

# Future Research Topics in Enterprise Architectures Evolution Analysis

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**Abstract:** An Enterprise Architecture (EA) embraces an organization’s technical infrastructure, applications, business capabilities, and relationships among them. Evolutionary design is a common characteristic for such an EA. An EA can be considered as a complex system of systems, whereas the actual efforts for its maintainability and evolution have a high influence on the enterprise’s capability to quickly respond to market changes. A common means to analyze an EA are visualizations. However, research on visual means for analysis of EA evolutions is scarce. In this paper we outline visual means to analyze the evolution of EAs and motivate research on this topic by outlining related challenges.

## 1 Introduction and Motivation

Over the past decades enterprise application landscapes have grown to complex systems of systems intrinsically complex and hard to manage as a whole [WR09]. As a reaction, Enterprise Architecture (EA) management seeks to cope with this complexity. Goal of this young discipline is to increase business/IT alignment, while reducing operational costs in order to respond to frequently changing business models, to enable faster business transformations, and, thus, increase shareholder return. Commonly, an EA endeavor starts by documenting the current (AS-IS) state in an EA repository. Especially when focusing on recent trends [BE12] such as *automated EA documentation* (cf. [Bu12,Gr12,Fa13,Ro13]) the underlying information model (cf. [Le99]) of such an EA repository tends to change frequently. Automated EA documentation consolidates existing EA information sources from an operative IT environment in order to gather relevant information. Practical applications show, that for automated EA documentation, the EA repository’s information model is extended over time [Ha12b], i.e. it evolves.

According to [Bu08], EA visualizations<sup>1</sup> consist of a finite number of variations identified as EA patterns, such that they can be predefined in an abstract manner by employing variability points [SMR12,Ha12a]. We implemented these visualizations

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<sup>1</sup> We refer the interested reader to [Bu08] for a predefined set of best-practice EA visualizations gathered from industry.

based on a non-rigid typed system called Hybrid wiki [Ma11]. This web-based wiki system allows capturing not only plain text, but also structured information in a user-friendly manner. Moreover, it can be used as a flexible store for automated EA documentation [Ha12b]. In [Bu10b] we sketched a conceptual model where we outlined the evolutionary characteristic of EA transformations guided by principles and standards. Thereby, also agile approaches, e.g. [Bu11], could be applied. With respect to agile approaches that may change EA information more frequently and against the background of the recent trends of automated EA documentation, an overview of the EA evolution could be highly beneficial for an evidence-based management of the EA.

EA management has to serve information to multiple stakeholders with different concerns and often unclear goals. Due to the diverse nature of these concerns, stakeholders require their individual viewpoints (cf. [ISO07]). Large enterprises commonly comprise  $10^2$ - $10^3$  information systems interconnected via interfaces, i.e. respective viewpoints represent complex interlinked data such that visualizations (views) have been established as a common means for analysis [Ha12a].

As of today, visualizations can be generated based on EA models applying transformation techniques [Ha12a,SMR12]. However, when it comes to historical information of EAs, i.e. analyzing its evolution, literature is scarce. In this paper we outline a brief example for a fictitious enterprise to illustrate challenges and the complexity EA management has to deal with. Our long-term research question is: *How can we visualize the evolution of an EA model?* This paper serves as a basis for discussion and problem understanding.

## 2 Analyzing the Evolution of Enterprise Architectures

In our example (cf. Figure 1), a fictitious enterprise has been grown by Mergers & Acquisitions (M&A). For the application landscape consolidation, they chose an absorption strategy (cf. [Ec12]). In this particular scenario, a new subsidiary in Hamburg has been acquired. The respective applications of acquired (and mostly redundant) business units have to be migrated in terms of customer data and/or entire application systems. The former often represents the real asset acquired through an M&A. However, for simplicity, we abstract from that.

Figure 1 illustrates multiple migration steps beginning with the acquisition in 2012 until a final state in 2016. Until then, acquired business units should be entirely absorbed by the existing ones. Applications of a consolidated business unit are not used, but fully functional for the purpose of proper data migration. In 2013, the enterprise plans to migrate applications of the IT department located in Hamburg to the applications of the IT department located in Berlin. In 2014, most of the applications of the R&D unit located in Hamburg should be absorbed by the R&D unit located in Frankfurt. In 2015, remaining applications of HR, production, and R&D located in Hamburg should be absorbed by the respective facilities in New York.

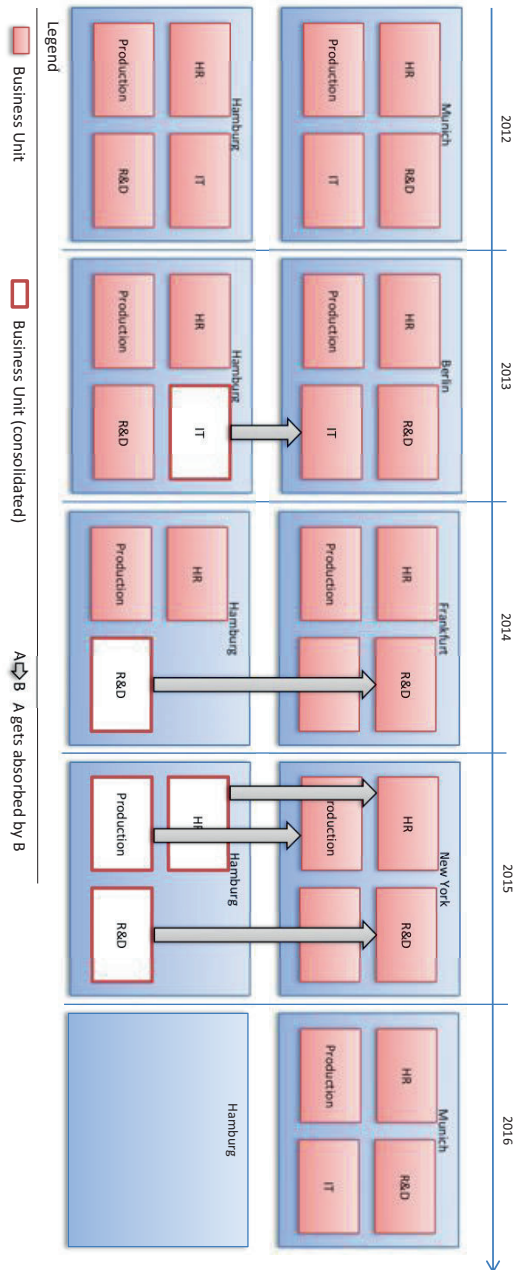


Figure 1: Visualization of multiple migration steps of an EA during an M&A scenario.

In Figure 1, we applied time series [Tu01] to the domain of software cartography [Ma08]. The boxes are ordered by the transformation steps. Note that the outer boxes stay at the same size, such that existing box layout algorithms, e.g. the next-fit decreasing height (NFDH) algorithm, cannot be applied to sort and layout visual elements.

### 3 Limitations, Challenges, and Ideas for Future Research

Against the background of automated EA documentation, we assume that increasingly operative information will be imported in EA tools. Thus, the amount of data will increase and for planning purposes must be compared with existing 1) previous data, 2) planned states, and 3) a target state. During implementation, we identified the following challenges that arise when visualizing the evolution of EAs:

**Scalability.** The presented solution can only be applied when comparing two entities (business units) with each other. We identify the arrangement of multiple business units, or more general multiple entities becomes an issue when applying existing EA viewpoints to historical information. Viewing at more than one dimension at a time easily ends up in an information overflow. Different visualizations known from EA management must be re-evaluated, whether they might serve for the visualization of evolutionary information, e.g. binary/ternary matrix, (directed acyclic) graph, (cf. e.g. [Bu08]).

**Scoping vs. “Big Picture”.** Other scenarios often seen in the domain of EA management are standardization of business applications, harmonization, etc. (cf. also Figure 2) such that the history (versions) of one business unit or one business application could be subject of interest for a deeper analysis. In contrast, a high-level overview sometimes is also beneficial. Of course, this strongly depends on the actual stakeholder.

**Layout algorithms.** So far applied layout algorithms for EA visualizations aim at esthetical pleasing layouts, e.g. decreasing the overall height of boxes with respect to an aspect ratio in case of the NFDH algorithm. For instance this particular algorithm would close any open space (white-spots) that are created, e.g. during migrations and are actually useful to communicate (the amount of) change when analyzing EA evolutions.

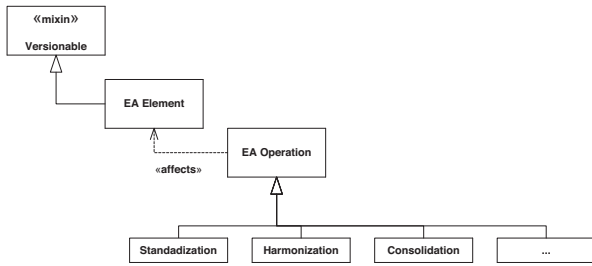


Figure 2: Meta-model to illustrate the relationship between versions, EA Element, and EA Operations

**Generic vs. special purpose solutions.** We expect some of the solutions developed will be generic, whereas others will be very specific for the domain of EA and EA management (similar to [Bu10a]). Figure 2 illustrates the relationship of versions of EA elements to EA operations. These operations are usually executed as methods through a project. In order to communicate change, the actual applied method must also be captured by an EA meta-model. The (meta-)data required to generate such visualizations of the EA evolution in an automated manner currently has not been addressed by existing EA literature. For instance, must transformation operations be modeled and maintained explicitly or is it possible to infer respective information from existing data or at least in an automated manner from existing information sources.

**Communication of timespans.** When comparing two different EA states with each other, it might be beneficial to get visual feedback on the actual timespan (and time differences) visualized. Existing visualization approaches, e.g. [Tu01], may be helpful for this purpose.

Above outlined challenges represent a non-extensive list to be addressed by further research. In a first step, this list should be evaluated concerning practical relevance in the domain of EA management.

## 4 Outlook

In this paper we illustrated a brief example of an organization which absorbed an entire EA in the vein of an M&A scenario. Especially when focusing on historical information (versions of the EA) we outlined several issues to be addressed by further research. The illustrated example serves to motivate the problem and its complexity rather than sketching a solution.

We seek to discuss the presented approach, other visual representations and possibilities to communicate evolution of models in general and in particular of EA models at the Design for Future 2013 workshop. In particular we foresee discussions about analogies between communication of change (and evolution) of software architecture and EA models.

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