Emergent Changes in Enterprise Architectures: Framework and Case Study

Short Paper

Daniel Fürstenau
Freie Universität Berlin
School of Business & Economics
& Einstein Center Digital Future
Garystr. 21, 14195 Berlin, Germany
daniel.fuerstenau@fu-berlin.de

Carson Woo
University of British Columbia
Sauder School of Business
2053 Main Mall, BC V6T 1Z2, Canada
carson.woo@sauder.ubc.ca

Abstract

We suggest an emergent change framework for enterprise architecture. Drawing on Leavitt's Change Model of Organizations, our framework focusses on socio-technical changes in tasks, structures, actors, and technologies. By applying the framework to a medium-sized company from the media industry and drawing on a relatively unique panel data set (2014, 2016, 2018), we demonstrate the amount of emergent changes and confirm three patterns of change. These findings help to advance the study of change and its propagation across different components of an enterprise over time.

Keywords: Enterprise architecture, emergent changes, organizational change

Introduction

Enterprise Architecture (EA) is an overview of a set of frameworks, processes, and concepts used to manage the digital infrastructures of organizations (MacCormack et al. 2015). Organizations using EA gain access to rich toolsets that can offer many benefits (Shanks et al. 2018; The Open Group 2018; Zachman 1987). In particular, EA promises managing an organization's digital infrastructure over time by strategically orchestrating many interdependent elements and letting them form a coherent whole.

While current EA literature offers much guidance in general, EA's impact often remains limited in the daily swamp of decision-making. People introduce tools locally to support their actions. They draw on "shadow IT" (Fuerstenau and Rothe 2014), "end-user developments" (Panko and Port 2012), "workarounds" (Alter 2014), or "business-managed IT" (Kopper et al. 2018). A recent CIO survey found that 64% of organizations allow technology expenditure controlled outside the IT department (Harvey Nash and KPMG 2019). This affects the architecture and introduces additional "drift" (Ciborra 2000). Apart from *strategic change,* the important role of *emergent change* is often underestimated and has to be considered more carefully. Strategic change refers to planned interventions fundamentally transforming the organization (Proper et al. 2017). Emergent change in turn refers to ongoing accommodations, adaptations, and alterations producing fundamental change without a prior intention to do so (Weick 2012). An enterprise architecture emerges from combining both types of change to different proportions.

In this vain, our current understanding of enterprise architectures and the processes driving their evolution is partial. While previous research has highlighted the mechanisms underlying emergent changes such as hacking, bricolage, and improvisation (Ciborra 2000; Rolland et al. 2015; Strong and Volkoff 2010), literature from an emergence perspective has stayed largely disconnected from mainstream EA literature. Moreover, current EA literature has rarely assessed the amount of emergent changes in an organization as well as the propagation of changes between different components of it.

The purpose of this paper is to *give profound insight into how emergent changes occur in different components of an organization*. Taking as a vantage point Leavitt's (1965) socio-technical model of organizational change and drawing on a comprehensive characterization of a media organization at three points in time, we consider changes in an organization's technology, structure, task, and actor component.

The viewpoint advanced here diverges from earlier studies on strategic EA change (e.g., Proper et al. 2017). Instead, it presents a complementary viewpoint that highlights the study of architectures in action. In doing so, it furthers the efforts by Dreyfus et al. (2008), MacCormack and Lagerström (2017), and others who began to formalize the notion of architecture using a network-based vocabulary. It contributes three change patterns as well as an emergence perspective that is sensitive to how local initiatives manifest in and affect EAs across its different components. This is important in an age where technology investments become more business-driven and digital technologies become less encapsulated within IT departments.

Literature Review: Emergent Changes in Enterprise Architectures

The EA literature has developed a rich, contextual understanding of the kind of changes that take place in organizations and has provided methodological guidance in navigating it. While the current literature has largely contrasted large-scale, planned, strategic change and continuous, bottom-up, evolutionary change (Proper et al. 2017), it has underestimated the extent to which emergent changes transform architectures.

To support strategic change, many *deliberate EA frameworks, methods and concepts* have emerged (Gong and Janssen 2019). One of the most popular EA frameworks is that proposed by Zachman (1987). It is composed of two dimensions: (1) questions of the EA (i.e., the What, How, Where, Who, When, and Why), and (2) perspectives of the EA (i.e., executive, business management, architect, engineer, and technician). These two areas span the 30 model types to be documented. Many other EA frameworks exist (e.g., TOGAF and DODAF), but the fundamental ontology is still Zachman's framework. These frameworks do, however, primarily intend to guide strategic change while they are less sensitive to emergent changes.

A comprehensive method to support strategic change programs is presented in Proper et al. (2017). These authors have developed a research program around architectural coordination for enterprise transformation (ACET). They understand ACET as a planned, purposeful, holistic, and long-term method for guiding enterprise transformation. Focusing on strategy planning, *EA master planning* helps aligning corporate strategies with architectural blueprints (Bernus et al. 2015). *EA road map* charts strategic plans to concrete IT architecture projects and programs (Aier et al. 2008). *EA principles* represent cornerstones for transformation (Lankhorst 2012). EA also supports strategy planning through options analysis by architects (Radeke 2011) or prioritization of the project portfolio from an architectural viewpoint (ibid.). Regarding strategy implementation, much work considers *impact assessment* and *interdependency analysis*. MacCormack et al. (2015) have used design-structure matrices for analyzing IT costs arising from interdependencies. Other works have dealt with *standards compliance monitoring and evaluation* (for an overview, see Radeke 2011). However, these works are less sensitive to how actors deviate from plans and what the unintended consequences of alterations are.

A less prominent stream in the EA literature considers emergent changes (Gregory et al. 2015; Rolland et al. 2015). Building on Orlikowski (1996) and others, such works sees change as arising from the bottom up, more subtly, and emergently, occurring from the situated and contextual actions of actors. While strategic change can largely impact performance, culture, and agility, it also comes with associated risks such as high probability of relapse, unintended consequences due to limited foresight, or large short-term losses that are difficult to recover (Weick 2012). Gregory et al. (2015) found that large IT transformation programs can produce unintended consequences because of internal conflicts in the environment requiring situated action. Rolland et al. (2015) study architects' activities towards a target architecture and found that architecting means both purposely implementing new technologies as well as fixing historically entrenched architectures. Emergent changes beyond strategic programs can also hugely impact organizations. Fürstenau et al. (2019) show how shadow IT and local actions by front line workers create parallel infrastructures, hard to reconcile with central's intentions. Kopper et al. (2018) study an e-commerce firm that has gradually build an e-commerce platform, to the extent that business-managed IT eventually ran the entire business.

To conclude, EA results from strategic and emergent changes, collectively. First, strategic change has emergent elements to it. Considering paper blueprints only is insufficient here. One must instead follow an architecture's evolution to understand emergent changes. Second, emergent change can create far-reaching implications beyond anyone's intentions. By contrasting strategic change only with minor adaptations, the EA literature downplays how emergent changes transform architectures. However, little empirical research investigated emergent changes in different components of an enterprise, which this study sets out to do.

Leavitt's Model of Organizational Change

Some Information Systems Research (ISR) frameworks explicitly regard information systems as socio-technical systems and examine various social and technical components in them. Drawn from Leavitt's socio-technical change model of organization (Leavitt 1965), Lyytinen and Newman (2008) analyze the information systems change from a social-technical systems perspective and elaborate how any misalignment within and between various social and technical components in the information systems and the associated environment shapes a dynamic change model in information systems (Lyytinen and Newman 2008). For this reason, we revisit Leavitt's change model of organizations and apply it to represent changes in enterprise architecture.

Leavitt's (1965) Change Model of Organizations (Figure 1) consists of four components, namely, technology, task, structure, and actor, as well as the relationship between them (i.e., change in any of these components has a direct/indirect change effect on all the other ones). According to Leavitt, technology refers to direct problem-solving inventions like computers. Task is the production of goods and services. Structure includes systems of communication, systems of authority, and systems of workflow. Actor refers to those who execute organizational work. Actors are mainly people but need not remain exclusively so.

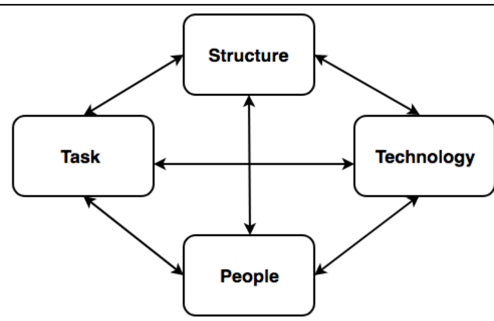

Figure 1. Leavitt's Change Model of Organizations

Leavitt's model has been widely used in change management (Paton and McCalman 2008), which is the adjustment of organizational structure, processes, roles and responsibilities when introducing a new technology. Although Leavitt's model forms the foundation for change management, thus far, no one has used it as a foundation to track emergent changes in EAs. In change management, technology has often been regarding as the component that originate the changes and the other three components (especially people and task) need to be adjusted to accommodate the technology change (Markus and Robey 1988).

In EA, change can originate from any of the four components: *Technology changes* could be induced strategically when one deliberately replaces technology products. They could also occur emergently when shadow IT gradually builds up and leads to lock-in situations (Fürstenau et al. 2019). Task changes could occur strategically when altering or ceasing IT-supported capabilities. They may also happen emergently when work routines drift, resulting in avalanche effects (Pentland et al. 2020). Structural changes could be induced strategically when hierarchies, reporting or workflow structures are altered. They could also occur emergently through a gradual reconfiguration of informal social or advice networks in an organization. The actor component may be changed strategically using a hiring campaign or emergently when a new generation of employees with new skills gradually enters the organization.

Lyytinen and Newman (2008) provided some measures of some of the social-technical components. For example, the "actor/people" component can be operationalized using attitude, willingness, motivation, knowledge, beliefs, and commitment. The "structure" component can be operationalized using systems of communication, system of authority, management style, system of workflow and business processes, expectations and duties set for people, geographical dispersion, and level of specialization. Finally, the "task" component can be operationalized using size, complexity, interdependency, uncertainty, ambiguity, stability, time, and performance criticality.

An Emergent Change Framework for Enterprise Architecture

We turn to tailoring Leavitt's model of organizational change to enterprise architecture and explain the context in which the newly derived framework has been applied.

Case Context and Selection

Drawing on a case study approach (Yin 2013), we studied a European media company, anonymized as EuroMedia. EuroMedia operates TV channels and several further TV and radio programs. EuroMedia has a revenue in the lower two-digit billion range and less than 10,000 employees. It is a case in point for our study, because it was–in our study period–relatively free from major external events, thus, making it possible to observe how changes in one component affect another component over time. It was also a good case because we received data from the company's EA repository that covered a panel data over three points in time (2014, 2016, and 2018); thus, allowing for a longitudinal view on the changes of the EA. The case company is also suitable because it operated in a relatively stable regulatory environment. The amount of funding did not change significantly during the study period. The company is similar to other media organizations in Europe and can be categorized as a medium-sized enterprise.

Operationalization of the Framework Constructs and Analytical Procedures

We turn to operationalizing Leavitt's Change Model of Organizations in what we call an *Emergent Change Framework for Enterprise Architecture*, shown in Table 1. The premise of the framework is to capture important attributes of the number of elements in each component, their variety, and interconnectedness (Schneberger and McLean 2003). As our main source of data, we used the EA repository of the company. The data was cleansed and validated together with the company over multiple rounds. In addition, we used publically available data to capture organizational structures as described earlier.

Table 1. Operationalization of Framework Constructs

Component	Operationalization in study	Source
Tasks	*Size*: Applications (count)	EA repository
	Complexity: Interfaces between applications (count)	
Structures	*Organizational structure:* Business units (count)	EA repository
	Workflow structure: Business processes (count)	
Actors	*Size:* Employees (count)	Annual report & public sources
	Knowledge: Competency profiles (count)	
Technology	*Size:* Operational technologies (count)	EA repository
	Cohesion: Co-occurrence of technologies (count)	

The *task* component was decomposed into "task size" and "task complexity." Since EA aims to capture the whole enterprise, we need to look at all tasks of an organizations. The number of applications provides a way to approximate this, since applications provide IT capabilities and business logics for task support (Hanseth and Lyytinen 2010). After removing two pseudo entries, we identified 260 used applications. In addition, we are interested in how task-supporting applications are interconnected and thus measure *task complexity* as the count of interfaces between applications. As suggested by Santana et al. (2016), we used network-analytic methods to process the EA data. We constructed a directed network in which an incoming link described a dependency of a focal application on data and functions of another application, and vice-versa, which was derived from information flow data from the EA repository.

We operationalized the *actor* component in terms of "actor size" and "actor knowledge." From an enterprise-wide perspective, it is important to capture to size of the workforce. Using publically available data, we used the count of employees at EuroMedia as a measure. *Actor knowledge*, an attribute proposed by Lyytinen and Newman (2008), in turn captures the diversity of actors in terms of what skills they contribute to the organization. We collected data on available job offers from EuroMedia for 2014/15, 2016/17 and 2018/19 and searched for newly emerging digital competencies within the offers.

The *structure* component was operationalized in terms of "organizational structure" and "workflow structure." While *organizational structure* has many dimensions, we focus on the grouping together of actors into departments, giving insight into the organization's division of labor. For organizational structure, we used the count of business units in the EA repository. After processing the data, we identified 245 organizational units. For workflow structure, an attribute proposed by Lyytinen and Newman (2008), we used the count of business processes automatically extracted from the EA repository. From the data, we identified 68 business processes.

In the *technology* component, we measured *technology size* by drawing on the count of used technologies. Technologies are defined as architectural elements combined and used in applications to perform business services. After cleaning several pseudo entries, we ended with 263 technologies used at the three time points. This represents the number of (logical) technology products used (e.g., MySQL 5.2, PHP Runtime 3.4, JRE 6). Additionally, we have captured *technology cohesion* by tapping into the co-occurrence of technologies by considering which technologies co-occur within an application.

Our analysis was explorative in nature. From the data in the task, structure, actor, and technology component, we constructed statistics on the extent and volatility of change. Using Gephi (Bastian et al. 2009), we additionally created network plots to support change propagation and interdependency analysis. Our contact with the company began already before 2014 and intensified during the research project. The majority of the data analysis took place during a three-month period in the summer of 2018. We interacted regularly with the company's EA office and presented multiple iterations of our analysis to the EA team. Among our exchanges were a number of semi-structured interviews with the EA team, delving into questions of main strategic changes, examples of changes in the four components, used planning techniques, as well as current pain points. These additional data helped to verify and triangulate our views.

Results

Our data confirmed that a broad range of changes could be captured by drawing on the four components of our framework. Table 2 gives an overview of the changes.

Table 2. Organizational Change Absolute (abs.) and in Percentage Points (% Change)

		2014	**2016**		**2018**	
		Abs.	*Abs.*	*% change*	*Abs.*	*% change*
Task	Size	227	231	1.76	234	3.08
	Complexity	487	505	3.70	547	12.32
Structure	Organizational	152	149	-1.97	157	3.29
	Workflow	66	68	3.03	68	3.03
Actor	Size	3,509	3,454	-1.57	3,404	-2.99
	Knowledge	3	5	66.67	4	-25.00
Technology	Size	195	207	6.15	231	18.46
	Cohesion	1,780	2,178	22.36	2,539	42.64

The table shows that the task size (count of applications) is subject to a percentage increase of 3.08% in the period 2014-2018 and the task complexity increased by 12.32% (count of interfaces between applications). The organizational structure (count of business units) showed an increase of 3.29% and the workflow structure size increased by 3.03%. In the actor component, actor size (count employees) decreased steadily by 2.99% while actor knowledge (competence profiles) fluctuated. In the technology component, technology size (count technologies) has increased strongly by 18.46% and technological cohesion by 42.64%.

Changes in task-supporting applications. The data suggests that changes in task size (number of applications) remained limited. Over the study period, we saw an increase of only 3.08%. Additional analyses of task complexity showed an increase of 12.32% over the study period. Figure 3–a network plot of the interdependencies–suggests that the overall task structure drifted slightly. There are five main task areas emerging in the company: Rights/contract management, Human resources and financial accounting, ERP production, program planning, and graphics. Another cluster of host/mainframe based primarily technical systems (e.g., user management) merged with other clusters over the study period. This indicates a slight drift. Modularity, a measure of the clustering in the network, increased slightly from 0.45 to 0.48 in the study period, indicating that cluster differences became more pronounced.

Changes in structures. The data suggests a relatively stable organizational setup. The overall amount of business units increased by 3.29% between 2014 and 2018. EuroMedia is organized in a relatively hierarchical fashion with departments, divisions, and teams. At the considered level of departments and divisions, this structured remained almost hyperstable over the considered study period. Furthermore, the workflow structure remained largely constant (increase of 3.03%).

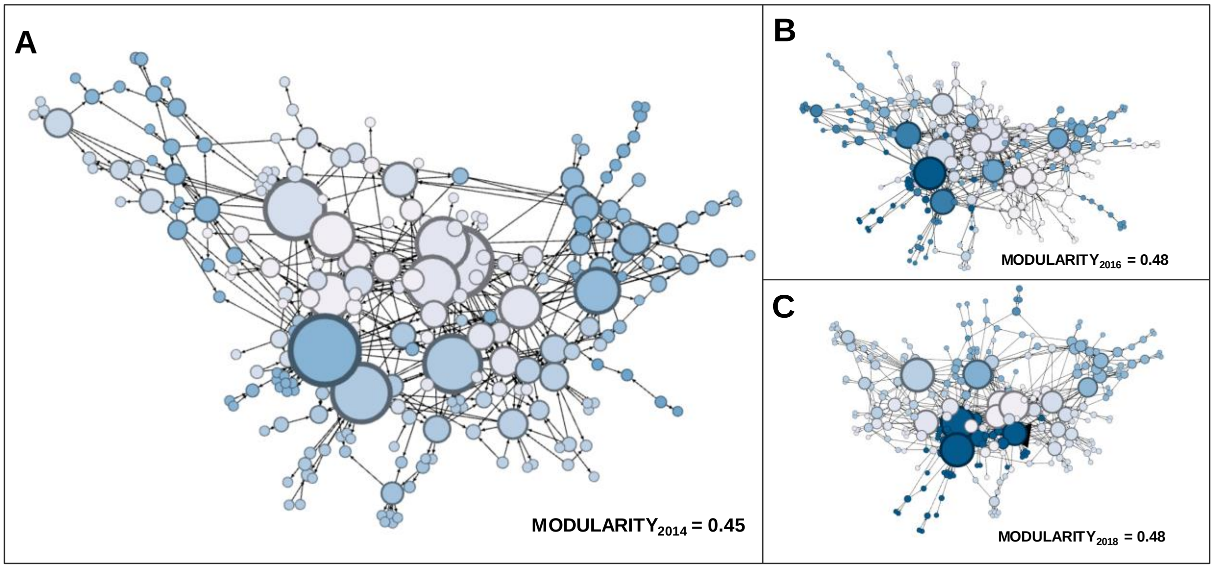

Figure 3. Application Landscape (A) 2014, (B) 2016; (C) 2018; Information Flow Dependencies Depicted as Directed Links; Color Represents Modularity Clustering

Changes in actors. We turn to an analysis of headcounts. The mean headcount is 585 (2014), 576 (2016), and 567 (2018). It becomes clear that there is little fluctuation between the different departments in the considered period. This is mainly due to the fixed budgeting structure and organizational inertia. Regarding actor knowledge, we found some new competency profiles such as virtual reality designer, social media editor, or technology coordinator emerging. The emergence of these profiles fluctuated across periods.

Changes in technologies. The data shows an 18.46% increase in the number of used technologies (technology size) over the study period. From Figure 4A, we can identify cohesive technologies from a network plot of co-occurrences of technologies in applications. A link represents that two technologies were used together at least once in an application. The ticker the link, the more often technologies have been used together. Cohesive clusters emerge in the areas of Microsoft- and Oracle-related technologies, host / mainframe, web, and SAP technologies. A closer look at the figure reveals multiple redundant technologies per cluster, suggesting potential for further research.

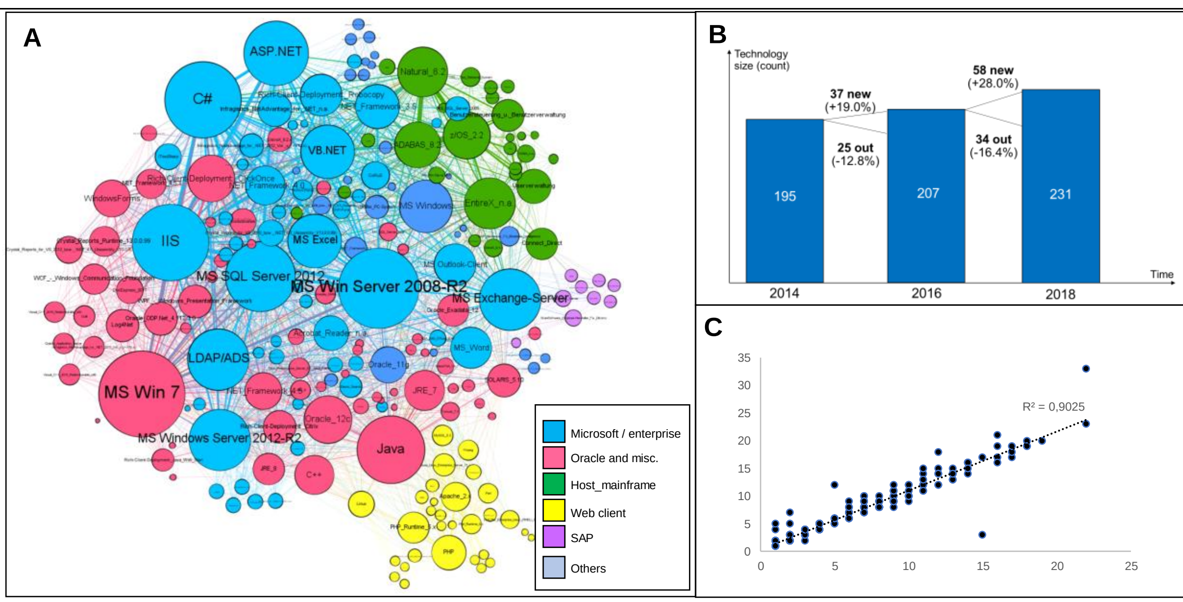

Figure 4. Technology Component of EuroMedia. (A) Technology Cohesion, (B) Growth of Technology Size, (C) Regression of Technology Use per Application 2014 vs. 2016

Figure 4B shows the amount of technologies added and removed from the enterprise architecture. The numbers indicate an expansion of technologies despite articulated attempts by the organization to consolidate the technology landscape. Respondents indicated that a reason for this lied in the fact that legacy technologies often cannot be replaced at the same pace as new ones are introduced. Figure 4C, a scatter plot of the number of technologies used per application in 2014 versus 2016, suggests that technology size per application is correlated across time, but there is also some variation in the number of used technologies per application from period to period. Taken together, Figure 4B and C suggest that emergent local decisions to alter the technology base of an application may gradually result in crippling vendor lock-ins. This seemed to be the case for some of the most common technologies in Figure 4.

Patterns of Change and Their Propagation

Our analysis suggests three broad patterns of EA-related organizational change. As shown in Table 3, these are *task-*, *technology-*, and *structure-induced change*.

Table 3. Patterns of EA-related Change in the Company

Pattern of change	**Locus of change**	**Further affected component**	**Exemplary initiative in case company**
Task-induced change	Tasks	Change in technologies Change in actors	Outsourcing (cloud)
			IT consolidation
Technology-induced change	Technologies	Change in tasks Change in actors	Host migration
Structure-induced change	Structures (potentially)	Potential changes of tasks and technologies	Business-managed IT

Task-induced change. Task-induced change describes changes having its starting point in the tasks and capabilities of an organization. It was present in our data firstly in the form of *outsourcing* attempts. Decisions were currently made in the company which services and functions to outsource to the cloud. Individual decisions considered data security and privacy issues as well as location aspects (i.e., European data center). The company had begun to outsource (and cloud-source) its main ERP system, which was used for financial, accounting, and other purposes. Since this effort already began in 2016, this was present in our data in the form of links between tasks and technologies being cut and rewired to other technologies. Task-induced change was also present in the data in the form of an *IT consolidation*. It started with a new capability map, which was created in 2017, replacing an old capability model that was too fine-grained. Based thereupon, strategic goals for application and technology consolidation were formulated to reduce the overall amount of and the redundancies between different applications and technologies. In the data, the effect of this task-induced change had not yet been very prominent due to lacking implementation.

Technology-induced change. When an organization introduces, alters, or discontinues technologies, this can lead to changes in other components of the organization. Our data showed a major *mainframe migration* going on for several years. The transformation presented the attempt to escape a vendor lock-in. It moved EuroMedia away from Natural / Host-based legacy systems to Java code. Changes in technologies affected the task component by task-supporting applications being phased-out or altered when underlying technologies were discontinued. It also led to changes in task complexity where new interfaces were created. Technological change also induced changes in the actor component as workers with changed competence profiles (e.g., Java developers) were hired or externally contracted. In some areas such as with the most common technology products, technology-induced change may, however, be very difficult if intended.

Structure-induced change. Structure-induced change starts in the organizational structures of an organization. This can be illustrated by the example of business-managed IT as found in the company. Due to structural decisions carrying some historicity, the company had begun to build social media and content management systems inside some business units. The emergent built-up of these task-supporting applications was induced by the growth of these local units without much integration with the central IT. The applications gradually grew into streaming and content marketing solutions, distributing the content to viewers via the web. However, to achieve a stronger connectivity of IT (e.g., metadata, interfaces, authorization, security, etc.), IT involvement and consultation was desired. Therefore, further structural changes were desired in the future to simplify subsequent adaptions to tasks and technologies.

Discussion and Conclusion

This paper aimed to give insights into emergent changes in the components of an enterprise architecture. Applying our framework illustrated the importance of emergent changes in a media company and revealed three broad patterns of change (technology-, task-, and structure-induced). Our framework's quality should be discussed in the light of the problems that it can uncover. Other frameworks such as Zachman (1987) are more complete, which is why they should uncover more problems. However, our framework is more parsimonious and yet covers a broad range of changes in organizations. Our framework showed how emergent changes led to a situation in which technology consolidation was intended but an expansion of technologies occurred. This expansion was the result of unintended local decisions. It created the need for some more technology-induced changes (i.e., mainframe/host migration), while preventing others. Our analysis also helped to uncover structural patterns in the task component indicated by an increasing complexity of application size and complexity, which built the emergent base for task-induced changes (i.e., IT outsourcing based on capability mapping). In revealing these patterns, it can inform research on how to manage an organization's digital infrastructure over time.

Our study is limited to the example of one company from one industry. Further research should study more and other cases. An observation from applying our framework was that, in the case company, while the number of people decreased, the amount of technologies increased over the study period. This should be explored further. Further need for research arises from our study. The first is to conduct further multi-case research to support the development of hypotheses and to enable the creation of a survey targeted toward managers to test the sufficiency of our framework and concepts in a broader population of people, companies, and industries. It would also be desirable to link our findings to outcome variables of interest (e.g., firm profit, agility, open issues from ticketing systems, or project success) to measure their impact.

Two broad implications emerge from our study for the EA literature. First, previous research has focused on deliberate planning for strategic change. Instead, we present a framework for capturing emergent changes. Our work responds to recent calls in the literature to create richer EA frameworks to support ongoing adaptations (Babar and Yu 2015). Such works call into question the rational engineering view of EA and propose the view that architectures change more subtly, emergently, and endogenously. This is also the view proposed in our paper. This should help to track development patterns and optimize dependency structures in an EA over time—guiding and cultivating its evolution without fully controlling it. In accordance with Rolland et al. (2018), it is sensitive to the technical debt imposed on user organizations through their emergent architecture. The network-analytical methods we use are related to design structure matrices (MacCormack et al. 2015; MacCormack and Lagerström 2017). We present initial steps towards analyses of dynamic interdependencies between different elements of an EA. The second implication from our study is that the propagation of changes should be considered within and between different components of an EA. Research has too often portrayed application, process, or technological architectures as isolated without considering their interdependent nature. Enterprise architectures consist of multiple inter-dependent components evolving in relation to each other and EA should reflect this viewpoint.

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