

# Using Enterprise Architecture Management Patterns to complement TOGAF

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**Abstract**—The design of an Enterprise Architecture (EA) management function for an enterprise is no easy task. Various frameworks exist as well as EA management tools, which promise to deliver guidance for performing EA management. Nevertheless, the approaches presented by them stay either on a level too abstract to provide realization support or are far too generic, neglecting enterprise-specific EA related concerns. In this article, we discuss the architecture framework of The Open Group (TOGAF) and detail on its promising but nevertheless highly generic architecture development method (ADM). This article shows how the generic development steps can be complemented by a pattern based approach to EA management providing guidance for addressing specific EA related concerns with step-by-step methodologies as well as with corresponding viewpoints and information models.

## I. INTRODUCTION & MOTIVATION

Enterprise Architecture (EA) management forms an interesting research subject of the information systems discipline. But the design of the EA management function in an enterprise is undisputedly also a topic of high relevance for practitioners. This is especially true for enterprises that are on the way to establish an EA management, which should help them to e.g. increase alignment of business and IT. If these enterprises want to step beyond the initial declaration of intent, different frameworks and tools are await, promising to provide guidance for the establishment and execution of EA management. An extensive survey [1] on EA management tools nevertheless showed that only some of the tools pursue a *methodology* or *process driven* approach, which provide guidance for EA management execution. As discussed in [2], this guidance lacks specificity, i.e. is not tailored to the specific EA management understanding of the specific enterprise.

The prominent EA (management) frameworks fall for a similar problem. They cannot provide guidance without reducing specificity of their approach. This can be exemplified with the Zachman framework [3], which gives quite abstract indications on how to perform EA management merely by providing structuring guidelines for the EA. In contrast, the federal enterprise architecture framework (FEAF) [4] can give rather concrete EA management guidance, which is nevertheless specifically tailored to the application in governance agencies in the United States. The architecture framework of The Open Group (TOGAF) [5] is considered by practitioners as an interesting framework in this context. By providing a development method for enterprise architecture, the so called

*architecture development method (ADM)*, it provides guidance on a less abstract level than the Zachman framework. Nevertheless, the ADM is developed to be a generally applicable EA management process, not tailored to a narrow application field as FEAF. With the recent rework of TOGAF for version 9, the ADM was further complemented with an *information model*, describing the information about the EA, which should be stored to support EA management. Due to the genericity of the EA management approach, the information model of TOGAF is designed to all-embracingly cover the concepts needed to describe an EA. An enterprise trying to establish an EA management process in accordance to TOGAF 9 is likely to run into the problems associated with highly generic models as discussed in [6].

In this article, we discuss how the pattern-based approach for EA management as discussed in [7], [6], [8] can be used to complement the ADM of TOGAF with appropriate and extensible information model fragments as well as visualization forms to support EA management. We further discuss, how these patterns can be employed to construct an enterprise-specific implementation of the ADM, and sketch for an exemplary EA management task, how such a tailored ADM could look like. Section II gives an overview on TOGAF with an emphasis on the ADM described therein. Additionally, TOGAF is juxtaposed by the EA management pattern catalog [9] – a realization of the pattern-based approach to EA management. The aforementioned discussion on how the EA management pattern catalog can be used to complement TOGAF with implementation details is performed in Section III. Section IV discusses how roadmaps for application landscape management can be developed according to the pattern-based approach, and shows how these patterns can be employed to complement the ADM. Final Section V concludes the article and sketches future directions of research.

## II. EXISTING EA MANAGEMENT APPROACHES

Various approaches for EA management are known originating from governmental institutions (see e.g. [4], [10]), standardization bodies (see e.g. [5]), academia (see [9], [11], [12]), and practitioners (see e.g. [13], [14], [15]). According to [16] two of the more promising approaches are the TOGAF framework [5] and the EAM pattern approach [9], which will be detailed in this section to lay a basis for integrating both approaches.

### A. The Open Group Architecture Framework

In February 2009 version 9 of the TOGAF framework [5] superseded version 8.1.1. The new version introduced some additional features to support an enterprise-specific EA management approach:

**Modular structure:** In TOGAF 9, content that was contained in the resource base in TOGAF 8.1.1, has been modularized to improve usability and incremental adoption.

**Content framework:** TOGAF 9 includes a content framework with a model of architectural work products for improving consistency throughout the created deliverables<sup>1</sup>.

**Extended guidance:** TOGAF 9 has been extended by a logical information model and a capability framework with definitions of the organization, skills, roles, and responsibilities.

**Architectural styles:** This feature provides a set of additional guidelines on how to adapt the process of TOGAF to specific situations like service oriented architecture (SOA) or how to address a security architecture.

In version 9 TOGAF consists of six main parts.

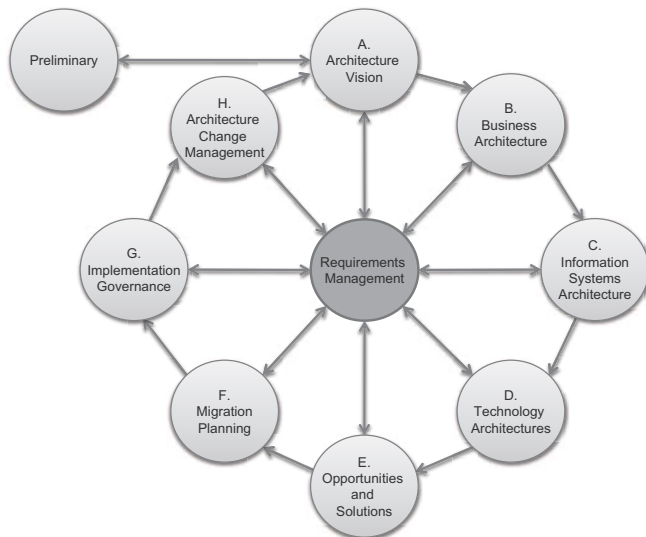


Fig. 1. The architecture development method cycle [5]

The *ADM* describes the ten different phases of EA development (see Figure 1) as a generic method. These phases are detailed in Section III and are discussed in more depth in Section IV. TOGAF 9 discusses different ways to adapt the method to different *process styles* and to utilization on different *enterprise levels*. These ways are discussed in the *ADM guidelines & techniques* section of the framework. Nevertheless, the adaptation possibilities are limited in some ways, as e.g. different ways to organize the enterprise's IT function (cf. [17]) are not alluded to.

The *content framework* is one of the novelties of TOGAF 9. It provides a conceptual metamodel for describing architectural artifacts. TOGAF 9 does nevertheless not regard this

<sup>1</sup>A deliverable according to TOGAF is a *work product that is contractually specified and in turn formally reviewed, agreed, and signed off by the stakeholders*. [5]

metamodel to be compulsory and explicitly accounts for the combined usage with other conceptual metamodels, like the Archimate model [12].

The *enterprise continuum* provides a model for structuring a "virtual" repository that can be filled with architectural assets and their possible solutions like models, patterns, architectural descriptions, etc. Two main goals of the enterprise continuum are to emphasize reuse and to support communication.

The *TOGAF reference models* are divided into the *TOGAF foundation architecture* and the *integrated information infrastructure reference model (III-RM)*. The foundation architecture is embodied in the *technical reference model (TRM)*, which is universally applicable and can be used to build any system architecture. The III-RM helps to address the need to design an integrated information infrastructure with reference designs.

### B. EAM Pattern Approach

Documenting proven-practice solutions to recurring problems in a specific context by so called *patterns* has initially been introduced by [18] in the field of architecture. Computer science has adopted this approach in the field of software engineering [19] and software architecture [20]. EAM patterns, as proposed in [8], provide general, reusable solutions to common problems in EA management, in a given context, identifying driving forces, denoting known usages, and consequences. Thus, EAM patterns are descriptions of a real world solution gained from observation.

The pattern-based approach to EA management has been developed to address typical problems of existing EA management approaches like too abstract guidelines, which lack appropriate guidance to be used in practice, or monolithic approaches pursuing an all or nothing approach neglecting the specific demands of an enterprise. An initial set of pattern has been collected from literature and practice, and has been evaluated in an extensive survey, resulting in version 1.0 of the EA management pattern catalog containing 120 EAM patterns.

Four types of patterns for EA management have been identified. Methodology Patterns (*M-Pattern*) define steps to be taken in order to address a given problem (also known as concern). Viewpoint Patterns (*V-Pattern*) provide a language used by one or more M-Patterns and thus propose ways to present data stored according to one or more information model patterns. Information Model Patterns (*I-Pattern*) supply an underlying model for the data visualized in one or more V-Patterns. In contrast to those three EAM patterns types, Anti-Pattern for EA management document solutions, which have proven not to work in order to prevent blind alleys. Patterns of all the aforementioned types form a pattern language for EA management, which is continuously improved and extended<sup>2</sup>.

The EA management pattern catalog supports different usage scenarios, of which two are of major importance for this article and are detailed below. For information on the other

<sup>2</sup>For current information on the EA management pattern catalog see the EAM Pattern Catalog Wiki <http://eampc-wiki.systemcartography.info>.

scenarios see [21]. The first usage scenario is *establishing a light-weight, enterprise-specific approach to EA management based on best-practices*. In this scenario, the concerns of the stakeholders in the enterprise have to be identified. These concerns are subsequently used to select the appropriate EAM patterns for addressing these concerns. The selected patterns are integrated to a conceptual model, which is subsequently implemented, e.g. using an EA management tool. Figure 2 shows the steps of this usage scenario.

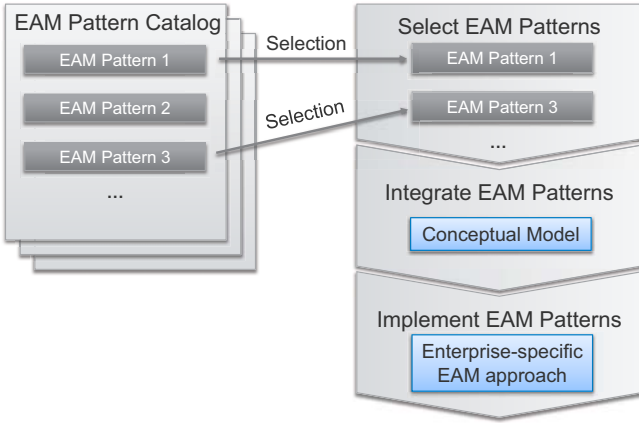


Fig. 2. The EAM pattern approach

A second usage scenario for the EAM pattern approach is to *inspire and assess an existing EA management approach*. In this case the EA management pattern catalog is used as a reference book for suggestions for improving the approach currently executed in an enterprise. Another aspect in this usage scenario is the extension of an already established EA management approach by utilizing an important aspect of a pattern language, the relationships between patterns. An EAM pattern includes references to other patterns, which can then give suggestions, which EAM patterns could be used to extend and improve the current EA management approach.

TOGAF and the EA management pattern catalog both provide means to develop an enterprise-specific EA management approach. As TOGAF explicitly states that the ADM complements and can be used in conjunction with other frameworks [22]. The ADM establishes the cyclic process to manage the EA and thereby addresses the business requirements. The EA management pattern catalog in contrast does currently not contain an integrated process description for EA management, but best-practice solutions how to address specific EA management concerns. In the subsequent sections, we detail on how a comprehensive, enterprise-specific EA management approach can be developed and established within an enterprise utilizing TOGAF and EAM patterns.

### III. COMPLEMENTING TOGAF USING THE EA MANAGEMENT PATTERN CATALOG

The EA management pattern catalog provides best-practices for addressing typical EA management concerns. These best-practices employ their own process descriptions. Due to this

specificity of the approach, the EA management pattern catalog does not provide an overall process description. In contrast, TOGAF provides a cyclic process model – the ADM, which details on a sequence of phases to develop and evolve an EA. The distinct phases of the ADM provide a description for the objectives, an overview about the pursued approach, the required inputs, the steps to be executed, and the resulting outputs of the phase, which might serve as input for the next phase of the ADM cycle.

Subsequently, we detail the single phases of the ADM cycle, give a short overview on the steps conducted in each phase, and give indications how the EA management pattern catalog can be used to complement the generic methodology of TOGAF with best-practice solutions gathered from practitioners and academia. The EA management pattern catalog is continually improved and extended, therefore not for all phases of the ADM cycle best-practice solutions have yet been documented. Although TOGAF and the EA management pattern catalog are both based on the terminology introduced in the IEEE 1471-2000 [23] the terms employed in the approaches differ slightly. The terminology used throughout this paper is equivalent to the one used in the EA management pattern catalog and a mapping to the wording used in TOGAF is given, if necessary.

The TOGAF ADM cycle starts with the *Preliminary* phase, which prepares and initializes the EA management approach. Typical tasks executed in this phase include the definition and establishment of the EA team, the selection and implementation of supporting tools, as well as the definition of architecture guidelines and principles.

After the preparation and initialization activities are performed, the scope of the EA management endeavor is defined within the *Architecture Vision* phase (A). A core objective of this phase is to identify the relevant stakeholders and their concerns. Whereas TOGAF details on the management of stakeholders and explicates categories of stakeholders, e.g. *Executives, Line, Manager, and Business Process Experts for the Project Organization*, no procedure how to gather the relevant concerns is given. Based on the identified stakeholders and concerns a high-level architecture vision of the enterprise is derived in this phase.

*How the EA management pattern catalog can complement the ADM phase A:* The EA management pattern catalog can be used to support the identification of relevant concerns, as it explicitly lists typical concerns in the context of EA management. These concerns can be used as input to the stakeholders identified according to TOGAF.

Based on the architecture vision developed in the preceding phase A, the corresponding business, information systems, and technology architecture is developed in the following *Business Architecture (B), Information Systems Architectures (C), and Technology Architecture (C)* phases. The fundamental make up of these three phases is very similar: Initially, the current architecture<sup>3</sup> is described. Based on this architecture

<sup>3</sup>The current architecture is referred to as *Baseline Architecture* in TOGAF [5].

architecture is developed taking the architecture vision into account. This vision was formulated as part of the preceding phase. A gap analysis is performed to evaluate the differences between the current and the target architecture.

*How the EA management pattern catalog can complement the ADM phases B,C, and D:* TOGAF describes only a generic EA management process, which needs to be adapted to the specific needs of an enterprise. In order to perform this adaption the EA management pattern catalog can be used to facilitate the following considerations:

- Identify concepts to be collected – No information about the exact data to be gathered within the Phases B to D is given. Nevertheless, the importance of gathering only the necessary information to avoid gratuitous effort is referred to by an advice given in TOGAF: *Gather and analyze only that information that allows informed decisions to be made relevant to the scope of this architecture effort.* [5]. The EA management pattern catalog can be used here, to derive the needed information from the concerns identified in the *Architecture Vision* phase. In contrast to TOGAF, the EA management pattern catalog follows a concern-driven approach and supports the deduction of relevant information model fragments corresponding to the selected concerns.
- Determine overall modeling process – In order to perform this task, best-practice solutions as documented in the M-Patterns of the EA management pattern catalog can be used. Best-practice solutions for information modeling and data maintenance processes can e.g. be found in [24].
- Identify required visualizations – TOGAF details on the importance of choosing the appropriate viewpoints to ensure that the concerns of the stakeholders are covered. Furthermore, the viewpoints need to be selected according to their appropriateness for the stakeholders involved. The EA management pattern catalog can be used to ensure the suitability of models and viewpoints as it directly links V-Patterns to concerns.

The phase *Opportunities and Solutions (E)* is concerned with the derivation of projects and programs, which describe the transformation from the current to the target architecture via intermediate planned architectures<sup>4</sup>. The major steps to be performed in this phase are the consolidation of the gap analyses from phases *B* to *D*, the identification, refinement, and validation of dependencies between the different architectural layers, and the derivation of planned architectures, which group projects and portfolios.

*How the EA management pattern catalog can complement the ADM phase E:* The deduction of planned states can be supported by the EA best-practice solutions as documented in the EA management pattern catalog. Lankes [25], for example, proposes an M-Pattern to automatically generate possible planned architectures in the context of failure propagation.

The aforementioned planned architectures form the input of the *Migration Planning* phase (*F*), which is concerned with

the formulation of an implementation and migration plan that schedules and realizes some or all of the planned architectures. The major steps within this phase are the assignment of a business value to each project, the prioritization of projects, and the generation of a roadmap and migration plan.

*How the EA management pattern catalog can complement the ADM phase F:* The aspect of time-dependence arising in the context of migration planning leads to certain demands regarding an information model and the visualizations used in this phase [26], [27]. An exemplary information model and viewpoints supporting this phase are given in Section IV.

In the phase *Implementation Governance (G)* the projects selected for realization in the preceding phase are executed. Major tasks of this phase are the identification of deployment resources and skills, monitoring of the execution, and the conduction of reviews, e.g. regarding architecture compliance.

*How the EA management pattern catalog can complement the ADM phase G:* The implementation aspects of concerns are addressed in the EA management pattern catalog as part of the EAM patterns, which give indications on implementation details. An example of an implementation detail originating from the context of architectural standardization is discussed in [7].

The *Architecture Change Management* phase (*H*) concludes an ADM cycle and prepares the initiation of another cycle. As part of the phase, the changes of the architecture are assessed. Key tasks of this phase are the deployment of monitoring techniques for the architecture process, the development of change requirements to meet performance targets, and the management of the governance process.

Above, possibilities to complement the generic process of TOGAF with patterns from the EA management pattern catalog were discussed. The concern-driven approach of the EA management pattern catalog is thereby used to realize the generic steps of TOGAF. Especially the possibility to derive the information model from the concerns risen by the stakeholder provides an extension to the methodology of TOGAF. Furthermore, the best-practice visualizations of the EA management pattern catalog can be used to augment the deliverables defined within TOGAF. An application example showing how selected phases of the TOGAF ADM can be complemented with specific patterns from the EA management pattern catalog is given in the following section.

#### IV. DEVELOPING A ROADMAP FOR APPLICATION LANDSCAPE EVOLUTION

The managed evolution of the application landscape is commonly regarded a focal point of EA management endeavors [28], [29], [30], [31], [32]. Hence, application landscape management is used as an application example for the approach presented above. The application landscape can be seen as a juncture of business and IT as its central concepts are the business applications, which on the one hand provide support for business processes and therefore exchange information via certain interfaces and on the other hand run on certain IT

<sup>4</sup>Planned architectures are called *Transition Architecture* in TOGAF [5].

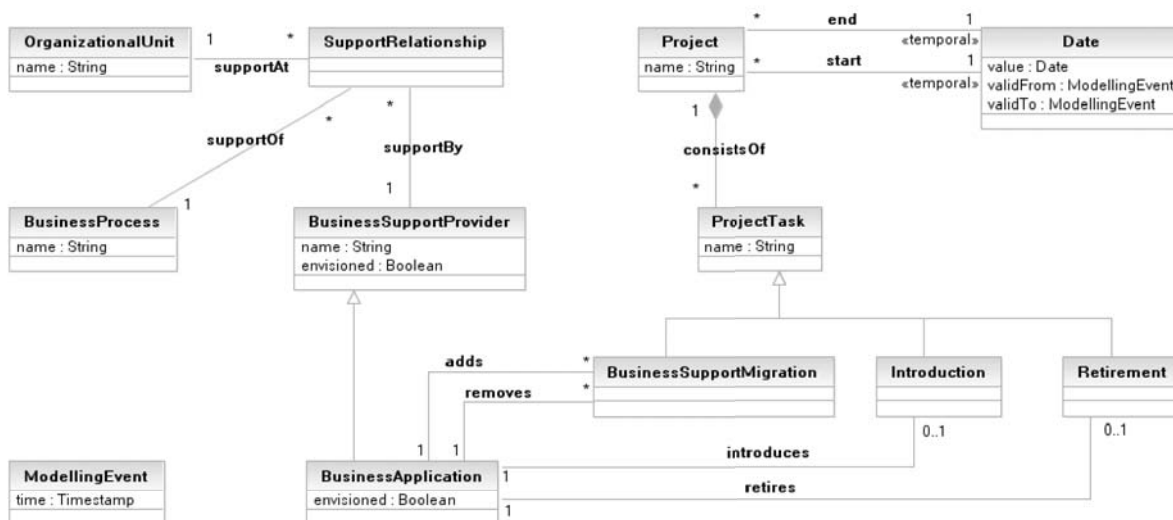


Fig. 3. Information model for the managed evolution of application landscapes

infrastructure. As explicated in Section III the core contributions of the EA management pattern catalog can be found in the phases *A* to *G*. Therefore, these phases are subsequently detailed and the potential for complementing these phases by the EA management pattern catalog is explicated.

Following the ADM cycle, the stakeholders of the application scenario are identified in phase *A* – Architecture Vision. Exemplary stakeholders, which are concerned about the managed evolution of the application landscape are e.g. CxOs, the Program Management Office, and Executives. The concerns of these stakeholders need to be defined in order to ensure their commitment to the EA management endeavor and keep them satisfied. The list of EA management concerns as contained in the EA management pattern catalog can be used to facilitate the discussions during identification of the stakeholders’ concerns. The following concern was selected to motivate the application example:

How can we ensure a managed evolution of the application landscape? Thereby, future planning and traceability of management decisions needs to be supported and business as well as technical aspects needs to be taken into account.

Prior to developing an integrated view on the EA, the ADM cycle starts with the documentation of the business architecture (phase *B*), information systems architecture (phase *C*), and technology architecture (phase *D*) of the enterprise. Thereby, the EA management pattern catalog can be used to derive information about the data that needs to be gathered in order to address the above stated concern. The corresponding

information model of an I-Pattern is shown in Figure 3<sup>5</sup>.

The EA management pattern catalog provides a glossary of the terms used in the I-Pattern to ensure a common understanding of the involved stakeholders regarding the concepts in the information model:

- **Business application** is a software system, which is part of a business information system of an organization. A business application thus provides support for at least one business process, i.e. infrastructure systems are not considered business applications in this context.
- **Business process:** A business process is defined as a sequence of logical, individual functions with connections in between. A process here should not be identified with a single process step, as found e.g. in an event driven process chain (EPC). It should be considered a coarse grained process at a level similar to the one used in value chains, i.e. partially ordered, linear sequences of activities. Additionally, a process maintains relationships to the business applications, which support it at the different organizational units. As in application landscape management, the business processes are considered to be fixed, i.e. they are not transformed by projects.
- **Business Support Migration** represents a project task migrating the provision of a specific business support from a **source** business application to a **target** one. The business support is considered fully migrated, once the date specified in **endsAt** has passed.
- **Business support provider:** A business support provider is a constituent of an application landscape, used to

<sup>5</sup>When describing the concepts of the information model the terminology used in the EA management pattern catalog, as the content metamodel of TOGAF does not bring along concepts for modeling temporal aspects of EAs.

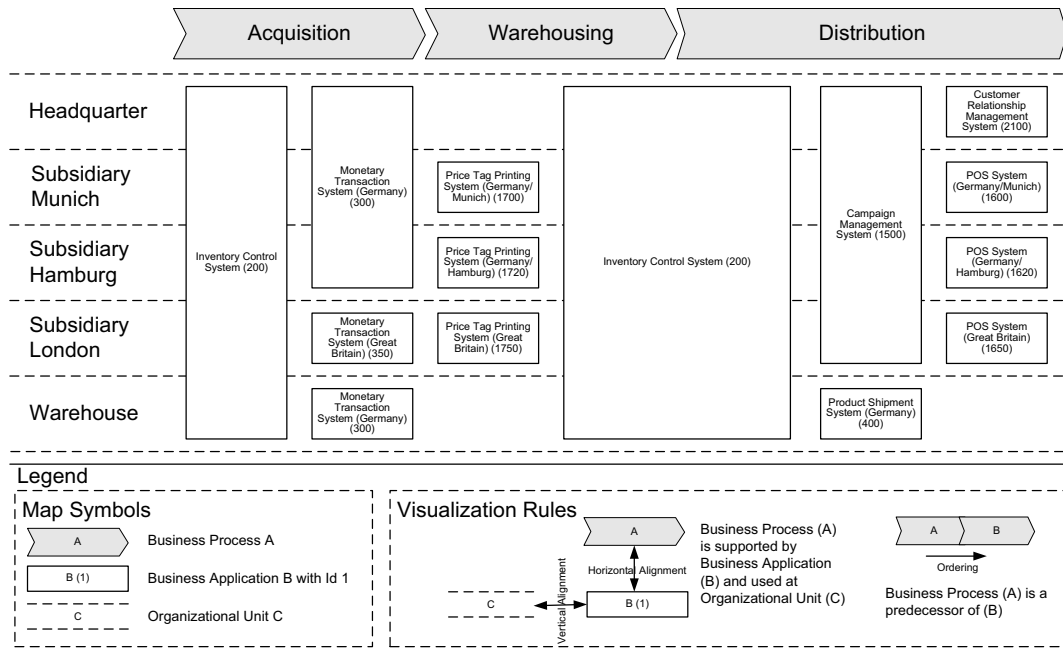


Fig. 4. Exemplary view according to V-Pattern business process support map

indicate that a related business process is supported at a distinct organizational unit, without giving a specification, which business application is likely to provide this support, if any. In spite of the similarities to the business application, the envisioned support provider is not affected by projects but has nevertheless a period of validity associated. Thereby, it references the point in time it has been modeled at and (optional) the point in time, the provider became invalid.

- **Introduction** is a specific type of project task introducing a distinct business application. After the date specified in **endsAt**, the associated business application is considered to be *in production*.
- **Organizational unit:** An organizational unit represents a subdivision of the organization according to its internal structure. An organizational unit is a node of a hierarchical organization structure, e.g. a department or a branch. In application landscape management, organizational units are considered fixed - thus, they are not transformed by projects.
- **Project:** Projects are drivers of organizational change. Therefore, adaptations of the application landscape are the result of a project being completed. Projects are scheduled activities and thus hold different types of temporal attributes, their **startDate** and **endDate** on the one hand. On the other hand, projects are **plannedAt** respectively **removedAt** certain points in time referring to the time of their creation or deletion. This effectively results in a period of validity, which is assigned to each project. In application landscape management, projects are considered to only affect business applications in

general and their business support provided, in special. Projects do not affect business processes or organizational units in this model.

- **Project task** is the abstract base concept for the different accomplishments of projects as considered in this pattern. Each project task spans a distinct period of time, enclosed by the two points in time **startsAt** and **endsAt**. The project tasks indicate the discrete events of change, connecting the different states of the EA to a chronological sequence.
- **Retirement** is a specific type of project task retiring a distinct business application. After the date specified in **startsAt**, the associated business application is considered to be *in retirement*.
- **Support relationship:** represents the support of a specific business process by a specific business support provider at a specific organizational unit.

In order to gather data according to the aforementioned information model, different M-Patterns ranging from automatic via centralized to decentralized manual data acquisition as described in [24] can be utilized. Furthermore, the EA management pattern catalog provides support for the identification of required viewpoints, which visualize the respective concepts of the information model. A cluster map [33] can be utilized to describe the information systems architecture and explicate the business applications of the enterprise and their responsible organizational units.

Based on the development of the individual architectures (business, information systems, and technology) an integrated view on the current and target architectures is created in the opportunities and solutions phase *E* of the ADM. Therefore, a



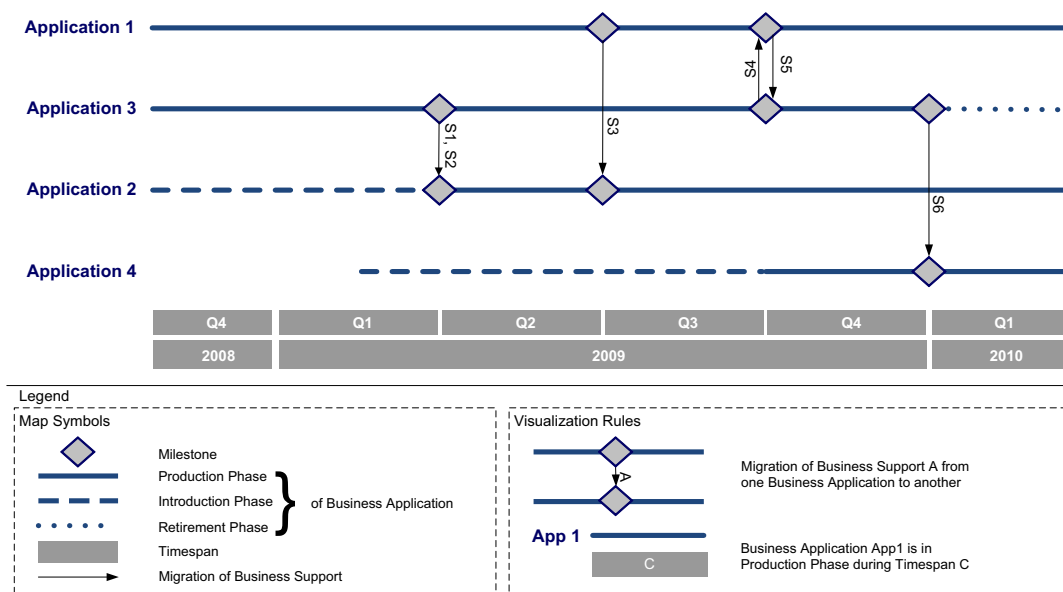


Fig. 5. Exemplary view according to V-Pattern business support migration roadmap plan

viewpoint according to V-Pattern process support map (see Figure 4) can be utilized. The viewpoint visualizes which business application supports which business process at which organizational unit.

Viewpoints, like the process support map can additionally be used to perform gap analyses between different states of the architecture [1]. Thereby, differences between the states are highlighted on the viewpoint e.g. via color-coding, shadowing, or hatching [9]. In order to derive intermediate planned states of the EA, M-Patterns as e.g. introduced in [26] or [25] can be utilized. [26] for example explicates a method how different planned states of the EA can be derived from a project portfolio selection.

The developed planned states of the EA provide input for the migration planning phase *F* of the ADM. Within this phase a roadmap for the transformation of the EA is developed including milestones for the evolution of the EA. While TOGAF only details on viewpoints, which provide snapshots of the EA at a certain time, similar to the process support map introduced above, the EA management pattern catalog contains V-Patterns, which can be utilized to detail on transformation impacts of the provided business support of an enterprise [27]. Figure 5 provides a business support migration plan, which explicates the migration of business support during the transformation of the application landscape.

In order to document information according to the viewpoints from Figure 4 and Figure 5 an information model suitable to store time-related information as introduced above is necessary. Although, TOGAF contains an information model, time-related aspects are not referred to in the current version.

After the roadmap for the EA transformation is developed and decided upon in phase *F*, phase *G* – implementation governance – realizes the transformation. M-Patterns of the

EA management pattern catalog can provide input for the implementation of this phase. An M-Pattern, for example, provides information how to identify critical projects, e.g. due to high risks, business impact, or changes to critical business applications. Furthermore, a procedure how to establish quality gates to ensure the architecture-conform development of the project is explicated in the M-Pattern.

## V. REFLECTION AND OUTLOOK

In this paper, we discussed the ADM of TOGAF, which provides guidelines for establishing and executing an EA management process. These guidelines nevertheless stay on a rather generic level and might hence not be directly applicable to a specific enterprise. Subsequently, the pattern-based approach to EA management as presented in the EA management pattern catalog was discussed, which provides guidance for addressing specific EA related concerns with methodologies, viewpoints, and information models. From this, we elaborated how the pattern-based EA management approach can be used to complement the ADM, in order to create an enterprise specific EA management approach accounting especially for the enterprise's high priority EA related concerns. The idea was further exemplified in Section IV with a description, how the managed evolution of application landscapes reflected in TOGAF steps *E* and *F* can be supported by selected EAM patterns.

Due to the novelty of TOGAF 9, the presented idea of complementing the ADM with EAM patterns has yet not been assessed in practice. A current research project is trying to show the applicability of the proposed approach in cooperation with a telecommunications company. The EA management process of this company is structured according to the TOGAF ADM – the details of the process are established using the EAM patterns.

The utilization of EAM patterns for complementing an EA management reference process gives rise to a research question for the further development of pattern-based EA management. The patterns currently documented in the EA management pattern catalog are very likely to span different phases of an EA management process, as they provide comprehensive best-practices for addressing a specific concern as a whole. It might nevertheless be interesting to investigate, if these pattern could be organized according the phases of an EA management process in addition to their specialization on distinct concerns. Doing so, modularity of the EA management approach could be further promoted, allowing an enterprise to choose the patterns e.g. for documenting concern-specific information independently from the patterns for enacting control over the projects, in which the respective concern is addressed. In this context more in-depth considerations on an EA management reference process would be necessary.

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