Theories to Understand the Dynamic Nature of Enterprise Architecture

Raphael David Schilling
Institute of Information Management
University of St. Gallen
St. Gallen, Switzerland
raphael.schilling@unisg.ch

Understanding and dealing with the dynamic nature of Enterprise Architecture (EA) is a key challenge in successfully guiding its long-term evolution. While a considerable number of publications offer prescriptive knowledge on the design of Enterprise Architecture Management (EAM), explanations and descriptions of the dynamic nature of EA are rare. This is surprising, as an improved understanding on the dynamic nature of EA could enhance the tools and guidelines used in EAM. This paper aims at systematically identifying, discussing and comparing theories that have been applied to better to understand, explain and deal with the dynamic nature of EA. Based on a literature review, five distinct theories are identified and analyzed through a framework covering the main aspects of dynamics in EA. The resulting overview may support academics in identifying suitable theoretical lenses and motivates for a multi-theoretical perspective on the dynamic nature of EA.

Enterprise Architecture; Dynamics; Theory; Review

I. INTRODUCTION

Fast changing environmental conditions such as technology innovations, newly arising business models, or regulatory enforcements make the continuous change in existing, and the development of new Information Systems (IS) inevitable for most contemporary organizations. In consequence, the *Enterprise Architecture (EA)*, i.e., the actual and envisioned component structure of the organization's IS and their interrelations as well as principles that guide the IS development [1], is exposed to constantly changing strategic orientations and values [2]. EA is *dynamic*, i.e., in a constant process of creating, extending, or modifying its resources, structures and values [3]. In *Enterprise Architecture Management (EAM)*, i.e., the attempt to systematically plan and steer the evolution of EA [4-6], this circumstance should be actively considered. In fact, it has been argued that the long-term evolution of EA can most likely not be determined upfront, and that the goals and implementation of EAM have to be adapted over time [2, 7]. To do so, the dynamic nature of EA needs to be well understood. But what exactly is known about the dynamic nature of EA?

In research, *theory*, i.e., statements targeted at describing, explaining, and predicting real world phenomena, is the most common form to accumulate knowledge in a systematic manner [8, 9]. The careful analysis of theory will thus reveal what is known about a phenomenon of interest. Compared to the design and development of architectural tools and guidelines, the use of theory for explanatory purposes is not as common in the field of EA research [10, 11]. However, a profound, theory based understanding on the dynamic nature of EA (i.e., descriptive knowledge) would allow to design, select and change appropriate tools and guidelines to guide the evolution of EA over time (i.e., prescriptive knowledge) [12].

A smaller group of EA researchers has applied a multitude of theories to understand the dynamic nature of EA [2, 13-26]. These researchers provide well elaborated arguments why a given theory has been considered to be suitable but do not compare them with each other nor use them in combination. Arguably, a comprehensive overview on theories that have been applied to understand the dynamic nature of EA is lacking.

The paper at hand aims at addressing this shortcoming by spotlighting and comparing theories which have been used to explain the dynamic nature of EA. This supports knowledge transfer between researchers and may motivate for more descriptive research based on multiple theories. A multi-theoretical perspective may generate new insights for both, practice and research. Consequently, the following research question is addressed: Which theories have been used in EA literature to better understand the dynamic nature of EA and what can we learn from these theories?

To this end, the recently published and comprehensive review on EA literature conducted by Kotusev [27] functions as a starting point to identify relevant theories. Based on the careful analysis of 67 selected articles, five explanatory theories are identified and discussed based on a purposefully developed analysis framework covering the core aspects of the dynamic nature of EA. The resulting overview on theories may guide other researchers while selecting an appropriate theoretical lens and support practitioners in finding explanations for the dynamic nature of EA.

Following this introduction, related literature is discussed. The method section then provides information on how the presented theories were identified and analysed. Then, the five identified theories and their use in EA research are discussed before the author concludes with a reflective discussion on the paper's findings and implication.

II. Related Research

Over the past few decades, EA has received considerable attention in both academia and in practice [28-30]. Literature offers a broad scope of descriptive knowledge, including guidelines for appropriately representing EA [31, 32], design principles [5], modelling methods [33-35], as well as performance measurement [6, 36]. However, while the overall maturity level of many EAM initiatives has reached a well-advanced level [37], a considerable amount of organizations still do not consider their EAM initiatives to be successful [38]. To address this issue, recent research has argued that more attention should be given to the dynamic nature of EA [22, 39]. The interests and needs of EA's stakeholder would change over time, limiting the long-term acceptance and appropriateness of EAM initiatives not addressing the dynamic nature of EA. It also has been argued that the design of EAM initiatives could be improved through the use of theories, as they can be supportive in understanding and guiding the evolution of EA [10].

There are several publications providing valuable overviews on a broad range of theories. For IS research in general, the IS Research Wiki alone lists and explains around 100 theories [40]. Through the means of a complex network analysis, Lim et al. [41] have identified 174 distinct theories that have been applied in articles published in two major IS journal between 1998 and 2006. This high number may be interpreted as an indicator of the "theory fetish" IS research has been criticized for [42]. In the field of EAM research, theories have been used less extensively [11]. Weiss et al. [43] propose twelve IS theories which could be of use in EA research. Al-Kharusi et al. [10] discuss twelve theories which have been utilized in EA studies between 2010 and 2016 and motivate for an intensified use of theory in EA research.

In addition to these publications, this paper extends the existing body of knowledge by putting the dynamic nature at the centre of the discussion and investigates on the relation between the theories. By systematically analysing the applied theories, the overall understanding on the dynamic nature of EA is expected to increase.

III. Research Method

The following section explains how the discussed theories were identified and how the applied analysis framework was derived.

A. Theory identification & selection

In order to gain a comprehensive overview on the theories applied in EA research, which were used to better understand the dynamic nature of EA, the identification and selection of publications had to be exhaustive [44]. To ensure a broad coverage of EA literature, the 1008 articles identified by Kotusev [27] were used as a starting point when initiating this research endeavour. This data set was preferred, as it is not limited to publications in top academic journals, and thus covers a "relatively complete census of relevant literature" [44, p. 16].

The original data set of publications covers articles published between 1980 and 2017, addressing EA topics in journals, conferences as well as non-academic outlets [27].

In a first step, the original set of publications was filtered based on their theory type as classified by Kotusev [27]. This classification refers to the theory types proposed by Gregor [8] and distinguishes articles aiming at analysing, explaining, predicting, explaining and predicting, and designing EA. Given the purpose of this research, articles of the two categories "explaining" and "explaining and predicting" were considered to be relevant. These 67 articles provide explanations by stating the what, the how, the when, and the where of the object of interest [8]. The fact, that the number of potentially relevant articles was relatively low, is in line with earlier observations, finding literature in EAM to be of mostly prescriptive in nature [11].

In a second step, all 67 articles were carefully reviewed by reading their abstract, introduction and conclusion section. Whenever articles covered a topic related to the dynamic nature of EA (i.e., if they discussed processes of creating, extending, or modifying resources, structures, or values) and applied a theory for explanatory purposes (e.g., institutional theory, actor network theory), they were considered to be relevant. After including articles identified through forward and backward search activity, a total of 15 articles discussing the dynamic nature of EA through various theoretical lenses were identified (Table I).

TABLE I.
ARTICLES INCLUDED IN THE REVIEW

Articles selected in Kotusev [27]	**#**
[13-21]	9
Additional Articles included to the review after back- and forward search	**#**
[2, 22-26]	6

B. Analysis framework development

In order to carefully analyse and adequately discuss the nature of the theories applied, an analysis framework was created for reviewing the articles [44, 45]. Following Nickerson et al. [46], the characteristics of the object of interest, i.e., the dynamic nature of EA, have been used as classification scheme. Such a classification [46]. The classification approach by Nickerson et al. is preferred over other classification approaches, as it allows to investigate in a top-down, deductive manner which is supposed to bring order into complex areas and build the foundation to describe the phenomenon of interest [47].

The dynamic nature of EA could result in the creation, extension or modification of an object [3]. Given that EA reflects a socio-technical system, this object could refer to both, the social and/or technical sub-system [48]. Depending on the scope of the respective research, the dynamic nature could discuss dynamics on the inter- or intra-organizational level [49] (Table II).

TABLE II.

ANALYSIS FRAMEWORK

Result of dynamics			**Object of dynamics**		**Organizational level of dynamics**	
[48]			[50]		[49]	
Object creation	Object extension	Object modification	Social Sub-System	Technical Sub-System	Intra-Organizational	Inter-Organizational

Result of dynamics: The dynamic nature of EA could refer to the creation, the extension or the modification of an object [48]. While creation describes the process of bringing something into existence, extension refers to the process of spreading an object within an organization. Modification refers to the change of an existing object in response to evolving environmental conditions.

Object of dynamics: Given the socio-technical character of EA, dynamics could encompass changes to both, the social and the technical sub-system [50]. The social sub-system refers to the human relations (i.e., structure), capabilities (i.e., knowledge) and values in an organization. The technical sub-system encompasses technical infrastructure (i.e., tools, techniques) to capture, store and process data [50].

Organizational level of dynamics: Following organizational theory, a difference is made between the dynamics within (i.e., intra-organizational) and among (i.e., inter-organizational) organizations [49]. The intra-organizational level describes the linkages between different units within the organization, while the inter-organizational level refers to the interaction between multiple organizations.

IV. RESULTS

Throughout the systematic review of the identified publications investigating the dynamic nature of EA, five distinct, to various degrees related, theories were identified and analysed based on the analysis framework (Table II). Researchers applied these theories to understand, explain and deal with the dynamic nature of EA in different ways. In the following, each of these theories is briefly introduced and its use in IS research in general and in the context of EA is discussed. Given the broad scope and evolution history of these theories, the explanation of the theories is limited to their core constructs and major seminal articles, while the discussion of the corresponding EA publications reveals more details. Table III provides an overview on the identified theories based on the applied analysis framework.

TABLE III. A

IDENTIFIED THEORIES

Institutional Theory	
Selected seminal articles	[51, 52]
Result of dynamics	Modification of organizational practices
Object of dynamics	Social- and technical-subsystem
Organizational level of dynamics	Traditionally inter-organizational, recently more intra-organizational
EAM publications	[18, 19, 21-23, 25]
Actor Network Theory	
Selected seminal articles	[53-55]
Result of dynamics	Creation and modification of socio-technical subsystems
Object of dynamics	No differentiation is made
Organizational level of dynamics	Intra-organizational
EAM publications	[16, 17, 26]
Archetype Theory	
Selected seminal articles	[56-58]
Result of dynamics	Modification of socio-technical structures
Object of dynamics	Social- and technical-subsystem
Organizational level of dynamics	Intra-organizational
EAM publications	[2]
Morphogenetic Theory	
Selected seminal articles	[59]
Result of dynamics	Creation, extension and modification of social practices
Object of dynamics	Social- and technical-subsystem
Organizational level of dynamics	Intra-organizational
EAM publications	[13, 14, 20]
Chaos & Complexity Theory	
Selected seminal articles	[60]
Result of dynamics	Modification of system behavior
Object of dynamics	No differentiation is made
Organizational level of dynamics	Intra-organizational
EAM publications	[15, 24]

A. Institutional Theory

(Neo) Institutional theory is a dominant lens to study the adoption, i.e., modification of organizational practices *(result*

of dynamics). In the perspective of the supporter of this theory, organizations are social constructs of individuals seeking to gain legitimacy for their actions. Therefore, individuals adhere to the rules and belief systems in their environment, i.e., institutional pressures [51, 52]. As institutional pressures affect the behaviour of individuals, the social- and technical sub-systems *(object of dynamics)* of organizations and industries become isomorphic (i.e., homogenous, similar) in the long run *(organizational level of dynamics)*. Dimaggio and Powel [52] differentiate three types of institutional pressures, namely, coercive, mimetic, and normative pressures. Coercive pressures are enforced by other organizations and rule making institutions (e.g., regulatory guidelines set by governments). Mimetic pressures describe an assimilation, where organizations model other, typically successful, organizations. Normative pressures finally describe prevalent social norms, values and beliefs.

Institutional theory has a long tradition in IS research [61]. The theory has for instance been applied to explain the diffusion of IT innovations, how IT artefacts such as business applications or standards became institutionalized [62]. There is also a growing body of EA literature applying institutional theory to explain EAM institutionalization and EAM adaption. Such studies were considered to be relevant as EAM adaption is seen as a means to deal with the dynamic nature of EA.

In his studies on the implementation [18] and adaption [19] of EAM in public agencies, Hjort-Madsen applies institutional theory to explain the different EAM adoption patterns across twelve public agencies. All agencies were confronted with the same regulations, but their EAM implementation differed. Hjort-Madsen argues that these differences are due to different institutional pressures at the micro and macro level of organizations (e.g. due to strong internal normative isomorphic pressure). Subsequently, several researchers have started to investigate on the intra-organizational level. Weiss et al. [21] extended the institutional perspective on EAM and discuss the institutionalization within organizations based on quantitative data from multiple organizations. They identify top management support, social legitimacy and the position of architects as relevant institutional pressures in the process of EAM institutionalization. Dang [22] has further developed this perspective and analysed EAM institutionalization in state agencies through a qualitative research approach. He finds the top management's attitude towards EAM to be a decisive factor for the design of EAM in a given organization. Dang and Pekkola [22, 23] discuss the institutionalization of EA in the context of public agencies and identify the kind of EA stakeholders and structures to be an explanation for the dynamic nature of EA. Brosius et al. [25] finally discuss the relation between institutional pressures in the process of aligning local and global perspectives and show that it are mostly mimetic pressures which influence normative and coercive pressures within organizations.

Institutional theory in its original setting is used to explain the phenomenon of organizational isomorphism across industries and was only recently also applied to study intra-organizational processes. In management science, the study of dynamics on intra-organizational level has a long tradition, reflected by a large number of respective theories. Three of them, the actor network theory, the archetype theory, as well as Archer's morphogenetic theory have also been applied in EA research and are discussed in the following. The main difference between these theories is their conceptualization on the relation between structure (i.e., patterns that order social life) and agency (i.e., individual's actions) [63].

B. Actor Network Theory

Actor network theory classifies as a socio-technical process theory and was initially proposed by Latour, Collon and Law [53-55]. The theory is primarily used to gain a deeper understanding on the generation and modification of socio-technical systems *(result of dynamics)*. Of particular interest is the question why and how specific designs within organizations emerge in a process of technical and social interactions *(organizational level of dynamics)*. A central theme in actor network theory is that actors manifest and assimilate their interests in organizations through the creation of actor-networks. The theory thereby does not make any distinction between human (e.g., employee of an organization) and non-human (e.g., information systems) actors and defines actors as "any element which bends space around itself, makes other elements dependent upon itself and translates their will into the language of its own" [64, p. 286] *(object of dynamics)*. Actor networks are created through a four stage process during which actors align to solve a problem or task which was identified by one of the actors and who convinces others to take over certain roles [65].

In IS research, actor network theory has been used to entangle the complexity of networks consisting of social and technical actors and to investigate the social change associated with the introduction of new technologies [66]. The development of a new application for example is described as a negotiation process where various actors (developers, business owners, technological standards, etc.) align their interests. Sidorova and Kappelmann [16, 26] find the actor network theory to be a suitable lens to investigate on the dynamic nature of EA. They argue that "the architecture of an enterprise is not typically defined a priori, but rather emerges through the translation process and reflects the current state of alignment of the interests of various heterogeneous actors representing the enterprise actor network" [26, p. 323] In this setting, EAM is supposed to (1) facilitate the alignment of interests within the enterprise and to (2) protect the interests of the enterprise in internal and external negotiations [16].

Actor network theory has been criticized for its missing distinction between structure and agency while studying EA. Two theoretical lenses which explicitly differentiate between structure and agency are archetype theory and morphogenetic theory [67].

C. Archetype Theory

One of the core argument*s* in institutional theory is that organizations become isomorphic in the long run. However, organizations have been found to evolve differently, even when being exposed to same institutional pressures [56]. Archetype theory [56-58] has been proposed as a theory to better understand the dynamics of change and explain how different organizational configurations emerge *(result of dynamics)* among organizations *(organizational level of dynamics).* To this end, the theory conceptualizes organizational configurations, i.e., archetypes, to compromise a structural arrangement (i.e., organizational structure and processes) and an interpretative scheme (i.e., values, ideas, beliefs) *(object of dynamics)*. Organizations are assumed to constantly evolve, through the process of organizational change tracks, towards a situation of coherence, where the structural arrangement and the interpretative scheme represent an "appropriate design for adequate performance" [57, p. 295].

Despite its potential to explain the dynamics of organizational configurations (i.e., structures, patterns, arrangements), a recent literature review has revealed that archetype theory has not gained much attention in IS literature [68]. One of the very few exceptions is the research of Haki & Legner [2], making use of archetype theory to explain the dynamics of IS adaption and describing IS architecture archetypes in multi-national organizations. They argue that the dynamic nature of EA can be seen as an act of balancing between global integration and local responsiveness.

A similar distinction between structural and social elements of an organization and their development over time is made in Archer's morphogenetic theory.

D. Morphogenetic Theory

Archer's morphogenetic theory represents the philosophical research paradigm of critical realism, where "[the] subjective knowledge of social actors in a given situation as well as the existence of independent structures that constrain and enable these actors to pursue certain actions in a particular setting" [69, p. 787] are considered *(organizational level of dynamics)*. According to the theory, social change is the result of an interplay between structure and agency over in time *(result of dynamics)*. Structure and agency are thereby seen to be interdependent *(object of dynamics)*. This is an important distinction and differentiates the theory from other theories such as structuration theory because it motivates to look at pre-existing structures which may constrain certain actions in the present [70]. Accordingly, the theory motivates to analyse structure and agency separately. To do so, the concept of a "morphogenetic cycle" consisting of three phases is assumed to exist. Phase one refers to the structural conditioning, i.e., the structural properties present at an initial stage prior an intervention takes place. These could for example be social norms which are present in the society we are born into. Phase two describes the social interaction taking place. In this phase, actors engage with the pre-existing structures. One could for example think of a young adult challenging some of the traditional social norms of the society he or she was born into. Phase three, the structural elaboration, refers to the reproduction or transformation of existing structures. This could for example mean that some of the social norms of a society change based on the activities of young adults. The adjusted structure finally is the starting point of a new morphogenetic cycle [59].

The use of critical realism and morphogenetic theory in IS research has long been motivated in theoretical discussions [69]. Only recently, the theory was used to explain the mechanisms in the evolution of digital infrastructures [71]. Alwadain et al. [13, 14, 20] apply Archer's morphogenetic theory to understand the EA evolution process by considering the role of pre-existing EA (structure) and the emergence of a new trend (agency), in this case Service-Oriented Architecture (SOA). The morphogenetic cycle of this research considers EA maturity, EA frameworks and EA objectives as the structural properties and the introduction of SOA as social interaction. Depending on the pre-existing EA, this social interaction leads to changes in "EA methods and tools" and/or "EA governance". In particular, the authors argue based on Archer's morphogenetic theory, that the likelihood of a successful SOA integration increases, if the pre-existing EA maturity is high and the adapted EA framework is capable to handle SOA [13, 14, 20].

E. Chaos and Complexity Theory

Both, chaos and complexity theory are used to explain nonlinear dynamics in complex systems that do not follow clearly predictable and repeatable pathways [72, p. 235]. While chaos theory shows how simple laws can have complicated, unpredictable consequences, complexity theory explains how complex causes can produce simple effects [73, p. 217]. Chaotic systems react to environmental changes in non-linear ways, so that their dynamic behaviour is very difficult (but still possible) to predict. This is where chaos theory sets in, aiming at improving the understanding on the adaptive, dynamic behaviour of such chaotic systems *(result of dynamics)*. The effects of changes in the environment on the behaviour of chaotic systems are found to be highly sensitive to the initial conditions [60] *(organizational level of dynamics).* Since the initial state may not be measured and specified with infinite accuracy, the observed behaviour of a chaotic systems may still differ compared to the expected one [72].

It has been argued that the chaos and complexity theory is a suitable theoretical perspective to study IS. The long-term development and the outcomes of change in IS would be inherently unpredictable because successful IS implementations would depend on more than the adaption to its environment [74]. In the context of EA, Saat et al. [15] apply chaos theory to derive requirements for EA planning methods. The authors find chaos theory to provide valuable orientation while dealing with the complex and dynamic nature of EA. They argue, that EA should address the sensitivity to initial conditions by designing flexible plans and adjustable, multivariant models [15]. By taking a complex adaptive systems perspective, Schilling et al. [24]

analyse the relation between EA complexity and expected EAM outcomes and argue that the dynamic nature of EA, evolutionary change in particular, calls for a differentiated perspective on EA complexity.

V. Discussion and Conclusion

In the previous section, five distinct theories, which have been applied to better understand, explain and deal with the dynamic nature of EA are presented. Building on these insights, it is now discussed, what can be learnt from these theories and future research opportunities are outlined.

A. Main Findings

Based on the applied analysis framework, Table III provides a consolidated overview on the identified theories. Considering the *result of dynamics* all theories have been used to better understand modification processes of some kind (e.g., actor network theory explains the dynamic nature of EA as emerging out of the alignment of different interest groups). The observation that creation and extension were less often discussed, might be due to the fact that most organizations already have large EAs and well-advanced EAM implementations in place [37]. When looking at the *object of dynamics*, the majority of theories applied to study the dynamic nature of EA consider and differentiate the technical and social sub-system (e.g., archetype theory describes EA as an interplay between structural arrangements [the technical sub-system] and interpretative schemes [the social sub-system]). An exception are chaos theory and complexity theory where this differentiation is not explicitly made, since the non-linear behaviour of systems is discussed on a rather abstract level. Considering the *organizational level of dynamics*, the identified theories are predominantly used to explain intra-organizational dynamics (e.g., while originally designed to explain organizational isomorphism, institutional theory is nowadays used to explain intra-organizational adaption processes). After having given considerable attention to organizational contingencies [75-80], the focus of EA research seems to shift towards the intra-organizational particularities.

Despite the conclusions drawn based on the analysis framework, some additional findings can be drawn from this review. The identified theories are predominantly used by individual teams of authors (institutional theory is the only one which has been used by several different teams of authors), implicating that the community of EA researchers has not yet agreed upon a common ground of theories to study the dynamic nature of EA. Interestingly, the authors mainly argue why a given theory is suitable to study the dynamic nature of EA but not why other – apparently also suitable – theoretical lenses have not been considered. The proposed framework may be supportive for such discussions in the future. Considering the origin of the theories, the majority of theories was originally proposed in management and organization science.

B. Limitations

There are some limitations that need to be considered when interpreting the results of this paper. First of all, the selection of reviewed publications is based on the classification made by Kotusev [27]. While the re-use of a recent literature review allowed to spend more time on the careful study of the selected publications, a literature-review process designed for this research might have resulted in a different set of publications. This limitation was addressed by extending the set of reviewed publications through forward and backward search activities. Second, the explanation of the theories had to be limited given the space limitation. In fact, the presented descriptions cover in most cases only the surface of the broad concepts of the reviewed theories. The provided reference to seminal articles may offer a valuable source of information for readers who would like to see more detailed explanations.

C. Implications and Future Research

By grounding their research on well-advanced theories from other research fields such as management, organization as well as natural science, a growing stream of EA research aims at bringing light into the dynamic nature of EA. The selection of the theories indicates, that the conscious consideration of the social- and technical-subsystem, as well was the differentiation between dynamics on inter- and intra-organizational level are important when studying the dynamic nature of EA.

The results of the studies discussed as part of this review may motivate others to apply or even develop theory in their EA research as well. The presented overview on theories may offer an opportunity to identify theories, which were already helpful in studying the dynamic nature of EA. Ideally, different teams of researchers make use and develop the same theories further, so that the theoretical foundation of EAM research remains straightforward and is further developed.

Given the complexity when studying dynamics in socio-technical systems, future research might consider the inclusion of a multi-theoretical perspective. The proposed analysis framework may help to argue for the selection of the underlying theoretical lenses. Independently of the number of theories, researchers should concisely argue why they opted for a specific theory while ignoring other perspectives.

For practitioners, theoretical discussions might look a bit superfluous at first sight. However, the theories presented in this paper may offer them new perspectives on how to look at EA. Institutional theory for example may motivate them to consider the use of additional means to guide the evolution of EA.

An improved understanding of the dynamic nature of EA will also be supportive in further developing EAM. Recent research for example motivates for an inclusion of the control theory perspective in EAM and dynamically adjusting the control portfolio in order to cope with the dynamic nature of EA [81].

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