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Assessing the Complexity of Dynamics in Enterprise Architecture Planning – Lessons from Chaos Theory

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ABSTRACT

Enterprise Architecture (EA) models capture the fundamental elements of organizations and their relationships to serve documentation, analysis and planning purposes. As the elements and their relationships change over time, EA planning becomes increasingly complex. An analysis of existing methods shows that the complexity of dynamics is not sufficiently addressed. We argue that a sophisticated understanding of the complexity matter is prerequisite for EA planning method construction. As Chaos Theory (CT) is deployed in natural and social sciences—as well as in different contexts of IS research—to describe and understand the behavior of complex systems over time, we use properties of CT to assess the complexity of dynamics in EA planning and to derive requirements for EA planning methods. Our findings emphasize the importance of initial conditions of the architecture for EA planning and the need to harmonize planning granularities in order to achieve predictable results.

Keywords

Enterprise architecture planning, enterprise architecture modeling, complexity of dynamics, chaos theory

INTRODUCTION

Enterprise Architecture (EA) can provide systematic support to organizational change and transformation that affects both business and IT structures. Architecture is thereby understood as “the fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution” (IEEE, 2000). Therefore, EA provides a broad and aggregate structure of an entire corporation or government agency (Rohloff, 2008; Tyler and Cathcart, 2006). In order to support transformation in an efficient way EA has to be driven by business and IT oriented application scenarios (Winter, Bucher, Fischer and Kurpjuweit, 2007) based on stakeholders’ concerns (Niemi, 2007). As a prerequisite for organizational change, the structures of the corporation or government need to be transparent in order to plan and to support change processes and to understand the consequences of change (Veasey, 2001). Thus, the main goals of EA can be summarized as follows:

- *Documentation* of current enterprise structures including artifacts from business and IT and their interrelationships (as-is model),
- *Analysis* of dependencies and relationships in as-is models,
- *Planning* and comparing future scenarios (to-be models), as well as deriving transformation projects and programs to achieve a desired EA.

While documentation and analysis of as-is models are well covered in scientific and practitioners’ approaches (e.g. Johnson and Ekstedt, 2007; Lankhorst, 2005; Niemann, 2006), EA planning is subject to rather few activities so far. Most publications are thereby based on the implicit assumption of stability. Since neither the corporation or government agency itself nor its environment remain static over time, the consideration of dynamics in EA is an important aspect for EA planning (Aier, Gleichauf, Saat and Winter, 2009; Buckl, Ernst, Matthes and Schweda, 2008). This contribution focuses on the assessment of dynamics for planning purposes. Organizations are viewed as large systems with inherent complexity which needs to be captured in EA models in order to understand and manage the evolution of the organization.

Chaos theory (CT) originates in natural science and deploys an explanatory approach to understand seemingly non-deterministic behavior of complex systems. Chaos theory is primarily applied to complex natural phenomena, but also to organizational design and IS research to describe and understand the complexity of large systems’ behavior. Thereby, shared characteristics, such as complex relationships between elements over time and limited predictability of influencing factors in the future allow for parallels between complex natural phenomena and EA planning.

Origins of CT are to be found in mathematical physics as part of the Complex Systems Theory. The behavior of a complex system over time is assessed defining the initial state of the system and observing the development of the system. Changes to the initial system adhere to the laws of physics. In spite of the strictly deterministic evolution of a system, an observation made in all chaotic systems is that the system's long-term development is highly sensitive to the initial-state parameters. The final state of the system after a given period of time is typically completely different, even if the respective start parameters were almost—but not quite—identical to each other. In real-world systems, it is impossible to measure an initial state to infinite accuracy. This leads to practically unpredictable long-term behavior of the system, as the slightest change in the initial state yields a completely different final state. The resulting system behavior appears to an observer to be completely unpredictable, random and "chaotic". This effect occurs even if the system in fact does evolve perfectly deterministic, which historically lead to the term "deterministic chaos" (in CT commonly referred to as "chaos"). In order to assess and predict the behavior of such systems as closely as possible, CT uses mathematical models to understand possible states and future conditions of complex systems (Schuster and Just, 2006). Apart from simulations, chaotic behavior in natural sciences is readily observed in fields of atmospheric sciences, such as weather forecasts (Lorenz, 1963). As organizations and information systems (IS) are also partially governed by nonlinear relationships, they also represent dynamic systems with inherent complexity. CT applications can therefore be found in organizational design (Cheng and Van de Ven, 1996; Thietart and Forgues, 1995) and also IS research (Dhillon and Ward, 2002; McBride, 2005; Samoilenko, 2008).

Throughout this article we condense properties of CT that have been applied on organizational and IS design in published research and derive implications for EA planning. These findings provide assistance in the assessment of the complexity of dynamics to divide and conquer existing challenges and therefore support EA planning approaches. As a result of the analogy requirements for EA planning methods are presented.

The remainder of this article is structured as follows. After giving a brief overview on research paradigms employed and related work covering aspects of EA planning, we present the essence of two case studies from the financial services industry. Results from the case studies and related work indicate that the management of dynamics in EA planning is an open issue and that there is a practical need for more sophisticated planning methods to capture the complexity of planned and unplanned changes over time. In order to assess this complexity and understand the nature of interdependencies of architectural elements over time, we take advantage of CT applications in related disciplines and derive similarities among properties of CT and EA planning. Subsequently requirements for EA planning methods are presented. As the paper presents research in progress, it concludes with a critical reflection of the findings and the roadmap for future work.

REMARKS ON DESIGN AND EXPLANATION

Available EA planning approaches originate from the area of design research (Hevner, March, Park and Ram, 2004), focusing on the design of generic artifacts (Simon, 1996) to address relevant IS problems in academia and industry (March and Smith, 1995), such as planning methods, planning processes, or modeling techniques. Design research is classified to be a *problem solving paradigm* (March and Smith, 1995). At the same time, originating from natural sciences, explanatory approaches exist in the IS domain to investigate behaviorist aspects, such as research on critical success factors (e.g. Rosemann, Sedera and Gable, 2001) or matters of stakeholder's acceptance (e.g. Venkatesh and Bala, 2008). Behavioral science is therefore classified to be a *problem understanding paradigm*. Recent discussion in IS research demands for methodic pluralism (Frank, 2006) in order to combine the strengths of explanatory theories to understand the problem and ultimately derive conditions and implications for design and of the design itself (providing useful artifacts to relevant problems). The combination of design-oriented and explanatory methods is described in reference processes for IS research as proposed by several authors (e.g. Peffers, Tuunanen, Rothenberger and Chatterjee, 2007).

Within this article we use CT as explanatory theory to investigate and understand the problems arising from complexity of dynamics in EA planning. The results may serve as foundation for the design of artifacts, such as EA planning methods to manage the complexity of dynamics.

EXAMPLES FOR CURRENT CHALLENGES IN EA PLANNING FROM THE FINANCIAL SERVICES INDUSTRY

In order to illustrate the need to capture the complexity of dynamics in EA planning, current challenges from the Swiss financial services industry are briefly presented.

The first company provides IT outsourcing services and banking solutions. Current EA planning efforts focus on the management of application development within the main product which is a core banking platform. Major challenges within the architectural development plan are the coordination of the activities of the development teams (projects and programs) and assurance that milestones of the various integration and development activities are met simultaneously (management of interrelationships over time). If, for example, a component of an application needs an interface to a component of another application at a certain time for a certain milestone (e.g. test or release), it has to be assured that both components are available at that very time. Therefore, the architectural development plan needs to capture information on the relationships between the architectural elements over time and on the impacts of local changes on elements within other architectural domains or layers.

The second company, an internationally operating bank based in Switzerland, has a similar architectural focus but faces different challenges. More than 90 architects use means of EA management to enforce architecture governance within individual IS projects and manage the interdependencies of these projects on different levels of granularity. However, while the structures in the bank's home country are consistently managed within the EA, documentation and planning challenges arise from heterogeneous and local solutions in almost every other operating country. An ongoing EA project focuses on an integrated view on the different solutions the IT departments offer to the company's business units worldwide. Such a comprehensive view requires consolidated information about different projects affecting application development, e.g. release planning, component development and customer request management for customized applications.

As space limitations inhibit an extensive discussion of these case studies, the examples show a fraction of the multitude of dynamic aspects that need to be considered in EA planning and evolution. For example, the first company has identified the need to combine to-be modeling with lifecycles on one hand and the coordination of development activities on the other hand. Similarly, the second company is aiming at an alignment of application roadmap planning and multi project planning. Additionally, complex temporal as well as technical interdependencies between the planning of EA elements, of partial architectures and of projects need to be addressed.

The challenges of complexity of dynamics identified in the presented industry cases can be summarized as follows:

C1. Volatility of architectural layers, architectural elements and their interrelationships (frequencies of change and lifecycles),

C2. harmonization of projects and programs, and

C3. prediction and management of impacts of changes on different granularity levels.

RELATED WORK

Related work on EA planning provides approaches that follow two basically distinct ideas of the term "EA planning": Spewak first introduced the term EA planning and defines it as "the process of defining architectures for the use of information in support of the business and the plan for implementing those architectures" (Spewak and Hill, 1993). Plan—in this context—is referred to as the definition of the blueprint for data, application, and technology of a corporation or government agency as well as the process of implementing the blueprint (Spewak and Tiemann, 2006). A similar approach, a process for stepwise planning and development of EA, is presented by Pulkkinen (2006). However, this approach applies to discrete EA construction projects only. Both examples do not explicitly consider external influences on the planning process, changing conditions in the enterprise's environment or existing legacy architectures that need to be integrated. Furthermore, they focus on a unidirectional EA planning process that aims at constructing an EA from scratch or at improving the current architecture by a discrete development project.

On the other hand, some authors interpret the term EA planning in the meaning of a continuous evolution of the architecture. "Managed evolution" aims at balancing the ratio between the benefits for business and the IT development efficiency while continuously advancing the EA (Murer, Worms and Furrer, 2008). This approach addresses the challenges that are faced by complex architectures in terms of high volatility and large proportions of legacy systems. Therefore, projects with short time horizons are planned in order to carefully meet changes resulting from the environment or new business demands. The work of Buckl, Ernst, Matthes and Schweda (2008) focuses on models for the management of application landscapes with emphasis on temporality aspects. The authors identify the need to capture the time a landscape is planned for as well as the point in time the landscape model has been created. Thus, it is possible to capture and trace effects on the planned status of landscape models during the EA planning process, i.e. to respond to continuous changes and adjust the EA planning process.

The following shortcomings can be summarized:

S1. Existing work on EA planning lacks a *comprehensive consideration of dynamic aspects* such as interdependencies, volatilities and impacts of changes (derived in challenges C1-C3 in previous section).

S2. As there is some research on aspects of temporality, it focuses application landscapes only, which does not satisfy the premise of a *holistic scope* of EA considering structures from both business and IT.

Following methodic pluralism, a sophisticated understanding of the field of EA planning and the inherent complexity of dynamics is needed as a foundation for the construction of useful EA planning methods. In order to improve this understanding, the next section investigates how properties form CT can be deployed to address the indentified shortcomings.

STRUCTURING AND UNDERSTANDING THE COMPLEXITY OF DYNAMICS FOR EA PLANNING USING PROPERTIES OF CT

Based on the findings from case studies and related work, planning methods are missing to sufficiently address the challenges of complexity of dynamics so far. Using the findings from application of CT to organizational design and IS research (Cheng and Van de Ven, 1996; Dhillon and Ward, 2002; McBride, 2005; Samoilenko, 2008; Thietart and Forgues, 1995), five properties of CT were condensed that provide potential benefits for EA planning:

(1) sensitivity to initial conditions,

(2) discreteness of change,

(3) attraction to specific configurations,

(4) structural invariance at different scales, and

(5) irreversibility and bifurcation.

The following sub-sections derive implications for EA planning. In order to deploy these theoretical considerations for EA planning, a high degree of abstraction is necessary. Examples and links to the case studies are given to illustrate how the properties can be used to describe situations in EA planning, while some properties describe underlying inherent means of complexity.

(1) Sensitivity to Initial Conditions

Meaning in CT: Future development of a complex system is highly dependent on its initial conditions. Slight changes in the initial parameters lead to entirely different outcome scenarios. With increasing complexity of the system, i.e. increase in the number of initial parameters, the time period before chaotic behavior becomes apparent tends to become shorter (Samoilenko, 2008).

Implications for EA planning: The as-is architecture at a certain time is the foundation for EA planning. A desired future state of the as-is architecture is modeled as to-be architecture. External, non-modeled or non-modelable forces, such as changing market situations or changing regulatory requirements of the organization might cause unplanned and unplannable shifts in the transformation and the desired to-be models. These aspects are beyond the scope of EA models. Therefore they cannot be explicitly included in EA planning, but cause the necessity to design adjustable transformation plans and flexible to-be models (Figure 1).

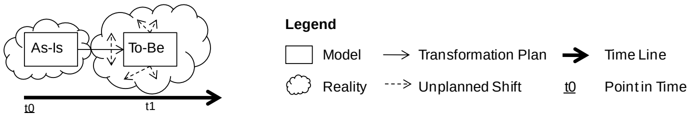

Figure 1. Sensitivity to Initial Conditions in EA planning (I)

Depending on the complexity of relationships in EA models (e.g. the degree of coupling; the way an application supports a business process, carried out by a specific organizational unit in order to provide a product) and of architectural elements (e.g. application, process, product), potential changes to an element may cause foreseen und unforeseen changes to other elements and also to transformation plans (Figure 2).

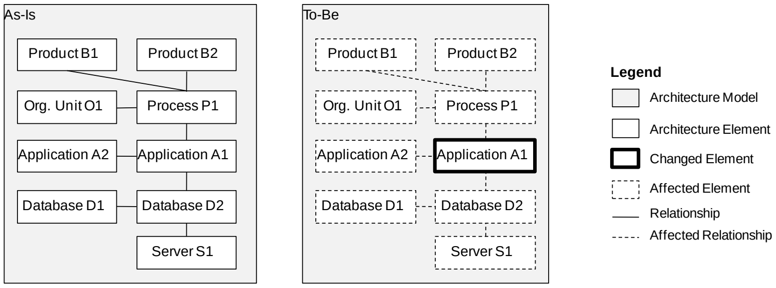

Figure 2. Sensitivity to Initial Conditions in EA planning (II)

Different change volatilities and lifecycles of elements may further decrease the predictability of to-be models and therefore add complexity to EA planning (cf. C1). The change to an element might have impact on other architectural elements, which might also be subject to change. Same applies for the interconnections among projects (cf. C2). Furthermore, the affected architectural elements might phase out in the mean time and new ones that are also potentially affected might be added. Conflicting plans might arise if e.g. different stakeholders plan to-be architectures with effects on the same elements. For example, the application architect in t0 plans an upgrade to a higher release of application A1 for t1 that provides new functionality allowing for more process efficiency of P1. At the same time the product manager plans a change for B2 in t1 that relies on the functionality of A1 and the t0 version of P1 (cf. C2). Such conflicts need to be detected by the EA management and considered by EA planning methodologies. In order to identify dependencies, potentially affected architectural parts must lie within the modeling scope of EA (cf. S2).

(2) Discreteness of Change

Meaning in CT: The process from a stable and orderly state to a potentially chaotic state follows a discrete process of change (Thietart and Forgues, 1995).

Implications for EA planning: While some parts of the EA are explicitly planable and designable, there are non-modelable and unpredictable forces influencing the EA transformation (cf. C3). This might also be caused by projects in different organizational units that are beyond the scope of the models used (e.g. project X needs a deliverable from project Y which for some reason cannot be provided; cf. C1). As transformation needs close monitoring and to-be models need adjustment this aspect also contributes to the complexity of EA planning. During the transformation from as-is to to-be, say in t0.5, changes might occur which cause unplanned shifts and adjustments in the transformation plan and the to-be architecture, which we then call the will-be model (Figure 3).

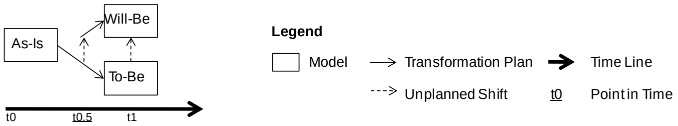

Figure 3. Discreteness of Change in EA Planning (I)

The will-be model created in t0.5 for t1 (again depending on the time and uncertainties between t0.5 and t1), however, might differ from the actual as-is model in t1. The actual model in t1 then serves as foundation for future planning for t2 (Figure 4).

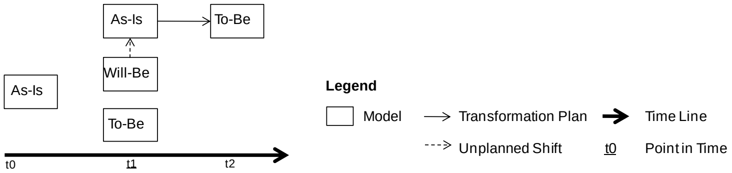

Figure 4. Discreteness of Change in EA Planning (II)

(3) Trajectories and Attractors

Meaning in CT: Small changes to a potentially chaotic system can cause large consequences that are not predictable in the long term. Applied to astronomy, this means calculations cannot exactly predict the long-term path an object will take moving through space. This path is called trajectory. So-called attractors are stable configurations to which a dynamical system finally evolves. These attractors might be periodic attractors (recurring stable states), or strange attractors (erratic behavior leads to stable states) (Dhillon and Ward, 2002; Thietart and Forgues, 1995).

Implications for EA planning: With increasing temporal planning scope, the predictability for the suitability of to-be models decreases. Multi-periodic planning therefore becomes especially challenging (cf. C3). We assume that multiple alternative versions of to-be models for a given future time are developed in EA planning (e.g. representing different stakeholders' priorities). Furthermore, methods to evaluate these alternatives are deployed to support the selection which to-be model is most desirable for a certain point in time. Therefore it is not entirely predictable which trajectory (here: combination of transformation plans and favored to-be models) the organization will chose (Figure 5).

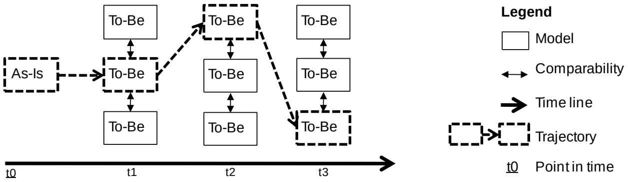

Figure 5. Trajectories and Attractors in EA Planning

Planned to-be models for the different points in time (e.g. t1, t2, t3) represent *periodic attractors* (orderly and stable states) if the transformation is executed as planned. Following the implications from discreteness of change, stable states may occur unplanned and non-periodic (so called *strange attractors*) as depicted as will-be model.

(4) Structural Invariance at Different Scales

Meaning in CT: Different characteristic patterns of structure and change can be found at different scales (Thietart and Forgues, 1995).

Implications for EA planning: There are different planning levels with recurring structures and methods, e.g. when planning the entire EA, an architectural layer or parts of it (e.g. application landscape), or a single architectural element (e.g. application) or parts of it (e.g. components) (Figure 6). Same applies if planning tasks are decentralized as described in the second case study above (cf. C3).

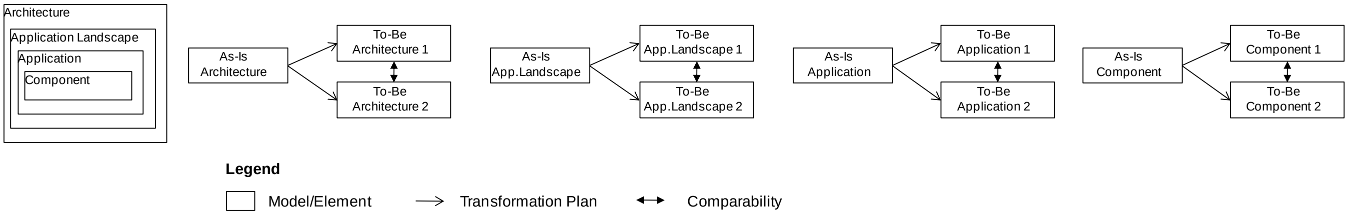

Figure 6. Structural Invariance at Different Scales in EA Planning

(5) Irreversibility and Bifurcation

Meaning in CT: Changes to complex, potentially chaotic systems may lead to a state where these changes cannot be undone. This state is called bifurcation. Moreover, these changes cannot be repeated leading to identical results. Measuring the state of a system at a given point of time does not allow to deduce the state of an earlier time, including the initial conditions (McBride, 2005; Thietart and Forgues, 1995).

Implications for EA planning: EA transformation projects are irreversible and unrepeatable at different points in time (or in different organizations). Certainly there exist best practices and generic methods giving advice on experiences, yet detailed recapitulation is impossible, due to differences in internal and external conditions at different points in time and across different organizations. This characteristic underlines the proposal of an evolutionary approach because EA planning is not conducted in a completely deterministic environment and usually does not start in green field scenarios.

REQUIREMENTS FOR EA PLANNING METHODS

Based on the findings discussed above, the following requirements for EA planning methods can be derived:

R1. *The current state is foundation of planning.* The more is known about the as-is architecture, the more reliable transformation plans and to-be architectures can be developed. Planning methods therefore must be tightly coupled with documentation and analysis capabilities.

R2. *Planning relevance.* There are modelable and non-modelable aspects that might cause unexpected change. The challenge is to identify all modelable elements and relationships that are relevant for planning. Hereby the tradeoff between increased predictability on one hand and the task not to jeopardize the value of EA by exploding costs for modeling and model maintenance on the other hand arises. In order to address the latter challenge, the models should be as lean as possible. Planning relevance of elements and relationships can be assessed by their potential sensitivity to the planned change and their probability to change within the temporal planning scope.

R3. *Separation of points in time.* To-be models are developed at a given time (e.g. t0) for a given time (e.g. t1). As reality continuously evolves during transformation, plans are subject to adjustment during execution. Planning methods must support versioning of to-be models as well as adjustment mechanisms to control and re-plan transformations.

R4. *Affected architecture.* Changes to elements potentially cause snowball effects of changes to other elements which amplifies the impact of the initial change. Planning methods must support impact analysis of to-be models.

R5. *Volatility and life cycles.* Some architectural layers and elements of the EA change more often and faster than others. Therefore each element and each relationship between elements has its own life cycle. Planning methods must support dependency analysis of to-be models.

R6. *Different levels of planning.* EA planning can be conducted on different levels of granularity. Therefore, there might also exist development trajectories for different granularities (e.g. entire EA, software and data architecture, application landscape, application, component). As potential planning conflicts arise (e.g. from different priorities of different stakeholders and/or different granularity levels of planning) EA planning aims at consistent to-be models on all levels of granularity and across architectural layers. Planning methods must support consolidation of distributed plans including assurance of consistency.

DISCUSSION AND CONCLUSION

The article discusses analogies between CT and EA planning and contributes to a better understanding of the complexity of dynamics in EA planning by deriving requirements for EA planning methods. It shows that findings from CT as explanatory research can provide lessons for further structuring the field of EA planning. Our contribution is explanatory for the time being, and not construction oriented because no solutions to the addressed problems are implemented. Yet the findings enhance the existing knowledge base in the field of EA planning and may provide guidance for method construction.

Experiences from industry projects confirm that EA models need to remain on an aggregated level instead of modeling very detailed structures. It is vital to adhere to this constraint in order to preserve an acceptable cost/benefit ratio of EA. Therefore our research does not aim at applying mathematical models from CT to EA as opposed to natural sciences. However, we hypothesize that the phenomena and characteristics described by CT support the construction of useful methods for EA planning.

Consequently, our agenda for future research reads as follows: The lessons from CT are used to structure and formalize the resulting requirements for an integrated method. As there is no integrated method capturing all relevant aspects available, there are solution components to be found in the EA research community that will be evaluated against the requirements. Suitable existing components and novel engineered fragments can then be combined and integrated to provide more sophisticated guidance to address the dynamics of complexity in EA planning. A current research project thereby investigates means of simulation to assess the behavioral complexity of EA over time. Further planned activities focus on industry specific stability and volatility of architectural parts to assess insights on planning relevance and change frequencies. Resulting EA planning methods will then be tested in industry cases.

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REFERENCES

1. Aier, S., Gleichauf, B., Saat, J. and Winter, R. (2009) "Complexity Levels of Representing Dynamics in EA Planning," Proceedings of the 5th International Workshop on Cooperation & Interoperability – Architecture & Ontology (CIAO! 2009) in conjunction with the CAiSE'09 conference, Amsterdam.
2. Buckl, S., Ernst, A., Matthes, F. and Schweda, C.M. (2008) "An Information Model for Landscape Management - Discussing Temporality Aspects," Proceedings of the 3rd Workshop on Trends in Enterprise Architecture Research (TEAR 2008), Sydney.
3. Cheng, Y.-T. and Van de Ven, A.H. (1996) "Learning the Innovation Journey: Order out of Chaos?," Organization Science, 7, 6, 593-614.

4. Dhillon, G. and Ward, J. (2002) "Chaos Theory as a framework for information systems research," Information Resources Management Journal, 15, 2, 320-337.
5. Frank, U. (2006) "Towards a Pluralistic Conception of Research Methods in Information Systems Research," ICB-Research Report No. 7, Institut für Informatik und Wirtschaftsinformatik (ICB), Universität Duisburg-Essen,
6. Hevner, A.R., March, S.T., Park, J. and Ram, S. (2004) "Design Science in Information Systems Research," MIS Quarterly, 28, 1, 75-105.
7. IEEE (2000) "IEEE Recommended Practice for Architectural Description of Software Intensive Systems (IEEE Std. 1471-2000)," IEEE Computer Society,
8. Johnson, P. and Ekstedt, M. (2007) Enterprise Architecture - Models and Analyses for Information Systems Decision Making, Studentlitteratur, Pozkal.
9. Lankhorst, M. (2005) Enterprise Architecture at Work: Modelling, Communication and Analysis, Springer, Berlin et al.
10. Lorenz, E.N. (1963) "Deterministic Nonperiodic Flow," Journal of the Atmospheric Sciences, 20, 2, 130-141.
11. March, S.T. and Smith, G.F. (1995) "Design and Natural Science Research on Information Technology," Decision Support Systems, 15, 4, 251-266.
12. McBride, N. (2005) "Chaos theory as a model for interpreting information systems in organizations," Information Systems Journal, 15, 3, 233-254.
13. Murer, S., Worms, C. and Furrer, F. (2008) "Managed Evolution - Nachhaltige Weiterentwicklung grosser Systeme," Informatik-Spektrum, 31, 6, 537-547.
14. Niemann, K.D. (2006) From Enterprise Architecture to IT Governance. Elements of Effective IT Management, Vieweg, Wiesbaden.
15. Niemi, E. (2007) "Enterprise Architecture Stakeholders - A holistic view," Proceedings of the 13th Americas Conference on Information Systems (AMCIS 2007), Keystone, CO.
16. Peffers, K., Tuunanen, T., Rothenberger, M.A. and Chatterjee, S. (2007) "A Design Science Research Methodology for Information Systems Research," Journal of Management Information Systems, 24, 3, 45-77.
17. Pulkkinen, M. (2006) "Systemic Management of Architectural Decisions in Enterprise Architecture Planning. Four Dimensions and Three Abstraction Levels," Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS 2006), Honolulu, Hawaii, 179a (1-9).
18. Rohloff, M. (2008) "Framework and Reference for Architecture Design," Proceedings of the 14th Americas Conference on Information Systems (AMCIS 2008), Toronto.
19. Rosemann, M., Sedera, W. and Gable, G. (2001) "Critical Success Factors of Process Modeling for Enterprise Systems," Proceedings of the 7th Americas Conference on Information Systems (AMCIS 2001), Boston, MA.
20. Samoilenko, S. (2008) "Information systems fitness and risk in IS development: Insights and implications from chaos and complex systems theories," Information Systems Frontiers, 10, 3, 281-292.
21. Schuster, H.G. and Just, W. (2006) Deterministic Chaos: An Introduction, Wiley-VCH, Weinheim.
22. Simon, H.A. (1996) The Sciences of the Artificial, MIT Press, Cambridge, MA.
23. Spewak, S.H. and Hill, S.C. (1993) Enterprise Architecture Planning - Developing a Blueprint for Data, Applications and Technology, John Wiley & Sons, New York.
24. Spewak, S.H. and Tiemann, M. (2006) "Updating the Enterprise Architecture Planning Model," Journal of Enterprise Architecture, 2, 2, 11-19.
25. Thietart, R.A. and Forgues, B. (1995) "Chaos Theory and Organization," Organization Science, 6, 1, 19-31.
26. Tyler, D.F. and Cathcart, T.P. (2006) "A structured Method for Developing Agile Enterprise Architectures," Proceedings of the International Conference on Agile Manufacturing (ICAM 2006), Norfolk, Virginia, USA, 1-8.
27. Veasey, P.W. (2001) "Use of enterprise architectures in managing strategic change," Business Process Management Journal, 7, 5, 420-436.
28. Venkatesh, V. and Bala, H. (2008) "Technology Acceptance Model 3 and a Research Agenda on Interventions," Decision Sciences, 39, 2, 273-315.
29. Winter, R., Bucher, T., Fischer, R. and Kurpjuweit, S. (2007) "Analysis and Application Scenarios of Enterprise Architecture - An Exploratory Study," Journal of Enterprise Architecture, 3, 3, 33-43.