EAI's Impact on Enterprise Architecture and How to Handle It

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Today large companies often have to cope with complex and heterogeneous IT infrastructures. A recent approach to this issue is Enterprise Application Integration (EAI). EAI provides a platform for business process oriented system integration. The aim of EAI is to consolidate the number of point to point interfaces of integrated applications in a centralized hub and spoke architecture. In contrast to former middleware approaches EAI provides integration not only on a technical level but on a business process level too. According to this we consider EAI as an architectural element affecting IT as well as organizational issues and thus Enterprise Architecture. Hence EAI again raises the question for interdependencies between IT and organization.
In a study we analyzed how EAI is used in large-scale companies and which effects it has on the Enterprise Architecture of those companies. The results illustrate that EAI is a major component in complex IT infrastructures which has a significant influence on business processes. But the study also shows that there is a considerable gap between the importance of EAI in Enterprise Architecture and the way it is used in companies today. As a result EAI as it is used today may provide a way to connect IT systems but it is hardly capable of handling architecture's complexity. Eventually this article points out what has to be done to move toward a manageable enterprise architecture.

1 EAI and Enterprise Architecture

Today IT definitely is a determining success factor for enterprises. Especially in large companies grown IT infrastructures can be described as extremely complex and heterogeneous. Therefore integration and interoperability is one of the main issues developing and operating these infrastructures at reasonable costs. As a matter of fact the conventional way of using individually coded point to point interfaces to connect systems is getting beyond control due to increasing overall system complexity. On the one hand one has to consider the costs for IT operation and maintenance of up to thousands of interfaces and on the other hand adaptations caused by the introduction of new systems (or system upgrades) and/or procedural-organizational stipulations are almost non-manageable due to complexity of element interdependencies [1]. Enterprise Application Integration (EAI) introduces an approach which substitutes point to point interfaces by centralized integration features. EAI promises to extend middleware approaches by integration on business process level (Fig 1) [2-5].

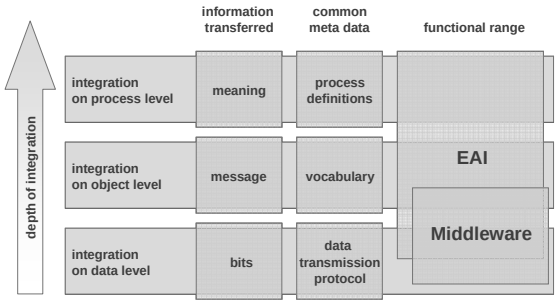

Fig. 1: Integration level [6]

The additional feature of business process integration results in two views on EAI:

- *EAI as a technology* subsumes technical solutions to solve rather technical integration issues.
- *EAI as a concept* describes a more abstract and comprehensive approach which takes EAI into account as an architectural element.

This paper deals with EAI as a concept primarily because we presume that EAI – integrating on a business process level – has a significant impact on business processes and thus on enterprise architecture. That it is why further aspects as methodologies, modeling and particularly architectural management components become very important. At this point it is important to understand that the technology used may be EAI – but it is of no necessity. It is not necessarily a specific EAI product or even a strict centralized integration approach. Depending on the individual requirements a mixture of different integration technologies as point to point interfaces or service oriented architecture are possible or even as likely as not. They all have their pros and cons (which will not be discussed here) and thus they add further alternatives to an integration toolset.

The following sections depict IT, EAI and Organization as parts of the overall Enterprise Architecture (EA). Afterwards the paper describes the research method and results of the empirical study analyzing the impact EAI has on EA. The paper concludes with recommendations how to increase interoperability in a sustainable EA.

2 The Role of EAI in Enterprise Architecture

The term of *Enterprise* A*rchitecture* is used in multiple meanings and suffers from a lack of consistent definition appropriate to specific research domains as Information Systems, Computer Science or Management Science [7]. In a few words an architecture can

be defined as an abstract and holistic concept of structures and patterns considering planning aspects [7-10]. Architectures are generally results of planning efforts [11] and offer by definition a master plan supporting holistic implementation of future actions [12]. These universal characteristics can be used for planning and designing of enterprise structures and strategies too. Furthermore an Enterprise Architecture considers organizational, technical and psychosocial aspects for planning and building Information Systems (IS) in a socio-technical manner [13]. The following study particularly focuses on organizational and technical dimensions of EA. Therefore we use the terms *Organizational Architecture* and *IT Architecture* (Fig. 2).

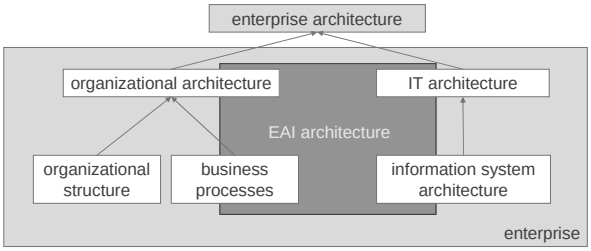

Fig. 2: Enterprise Architecture [14]

Organizational Architecture contains all non-technical elements of the EA. Accordingly we differentiate the Organizational Architecture in Organizational Structure and Business Processes [15, 16]. On a par with the Organizational Architecture is the IT Architecture which contains all technical elements of the EA. In particular IT Architecture covers the IS which are described with their own architecture: the IS Architecture. Both architectures Organizational and IT Architecture will be considered being equivalents but observed separately to take account of the fact that both architectures are very relevant for the organization's efficiency and do have complex interdependencies to each other [2]. Scientific literature very often refers to the terms Organizational and IT Architecture but uses multiple term understandings. Depending on the authors scientific background the Organizational Architecture contains technical concepts too [17] and the IT Architecture organizational aspects respectively [18].

By definition EAI delivers not just concepts for connecting IS (EAI as a technology) but align IS and business processes (EAI as a concept). Both integration aspects are already considered in the technical definition of EAI which describes a business process driven IS integration. Therefore EAI is predestined to serve as a mediator between different elements of the EA. To better understand the challenge of this mediator role we will discuss some theoretical foundations about interdependencies between IS and organizational issues.

3 The Role of IT and Organization in Enterprise Architecture

EAI as a technology claims to be business process oriented therefore it is assumable that there is an impact on the companies' operational and organizational structure. Understanding EAI as a concept integrating enterprise architecture it is even more important to look at the interdependencies between organizational and technical aspects. The following considerations reflect the main aspects which have been discussed for many years already by the community of Management Science [19].

The question of how the use of IT influences or even dominates organizational issues is as old as the first IS implementation in a company. There have been many approaches to analyze these interdependencies. Despite many scientific efforts there is still no common theory. Therefore it seems difficult to prove the evidence of unidirectional interdependencies between EAI and EA based on theoretical scientific statements. Particularly dependencies on the technology used, different methodologies and diverse underlying paradigms of organizational understanding are main reasons for the difficulties in establishing a common theory about the described interdependencies [19, 20].

MARKUS/ROBEY identified three basic assumptions examining interdependencies between IT and Organization: the *technological imperative*, the *organizational imperative* and the *emergent perspective* [21].

The technological imperative basically considers IT as an exogenous factor significantly influencing organizational structure and behavior. Organizational structure therefore is the dependent variable. Organizational structure is unidirectional depending on IT [21, 22].

The organizational imperative describes IT being determined by organizational requirements. Organization is the independent variable. IT is being used to fulfill organizational objectives. Costs and risks using IT in a specific organizational context are considered to be known or at least predictable [7, 21]. The organizational imperative assumes IT as unidirectional depending on organizational issues.

The basic assumption of the emergent perspective considers the use of IT being non-predictable depending

on the complex socio-technical organizational interactions. To determine the impact of IT on an organization it is insufficient to know IT characteristics and organizational objectives only. In fact it is furthermore indispensable to have a detailed understanding of the dynamic organizational processes [21].

Compared to the two imperatives and their basics assumptions the emergent perspective does not imply a stringent causal determined dependency as a unidirectional interrelation. A more complex and multidirectional interdependency between IT and Organization is expected. Beside controversial technological and organizational objectives and strategies other factors as irrational human behavior are taken into consideration [7].

Most experts today decline the exclusive existence of unidirectional and stringent causal determined dependencies between IT and organization. As a matter of fact IT is considered to be an enabling factor which widens the options of an organization [23, 24]. This is particularly obvious in case of organizational restrictions solved by technology.

4 Quantitative Research – Objectives and Method

Our study analyses how large organizations effectively implement and use EAI concepts to find out about the impact of EAI on Enterprise Architecture and particularly organizational issues. While surveying a specific technology (EAI) and their interdependencies to the organization the study follows the tradition of [19, 21, 25-29]. Finally it has to be argued whether the pronounced capabilities of EAI are just marketing slogans used by vendors and consultants or meeting the requirements to create an integrated EA.

These research issues have been analyzed in a descriptive and explorative manner. The study has been designed as a non-experimental cross section enquiry over a short period of time primarily using a written standardized questionnaire. Based on the results of the predominant descriptive and quantitative analysis a second questioning has been made with expert interviews hold individually or in small groups. The purpose of this evaluation was to verify the results and possibly underlying theses.

The study addresses three different target groups. The first step was to analyze organizations which already use EAI and hence are experienced in planning, implementing and/or operating the technical integration infrastructure. This group is called EAI User.

The two other groups are the EAI Vendors and the EAI Consultants. These groups are usually directly participating in EAI projects of EAI Users. Hence being a service provider they have relevant experiences in the context of the study described above. After finishing the questioning of the EAI Users the other two groups had been evaluated.

In total 104 EAI User, 109 EAI Consultants and 84 EAI Vendors has been chosen to be contacted and questioned. There was a feedback of 30,8% within the EAI Users, 21,4% within the EAI Vendors and 8,3% within the EAI Consultants. The evaluation has been done two month after the first round was finished and first results were analyzed. The workshop and the expert interviews started with an explanation of the first round results. Results and possible underlying theses have been discussed for at least two hours at each event and have been extensively recorded.

The extracted conclusions have been analyzed in an explorative and qualitative manner to be condensed in the following results.

5 Results of the Study – The Impact of EAI

First the understanding of EAI is described to show EAI implementation and operation and its interdependencies with the operational and organizational structure afterwards.

The Understanding of EAI in the Market

EAI is generally understood as an established technology predominantly used in large organizations to replace individually coded point to point interfaces and/or conventional middleware concepts. It is considered to be a strategic long-term element of IT Architecture providing a modular toolset basically including software adapters (connectors), data transformation tools (mapping), monitoring and workflow features and business process management functionality.

EAI's importance as a significant part of the IT Architecture can be shown particularly by the following two results. About two third of all IS are going to be connected via EAI and more than half of them are already connected today (Fig. 3).

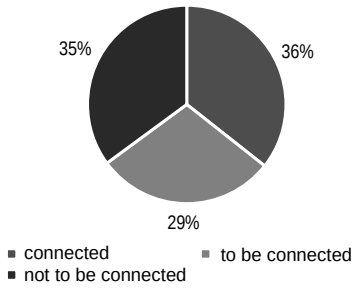

Fig.3: IS connected or to be connected via EAI

Most of the EAI projects started in 2000–2002 there is an up and down but no clear development (Fig. 4).

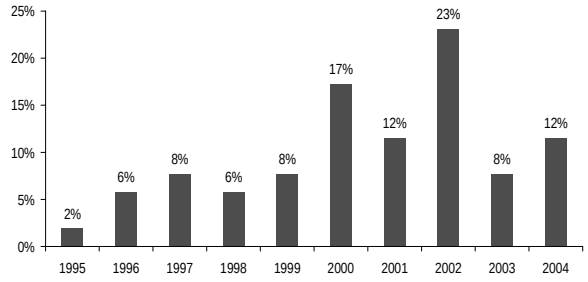

Fig. 4: Start of EAI projects

The gradient of EAI starting projects over the years 1998–2004 affirms statements about the similar development of EAI and E-Business (e.g. [4]). Particularly technology driven approaches are pushed by an initial euphoria followed by a disillusioning crisis and after all picking up a steady growth [30].

Implementation and Operation of EAI

The initial implementation of EAI is always project oriented and usually supported by external consultants. Due to the need of extensive technological and methodological EAI knowledge external support is the only solution for managing the challenges of an EAI project.

To operate implemented EAI entities even huge organizations employ only a few technically well educated persons (less than 10). Compared to the immense effort accepted during the implementation phase it is surprising that just a few people are carrying the valuable knowledge according to a very expensive infrastructural investment.

This circumstance speaks for itself hence many organizations do not pay as much attention as necessary to an integrated understanding of the EA. Even if the EAI responsibility is located in an existing Enterprise Architecture Department usually there are too few people to manage the challenge.

Unfortunately the common understanding of EAI is technology driven hence the IT department operates EAI. They have enough manpower but not the organizational understanding of business processes nor the authority to influence organizational issues. Therefore the IT Department is usually not the right instance to be responsible for EA issues in the manner of a holistic conception.

63% of the questioned companies (EAI User) operate EAI centralized in their IT department. 22% have given EAI responsibility to the business departments which use the integrated IS or own the according business processes integrated with EAI. Only 9% define EAI as a central staff function and further 6% as a central function in the meaning of line management (Fig. 5).

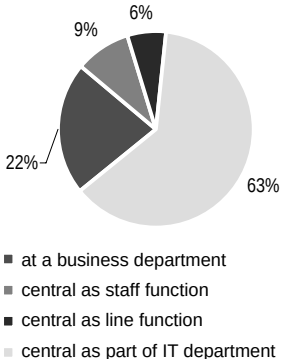

Fig. 5: Organizational implementation of EAI

About a third of the companies evaluated widen responsibility for the EAI infrastructure with non-technical tasks of the Enterprise Architecture as modeling and business process reengineering (Fig. 6).

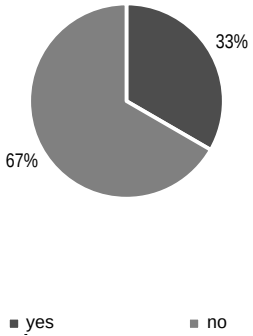

Fig. 6: Is the EAI department responsible for further architecture?

The majority of the EAI entities are part of the IT department thus usually IT architects with a very tech-

nology driven understanding are responsible. Enterprise Architects – in case the job profile exists – do not influence or even take responsibility for EAI issues. This statement is not surprising due to the fact that EAI as a new technology had been of interest particularly to IT experts a few years ago [4, 5].

But very soon after the introduction of EAI as a technology many scientists and strategic consultants pointed out the importance of a holistic and integrated approach considering business process orientation and management issues as monitoring or life cycle aspects. This challenge has not been taken so far even if the advantages are obvious and widely communicated. Details are described in the following chapter.

Business Process Integration

The objective to design and run EAI conceptions in a business process oriented fashion has rarely been reached in practice yet. Implementations done in a process oriented way usually mean technical processes as e.g. message queuing not business processes (Fig. 7).

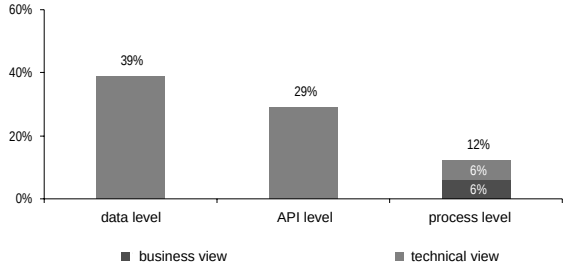

Fig. 7: EAI integration level (EAI Users only)

Nevertheless EAI implementations cause changes in business processes. 20% of the EAI Users affirm that they have changed business processes to be able to use EAI features. 76% described reasons for business process adaptations being primarily business driven and not caused by changes of the IT infrastructure (EAI). 15% have not changed business processes due to EAI projects at all (Fig. 8).

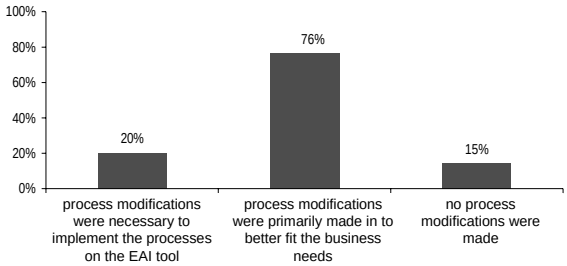

Fig. 8: EAI impact on business process adaptations

The study proves that there are business process adaptations due to EAI projects which supports the theory of an organizational imperative described above (Fig. 8).

EAI Users describe a higher level of process automation and an improvement of process quality with 79% as the main issue in EAI impact on business process adaptations. 71% reached shorter processing times due to EAI implementations.

To categorize process adaptations the organizational structure dimensions by KIESER/WALGENBACH can be used. They describe specialization, coordination, configuration, delegation of decisions and formalization [31]. Specialization means a wider responsibility assignment to the company's employees in the meaning of division of work, coordination describes the regulation of the work division interrelations, configuration subsumes all general rules of the managerial system, delegation of decisions means the allocation of competence in the organization and formalization defines the manner of communication through documents.

Using these dimensions the majority of business process adaptations caused by EAI are in the dimensions division of work and formalization. Changes in the dimension delegation of decisions are relatively rare.

Considering changes in division of work tasks the EAI Users mainly answer that the fulfillment of some specific tasks has become possible due to EAI the first time. Picking up the discussion about interdependencies between IT and Organization again many authors emphasize that the state of IT is a contingency factor with impact on the organizational architecture hence the business processes. Usually this is called the enabling factor of IT which means that IT provides features which enable process innovation or other strategies and adaptations in Enterprise Architectures. Even though this aspect has been always contrary discussed it is undeniably relevant [31].

Therefore the result described above confirms the `IT being an enabler` perspective. According to the authors experiences this perspective should differentiate between direct and indirect enabling as described in [32]. IT with direct impact would enable organizational issues in a more adjusted manner. In the study's context there is an indirect enabling impact only.

Organizational Structure and EAI

There is almost no impact of EAI on the organizational structure. The only structural adaptations are a

stronger formalization and a documentation of organizational structures (Fig. 9).

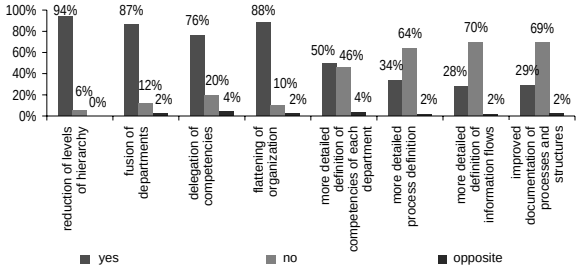

Fig. 9: Changes in Organizational Structure due to EAI

PUGH ET AL. differentiate the structural dimension formalization into three sub-dimensions. Formalization is defined as written fixation of organizational rules using figures, process manuals and guidelines. Furthermore formalization could be a documentation of traceable information flows and finally the measurement and evaluation of work performance. [33].

The study results show that written fixation is dominant compared to the other dimensions. This dimension is used to support the necessary business process and contextual understanding to model the EAI implementations. Due to the wider character of EAI projects integrating a large number of IS the modeling will be more comprehensive as in conventional IS projects (e.g. ERP implementations).

6 Conclusions – How to Handle It

EAI as a central integration technology meets the technological requirements of integration. But EAI fails with the actual new challenge to integrate heterogeneous IS on the business process level. Thus EAI is not the ultimate mediator between IT and Organization in our understanding of an integrated Enterprise Architecture yet. Standing for its own this result is not much of a problem. But taken EAI's impact on Enterprise Architecture into account it has two consequences:

1) EAI has a significant impact on Enterprise Architecture. The ignorance of this impact by implementing EAI as an exclusively technical issue makes the impact uncontrollable and thus maybe dysfunctional.

2) By limiting EAI to technology a valuable opportunity to align business needs and technology's possibilities is missed.

The mainly technology driven understanding of EAI is not due to deficits of the approach itself but the poor manner organizations use EAI. The majority designs and operates EAI as an exclusively technical infrastructure. Hence IT departments are responsible for the issue. We suggest the following points to solve the problems described above:

1) *Introduction of an integrative architectural management approach:* An Architecture Management is a communication broker between IT and other departments improving an integrated understanding of business and technology issues. The role of an enterprise architect is neither in the IT nor any other department implemented yet. An Architecture Management needs to be provided with power, resources and direct assignment by the top management to assure the enforcement of architectural guidelines all over the organization. Only an institutional instance is able to implement an integrated Enterprise Architecture to reconcile business and technology driven issues.

2) *Clear definition of objectives:* Starting an EAI initiative needs a prior definition of objectives to be fulfilled. Integration methods and tools are absolutely different for data oriented integration or business process oriented integration. There is no soft merging later on. Defining clear project objectives is the only way of measuring project success. One of the most important criteria is the integration level.

3) *Life Cycle based Implementation Methodology:* EAI projects are different from most other initiatives. Complexity, costs, duration, long term architectural impact and a large number of heterogeneous participants involved are very demanding conditions [34]. Different life cycle phases of elements (IS, partial processes, people, structures etc.) are even more demanding because time line effects are not particularly considered in project methodologies but definitely have to be modeled.

4) *Integrative Enterprise Architecture Model:* Complexity caused by multiple architectural levels as IS, technical and business processes, people, diverse aspects of operational and organizational structures etc. is not manageable by written descriptions or even without a structured documentation method. Modeling notations, methods and tools to document the diverse Enterprise Architecture elements and their interdependencies in an integrated way are basic requirements to handle this complexity.

5) *Accept the fact: The only constant is change:* There is no final EAI system or architecture at the end of a project. The objective is to shape a sustainable Enterprise Architecture with the right EAI components to enable the organization managing steady change which means particularly to modularize the IT Architecture to avoid IS being a barrier for organizational change. It is much more a value guiding change than a specific architectural structure [35].

The suggestions made above do not guaranty an integrative Enterprise Architecture but give some further aspects to improve the situation which has been described as a result of the empirical study focused in this paper. There are already some successful approaches in practice but definitely no common understanding or even solutions [1].

References

[1] C. Hagen, "Integrationsarchitektur der Credit Suisse," in *Enterprise Application Integration – Management komplexer Architekturen*, vol. 1, *Enterprise Architecture*, S. Aier and M. Schönherr, Eds. Berlin: Gito, 2003, pp. 61–83.

[2] S. Aier and M. Schönherr, "Flexibilisierung von Organisations- und IT-Architekturen durch EAI," in *Enterprise Application Integration – Management komplexer Architekturen*, vol. 1, *Enterprise Architecture*, S. Aier and M. Schönherr, Eds. Berlin: Gito, 2003, pp. 3–56.

[3] M. Kaib, *Enterprise Application Integration: Grundlagen, Integrationsprodukte, Anwendungsbeispiele*. Wiesbaden: DUV, 2002.

[4] W. Keller, *Enterprise Application Integration – Erfahrungen aus der Praxis*. Heidelberg: Dpunkt, 2002.

[5] D. S. Linthicum, *Enterprise Application Integration*. Amsterdam: Addison-Wesley Longman, 2000.

[6] K. Ring, *EAI: Making the right Connections*. Boston, 2000.

[7] F. Wall, *Organisation und betriebliche Informationssysteme – Elemente einer Konstruktionslehre*. Wiesbaden: Gabler, 1996.

[8] E. Horn and T. Reinke, *Softwarearchitektur und Softwarebauelemente: Eine Einführung für Softwarearchitekten*. München, Wien: Hanser, 2002.

[9] L. Bass, P. Clements, and R. Kazman, *Software Architecture in Practice*, 2 ed. Boston: Pearson Education Inc., 2003.

[10] S. Pohland, *Globale Unternehmensarchitekturen – Methode zur Verteilung von Informationssystemen*. Berlin: Weißensee-Verlag, 2000.

[11] H. Krcmar, "Bedeutung und Ziele von Informationssystem-Architekturen," *Wirtschaftsinformatik*, vol. 32, pp. 395–402, 1990.

[12] J. Schmalzl, *Architekturmodelle zur Planung der Informationsverarbeitung von Kreditinstituten*, vol. 13. Heidelberg: Physica, 1995.

[13] N. Gronau, *Wandlungsfähige Informationssystemarchitekturen – Nachhaltigkeit bei organisatorischem Wandel*. Berlin: Gito, 2003.

[14] S. Aier and T. Dogan, "Indikatoren zur Bewertung der Nachhaltigkeit von Unternehmensarchitekturen," in *Wirtschaftsinformatik 2005: eEconomy, eGovernment, eSociety*, O. K. Ferstl and E. J. Sinz, Eds. Heidelberg: Physica, 2005, pp. 607–626.

[15] P. M. Blau and R. A. Schoenherr, *The structure of organizations*. New York et al.: Basic Books, 1971.

[16] T. H. Davenport and J. E. Short, "The new Industrial Engineering – InformationTechnology and Business Process Redesign," *Sloan Management Review*, vol. 31, pp. 11–27, 1990.

[17] D. A. Nadler, M. S. Gerstein, and R. B. Shaw, *Organizational architecture – designs for changing organizations*, San Francisco: Jossey-Bass, 1992.

[18] J. A. Zachman, "A Framework for Information Systems Architecture," *IBM Systems Journal*, vol. 26, pp. 276–292, 1987.

[19] A. Y. Lewin and S. D. Hunter, "Information Technology & Organizational Design: A Longitudinal Study of Information Technology Implementations in the U.S. Retailing Industrie, 1980–1996," in *Organisation im Wandel der Märkte*, H. Glaser, E. F. Schröder, and A. v. Werder, Eds. Wiesbaden: Gabler, 1998, pp. 251–286.

[20] A. G. Scherer, "Kritik der Organisation oder Organisation der Kritik? – Wissenschaftstheoretische Bemerkungen zum kritischen Umgang mit Organisati-

onstheorien," in *Organisationstheorien*, A. Kieser, Ed., 5 ed. Stuttgart: Kohlhammer, 2002, pp. 1–37.

[21] M. L. Markus and D. Robey, "Information Technology and Organizational Change: Causal Structure in Theory and Research," *Management Science*, vol. 34, pp. 583–589, 1988.

[22] A. Krahe, *Unterstützung des Prozeßmanagements mit modernen Informationstechnologien*. Wiesbaden: DUV, 1998.

[23] E. Frese, *Grundlagen der Organisation: Konzept – Prinzipien – Strukturen*, 8 ed. Wiesbaden: Gabler, 2000.

[24] N. V. Venkatraman, "IT-Induced Business Reconfiguration," in *The Corporation of the 1990s. Information Technology and Organizational Transformation*, M. S. Scott Morton, Ed. New York: Oxford University Press, 1991, pp. 122–158.

[25] J. F. Rockart and J. E. Short, "IT in the 90's: Managing Organizational Independence," *Sloan Management Review*, pp. 7–17, 1989.

[26] R. A. Teubner, *Organisations- und Informationssystemgestaltung*. Wiesbaden: DUV, 1999.

[27] H. J. Leavitt and T. L. Whisler, "Management in the 1980s: New Information Flows Cut New Organization Flows," *Harvard Business Review*, vol. 36, pp. 41–48, 1958.

[28] L. M. Applegate, J. I. Cash, and D. Q. Miles, "Information Technology and Tomorrow's Manager," *Harvard Business Review*, vol. 66, pp. 128–136, 1988.

[29] G. P. Huber, "A Theory of the Effects of Advanced Information Technologies on Organizational Design, Intelligence, and Decision Making," *The Acadamy of Management Review*, vol. 15, pp. 47–71, 1990.

[30] "Top Issues in Gartner Research," in *The Monthly Research Review*, 2001.

[31] A. Kieser and P. Walgenbach, *Organisation*, 4 ed. Stuttgart: Schäffer-Poeschel, 2003.

[32] C. Lang and H. Utikal, "Organisatorische Impulse durch Internet – Technologie und technologieinduzierte Strategien," in *E-Organisation*, E. Frese and H. Stöber, Eds. Wiesbaden: Gabler, 2002, pp. 155–189.

[33] D. S. Pugh, D. J. Hickson, C. R. Hinnings, and C. Turner, "Dimensions of organization structure," *Administrative Science Quarterly*, vol. 13, pp. 65-105, 1968.

[34] S.-C. Strüver, "Das fehlende Teil im EAI-Puzzle: Die Komponente Mensch," in *Enterprise Application Integration – Management komplexer Architekturen*, vol. 1, *Enterprise Architecture*, S. Aier and M. Schönherr, Eds. Berlin: Gito, 2003, pp. 147–173.

[35] S. Aier, "Sustainability of Enterprise Architecture and EAI," in *Information Technology and Organizations in the 21st Century: Challenges & Solutions. Proceedings of The 2004 International Business Information Management Conference*, K. S. Soliman, Ed. Amman, Jordan: International Business Information Management Association (IBIMA), 2004, pp. 182–189.