the goal of design science is utility (Winter, 2008). Therefore, the research approaches (data collection techniques, research methods) employed for the research projects presented here are mainly based on design science, see Figure 1:

Qualitative Approaches ◄——► Quantitative Approaches

Research Projects		Empirical data		Part A: ECM						Part B: Survey DS			Part C: DSS	Design Artefact			
Outlet	Ch.	Interview	Question	QDA	Review	DSR	ADR	AC	GT	QDA	Delphi	Survey	DSR	Construct	Model	Method	Instant.
AMCIS 2012	2			X	X												
ECIS 2012	3	X		X		X		X							X	X	(X)
MWKI 2014	(3)	X	X	X			X								X		
HICSS 2014	4			X		X								X	X	X	X
IJeC	(4)	X		X		X		X						X	X	X	X
Submitted	5	X		X					X								
Submitted	6	X								X	X						
ICIS 2014	7		X							X		X					
ECIS 2013	8												X		X		X
MKWI 2014	(8)												X		X		X
OR 2014*	9												(X)		X		X
Submitted	9												X		X		X
MKWI 2012	10.1												X		X	X	X
WuM	10.1												X		X	X	X
IWI DP	10.2												(X)		X	X	X

* forthcoming

Interview: In-Depth Interview and Focus Group, Question: Questionnaire, QDA: Qualitative Data Analysis and Coding, Review: Systematic Literature Review
DSR: Design Science Research, ADR: Action Design Research, AC: Applicability Check, GT: Grounded Theory, Delphi: Delphi Study, Survey: Survey Research

Figure 1: Schematic Overview of Employed Research Designs Including Outline of Methods, Methodologies, and Resulting Design Artifacts.

The research publications and underlying research projects, as divided thematically into three parts, have different qualitative and quantitative research methods. Figure 1 gives a schematic overview of the employed research designs including research methods, methodologies, techniques for (qualitative) data collection and analysis, as well as resulting design artifacts. The figure is for illustrative purposes only without being exhaustive. It aims to give a short graphical overview of the research designs and is clustered according to the employed approaches and different parts of the thesis. While Part A builds on qualitative social research methods, qualitative and quantitative survey research methods are used in Part B, and Part C largely draws from quantitative methods. Concerning this thesis, quantitative methods are not to be understood as behavioral approaches with statistical techniques to test theory, but as the numerical optimization of certain problems with the help of OR procedures and DSS. In the following, the research approaches employed for the different research projects and papers are presented. More detailed information about the research design and the underlying methodological literature can be found in the specific chapters and the corresponding papers.

Part A of this thesis revolves around ECM and includes four chapters with five underlying research projects resulting in six papers. Due to the youth of the ECM research field, qualitative research approaches were chosen. As any rigorous academic work needs to review prior relevant literature (Webster and Watson, 2002), a comprehensive literature review was conducted to set the starting point for the ECM research activities in chapter 2. The next three research projects respectively four papers are based on design-oriented research, see chapter 3 and 4. In this context, Design Science Research (DSR) and Action Design Research (ADR) were used in industrial environments to build and evaluate artifacts iteratively, see design artifacts in Figure 1. Next to other empirical materials from the case companies, qualitative interviews were conducted and served as an important means for the research activities. In two projects, the applicability check according to Rosemann and Vessey (2008) was used to check the practical importance, accessibility, and suitability of the designed research artifacts. With regard to the Enterprise Social Networking (ESN) research project, the ADR method according to Sein et al. (2011) allowed to test the artifact within the case company and then reflect and formalize the findings. However, the ESN project will not be presented and discussed in detail within this thesis. In order to further examine the ECM domain and generate theory

inductively from diverse empirical material, grounded theory methodology was employed to create a comprehensive model, see chapter 5. Next to the research methods and approaches stated above, qualitative data analysis and coding techniques were used in all research activities presented in Part A of the thesis.

Part B of this thesis deals with survey-based decision support and includes two chapters with two underlying research projects resulting in two papers. Qualitative and quantitative approaches drawing from survey research methodology were used in this context. For the first research project in chapter 6, qualitative interviews were conducted in the context of a Delphi Study within two phases (explorative, confirmative) and a reference model was created based on the empirical data. For the next project in chapter 7, qualitative as well as quantitative data was gathered with a questionnaire and analyzed within an explorative survey among leading IS researchers. Again, qualitative data analysis and coding techniques were used in the research activities presented in Part B of the thesis.

Part C of this theses deals with quantitative optimization with DSS and includes three chapters with four underlying research projects resulting in eight papers. Therefore, design-oriented research based on DSR was chosen to create and evaluate research artifacts. The artifacts constructed here as outputs of DSR can be classified as models, methods, and instantiations, see March and Smith (1995). To optimize car sharing stations, a model and an instantiation in form of a mathematical formulation and a DSS were build and evaluated in different cities, see chapter 8. The DSS is used to show the feasibility and operationalizes the underlying optimization model and employs a numerical solver. The research artifacts were then refined in order to integrate electric cars into car sharing and provide decision support, see chapter 9. The research design of one of the papers was not explicitly stated due to length restrictions, but it also bases on DSR. In chapter 10, design-oriented research according to the DSR principles was used to address two optimization problems. A DSS to optimize operative freight transport in intermodal networks was constructed based on an underlying heuristic method to solve the implicit transport model, see chapter 10.1. Similarly, a heuristic method, an optimization model, and a DSS as instantiation were build and evaluated to enable the scheduling of prototypes for data transmission systems, see chapter 10.2. The research designs are based on DSR but were not explicitly described due to length restrictions.

1.3 Structure of the Thesis

Beginning with an overview of publications and an introduction in chapter 1, the thesis is divided into three thematic parts, and is then concluded with limitations and an outlook in chapter 11. Each of the three parts of the thesis are introduced by a primer concerning the topic and then present research results from the underlying research projects and academic papers. The thematic structure of the thesis is shown in Figure 2:

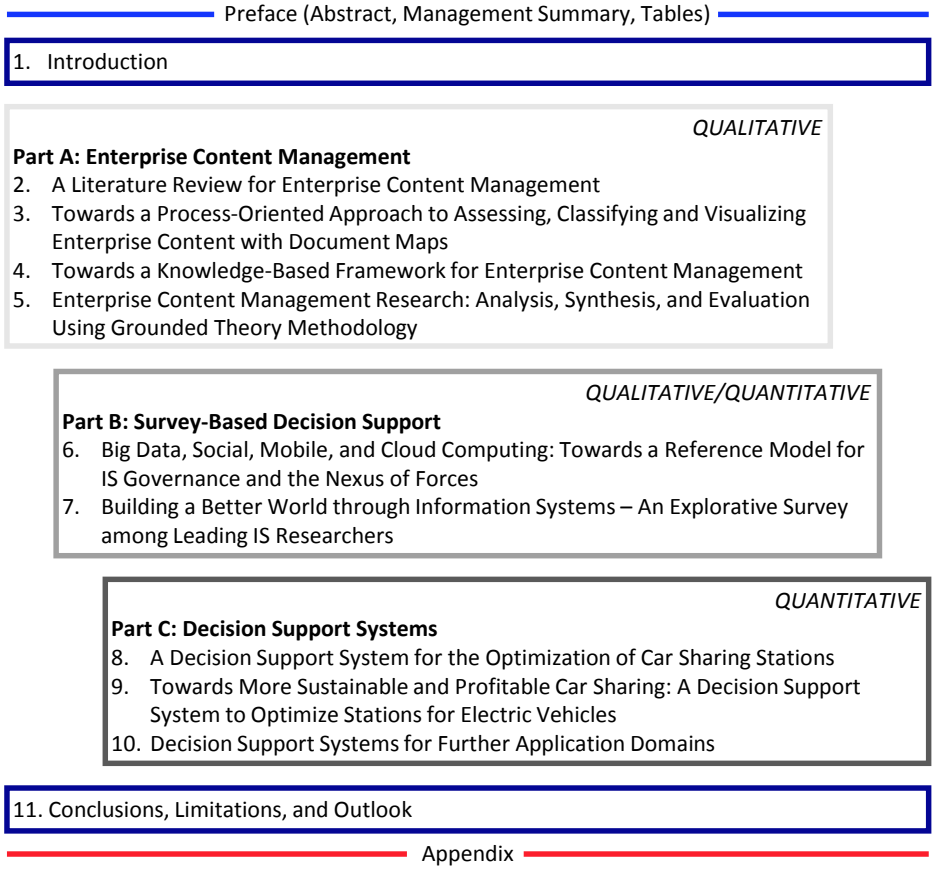


Figure 2: Thematic Structure of the Thesis.

The overview of publications in chapter VII provides a chronological outline of the publications that build the foundation for this thesis and classifies the publications based on its topic into the three parts of the thesis. The introduction in chapter 1 includes motivation and research topics, and gives an overview of research approaches and the structure of the thesis. Each of the following chapters (chapter 2 to 9) includes a motivation of the topic, methodology or research design, summary of results, limitations, implications, and academic classification in different levels of detail. Specific chapters are more detailed and include related literature and concluding remarks. Chapter 10 gives a brief overview of DSS for further application domains for the sake of completeness. Conclusions, limitations, and an outlook across chapters are given in chapter 11.

Part A is titled Enterprise Content Management and deals with ECM as a comprehensive research topic and includes four chapters. The foundation is set by a review of literature on ECM in chapter 2. Based on this, the practically important task of assessing, classifying, and visualizing enterprise content is investigated within chapter 3. A theoretical foundation for content assessing and managing based on the perspective of knowledge components is proposed in chapter 4 to enable Knowledge Management (KM) on the basis of enterprise content. Coming back to enterprise content from a theoretical point of view, a comprehensive model for the ECM domain is introduced in chapter 5. This part of the thesis shows contributions and examples of the decision support capabilities of ECM based on enterprise content and is therefore classified as qualitative decision support.

Part B is titled Survey-Based Decision Support and deals with survey research and includes two chapters. In chapter 6, expert interviews within a Delphi study are conducted to examine how the new challenges of big data, social, mobile, and cloud computing influence IS governance. A reference model is created, which allows organizational decision makers to develop an effective IS governance implementation. Drawing from a more formalized survey method with a questionnaire among leading IS researchers and a higher amount of participants, it is investigated how IS research and practice can contribute to build a better world, see chapter 7. This part of the thesis aims to show that surveys and the collected qualitative and quantitative data can enable decision support and is therefore classified as qualitative and quantitative decision support.

Part C is titled Decision Support Systems and deals with optimization-based decision support and includes three chapters. To determine the prime location and size of car sharing stations, an optimization model and the DSS OptCarShare 1.0/1.1 are implemented, see chapter 8. Based on this and in order to increase the sustainability and profitability of car sharing, the refined model and DSS integrate electric cars and the company's revenue within the optimization, see chapter 9. Chapter 10 briefly presents examples of DSS for further application domains, which are namely operative freight transport in chapter 10.1 and the scheduling of tests on prototypes in chapter 10.2. This part of the thesis shows that model-driven DSS based on quantitative data enables decision support and is therefore classified as quantitative decision support.

PART A: ENTERPRISE CONTENT MANAGEMENT

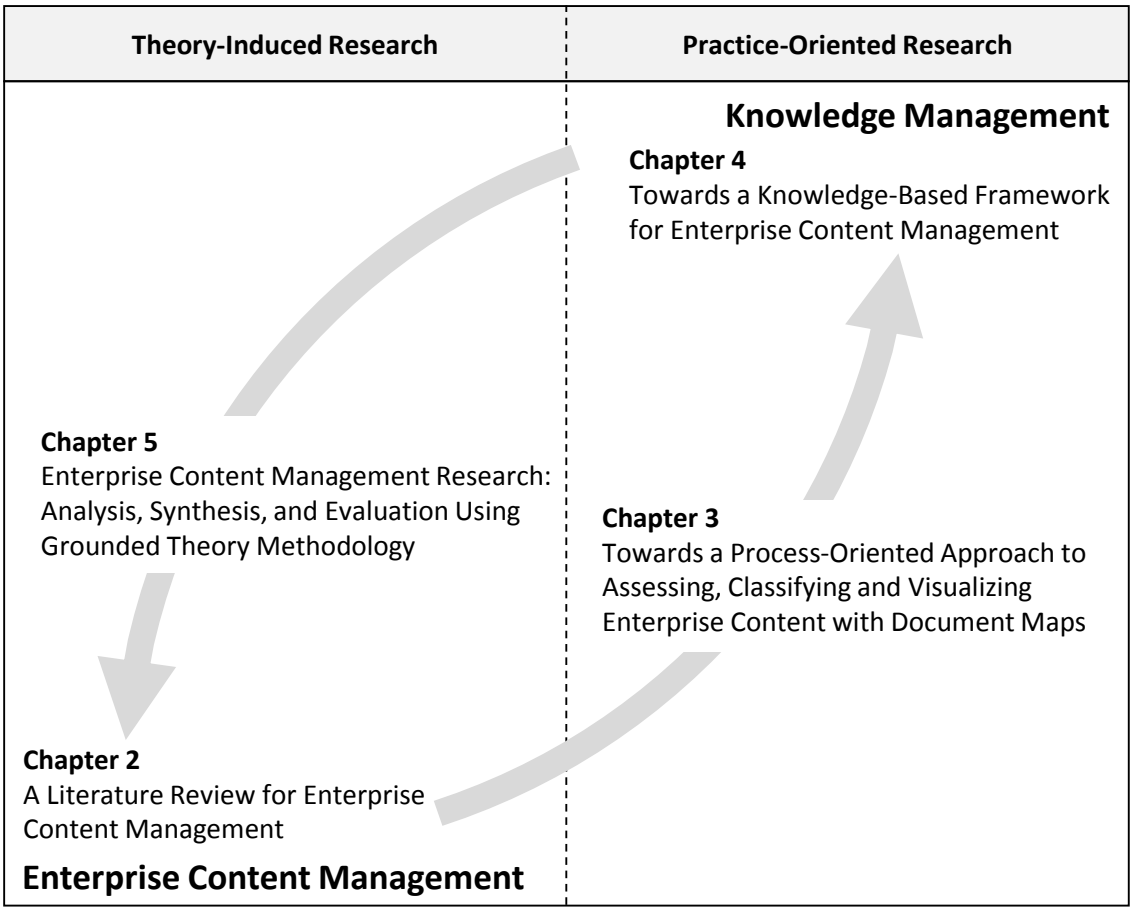


Figure 3: Structure of Part A: Enterprise Content Management

A Primer to Enterprise Content Management

ECM has gained much attention from practitioners in recent years (vom Brocke et al., 2011a). As a matter of fact, it "has been one of the fastest growing areas of IT" (Miles, 2011). Along with the practical relevance of the topic, Tyrväinen et al. (2006) state the importance of ECM for IS research: "[…] ECM provides an important and complex subfield of Information Systems". However, since the term ECM was introduced around the turn of the millennium, it is still not entirely clear what lies beyond the concept (vom Brocke et al., 2011a). Numerous authors define ECM in papers but there is no single acknowledged definition of ECM and what it stands for (Grahlmann et al., 2012). Coming from a definition with a rather technical focus, the definition evolved, which caused confusion and ambiguity (Smith and McKeen, 2003). As now organizational aspects gain importance, Smith and McKeen (2003) define ECM as "an integrated approach to managing all of an organization's information including paper documents, data, reports, web pages, and digital assets. ECM includes the strategies, tools, processes, and skills an organization needs to manage its information assets over their lifecycle." O'Callaghan and Smits (2005) state that "ECM has become the umbrella term for a technology category for managing unstructured content" and that "ECM tools and strategies allow the management of an organization's unstructured information, wherever that information exists." Päivärinta and Munkvold (2005) simply characterize it as an integrated approach to IM. Tyrväinen et al. (2006) emphasize the management of all content assets in organizational or inter-organizational contexts. A more detailed definition is introduced by Grahlmann et al. (2012). A practical definition comes from the Association for Information and Image Management (AIIM) (2014) defining it as "[...] the strategies, methods and tools used to capture, manage, store, preserve, and deliver content and documents related to organizational processes. ECM tools and strategies allow the management of an organization's unstructured information, wherever that information exists."

ECM is a multifaceted research topic emerging around related and preceding concepts, systems, and disciplines (Rickenberg et al., 2012a). It combines and integrates several formerly autonomous approaches on an enterprise-wide scale throughout the entire content lifecycle. Vom Brocke et al. (2010a) point out that "ECM takes a holistic view on the content lifecycle" and that it can be "best understood as a convergence of

related concepts". Päivärinta and Munkvold (2005) state that ECM consists of a wide set of interrelated issues and that it integrates several areas of IM. Typical components and functionalities fall under the umbrella of ECM: the management of documents within the organizational context is facilitated by means of Document Management (DM or EDM). For the work-intensive management of websites, Web Content Management (WCM) is employed. IM and KM are used to manage information and knowledge assets of an enterprise. Workflow management allows to manage, automate, and route tasks and activities. The management, execution, and improvement of business operations and processes is facilitated by Business Process Management (BPM). Records management (RM) is used for permanent storage to preserve static documents and ensure compliance. Rich media content such as video files can be managed by Digital Asset Management. Dealing with management of data, content, documents, information, and knowledge in some way, the above concepts partly overlap. With an enterprise-wide scope, ECM combines and integrates concepts that were previously separate IS research fields. Depending on the scope, functionalities and components of an ECM system, the concepts can be consolidated within one integrated system to reduce content silos.

Based on mostly unstructured and qualitative data, ECM is an important basis to enable decision support and good and timely decision making. The relationship between ECM and decision support is investigated by Zardini et al. (2010), Alalwan and Weistroffer (2011), and Alalwan (2012a, 2012b, 2013). These researchers conclude that ECM systems have the capabilities of DSS, however, very few companies utilize enterprise content to provide decision making information (Alalwan, 2013). Against this backdrop and as encouraged by Alalwan and Weistroffer (2011), further research is required.

This part of the thesis shows contributions and examples of the decision support capabilities of ECM. Part A deals with ECM as a comprehensive research topic and includes four chapters, see Figure 3 for the structure of Part A. The foundation is set by a review of literature on ECM in chapter 2. Based on this, the practically important task of assessing, classifying, and visualizing enterprise content is investigated within chapter 3. A foundation for content assessing and managing based on the perspective of knowledge components is proposed in chapter 4 to enable KM on the basis of enterprise content. Coming back to enterprise content from a theoretical point of view, a comprehensive model for the ECM domain is introduced in chapter 4.

2. A Literature Review for Enterprise Content Management

2.1 Motivation and Methodology

Huge amounts of content are produced at an increasing rate every year. The terms *information overload* and *content chaos* aptly describe the inefficient situation prevailing in many organizations (Eppler and Mengis, 2004; vom Brocke et al., 2011b; Sabeeh and Ismail, 2013; Zou and Webster, 2014). Employees, and especially information workers, search for documents and information in different repositories through the entire company. Documents are stored in different locations and systems, in different versions, languages and formats. Collaboration on documents and co-authoring is complicated; important documents are shared via email. The management of content on an enterprise-wide scale poses a challenge to companies. Even worse, unstructured data makes up 80% of the content (O'Callaghan and Smits, 2005). However, data and information quality of unstructured data is crucial because it contains important, innovative, and decision-relevant information that is increasingly becoming a key business resource.

To solve content chaos, ECM evolved as an integrated approach to IM (Päivärinta and Munkvold, 2005). ECM enables content to be managed on an enterprise-wide scale and has received a lot of attention from industry (Wiltzius et al., 2011). The market for ECM is booming as more and more companies adopt it (vom Brocke et al., 2011b). In contrast to the significant attention from companies and practitioners, ECM only received little consideration from scholars. As an emerging field in IS research, limited research has been conducted so far (Wiltzius et al., 2011). Based on a slowly but steadily growing body of literature, the current state of academic ECM literature is extensively and systematically reviewed. This comprehensive, in-depth review helps practitioners and scholars to get started with the complex and multifaceted topic of ECM, shows the current state of literature, and points out relationships. Research gaps and tendencies are shown and trends are forecasted. The research design consists of two phases: the literature search process based on vom Brocke et al. (2009), and the systematic review of the relevant literature according to Webster and Watson (2002) using open and axial coding (Flick, 2006; Myers, 2009). After the literature search, approximately 900 articles were identified and based on the screening narrowed down to 68 relevant articles. **This chapter is largely based on Rickenberg et al. (2012a), see Appendix 6.**

2.2 Summary of Results and Limitations

"A review of prior, relevant literature is an essential feature of any academic project" as it sets the basis for advancing knowledge and any rigorous academic work (Webster and Watson, 2002). With a coherent review of ECM research in the IS domain, this review focuses on accumulating ECM knowledge. In 2006, Tyrväinen et al. (2006) introduced the framework for ECM research which is widely accepted and has been applied by numerous scholars. It encompasses four perspectives: enterprise, content, processes, and technology and serves as an important foundation for this review as it is refined based on the reviewed literature and the application of coding techniques. The resulting extended framework for ECM research was elaborated with regard to the enterprise perspective and two further perspectives were added: drivers and potential benefits of ECM adoption, and ECM research itself, see Figure 4:

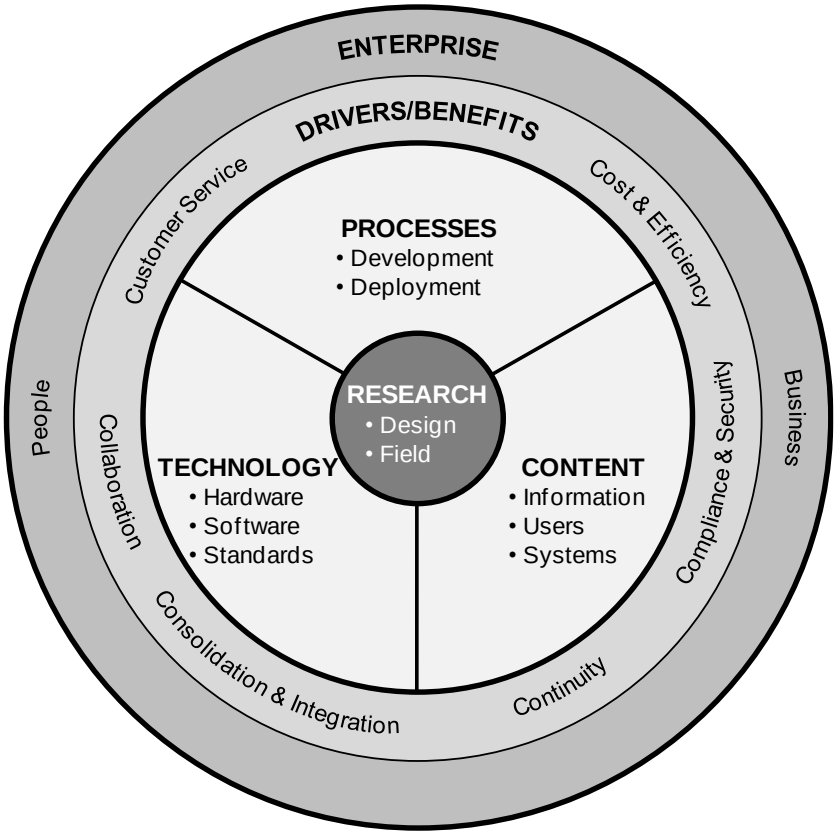


Figure 4: Extended Framework for ECM Research, Based on Rickenberg et al. (2012a), Refined from Tyrväinen et al. (2006), vom Brocke et al. (2011b).

Based on insights gained within the literature study and prior ECM literature – particularly Tyrväinen et al. (2006), Wiltzius et al. (2011), and Grahlmann et al. (2012) – working definitions are created to describe the research perspectives of the framework (Webster and Watson, 2002):

The *enterprise perspective* provides the context and deals with organizational, social, legal, and business issues of content management (Tyrväinen et al., 2006) and includes two views. Business processes, economic, and commercial issues are the central topics of the business view. The people view deals with organizational, cultural, political, social, and legal issues emerging around the stakeholders of the enterprise and in particular its employees. People-centric issues relate to groups and not individuals, such as group behavior, adoption, cultural change, and change management. Closely related to the enterprise perspective are the *drivers/benefits* of ECM. The framework covers six drivers and benefits which were extracted from academic literature (e.g. Usman et al., 2009) as well as practitioners' literature (e.g. AIIM case studies, white papers, etc.).

While content is something contained in an entity, the *content perspective* includes three views. The *information view* deals with the representation and semantics of the content, which is in particular the clustering, granularity, ontology, taxonomy, and metadata. The relationship between the user and the content is represented by the *user view* which focuses on the interaction between the user and the system. It includes the usage of the content, personalization, and resulting information needs. The *system view* deals with the containers in which the content resides and is related to the technology perspective, but is more abstract and less specific in technical aspects. It specifies functionalities of an ECM system and deals with abstract architectures and business-driven models. The *process perspective* can be defined as activities that build and implement an ECM system. The *development view* deals with the process of conception, implementation and maintenance of ECM systems and is related to change management. The *deployment view* includes the implementation of content life-cycle activities, the process of ECM system basic configuration, and the procedure of embedding it into the enterprise. Dealing with base technologies, the *technology perspective* includes three views. Typical topics for the *hardware view* include specific servers, clients, networks, and mobile devices used in an ECM system. The *software view* deals with actual software solutions of vendors but excludes prototypes and pure concepts of software. The *standards view* deals with established specifications that concern ECM on a technical level.

The *research perspective* deals with ECM as a *research field* and the *research design*. The research field deals with ECM as a research issue and not with the management of content. The research design deals with the (main) underlying research method.

Key results of the literature review are summarized subsequently, more detailed information including the categorization of the specific articles can be found in Rickenberg et al. (2012a). The reviewed papers are categorized in a concept-centric way (Webster and Watson, 2002). The seven concept-centric clusters are: people-centric (8 papers), business-centric (14), information modeling (16), user-centric (3), ECM system (20), technical approaches (3), and research field (4). With regard to the traditional ECM research perspectives (Tyrväinen et al., 2006), almost all papers (64) deal with the content perspective in some way, either with regard to information, user, or system views. Numerous (54) of the reviewed papers deal with the enterprise perspective. The technology perspective is addressed by 40 papers and the process perspective of ECM by 45 papers. Almost all papers (62) mention or deal with at least one ECM driver or benefit, while the ECM research field itself is addressed by 27 papers.

The content perspective is considered most frequently: Almost every paper deals with the system (62) and with the information view (56). The user view is considered less often. Approximately every second paper (36) takes the user of ECM systems into account. Within the enterprise perspective, the business view is considered slightly more often (46) than the people view (41). With regard to the technology perspective, the software (34) and the standards view (23) are the focal point, while the hardware view (13) is considered less often. Every second paper somehow deals with the software view, however, the topic usually plays a minor role within the papers. Concerning the process perspective, the development view received more attention from scholars than the deployment view. With 37 papers, approximately every second paper deals with the development view and 26 papers deal with the deployment view. The two most important drivers found in the literature are cost/efficiency and compliance/security. In every second paper, collaboration is mentioned as a driver. Consolidation/integration is an important driver, while customer service and continuity have less relevance. The most often identified research method is conceptual research (23), followed by case study research (16). Further methods applied include argumentative approaches (9), surveys (6), prototyping (5), and others (9). A connection between the research method and the classification can be recognized. While conceptual and case study research is applied for papers dealing with the enterprise perspective, prototypes are used for more technical approaches.

The reviewed literature is diverse: in length, focus, and in its research contribution. Although some papers lack scientific background, several made an important contribution to IS research. However, ECM as a research topic has not yet reached the highest academic outlets and conferences are the main source of ECM literature. This review supports findings that ECM research is still in an immature state (vom Brocke et al., 2011a) and includes a small body of literature (Grahlmann et al., 2012). It also supports findings that ECM papers mainly deal with constructive studies, conceptual ideas, frameworks, and technological aspects (Nordheim and Päivärinta, 2006; Usman et al., 2009). It addresses technological issues and functionalities or investigates the application of ECM in an organizational context, often within a case study (Grahlmann et al., 2012). Due to the youth of the research field, the diversity of the methods applied is limited; explorative results were produced and little quantitative work has been carried out.

This review of ECM research literature synthesizes and summarizes prior research and integrates the findings in a concept-centric way. A total of 68 articles were reviewed and classified. The ECM domain was characterized; main topics and concepts were derived. An established framework was adopted, refined and explained together with working definitions. The content perspective is dealt with the most, followed by the enterprise perspective. The process and the technology perspective received less attention. Some papers have a practical focus or technological view, while others take content aspects and the organizational context into account. The current state of ECM research is still premature – the body of literature of the field is small, but steadily growing.

Certain limitations have been identified: Since ECM research is still relatively young, it lacks consistent and well-accepted definitions (vom Brocke et al., 2011b). ECM as a concept and research field is still evolving, therefore definitions are not final. Accordingly, our definitions are labeled as working definitions and do not claim to be final. Further, there is no guarantee that some relevant articles were not found or considered, even though the search process was exhaustive. There were no boundaries with regard to the time period. However, there is a thematic restriction to the ECM domain. EDM as one of the closest ancestors of ECM was not included (Päivärinta and Munkvold, 2005).

2.3 Implications for Further Research and Practice

Based on the review, implications for targeted research are derived. There is little need for technical approaches, but for more research focusing a detailed reference model, ECM processes, the enterprise perspective and users of ECM systems. In general, more quantitative work is required. Based on the extended framework, the review, and classification of ECM literature, research gaps and research directions are identified.

With regard to the process perspective, a comprehensive reference model for the implementation of ECM is needed. In the course of the implementation, content needs to be structured and modeled. Numerous authors emphasize the importance of corporate taxonomy and metadata. Therefore, detailed guidelines that are generally applicable to the ECM domain seem to be useful. Further, the operation of ECM systems must be investigated. Validated research about the operation of already implemented systems that goes beyond vendor reports, lessons learned, and case studies is necessary. Even though hardware barely received attention from scholars, there is little need for further research since technology appears not to be a Critical Success Factor (CSF) to ECM adoption, see Tyrväinen et al. (2006). In cloud-based ECM and multi-tenancy contexts, however, hardware and performance are relevant factors. There is need for focusing on social and organizational issues. ECM goes beyond content management as a plain technical concept. ECM research has to pay more attention to the user of ECM systems, user acceptance, and critically examine the impact of ECM on employees.

Because little quantitative research has been conducted, there is a need to validate ECM benefits empirically and quantitatively. A framework for monetary evaluation of ECM success and impact beyond simple ROI calculations that includes long-term benefits is necessary. In addition to the drivers mentioned here, other drivers should be considered in the future, such as consistency, content quality, and content intelligence. For a quantitative measurement of benefits, a fine-grained categorization is useful.

Studies that discuss ECM as a research field and not the management of enterprise content are needed, see Rickenberg and Breitner (2014a) and Appendix 20. A homogenization and establishment of widely acknowledged definitions is necessary and can help to distinguish ECM from related research areas. Based on our review, more detailed models and extended discussions can follow and a research agenda can be created.

From a more practical point of view, more and more companies are in the process of adopting or already have adopted ECM. A number of trends will influence the ECM market in the future: As cloud solutions are popular nowadays, some content and ECM services will be moved into the cloud, whether a public, hybrid or private one. Cloud ECM is supposed to be scalable and cost-efficient and enables another trend: mobile devices in the ECM context. Due to more sophisticated mobile devices and faster cellular networks, enterprise content can be available from everywhere at any time. A trend that is already present to a certain extent is ESN, see Yücel et al. (2014) and Appendix 12. It has the potential to connect content, knowledge and expertise to people. Further, rather content-centric trends in ECM are: big data and big content, the combination of structured and unstructured data, and content intelligence. The convergence of social, mobile, and cloud computing and big data is investigated in Lebek et al. (2014), Appendix 19. In addition to the practical application of (ECM) trends, IS research needs to be aware of the trends and conduct targeted research.

2.4 Academic Classification of the Publication

The research paper entitled “Enterprise Content Management - A Literature Review” was developed together with Markus Neumann, Bernd Hohler, and Michael H. Breitner, see Rickenberg et al. (2012a) and Appendix 6. The resulting paper was accepted after a double-blind peer review (mini-track chair and two full reviews) without mandatory changes at the 18th Americas Conference on Information Systems (AMCIS) and presented in August 2012.

The AMCIS as an annual conference “is viewed as one of the leading conferences for presenting the broadest variety of research done by and for IS/IT academicians in the Western Hemisphere” (AISeL, 2014). With over 700 submissions each year, it is held in North, Central, and South America and attracts around 800 IS academicians and professionals from all around the world (AIS, 2014a,b).

The paper was published in the proceedings of the 18th AMCIS. According to the German Academic Association for Business Research (VHB), the conference proceedings are ranked in category “B” for the WI/IS research domain and “D” for the VHB JOURQUAL 2.1 (WKWI, 2008; Schrader and Hennig-Thurau, 2009).

2.5 Enterprise Content Management Research in 2014: An Update

Compared to the literature review in early 2012, the amount of available scientific articles approximately doubled. As of June 2014, there are 77 articles that mention "Enterprise Content Management" somewhere in the text or references in AISeL and 5,920 in Google Scholar. The number of publications that mention ECM is shown in Figure 5:

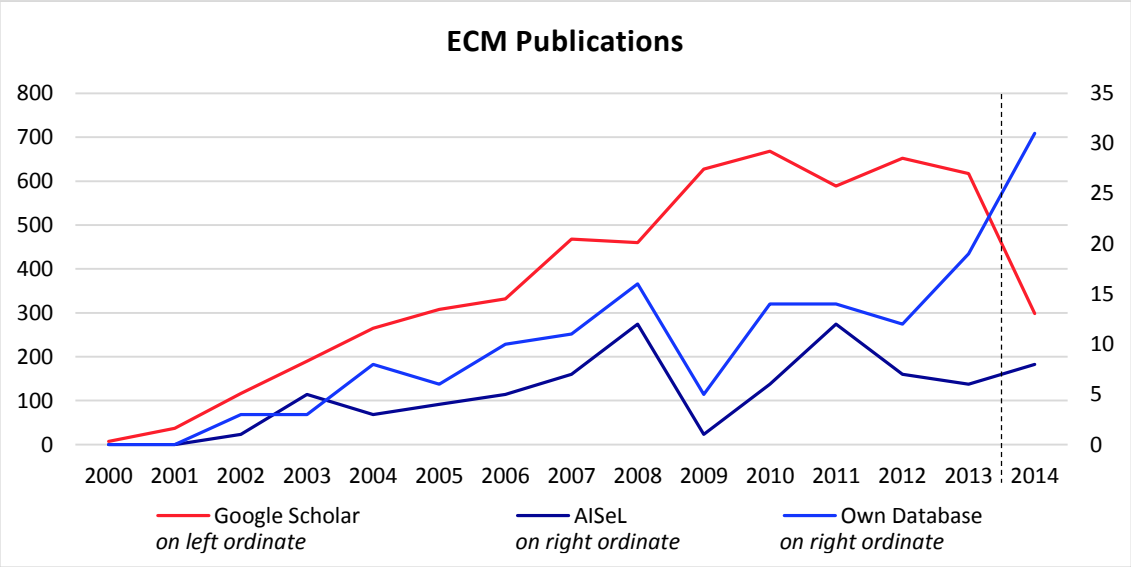


Figure 5: Number of Publications that Mention "Enterprise Content Management" per Year.

While we identified and retrieved 68 relevant articles in the literature review in 2012, we were able to add 84 articles to our ECM literature database, summing up to a total of 152 papers. This includes only articles which were screened and therefore deal with ECM and not articles that only mention ECM somehow in the text or references. However, this includes a few German articles, final theses, and papers that were published before 2012 but were not included within the initial review. As tested with trend lines for the different time series and also seen from the figure above, the number of ECM publications per year is slightly increasing. Even though the final amount of publications in 2014 cannot be determined yet, the number of publications in AISeL and our own database increased compared to 2013. In early 2014, vom Brocke and Simons published a book that collects ECM research articles from the academic discipline of IS. Concerning Google Scholar, the number of publications is significantly higher than in the two other databases since it includes articles from popular science that were not peer reviewed. These figures confirm the findings of our literature review, that the literature of the emerging ECM research field is small, but steadily growing (Rickenberg et al., 2012a).

The analysis of 58 relevant papers from 2012 to 2014 indicates, that recent ECM research can be categorized in twelve topic clusters as described in the following:

Actual use of ECM systems, experiences, and lessons learned (13 papers). Afonso et al. (2014) report on the effects of several post-adoption behaviors of EDM systems and conduct a survey with more than 2,000 employees. The classic paper about the Knowledge Garden at J.D. Edwards and lessons from the underlying KM and ECM project is reissued by Scott (2014). Arshad et al. (2012, 2013, 2014b) analyze the use of ECM systems to support business processes in different types of organizations (coordination, replication, and unification types) based on case studies. Insights about ECM systems in small and medium-sized enterprises (SMEs) on the basis of a longitudinal study of an ECM project are presented by Haug (2012). Katuu (2012) assesses how ECM has been implemented in South Africa and reports about ECM implementation experience. Simons et al. (2014b) summarize experiences and lessons learned from an ECM program in the public administration context, while Pfister and Schwabe (2014) show how advisory support IS are able to benefit from ECM. Concerning technical communication, Clark (2014) presents rhetorical concerns and challenges of writing specialists with regard to ECM and the implications for the design and implementation of ECM systems. An implementation of an ECM system to handle heterogeneous oceanographic data with frameworks and architectures is presented by Bechini and Vetrano (2013). The classic paper of O'Callaghan and Smits about a framework for strategy development for ECM and results from a test in a large high-tech organization is reissued again (Smits and O'Callaghan, 2014). Based on lessons learned from ERP systems, van Rooij (2013) addresses legacy issues in the implementation of ECM.

Reviews and overviews (7 papers). In literature reviews, Rickenberg et al. (2012a), Alalwan and Weistroffer (2012), and Simons and vom Brocke (2014) provide a comprehensive overview of ECM literature within the IS research domain. Concerning the market for ECM software, Böhn (2014) demonstrates a way to classify ECM software and gives an overview of the development within the market. Herbst et al. (2014b) use a sematic approach to identify and analyze topics in ECM vendor case studies. Laumer et al. (2014) take up ECM as a catchword and briefly describe the concept, while van der Lans (2013) describes the concept and components in context of the information lifecycle and maturity.

Content assessment, classification, and modeling (6 papers). Le Dinh et al. (2014) propose a knowledge-based framework for ECM based on the perspective of knowledge components which allows to classify and model enterprise content to enable KM. Zykov (2014) develops a formal model-based approach to ECM with object-based models and software engineering tools and implements the approach in several enterprises. Ribeiro (2013) proposes guidelines to structure information assets with the use of information architecture in order to improve the identification and categorization of information. Rickenberg et al. (2012b) present an approach that allows to assess, classify, and visualize enterprise content from a process point of view and check its applicability in an engineering company. Similarly, vom Brocke and Herbst (2013) propose in a German white paper a method to analyze the content situation in enterprises with content audits. To analyze enterprise content and document assets, Simons et al. (2014b) develop a content model and build on the ECM language proposed by vom Brocke et al. (2008b).

ECM in the context of decision support (4 papers) and KM (1 paper). Bashiri (2014) analyzes ECM and its different components as empowering factor of KM. Concerning decision support, Alalwan (2012a) investigates the relationship between decision support and ECM systems and of trends within this domain. Based on this, he proposes a taxonomy to highlight the types of decision support capabilities of ECM systems (Alalwan, 2013). In his thesis, he addresses the strategic association between decision support and ECM (Alalwan, 2012b). Yi and Xu (2013) create a decision making model for business process outsourcing of ECM and address outsourcing decision strategies in content management. Further, Arshard et al. (2013, 2014a) and Samsudin et al. (2014) also deal with the topic of decision support, see topic clusters above and below.

Records Management (4 papers). Kulcu and Cakmak (2012) analyze the relationship and convergence of RM and ECM in the digital environment based on a literature review. Concerning digital preservation, Burda and Teuteberg (2013) report about needs, capabilities, and alignment mechanisms of firms based on an explorative case study with three companies. Svärd (2013) investigates whether ECM and records continuum model frameworks can solve as a strategy to mitigate challenges of long-term preservation in two government authorities as case studies. In the same context, Svärd (2014) explores the differences and similarities between RM and ECM.

Semantic approaches (3 papers) and ontologies (2 papers). Kumaran and Tao (2014) extend an ECM system with sematic technologies to allow efficient information access. Becker et al. (2014) propose a conceptual specification of a portal structure to enable semantic standardization of content and address its lack of consistence and comparability. To enable expertise mining, Bordea et al. (2012) propose a set of methods for automatic content analysis for ECM platform configuration by using term extraction, semantic term grounding, expert profiling, and expert finding. As mentioned above, Herbst et al. (2014b) employ latent semantic analysis to identify and characterize topics in ECM. In respect of ontologies, Samsudin et al. (2014) develop and evaluate a semantic domain ontology to provide a context-specific RM approach in order to enhance decision support. Briola et al. (2013) create an ontology to better classify, retrieve, and share documentation and employ it in an ECM prototype for industrial application.

Factors for ECM success and acceptance (3 papers). Vom Brocke et al. (2014a) addresses the measurement of ECM success with a survey-based tool that assesses content-management practices related to an ECM system. In the same breath, Herbst et al. (2014a) identify a set of CSFs and present a framework for readiness assessment. Further, the classic paper of Wiltzius et al. (2011) about the acceptance of ECM systems and the underlying factors is reissued (Wiltzius et al., 2014).

Business processes and BPM (3 papers). Arshard et al. (2014a), see also Arshad et al. (2012, 2013, 2014b), explore the use of ECM systems in different organizations to support standardized business processes and decision making. Vom Brocke (2013) reports about the role of content in BPM, the interrelationships between ECM and BPM, and demands for content-aware BPM. From a financial point of view, vom Brocke et al. (2014b) present benefits of ECM to evaluate and justify ECM investments based on the business process structure of an organization and build on the article by vom Brocke et al. (2010b).

Cloud ECM (3 papers). Gonzenbach et al. (2014) investigate the factors that impact the adoption of the cloud in the context of enterprise content. In line with this, Klegová and Rábová (2013) propose a phase model of ECM in the cloud with a list of potential risks. Dhouib and Ben Halima (2013) survey web-based collaboration tools and carry out a comparative study on three different software solutions on-premises and in the cloud.

ECM in academic environments (3 papers). Easton and Easton (2014) report about the use of an ECM system as course management system and for academic purposes. In the same vain, Bennett et al. (2013) construct an ECM system based on open-source software within the infrastructure of a university and present findings from the use of the system. Concerning research content, Wolski et al. (2013) explore the synergies between institutional repositories and ECM systems in universities as well as the role and integration of research content management systems.

Social and cultural aspects (3 papers). With regard to social aspects in the context of ECM, Herbst and vom Brocke (2013) investigate the challenges and new opportunities of social content and technology through a survey of 89 professionals. Kunstová (2012) describes how social networks and ESN in companies can change approaches to team collaboration on the example of a specific social software. Also related to social aspects, Schmiedel and vom Brocke (2014) analyze the role of organizational culture and intangible aspects when implementing and operating ECM.

Information overload (3 papers). An overview of data and information overload on productivity in enterprises is given in the literature review of Sabeeh and Ismail (2013). In this context, Zou and Webster (2014) examine potential causes of perceived information overload when using an ECM and the effects of it on actual performance outcomes and on users' system evaluations. In the context of a tremendous amount of content and information, Herbst and vom Brocke (2012) examine in an empirical study the information seeking strategies of users in the organizational information architecture and in particular at organizational file servers.

As seen from the topics above, recent ECM literature tends to be less technical than within the first years of ECM research and rather focuses on organizational aspects. This supports our statement (Rickenberg et al., 2012a), that there is need for research concerning social and organizational issues, but little need for research concerning technology, since it appears not to be a CSF to ECM adoption. We also demanded for research concerning the operation of already implemented ECM systems that goes beyond vendor reports, lessons learned, and case studies. The 58 papers from 2012 to 2014 should be categorized according to the (extended) framework for ECM research in future works, see Figure 4, Tyrväinen et al. (2006), and Rickenberg et al. (2012a).

3. Towards a Process-Oriented Approach to Assessing, Classifying and Visualizing Enterprise Content with Document Maps

3.1 Motivation and Research Topic

Companies continue to produce large amounts of content at ever increasing rates each year. Unstructured documents make up the biggest part of the content and are generally spread over different storage locations and systems and therefore still pose a challenge. However, unstructured documents often contain important, innovative and decision-relevant information, and this information is increasingly becoming a key business resource. To manage content on an enterprise-wide scale, ECM evolved as an integrated approach to IM and serves as a knowledge resource and support for business processes (Päivärinta and Munkvold, 2005).

The practical relevance of ECM is confirmed by Gartner (2011): The ECM market shows strong growth, is "booming" (vom Brocke et al., 2011b) and is "hot and is getting hotter" (Andersen, 2008). However, software and technology itself are not the CSF for the implementation of ECM systems (Tyrväinen et al., 2006). Success is determined by organizational aspects, which are the business processes, content, and users. Integrating content management systems on an enterprise-wide scale poses a challenge to practitioners and researchers. ECM solutions are not typically out-of-the-box; they are one of the most complex rollouts in an organization (vom Brocke et al., 2011b). It is crucial to consider the business process landscape: along with the processes of the company, a "diligent analysis of content is the prerequisite for ECM adoption success and represents a highly complex and challenging task" (vom Brocke et al., 2011b).

Concerning scientific ECM literature, there is in particular a gap in the research on process-oriented guidelines (see Tyrväinen et al., 2006; vom Brocke et al., 2011b). Little research has been conducted from a process point of view that highlights the relevance of business processes for ECM adaptation (vom Brocke et al., 2011b). Few process-oriented guidelines are available for the complex assessment of enterprise content. Considering the entire enterprise and focusing on the content and the business process landscape in order to derive technology, we pursue the following RQ: *How can enterprise content be identified, assessed and visualized from a process point of view?*

This chapter is largely based on Rickenberg et al. (2012b), see Appendix 5.

3.2 Theoretical Foundations

An important basis for this research and the management of documents is the genre theory of organizational communication by Yates and Orlikowski (1992). It is a "theoretical lens to view organizational information management" (Tyrväinen and Päivärinta, 1999) and provides researchers with accepted terminology to identify and analyze content. Tyrväinen and Päivärinta (1999) note that organizational DM needs to be rethought, Karjalainen et al. (2000) present an abstract genre-based method for EDM including metadata, while Honkaranta and Tyrväinen (2003) operationalize the method within case studies. Honkaranta (2003) provides an overview of genres with regard to document and content management. Salminen et al. (2000) perform document analysis in the EDM domain, emphasizing the work context of documents and business processes. They provide fundamental work with regard to document standardization and modeling techniques on an abstract level but for practitioners, the presentation of the approaches is not tangible enough and is not able to serve as an integrated guideline.

Based on this, Munkvold et al. (2006) identify and document ECM issues and challenges, while Nordheim and Päivärinta (2004) explore the customization of ECM systems. Päivärinta and Munkvold (2005) identify major ECM issues by analyzing case narratives and emphasize the integrated, holistic perspective of ECM. The actual implementation of ECM is examined by Nordheim and Päivärinta (2006). Tyrväinen et al. (2006) examine the contemporary state of the literature and provide a framework of ECM research. ECM literature mainly deals with topics about technology, strategy, and implementation (vom Brocke et al., 2008a). Vom Brocke et al. (2008a) indicate a lack of process-oriented guidelines in ECM literature and introduce a business process perspective on enterprise content within an integrated approach. This important framework consists of five phases that support the implementation of ECM. The phases are outlined roughly, but the framework does not provide detailed information for each phase. In a research agenda, vom Brocke et al. (2011b) state that methodological support for the distinct phases is needed. For content analysis as the second phase, this is in particular: guidelines for interviews with content users and document analysis, a systemization of attributes and values, and conceptual modeling of enterprise content. This research gap is addressed here with a process-oriented approach to substantiate the first two phases to identify, assess, document, classify, plus to visualize content.

3.3 Research Design and Methodology

The research design consists of two main phases. During the first phase, the design of the research artifact was the focal point. We conducted a comprehensive literature review within the research domain of ECM and a targeted review within the DSR domain. Despite the fact that ECM research is still at an immature state (Rickenberg et al., 2012a; Grahlmann et al., 2010), selected studies built an important basis for our own research aims. To ensure the quality of the research artifact and the underlying design process, we also used key recommendations provided by DSR. Especially the guidelines of Hevner et al. (2004), March and Smith (1995) and advice regarding the research process by Peffers et al. (2007) and Offermann et al. (2009) were used.

The second phase of our research design included analyzing the practical applicability of the research artifact. For this purpose, we used the widely recommended applicability check designed by Rosemann and Vessey (2008) as the underlying method. In terms of a pre-test, the research artifact was checked at a globally operating engineering company (3,500 employees worldwide) for twelve months. We applied qualitative research methods that are recommended for an empirical evaluation of the applicability of research propositions or artifacts (Myers, 2009; Rosemann and Vessey, 2008). These research methods primary aim to analyze relationships and circumstances within a specific business situation (Punch, 2005). We were regularly present at a variety of company locations and primarily used three data sources: company documents, open-ended interviews, and observations. Guided interviews were organized and they lasted between 60 and 240 minutes. The interview guide contained questions regarding the company's ECM projects and ECM strategy as well as the importance, accessibility, and suitability of our research artifact. Participant-observations were enabled by regular meetings of the ECM project. For both data sources, minutes were taken during the events. In preparation, we collected and analyzed documents from past and current ECM projects, and studied the ECM strategy of the company. Together with the minutes, we analyzed these documents using open and axial coding (Flick, 2009; Myers, 2009), focusing on the definition of sub-categories related to the main categories that are provided by the applicability check. To ensure objectivity during the process of data collection and analysis, three researchers were involved. After first analyzing single data sources, an aggregated overall analysis was done in terms of a group discussion to achieve consensus decisions.

3.4 Summary of the Results and Limitations

3.4.1 A Process-Oriented Approach to Enterprise Content

Based on a process-driven framework (vom Brocke et al., 2008a) and the genre theory, we present a process-oriented approach to enterprise content. We strongly recommend starting with the business process landscape and assessing content along the processes. The document map concentrates on the content perspective including users, information, systems, as well as on the process perspective, and finally combines them.

Business Processes: Using business processes as starting point, the enterprise and its business process landscape set the structure for the procedure. All processes, including core, management and support processes, must be taken into account and information about their users, owners and responsibilities has to be collected. The management system and BPM usually provide this information. If event-driven process chains or further documentation is available, content entities, IT systems, and organizational units can be outlined. Since individuals cannot comprehend all of a company's content on their own (see Tyrväinen and Päivärinta, 1999), process owners, domain experts, and key users have to be involved. Interviews, referred to as content audits, have to be arranged for each business process to assess content together with the users to ensure an accurate and complete assessment. To expedite the arrangement of content audits and obtain support of the process owners, it is important to involve them at an early stage.

Content: The genre theory is the study of classifying texts into kinds and types and provides a common language for documents and content. A genre is a "typified communicative action[s] characterized by a similar substance and form and taken in response to recurrent situations" (Yates and Orlikowski, 1992). Similar to a genre, we propose the use of document types to identify content and classify it with specified attributes. A document type is a homogenous class that includes all documents of the same kind, with the same purpose and similar properties. For example, the document type incoming invoice represents all invoices that a company receives. All invoices have similar properties and can be differentiated from other document types. The distinction between the types is not made based on technical grounds, but on the socio-organizational purpose shared by the class of documents. Content is not distinguished by its media or its physical condition, but by its informational and organizational context (vom Brocke et al., 2008a).

During content audits, the actual document types are identified by the key users with regard to the process in its organizational context. A classification of process-specific content into three categories helps to reduce the complexity and ensure the completeness of the assessment: Specification documents serve as an input for the process, supporting documents are used within the process as an information source, and proof documents are the output of the process (see Figure 7a). The content entities are identified and the document types characterized and documented with their attributes. Before interviews can take place, the content survey has to be designed to determine which attributes to assess. To make the design efficient and assess the metadata in a structured way, we present the 7W Framework (see Figure 6). With seven categories, the generic framework provides predefined attributes and attribute values. Once the content audits are conducted and all document types and attributes are collected, the visualization and analysis follow. The document map, as a visual representation of all content with its key attributes, helps make content more tangible. Mapping enterprise content with the business processes helps eliminate the content chaos, enhances transparency and improves workflows. Inefficiencies, improvement opportunities, parts of processes with quick wins and typical use cases can be derived from the map. A leading document can be defined which also helps to identify and avoid redundancies with regard to storage locations and formats. In consequence, the consistency of the enterprise content can be improved. Statistical analysis of the attributes provides rich insights and substantial understanding of the content situation within the company.

Technology: While processes and content are largely determined within the company, technology is specified rather exogenously. We concentrate on organizational and human aspects rather than on technical aspects (see Honkaranta and Tyrväinen, 2003). Grahlmann et al. (2010) conclude that “[...] the functionalities of an ECM system need to be aligned with the nature of the processes of the implementing organization”. Because the content survey is designed independently of technologies, hard- and software requirements can be derived from the document map. For the purpose of decision support, the collected information is essential to analyzing requirements and provides the basis for selecting and implementing ECM software (see O’Callaghan and Smith, 2005). Identified document types, together with the metadata, can be used to specify requirements, check functionalities of ECM software solutions, and determine their suitability.

3.4.2 Survey Design and Content Audits

To prepare content audits, a questionnaire needs to be developed. Categorized into seven categories, the 7W Framework (7WF) lists important attributes and typical attribute values for content assessment. Our universal framework was developed independently, but it contains elements that were used in a similar context. For example, Yoshioka et al. (2001) use the 5W1H framework which is a similar approach that categorizes attributes within a genre taxonomy. Honkaranta (2003) used the 5W1H framework for genre analysis. The seven categories that we propose are: what (general information and organizational background), worth (value and importance for the company), where (storage and archive location), which format (physical representation and conventions), who (people), when (lifecycle), and why (purpose and legal regulations), see Figure 6:

Category	Attribute	Attribute value
WHAT	Document Type	String: *GENERIC NAME*
	Process	Classified: *PROCESS NUMBER/NAME*
	Origin	*Classified: *OWN CREATION, INTERN, EXTERN*
	Destination	*Classified: *OWN USE, INTERN, EXTERN*
	Association	Classified: *ASSOCIATED WITH OTHER CONTENT*, no
	Template	Classified: *EXISTING*, not existing
WORTH	Confidentiality	Classified: open, intern, confidential, (top) secret
	Relevance	Classified: low, medium, high, very high
WHERE	Storage Location	*Classified: *LOCAL, FILE SERVER, EMAIL, PAPER-BASED, INFORMATION SYSTEM (ERP, CRM, ETC,), OTHER*
	Archive Location	Classified: *KNOWN ARCHIVE*, unknown, none
WHICH FORMAT	Storage Format	*Classified: .doc, .xls, .ppt, .pdf, image, plain text, paper, *OTHER*
	Archive Format	Classified: as storage format, *OTHER, none*
	Naming Convention	Classified: *KNOWN*, unknown
	Storage Convention	Classified: *KNOWN*, unknown
WHO	Owner	String: *PERSON*
	Involvement	String: *PERSONS, DEPARTURES, COMPANIES*
WHEN	Creation	String: *GENERIC POINT OF TIME*
	Publication	Classified: *DATE KNOWN*, unknown
	Archiving	Classified: *DATE KNOWN*, unknown
	Deletion	Classified: *DATE KNOWN*, unknown
	Creation Frequency	Classified: low, medium, high
	Change Frequency	Classified: low, medium, high
	Frequency of Use	Classified: low, medium, high
	States	Classified: in process, finished, approved, published, locked, active, inactive, *OTHER*, not applicable
WHY	Storage Reason	String: *GENERIC REASON*
	Retention Period	Classified: DURATION, none
	Audit-Proof	Classified: yes, no
	Version Control	Classified: yes, no

Underlined: Main Attribute, SMALL CAPS: Further Specification needed/possible, *: Multiple Choice

Figure 6: 7W Framework (7WF) for Content Assessment, Based on Rickenberg et al. (2012b).

It is not necessary to integrate all categories and attributes into the survey, since some are more essential for a specific context than others. The 7WF is a list of attributes to choose from and create a customized survey. We recommend including the highlighted main attributes in any survey. Attribute values can be chosen from predefined sets for most attributes. Some attributes allow multiple choices (e.g. storage in different

formats or multiple systems) or further specification of the attribute value. To ensure consistent and analyzable answers, attribute values can be specified in advance.

As part of the preparation, information about the content audit and the procedure should be sent to the interviewee and process owner well in advance. Document types that have already been identified from documentation should be provided. Spreadsheets or online survey applications are efficient means to record document types with metadata. The creation of a survey template ensures smooth and quick assessment. In each case, all data is to be gathered within a database to allow for further analysis.

At the beginning of each content audit, the attendees (process owners, key users, interviewers) should introduce themselves and a short thematic introduction given. Possible questions or uncertainties can be settled beforehand. Then the actual document types can be identified in series before their attributes are specified. Typical document types and examples help the participants make the subject more tangible. Open questions allow insufficiencies and possible improvements to be detected from a user's point of view. Suggestions and subjective valuations serve as an important source of informal information. Important aspects and findings must be written down and minutes should be taken. A document type is recorded if it is process-relevant and if it is relevant for at least one recipient other than the author (Tyrväinen and Päivärinta, 1999). To identify document types for the particular process, questions can be used: *Which documents do you work with?, Which documents assists you in your work?, Which documents do you receive from others/send to others?, Which documents do you store in which system?*. Specification documents (input of the process), supporting documents (information source), and proof documents (output) can be identified along the business process.

The effort to assess enterprise content together with the metadata is not be underestimated. Personal interviews are necessary to explain the task, clear up confusion, ensure adequate results, and involve key users. Personal contact and interaction with key users and process owners at an early stage of an ECM project leads to higher acceptance. Further, it is impossible for one person to identify, record and characterize all enterprise content (Tyrväinen and Päivärinta, 1999). Content entities must be analyzed in their context due to specific terms and the development of company terminology and acronyms (Yates and Orlikowski, 1992; Honkaranta and Tyrväinen, 2003).

3.4.3 Visual Representations and Content Analysis

We propose different visualizations to present enterprise content and information graphically based on the assessed document types and the metadata: a process-oriented view, a document-oriented view, an analysis-based view, an overview called document map, and we further added a lifecycle view, and a system view, see Figure 7:

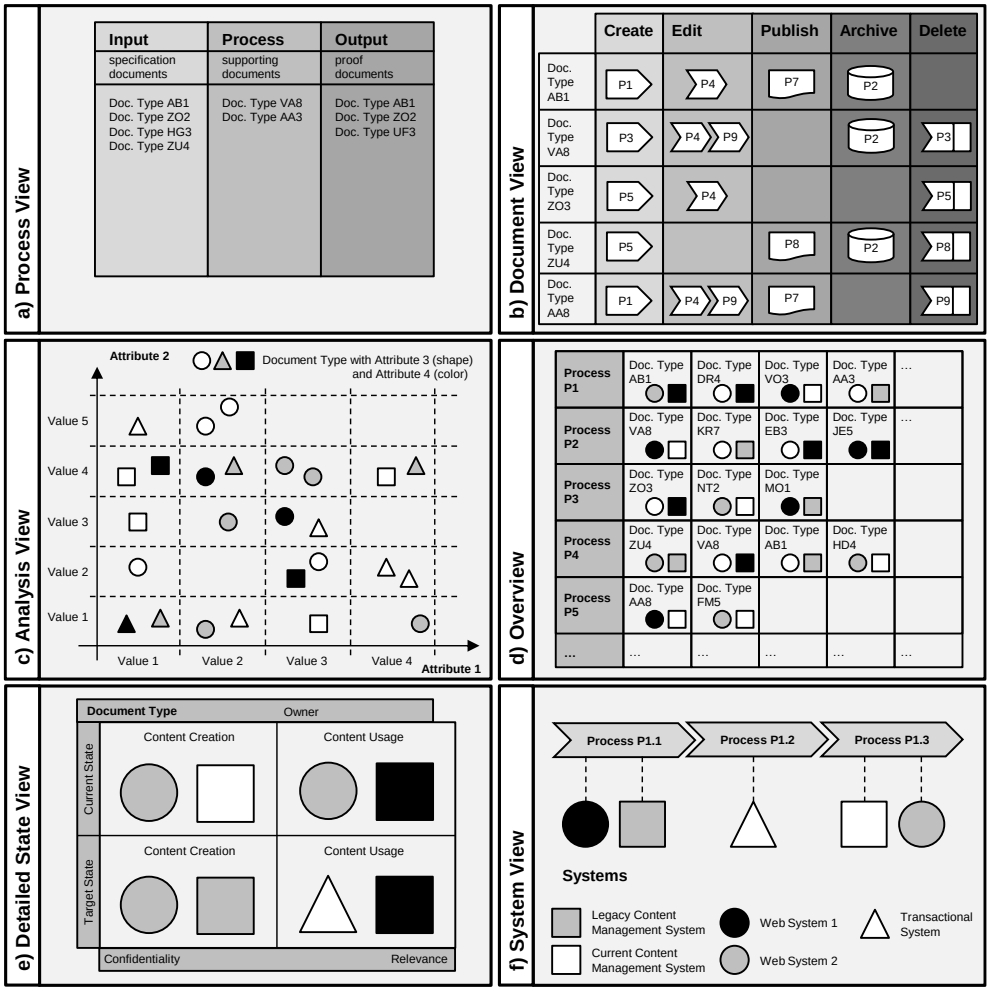


Figure 7: Visual Representations of Enterprise Content, refined from Rickenberg et al. (2012b).

The views and representations have different purposes and applications. The process view (a) shows a business process with input, supporting, and output document types. With regard to the lifecycle, the document view (b) helps to break down complexity. For analytical purposes, different attributes can be applied to each other (c). The process-oriented document map provides an overview by combining business processes and enterprise content (d). The detailed state view (e) shows the current and target state of a document type for the creation and usage phase. The system view (f) shows which systems are used within the specific processes. Once all information is gathered in a spreadsheet or database, extensive content evaluation and analyses are enabled.

3.4.4 Contributions and Limitations

Driven by our RQ, we developed a process-driven approach for identifying, assessing and visualizing enterprise content from a process view. We tested the applicability of our research artifact in an engineering company. In terms of accessibility, our approach serves as a consistent guideline that can easily be understood by practitioners. The 7W Framework for content assessment can be used to create customized surveys to document business-critical content. We proposed different ways of representing content visually, including a document map. By combining business processes and content, the map provides an illustration of the current content situation and can also serve as a regulatory instrument. It enables management, in-depth analysis and refinement of content. Technical requirements can be derived from the map and decision support is provided. We further provided practical insights and methodological support.

We did identify certain limitations of our approach: First, the assessment of enterprise content together with metadata is time consuming and there is a lot of information to collect. Content assessment is essential though, since “the core of any ECM solution resides in understanding the content itself and its role in the organizational context” (Päivärinta and Munkvold, 2005). In particular, participants found the amount of attributes to be high. We propose the use of context-specific subsets of attributes and greater concentration on the main attributes to streamline the assessment process. Second, it was initially assumed that one survey round was sufficient to assess the information in one go. Within the pre-test, participants stated that a content review was useful. Content reviews can improve both data quality and understanding of the entire content situation. Thus, the big picture of the actual content situation can be completed. Third, structured into seven categories, the 7W Framework lists attributes and typical attributes values for content assessment. The framework is comprehensive, but does not purport to be complete, so that in particular cases, adjustments might be necessary. Especially the attribute values have to be adapted to the context of the company. Fourth, further validation of our approach is needed: we were able to show its applicability within one company, but it has not been checked within other business contexts. Fifth, the content life cycle is a complex task and enhancements are needed to improve the maturity of our approach. One step towards deeper integration can be achieved by including both the creation phase and the usage phase of documents, see also Figure 7e.

3.4.5 The Document Map in 2014: Actual Assessment and Use

Based on the research paper and the findings in the practical phase within the case company, we created a document map as a comprehensive overview of the enterprise content. We therefore conducted several interviews and workshops with process owners and key users. In content audits, which served as the first round of assessment, we identified and documented 327 document types within 40 interviews. Due to the recommendations from the applicability check and to create a more consistent and complete overview of the content situation, a second round of interviews was arranged. Within 14 content reviews, we were able to identify and document further document types and the participants were able to revise their answers based on illustrative visual representations of the specific content. In total, 499 document types were documented with their attributes and then visualized. While most document types were documented with the full set of 29 attributes, some were documented only with the base attributes as suggested in the applicability check. The document map is shown in Figure 8:

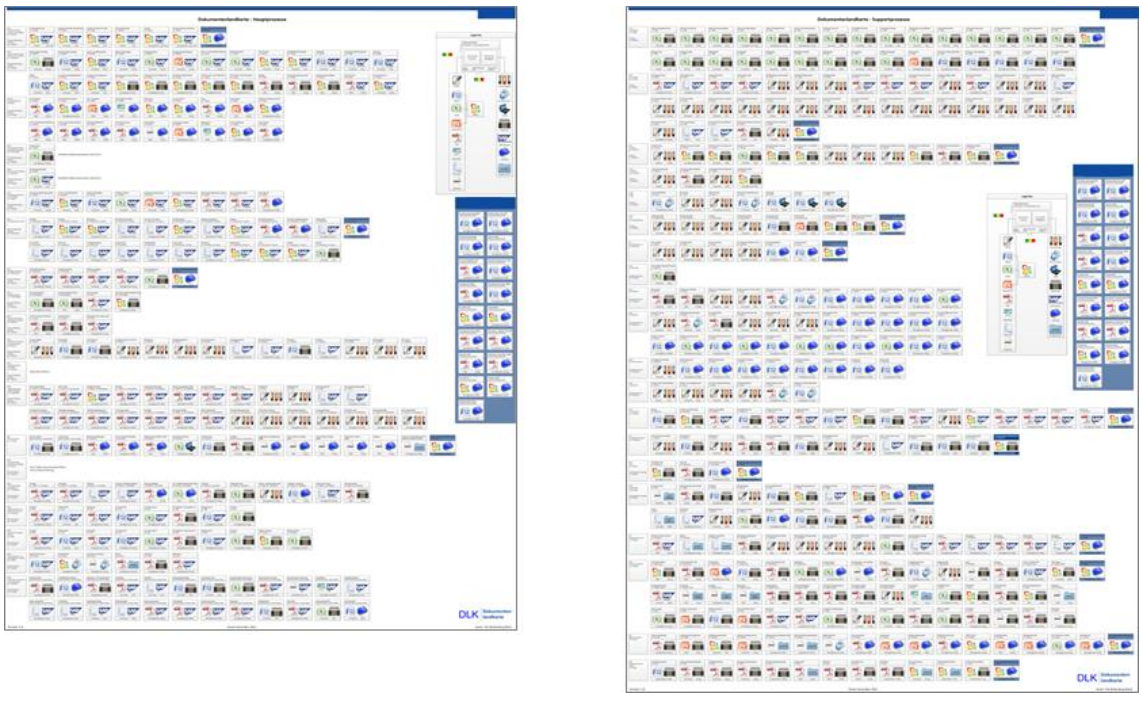


Figure 8: Actual Example of a Document Map.

Next to the transparent visualization, structuring, and classification of enterprise content, the document map now serves as an important instrument for the migration of a legacy ECM system to a more integrated, modern solution. Within the content concept phase as a third phase, interviews and workshops for specific processes, projects, and departments are used to create content structures, intranet sites, and portals.

3.5 Conclusions and Implications for Further Research

We address the general lack of ECM literature, the deficient consideration of the process perspective, and the complex task of classifying, documenting, analyzing, and visualizing enterprise content in particular. Existing, rather abstract approaches were substantiated to a practicable level. We suggest useful guidelines, the 7W Framework, and visual representations, including a document map. The applicability of the approach was initially tested and shown within a globally operating engineering company.

Further research steps are required with regard to our approach. It can be enriched by a more detailed representation of the content life cycle and the validation of our questionnaire. Deeper empirical validation that goes beyond a check of its applicability is required. Employing action research within a comprehensive ECM project, we plan to report about the actual use of our approach and the document map. As implication for further research, the suggested approach can be applied, tested and refined by researchers to improve its generalizability. There is need for a more comprehensive procedure model for the task of managing enterprise content. A framework for systematic analysis of ECM solutions can complement our work from a market-based view.

3.6 Academic Classification of the Publication

The research paper “Towards a Process-Oriented Approach to Assessing, Classifying and Visualizing Enterprise Content with Document Maps” was developed together with Markus Neumann, Bernd Hohler, and Michael H. Breitner, see Rickenberg et al. (2012b) and Appendix 5. The paper was accepted after a double-blind peer review (associate editor and three full reviews) with one revision at the 20th European Conference on Information Systems in the track “Business Intelligence and Knowledge Management”. It was presented at the ECIS in June 2012 in Barcelona.

The ECIS is the premier IS event in the European region (ECIS, 2012). It is the largest and most prestigious conference on IS in AIS region 2 (ECIS, 2010) and is seen as the European counterpart of the ICIS. Recent acceptance rates have been roughly 30% range (ECIS, 2012): 2012: 29%, 2013: 32%, 2014: 34%, see also Galliers et al. (2012) and conference programs books. The paper has been published in the proceedings of the 20th ECIS, which are ranked in category “A” for the WI/IS research domain and “B” for the VHB JOURQUAL 2.1 of the VHB (WKWI, 2008; Schrader and Hennig-Thurau, 2009).

4. Towards a Knowledge-Based Framework for Enterprise Content Management

4.1 Motivation and Research Methodology

Content in companies is growing at a rapid speed and is covering the majority of business information. About 80% of the enterprise content is unstructured (O'Callaghan and Smits, 2005) which represents a challenge to companies for managing and using this content. Huge amounts of content are produced every year and need to be captured, managed, stored, preserved, and delivered efficiently on an enterprise-wide scale (AIIM, 2014). In this context, content is usually only means to an end since it contains important business information. Companies want to make use of business-critical information, which often resides scattered across several repositories and systems. Especially for knowledge-intensive enterprises, information is a driver of business in general and innovation in particular. Based on content and information, the accumulation and application of information lead to organizational knowledge. As decision making basis and to perform efficiently, employees need to have access to organizational knowledge and to the right information at the right time. When being time-stressed or overloaded with information, people cannot make good decisions (Hayes-Roth, 2005).

While ECM enables the management of content on an enterprise-wide scale (vom Brocke et al., 2011a), an integration of ECM and KM is important and indispensable. Effective knowledge flows, within and between enterprises, and managing knowledge inside ECM systems become a vital factor. We therefore investigate, how enterprise content can be assessed and classified based on the perspectives of knowledge components. Based on a literature review within the ECM, IM, and KM research domain according to Levy and Ellis (2006), we create and evaluate the Knowledge-Based Content Management (KBCM) framework and an illustrative example within design-oriented research. Accordingly, the research design consists of two phases, which are the design and evaluation of the research artifacts and a subsequent pre-test of them. Concerning the research process and methodology, we chose DSR to explore our RQ according to Hevner et al. (2004). We further used well-known DSR recommendations and guidelines, see particularly Hevner (2007), March and Smith (1995), and Offermann et al. (2009). **This chapter is largely based on Le Dinh et al. (2014), see Appendix 10.**

4.2 Summary of Results, Limitations, and Implications

In accordance with DSR principles and its common research outputs (March and Smith, 1995; Bichler, 2006), the KBCM framework consists of a set of constructs, a model, a method, and a set of instantiations. Within this context, the constructs represent different types of concepts related to IM and KM facets. Content that resides in ECM systems, which represents a perspective within the fundamental framework for ECM research as proposed by Tyrväinen et al. (2006), can be regarded according to three views: system view, information view, and user view. The KBCM framework comprises these three views and further proposes a new view: The network view represents the way of collaborating on content in a network between an organization and its partners. The objective of the meta-model of the KBCM framework expresses the relationships between the elements of the framework and is specified using a simplified Unified Modeling Language (UML) notation, as seen subsequently in Figure 9:

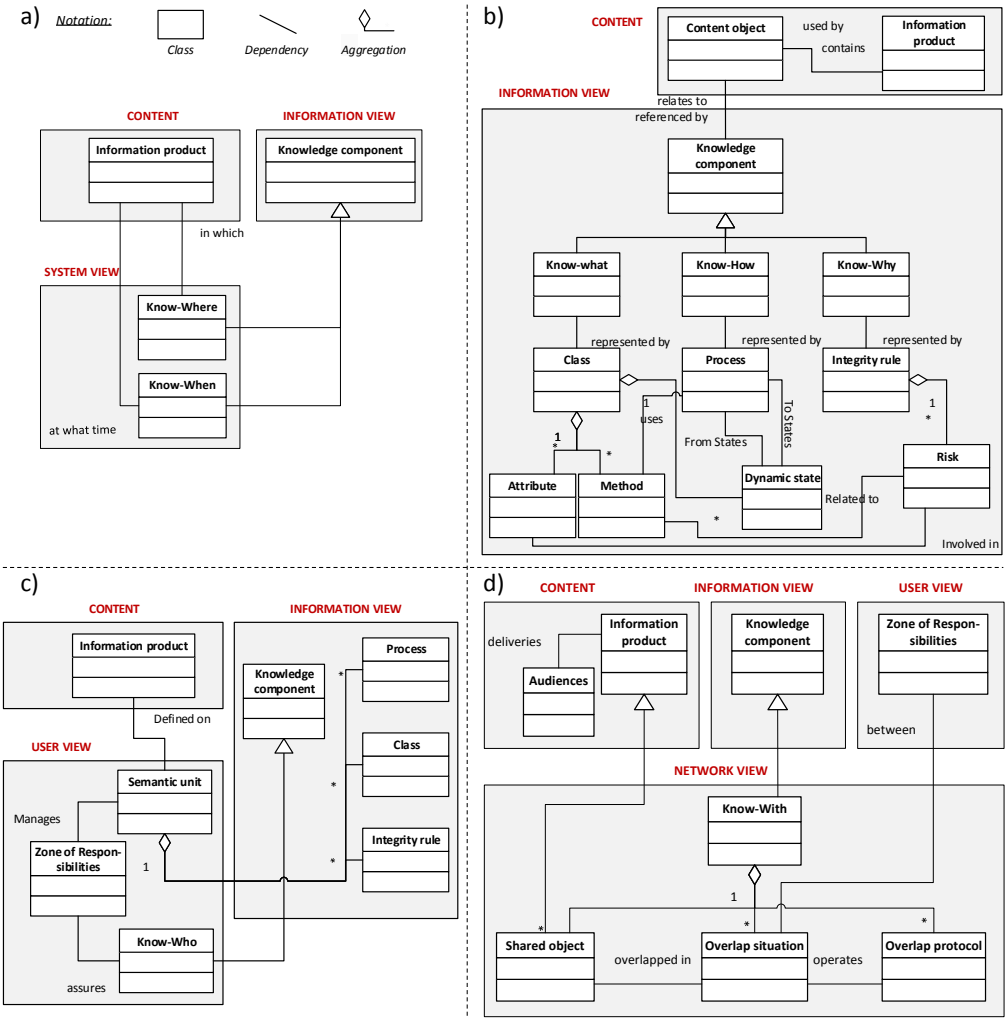


Figure 9: Excerpts of the KBCM Meta-Model: a) System, b) Information, c) User, d) Network View, Based on Le Dinh et al. (2014).

The method of the KBCM framework is a set of activities supporting both the process of content management and knowledge development and aims to integrate these activities, see Figure 10. The process of content management includes the following key activities: assessing, organizing, sharing, and using (Le Dinh et al., 2012). According to Alavi and Leidner (2001), the organizational management processes are knowledge creation, storage/retrieval (which is referred to as organization), transfer, and application. The method therefore supports the knowledge processes based on enterprise content and on the data-information-knowledge-wisdom (DIKW) hierarchy (Rowley, 2007). Accordingly, enterprise content is a typical type of mostly unstructured data. Information is data that is processed to be useful and provides answers to what, who, when and where questions. Knowledge is the application of data and information and provides answers to how questions. Wisdom is an evaluated understanding and provides answers to why questions.

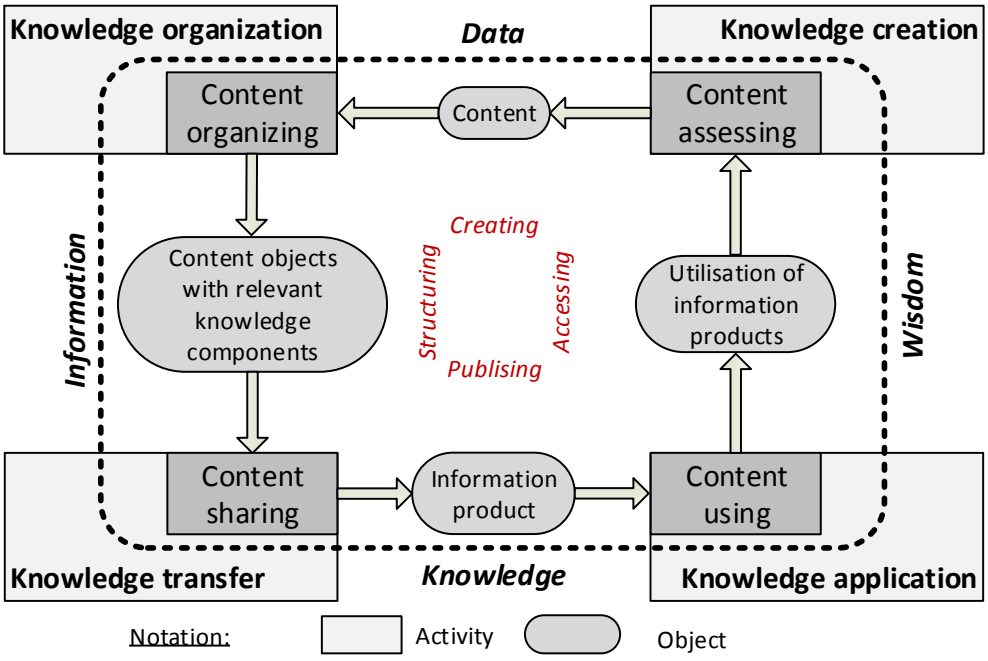


Figure 10: Method of the KBCM Framework, Based on Le Dinh et al. (2014).

Finally, an illustrative but realistic example of a KBCM-based system is generated in form of an instantiation. In a pre-test of the artifacts, analytical and descriptive evaluation methods are used to examine the static qualities of the artifacts and for building arguments to describe its utility (Hevner et al., 2004). With the example, we aim to show that the artifacts are able to help enterprises with the complex task of assessing, organizing, sharing, and using content based on knowledge perspectives.

We did identify certain limitations within our approach, especially with regard to the empirical validation and completeness of the framework. To test the framework, we successfully evaluated the artifacts within a pre-test in the form of an illustrative example, but further empirical validation is required. We argue that our approach is comprehensive and applicable, but we do not claim that it is entirely complete for all circumstances. Especially in specific business contexts and special cases, adjustments can be necessary. Furthermore, KM involves various aspects such as socio-cultural, organizational, and technological aspects, while we here focus on technological aspects.

Concerning practical and theoretical implications, the KBCM framework aims to link KM and ECM. Due to different levels of views, we suggest that the artifacts can be adapted to several real-world scenarios whereas each view could be more and less important. Integrating KM within the ECM context with our knowledge-based framework can help practitioners to make better use of their content and information assets and to accumulate organizational knowledge. When an enterprise intends to use an ECM system, the KBCM framework provides a starting point to assess and organize content according to their knowledge components, and then share content within and between organizations. From an academic point of view, the suggested approach can be applied and refined by researchers to improve its generalizability and broaden its scope. An integration of KM and ECM as IS research disciplines and the future development of those two disciplines will play a vital role in science as well as in practice.

To conclude, the approach is one of the first that focuses on applying a knowledge perspective on ECM by proposing a theoretical foundation for content assessing and managing based on the perspective of knowledge components. Based on our RQ, we proposed a knowledge-based framework for assessing, classifying, and managing enterprise content, called KBCM framework. According to the DSR principles, we designed and evaluated artifacts using UML. As defined in DSR (March and Smith, 1995), the framework consists of different artifacts with different level of abstraction: construct, model, method, instantiation. The objectives are to analyze and optimize the interplay of ECM and KM, add more business value to ECM systems, promote knowledge development, and enhance intellectual capital.

To address one major limitation of the paper concerning the empirical validation, further research and empirical investigation was conducted. Therefore, an applicability check according to Rosemann and Vessey (2008) was performed at an IT service company in Vietnam. The results are reported in an extended and refined version of the paper, see Le Dinh et al. (2015) and Appendix 16.

4.3 Academic Classification of the Publication

The research paper "Towards a Knowledge-based Framework for Enterprise Content Management" was developed in an international collaboration together with Thang Le Ding, Hans-Georg Fill and Michael H. Breitner, see Le Dinh et al. (2014) and Appendix 10. It builds on the two research papers Rickenberg et al. (2012b) and Le Dinh et al. (2012), brings together ECM and KM aspects, and integrates them. The international collaboration emerged from a discussion on ECIS 2012 within a session which was chaired by Hans-Georg Fill. The resulting paper was accepted after a double-blind peer review (associate editor and three full reviews) and one revision at the 47th Hawaii International Conference on System Science (HICSS) and was presented at the HICSS in January 2014.

The HICSS is one of the longest-standing continuously running scientific conferences and provides an international setting with participants from usually more than 40 countries to present and discuss research findings (HICSS, 2014). The acceptance rates of the conference vary from year to year, but are typically lower than 50% – with lower rates in mature fields and slightly higher rates for new emerging topics (HICSS, 2008).

The paper was published in the proceedings of the 47th HICSS, which are in the top 2% of IEEE conferences concerning the access and further it is the leading IS conference (#1) with regard to the citations as recorded by Google Scholar (HICSS, 2014). According to the German Academic Association for Business Research (VHB), the conference proceedings are ranked in category "B" for the WI/IS research domain and "C" for the VHB JOURQUAL 2.1 (WKWI, 2008; Schrader and Hennig-Thurau, 2009). An extended and refined version of the HICSS paper with the title "Enterprise Content Management as a Knowledge Infrastructure: The Knowledge-Based Content Management Framework" was published in the International Journal on e-Collaboration (IJeC), see Le Dinh et al. (2015) and Appendix 16.

5. Enterprise Content Management Research: Analysis, Synthesis, and Evaluation Using Grounded Theory Methodology

5.1 Motivation and Research Topic

Despite the high interest of practitioners in ECM, it has received too little attention from academic research (Tyrväinen et al., 2006). The ECM research domain is still young and remains in an immature state (vom Brocke et al., 2011a). It lacks its own mature theoretical foundation and little theory has been developed. Rickenberg et al. (2012a) proclaim the need for research that discusses ECM as a research field and not the management of enterprise content. In the same vein, Alalwan and Weistroffer (2012) declare that it "lacks meta-analysis research that explains the current state of the field". Grahlmann et al. (2012) state that research about ECM as a research field is needed which includes "the differences and similarities of ECM with other fields of research". Theory-generating research synthesis of the domain is required. The questions arise whether ECM research is relevant, whether it actually represents anything new compared to established domains, and what the theoretical and practical implications are.

Focusing on the lack of substantive and mature theory in the emerging ECM research field, we analyze and address this phenomenon by applying grounded theory. This qualitative method offers a systematic but flexible way to generate theory inductively from data (Urquhart and Fernández, 2013) and allows "researchers to conduct pioneering research with both flexibility and rigor" (Birks et al., 2013). Especially for under-researched phenomena and domains with little theory development, this method is particularly useful (Orlikowski, 1993). While grounded theory is usually employed to develop theories about real-world phenomena, we use the method to first analyze and synthesize and then evaluate the research domain in the sense of a meta-analytic review. As empirical input, we collected and sampled empirical snippets from six sources: scientific ECM and KM literature, practitioners' literature, websites, social media content, documents from an engineering company, and semi-structured interviews. Based on the construction of a grounded theory for ECM research, we investigate: RQ1: *Is ECM research a relevant subfield of IS research?* RQ2: *What are the theoretical and practical implications of ECM research?* RQ3: *What are likely scenarios for future ECM research?*

This chapter is largely based on Rickenberg and Breitner (2014a), see Appendix 20.

5.2 Theoretical Foundations

More and more companies are adopting ECM systems and commercial software solutions become more mature and sophisticated. ECM is presented in practitioners' literature as the panacea to cure all content, information, and knowledge issues in enterprises (Smith and McKeen, 2003). However, it received little scientific attention and is still a young IS research domain (Tyrväinen et al., 2006; Grahlmann et al., 2010). The body of ECM literature was reviewed in literature reviews from Tyrväinen et al. (2006), Usman et al. (2009), Rickenberg et al. (2012a) and Alalwan and Weistroffer (2012). Much of the ECM literature is design-oriented (Wiltzius et al., 2011, 2014), deals with constructive studies, conceptual ideas and frameworks, and technological functionalities (Usman et al., 2009). The ECM research domain lacks its own mature theoretical foundations.

In contrast to the relatively small scientific body of ECM literature, related research disciplines such as KM and the overarching IM are more mature and exhibit a comprehensive body of literature. Since ECM is composed of a plurality of concepts, literature from these underlying and more mature research domains can be used to some extent and the boundaries between the different areas of research are indistinct.

The question arises as to whether the characteristic of ECM as an integrated enterprise-wide approach to preceding and related concepts is sufficient as a right to exist for the research domain. Focusing on the lack of substantive and mature theory in the emerging ECM research field, it is necessary to define the characteristics of ECM, build substantive theory, and evaluate the research domain.

5.3 Research Design and Methodology

The research design is based on the grounded theory method according to the classic approach of Glaser and Strauss (1967). Grounded theory is an inductive research methodology to systematically and rigorously develop theory that is grounded in empirical observations or data (Martin and Turner, 1986). It has become a well-accepted research method (Seidel and Recker, 2009) and "is employed increasingly in the IS field" (Butler and O'Reilly, 2010). Given the widely unexplored nature of the ECM research domain, we used the grounded theory method to gain a deeper understanding of the phenomena and to derive theory from the different types of data that we gathered. The substantive area and scope of our research is primarily the ECM research domain.

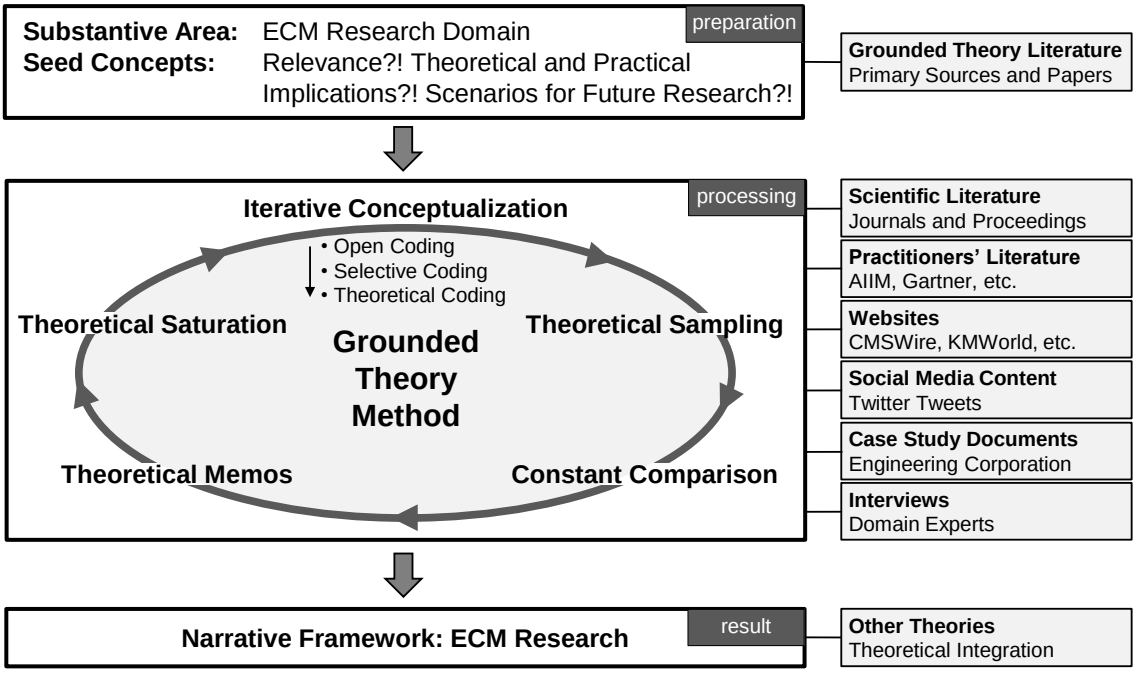


Figure 11: Research Design with Grounded Theory Methodology, Based on Rickenberg and Breitner (2014a).

The underlying process-oriented research design, the key elements of the grounded theory method and our main sources of data are shown in Figure 11. Starting with the substantive area and grounded theory literature, we developed seed concepts that are closely related to our research questions. We then started with the grounded theory procedure within a highly iterative process. As indicated by Glaser and Strauss (1967), we performed the different coding steps to increase the level of abstraction for iterative conceptualization. Within open coding, we identified concepts and attached initial labels to our data (Urquhart, 2013). When no new open codes suggested themselves and theoretical saturation occurred, the level of abstraction was increased and selective coding was performed. Finally theoretical coding was used to analyze and build relationships between the categories (Urquhart, 2013). Based on our sources of data, we performed theoretical sampling to decide on analytic grounds where to sample from next. Data were collected mainly from six different sources: scientific literature, practitioners' literature, websites, social media content, company documents from a globally operating engineering corporation, and semi-structured interviews. Within the interplay of data collection and analysis, constant comparison was employed to compare instances from new data with existing codes. During the coding, theoretical memos were written for each source to record important insights. As result of the research procedure, a grounded theory in form of a narrative framework was generated, see Figure 13.

5.4 Summary of the Results and Limitations

5.4.1 Analysis and Synthesis of Enterprise Content Management Research

The ECM research perspective and underlying process is illustrated schematically in Figure 12 to set a basis for the analysis and synthesis of the domain. It deals with the ECM research input, the actual ECM research topics, and the ECM research output.

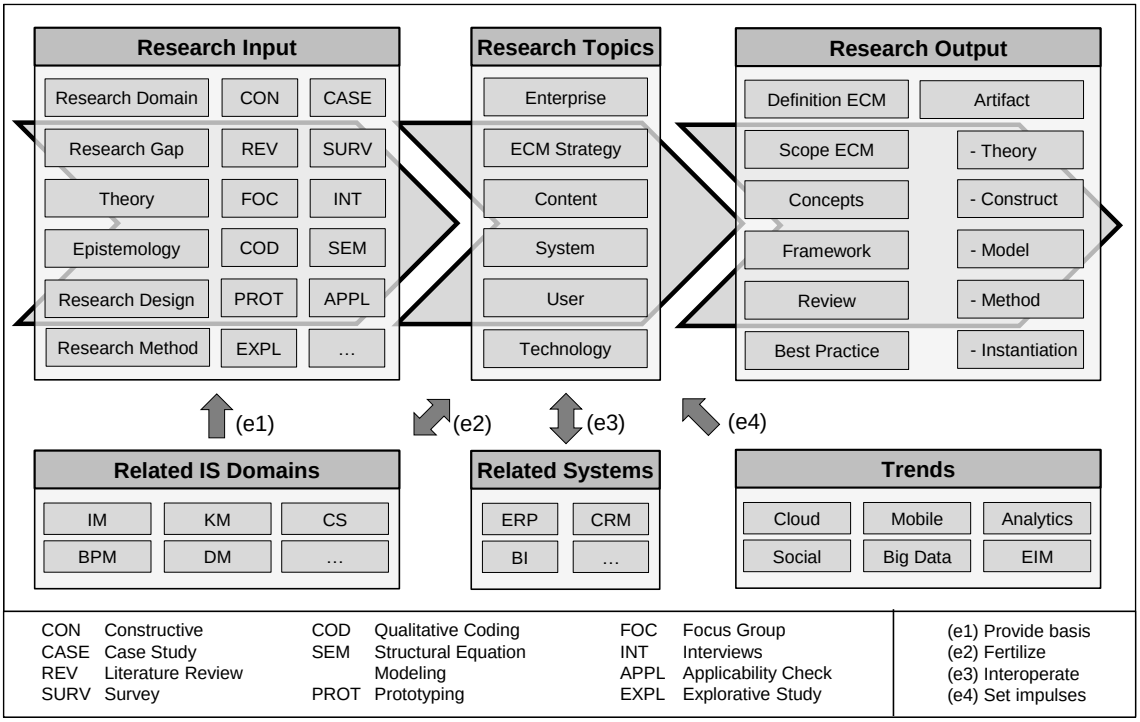


Figure 12: ECM Research Perspective and Underlying Process, Based on Rickenberg and Breitner (2014a).

An ECM research process starts with the research input, which consists of several categories. Besides the ECM research domain itself and a research gap, the theoretical input and the underlying epistemology are decisive for the research procedure and outcome. Theoretical input that was used within ECM literature includes the IT-business alignment, structural contingency theory, genre theory of organizational communication, and resource-based view of the firm. Tyrväinen et al. (2006) employ Iivari's (1989) framework for IS to generate one for ECM which is used by several ECM authors as a theoretical foundation for their work. Based on the theoretical input and the ECM literature, the research design and method determine the research process and outcome. Much of ECM research is design-oriented (Wiltzius et al., 2011). It deals with constructive studies, conceptual ideas and frameworks and technological functionalities (Rickenberg et al., 2012a). The ECM research topics are briefly explained below.

As one research output of the ECM domain, numerous authors define the concept and scope of ECM. However, there is no single acknowledged definition of ECM. The type of research outcome is largely determined by the underlying research design and methods. The most often identified research method is conceptual and generates concepts as a research outcome. Further, artifacts in the form of constructs, models, methods, and instantiations are common outputs. Numerous framework have been generated: technical frameworks, functional frameworks, organizational frameworks, and theoretical frameworks. Reviews of scientific and practitioners' literature, best practice and lessons learned from case studies are results of ECM research (Scott et al., 2004).

ECM research is influenced by three external constructs: related and preceding IS domains that provide the background and input for ECM research, related systems that interoperate with ECM systems, and recent IS trends influencing ECM research outputs and topics. Literature and theory of related IS research domains also provide input for ECM research (e1). Further, ECM and the related research fields fertilize each other with new and related topics and impulses (e2). However, the effect and influence of the related fields such as KM on ECM is stronger than the other way around. ECM systems interoperate with other IS (e3). Due to this interoperation, the systems and topics influence each other. Recent IS trends such as cloud, mobile, and social computing set new impulses for the ECM research domain (e4), see Rickenberg et al. (2012a).

Based on the ECM research perspective and underlying process (Figure 12), we present a grounded theory in a narrative framework for ECM research (Figure 13) which was generated inductively from diverse sources. In contrast to most frameworks and reviews, our framework shows the concepts that ECM research deals with and also relates the concepts to each other explicitly. It involves a plurality of topics and issues and illustrates the different constructs and relationships of the research topics and the ECM elements. The enclosing construct enterprise provides the background for ECM activities and includes business processes and people as sub-categories. Any ECM endeavor starts with a driver that emerges within the company or is induced from outside (e.g. compliance) and initiates projects and programs (1). The construct strategy, operation and organization provides the organizational foundation and context and sets the basis for the initialization, implementation, and operation of ECM (2). The characteristics of the content need to be taken into account and sets requisites (3).

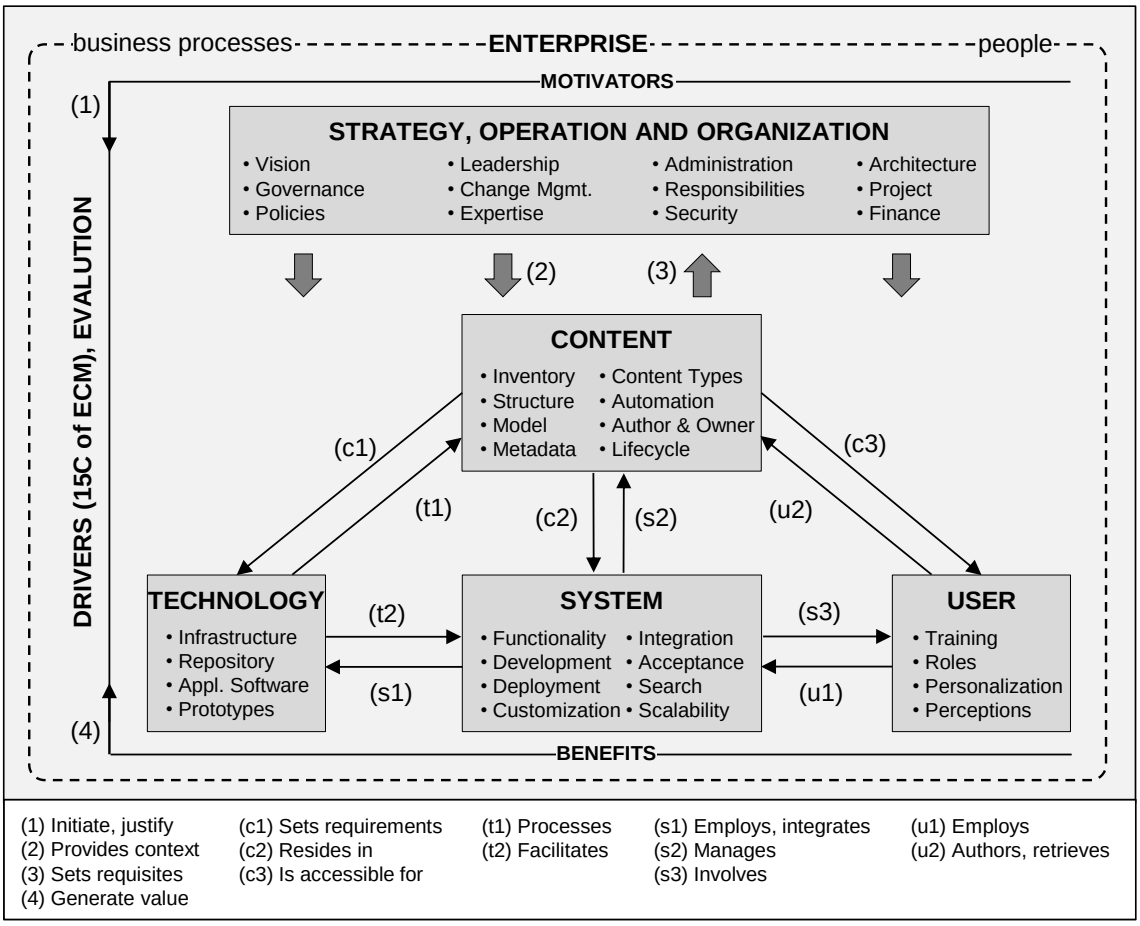


Figure 13: Narrative Framework for ECM Research, Based on Rickenberg and Breitner (2014a).

Content has an influence on the underlying base technology by setting the requirements for it (c1). The content of the enterprise is supposed to reside in ECM systems (c2) and is accessible for users (c3). Technologies such as hardware and software process content (t1) and facilitate ECM systems with different base functionalities and components (t2). An ECM system itself employs different technologies and integrates them (s1) to allow the management of content (s2) and has a set of users (s3). Users employ ECM systems (u1) to author and retrieve content (u2). Finally, any ECM endeavor is supposed to create benefits and generate value for the enterprise (4) and these need to be evaluated against the motivators and drivers. As seen from the framework, enterprise content is the central aspect of ECM. Together with motivators and the organizational context, it determines the derived constructs (technology, system, and user). The derived constructs have a sequence and dependence: technology sets the basis for the accessible ECM system while the use of the system by the user represents the actual purpose of ECM and delivers benefits. More information about the constructs of the grounded theory and its theoretical integration can be found in Rickenberg and Breitner (2014a).

5.4.2 Evaluation of Enterprise Content Management Research

Building on the analysis and synthesis of ECM research and the grounded theory, we evaluate the maturity of the ECM research domain. Recent, ongoing discussions focused on determining quality criteria and directions for IS research, see e.g. Österle et al. (2011), Baskerville et al. (2011), and Straub and Ang (2011). Aiming at RQ1, that is, whether ECM research is a relevant subfield of IS research, we utilize the preliminary results of this discussion. Research outcomes and domains in the IS field matter if they fulfill the requirements of relevance and rigor. With regard to the narrative framework, mainly the input and output of the ECM research process have to be considered to evaluate research against the relevance criteria. At the same time, research has to be rigorous which means that it has to fulfill quality standards regarding validity and reliability (Benbasat and Weber, 1996; Rosemann and Recker, 2009). Both criteria have to be considered for the first two of our research questions. We therefore employ these two aspects along the ECM research process procedure (input, process, and output) and use the generated grounded theory and the underlying data from the coding process.

Concerning the input step of the ECM research process, the research questions of ECM appear to be highly relevant. The topics largely correlate with recently published practitioners' papers and studies and our interviews mostly confirm the relevance of the topics. However, ECM research tends to neglect some organizational issues and current trends and there are some shortcomings regarding the rigor of the research input. Few ECM papers explicitly state the research design or method(s) used and the theories that the work uses as a foundation. Therefore, the criteria of transparency is only partially fulfilled, and the validity and reliability of the research steps can hardly be evaluated.

Rigor is particularly important for the actual research process. It is recommended that authors use accepted research methods and describe the research design and procedure transparently to fulfill both criteria: validity and reliability. However, many authors do not present and discuss the design decision and the research methods. Papers with an underlying design-oriented approach that addresses validity and reliability insufficiently do not contribute to the ECM research and practical community.

It is surprising to see that despite the highly relevant research input, the output of the ECM domain can be rated as rather low in quality. Most of the papers do not

explicitly use accepted theories and there is only very limited output concerning theoretical contribution. Some papers define ECM and its scope, but unfortunately do not generate theory. Further, only few research thoroughly examines the relationships and boundaries of ECM research to other disciplines. Due to the fact that ECM research is constructive, much of the ECM research output includes artifacts, mostly in the form of technical or functional frameworks or dealing with the system perspective. Little research output is available at the level where ECM actually generates benefits: on the enterprise and user level. One exception is the framework from Tyrväinen et al. (2006), which is widely used in numerous research papers. With regard to the rigor criteria, the generated research output must be criticized. Few research papers that use accepted methods or guidelines for artifact construction such as Hevner et al. (2004). This is one reason why most of the artifacts are rarely reused by other ECM authors, are not used within other research fields, and have not found their way into practical literature.

With regard to the evaluation of the current state of a research field, the lack of accepted definitions, steady promotion of not proven benefits, and the emergence of systematic reviews can be used as indicators. ECM exhibits a multi-faced nature and is evolving quickly. Therefore, definitions and scope of the concept are not final, still changing, and need to be established. Within many papers, the benefits of ECM are praised without exact empirical investigation or quantification. Quantitative studies that measure the actual outcome and benefits of ECM can increase the maturity of the domain. According to Brown et al. (2012), “the maturity of a research domain is denoted by the emergence of systematic reviews within it.” During 2011 and 2012, three systematic literature reviews of the ECM research domain were published. While the first two aspects are indicators for an immature state, the third one shows that ECM research is slowly maturing, but is compared to other related domains still in its early stages.

To sum up our investigation and evaluation and address RQ1, we use the empirical data and argue that ECM research does matter and is a relevant subfield of IS research. However, to increase the impact and relevance of ECM research, the focus needs to be adjusted. According to the enterprise-wide character as a main distinction of ECM practice and research to other domains, research needs to be directed at organizational and strategic issues rather than on technical aspects. The technology of the adjacent disciplines is mature and well researched when deployed on their own. However, ECM is an

organizational concept and not just a set of technologies (vom Brocke et al., 2010a). So what really matters within the ECM context are organizational challenges, that is, how to set up ECM and keep it running efficiently. Enterprise-wide management of content and information poses new challenges such as governance, managing content types, metadata, and taxonomies from a holistic point of view. This also includes integration issues, enterprise-wide and global structures, and content-related processes.

To address RQ2 and to show the implications of ECM research, we first point out the implications of ECM practice. Reimer (2002) states that ECM seeks to meet the superset of requirements of related and preceding point solutions. While these point solutions can partly overlap in function and exist in parallel somewhat uncoordinatedly, ECM aims at an integrated enterprise-wide approach to IM. The implications of ECM can be transferred to the research domain: ECM research takes up the topics – and partially the results and theories – of related research disciplines to address their challenging and complex integration into a holistic approach, see Päivärinta and Munkvold (2005). While topics of the related disciplines were absorbed well, existing results and theories need to be incorporated and synthesized more effectively to reinforce the impact of ECM research. Therefore, ECM researchers need to look at the bigger picture, think outside of the box and the ECM domain, and try to incorporate relevant research results from related domains. Concepts and ideas from related disciplines can be adopted, expanded, and integrated to an enterprise-wide scope. This goes in line with our remarks about the importance of strategy, organizational issues, and holistic considerations of ECM.

5.4.3 Relationship with Knowledge Management and Scenarios

ECM research interacts with several related research fields, but the relationship with KM is discussed most often. A hierarchical view of data and content, information, and knowledge has been established within IS literature (Alavi and Leidner, 2001). ECM systems hold data or content that can be processed and interpreted and then serve as information. One step further, authenticated and personalized information related to certain context can be regarded as knowledge. With respect to RQ2, we argue that another implication of ECM is its ability to enable KM and support the four KM processes.

There is no consensus within literature concerning the relationship between ECM and KM. Päivärinta and Munkvold (2005) state that “ECM could be phrased as a subarea

of KM to manage the directories of 'explicit' knowledge." Consistent with our remarks, they further argue that although KM represents a wider concept, ECM incorporates fields different from KM and has its own special challenges. Vom Brocke et al. (2008a) positions ECM as an important instrument for effective KM. Alalwan (2012b) provides a short discussion of the context of KM and ECM and states that "many researchers believe that ECM overlaps with KM," other authors "suggested ECM as one type of KM" and some consider "ECM a subfield of KM." From a practical point of view, ECM and KM are sometimes considered to be redundant constructs, but they indeed have very different characteristics and functions (Oracle, 2011): While ECM focuses on the management of content, KM allows finding information that is relevant in a given context.

According to different views of knowledge, it can be argued whether ECM and KM differ from each other significantly (Alavi and Leidner, 2001). While two perspectives (knowledge as object, access to information) imply that ECM and KM systems do not differ substantially from each other, three perspectives oppose this point of view: knowledge as a state of mind, as a process, and as a capability. Given these perspectives, KM and KM systems have a wider scope than ECM systems. Knowledge is not regarded as an object that can be easily transferred, but involves more complex constructs such as human understanding, expertise, and know-how. We conclude that KM is a wider concept that partly overlaps with ECM in functionality and scope. ECM is an important enabler of KM with its objective of an enterprise-wide approach with holistic structures.

Aiming at RQ3, several likely scenarios of the ECM research domain can be envisioned. One likely scenario is the existence of ECM research as it is with moderate impact and little theory development. Another scenario is that ECM research fully takes in the preceding and some related disciplines due to its holistic perspective. In contrast to this, ECM research could be taken up by a related research discipline such as KM if ECM turns out to only be a temporary phenomenon. One less likely scenario is that ECM and ECM research breaks down into its component parts such as content and workflow management. More likely is a focus on integration and consolidation which could lead to a convergence with Enterprise Information Management (EIM) to integrate the management of structured and unstructured data. Which of these or other paths ECM research will take depends on the practical development and future relevance of ECM, the development of IS research in general, and the quality of ECM research in particular.

5.4.4 Limitations and Practical Implications

We identified certain limitations with regard to the applied research method, research process, our data sources, and the generated theory. Grounded theory has some weaknesses and critiques. The paradigmatically neutral method is influenced by the underlying epistemology, however, our research stance is consistent with the choice of grounded theory as a research method. It is a common myth that grounded theory produces low-level theories that do not do much (Urquhart and Fernández, 2006). We aimed to extend the scope by theoretical sampling (Urquhart, 2013) and to scale up the theory and its generalizability by including KM literature and practitioners' sources. However, the generated theory can be further scaled up and the scope can be broadened to develop theories of greater scope and formal concepts (Urquhart et al., 2010).

Concerning the research process, a common myth about grounded theory is that researchers must not know any relevant literature before applying it (Urquhart, 2013). It is true that researchers have to set aside existing theory when conducting research (Urquhart and Fernández, 2013). We conducted research in this domain before and thus already knew ECM literature. Therefore it was necessary to separate existing theory from the actual research topics. We support the statement of Dey (1999) that research has to be conducted with an open mind and not an empty head. Another myth is that conducting grounded theory takes a lot of time (Urquhart, 2013). While we do not agree with other myths, we agree with this one because of the very time consuming coding.

We used academic literature as a data source. According Glaser (1999; cited in Urquhart and Fernández, 2006), "Grounded theory is a general method. It can be used on any data or combination of data." We therefore argue that the use of academic literature is legitimate since the choice of sources matches our substantive area. However, the analysis of Twitter tweets was more problematic than assumed since the tweets often included hyperlinks to further content and did not include the main message itself. Despite these troubles, we propose that social media content could be used for other studies due to the possibility of quickly gathering diverse and a broad range of opinions.

The grounded theory as a meta-framework does not solely deal with the management of content; instead it deals with the topics of the ECM research domain. While special aspects can be missing, main aspects are identified, included, and theorized.

With regard to the practical implications, we identified several trends and future opportunities within the ECM context: social business, mobile ECM, cloud ECM, big data, and integration. These trends are omnipresent in practitioners' literature, tweets, and on websites, but have not yet gotten through to academic literature and the interviewees. CMS formerly stood for content management systems, but it now might stand for Cloud-Mobile-Social (Walker, 2011). Moving content and ECM services into the cloud, employing mobile devices such as smart phones and tablets in the ECM environment, and deploying social business and ESN are the next big steps. AIIM describe the current time as "era of social, mobile, cloud and big data" (Miles, 2012). Along these lines, Gartner defines the Nexus of Forces, which is the convergence of social, mobile, cloud, and information (Gartner, 2013), see chapter 6. Big data, and also content analytics and content intelligence, become increasingly important (Chen et al., 2012) and ECM can be an enabler of big data to supply it with decisive content. However, companies still struggle to achieve the vision of a single ECM system and enterprise-wide integration (Miles, 2011). Research about these issues and trends within the ECM context is key to increase the practical and academic relevance of ECM research.

5.5 Conclusions and Outlook

ECM research and the current state of the field are in need of thorough investigation and deeper analysis. We address this issue by generating a grounded theory of the ECM research field and provide a formal description of constructs and relationships within the ECM domain in form of a narrative framework. The framework takes into account the different theoretical views expressed in the IS literature and also incorporates the viewpoints of diverse practical sources. Based on the insights generated from the closeness to the data, we used the grounded theory for meta-analytic purposes within this novel approach to analyze the relevance and impact, theoretical implications for IS research and practical implications, and scenarios for ECM research.

We conclude that ECM research is relevant, but more rigorous research, further theory building, and discussions within the IS research community are necessary to increase its maturity. Research topics need to be adjusted to match the enterprise-wide scope, which represents a key characteristic of ECM. This corresponds with the implications of ECM research: it absorbs and combines research results from preceding and

related concepts to address their challenging, complex integration into a holistic enterprise-wide, often global approach that emphasizes strategic and organizational issues.

Several likely scenarios for ECM research can be envisioned. The actual future development depends on the practical evolution and future relevance of ECM, the development of IS research in general, and the quality of ECM research in particular. Concerning future practical implications of ECM, the all-embracing trends are cloud, mobile, and social ECM, also called CMS (Walker, 2011). Big data and content analytics, as well as deeper integration of ECM-related systems, are further practical implications.

We hope that the narrative framework can fertilize ECM research and theory building. We suggest that the grounded theory with its constructs and relationships can acts as a reference model. This abstract, domain-specific ontology can help to enable consensus within the multifaceted ECM research domain that has not yet been achieved (Grahlmann et al., 2012). Future research topics of ECM should be aligned with the narrative framework to address important strategic and organizational issues including the challenging operation of ECM systems. Identified trends need be investigated from a theoretical point of view to increase the impact and relevance of ECM research.

5.6 Academic Classification of the Publication

The research paper “Enterprise Content Management Research: Analysis, Synthesis, and Evaluation Using Grounded Theory Methodology” was written together with Michael H. Breitner and submitted to an IS journal, see Rickenberg and Breitner (2014a) and **Appendix 20**. According to the German Academic Association for Business Research (VHB), the journal is ranked in category “A” for the WI/IS research domain and “A” for the VHB JOURQUAL 2.1 (WKWI, 2008; Schrader and Hennig-Thurau, 2009).

PART B: SURVEY-BASED DECISION SUPPORT

Interviews	Questionnaire
Chapter 6 Big Data, Social, Mobile, and Cloud Computing: Towards a Reference Model for IS Governance and the Nexus of Forces	**Chapter 7** Building a Better World through Information Systems – An Explorative Survey among Leading IS Researchers

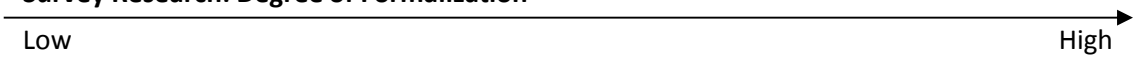


Figure 14: Structure of Part B: Survey-Based Decision Support.

A Primer to Survey-Based Decision Support

Survey research allows to gather information of a large group of people and is conducted to advance scientific knowledge (Pinsonneault and Kraemer, 1993; Babbie, 1990). Concerning IS research, Newsted et al. (1998) state that surveys are among the popular methods used by the research community. In fact, survey research belongs to the most important areas of measurement in applied social research (Trochim and Donnelly, 2006) and can be classified by purpose according to Pinsonneault and Kraemer (1993): Survey research in exploration is employed to become familiar with a topic and try out preliminary concepts about it; survey research in description is used to find out what situations, events, attitudes, or opinions are occurring; and survey research in explanation is utilized to test theory and causal relations. Further, survey research can be classified according to the time frame for data collection (typically cross-sectional or longitudinal) and by the data collection method, such as different types of questionnaires and interviews (Pinsonneault and Kraemer, 1993).

Deriving information from qualitative and quantitative survey data, survey research is able to promote decision support and decision making, see e.g. Xu et al. (2009). With varying degree of formalization and structuredness, both – qualitative and quantitative data from surveys – serve as an important input for data analysis and synthesis, which then can enable survey-based decision support.

This part of the thesis deals with decision support based on data that is collected with survey research in exploration and includes two chapters, see Figure 14 for the structure of Part B. Two examples aim to show that surveys and the collected data can enable decision support. To examine how the new challenges of big data, social, mobile, and cloud computing influence IS governance, we employ exploratory and confirmatory expert interviews within a Delphi study and create a reference model, which allows organizational decision makers to develop an effective IS governance implementation, see chapter 6. Drawing from a more formalized survey method and a higher amount of participants, we explore how IS research and practice can contribute to build a better world and therefore conduct a questionnaire among leading IS researchers in chapter 7.

6. Big Data, Social, Mobile, and Cloud Computing: Towards a Reference Model for IS Governance and the Nexus of Forces

6.1 Motivation and Research Topic

Our current decade can be characterized by the rapid development of technical innovations, their adoption, and diffusion. New technologies – such as the rising trends of social, mobile, and cloud computing, as well as big data analytics (Goes, 2013) – enable groundbreaking opportunities that impose far-reaching changes to business, economies, and societies. Especially these four forces are predicted to have a lasting impact on the IS domain and provide implications and opportunities that go beyond mere technical aspects. The IT research and advisory company Gartner (2013) defined these trends as the "Nexus of Forces", referring to the convergence and mutual reinforcement of the four interdependent trends. Both individually and combined, the Nexus of Forces empowers individuals in their interaction with each other and with associated information through well-designed ubiquitous technology (Gartner, 2013). The forces are innovative and disruptive on their own, but together they have the power to revolutionize business and society, breaking down old business models and creating new leaders.

As enterprises turn digital and reinvent traditional IT and IS, the Nexus of Forces is becoming real. However, organizations face the problem of how to take advantage of the opportunities and maximize the benefits while mitigating associated risks. Traditional management approaches and control mechanisms are influenced by a shift in power towards the user and demand for a robust framework to govern these technologies. Against this backdrop, IS governance seems to be a suitable mean, as it focuses on aligning business and IT (De Haes and van Grembergen, 2004, 2005, 2006; van Grembergen et al., 2004). While recent studies address IS governance in the context of one of the trends, the interconnections among the four forces provide novel challenges for IS governance. Since academic research is currently not taking this into account, the paper pursues the following RQ1: *How do the new challenges of big data, social, mobile, and cloud computing influence IS governance?* In order to uncover potential research areas and provide guidance for future research, we examine the following RQ2: *What key areas for future research are evolving concerning IS governance and the Nexus of Forces?*

This chapter is largely based on Lebek et al. (2014), see Appendix 19.

6.2 Theoretical Background and Methodology

6.2.1 IS Governance in the Context of the Nexus of Forces

IS governance is commonly referred to as an integral part of corporate governance and draws from its principles while focusing on the management and use of IT in order to achieve corporate performance goals (Weill and Ross, 2004; Webb et al., 2006; Burtscher et al., 2009). It specifies the leadership and organizational structures, processes, and relational mechanisms to ensure that IT is properly aligned to the business strategies and objectives (De Haes and van Grembergen, 2005, 2008; Burtscher et al., 2009; Zarvic et al., 2012; Urbach et al., 2013). Its goals are strategic alignment, resource management, and performance measurement, which are the drivers, as well as value delivery and risk management, which are the outcomes (Burtscher et al., 2009). IS literature distinguishes between central and decentralized IS governance designs (Peterson, 2004; Brown and Grant, 2005). The actual form of IS governance is impacted by multiple contingencies, which are divided into internal and external influence factors (Sambamurthy and Zmud, 1999; van Grembergen et al., 2004; Brown and Grant, 2005).

While IS research is starting to address IS governance in the context of one of the forces, research is required that examines the Nexus of Forces on the whole and with the interconnections among the four individual forces. Based on existing governance literature and the findings by Gartner (2013), we formulated a conceptual model that provides the baseline for our research (Figure 15). We examine the influence of the Nexus of Forces and of the four forces on organizations in general and governance structure in particular. The effect is moderated by the consumerization pressure, as well as by external and internal contingencies. The governance structure consists of the corporate and IS governance including their goals and archetypes as well as related subjects.

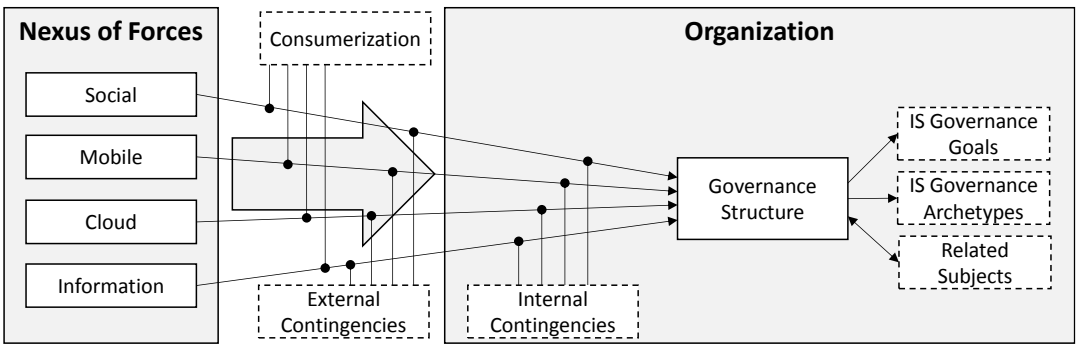


Figure 15: Conceptual Model of IS Governance and the Nexus of Forces, Based on Lebek et al. (2014).

6.2.2 Research Design and Data Collection

The Delphi method is a "systematic interactive research method that relies on a panel of independent experts" (Olbrich et al., 2011). This flexible method for structuring a group communication process (Linstone and Turoff, 1975) is especially suitable to explore new issues with subjective and complex judgments of experts within a series of questionnaires until consensus is reached (Kendall, 1977). It is characterized by four core elements (Rowe and Wright, 1999): anonymity, iteration, controlled feedback, and statistical aggregation of group response. The research design consists of five phases (Figure 16) in which a reference model is iteratively generated from our conceptual model.

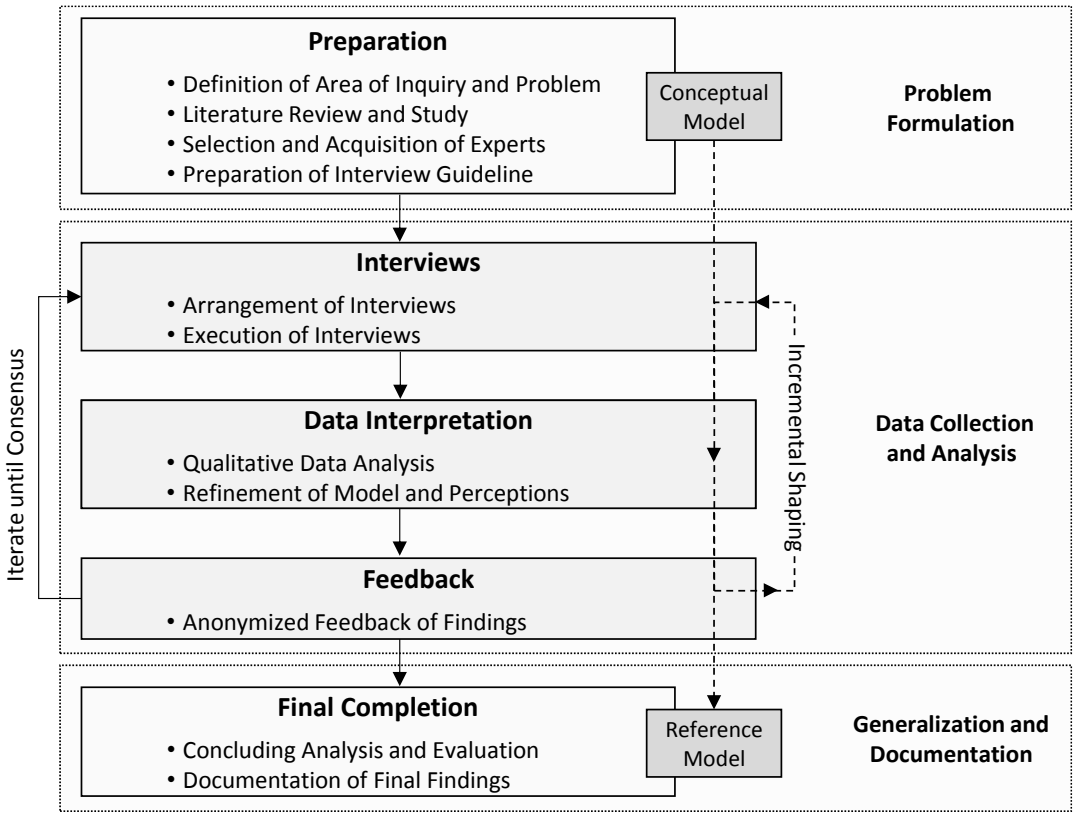


Figure 16: Research Design, Based on Lebek et al. (2014).

Within the preparation phase, initial investigation and theoretical grounding were the focal point and a comprehensive literature review was conducted (Webster and Watson, 2002; vom Brocke et al., 2009). An iterative procedure of data collection and analysis followed. We acquired 18 experts from different branches and conducted a first round of explorative interviews. Qualitative data analysis (Punch, 2005) and coding techniques (Glaser and Strauss, 1967; Strauss and Corbin, 1998) were used to analyze and interpret the data. During a second round, a high consensus degree was reached and therefore the incremental shaping of the model was finished and results were finalized.

6.3 Summary of Results, Limitations, and Implications for Further Research

In order to assess RQ1, we investigate the impact of the forces and iteratively constructed a reference model (Figure 17). The model basically consists of the four forces as well as consumerization, which are closely interrelated and mutually reinforcing one another. Mobile device enables access to corporate information resources, independent from restrictions regarding time and location. They provide a platform to communicate via public and enterprise social networks and create a great amount of information. The cloud represents a transmission medium for delivering information. The consumerization of IT describes the use of consumer IT in the organizational context. It leads to an adoption pressure that forces organizations to react and to adjust governance structures including corporate governance, IS governance, and IS management.

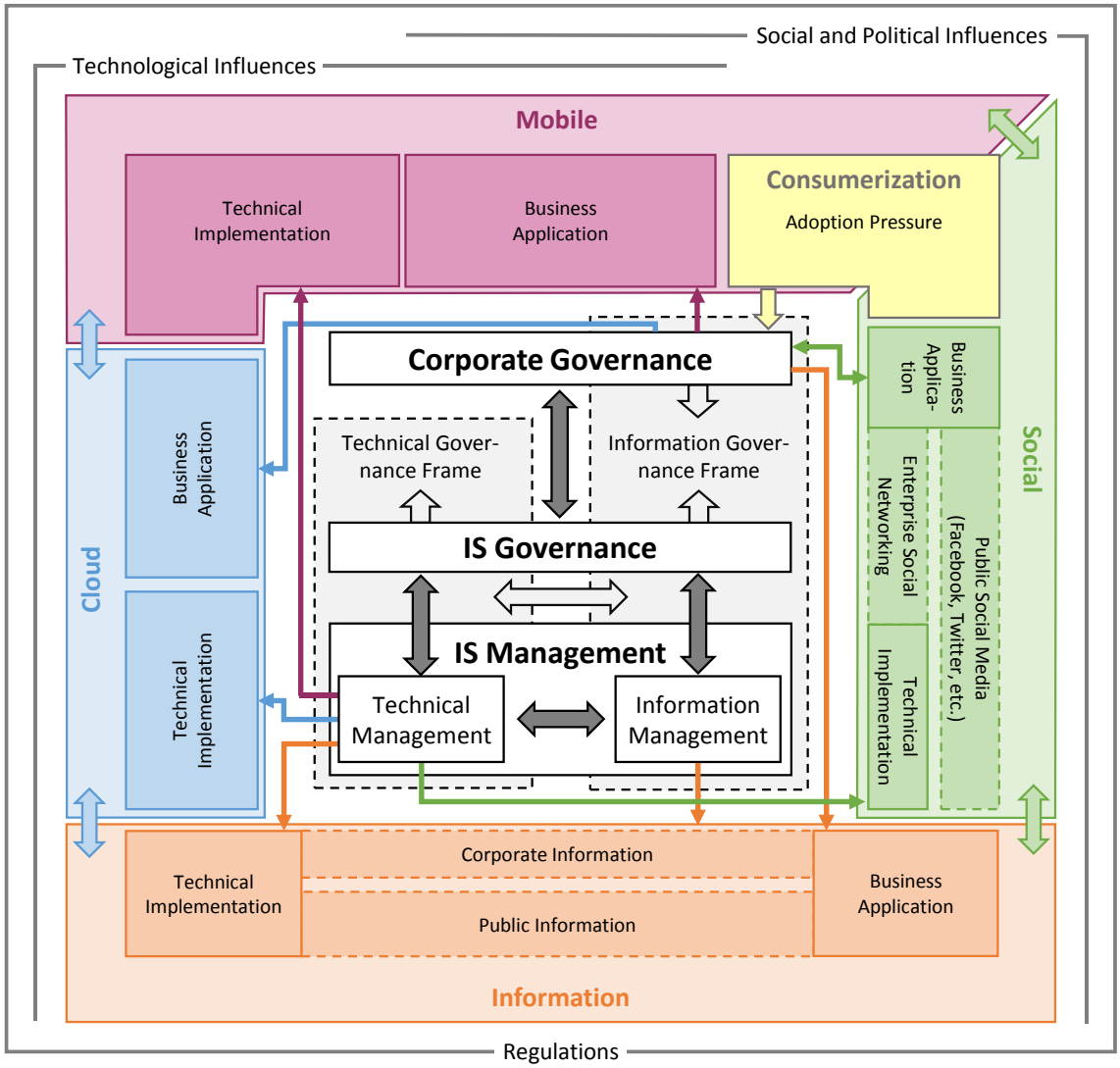


Figure 17: IS Governance Reference Model for the Nexus of Forces, Based on Lebek et al. (2014).

The potential effects created by the Nexus of Forces are significantly influenced by regulations, technical influences, and social and political influences. Organizations operate within an environment that is strongly determined by the geographical, political and cultural region, as well as the industry or branch. Consequently, organizations are exposed to the influence of various external contingencies (Burtscher et al., 2009).

The inner part of the reference model describes core elements and interrelationships of the organizational governance and decision making structure. The hierarchy extends over the three levels of corporate governance, IS governance, and IS management. The corporate governance defines IT principles based on the strategic direction of the organization and is responsible for the business application of the Nexus of Forces. While the corporate governance defines the mission statement, the IS governance ensures that the IT is properly aligned to business strategies and objectives. IS governance must be driven by corporate governance and not by the IT department (Webb et al., 2006). In the model, IS governance consists of two core frames: The technical governance frame is defined on IS governance level and sets specifications for architecture and infrastructure focusing on technical decisions on hardware, software, and systems. The information governance frame is defined by an interaction of the corporate and IS governance and sets basic rules and policies for managing information assets without primarily focusing on technical aspects. Consequently, corporate and IS governance set the scope for the actual operative execution, which is the responsibility of IS management.

Adoption pressure arises from the private use of mobile and social computing and forces organizations to adopt these new capabilities. Consumerization is a socio-cultural construct and the main driver of the Nexus of Forces that creates an impact on an organization. Employees ask for new technical solutions and trigger request and demand management processes within operative IS management. This adoption pressure accumulates on the IS management level and is handed up hierarchically to the corporate (governance) level so that a fundamental business decision need to be made.

Regarding the internal contingencies, the role and perception of IT and the attitude towards technology within the organization are substantial factors. The impact of the Nexus of Forces depends on the role of IT and partially on the branch of the organization. If the importance of IT is high, then the potential impact that the Nexus of Forces

is able to create is high as well. However, next to the new opportunities that the Nexus of Forces presents, new risks, threats, and challenges emerge. While marketing, advertising, and popular science mainly emphasize the benefits, the participants of the study also expressed doubts and concerns concerning the Nexus of Forces.

To sum up the results, we provide decision support based on the Delphi survey technique. Our study and the reference model provide initial insight into the challenges and influences that the interacting forces of big data, social, mobile, and cloud computing provide to organizations and governance structures. The reference model depicts the interrelationships of the Nexus of Forces with organizational governance structures, as well as the decision making structure and responsibilities. The capability of the Nexus of Forces to create an impact on organizations and IS governance structures depends on the environment of an organization as well as the internal and external contingencies. Consumerization is the main driver of the Nexus of Forces and influences organizations particularly on the business level. The role of corporate governance concerning IS decisions is increasing. It is responsible to determine the business application of the Nexus of Forces. IS governance focuses on technical aspects and provides consulting input into top level decisions. It defines the technical governance frame by setting guidelines with regard to IT architecture and infrastructure. The information governance frame sets basic rules and policies for managing information assets and is defined by corporate in combination with IS governance. Finally, IS and technical management realize the actual technical implementation according to the specifications of the governance entities.

We identified certain limitations of the study. With regard to the proposed IS governance reference model, this study does not raise the claim to be exhaustive. We aimed to provide initial inside to enable further investigation. Consequently, the model should be refined and validated by future research. With regard to the research process, the amount of participants was rather limited compared to other Delphi studies. We aimed to provide contemporary insights into the subject matter and thus a long enquiry period was not applicable. Further, the gain of new evidence decreased constantly and finally came to halt, so no additional experts were acquired. The experts were able to provide rich insights and due to the high quality of answers, additional participants were not required. Another limitation arises from the industry affiliation of the participants since they mainly come from the industry branch. When interpreting our results, it has to be

considered that the impact of the Nexus of Forces varies between different organizations and branches. We only conducted two rounds within our Delphi approach. Due to the lengthy and comprehensive interviews and focus group discussion, consensus was reached quickly and therefore additional rounds were not required. The mix of interview types is uncommon for Delphi studies. We decided to incorporate a focus group, however, were unable to conduct focus groups with all members.

Concerning RQ2, implications and areas for future research arise from our study. The reference model can act as a basis for refinement concerning partial aspects or its operationalization including the investigation and definition of roles and responsibilities within IS management. Hybrid approaches and federal governance archetypes require further attention. The influence of the Nexus of Forces and of consumerization on methods and processes to achieve the goals of IS governance require further research. This includes new IS solutions that apply the forces to generate additional business value and the management of novel risks of the technologies. Practical changes in organizations as well as the impact on societies that result from the Nexus of Forces demand empirical investigation. These trends and digital business strategy come along with key organizational shifts concerning the role of IT in organizations (Bharadwaj et al., 2013).

6.4 Academic Classification of the Publication

The research paper “Big Data, Social, Mobile, and Cloud Computing: Towards a Reference Model for IS Governance and the Nexus of Forces” was written together with Benedikt Lebek, Bernd Hohler, and Michael H. Breitner and submitted to an IS journal, see Lebek et al. (2014) and Appendix 19. According to the German Academic Association for Business Research (VHB), the journal is ranked in category “A” for the WI/IS research domain and “B” for the VHB JOURQUAL 2.1 (WKWI, 2008; Schrader and Hennig-Thurau, 2009).

7. Building a Better World through Information Systems – An Explorative Survey among Leading IS Researchers

7.1 Motivation and Research Topic

As stated recently by Grover (2014), "most of our research doesn't take on the big questions." The Millennium Development Goals (MDGs) as established by the United Nations (UN) can be seen as major global challenges and the big questions of our century. This includes the eradication of poverty and hunger, universal and affordable access to healthcare and education, environmental sustainability, gender equality, and a global partnership for development (UN, 2014). While the IS community is generally well positioned to assist in addressing these challenges, the underlying research discipline has been criticized to lack transformational impact on issues with high visibility, such as the MDGs (Agarwal and Lucas, 2005; Wang et al., 2010). IS have a major contribution on increasing global productivity (Watson et al., 2010) and advancing individual lifestyle and thus can contribute – and are already contributing – to building a better world. However, IS research is still deemed to lack relevance to IS practice (see e.g. Benbasat and Zmud, 1999, 2003; Rosemann and Vessey, 2008; Straub and Ang, 2011).

Even though leading researchers demand for more attention to relevance (Rosemann and Vessey, 2008), sustainability (Watson et al., 2010; Seidel et al., 2013), responsibility, reverberation, and impact (Desouza et al., 2006a, 2006b, 2007), the frequently recurring discussion about the value, impact, and relevance of IS research and a crisis of the domain has been stimulated again by Hassan (2014). To increase the value of IS research, the community needs to tackle major challenges such as the MDGs and contribute to building a better world. Hasan and Watson (2014) state positive actions of IS – such as facilitating communication for accessing education, connecting diaspora, and participation in government, and optimizing the production and distribution of food and energy – which are in need of further investigation and research. To address these topics and set a starting point for discussion and research, we have designed an explorative survey among leading IS researchers. We aim to show and discuss that IS – practice and the research domain – can take on the big questions and help to build a better world. We pursue the RQ: *How can IS research and practice contribute to build a better world?*

This chapter is largely based on Rickenberg et al. (2014) and Appendix 14.

7.2 Theoretical Background and Methodology

7.2.1 Millennium Development Goals and Related Work

As defined by the world leaders, the Millennium Declaration comprises general statements about values, principles, and objectives for the international agenda for the twenty-first century. The involved nations strive for a new global partnership which aims to reduce extreme poverty and set out a series of time-bound objectives with a deadline of 2015. These objectives have become known as the MDGs which contain eight goals: (1) Eradicate extreme poverty and hunger, (2) Achieve universal primary education, (3) Promote gender equality and empower women, (4) Reduce child mortality, (5) Improve maternal health, (6) Combat HIV/AIDS, malaria, and other diseases, (7) Ensure environmental sustainability, and (8) Develop a global partnership for development, see UN (2014) for additional information. To set a common understanding of the term 'better world' and a baseline for our survey, we refer to and employ the MDGs as they address a wide variety of global issues concerning a big majority of all human.

There are certain publications within the IS research domain that directly refer to the MDGs, see Afridi and Farooq (2011), Calloway (2011), Ditsa and Ojo (2011), Ezenwa and Brooks (2013), Ramiller and Pullman (2008), Wang et al. (2010). For instance, Wang et al. (2010) state that in the developing world, millions of people die due to poor information management. They illustrate the potential of IS regarding this issue and provide a solution based on a combination of various technologies to improve vaccination management in developing countries. Afridi and Farooq (2011) directly address goal (5) of the MDGs to improve maternal health by presenting a health tool that uses data mining techniques for a risk classification of pregnant women. The tool can be used to increase the quality of care in rural areas. Calloway (2011) reports about an applied sustainability learning model which relates information and communication technologies with the MDGs. Ramiller and Pullman (2008) describe their efforts in a project that aimed at building a system to support sustainable community development.

To the best of our knowledge, no study exists that focuses on examining the value of IS research regarding humanity's goals by involving a significant number of leading IS researchers from all different areas. It is time for the IS community to help to solve some humanity's grand challenges and suggest some practical solutions (Hassan et al., 2013).

7.2.2 Research Design and Data Collection

We designed a cross-sectional survey to explore in which ways and to which extent IS can help to build a better world. Surveys are a popular method used by the IS research community as they epistemologically provide a way to obtain and validate knowledge (Newsted et al., 1998). Survey research in exploration is used to become familiar with a relatively new topic, to try out preliminary concepts about it, and to discover and raise new possibilities and dimensions (Pinsonneault and Kraemer, 1992). The resulting research design consists of five phases and is presented subsequently in Figure 18:

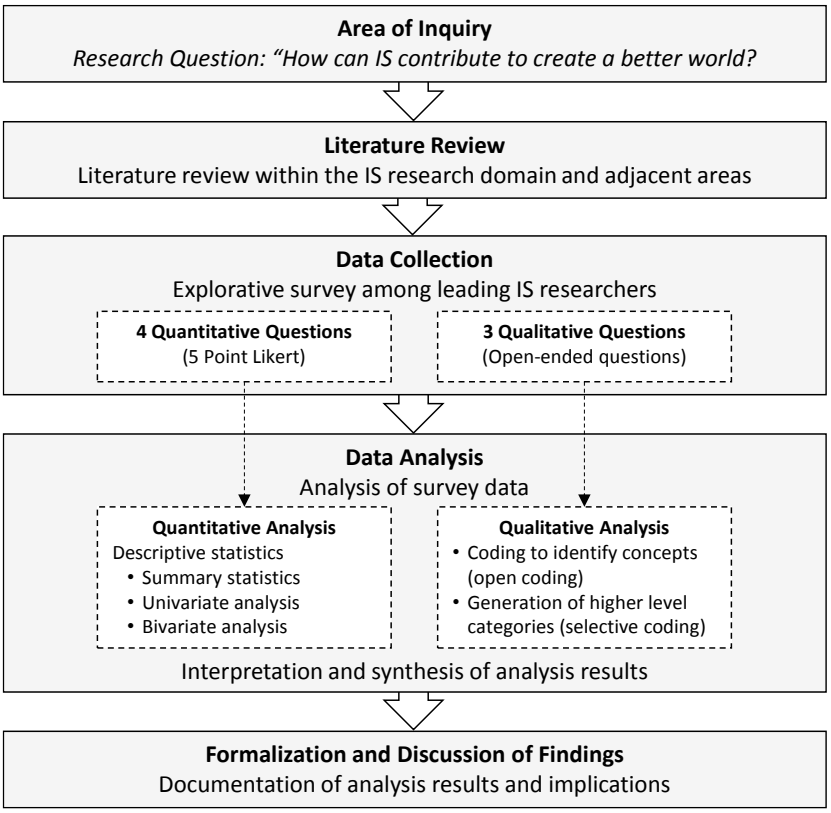
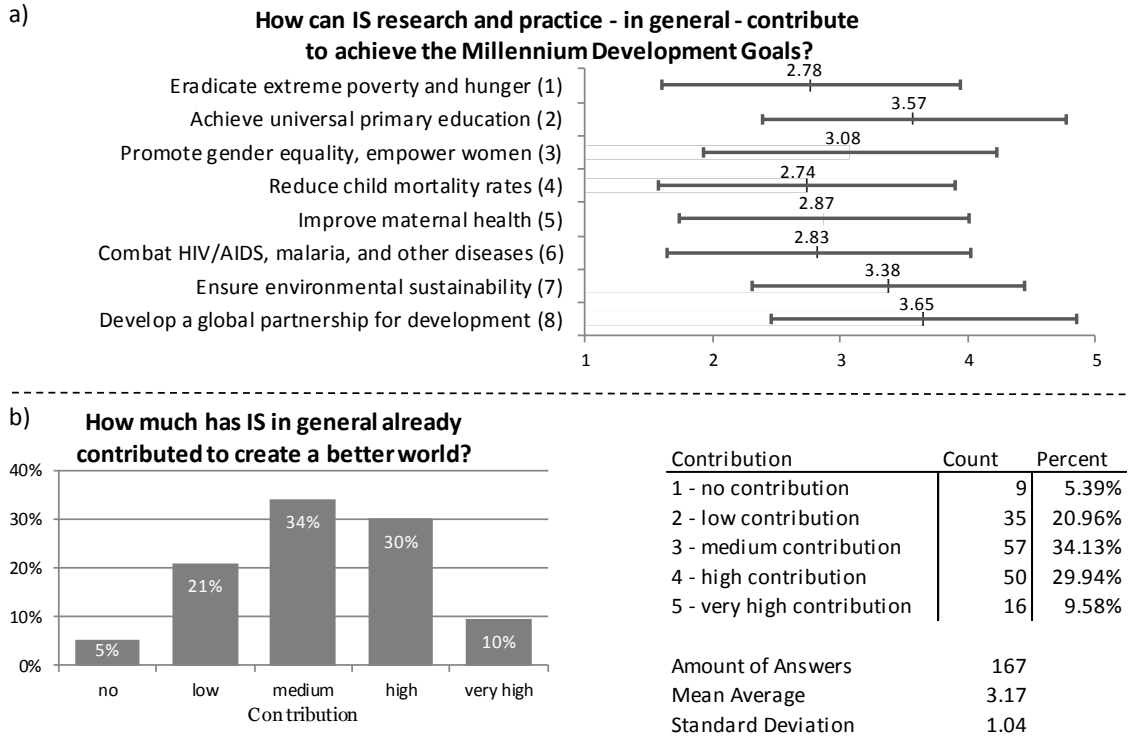


Figure 18: Research Design, Based on Rickenberg et al. (2014).

The refinement of the area of inquiry set the starting point. We then conducted a literature review within the IS research domain and adjacent areas (Webster and Watson, 2002; vom Brocke et al., 2009). The questionnaire was created using survey research methodology (Pinsonneault and Kraemer, 1992; Babbie, 1990; Schutt, 2011), see online supplementary (http://bit.ly/R8J9ei). Track chairs of international IS conferences were perceived as the most suitable group to conduct the survey. We collected 2,877 email addresses, sent 1,506 emails, and received 171 answers, which were examined by qualitative and quantitative data analysis (Punch, 2005; Glaser and Strauss, 1967; Strauss and Corbin, 1998). In the final phase, findings and results were documented.

7.3 Summary of Results, Limitations, and Implications

Divided in two parts, the survey asked about the contribution of IS in general to build a better world and of the contribution of specific IS research streams and tracks. Within the first part of the survey, the participants were asked how much IS – research and practice – generally are able to contribute (Question 1; Q1) and how much it already has contributed (Q2). Concerning the first question, we employed the MDGs to measure the perceived contribution of IS. The results of Q1 and Q2 are illustrated in Figure 19:



Contribution	Count	Percent
1 - no contribution	9	5.39%
2 - low contribution	35	20.96%
3 - medium contribution	57	34.13%
4 - high contribution	50	29.94%
5 - very high contribution	16	9.58%

Amount of Answers	167
Mean Average	3.17
Standard Deviation	1.04

Figure 19: Results of Survey Questions a) Q1 and b) Q2, Based on Rickenberg et al. (2014).

As seen from Figure 19a, the highest perceived contribution of IS on the MDGs is on the goal 'Develop a global partnership for development' (3.65), followed by 'Achieve universal primary education' (3.57) and 'Ensure environmental sustainability' (3.38). Therefore, the two goals that can be achieved by facilitating access, communication, and participation via IS were rated highest by the participants. The contribution concerning 'Promote gender equality and empower women' was rated medium (3.08). The impact of IS on the three goals related to health ('Reduce child mortality rates', 'Improve maternal health', and 'Combat HIV/AIDS, malaria, and other diseases') and the goal 'Eradicate extreme poverty and hunger' with values around 2.8 was estimated below average. While the potential of IS in high-tech healthcare is widely considered as high, the impact of IS on these three rather basic but fundamental goals was rated quite low. However,

the average impact of IS on these goals was still rated close to '3 - medium contribution'. The mean contribution of IS on all goals is 3.11 and therefore between '3 - medium contribution' and '4 - high contribution' while the standard deviation concerning the particular goals and in general is slightly over one (~1.1). Concerning all goals on average, 75% of the participants rate the contribution of IS as 'low' (23%), 'medium' (28%), or 'high' (24%), while 10% see 'no' and 15% a 'very high' contribution. This leads to the assessment of the contribution of IS that has actually been realized as shown in Figure 19b. Most of the participants rated the amount of how much IS generally already contributed to a better world as medium (34%). In total, 85% of the participants rated it as 'low' (21%), 'medium' (34%), or 'high' (30%), while 5% see 'no' and 10% a 'very high' contribution. The mean average of the realized contribution (3.17) is higher than the estimation of how much IS can contribute concerning the MDGs (3.11) since the investigated area (IS in general) is wider than the eight MDGs.

Within the second part of the questionnaire, the participants were asked about the general contribution (Q3), already achieved contribution (Q5), and potentials and challenges (Q7) of particular research streams within the IS domain with regard to building a better world through IS. Further, a numerical assessment was performed with Q4 (how much can the track contribute?) and Q6 (how much has the track already contributed?). We assigned each participant to one of 20 track clusters concerning specific tracks of IS conferences and then aggregated and synthesized results for each track cluster. The quantitative results are shown in Table 2 and explained subsequently:

Table 2: Quantitative Results for the Track Clusters, According to Rickenberg et al. (2014).

Track Cluster	Ø Q4	Ø Q6	Answers
Economy and Commerce	2.25	2.38	8
E-Government	3.60	3.20	5
Human Behavior and Computer Interaction	3.09	2.64	11
Human Capital and IS	3.33	2.67	3
ICTs in Global Development	4.40	3.60	5
Innovation	3.00	2.89	10
IS Education	3.50	3.00	4
IS Governance	2.75	2.75	4
IS in Society and Culture	3.43	2.67	7
IT and Business Services	3.50	2.50	7
IT in Healthcare	3.57	2.71	8
Knowledge Management and Decision Support	2.80	2.55	11
Organizational IS and Technology	3.61	2.67	18
Project Management	3.29	2.50	7
Regional Topics and Issues	3.00	2.75	5
Research Theory, Methods, and Philosophy	2.73	2.18	11
Security and Privacy	3.50	2.25	4
Social Media and Collaboration	3.45	2.92	13
Software and System Engineering	3.22	2.38	10
Sustainability and Green IS	3.40	2.36	11
162 Answers	3.25	2.63	8.10

The perceived contribution of the track clusters varies considerably. While the overall mean contribution of a track (Q4) is 3.25, it is lower (2.63) for the already achieved contribution (Q6). The highest perceived ability to contribute shows 'ICT in Global Development' (4.40) with a large gap to the next track clusters. This track cluster is also closely connected with goal (8) of the MDGs, which is to develop a global partnership for development. The lowest perceived ability to contribute shows 'Economy and Commerce' (2.25). Particularly the contributions of 'Research Theory, Methods, and Philosophy' (~2.7) to build a better world through IS are of indirect nature, as also indicated by participant #86. Concerning the perceived contribution that has already been realized, 'ICT in global development' (3.60), 'E-Government' (3.20) also show the highest values followed by 'IS Education' (3.00). This indicates that, as proposed by Hasan and Watson (2014), facilitating communication for accessing education and participation in government are opportunities to build a better world through IS. The lowest perceived realized contribution is shown by 'Research Theory, Methods, and Philosophy' (2.18). With regard to the largest gap between the ability to contribute and the already realized contribution, 'Security and Privacy', 'Sustainability and Green IS', and 'IT and Business Services' show a gap of one or more (≥ 1). Due to recent violations of privacy rules, e.g. by the US National Security Agency with the PRISM program (De Goede, 2014), the perceived realized contribution of 'Security and Privacy' is low (2.25) – even though the general ability to contribute was rated high (3.50). The IS research steam 'Sustainability and Green IS' is still in its early stages which results in a remarkable gap between the ability to contribute (3.40) and the realized contribution (2.36). As opposed to this, 'IS Governance' and 'Innovation' show a marginal gap (~0), while the gap is negative for 'Economy and Commerce' (-0.13) which suggests that the heyday of this area is over. While it is widely accepted and often stated by the participants that 'Knowledge Management and Decision Support' and 'IT in Healthcare' can significantly contribute to build a better world, the perception of the domain experts is lower (2.80, 3.57).

We provide decision support based on survey research methodology and a questionnaire. The aim of this study is not to provide final solutions of how to build a better world through IS, but to set a basic starting point, create awareness, and provide a basis for future discussion and research. We synthesized further aspects from the survey data concerning (1) areas with high contribution, (2) general challenges, (3) negative aspects

and risks of IS, (4) the indirect impact of IS, (5) value of conferences in IS research, and (6) critique about IS research and IS conferences. These interesting and important statements by the participants represent a starting point for future discussion and research.

We identified certain limitations with regard to the survey and its explorative character. Due to the limited amount of responses (n=171), there is only a decent amount of responses for each track cluster (~8). The results for clusters with a lower amount of answers are less representative, but aim to form a consistent overall first impression and overview of the clusters and the underlying research streams. With regard to the responses, a bias cannot be excluded due to two reasons. First, some groups of researchers are more likely to volunteer to be in the sample than others. In general, systematic selection biases are inherent in non-probability samples and cannot be excluded here. Second, we intentionally only asked IS researchers to participate in our survey. Other groups likely have different perceptions of the contribution of IS to build a better world. Concerning the understanding of the survey, not all respondents were familiar with the MDGs and a short introduction would have helped to build a better understanding for participants less familiar with this topic. Additionally, some participants stated that 'building a better world' is a relatively vague idea and is too broad to be discussed in a direct way. We certainly agree that this is a rather broad and complex construct, however, this is owed to the explorative and intentionally broad character of the study. Based on numerous high-quality and sophisticated answers within the survey, we argue that a subsequent study is useful to substantiate our initial results. Further, few participants found the distinction between IS research and practice not sharp enough. We asked for answers that concern both, IS research and practice, since relevant IS research needs to address important topics of IS practice and deepen the understanding of it.

Several theoretical as well as practical implications can be drawn from the survey and the findings. Based on the survey results, we were able to show that the perceived contribution of IS concerning particular MDGs is lower than for others. It is important to investigate (a) why the contribution of IS is rather low concerning these goals and (b) how the impact of IS with regard to these goals can be raised. We also indicated that some IS research track clusters have a lower perceived impact on building a better world than others. The MDGs or a 'better world' are complex and high-level goals which are certainly not the main goals to be addressed by all IS research streams, however, it is

necessary to (a) analyze why the impact on these goals is lower of certain streams and (b) take action to raise the contribution of these streams. Similarly, we showed that some IS research streams do not tap the full potential yet. For example, 'Sustainability and Green IS' can, according to the participants of the survey, contribute a great deal to build a better world, but was not able to contribute heavily yet. Even though '*money makes the world go around*' (see e.g. Agnew, 2010), IS research and research in general must not disregard the social and environmental dimensions of sustainability. To tackle the big questions, grand challenges, and humanity's goals, holistic approaches are needed that are not centered on economic aspects. This implies that we, as IS researchers, need to promote the use of sustainable goals and metrics to measure the impact and contribution of our research instead of using only economic metrics. Another implication is the need of interdisciplinary approaches since broad goals ('better world') and challenges (MDGs) cannot be accomplished by single research disciplines on their own.

7.4 Academic Classification of the Publication

The research paper "Building a Better World through Information Systems – An Explorative Survey among Leading IS Researchers" was written together with André Koukal and Michael H. Breitner, see Rickenberg et al. (2014) and Appendix 14. The paper was accepted after a double-blind peer review (associate editor and two full reviews) with one revision at the International Conference on Information Systems (ICIS) 2014 in the conference theme track "Building a Better World through IS".

The ICIS is the most prestigious IS conference worldwide and the major annual meeting of the Association for Information Systems (AIS) (ICIS, 2014). With more than 1,000 participants from all around the world, the ICIS as the AIS flagship conference is the most respected gathering of academics and practitioners in the IS discipline (ICIS, 2014). Due to its competitive and renowned character, the conference usually has a low acceptance rate between 25 to 30% (2010: 30%, 2011: 30%, 2012: 29%, 2013: 26%, 2014: 27%, see AIS Electronic Library). According to the German Academic Association for Business Research (VHB), the conference proceedings are ranked in category "A" for the WI/IS research domain and "A" for the VHB JOURQUAL 2.1 (WKWI, 2008; Schrader and Hennig-Thurau, 2009).

PART C: DECISION SUPPORT SYSTEMS

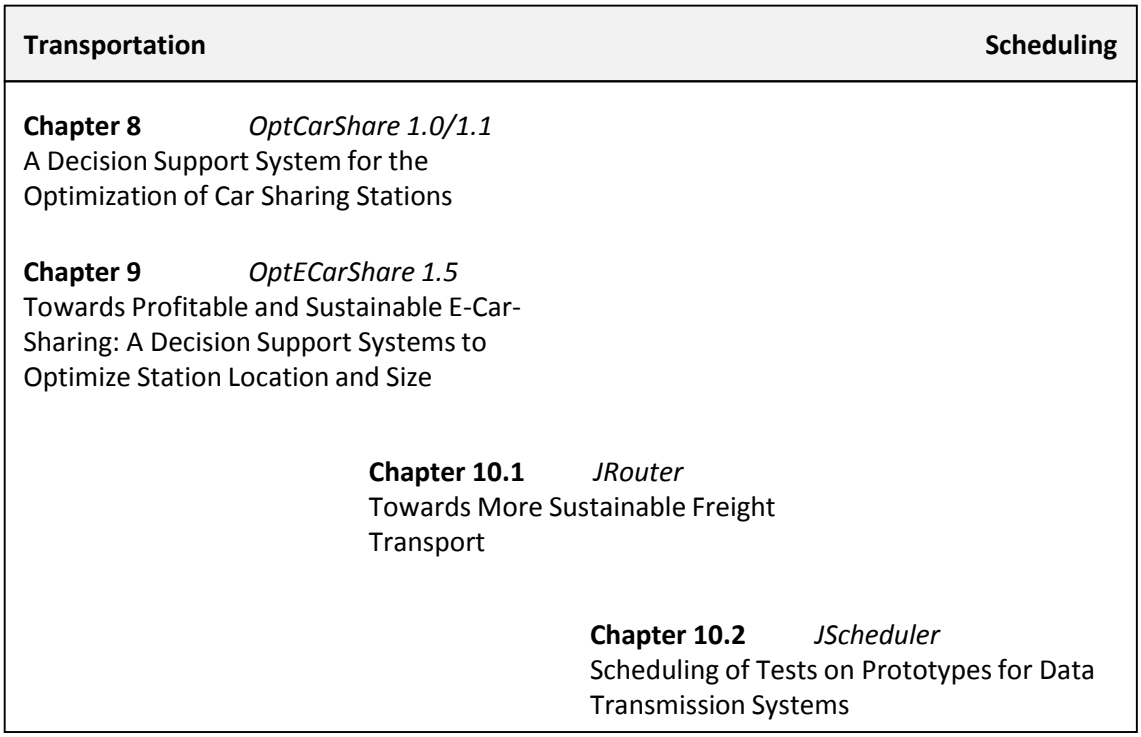


Figure 20: Structure of Part C: Decision Support Systems.

A Primer to Decision Support Systems

DSS can be defined as “computer technology solutions that can be used to support complex decision making and problem solving” (Shim et al., 2002). The idea of DSS evolved in the early 1970s as “interactive computer based systems, which help decision makers utilize data and models to solve unstructured problems” (Sprague, 1980). Around 1980, when this concept was on the rise, it was classified between being a big breakthrough or as just another buzz word (Sprague, 1980). Since then, DSS technology and applications have evolved significantly (Shim et al., 2002) and DSS are fully established and are an important part of (IS) research and practice.

Model-driven DSS employ “algebraic, decision analytic, financial, simulation, and optimization models” to enable decision support (Power and Sharda, 2007). Based on the definition of quantitative models and an algorithmic solution procedure, model-driven DSS allow the user to manipulate model parameters and perform sensitivity analysis (Power and Sharda, 2007). Graphical visualizations that display results in easy to use format can increase the usability of the system and the analysis of possible solutions, which can further improve decision making.

This part of the thesis focusses on optimization-based decision support (Shim et al., 2002) and includes three chapters, see Figure 20 for the structure of Part C. Model-driven DSS are in need of additional research (Power and Sharda, 2007). To determine the prime location and size of car sharing stations, the DSS OptCarShare 1.0/1.1 uses exact algorithms to solve the underlying optimization model and integrates several applications to import, edit, and export data, and visualize optimization results, see chapter 8. Based on this and in order to further increase the sustainability and profitability of car sharing, the refined optimization model and the DSS OptECarShare 1.5 integrate electric cars and the company’s revenue into the optimization, see chapter 9. Chapter 10 briefly presents examples of DSS for further application domains. The DSS JRouter employs heuristic and exact solution procedures to increase the sustainability of freight transport through increased use of intermodal transport and a reduction of energy consumption and emissions, see chapter 10.1. Finally, the DSS JScheduler uses heuristic procedures to solve a formal model and provide decision support for the scheduling of tests on functional prototypes, see chapter 10.2.

8. A Decision Support System for the Optimization of Car Sharing Stations

8.1 Motivation and Research Topic

The majority of the world's population is living in cities (Buhaug and Urdal, 2013) and it continues to grow (Shaheen and Cohen, 2013). It is projected that by 2050, two in every three persons will live in urban areas and that the world's urban population increases by more than 3 billion people (UN, 2010; Buhaug and Urdal, 2013). Next to urbanization, shortage of space, and increasing traffic congestion, further factors like scarce natural resources, rising energy costs, and environmental pollution require populations to rethink personal vehicle ownership. Aside from public transportation, car sharing is an alternative to address these issues. This concept is becoming a mainstream transportation solution with more than a million users in over 26 countries (Shaheen and Cohen, 2013). By sharing a vehicle sequentially, individuals, especially young adults, are able to satisfy their basic needs for mobility without owning a car. The location and accessibility of car sharing stations is a CSF. However, positioning and sizing of stations in order to design an efficient transport network is challenging.

Sustainability and Green IS are becoming major topics within the IS research domain (Dedrick, 2010). While heavy use of IT is a factor of higher energy consumption and emission of greenhouse gases (Butler, 2011), intelligent utilization of IS can contribute to higher sustainability. Through an interaction of IT and people, Green IS enables the optimization of processes and products to raise resource efficiency. Thus, direct and indirect conservation of resources and higher sustainability can be achieved. Car sharing itself is a sustainable mobility concept (Duncan, 2011; Firnkorn and Müller, 2011; Nobis, 2006). Within existing literature, little methodological support for car sharing is available. The optimal location and size of stations lack thorough and quantitative investigation. We provide decision support for planning stations optimally by determining the prime location and size. We formulate an optimization model and construct a DSS, evaluate the applicability of the artifacts, and examine the impact of certain parameters on the results for two different major cities. We pursue the RQ: *How can the optimal location and size of car sharing stations be determined and decision support be provided?*

This chapter is largely based on Rickenberg et al. (2013a), see Appendix 7.

8.2 Theoretical Foundations

Important new topics have come into focus of IS research, when Watson et al. (2010) called for more attention to energy informatics, eco-friendliness, and sustainability. Initially, resource-saving information technology was the main topic of research in Green IT (Dedrick, 2010). However, the actual use of IS is to broaden the scope and potential of environmental sustainability. Many researchers now established frameworks or provided guidelines, principles, and criteria to support and improve the research and implementation of Green IS (e.g. Boudreau et al., 2008; Elliot, 2011; Loos et al., 2011; Malhotra et al., 2013; Melville, 2010; Seidel et al., 2013). By employing information and communication technology, Green IS enables direct and indirect resource conservation and thus increases environmental sustainability. Sustainability is divided in three components: social equity, economic efficiency, and ecologic awareness, while Green IS focusses on the economic and ecologic dimension (Kossahl et al., 2012).

The concept of car sharing emerged in Switzerland in 1948 (Shaheen et al., 1998), when a small private community had the basic idea to share cars and thus split ownership costs. First successful car sharing organizations were founded in Germany and Switzerland (Katzev, 2003; Shaheen et al., 2006) and car sharing has become more popular with a rising number of users. With strong growth especially in Europe and North America, the demand for alternative mobile services exists primarily in industrial countries (Shaheen and Cohen, 2007). Car sharing is defined as a mobility service which offers consumers the use of vehicles in an organized and collaborative manner. Before a car sharing vehicle can be used, the consumer has to register at a car sharing organization. A contract between the consumer and the car sharing organization will facilitate convenient use. A desired vehicle from the fleet is reserved for a specific period, retrieved at a specific location, and parked again after the use. The consumer can reserve and use a vehicle at any time of the day and pays for the rented time and driven distance. In most cases, the car is used for short trips within a city. By utilizing car sharing, fewer vehicles are needed to satisfy the same transport demand, however, car sharing can only be integrated in areas where people do not strongly depend on cars (Celsor and Millard-Ball, 2007). Further details about car sharing and its different concepts can be found in specialized literature, such as Barth and Shaheen (2002), Stillwater et al. (2009), and a recent literature review of Degirmenci and Breitner (2014).

8.3 Research Design and Methodology

To address relevance and enhance rigor of the research process and outcome, our research was conducted using the DSR principles. The design and evaluation of artifacts that can promote ecological and sustainable action was our main objective. We used recommendations provided by Hevner et al. (2004, 2007) and March and Smith (1995). The research process was advised by Peffers et al. (2007) and Offermann et al. (2009).

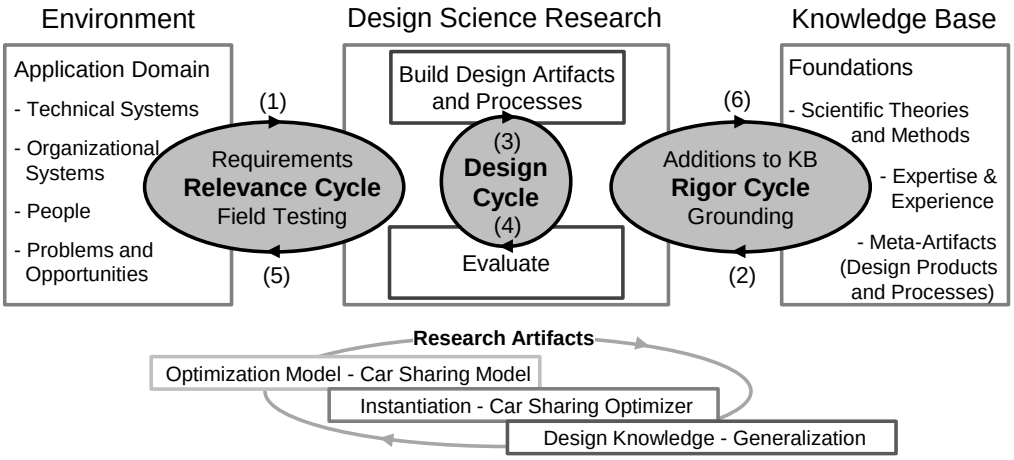


Figure 21: Research Design According to DSR, (Hevner, 2007) and Rickenberg et al. (2013a).

The actual research design is depicted in Figure 21 with the three DSR cycles. The research process was initiated by the relevance cycle (1) and the growing interest of society concerning sustainable mobility. A cooperation with a major German car sharing company allowed us to identify the optimization of car sharing stations as a challenging problem. To ensure methodological rigor, foundational information must be gathered from the scientific knowledge base (2). We gathered and analyzed knowledge for ideas and state-of-the-art within a comprehensive literature review. We drew from descriptive and propositional knowledge as well as prescriptive knowledge from the IS and DSR domain, the car sharing community, and the OR domain (Gregor and Hevner, 2013). The practical input and the scientific grounding are used in the design cycle to build (3), evaluate (4), and refine artifacts in a tight loop with rapid interactions. We constructed a basic car sharing model as first research artifact, which was then refined with extra parameters, variables, and constraints within an iterative approach. We further implemented a DSS as an instantiation and created realistic input for the cities of Hannover and Zürich. The illustrative examples allowed extensive tests of the artifacts (5) and a proof-of-concept demonstration of their applicability within real-world contexts. A contribution to the knowledge base and publication of results complete the DSR cycles (6).

8.4 Summary of the Results and Limitations

8.4.1 Optimization Model and Decision Support System

In order to find the best location and size of car sharing stations, the model minimizes the total cost while satisfying consumer demand and preferences. The model is subject to the following assumptions: Total demand is stochastic and modeled by a normal distribution. The demand is represented on a punctual basis and aggregated in specific demand locations within a city. Car sharing cars have to be parked at designated stations. Each car occupies one of the parking lots of a station. Further, the car sharing organization uses one type of vehicle. In addition to location, number, and size of stations, the maximum distance to a station is an important determinant which is calculated using geographic coordinates. The optimal balance between number and size of stations has to be determined. Population density of different areas represents a major factor due to its impact on the utilization of car sharing (Millard-Ball et al., 2005). The resulting mathematical problem can be formulated as follows in Figure 22:

$$(1) \quad Min. \;\; F(f,y) = \sum_{i=1}^{m} \left[f_i(kf + ka) + y_i \cdot ks \right]$$

$$(2) \quad d_{ij} \cdot z_{ij} \leq maxd \quad \forall \; i = 1,...,m \;\text{ and }\; j = 1,...,n$$

$$(3) \quad \sum_{i=1}^{m} z_{ij} = 1 \quad \forall \; j = 1,...,n$$

$$(4) \quad y_i \geq z_{ij} \quad \forall \; i = 1,...,m \;\text{ and }\; j = 1,...,n$$

$$(5) \quad f_i \cdot kp \geq \sum_{j=1}^{n} n_j \cdot z_{ij} \quad \forall \; i = 1,...,m$$

$$(6) \quad f_i \leq maxp_i \quad \forall \; i = 1,...,m$$

$$(7) \quad y_i \, v_i \leq a \quad \forall \; i = 1,...,m$$

$$(8) \quad w_i \geq minb \; y_i \; \forall \; i = 1,...,m$$

$$(9) \quad z_{ij};\; y_i \in \{0,1\} \quad \forall \; i = 1,...,m \;\text{ and }\; j = 1,...,n$$

$$(10) \quad f_i \geq 0 \quad \forall \; i = 1,...,m$$

i = potential station locations (i = 1,…, m);
j = demand location (j = 1,…, n);

ks = costs for a station;
ka = costs for a parking lot;
kf = costs for a vehicle;

$\mathbf{n_j}$ = normal distributed demand;
kp = customer parameter: number of customers who can be served by one vehicle a day;

a = default shortage of parking;
$\mathbf{v_i}$ = actual shortage of parking;
minb = default population density;
$\mathbf{w_i}$ = actual population density;
maxd = max. distance btwn demand point and station;
$\mathbf{d_{ij}}$ = actual distance between i and j;
$\mathbf{maxp_i}$ = maximum number of parking lots;

$\mathbf{f_i}$ = actual number of parking lots and cars;
$\mathbf{z_{ij}}$ = 1 if demand point j is served by station i, else 0;
$\mathbf{y_i}$ = 1 if station i is built, else 0.

$\mathbf{v_i}$ = free parking lots around station **i** / registered vehicles around station **i** * 100 [%]
$\mathbf{w_i}$ = population at station **i** / area at station **i**

Figure 22: Optimization Model, Based on Rickenberg et al. (2013a) and Olivotti et al. (2014).

Total cost, comprising the annual fees for renting vehicles and parking lots, plus annual costs to maintain stations, is minimized by the objective function (1). The distance between a demand point and a car sharing station cannot exceed a maximum distance (2). Each demand point is served by one car sharing station (3). A demand point can only be assigned to a station if it is built (4). Total demand needs to be satisfied (5). The model includes four threshold values (a, minb, maxd, $maxp_i$) plus four variables for

the actual values of the items (v_i, w_i, d_{ij}, f_i). A station cannot provide space for more vehicles than there are allotted (6). The actual shortage of parking cannot be bigger than the default shortage of parking (7). A minimum level of population density within each area needs to be reached (8). Equations (9) and (10) constitute the value range of the decision variables f_i, y_i, z_{ij}.

The DSS integrates the optimization model and several applications within one system to enable decision support. The OptCarShare 1.1 web application, underlying model, and sample data pools are available via open access at: www.iwi.uni-hannover.de/CarSharing. The system architecture, data flow and the Graphical User Interface (GUI) of the DSS with data, parameters, and functions can be seen from Figure 23:

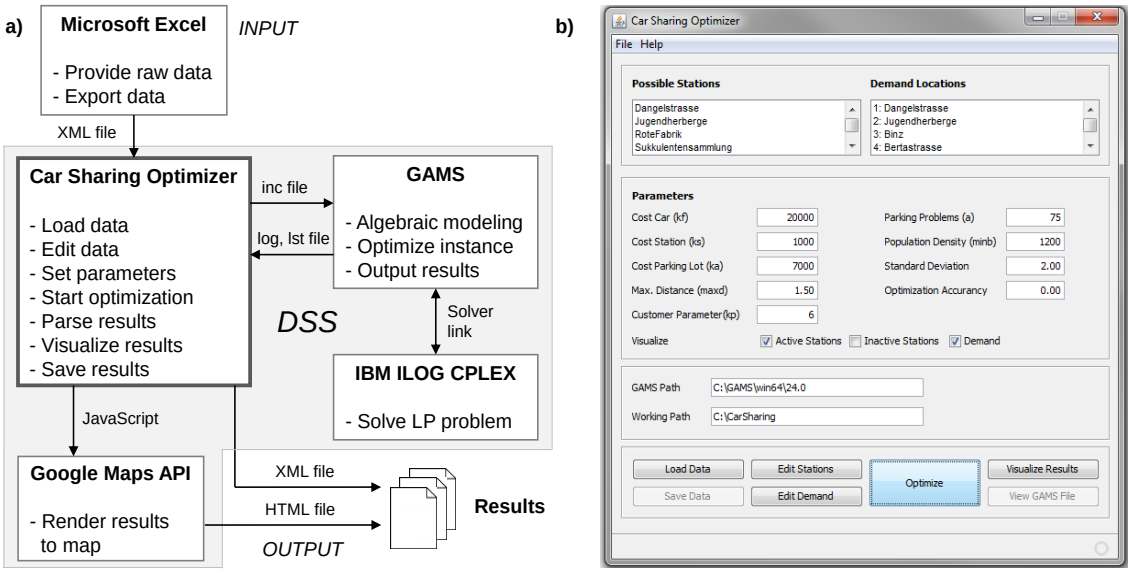


Figure 23: **(a) System Architecture and Data Flow, (b) GUI with Data, Parameters, Functions, Based on Rickenberg et al. (2013a) and Olivotti et al. (2014).**

Raw data about stations and demand can be kept in a spread sheet and be exported to an XML file. When data is loaded from an XML file into the DSS, the GUI shows and allows editing of data and parameter configuration. When the optimization process is triggered, information is sent to the General Algebraic Modeling System (GAMS) which provides the mathematical modeling. IBM ILOG CPLEX solves the underlying mixed integer programming model numerically while the optimization progress is presented on screen. Once the optimal solution is found, results can be visualized and saved to a file. Mashup technologies (Google Maps API) are used for the visualization of results to enable instant graphical validation.

8.4.2 Optimization and Evaluation of Car Sharing in Hannover

To show the applicability of our research artifacts, the DSS and the underlying model are validated in application examples. With varying parameters, optimal locations and sizes for car sharing stations are exemplified by the German city of Hannover, as presented below, and the Swiss city of Zürich, as presented in the next sub chapter.

Hannover has an appropriate size (about 500,000 people), population density, and public transportation to allow car sharing. The data set includes 100 potential stations and 30 demand locations with geographic information. For each potential station, the shortage of parking (v_i) and population density around the station (w_i), and the maximum number of parking lots ($maxp_i$) are contained within the data set. Each demand location specifies the expected value of customer demand (n_j) within the area. The setting of independent variables (kf, ks, ka, maxd, kp, a, minb) is depicted in Figure 23b. The maximum distance between a station and a demand point is a critical determinant and is initially set to 1km. While Katzev (2003) states that car sharing is mainly used by people living no more than 10.75 minutes by foot to a station, Stillwater et al. (2009) name 400 meters as an appropriate value. Due to divergent statements in academic literature, the setting is varied between 0.3 and 2.0 [km]. The customer parameter describes the number of customers that can be served by one vehicle a day and is varied between 1 and 8. Low values imply that consumers use vehicles for a greater amount of time, while high values indicate that vehicles are used for shorter amounts of time. The parameters for shortage of parking and population density are set to realistic values for this area. The benchmarks are carried out on a notebook (Intel i7 2.67 GHz CPU, 4 GByte RAM) using GAMS 23.6.5 and CPLEX 12.2.0.2 with an optimization gap of 5%.

The results of the optimization are shown in Figure 24 with a) numerical results and b) a graphical representation for one specific instance. Depending on the available capital and the main objectives of the car sharing company, one of the presented alternatives can be chosen. While column ‘s’ represents the number of stations to be built and column ‘#’ stands for the total amount of vehicles, the resulting costs and computing time are also indicated for each alternative. The optimal amount of stations and vehicles heavily depends on the set of parameters maxd and kp. For low values of kp, the total customer demand cannot be satisfied due to the limited number of parking lots; thus no

feasible solution can be found. Concerning the maximum distance to a station (maxd), no feasible solution can be found for values lower than 0.3 because some demand points are not close enough to a station. Further, the lower the value of kp, the more cars are required because fewer customers can satisfy their need for mobility with the same car sequentially. Because each station has a maximum number of parking lots and cars, more stations are needed. As the value of maxd falls, the demand for stations rises in order to guarantee a short distance between a demand location and a station. Total cost falls with higher values of maxd and kp because less stations and cars are needed. Since the costs of a car are higher than of a station, total cost rather depends on kp than on maxd. The computation time heavily depends on the settings of the parameters. To validate results, visualizations using Google Maps can be generated instantly by the DSS.

a)

	maxd=0.30				maxd=0.50				maxd=0.75				maxd=1.00			
	s	#	costs [€]	t [s]	s	#	costs [€]	t [s]	s	#	costs [€]	t [s]	s	#	costs [€]	t [s]
kp=1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
kp=2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
kp=3	24	55	1509000	0.33	16	48	1312000	0.32	13	48	1309000	0.97	12	46	1254000	0.78
kp=4	21	44	1209000	0.34	13	36	985000	0.40	13	35	958000	0.99	12	34	930000	42.12
kp=5	25	40	1024000	0.31	13	31	850000	0.57	9	28	765000	1.78	8	27	737000	0.90
kp=6	25	36	916000	0.36	12	26	714000	2.82	10	24	658000	0.46	7	23	628000	1.89
kp=7	23	30	806000	0.41	12	23	633000	1.25	10	20	550000	0.48	6	20	546000	1000.00
kp=8	22	27	751000	0.33	12	21	579000	1.53	8	18	494000	0.92	6	17	465000	2.21

	maxd = 1.25				maxd = 1.50				maxd = 1.75				maxd = 2.00			
	s	#	costs [€]	t [s]	s	#	costs [€]	t [s]	s	#	costs [€]	t [s]	s	#	costs [€]	t [s]
kp=1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
kp=2	---	---	---	---	---	---	---	---	15	69	1878000	1.71	15	69	1878000	1.41
kp=3	11	45	1226000	1.29	11	45	1226000	16.47	10	45	1225000	4.11	10	45	1225000	2.86
kp=4	9	34	927000	1.50	8	34	926000	1.39	8	34	926000	2.43	7	34	925000	1.13
kp=5	8	27	737000	0.95	8	27	737000	2.26	6	27	735000	1.76	8	27	737000	2.37
kp=6	6	22	600000	980.29	6	23	627000	1000.00	5	22	599000	69.86	5	22	599000	71.29
kp=7	6	19	519000	22.25	5	19	518000	3.29	6	19	519000	1.36	4	19	517000	3.87
kp=8	7	17	466000	1.15	5	17	464000	1.3	5	17	464000	1.19	6	17	465000	0.69

b)

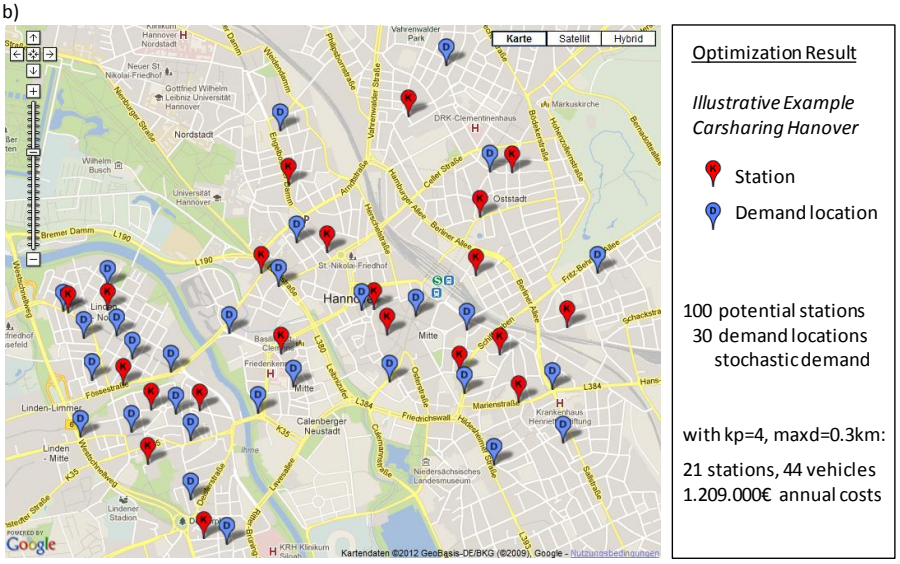


Figure 24: **Benchmark Results for Hannover with a) Numerical Results and b) Visualization, Based on Rickenberg et al. (2013a).**

8.4.3 Optimization of Car Sharing in Zürich and Generalized Relationships

For further evaluation, Zürich serves as an illustrative example. With approximately 400,000 inhabitants in the urban core and significantly more within the metropolitan area, Zürich has an appropriate size to serve as an example. Next to its size, the structure of the city and the existence of a well-developed public transport network enable car sharing. Zürich is also known for high-quality living and high purchasing power. Data about potential station locations and demand locations is used as main input source. A network with 50 demand points and different patterns of demand (low, medium, high) were created. Demand points as well as possible stations were positioned near public transport stations because sufficient demand is assumed to be prevalent there. Geographic coordinates of the demand points were collected and demand was estimated based on various sources and statistics (composition and size of population, location, etc.). Concerning potential station locations, two networks (N100, N200) were constructed. The first network includes 200 stations and the second one is reduced to 100 potential stations. For each potential station, the geographic coordinates, population density, maximum number of parking lots, and parking situation were set.

The impact of certain parameters on the optimization results is analyzed: distance to a station, the number of persons that are able to share a vehicle a day, different patterns of demand, cost parameters, network density, and computational complexity, see Olivotti et al. (2014). Based on the benchmarks, relationships between the optimization variables and parameters were generalized to create knowledge descriptions at an abstract level (Gregor and Hevner, 2013). For a model to optimize car sharing stations in location and size, which minimizes total cost for a given demand, the following findings can be abstracted, see Figure 25. The distance to a station, customer parameter, and total demand heavily influence the number of stations and cars. The price parameters (ks, ks, kf) have less impact on the number of stations and cars, since the demand must be satisfied. The runtime correlates positively with maxd and negatively with the gap.

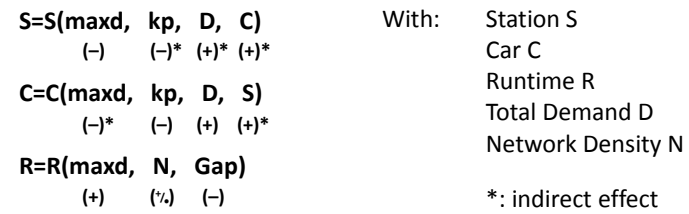


Figure 25: Generalized Relationships, Based on Olivotti et al. (2014).

8.4.4 Limitations and Implications

With regard to our research artifacts, we were able to identify certain limitations, especially concerning the evaluation, objective function, free floating and one way trips, and demand function. We evaluated the research artifacts within two business contexts, however, our optimization model and DSS should be evaluated for other cities. As stated by Arnott and Pervan (2012), the goal of DSR is that practitioners adopt the optimization model and DSS. Yet, only 13.5 percent of DSS DSR artifacts are evaluated in the field (Arnott and Pervan, 2012). Deeper empirical evaluation in the field by car sharing experts will help to increase rigor and generalizability for our approach.

Concerning the objective function, the model does not seek to maximize the profit but to minimize total cost while satisfying stochastic user demand. While most companies aim to maximize profit, in case of car sharing, however, organizations may have alternative goals, such as reputation, sustainability, and gaining experience for future application. Some companies do not seek to maximize income from car sharing in the short run. After successful penetration of the market, the maximization of profit can come into focus. We therefore currently construct a model that aims to maximize profit.

Further, the optimization model does not allow free-floating or one way trips explicitly. While for most car sharing organizations, free-floating or one way trips are not needed, several use the free floating concept and few allow one way trips. In our current research, we aim to combine station-based and free floating concepts within one integrative approach and model. We further examine one way trips in the context of station-based car sharing, which includes the challenge of returning vehicles to different stations and the resulting relocation effort.

We modeled a stochastic but discrete demand on a punctual basis which is time-invariant. The total demand does not have a continuous character but is concentrated at certain points within a city. Within the examples, we recognized that a discrete representation is adequate but that the number of demand locations needs to be high enough. An advantage of discrete modeling is that surveys can be used to determine customer demand at these spots. Further, the demand should be refined to a time-variant function. This includes to take peaks and off-peaks into account and consider different demand patterns for different times of the day.

While we are currently working on the above mentioned aspects, the model could be refined in certain aspects by adding extra variables and constraints. For instance, different price levels for parking lots in different city districts or different types of cars can be integrated. A variable for the individual preference of potential stations and soft factors could provide further utility for planners. In future research, we also intend to investigate the visibility of stations, prosperity in various districts, different types of parking lots (private vs. public), and cooperation with public transportation.

Practical and theoretical implications result from the research artifacts and findings. With regard to theoretical implications, the OR and IS research community now has an initial mathematical model to determine the optimal location and size of car sharing stations. The optimization model can be used as foundation for other research dealing with similar optimization problems. Researchers can gather the model from the academic knowledge base, adopt, and apply or refine it for a specific task. For instance, the sustainability of car sharing can be increased by integrating all-electric cars. The optimization model represents a starting point to optimize electric car sharing stations; however, adjustments of the model are required. Concerning the economic and ecologic sustainability, theoretical and practical implications can be drawn. Researchers and car sharing experts can use our quantitative approach to evaluate and increase the sustainability of car sharing. From an academic point of view, we state that Green DSS is an important subfield of Green IS and we provide an example of an actual Green DSS. Our model and DSS aim to increase the sustainability of individual mobility in cities. In practical terms, cities that experience ecological issues due to increased traffic can use our DSS to plan a car sharing network. Our DSS enables faster and better decision making. To address changing variability, managers and planners can use our system to run through different scenarios by setting parameters, e.g. cost structure or customer demand, and visualize optimization results instantly with the DSS.

8.5 Conclusions and Outlook

Important issues concerning car sharing, sustainable mobility, and Green IS are in need of further research. Traffic problems in cities and urban areas, such as congestion and pollution, will be a challenge for the near future. To address these issues and to

enable successful car sharing, we provide decision support for the complex task of planning a network of car sharing stations. Within design-oriented research, we constructed and evaluated research artifacts – an optimization model and the DSS OptCarShare. We checked and demonstrated the applicability of the DSS and the underlying optimization model in two representative examples with varying parameters. The DSS as a Green IS optimizes car sharing and thus contributes to environmental sustainability.

Based on the presented model, we are currently investigating the optimization of all-electric car sharing stations, the maximization of profit, and time-variant demand functions (Kühne et al., 2014, Appendix 15; Kühne et al., 2015, Appendix 17), as well as the integration of one way trips in the context of station-based car sharing.

8.6 Academic Classification of the Publication

The research paper "A Decision Support System for the Optimization of Car Sharing Stations" was developed together with Andreas Gebhardt and Michael H. Breitner, see Rickenberg et al. (2013a) and Appendix 7. The paper was accepted after a double-blind peer review (associate editor, three reviews) without revision (four times definite accept) at the 21st European Conference on Information Systems in the track "Green IS". It was presented at ECIS in June 2013, which had 530 participants (ECIS, 2013).

The ECIS is the premier IS event in the European region (ECIS, 2012). It is the largest and most prestigious conference on IS in AIS region 2 (ECIS, 2010) and is seen as the European counterpart of the ICIS. Recent acceptance rates have been roughly 30% range (ECIS, 2012): 2012: 29%, 2013: 32%, 2014: 34%, see also Galliers et al. (2012) and conference programs books. The paper has been published in the proceedings of the 21st ECIS, which are ranked in category "A" for the WI/IS research domain and "B" for the VHB JOURQUAL 2.1 of the VHB (WKWI, 2008; Schrader and Hennig-Thurau, 2009).

An advanced version of the ECIS paper with the title "Car Sharing in Zürich – Optimization and Evaluation of Station Location and Size" was submitted to the Multikonferenz Wirtschaftsinformatik (MKWI) 2014 and accepted after a double-blind peer review (two reviews) without mandatory changes, see Appendix 11. According to the VHB ranking, the proceedings are ranked in category "C" for the WI/IS research domain and "D" for the VHB JOURQUAL 2.1 (WKWI, 2008; Schrader and Hennig-Thurau, 2009).

9. Towards More Sustainable and Profitable Car Sharing: A Decision Support System to Optimize Stations for Electric Vehicles

9.1 Motivation and Research Methodology

Certain factors require populations to rethink personal car ownership (Rickenberg et al., 2013a). Important and decisive factors are rising energy and ownership costs, environmental pollution, and urbanization which causes shortage of space and increasing traffic congestion. Further, the public awareness of environmental sustainability is growing (Dedrick, 2010) and increasing importance of corporate social responsibility causes people to re-think car usage and employ transportation alternatives (Shaheen and Cohen, 2013). Besides other means of public transport, the concept of car sharing has thus become a mainstream way of travelling, with more than one million users worldwide and the number of users is growing exponentially (Rickenberg et al., 2013a; Shaheen and Cohen, 2013). It enables users to satisfy their mobility needs without owning a car by paying trip-dependent fees. To reach the largest amount of potential users as possible, the challenging task of positioning and sizing of car sharing stations is a CSF (Rickenberg et al., 2013a).

Even though car sharing is an essential concept to increase sustainability of individual mobility, existing literature gives little methodological support in the context of Green IS. Based on our previous research (Rickenberg et al., 2013a; Olivotti et al., 2014; Kühne et al., 2014), we refine an existing optimization model and a DSS with regard to three main aspects. We employ electric cars instead of conventional cars with combustion engines to further increase the environmental sustainability of car sharing. Therefore, numerous parameters and variables have been integrated in the model. Further, the objective of the optimization model is now to maximize the profit instead of minimizing total cost, which aims to increase the profitability of car sharing. Instead of a time-invariant demand, the customer demand is now modeled with six distinct time windows to describe the alternating user behavior within a day. To refine the artifacts, DSR was used according to recommendations of Hevner et al. (2004, 2007) and Peffers et al. (2007). Accordingly, the paper pursues the RQ: *How can a decision support system be provided to optimize car sharing stations for electric vehicles and maximize profit?*

This chapter is largely based on Kühne et al. (2015), see Appendix 17.

9.2 Summary of Results and Limitations

9.2.1 Refined Optimization Model and Decision Support System

The refined optimization model aims to find the best distribution of stations and cars of a two-way electric car sharing fleet while maximizing the net profit over the time horizon of a year. Each vehicle occupies one dedicated parking lot at a specific station, where the vehicle has to be returned to after finishing the trip. The fleet of electric vehicles is homogeneous, however, the trip-dependent loading cycles can be conducted via standard chargers or via more efficient fast chargers. Candidate stations and demand locations are set on a punctual basis with geographic coordinates. Customer demand is served completely and is modeled stochastically with a normal distribution. It is time-dependent based on six time windows within a day. A maximum distance between demand and supply has to be met as well as a minimum population density and a maximum shortage of parking. The mathematical problem and notation is specified as follows:

$$Max.F(vreg, vfast, y) = \overbrace{\sum_{j=1}^{n} d_j * (min * rev)}^{revenue} - \overbrace{\sum_{j=1}^{n} d_j * (trip * energy * price)}^{variable\ costs} - \overbrace{\sum_{i=1}^{m} (vreg_i * (lv + ll + lireg) + vfast_i * (lv + ll + lifast) + y_i * ls)}^{leasing\ costs} \quad (1)$$

$$\sum_{i=1}^{m} z_{ij} = 1 \quad \forall j = 1, \dots, m \quad (2)$$

$$y_i \geq z_{ij} \quad \forall i = 1, \dots, m \text{ and } j = 1, \dots, n \quad (3)$$

$$u * (vreg_i * xreg + vfast_i * xfast) \geq \sum_{j=1}^{n} dmax * z_{ij} \quad \forall i = 1, \dots, m \quad (4)$$

$$vreg_i + vfast_i \leq maxl_i \quad \forall i = 1, \dots, m \quad (5)$$

$$vfast_i \leq maxlfast \quad \forall i = 1, \dots, m \quad (6)$$

$$dist_{ij} * z_{ij} \leq maxdist \quad \forall i = 1, \dots, m \text{ and } j = 1, \dots, n \quad (7)$$

$$sp_i * y_i \leq maxsp \quad \forall i = 1, \dots, m \quad (8)$$

$$pd_i \geq minpd * y_i \quad \forall i = 1, \dots, m \quad (9)$$

$$xreg = \frac{duration\ of\ a\ period}{duration\ of\ a\ trip} * \left(1 + \frac{maximum\ charging\ time\ regular * average\ speed\ of\ a\ trip}{maximum\ range\ of\ a\ trip}\right)^{-1} \quad (10)$$

$$xfast = \frac{duration\ of\ a\ period}{duration\ of\ a\ trip} * \left(1 + \frac{maximum\ charging\ time\ fast * average\ speed\ of\ a\ trip}{maximum\ range\ of\ a\ trip}\right)^{-1} \quad (11)$$

$$sp_i = \frac{average\ free\ parking\ lots\ aroud\ station\ i}{registered\ vehicles\ around\ station\ i} * 100\% \quad (12)$$

$$pd_i = \frac{population\ at\ station\ i}{area\ at\ station\ i} \quad (13)$$

$$y_i \in \{0, 1\} \quad \forall i = 1, \dots, m \quad (14)$$

$$z_{ij} \in \{0, 1\} \quad \forall i = 1, \dots, m \text{ and } j = 1, \dots, n \quad (15)$$

$$vreg_i, vfast_i \geq 0 \quad \forall i = 1, \dots, m \quad (16)$$

Figure 26: Optimization Model for Electric Car Sharing, Based on Kühne et al. (2015).

$i = \{1, \dots, m\}$: *potential station location* $j = \{1, \dots, n\}$: *demand location*

d_j: *normal distributed demand* min: *expected duration of rent*
rev: *revenue per minute renting* $trip$: *expected distance driven*
$energy$: *avergae energy consumption per km* $price$: *price per kwh*

lv: *leasing cost of a vehicle* ll: *leasing cost of a parking lot*
$lireg$: *leasing cost for charging infrastructure regular* $lifast$: *leasing cost for fast chargers*
ls: *leasing cost of a station*

u: *average utilization of supplied vehicles* $dmax$: *demand of most used interval*
$xreg$: *possible trips regular* $xfast$: *possible trips fast*

$maxl_i$: *maximum number of possible parking lots at station i*
$maxlfast$: *maximum number of possible parking lots with fast charger*
$dist_{ij}$: *distance between station i and demand location j*
$maxdist$: *maximum distance between station i and demand location j*

sp_i: *shortage of parking at station i* $maxsp$: *general shortage of parking*
pd_i: *population density at station i* $minpd$: *minimum population density*

$vreg_i$: *actual number of vehicles resp. parking lots at station i*
$vfast_i$: *actual number of vehicles resp. parking lots with fast charging infrastructure at station i*

$z_{ij}: \begin{cases} 1, & \text{if demand location } j \text{ is served by station } i \\ 0, & \text{else} \end{cases}$ $y_i: \begin{cases} 1, & \text{if station } i \text{ is bulit} \\ 0, & \text{else} \end{cases}$

Figure 27: Notation of the Optimization Model, Based on Kühne et al. (2015).

The objective function (1) maximizes the net profit of a car sharing company by calculating the trip-dependent revenue and subtracting the costs on a yearly base. This includes variable parts in form of costs for trip-dependent energy consumption and fix parts in form of annual leasing costs for vehicles, parking lots, and charging infrastructure. To avoid redundancy, every demand location is served by exactly one car sharing station (2). Constraint (3) ensures that every demand point can only be assigned to a station that is built. The existing demand has to be fulfilled while taking into account the utilization and electric power limitations by constraint (4). Every station has a certain limit of parking space for vehicles (5), while (6) sets a maximum amount of fast chargers at the stations. Constraint (7) ensures that a maximum distance between a demand location and a station is not exceeded. The shortage of parking at each station must satisfy a certain threshold value (8) and a certain level of population density has to be reached (9). Equations (10), (11), (12), and (13) are required to calculate parameters: (10) and (11) determine the amount of feasible trips per period, considering the individual trip times and resulting charging times, with (10) used for regular charging and (11) for the use of 50kW DC fast chargers. The local shortage of parking is calculated via (12) and equation (13) then determines the population density at each individual station. Equations (14), (15), and (16) set the specific value range of the decision variables.

The DSS OptECarShare 1.5 was refined to optimize electric car sharing and employs the optimization model and several applications within one system to enable decision support. The GUI of the DSS can be seen subsequently from Figure 28:

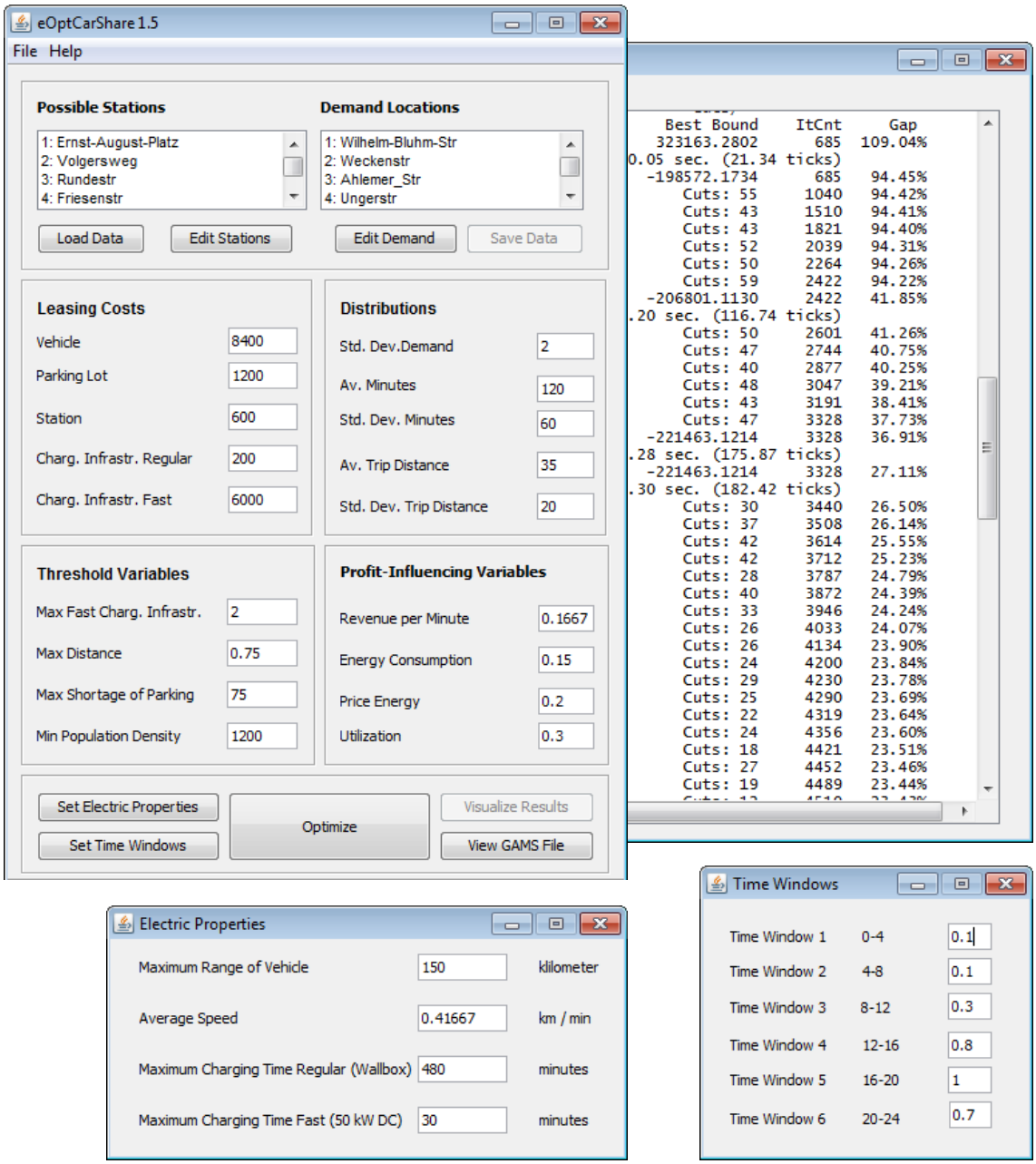


Figure 28: Graphical User Interface of the DSS OptECarShare 1.5.

9.2.2 Optimization and Evaluation of Electric Car Sharing in Hannover

The applicability and feasibility of the developed research artifacts are tested and exemplified again in the illustrative example of the German city of Hannover. The data and configuration applied in this example can be seen from the GUI in Figure 28: The parameters for electric mobility are set to realistic values in accordance with the latest technology. Six distinct time windows are used to describe the alternating user behavior

within a day. The typical distribution of two-way car sharing usage was set in dependence on the experience of our industry partner. Before 12 o'clock the demand is low, but considerably increases in the afternoon, reaching its peak in the evening between 4 pm and 8 pm and then decreases again. The utilization, the cost of fast charging infrastructure, and the maximum distance between stations and demand points are the most important parameters with regard to the optimization results. Figure 29 shows the relationships and effects when varying these parameters. The benchmarks were conducted on a PC (Intel i5 3.3 GHz CPU, 16 GB RAM) using GAMS 24.1.3 and CPLEX 12.5.1 with an optimization gap of 3% and a maximum computing time of 1000 seconds.

		lifast = 2000					lifast = 4000					lifast = 6000					lifast = 8000				
	u	profit	y	vreg	vfast	t [s]	profit	y	vreg	vfast	t [s]	profit	y	vreg	vfast	t [s]	profit	y	vreg	vfast	t [s]
maxdist=0.50	0.1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	0.2	-115705	26	24	45	0.22	-205705	26	24	45	0.22	-293305	25	27	43	0.27	-381305	25	29	42	0.38
	0.3	186294	19	9	32	1.11	122894	18	9	32	1.09	61294	17	12	30	1.92	1294	17	12	30	1.36
	0.4	307294	15	4	26	0.22	255294	15	4	26	0.27	203294	15	4	26	0.27	151294	15	4	26	1.26
	0.5	361694	15	2	23	0.23	315694	15	2	23	0.20	275494	15	3	22	0.27	230094	14	5	21	0.33
maxdist=0.75	0.1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	0.2	-110305	23	26	43	0.86	-200705	24	25	44	0.98	-279905	22	29	41	0.86	-369705	22	28	42	1.20
	0.3	205294	17	6	33	0.67	139294	17	6	33	2.11	75694	16	9	31	14.63	13694	16	9	31	1000
	0.4	310894	15	6	24	2.87	263494	14	6	24	2.71	220694	15	7	25	12.46	175894	13	7	23	59.76
	0.5	387294	11	2	21	0.94	340894	12	1	22	1.78	305694	10	5	19	3.10	267894	13	3	20	7.10
maxdist=1.00	0.1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	0.2	-105505	21	28	41	2.87	-186905	21	28	41	2.06	-267105	20	31	39	2.84	-351505	21	28	40	2.15
	0.3	215094	17	5	33	1.45	149094	17	5	33	3.95	85494	16	8	31	24.85	23494	16	8	31	1000
	0.4	331694	14	4	26	0.76	279894	13	3	25	3.82	235094	14	4	24	5.13	188294	12	4	24	18.89
	0.5	395294	11	0	22	2.65	354494	12	1	21	2.98	318894	11	2	20	0.72	278894	11	2	20	4.03

Figure 29: Benchmark and Optimization Results, Based on Kühne et al. (2015).

The results of the benchmarks are divided into three parts (0.5 km, 0.75 km, 1 km) for the maximum distance between a demand point and the next station, the utilization rate of the cars (10% to 50%), and the yearly costs for a fast charger (2000€, 4000€, 6000€, 8000€). These numbers have been chosen in correspondence with current literature. Katzev (2003) proposes a maximum walking time of 10.75 minutes to a station, which was converted into 1 km. The average utilization rate of car sharing in Germany ranges between 25% and 30% (BCS, 2012). This range has been expanded to 10% to 50% to examine effects at the boundaries of possible utilization rates. Information about fast charging infrastructures has been provided via our cooperation with a German car sharing company. Lower infrastructure costs, which were also examined here, take possible subsidies of the government into account, e.g. to enable sustainable individual mobility.

Certain findings can be derived from the benchmark results. For a utilization rate of 10%, no feasible solution can be found and the optimization terminates with an error. This is due to the satisfaction of the demand, since for u=0.1 more cars are required than parking lots are available. The number of chargers decreases significantly with increasing utilization, since less cars are needed to satisfy customer demand. Further with rising utilization, the profit rises notably. The most significant increase is between 20% and 30% of the utilization rate, which also incorporates the break-even point of the examples above. With increasing costs for fast chargers, more regular chargers are built in order to compensate the higher price. For different costs for fast chargers, the number of stations stays roughly the same with a tendency towards less stations. The shorter the maximum distance to a station, the more stations are built, since certain demand points need to be re-assigned to other stations. The number of vehicles per station alternates without a specific pattern or scheme for both, regular and fast chargers, which can be result of the optimization gap of 3%. Due to this gap, the computing time was usually below four seconds, however, in two cases it went up to 1000 seconds and the calculation stopped automatically due to our GAMS settings. Longer runtimes are possible as this is a strategic problem which does not require re-calculation on a daily basis.

9.2.3 Contributions, Limitations, and Implications

As main contribution, research artifacts have been created, refined, and evaluated to provide decision support for the optimization of location and size of electric car sharing stations. The refined optimization model is based on existing OR models and integrated into a DSS to provide further usability by providing an intuitive interface for managers, planners, and decision makers. Characteristics of a city, here in our example the city of Hannover, can be easily integrated to help planners solve the complex problem of determining locations and sizes of car sharing stations. Results can be found quickly and instances can usually be solved within a few seconds. As car sharing and especially electric car sharing aim for a clean environment with state-of-the-art technology, the optimization model contributes to ecological sustainability. The model and DSS allow car sharing companies to plan their station arrangements in a time-saving, yet optimal manner. This makes the artifacts a part of the Green IS concept, as IS technology is utilized to address environmental issues with a potential worldwide applicability. The DSS incorporates the optimization model, thus, the DSS can be called a Green DSS.

Certain limitations and possible enhancements need to be considered. The evaluation of the model and its applicability has so far only been carried out for the inner city of Hannover. Further test for bigger cities and larger metropolitan areas are required. The model and also the DSS should therefore be applied for other exemplary cities to ensure transferability and generalizability. As advised for DSR, empirical evaluation in the field forms a major part of the relevance cycle and can increase practicality and generalizability of our approach. As in 86,5% of DSS DSR artifacts (Arnott and Pervan, 2012), no complete field trial has been realized here, however, information exchanged within our project with a major German car sharing company gave us important input on how to refine the model. Furthermore, the punctual character of the demand should be questioned critically. Although the stochastic demand is modeled on a discrete basis, the application example shows that the modeling of the demand is adequate, but an increase of demand locations can enhance the model and results. An aspect that can be discussed as a limitation is that the model does not allow free-floating or one-way trips. With regard to the charging cycles of electric vehicles, however, free-floating does not seem applicable or useful. One-way trips are also challenging to implement, because enough charging infrastructure and additional parking lots are required to address imbalances in the car sharing network. One-way trips in station-based car sharing do not appear practical in operative application, since it requires clients to predefine the exact time frames, start and end points of their travel. Thus, we argue, that the proposed two-way model represents an effective way of electric car sharing with today's technology.

Certain refinements can enhance the quality of the model. A promising adjustments concerns the customer demand since it has to be satisfied under all circumstances in the model. A minimum satisfaction of demand of e.g. 95% can address this issue and can increase the profit of the car sharing company. Moreover, a demand point of the model may be assigned to more than one station and a simulation of the demand can bring additional insights. The implementation of multi-mobility-constraints or the creation of timeframes throughout both, the day and the week, in combination with a price-related demand are more examples to elaborate the demand-side of the model. Costs for stations and corresponding parking lots could be amended by choosing more precise values for the respective locations, meaning that a parking lot next to the central station is more expensive than an outer one. Future research should also evaluate the accuracy

concerning the breakdown of the renting time into 2/3 of driving and 1/3 of parking time and may include additional types and sizes of electric vehicles. Soft factors allow to integrate locations with strategic importance e.g. for a desired clientele. On-street instead of off-street parking can increase the visibility of car sharing. Cities can subsidize free parking lots or even free charging infrastructure to promote sustainable mobility.

Several theoretical and practical implications can be derived. From a theoretical point of view, we add a car sharing model for electric vehicles to the knowledge base which can be used, extended, and deployed beyond the application of electric car sharing on similar optimization problems. Practical implications also concern the environment. The research artifacts are a Green IS approach and address sustainability through easy and self-explanatory usage of the DSS. Cities that experience traffic or ecological issues can use the model and DSS to countervail these with the implementation of a car sharing network. Decision support is realized by the visual representation of optimization results, which further facilitates usability and improves opinion forming. This enables the implementation of successful car sharing and a greener future. To conclude, our results based on varying parameters demonstrate the applicability of the optimization model and DSS and indicate that profitable operation of electric car sharing is possible.

9.3 Academic Classification of the Publication

The research paper “Towards Profitable and Sustainable E-Car-Sharing: A Decision Support Systems to Optimize Station Location and Size” was developed together with Kathrin Kühne, Marc Sonneberg, and Michael H. Breitner and submitted to an IS conference, see Kühne et al. (2015) and Appendix 17. The conference proceedings are ranked in category “A” for the WI/IS research domain and “B” for the VHB JOURQUAL 2.1 of the VHB (WKWI, 2008; Schrader and Hennig-Thurau, 2009).

10. Decision Support Systems for Further Application Domains

10.1 Towards More Sustainable Freight Transport

Among other resource-intensive industries, the transportation industry is particularly characterized by high consumption of fossil energy and high emissions. Thus, the logistics sector has the potential, as well as the duty, to contribute to sustainability and environmental protection. Sustainability means to consider economic, environmental, and social aspects on equal terms. We examine whether DSS can contribute to the optimization of operational freight transport and to improve sustainability. In the context of design-oriented research and the DSR principles, research artifacts have been developed for this purpose: The basis sets a model for operative transport planning which integrates line hauls and regional transportation for groupage freight forwarding. Building on this, optimized transport chains are generated with a hybrid routing algorithm, see exemplarily Figure 30c. The DSS with its GUI (Figure 30a) uses the routing algorithm to plan and schedule transport orders in complex transportation networks. The minimization of transport costs, an optimized mobility mix through increased use of intermodal transport, and a reduction of energy consumption and emissions can be achieved. Within a feasibility study, it is suggested that DSS can contribute to improve sustainability, e.g. through an intermodal approach. Here, an intermodal transport network (Figure 30b) can, depending on the load factor (Figure 30d), save up to 31% on fuel consumption and emissions compared to a road-based network.

First research results concerning decision support in the context of sustainable freight transport were published as working paper without review in form of an IWI discussion paper. This paper titled “Plattformunabhängiges Softwareengineering eines Transportmodells zur ganzheitlichen Disposition von Strecken- und Flächenverkehren” bases on a project paper. Hans-Jörg von Mettenheim and Michael H. Breitner were co-authors, see Rickenberg et al. (2010) and Appendix 2. Based on this, we refined the research artifacts and evaluated their feasibility and applicability in an illustrative example. The resulting paper “Green by IT – Nachhaltiger Gütertransport durch Entscheidungsunterstützungssysteme”, written by the same authors, was submitted to the Multikonferenz Wirtschaftsinformatik (MKWI) 2012 in Braunschweig. It was accepted after a double-blind peer review (three reviews) without mandatory changes, see Rickenberg

et al. (2012c) and Appendix 4. According to the VHB ranking, the conference proceedings are ranked in category “C” for the WI/IS research domain and “D” for the VHB JOURQUAL 2.1 (WKWI, 2008; Schrader and Hennig-Thurau, 2009). Additional computational benchmarks were conducted and the paper “Nachhaltigerer Gütertransport – Eine Machbarkeitsstudie mit Entscheidungsunterstützungssystem”, written together with Michael H. Breitner, has been published in the journal Wirtschaftsinformatik & Management in 2014, see Rickenberg and Breitner (2014b) and Appendix 13.

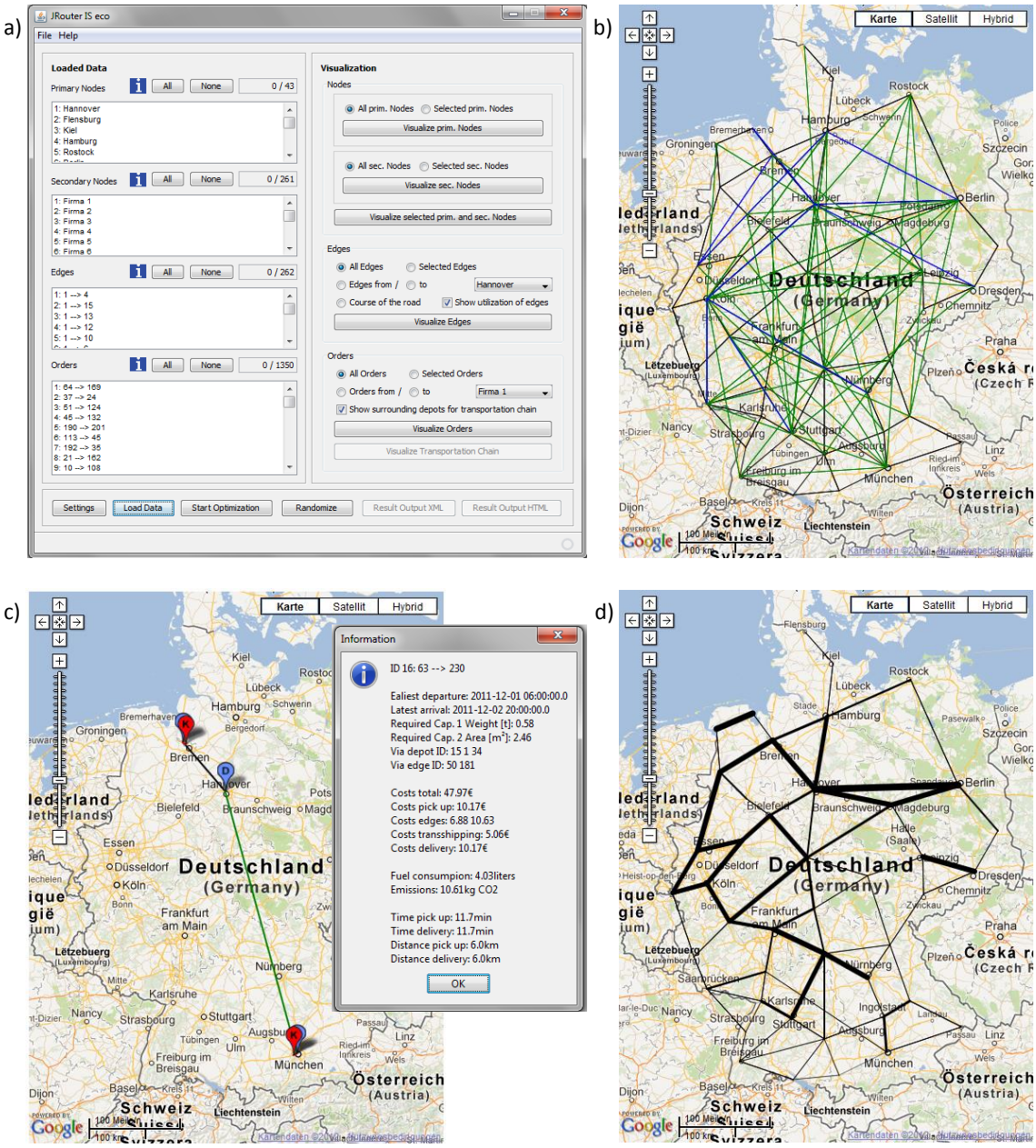


Figure 30: **Graphical User Interface and Mash-Up Visualizations.**
a) Graphical User Interface of the Decision Support System
b) Transportation Network with Different Transport Carriers
c) Optimized Transport Chain with Intermodal Transport Data
d) Load Factors for Road-Based Transport

10.2 Scheduling of Tests on Prototypes for Data Transmission Systems

Modern communication products are complex and multi-layered systems. Before technical products in general and communication products in particular can go into mass production, a significant amount of tests must be performed on prototypes, see Limtanyakul and Schwiegelshohn (2012). Individual components of the product, the interaction of the components, and the system as a whole including hardware and software must be verified. This results in a variety of tests and test arrangements, which need to be arranged, timed, and allocated. To meet regulatory obligations regarding quality and safety standards, testing can be extensive and takes considerable time and monetary resources. Even more challenging, manufacturers face shortening product life cycles and aim to reduce the time-to-market by shortening development and test phases.

The planning and scheduling of tests on prototypes is a complex task and needs decision support in order to generate feasible or – significantly more challenging – optimal timetables. Tests have to be scheduled to minimize the total test time, reduce personal and material costs, and ensure efficient operations. In this context, resources are limited and restrictions are prevailing. With a limited number of prototypes, a given number of testers have to perform numerous tests within a certain period of time while adhering to other temporal constraints. Test arrangements have to be prepared with limited testing equipment in accordance with the test specifications and tests have to be performed by testers according to their availability and skills. A prioritization of tests and dependencies is needed to find crucial errors and failures early in order to avoid the start of production to be delayed and to help shorten the time-to-market. Accordingly, tests, equipment, test arrangements, and testers must be coordinated optimally in time, location, and assignment and allocated according to compatibility with each other.

We provide decision support for the scheduling of tests on functional prototypes, particularly for transmission components and systems for telecommunication networks, see Rickenberg et al. (2013b), Appendix 8. Hence we design, implement, and evaluate a DSS called JScheduler (see Figure 31), which enables the scheduling of tests on network components. Based on various sets of real world data of a leading manufacturer of data transmission systems, we derive topologies (Figure 31a) and develop a formal descrip-

tion of the problem. We apply OR methods to solve the formal model and generate optimized test sequences. The multi-stage algorithm called MOSAP (Figure 31c) consists of construction heuristics and neighborhood search and minimizes the objective function. The DSS supports planners with the scheduling: Raw data is imported from a database, processed by the scheduling algorithm, and results and timetables are output to screen and files (Figure 31b). With the help of the DSS we are able to compare the solution procedures and evaluate the optimization results (Figure 31d). We also presented first research results at the International Annual Conference of the German OR Society 2012.

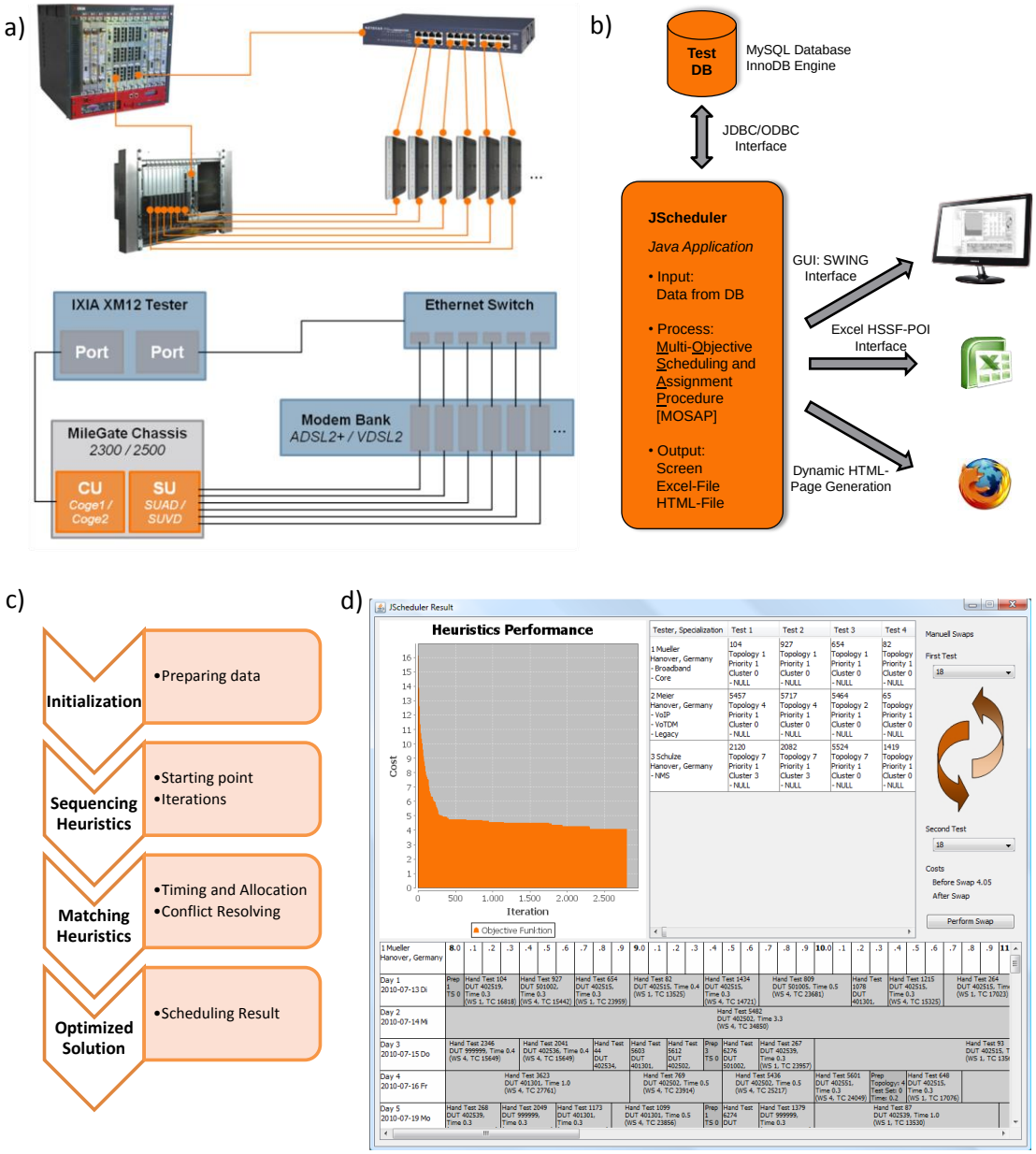


Figure 31: Overview of Scheduling Topic and DSS.
A) Schematic Overview of a Simple Topology to Test Data Transmission Systems
B) Dataflow and Interfaces of JScheduler
C) Scheme of the Multi-Objective Scheduling and Assignment Procedure [MOSAP]
D) Visualization of Optimization Results and Schedule

11. Conclusions, Limitations, and Outlook

11.1 Summary of Results and Overall Conclusions

Decision-making is an important task and essential for each of us on a daily basis. Good and timely decisions are to be prepared based on manifold kinds and huge amounts of data from diverse sources in order to find the best alternative. Qualitative data in the form of enterprise content, expert opinions gathered with survey (research) methodology, and quantitative data are important and decisive input for decision support processes. Within this cumulative doctoral thesis, particular exemplary studies in the context of qualitative and quantitative decision support are presented and discussed. For each part of the thesis, the main contributions of the underlying papers and the conclusions with respect to the specific RQs are summarized briefly in the following.

Part A deals with ECM as a comprehensive topic which is popular in practice and is gaining more attention from science. To set the basis for advancing knowledge and rigorous research, a systematic and coherent review of ECM literature in the IS domain was conducted including 68 articles in 2012 and an update of 58 articles in 2014 (chapter 2). All articles were reviewed, classified, and categorized and main topics were derived in a concept-centric way. As conclusion, the body of literature is small but steadily growing while the literature from the IS domain tends to be less technical than within the first years of ECM research and focuses more on organizational aspects. However, companies still struggle with the identification, assessment, classification, and visualization of the huge amounts of content that are created at ever increasing rates each year. Towards these ends, a process-oriented approach that uses the business process structure as an entry point to enterprise content was presented (chapter 3), which comprises practical guidelines, the 7W Framework, and different visual representations including a document map. The actual practical usefulness of a document map was shown by the assessment and use of it in an engineering company as per 2014. Based on this and in order to provide more business value, enterprise content can be assessed and classified with the perspective of knowledge components to transform content into organizational knowledge. An approach was presented that applies a knowledge perspective on ECM and introduces a knowledge-based framework for assessing, classifying, and managing

enterprise content called KBCM framework (chapter 4) which consists of different research artifacts on different levels of abstraction. From a more theoretical point of view, the ECM research field and its current state are in need of thorough investigation, especially concerning its relevance, implications, and future development. Accordingly, the ECM research domain was analyzed, synthesized, and evaluated using grounded theory methodology to create theoretical foundations and investigate its status quo (chapter 5). Based on a formal description of the grounded theory, it can be concluded that ECM research is relevant but more rigorous research, further theory building, and discussions are necessary to increase its maturity and positively influence its future development. Research topics need to be adjusted to address the enterprise-wide scope and the challenging and complex integration of preceding and related concepts into a holistic view, which represents a key characteristic and a main implication of ECM. To conclude Part A, ECM systems have the capabilities to support qualitative decision support, however, enterprise content is hardly used systematically to provide decision making information.

Part B deals with two examples of survey-based decision support which focus on deriving information from qualitative and quantitative survey data. The current era is shaped by the Nexus of Forces which comprises big data, social, mobile, and cloud computing as all-embracing trends. Based on qualitative survey methods employed in an iterative Delphi study, a reference model and initial insights were provided to address the challenges and influences that the interacting forces pose to organizations and governance structures (chapter 6). As a result of the consumerization pressure, corporate and IS governance structures need to be adjusted to increase the role of corporate governance concerning IS decisions. Hybrid governance approaches and federal archetypes are key areas for future research. With regard to the abstract and high-level question of how IS can contribute to build a better world, decision support based on survey research methodology and a questionnaire was provided (chapter 7). Qualitative and quantitative survey data gathered from leading IS researchers indicates that with the right focus and alignment, IS – practice and the underlying research domain – has the potential to take on the big questions and can help to build a better world. To this end, the community of IS researchers needs to step up and challenge established practices and habits. To conclude Part B, survey research is able to contribute to decision support and decision making based on information derived from qualitative and quantitative survey data.

Part C deals with optimization-based decision support using mainly quantitative data as input for DSS. Real-world examples of complex decision making and problem solving that evolve from the application domains transportation and scheduling were illustrated based on the implemented (prototype) DSS. Car sharing is a sustainable mobility concept that allows urban individuals to share a car sequentially, however, the positioning and sizing of stations is challenging. An optimization model was created to determine the prime location and size of car sharing stations and was integrated into the DSS OptCarShare 1.0 to enable numerical solving and visualization (chapter 8). Within two application examples with varying parameters, we illustrated that the research artifacts provide decision support for planning car sharing stations and can thus contribute to environmental sustainability. Electric car sharing represents an approach to further increase the sustainability of car sharing, however, its profitable operation still poses a problem for car sharing organizations. The existing optimization model and DSS were refined to match the specific characteristics and parameters of electric car sharing and further demonstrated and evaluated within an illustrative example (chapter 9). The benchmark results with the DSS OptECarShare 1.5 indicate that profitable operation of electric car sharing is possible nowadays. Further RQs about decision support by quantitative optimization in the context of sustainable operative freight transport and scheduling of prototypes were investigated briefly (chapter 10). To conclude Part C, DSS allow complex decision making and problem solving based mostly on quantitative data.

Decision support based on quantitative and also on qualitative data allows to prepare organizational decision making and can lead to better and effortless decisions (Todd and Benbasat, 1992). As motivated in the introduction of the thesis (The Economist, 2010) and as recently stated by Goes (2014) in the editorial of the MIS Quarterly, “Data are becoming the new raw material of business”. “The ever-increasing creation of massive amounts of data through an extensive array of several new data generating sources has prompted organizations, consultants, scientists, and academics to direct their attention to how to harness and analyze big data” and “[…] the generation of knowledge and intelligence to support decision making and strategic objectives” (Goes, 2014). Along these lines, the relevance of qualitative and quantitative decision support to gain technology-based competitive advantage will further increase within the future.

11.2 Overall Limitations

The thesis is examined and evaluated in this critical assessment, which comprises in particular the employed research methods, designs, and processes, as well as the generated results and conclusions. While the specific, identified limitations are already discussed in the thematic chapters of the thesis (chapters 2-10) and in further detail within the corresponding research papers, the presented studies, results, and the underlying research designs are critically reviewed here from an overall point of view.

The comprehensive study area of this cumulative doctoral thesis consolidates diverse research topics under the umbrella of business decision aid and making. Various research questions from different IS research streams were investigated which implies that the research papers are of exemplary nature in addressing qualitative and quantitative decision support. The studies particularly contribute to the knowledge in the field ECM, specific issues investigated with survey-research methodology, and optimization-based decision support with DSS. Even though the research questions were addressed thoroughly, the studies presented here and the thesis in general do not claim to cover and explain the broad and multi-faced field of qualitative and quantitative decision support in its entirety. Further research in the future is needed to provide all-encompassing answers that can conclusively and completely explain this comprehensive field.

Certain research topics of this thesis were analyzed from an abstract point of view and with rather high granularity, such as the analysis of the impact of the Nexus of Forces on organizational governance structures (chapter 6) and the examination of how to create a better world with IS (chapter 7). These research issues certainly need further, thorough investigation on a fine-grained level of analysis in future research. The intention of these research projects was, however, to provide initial insights into these contemporary and important issues. Our research findings can act as a basis for researchers to refine and extend the results. To get more definite answers, it is necessary to break down the area of investigation into smaller parts and investigate certain specific aspects, such as the use of IS to achieve one specific MDG or the impact of the Nexus of Forces on the demand management in companies across different branches. While these research findings provide initial insights on an abstract level, other research topics were drilled down to the very detail. For instance, the ECM research domain was analyzed,

synthesized, and evaluated in a very detailed way with extensive coding efforts. This allowed to generate rich and particularized insights into the ECM research domain.

The ongoing debate about rigor and relevance in IS research and the two alleged gaps of topic usefulness and knowledge transference (Straub and Ang, 2011) can also be applied here. While certain of the presented research topics and projects were inspired and initiated from a practical standpoint, others were induced from theory. For instance, the reference model for the Nexus of Forces and the document map addressing content chaos were driven from a practical point of view. These issues represented pressing problems in the field for which the academic community provided no sufficient answers. Other research endeavors were driven from a rather theoretical point of view, such as the analysis, synthesis, and evaluation of the ECM research domain. Even though the generated grounded theory mainly serves the academic community, the generated insights, however, can also contribute to ECM practice, e.g. in the form of a universally applicable reference model. In the academic context, "rigor addresses the way in which research is conducted" and can be "achieved by appropriately applying existing foundations and methodologies" (Hevner et al., 2004). The research methods and the resulting research designs employed here are prone to certain limitations. Main aspects of the identified limitations concerning this thesis are discussed subsequently.

Applicability checks according to Rosemann and Vessey (2008) aim to improve the relevance of IS research and can be conducted with practitioners for instance on technical artifacts. This actionable, systematic approach can be carried out as an additional step at the beginning or the end of the traditional research life cycle (Rosemann and Vessey, 2008). However, it leaves untouched the rigorous methods used to conduct the research study and further deeper empirical validation can be necessary subsequent to the applicability check. Here, applicability checks were used to initially test the importance, accessibility, and suitability of research artifacts, see e.g. chapter 3, which allowed to publish relevant research results. Deeper empirical investigation of the artifacts, namely the process-oriented approach to assessing, classifying, and visualizing enterprise content and the document map, was conducted at the case company and reported in chapter 3.4.5. Even though the validation of the research artifacts was successful in this context, the artifacts should be checked within other business contexts and the final research results should be published in an IS research outlet in the future.

Grounded theory offers a lot of advantages, but there are also some weaknesses and critiques. The most common myth is that researchers must not know any relevant literature before applying grounded theory (Urquhart, 2013). It is true that researchers have to set aside existing theory when conducting research, however, that does not imply that researchers have to ignore existing literature and that they have to be a blank slate (Urquhart and Fernández, 2013). Here, extensive research has been conducted within the ECM domain before the generation of a grounded theory. Due to the systematic and comprehensive ECM literature review (chapter 2), most of the ECM literature was already known. During research, existing theory was separated from the actual research topics and was not included in the coding so as not to impose it upon the emerging theory. While "it is impossible to not be influenced by the background knowledge that one has" (Wolfswinkel et al., 2013), it is important that grounded theory research has to be conducted with an open mind and not an empty head (Dey, 1999). Another myth is that conducting grounded theory takes a lot of time (Urquhart, 2013). Due to the experience with the coding of the grounded theory for ECM research, it can be agreed to this myth. The coding of large data collections is very time consuming, however, it allows researchers to gain proximity to the data and generate rich insights. For the conducted coding, academic literature was used as a data source. Grounded theory can be used on any type of data or combination of data (Urquhart and Fernández, 2006), therefore the use of academic literature seems legitimate even though it is unusual. This innovative approach should be evaluated and used in future research.

Concerning survey research, systematic selection biases are inherent in non-probability samples. Depending on the selected inclusion and exclusion criteria of the study, selection biases can have an influence on the research findings (Pinsonneault and Kraemer, 1993). For both surveys that are presented here, a significant number of experts was contacted and asked to participate in the survey (chapters 6 and 7). In these volunteer samples, some individuals are more likely to participate, for instance because they find the topic of the study interesting or conduct similar research which could result in a selection bias. This had to be taken into account, when the findings were analyzed, documented, and generalized as well as when they are interpreted by the reader.

Design-oriented research approaches, such as DSR and ADR, produce socio-technical artifacts as research output and research contribution (Hevner et al., 2004). These

artifacts are typically constructs, model, methods, and instantiation (March and Smith, 1995; Hevner et al., 2004) as well as design theory (Gregor, 2006; Gregor and Hevner, 2013). While the goal of design science is utility (Winter, 2008), this also true for the artifacts that were created in the context of this thesis. Therefore, no mid-range or even grand theories have been built in this thesis or the papers with design-oriented research approaches (Gregor and Hevner, 2013). The constructs, methods, and models constructed here can be classified as nascent design theory which provides knowledge as operational principles or architectures, while the instantiations as research deliverables serve as situated implementations of the artifacts (Gregor and Hevner, 2013).

Another limitation concerning the design-oriented approaches of this thesis is the empirical evaluation of the research artifacts. Peffers et al. (2007) define evaluation as the process to "observe and measure how well the artifact supports a solution to the problem" and state that it "could take many forms". Hevner et al. (2004) propose five design evaluation methods for this "crucial component of the research process": observational, analytical, experimental, testing, and descriptive. Despite the rigor of these evaluation methods, field-based evaluation is most likely the most effective and convincing evaluation once an artifact has reached a certain maturity. However, only 13.5 percent of DSS DSR artifacts are evaluated in the field and even 42.3 percent do not undertake any form of evaluation at all (Arnott and Pervan, 2012). Certain methods were employed to evaluate the constructed artifacts and their practical suitability concerning the particular problems of this thesis and the corresponding research papers: applicability checks, analytical and descriptive evaluation methods, pre-tests of illustrative and application examples, and concurrent evaluation with ADR methods in the field and its organizational setting. Undoubtedly, further empirical evaluation in the field, preferably by domain experts or end-users, will help to increase rigor and generalizability of the approaches. For instance, the DSS could be evaluated against manual planning approaches concerning quality and efficiency. Practitioners could use the research artifacts to check their utility and resulting benefits. The use of other data sets or other real-world instances can help to increase the transferability and generalizability of the artifacts. Finally, artifacts such as the optimization models or DSS, can be refined with regard to certain aspects. For instance, the car sharing model and particularly its demand

function can be enhanced, since the stochastic demand must be satisfied under all circumstances in the current version of the optimization model. This is just an example of possible refinements, see the chapters and research papers for more details.

While research methods belonging to the qualitative IS research paradigm were mainly employed in Part A of this thesis, design-oriented research methods and quantitative optimization approaches were used in Part C. A combination of quantitative and qualitative research methods in mixed methods approaches can help to develop rich insights into various phenomena of interest (Venkatesh et al., 2013). For instance, the combination of qualitative and quantitative research approaches within the ECM context, e.g. to investigate its benefits in a comprehensive empirical study, can certainly help to develop a better understanding of this practically and theoretically important issue. In conclusion of this critical assessment, the identified limitations and discussed aspects are subject to further research and should to be addressed in future studies.

11.3 Outlook

While implications for further research are shown in the thematic chapters of the thesis and described in detail in the associated papers, an overall outlook is given here.

The complex and multi-faced task of managing enterprise content requires further investigation from the IS research community. To support practitioners, a comprehensive process model that covers all stages of the content lifecycle as well as the ECM system lifecycle is required. In this context, operational and organizational aspects and integrative approaches are more important than plain technical considerations. A deeper integration of ECM with KM, respectively of ECM systems and KM systems, can help to increase the business value of ECM. While the grounded theory presented here can act as a reference model and serve as a basis for the process model, the KBCM-framework represents a foundation to align ECM and KM. The combination of qualitative and quantitative data in an enterprise-wide approach, such as EIM, enables decision support and business analytics from a holistic point of view. More and more and also new kinds of data can be taken into account for decisions and thus the theoretical and practical relevance of decision support will grow. The research community needs to provide solid foundations for future decision support tools, such as complex and comprehensive consolidation and analysis approaches.

The amount of enterprise content and of data in general will grow at an increasing rate within the future. Based on the current trends of cloud, mobile, and social computing and the massive data streams, ECM will evolve in the future. Cloud and mobile ECM allow to access enterprise content from everywhere and at any time. Social computing aspects such as ESN enable social networking in the professional business context inside of organizations. A consolidation of ECM and ESN allows an integrative perspective on content, people, and processes. The Internet of Things, Industry 4.0, and sensor data will create even more massive data streams that can be analyzed, e.g. with big data approaches, to create information and additional value. All these trends coming from practice will be of growing importance within the next years and need to be analyzed from a theoretical point of view in further research. Goes (2013) states that innovating forces and technology waves, such as social computing, mobility, the cloud, and big data analytics, impose dramatic changes to businesses, economies, societies. The Nexus of Forces which combines these four trends will have strong and broad impact on business organizations and all kinds of organizations, but and on people and societies in general.

Environmentally sustainable development and Green IS encompass important issues and are of increasing relevance for the IS research community (Watson et al., 2010; Seidel et al., 2013). As one of many examples of application, decision support for electric car sharing networks can increase the sustainability of urban individual mobility. For instance, efficient car sharing networks can help to reduce emissions within cities and also decrease the total amount of cars in cities. In general, other Green IS should be constructed and evaluated by IS researchers for all possible application domains.

Next to environmental issues, IS research should also put more emphasis on important contemporary societal issues and needs to take on the big questions and global challenges (Rickenberg et al., 2014). The promotion of social and sustainable goals and review metrics to measure the impact and contribution of IS research is needed. Holistic approaches that are not centered on economic aspects can help to further increase the impact and value of IS research for society and mankind. Thus, the IS research community can really take on humanity's grand challenges and strive to reach high level goals. Since science ultimately has to serve humanity, it is time for the IS community to engage in this challenge and suggest practical solutions for these highly relevant and substantial issues (vom Brocke et al., 2013; Hassan et al., 2013; Rickenberg et al., 2014).

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Appendices

Appendix 1: Komplexe Prozesse mit Personenerkennung und Zeiterfassung in Hotels

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Appendix 1: Komplexe Prozesse mit Personenerkennung und Zeiterfassung in Hotels

Authors: Tim A. Rickenberg, Daniel Wenzel, Tim Zinovsky (Alphabetic Order)

Outlet: RFID-Anwendungen - Einführung, Fallbeispiele und Szenarien in der Praxis (Eds. Wohlers, G.; Breitner, M.H), Shaker Verlag, 01/2008, pp. 67-117.

Appendix 2: Plattformunabhängiges Softwareengineering eines Transportmodells zur ganzheitlichen Disposition von Strecken- und Flächenverkehren

Authors: Tim A. Rickenberg, Hans-Jörg von Mettenheim, Michael H. Breitner

Outlet: IWI Discussion Paper #38, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, 01/2010, pp. 1-38.

Abstract: Die vorliegende Arbeit befasst sich mit der automatisierten Generierung optimierter Transportketten zur Disposition von Strecken- und Flächenverkehren in komplexen Transportnetzen. Trotz fortschreitender Informationstechnologien wird die Disposition von Transportaufträgen im Allgemeinen noch manuell durch einen Disponenten durchgeführt. Im Laufe dieser Arbeit werden Operations Research Verfahren wie z.B. Heuristiken implementiert, um diese umfassende Aufgabenstellung automatisch zu lösen. Unter Berücksichtigung der Restriktionen und Nebenbedingungen (wie Kapazitäten und Zeitfenster) werden durch den erstellten Routingalgorithmus Potentiale zur Kostenreduzierung aufgedeckt. Um dem Nutzer die erstellten Forschungsergebnisse bereitzustellen, wurde eine Internetplattform erstellt, auf der die plattformunabhängige Software im Sinne des Open-Source Gedanken frei zugänglich gemacht wird. Die internetfähigen Java Programme ermöglichen Import und Erstellen von Logistikdaten sowie deren Verarbeitung im Routingalgorithmus und die Visualisierung.

Appendix 3: Beiträge zur Transformation des deutschen Energiesystems

Authors: Michael H. Breitner, Cornelius Köpp, Tim A. Rickenberg, et al.

Outlet: IWI Discussion Paper #50, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, 02/2012, pp. 1-560.

Appendix 4: Green by IT – Nachhaltiger Gütertransport durch Entscheidungsunterstützungssysteme

Authors: Tim A. Rickenberg, Hans-Jörg von Mettenheim, Michael H. Breitner

Outlet: Tagungsband der Multikonferenz Wirtschaftsinformatik (MKWI 2012), Braunschweig, Deutschland, 03/2012, pp. 1487-1498.

Abstract: Der Beitrag stellt ein Software Artefakt vor, das Disponenten beim Routing von Aufträgen in einem Transportnetzwerk unterstützt. Grundlage ist ein problembezogenes Modell zur Beschreibung der Transportprozesse in intermodalen Netzstrukturen. Ein hybrider Routingalgorithmus zur Lösung des operativen Transportproblems setzt darauf auf. Dieser führt das Routing der Transportaufträge in einem Netzwerk aus Knoten und Kanten aus. Unser Ansatz optimiert den Mobilitätsmix und trägt zu effizienterem und nachhaltigerem Gütertransport bei.

Appendix 5: Towards a Process-Oriented Approach to Assessing, Classifying and Visualizing Enterprise Content With Document Maps

Authors: Tim A. Rickenberg, Markus Neumann, Bernd Hohler, Michael H. Breitner

Outlet: Proceedings of the European Conference on Information Systems (ECIS 2012), Barcelona, Spain, 06/2012, pp. 1-12, available online at: http://aisel.aisnet.org/ecis2012/118/.

Abstract: Nowadays, documents can be scattered across a company in different versions, formats, and languages, and even on different systems. Not only is the resulting content chaos inefficient, it brings with it a number of risks. However, information that is contained in unstructured documents is increasingly becoming a key business resource. Enterprise content management (ECM) is used to manage unstructured content on an enterprise-wide scale. Despite the practical importance of ECM, research is still at an immature state and the process perspective is widely neglected. We suggest a process-oriented approach to identifying, assessing, documenting, classifying and visualizing enterprise content. Within a globally operating engineering company, we check to what extent the applicability of the designed research artifact can be assumed. We give process-oriented guidelines to identify and document enterprise content. Our 7W Framework (7WF) for content assessment contains a collection of metadata (attributes, typical attribute values) to create customized content surveys. Different visual representations of content are proposed, including a document map. Combining business processes and the content of an enterprise, the document map is able to integrate the ECM perspectives and provides decision support. Technical requirements can be derived from it and in-depth analysis of business-critical content is enabled.

Appendix 6: Enterprise Content Management – A Literature Review

Authors: Tim A. Rickenberg, Markus Neumann, Bernd Hohler, Michael H. Breitner

Outlet: Proceedings of the Americas Conference on Information Systems (AMCIS 2012), Seattle, USA, 08/2012, pp. 2132-2144.

Abstract: Managing information and content on an enterprise-wide scale is challenging. Enterprise content management (ECM) can be considered as an integrated approach to information management. While this concept received much attention from practitioners, ECM research is still an emerging field of IS research. Most authors that deal with ECM claim that there is little scholarly literature available. After approximately one decade of ECM research, this paper provides an in-depth review of the body of academic research: the ECM domain, its evolution, and main topics are characterized. An established ECM research framework is adopted, refined, and explained with its associated elements and working definitions. On this basis, 68 articles are reviewed, classified, and concepts are derived. Prior research is synthesized and findings are integrated in a concept-centric way. Further, implications for research and practice, including future trends, are drawn.

Appendix 7: A Decision Support System for the Optimization of Car Sharing Stations

Authors: Tim A. Rickenberg, Andreas Gebhardt, Michael H. Breitner

Outlet: Proceedings of the European Conference on Information Systems (ECIS 2013), Utrecht, The Netherlands, 06/2013, pp. 1-12, available online at: http://aisel.aisnet.org/ecis2013_cr/207.

Abstract: Approximately half of the world's population is living in cities and it continues to grow. Along with urbanization, scarce natural resources, rising energy costs, shortage of space, increasing traffic congestion, and environmental pollution require populations to rethink personal vehicle ownership. Car sharing is an alternative that allows individuals to satisfy their mobility needs and addresses modern transportation issues. The location and accessibility of car sharing stations are critical success factors. We provide decision support for planning car sharing stations, both existing and new ones. Therefore, we constructed and evaluated research artifacts according to the design science research principles. We suggest an optimization model to determine the prime location and size of car sharing stations. Based on this model, a decision support system (DSS) called OptCarShare 1.0 is used for exact optimization. This system integrates several applications to import, edit, and export data, solve the problem numerically and visualize optimization results. Using a major German city with 500,000 people to illustrate solutions, we evaluate and show the applicability of the DSS OptCarShare 1.0. According to Green IS, our DSS can provide a contribution to environmental sustainability.

Appendix 8: Design and Implementation of a Decision Support System for Complex Scheduling of Tests on Prototypes

Authors: Tim A. Rickenberg, Hans-Jörg von Mettenheim, Michael H. Breitner

Outlet: IWI Discussion Paper #57, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, 08/2013, pp. 1-11.

Abstract: Timing and allocation of resources for testing prototypes is a complex problem. Often hundreds of tests (hardware as well as software tests) have to be performed on a technical product before it can go into mass production. In this context, resources are limited: Next to a limited number of prototypes, a given number of testers with different sets of skills have to perform various tests with limited testing equipment within a certain period of time. It is necessary to assign tests to equipment and testers according to their availability. Tests have to be put in an appropriate order. For this complex task, decision support is needed in order to accelerate the manual planning process and the actual testing phase. Shortening the total test time can reduce costs and helps in achieving the start of production (SOP).

For scheduling tests on prototypes, we design, implement, and evaluate a decision support system (DSS). More precisely, our DSS enables the scheduling of tests on network components. With given sets of real world data of a leading manufacturer of data transmission systems, we suggest a formal description of the problem. We apply operations research (OR) methods to solve the underlying formal model and to generate optimized test sequences. Due to problem size and the number of variables and restrictions, we use heuristic methods in a multi-stage algorithm. The scheduling algorithm combines several heuristics in order to minimize the multi-criteria objective function. The graphical user interface (GUI) allows the user to interact with the DSS and to configure the optimization process. Also, the GUI can output scheduling results and timetables to screen and files in html or xls format.

Appendix 9: Innovation Management: How to Drive Innovation Through IT – A Conceptual Model

Authors: Cary Edwards, Tim A. Rickenberg, Michael H. Breitner

Outlet: IWI Discussion Paper #62, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, 12/2013, pp. 1-40.

Abstract: This paper focuses on innovation management and how to drive innovation through IT. While the IT used to operate in the back ground of a business organization, it is now responsible to create a competitive advantage. Especially, when today's business environment becomes hypercompetitive, business organizations have to consider how to become more competitive. To achieve a competitive advantage many business organizations focus on IT innovations. In this context, this paper describes how the IT can be used as an internal strategic resource by creating an IT strategy with regard to the business value and goals. Based on the aligned IT strategy this paper presents an approach which describes how the IT department can engage in business processes and creates an IT value to the entire business organization. The IT value is an important precondition for being accepted as a source to drive innovation. On the basis of the IT strategy and IT value an IT innovation management model is created, which includes organizational relationships that have to be noted when implementing an IT innovation management approach. The theoretical model describes how the IT department can contribute to drive innovation and business opportunities by operating a centralized IT Business Innovation Center (IT-BIC).

Appendix 10: Towards a Knowledge-based Framework for Enterprise Content Management

Authors: Thang Le Dinh, Tim A. Rickenberg, Hans-Georg Fill, Michael H. Breitner

Outlet: Proceedings of the Hawaii International Conference on System Science (HICSS 2014), Big Island, USA, 01/2014, pp. 3543-3552.

Abstract: Nowadays, critical information that is contained in mostly unstructured documents is increasingly becoming a key business resource. Accordingly, enterprises need a foundation for managing content to understand its value and transform it into information and organizational knowledge. Enterprise Content Management (ECM) is an integrated approach to Information Management. There is a need for enhancing this approach to support the transformation from information into organizational knowledge. However, assessing, organizing, sharing, and using content based on knowledge perspectives are crucial, especially for knowledge-intensive enterprises. Those enterprises provide knowledge-intensive products and services that require a robust foundation for knowledge management and innovation capacity. We present the KBCM (Knowledge-Based Content Management) framework for ECM based on the perspective of knowledge components. This paper seeks to create more business value by transforming content into valuable information assets and then from information into organizational knowledge. To demonstrate the framework, an illustrative example is constructed and evaluated.

Appendix 11: Car Sharing in Zürich – Optimization and Evaluation of Station Location and Size

Authors: Daniel Olivotti, Tim A. Rickenberg, Michael H. Breitner

Outlet: Tagungsband der Multikonferenz Wirtschaftsinformatik (MKWI 2014), Paderborn, Deutschland, 02/2014, pp. 1500-1512.

Abstract: Car sharing is a sustainable mobility concept which can help to reduce environmental pollution, traffic congestion, and shortage of parking spaces in cities. By sharing a vehicle sequentially, individuals can satisfy their mobility needs without owning their own car. Within this context, the location and accessibility of stations are critical success factors. We provide decision support for planning and managing a network of stations in order to minimize cost while satisfying total demand. Therefore, we created and evaluated an optimization model and the decision support system (DSS) OptCarShare 1.1 according to the design science research (DSR) principles. The DSS is able to import, export, and edit data, solve the numerical problem, and visualize the optimization results. We used the Swiss city of Zürich as an illustrative example to show the applicability of the artifacts and evaluate the results in detail. Further we created various patterns of stochastic demand for two different network densities.

Appendix 12: Anforderungsanalyse von Enterprise Social Networking Anwendungen – Eine Action Design Research Studie

Authors: Aylin E. Yücel, Tim A. Rickenberg, Michael H. Breitner, Bernd Hohler, Malte Schlüter

Outlet: Tagungsband der Multikonferenz Wirtschaftsinformatik (MKWI 2014), Paderborn, Deutschland, 02/2014, pp. 1707-1720.

Abstract: Technologische Trends und Wandel im Arbeitsleben stellen die bisherigen Informationssysteme vor neue Herausforderungen. Um menschliche Zusammenarbeit zu unterstützen, findet Enterprise Social Networking (ESN) zunehmend Einsatz in der unternehmensinternen Kommunikation. Damit ESN erfolgreich im Unternehmenskontext integriert werden kann, sind die grundsätzlichen Anforderungen an solche Plattformen zu analysieren. Hierzu wurde eine Action Design Research (ADR) Studie in einem Unternehmen für Antriebs- und Automatisierungstechnik durchgeführt. Im Rahmen der Studie wurde ein ESN Prototyp konzipiert und mit qualitativen Interviews und quantitativen Umfragen evaluiert. Das Ergebnis der Anforderungsanalyse stellt organisatorische, funktionale und nicht-funktionale Anforderungen auf, die einen Ansatzpunkt zur Einführung einer ESN Anwendung darstellen.

Appendix 13: Nachhaltigerer Gütertransport – Eine Machbarkeitsstudie mit Entscheidungsunterstützungssystem

Authors: Tim A. Rickenberg, Michael H. Breitner

Outlet: Wirtschaftsinformatik und Management (WuM), Issue 4|2014, 07/2014, pp. 52-60.

Abstract: Die Gütertransportbranche ist durch großen Verbrauch fossiler Energieträger und hohe Emissionswerte geprägt. Dadurch hat die Branche besonderes Potenzial zur Energiewende, neuen Mobilität und zur Nachhaltigkeit beizutragen. In diesem Artikel wird untersucht, ob Entscheidungsunterstützungssysteme zur Steigerung der ökologischen und ökonomischen Nachhaltigkeit im operativen Güterverkehr beitragen können. Mit gestaltungsorientierter Forschung werden Artefakte entwickelt: Grundlage ist ein Ansatz zur Tourenplanung und zur Integration von Strecken- und Flächenverkehr für Stück- und Sammelgüter. Darauf aufbauend werden durch einen hybriden Routingalgorithmus optimierte Transportketten generiert. Das Entscheidungsunterstützungssystem nutzt den Algorithmus zur Disposition von Aufträgen. Dabei werden im Sinne von Green IS die Minimierung der Transportkosten, ein optimierter Mobilitätsmix sowie die Reduktion von Energieverbrauch und Emissionen erreicht. In einer praxisrelevanten Machbarkeitsstudie werden quantitativ Einsparpotenziale aufgezeigt.

Appendix 14: Building a Better World through Information Systems – An Explorative Survey among Leading IS Researchers

Authors: Tim A. Rickenberg, André Koukal, Michael H. Breitner

Outlet: Proceedings of the International Conference on Information Systems (ICIS 2014), Auckland, New Zealand, 12/2014, pp. 1-19.

Abstract: IS research and practice needs to take on the big questions and global challenges. While the IS community is well positioned to assist in addressing these challenges, IS research has been criticized to lack relevance. We investigate how and to which extent IS can contribute to build a better world, in particular with regard to the Millennium Development Goals (MDGs). We therefore conduct an explorative survey among leading IS researchers on a global scale. Based on 171 responses, we employ qualitative and quantitative analysis methods to synthesize the survey data, document and discuss results, and derive implications. Besides positive aspects, the survey also reveals challenges and critique concerning IS research. We provide a starting point, create awareness, and stimulate further discussions and research. With the right focus and alignment, IS practice and research has the potential to take on the big questions and can help to build a better world.

Appendix 15: An Optimization Model and a Decision Support System to Optimize Car Sharing Stations with Electric Vehicles

Authors: Kathrin Kühne, Tim A. Rickenberg, Michael H. Breitner

Outlet: Forthcoming in: Selected Papers of the International Conference on Operations Research 2014, Aachen, Germany.

Abstract: An increasing environmental awareness, rising energy cost, progressing urbanization, and shortage of space cause to rethink individual mobility behavior and personal car ownership in cities. Car sharing is a sustainable mobility concept that allows individuals to satisfy their mobility needs without owning a car and addresses modern mobility. Car sharing is particularly suitable to cover medium-range distances and can be linked to the public transport of major cities (intermodal mobility). Within this context, the integration of electric vehicles represents an opportunity to further protect the environment and potentially save energy cost.

In order to create an efficient car sharing transportation network, the location of stations, the number of vehicles and the availability of electric fast charging infrastructure are critical success factors. We provide a decision support system (DSS) to plan and optimize car sharing stations for electric vehicles. An optimization model and the DSS OptCarShare 1.1 enable to optimize stations and visualize results. Parameters, such as the annual lease payment for charging infrastructure, the expected travel time of consumers, the charging time of electric vehicles dependent on available charging infrastructure, affect the decision variables such as the number of car sharing stations, vehicles and fast chargers. On the basis of evaluations and benchmarks for the cities of Hannover and Zürich, we establish generalizations for the parameters of the model. The results show a high impact of fast chargers (half an hour to fill 80% of the battery) on the current model and the optimal solution.

To be published in: Lübbecke et al., Operations Research Proceedings 2014 – Selected Papers of the Annual International Conference of the German Operations Research Society (GOR), RWTH Aachen University, Germany, September 2-5, 2014 (Springer, 2015).

An Optimization Model and a Decision Support System to Optimize Car Sharing Stations with Electric Vehicles

Kathrin Kühne, Tim A. Rickenberg and Michael H. Breitner

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1 Introduction

Automobile traffic is one major factor of air pollution and noise annoyance in cities. A good alternative to private cars is car sharing which allows to remain mobile

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without owning a car while saving cost and emissions. In this concept, individuals, especially young adults share vehicles which are property of an organization [3]. Car sharing is particularly suitable to cover medium-range distances and can be linked to the public transport of major cities such as e.g. Hannover or Zürich. It thus fills the gap between public transport and private automobile [7].
Car sharing in connection with electric vehicles has great potential with regard to sustainability. It can not only protect the environment (less CO2, noise and required parking area), it represents cost security for customers and their mobility needs [4]. Since 2005 with the increase in the sales figures, electric cars have become a serious alternative to conventionally propelled vehicles. [1]. Electric vehicles differ in the range and the maximum speed, many of them have an average of around 150 km range with a maximum speed of about 130 km/h [2]. An important component of a pure electric car is the battery (lithium-ion) which typically needs to be charged for eight hours on a conventional wall socket. These batteries may also be subjected to a fast charge, which takes about 0,5h to fill 80% of the battery, but this is associated with high investments. With regard to the cost of a car sharing organization and the satisfaction of the customer demand, the limited range and long charging times respectively expensive fast charging infrastructure represent challenges.
The protection of the environment and scarce natural resources as well as limited parking space caused by urbanization are urgent topics and are basis for the idea to refine an optimization model for car sharing stations by Rickenberg et al. [6]. The question, how many fast chargers need to be positioned will be addressed with an enhanced optimization model. We pursue the following research questions:
RQ 1: What factors of electric vehicles need be considered to optimize the location and size of car sharing stations? and
RQ 2: What influence do exogenous parameters have on the decision variables?

2 Optimization Model and Decision Support System

The objective of this model is to determine optimal locations of candidate car sharing stations i $(i = 1,\ldots,m)$ as well as to optimize the number of vehicles with fast charging $(f_i^{fc} \in \mathbb{N})$ and with regular charging infrastructure $(f_i^{rc} \in \mathbb{N})$. The minimization of total cost and the satisfaction of the customer have the highest priority. The maximum distance of any demand point j $(j = 1,\ldots,n)$ to the next car sharing station must not exceed a definite limit $(maxd)$. In our case, any period (t^{period}) is 24 hours and is related to the normal-distributed demand n_j, which is also given for one day (24h). A vehicle is available when the travel time (t_i^t) and the appropriate charging time (tc_i) is over. To calculate the charging time a coefficient (γ) and the expected travel time (normal-distributed) are needed. There are two varieties for γ, one for the fast charging and one for regular charging infrastructure. At any station are limited parking lots $(maxp_i)$ available and limited fast chargers $(maxfcs)$ possible. Since electric cars of one single type are used in this model, a homogenous fleet is assumed. The mathematical problem can be formulated as follows:

$$Min.\ Z = \sum_{i=1}^{m} [f_i^{rc}(kf + ka + kl^{rc}) + f_i^{fc}(kf + ka + kl^{fc}) + y_i * ks] \tag{1}$$

$$d_{ij} * z_{ij} \leq maxd \quad \forall i; j \tag{2}$$

$$\sum_{i=1}^{m} z_{ij} = 1 \quad \forall\, j \tag{3}$$

$$y_i = z_{ij} \quad \forall\, i; j \tag{4}$$

$$f_i^{rc} \frac{t^{period}}{t_i^t + tc_i^{regular}} + f_i^{fc} \frac{t^{period}}{t_i^t + tc_i^{fast}} \geq \sum_{j=1}^{n} n_j * z_{ij} \quad \forall\, i \tag{5}$$

$$f_i^{rc} + f_i^{fc} \leq maxp_i \quad \forall\, i \tag{6}$$

$$f_i^{fc} \leq maxfcs \quad \forall\, j \tag{7}$$

$$y_i * v_i \leq a \quad \forall\, i \tag{8}$$

$$w_i \geq minb * y_i \quad \forall\, i \tag{9}$$

$$z_{ij};\ y_i; \in \{0,1\} \quad \forall\, i; j \tag{10}$$

$$f_i^{rc};\ f_i^{fc} \quad \in \mathbb{N} \quad \forall\, i \tag{11}$$

The objective function (1) describes the incurred cost of a car sharing organization which are to be minimized. The cost is accumulated annual fees for renting vehicles (kf), parking lots (ka), charging infrastructure (kl^{rc} and kl^{fc}) as well as annual cost to maintain stations. Restriction (2) implies that the distance between a demand point and a station must not exceed a maximum value and constraint (3) assigns every demand point to a station but only if the station is actually built (4). The fulfillment of the demand is ensured by restriction (5). The variables $tc_i^{regular}$ and tc_i^{fast} are calculated as follows: $tc_i^{regular} = \gamma^{regular} * t_i^t$ and $tc_i^{fast} = \gamma^{fast} * t_i^t$. The coefficient γ describes the charging time per travel hour dependent on the maximum range of electric vehicles, the average speed and the charging time. It is calculated as follows: $\frac{max\ range}{average\ speed} = max\ travel\ time$ and accordingly $\gamma^{regular}$ and $\gamma^{fast} = \frac{max\ charging\ time}{max\ travel\ time}$.

The total number of vehicles (also the number of associated parking lots) must be smaller than the maximum number of parking lots for each station (6) [5]. Restriction (7) guarantees the electricity supply. Parameter v_i is defined as follows: v_i = free parking lots around station i / registered vehicles around station i * 100%. The smaller parameter v_i, the higher is the shortage of parking. Due to (8), the actual shortage of parking cannot be bigger than the default shortage of parking (a). Parameter w_i is defined as follows: w_i = population at station i /area at station i [6]. Because of (9) a minimum level of population density within an area is reached. In equations (10) and (11) are the binary variables and decision variables defined.

Based on the optimization model, we implement the decision support system (DSS) OptCarShare 1.1 to enable the optimization of stations and visualization of results. The DSS, the underlying model, and sample data pools are available online at http://archiv.iwi.uni-hannover.de/CarSharing/.

3 Benchmarks in Hannover and Zürich

Influence of charging-infrastructure – charging time and infrastructure cost: We run several benchmarks by using different values for the parameters and show thereby the applicability of the optimization model. We choose the German city Hannover and the Swiss city Zürich since both have an appropriate size, population density and well public transportation to allow efficient car sharing [5, 6].

The initial values for the benchmarks are $i^{Hannover} = 100$, $j^{Hannover} = 30$, $i^{Zürich} = 200$, $j^{Zürich} = 50$, $kf = 25{,}000$€, $ka = 7{,}000$€, $t^{period} = 24h$, $GAP = 3\%$, $maxp_i = 5$, $maxfcs = 2$, $minb = 1{,}200$, $maxd = 1km$. Parameter γ is not a fixed value and varies with the average speed, maximum range or required charging time. Our initial values are: $\gamma^{regular} = \frac{4}{3}$ and $\gamma^{fast} = \frac{1}{12}$ with a maximum range of 150km, average speed of 25km/h and a required charging time of 0.5h or 8h. We ignore the low cost of regular charging infrastructure and consider only the annual fees of fast charging infrastructure. There are different providers and types of charging infrastructure, which is still in development phase and therefore the cost of the fast chargers could decrease within the coming years. It is even possible that the regular charging infrastructure could improve and thus the gap between these two possibilities could diminish. Here, the smaller the charging coefficient, the more efficient the regular charging infrastructure works. We vary the charging coefficient $\gamma^{regular}$ and the cost kl^{fc} to investigate their influence, which can be seen from the following table.

Table 1 Influence of charging coefficient $\gamma^{regular}$ and cost of fast charging infrastructure kl^{fc}

Hannover	kl^{fc} = 5,000EUR				kl^{fc} = 26,000EUR				kl^{fc} = 35,000EUR			
	s	f_i^{fc}	f_i^{rc}	cost	s	f_i^{fc}	f_i^{rc}	cost	s	f_i^{fc}	f_i^{rc}	cost
$\gamma^{regular}$ = 4/3	8	12	0	452,000	8	10	3	684,000	8	7	9	765,000
$\gamma^{regular}$ = 3/3	8	12	0	452,000	9	5	11	651,000	8	2	17	686,000
$\gamma^{regular}$ = 2/3	9	11	1	474,500	9	2	14	573,000	8	0	18	584,000
Zürich	kl^{fc} = 5,000EUR				kl^{fc} = 26,000EUR				kl^{fc} = 35,000EUR			
	s	f_i^{fc}	f_i^{rc}	cost	s	f_i^{fc}	f_i^{rc}	cost	s	f_i^{fc}	f_i^{rc}	cost
$\gamma^{regular}$ = 4/3	14	18	3	776,000	17	18	3	1,181,000	16	10	18	1,262,000
$\gamma^{regular}$ = 3/3	16	17	4	773,000	17	12	12	1,157,000	18	1	32	1,141,000
$\gamma^{regular}$ = 2/3	16	16	5	768,000	17	3	24	959,000	19	0	30	979,000

A reduction of $\gamma^{regular}$, which implies shorter charging time, results in less total cost, since less vehicles with fast charging infrastructure are needed to meet customer demand. For example in Zürich and annual fees of the fast chargers of 26,000€, the amount of car sharing stations always remains equal at 17, while the number of vehicles related to fast or regular charging infrastructure varies. For $\gamma^{regular}$ = 4/3, the total cost is 1,181,000€, but the cost decrease to 959,000€ for $\gamma^{regular}$ = 2/3. Because of less charging time for vehicles even with regular charging infrastructure, more vehicles of this type will be deployed. The effect is higher, the higher the annual fees of the fast chargers are.

Influence of different driving time profiles and max. distance to station: The distance to the next car sharing station is an important factor since consumers do not want to walk a long way, e.g. from public transport stations and also from home, to satisfy their mobility needs [8]. For that reason, we vary the parameter *maxd* and compare it against three different expected travel time profiles.

Table 2 Max. distance to station *maxd* and expected travel time

Hannover	*maxd* = 0.5km				*maxd* = 1km				*maxd* = 1.25km			
	s	f_i^{fc}	f_i^{rc}	cost	s	f_i^{fc}	f_i^{rc}	cost	s	f_i^{fc}	f_i^{rc}	cost
low travel time	11	2	9	373,000	5	1	4	170,000	4	1	3	137,000
med. travel time	14	10	3	479,000	7	7	1	298,000	4	7	0	263,000
high travel time	14	16	2	670,000	9	14	0	527,000	7	13	1	520,000
Zürich	*maxd* = 0.5km				*maxd* = 1km				*maxd* = 1.25km			
	s	f_i^{fc}	f_i^{rc}	cost	s	f_i^{fc}	f_i^{rc}	cost	s	f_i^{fc}	f_i^{rc}	cost
low travel time	26	4	21	846,000	11	1	10	368,000	9	1	7	270,000
med. travel time	29	12	16	985,000	14	11	3	517,000	11	9	1	413,000
high travel time	31	24	11	1,470,000	15	19	3	814,000	14	19	1	934,000

The total number of vehicles increases, the higher the average travel time is. The vehicles are longer on the roads and therefore need longer charging time which results in a lower availability of the vehicles. The more vehicles are deployed, the higher the total cost for the car sharing organization. For low average travel time, significantly more vehicles are used with regular charging infrastructure, because the vehicles only need a brief time to be charged even with regular charging infrastructure to be available for the next customer. However, with higher travel time, more vehicles with fast charging infrastructure are required. To meet the demand, a certain number of vehicles is needed. For low *maxd*, e.g. 0.5km for Zürich at the medium travel time, the total cost is 985,000€, but for higher *maxd* (1.25km), the cost decrease to 413,000€, although the demand and travel time are still the same.

4 Generalization, Limitations and Conclusion

Concerning RQ2 and based on the benchmarks of Hannover and Zürich, the influences of selected parameters can be generalized to establish a general relationship between the exogenous parameters and the resulting effect on decision variables.

Number of car sharing stations: With higher expected travel time as well as an increasing coefficient of regular charging infrastructure, the number of car sharing stations increases since more vehicles are needed. If the coefficient of the fast charging is lower, the number of car sharing station is reduced by having less vehicles.

Charging infrastructure: Analogous to the number of stations, the number of vehicles with fast charging infrastructure increases with higher travel time since the efficient fast chargers allow to reduce the charging time. However, the more expensive the fast charging infrastructure is, the less vehicles will be deployed with

this infrastructure and in consequence the amount of regular charging infrastructure increases. If the coefficient $\gamma^{regular}$ decreases, the number of vehicles with regular charging infrastructure increases and the number of vehicles with fast charging infrastructure decreases due to their higher cost. With less fast chargers or more efficient regular charging infrastructure, the total cost decreases. The effect of γ^{fast} is opposed to $\gamma^{regular}$. The more vehicles are required, the higher is the total cost. While minimizing total cost, it is affected by the mentioned parameters. If $\gamma^{regular}$ increases, less vehicles are needed and in consequence the total cost decreases.

$$t_i^t(\uparrow) \Rightarrow \sum_i y_i(\uparrow) \quad \gamma^{regular}(\downarrow) \Rightarrow \sum_i y_i(\uparrow) \quad \gamma^{fast}(\uparrow) \Rightarrow \sum_i y_i(\downarrow) \tag{12}$$

$$t_i^t(\uparrow) \Rightarrow \sum_i f_i^{fc}(\uparrow) \quad \gamma^{regular}(\downarrow) \Rightarrow \sum_i f_i^{fc}(\downarrow) \quad kl^{fc}(\uparrow) \Rightarrow \sum_i f_i^{fc}(\downarrow) \tag{13}$$

$$t_i^t(\uparrow) \Rightarrow \sum_i f_i^{rc}(\downarrow) \quad \gamma^{regular}(\downarrow) \Rightarrow \sum_i f_i^{rc}(\uparrow) \quad kl^{fc}(\uparrow) \Rightarrow \sum_i f_i^{rc}(\uparrow) \tag{14}$$

$$t_i^t(\uparrow) \Rightarrow Z(\uparrow) \quad \gamma^{regular}(\downarrow) \Rightarrow Z(\downarrow) \quad kl^{fc}(\uparrow) \Rightarrow Z(\uparrow) \tag{15}$$

Concerning the limitations, this model can be used for strategic and tactical planning since a homogenous fleet is assumed and no operative factors (booking management, max range, etc.) are considered. Furthermore, we regard a normal distributed demand and do not consider peaks and off-peaks. Here, only one vehicle can be assigned to a fast charger, but in reality it could be possible to share a fast charger.

To conclude, the optimization model and the DSS are a first approach to support the planning of car sharing stations for electric vehicles. The results of the benchmarks of Hannover and Zürich show that fast chargers and the charging infrastructure in general heavily determine the amount of stations, cars, and total cost.

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Appendix 16: Enterprise Content Management Systems as a Knowledge Infrastructure: The Knowledge-Based Content Management Framework

Authors: Thang Le Dinh, Tim A. Rickenberg, Hans-Georg Fill, Michael H. Breitner

Outlet: International Journal of e-Collaboration (IJeC) 11(3), 05/2015, pp. 49-70.

Abstract: The rise of the knowledge-based economy has significantly transformed the economies of developed countries from managed economies into entrepreneurial economies, which deal with knowledge as input and output. Consequently, knowledge has become key assets for organizations and knowledge management is one of the driving forces of business success. The management of knowledge assets as well as of the collaboration process between knowledge workers is one of the most important challenges faced by enterprises today. Critical business knowledge and information are often contained in mostly unstructured documents within content management systems. Therefore, content management based on knowledge perspectives is crucial for organizations, especially knowledge-intensive organizations. Enterprise Content Management has evolved as an integrated approach to manage documents and content on an enterprise-wide scale. There is a need to enhance this approach in order to build a robust foundation to support knowledge development and collaboration process. This paper presents the KBCM (Knowledge-Based Content Management) framework for constructing a knowledge infrastructure based on the perspective of knowledge components that could help enterprises to create more business value by classifying content formally and enabling its transformation into valuable knowledge assets.

Appendix 17: Towards Profitable and Sustainable E-Car-Sharing: A Decision Support Systems to Optimize Station Location and Size

Authors: Kathrin Kühne, Marc Sonneberg, Tim A. Rickenberg, Michael H. Breitner

Outlet: Submitted.

Abstract: Electric car sharing is a new mobility concept that addresses the world's growing interest in sustainability and that reduces greenhouse gas (GHG), traffic congestion and noise, and the shortage of parking spaces in cities. The positioning and sizing of car sharing stations is a critical success factor for reaching many potential users. To provide decision support in anticipating optimal locations and to further achieve profitability, we developed an optimization model in accordance with operation research principles. The integration of the model into the decision support system (DSS) OptECar-Share 1.5 enhances the operability by providing a graphical user interface, which helps the user import, edit, export, and visualize data. Using the example of a major German city, solutions are illustrated and discussed. Results demonstrate the applicability of the DSS and indicate that profitable operation of electric car sharing is possible, today. According to Green IS/DSS, our research therefore contributes to a more sustainable environment.

TOWARDS PROFITABLE AND SUSTAINABLE E-CAR SHARING: A DECISION SUPPORT SYSTEM TO OPTIMIZE STATION LOCATION AND SIZE

Abstract

Electric car sharing is a new mobility concept that addresses the world's growing interest in sustainability and that reduces greenhouse gas (GHG), traffic congestion and noise, and the shortage of parking spaces in cities. The positioning and sizing of car sharing stations is a critical success factor for reaching many potential users. To provide decision support in anticipating optimal locations and to further achieve profitability, we developed an optimization model in accordance with operation research principles. The integration of the model into the decision support system (DSS) OptECarShare 1.5 enhances the operability by providing a graphical user interface, which helps the user import, edit, export, and visualize data. Using the example of a major German city, solutions are illustrated and discussed. Results demonstrate the applicability of the DSS and indicate that profitable operation of electric car sharing is possible, today. According to Green IS/DSS, our research therefore contributes to a more sustainable environment.

Keywords: Car Sharing, electric vehicles, sustainability, decision support system, optimization model.

1 Introduction and Motivation

Growing level of eco-consciousness in both public and business sectors, combined with an increasing percentage of the world living in cities, evokes a rethinking of car usage and personal vehicle ownership (Dedrick, 2010; Shaheen and Cohen, 2013). Factors such as rising energy and ownership costs, sensitivity to environmental sustainability and growing importance of corporate social responsibility cause people to employ transportation alternatives (Dedrick, 2010; Katzev, 2003). Besides other means of public transport, the concept of car sharing has thus become a mainstream way of travelling, with more than one million users worldwide and the number is growing exponentially (Shaheen and Cohen, 2013). Car sharing is increasingly becoming a good alternative to private cars because users pay trip-dependent fees to remain mobile, while saving on both costs and emissions. Since electric vehicles save emissions and reduce noise in comparison to conventionally driven vehicles, they are perfectly suitable for a car sharing concept. Critical success factors of car sharing are the availability of the vehicles and the location of the stations in order to meet customer demand (Rickenberg et al., 2012).

Car sharing needs to be optimized due to greater levels of the environmental consciousness and the technological progress of electric vehicles. The sales figure of electric vehicles have increased for the first since 2005, which means that electric vehicles have not been associated with car sharing for very long (Dijk et al., 2012). Electric vehicles in the fleet of a car sharing organizations presents a sustainable and future-oriented concept. As a key factor in environmental issues and concerns, technology also holds a potential solution: Green IS contributes to sustainability by utilizing adequate design and implementation of information systems (IS) (Boudreau et al., 2009). Application of Green IS through an interactions between information technology (IT) and people enables the optimization of processes and products to increase resource efficiency, and directly and indirectly conserving resources, and achieving higher sustainability. The integration of electric vehicles represents a chance to fulfil customer demand and consider sustainable mobility. Since car sharing organizations need both the customer demand and a profitable concept to provide car sharing, the costs and revenues are both considered and optimized within our model. Without a profitable concept of e-car sharing, organizations have no incentive to integrate electric vehicles into their fleet, except for prestige reasons, and therefore profit maximization is a basic requirement for them. It enables a realistic implementation.

In order to use the optimal number of electric vehicles and to position the optimal location of a station, the optimization model of Rickenberg et al. (2013) was expanded to include the influencing factors of electric vehicles. The first model only examined conventionally powered vehicles and there were no electric vehicles in the fleet. Based on existing work on decision support for planning stations and operation research (OR) models, this paper introduces an optimization model and a decision support system (DSS), taking into account electric vehicles in a two-way mode, station-based and time-dependent demand while maximizing the profit of the car sharing organization. The graphical user interface (GUI) of the DSS helps the user import, edit, export, and visualize data. The DSS allows the user to set parameters, trigger numerical solving of the underlying model, and visualize optimization results. This enables instant validation, comparison and assessment of results and scenarios. Hence the research question of this paper is:

RQ: How can car sharing organizations provide profitable e-car sharing?

The remainder of this paper is structured as follows: first the research background is described, covering related work and research design. The optimization model is then explained and formally noted. Next, the DSS, which employs the underlying model, is presented. The applicability of the model is checked based on a German city and optimization results are based on the selected parameters. Section five discusses the presented model, DSS, and corresponding results, followed by theoretical and practical recommendations and limitations. The paper finishes with a conclusion and outlook.

2 Research Background

2.1 Car Sharing

"Never before has world opinion been so united on a single goal as it is on achieving sustainable development" (Glenn and Gordon, 1998; Watson et al., 2010). With this citation, Watson, Boudreau, and Chen (2010) appeal to the academic IS community to use the "transformative power" of IS to ensure and enhance environmental sustainability and address the resulting challenges (Watson et al., 2010). The importance of IS to achieve improvements on sustainability across the economy, defined as Green IS, is growing exponentially (Dedrick, 2010). With increasing public consciousness concerning the environment and with policy introducing new initiatives to reduce global warming, the industry faces challenges that the Green IS approach is able to address (Dedrick, 2010).

Car sharing is a transportation strategy that offers the use of vehicles to people who have the necessary permit and who pay variable, trip-dependent fees. After they register at a car sharing organization, they can use a vehicle from the fleet by picking it up and dropping it off at the same location, which is typical for the two-way car sharing considered in this paper. Members can utilize any available vehicle of the fleet as long and as often as they want to satisfy their mobility needs. To ensure availability, members may reserve a vehicle by phone, internet, or mobile phone; however, spontaneous rides are possible as long as no reservation exists.

The earliest, yet unsuccessful, attempts of setting up car sharing by organizations in Europe go back to the late 1940s (Millard-Ball et al., 2005; Prettenthaler and Steininger, 1999). The first time car sharing was successfully introduced was in the late 1980s in Switzerland and Germany, with other European, and since 1994, even North American countries, following (Kemp et al., 2000; Shaheen et al., 2009; Steiniger et al., 1996). Ever since then, the concept of car sharing has grown in popularity, with promising forecasts revealing its potential, predicting growth rates of worldwide users of approximately 2100% between 2010 and 2020 (Frost & Sullivan, 2014; Shaheen and Cohen, 2013). Africa is the only continent without an existing formal car sharing organization, however that will not be the case for long as there are plans to implement car sharing in South Africa, Kenya and Zambia (Shaheen and Cohen, 2013).

The reasons for the growing popularity of car sharing are manifold, however they can predominantly be summarized using the three types of sustainability that car sharing addresses: social equity, economic efficiency, and ecological awareness (Boudreau et al., 2009). Social equity is achieved by anti-discriminatory registration of car sharing organizations, meaning that anyone can use a vehicle independent of social background or income. Economic sustainability often represents the most important criterion for joining a car sharing organization, as members can achieve tremendous savings with very calculable costs per ride when compared to a private vehicle. Costs, such as procurement or leasing, fuelling, depreciation, residential parking, insurance, registration fees, maintenance, repair, and car-dependent taxes simply do not affect a car sharer (Duncan, 2011). Especially the usage of electric vehicles further leads to the third type of sustainability: ecological awareness. For instance, in North America a car sharing vehicle removes approximately 15 private cars (Cohen et al., 2008). According to a survey by Martin and Shaheen, the number of car sharing users with their own vehicles is significantly reduced. Before becoming a customer of a car sharing organization, 0.47 vehicles per household were used, this decreased to 0.24 vehicles after starting to use car sharing (Martin and Shaheen, 2011).

Car sharing vehicles are younger, create less pollution, and are much more fuel-efficient than most private ones; often hybrid or electrical vehicles are used to reduce the pollution even more (Millard et al., 2005; Barth and Todd, 1999). Moreover, the typical way people use cars changes, members usually use the shared vehicle less than they would use a private one, more trips are done by walking, bike, or with local public transportation systems. The perfect integration of car sharing into the public transport of any city brings the most potential customers and completes the sustainable concept of mobility. Resulting advantages affect the whole community, which profits due to less traffic, less pollution, less noise, and it frees up parking space, which can be replaced with green areas (Millard et al., 2005).

The typical user appreciates the above advantages, and accordingly is ecology-minded, well-educated, active, socially engaged, does not own a vehicle and thus regularly uses public transportation, and is usually between 24 and 40 years old, irrespective of gender (Martin et al., 2010). Correspondingly geographic factors such as high population density, walkability and mixed used urban areas with a good coverage of local public transfer are important for the success of a car sharing organization (Cohen et al., 2008; Celsor and Millard-Ball, 2007).

Many articles deal with a successful car sharing concept and consider the customer demand, but seldom the cost which arise when operating car sharing (Duncan, 2011; Efthymiou, 2013). For example, Shaheen's (2013) article provides a global perspective on car sharing growth and future developments and anticipates electric vehicle in the coming years in fleets of car sharing organizations. The motivation behind car sharing users and what kind of people join their ranks are both investigated by Bonsall et al. (1984), but they do not consider any costs or revenues. Caulfield (2011) examines households in Ireland that own more than one vehicle and have the potential to become car sharing users. The potential and development of car sharing is much discussed in further articles and competitive conditions are also considered (Shaheen et al., 2010). Within a competitive situation, the cost and revenues are even more relevant and the maximization of the profit helps to achieve a large market share. The operative level is optimized in a paper from Cepolina and Farina (2012), where the reallocation problem for one-way-trips and unbalanced demand is considered, but not optimal location and size. The allocation of rides to reduce the number of vehicles on the streets was examined by Costa et al. (2012). The research gap is exactly between the demand and the operative level. Compared to the rather broad range of literature on the history and statistics of car sharing, work on strategically optimizing the positioning of stations is fairly limited. Hence our research concentrates on the strategic level and gives decision support for planning a both profitable and sustainable car sharing concept in any city. Rickenberg et al. (2012), Olivotti et al. (2014) and Kühne et al. (2014) already address this issue. This paper incorporates the above considerations into a new and more ecological model for electric car sharing. The model represents an approach reducing pollution and contributing to a cleaner and more sustainable environment. In this paper, we expand the existing model and provide a first decision support for a profitable e-car sharing concept for car sharing organizations. With the enormous growth rates, the rising importance of sustainability and Green IS as well as the current literature about demand and potential users of car sharing in mind, decision support for optimizing the location of car sharing stations is becoming more valuable for organizations. It ensures expeditious, effective and successful planning of the stations.

2.2 Research Design

Our research is based on the operations research strategy (Domschke and Drexel, 2007), see Figure 1:

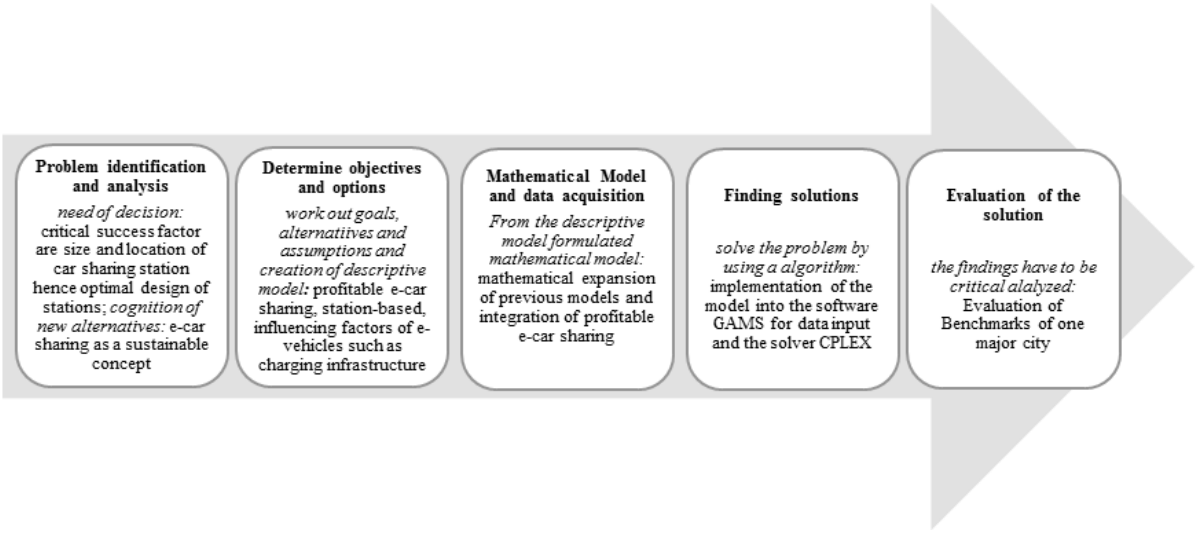

Figure 1. Research Design

The main objective was to plan and decide practice-relevant and realistic problems, like location issues. We conducted our research design several times to ensure that environmental requirements were met on the one hand and scientific methods and existing expertise were considered on the other. The research process began with problem identification and analysis and included a review of existing knowledge. The literature review showed the research gap and the problem. An optimal decision was required to achieve the maximal demand of potential car sharing users. A new alternative to conventionally powered vehicles are electric vehicles, which are considered in our model to meet the environmental awareness of humans in cities. As already mentioned, a successful concept and management of car sharing is only realistic when positive profit can be achieved. Therefore the influencing factors of electric vehicles, the cost of charging infrastructure, and the cost of the vehicles and the stations are considered. Using these factors and assumptions around the environment and other restrictions, we formulated a mathematical model to implement it into the software GAMS (General Algebraic Modeling System) and to show the results with a developed DSS called OptECarShare 1.5. The DSS and the underlying optimization model were tested extensively to enable proper documentation and publication of research results.

3 Model

The objective of the optimization model is to find the best distribution of stations and vehicles of a two-way electric car sharing fleet in an urban area while maximizing the net profit over a period of one year. Considered costs included fix cost of fix, e.g. annual leasing costs for a vehicle, and variable costs, such as energy consumption costs for trips. Kühne et al. (2014) explained that the charging infrastructure plays a major role since there are two considered possibilities for charging an electric vehicle. The first option is the regular charging infrastructure, which typically requires eight hours on a conventional wall socket to charge the battery. A fast charging infrastructure represents the second option, where the battery need only 0.5 hours to charge 80%. Since satisfaction of the demand is in the focus of this research, the fast charging infrastructure is a good option to provide a vehicle as soon as possible for the next customer. A vehicle is then available when the expected driving time and the calculated charging time is over during one period. Then, the vehicle can be used again to fulfil the demand. Hence the number of vehicles with regular and with fast chargers are optimized and the number of parking lots at the responding station as well. The problem of optimal number of vehicles with regular and fast charging create a new decision and optimization problem, and one that was not considered in the model from Rickenberg et al. (2012). In the case of two-way car sharing, every vehicle occupies one dedicated parking spot at a specific station, and the vehicle has to be returned there after the trip. The fleet of electric vehicles is homogeneous to keep the model simple. We do not consider any one-way-trips due to charging infrastructure (regular and fast), which is required for the use of electric vehicles. On every station the optimal number of charging infrastructure is placed, so that with one-way-trips the risk exist, that no charger is available.

The candidate stations and demand locations are set on a punctual basis with specific geographic coordinates within the observation area. We chose the demand points using “Google Maps” and set them close to public transport stations and residential areas. The potential stations were found to be similar, but here we also considered the space required for any station and thus parking lots. To satisfy the mobility needs of the customers, the existing demand is served completely. These mobility needs are modelled stochastically and are normal distributed. The demand is time dependent based on six different time windows within a day to illustrate peaks and off-peaks. Based on data from a cooperating car sharing organization, we know that the highest demand is between 4pm and 8pm every day. The location of the stations is essential finding the optimal balance between number and size of stations. The maximum distance between a demand point and a car sharing station must not exceed a determined value to satisfy customer requirements (Katzev, 2003; Stillwater et al., 2009). A minimum population density and a maximum shortage of parking can be calculated. The optimization model from Rickenberg et al. (2012) served as basis. The notation and the resulting mathematical problem are specified as follows:

Sets:

$i = (1, \dots m)$: *potential station location* — $j = (1, \dots, n)$: *demand location*

Parameters:

d_j: *normal distributed demand* [*rents/day*] — *min*: *expected duration of a rent* [*min*]
rev: *revenue for renting* [€/*min*] — *trip*: *expected distance driven* [*km*]
energy: *average energy consumption* [*kwh/km*] — *price*: *price* [€/*kwh*]

lv: *leasing cost of a vehicle* [€ /*year*] — *ll*: *leasing cost of a parking lot* [€ /*year*]
lc^{reg}: *leasing cost of regular charger* [€ /*year*] — lc^{fast}: *leasing cost of fast charger* [€ /*year*]
ls: *leasing cost of a station* [€ /*year*]

x^{reg}: *possible trips regular* [*units*] — x^{fast}: *possible trips fast* [*units*]
dmax: *demand of busiest interval* [*rents/day*]

$maxl_i$: *max. lots at station i* (#) — *maxlfast*: *max. lots with fast charger* (#)
$dist_{ij}$: *distance betw. station i and demand point j* [*km*] — *maxdist*: *max. distance betw. i and j* [*km*]
sp_i: *shortage of parking at station i* [%] — *maxsp*: *general shortage of parking* [%]
pd_i: *population density at station i* [*inhab./area*] — *minpd*: *min. population density* [*inhab./area*]

Figure 2. Sets and Parameters

$$Max.F(v^{reg}, v^{fast}, y) = \overbrace{\sum_{j=1}^{n} d_j * (min * rev)}^{revenue} - \overbrace{\sum_{j=1}^{n} d_j * (trip * energy * price)}^{variable\ costs} - \overbrace{\sum_{i=1}^{m} \left(v_i^{reg} * (lv + ll + lc^{reg}) + v_i^{fast} * (lv + ll + lc^{fast}) + y_i * ls\right)}^{leasing\ costs} \quad (1)$$

$$\sum_{i=1}^{m} z_{ij} = 1 \quad \forall j \quad (2)$$

$$y_i \geq z_{ij} \quad \forall i \text{ and } j \quad (3)$$

$$v_i^{reg} * x^{reg} + v_i^{fast} * x^{fast} \geq \sum_{j=1}^{n} (dmax_j * z_{ij}) \quad \forall i \quad (4)$$

$$v_i^{reg} + v_i^{fast} \leq maxl_i \quad \forall i \quad (5)$$

$$v_i^{fast} \leq maxlfast \quad \forall i \quad (6)$$

$$dist_{ij} * z_{ij} \leq maxdist \quad \forall i \text{ and } j \quad (7)$$

$$sp_i * y_i \leq maxsp \quad \forall i \quad (8)$$

$$pd_i \geq minpd * y_i \quad \forall i \quad (9)$$

$$y_i \in \{0, 1\} \quad \forall i \quad (10)$$

$$z_{ij} \in \{0, 1\} \quad \forall i = and\ j \quad (11)$$

$$v_i^{reg}, v_i^{fast} \geq 0 \quad \forall i \quad (12)$$

Figure 3. Mathematical Model

The objective function (1) maximizes the net profit of a car sharing organization by calculating the revenue and subtracting the resulting variable and leasing costs annually. To avoid redundancy, every demand location is served by exactly one car sharing station (2). Constraint (3) ensures that every demand point can only be assigned to a station, which is actually built. The existing demand has to be fulfilled in compliance with electric power limitations (x: it is calculated in equations 13 and 14) by constraint (4). Every station has a certain limit on parking space for vehicles (5) since limited parking is available around any station. While (6) sets a maximum amount of fast-charging infrastructures at all stations, the provision of electric power is ensured. Constraint (7) ensures that a maximum distance between a demand location and a station is not exceeded since the distance is a critical success factor to car sharing. The shortage of parking at a station (calculated in equation 15) must not exceed the general shortage of parking (8) and a minimum level of population density (calculated in equation 16) can be set by constraint (9). Equations (10), (11), and (12) set the specific value range of the existing decision variables.

Equations (13), (14), (15), and (16) are required to calculate parameters; (13) and (14) refer to feasible trips per period (x^{reg}; x^{fast}), considering the individual trip times and resulting charging times, with (13) used for regular loading and (14) for the use of 50kW DC fast chargers. The duration of a period is set to four hours and the duration of a trip is an average value of two hours. Both are assumptions based on data from a cooperating car sharing organization. The maximum charging time of a completely empty battery is different and depended on charging infrastructure (eight hours or a half-hour). Due to a maximum range of an electric vehicle, it is only possible to drive a maximum distance of 150 km with an assumed average speed of 0.41667km/min.

The local shortage of parking is calculated via (15). To meet the demand of potential car sharing users it is necessary to have a critical value of shortage of parking around any station, and the parameter $maxsp$ is set to observe that value (in our calculations it is set at 75). Equation (16) then determines the population density at each individual station so that a minimum level of population density is required for the positioning of a station. The initial value of $minpd$ is set at 1200.

$$x^{reg} = \frac{duration\ of\ a\ period}{duration\ of\ a\ trip * \left(1 + \frac{maximum\ charging\ time\ regular}{\left(\frac{maximum\ range\ of\ a\ trip}{average\ speed\ of\ a\ trip}\right)}\right)} \quad (13)$$

$$x^{fast} = \frac{duration\ of\ a\ period}{duration\ of\ a\ trip * \left(1 + \frac{maximum\ charging\ time\ fast}{\left(\frac{maximum\ range\ of\ a\ trip}{average\ speed\ of\ a\ trip}\right)}\right)} \quad (14)$$

$$sp_i = \frac{average\ free\ parking\ lots\ aroud\ station\ i}{registered\ vehicles\ around\ station\ i} * 100\% \quad (15)$$

$$pd_i = \frac{population\ at\ station\ i}{area\ at\ station\ i} \quad (16)$$

Figure 4. Calculations

The DSS integrates the optimization model and several applications within one system to enable decision support. The OptECarShare 1.5 web application, the optimization model, and sample data pools for Hanover and Zurich are available under: http://130.75.2.178/optecarshare.html.

Raw data about stations and demand can be kept in a spread sheet and be exported to an XML file. The data can be loaded from an XML file into the Java application and the GUI (see Figure 5). The imported data and parameter configuration can be viewed and edited at any time. The optimization starts by sending information to GAMS, which provides the mathematical modelling. The mixed integer programming (MIP) model is solved by IBM ILOG CPLEX. During the optimization, the progress is presented on screen, shown on the left side of Figure 5:

Once the optimal solution is found, results can be visualized and saved to a file. The optimization problem is np-hard. Especially for large instances, the optimal solution is hard to determine. The actual time to solve the problem depends on the size of the instance and settings. Mashup technologies (JavaScript, Google Maps API) are used for the visualization of results to enable instant graphical validation.

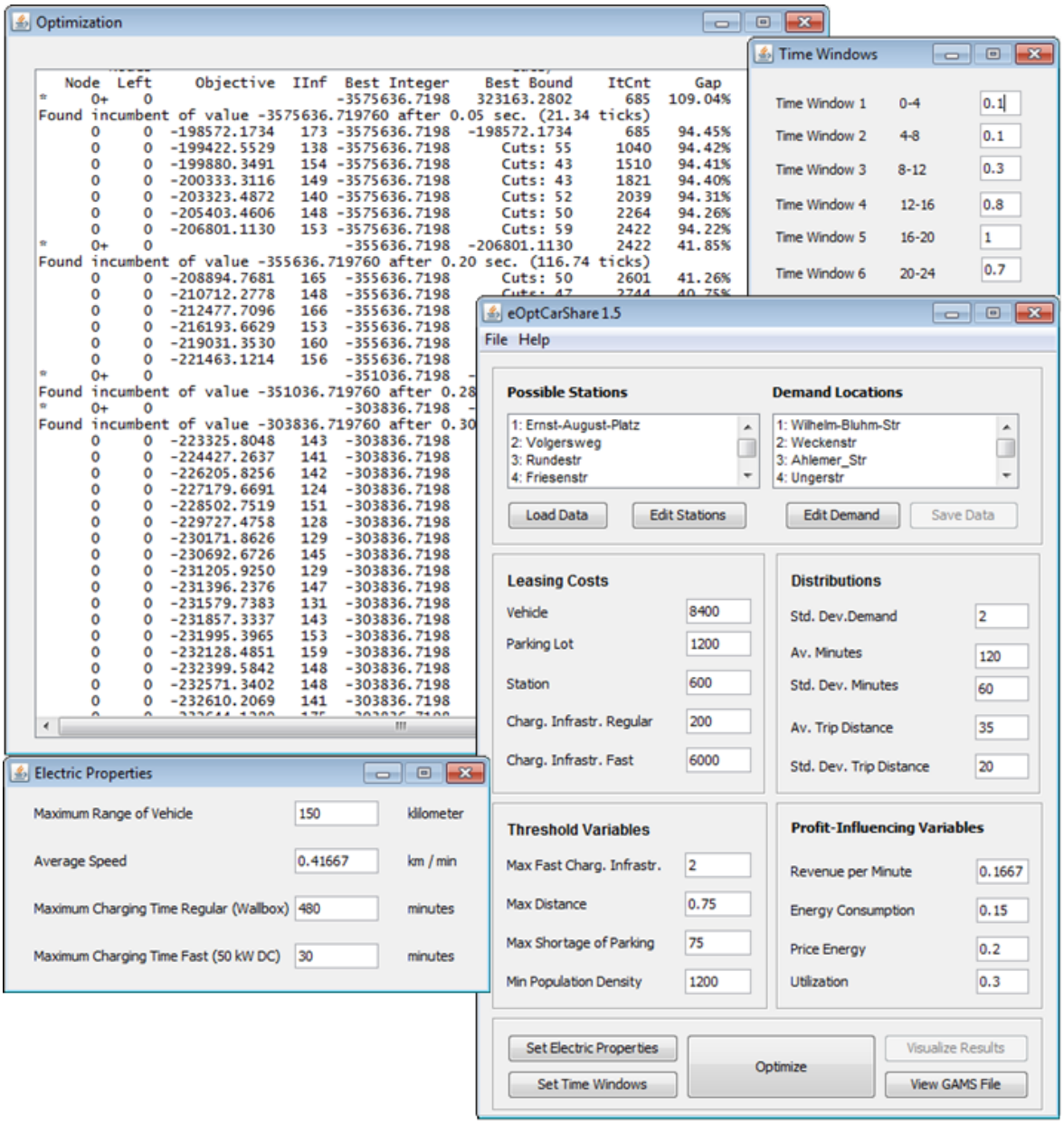

Figure 5. Screenshots DSS

4 Benchmarks

The applicability and feasibility of the developed research artifacts – the DSS and the mathematical model – are tested and exemplified in an illustrative example of the German city of Hanover. The city has an appropriate population of 525,000 people, as well as the population density, and public transport required to allow for car sharing.

The GUI with the data and configuration applied in this example is shown in Figure 5. It includes 30 demand locations, which can be served by 100 candidate car sharing stations. The potential stations are located off-street with access to public transportation nearby. A limit of possible parking lots, an on-hand shortage of parking, and an existing population density is assigned to each candidate station. The electrical parameters are set to realistic values in accordance with the latest technology, as shown in the respective window in Figure 5. Total demand is aggregated within certain demand locations with normal-distributed demand patterns. For increased accuracy, six distinct time windows are used to describe the alternating user behavior within a day. The typical distribution of two-way car sharing usage, as experienced by our research partner, is presented in "Time Windows" in Figure 5. The turning point is clearly visible: Before 12 o'clock the demand is low, but it increases considerably in the afternoon, reaching its peak in the pre-evening between 4 pm and 8 pm, when it decreases again. The trip-dependent and profit-influencing parameters, the yearly leasing costs, and the threshold values are illustrated in Figure 5. Yearly leasing costs include all resulting costs for maintenance, repair, cleaning, insurance, taxes, and depreciation, with a planned amortization time of ten years. The revenue per minute is 0.20€ per minute for driving and 0.10€ per minute for parking with an assumed breakdown of 2/3 for driving and 1/3 for parking time.

From the above parameters, the expected travel time of a car sharing customer, the cost of fast charging infrastructure, and the maximum distance between stations and demand points are the most influencing ones with regards to the optimization results. Figure 6 therefore shows the relationships and the effects, when the parameters vary. The benchmarks were conducted on a standard-PC (Intel i5 3.3 GHz CPU, 16 GByte RAM) using GAMS 24.1.3 and CPLEX 12.5.1 with a set optimization gap of 3% and a maximum computing time t[s] of 1000 seconds.

Figure 6 is divided into four tables, 0.5 km, 0.75 km, 1 km and 2 km as maximum distance between each demand and the next station. Each table also shows the annual costs for each fast charging infrastructure of €4,000, €8,000, €10,000 and €15,000. The two benchmarks were conducted in different driving time profiles, since the expected driving times greatly influence the corresponding standing and charging time of an electric vehicle, which contrasts greatly to conventional powered vehicles.

low travel profile	max. dist. = 0.5 km				max. dist. = 0.75 km				max. dist. = 1 km				max. dist. = 2 km			
	profit (€)	y (#)	vreg (#)	vfast (#)	profit (€)	y (#)	vreg (#)	vfast (#)	profit (€)	y (#)	vreg (#)	vfast (#)	profit (€)	y (#)	vreg (#)	vfast (#)
lcfast = 4000€	142347	12	3	11	174147	8	0	11	179147	6	1	10	179747	5	1	10
lcfast = 8000€	98347	12	3	11	129547	8	0	11	139147	6	1	10	139747	5	1	10
lcfast = 10000€	76347	12	15	5	108147	8	2	10	119147	6	1	10	119747	5	1	10
lcfast = 15000€	75747	13	25	0	92147	9	21	1	108147	8	22	0	109947	5	22	0
high travel profile	max. dist. = 0.5 km				max. dist. = 0.75 km				max. dist. = 1 km				max. dist. = 2 km			
	profit (€)	y (#)	vreg (#)	vfast (#)	profit (€)	y (#)	vreg (#)	vfast (#)	profit (€)	y (#)	vreg (#)	vfast (#)	profit (€)	y (#)	vreg (#)	vfast (#)
lcfast = 4000€	310410	12	5	17	336610	11	1	18	337810	9	1	18	347010	10	0	18
lcfast = 8000€	242410	12	5	17	265210	10	1	18	265810	9	1	18	275610	9	0	18
lcfast = 10000€	208410	12	9	15	229210	10	1	18	230410	8	7	15	240210	8	4	16
lcfast = 15000€	178210	13	37	2	199610	10	35	2	205210	9	37	0	210810	8	39	0

Figure 6. Benchmarks Hanover

These numbers were chosen in correspondence with current literature. For example, Musso et al. (2012) state that the distance between demand and station should not exceed 500 m. To investigate the influence of the distance, we varied this value, but the customers willing has to be given to walk longer to the next station. Costs for fast charging infrastructures were provided by a German car sharing company. In the future, the costs might be lower due to mass production and better technology. The lower costs take

possible subsidies from the government into account, e.g., to enable sustainable individual mobility in cities.

Looking at the Figure 6 and by a comparison of the two different travel profiles it is apparent that many more vehicles are used and some more stations are built with a higher travel profile. In the second travel time profile, the higher number of stations results from the higher number of total vehicles, since more parking lots are needed. As already mentioned, the travel time has a big influence on the charging time. A vehicle is only available to the next customer when it is fully charged. The longer a trip takes, the longer the charging time. Since the regular charging infrastructures require almost eight hours at the high travel profile (180 min), the vehicles with fast charging infrastructure are used more than in the lower profile (120 min). But with the higher travel time, comes another advantage, because car sharing customers have to pay for the entire time, so higher revenue can be realized and therefore profit increases.

Considering the maximum distance, it is noticeable that with a longer distance between a demand point and a station fewer vehicles are needed. Especially the number of vehicles with regular charging infrastructure decreases. This suggests that the vehicles on a lower maximum distance set are not fully used and therefore the profit is even lower. However, some potential customers need a short distance to become a user of car sharing, which makes the distance critical. In addition, for the car sharing organization it is required to provide more stations to satisfy the customer demand and wishes with a low distance.

With increasing costs for fast charging infrastructures generally more regular chargers are built in order to compensate for those costs. At the same time the number of stations stays mainly alike, with a small tendency to less stations, which is independent of travel time profile and distance between station and demand location. At the last tested yearly leasing cost of 15,000€ the effect is even higher as with the previous tested costs. This means, that the fast charging infrastructure becomes more unattractive due to the high cost even it is still much more efficient that the regular charger.

The computing time was usually below four seconds; however, with a maximum distance of 1 and 2 km it went up to 1000 seconds and the calculation stopped automatically due to our GAMS settings. Longer runtimes do not affect the utility of the model though, as it solves a strategic problem that does not require re-calculation on a daily basis.

The DSS enables the user to easily create visual representations of stations built and demand points using Google Maps. It validates the outcome of the optimization process. Figure 7 shows the optimal results for Hanover with an allowed gap of 3% using the following settings: with a maximum distance of 0.75 km, a low travel time profile, and costs for fast charging infrastructures of €8,000. In order to maximize profit, the car sharing organization should open eight stations with a total of eleven vehicles, all of which use fast charging infrastructure. The overall profit then amounts to €129,547. Demand locations are represented by blue markers in the map; stations are indicated by green markers. When users click the markers in Google Maps, the properties of the station are shown, i.e., the specific number of regular and fast chargers. In general, the optimal values to maximize profit depend on the settings and variables used. Different alternatives can be calculated and visualized to allow decision support for the process of finding the solution that best meets the actual budgetary or strategic goals of the car sharing organization. These needs may vary in their focus, such as. ecological and economic sustainability, keeping the costs as low as possible, or reaching the highest levels of customer satisfaction.

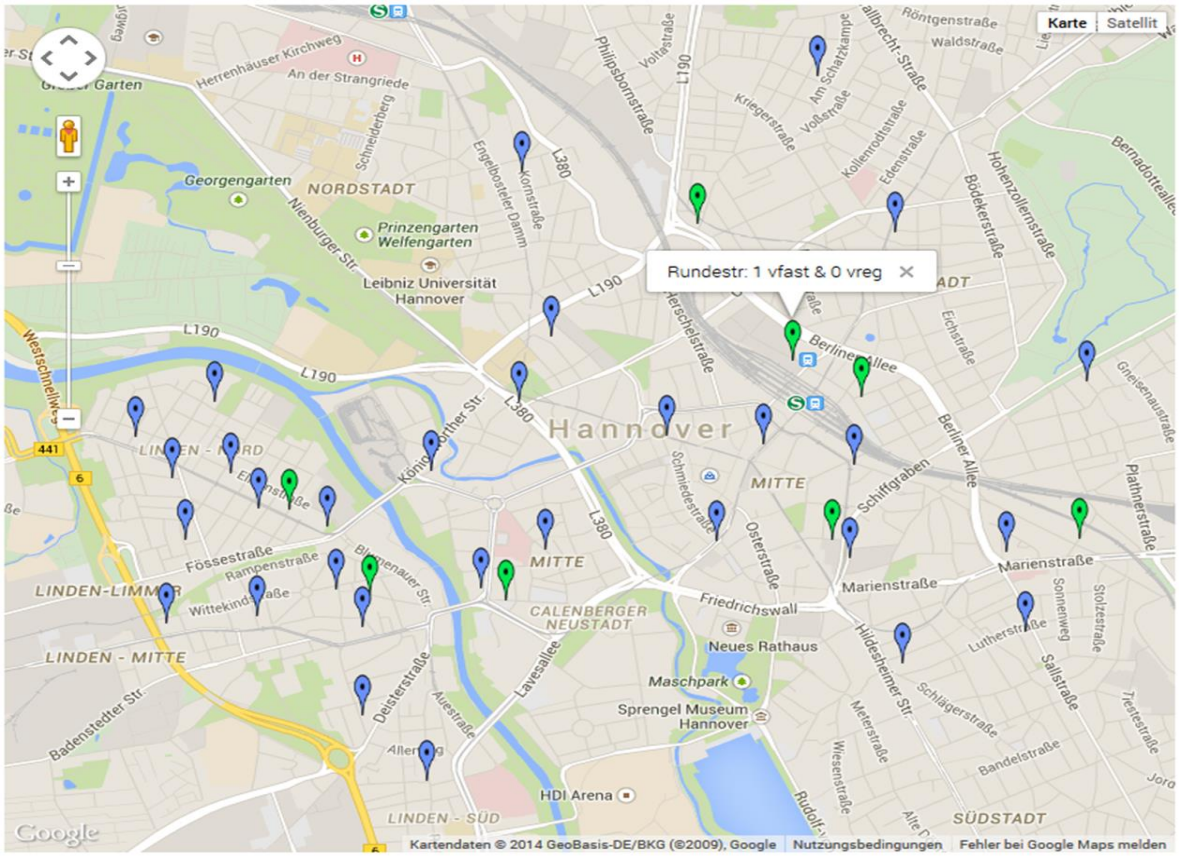

Figure 7. Visualization of results

5 Discussion, Recommendations, Limitations, and Implications

We created research artifacts and refined them, and evaluated in order to provide decision support for the optimization of location and size of electric car sharing stations. The introduced optimization model is based on existing OR models and is integrated into a DSS to provide further usability by creating an intuitive interface for managers, planners, and decision-makers. Characteristics of a city, in our example the city of Hanover, can be easily integrated to help planners solve the complex problem of determining location and size of car sharing stations. In order to realize low computing times for standard PCs or notebooks, a gap of 3% was set so that a result can be found quickly and instances can usually be solved within a few seconds. An improvement beyond the above gap is possible through additional computing time, however, since the model addresses strategic planning as compared to e.g. operative control, computing time does not represent a critical aspect.

As car sharing and especially electric car sharing focuses on a clean environment with state-of-the-art technology, the introduced model contributes to enhanced ecological sustainability. The model and DSS allow car sharing companies to plan their station arrangements in a time-saving, yet optimal manner. The DSS provides the main user interface and incorporates the underlying model to facilitate its usage, therefore, the DSS may also be called a Green DSS.

Even though our model and DSS create a precise recommendation of station allocation throughout a city, certain limitations and possible enhancements need to be considered. Theoretically, the applicability of the model is not limited, i.e. it can be used for any city worldwide that fulfils the discussed conditions with regards to public transport and population density. The evaluation of the model and its applicability, however, has so far only been carried out for the inner city of Hanover. Further test for bigger

cities and larger metropolitan areas are required. The model and also the DSS therefore should also be applied on other exemplary cities to ensure transferability and generalizability.

Our model is based on many simplifications and assumptions of input data, especially the demand. The information exchanged within our project with a major German car sharing organization gave us important input on how to further refine the model in the future. Furthermore, the punctual character of the demand should be critically considered. Although the stochastic but discrete demand is not subject to a continuous concentration, the application example shows that the modelling of the demand is adequate. The use of a static and rather deterministic model that still has stochastic parameters provides a starting point to modelling and optimizing this real-world problem. An increase in the number of demand locations certainly enhances the model and draws an even more realistic image of reality. An additional aspect that can be discussed as a limitation is that the model does not allow free-floating or one-way trips. With regard to the charging time of electric vehicles, free-floating does not seem applicable or useful. One-way trips are also challenging to implement, because enough charging infrastructure or reallocation and additional parking lots are required to address possible imbalances in the car sharing network. Though possible, one-way trips do not appear practical in operative application, since they require clients to predefine the exact time frames, start and end points of their travel. They can furthermore stop trips from happening as planned due to occupied charging infrastructure, which could actually be available at the time of the trip. Thus the proposed two-way model represents an effective way of electric car sharing using today's technology.

Despite the applicability and performance of the introduced model and DSS, certain refinements may enhance the quality of the model. The most promising adjustments can be achieved in the context of the demand. The constraint to satisfy demand completely forces the installation of a station even if that station is then used by only a few people, meaning that this specific station is actually non-profitable. A minimum satisfaction of demand of e.g., 75% can solve this issue and can increase the profit of the car sharing organization. In contrast to this, demand can decrease due to dissatisfaction of potential customers. The reputation of the car sharing organization can deteriorate and therefore less demand accrues, decreasing profit. Moreover, a demand point of the model may be assigned to more than one station, i.e., if all vehicles from a station are in use, a client could use a vehicle from another station, which means that the total amount of required vehicles could decrease. Currently only one vehicle is assigned to one charging station. To optimize the profit even more, further assumptions can be made for the charging infrastructure by assigning two or more vehicles to one infrastructure. For these assumptions, a safety parameter should be included to cover the risks so that more vehicles are available in case one vehicle cannot be charged on time. Further conceivable refinements include a simulation of the demand. This could create forecasts and help find popular stations, which could then be opened preferentially. Further, the implementation of additional multi-mobility-constraints, i.e., emphasizing the importance of stations near public transportation and especially the central station, or the creation of timeframes throughout both the day and the week, in combination with a price-related demand are more examples of expanding the demand-side of the model. In addition, costs for stations and corresponding parking lots should be amended by choosing more realistic values for the respective location, meaning that a parking lot next to the central station is more expensive than one farther away. Future research should also evaluate the accuracy of the breakdown into 2/3 of driving and 1/3 of parking time and may include additional types and sizes of electric vehicles. Thinking outside of the box, more refinements may help gain the attention of prospect clients who then can become a part of the car sharing community. These adjustments also include soft factors to integrate locations with strategic importance e.g., for desired clientele. On-street instead of off-street parking of vehicles can increase the visibility of car sharing in case this is permitted in the respective area. For example, cities can subsidize free parking lots or even free charging infrastructures in order to promote sustainable mobility. In order to plan optimally, the biggest challenge of the car sharing organization is to investigate realistic data on demand and expected traveling time. Precise values are essential to satisfying customer needs and maximizing profit simultaneously.

This paper addresses electric mobility in a car sharing environment as an economic and ecological sustainability approach from which several theoretical and practical implications arise. Using the operations research design, the theoretical side covers the addition of a car sharing model to the knowledge base that can be used, extended, or amended as required, and deployed beyond the sole application of electric car sharing on similar optimization problems. Practical implications concern the environment in the research design. The research artefacts are a Green IS approach and allow for improved sustainability through easy and self-explanatory usage of the DSS. Cities that experience traffic or ecological issues can use the model and DSS to countervail these with the implementation of a car sharing network. The required decision support is realized by the visual representation of optimization results, which further facilitates utilization and opinion forming. This enables the implementation of car sharing and a greener future.

6 Conclusion and Outlook

In this paper, we introduced a model to provide decision support for the complex task of planning the optimal locations and sizes of electric car-sharing stations. The integration of the model into a DSS enhances the applicability and usability of our approach. The DSS provides a user-friendly interface, allows data import, and triggers the optimization and visualization of results. The DSS and the underlying model were evaluated and demonstrated using the example of a major German city. The close relationship between our Green IS approach and artifacts of electric car sharing was explained together with its possible contribution to environmental sustainability.

While the applicability and usefulness of the optimization model and the DSS were evaluated and shown, certain limitations were identified. Considerable benefits could be drawn from deeper empirical evaluation in the field and from a more profound quantitative analysis, which is suggested to be carried out in the context of the research design. The ongoing cooperation with a German car sharing company will help implement us implement this suggestion and also to take further unconsidered requirements into account.

Especially when discussing the model, implications and recommendations for additional research can be derived. The optimization model itself can and should be further refined by the scientific community to achieve constantly increasing sustainability through Green DSS. To conclude, we emphasize that the potential of Green IS and sustainable e-car sharing is high. Our model allows car sharing in combination with electric vehicles in major cities and supports decision makers at the strategic level. The e-car sharing concept can be connected to existing public transport while reducing GHG emissions and noise, as well as the number of vehicles and therefore parking space. We would like to see further examples in all kinds of possible application domains.

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Appendix 18: A Process Model to Integrate Data Warehouses and Enable Business Intelligence: An Applicability Check for the Airline Sector

Authors: Cary Edwards, Tim A. Rickenberg, Michael H. Breitner

Outlet: IWI Discussion Paper #64, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, 11/2014, pp. 1-17.

Abstract: Since the data warehouse allows the extraction of needed information for organizational decision making processes, it has received great attention by many companies. However, companies often face the problem that many heterogeneous data warehouses accumulated over the past. Executives and business users are often unaware of the existence of accurate information. To receive a unique overview and, consequently, having consistent shared data, an integration of independent data warehouses must be realized. This can help to improve decision support, business intelligence, and even knowledge management. Therefore, we constructed and introduce an iterative data warehouses integration process model (DWH-IPM) as a first approach. Our process model is divided in to six main phases including several activities to achieve a successful integration outcome. Within a globally operating flight company, we check to what extent the applicability of the designed research artifact can be assumed.

Appendix 19: Big Data, Social, Mobile, and Cloud Computing: Towards a Reference Model for IS Governance and the Nexus of Forces

Authors: Benedikt Lebek, Tim A. Rickenberg, Bernd Hohler, Michael H. Breitner

Outlet: Submitted.

Abstract: The Nexus of Forces describes the convergence and mutual reinforcement of the four interdependent trends big data, social, mobile, and cloud computing. Organizations aim to maximize the benefits resulting from the forces while mitigating the associated risks. It is assumed that the interconnectivity of the four individual forces provide unique challenges for IS governance. Although recent studies begin to investigate single forces with regard to IS governance, none of these combine the forces within a comprehensive and integrated reference model. To address this gap, we conduct a Delphi study with 18 business and IT/IS managers from companies across different industries. Based on qualitative data analysis, we create and introduce an initial reference model that helps understanding the impact of the Nexus of Forces on organizational IS governance structures. Drawing from the model, implications and areas for future IS research are derived. The reference model encourages clear communication and provides IS researchers with a basis to develop specific models. Concerning IS practice, the model allows organizational decision makers to derive an effective IS governance implementation.

Big Data, Social, Mobile, and Cloud Computing: Towards a Reference Model for IS Governance and the Nexus of Forces

Abstract

The Nexus of Forces describes the convergence and mutual reinforcement of the four interdependent trends big data, social, mobile, and cloud computing. Organizations aim to maximize the benefits resulting from the forces while mitigating the associated risks. It is assumed that the interconnectivity of the four individual forces provide unique challenges for IS governance. Although recent studies begin to investigate single forces with regard to IS governance, none of these combine the forces within a comprehensive and integrated reference model. To address this gap, we conduct a Delphi study with 18 business and IT/IS managers from companies across different industries. Based on qualitative data analysis, we create and introduce an initial reference model that helps understanding the impact of the Nexus of Forces on organizational IS governance structures. Drawing from the model, implications and areas for future IS research are derived. The reference model encourages clear communication and provides IS researchers with a basis to develop specific models. Concerning IS practice, the model allows organizational decision-makers to derive an effective IS governance implementation.

Keywords: big data, mobile computing, social computing, cloud computing, IS governance, Delphi study, reference model

1. Introduction

The rapid development of technical innovations and their adoption and diffusion is shaping our current decade. New technologies enable groundbreaking opportunities that impose far-reaching changes to business, economies, and societies. Based on recent advances in processor speed, network bandwidth, and storage, the trends of social, mobile, and cloud computing, as well as big data analytics are on the rise (Goes, 2013). These four forces are predicted to have a lasting impact on the information systems (IS) domain and provide implications and opportunities that go beyond mere technical aspects. In a recent study, the IT research and advisory company Gartner defined these trends as the "Nexus of Forces", referring to the convergence and mutual reinforcement of the four interdependent trends.

Both individually and combined, the Nexus of Forces empowers individuals in their interaction with each other and with associated information through well-designed ubiquitous technology (Gartner, 2013): Information provides the context within the Nexus of Forces for rich social and mobile user experiences. Mobile devices offer a platform for pervasive social networking and new ways of working. Social media and social content allow people to connect with each other and their work in new and innovative ways. Cloud deployment enables ubiquitous and easy access to information and functions for users and IS. Although these forces are innovative and disruptive on their own, together they have the power to revolutionize business and society, breaking down old business models and creating new leaders. Gartner (2013) defines the Nexus of Forces as the basis of the technology platform of the future.

The Nexus of Forces is becoming real as enterprises turn digital and reinvent traditional IT and IS. There is a shift in power towards and emancipation of the users that will also influence traditional management and control mechanisms such as IS governance. Organizations face the problem of how to take advantage of the opportunities that evolve from the Nexus of Forces and maximize the resulting benefits while mitigating the associated risks. A demand for a robust

framework to govern these technologies arises. In this context, IS governance is of high relevance, as it focuses on aligning business and IT (De Haes and van Grembergen, 2004; van Grembergen et al., 2004; Dahlberg and Kivijärvi, 2006). By creating flexible IT and IS structures and processes, IS governance addresses the design and implementation of effective organizations (Patel, 2002) and directly influences the benefits generated by organizational IT investments (Webb et al., 2006). A positive correlation between IS governance and organizational performance has been confirmed by several studies (Looso, 2010). For example, Weill and Ross (2004b) state that companies with above average governance earn more than 20 percent higher return on assets (ROA) than organizations with weaker governance. To meet these goals, practitioners have developed several frameworks and tools for IS governance, including COBIT, ITIL, CMMI, and ISO/IEC 17799.

IS governance is an important topic, not only for practitioners, but also for researchers (Webb et al., 2006; Dahlberg and Kivijärvi, 2006). Several recent studies addressed IS governance in the context of one of the trends social, mobile, and cloud computing or big data analytics (e.g., van Osch and Coursaris, 2013; Heier et al., 2012; Malik, 2013). However, the interconnections among the four individual forces provide novel challenges for IS governance and academic research is currently not taking phenomenon into account. In order to address this gap, the purpose of our research is to set up recommendations and to use Delphi methodology to create a reference model that addresses the new requirements and challenges presented by the Nexus of Forces. We pursue the following research question:

RQ: How do the new challenges of big data, social, mobile, and cloud computing influence IS governance?

Existing research in the area of IS governance typically focuses on IT organization, allocation of decision rights for main IT decisions, aligning business and IT, and the consequences of alternative governance and alignment arrangements (Dahlberg and Kivijärvi, 2006). Due to the

importance of the emerging trends of social, mobile and cloud computing and big data analytics and their independencies, scientific research that addresses the interaction of the forces and their impact on corporate IT is needed. Following Goes' (2013) proposal that IS research has the task to "recognize emerging areas and phenomena brought about by innovations", (p. v) also aim to uncover potential research areas and provide guidance for future research.

This paper is structured as follows: After the introduction, the theoretical background provides an overview of the related literature explaining IS governance and the Nexus of Forces. On this basis, a conceptual model is formulated to provide the baseline for our research. The next section depicts the underlying research design, including a description of the processes for collecting and analyzing data. Afterwards, a reference model for IS governance and the Nexus of Force is introduced and explained. A discussion with implications for further research follows and provides key areas for future research. Finally, the paper ends with identified limitations and a short conclusion with outlook.

2. Theoretical Background

IS governance is commonly referred to as an integral part of corporate governance (Webb et al., 2006; Burtscher et al., 2009). It draws from corporate governance principles and focuses on the management and use of IT in order to achieve corporate performance goals (Weill and Ross, 2004b). IS governance is closely related to the subjects of IT management, information governance, strategic information systems planning (SISP) and related practitioners' frameworks such as COBIT, ITIL, CMMI, VAL IT, and ISO/IEC 17799 (Burtscher et al., 2009). IS governance forms refer to the placement of decision-making structures within organizations. Literature typically distinguishes between two basic governance designs: centralized and decentralized IS governance (Peterson, 2004; Brown and Grant, 2005). IS governance and its outcomes are impacted by multiple contingencies (Sambamurthy and Zmud, 1999; van Grembergen et al., 2004; Brown et al., 2005; Dahlberg, 2006), which can be divided into internal

and external influence factors. With regard to the time dimension and the business orientation, IS governance has a strategic character and must be distinguished from operative IT management.

IS research is starting to address IS governance in the context of one of the forces. Governance of information refers to the structures and processes required to turn data into strategic information assets (Malik, 2013). When dealing with the challenges of data volume, velocity, and variety (Buhl, 2013; Kaisler, 2013), the primary task of governance concerning this regard is the efficient generation of information value while mitigating related risks (Malik, 2013; Tallon, 2013). Due to the increased use of the internet, mobile devices, and social media, new sources for data analysis occur (Chen et al., 2013) and are impacting information governance (Malik, 2013; Tallon, 2013). Cloud governance draws from service oriented architecture (SOA) governance (Guo, 2010; Fortis et al., 2012) and "aims at providing optimum service quality, consistency, predictability and performance" (Guo, 2010, p. 1). Research in this area is needed, as it is expected that cloud computing presents challenges to the IT organization to stay involved and in control (Heier et al., 2012). The transfer of organizational data to cloud providers and the possibility of information crossing national borders leads to unclear data ownership and difficulties concerning privacy laws and other regulations (Janssen, 2011; Kshetri, 2013; Heier et al., 2012). Organizational use of social media has the potential to change processes, collaboration, and communication. However, van Osch and Coursaris (2013) state that there is a lack of studies analyzing the influence of social media on corporate governance in organizations. Increasing convenience, efficiency, and productivity of mobile working drive organizations to implement mobile devices into the IT infrastructure to take advantage of the flexibility these devices offer (Scheepers and Scheepers, 2004). The concepts of consumerization and bring-your-own-device (BYOD) are strongly related to the topic of mobile device usage in organizations. BYOD creates a "unique set of challenges for IT professionals"

(Johnson and Joshi, 2012) as it "redefines the relationship between employees...and the IT organization" (Niehaves et al., 2012, p. 1). In this context, the compliance to legal, privacy, and security regulations becomes important (Lebek et al., 2013).

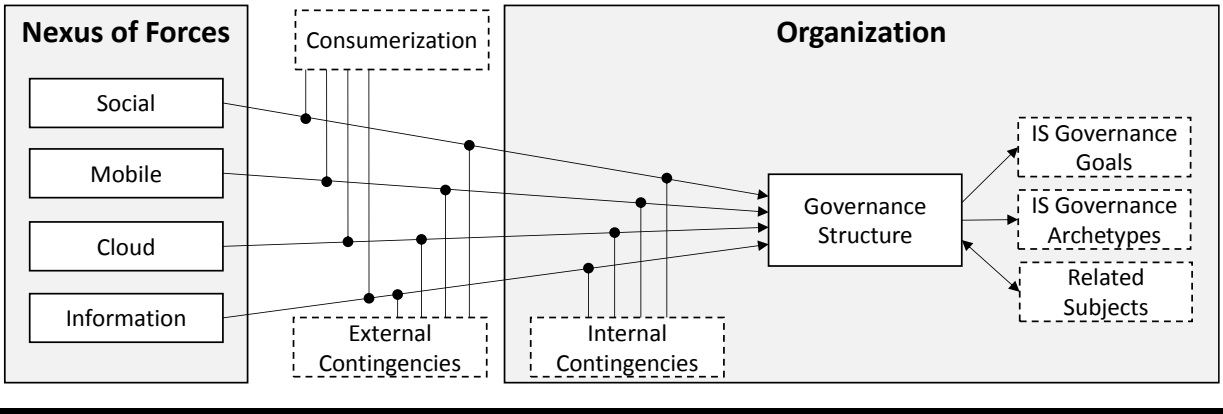

Figure 1. Conceptual Model

Based on existing governance literature and the findings by Gartner (2013), we formulated a conceptual model that provides the baseline for our research (Figure 1). We investigate the influence of the Nexus of Forces on organizations in general and the organizational governance structure in particular. For this purpose, we regard each of the four forces (social, mobile, cloud, and information) and their impact on governance structure. The effect of the forces is moderated by the consumerization pressure, as well as by external and internal contingencies. The governance structure comprises the corporate governance and IS governance including their goals and archetypes as well as related subjects.

3. Research Design and Data Collection

The purpose of this study is to construct a reference model based on our conceptual model and empirical material obtained from qualitative expert interviews. For this purpose, we chose the Delphi method as the underlying research design of this paper. The Delphi method is a “systematic interactive research method that relies on a panel of independent experts" (Olbrich

et al., 2011, p. 7). This flexible method for structuring a group communication process (Linstone and Turoff, 1975) is especially suitable to explore new issues with subjective and complex judgments of experts within a series of questionnaires until consensus is reached (Kendall, 1977). Four core elements characterize a Delphi procedure (Rowe and Wright, 1999): anonymity, iteration, controlled feedback, and the statistical aggregation of group response. Anonymity is ensured by questionnaires and one-on-one interviews which allow participants to express opinions and judgments privately without social pressures. The iterative process allows them to change and advance personal judgments and revise earlier answers in light of replies of the other panel members (Olbrich et al., 2011). Controlled feedback between the rounds informs the participants of the opinions of the anonymized panel. The group judgments is created by aggregating and averaging the responses of the iteration. The procedure stops when a stop-criterion is reached or consensus is achieved. Figure 2 shows the research design applied here which includes five phases.

A reference model is a recommendation that is useful for the development of specific models (Goeken, 2003). It provides general solutions for an abstract class of problems and supports the solution of specific tasks. A reference model constitutes a starting point and serves as a pattern for a general class of modeling issues. The content of reference models is intended for the re-use in the design and construction of further specific models. Recommendations contained in a reference model must fulfill the requirements of general validity and applicability. Consequently, a reference model is an interlinked set of defined concepts providing an abstract framework or domain-specific ontology, which can be created by an expert or body of experts and aims to encourage clear communication (Fettke and Loos, 2007; Falconer, 2014).

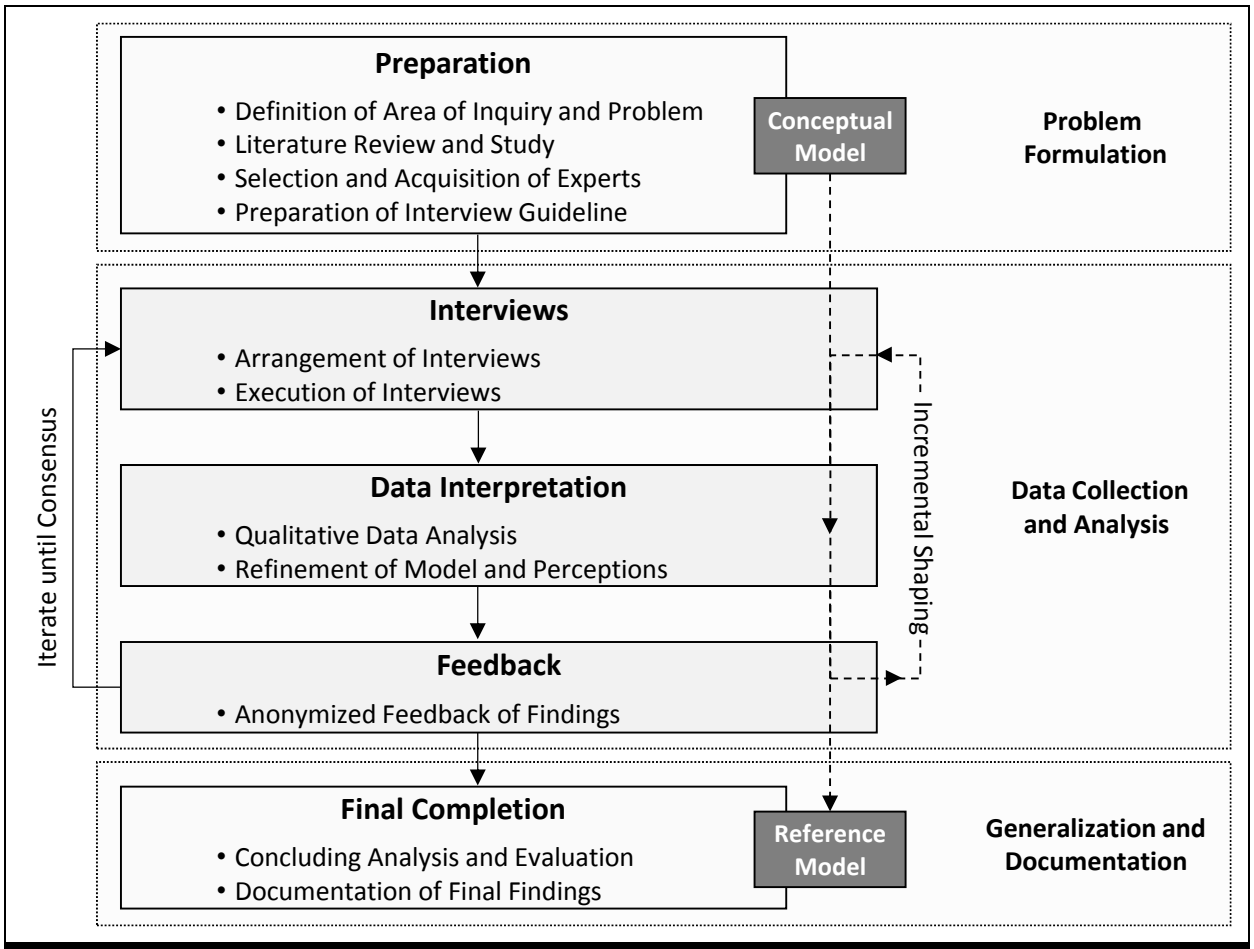

Figure 2. Research Design

Within the preparation phase, initial investigation and problem formulation as well as the creation of theoretical grounding were the focal point. To ensure rigor, a comprehensive literature review was conducted. We used established guidelines for reviewing literature (see Webster and Watson, 2002; Levy and Ellis, 2006; Vom Brocke et al., 2009). A list of search terms was used, including "IT/IS governance", "Nexus of Forces", and search strings referring to the individual forces. We primarily searched within databases (AISeL, IEEExplore, ScienceDirect, etc.) but also directly in IS research journals and conferences. Based on the hit lists, the papers were screened and relevant ones were selected. In addition to scientific literature, we included non-scientific literature such as practical literature and websites as clinical perspective to reduce the gap between the scholars' and practitioners' point of view

(Grahlmann et al., 2011). To analyze relevant literature, we used coding techniques (Glaser and Strauss, 1967; Strauss and Corbin, 1998) to generate initial assumptions about possible effects of the Nexus of Forces on organizational governance structures. We created the conceptual model as a basis for the iterative refinement. A Delphi approach was chosen since there were little sources of factual data but a basis for an opinion existed (Grey and Hovav, 2008). To ensure valid and robust results, experts with significant experience in the fields of IS governance and the Nexus of Forces were selected. We were able to acquire 18 participants from different branches for our study; see Table 1 below. The final step of the preparation phase was the creation of an interview guideline and a questionnaire.

Table 1: Participants of the Delphi Study

#	Role	Focus	Branch
1	Senior IT manager	Enterprise architecture and is strategy	IT services
2	Chief information officer (CIO)	General management of IS	IT services
3	Senior IT manager	Demand and service management	IT services
4	Manager in strategic marketing	Strategy development, market research	Automation Technology
5	Senior business manager	Business process management	Automation technology
6	Senior IT manager	Application development	IT services
7	IT consultant	Security and governance consulting	IT services
8	Software developer	Development of ECM portal solutions	Software development
9	Sales process manager	Management of IT applications sales	Automation technology
10	Chief information officer (CIO)	General management of IS	Automation technology
11	Chief information officer (CIO)	General management of IS	Steel industry
12	Director IS and services	General management of IS	Mechanical Engineering
13	Senior IT manager	Management of IT applications sales	Automation technology
14	Executive director	General business management	Automation technology
15	Senior IT manager	Department manager new technologies	Manufacturing
16	Chief information officer (CIO)	General management of IS	Mechanical engineering
17	Business manager	Business development and restructuring	Finance
18	Senior IS researcher	Enterprise modeling and architecture	IS research

An iterative procedure of data collection and analysis followed. The first explorative round of interviews was conducted within a period of four month within, 2013. This round of interviews was used to explore the opinion of the experts and to evaluate our initial assumptions and model. Half of the interviews were performed in person and the other half with an online collaboration and conference tool. Each of the interviews lasted between 60 to 90 minutes, and each was recorded and transcribed. After (1.) an introduction, the experts were asked to (2.) draw initial sketches linking an exemplary organizational governance model with the Nexus of Forces graphically and to illustrate the impacts. Then (3.) the evaluation of initial assumptions and (4.) a detailed discussion were performed before (5.) a wrap-up concluded the interviews. Qualitative data analysis (Punch, 2005) and coding techniques were used to analyze and interpret the transcribed responses and sketches. We performed open coding to identify concepts and attached initial labels to the data. Within selective coding, higher level categories were generated from the descriptive open codes. Based on the coding, an aggregated group response was generated and the conceptual model was refined. The participants were informed of the anonymized group response and the refined model by controlled feedback. Consistent with the iterative character of the Delphi methodology, the participating experts from the first round were invited to a second survey round to advance the judgments and opinions. The effective response rate of the second round was 78 percent (14/18). To enable discussion between the experts and test the refined conceptual model, specific participants (7) were invited to a focus group (Krueger and Casey, 2009), which lasted 90 min, and which was also recorded and transcribed. The other participants were again surveyed using interviews (2) or written questionnaires (5). To interpret the additional data, we used the same analysis methods as in the previous round. While the model was essentially confirmed, it was significantly extended and advanced based on the profound statements from the participants.

“One of the more difficult aspects of the Delphi process is the appropriate method of measuring consensus" (Hallowell and Gambatese, 2010, p. 103). The characteristics of the data and empirical material that we gathered pose a further challenge: Due to the qualitative character of our study and the participants’ responses, no quantitative consensus methods were applicable. Instead, we critically reviewed the individual answers and used interpretive reasoning to assess and measure the variance. During the second round of data collection and analysis, and especially during the focus group, a high consensus degree was reached and a consistent model was created. Consequently, the interviews and incremental shaping of the model were finished. Within a phase of final completion, the reference model was finalized and the findings were documented.

4. Results

4.1 An IS Governance Reference Model for the Nexus of Forces

For assessing our RQ whether the Nexus of Forces has an influence on organizations in general and IS Governance in particular, we create and introduce an initial reference model (Figure 3) based on our empirical insights and findings which were gathered within the Delphi study. As proposed by Gartner (2013), the model basically comprises the four forces, information, mobile, social, and cloud computing, as well as consumerization. The four individual forces are closely interrelated, which leads to a mutual reinforcement. The use of mobile devices enables access to corporate information resources, independent from restrictions regarding time and location. Moreover, mobile devices provide a platform to communicate via public and enterprise social networks and thus create a great amount of information. In this context, the cloud represents a necessary transmission medium for delivering information. The consumerization of IT leads to a "blurring of business and personal boundaries" (Niehaves, 2012, p. 2) because this term describes the use of consumer IT in the

organizational context. Consumerization leads to an adoption pressure that forces organizations to react and to adjust governance structures including corporate governance, IS governance, and the operative IS management. The reference model and findings are explained in detail in the following sub sections.

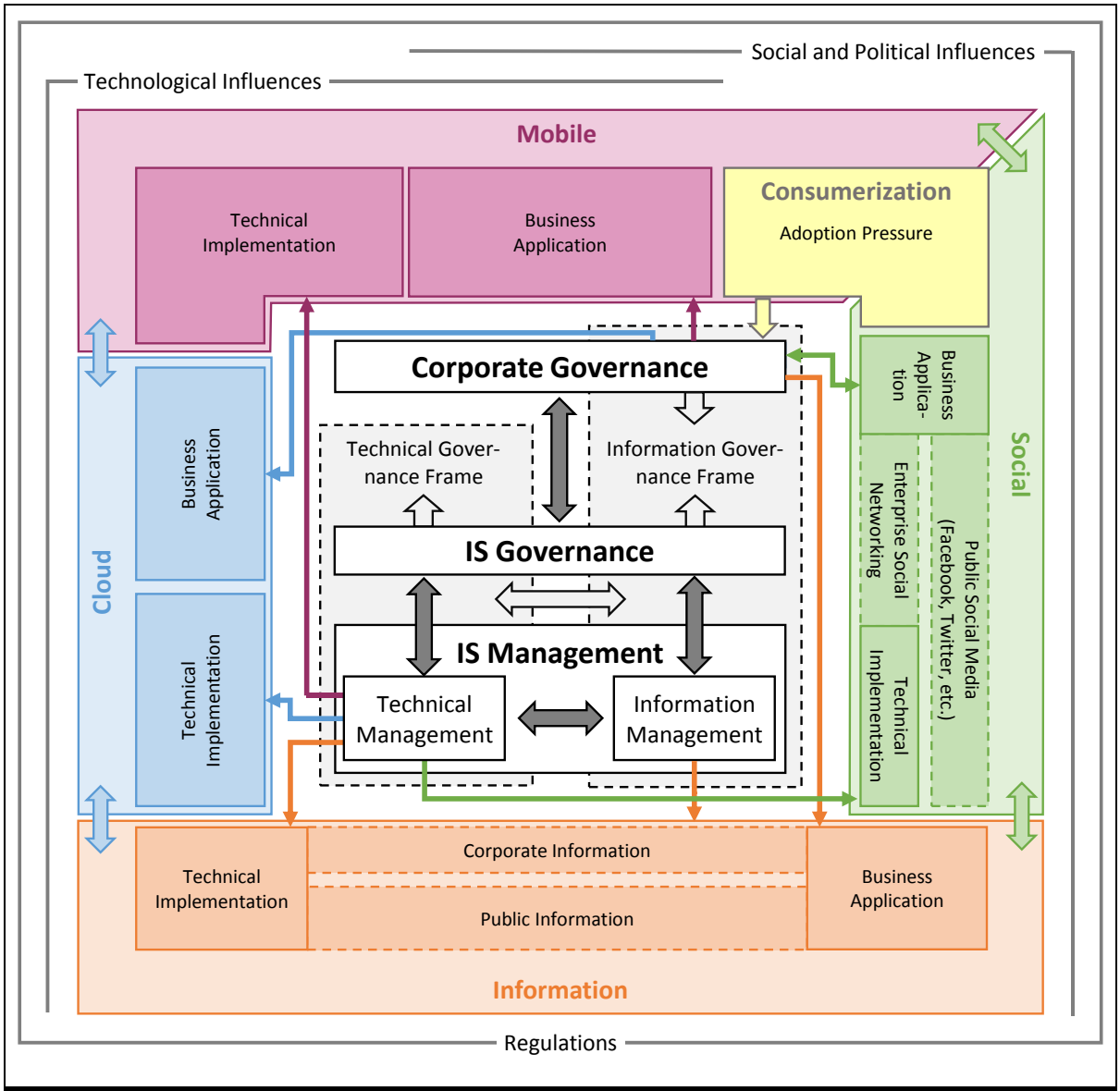

Figure 3. IS Governance Reference Model for the Nexus of Forces

4.1.1 External Contingencies

Organizations operate within an environment that is strongly determined by the geographical, political and cultural region, as well as the industry or branch. Consequently, organizations are exposed to the influence of various external contingencies (Burtscher et al., 2009). The potential effects created by the Nexus of Forces are significantly influenced by regulations, technical influences, and social and political influences. Regulations represent an enclosing frame that prescribes legal guidelines for organizations and its members. In this context, especially statutory requirements relating to data protection and information security are particularly of importance. For example, specifications for collecting, processing, and storing data and information significantly affect the use of cloud services or the possibilities of analyzing user data from social networks.

Within the regulatory frame, social and political influences affect organizations mainly with regard to the areas of mobile, social, and information. The proliferation of mobile computing devices continues to increase as tablets and smartphones became a part of daily life for many users (Moreno et al., 2012). As a result, mobility emerged as a main driving factor of the modern service society (Zaplata et al., 2009) pressuring organizations to find ways to implement mobile devices into their IT infrastructure in order to take advantage of the flexibility these devices offer (Scheepers and Scheepers, 2004). Organizations operating in branches with a close proximity to consumers must also be present within public social media (Jarvenpaa and Tuunainen, 2012). Moreover, because they are familiar with the advantages of public social media for communicating in private life, employees demand adoption of social media technology within the working context. Last, social and political conditions influence organizational handling of information. This aspect mainly refers to the collection, storage and analysis of personal data from social networks, but also refers to data and information that organizations provide to their environment.

Technological influences refer to (technical) innovations in the areas of mobile devices, cloud computing, and data processing. As a result of improvements in functionality and usability of mobile devices and the development of mobile data network coverage (Tu and Yuan, 2012), tablets and smartphones provide a convenient platform to perform various work processes and tasks. With increasing mobility of the workplace, cloud services emerged as a platform to provide time and location independent access to applications and information. Moreover, recent developments in the area of data analytics (e.g., in-memory computing) allows organizations to gain information from data that was previously merely used and thus is able to create business insights and advantages.

4.1.2 Governance and Decision-Making Structure

The inner part of the reference model describes core elements and interrelationships of the organizational governance structure. According to Weill and Ross (2004a), IS governance encompasses five major domains of decision-making in relation to the management and use of IT in organizations: (1) IT principles relate to corporate level statements about the strategic role of IT in the organization, (2) IT architecture refers to technical choices to satisfy business needs, (3) IT infrastructure are centrally coordinated IT services that provide the foundation for organization-wide IT capabilities (e.g., network services, security, help desks, etc.), (4) business application addresses the opportunities provided by new technologies and (5) IT investment deals with budgeting for IT, including project approvals, and justification techniques. Within the proposed IS governance reference model, the decision-making hierarchy extends over the three levels of corporate governance, IS governance, and IS management.

IS governance must be driven by corporate governance and not by the IT department (Webb et al., 2006). According to its goals, namely value delivery and risk management, corporate governance defines IT principles based on the strategic direction of the organization and is responsible for the business application of the Nexus of Forces. This need to shift accountability

and responsibility for IS decisions towards corporate governance is emphasized by the Nexus of Forces.

> *"The Nexus of Forces is a comprehensive issue that needs to be regulated across the organization, and IT can ultimately be used as a tool. But the definitions and regulations must be established on [corporate governance] level". (#10, CIO)*

Based on cost benefit-analyses, corporate governance sets the degree of adoption of new technologies and trends within the organization, defines necessary adjustments of business processes, and establishes rules for implementing the Nexus of Forces.

While corporate governance defines the mission statement, IS governance ensures that the IT is properly aligned to business strategies and objectives. The IS governance includes two main rights: decision rights, such as architecture and infrastructure, which are the core responsibilities of IS governance (Weill, 2004) and input rights with regard to investments, business application, and IT principles. Input rights provide expert advice on key IT decisions (Dahlberg and Kivijärvi, 2006) that are made on corporate governance level. In the reference model, IS governance includes two core frames that are closely related with strong interdependencies. The technical governance frame sets specifications for architecture and infrastructure focusing on technical decisions on hardware, software, and systems. The information governance frame sets basic rules and policies for collecting, processing, and storing information assets at an enterprise level without primarily focusing on technical aspects. While technical governance is defined on the IS governance level, information governance is set by an interaction of the corporate and IS governance linking business and IT aspects. Corporate and IS governance set the scope for the actual operative execution, which is the responsibility of IS management. Within practice, the boundaries between these entities are not distinct.

> *"The problem is of course: where is the boundary between IS management and IS governance? IS governance defines the basic structures and established processes,*

and the principal things. And then, of course, the two quite massively correlate“. (#12, Director IS and Services)

Similar to IS governance, operative IS management is divided into two interacting parts: technical and information management. IS management represents the alignment of the actual operative execution and realization to the IS strategy, which is determined by corporate and IS governance decisions. The scope of technical and information management is defined by the respective governance frame. Both technical and information management provide feedback to the IS governance by means of input rights.

4.1.3 Consumerization Pressure

Consumerization as a socio-cultural construct is the main driver of the Nexus of Forces that creates an impact on an organization. The adoption pressure arising from it results from the private use of mobile and social computing and forces organizations to adopt these new capabilities for working purposes.

"The [adoption] pressure arises from the employees; they say: I know it one way [from private use], you can do that way, but why is this so complicated in our organization?“ (#9, Sales Process Manager)

In the first place, the adoption pressure affects organizations on the business level and interacts with the corporate governance. As a result, the adoption pressure mainly impacts the corporate governance, which can require a change of the business and IS strategy.

"The pressure is really on the IT organization via the [corporate] governance... But what is becoming more important is business transformation...to realize the goals of an organization, which are defined by the corporate governance – but no matter what you specify in the business strategy, there will be changes to IS“. (#1, Senior IT Manager)

General rules about the use of the arising technologies and resulting business opportunities and risks have to be set on the corporate governance level. In order to maximize the benefits and to mitigate the risks associated with the Nexus of Forces, organizations must adjust and improve their business processes, business applications, and possibly their business model. While these possible business changes on governance level ideally follow a top-down approach, the actual trigger originates from the employees as a bottom-up process. Employees ask to use (new) technical solutions for working purposes that they primary know from private life and therefore trigger request and demand management processes within operative IS management. This adoption pressure eventually accumulates on the IS management level and is handed up hierarchically to the corporate (governance) level so that a fundamental business decision can be made.

> *"The big challenge is to accomplish that requests within the IS management are mapped in direction of the governance: When do we get iPhones? What can we do with it? Why can't we do this and that?"* (#6, Senior IT Manager)

User requests mainly focus on social and mobile computing and not, as initially assumed, on cloud computing. Within the study, the participants largely stated that cloud computing as a transfer medium is a rather technical aspect within the backend systems that enables ubiquitous data access, for example for mobile and social services.

> *"The cloud is to me more like some, I'll say it casually: a technical thing that allows me to be mobile and to have access on information, which is perhaps even driven through social media. But [the cloud] is rather a vehicle for me".* (#9, Sales Process Manager)

This also remains true for information as a force of the Nexus. Large amounts of data are produced within the private context, however, data analytics do not originate from and are not

driven by the private sector or consumerization. Therefore, the forces cloud computing and information do not represent core components of consumerization within the reference model.

> *"The area of information and big data, I don't think that this actually originates directly from the private sphere".* (#4, Manager in Strategic Marketing)

4.2 Application and Impact of the Nexus of Forces

4.2.1 Corporate Governance

The impact of the Nexus of Forces on an organization is described along the governance hierarchy. Corporate governance aims to maximize the benefits and mitigate the risks associated with the Nexus of Forces and is therefore responsible for defining the frame for the business application in a specific organizational context. Further organizational processes and structures, and possibly the business model, need to be examined and adjusted for useful business applications in order to take advantage of new opportunities provided by the emerging technologies.

> *"IT is not such a big issue at this level and stage – organizations rather...have to look for useful business applications. And if the usefulness is not given, then it does not matter, what kind of innovations are out there".* (#12, Director IS and Services).

Concerning the mobile force, corporate governance regulates whether mobile devices such as smart phones and tablets can be used within the organization, and for which business cases and in which contexts. It defines for instance, whether BYOD is allowed, general restrictions for mobile data access, mobile app restrictions, and allowed standard devices. Due to extensive private use and experience of mobile devices and the resulting adoption pressure, it is particularly crucial to create an effective business application for mobile systems. This emerges from two reasons: First, not to yield to the adoption pressure prematurely without accurately analyzing opportunities and threats. Second, that users already have rich experience with

mobile devices from private life and therefore have certain expectations concerning usability and usefulness within the professional working context.

This also applies to the social force. While employees gain rich experience in public social media networks, the use of social media and networks within organizations is relatively new. The reference model differentiates between public social media (Facebook, Twitter, Xing, etc.) and enterprise social networking (ESN), which is defined as the use of "technologies that emerged on the public internet within the workplaces of organizations to facilitate work-related communication and collaboration" (Richter and Riemer, 2013, p. 2). Corporate governance defines the use of both aspects via the business application. The relationship of the business use of public social media is twofold. On the one hand, corporate governance regulates the way of communicating with the public and thereby it shapes the perception of the organization within society. On the other hand, public social networks represent new opportunities for organizations such as direct contact with customers and undelayed feedback, which in turn can affect the organizational strategy.

The business application of the information and cloud forces is regulated by the corporate governance as well. For instance, rules about the general use of the cloud, whether private, hybrid, or public, have to be set. The business application further specifies rules for the storage and transmission of data via the cloud with regard to information security and data protection policies. Concerning the force information, the business application stands for the definition of general rules about the use of information.

> *"In the corporate governance it is defined or must be defined how to deal with information and [later] the IT governance must ensure that [certain information] can only be accessed by authorized people".* (#6, Senior IT Manager)

These general rules describe the development and implementation of processes for collecting, storing, and processing data. Corporate governance specifies to what extent internal sources

(e.g., ERP, CRM, and ECM systems) and external sources (e.g., public social media, market research) are used to collect data. Further these rules address the classification of data and provide guidelines regarding which types and classes of data can be stored in which repositories (in the cloud or on-premise) and processed to generate business information, especially with regard to big data and content analytics. The reference model differentiates between corporate information that is created and used within the organization and public information that is created and resides outside of the organization, including information that the organization publishes to its environment.

4.2.2 IS Governance and IS Management

Subordinated hierarchically under the corporate governance, IS governance in combination with the operative IS management regulates the technical implementation of the forces. Technical management aims to facilitate and to put the business applications in concrete terms in form of tangible technical solutions. Thus, technical management operates within the frame that is set by the governance entities. This means, for instance, if the use of cloud services is prohibited by corporate governance, the technical management for this aspect becomes irrelevant. Concerning the cloud, technical management defines service level agreements (SLA) with public cloud providers, wide area networks (WAN) connections to the cloud, and so forth. The technical implementation of mobile systems takes aspects such as mobile device management (MDM), the employed technical data encryption, and so on into account. With regard to social, technical implementation mainly deals with the deployment of internal social networks rather than adoption of public social media. It includes the selection and sizing of internal ESN systems and their customization. The use of public social media does not require an internal technical implementation and expertise and is therefore not a primary IS topic. The technical implementation of the force information realizes internal and external data and content management systems and their characteristics, for example technical design of database

schemes, selection and customization of ECM systems, and implementation of technologies for data analytics. The operative information management on the other hand includes non-technical aspects such as enterprise-wide metadata, taxonomies, and classification of data and information.

5. Discussion

5.1 Research Contribution

To address our RQ, we iteratively derive a reference model from empirical evidence that we gathered from qualitative interviews within a Delphi study. The reference model facilitates clear communication and provide IS researchers with a basis to develop specific models. Further, the model allows organizational decision-makers to design an effective IS governance implementation. Our main findings suggest that the Nexus of Forces' capability to create an impact on organizations and IS governance structures depends on the organization's environment and external contingencies. Consumerization is the main driver for adapting the Nexus of Forces within organizations and influences organizations particularly on the business level. Therefore it is primarily the responsibility of corporate governance to set structures concerning IT investment, business application, and IT principles. Due to increasing quantity and importance of information, information governance is gaining in significance – without a primary focus on technical solutions. The information governance frame is a set of basic rules and policies for collecting, processing, and storing information assets and is defined by corporate governance in combination with IS governance. The IS governance focuses on technical aspects and defines the technical governance frame by setting guidelines with regard to IT architecture and infrastructure. Similar to the governance level, the executing IS management is divided into technical and information management parts. While the business application of the Nexus of Forces is determined by the corporate governance, the IS and

technical management realize the actual technical implementation according to the specifications of the governance entities. The proposed reference model depicts the interrelationships of the Nexus of Forces with organizational governance structures, as well as the decision-making structure and responsibilities.

Based on our empirical findings from the results section above, we discuss the Nexus of Forces in the context of its organizational application and relate it to existing IS research literature. This mainly includes the role of internal contingencies, the Nexus of Forces' impact on governance archetypes, threats and challenges emerging from the Nexus of Forces, and socio-technical aspects.

5.2 Interpretation of Results and Comparison with Prior Work

The internal and external contingencies within an organization and its environment determine the impact and adoption pressure that the Nexus of Forces exerts on that organization. Regarding the internal contingencies, the role and perception of IT and the attitude towards technology within the organization represent a substantial factor. While IT constitutes an important part and plays a significant role in some organizations, the significance of IT and of IT innovations is fairly low. As proposed by Chen et al. (2010) and Leidner et al. (2010), organizations can regard IT and IS as innovators or from a rather conservative point of view (IS conservative). Chen et al. (2010) operationalize IS strategy as the degree to which organizations have a shared perspective to seek innovation through IS. Concerning IS as innovator, IT holds a consultative function and initiates innovations that help the business to stay competitive and seek new opportunities. In stark contrast, IS conservative represents a safe and stable approach in which changes to IT are only carried out if they are really promising or necessary, have been carefully examined, and are proven in practice. Along these lines, the impact that the Nexus of Forces is potentially able to create within an organization depends on the role of IT and partially on the branch of the organization. If the importance of IT in an

organization is high, then the potential impact that the Nexus of Forces is able to create high as well. Within the study, participants from organizations that regarded IS as an innovator rated the potential impact of the Nexus of Forces higher than participants with a rather conservative attitude towards IT. For instance, organizations from our study that operate close to the consumer assessed the new opportunities and additional value coming from the Nexus of Forces as being higher than organizations with a rather static business environment. Especially organizations within rigid and regulated markets that were slow to change have not yet taken advantage of cloud, mobile, and social computing or big data. They barely saw the need to investigate these new trends and did not see much potential in them. In contrast, the organizations that operate on the consumer market have experience with the new technologies and are steadily exploring new opportunities arising from the Nexus of Forces.

With regard to the design of decision-making structures, the experts who participated in this study unanimously stated that the Nexus of Forces impacts the governance archetypes within organizations. According to IS governance literature, governance approaches can vary from centralized to decentralized structures. Weill and Ross (2004b) showed that centralized governance approaches are to be found in organizations that mainly focus on profitability. These organizations aim to reduce business process cost and therefore establish a high degree of standardization for business and IT. This includes centralized processes for architecture compliance and organization-wide IT investment decisions. On the other side, organizations that are focused on innovation aim for local accountability through decentralized decision-making structures. These organizations establish only a few organization-wide standards in favor of creativity, business unit autonomy, and proximity to local customers. However, during the interviews, it became apparent that the Nexus of Forces continues to challenge stringent centralized or decentralized governance designs. On the one hand, specific characteristics of consumerization pressure depend on cultural, social, and regional aspects and force

organizations to increase responsiveness to local employee demands. Apparently, centralized governance approaches fail due to inflexibility with regard to requests that result from extensive communication and coordination processes. On the other hand, decentralized approaches can fall short in defining stable and lasting infrastructures due to proliferation of solutions and inherent risks. Therefore, hybrid approaches will gain importance (Andriole, 2012) as these attempt to balance the contrasts of standardization and innovation (Weill and Ross, 2004a).

In addition to the advantages and new opportunities that the Nexus of Forces presents, new risks, threats and challenges emerge. While marketing and advertising, as well as outlets of popular science mainly emphasize the benefits, the participants of our study also expressed their doubts and concerns. Typical critical remarks from participants concerning mobile computing centered on the ubiquitous availability – anywhere and at any time. This can be an advantage, but it can also create stress and can interfere with the private lives of employees; see also Niehaves et al. (2012). A main concern of participants with regard to cloud computing is the perceived security risks (see Ackermann et al., 2012), especially when a public cloud is used for sensitive data and the servers are located in a foreign country. Typical critical concerns towards social networking and computing are additional workload and negative comments that can escalate into so-called shit-storms (Yang and Albers, 2013). Information overload, in particular in combination with social media and content, was mentioned by the participants as being a main challenge and risk of the information force. While important negative issues are raised here, the list is merely illustrative rather than exhaustive. In combination, the forces represent an increased level of complexity to some of the participants. This seem to be a contradiction, since these new technologies such as the cloud aims to hide technical complexity. However, organizations have established IT infrastructures, and new technologies require investigation before they can be adopted and integrated. As a result, organizations have to analyze the opportunities and threats of the Nexus of Forces diligently and must adjust

governance structures as a consequence. Thus, organizations are not exposed to the risk of reacting too late to the upcoming adoption pressure, but are able to act early and with foresight. Another risk of disregarding or banning the Nexus of Forces is that shadow IT can emerge. Users know the new technologies from private use and also want to take advantage of them in the working context. Next to the use of private smart phones, called BYOD, another trend is emerging: BYOC – bring-your-own-cloud (Costello and Prohaska, 2013). If organizations fall short in creating useful systems and applications that users know from consumerization, users might try to build their own illegal solutions in terms of shadow IT. Therefore, prohibiting the new technologies does not represent a satisfactory solution. Certainly organizations do not have to adopt all of the forces and under all circumstances. As part of a cost-benefit analysis, organizations need to decide what is worthwhile and what is not investigating further. Accordingly, IT in particular and the organization in general needs to position itself towards the Nexus of Forces, establish rules and a strategy, and adjust governance structures. A well-implemented governance can help to keep the new technologies and opportunities manageable.

Driven by both technical and social developments, the Nexus of Forces impacts organizations on a socio-technical level. Stemming from the context of labor studies, socio-technical refers to the reciprocal interrelationship of social and technical aspects of an organization or the society as a whole (Ropohl, 1999). As Emery et al. (1964) stated, organizational success strongly depends on the organization's ability to work as a socio-technical system. Accordingly, organizations will fail to succeed if they consider themselves to be a solely technical system with individuals that have to adapt to the system and can be replaced. The importance of social and behavioral aspects in the area of management information systems (MIS) has been recognized by practitioners and research for a long time. Bostrom and Heinen (1977) stated that IS will fail if organizational, social, and behavioral aspects are ignored in the design and operation of information systems. If organizations are not able to understand and consider these aspects, IT

investments will not benefit since systems are not accepted by users. This rationale is also reflected in the technology acceptance model (TAM) by Davis et al. (1989). The TAM postulates that users' perceptions of usefulness and ease of use of technologies determine their intention to use technology. The consumerization pressure related to the Nexus of Forces emphasizes the importance of the socio-technical and user acceptance perspective once again. Employees form expectations towards the usefulness and ease of use of technologies, such as smartphones or social networks, based on experience from private usage. Organizations now face the challenge of adopting these technologies without failing to live up to employees' expectations. Reasons for missing expectations are for example, restrictions on functionality due to information security measures. Furthermore, our interviews revealed that employees' expectations vary among generations. Different generations of employees that work together in an organization have different experiences and different ways of thinking. Older employees tend to be more skeptical about new technologies while young employees are more open to new technologies (Koning and Gelderblom, 2006). Organizations are challenged to manage this conflict.

5.3 Implications and Key Areas for Future Research

While this study relates to the Nexus of Forces with organizational governance structures, implications and key areas for future research arise. The reference model proposed here can act as a basis for further refinement that focuses on partial aspects and operationalizes the model. For instance, this includes the investigation and definition of roles and responsibilities within IS management concerning the new technologies of the Nexus of Forces. With regard to the archetypes as proposed by Weill and Ross (2004b), hybrid approaches and federal archetypes require further attention since they are becoming more important within the IS governance research domain. Further, the influence of the Nexus of Forces and of consumerization on methods and processes to achieve the five goals of IS governance requires

investigation. This applies in particular to value delivery and risk management as the outcomes of IS governance. For instance, this includes the construction of new IS solutions that apply the forces in order to generate additional business value or evaluate and manage the novel risks of the technologies. Irrespective of the proposed reference model, practical changes within organizations that result from the Nexus of Forces demand empirical investigation. The interviews revealed that the organizations are facing or currently starting a transition process that will create measurable empirical evidence within the next few years. Accordingly, based on this initial study, further analysis of the general impact of the Nexus of Forces on society, organizations, and employees are necessary. This goes in hand with recent findings of Bharadwaj et al. (2013) and Andriole (2012) that state that in addition to the digital trends (i.e., big, data, cloud, pervasive connectivity, social, etc.), there are also key organizational shifts concerning the role of IT in organizations. Accordingly, we endorse Bharadwaj et al. (2013), who propose a digital business strategy and argue that "the time is right to rethink the role of IT strategy“ (p. 471).

5.4 Limitations

After outlining potential practical and theoretical implications of our research, we would like to point out the limitations of the current study. With regard to the proposed IS governance reference model, this study does not raise the claim to be exhaustive. We provide initial inside to this research topic and to facilitate further investigation. The reference model should be refined and validated by future research and discussions. Concerning the research process, the amount of participants was rather limited compared to other Delphi studies for three reasons. First, the topic of the Nexus of Forces is relatively new as it was mainly triggered by Gartner in, 2012. Since our intention was to provide a contemporary and initial insight into the subject matter in order to facilitate further research, a long enquiry period was not applicable. Second, in the course of the first round of interviews we asserted that the gain of new evidence decreased

constantly and finally came to halt so that we stopped recruiting new experts after 18 interviews were completed in accordance with our pre-defined stop criteria. Third, we mainly recruited top management experts on CIO and senior management level who were able to provide rich insights regarding the subject-matter during in-depth qualitative interviews. A limitation arises from the fact that the participants mainly come from the industry branch. When interpreting our results, it has to be considered that the impact of the Nexus of Forces varies between different organizations and branches, as stated in the discussion. It would be interesting for future research to focus on those variances between different branches. Furthermore, participants come mainly from the IT side of the organization. This represents a limitation since one of the profound effects of the Nexus of Forces is the shifting of IT responsibilities to other functional areas, such as marketing.

Another limitation is that we only conducted two rounds within our Delphi approach. Due to the lengthy and comprehensive interviews and focus group discussion, as well as detailed written feedback from the participants in the second round, a consensus was reached rather quickly and further rounds became non-essential. The mix of interview types (single interviews, focus group, and written feedback) is uncommon for Delphi studies. We have chosen to incorporate a focus group in order to use its advantages to gain inspiration for further, more detailed, more profound statements from the participants. Due to time restrictions of the members of our expert panel, we were unable to conduct focus groups with all members. However, the focus group provided evidence that was discussed with the remainder of the expert panel in personal or written interviews.

6. Conclusions and Outlook

Our investigation provides initial insight into the challenges and influences that the interacting forces of big data, social, mobile, and cloud computing provide to organizations and governance structures. The starting point for this study was a conceptual model that we derive from a

literature and status quo analysis. Following a research design based on the Delphi method, 18 top management experts of IS (governance) field are interviewed in two rounds. To address the identified research gap, a reference model for IS governance and the Nexus of Forces is proposed based on evidence from these interviews. From the reference model, we conclude that the role of corporate governance concerning IS decisions is increasing due to the Nexus of Forces and the underlying consumerization pressure. In this context, IS governance focuses on technical aspects of IS and provides consulting input into decisions made on the top management level within an organization. This shift of responsibility and accountability is accompanied by the introduction of two interacting governance frames for technical and information governance.

As we assume that the Nexus of Forces demands hybrid governance approaches and federal archetypes, future research and discussions are required to examine changes within the governance archetypes as defined by Weill and Ross (2004a). In this context, Gartner (2013) recently introduced the term "democracy of IS“. Future research must investigate whether existing governance approaches can be extended or modified in order to meet the challenges at all. Moreover, the question arises as to whether methods and processes to achieve the five goals of IS governance are impacted by the Nexus of Forces. Digital trends such as big data, social, mobile, and cloud computing are already impacting organizations and are gaining increasing attention from practitioners and outlets of popular science. To increase the relevance of IS research and to not fall behind popular science, it is necessary to investigate practically relevant topics, such as the Nexus of Forces.

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Appendix 20: Enterprise Content Management Research: Analysis, Synthesis, and Evaluation Using Grounded Theory Methodology

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Outlet: Submitted.

Abstract: Managing content on an enterprise-wide, global scale is both important and challenging. Huge amounts of content are produced every year and the content needs to be managed efficiently. To reduce content chaos, enterprise content management (ECM) evolved as an integrated approach to information management. The ECM research domain and its status quo lack meta-analysis and need thorough investigation and mature theoretical foundations. We address these issues by analyzing, synthesizing, and evaluating the ECM research domain using grounded theory methodology. We inductively generate a grounded theory and introduce a narrative framework for ECM research. Based on insights we generate, we examine and discuss relevance and impact, theoretical and practical implications, and likely future scenarios of ECM research. We conclude that ECM research is relevant, but also postulate that more rigorous research and theory building are necessary. ECM research has to be adjusted to match the enterprise-wide scope, which is a key characteristic of ECM. Future implications for practice and research include cloud, mobile, and social ECM, and also big data, and content analytics.

Enterprise Content Management Research: Analysis, Synthesis, and Evaluation Using Grounded Theory Methodology

Abstract

Managing content on an enterprise-wide, global scale is both important and challenging. Huge amounts of content are produced every year and the content needs to be managed efficiently. To reduce content chaos, enterprise content management (ECM) evolved as an integrated approach to information management. The ECM research domain and its status quo lack meta-analysis and need thorough investigation and mature theoretical foundations. We address these issues by analyzing, synthesizing, and evaluating the ECM research domain using grounded theory methodology. We inductively generate a grounded theory and introduce a narrative framework for ECM research. Based on insights we generate, we examine and discuss relevance and impact, theoretical and practical implications, and likely future scenarios of ECM research. We conclude that ECM research is relevant, but also postulate that more rigorous research and theory building are necessary. ECM research has to be adjusted to match the enterprise-wide scope, which is a key characteristic of ECM. Future implications for practice and research include cloud, mobile, and social ECM, and also big data, and content analytics.

Keywords

Enterprise content management, information management, knowledge management, grounded theory, research meta-analysis.

Introduction

Managing information and content on an enterprise-wide, global scale is challenging. Huge amounts of content are produced every year and this content needs to be captured, analyzed, managed, stored, preserved, and delivered efficiently (AIIM 2014). Especially the management of unstructured content, which makes up the largest share of data volume (~80%), still poses a challenge for companies (O'Callaghan and Smits 2005, p. 1; Kuechler 2007, p. 86). To reduce information overload and content chaos, enterprise content management (ECM) evolved as an integrated approach to information management (IM) (Reimer 2002, p. 18; Päivärinta and Munkvold 2005, pp. 8-9; vom Brocke et al. 2011a, p. 2). It enables the management of particularly unstructured content on an enterprise-wide, global scale (Rickenberg et al. 2012a, p. 1). ECM is highly relevant for practice and the market is booming (Wiltzius et al. 2011, p. 624; Andersen 2008, p. 65; vom Brocke et al. 2011c, p. 492). More and more companies are adopting ECM systems and commercial software solutions become more mature and sophisticated.

Despite the high interest of practitioners in ECM, it has received too little attention from academic research (Tyrväinen et al. 2006, p. 627). The ECM research domain is still young and remains in an immature state (vom Brocke et al. 2011b, p. 10). Much of the existing ECM literature is design-oriented (Wiltzius et al. 2011, p. 1) and deals with constructive studies, conceptual ideas and frameworks, and technological functionalities (Usman et al. 2009, p. 286). Along with the research output, the ECM research domain lacks its own mature theoretical foundation. With the exception of some major cornerstones, little theory has been developed within the small body of ECM literature. Rickenberg et al. (2012a, p. 9) proclaim the need for research that discusses ECM as a research field and not the management of enterprise content. In the same vein, Alalwan and Weistroffer (2012, p. 442) declare that the "ECM field lacks meta-analysis research that explains the current state of the field" and Grahlmann et al. (2011, p. 12) state that research about ECM as a research field is needed. They continue that this includes "the differences and similarities of ECM with other fields of research". Against this background, theory-generating research synthesis of the ECM research domain is required. The questions arise whether ECM research is relevant, whether ECM actually represents anything new compared to established domains, and what the theoretical and practical implications of ECM research are.

Focusing on the lack of substantive and mature theory in the emerging ECM research field, we analyze and address this phenomenon by applying grounded theory. As defined by its creators Glaser and Strauss (1967), grounded theory is "the discovery of theory from data – systematically obtained and analyzed in social research." This qualitative method offers a systematic but flexible way to generate theory inductively from data (Urquhart and Fernández 2013) and allows "researchers to conduct pioneering research with both flexibility and rigor" (Birks et al. 2013, p. 1). Especially for under-researched phenomena and domains with little thorough theory development, this method is particularly useful (see Orlikowski 1993, p. 311; Seidel and Recker 2009, p. 3-4). While grounded theory is usually employed to develop theories about real-world phenomena, we use the method to analyze, theorize, and evaluate a research domain in the sense of a meta-analytic review. According to the traditional Bloom's taxonomy of the cognitive domain (Bloom et al. 1956), we employ the order of different cognitive levels for our research procedure: first analysis and synthesis and then evaluation. We gather, code, analyze, cluster, and interpret different qualitative sources about ECM and adjacent IS research domains. We mainly use the original recommendations by Glaser and Strauss (1967) and the guidelines by Urquhart (2013). We also follow steps from Wolfswinkel et al. (2013) who use this method to rigorously review literature, but beyond that, we theorize, evaluate, and discuss the synthesized results and use more diverse sources. As empirical input, we collected and sampled empirical snippets from six major sources: scientific ECM and Knowledge Management (KM) literature, practitioners' literature, websites, social media content, company documents from a globally operating engineering corporation, and semi-structured interviews. Along these lines and based on the construction of a grounded theory for ECM research, we investigate the research questions:

RQ1: Is ECM research a relevant subfield of IS research?

RQ2: What are the theoretical and practical implications of ECM research?

RQ3: What are likely scenarios for future ECM research?

The remainder of this paper is structured as follows: after this introduction, the research background is addressed, including an introduction to ECM research and practice and the underlying research design. The analysis and synthesis starts with the ECM research perspective and underlying research process. To lay the foundation for an evaluation of the ECM research domain, the inductively built grounded theory is presented together with its constructs and relationships and a theoretical integration. The evaluation of the research domain builds on the foundation and in-

vestigates its maturity and relationship with KM as a related field. Then, implications for practice and trends are outlined. A discussion of recommendations and identified limitations follows. The paper ends with conclusions and an outlook.

Background

What is Enterprise Content Management? An Introduction to Research and Practice

Since the term ECM was introduced around the turn of the millennium, it is still not entirely clear what lies beyond the concept (vom Brocke et al. 2011d, p. 967). Numerous authors define ECM in their papers but there is no single acknowledged definition of the ECM concept and what it stands for (Grahlmann et al. 2011, p. 4). Coming from a definition with a rather technical focus, as the definition evolved, it caused confusion and ambiguity (Smith and McKeen, 2003, p. 648) and now emphasizes the importance of organizational aspects. A commonly used definition of ECM comes from Smith and McKeen (2003, p. 647): ECM " is an integrated approach to managing all of an organization's information including paper documents, data, reports, web pages, and digital assets. ECM includes the strategies, tools, processes, and skills an organization needs to manage its information assets over their lifecycle." According to O'Callaghan and Smits (2005, p. 3), "ECM has become the umbrella term for a technology category for managing unstructured content." They also state that "ECM tools and strategies allow the management of an organization's unstructured information, wherever that information exists." (ibid.). Päivärinta and Munkvold (2005) simply characterize ECM as an integrated approach to information management (IM). Tyrväinen et al. (2006, p. 627) emphasize the management of all content assets in organizational or inter-organizational contexts. A discussion about the lack of consensus and a detailed definition is given by Grahlmann et al. (2011). A practical, yet acknowledged, definition of ECM comes from the AIIM defining as "[...] the strategies, methods and tools used to capture, manage, store, preserve, and deliver content and documents related to organizational processes. ECM tools and strategies allow the management of an organization's unstructured information, wherever that information exists."

ECM is a multifaceted research topic emerging around several related and preceding concepts, systems, and disciplines (Rickenberg et al. 2012a, p. 2). It combines and integrates several formerly autonomous approaches on an enterprise-wide scale throughout the entire content lifecycle. Vom Brocke et al. (2010, p. 2) point out that "ECM takes a holistic view on the content

lifecycle" and that it can be "best understood as a convergence of related concepts". Päivärinta and Munkvold (2005, p. 8) state that ECM consists of a wide set of interrelated issues and that it integrates several areas of IM. Similar to the definition of ECM, the scope of it is not clearly demarcated. As mentioned in vom Brocke et al. (2011c) and Rickenberg et al. (2012a), typical components and functionalities fall under the umbrella of ECM: the management of documents within the organizational context is facilitated by means of document management (DM or EDM), see Sprague (1995). Especially for the work-intensive management of websites, web content management (WCM) is employed. IM and KM are used to manage information and knowledge assets of an enterprise, see Alavi and Leidner (2001). Workflow management allows to manage, automate, and route tasks and activities. The management, execution and improvement of business operations and processes is facilitated by business process management (BPM). Records management (RM) is used for permanent storage to preserve static documents and ensure compliance. Rich media content such as audio and video files can be managed by digital asset management (DAM). Dealing with management of data, content, documents, information, and knowledge in some way, the above concepts partly overlap. Depending on the scope, functionalities and components of an ECM system, these concepts can be consolidated within one integrated system to reduce content silos.

While ECM is presented in practitioners' literature as the panacea to cure all content, information, and knowledge issues in enterprises (Smith and McKeen 2003, p. 647), it received little scientific attention and is still a young IS research domain (Tyrväinen et al. 2006, p. 627; Grahlmann et al. 2010, p. 2). The existing body of ECM literature was reviewed in literature reviews from Tyrväinen et al. (2006), Usman et al. (2009), Rickenberg et al. (2012a) and Alalwan and Weistroffer (2012). In contrast to the small scientific body of ECM literature, related research disciplines such as KM and the overarching IM are more mature and exhibit a comprehensive body of literature. Since ECM is composed of a plurality of concepts, literature from these underlying and more mature research domains can be used to some extent and the boundaries between the different areas of research are indistinct. The question arises as to whether the characteristic of ECM as an integrated enterprise-wide approach to preceding and related concepts is sufficient as a right to exist for the research domain. Focusing on the lack of substantive and mature theory in the emerging ECM research field, our objective is to define the characteris-

tics of ECM, build substantive theory, and evaluate the research domain. We investigate and discuss: "ECM research – does it matter?! – And so what?!"

Research Design – Grounded Theory Method

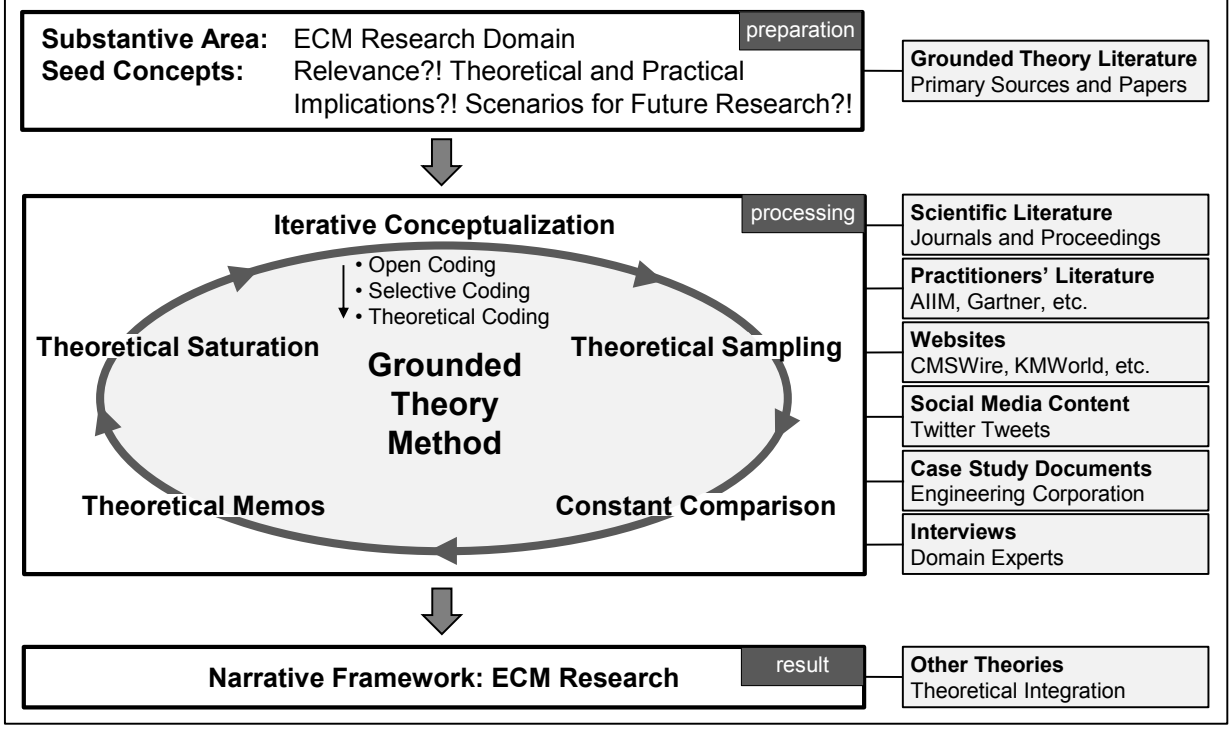
The underlying research design of this paper is based on the grounded theory method according to the classic approach of Glaser and Strauss (1967). The development of theory is key to IS research and to any scientific endeavor in general (Seidel and Recker 2009, p. 3). Grounded theory is an inductive research methodology to systematically and rigorously develop theory that is grounded in empirical observations or data (Martin and Turner 1986, p. 141). This method has become a well-accepted research method (Seidel and Recker 2009, p. 3) and "is employed increasingly in the IS field" (Butler and O'Reilly 2010, p. 2).

Given the widely unexplored nature of the ECM research domain, we used the grounded theory method to gain a deeper understanding of the phenomena and to derive theory from the different types of data that we gathered. While grounded theory is generally employed to real-world phenomena, we used this method to perform analysis, and to review, theorize, evaluate and discuss the ECM research field. Besides the advantages of the method itself, we provide two arguments to support our decision: firstly, similar to Seidel and Recker (2009, p. 5-6), we state that the ECM research domain is a primary application area of grounded theory due to the complex and contextualized nature of its associated phenomena. ECM itself and the ECM research field are multifaceted domains that emerge around related and preceding concepts and disciplines. Second, grounded theory is particularly "applicable to research domains that are characterized by their emergence and lack of substantive theory" (Seidel and Recker 2009, p. 3). Since there is not much ECM theory to extend or validate, an inductive method to build theory from data is applicable (see Orlikowski 1993). Along these lines and due to the under-researched nature of our research topic and the lack of substantive, mature theory in the research field, we reason that it is useful to adopt grounded theory here.

The substantive area and scope of our research is primarily the ECM research domain itself and not solely the actual management of enterprise content. Our research questions evolved from our seed concepts. The close proximity to the data within the research process gave us all sorts of insights, see Urquhart (2013, p. 4). In addition to the original source about grounded theory from Glaser and Strauss (1967), we also used advice and recommendations from Butler and O'Reilly

(2010), Dey (1999), Glaser (1992), Seidel and Recker (2009), Urquhart and Fernández (2006), Urquhart et al. (2010), Urquhart and Fernández (2013) and finally the practical guidelines provided by Urquhart (2013).

Figure 1: Research Design – Grounded Theory Methodology



Our process-oriented research design, the key elements of the grounded theory method and our main sources of data are shown in Figure 1. Starting with the substantive area and grounded theory literature, we developed seed concepts that are closely related to our research questions. Then we started with the grounded theory procedure within a highly iterative process. As indicated by Glaser and Strauss (1967), we performed the different coding steps to increase the level of abstraction for iterative conceptualization. Based on our six main sources of data, we performed theoretical sampling to decide on analytic grounds where to sample from next. More detailed information about the data sources and the coding steps are provided below; additional information can be requested from the authors. Within the interplay of data collection and analysis, constant comparison was employed to compare instances from new data with existing codes. During the coding, theoretical memos were written for each source to record important insights. The coding procedure was stopped when no new concepts and codes evolved from the data and further data collection was unlikely to alter the theory being generated. As result of the research

procedure, a grounded theory in form of a narrative framework (see Figure 3) was generated to give an overview of the ECM research domain, underlying topics and relationships.

Data Collection and Theoretical Sampling

Data were collected mainly from six different sources: scientific literature, practitioners' literature, websites, social media content, company documents from a globally operating engineering corporation, and semi-structured interviews, see Figure 1. As proposed by Glaser and Strauss (1967), we included multiple data collection techniques to consider multiple viewpoints of the emerging concept (see Seidel and Recker 2009, p. 7). Urquhart (2013, p. 18) states, that the more diverse the empirical slices, the better for building the theory out and upwards. While an extensive collection of scientific literature gave us deep insight into the ECM research domain, the other data sources also acted as a practical counterpart and revealed emerging trends. In the following, more specific information about the different sources of qualitative data is given.

As scientific snippets, relevant ECM and KM literature from the academic knowledge base of the IS domain was gathered as main source of samples. To collect potential ECM sources, three literature reviews of Rickenberg et al. (2012a), Alalwan and Weistroffer (2012), and Grahlmann et al. (2011) were used as a starting point to identifying relevant literature. Additionally, newer articles were gathered by searching academic search engines such as AISeL, ACM Digital Library, IEEExplore, and ScienceDirect. According to the recommendations of Webster and Watson (2002), we performed forward and backward search on this basis. The screening was rather mild, thus all academic articles dealing with ECM in some way were included. A detailed breakdown of the scientific ECM literature can be given upon request.

According to Schein (1987), including non-scientific literature represents the clinical perspective to reduce the gap between the scholars' and practitioners' point of view, see also Grahlmann et al. (2011, p. 3-4).We included practitioners' literature that met certain quality standards in our base of empirical sources. To limit bias, numerous whitepapers from different sources such as analysts and consultants (AIIM, Gartner, etc.) and vendors (Oracle, EMC, Microsoft, etc.) were gathered.

Websites about information, content, enterprise content, and knowledge management served as another source from a practitioners' point of view. For instance, websites such as KMWorld,

CMSWire, and AIIM were combed. Websites from common ECM vendors were also taken into account.

Concerning social media content, we were able to gather the opinions and contributions of a large and diverse group of people. Urquhart and Vaast (2012) recently introduced building theory from social media as new frontier for IS research. Accordingly, we extracted and analyzed tweets about ECM from Twitter with the qualitative data analysis (QDA) software NVivo.

Company documents about past and current ECM projects and strategy served as another empirical source. The documents come from a globally operating engineering corporation within the automation branch hereafter referred to as Engineering Corporation A. The company employs 3,500 employees worldwide and has been conducting ECM projects and pursuing an ECM strategy since 2004.

Another main data source is semi-structured interviews conducted within the extended environment of Engineering Corporation A. In total, eight interviews were conducted in which employees from four different companies were questioned. The interviews were conducted within 2013 and were recorded with a total duration ranging from 40 to 50 min. According to a defined procedure, the interviews included five open-ended questions: (1) position and role of the interviewee in general and in the ECM context, (2) understanding and definition of ECM and its scope, functions and components, (3) personal experience (positive, negative, lessons learned) with regard to ECM, (4) understanding and definition of KM; relationship between KM and ECM, (5) trends within the ECM and KM context. An introduction of the interview procedure, confidentiality, and the research project as well as a wrap-up and closing remarks were carried out. Table 1 provides an overview of the participants and their backgrounds:

Table 1: Overview of Interviewees and Background			
#	In ECM	Company	Position in company. *Role in ECM context.*
1	since 2005	IT Service Organization B	Technical Project Manager. Technical management of sub-projects.
2	since 2008	IT Service Organization B	Department Manager Applications. Temp. responsible for ECM program.
3	since 2003	Sales Company Europe A	Process Owner Sales. ECM and DM champion, ECM core team.
4	since 2008	IT Service Organization B	Application Developer. Programming and customization of solutions.
5	since 2005	IT Service Organization B	Senior Manager. Technical responsibility of ECM program.
6	since 2010	Engineering Corporation A	Senior Manager. Business responsibility of ECM program.
7	since 2006	IT Service Organization E	Project Management. Responsible for ECM projects.
8	since 2002	Engineering Corporation A	Chief Information Officer. Responsible for ECM projects and operation.

According to Urquhart et al. (2010), the grounded theory principle of theoretical sampling is the decision on analytic grounds where to sample from next. Thus, the interplay between data collection and analysis was ensured. We employed theoretical sampling by picking different empirical snippets according to the actual state of analysis. According to the original grounded theory source (Glaser and Strauss 1967), several options are available for theoretical sampling. One of the more extreme options is to maximize the similarity in data; the other one is to maximize the diversity in data. Similar data was picked from the same category of sources (such as different papers from scientific literature) and diverse data was picked from dissimilar categories of sources (such as scientific literature opposed to tweets). Theoretical memos were used to decide from which source to sample from next.

Coding Procedure

The coding was performed by a coding team under the guidance of a leading coder according to our underlying research epistemology of interpretivism and the classic coding steps by Glaser and Strauss (1967). Within open coding, we identified concepts and attached initial labels to our

data, see Urquhart (2013, p. 23-24). Due to the high abstraction of our substantive area and the research questions, the coding was generally performed on the level of paragraphs. We argue that this level of detail is appropriate in our case due to the abstract research approach, the high-level of the ECM research domain as phenomenon to be analyzed, and the objective style of writing in scientific literature. However, we did break our coding approach down to line-by-line coding if necessary, e.g. for particularly relevant paragraphs and in selected practitioners' literature. Even though the coding was mainly performed on the level of paragraphs, the empirical sources were read and analyzed in detail line-by-line. Interviews were coded on the basis of recordings, directly and without transcription.

When no new open codes suggested themselves and theoretical saturation occurred within the late stages of open coding, the level of abstraction was increased and selective coding was performed (Urquhart 2013, p. 24). Within this coding stage, we grouped the rather descriptive open codes into higher level categories in a manual coding approach with spreadsheets. When selective codes emerged from the open codes, theoretical coding was used to analyze and build relationships between the categories. During theoretical coding, we were guided and inspired by the different coding families that Glaser (1978, 2005) suggested, see Urquhart (2013, p. 109). We did not limit ourselves to Glaser's coding families and generated our own coding paradigms in order to describe the relationships between the constructs. Theoretical memos that we wrote while coding the data were used for further ideas within this step to theorize. The resulting grounded theory is presented within a narrative framework (see Figure 3).

Analysis and Synthesis of Enterprise Content Management Research

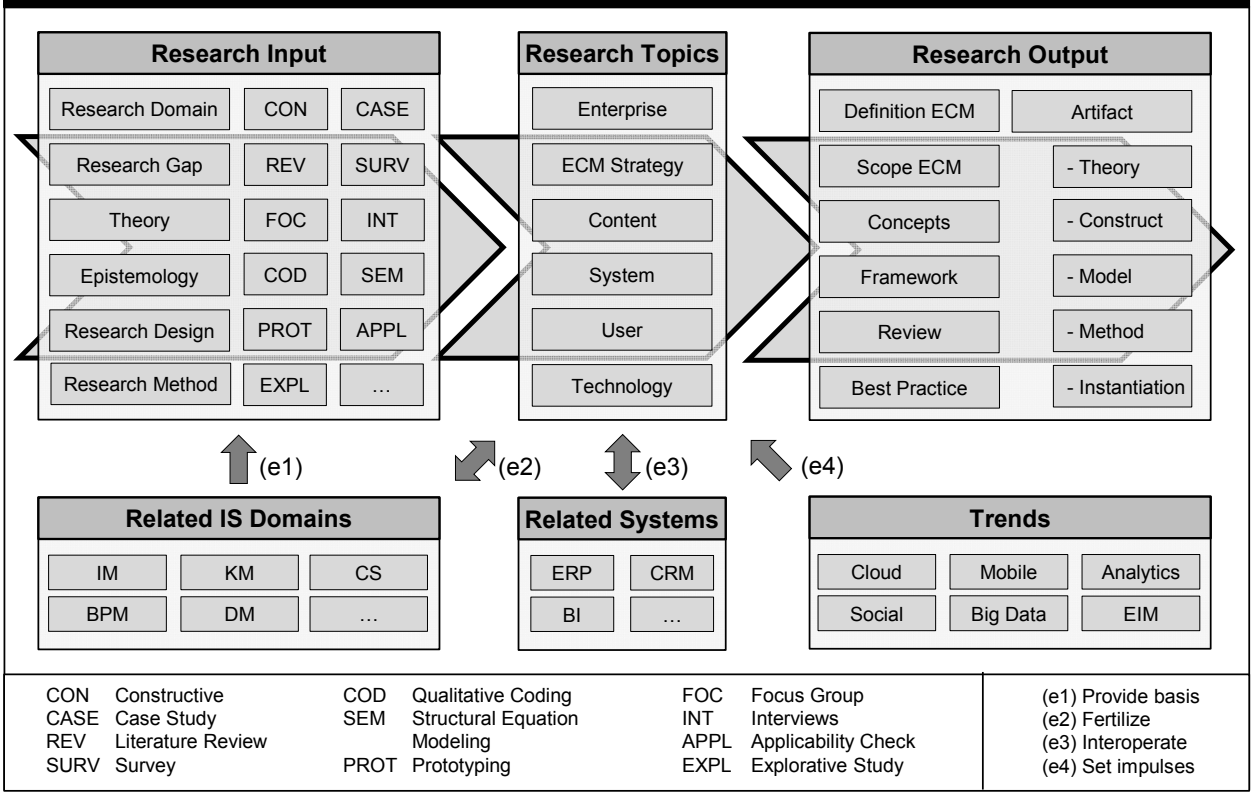
Enterprise Content Management Research Perspective and Process

Bloom's taxonomy of the cognitive domain offers a systematic classification of different cognitive levels (Bloom et al. 1956): (i) knowledge, (ii) comprehension, (iii) application, (iv) analysis, (v) synthesis, and (vi) evaluation. We adopt this taxonomy and argue based on the current state-of-the-art that there is adequate knowledge about ECM and the ECM research domain, that it is comprehended, and sufficiently applied in practice. Accordingly, we analyze, synthesize, and evaluate the ECM research domain in order to take ECM research and practice to the next levels of Bloom's hierarchy. Within this chapter, ECM research is analyzed and synthesized. While the analysis level of the taxonomy encompasses "examining and breaking information into parts by

identifying motives or causes; making inferences and finding evidence to support generalizations", synthesis encompasses "compiling information together in a different way by combining elements in a new pattern or proposing alternative solutions" (Cerbin 2011, p. 33; Bloom et al. 1956).

To set a basis for the analysis and synthesis of the ECM research domain, the research perspective and underlying process is illustrated schematically in Figure 2. It deals with the ECM research input, the actual ECM research topics, and the ECM research output. ECM research is influenced by three external constructs: related systems that interoperate with ECM systems, related and preceding IS domains that provide the background and input for ECM research, and recent IS trends influencing ECM research outputs and topics. While the research input, output, and the external constructs are described in the subsequent paragraphs, the narrative framework and the actual ECM research topics are explained within the next section.

Figure 2: ECM Research Perspective and Underlying Process



An ECM research process starts with the research input, which consists of several categories. Besides the ECM research domain itself and a research gap, the theoretical input and the under-

lying epistemology are decisive for the research procedure and outcome. Theoretical input that was used within ECM literature includes the IT-business alignment (Henderson and Venkatraman 1992) and structural contingency theory (Venkatraman and Prescott 1990) by vom Brocke et al. (2008a), genre theory of organizational communication (Yates and Orlikowski 1992) by Tyrväinen et al. (2006) and Rickenberg et al. (2012b). Also, certain authors (Zardini et al. 2011; Päivärinta and Munkvold 2005) use the resource-based view of the firm (Wernerfelt 1984; Barney 1991). Tyrväinen et al. (2006) employ Iivari's (1989) framework for IS to generate one for ECM research. Several authors, such as vom Brocke et al. (2008a), Rickenberg et al. (2012a,b) and Wiltzius et al. (2011), used this framework as a theoretical foundation for their work.

Based on the theoretical input and the ECM research literature, the research design and method determine the research process and outcome. Much of ECM research is design-oriented (Wiltzius et al. 2011, p. 1) and deals with constructive studies, conceptual ideas and frameworks and technological functionalities (Rickenberg et al. 2012a, p. 9). Apart from a few exceptions (Scott 2011; Kunstová 2010a; 2010b), ECM research is qualitative. In numerous papers, neither the underlying theory nor the employed research methods are stated explicitly. As Tyrväinen et al. (2006, p. 632) state, constructive and design science approaches (Hevner et al. 2004) are common in ECM research, see vom Brocke et al. (2008c) and Rickenberg et al. (2012b). Case study research is another common approach, see Korsvik and Munkvold (2010), and Munkvold et al. (2003). Literature reviews of practitioner's texts (Nordheim and Päivärinta 2004) or academic literature (Alalwan and Weistroffer 2012; Rickenberg et al. 2012a) are another common approach. Some authors (Kunstová 2010a, 2010b; Nguyen et al. 2008a) conducted surveys. Other research approaches include focus groups by Smith and McKeen (2003), interviews by Nordheim and Päivärinta (2006), coding approaches by Grahlmann et al. (2011), and Erickson and Brickey (2008), the technology acceptance model (TAM) in Wiltzius et al. (2011) in combination with structural equation modeling (SEM) in Scott (2011), prototyping by Banks et al. (2009) and Wang and Pan (2006), applicability checks by Rickenberg et al. (2012b), and explorative studies such as Nordheim and Päivärinta (2004).

The outcome of an ECM research process is the research output. As stated in the previous section, numerous authors define the concept and scope of ECM, but there is no single acknowledged definition of ECM. The type of research outcome is largely determined by the underlying research design and methods. In accordance with Rickenberg et al. (2012a, p. 8), the most often

identified research method is conceptual and generates concepts as a research outcome. Artifacts in the form of constructs, models, methods, and instantiations are common outputs, see various works of vom Brocke et al. Numerous framework have been generated: technical frameworks (Chieu et al. 2007, 2008a, 2008b), functional frameworks (Grahlmann et al. 2011), organizational frameworks (Nordheim and Päivärinta 2004; Päivärinta and Munkvold 2005), and theoretical frameworks (Tyrväinen et al. 2006; Rickenberg et al. 2012a). Reviews of scientific and especially practitioners' literature are also results of ECM research. Another output is best practice and lessons learned, usually coming from case studies (Scott et al. 2004).

The external constructs interact with the ECM research topics and partly serve as input for ECM research. Literature and theory of related IS research domains also provide input for ECM research (e1). ECM and the related research fields fertilize each other with new and related topics and impulses (e2), see Erickson and Brickley (2008) for ECM and KM and vom Brocke et al. (2008a, 2011a) for ECM and BPM. The effect and influence of the related fields such as KM on ECM is stronger than the other way around. ECM systems interoperate with other IS such as enterprise resource planning (ERP) systems (e3). Due to this interoperation, the systems and topics influence each other, see Nguyen et al. (2008b) for ECM and ERP. Recent IS trends such as cloud, mobile, and social computing set new impulses for the ECM research domain (e4), see Rickenberg et al. (2012a, p. 9-10).

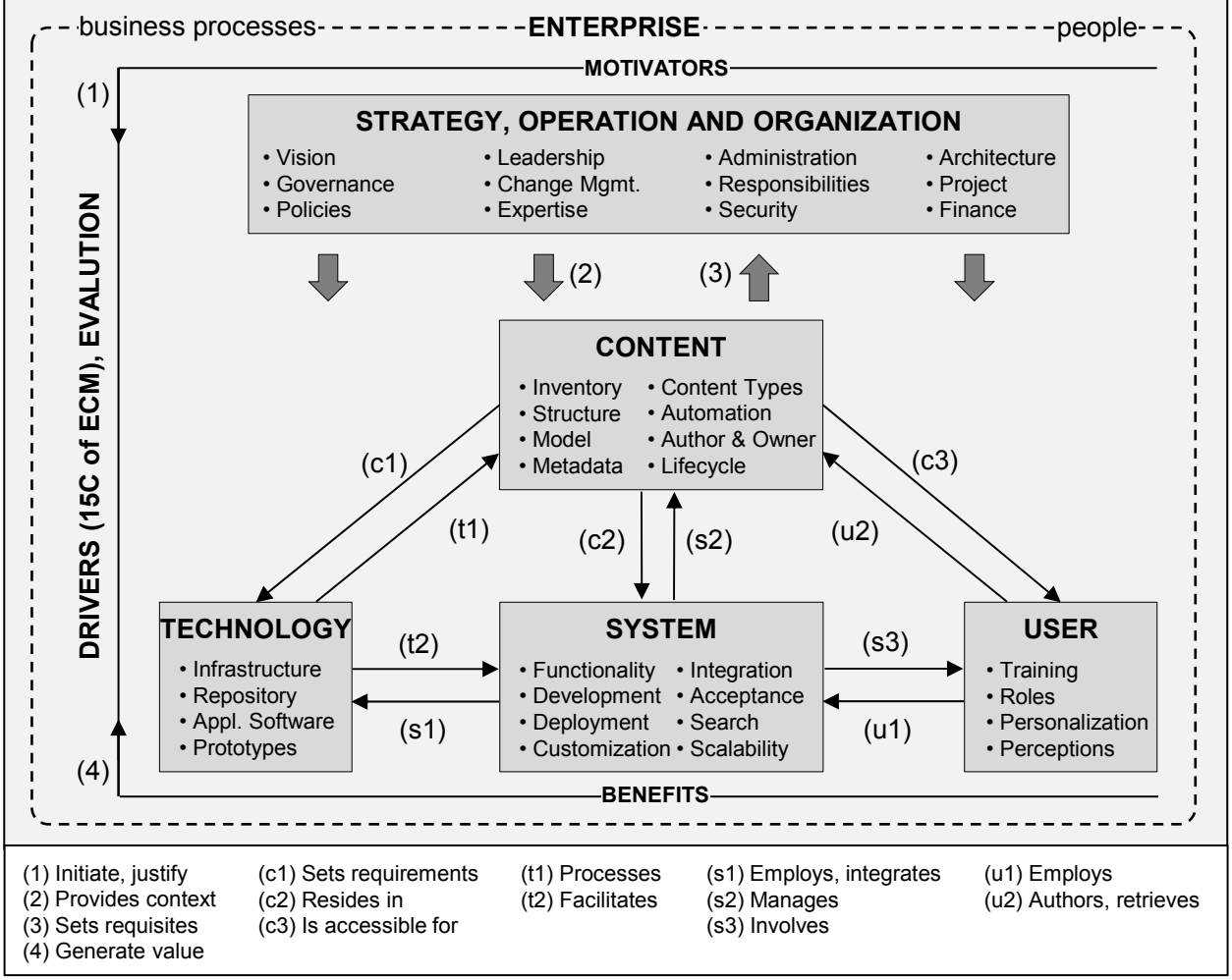
A Framework for Enterprise Content Management Research

We present a grounded theory in a narrative framework for ECM research (Figure 3) which was generated inductively from diverse sources. Any theory consists of constructs and relationships; there is no theory without relating the categories to each other (Urquhart 2013). In contrast to most frameworks and reviews, our framework shows the concepts that ECM research deals with and also relates the concepts to each other explicitly. It explains the constructs and relationships of the research topics and the ECM elements, which consist of drivers, the main constructs, and an enclosing construct providing the background. In the following paragraphs, the constructs and relationships of the theory are explained and representative literature is provided exemplarily.

ECM research involves a plurality of topics and issues and is represented by different constructs. The enclosing construct enterprise provides the background for ECM activities and includes business processes and people as sub-categories. Any ECM endeavor starts with a driver that

emerges within the company or is induced from outside (e.g. compliance) and initiates projects and programs (1). The construct strategy, operation and organization provides the organizational foundation and context and sets the basis for the initialization, implementation, and operation of ECM (2). The characteristics of the content need to be taken into account and sets requisites (3).

Figure 3: Theory Building – Narrative Framework for ECM Research



Content has an influence on the underlying base technology by setting the requirements for it (c1). The content of the enterprise is supposed to reside in ECM systems (c2) and is accessible for users (c3). Technologies such as hardware and software process content (t1) and facilitate ECM systems with different base functionalities and components (t2). An ECM system itself employs different technologies and integrates them (s1) to allow the management of content (s2) and has a set of users (s3). Users employ ECM systems (u1) to author and retrieve content (u2). Finally, any ECM endeavor is supposed to create benefits and generate value for the enterprise

(4) and these need to be evaluated against the motivators and drivers. As can be seen from the framework, enterprise content is the central aspect of ECM. Together with motivators and the organizational context, it determines the derived constructs (technology, system, and user). The derived constructs have a sequence and dependence: technology sets the basis for the accessible ECM system while the use of the system by the user represents the actual purpose of ECM and delivers benefits. The particular research topics are explained in more detail in the following.

ECM exhibits challenges and a number of drivers that can result in benefits if it is successfully implemented and adopted. Negative drivers and challenges can trigger an ECM endeavor due to potential risks and inefficiencies that need to be addressed. These include content chaos and information overload (Gromoff et al. 2011, p. 271), content silos due to point solutions and a lack of integration (Rockley and Cooper 2012), outdated content and lack of content maintenance (Smith and McKeen 2004), and security and compliance issues (Jenkins 2004, p. 37ff.). There is a plethora of intertwined motivators, objectives, and potential benefits (Usman et al. 2009; vom Brocke et al. 2011b,d; Rickenberg et al. 2012a). As synthesized from literature, important drivers are presented here as the 15C of ECM: cost and efficiency (more efficient and streamlined processes), collaboration, compliance and security, consistency and accuracy (content is exact and structured properly), consolidation and integration (unite heterogeneous architectures), customer service (new or better services), continuity (business continuity, disaster management), content quality and reliability (content is correct in substance), content accessibility (retrieve content if permitted), control and governance (ensure how content has to be dealt with), content intelligence and analytics (obtain business insights from unstructured data), convenience (less cumbersome workflows and procedures), corporate identity and culture (ensure uniform appearance), content availability (content can be retrieved whenever needed from wherever), and content reuse (content items can be assembled from snippets).

The construct strategy, operation and organization deals with the organizational issues of an ECM endeavor and comprises a number of aspects. The vision is the big picture of ECM and involves topics such as the pursued strategy, roadmaps, and future goals, see Smith and McKeen (2003). Properly formalized governance ensures that ECM runs successfully and deals with processes, procedures, roles, and responsibilities (Weintraub et al. 2011), see Scott et al. (2004, p. 46) and Jenkins (2004, p. 37ff). Policies are a set of rules such as retention, privacy or publishing policies that need to be complied with, see Chiu and Hung (2005). Leadership, top-management

support and change management are essential to successfully introduce ECM into a company, see Bridges (2007). Development of in-house expertise and competence reduces the dependence on vendors and consultancy, see Munkvold et al. (2006). Administration is intertwined with policies, regulations, responsibilities, procedures, and routines to keep ECM running, see Päivärinta and Munkvold (2005, p. 6), and Korb and Strodl (2010). Within an ECM project and program, responsibilities in the form of roles and accountabilities need to be assigned, see Smith and McKeen (2003). Further, security issues such as privacy and access rights need to be addressed, see Chieu et al. (2007). ECM architecture with underlying components, interfaces, middleware, applications and services is necessary, see Dilnutt (2006). Another topic is detailed planning and management with regard to ECM projects and financial aspects, see Allen (2007) and Zelko and Lavrin (2007).

The construct content concerns content items and characteristics of the content. An assessment of content with audits helps to create a content inventory or document map (Rickenberg et al. 2012b). This also involves the model, metadata and types of content. Content can be structured, semi-structured and unstructured and of different granularity, see Päivärinta and Munkvold (2005, p. 3). A content model defines the characteristics of the content such as metadata, taxonomies and the life-cycle (ibid.). Metadata can be defined as data about data and provides additional information and context about the item, see Rockley and Cooper (2012). Content types are used to define attributes such as metadata, workflows, templates, and behaviors for specific types of content, see vom Brocke et al. (2008b,c). Content automation encompasses automatic tagging, workflows, versioning, and content reuse (O'Callaghan and Smits 2005). Ownership, authorship and stewardship of content can be distinguished, see Smith and McKeen (2003, p. 655). The content lifecycle involves activities such as to create, capture, organize, store, access, process, retrieve, publish, maintain, retain, and finally delete content items (Tyrväinen et al. 2006, p. 631).

An ECM system mediates among different base technologies, the stored content and the actual users. A system provides different functionalities and enables particular business functions to be executed, see Grahlmann et al. (2011) for an overview of functions. While tailor-made software is possible, the development of an ECM system often means the adjustment and adoption of an existing commercial software package to specific needs, see Nordheim and Päivärinta (2004). The deployment of the system that follows embeds the system into the enterprise, see vom Brocke et al. (2008a). Customization is needed to alter a software package to specific require-

ments, see Nordheim and Päivärinta (2004). Integration consolidates underlying base technologies and software solutions to a seamless user experience to ensure acceptance of the system, see Nordheim and Päivärinta (2006). Concerning the users' perceptions, the ultimate target is the acceptance of the system by users, see Wiltzius et al. (2011). An enterprise search that is personalized or the ability to actually find content and information contributes to user acceptance of the system, see van Delft (2011). Scalability aims at the efficient operation of the system, even with a growing user base or increasing data traffic, see Banks et al. (2009).

The technology construct deals with base technologies and infrastructures such as hardware and software. Infrastructure involves hardware issues such as servers, clients, mobile devices, and networks, see Päivärinta and Munkvold (2005, p. 6). Content items need to be stored physically in repositories, see Grahlmann et al. (2011, p. 7). Generic application software and solutions from software vendors represents another base technology that needs to be adjusted and integrated into the actual ECM system, see Gilbert et al. (2011). Therefore, prototypes are an efficient mean, see Wiltzius et al. (2011, p. 627).

Topics within the user construct emerge around the end user who authors and works with the content. Involvement and training of the user is a mean to achieve acceptance. Within this context, the identification and motivation of key users and ECM champions is a crucial facilitator, see Wiltzius et al. (2011, p. 629). Users obtain different roles and rights within content-centric procedures and workflows throughout the content lifecycle, see Päivärinta and Munkvold (2005, p. 5). These roles and user groups have different needs, therefore personalization of content, search results, and portals allows users to get a personal view of the content, see Muresan et al. (2006) and Nordheim and Päivärinta (2004). User ratings, feeds, blogs, wikis, forums, tagging, feedbacks and networking bring in the social aspects of ECM. As already stated, the perceptions of the user are an essential aspect of any ECM endeavor, see Scott (2011).

Theoretical Integration

A grounded theory needs to be related and integrated with literature and existing theories in general and IS theory in particular (Urquhart 2013, p. 169). Concerning the ECM domain, Tyrväinen et al. (2006) introduce the framework for ECM research. This framework can be regarded as low level theory of ECM research. It consists of four main constructs: enterprise, content, processes and technology. Rickenberg et al. (2012b) employ the framework and add drivers, the ECM re-

search domain, and refine the enterprise perspective. The constructs of our grounded theory introduced here show similarity to the constructs of these two frameworks. All three of them use the enterprise to provide the organizational background, the content construct as a central aspect, and the technology as an enabler. While users and systems are subcategories within the framework for ECM research, these aspects represent main constructs here. The grounded theory suggested here also takes the ECM research perspective and underlying process (Figure 2) more into account and embeds it into its surroundings, including related research domains and systems, as well as trends. While the development and deployment of processes represents a separate construct within the framework for ECM research, these aspects belong to the system within the grounded theory. Strategy, operation and organization of ECM is an important aspect within the grounded theory but it is not mentioned explicitly and rather belongs to the enterprise perspective within the other frameworks. The established frameworks do not explicitly visualize relationships between constructs, but they are related in our grounded theory. Furthermore, the grounded theory suggested here has similarities with the framework of IS (Iivari 1989), which centers around the system as focal construct instead of content and organizational aspects.

The grounded theory for ECM research is put into the context of KM and IS theories, since theoretical integration means also relating the grounded theory to other theories from similar fields (Urquhart et al. 2010, p. 369). Essential KM literature and theory comes for instance from Nonaka (1994) and Alavi and Leidner (2001), who deal with knowledge processes and the creation of organizational knowledge. According to them, there are four KM processes: (1) knowledge creation, (2) storage and retrieval, (3) transfer, and (4) application (Alavi and Leidner 2001, p. 125). Alavi and Leidner (2001) state that IT is able to facilitate these processes. Within this context, ECM and ECM systems can be an efficient means to support (1) externalization of knowledge to content items, (2) storage of explicit knowledge and organizational memory in content, documents, wikis and other repositories, (3) spreading knowledge in the form of content items within and between organizations by means such as intranet portals and collaboration tools, and (4) accessing knowledge efficiently and embedding it into organizational routines by workflows. In this context, content and explicit knowledge in the form of content represents a valuable resource. According to the resource-based view of the firm, which originates from Penrose (1959), Wernerfelt (1984), and Barney (1991), resources such as knowledge can lead to the creation of competitive advantage. Päivärinta and Munkvold (2005, p. 8) argue that ECM somehow unites

the resource-based with the process-based view of the firm. The knowledge-based view of the firm (Grant 1996) builds upon and extends the resource-based view of the firm and positions knowledge as the most strategically significant resource.

Evaluation of Enterprise Content Management Research

Maturity of the Enterprise Content Management Research Domain

Following up on the analysis and synthesis of ECM research and the presentation of the grounded theory, we evaluate the maturity of the ECM research domain. According to Bloom's taxonomy, evaluation as the final level encompasses "presenting and defending opinions by making judgments about information, validity of ideas or quality of work based on a set of criteria" (Cerbin 2011, p. 33; Bloom et al. 1956, p. 207). Recent, ongoing discussions focused on determining quality criteria and directions for IS research, see e.g. Österle et al. (2011), Baskerville et al. (2011), and Straub and Ang (2011). Aiming at RQ1, that is, whether ECM research is a relevant subfield of IS research, we utilize the preliminary results of this discussion.

Research outcomes and domains in the IS field matter if they fulfill the requirements of relevance and rigor. Concerning the relevance criteria, a research stream matters if it fulfills two requirements, see e.g. Benbasat and Zmud (1999), Rosemann and Vessey (2008), and Straub and Ang (2011): (1) it tackles topics that are relevant for both (IS) scholars and practitioners, and (2) it leads to a research output that is relevant for both – IS research community and practitioners. With regard to the narrative framework described in the previous section, mainly the input and output of the ECM research process have to be considered to evaluate research against these requirements, see Figure 2. At the same time, research has to be rigorous which means that it has to fulfill defined quality standards regarding transparency, validity, and reliability (Benbasat and Weber 1996; Rosemann and Recker 2009). A rigorous research process ensures that the output is actually able to contribute to the scientific knowledge base and to improve the state of knowledge of the research community. With regard to the first two of our research questions, both criteria have to be considered. We employ these two aspects along the ECM research process procedure: input, process, and output. For this purpose, we used the generated grounded theory and the underlying data from the coding process.

As a starting point for the evaluation of the maturity of ECM research, we analyze the input step of the ECM research process. The research questions of ECM appear to be highly relevant for

both, the research community and practitioners. An increasing number of ECM research papers are clustered within Figure 3. The topics largely correlate with recently published practitioners' papers and studies (see e.g. AIIM). Also, the results of our interviews mostly confirm the relevance of the topics covered by ECM research. However, ECM research tends to neglect some organizational issues and current trends within the IS research field. Despite that, there are some shortcomings regarding the rigor of the research input. Very few ECM papers explicitly discuss the research design or method(s) used and the theories that the work uses as a foundation. As discussed in the previous section, most existing ECM research is constructive and design-oriented. The reasons why constructive approaches were pursued, however, are hardly discussed and the methods described insufficiently. Concerning the ECM research input, the criteria of transparency is only partially fulfilled, and the validity and reliability of the research steps can hardly be evaluated.

When collecting data, performing analysis and constructing artifacts as part of ECM research input processing, rigor is particularly important. For this purpose, it is recommended that authors use accepted research methods and describe the research design and procedure transparently to fulfill the validity and reliability criteria. A lot of authors do not present and discuss the design decision and the research methods. Papers with an underlying design-oriented approach that addresses validity and reliability insufficiently do not contribute to the research community and most likely do not find their way into practitioners' guidelines.

The main output of research in general is theories, artifacts or theoretical contributions, and descriptions of relationships or boundaries with other disciplines. It is surprising to see that despite the highly relevant research input, the output of the ECM domain can be rated as rather low in quality. Because most of the papers do not explicitly use accepted theories no research output falls into the category of proven or disproved theories. In IS research, mainly quantitative research methods are used to prove or disprove theories. Since quantitative methods are rarely applied in ECM research (see previous section), very little research output can be found in this category. Also, there is only very limited output concerning theoretical contribution. Some papers define ECM and its scope, but unfortunately do not generate theory. Further, little research thoroughly examines the relationships and boundaries of ECM research to other disciplines.

Due to the fact that ECM research is constructive, much of the ECM research output includes artifacts, mostly in the form of frameworks. Almost all of these frameworks deal with the system perspective, and are technical or functional frameworks. In contrast, very little research output is available at the level where ECM actually generates benefits: on the enterprise and user level. This is one reason why few of these frameworks have found their way into practical literature. One exception is the theoretical framework from Tyrväinen et al. (2006), which is widely used in numerous research papers. With regard to the rigor criteria, the generated research output must be criticized. There are very few research papers that use accepted methods or guidelines for artifact construction such as Hevner et al. (2004). This is one reason why most of the artifacts are rarely reused by other ECM authors and are not used within other research fields.

The lack of commonly accepted definitions, steady promotion of ECM benefits, and the emergence of systematic reviews are indicators for the state of the research field. ECM exhibits a multi-faced nature and is evolving quickly. Definitions and scope of the concept are not final, still changing, and need to be established. Within many papers, the benefits of ECM are praised without exact empirical investigation or quantification. Quantitative studies that measure the actual outcome and benefits of ECM with the 15C of ECM suggested here can increase the maturity of the domain. According to Brown et al. (2012, p. 180), "the maturity of a research domain is denoted by the emergence of systematic reviews within it." During 2011 and 2012, three systematic literature reviews of the ECM research domain were published. While the first two aspects are indicators for an immature state, the third one shows that ECM research is slowly maturing. Compared to other related systems such as ERP, ECM research is still in its early stages.

Pärivärinta and Munkvold (2005, p. 1) wondered, "whether ECM actually represents anything new compared to the established constructs of information management" and what ECM and ECM research offers to justify its current standing as a new domain. We address this issue and RQ1 by summing up our investigation and evaluation. We use the analyzed empirical data to argue that ECM research does matter and is a relevant subfield of IS research. To increase the impact and relevance of ECM research, the focus needs to be adjusted. If the main distinction of ECM practice and research to other domains is the enterprise-wide character, then research needs to be directed at organizational and strategic issues rather than on technical aspects. The technology of the adjacent disciplines is mature and well researched when deployed on their own. However, ECM is an organizational concept and not just a set of technologies (vom Brocke et al.

2010, p. 1). Given the enterprise-wide scope, the research topics and activities need to be aligned with this key characteristic of ECM. So what really matters within the ECM context are organizational challenges, that is, how to set up ECM and keep it running efficiently. Enterprise-wide management of content and information poses new challenges such as corporate governance, managing content types, metadata, and taxonomies from a holistic point of view, see Päivärinta and Munkvold (2005, p. 8). This also includes integration issues, the management of enterprise-wide structures, and content-related processes. The special organizational challenges of ECM include new roles, threats, and opportunities that emerge within enterprises due to social media, Enterprise 2.0, and role-based intranet portals.

To show the implications of ECM research, we first point out the implications of ECM practice. Reimer (2002, p. 21) states that ECM seeks to meet the superset of requirements of related and preceding point solutions. While these point solutions can partly overlap in function and exist in parallel somewhat uncoordinatedly, ECM aims at an integrated enterprise-wide approach to IM. These implications of ECM can be transferred to the research domain to answer the theoretical part of RQ2: ECM research takes up the topics – and partially the results and theories – of related research disciplines to address their challenging and complex integration into a holistic approach, see Päivärinta and Munkvold (2005, p. 7). While topics of the related disciplines were absorbed well, existing results and theories need to be incorporated and synthesized more effectively to reinforce the impact of ECM research. ECM researchers need to look at the bigger picture, think outside of the box and the ECM domain, and try to incorporate relevant research results from related domains. Often existing research results are available in related disciplines so that researchers do not have to reinvent the wheel, but to expand and integrate the results on an enterprise-wide scope. This goes hand in hand with our prior remarks about the importance of strategy, organizational issues and holistic considerations of ECM, or as Smith and McKeen (2003, p. 649) put it: “ECM strategy could easily turn out to be the biggest challenge of the next decade”, see Lyman and Varian (2003).

Relationship with Knowledge Management and Scenarios

Even though ECM research interacts with several related research fields, the relationship with KM is discussed most often. A hierarchical view of data and content, information, and knowledge has been established within IS literature (Alavi and Leidner 2001, p. 109). ECM sys-

tems hold data or content that can be processed and interpreted and then serve as information. One step further, authenticated and personalized information related to certain context can be regarded as knowledge. With respect to RQ2, we argue that another implication of ECM is its ability to enable KM and support the four KM processes, which can then lead to increased performance and profit, see Ko and Dennis (2011).

Concerning the relationship between ECM and KM, there is no consensus within IS literature. Päivärinta and Munkvold (2005, p. 7-8) relate ECM to its referential areas and state that "ECM could be phrased as a subarea of KM to manage the directories of 'explicit' knowledge." They also argue that although KM represents a wider concept, ECM incorporates fields different from KM and has its own special challenges. This is consistent with our remarks within the previous chapter. Vom Brocke et al. (2008a. p. 2) positions ECM as an important instrument for effective KM. Alalwan (2012, p. 8-9) provides a short discussion of the context of KM and ECM and states that "many researchers believe that ECM overlaps with KM," other authors "suggested ECM as one type of KM" and finally some consider "ECM a subfield of KM."

From a practical point of view, ECM and KM are sometimes considered to be redundant constructs, but they indeed have very different characteristics and functions (Oracle 2011, p. 1-2). While ECM focuses on the management of content, KM allows finding information that is relevant in a given context (ibid.). McNulty (2012) states that KM is broader in scope, has a higher level of abstraction and is independent of technical tools such as Microsoft SharePoint. Both concepts "can be important parts of a strategy to improve the quality and usage of information" (Oracle 2011, p. 1). Within the conducted interviews, most interviewees saw ECM as a subfield of KM. They stated that ECM enables KM by providing it with information from enterprise content and allows users to retrieve content and information with search functionalities. In contrast, one interviewee saw KM as a subfield of ECM because it can be used for intranet portals that are able to bring together items from different knowledge repositories.

According to different views of knowledge, it can be argued whether ECM and KM, as well as ECM and KM systems, differ from each other significantly. Alavi and Leidner (2001) summarize different perspectives on knowledge: one perspective posits that knowledge is an object that can be stored and manipulated. According to this view, ECM and KM systems do not differ substantially from each other, since ECM systems are able to store objects at different levels of

granularity. This position is supported by the view of knowledge as a condition of access to information. From this point of view, knowledge has to be organized to allow access to and retrieval of content. Three perspectives oppose this point of view: knowledge as a state of mind, as a process, and as a capability. Given these perspectives, KM and KM systems have a wider scope than ECM systems. Knowledge is not regarded as an object that can be easily transferred; but involves more complex constructs such as human understanding, expertise, and know-how. We conclude that KM is a wider concept that partly overlaps with ECM in functionality and scope. ECM is an important enabler of KM with its underlying objective of being an enterprise-wide approach with holistic structures.

Coming from the relationship between ECM and KM and to answer RQ3, several likely scenarios of the ECM research domain can be envisioned. One very likely scenario is the existence of ECM research as it is with moderate impact and little theory development, positioned next to related IS disciplines such as KM and BPM. If more rigorous research is conducted and theoretical output can be increased, the impact and relevance of ECM research can be strengthened. Another likely scenario is that ECM research fully takes in the preceding and some related disciplines due to its holistic perspective. In contrast to this, ECM research could be taken up by a related research discipline if ECM turns out to only be a temporary phenomenon. A possible candidate to incorporate ECM would be KM, which thus could substantiate its position and scope as integrated perspective on the knowledge lifecycle with enterprise-wide structures. One less likely scenario is that ECM and ECM research breaks down into its component parts such as content and workflow management. More likely is a stronger focus on integration and consolidation to achieve common structures. Then ECM research and practice could converge with enterprise information management (EIM) to integrate the management of structured and unstructured data. Which of these or other likely paths ECM research will take heavily depends on the practical development and future relevance of ECM, the development of IS research in general, and the quality of ECM research in particular.

Practical Implications and Trends of Enterprise Content Management

We identified several trends and future practical implications of ECM. With regard to practical aspect of RQ2, the most important trends within the current ECM context are social business and media (see Aral et al. 2013), mobile ECM, cloud ECM, big data, and integration. While the iden-

tified trends are omnipresent in practitioners' literature, tweets, and on websites, the trends have not yet gotten through to academic literature and the interviewees.

While CMS formerly stood for content management systems, it now might stand for Cloud-Mobile-Social (Walker 2011). As already stated by Rickenberg et al. (2012b, p. 9-10), moving content and ECM services into the cloud, employing mobile devices such as smart phones and tablets in the ECM environment, and deploying social business and enterprise social networking (ESN) are the next big steps. AIIM describe the current time simply as "era of social, mobile, cloud and big data" (Miles 2012, p. 1). Along these lines, Gartner defines the Nexus of Forces, which is the convergence of social, mobile, cloud, and information (Plummer and Sribar 2013). They forecast that the challenging combination of forces will lead to upheaval and far-reaching change, as well as increased consumerization of ECM and IT.

Whether big data, content analytics or content intelligence – the term big data is still fuzzy (Pospiech and Felden 2012, p. 1). From a practical point of view, big data means to store and query very large datasets to gain business insights by employing analysis techniques against structured and unstructured content repositories, see also Miles (2012, p. 3). Chen et al. (2012, p. 1165) state that big data analytics has become increasingly important. Efficient ECM can be an enabler of big data to supply it with decisive input data in the form of (unstructured) content.

The interviewees in our study hardly mentioned the trends and hypes stated above. Instead, they focused on organizational issues and integration of existing ECM architecture as future practical implications. While companies still struggle to achieve the vision of a single ECM system and enterprise-wide integration (Miles 2011, p. 3), the next big challenges are already prevailing or are just around the corner. Big ECM solutions from single vendors that are enterprise-wide, modular suites or rather architectures can help to address this issue. In the near future, ECM can turn into infrastructure and become the second standard backbone within companies next to the transactional ERP backbone. The integration of structured and unstructured data within EIM is another path of development of ECM.

Concerning the future of the IS, Goes (2013, p. V) states that emerging areas and phenomena that arise from innovations need to be recognized. He particularly names social, mobile and cloud computing, as well as big data analytics as innovative forces (ibid.). Against this backdrop, research about the above-mentioned trends within the ECM context is essential to increase the

practical and academic relevance of ECM research. Again, research about organizational issues is more important than technical driven approaches.

Recommendations

In order to link the theoretical and practical findings, the following recommendations can be given. Commercial ECM solutions are becoming more mature, complete in vision, and executable (Rickenberg et al. 2012b, p. 1; Gilbert et al. 2011), however, there are still prevailing challenges, often of organizational nature. These solutions enable more than plain content management and can be seen as framework or even as architecture. For instance, communication and collaboration are facilitated by virtual project rooms, blogs, and wikis, while social media and social business have moved into the spotlight due to consumerization. ECM research needs to address these challenges and issues.

While this paper gives an insight into the ECM research domain, topics for future research arise. In addition to organizational and strategic issues, we emphasize the need to investigate the operation of ECM systems. Within practice, it is common that content chaos breaks out again even though an ECM system has been established as described in the contagion stage in Scott et al. (2004). Along these lines, Rickenberg et al. (2012b) proclaim the need of a procedure model that not only takes the implementation, but also the challenging operation of an ECM system into account. Commonly accepted definitions need to be established soon or the practical definition of AIIM can be adopted. While immediate benefits are often used to justify ECM adoption, other long-term benefits are harder to quantify (Smith and McKeen 2003, p. 650). We suggested the 15C of ECM to address and stimulate the measurement and quantification of ECM benefits. Since Alalwan and Weistroffer (2012, p. 451ff.) suggest an agenda for ECM research, we will not provide a detailed agenda and instead refer to theirs.

As stated by Watson (2001, p. 104), scholars should investigate and improve "[…] the efficiency and effectiveness of communication technologies to improve knowledge sharing." Along these lines, we state that ECM is an important subfield of IS research and it is in need of further investigation and is able to improve knowledge sharing within organizations. With our emerging grounded theory for ECM research, we do not construct an all-encompassing grand theory, but a theory that is important and particularly unique to IS theory, see Markus and Saunders (2007, p. iv). We synthesized prior research results and provide a conceptual foundation for future re-

search with the emerging grounded theory and the evaluation of the ECM research domain. We believe that the use of grounded theory is able to contribute additional value compared to regular reviews by theorizing and thus conceptualizing and constructing relationships.

Limitations

We identified certain limitations with regard to the applied research method, research process, generated grounded theory, and our data sources. Grounded theory offers a lot of advantages but there are also some weaknesses and critiques, such as the epistemological grounding. Urquhart and Fernández (2006, p. 462) argue that grounded theory can be characterized both as positivist and interpretivist, and that the paradigmatically neutral method is influenced by the underlying epistemology. Our research stance is consistent with the choice of grounded theory as a research method. It is also a common myth that grounded theory produces low-level theories that do not do much (Urquhart and Fernández 2006, p. 457). Grounded theories need to be scaled up and integrated with existing literature and theories. We aimed to extend the scope by theoretical sampling (Urquhart 2013, p. 106). To scale up the theory and its generalizability, we included KM literature and practitioners' sources. However, the generated theory can be further scaled up and the scope can be broadened. It can be tested deductively and built upon by IS researchers. Starting from our theory, researchers can develop theories of greater scope and formal concepts (Urquhart et al. 2010, p. 365-368).

With regard to the research process, we identified limitations concerning the prior knowledge within the substantive area and the time-consuming character of the research method. The most common myth about grounded theory is that researchers must not know any relevant literature before applying it (Urquhart 2013, p. 29). It is true that researchers have to set aside existing theory when conducting research (Urquhart and Fernández 2013, p. 3). That does not imply that researchers have to ignore existing literature and that they have to be a blank slate (ibid.). Regarding our prior knowledge of ECM, we conducted research in this domain before and thus already knew relevant ECM literature. During research, we separated existing theory from the actual research topics and did not include it in the coding so as not to impose it upon the emerging theory. We agree with Wolfswinkel et al. (2013, p. 53), who stated that "it is impossible to not be influenced by the background knowledge that one has" and support Dey (1999) that research has to be conducted with an open mind and not an empty head. Another myth is that conducting

grounded theory takes a lot of time (Urquhart 2013, p. 32). While we do not agree with other myths about the method, we somewhat agree with this one. The coding of large data collections is very time consuming, but due to the researchers' proximity to the data and rich insights being generated, it is often worth it.

We generated a narrative framework for ECM research. As a meta-framework, it does not solely deal with the management of content as a topic; instead it deals with the topics of the ECM research domain. While special aspects can be missing, main aspects are identified, included, and theorized.

We used academic literature as a data source. According Glaser (1999; cited in Urquhart and Fernández 2006), "Grounded theory is a general method. It can be used on any data or combination of data." We argue that the use of academic literature is legitimate and the choice of sources matches our substantive area. Concerning the gathered social media content, the analysis of tweets was more problematic than assumed. The tweets often included hyperlinks to additional content and did not include the main message itself. Concerning social media analysis from a theoretical point of view, Urquhart and Vaast (2012) recently stated that IS research should consider using crowdsourcing to build theory. Despite some trouble we had when analyzing tweets, we strongly agree with this statement. We propose that crowdsourcing and social media content should be applied for other studies in the IS domain due to the possibility of quickly gathering diverse and a broad range of opinions.

Conclusions and Outlook

ECM research and the current state of the field needs thorough investigation and lacks deeper analysis. We address this issue by generating a grounded theory of the ECM research field. We provide a formal description of constructs and relationships within the ECM domain in form of a narrative framework. The frameworks takes into account the different theoretical views expressed in the IS literature and also incorporates the viewpoints of diverse practical sources. Based on the insights generated from the closeness to the data, we used the grounded theory for meta-analytic purposes within this novel approach to analyze the relevance and impact, theoretical implications for research and practical implications, as well as scenarios for ECM research.

We conclude that ECM research is relevant; however, more rigorous research, further theory building, and discussions within the IS research community are necessary. ECM research needs

to be adjusted to match the enterprise-wide scope, which is a key characteristic of ECM. This corresponds with the implications of ECM research: it absorbs and combines research results from preceding and related concepts to address their challenging and complex integration into a holistic enterprise-wide, often global approach that emphasizes strategic and organizational issues. Several likely scenarios for ECM research can be envisioned. The actual future development depends on the practical evolution and future relevance of ECM, the development of IS research in general, and the quality of ECM research in particular. Concerning future practical implications of ECM, the all-embracing trends are cloud, mobile, and social ECM, also called CMS (Walker 2011). Big data and content analytics, as well as deeper integration of ECM-related systems, are also practical implications.

We aim to bring ECM research a step forward and fertilize research and theory building. We suggest that the narrative framework and the grounded theory with its constructs and relationships can act as a reference model. This abstract, domain-specific ontology can help to enable consensus within the multifaceted ECM research domain that has not yet been achieved (Grahlmann et al. 2011; Al-Debei and Avison 2010). Future research topics of ECM should be aligned with the narrative framework to address important strategic and organizational issues including the challenging operation of ECM systems. Identified trends need be investigated also from a theoretical point of view to increase the impact and relevance of ECM research.

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