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Systemic Management of Architectural Decisions in Enterprise Architecture Planning. Four Dimensions and Three Abstraction Levels

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Abstract

This paper presents a process model for the management of architectural decisions in enterprise architecture planning. First, decisions are made at the enterprise level, with strategic business considerations on the enterprise information, systems and technology strategy and governance issues. The next step is to define the domains, to then go on with domain architecture decisions. At the systems level, the enterprise and domain architecture decisions are collected and converted into architecture descriptions accurate in precision, form and detail to be given as input to the information systems development process, following the architectural planning. The model is derived from previous work and empirical findings in three large organizations, where the enterprise architecture and enterprise systems have been developed. This case study contributes with considerations on the domains, their definition, and produces refinements to an enterprise architecture process model presented before. For the development of the model, the "living system" paradigm is followed.

1. Introduction

Finding the right strategies for ICT investments and the implementation of any technologies takes careful planning at the managerial level. Both private business and public organizations face the challenges of rapidly evolving technologies and business environments. This study presents a process model for managing architectural plans and decisions from high level business and ICT planning to system development. This means creating a consistent flow of operations and deliverables from the enterprise architecture (EA) planning, conducted collaboratively by business and IT managers, to the systems development implementing the plans. A three-year research project with three ICT provider companies has been exploring the problems of planning and designing IT architectures for large organizations. In

this project, for one of the participating companies, an enterprise architecture management methodology has been created. The company is a growing international ICT services provider with 15 000 staff members and activities in 25 countries. The method was integrated into the company's software development methodology. This study provides insight into the core of the EA method, and contributes with new findings to the method process, using the "living systems" paradigm [20]. For the refined EA planning, drilling down into the organizational reality, domains are identified within the enterprise. The domain concept is considered in this study, and the succession from level to level is clarified.

The objective is to construct a process model that can be further applied both by ICT end user organizations managing their EA, and by ICT services providers in assignments concerning enterprise architecture, or IT architecture, planning and development. These activities precede systems development and implementation, and are especially of importance for the development of the so-called enterprise systems, like ERP or MRP, PDM, CRM, and the like. The goal is to cover both areas of activity: the EA planning and enterprise systems development, with a consistent methodology, to save time and resources along the process.

1.1 Enterprise architecture: linking business and ICT

The general goal of the research project this study is part of was to develop methods for high level architecture management and planning that would enable a better business linkage of ICT for the user organizations. Further, for the ICT providers, methodic approaches were sought that would ensure the mediation of architectural decisions and designs to systems design and implementation. The partner companies had dissimilar method repertoires to start with, and their services portfolios are different. However, in the course of the project, the view has

been confirmed with all three companies that enterprise architecture is a well suited tool for interconnected planning of business strategies, models and structures, and IT architectures. Also, a better governance of IT architectures and the whole organizational ICT both in large private companies and in public organizations can be ensured with the EA approach. This view is widely shared [2], [3], [4], [5], [11], [18], [19], [20].

Higher level architectural planning, with systematically accounted (managerial) decisions, provides valid inputs to any system development process [18]. With systematic architectural work, early system process phases, like requirements elicitation, are likely to be disburdened. Moreover, with this policy, the evaluation of architectures stands on a solid ground. This study takes as starting point a process model for the management of architectural decisions that is part of an EA method integrated to systems development methodology of an ICT services provider. The model is constructed with the four dimensions of, or views to EA (business, information, applications and technology architecture) widely accepted within the enterprise architecture field of study [7], [8], [11], [19]. A suggested process model [16] builds on these dimensions, and three decision making levels: Enterprise, Domain and Systems, as proposed in [8] and [10]. This study proposes some improvements to these pieces of work.

1.2. Analysing the Enterprise Architecture

For the EA analysis, several frameworks have been put forward, [21] gives a summary. Also, a variety of process models have been proposed; [16] accounts 15 different EA processes. The framework of reference and the process model the present study builds on, are briefly introduced in the following.

EA dimensions. Four views to the enterprise architecture are supported in the literature [7], [11], [15], [19]. These main dimensions of EA are:

1. Business Architecture. BA depicts the business dimension (Business processes, service structures, organization of activities)
2. Information Architecture. IA captures the information dimension of EA; high level structures of business information and, at a more detailed level, the data architecture.
3. Systems Architecture. SA/AA, contains the systems dimension, the information systems of the enterprise. Some conventions call it the Applications Architecture or Portfolio, the latter stressing the nature of the information systems as a business asset.

4. Technology Architecture. TA, or the technology dimension covers the technologies and technological structures used to build the information and communication systems in the enterprise.

Each dimension covers a larger area compared e.g. to any column in the Zachman Framework [17], [23]. The set of four architectural dimensions has, however, proven suitable for this level work [11], [15],[19], whereas the Zachman Framework has been perceived as too analytical and detailed for the high level planning and communication with the business management [8]. At a higher abstraction level, especially for business planning, and negotiations on business/ICT alignment, more aggregate descriptions are used.

Another drawback with frameworks like Zachman is, that they lack the technology dimension at the higher abstraction levels: "Scope" or "owner" and "business model" viewpoints in [17],[23]; BA in [13]. yet the owner, or the business manager, is making decisions on investments in ICT, and has therefore to consider the capabilities, qualities and cost of different technologies for the present business mission and future business scenarios. This makes the technology and applications a vital part of high level EA descriptions. An overview of the levels is presented next.

EA levels. There is a tradition to see the above mentioned dimensions as layers that imply a process of defining the architecture by starting at the top (BA), and going down layer by layer making the architectural decisions for each dimension. The NIST EA model is the first EA model to suggest this [13], and also [14], building on [23], supports this view. However, examinations of several industry IT architecture projects prove that architecture design has to consider all the four EA dimensions at various levels of abstraction before defining and developing the architecture either for the whole enterprise or for parts of it [8], [16]. It might not be even possible to proceed by taking into consideration only one of the four dimensions at a time, and make all the decisions on it before planning for the others.

Abstraction level differentiation is, however, necessary. This is the main point made also by [23]. For the EA framework in [8], the levels of architectural decision making suggested by [10] are adopted with adaptations to planning work:

- Enterprise level (The Enterprise Architect's decision scope is the whole enterprise).
- Domain level (The Domain Architect's decision scope is a domain within the enterprise).
- System level (The System Architect's decision scope is a system he works with).

Table 1 The EA Framework called the EA Grid with major contents of the dimensions at each level

The EA Grid	BUSINESS ARCHITECTURE (BA)	INFORMATION ARCHITECTURE (IA)	SYSTEMS (APPLICATIONS) ARCHITECTURE SA /AA	TECHNOLOGY ARCHITECTURE (TA)
ENTERPRISE LEVEL	Business and management decisions, portfolio of businesses, Mission, business strategies and visions	Strategic information management considerations; Information value chain	Strategic systems portfolio (Application portfolio)	Strategic technology portfolio; Vendor relationships, Enterprise technology guidelines and policies
DOMAIN LEVEL	Services/ products in the domain, Business processes for their production	Information management of the domain	Domain systems map Interoperability	Technologies Infrastructure: platforms, networks, data communication
SYSTEMS LEVEL	Business requirements for the systems and data management	Data architectures Data harmonization principles Data storages	Systems architecture; ISA, Application patterns; Developer guidelines	System-level technology architecture; Technical implementation guidelines

- Component level (Developer's decisions on component architecture). This is considered to belong to the system implementation, and thus not included in the framework for the EA planning and management.

Table 1 presents the EA Grid [8],[16] that is the result of taking the four main architectural dimensions and the decision making levels as three main abstraction levels. From the methodology developed on this basis, each table cell presents examples of major deliverables for the dimension at a level

Like pointed out by [23], different stakeholder groups make decisions with a different level of abstraction. The top managers (the business managers) make the strategic decisions for the enterprise and guide and plan the business structuring, i.e. business architecture. Today, they also need to make decisions on technology investments and need information to support the decisions. The information has to be presented at an accurate level of abstraction and aggregation. This is why the four architectural dimensions and the architectural decision making levels seem plausible: technology and information systems questions (Information Architecture; Systems or Applications Architecture; Technology

Architecture views) are presented already at the enterprise level, which is the managerial and strategic decision making level concerning the whole enterprise. This is novel compared to the top-down models presenting technology questions only at the bottom levels, like [13], [14], [23] and [17]. The enterprise level is the level at which the organization is shaped, also with the technology enabled systems [1]. Here, the business – ICT alignment takes place and the business and ICT management need to collaborate. The EA Grid shows the dependencies of the EA dimensions, and it can be used as a coordination tool for the joint efforts.

The process model in [16] suggests a top-down spiral for holistic architectural planning within an enterprise. The spiral goes through the framework (see Table 1) levels, crossing every dimension at a level. Iterations within a level are possible and likely occur. When all relevant decisions are made, the planning activity proceeds to the next level below.

Drawing on some empirical data, the present study adds some aspects to this model. In the next sections, three case examples are briefly presented and discussed. Modifications of the model and further refinements to it are suggested.

4. Three EA planning cases

The research follows the qualitative paradigm, and a case study approach [22] is taken. Within the research project, it would not have been possible to gather a large enough sample of planning projects for a quantitative analysis. There was only a small number of this type of consulting projects that could be examined (i.e. the client gave the permission). Qualitative analysis also allows for a richer picture of each case.

For this study, 3 case organizations were chosen within the clientele of one provider. With each of them, more projects had been undertaken recently, starting from 2001 up until 2004 when the data was collected. The interviews with the provider's project

managers and IT architects focus on one project with each client, but the preceding and following projects with the client were also discussed. The clients represent different industries and are either private companies or public organizations. Their characteristics cannot be further specified due to the confidentiality of the data. The interviews were taped and the essential information transcribed [6]. As additional data, project documentation could also be viewed by the researcher [9].

Tables 2, 3 and 4 present the provider's project work in the current project in the case organizations, presentation follows the concepts discussed in section 2. An "X" in the table means constructed architectural deliverables.

Table 2. Case 1: An EA case taking place at the domain level, with three parallel domains

CASE 1 70 pwd	Business Dimension	Information Dimension	Systems (Applications) Dimension	Technology Dimension
Enterprise	Work at the enterprise level precedes, and the enterprise level decisions are delivered by the client. (E.g. strategy documents, considering, business, information and technology) BA outlines are available for the whole enterprise.			
Domain	BA of the domains is given	XXX (Three domains are developed in parallel)		Next, TA project is launched.
Systems				

Table 3. Case 2 An EA case taking place within one major domain, continuing at the systems level

CASE 2 350 pwd	Business Dimension	Information Dimension	Systems (Applications) Dimension	Technology Dimension
Enterprise	Enterprise level decisions are delivered by the client (no changes in strategies or business structures are made at this point)			
Domain	BA is given	X	X	X
Systems	X	X	X	X

Table 4. An EA case where four domains were detected in the revision of the enterprise level business architecture.

CASE 3 400 pwd	Business Dimension	Information Dimension	Systems (Applications) Dimension	Technology Dimension
Enterprise	X (Revision of the business architecture, 4 main domains defined)	Strategic decisions are given, planning continues at the domain level.		X New, enabling technologies are considered and the TA is planned
Domain	XXXX	X	X	X
Systems				

Also mentioned are the preceding efforts that deliver inputs, and the following projects that take on the outputs of the current project. The project size is given in person work days (pwd).

In cases 1 and 2, the client had undertaken themselves enterprise level planning. The documentation was delivered as input for the assignment of the provider. Three major domains were defined in case 1 and the current project works on them. A major driver for the project was to take advantage of the business integration possibilities, and to leverage business information. An integration project followed, continuing with the realization of the plans to achieve enterprise information integration. In case 3, the project started with enterprise level work, mainly concentrating on joint planning of technology and business architectures. This resulted in a revised BA that takes into account enabling technologies, and the defining of the enterprise level TA. Four domains were defined in the enterprise level BA and the current project continues the work with one of them. Multiple projects were launched for the other domains continuing the preceding enterprise level work at the domain (and systems) level.

The domain concept was used in all cases to divide EA development work into reasonable ("workable") entities. In case 1, the major business processes were defined as domains, for each of which core systems (enterprise systems) were planned, (e.g. a product data, or customer resource management system).

Case 2 concentrated on a major information system that supports core business processes. The system scope was defined as a domain, which was found to clarify the planning responsibilities with the client, and later the system ownership.

In case 3, the four domains were functional areas of the organizational activities. The planning work continued in several projects with the definition of all four EA dimensions for each domain. Also systems projects were launched.

5. Analysis

The EA planning and development efforts are not conducted within a single project in large organizations, but in several consequent and interdependent projects. The case organizations extended the EA development work to several projects. There was a project delivering an EA outline (sometimes very coarse grained), and a division to domains. Further projects were launched for planning and development of domain-level architectures (integration, networks, large enterprise-wide systems

that may cross several domains). In organizations that have taken up active management of their information and communication technologies, the strategic outlines could be taken as given, and the project could go on with the planning at the specified domains. In the projects examined, it was observed that within a level, inter-exchange between the dimensions is needed (Figure 1). There were typical directions (which are natural, thinking of the common information system development paradigm): business architecture is the starting point, and information architecture follows, or is designed next in parallel with the systems / applications architecture.

Technology architecture within a level is the last to be designed in detail, but, on the other hand, it was delivering inputs into the business architecture planning: the information on enabling technologies and technology qualities is needed for e.g. the design of business models and electronic services. Cost of technology is also utmost important for BA decision making. Further, existing technologies that will be retained in the enterprise or a domain, constrain the decision making for the other dimensions.

The planning alone may mean more than one assignment, and the actual enterprise integration and enterprise systems development takes place in separate implementation projects. For the planning, the scope is defined in the project plan: the target architecture can be planned for the whole enterprise, or for one or more specified domains within the enterprise.

In [8], the domain level EA work is described as the materialization of enterprise level plans, with involvement of business operations managers and business process owners of the client. It was found in this study, that an important step in the EA planning work is the recognition and definition of the domains. The domain may be a business process, like suggested in [19], or a business unit or function. Even in the age of process organizations and service business, there is a need for some basic business functions, and it can be rational to treat a function (e.g. accounting) as a domain.

Definition of the domains depends on the organization: its size, how the activities are structured, how the information system support is arranged for the activities. Some domains can be seen as permanent (e.g. a major system supporting the whole enterprise, one or more of its core processes like an ERP or CRM system). In one case, an enterprise wide point of sales system (POSS) was defined as a major domain, with interfaces to other domains.

Other domains are development-time domains that are later released, i.e. the ICT support for a (newly

defined) business unit is planned in one effort, yet the process and system ownership may not remain within the unit. Like the enterprise, the domain is also connected to decision making power, and also financial power. A system owner is nominated in the case a system serves more than one unit, to arrange for the maintenance responsibilities.

The process model proposed by [16] sufficiently explains the overall process in the three cases. As suggested in the model, the planning started with the enterprise level considerations: strategies for all four dimensions of the EA. The starting point is the business and the organization of the business activities (which essentially is depicted in the business architecture). How to organize and exploit the

information is a question handled with the information architecture. The application portfolio and technology portfolio questions were dealt with in describing the respective architecture.

As implied in the model, the further planning takes more precision and deals with more concrete issues. Domain level plans implement the strategic decisions and systems level plans interpret them to systems designers' language, besides adding the necessary details.

However, the process could be improved with further precision on the issues presented above. Figure 2 presents the improved model.

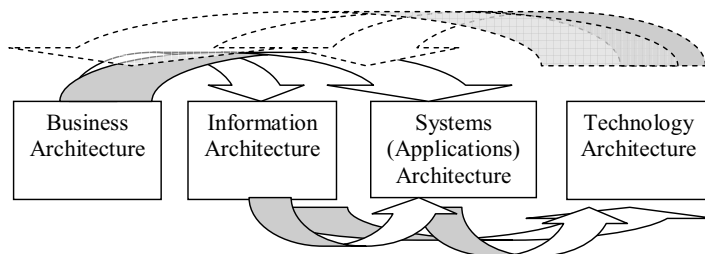


Figure 1 The process within a level: proceeding from left to right, but taking input from right to left

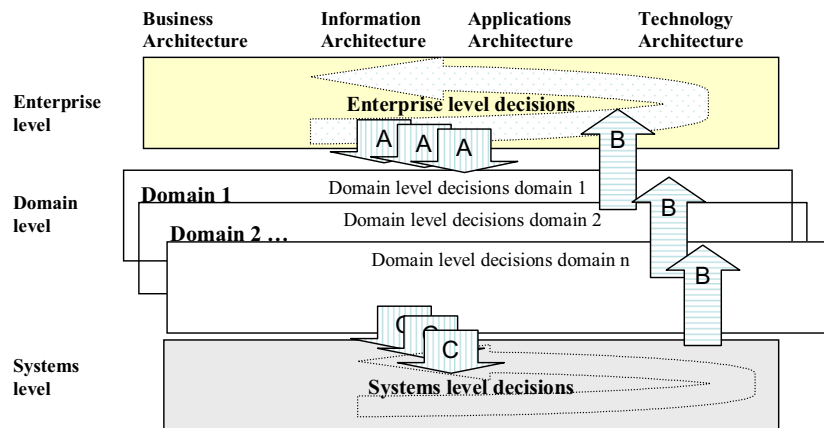


Figure 2 The refined EA process: enterprise level decisions (A), decisions for parallel domains to systems (C), and systems, and an upstream (B): From successful implementations to enterprise wide standards.

The SEAM methodology [20] implements the living systems paradigm. This paradigm helps to understand the course of action in the case examples in this study: A living creature can be looked as a whole ('a human being'), and further as smaller parts, (organs) within (e.g. 'the lungs', 'the digestive system'), and finally as the cell level system. The SEAM methodology brings this paradigm to enterprise architecture planning, which helps to understand the division to the levels enterprise – domain – systems, and the parallel domains.

The enterprise level (with four dimensions) can be seen as the entire "living system". For it, holistic (strategic) plans and decisions are made. To cause the whole enterprise to move to a desired state (target enterprise performance, supported by the target enterprise architecture), further work is conducted at the domain level. (Metaphorically: if a 'human being' wants to improve his/her overall physical fitness, single organs have to improve: lungs, muscles etc.). The city – area – house planning metaphor [12] also supports this view to EA work.

Cases 1 and 3 in the empirical material show explicitly that there are parallel domains. The development process takes place simultaneously in them. After having started as one process at the enterprise level, the process is divided into parallel spirals (with a narrower radius) for the domain level development that is conducted individually by domain. However, it is important that this work is coordinated by the enterprise level decisions, and further enterprise level planning. This is important to ensure connectivity and interoperability across the enterprise. The enterprise level decisions set the basic constraints for the domain and systems level. These constraints can involve e.g. platform or other standards, and partnerships with vendors.

To use experiences within domains for further development in the whole enterprise, the systems and domain level decisions need to be fed back into the enterprise level EA information. Another reason for an upstream flow in the process model (see "B" in Figure 2) is to take into consideration constraints, e.g. existing systems in a domain that will be retained thus setting limits to the EA development. Sometimes a solution is tested in a smaller scope before adopting it for wider use. The feedback is then considered at upper level decision making.

6. Discussion

In this study, the focus is on enterprise architecture planning. Software architecture requirements are derived from high level architectural plans coming

from the top managerial, business operative and from information management level in the end-user organization. These plans set the guidelines, the core requirements and constraints for the design of system architectures. System and software architecture quality assurance starts with valid inputs from these planning efforts.

The enterprise architecture concept in this study is interpreted as the end user organization's view to its comprehensive information and communication technology support for the organizational activities and information management. For this study, the ICT architecture management in three large organizations has been examined, all served by one ICT provider company. As case examples, EA projects conducted in them are studied. Based on this case study we suggest refinements to the enterprise architecture management process adopted in the company's EA method.

Hierarchical systemic enterprise development suggested in this study continues from the enterprise level planning cycle to 1-n domain level cycles, taking the domain scope, for the domains within the enterprise. (Figure 2)

When large organizations are in question, it seems necessary to divide the enterprise to a number of domains. The domains can be permanent or development-time domains. A permanent domain is e.g. a business process, a business function or a business unit. The ICT support for these can be developed and maintained as one entity, i.e. a domain.

Non-permanent, or development-time domains are defined as logically coherent areas for the time of the development. There may be e.g. several business processes that are supported with the developed architecture, each with their own process owners, but they may be dependent on one information system (or several systems) whose owner is another process or unit. After the plans are made, the implementation and maintenance are left with the system owner, so the planning domain can be released after the project.

At the domain level, the decisions are enriched and refined with more detail. The domains have to some extent decision making power (linked to financial resources), but for major investments the decision making (or financial) power is with the top management (or at the enterprise level). In one of the cases it was explicitly pointed out: The case project conducted at that point at the domain level, had to ask for funding for a large infrastructure investment.

The development is further continued at systems level, with a cycle that consists of the general systems level decision making for multiple systems within the enterprise. The systems level decisions include e.g.

shared data architectures, application technologies, use of patterns etc, as well as technology details.

The enterprise architecture is thus created at the enterprise level as a coarse grained outline, and decisions for its dimensions set both the guidelines for and limits to the planning at the lower levels. This helps to avoid overlaps, or lack of interoperability at systems level.

As a summary, revisions to the EA process model in [16] are proposed as follows.

- Interdependencies of dimensions in the decision making within a level are detected as shown in Figure 1. The requirements are derived from BA and IA to systems and technology architectures, but as important are the enablers and constraints from the systems and technology dimensions.

- A process model is created that is cyclic and divided into sub-cycles for the domain level development (Figure 2), with parallel domains.

- Detection of the domains as part of the enterprise level work is suggested, and the permanent and non-permanent (or development time) domains defined.

- An upstream is added to the main top-down process, meaning the reuse of successful solutions, and e.g. the piloting of new applications within a smaller scale. This also shows the constraints possibly coming from a domain for the whole EA.

7. Conclusions

This study concentrates on the construction of a process model that is plausible for the management of architectural decisions. To reach the alignment of ICT investments with business goals, the examination of architecture requirements has to start at the enterprise level strategic planning. Enterprise architecture is seen as a common framework of reference that helps to bring together different concerns and to coordinate the planning and management of ICT assets of an organization.

The four architectural dimensions (business, information, systems or applications, and technology), and the three levels (enterprise, domain, systems) seem to make a framework that is comprehensible for the stakeholders concerned. The level of abstraction is accurate for each level of decision making. The architecting of the enterprise systems will follow the EA descriptions resulting from the planning at the higher levels.

This study is limited to one provider, whose three clients and the mutual experiences with enterprise architecture projects were investigated. The starting point was the EA methodology of the provider. This effort brought a deeper understanding and some refinement to the method process and more

information on the domain concept in the enterprise architecture. In the light of the examined cases, it was found that the methodology framework and the process model did not need fundamental changes.

The understanding of parallel domains and the emphasis on enterprise level coordination of the planning efforts are issues that, to our view, can be generalized to other enterprise architecture planning efforts. Also, alleviating risks with pilot implementations within domains which makes an upstream flow in the top-down process is an idea probably applicable in other contexts. Sometimes good solutions are invented in the enterprise sub-units, and can later become enterprise standards.

The scope of the study does not allow for presenting the descriptions and deliverables used in the EA planning projects. Only with them the process model makes a consistent method. Yet the process model is open to application independent of the descriptions and architecture models that are used. The enterprise level architecture of various systems is the next step that follows the described EA management and planning steps. The findings of this study can bring useful information also for the architecting of these systems.

The general target of this study is the development of a consistent methodology covering both the EA planning projects and the following systems projects. This means a step towards better management of both enterprises and their ICT assets, and the aligning of these two. Also, the development and management of the ICT architectures and architectures of the enterprise systems is backed up with a general understanding of the enterprise context, both the business structures and goals, as well as the technological environment and its development guidelines and constraints.

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