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A Federated Approach to Enterprise Architecture Model Maintenance

Enterprise architecture is gaining acceptance as an approach to manage change and foster IT/business alignment by (1) propagating strategy and process changes to the software and infrastructure level, by (2) supporting consistent business transformation enabled by technology innovations, and by (3) decoupling business-oriented and technology-oriented architectures. Due to constant change in business as well as in technology, enterprise architecture management is a permanent process rather than a one-time effort. To keep enterprise architecture models up-to-date, a well-engineered maintenance concept including processes, roles and schedules is needed. This paper discusses the shortcomings of existing approaches to enterprise architecture model maintenance, proposes a federated approach, and reports on its implementation at a large financial service provider.

1 Introduction

In recent years, companies are exposed to frequent changes in their social and economic environment. In particular, companies are faced with major challenges such as:

- An increasing complexity of business transactions due to customization of products and services as well as growing globalization with respect to service development, service creation, and service distribution [RoWR06; WBLS05].
- An accelerated rate of change in business models due to fierce, international competition [RoWR06; Sche05a; WBLS05].
- A growing regulatory framework, which forces companies to prove that they have a firm understanding of their operations and that they comply with applicable regulations [Lank05; Sche05a] such as Sarbanes-Oxley Act (SOX), Basel II or Solvency II.
- A growing dependency on information technology which enables completely new products and business processes [Dave93; Venk91]. As a consequence thereof, companies are increasingly threatened by technology-related risks.

Companies have to adapt their corporate strategies continuously and have to align corporate structures with strategic goals. Corporate structures comprise organizational structures and processes as well as supporting information systems and technologies. Enterprise architecture (EA) describes the fundamental structure of an enterprise [Open03; Rood94; Sche04; WiFi06] and supports transformation by offering a holistic perspective of as-is as well as to-be structures and processes [Lank05].

EA is gaining acceptance as an approach to manage change and foster IT/business alignment by (a) propagating strategy and process changes to the software and infrastructure level, by (b) supporting consistent business transformation enabled by technology innovations, and by (c) decoupling business-oriented and technology-oriented architectures [BuSo02; RoWR06; Veas01; WBLS05]. Empirical studies confirm the strategic importance of EA. According to a study conducted in 2005 by the Institute for Enterprise Architecture Developments (IFEAD), 66% of the respondents consider EA as an important element of their strategic governance processes [Sche05b]. Another study conducted in 2006 among Swiss and German companies reveals that 38 from 51 interviewed companies are either currently implementing EA models, or are already using EA models [BFKW06]. Besides supporting strategy execution, a large number of other EA application scenarios exist, e. g. business continuity planning, security management, compliance management and sourcing management [BFKW06; RoBe06]. EA is the primary tool for impact assessment and tradeoff analysis in these scenarios.

In summary it can be stated that the main goals of EA are

- documentation and communication of as-is corporate structures/processes,
- support for the design of to-be structure/ processes, and
- support for projects that transform as-is into to-be structures/processes.

EA models support these goals by creating more transparency, measurability, and consistency. Consequently, EA models must remain up-to-date and reflect the current state of corporate structures and processes [Chie01]. Hence, EA models need regular maintenance [CaTr04; Lank05]. This necessitates processes for EA management and communication in general, and in particular a specific organizational design that ensures the completeness and consistency of EA models over time.

Various approaches for managing EA have been developed by academia as well as by practitioners. Documentation of these approaches differs substantially with respect to quantity and formalization. A common problem is a lack of completeness and/or insufficient level of detail. In particular, existing approaches to EA management pay little attention to specifying maintenance procedures for EA models in detail. Given the shortcomings of existing approaches, this paper focuses on the maintenance process and reports on a federated approach to maintain a current-state EA model.

The remainder of this paper is organized as follows: In section 2 we analyze several existing approaches to EA management. Based on this analysis, we specify the research gap. Possible basic strategies for EA maintenance are discussed in section 3. In section 4 we propose a federated approach to EA maintenance. The implementation of this approach at a large financial service provider is presented in section 5. In section 6, conclusions regarding success factors and obstacles for federated EA maintenance are drawn, and an outlook to further research is given.

2 State-of-the-Art of Enterprise Architecture Maintenance

A multitude of methods for enterprise architecture management has been developed by academia and practitioners (e. g. [AOMS05; AOMS06; BiKr05; Chie01; Depa01; Ifip99; Open03; SpHi93; WBLS05]. These methods usually distinguish between the following EA management processes: (a) strategic dialogue/architecture visioning, (b) development and maintenance of current-state EA models, (c) development and maintenance of future-state EA models, (d) migration planning, and (e) EA implementation.

Documentation of the aforementioned approaches differs substantially with respect to quantity, level of detail, and formality. Even worse, almost all of these approaches to EA management pay little attention to specifying maintenance procedures for EA model data in detail. In order to substantiate this assessment, we provide an analysis of three popular, comprehensive approaches to EA management on how much they incorporate maintenance aspects. These approaches include the Chief Information Officer Council's "A Practical Guide to Federal Enterprise Architecture" [Chie01], the Open Group's "TOGAF" (The Open Group Architecture Framework Version 8.1 "Enterprise Edition") [Open03], and Wagter's et al. "Dynamic Enterprise Architecture: How to Make It Work" [WBLS05].

While [Chie01] and [WBLS05] mention an EA maintenance process, EA maintenance activities are not specified in detail, and specific roles/responsibilities are not defined. Although it has to be mentioned, that the Chief Information Officer Council defines a maintenance process for their own reference model [Chie05]. This process may be adapted for maintaining EA models, too. TOGAF [Open03], one of the most widely-used approaches, does not even mention a maintenance process. Other researchers come to the same conclusion. As Jonkers et al. state: "The instruments needed for creating and using enterprise architecture are still in their infancy" [JLD+06, 65]. Given the lack of existing approaches, the following research question is addressed in this paper:

> *How should an EA maintenance concept be designed to ensure the sustainable and efficient usage of EA as an instrument for strategic change and alignment?*

In a design research approach [HMPR04], this contribution pursues the following design goals:

- Design of operational structures for EA maintenance: Detailed, formal description of a process necessary to maintain EA content.
- Design of organizational structures for EA management: Specification of roles to execute, manage and control all maintenance process activities.
- Integration of operational and organizational structures: Mapping of roles to process activities by means of responsibility charting (i.e. by specification of responsibility, accountability, etc. for each process activity).

3 The Challenge of Enterprise Architecture Maintenance

EA is comprised of a large number of business related and IT related artifacts. Popular framework approaches to EA including [Ci99; Og03; Sc99; WF06] propose the following set of EA core artifacts:

- Strategy specification ("what" questions): Hierarchy of organizational goals and success factors, product/service model (including partners in value networks), targeted market segments, core competencies, strategic projects, business principles, and dependencies between these artifacts.
- Organization/process specification ("how" questions): Specification of structure (organizational unit hierarchy, business location hierarchy, business role hierarchy, dependencies between these artifacts), specification of behavior (business function hierarchy, business process hierarchy including inputs/outputs, internal and external business services including service levels, performance indicators, service flows), specification of information logistics (business information objects, aggregate information flows), and dependencies between these artifacts (e.g. responsibilities, information requirements).
- Integration/Application specification (IT/business alignment questions): Specification of applications and application components, enterprise services, service components and dependencies between these artifacts.
- Software specification: Specification of software components (functionality hierarchy, event/message hierarchy), data resources (conceptual, logical and physical data models), and dependencies between these artifacts (e.g. data usage by software components CRUD).
- Technical infrastructure specification: Specification of IT components (hardware units, network nodes, etc.) and dependencies between these artifacts.
- Specification of dependencies between layers, e.g. organizational goals/success factors vs. process metrics, products/services vs. process deliverables, organizational units vs. applications ("ownership"), activities vs. applications, activities/business processes/information requirements vs. enterprise services ("orchestration"), applications/enterprise services vs. conceptual data entity types, and applications/enterprise services vs. software components ("composition").

Most of the EA artifact classes can be modeled as aggregation hierarchies, i.e. can be represented on various levels of aggregation. It is obvious that the complexity of a medium or large corporation (or government agency) cannot be covered by one single EA model. In real life, several models for different parts of the enterprise might be maintained, and/or EA will co-exist with other, more specialized architectures that cover a subset of those artifacts [Be05; WF06]. EA comprises only aggregate artifacts and their relationships within and across all layers (cf. Figure 1).

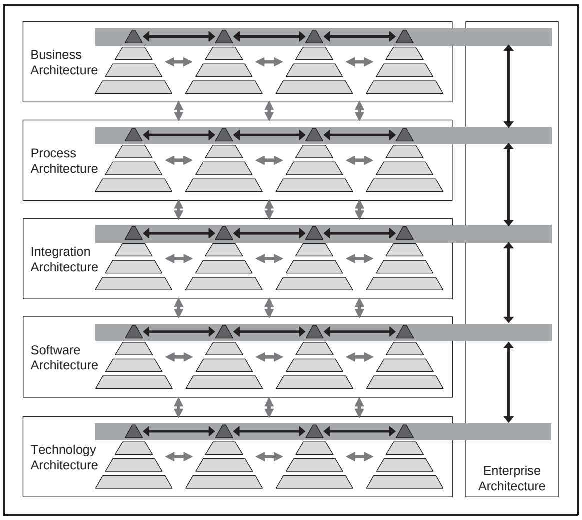

Figure 1: Enterprise architecture as cross-layer view of aggregate artifacts [WiFi06]

We agree with other researchers, that EA modeling should focus on consolidating models, modeling techniques and tools already existing in a company and integrating these at an appropriate level of abstraction [DoLa04]. Hence useful interfaces between EA and specialized architectures have to be specified and maintenance processes have to be established. According to [WiFi06], appropriate interfaces to at least the following specialized architectures are needed:

- product/service architecture (managed e.g. using a product management tool),
- metrics architecture (managed e.g. using a performance management tool),
- process architecture (managed e.g. using a process modeling tool and workflow management systems),
- information/data architecture (managed e.g. using a data modeling tool and database management systems),

- software architecture (managed e.g. using a software design tool and a configuration management tool), and
- technology architecture (managed e.g. using a computer system management tool).

Basically, two strategies for maintaining architectural data exist [MKM+06]:

- establishing a holistic EA model, or
- implementing a federated EA model.

A holistic EA model means that there is only a single model comprising all artifact classes necessary to describe EA. Models from specialized architectures are submitted to the EA team. The EA team interprets these models and remodels them using the components specified in the EA meta-model.

A federated EA model means that existing models (that originate from specialized architectures) are used. These models are linked to the EA model by meta-model integration. Two possibilities for model data management exist in this context: (a) Either retrieving model data on the fly when generating EA reports or (b) storing a copy (of the relevant subset) of model data from specialized architectures in the EA repository and periodically updating these data.

The latter strategy was chosen for the approach we propose in the next section. A federated bottom-up approach supported by a common set of rules requires less management effort (especially if specialized models change), provides up-to-date data, yields a higher acceptance of the resulting EA models, and avoids misinterpretation of specialized models during remodeling [Broc03; Mint79; PfLe77].

4 A Federated Approach to Enterprise Architecture Maintenance

To address the challenge of keeping EA models up-to-date, we propose a federated approach. In this approach, the EA repository is designated to store a copy of model data from specialized architectures relevant for EA purposes. Formerly independent models from specialized architectures are linked to the EA repository.

4.1 Maintenance Concept

We suggest that an EA model should – wherever possible – use data from existing specialized architectures to keep modeling efforts low. This necessitates the implementation of interfaces to source systems storing model data of specialized architectures into the EA repository and the establishment of a formal data maintenance process (ref. section 4.2) for each data source. To ensure data quality, we propose the concept of data delivery contracts. A data delivery contract includes a definition of the interface to the source system, descriptions of model data from the specialized architecture to be stored in the EA repository, transformation rules and a maintenance schedule. A data delivery contract also has to specify, who will be responsible for maintaining relationship data for artifacts which are maintained in different specialized architectures. Data maintenance processes are executed in regular intervals. Special events however, may trigger additional maintenance cycles. Before model data from specialized architectures are stored in the EA repository, consistency checks are performed.

4.1 Maintenance Process

To derive the maintenance process, we followed the process design method Promet BPR [BBHÖ96, 260; Info97; Öste95]. In this context, the respective specialized architecture model to be updated defines the core business object around which the processes are built [Öste95, 86]. In order to promote a comprehensive specification of maintenance process tasks, we used the generic activities proposed in [MCL+03; MCL+99].

We distinguish between a periodic and a non-periodic maintenance cycle. A periodic maintenance-cycle is initiated by the EA team based on the maintenance schedule defined in the data delivery contract. The EA team informs the respective data owner to provide the model data defined in the data delivery contract.

Non-periodic maintenance cycles may be triggered by the EA team as well as the respective data owner. These cycles are initiated e.g. if models of specialized architectures have changed significantly due to project work. At the end of the project the respective data owner informs the EA team about the changes. The EA team then decides whether or not a non-periodic maintenance cycle for this data source is necessary.

Apart from the triggering event of the maintenance cycle (activity 1), further operational sequences are identical for periodic and non-periodic maintenance cycles. Figure 2 depicts the complete process sequence. Process activities are numbered. Swim lanes denote accountabilities of the roles involved in process execution (for details cf. section 3.3).

First, on request by the EA team, the respective data owner delivers updated model data of its specialized architecture as specified in the data delivery contract

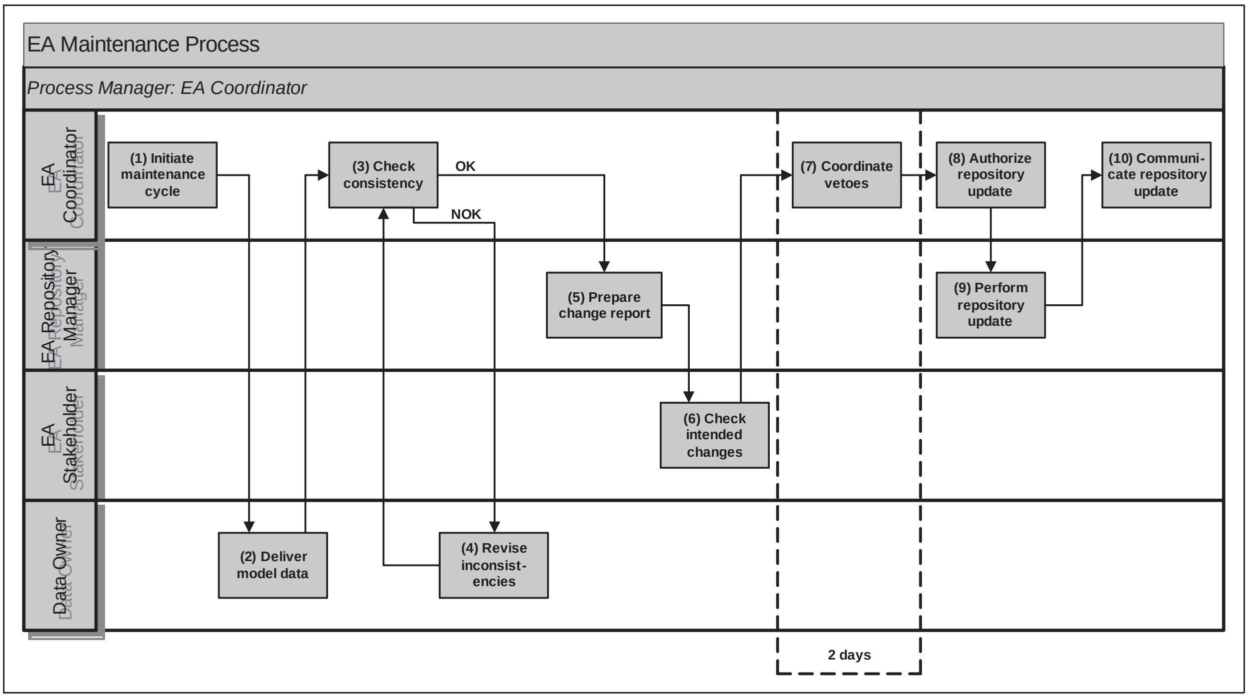

Figure 2: EA Maintenance Process

(activity 2). The data owner is responsible for providing model data in the correct data format. In most cases data will be delivered as an XML or CSV file, as most EA tool vendors provide technically mature concepts for fully semi-automated data transfer [ABB+07]. The EA team subsequently performs consistency checks with the model data from specialized architectures (activity 3). In case of inconsistencies the data owner gets informed and is requested to revise the data set (activity 4)). After the revision, the data owner resubmits the data set to the EA team. The EA team again checks the revised data set and decides whether another revision cycle is necessary or not.

If the data set has eventually passed the consistency check, the EA team prepares a report which contains all intended changes to EA models (activity 5). The report is derived through a comparison between data currently stored in the EA repository and the updated dataset from the respective specialized architecture model. This report is sent to all affected EA stakeholders (i.e. to all departments which have subscribed to EA reports using those data intended to change). The affected EA stakeholders evaluate the intended changes (activity 6). If a stakeholder enters an objection, the EA team must initiate a process of coordination involving the stakeholder who vetoed, the data owner, and – if necessary – other EA stakeholders who might be affected (activity 7).

If all issues are resolved (i.e. if all stakeholders have finally approved the intended changes), the EA coordinator authorizes the EA repository manager to load the updated data into the EA repository and built a new version of the current-state EA (activity 8). Finally, after loading the updated data into the EA repository (activity 9), the availability of a new release of the current-state EA is communicated to all EA stakeholders (e.g. via e-mail, activity 10).

4.1 Roles

In this section we describe the roles involved in EA maintenance activities. These roles are derived from the organizational units involved in the model update process. Regarding the activities which have to be performed by the EA team, we differentiate between a technology orientated management role (EA repository manager) and a business orientated management role (EA coordinator) because the required qualification profiles are widely different. In addition, we define the roles of EA stakeholders and data owners of specialized architectures.

Being not involved in maintenance activities, the chief enterprise architect is informed about repository updates on a regular basis. The maintenance process is managed by the EA coordinator. The EA coordinator is a member of the EA team. He or she reports to the chief architect. His or her main responsibilities include

EA meta-model enhancement, specification of interfaces to specialized architectures, maintenance of EA repository data, and design of EA reports.

The EA repository manager is responsible for all technical issues related to the EA repository. These include user administration, software updates, data backup, and particularly loading updated model data from specialized architectures into the repository. He or she is a member of the EA team.

EA stakeholders are business and IT units using EA to facilitate the understanding of multi-layer dependencies within different application scenarios (e. g. strategy execution, business continuity planning, and security management). Each business or IT unit representing an EA stakeholder names a contact person. The contact person ensures fast and effective communication between the EA team and the respective organizational unit.

For every specialized architecture, a data owner should be defined. On request by the EA team, the data owner provides model data to keep the EA repository up-to-date. Furthermore he or she assists the EA team in specifying and maintaining the interface between the EA repository and the specialized architecture repository or modeling tool.

		Roles				
Activities		Chief Enterprise Architect	EA Coordinator	EA Repository Manager	EA Stakeholder	Data Owner
(1)	Initiate maintenance cycle		A, R	I		R
(2)	Deliver model data from specialized architecture		I			A, R
(3)	Check data consistency		A	R		I
(4)	Revise inconsistencies		C	I		A, R
(5)	Prepare change report & notify affected stakeholders		I	A, R	I	
(6)	Check intended changes		I		A, R	
(7)	Coordinate vetoes		A, R	I	C	C
(8)	Authorize repository update		A, R	I		
(9)	Perform repository update		I	A, R		
(10)	Communicate repository update	I	A, R	I	I	I
	Responsible	Position working on the activity				
	Accountable	Position with yes/no authority				
	Consult	Position involved prior to decision or action				
	Inform	Position that needs to know of the decision or action				

Figure 3: RACI matrix for EA maintenance process

Figure 3 presents the RACI matrix [SmEr07] used to describe the responsibilities of the roles involved in the EA maintenance process in detail. It is especially useful in clarifying roles and responsibilities in cross functional/cross departmental processes such as the one at hand. The RACI matrix breaks maintenance tasks down to four responsibility types that are then assigned to the different roles involved in the main-tenance of the current-state EA.

5 Implementation at a Large Financial Service Provider

This section reports on the evaluation of our federated approach to EA maintenance. We use the case of a large financial service provider which implemented our approach. Unlike many other organizations, IT/ business alignment has not been the major driver for EA efforts in this company. Instead, EA aims at supporting strategy implementation, in particular at supporting the project selection/project portfolio planning process. In addition, EA is regarded as foundation of business continuity planning, service management and security management.

The financial service provider's EA program was initiated in 2005 because an aggregate, enterprise-wide view of important entities and dependencies did not exist. The program is ongoing and aims at establishing EA as a service to business and IT units. The project we report on has been carried out in 2006 and belongs to a comprehensive EA program. It was started because past approaches to solve the problem of managing the intertwined dependencies of EA artifacts were expensive, since they required scarce experienced architects, time consuming, since the required data were not at hand, frequently incomplete, since the effort to document every aspect was not justifiable, and often out of date since the ongoing expense of maintaining this information was too high [see also GaKC06].

In order to address the challenge of keeping EA data up-to-date, the financial service provider decided to pursue a federated approach. In this approach the responsibility for maintaining artifact descriptions is delegated to the team that is responsible for this artifact class. A self-developed EA repository (based on a relational database) has been implemented to store a copy of model data from those specialized architectures (Figure 4) which are relevant for EA purposes.

If needed for analyses, formerly independent models from different specialized architectures have been linked. Interrelating models was accomplished by the EA team together with the respective data owners of the underlying models. Relationship ownership was eventually assigned to one of the participating data owners for further maintenance. For each data source, a maintenance process similar to the one described in section 4 has been established and the necessary roles have been implemented in the organizational structure.

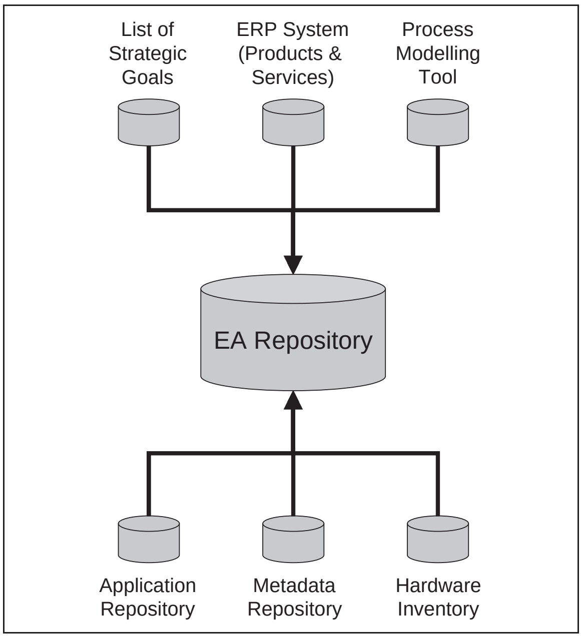

Figure 4: Primary data sources for EA content

Model data transfer from specialized architectures to the EA repository is primarily accomplished by means of CSV files. A fully automated data transfer is considered as a future option. While efforts for an automation of repository updates will keep within reasonable limits for clearly structured data with well defined intersubjectively comprehensible semantics like, e.g. hardware inventory data, automation will be more complex for e.g. business process models exported from process modeling tools. Therefore the implementation of automated repository updates has to be decided on a case by case basis.

After the first domain-specific repository has been connected to the EA repository in February 2006, more than 40 maintenance cycles have been carried out. In this relatively short time, the EA repository has already provided important insights into the company's enterprise architecture that were unavailable so far. First, it has provided a holistic view which not existed before. Secondly, it has provided a means of centrally storing relevant information about enterprise architecture artifacts and their relationships so that various inconsistencies could be identified. Up to now, more than 100 inconsistencies have been identified and addressed by respective change requests. Third, and definitely most important, the EA repository has enabled a number of analyses that were either unavailable or were difficult and costly to perform before. More than 40 analyses related to 10 different application scenarios have been performed since the first release of the repository. These architectural and risk analyses helped to highlight a number of significant risks and issues relating to strategic options, redundancy and business continuity.

6 Conclusions and Future Work

One major finding from implementing a federated approach to maintain EA models is that the integration of existing models from specialized architectures strongly influenced the acceptance of EA as a management tool. For the EA stakeholders it became a very powerful tool since it provides valuable insights in the current and future architecture that were not available before. Due to the organizational fragmentation which most large service companies show, particularly the different relationships between the specialized architectures were not available for analysis before. The acceptance of this solution among the providers of the specialized architectures is very high because they remain the owners of the respective architecture models.

Another insight gained from the implementation is worth mentioning: The integration of model data from specialized architectures into the EA repository is an ongoing process rather than a one-time effort. It is necessary to monitor the quality of model data from source systems continuously – particularly regarding their consistency.

From our experience, further research is needed for integrating the maintenance process into a holistic EA management and usage process. Furthermore, tool support needs to be extended. In particular, the process of loading specialized architecture model data needs more automation. However, the automation of model data updates may not be reasonable for every specialized architecture model. Especially in the case of rarely changing models there may not be a business case for an automation of updates. Criteria influencing the cost-benefit ratio of an automated approach need to be elaborated.

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