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Integrating IT Portfolio Management with Enterprise Architecture Management

The management of information technology (IT) as a business has become a crucial factor in today's complex and dynamic environments. Many firms thus have implemented IT portfolio and enterprise architecture (EA) management practices, and academic research has paid increasing attention to these concepts. However, their integration seems poorly substantiated; this article therefore seeks to answer two main questions: (1) What are differences and common characteristics of IT portfolio and EA management, and in what way can they be integrated? and (2) what factors and types might describe an integrated process design of EA management and project portfolio management in particular? To answer these questions, this study synthesises previous research and surveys EA practitioners to propose an EA management process map, as well as three descriptive factors and four clusters, which provide an integrated process design with project portfolio management. The interrelations with organisational aspects and software tool support are also explored. This article thereby clarifies and systematises the subject area while also offering advice for researchers and practitioners.

1 Introduction

The notion of managing information technology (IT) as a business (Lientz and Larssen 2004) has attracted significant attention, particularly as IT environments grow steadily more complex and thus more difficult to manage. In addition, regulatory requirements (e.g., the Clinger-Cohen Act) demand the management of IT assets as an efficient and profitable business (Kersten and Verhoef 2003) through careful investments in both existing and new assets. In light of these challenges, two concepts have become common to IT managers' vocabulary: IT portfolio management and enterprise architecture (EA) management.

The former refers to the ongoing application of systematic management to large classes of IT items (Betz 2007), including applications, infrastructure, services, and projects (Maizlish and Handler 2005), grouped together to facilitate their efficient and effective management (Benson et al. 2004; University of Utah 2011). As such, IT portfolio management is "the definitive professionalization of the activities dealing with the integration of IT" (Bloem et al. 2006) and a cornerstone of a structured, business-like approach to IT management that comprises application, infrastructure, service, and project portfolio management (Benson et al. 2004; Kaplan 2005).

Integration is equally critical to EA management, though this notion goes beyond IT. In general, enterprise architecture entails a structured, aligned collection of plans aimed at the integrated representation of an enterprise's business and IT landscapes—past, current, and future (Niemann 2006). Therefore, EA management captures the processes, methods, tools, and responsibilities needed to build a holistic, integrated view of the enterprise that will support continually aligned directions for business and IT (Matthes et al. 2008; Niemann 2008). It thus deals with different layers such as business, information, application, and technology architectures (The Open Group 2009).

Accordingly, IT portfolio and EA management seem to share common ideas and concepts; they might even be just "two different views on the same problem" (Betz 2007), namely, ways to address increased complexity. Whereas IT portfolio management aims to quantify the enterprise's IT assets to enable objective evaluations of investment scenarios, EA management is "particularly concerned with dependencies, categorizations, and modeling techniques" (Betz 2007).

Yet no common and integrated view details the relation of IT portfolio management and EA management; previous research instead provides multiple interpretations of their link and questions where to separate them. Some sources regard them as two separate disciplines (e.g., The Open Group 2009); others consider project portfolio management, one of the major tasks of IT portfolio management (Benson et al. 2004), a significant application scenario of EA management (cf. Aier et al. 2008b).

With that confusion in mind, time seems to have come for the field to engage in a thorough introspection and sort out and integrate the two concepts (cf. Schwarz et al. 2007). Yet there is not only an academic need for a conceptual clarification and integration; generally, the two concepts find themselves (at least partially) represented in dedicated enterprise functions in practice, making their coordination a significant real-world issue as well (cf. Hanschke 2010; Niemann 2006; Winter et al. 2010). Establishing links between EA management and other management practices in the enterprise and thus connecting it with other processes, such as project prioritisation, is actually considered particularly crucial for its success (Ahlemann et al. 2012).

Having said this, we aim to shed light on the relation between IT portfolio and EA management and clarify the distinction between. Therefore, the first main research question we seek to answer is: (a) what differences and common characteristics mark IT portfolio and EA management, and (b) in what way can they be integrated, especially at the process level? Of particular interest in that context are the interfaces around project portfolio management, which seems to be at the heart of IT portfolio management in practice (Benson et al. 2004), while its interaction with related EA management activities has apparently not yet been detailed in a comprehensive picture. As there may be different approaches to the design of this interaction in practice (according to, e.g., main stakeholder concerns as well as specific contextual factors such as culture (Buckl et al. 2011) and maturity/ skills), in which situational rather than "one-size-fits-all" artefacts are needed (Aier and Riege 2009), we thus target a second main research question: which factors and types are particularly pertinent in terms of an integrated process design of EA and project portfolio management?

Given our main research questions, we ground our study on both literature and empirical data about prevalent approaches, which we gathered through a survey of practitioners. To answer the first research question, we develop, among others, a process map for EA management that includes the main areas of IT portfolio management; on this basis, we detail the procedural interplay with project portfolio management, as per our second research question. We also explore the integration of the two concepts at levels other than processes, such as organisational and software tool levels. Finally, we translate our insights into suggestions for practice.

Accordingly, the remainder of this paper is structured as follows. In Section 2, we survey past research dealing with the integration of IT portfolio and EA management. Section 3 sketches the research methodology we used. Section 4 then provides our conceptual characterisation and integration. Based on the process map for EA management in which IT portfolio management gets integrated, we focus on the interplay with project portfolio management in Section 5, using the results of our survey of architecture practitioners. Finally, we summarise our results and present our final conclusions in Section 6.

2 Related Work

IT portfolio management has been subject to various research efforts. Benson et al. (2004) offer a "strategy-to-bottom-line value chain" for integrating different IT practices, such as alignment and performance measurement; portfolio management is a concept that provides support for these practices. Bloem et al. (2006) discuss how IT governance may work in the face of current compliance pressures and identify the principles of IT portfolio management as highly promising; similar conclusions are drawn by de Haes and van Grembergen (2009), who find out that business-IT alignment is higher when organisations apply a mix of mature IT governance practices, one of which is portfolio management.

In general, most of the IT portfolio management research centres on application portfolio management (APM), and, in particular, project portfolio management (PPM). Simon et al. (2010) develop an integrated framework for APM that comprises data collection, analysis, decision making, and optimisation. McKeen and Smith (2010) stress that organisations must establish three major capabilities to deliver value with APM: (1) strategy and governance, (2) inventory management, and (3) reporting and rationalisation. Levine (2005) deals with PPM and divides it into two major phases: project selection and project portfolio maintenance; Schwarze (2006) focuses on the IT project portfolio and describes a method for aligning it with the corporate strategy using a so-called enterprise value map. In their comprehensive examination of IT portfolio management, Maizlish and Handler (2005) even offer a step-by-step guide for establishing and running IT portfolio management in practice.

Still, what remains unclear is the relation of IT portfolio to EA management, even though some authors consider PPM, and APM in particular, specific activities of EA management. In illustrating main EA management processes, Keller (2007) cites APM and project portfolio monitoring, and also Riempp and Gieffers-Ankel (2007; 2010) investigate APM from an EA perspective, presenting APM as a specific aspect of EA management. This approach may be reasonable, considering the structured representation of the application landscape maintained within the enterprise architecture, which can facilitate a managed application landscape evolution that matches the city planning metaphor advocated by Namba and Iljima (2004) and Longépé (2003), who draw an analogy between the building, improvement, and maintenance of information systems and those of a city.

However, other researchers insist EA management and IT portfolio management are rather separate approaches, associating the latter specifically with the project portfolio. The Open Group Architecture Framework (TOGAF) (The Open Group 2009) notes a structured relation between EA management and PPM (Fig. 1): EA management provides a structured context for making decisions about projects and investments (e.g., using architectural structure and dependencies to value projects (Lankhorst and Quartel 2010)), but PPM manages the realisation and delivery of the specified architectural components. Therefore, TOGAF recommends viewing project portfolio managers as key architectural stakeholders, because "an understanding of project content and technical dependencies between projects adds a further dimension of richness to portfolio management decision-making" (The Open Group 2009). Simon (2009) provides further details, noting that integration with PPM is crucial for successful application landscape transformation (cf. Dern 2006). The result may be a detailed roadmap illustrating the transformation timeline, phases, projects, and transition landscapes; the latter represent milestones toward the envisioned target (cf. Smith 2011). The development of such a roadmap involves the consideration of any inherent temporal dependencies (cf. Saat 2010) and reviews of the project portfolio according to the applications already planned, being implemented, or subject to modification, to avoid duplicate efforts and cope with possible project conflicts. Similarly, Fischer et al. (2005) suggest various relations among the IT management processes of landscape, project portfolio, and synchronisation management, which addresses the problem that arises when IT

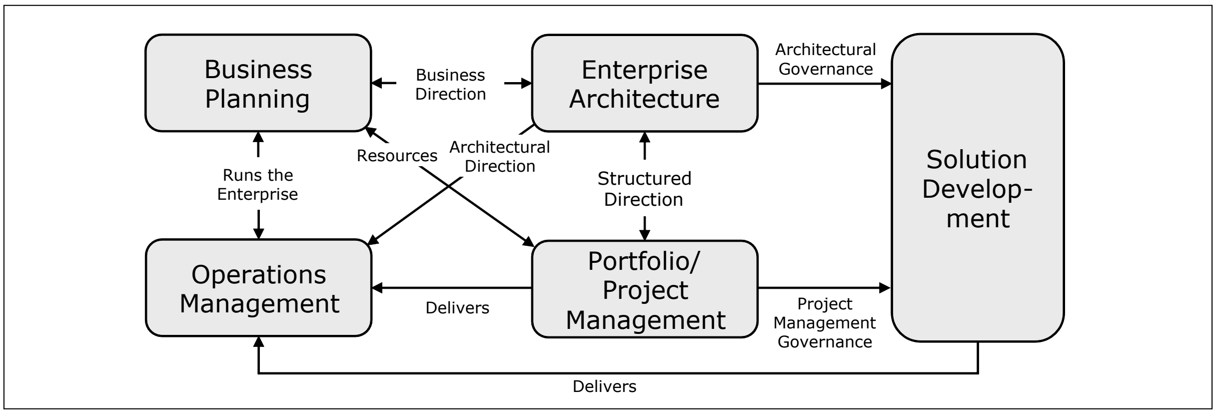

Figure 1: Relationships between EA and other management practices (The Open Group 2009).

projects have dependencies with other projects (considered separate from PPM by these authors).

All in all, there remains a lack of clarity and common understanding in terms of the relations of IT portfolio and EA management. The fact that the field itself has remained rather shattered or, say, unorganised (despite the identified need for coordination in practice), while information systems—a main subject in scope of both concepts—play an integrating role in modern enterprises, may left one puzzled and thus motivates this research.

3 Research Methodology

Having identified the need for this study, we initially developed a thorough conceptual differentiation of IT portfolio and EA management and, based on that refined understanding, a theoretical framework that identifies integration dimensions (cf. Frick and Schubert 2009) across them, as requested by our first research question ("What differences and common characteristics mark IT portfolio and EA management, and in what way can they be integrated?"). In line with Schwarz et al. (2007), the framework reflects our conceptualisation of the field, or, in other words, the territory of integration. Furthermore, our main research proposition—that the main areas of IT portfolio management (e.g., APM, PPM) are fundamental application scenarios of EA management, such that the latter provides the underlying structure and information base—is central to our framework. We derived this proposition in 2011 from a synthesis of prior research and the support by our practitioner survey results.

For the study of the literature, we drew upon the guidelines for literature reviews set forth by vom Brocke et al. (2009). That is, before we began collecting relevant sources, we defined the scope and flavour of the literature study. With our focus on prior research outcomes and practices/applications, our goal was to synthesise previous research. Therefore, the coverage of sources was intended to be exhaustive, but with selective citation (i.e., considering as many relevant sources as possible, but describing only parts of it, such as, e.g., in the related work section). To this end, we based our study on the sources documented in two overall analyses of the research field (Mykhashchuk et al. 2011; Simon et al. 2013) and their comprehensive literature compilations, thereby considering hundreds of works on EA management and/or IT portfolio management (and their subareas) published up to mid-2010. A complementary search with analogous keywords focusing on the subsequent time up to early 2011 (using the AIS Electronic Library, as well as Google to capture relevant works—specifically books—from practitioners) identified some additional works that we included in our analysis.

The survey featured a (relatively short) questionnaire that we structured in six parts: general information (e.g., IT organisation's size, EA management function's age), followed by the five framework dimensions (which we detail in the next section). We addressed each of the latter through a set of closed questions (Gendall 1998) pertaining to current practices for integrating EA and IT portfolio management (the items and their grounding in the literature are presented successively in the remaining sections). We asked subject matter experts from research and practice to review the initial version, then revised the questionnaire on the basis of their comments, and included some notes on terminology. After that, we carried out a small pretest with selected target participants, which allowed us to detect problems that respondents may have in answering the questionnaire and to adapt it accordingly. Altogether, this, along with the grounding of the items in the literature, allowed us to ensure adequate content validity. The final questionnaire was distributed to enterprise, business, and IT architects during a German conference on EA management in February 2011 and to other architecture practitioners (German, Swiss, and Austrian) via e-mail between March and June 2011. We gathered the e-mail addresses from the social networking platform Xing.com and with the assistance of an EA management consultancy. In total, the questionnaire was provided to 92 practitioners, and we received 32 completed responses, for a response rate of 34.78%. Figure 2 details the resulting sample by industry; though the sample is not fully representative, it includes major industries and reveals a diverse portfolio of respondents from different companies that constituted immediate users (consultancies were not included). The insights are also not exclusive to the German-language community, as many participants represented organisations that operate globally.

With respect to the first research question, the main purpose of the practitioner survey was the validation of our research proposition and the underlying basic conceptual clarification (see Sections 4.1, 4.2, and 4.3). So, with our basic research proposition, supported by the survey results (second and third part)—that is, EA management application scenarios and their manifestation in metamodels in practice—we could then address the actual integration of the two concepts and proceeded with our literature study to guide the design of a process map for EA management, in which IT portfolio management is integral (see Section 4.4). Here, we methodically refer to the design science paradigm as described by Hevner et al. (2004) and Baskerville (2008). To extend "the boundaries of human and organizational capabilities" through "new and innovative artifacts" (Hevner et al. 2004), design science—as a general research approach—is useful in combination with various research methods (Gregory 2010). Accordingly, we employed literature analysis to assimilate diverse prior research and build an integrated conceptual model of processes that addresses the lack of clarity in the relation of the two concepts identified as the problem to be resolved at the outset of this paper.

Another reason for the use of the survey related to the second research question ('What factors and types might describe an integrated process design of EA management and project portfolio management'), which targets concrete process interfaces to/from project portfolio management prevalent in the practical application. As such, it called for a larger empirical data set that captures actual practices of interfacing with one another to help clarify and substantiate potential relations. So, having designed the process map, we returned to the completed questionnaires, the fourth part of which enquired about such procedural relationships. On this basis, we examined the procedural interplay between architectural landscape management (as a main EA management constituent) and project portfolio management in further detail.

Adopting a descriptive research approach (Babbie 1989), we applied factor and cluster analysis to the data set to structure potential process interfaces and identify alternative types of integration.

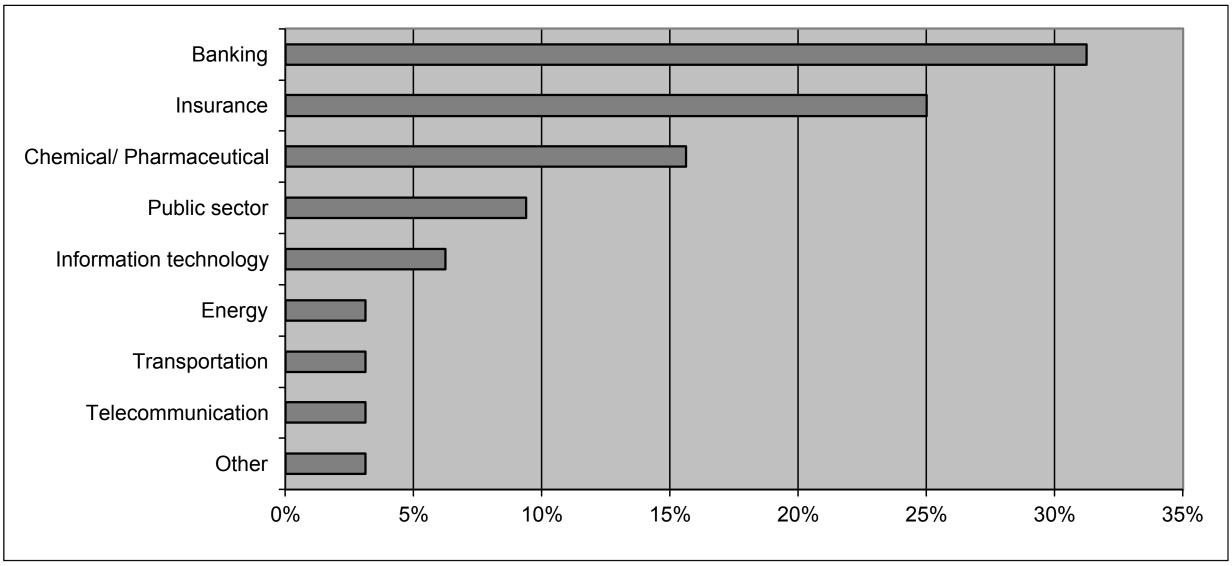

Figure 2: Represented industries in the data set.

Whereas factor analysis helps identify a few latent factors in the data set that reduce the items according to common characteristics, cluster analysis supports the classification of the respondents in terms of a focus on one or more of the identified factors.

With eight variables (i.e., process interfaces) being factor analyzed (see Section 5.1), the sample size meets the minimum ratio of cases to variables of 4-to-1 in terms of a reasonable use of factor analysis, as suggested by Cattell (1952). The data set is adequate for factor analysis as well, as indicated by the Kaiser-Meyer-Olkin (KMO) score (Kaiser and Rice 1974) we computed prior to the analysis. We factor analyzed the data set along the following steps: (1) factor extraction (using the principal component method with Varimax rotation, followed by a scree test to determine the number of factors to retain); (2) assignment of items to factors (for which they had the highest loadings, with a minimum level of .5); (3) factor validation, such as in terms of internal consistency (by calculation of Cronbach's Alpha); and (4) factor interpretation. Subsequent cluster analysis went through two stages: (1) hierarchical clustering to determine the number of clusters; and (2) k-means cluster analysis (McQueen 1967) on the factor scores to form and characterise these clusters.

Finally, we analyzed the data in terms of integration practiced on other dimensions captured in our framework below, such as the organisational dimension (see Section 5.2); by relating these findings to the mentioned integration types, we derived suggestions for practice (see Section 6).

Table 1 summarises the research questions, the research methods employed (with respect to the survey, complemented with information about the composition of the questionnaire and the techniques used for data analysis), and the research outcomes.

4 A Conceptual Integration

4.1 Conceptual Characterisation

From our thorough review and synthesis of previous research (see Section 3), we suggest that EA management and IT portfolio management can be distinguished along three aspects: scope, focus, and methods (see Tab. 2). IT portfolio management focuses on collections or, say, large classes of IT items (Simon et al. 2010) (e.g., applications) and manages investments in these items (Benson et al.

Research Question	Research Methods			Results
RQ1				Section 4
(a) What differences and common characteristics mark IT portfolio and EA management…	Literature Study			Section 4.1
(b) …and in what way can they be integrated, especially at the process level?	Survey			
	Part 2 (Scenarios)	20 questions *(see Figure 3)*	Univariate analysis • Arithmetic mean	Section 4.3
	Part 3 (Content)	13 questions	Univariate analysis • Relative frequency	Section 4.3
	Literature Study			Section 4.4
RQ2				Section 5
What factors and types describe an integrated process design of EA management and project portfolio management in particular?	Survey			
	Part 4 (Processes)	8 questions *(see Table 3)*	Multivariate analysis • Factor analysis • Cluster analysis	Section 5.1
	Part 5 (Organisation)	2 questions *(see Table 6)*	Univariate analysis • Relative frequency Bivariate analysis • Correlation analysis	Section 5.2
	Part 6 (Tools)	3 questions	Univariate analysis • Relative frequency	Section 5.2
Number of survey questions (except introductory part)		46 questions		

Table 1: Overview of research questions, methods, and results sections.

2004); in contrast, management of the enterprise architecture—the fundamental conception of an enterprise in its environment, embodied in its elements, their relationships, and the principles of its design and evolution (International Organization for Standardization 2011)—entails documenting, designing, and maintaining landscapes of both business and IT elements. In particular, EA management focuses on the relations and dependencies among these elements. For this purpose, it makes use primarily of modelling. In contrast, IT portfolio management centers on a quantitative measurement (of IT items) that relies on adequate evaluation metrics.

	EA Management		IT Portfolio Management
Scope	Business	IT	IT
Focus	Relations and dependencies		Quantitative measures
Methods	Modelling		Evaluation metrics

Table 2: Differentiation of EA and IT Portfolio Management.

For an accurate quantification of the IT portfolio items, such as in terms of value and risks, a consideration of the supported business, dependent systems, and investments seems essential though. The relations and dependencies captured in the EA model may thus create the necessary foundation and deliver crucial insights for IT portfolio management. Common to the concepts is their strategic and holistic nature. Both also address aspects of enterprise transformation, that is, “fundamental changes in terms of relationships to markets, product and service offerings, market perceptions, and/or cost pressures” (Rouse 2005), which thus “substantially alters an organization’s relationships with one or more key constituencies, e.g., customers, employees, suppliers, and investors” (Rouse 2005). For example, IT portfolio management selects, allocates resources to, and monitors “delivery vehicles” of transformations (The Open Group 2009), that is, projects and programs (Harmsen et al. 2009), whereas EA management identifies the elements of transformation and deliverables to be achieved at certain stages (cf. Saat 2010), which can be documented in future architectures. In this sense, it provides a design framework for shaping the future, as finally delivered by the aforementioned vehicles.

4.2 A Framework for Integration

The chain of reasoning offered in the previous subsection argues for an EA-based approach to IT portfolio management, which we translate into our basic research proposition:

The IT portfolio management areas are main application scenarios of EA management.

The basis for this is the structured representation of business and IT landscapes in architectural models. So, according to this proposition, IT portfolio management would need to be represented in the core dimensions of EA management (cf. Leist and Zellner 2006; Niemann 2008; Schmidt and Buxmann 2011; Smith 2011; The Open Group 2009). We capture them in our theoretical framework—a framework in the purest sense, that is, a skeletal structure to organise the territory of integration:

- Charter of EA management: mission, vision, goals, objectives, strategy, and principles.
- Metamodel and content of EA management: conceptual scheme of EA content, including elements, their relationships, and their attributes, along with models and viewpoints capturing the content.
- Processes of EA management: strategic and operational tasks and procedures.
- Organisation of EA management: structure, roles, responsibilities (primary organisation), and boards (secondary organisation).
- Tools of EA management: repository for storing and visualising EA content, together with templates, checklists, and so on.

As part of the response to our first research question, this organising structure systematises the different levels of a conceptual integration; as such, it also serves as the basis that guides the detailed exploration that follows, beginning with the validation of the basic research proposition.

4.3 Application Scenarios and Content of EA Management

The basis for an EA management practice is its charter (as reflected in the framework), where the EA “use cases” get defined. According to our research proposition (see above), one such case could be IT portfolio management. This possibility was the focus of the second part of our survey questionnaire (following the general information part), such that we asked about the relevance of EA management (not important [1], partially important [2], largely important [3], important [4], or very important [5]) in the scenarios illustrated in Fig. 3 (including irrelevant scenarios for comparative reason), thus dealing with issues typically addressed in a charter. The management of the application portfolio emerged as the most important application scenario; scenarios of managing the IT service, project, and infrastructure portfolio also implied considerable relevance in terms of the benefits that could accrue through EA management (Fig. 3).

In addition, we asked about the degree of realisation, that is, the actual use of EA management in these scenarios (nonexistent [1], partially implemented [2], largely implemented [3], completely implemented [4], or optimised [5]). The scores were much lower. However, the represented enterprises established their EA management functions relatively recently, in 2005 on average, so many participants mentioned that they were still developing. Management of the application portfolio earned the highest rating in realised support by EA management, followed by management of the project portfolio. Further, EA management support for the management of the IT infrastructure and service portfolio was at least partially implemented.

So, the fact that the IT portfolio management scenarios earned considerable ratings in terms of not only perceived relevance but also actual practice (as opposed to several other scenarios being rated lower), whereas EA practitioners are not likely to welcome the integration with any topic in general given today's challenges and complexity they face anyway (cf. Lucke et al. 2010), explains the meaningfulness of these findings. In addition, the findings persist in the responses in the next part of our questionnaire, which inquired about the existence of the metamodel entities below. Of the represented organisations, 96% included application systems and 94% included infrastructure components in their EA metamodel. The IT service was mentioned by 75% of respondents (service-level and operational-level agreement were not as common, as we discuss in Section 4.4.1), and the project was cited in 67% of responses. The IT portfolio management core items are thus largely reflective of EA models in practice. Furthermore, our sample indicates that business capabilities have found their way into the majority of EA models (63%). This is an interesting finding, as the potential relationships of portfolio items with this entity in the EA model may facilitate portfolio prioritisation, such that the items can be assigned a business value according to their impact on the most important capabilities (Aier et al. 2008a; Hanschke 2010).

These survey results thus support our research proposition for an EA-based approach to IT portfolio management, according to the structured information captured and maintained in EA models. With this support, we detail our proposed approach to integrate IT portfolio into EA management (which is not meant to make the role of IT portfolio managers obsolete). We do this by systematising EA management processes in the next subsection. Later, Section 5 focuses on EA management's relationships with PPM, not only at the process, but also at the organisational and software tool level.

4.4 An EA Management Process Map and the Position of IT Portfolio

Turning to our framework's process dimension, this subsection draws upon our literature sources (i.e., it integrates different sources into a coherent whole) to construct a map of EA management processes, in which IT portfolio management gets integrated. In process classification terms, this map distinguishes core, management, and supporting processes of EA management (see Fig. 4) (Keuntje and Barkow 2010).

4.4.1 Core Processes

Core processes deliver architectural services to stakeholders and define the main tasks of EA management. A fundamental core process is IT landscape management (cf. Hafner and Winter 2008; Hanschke 2010; Niemann 2006), that is, the management of the entirety of an enterprise's IT components (at the level of types, not configuration items/instances) and their relationships to other elements (e.g., their use in business activities). It may be decomposed into strategic and tactical tasks (Keuntje and Barkow 2010). Whereas strategic IT landscape management produces the long-term picture (of this macro architecture) based on the strategic direction and manages the transformation toward this picture, tactical IT landscape management regularly addresses specific requirements and needs for action and reconciles them with the envisioned future IT landscape. A complementary process is solution architecture management (cf. Keller 2007; Niemann 2006; Slot et al. 2009), which represents operational activities at the project level at

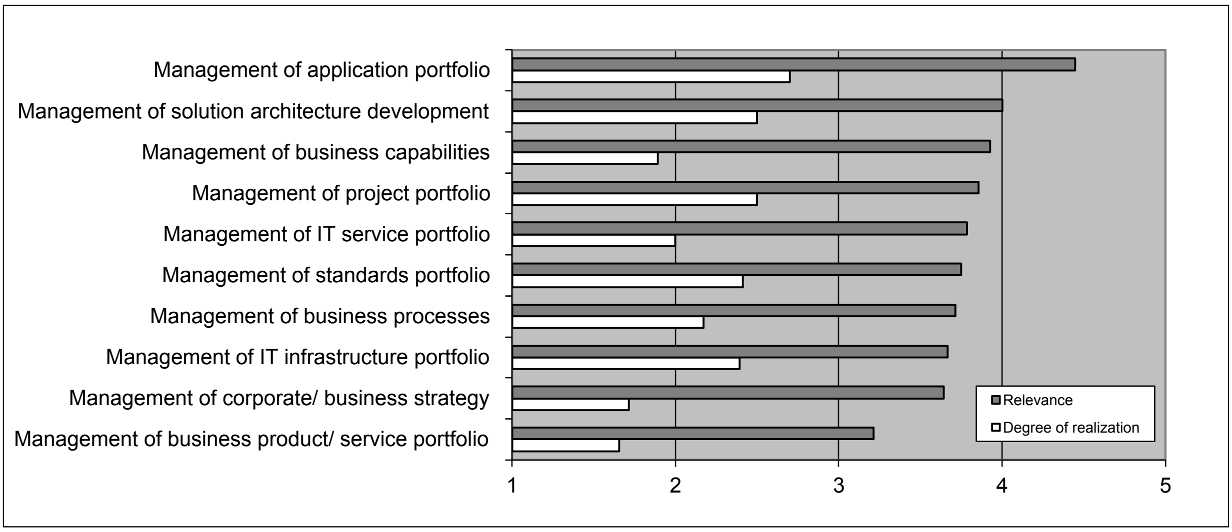

Figure 3: Application scenarios of EA management.

which the concrete architectural solutions (micro architectures) are developed.

Both business architecture management and standards management (Hanschke 2010; Keuntje and Barkow 2010; Schmidt and Buxmann 2011) span these different levels. As such, the former can be decomposed into subprocesses such as

- strategic planning ("whereby goals and objectives are identified, policies are formulated, and strategies are selected in order to achieve the overall purposes or mission of an organization" (Steiss 1985));
- business model design (i.e., the design of the fundamental system of creating, delivering, and capturing value, thus including aspects such as products/services, distribution channels, customer segments, and the revenue model (Osterwalder and Pigneur 2010));

and subordinated

- business capability management,
- business process management,
- business object management (i.e., the conception of objects of business activity, such as customer, product, and contract, including their relationships), and
- organisational design.

It thus involves developing strategic business requirements that should be met by the future IT landscape, optimising business operations (and the corresponding landscape of business processes, objects, and organisational structures), and translating this architecture into individual solution projects. Likewise, standards management, which defines, maintains, and governs architectural standards (e.g., technology components, reference architectures), supports plans for the future IT landscape, on the one hand, and enables the design of specific solutions with adequate standards, on the other hand.

Although still uncommon (Keller 2009) but supported by the results of our survey (see Section 4.3), project portfolio management may constitute another core EA management process (cf. Matthes et al. 2008). Eventually, innovation management (i.e., the identification, evaluation, and adoption/implementation of new ideas and trends), which may inform both IT landscape management and standards management, may also become a dedicated EA management process (though it is not represented in Fig. 4, as this seems rarely the case in practice) (Hanschke 2010; Keuntje and Barkow 2010; Rohloff 2011).

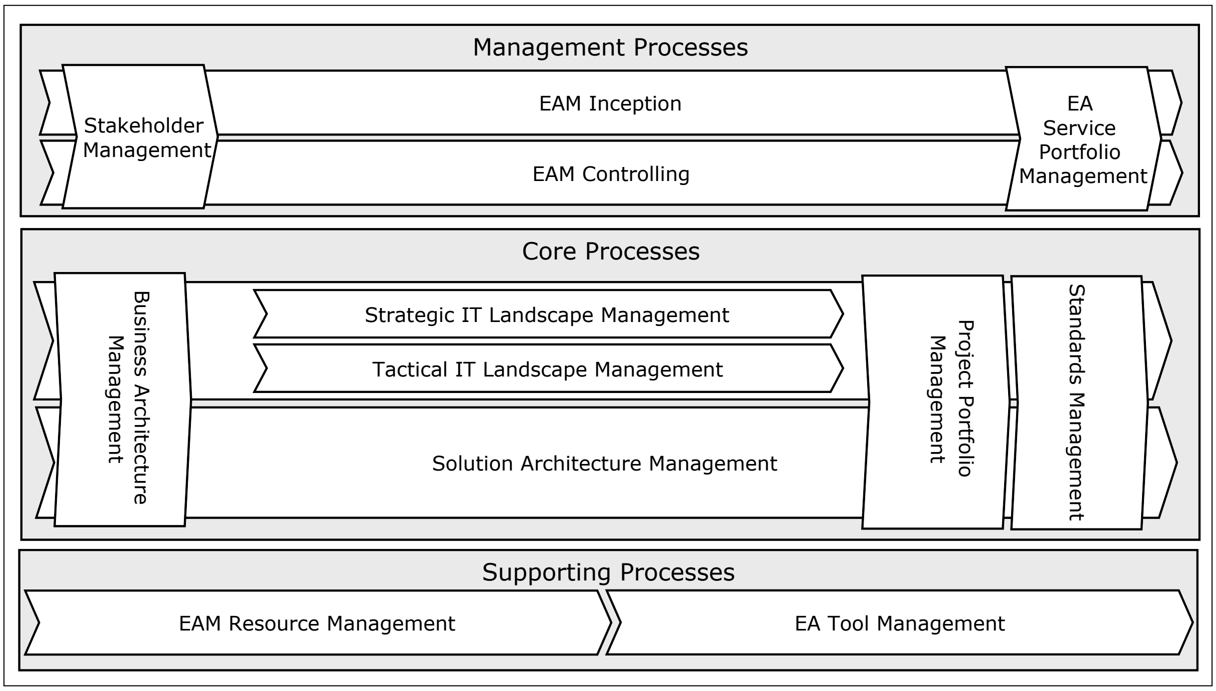

Figure 4: EA management process map.

4.4.2 Management Processes

Management processes—the second class featured—ensure the supervision and controlling of architectural activities, the management of benefits, and the maintenance of the architectural framework, methods, and directives. They include the process of EA management inception (corresponding to what TOGAF calls "preliminary phase"), that is, the establishment and maintenance of the EA charter and methodology (e.g., principles, metamodel, core processes) (Kurpjuweit and Winter 2007; Smith 2011; The Open Group 2009). The process of EA management controlling defines and uses key performance indicators to measure EA management success (Kersten and Verhoef 2003; Niemann 2006; Smith 2011).

Both EA management inception and controlling are driven or at least affected by the process of stakeholder management, which refers to the identification, analysis and prioritisation of and communication with EA stakeholders. These are individuals, teams, or units with interests in, or concerns relative to, EA management (Smith 2011; The Open Group 2009). In a stakeholder-oriented approach to EA management, the definition of EA management goals, methodology, and key figures relies primarily on stakeholder concerns. The main EA management services do as well, derived from the results of the inception process and then specified and managed according to their fulfillment, costs, and priorities in the overall EA service portfolio management process (The Open Group 2009), in which the continued alignment of the service offering (essentially, in the form of views of the architecture) with major needs is ensured (cf. COBIT 5: A Business Framework for the Governance and Management of Enterprise IT). As such, the EA service portfolio management process also connects to EA management controlling.

4.4.3 Supporting Processes

Finally, supporting processes for EA management serve to establish and maintain the necessary means for service delivery (Keuntje and Barkow 2010), including resource management (The Open

Group 2009) as a designated process for budgeting (Op't Land et al. 2009), architectural project staffing (Schmidt and Buxmann 2011), and architects' skill development (Niemann 2006). Another supporting process, EA tool management, organises the administration and maintenance of the EA repository (Keuntje and Barkow 2010) and other supporting tools (e.g., templates, checklists).

4.4.4 Analyzing the Position of IT Portfolio Management

The core processes of IT portfolio management can be considered integral parts of the designed process landscape for EA management. Project portfolio management has already emerged as a potential core process. Moreover, APM apparently represents a major constituent of IT landscape management, in that it entails inventorying, analyzing and planning investments into applications and thus contributes to the managed evolution of the application landscape (recall that the portfolio may have a narrower focus than the landscape perspective, in that the former addresses the entirety of applications and their main properties, while the latter further systematises their use in business activities (cf. Buckl et al. 2008a). Because IT landscape management also can take place on the infrastructure level (cf. Niemann 2006), infrastructure portfolio management may form another part of this process (cf. Dern 2006). However, infrastructure portfolio management can be mapped further onto the standards management process, because infrastructure may be largely a "commodity" (Carr 2003) and thus subject to standardisation. In the architectural context, it is again, however, important to note that the infrastructure is not managed at the level of configuration items but rather at the level of types.

In a service-oriented approach to IT landscape management, with services instead of entire applications providing the planning elements (Buckl et al. 2008b), IT service portfolio management also finds its place in the EA management process landscape (Jung 2009; Lankhorst and Quartel 2010). It also can be mapped onto the business architecture management process when the business architecture of the IT organisation—that is, its business model in particular, which includes the internal and external services (Kohlborn et al. 2009) of the IT organisation, such as human consulting, help desk, and training services (Braun and Winter 2007)—becomes part of the EA content model. In general, the operational management of the IT service portfolio, including service level management, remains a task of the IT service management function though, in line with the results of our survey. That is, rather few EA metamodels include entities such as service-level agreement (46%) or operational-level agreement (23%). Although these aspects can be integrated into the EA metamodel, and thus provide detailed support for IT service management (Correia and Abreu 2009), we do not consider this effort an original task of EA management.

The different processes of IT portfolio management have varying relationships with one another. For example, the analysis of the application portfolio can be supported by analytical insights into the infrastructure portfolio (Dern 2006) that indicate whether application issues related to technical health and performance (Simon et al. 2010) are due to underlying infrastructure deficiencies. The subsequent development of a future application portfolio may involve evaluations of alternative scenarios that may vary in their associated costs, risks, or timelines (Niemann 2006). In this case, another review of the available infrastructure is required, because the procurement needed for additional infrastructure may incur considerable costs. In contrast, infrastructure portfolio management needs information about the future application portfolio, as developed during planning, to make adequate decisions about the future (Dern 2006).

According to the EA management process map, these activities can occur completely inside the EA management arena, but they also may expand across separate IT portfolio management practices. A detailed picture of their interrelations thus depends on where the enterprise draws the line between these concepts and which areas of IT portfolio management it assigns to EA management. Usually, IT portfolio management practices focus on project portfolio management (Benson et al. 2004), which means PPM is associated most closely with IT portfolio management and remains most likely a separate function. Realising this point, we detail the interplay of architectural landscape management (going beyond IT landscape management to include business architecture content at the level of business operations, that is, business processes, organisation, and suchlike) with PPM.

5 A Focus on the Integration with Project Portfolio Management

In this section, we return to the analysis of our empirical data set. In the fourth part of our survey questionnaire, we asked about the existence of potential interfaces between EA management (in the shape of architectural landscape management) and PPM (measured by agreement with the survey items listed in Tab. 2), which we found cited in the literature and which we thus aimed to verify and evaluate further. The results of our analysis follow (note that these results represent actual practice, not individual opinions), complemented by insights into the integration at the organisational and software tool level.

5.1 The Interplay of Architectural Landscape Management with Project Portfolio Management

The most prevalent interfaces according to our respondents were EA management informed of new projects by project portfolio management (2) and transformation planning and governance supported by the use of roadmaps (8), which detail project timelines, orders, and deliverables to transition and target states of transformation (The Open Group 2009). In most organisations that apply roadmaps (69.56%), EA management takes charge of their development and control (cf. Tiemeyer 2008); few assign it to project portfolio management (17.39%) or consider it a joint activity (13.04%).

Apparently, most enterprises implement architecture checks of projects by EA management before approval (7), which may include assessments of project impacts on the architectural landscape (Buckl et al. 2008b). In other words, the project's architectural content gets surveyed, to avoid duplicate efforts and project redundancies and ensure initial conformance with architectural standards (Radeke 2011; Simon 2009; Zimmermann et al. 2010).

After project approval, architectural compliance is then governed by regular architectural reviews (5), as part of project portfolio monitoring activities in most organisations. These activities may involve the use of different instruments to ensure compliance, such as veto rights, budgetary obligations to projects that do not meet architectural requirements without reasonable justification, or incentives for compliant solutions (cf. Simon 2011). To determine which architectural project support is most appropriate (e.g., regular compliance reviews, ongoing participation) (Simon 2011; The Open Group 2009), most organisations conduct a check of architectural relevance at the beginning of a project (3). Architecture contracts (The Open Group 2009) can specify architectural support, as well as the architectural deliverables to be achieved by the project, including updates of the EA model—a contribution that seems relevant throughout the project lifecycle (Buckl et al. 2009). Projects are then assigned a budget for feeding back project results into the EA model; potentially, no project sign-off would occur without this feedback (Op't Land et al. 2009).

Still, in the majority of organisations, projects can be initiated by the EA management function itself (1), based on a target landscape developed during the process of landscape management, as well as on the gaps subsequently identified through the comparison with the current landscape. According to common practice, gaps are then consolidated and assigned to projects to be closed (The Open Group 2009). Important considerations in this context are other projects that are already planned or implemented (Dern 2006), which of these projects may be used to realise synergy effects and close identified gaps (Niemann 2006), or which gaps may already be addressed by these projects (Simon 2009). The assignment of gaps to projects may thus result in a request for a new project, including a specified business case (Bernard 2005; Niemann 2008), or an expansion of the scope of an existing project. Therefore, the core concerns in this context are project definition and scope, then translating the outcomes into proper project proposals or "change requests". In addition to the gaps derived from landscape management, this work should consider other business demands and early project ideas (Radeke 2011), which, after being refined (Bernard 2005; Hanschke 2010; Zimmermann et al. 2010) and consolidated, get also passed on to project portfolio management.

Subsequent project prioritisation is also supported by EA management in most organisations (4), likely because EA management can help uncover and better understand the interdependencies with strategic goals (Radeke 2011), systematically assign projects to the affected business capabilities (Aier et al. 2008a), and unravel their strategic importance.

The efforts to manage project dependencies and synchronise them exhibit the lowest agreement in terms of their support by EA management (6). Still, organisations with these interfaces represent a great minority, which seems reasonable, considering the relevance of informing activities in the preparation of a roadmap of critical dependencies (Radeke 2011).

Figure 5 depicts this interplay graphically using a (simplified) BPMN-like notation (OMG 2011), along the project lifecycle from a project idea or demand, through a defined project proposal, to an approved and then active and finally closed project (using the BPMN data object element). In this sense, it describes the preceding activities in logical order. We adopt the PPM point of view, which is central to this process. Therefore, the figure shows only few sequence flows between activities in the architectural landscape management pool. For readability, we also used a message flow element to indicate bidirectional collaborations between the two "actors" (architectural landscape and project portfolio management), with exchanged data objects on the respective lines, but we did not further distinguish different states of the data objects (e.g., approved project checked for architectural relevance and one already integrated into a roadmap).

The different shades for the activities within the architectural landscape management pool (except for those of elaborating a project idea, developing an architecture contract, and updating the EA model, which were not explicit elements in our questionnaire) represent the results of our analyses to investigate the existence of interactive patterns. We applied factor analysis to identify a few latent factors in the data set that reduce the items according to common characteristics. Prior to the application of factor analysis though, we must test the adequacy of the data set. As outlined in Section 3, we thus computed a Kaiser-Meyer-Olkin (KMO) measure; the resulting score of .65, which can be considered "mediocre" (Kaiser and Rice 1974), proves its general suitability for factor analysis. We factor analyzed our data set using the principal component method with Varimax rotation. With a scree test (to determine the number of factors to extract), we extracted three factors that account for 74.92% of the variance. We list them in Tab. 4 in order of the variance accounted for: factor 1 for 37.01%, factor 2 for 23.78%, and factor 3 for 14.12%, which signals relative factor breadth.

Items are assigned to a factor according to their loadings; the factor loadings indicate the extent to which items can be explained by the factors, which supports factor interpretation. We assigned items to the factor for which they had the highest

Items	References	Survey
(1) EA management hands over project proposals that have emerged from (IT)landscape management to project portfolio management.	Dern 2006, Simon 2009, Simon et al. 2010, Niemann 2008, Schmidt and Buxmann 2011, Zimmermann et al. 2010, McKeen and Smith 2010	59.37%
(2) EA management is informed of new projects by project portfolio management.	Fischer et al. 2005, Keller 2007	78.12%
(3) EA management checks projects initially for architectural relevance to identify the adequate degree of architectural project support.	Keller 2007, Zimmermann et al. 2010, Simon 2011, Buckl et al. 2009, Niemann 2006	65.62%
(4) EA management supports project portfolio management in project prioritisation.	Lankhorst and Quartel 2010, Hanschke 2010, Simon 2009, Niemann 2008, Radeke 2011	59.37%
(5) Projects of architectural relevance are regularly checked for architectural compliance.	Keller 2007, Simon 2009, Foorthuis et al. 2010, Schmidt and Buxmann 2011	68.75%
(6) EA management supports project portfolio management in managing project dependencies and synchronising projects.	Fischer et al. 2005, Niemann 2006, Simon 2009, Saat 2010, Zimmermann et al. 2010, Radeke 2011	43.75%
(7) EA management conducts an architecture check of projects before their approval.	Keller 2007, Simon 2009	68.75%
(8) Transformation planning and governance receive support by using roadmaps.	Buckl et al. 2008a, Simon 2009, Simon et al. 2010	71.87%

Table 3: Interfaces between architectural landscape and project portfolio management.

loading, with a minimum level of .5 (Hair et al. 2006) (Tab. 4).

To verify that the factors are assigned on substantive (content-based) rather than solely statistical bases, we reviewed the item means (Tab. 3); no one factor includes mostly items with high response levels, intermediate response levels, or low response levels (Bernstein et al. 1988). In addition, Cronbach's Alpha values of .802 for factor 1 and .712 for factor 2 (for factor 3 no such value

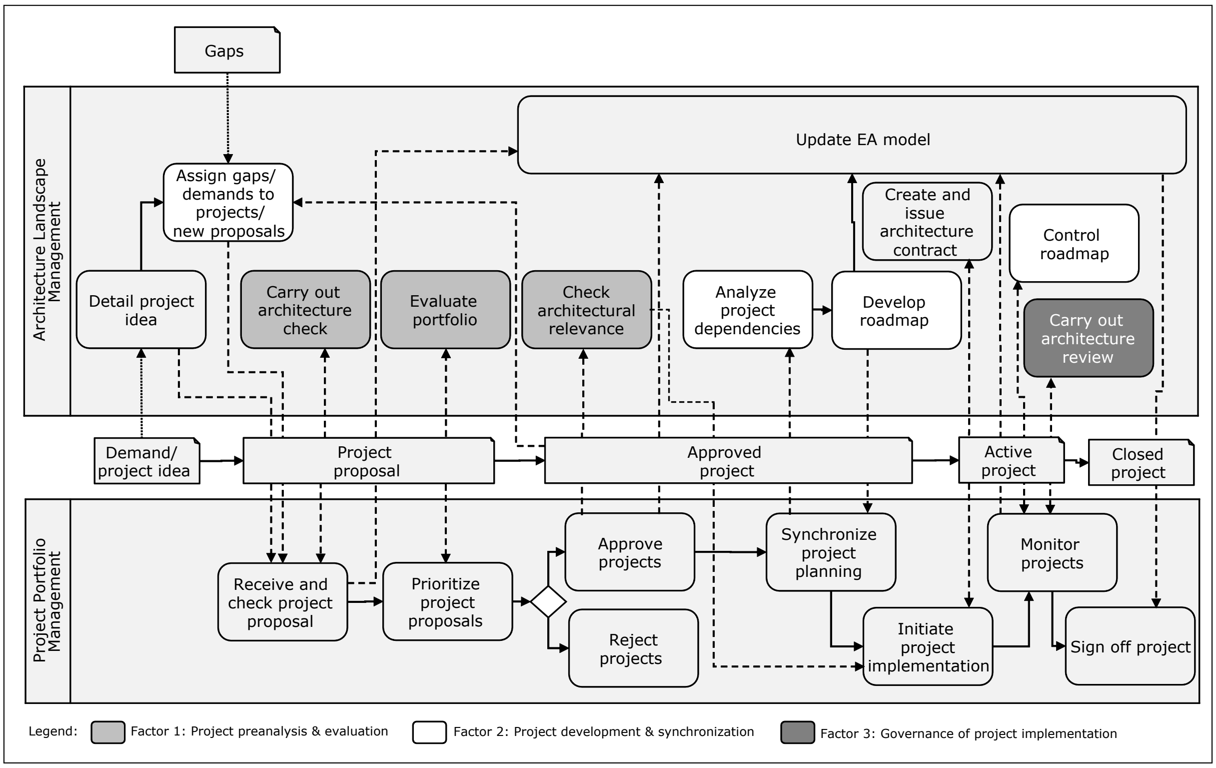

Figure 5: Process diagram of interfaces between architectural landscape and project portfolio management.

exists as it is composed of one item only) indicate adequate internal consistency of the factors (cf. Hair et al. 2006).

Against this background, we interpret and label the three factors (Tab. 4). Factor 1 includes interfaces that target the early analysis and evaluation of projects to justify their implementation, determine their priority, and ensure ongoing architectural support if needed. In contrast, factor 2 captures multiproject planning and synchronisation, and project definition and scoping by the EA management function, based on a designed target landscape. Finally, factor 3 is a single item: regular compliance checks, which represent a focus on governance of project implementation. The most prevalent interfaces (at least 68.75% agreement) are thus represented in different factors (two items are captured in factor 1 though). It is also interesting that, to some extent, the identified factors seem to be in some sort of chronological order and can thus be mapped accordingly onto the project lifecycle phases displayed in Fig. 5 (note that although factor 2 primarily captures activities after project approval, it is also present at the very beginning of the lifecycle).

Next, we performed cluster analyses to determine the distribution of identified factors in the sample and identify groups of respondents that apply similar approaches for integrating architectural landscape management with PPM. That is, whereas factor analysis has revealed descriptive categories of this procedural integration, cluster analysis identifies specific types of integration with respect to these factors. The clusters thus reflect the factor scores from our previous analysis. Following Punj and Stewart (1983), we applied two-stage clustering. So, to avoid constraining our solution with ex ante presumptions (Hair et al. 2006), we determined the number of clusters using hierarchical clustering first. The resulting agglomeration schedule and dendrogram indicated a four-cluster solution. To form

	Factor 1: Project preanalysis & evaluation	Factor 2: Project development & synchronisation	Factor 3: Governance of project implementation
EA management checks projects initially for architectural relevance to identify the adequate degree of architectural project support.	0.824	0.190	0.058
EA management supports project portfolio management in project prioritisation.	0.815	0.131	-0.323
EA management conducts an architecture check of projects before their approval.	0.761	0.073	0.307
EA management is informed of new projects by project portfolio management.	0.716	-0.159	0.175
EA management hands over project proposals that have emerged from (IT) landscape management to project portfolio management.	0.164	0.867	0.093
Transformation planning and governance receive support by using roadmaps.	-0.355	0.728	0.328
EA management supports project portfolio management in managing project dependencies and synchronising projects.	0.590	0.695	0.017
Projects of architectural relevance are regularly checked for architectural compliance.	0.155	0.232	0.884

Table 4: Factor analysis results.

and characterise these four clusters according to the identified categories, we then performed k-means cluster analysis (McQueen 1967) on the factor scores, using cluster centroids from the initial hierarchical solution. In Tab. 5 we present the mean factor scores for the four clusters, the number of cases (respondents) within each cluster, the mean year of inception of the respondents' EA management function, and the mean size of their IT organisation, the latter of which served as control variables.

The first cluster comprises only four organisations; it displays a focus on PPM support by EA management for multiproject planning purposes (cf. Tiemeyer 2008). Therefore, the integration in this cluster refers to EA planning; architects take over the role of planners. Furthermore, the organisations in this cluster represent the longest established EA management functions on average, but the mean size of their IT function is lower than in other clusters.

The second cluster includes ten organisations that limit the integration between architectural landscape and project portfolio management to EA policing. They score highest on the governance of project implementation factor but show negative values for other factors. In this approach, architects are likely considered controllers or police, which can create difficulties for the acceptance of EA management activities (Simon 2011) and overcoming the "ivory tower" phenomenon (van der Raadt et al. 2008) though. Organisations in this cluster, however, have the youngest EA management functions on average, so they may have concentrated on implementing compliance reviews as a first step.

The third cluster groups twelve organisations that seem to understand EA as a valuable instrument for both project portfolio analysis and planning, which we denote EA direction and guidance (cf. Simon 2011). Architects are proactive partners, who also initiate projects, and trusted PPM advisors. Evidence of such guidance also emerges because these organisations most commonly make solution architects representatives of the EA management function for architecturally relevant projects (see Tab. 6). In addition, they have the largest IT organisations on average,

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Project preanalysis & evaluation	-1.58522	-0.68499	0.69492	0.80862
Project development & synchronisation	0.04533	-0.28615	0.92927	-1.41184
Governance of project implementation	-1.22600	1.02515	-0.08958	-0.71209
Number of cases	4	10	12	6
Mean year of inception of EA management function	2001.00	2007.80	2005.18	2004.67
Mean size of IT function	625.00	784.44	2631.58	1096.67

Table 5: Cluster analysis results.

though counterintuitively, they do not exhibit the longest running EA management functions.

Finally, the cluster of the remaining six organisations centers on EA investigation, with a high value on the project assessments captured in factor 1, but no discernible focus on project portfolio planning and implementation governance, as represented by factors 2 and 3 respectively. In their role as investigators, architects provide assessments during the preproject and start-up phases.

These results reveal the varied practical approaches to the procedural interplay of architectural landscape with project portfolio management. The sizes of the clusters indicate two "mainstream" approaches, EA policing and EA direction and guidance; however, the former is predominantly applied by the younger EA management functions. A logical evolutionary path from this focused, lightweight approach to full-blown integration is not apparent. The EA direction and guidance cluster, which embodies the most advanced integration approach, actually includes the second youngest group of EA management functions.

5.2 An Integration at the Organisational and Software Tool Level

The factor and cluster analyses offer an understanding of the factors and types used to integrate EA management with PPM activities. In this section, we consider their integration in the organisational and software tool dimensions (as captured in our theoretical framework), to clarify their design in practice and the relationship to the identified clusters. The items to determine these insights appeared in the fifth and sixth sections of our questionnaire.

At the organisational level, several units offer key integration targets. The project management office (PMO), which takes central control over multiproject management (Spelta and Albertin 2012; Tiemeyer 2008), represents the highest oversight layer and provides support to all programs and projects (Bonham 2004). Different parties may play specific roles in the PMO and its core committees, including the architecture team (Bonham 2004). In addition, the project itself constitutes a temporary organisation, set up to deliver predefined products, according to an accepted business case and relevant architectural requirements. We thus asked about whether at least one representative of EA management worked in the PMO (or a similar unit) and in projects which had architectural relevance (i.e., a solution architect sent off to accompany such a project) (Foorthuis et al. 2010). In Tab. 6, we note the differences across clusters. Most EA management practices benefit from the assignment of solution architects to projects that have architectural relevance (74%). In the individual clusters, at least 60% of the organisations assign EA management representatives to projects. In contrast, EA management representatives in a PMO are relatively rare (32%). Only the EA direction and guidance cluster indicates a rate of at least 50%. This cluster scores highest on both organisational aspects of integration, in support of its status as the most advanced integration approach.

An analysis with the IT function's size and the EA management function's age as control variables also revealed a considerable correlation between the deployment of solution architects and the year of the EA management function's inception. In fact, the use of solution architects relates positively (.341) to age (coded on a scale from 1 [young] to 5 [old] for this purpose). No such correlations emerge for EA management's presence in the PMO.

Our inquiry about the software tool support yielded the following results. EA management is supported by a software tool in 77.42% of organisations in our sample, and 76.67% of the respondents had software tool support for their PPM; 56.25% used software tools for both. However, in most of these organisations (66.67%), the tools are not integrated, and only few have implemented interfaces between EA management and PPM tools, whether unidirectional (PPM to EA management, 11.11%) or bidirectional (16.67%). Only one organisation used the same tool for both EA management and PPM (equivalent to 5.55% of the organisations that used software tool support for both practices). These findings likely reflect the varying functionalities of these tools, but it nevertheless seems astonishing that even interfaces between the tools are rare, despite the need that our previous analysis reveals and the (redundant) work to be carried out manually in result. Perhaps the integration capacity of the tools is poor. However, we can also argue that most EA management practices recognise the importance of EA content management (i.e., most organisations use EA software tools) but apparently place lower emphasis on the management of their processes, such that they use automated workflows to integrate related management practices.

6 Summary and Conclusion

With this study, we have combined two management practices with increasing relevance and thereby developed an integrated view. Beyond the differential scope, focus, and methods of EA and IT portfolio management, we find strong support for our research proposition (see Section 4) that the activities of IT portfolio management represent significant application scenarios of EA management. This supported claim provides a basis for charting the integration of IT portfolio into EA management, in terms of the metamodel, process, organisation, and software tool dimensions (as per our first research question targeting the general integration of the two concepts). As a central outcome, our proposed process map distinguishes core, management, and supporting processes of EA management and also integrates IT portfolio management activities.

The empirical data we gathered through a practitioner survey support our (statistical) analysis of process interfaces between EA management and PPM (the particular focus of our second research question); they reveal different approaches to integration in practice. In general, all the interfaces indicated in the literature receive support as relevant in practice. However, we observe a differential focus on three extracted factors (project preanalysis & evaluation, project development & synchronisation, and governance of project implementation). In turn, we identify four clusters that represent different types of integration (EA planning, EA policing, EA direction and guidance, and EA investigation).

The EA direction and guidance approach is apparently the most advanced, achieving integration at the organisational level as well; we find the largest presence of EA management representatives in both the PMO and the project in this cluster. In general, most organisations assign solution architects as representatives in projects, but few have added EA management representation to the PMO. We also uncover moderate integration at the software tool level, such that interfaces between EA management and PPM tools are not yet common. Further research should extend this study to include investigations of the success promises of each type of integration (represented

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Mean
EA management is represented in projects of architectural relevance by at least one solution architect.	0.75	0.70	0.83	0.60	0.74
EA management is represented in the PMO by at least one person.	0.00	0.30	0.50	0.20	0.32

Table 6: Organisational integration across clusters.

by the clusters). With such information, we could identify outcomes and critical success factors of the integration of EA management with PPM.

Our approach, in which we design an EA management process map and explore descriptive factors and current tactics of integrating EA with project portfolio management, offers greater clarity and structure to this field. It also provides advice to academics and practitioners alike. For academics, our results offer a conceptual guideline for further research on EA and IT portfolio management. In particular, we provide a basis for determining the success of different designs of the integration of EA management with PPM, which could be done by longitudinal case studies, for example. In addition, the identified factors could be analyzed in further detail in terms of metamodel and viewpoint patterns (cf. Buckl et al. 2008b) suited to support the practices represented by the factors and to implement specific methods for valuing portfolio items (e.g., Bedell's method for portfolio management sketched in Quartel et al. (2012)). In general, modelling languages (such as, e.g., The Open Group 2012) may need to be enhanced to account for the patterns of collaboration prevalent in practice. Eventually, the designed EA management process map serves as a basis for developing detailed reference process models that go beyond current descriptions offered by well-known architectural frameworks (e.g., The Open Group 2009).

Other subjects of further research originate from the limitations of this study. As already indicated, the sample of 32 survey responses cannot be considered fully representative. Although the responses represent major industries and, unlike in other prominent surveys of EA practitioners (e.g., Aier et al. 2008b, Winter et al. 2010), each respondent represents a company distinct from the others in the sample and constitutes an immediate EA user, further research could involve a follow-up survey of a greater sample size. Such a study could also include additional fields related to EA management, such as business process management. The outcomes of the literature study could be reviewed (and possibly refined) as well; although our work involved a careful literature collection, there may still be some documents not included in the analysis, and further relevant works may have appeared during/after the production of this paper or may just be in the process of publication.

For practitioners, this study should help them establish closer integrations between EA and IT portfolio management, through the integration of not just at the process but also the strategy, metamodel, organisation, and software tool level. At the process level, this study identifies and systematises adequate interfaces between architectural landscape and project portfolio management in particular, thus offering structures in the creation and use of architectural deliverables that many of today's EA management functions seem to miss (cf. Lucke et al. 2010). In general, the factors and clusters coming out of the analysis help structure the interplay and understand patterns of collaboration which may be adopted by practitioners and with which any method support (e.g., models, viewpoints, techniques) in the enterprise should be aligned. Practitioners can use the corresponding process diagram, which shows the interfaces in a logical order, to design and integrate the affected processes, including checkpoints and quality gates. In this respect, they should consider the finding that EA management does not necessarily have to take a policing role. A crucial step toward the implementation of the advanced approach of EA direction and guidance is organisational integration with the PMO and the projects—a significant finding for practitioners aiming to become effective with overall architectures in actual transformation. The moderate degree of integration at the software tool level also indicates that the implementation of workflows could be a promising step for integrating related management practices closer with EA management.

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