August 2021

# Enterprise Architecture Erosion: A Definition and Research Framework

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# Enterprise Architecture Erosion: A Definition and Research Framework

*Emergent Research Forum (ERF)*

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## Abstract

Erosion is widely studied in software architecture referring to the gap between what is planned and what is implemented. However, it is not clear what the term means in Enterprise Architecture (EA), a field that deals with the inseparability of applications, business actors, processes, strategy, motivation, and physical infrastructure. This paper defines EA Erosion as a phenomenon of unplanned, emergent, and sometimes unstoppable change in the elements and interactions pertaining to the architecture, with impact in a service region of interest. A research framework is proposed to guide the identification of the regions of interest for erosion factors, impacts, and response actions. Our emergent research shifts the focus from EA representation gaps to the development of EA erosion management capabilities.

**Keywords**

Enterprise architecture, enterprise architecture erosion, change, capabilities, design science research.

## Introduction

"*Culture eats strategy for breakfast*" is a famous sentence attributed to Peter Drucker. The author of the quote was a visionary and changed the landscape of management pointing to the importance of people in organizations, increasingly supported by information technologies (IT). Enterprise architecture (EA) attempts to capture that complex business logic using models (Ross, Weill and Robertson, 2006), but when people starts using and adapting IT and the formal/informal business processes (Paul, 2007), there are inherent uncertainties that make all models wrong and some of them useful (Box, 1979).

Erosion is inevitable in nature. It is also perceptible in human creations like software architecture representing "*the most significant properties and design constraints of software systems. Thus, modifications to a system that violate its architectural principles can degrade system performance and shorten its useful lifetime*" (De Silva and Balasubramaniam, 2012). The gap between the planned architecture and the run-time architecture requires control measures. However, a definition using terms like "design constraints" or "degradation by violating architectural principles" seems unsuitable for models that aim to encapsulate the organization erosion in structure, behavior, and culture.

Enterprise architecture integrates different organizational layers. For example, ArchiMate® 3.1 specification considers six: strategy, business (e.g., actors, processes), application (e.g., software), technology (e.g., servers, networks), physical (e.g., facilities), and the implementation and migration. Architects can represent the *as-is* and the *to-be* of business and technology using the elements available in each layer. This is a never-ending story of alignment between plans and reality. It is therefore crucial to address the concept of erosion as a continuous transformation process that is sometimes invisible to our eyes, with no apparent change in structure, but with dramatic consequences (e.g., breach or desertification).

Two research objectives are posed in this paper, namely, *RO1: Define Enterprise Architecture Erosion*, and *RO2: Propose a research framework to assist EA professionals dealing with the phenomenon of erosion*. The next section presents background literature on the issues of erosion, EA evolution, and EA maintenance. Subsequently, a research framework is outlined to generate value with new EA management capabilities (Ahlemann, Legner and Lux, 2021). Inspired in these contributions, we propose our own

definition of EA erosion due to its distinctive characteristics and illustrate the initial steps of the framework in help desk scenario. The paper concludes by stating the main limitations and future research steps.

# Literature Review

## *Enterprise Architecture and Erosion: Establishing the Link*

EA is a high-level representation of a company's business processes and IT systems, their interrelationships, and the extent to which they are embedded in different parts of the company (Tamm, et al. 2011). Moreover, EA value is based on strategic plans (Ross et al., 2006) translating principles, capabilities, and objectives into systems and processes (Tamm, et al. 2011). Important frameworks like TOGAF® and languages like Archimate® were proposed to guide EA steps and create EA models (Glissman and Sanz, 2009). ArchiMate® suggests a service-oriented representation of the strategy, business, applications, technology, and physical assets, considering both the structure and the behaviors. Each layer is linked via services that represent the behavior exposed to the environment by a particular actor (e.g., business actor or application interface). However, when architecture and reality are not aligned, "*the company builds IT solutions rather than IT capabilities*" (Ross et al., 2006).

Erosion is a well-known concept in geology, caused by the continuous action of elements interacting over time (e.g., water, wind) in specific locations. Built facilities may also suffer from erosion or its consequences (e.g., metal corrosion in coastal regions). Software architecture erosion is another example in artificial contexts: software degeneration as a consequence of change that tamper with the design principles (De Silva and Balasubramaniam, 2012). Software is one of the important elements in EA, but there are others. Therefore, erosion may also exist in different layers of the organization (e.g., strategy or processes).

Interestingly, a search in Google Scholar (GS) with the keyword combination "enterprise architecture erosion" OR ("EA erosion" + "enterprise architecture") returns 0 results, and the few studies found in EA literature usually import the definition from the software architecture domain (De Silva and Balasubramaniam, 2012). Consequently, we extended the literature search to include related terms like "EA maintenance" (87 results searching for "EA maintenance" + "enterprise architecture" in GS) – the type of practices after EA deployment (Rouhani et al., 2015), and keyword variants such as "EA evolution" (Silva, Sousa e Da Silva 2021) with 134 hits or "EA change" (122) that is inherent to both (Rouhani et al., 2015). The findings are summarized in the following two sections.

## *Foundations for Erosion in Software Architecture*

Software architecture is a high-level vision of the software and its development project (De Silva e Balasubramaniam 2012), disassembling the system in small parts and supporting decision making (Andrews e Sheppard 2020). The architecture must derive from the customer's needs, the environment in which the software will be used, and the problems to which it intends to respond (Andrews e Sheppard 2020). However, during software development, the implemented architecture may deviate from the plan and the detection is often delayed until some problem appear (De Silva e Balasubramaniam 2012). The progressive deterioration of the software performance may lead to defective or unusable software (Wang, Wang e Li 2019). Therefore, erosion may exist in the EA representation and in the execution stages.

There are technical and non-technical causes of software architecture erosion (Andrews e Sheppard 2020). On the one hand, changes in the software lead to changes in the structural integrity. Moreover, the incorrect or inadequate transmission of the software design to the implementation team may trigger problems in the process. Other causes for technical erosion include duplicated or "cloned" code, and the introduction of different types of software in the portfolio (e.g., open source) (Andrews and Sheppard, 2020). On the other hand, it is necessary to balance the increasingly fast-paced change of the EA and the need to comply to high-quality standards and optimum performance (De Silva e Balasubramaniam 2012). The development process (or its ad-hoc nature in some cases) is another relevant erosion factor (Andrews e Sheppard 2020).

The impact of erosive factors may be invisible or unrecognizable in the early stages of development. The opposite can also happen with almost instant effect in the product or in the process. In the latter case, consequences for performance, cost, and degradation of quality attributes can be significant and increasingly difficult to repair (Andrews e Sheppard 2020). Three types of responses can be adopted: minimize, prevent, and repair / recover the erosion (De Silva e Balasubramaniam 2012).

Important insights can be identified in the field of software engineering. Managing erosion is mandatory in technical settings and ad-hoc approaches do not seem sufficient in an era of digital transformation. Nevertheless, the scope of EA and software architecture is not the same.

### *Gathering Inspiration in EA Literature: Evolution and Maintenance*

EA integrates social, technological, cultural, and organizational areas that are constantly evolving (Sabau, Hacks e Steffens 2021) but updating the portfolio of a company's architecture is usually a manual task (Sabau, Hacks e Steffens 2021). Therefore, evolving and maintaining the architecture can be problematic. For example, the adoption of solutions outside "official" application portfolio, commonly known as Shadow IT (e.g., excel files) without the knowledge of the EA team (Handel e Poltrock 2011). Thus, it is important to implement robust EA processes and maintenance tools (Silva, Sousa e Da Silva 2021).

There are important contributions to guide EA evolution (Fischer, Aier e Winter 2007) and maintenance (Silva, Sousa e Da Silva 2021). TOGAF is one of the most referenced frameworks to support EA change since it integrates the EA life cycle, which can be modeled with ArchiMate language (Luo, Fu e Liu 2016). Nevertheless, maintaining EA depends on the *modus operandi* and the company context and there is still no universal method for dealing with constant changes (Farwick, et al., 2012).

Digital transformation requires structural shifts (e.g., redesigned processes, new workers' skills, innovative technologies) in the company's strategy and information systems (Luo, Fu e Liu 2016). Therefore, EA architects need to make the evolution visible and address the debts of EA models (Sabau, Hacks e Steffens 2021). However, the literature in EA maintenance and evolution have scarcely addressed the emergent (non-prescriptive) change, sometimes difficult to spot when the structural elements (e.g., applications) seem stable in the model. The next section presents a starting point to define and manage EA erosion.

## A Framework for the Emergent Enterprise Architecture Erosion

Information systems emerge from the use and adaptation of IT and (formal/informal) business processes (Paul, 2007). We hypothesize that this emergent change is not necessarily a "deterioration" in architecture, needs to be routinely managed, and may be an opportunity to improve the models and its instantiations. Therefore, we define *EA erosion* as *a phenomenon of unplanned, emergent, and sometimes unstoppable change in the elements and interactions pertaining to the architecture, with impact in a service region of interest*. Figure 1 presents the initial version of a framework to manage EA erosion. The proposal is based on the literature review and the initial contacts with an organization that is participating in this research.

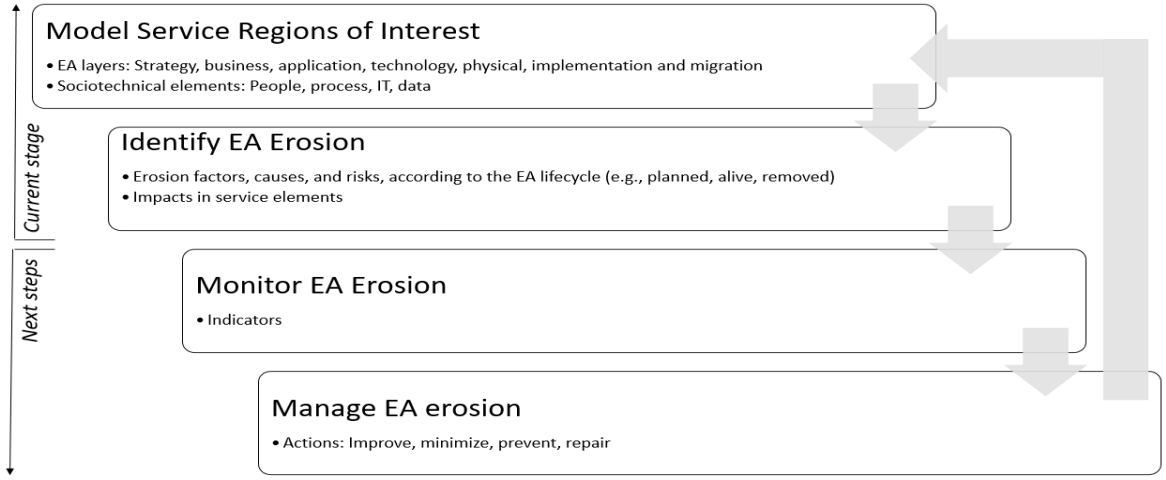


**Figure 1. EA Erosion Framework**

Erosion is transversal to the architecture, but it is necessary to model the most important regions of interest where key services are located (first step). The services are the elements where impact of erosion (positive, neutral, negative) can be evaluated. A service region of interest (SRI) may be a problematic piece of the architecture, a focus area for digital transformation, or other organizational priority. The term "region of

interest" is popular in the neuroimaging field, describing image areas relevant to understand specific phenomena (Brett, Anton, Valabregue and Poline, 2002). The EA layers and elements are inspired in ArchiMate. Erosion factors, causes, and risks (Andrews e Sheppard 2020) are identified according to the lifecycle stage (e.g., application entering the portfolio, active process, obsolete application). Moreover, indicators are necessary to monitor the (1) factors of erosion and (2) services exposed (for example, if the service improves and erosion factors are increasing, perhaps the problem is not with the violation of EA principles but with a poor EA model). Finally, actions must be implemented to develop EA erosion management capability. Figure 2 presents an illustrative scenario for help desk modeled in ArchiMate.

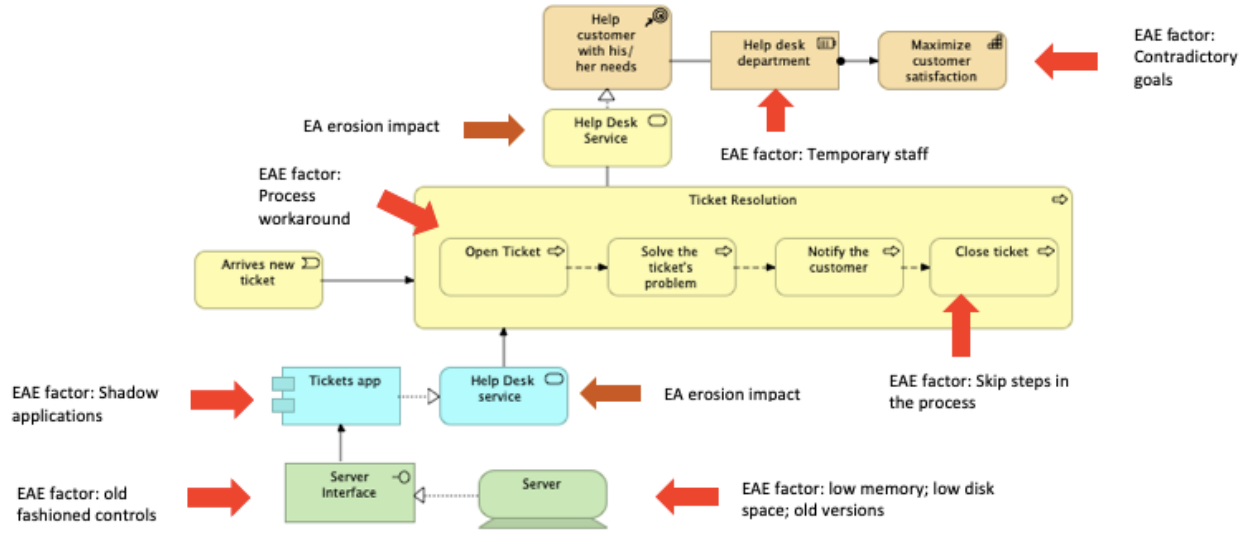


**Figure 2. EA Erosion Factors and Impact in the Help Desk Service Region of Interest**

Erosion can happen in all layers. For example, contradictory goals (e.g., performance bonuses reinforcing practices that may damage the help desk customer service), workarounds, or shadow IT (e.g., replace the help desk app by a phone call, social networks, excel files) may cause erosion in the entire SRI (EA erosion snowball effect). Skipping process steps also affect the normal flow and use of IT (data quality issues). Constant changes in the team with temporary staff is another possible example that calls for an efficient information exchange and proper training. Lastly, low memory, low disk space or old versions of servers may also affect the service, when reaching a specific threshold (not all erosion factors impact the service).

## Conclusion and Outlook

This ERF paper defined Enterprise Architecture Erosion and presented a research framework to answer the call for "*more configurable and adaptable methodical support of EAM initiatives that considers different strategic starting points and priorities*" (Ahlemann et al., 2021). EA erosion offers a promising perspective of EA value in emergent sociotechnical arrangements that are at the core of information systems (Paul, 2007). Erosion can occur in different layers (e.g., strategy and applications) and lifecycle stages (e.g., process redesign, application removal). Moreover, erosion exists in (1) structure, (2) behavior, or (3) motivation, varying in speed and impact, requiring more tailored management actions.

There are also limitations that must be stated. First, the specific keywords selected for the literature review. The search can be expanded using snowballing techniques. Second, although our framework identifies key steps and elements required to deal with EA erosion, additional work is necessary to build prescriptive knowledge. Future research will look at what is and what is not in the model. Design science research (Hevner, March, Park and Ram, 2004) is the selected research approach to continue our work in the EA branch of a major European retail group. First, the EA Erosion Framework will be implemented in a SRI selected by the case company to continuously (1) monitor, (2) trigger changes in the architecture and EA practices, (3) complete the set of routine and non-routine procedures, (4) evaluate, and (5) communicate the results. Second, the typification of erosion factors in different scenarios of the architecture will be modeled using ArchiMate. This output can assist enterprise architects in the prioritization of SRIs (e.g., balancing multiple collaboration elements in the application layer or competing strategies influencing the

business layer) and selecting the most effective indicators (for impact and factors) and actions (routine and procedures). Finally, we will evaluate the results in the case organization, projecting design principles (Baskerville and Pries-Heje, 2019) to improve EA erosion management capabilities.

For theory, this paper contributes to reveal the unique role of EA erosion in the creation of value. On the one hand, erosion can be visible in models lacking maintenance. On the other hand, erosion can be invisible in emergent and subtle arrangements of EA elements that exist in all organizations. For practice, this work can assist EA teams in their strategic intent to improve organizations through systems analysis and design.

## Acknowledgements

This work is funded by national funds through the FCT-Foundation for Science and Technology, I.P., within the scope of the project CISUC-UID/CEC/00326/2020 and by European Social Fund, through the Regional Operational Program Centro 2020.

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