Maturity and Effectiveness of Enterprise Architecture

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Maturity and Effectiveness of Enterprise Architecture

Volwassenheid en Effectiviteit van Enterprise Architectuur
(met een samenvatting in het Nederlands)

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Preface

Ever since I graduated in 1987, I entertained the idea of engaging in a PhD study, but I decided to first gain some years of experience in industry. And thus, after graduation, I accepted a job at the Dr. Neher Laboratory of KPN and started my career in enterprise architecture, which led to my current position as principal consultant enterprise architecture with Sogeti Netherlands. And although I never regretted this choice, the idea of doing a PhD study ‘some day, some way’ was locked somewhere in my brain. A wish I repeatedly expressed, though always with the additional words “but not now, sometime later”. Until my boss, Berend Roukes, approached me and said that Professor Sjaak Brinkkemper from Utrecht University had indicated to him that he had a place available for an external PhD student and was I interested? I was. And I fully enjoyed the ensuing four and a half years spending part of my time in academic research, leading up to this dissertation.

Looking back I am glad it happened the way it happened. I am convinced that the combination of relevant industrial experience and the rigor of academic research is beneficial for both the industrial and the academic work. I had no difficulties in identifying relevant research questions or finding companies for executing case studies. And engaging in academic research made me sharp again in my non-academic work, not taking things for granted too easily.

I am very grateful to all people who made this possible. First of all I want to thoroughly thank Jeroen Versteeg, Marc Ramselaar, Diederik Vieleers and Berend Roukes from Sogeti for allowing me time to work on my research. Not having to do it all in my spare time made all the difference. Once again, thank you.

I also want to thank all professional colleagues who made it possible for me to perform case studies in their companies and my colleagues at Sogeti who assisted me in performing the case studies and survey study. I am still positively surprised by the willingness of so many people to fully cooperate and invest their time in contributing to my research. To you all, thank you very much.

As far as my colleagues at Utrecht University are concerned, I first and foremost want to mention our EA research group: Ralph Foorthuis, Wiel Bruls, Nico Brand, Remko Helms and Rik Bos. Our ‘pizza sessions’ every month under the expert guidance of Sjaak Brinkkemper, are always inspiring and instructive. I really enjoy our discussions and hope to continue to do so for a

long time to come. Thanks also to Ronald Batenburg, Slinger Jansen, Inge van de Weerd and Willem Bekkers for your insightful reviews and discussions.

Of course, a lot of thanks to Sjaak Brinkkemper and Rik Bos, without whom I could not have achieved all this. Thank you, Sjaak, for guiding me through the academic world. And thank you, Rik, for keeping me sharp and my wording precise.

Finally, I would like to thank my husband, Bert Grootjans, for his continuous support throughout the years. Thank you for not minding when I had to spend another weekend on getting a paper ready for submission. But above all, thank you for reviewing all my work and for your undiminishing willingness to keep discussing in depth the scientific issues I encountered over the years. Your support was invaluable.

Marlies van Steenbergen, May 2011

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to this dissertation

Chapter 1

Introduction

The aim of the research presented in this dissertation is to add to the knowledge on how to implement and professionalize the practice of enterprise architecture (EA) in organizations. EA being a relatively young discipline, there are still many questions to be answered concerning what makes EA effective. This dissertation aims to answer some of these questions, taking into account the maturity of EA practices as well as the impact of contextual factors. By EA practice is meant the whole of activities, responsibilities and actors involved in the development and application of EA within the organization, both formally and informally.

1.1 The discipline of Enterprise Architecture

Enterprise Architecture is the discipline within organizations that is concerned with the integral structure of the processes, information distribution and technological infrastructure of the enterprise. To be able to meet continuously changing market demands, organizations themselves also experience continuous change. If not managed correctly this continuous change leads to increasing complexity in the organization. This complexity manifests itself especially in the information systems portfolio, leading to difficulties in ensuring reliability of information and in information sharing. There is a growing awareness that organizations need some kind of direction-setting frameworks to manage information systems development to 'keep in control'. EA provides such a framework. Based on the vision, mission and strategy of the enterprise, the EA discipline provides guidelines on how to structure processes, information systems and supporting technology in such a way as to enable the realization of the strategy. The value of EA lies in the fact that it provides an integrated view of the enterprise, taking all aspects of the organization into account. This view is usually presented as an integrated set of direction-setting architectural principles and models regarding products, processes, organization, data, applications and technical infrastructure, as well as their mutual interdependencies. EA provides insight into the impact of strategic choices, as well as directions as to the design choices made in realizing these strategic choices. Because of its integrated view, EA is expected to make complexity manageable and to prevent further increase in complexity (Lankhorst et al.

2005; Van der Raadt et al. 2004; Ross et al. 2006; Versteeg and Bouwman 2006). In the past decade many organizations have initiated an EA function. The EA function is responsible for the development, maintenance and application of the EA design principles and models.

EA is a diverse discipline operating at all management levels. At strategic level the architect interacts with senior management on fundamental strategic choices. These strategic choices are translated by the architect into high-level designs and design principles, usually called the enterprise architecture. These high-level designs and principles are further developed at the tactical level into directions and designs per business line and per technical domain, the so-called domain architectures. At the operational level the directions from strategic and tactical level are translated into specific rules for projects in project start architectures. This diversity is also reflected in the many types of architect that can be encountered in organizations. Besides the generalist enterprise architects operating on strategic level, one can find application architects, business architects, process architects, infrastructure architects and software architects, to name but a few. Thus, we see that the architecture of an enterprise usually consists of many documents covering different aspects of the enterprise and authored by different architects (Van Eck et al. 2004). The EA function is responsible for this whole.

EA is also a young discipline. Its origin lies in the 80's, though it wasn't called enterprise architecture at that time. It started out as part of the information planning discipline. Information planning was concerned with defining the need of the organization for new information systems (Lederer and Sethi 1992; Teo and King 1997). Several information planning methods were developed. A well-known example is the Information Strategy Planning phase that is part of the Information Engineering method (Martin 1989). Most of these methods contained steps of modeling the organization's business functions, data and information systems. The deliverables of these steps were usually called the information architecture. The information architecture was instrumental in defining the set of projects needed to provide the information need of the organization. This approach is also called the blueprint approach: a blueprint is designed which is to be realized in a number of projects. Many organizations experienced difficulties with information planning, however, as the realization of the plans proved very difficult. Also, in practice, organizations often initiated projects that were not part of the information plan (Lederer and Sethi 1988). These projects took place outside the scope of the architecture. Moving towards the 90's, awareness grows that architecture is a discipline in its own right. Architecture becomes no longer part of information planning, but an independent management instrument to aid decision making in all business projects. Architecture is regarded no longer only a blueprint, but also a framework for decision making. The term IT architecture comes into being. An important example of this shift is the publication of the well-known Zachman Framework (Zachman 1987). Also, government begins to demand the use of architecture in governmental organizations and suppliers (the Clinger-Cohen Act of 1996). Gradually, moving into the new millennium, the scope of architecture is broadened. Awareness grows, that for IT architecture to make the right choices and to be effective, it has to be aligned with the business strategy and choices. People begin to talk about enterprise architecture instead of IT architecture. Besides IT architects, business architects start to appear, as well as architects that bring all aspects together, the enterprise architects. EA, as it now comes to be called, is still very much an art though. Also, the discipline is very much focused on producing the EA deliverables and less on the processes of applying these deliverables in decision making and design. In the last decennium, therefore, we see a shift of attention to, on the one hand, the view of EA as a management discipline, as shown for instance in the emergence of the Dynamic Architecture approach, (Van den Berg and Van Steenbergen 2006; Wagter et al. 2005), and, on the other hand, to standardization, as shown in the emergence of The Open Group Architecture Framework (TOGAF) developments (The Open Group 2009) and the modeling language Archimate (Lankhorst et al. 2005).

Though different definitions of enterprise architecture are still being used, both by professionals and academics, there seems to be a move towards a certain degree of consensus. Most definitions share the element of structure and of prescription, i.e. the EA provides a view of how the enterprise should be structured. A much referenced definition is the IEEE 1471 definition of architecture, stating that architecture is "the fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution" (IEEE 2000). This definition places the emphasis on the structural aspect of architecture. Other definitions place more emphasis on the prescriptive part of EA, for instance the definition by Wagter et al. (2005), "The consistent set of rules and models that guide the design and implementation of processes, organizational structure, information flows, and the technical infrastructure within an organization" and the similar definition used by Lankhorst et al. (2005), "a coherent whole of principles, methods and models that are used in the design and realization of an enterprise's organizational structure, business processes, information systems, and infrastructure". In this dissertation the definition by Wagter et al. is adopted as this is a broad definition that encompasses all aspects of the organization, stresses the prescriptive nature of EA and includes both principles and models. At the present early stage of research into EA practices it is important not to exclude potentially relevant factors.

1.2 Practical relevance

Though organizations are becoming progressively aware that they need an EA practice to manage the complexity of their processes and IS, there are still many questions to be answered as to how to implement and maintain such an EA practice (Van der Raadt et al. 2007). That the field of EA is not fully established yet and that practitioners struggle with successfully exploiting EA, is illustrated by the practitioners conferences being held, which include topics like the value of EA, EA as a management discipline, increasing the effectiveness of EA, exploitation of EA, transforming EA into a business discipline and professionalizing the discipline of EA (Netherlands Architecture Conference 2010, Enterprise Architecture Conference Europe 2010, The Open Group Amsterdam 2010). It becomes increasingly clear to the field that EA is about decision-making processes and commitment to strategic and tactical choices and that EA is not the sole responsibility of a few designated architects, but ought to be on the agenda of corporate management. Among practitioners there is much debate on the best way to achieve this.

Another sign of EA being a field still being developed is the proliferation of types of architects. A large organization may easily employ a hundred employees with ‘architect’ in their job title. Architects may act on various management levels, strategic, tactical or operational, as well as focus on various aspects, for instance processes, data, information systems or technology. This division of work carries the risk of fragmentation of the EA, which may lead to inconsistencies in rules and guidelines (Van Eck et al. 2004).

As the promises of EA are high, so is the pressure to deliver. EA teams are under constant pressure to demonstrate their value to the organization (Weiss 2006). Being able to show the effects of EA becomes increasingly important.

The insights obtained in this dissertation are expected to provide practitioners with knowledge about what factors make an EA practice effective and to give them guidance in shaping their EA practice.

1.3 Scientific relevance

The research literature on EA is still relatively limited, though the last years have shown an increase in scientific publications. Whereas the earliest research on EA is mainly concerned with EA artifacts, addressing topics like EA modeling and EA frameworks (Iyer and Gottlieb 2004; Pulkkinen and Hirvonen 2005; Schekkerman 2006; Zachmann 1987), in the past few years studies have begun to appear on EA management, addressing the EA function and processes. The research presented here is to be positioned in this latter stream of research. Topics that emerge in this research stream are for instance stakeholder management, situational application of EA, EA as a management function and maturity of EA (Aier and Schelp 2010; Van der Raadt et al. 2007; Riege and Aier 2009; Winter et al. 2010). Research is based on both case studies (Aier and Schelp 2010; Van Eck et al. 2004; Van der Raadt et al. 2007) and survey studies (Riege and Aier 2009; Nakakawa et al. 2010; Winter et al. 2010). Several authors identify gaps in the scientific knowledge concerning EA effectiveness, like the lack of insight into the actual benefits of EA (Boucharas et al. 2010) and the influence of contextual factors on the EA practice (Riege and Aier 2009).

This dissertation purports to contribute to the scientific knowledge by studying the EA practice from several perspectives: the maturity of its implementation, its effectiveness in achieving desired results and the context in which it operates. By in-depth investigation of these aspects a contribution is made to filling the gaps identified and building a more comprehensive view of the EA practice.

1.4 Research area

The research presented in this dissertation is of a multi-disciplinary nature. It has its roots in IS research, but it also has strong links to organizational theory as it studies the EA practice in its organizational context. Also, insights from sociology are applied. The study of EA maturity draws upon a very specific line of research within the field of IS, that of maturity models.

1.4.1 Enterprise architecture

Research in the field of enterprise architecture shows a clear trend. The first publications dealt primarily with EA artifacts, focusing on EA as a consistent set of principles and models providing guidance to the design of organizational processes, information systems and technical infrastructure. Topics are EA frameworks and EA modeling (Iyer and Gottlieb 2004; Pulkkinen and Hirvonen 2005; Schekkerman 2006; Zachmann 1987). In more recent literature an increasing focus can be observed on the EA practices. Awareness is growing that effectively employing EA is not a matter of just delivering the right EA artifacts, but also of embedding the EA practice in the existing processes and governance structures (Aier and Schelp 2010; Van der Raadt et al. 2007; Riege and Aier 2009; Winter et al. 2010).

A field of study closely related to EA, is the study of business – IT alignment. As EA considers all aspects of an organization combined, the alignment between business and IT is a relevant part. An important theme in the literature on business and IT alignment is communication or relationship management (Basselier and Benbasat 2004; Chan 2002; Hu and Huang 2005;

Reich and Benbasat 2000). This theme also recurs in the EA management literature (Aier and Schelp 2009; Nakakawa et al. 2010; Winter et al. 2010). In this dissertation the role of communication in EA is further explored, both in terms of its relation to organizational culture and in terms of knowledge integration among architects.

Several authors argue that the influence of contextual factors should be taken into account (Riege and Aier 2009; Winter et al. 2010). In what way exactly contextual factors influence the EA practice has not been extensively studied yet. In this dissertation the influence of three types of contextual factors is studied: organizational culture, organizational structure and economic sector.

Some statistic evidence of EA effectiveness is appearing in the scientific literature (Bahadur et al 2005; Slot et al. 2009). However, statistic evidence alone does not provide much explanation on the how and why. Another limitation in the existing literature is that much effectiveness research concentrates on financial benefits (Bahadur et al 2005; Schekkerman 2005). It is questionable whether EA effectiveness is to be measured solely in financial terms. This dissertation argues that EA effectiveness is to be related to the achievement of the organizational goals and shows that these goals are not always primarily financial in nature.

1.4.2 Maturity models

Maturity models are a means to measure and improve the maturity of functional domains. They distinguish different maturity levels that an organization successively progresses through. As such they can be used as a guideline for balanced incremental improvement of a functional domain. There is an abundance of research literature on maturity models. Most of this literature describes a specific maturity model developed for a specific domain. Numerous maturity models for various functional domains have been developed over the past years (De Bruin et al. 2005; Davenport 2005; Mettler and Rohner 2009). Most of these maturity models are modeled after CMM, distinguishing a fixed number, usually around five, of generic maturity levels (Paulk et al. 1993). Each maturity level is associated with a number of processes that have to be implemented. Though well suited to assessing the maturity state of an existing functional domain, this type of fixed-level maturity model has its limitations, however, when it comes to guiding incremental development of a functional domain (De Bruin et al. 2005; Kuvaja 1998; Marshall and Mitchell 2004). As they are not geared to expressing interdependencies between the processes making up the maturity levels, they provide little guidance in determining the order in which to implement these processes, other than that processes at lower levels are to be implemented before processes at higher levels. In addition, the scientific justification of the generic maturity levels is not always clear as reflection on the theoretical foundation of the fixed-level maturity structure is very limited (Hansen et al. 2004). Another, much less-known type of maturity model, is developed by Koomen and Pol (1999). By departing from the idea of a limited number of generic maturity levels and instead identifying specific maturity levels per focus area, this latter type of maturity model, which we coin focus area maturity model (see chapter 6), is much better geared towards guiding incremental development.

A number of maturity models for the EA practice have been published over the years, mainly by government institutions like The US Government Accountability Office (GAO 2003) or the National Association of State Chief Information Officers (NASCIO 2003)) or analyst institutions like Gartner (Weiss 2006). Ross et al. (2006) discuss four stages that an organization passes through, making increasingly effective use of EA. All of these are based on the fixed-level structure. An exception to this is the research by Van der Raadt et al. (2007), who employ a multiple perspective assessment approach.

In this dissertation a focus area maturity model for the EA functional domain, the Dynamic Architecture Maturity Matrix, is defined. In addition, the concept of focus area maturity model is explored in depth and formalized into an instrument that can be applied by researchers to other functional domains as well.

1.4.3 Organizational theory

As this dissertation studies the EA practice, i.e. the whole of activities, responsibilities and actors involved in the development and application of EA within the organization, it also looks at the rich tradition of organizational theory for scientific foundation. Two strands of research especially appeared relevant to this study. First of all, the knowledge-based view of the firm focuses on the capability of organizations of integrating and applying the knowledge available throughout the organization (Grant 1996a; Grant 1996b). As EA is very much a practice of integrating knowledge, across the different domains of an organization, as well as across the different management levels, knowledge integration is expected to be an important factor for EA effectiveness. Four knowledge integration mechanisms are distinguished in the knowledge-based view: rules and directives, sequencing, routines and group problem solving and decision making. A case study is conducted to investigate the applicability of these knowledge integration mechanism to the EA practice. The case study shows that especially group problem solving and decision making, and to a lesser extent, rules and directives, are important mechanisms for the integration of EA knowledge.

A second strand of research relevant to this dissertation is the research on organizational culture. This research has a long tradition and the influence of organizational culture on functional domains like knowledge management (Alavi et al. 2006) and ERP system projects (Jones et al. 2006) has been established. To study the influence of organizational culture on the EA practice, use is made of an existing framework (Detert et al. 2000). This framework was chosen for various reasons: it distinguishes a number of cultural dimensions, making it possible to analyze in more depth the relation between cultural values and EA and it is based on a synthesis of earlier research on cultural dimensions, including well-known frameworks like the competing values framework (Quinn and Rohrbaugh 1983) and the organizational culture dimensions distinguished by Hofstede et al. (1990).

1.4.4 Sociology

The study of knowledge integration can also profit from insights gained in the field of sociology. To be able to integrate knowledge a common ground is needed. Sociology shows that boundary objects can provide such common ground (Star and Griesemer 1989). A boundary object is an artifact that has different meanings in different social worlds but that has a structure that is common enough to more than one world to make it recognizable. This makes boundary objects into a means of maintaining coherence across intersecting social worlds. Examples of boundary objects are shared concepts, repositories, frameworks and templates, for instance the use of maps by ecologists (Star and Griesemer 1989) and the use of layered plans and ordering lists by physical architects (Schmidt and Wagner 2002). The concept of boundary objects appears to be applicable to the function of EA as well. Boundary objects in this area are for instance shared documents like the project start architecture, shared EA frameworks that recur in various EA document templates and shared repositories of EA models.

1.5 Research description

To structure the research, a simple preliminary research model linking EA context, EA maturity and EA effectiveness is used (figure 1-1).

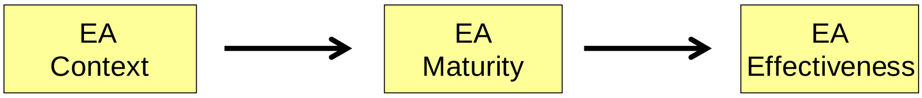

Figure 1-1: Research model

The model depicts a link between the maturity of the EA practice (EA maturity) and the effectiveness of the EA practice (EA effectiveness). *EA maturity* is the degree to which all relevant aspects of the EA practice are implemented. *EA effectiveness* is the degree to which the EA practice produces the desired results. It is widely believed that having a mature practice has a positive influence on its effectiveness. The model also reflects that the way an organization can best increase its EA maturity depends on the organizational context (EA context). *EA context* is the organizational environment in which the EA practice operates. Examples of EA context are the organizational culture, the organizational structure and the economic sector of the organization. The arrows in the research model are not simply to be read as causally relating independent and dependent variables. The relations seem to be too complex for that. Both the constructs, depicted by the rectangles, and the nature of the relationships between the constructs, depicted by the arrows, are object of investigation in this dissertation.

1.5.1 Research questions

The main research question in this dissertation is:

MRQ: How can an enterprise architecture practice achieve effectiveness?

This is a broad and open research question that, on closer inspection, contains a number of underlying themes needing further elaboration. First of all, the concept of effectiveness of an EA practice has to be determined more precisely. Secondly, it has to be established how EA practices can be implemented and further developed in order to achieve effectiveness. Finally, as EA practices do not function in isolation, the question of the potential impact of contextual factors has to be addressed. These three themes lead to three research questions, that are addressed in the three parts of this dissertation.

First, to answer the main research question, it is necessary to elaborate on what it means for an EA practice to achieve effectiveness. Hence the first research question:

RQ1: How can the effectiveness of an EA practice be determined?

There is no consensus yet on what constitutes EA effectiveness. The research literature mentions many possible benefits of EA (Boucharas et al. 2010; Foorthuis et al. 2010). Examples are better management of IT resources, cost reduction, reduction of development time and application and data integration (Boh and Yellin 2007; Morganwalp and Sage 2004; Niemi 2006). Statistical research shows a positive relation between the implemented IT architecture and financial performance (Bahadur et al. 2005) and between the use of solution architectures and project performance (Slot et al. 2009). It seems as if EA effectiveness can mean more than one thing. Thus, a definition of the concept of EA effectiveness as used in this dissertation, is needed. Hence the following sub-question.

SQ1.1: What constitutes EA effectiveness?

Once it is clear how EA effectiveness can be described, the next question is how to determine the effectiveness of a particular EA practice. In order to gain insight in how EA practices can achieve effectiveness, a means is needed of expressing the relation between the EA practice and its effectiveness. Literature review reveals that not much is known yet about exactly how EA techniques are linked to EA benefits (Boucharas et al. 2010). By linking specific activities of the EA practice to specific positive effects for the organization, the effectiveness of an EA practice can be made more explicit. Such an explicit relation can next be extended with key performance indicators, to be able to measure actual effectiveness. This leads to the second sub-question:

SQ1.2: In what way are EA practice activities related to organizational benefits?

Having established the concept of EA effectiveness, the next question is whether improvement paths can be defined for EA practices in order for them to become more effective. Much research has been done into the evolutionary growth of functional domains, using the concept of maturity levels (De Bruin et al. 2005; Davenport 2005; Mettler and Rohner 2009). The maturity models that exist for the domain of EA, however, are more suitable to benchmarking than to providing guidance in incrementally developing the domain. Hence the second research question:

RQ2: How can an EA practice grow in maturity?

To answer this question, first of all maturity stages of an EA practice have to be distinguished. This entails defining what aspects constitute an EA practice, as well as relating these aspects to levels of maturity. This must be done in a sufficiently fine-grained manner to support incremental development. In addition, insight is required in how practices can actively evolve through the maturity stages. These aspects are to be combined into a comprehensive instrument for measuring and increasing EA maturity. This leads to the sub-question:

SQ2.1: How can an instrument be developed to guide the development of EA practices?

In studying the EA practice maturity and EA practice development, knowledge of the common strengths and weaknesses of current EA practices can provide valuable additional insights. These insights can be used to prevent practitioners from falling into avoidable pitfalls. It also provides them with insight into which aspects might require special attention in developing their practice. From a research perspective, an overview of common strengths and weaknesses can support the scientific community in deciding where to focus research to actually improve the field of EA. Hence the second sub-question:

SQ2.2: What are the strengths and weaknesses of current EA practices?

The answer to the second research question provides a generic growth path for EA practices. Both scientific literature and industrial practice, however, suggest that implementation of the EA practice is contextually influenced (Van den Berg and Van Steenbergen 2006; Riege and Aier 2009; Winter et al. 2010). Depending on the circumstances, an EA practice may decide on various ways of implementing its improvement actions. As many EA practices are under close scrutiny of corporate management, and are still very much in the process of proving their added value, making the right choices in this matter is important. Therefore, the main research question cannot be fully answered without studying the impact of these contextual factors, which leads to the third and final research question:

RQ3: What is the impact of contextual factors on the EA practice?

Contextual factors impacting the EA practice may be of various types, leading to a number of sub-questions. As EA is much about decision making and commitment to strategic choices, acceptance of its ideas and actions by the organization is very important. Practice shows that techniques that are very effective in one organization, may be counterproductive in another organization. Acceptance is very much related to attitudes, values and beliefs. This suggests that organizational culture might influence the way the EA practice is approached. This leads to the first sub-question:

> *SQ3.1: How does organizational culture impact the way the EA practice is implemented?*

Secondly, as EA is a corporate-wide function, it might be expected that organizational size and structure may also impact the EA practice. If only in the number of architects needed to perform the function. When the number of architects becomes large, issues of knowledge integration among architects come into play. Measures have to be taken to ensure that all architects share the same vision and, as a group, communicate in a consistent manner. Also, in large organizations, decision-making becomes more diffuse. Architects have to deal with this. Hence, the following sub-question:

> *SQ3.2: To what extent does organizational structure impact the way the EA practice is implemented?*

The third contextual factor to consider is economic sector. Research shows that industry characteristics may influence organizational functions like human resource management (Datta et al. 2005). As far as EA is concerned, it can be observed that the penetration of EA differs between economic sectors. The financial sector has been employing EA for many years, while manufacturing and retail, for instance, have only recently shown an interest in EA. The government sector is somewhere in between. Less clear is whether economic sector also impacts the way EA is implemented. This leads to the final sub-question:

SQ3.3: To what extent does the economic sector impact the way the EA practice is implemented?

The combined answers to the three research questions, with their sub-questions, answer the main research question.

1.5.2 Research approach

The research approach applied in this dissertation is best explained using the IS research framework discussed in Hevner et al. (2004) and depicted in figure 1-2.

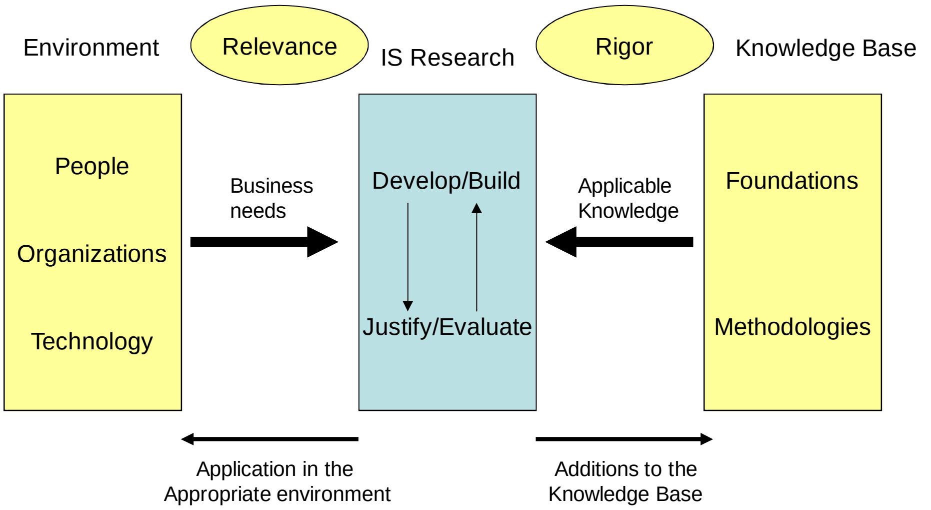

Figure 1-2: The IS research framework (Hevner et al. 2004).

The IS research framework distinguishes between design-science research (build and evaluate) and behavioral-science research (develop and justify). Whereas behavioral-science research aims at truth by developing and justifying theory that explains organizational and human phenomena, design-science research aims at utility by building and evaluating artifacts designed to meet business needs. Design-science research and behavioral-science research are complementary and both are needed in furthering the scientific knowledge. Both research paradigms should address not only rigor, but also relevance. Rigor is established by building upon the scientific knowledge base, both by using existing theories as foundation and by applying scientifically sound research methods. Relevance is established by basing IS research on an actual business need and ensuring applicability of the results in the industrial field.

In this dissertation both the design-science paradigm and the behavioral-science paradigm are applied. The design-science paradigm is used in designing artifacts to get to grips with the constructs of EA effectiveness and EA maturity. In order to study the concept of EA effectiveness, a model is designed, the Architecture Effectiveness Model (AEM), that relates EA efforts to the business goals of the organization (chapters 2 and 3). To study the state of the EA practice a maturity model, the Dynamic Architecture Maturity Matrix (DyAMM) is designed (see chapters 4, 5 and 6). The behavioral-science paradigm is used in building theories about the influence of contextual factors on the EA practice, applying concepts from organizational theory and sociology to the field of EA. This has resulted in additional insights into the application of knowledge integration mechanisms to EA teams (chapter 7), about the impact of cultural dimensions on the EA practice, leading to a Cultural Impact Model (chapter 8) and about the relation between the use of EA techniques and the perception of EA benefits (chapter 9).

1.5.3 Research methods

Both in applying the design-science paradigm and in applying the behavioral-science paradigm, various research methods are used. Taking into account the relatively new field of EA, primarily a qualitative approach is chosen. The research purports to gain more insight into the relation between contextual factors, EA maturity and EA effectiveness, before trying to establish empirical evidence of correlations. Not only must constructs like EA maturity and EA effectiveness be clearly defined, the relation of these concepts with contextual factors must be studied in depth. Not in order to establish simple causal relations, but to gain more insight in the ways these aspects may influence each other in various ways. This requires in depth investigation. To strengthen the findings, however, quantitative methods like statistical analysis and survey study were conducted in addition to the qualitative research. Thus the research approach is a mixed method approach, with qualitative research being dominant (Johnson and Onwuegbuzie 2004). Johnson and Onwuegbuzie position mixed method research as the natural complement to traditional qualitative and quantitative research, with pragmatism being the natural philosophical background for mixed method research.

The mixed method approach taken contains case study research, mathematical formalization, statistical analysis of datasets and survey research.

An overview of the application of the two paradigms, as well as of the research methods used, is given in table 1-1.

Table 1-1: Application of research paradigms and methods in this dissertation

Chapter	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Design science	X	X	X	X	X			
Behavioral science						X	X	X
Case study	X	X	X		X	X	X	
Mathematical formalization		X			X			
Statistical analysis				X				
Survey study								X

Case study research
Case studies are used both for theory testing and for theory building (Yin 2003; Eisenhardt 1989; Benbasat et al. 1987). Four multiple case studies are presented in this dissertation. Three of them concern theory testing, while the fourth concerns theory building.

Two types of theory testing case studies are performed. In the first place, multiple case studies are used to validate the artifacts designed within the design-science paradigm. The AEM is validated in three cases, the DyAMM is validated in two cases. Secondly, a multiple case study including three cases is performed within the behavioral-science paradigm to test a number of propositions concerning division of work and knowledge integration among architects.

Theory building is applied in the study of the influence of organizational culture on the EA practice. In a multiple case study including five cases a Cultural Impact Model is built and propositions are formulated from the data of the cases.

Mathematical formalization
Mathematical formalization is used to provide a more rigorous foundation to the artifacts designed in this dissertation. Both the DyAMM and the AEM are mathematically formalized. Building a mathematical formalization helped in thoroughly understanding the artifacts as well as in validating them.

Statistical analysis
One of the artifacts, the DyAMM, is used over the years to assess the maturity of existing EA practices. From these assessments a dataset of 56 reliable assessments is assembled and subjected to statistical analysis. This analysis not

only reveals the common strengths and weaknesses of the 56 cases, but it is also used to validate the DyAMM.

Survey research
Though the research is primarily qualitative, looking for in-depth explanations, a survey is done to complement the insights gained from the case studies. The survey is held among both architects and EA stakeholders and yielded 293 valid responses. It sheds light on the use of EA techniques, the extent to which EA benefits are perceived and the relations between these two.

This dissertation provides a number of specific contributions to the scientific knowledge. First of all, the concepts of EA effectiveness and EA maturity are elaborated into models: an *Architecture Effectiveness Model* (AEM) is developed that can be used to chart the manner in which EA activities lead to EA effectiveness; a *Dynamic Architecture Maturity Matrix* (DyAMM) is presented, aimed at supporting the incremental development and improvement of an EA practice. Secondly, insight is provided into the influence of contextual factors on the EA practice. This is elaborated into a *Cultural Impact Model*, a model of architectural knowledge integration and an empirical model relating EA techniques to EA benefits.

1.6 Dissertation outline

The dissertation consists of three parts: formalizing EA effectiveness, measuring EA maturity and shaping the EA practice. The three parts address the three research questions presented in section 1.5.1.

I Introduction

Chapter 1: Introduction
The research is positioned and the research questions are formulated.

II Formalizing enterprise architecture effectiveness

Chapter 2: Modeling the contribution of enterprise architecture practice to the achievement of business goals
Using a design-science research approach, an Architecture Effectiveness Model (AEM), is developed, as a means to express the intended contribution of an EA practice to the business goals of an organization. An AEM is developed for

three different organizations. These three instances show that the concept of the AEM is applicable in a variety of organizations. It also shows that the objectives of EA are not to be restricted to financial goals. The AEM can be used by organizations to set coherent priorities for their EA practice and to define key performance indicators for measuring the effectiveness of the practice. This work has been presented and published on the 17th international conference on Information Systems Development (ISD 2008), where it received a best paper award.

Chapter 3: The application of a prescriptive and constructive perspective to design-science research
In designing the AEM, two existing perspectives on design science, a prescriptive perspective and a constructive perspective, are combined and compared by applying both to the design of the AEM. Both perspectives can contribute to improving our understanding of rigor in design-science research within the field of Information Systems and they can add value when applied in combination. Applying the two perspectives to the AEM increased its rigor. The work was presented and published at the Third International Conference on Design Science Research in Information Systems and Technology (DESRIST 2008), where it received a best paper nomination.

III Measuring the maturity of the enterprise architecture practice

Chapter 4: A balanced approach to developing the enterprise architecture practice
To be able to assess the maturity of an EA practice, the Dynamic Architecture Maturity Matrix (DyAMM) is developed. The DyAMM is a focus area maturity model, differing from other existing models in that it departs from the standard generic fixed-level approach. It distinguishes 18 focus areas, which are relevant to developing an EA practice, each having its own maturity development path that is balanced against the maturity development paths of the other focus areas. Two case studies are presented to illustrate the use of the model. The work was presented and published at the Ninth International Conference on Enterprise Information Systems (ICEIS 2007).

Chapter 5: The Dynamic Architecture Maturity Matrix: instrument analysis and refinement

In the past few years the DyAMM has been applied to more than 50 EA practices to assess their EA maturity level. A statistical analysis of these assessments provides an overview of common strengths and weaknesses in existing EA practices. In addition, the set of assessments is used to analyze the DyAMM instrument for four types of potential anomalies. The work was presented and published at the Fourth Workshop on Trends in Enterprise Architecture Research (TEAR 2009).

Chapter 6: Improving IS functions step by step: the use of focus area maturity models

The DyAMM is one instantiation of a focus area maturity model. Other instantiations have been developed for other functional domains. The concept of focus area maturity model is formalized and a generic method for developing focus area maturity models is presented, based on both extensive industrial experience and scientific investigation. An earlier version of this work has been presented and published at the Fifth International Conference on Design Science Research in Information Systems and Technology (DESRIST 2010).

IV Shaping the practice of enterprise architecture

Chapter 7: The architectural dilemma: division of work versus knowledge integration

The tension that exists in many organizations between the need for division of work among architects and the requirement of developing an integrated set of architectural principles and models spanning all aspects of the organization is investigated. Two types of division of work are presented that set different requirements on knowledge integration. Drawing from insights of the fields of IS research (business-IT alignment), organizational theory (knowledge-based theory of the firm) and sociology (boundary objects) a conceptual model is derived linking knowledge integration mechanisms to types of division of work. The conceptual model is tested in three cases. The results show that the concepts of boundary objects and of interconnectedness are relevant in realizing the integration required. The work has been presented and published at the Third International Workshop on Business/IT Alignment and Interoperability (BUSITAL ’09).

Chapter 8: A Cultural Impact Model for enterprise architecture
In order to investigate the impact of organizational culture on how EA practices can be effectively implemented, a theory-building multiple case study is performed. This study led to a Cultural Impact Model. Three cultural dimensions in particular appear to impact the techniques used by EA practices: the degree of autonomy within the organization, the attitude towards collaboration and whether the organization is process oriented or result oriented. The impact of organizational culture appears to be twofold: it may both necessitate certain efforts and impact the way in which these efforts are realized. This work has been submitted for publication.

Chapter 9: Achieving enterprise architecture benefits – what makes the difference?
Finally, additional confirmation of the relation between organizational factors, EA practice implementation and EA effectiveness, is sought by performing a survey among both architects and stakeholders of EA in a wide range of organizations, which yielded a response of 293 valid returns. Employing ordinal regression techniques a model is built linking the use of specific EA techniques to EA effectiveness. Significant differences were found in EA practice effectiveness between economic sectors. This suggests that an organization dependent approach to EA might be appropriate. This work has been submitted for publication.

V Conclusion

Chapter 10: conclusion and outlook
The main research question and the sub-research questions are answered in this concluding chapter. The contribution of the research presented is reviewed. Limitations of the research are discussed and suggestions are made for further research.

Part II

Formalizing Enterprise Architecture Effectiveness

Chapter 2

Modeling the contribution of enterprise architecture practice to the achievement of business goals

Enterprise architecture is a young, but well-accepted discipline in information management. Establishing the effectiveness of an enterprise architecture practice, however, appears difficult. In this paper we introduce an Architecture Effectiveness Model (AEM) to express how enterprise architecture practices are meant to contribute to the business goals of an organization. We developed an AEM for three different organizations. These three instances show that the concept of the AEM is applicable in a variety of organizations. It also shows that the objectives of enterprise architecture are not to be restricted to financial goals. The AEM can be used by organizations to set coherent priorities for their architectural practices and to define KPIs for measuring the effectiveness of these practices[1].

2.1 Effectiveness of enterprise architecture

Enterprise architecture, the practice of developing and applying a consistent set of rules and models that guide the design and implementation of processes, organizational structures, information flows, and technical infrastructure within an organization (Wagter et al. 2005), is a relatively young, but well-accepted

[1] This work was originally published as: Steenbergen, M. van and Brinkkemper, S. (2008). Modeling the Contribution of Enterprise Architecture Practice to the Achievement of Business Goals. In Papadopoulos, G. A., Wojtkowski, W., Wojtkowski, W. G., Wrycza, S. and Zupancic, J. (Eds.), *Information Systems Development: Towards a Service Provision Society, Proceedings of the 17th international conference on Information Systems Development*, 609-618. Springer-Verlag: New York.

discipline (Bucher et al. 2006; Van der Raadt et al. 2007). The discipline is in a stage of development as is evidenced by the many practitioners conferences dedicated to the practice of enterprise architecture, the rapid emergence of books on the topic and the emergence of standardization efforts (Lankhorst et al. 2005; The Open Group 2007).

Establishing the effectiveness of enterprise architecture, however, appears difficult (Lankhorst et al. 2005; Schelp and Stutz 2007). The effect of architecture on the business goals is indirect and the difficulty in linking the two may be compared to the difficulty of linking learning and growth efforts to strategic objectives (Kaplan and Norton 2000). The wide ranging nature of enterprise architecture makes it difficult to quantify the impact of architecture (Lankhorst et al. 2005), though the need for clearly expressing the contribution of architecture to the organization's goals is increasingly felt. Enterprise architecture teams are under constant pressure to demonstrate their value to the organization (Weiss 2006). The topic of architectural effectiveness also starts to appear on professional conferences (EACE 2007; TOGAF 2007). Some statistical evidence of effectiveness is appearing (Bahadur et al. 2005). However, statistical evidence alone does not help an organization to clearly define the contribution of architecture to their business goals. In addition, much effectiveness research concentrates on financial benefits (Bahadur et al. 2005; Schekkerman 2005). We will argue that this is too limited a view.

In this paper we present an Architecture Effectiveness Model (AEM) that can be used to model the contribution of the architectural practice to the organization's business goals. The AEM is based on the concept of cause-and-effect. As such we work in the tradition of the balanced scorecard (Kaplan and Norton 1992; Kaplan and Norton 2006; Martinsons et al. 1999; Schelp and Stutz 2007) and especially the strategy map (Kaplan and Norton 2000). Other applications of the cause-effect model in the field of enterprise architecture are Van den Berg and Van Steenbergen (2006) and Op 't Land and Proper (2007). Though the cause-effect model can occasionally be encountered in the architecture profession to express the objectives of the architectural practice in a specific organization, extensive research into its use as an instrument to express intended and actual effectiveness of architecture has as yet not been done. Our research is akin to research on the maturity of enterprise architecture (Van den Berg and Van Steenbergen 2006; Van der Raadt et al. 2007; Van Steenbergen et al. 2007). However, we focus on the contribution of architecture to business goals, rather than on how well the architecture processes are performed.

The approach we took in developing the AEM is that of design-science research (Hevner et al. 2004; Verschuren and Harto 2005). We tested the concept of the AEM in three cases. We found that the AEM is applicable as an instrument in all three cases, but that the exact instantiations of the AEM in the three cases varies. It appears that the three cases differ in their objectives of practicing enterprise architecture and that these objectives are not limited to financial gains. In terms of the three domains of business performance of Venkatraman and Ramanujam (1986), architecture contributes to business performance, or even organizational effectiveness, not only to financial performance.

In section 2.2 the structure and aim of the AEM is discussed. Its application in three cases is described in section 2.3. Section 2.4 compares the three applications. In section 2.5, we discuss conclusions and suggestions for further research.

2.2 The architecture effectiveness model

The goal of our research is to develop an instrument for making explicit the intended and actual contribution of the architectural practice to the organizational goals. As we are dealing with a new solution to a hitherto unsolved problem: the explication of the effectiveness of an enterprise architecture practice, this may be considered a case of design-science research (Hevner et al. 2004). From our goal we defined requirements, assumptions and specifications for the instrument as recommended by Verschuren and Hartog (2005). Examples of the requirements we formulated are (1) *The formulation of the intended contribution of the architectural practice to the business goals must be tuned to the organization*. If the contribution of architecture is stated in general terms only, it is very difficult to make the connection to what is actually happening in the organization; (2) *The line of reasoning from architecture to business goals must be transparent*. The instrument must be crystal clear as architecture is often considered rather abstract. From the formulated requirements we reasoned that a cause-effect network seemed a suitable design, as such a network allows us to build an explicit link between architectural practice efforts and business goals by means of a number of intermediate steps. The choice for this kind of solution was strengthened by its similar kind of use in the strategy map of Kaplan and Norton (2000). The AEM that resulted relates architectural efforts to business goals by building a cause-effect based network. Figure 2-1 shows the general structure of an AEM.

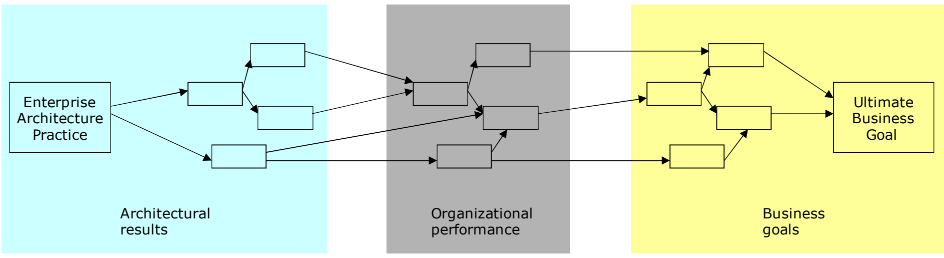

Figure 2-1: The general structure of an Architecture Effectiveness Model

The basic concepts of an AEM are the effect, represented by a rectangle and the cause-effect relation, represented by an arrow between two rectangles. An effect in this context is defined as an intended result. A cause-effect relation represents the purposeful contribution of one effect to another effect.

The AEM is intended to reflect the objectives of architecture for an organization in the next couple of years. The instantiation of an AEM differs between organizations. It shows what the architecture practice strives for. This implies that it represents a choice: there is not one right instantiation of the AEM for an organization, only one that is agreed upon within the organization. As figure 2-1 shows, the AEM contains on the left the enterprise architecture practice, the whole of activities, responsibilities and actors involved in the development and application of enterprise architecture within the organization. On the right it contains the ultimate business goal: the primary goal of the organization. The steps in between link the two.

The AEM can be modelled as an acyclic directed graph. It consists of nodes and directed edges. The nodes represent effects that are desirable for the organization. Examples are ‘having overview’ or ‘better project control’ or ‘reduced costs’. The edges represent the unidirectional relation ‘contributes to’. The word ‘contributes’ is used instead of ‘causes’ to reflect the fact that the contributing effect need not be the sole factor influencing the resulting effect. Experience with enterprise architecture in many organizations suggests that the effects (the nodes) can be divided into three types. The architectural results are positioned at the left hand of the graph. These are the effects that are fully determined by the architectural practice. The business goal effects are positioned at the right hand of the graph. These are the business results defined by senior management. The enterprise architecture practice is one of the factors contributing to these goals. In between we find effects in the area of the operations of the organization: the internal processes. We call these effects the organizational performance effects. This division into three types of effects echoes the categories of learning and growth, internal process and customer perspective of the balanced scorecard strategy map (Kaplan and Norton 2000).

> $AEM = (N,E)$ with $N = (AR \cup OP \cup BG)$ the set of nodes,
>
> where AR = Architectural Result effects; OP = Organizational Performance effects; BG = Business Goal effects and
>
> E the set of edges on N (i.e. E is a subset of $N \times N$) satisfying $OP \times AR \cap E = \emptyset$ and $BG \times OP \cap E = \emptyset$ and $BG \times AR \cap E = \emptyset$.

An AEM has only one source (node with indegree 0), the Enterprise Architecture Practice node, and usually also only one sink (node with outdegree 0), the Ultimate Business Goal, though more than one sink is possible if an organization has multiple purposes. Note that the model does not preclude AR effects to be related directly to BG effects. In an AEM the following key effects may be distinguished.

- *Key step.* A key step is defined as an effect that has both an indegree and an outdegree of a specified minimum s. In other words, it has at least s contributing effects and it contributes itself to at least s other effects. So $n \in N$ is a key step iff indegree(n) $\geq s$ AND outdegree(n) $\geq s$. The exact value of s is to be determined yet. On the basis of the three cases we have studied so far, we have set s to 3, for the time being. This seems a reasonable value with respect to the total number of nodes and edges in each of the three cases.
- *Key motivator.* A key motivator is defined as an effect with the largest indegree (i.e. the largest number of contributing effects). So $n \in N$ is a key motivator iff indegree(n) = max (indegree(m)), $m \in N$. It is an effect that is the aim of many other effects. Note that there may be more than one key motivator.
- *Key enabler.* A key enabler is defined as an effect with the largest outdegree (i.e. the largest number of effects it contributes to). So $n \in N$ is a key enabler iff outdegree(n) = max (outdegree(m)), $m \in N$. It is an effect that contributes to many other effects. There also may be more than one key enabler.

The model as such presents the intended contribution of architecture to the business goals by way of a number of intermediate results. By attaching key performance indicators (KPIs) to the effects, the actual contribution over time can be measured. Regarding the effects as goals, an approach like the Goal Question Method (Basili et al. 1994) can be adopted to formulate KPIs.

2.3 Three applications of the AEM concept

The AEM concept has been applied in three organizations: a large municipality, a university of professional education and an international financial institution.

Where, for readability purposes, in this section we speak of the AEM of an organization, we mean the instantiation of the AEM concept for that organization. The three organizations have in common that they had all been engaged in organization-wide enterprise architecture initiatives for two to three years. The building of the AEM was done by the architects of the organization, assisted by either business strategy documents or opinion leaders. The researcher only fulfilled a moderator role, asking questions and recording results. In each occasion the AEM went through at least two versions. The final version was accepted by the person in charge of the enterprise architecture practice. It was generally felt, however, that the AEM should always remain open to extension from new insights or needs.

The three organizations are of different type, one of them being a commercial profit organization, one an educational institution with a not-for-profit goal, but with some goals of growth and a limited sense of competition, and one a municipality strongly ruled by government regulations. This variation was intentionally sought, as our objective was to test the use of the AEM in different circumstances.

2.3.1 Case 1: A Municipality

The first application of the AEM is in a municipality of more than 200,000 citizens. The municipality has about 2200 employees, about 100 of which work in IT. Architecture is the responsibility of the Policies, Standards and Programs team which is positioned within the IT department and consists of seven employees, three of which have the role of enterprise architect.

A preliminary AEM was established in a workshop with eight participants. The lead architect selected the participants from the various architecture stakeholder groups: architects, program managers, controllers, information managers, IS management. Brown paper techniques were used to build the AEM. At the far left of the brown paper a card was put with the text ‘enterprise architecture practice’. At the far right a card was put with the text ‘coalition charter’, as the realization of the coalition charter was the primary goal of the municipality organization. The purpose of the exercise was explained as filling the gap between the two, or in other words, determining what the architectural practice should contribute to realizing the coalition charter. Participants were first asked to write down on cards the results they thought architecture should deliver or contribute to. These were used as a base to build the AEM together. Starting at the right, the moderating researcher asked if anyone had written down a result that would contribute to realizing the coalition charter. One participant volunteered a card with the text ‘customer service’ which was added to the brown paper to the left of the ‘coalition charter’ card. This called forth other cards from other participants. Each card was discussed and after consensus was reached it was added in the right place on the wall. When the flow of cards stagnated attention was turned to the left side of the wall. This time the question was to indicate the results of practicing enterprise architecture. This brought forth a new flow of cards, with architectural results like ‘standards’, ‘common framework’ and ‘overview’. When the participants felt they had no more cards to add, the group turned to closing the gap between left and right. This constituted the final stage of building the AEM. After the workshop, the AEM was distributed among the participants for review. A few simplifications were suggested, which were finalized in a second workshop. These simplifications dealt with combining a number of cards into one. For instance, the combination of ‘data consistency’, ‘data integrity’, ‘data reliability’ and ‘data security’ into the one result ‘trusted information’. In figure 2-2 the final AEM is shown. The colors reflect the three types of effects, grey (dotted line) for architectural results, dark grey (solid line) for organizational performance effects and light grey (stripes) for business goals.

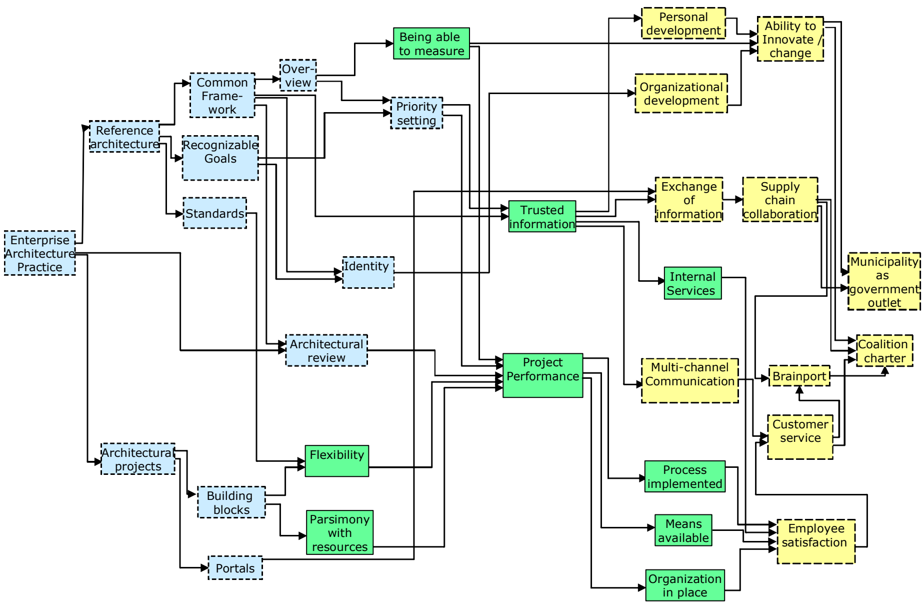

Figure 2-2: The AEM of a municipality

Effects like ‘employee satisfaction’, ‘personal development’, ‘organizational development’ and ‘identity’ show a focus on employees and organization. The key nodes are all in the categories of architectural results (‘common framework’) and organizational performance (‘project performance’ and ‘trusted information’). This case was the only one with two end nodes: ‘coalition charter’ and ‘municipality as government outlet’, reflecting the dual character of the municipality in having its own coalition goals as well as being a representative of government.

After it was completed, the AEM was used to define paths from the start node to the end node, in order to set priorities in architecture activities. An example is the path ‘enterprise architecture practice’, contributes to ‘architectural review’ contributes to ‘project performance’ contributes to ‘process implemented’, ‘means available’ and ‘organization in place’ contribute to ‘employee satisfaction’ contributes to ‘customer service’ contributes to ‘coalition charter’. It was decided to define KPIs on this path for the effects ‘project performance’, ‘process implemented’, ‘means available’, ‘organization in place’ and ‘employee satisfaction’.

2.3.2 Case 2: A University of Professional Education

The second application of the AEM concerns a university of professional education with more than 16,000 students and about 1500 employees. The university has an IT department of about 50 employees. Architecture is taken care of by the one information architect. The preliminary AEM was established in a joint effort between the information architect and one of the researchers. The researcher mainly asked questions for elaboration to sharpen the reasoning of the information architect, whereas the information architect built the actual AEM. In this case too, the building process started at the right, then turned to the left and finally closed the gap. The ultimate business goal for this organization was ‘playing its role in society’. Building the preliminary model took six hours. The resultant model was validated by the director of one of the divisions, the Centre of Innovation and Knowledge Distribution, a key stakeholder of enterprise architecture. The architect was also present in this discussion. We explained the purpose and structure of the AEM. Then we concentrated on the business goals and asked the director if he recognized the goals and if he had any additions. Apart from fine tuning some of the goals, the director made two main additions concerning accreditation and partnering. This worked through in the organizational performance effects by putting more focus on ‘exchange of information’ and ‘quality of information’. Architectural result effects were not changed. The focus in the emergent AEM was much on supporting the primary processes and facilitating collaboration. Most nodes fall within the category of business goal effects. The key nodes are all in the areas of organizational performance (‘exchange of information’) and business goals (‘aligned process’, ‘more students’). As with the municipality, financial goals do not occur in the model. Due to space limitations the actual AEM is not included.

2.3.3 Case 3: A Financial Institution

The third application concerns a multinational financial institution with more than 60,000 employees. Architecture is positioned within the Operations department (14,000 employees) and consists of both global architects and architects within the various divisions. In all there are about 175 architects.

In this case, the AEM was discussed and revised by various people in varying constellations. It was made within the context of an architecture maturity improvement program. The preliminary model was established in a joint effort between the person responsible for the architecture improvement program and the researcher and then refined over a number of seven versions, incorporating input from discussions with various architects, until the final version emerged. In this process each contributor added his own concerns to the model. One person focused on the professionalizing effect of architecture, another introduced effects concerning simplification. These additions concerned architectural result nodes and organizational performance nodes. The source for the business goal nodes were existing strategic documents. The ultimate business goal in this case was ‘continuity and profit’. Figure 2-3 contains the final AEM.

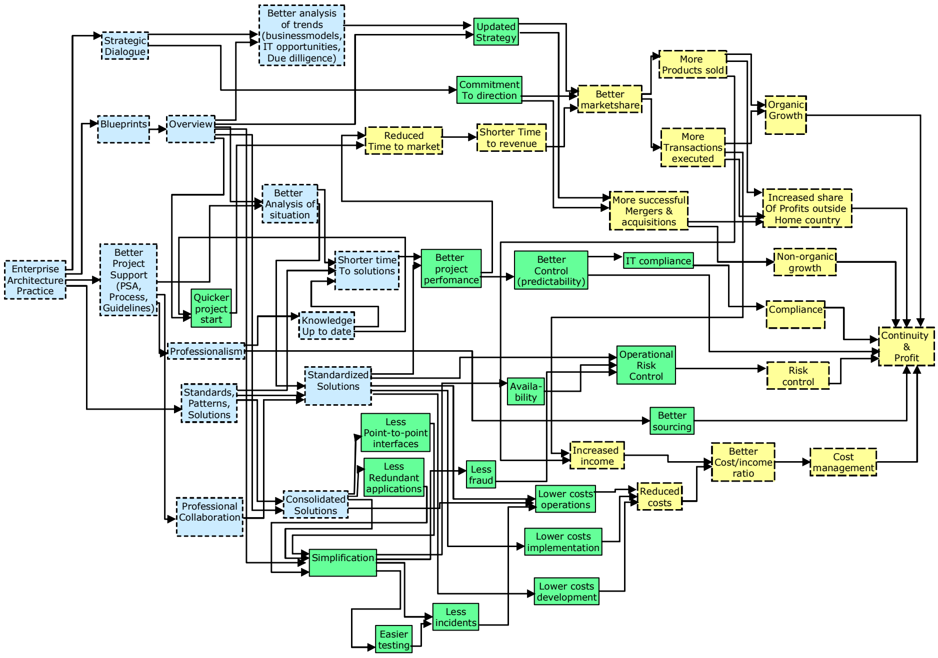

Figure 2-3: The AEM of a financial institution

The focus in the financial AEM is on organizational processes and control. The key nodes are in the architectural results area ('standardized solutions', 'overview') and organizational performance area ('simplification'). Professionalism and control are two areas that are unique to this case.

2.4 Discussion

The AEM instrument could be applied to all three cases. In all cases the distinction between architectural results, organizational performance effects and the business goal effects could be established. And though the actual definition of the nodes in these three categories differed, we can identify a common core: nodes like 'overview', 'standards', 'flexibility', 'exchange of information', and 'project performance' are shared among two or all three of the instantiations. Though the model does not preclude a direct relation between architectural results and business goal effects, the three cases show no such direct link. In the cases, all architectural results are linked to business goals via organizational performance effects. It is a matter for further research to investigate whether this is the case in general.

The differences between the three instantiations reflect the characteristics of the organizations. In terms of the value dimensions of Quinn and Rohrbaugh (1983), the municipality exhibits a more internal focus than the university which is more externally focussed. On the structure dimension the financial institution exhibits a greater tendency to control than the municipality. Though the number of three is too small to draw any definite conclusions, the cases do indicate that the intended contribution of the enterprise architecture practice to the business goals is partly organization specific and can not be expressed fully in general terms. In only one case financial results play an important role.

Table 2-1 shows some figures for the three cases. The numbers between brackets show the number of incoming (key motivator) or outgoing (key enabler) edges.

Table 2-1: Statistics of findings of cases

Characteristic	Municipality	Education	Financial
Number of effects	32	48	48
Distribution over EA/OP/BG	12 / 9 / 11	17 / 11 / 20	14 / 18 / 16
Number of relations	52	78	83
Key steps	Project performance	Aligned process	Simplification Standardized solutions
Key motivator	Project performance (5)	More students (5)	Standardized solutions (4)
Key enabler	Common framework (4) Trusted information (4)	Exchange of information (6)	Overview (6)

A number of additional observations can be made. The three cases do not differ greatly in AEM size and the distribution of nodes over the three categories is quite evenly. The cases do differ in key node type: architectural results (‘standardized solutions’ and ‘overview’) and organizational performance (‘simplification’) for the financial institution, organizational performance (‘project performance’ and ‘trusted information’) and architectural results (‘common framework’) for the municipality and business goals (‘aligned process’ and ‘more students’) and organizational performance (‘exchange of information’) for the university. The number of three cases is too small to draw any definite conclusions from these observations, so we will leave that to further research.

Much of the benefit of the AEM lies in the process of building. The three cases showed that building the cause-effect chain from the enterprise architecture practice to the primary business goals stimulates the architecture stakeholders to reflect on the real value of architecture for their organization. As the cases also show, the development of an AEM can be done in various settings, varying from a sequence of bilateral exercises to a workshop with up to ten participants. As the AEM is a normative model, essential in the process is the final acceptance of the result by the person responsible for the architectural practice.

An AEM can not only be used to show the intended contribution of the enterprise architecture practice to the business goals. It can be taken one step further in defining key performance indicators to measure this contribution over time. From a specific model we can select effects we wish to measure. Criteria for selecting these effects are the importance of the effect in the organization, the extent of influence of architecture on the effect and the feasibility of measuring KPIs for the effect. A good practice is to select two or more effects that are directly linked, at least one that is largely determined by the architecture practice and at least one that lies in the organizational performance or business goal area. In this way progress in an architectural result is linked to progress in an organizational result. In any AEM, many paths can be chosen from the start node to the end node. Each path represents a line of reasoning connecting the architecture practice to the business goals. By choosing KPIs on one path, a coherent priority setting is achieved.

2.5 Evaluation and conclusions

We evaluated the design of the AEM instrument against the seven guidelines formulated by Hevner et al. (2004). Table 2-2 summarizes the results of this evaluation.

There are some limitations to our research so far. The AEM has been applied to a municipality, a professional university and a financial institution. From these applications some interesting similarities and differences can be derived. However, the number of three cases is very limited. We intend to extend the number of AEMs in the future which will make it possible to analyze a larger sample. Also the three applications differed somewhat in the actual manner the AEM was built. Though in all cases the approach of starting at the right, moving to the left and then closing the gap was followed, this was done in a workshop setting in one case, in a face-to-face meeting with an information architect in the second case, and in a number of consecutive sessions with varying participants in the third case. These differences sprang from practical reasons mainly. As an anonymous reviewer pointed out to us, it might be interesting to investigate whether a standard implementation model could be developed.

It must be borne in mind that architecture is not the only factor contributing to the organizational performance and business goals. In practice this means that actual KPIs have to be closely investigated to explain their actual values. But this is good practice for any KPI measurements.

Table 2-2: Applying the guidelines of Hevner et al. (2004) to the AEM

Guideline 1: design as an artifact	Our research delivered a construct, a model and a method as described in sections 2.2 and 2.3.
Guideline 2: problem relevance	The AEM definitely seems to fulfill a need, as expressed in section 2.1 of this paper.
Guideline 3: design evaluation	The AEM is applied in three types of cases (external validity). Construct validity is striven for by using multiple participants in applying the model. The constructs behind the model were well understood. Besides, the constructs are precisely defined in a mathematical formalization. Reliability is achieved by describing the process by which the AEM instrument is designed and the different AEMs were built. Internal validity is not applicable as the case studies were exploratory in nature (Yin 2003).
Guideline 4: research contributions	The contribution is mainly to the design foundation in that it presents a novel way of making explicit the contribution of enterprise architecture to the business goals.
Guideline 5: research rigor	The approach is in the tradition of the balanced scorecard.
Guideline 6: design as a search process	Requirements were defined excluding certain approaches as described in section 2.2.
Guideline 7: communication of research	This paper to the research community.

In this paper we presented an instrument for modeling the contribution of the enterprise architecture practice to the organizational goals, the AEM. We tested the AEM in three very different organizations. The AEM appeared applicable to all three organizations, resulting in instantiations that clearly reflect the characteristics of the organization and provide a transparent connection between the enterprise architecture practice and the ultimate business goal. The AEM presents a novel way of making explicit the contribution of enterprise architecture to the business goals and as such enables further research into the effectiveness of enterprise architecture. It fills a gap that up till now existed between the architecture practice and the area of achieving business goals.

The three cases show that not every organization is focused on financial goals. Our conclusion is that the focus of much research on financial results is therefore excluding whole categories of use of enterprise architecture in organizations. In our view a purely financial approach to architecture effectiveness is too restrictive.

The AEM shows similarities with the balanced scorecard (BSC) strategy map in that it links organizational efforts to organizational objectives by a cause-effect relation. The BSC perspectives of customer and internal process are recognizable in the business goal effects and organizational performance effects, respectively. The architectural result effects are comparable to the learning and growth perspective. In organizations that have implemented the BSC, the AEM can be linked to the strategy map. If no BSC is implemented, the AEM might be a first step in doing so. As architects are usually very knowledgeable about the organization, they are likely candidates to initiate such an initiative.

The AEM adds to the existing research on architecture maturity (Van den Berg and Van Steenbergen 2006; Van der Raadt et al. 2007; Van Steenbergen et al. 2007) by focusing on the contribution of architecture to the business goals (effectiveness), rather than on how well the architecture processes are performed (maturity). It would be interesting to relate maturity and effectiveness. The hypothesis being that a greater maturity should lead to a greater effectiveness. We intend to perform a longitudinal study to investigate precisely this relation.

Chapter 3

The application of a prescriptive and a constructive perspective to design-science research

Design-science research is much valued for its relevance to the Information Systems community. How to achieve rigor in design-science research is less well-established. We compare two perspectives on design science that address rigor, by applying both to the design of the Architecture Effectiveness Model, a model for making explicit the contribution of practicing enterprise architecture to an organization's business goals. One perspective, which we will refer to as the prescriptive perspective, addresses design-science research in Information Systems. The other perspective, which we will refer to as the constructive perspective, addresses the process of designing in general. Our conclusion is that both perspectives contribute to improving our understanding of rigor in design-science research within the field of Information Systems. The two perspectives are complementary and can be applied in combination[1]*.*

3.1 Introduction

Design-science research is foundational to the IS discipline (Hevner et al. 2004). The increasing literature on design-science research attests to this (Markus et al. 2002; Aken 2004; Arnott 2006). One of the attractions of design

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science is its relevance to the IS community (Benbasat and Zmud 1999). However, as the rigor versus relevance debate suggests (Davenport and Markus 1999; Lee 1999), there appears to be a trade off between relevance and rigor. This justifies special attention to rigor in design-science research. By rigor we mean the correct use of methods and analyses appropriate to the tasks at hand (Benbasat and Zmud 1999).

Design-science research constitutes a paradigm that differs from natural science or behavioral science (March and Smith 1995; Hevner et al. 2004). This means that the approaches to rigor developed over the decades for these paradigms cannot simply be transferred to design science. Two papers that explicitly address the issue of rigor in design science are Hevner et al. (2004) and Verschuren and Hartog (2005). Hevner et al. (2004) present seven guidelines to conduct design-science research within the field of IS. They address the question of how to ensure a scientifically sound contribution to the IS research knowledge base. Design-science research delivers not only an artifact that solves an up till then unsolved problem, it also enlarges the research knowledge base. Verschuren and Hartog (2005) present a designing cycle and elaborate on how to conduct the six stages of this cycle. Their scope is not only IS research, but design in general, for instance in technical engineering or the social sciences. They discuss how to execute the process of designing by systematically applying evaluation methodology and research methodology.

The two approaches exhibit a difference in relative emphasis. In comparison, Hevner et al. (2004) place more emphasis on design-science research as adding to the prescriptive knowledge for solving certain kinds of problems. We will refer to this as the prescriptive perspective. Verschuren and Hartog (2005) place more emphasis on design-science as constructing validated artefacts that solve certain kinds of problems. We will refer to this as the constructive perspective. Hevner et al. (2004) and Verschuren and Hartog (2005) thus both provide instructions on how to conduct design-science research, but from different scopes and perspectives. Still, both appear to provide valuable insights in how to improve design-science research in IS. This brings up the question which of the two to apply when embarking on a design-science project. This paper addresses that question by comparing the two perspectives.

In this paper we apply both the prescriptive perspective of Hevner et al. and the constructive perspective of Verschuren and Hartog to a design-science research we recently conducted: the design of the Architecture Effectiveness Model (AEM), an instrument for making explicit the contribution of practicing enterprise architecture to the organization’s business goals. This provides us with a comparison of the applicability of the two perspectives each, as well as their combined effect. In addition we present a general comparison of the two perspectives as presented in Hevner et al. (2004) and Verschuren and Hartog

(2005). Our conclusion is that the two perspectives strengthen each other and can be combined to advantage.

In section 3.2 the two perspectives as presented in Hevner et al. (2004) and Verschuren and Hartog (2005) are briefly introduced. Though we realize that these papers are well-known in the field, we include this section to better be able to juxtapose the two perspectives further on in the paper. Section 3.3 discusses the design-science research into the AEM that will serve as a case to compare the two perspectives. The application of each perspective to the AEM case is presented in section 3.4. Section 3.5 contains a more general comparison of the two perspectives. In section 3.6, we discuss conclusions and suggestions for further research.

3.2 Two perspectives on design science research

In this section we introduce the prescriptive and constructive perspectives on design-science research as presented in Hevner et al. (2004) and Verschuren and Hartog (2005).

3.2.1 A prescriptive perspective on design science

In their 2004 paper Hevner et al. describe the performance of design-science research in IS via a conceptual framework and guidelines for conducting design-science research. They state as the primary goal of their paper to inform the community of IS researchers and practitioners of how to conduct, evaluate, and present design-science research. The paper presents what we call a prescriptive perspective in the sense that it clearly addresses the aim for design-science research to deliver prescriptive knowledge that can be used by others to solve relevant problems.

Hevner et al. present a framework for conducting IS research. A simplified version of this framework is given in figure 3-1. The framework distinguishes environment, IS research and knowledge base. The environment provides relevance to IS research (business needs). The effective use of the knowledge base provides rigor to IS research (by appropriately applying existing foundations and methodologies). The framework distinguishes design science from behavioral science. Behavioral science develops and justifies theories that explain or predict phenomena related to the identified business need. Design science builds and evaluates artifacts designed to meet the identified business need. The right hand side of the framework defines the difference between design science and routine design. In contrast to routine design, design science contributes to the knowledge base. This is because it addresses important up till now unsolved problems or solved problems in new, more efficient or effective ways.

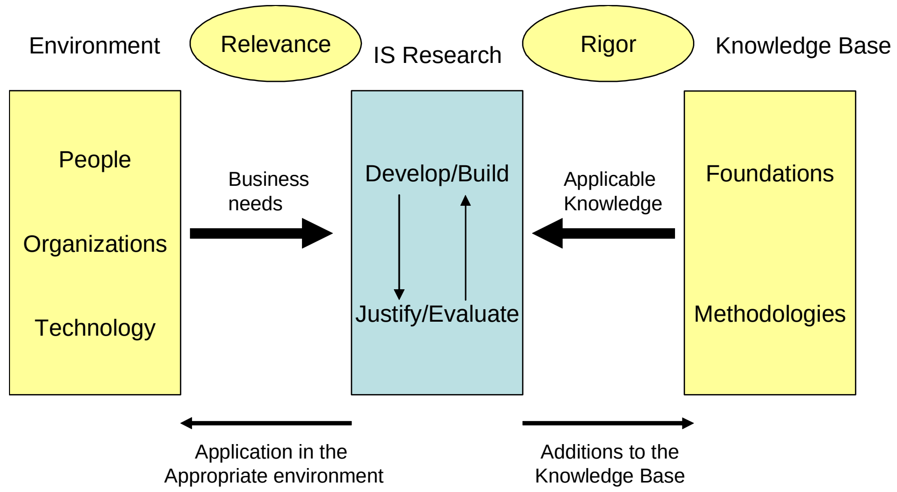

Figure 3-1: Information Systems Research Framework (derived from Hevner et al.2004).

Hevner et al. (2004) present seven guidelines to conduct well-validated design-science research providing a scientifically sound contribution to the IS research knowledge base.

- *Guideline 1: Design as an Artifact*
  Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
  Hevner et al. (2004) build on March and Smith (1995), who identify four design artifacts: constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices) and instantiations (implemented and prototype systems). Constructs provide the language with which to define problems and solutions. They enable the construction of models or representations of the problem domain. Methods provide a way of solving problems. Instantiations demonstrate the feasibility of the design process and the designed product.
- *Guideline 2: Problem relevance*
  The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
  Design-science research must develop artifacts that are useful to IS practitioners. Design-science research is to be evaluated on its utility. It is

intended to solve up till now unsolved problems that represent a true business need.

- *Guideline 3: Design Evaluation*
  The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
  The artifact is evaluated against the requirements from the business environment. One of the criteria is that it is well-integrated in the business environment. Examples of criteria are functionality, completeness, consistency, accuracy, performance, reliability, usability, fit with the organization. The knowledge base provides various methodologies for evaluating artifacts, like observational, analytical, experimental, testing or descriptive methods. The authors mention that the evaluation should include an assessment of the artifact's style.
- *Guideline 4: Research Contributions*
  Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
  Three types of research contributions are distinguished: (1) enabling the solution of heretofore unsolved problems (examples: system development methods, design tools, prototype systems); (2) constructs, models, methods, or instantiations that extend and improve the existing foundations in the design-science knowledge base (examples: modeling formalisms, problem and solution representations, design algorithms, innovative information systems); (3) novel ways to develop and use evaluation methods and new evaluation metrics.
- *Guideline 5: Research Rigor*
  Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
  Rigor is derived from the effective use of the knowledge base. This means that the appropriate techniques and methodologies are selected from the knowledge base for designing and evaluating the artifact.
- *Guideline 6: Design as a Search Process*
  The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
  Design is a search process to discover an effective solution to a problem. The design task involves the application of heuristic search strategies. The means are the actions and resources available to construct a solution. The ends are the goals and constraints on the solution. The laws are the uncontrollable forces in the environment.

- *Guideline 7: Communication of Research*
  Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.
  For technology-oriented audiences it is important to provide the detail needed to construct the described artifact and use it within an appropriate organizational context. Management-oriented audiences want to be able to determine if organizational resources should be committed to constructing and using the artifact within their specific organizational context.

These guidelines are reminiscent of similar sets of guidelines in for instance the fields of interpretive studies (Klein and Myers 1999) and action research (Davison et al. 2004).

3.2.2 A constructive perspective on design-science research

Verschuren and Hartog (2005) aim at improving the process and product of designing by systematically applying evaluation methodology and research methodology to the processes of designing. The focus of their paper is on research aiming at solving construction or inventive problems by creating a new artifact. They argue that evaluation should be an integral part of the designing process. Verschuren and Hartog (2005) is not limited to the field of IS, but considers design-oriented research in general, for instance in technical engineering or the social sciences.

Verschuren and Hartog elaborate extensively on the various steps in the designing process. They identify as important elements in this process the one or more goals (coded with [G]) that are to be realized with the artifact to be designed, the requirements [R] that are to be fulfilled to realize these goals, the assumptions [A] that the designer makes regarding the use of the artifact and the structural specifications [S] that are derived from the requirements and assumptions. Requirements can be distinguished into three types: functional requirements [R_f] indicating the functions that are to be fulfilled, user requirements [R_u] regarding the interface between user and artifact, and contextual requirements [R_c] concerning the environment in which the artifact is to be used. The same kind of distinction can be made for the assumptions.

Verschuren and Hartog elaborate on various types of evaluation. First of all they distinguish between plan evaluation, process evaluation and product evaluation. Plan evaluation involves the assessment of the quality of the design on paper. Process evaluation looks at the constructive activities and the means that are used in realizing the plan. Product evaluation concerns the results of the designing process, the value of these results and the short and long term effects of the results. In addition, evaluation can serve various purposes. Summative evaluation is performed after the artifact is finished, whereas formative evaluation is done in order to make improvements on the artifact. Ex ante evaluation is a feed forward evaluation performed before an activity has started, to increase confidence in the result. Ex post evaluation is done after the activity has been completed, to decide on continuation or provide feedback to the actor. Finally, goal based evaluation judges an artifact against its intended use, whereas goal free evaluation is done with regard to general professional criteria.

Verschuren and Hartog (2005) formulate a designing cycle with six stages. Each stage should be evaluated against evaluation criteria that are relevant to that stage. This can be depicted schematically as in figure 3-2.

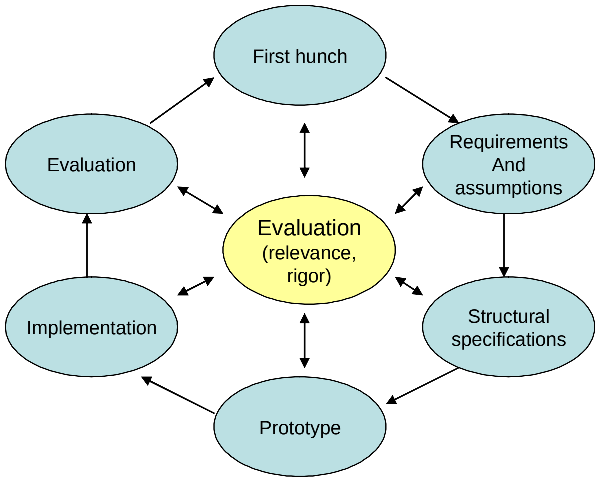

Figure 3-2: The designing cycle

1. *First hunch*
   The main result of this stage are the one or more goals that are to be realized with the artifact to be designed [G]. Evaluation should concentrate on the relevance of the goal(s). If the relevance is determined empirically, criteria to be checked are validity, reliability, researcher-independence and verifiability of the research. Design guidelines to apply are concerned with whether the designer put enough effort in understanding the field. Criteria for the goal(s) are: clearness, feasibility, affordability, opportunity, acceptance by the stakeholders, moral justifiability, and opportunity costs (product evaluation).

2. *Requirements and assumptions*
   This stage concerns the specification of the functional, user and contextual requirements [R] to be fulfilled within the context of the goal(s), as well as the functional, user and contextual assumptions [A]. Verschuren and Hartog mention as standard criteria for evaluation in this stage the empirical validity and reliability, as well as the researcher-independence and verifiability of the user and contextual requirements. On the functional requirements a logical test can be done. In addition, the relations between the three classes of requirements must be checked. The minimal form of process evaluation is to check whether a methodology is used in establishing the requirements and in translating them into design criteria. Also, the credibility and acceptance of the assumptions must be checked (empirical research).
3. *Structural specifications*
   In this stage the requirements and assumptions are translated into structural specifications [S]. The end product of the first three stages is a document describing a first draft of the design in full detail. Evaluation aims at an assessment of the quality of the translation of the design requirements into the structural specifications. This is a logical rather than an empirical test. Structural alternatives have to be investigated. Process evaluation is done by applying guidelines concerning the choice of feasible alternatives and not wasting time on unfeasible alternatives. After stage 3, a plan evaluation is called for, testing the adequacy of the goals, requirements, assumptions and specifications separately, as well as the way they relate to each other.
4. *Prototype*
   In this step a prototype is developed. The designer should make clear how all the structural specifications are preserved in the prototype. Process evaluation based on qualitative methods checks the transformation process from specifications to prototype. Product evaluation checks whether the prototype comes up to the structural specifications.
5. *Implementation*
   In the implementation stage the prototype is put into practice. This is the first check whether the artifact will work appropriately. In this step implementation process guidelines can be applied. It is checked whether the assumptions have been satisfied and if the right users were selected for implementation. The prototype must function well compared to the design criteria. Qualitative methods are used.
6. *Evaluation*
   This step involves the test whether the short and long term effects of utilization of the prototype fit the design goal(s) and satisfy the expectations of the designer and the various stakeholders. An assessment is done of the

effects of the artifact, looking for the causal or correlational relationship between artifact and effects, or by performing a case study.

The designing process is highly iterative, the designer going back and forth between the stages. Verschuren and Hartog argue that it is important that evaluation takes place during the whole process of designing, not only in the two final stages. Their perspective is what we call a constructive perspective in the sense that their guidelines on how to conduct the designing cycle are directed at delivering a well-validated tangible or intangible solution to a problem.

3.3 Design-science research case: the Architecture Effectiveness Model

To further investigate the two perspectives, we applied them to a design-science research we recently conducted, the development of an instrument, the Architecture Effectiveness Model (AEM), aimed at making explicit the intended and actual contribution of enterprise architecture to the organizational goals. In this section the AEM is introduced.

The AEM instrument is developed in the context of a wider program, called Dynamic Architecture (DYA for short). DYA aims at developing an effective architectural practice to better manage IS in organizations (Wagter et al. 2005; Van den Berg and Van Steenbergen 2006). Part of the program is to develop instruments to provide insight in various aspects that are relevant to the architectural practice. Examples are an architecture maturity matrix to measure architectural maturity (Van Steenbergen et al. 2007) and the AEM to make explicit architectural effectiveness. These instruments can be used in assessing and improving the architectural practice. We define enterprise architecture as the consistent set of rules and models that guide the design and implementation of processes, organizational structures, information flows, and the technical infrastructure within an organization (Wagter et al. 2005). By enterprise architecture practice we mean the whole of activities, responsibilities and actors involved in the development and application of enterprise architecture within the organization.

Enterprise architecture is a relatively young (Bucher et al. 2006), but well accepted (Raadt et al. 2007) discipline. Establishing the effectiveness of enterprise architecture, however, appears difficult (Lankhorst et al. 2005; Schelp and Stutz 2007). The effect of architecture on the business goals is indirect and the difficulty in linking the two may be compared to the difficulty of linking learning and growth efforts to strategic objectives (Kaplan and Norton 2000). Lankhorst et al (2005) indicate that the wide ranging nature of enterprise architecture makes it difficult to quantify the impact of architecture, though the need for clearly expressing the intended and actual contribution of practicing architecture to business value is increasingly felt. Enterprise architecture teams are under constant pressure to demonstrate their value to the organization (Weiss 2006). The interest in the effectiveness of the architectural practice is also illustrated in the fact that the topic starts to appear on professional conferences on enterprise architecture (EACE 2007, TOGAF 2007).

3.3.1 The Architecture Effectiveness Model

The AEM design aims to provide an instrument for modeling the contribution of the enterprise architecture practice to the business goals in a specific organization. This is done by building a cause-effect based model relating architectural efforts to business goals. Figure 3-3 shows the general structure of an AEM.

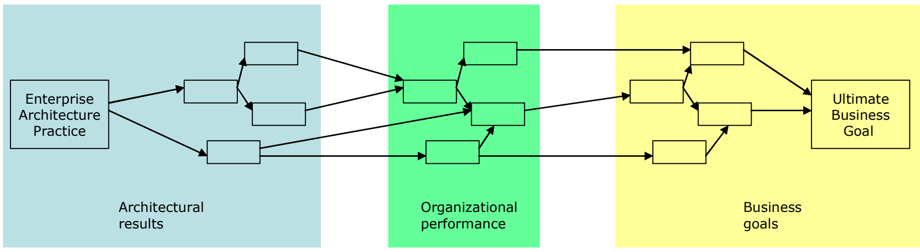

Figure 3-3: The general structure of an Architecture Effectiveness Model.

The basic concepts of an AEM are the effect, represented by a rectangle and the cause-effect relation, represented by an arrow between two rectangles. An effect in this context is defined as an intended result. A cause-effect relation represents the purposeful contribution of one effect to another effect. Figure 3-4 provides an example. This example should be read as 'the effect *simplification* contributes to the effect *fewer incidents*'. The term 'contributes' is used on purpose, choosing it above the alternative term 'causes'. The use of the term 'contributes' reflects the fact that the contributing effect need not be the sole factor influencing the resulting effect. In the example, simplification is not said to be the only factor leading to fewer incidents.

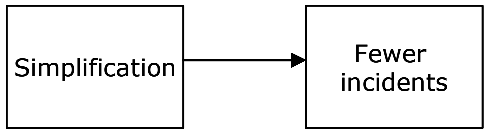

Figure 3-4: An example of a cause-effect relation.

The instantiation of an AEM differs from organization to organization. As figure 3-3 shows, an AEM contains on the left the enterprise architecture practice. On the right it contains the ultimate business goal, the main goal the organization aims for, like for instance continuity or growth. The steps in between link the two.

The AEM can be modelled as a directed acyclic graph. It consists of nodes and directed edges. The nodes represent effects that are desirable for the organization. Examples are 'having overview', 'better project control' or 'reduced costs'. The edges represent the unidirectional relation 'contributes to'. The effects (the nodes) can be divided into three types. First, the architectural results are positioned at the left hand of the graph. These are the effects that are fully determined by the architectural practice. The business goal effects are positioned at the right hand of the graph. These are the business results defined by senior management. The enterprise architecture practice is just one of the many factors contributing to these goals. In between we find effects in the area of the operations of the organization: the primary and secondary processes of the organization. We call these effects the organizational performance effects. Thus the AEM can be expressed as a directed acyclic graph:

> $AEM = (N,E)$ with $N = (AR \cup OP \cup BG)$ the set of nodes,
>
> where AR = Architectural Result effects; OP = Organizational Performance effects; BG = Business Goal effects and
>
> E the set of edges on N (i.e. E is a subset of $N \times N$) satisfying $OP \times AR \cap E = \phi$ and $BG \times OP \cap E = \phi$ and $BG \times AR \cap E = \phi$.

A path in AEM is a sequence $(n_1, \ldots, n_k)$ where $k \geq 0$ (paths may be empty) and every n_j is a node and every pair $(n_{j-1}, n_j) \in E$ is an edge $(1 < j \leq k)$. The length of the path is k-1. Sometimes a path will turn into what we will call a *stream*, which is a set of paths which share the same start and end sequence. More formally, given a path $p = (n_1, \ldots, n_k)$, a *prefix pf* of p is a sequence $(n_1, \ldots, n_i)$, where $0 \leq i \leq k$ and similarly, a *suffix sf* of p is a sequence $(n_j, \ldots, n_k)$, where $1 \leq$

$j \leq k + 1$ (note that if $i = 0$, *pf* denotes the empty path and similarly, if $j = k + 1$, *sf* denotes the empty path). Given a non-empty set *S* of paths, a *common prefix* is a path which is a prefix for all elements of *S*. Of course, the empty path is an example (albeit a not very interesting one) of a common prefix. Obviously, there is just one longest common prefix of *S* and similarly there is just one longest common suffix. Now a *stream* is defined as a non-empty set of paths for which both the longest common prefix and the longest common suffix are non-empty.

A cycle in a graph is a path of length at least 2 where the first and last node are equal. AEM is acyclic for otherwise at least one effect would (indirectly) be caused by itself, i.e. for all paths $(n_1, \ldots, n_k)$ in AEM $n_1 \neq n_k$, $k \geq 2$.

The indegree of node n is the number of edges with n as second node, while the outdegree of n is the number of edges with n as first node.

As an example, note that in figure 3-1 the node with label 'Enterprise Architecture Practice' has indegree 0 and similar, the node with label 'Ultimate Business Goal' has outdegree 0. Of course, in a finite directed graph without cycles, there must be at least one element with indegree 0 and similar for the outdegree.

In an instantiation of the AEM for a specific organization the following key effects may be distinguished.

- *Key step* A key step is defined as an effect that has both an indegree and an outdegree of at least *s*. In other words, it has at least *s* contributing effects and it contributes itself to at least *s* other effects. So $n \in N$ is a key step iff indegree(n) $\geq s$ AND outdegree(n) $\geq s$. The exact value of *s* is to be determined yet. On the basis of the three cases we have studied so far, we have set *s* to 3, for the time being. This seems a reasonable value with respect to the total number of nodes and edges in each of the three cases.
- *Key motivator* A key motivator is defined as an effect with the largest indegree (i.e. the largest number of contributing effects). So $n \in N$ is a key motivator iff indegree(n) = max (indegree(m)), $m \in N$. It is an effect that is the aim of many other effects. Note that there may be more than one key motivator.
- *Key enabler* A key enabler is defined as an effect with the largest outdegree (i.e. the largest number of effects it contributes to). So $n \in N$ is a key enabler iff outdegree(n) = max (outdegree(m)), $m \in N$. It is an effect that contributes to many other effects. Note that, similar to the above, there may be more than one key enabler.

The AEM as such presents the intended contribution of architecture to the business goals by way of a number of intermediate results. By attaching key performance indicators (KPIs) to the effects, the actual contribution over time can be measured, though it must be borne in mind that architecture is not the only factor contributing to the organizational performance and business goals. This means that in measuring actual KPIs they have to be closely investigated, to explain their actual values and their relation to other factors. But this is good practice anyhow.

3.3.2 Developing an AEM for a municipality

The concept of the AEM has been applied in three organizations of varying nature: a large municipality, a university of professional education and an international financial institution. This variation was intentionally sought, as one of our objectives was to investigate the practicality of AEM in different organizational circumstances. All three cases had been engaged in organization-wide enterprise architecture initiatives for two to three years. The AEM was built by the architects of the organization, assisted by either business strategy documents or opinion leaders, with the researcher acting as moderator. The case studies were exploratory in nature. Where, for readability purposes, in this section we speak of the AEM of an organization, we mean the instantiation of the AEM concept for that organization.

In this paper we will restrict discussion to the case of a municipality with more than 200,000 citizens and about 2200 employees, about 100 of which work in IT. Architecture is the responsibility of the Policies, Standards and Programs team which is positioned within the IT department and consists of seven employees, three of which have the role of enterprise architect.

A preliminary AEM for the municipality was established in a workshop with eight participants, who were selected by the lead architect and came from the various architecture stakeholder groups: architects, program managers, controllers, information managers, IS management. Brown paper techniques were used to build the AEM. At the far left of the brown paper a card was put with the text ‘enterprise architecture practice’. At the far right a card was put with the text ‘coalition charter’, the realization of the coalition charter being the primary goal of the municipality organization. The purpose of the exercise was explained as filling the gap between the two, or in other words, determining what the architectural practice was to contribute to realizing the coalition charter. Participants were first asked to individually write on cards the results they thought architecture should deliver or contribute to. These were then used as a base to build the effectiveness model together. Starting at the right, the moderating researcher asked for a card that contained a result that was closely linked to realizing the coalition charter. One participant volunteered a card with the text ‘customer service’ which was added to the brown paper, to the left of the ‘coalition charter’ card. This called forth other cards from other participants, like ‘supply chain collaboration’ and ‘multi-channel communication’. Each card was discussed and after consensus was reached it was added in the right place on the wall. When the flow of cards stagnated attention was turned to the left side of the wall. This time the question was to indicate the results of having an enterprise architecture practice. This brought forth a new flow of cards with architectural results like ‘common framework’, ‘standards’ and ‘overview’. When the participants felt they had no more cards to add, the group went to the final stage of the exercise, which was to close the gap between the left and the right. The participants made the link between architectural efforts and business goals by adding cards like ‘project performance’, ‘flexibility’ and ‘trusted information’. After the workshop, the resulting model was distributed among the participants for review. A few simplifications were suggested by one of the participants, which were finalized in a second workshop. These simplifications were mostly concerned with concentrating cards into one. An example is the concentration of ‘data consistency’, ‘data integrity’, ‘data reliability’ and ‘data security’ into the one result ‘trusted information’.

Figure 3-5 shows the final AEM. The colours reflect the three types of effects, grey (dotted line) for architectural results, dark grey (solid line) for organizational performance effects and light grey (stripes) for business goals.

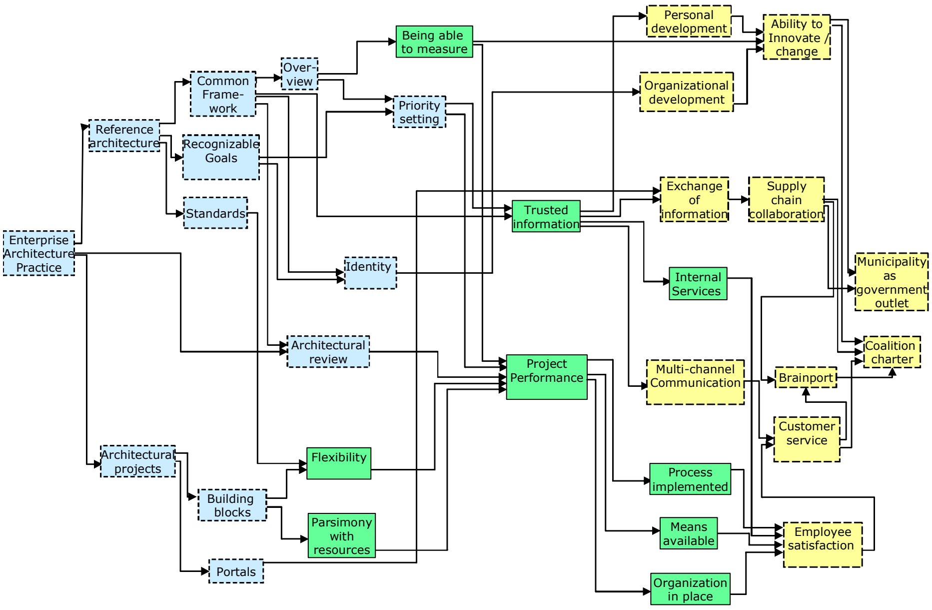

Figure 3-5: The AEM of a municipality.

The inclusion of effects like ‘employee satisfaction’, ‘personal development’, ‘organizational development’ and ‘identity’ in figure 3-5 shows a focus on employees and organization. In terms of the value dimensions of Quinn and Rohrbaugh (1983), we see that the municipality exhibits an internal focus. The key nodes in the AEM are all in the categories of the architectural results (‘common framework’) and organizational performance (‘project performance’ and ‘trusted information’). This case was the only one that has two end nodes: ‘coalition charter’ and ‘municipality as government outlet’, reflecting the dual character of the municipality in having its own coalition goals as well as being a representative of government.

The AEM shows the overall intended contribution of the enterprise architecture practice to the business goals. Organizations may want to set priorities on specific results. To this purpose so-called effectiveness streams can be defined. An effectiveness stream is one or more paths from the start node ‘enterprise architecture practice’ to the end note, ‘coalition charter’ in the case of the municipality.

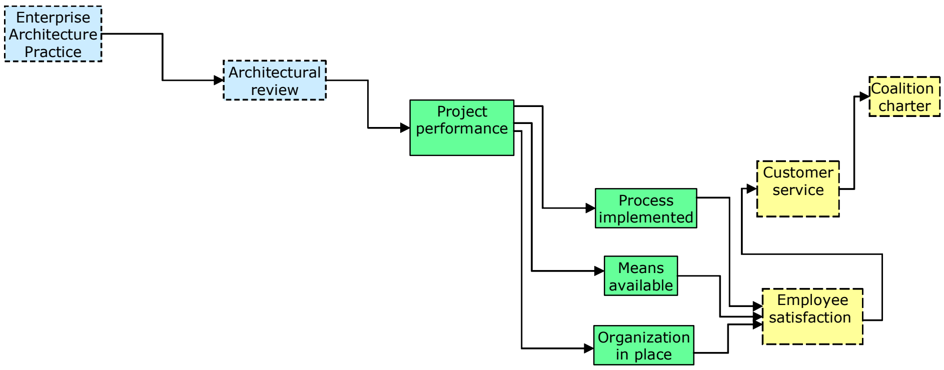

Figure 3-6: The effectiveness stream given priority in the municipality.

In the municipality, the AEM was used to define three architecture effectiveness streams in order to set priorities in architecture activities. One of these streams is represented in figure 3-6. By formulating KPIs on this stream, a coherent set of priorities could be defined. It was decided to define KPIs on this stream for the effects ‘project performance’, ‘process implemented’, ‘means available’, ‘organization in place’ and ‘employee satisfaction’.

3.4 Evaluation of the AEM

In this section we apply both Hevner et al. (2004) and Verschuren and Hartog (2005) to the design of the AEM instrument in order to compare how the two perspectives apply in practice.

3.4.1 Applying the prescriptive perspective to the design of the AEM

Hevner et al. (2004) provide seven guidelines for conducting design-science research. We applied them to the design of the AEM instrument to establish their applicability to our research.

- *Guideline 1: Design as an Artifact*
  The AEM research delivered various artifacts: a *language* is provided containing the constructs of effect, cause-effect relation, key step, key motivator and key enabler. A *model* is delivered that relates these constructs into a representation that can express the relevance of enterprise architecture to business goals. A *method* is presented in the form of guidelines for developing a specific AEM. An *instantiation* has been made in the form of a paper and pencil prototype. We are aware, however, that this may not be considered an instantiation by all. In the evaluation we will focus on the AEM as generic model that can be instantiated for specific organizations, i.e. the AEM as instrument.
- *Guideline 2: Problem relevance*
  The relevance of the AEM research can be derived both from literature (Lankhorst et al. 2005; Schelp and Stutz 2007; Weiss 2006) and from the fact that the topic starts to appear on practitioner's conferences on enterprise architecture (EACE 2007; TOGAF 2007). In addition, it is our personal experience from education and coaching activities, that many practicing enterprise architects find it extremely difficult to express concisely the value of their architecture efforts.
- *Guideline 3: Design Evaluation*
  Design evaluation is done by applying the concept of the AEM to three very different cases. In all three cases a graph from the enterprise architecture practice to the primary business goal could be built and in all three cases a distinction could be made between architectural effects, organizational performance effects and business goal effects. From the resulting AEMs we could derive characteristics of the organization that were clearly recognized by members of the organization. In the case of the municipality, the resulting AEM is used to set priorities and to define key performance indicators. In terms of the four types of validity as described by Yin (2003), construct validity is achieved by involving participants from various

backgrounds in the model building process. Construct validity is striven for by using multiple participants in applying the model. The constructs behind the model were well understood. Besides, the constructs are precisely defined in a mathematical formalization. External validity is supported by the fact that the AEM concept is applied in three very different types of organizations. Reliability is achieved by clearly describing the process by which the AEM instrument is designed and the different AEMs were built. Internal validity is not applicable as the case studies were exploratory in nature.

- *Guideline 4: Research Contributions*
  The main contribution of the AEM research is to the design foundation. The AEM presents a novel way of making explicit the contribution of the enterprise architecture practice to business goals. This enables further research into the effectiveness of enterprise architecture. The AEM instrument will be used in a longitudinal study into the effectiveness and continuity of a multinational financial institution. The AEM fills a gap that up till now existed between the architecture practice and the area of achieving business goals.
- *Guideline 5: Research Rigor*
  To construct the AEM use was made of the concept of cause-and-effect. As such we worked in the tradition of for instance the balanced scorecard (Kaplan and Norton 1992; Kaplan and Norton 2006; Martinsons et al. 1999; Schelp and Stutz 2007) and especially the strategy map of Kaplan and Norton (2000). The approach of using a cause-and-effect model was arrived at by deriving specifications from the formulated goal and requirements of an AEM. The concept of the AEM was tested in three case studies. As the study is strongly explorative in nature, however, at this point relevance was given priority above rigor.
- *Guideline 6: Design as a Search Process*
  The solution space was defined and explored by explicitly defining requirements and criteria for the effectiveness measurement instrument to be developed, based on the goal it was to fulfil. The formulated requirements excluded certain solutions, like focusing on financial benefits only (Bahadur et al. 2005; Schekkerman 2005) or on internally oriented architectural maturity (Van Steenbergen et al. 2007; Van der Raadt et al. 2007) as opposed to externally oriented effectiveness. The requirements also clearly pointed to the importance of having the organization itself involved in the building process of a specific AEM.

- *Guideline 7: Communication of Research*
  Communication about the AEM design has until now been focused on the scientific community, but communication will not be limited to this. The AEM will be included as an instrument in the DYA program to be used by practitioners to support organizations in clearly expressing their aims with practicing enterprise architecture.

The guidelines provided us with a context that was very helpful in establishing the scientific value of our AEM research.

3.4.2 Applying the constructive perspective to the design of the AEM

Verschuren and Hartog (2005) do not provide an explicit set of guidelines in the manner of Hevner et al. (2004). In applying the constructive perspective to the AEM research we therefore take the designing cycle as the starting point.

1. *First hunch*
   The Goal [G] of the AEM design was formulated as
   > *To develop an instrument for making explicit the intended and actual contribution of the architectural practice to the organizational goals*.

   The relevance of this goal is supported by literature (Lankhorst et al. 2005; Schelp and Stutz 2007; Weiss 2006) and practitioner's conferences (EACE 2007; TOGAF 2007).
2. *Requirements and assumptions*
   The Requirements [R] and Assumptions [A] formulated for the AEM are given in tables 3-1 and 3-2, where f stands for functional, u for user and c for contextual. The requirements and assumptions are based on empirical evidence from years of professional experience in the field of enterprise architecture. They were discussed with peer researchers in the field.

Table 3-1: Requirements for the design of an AEM.

Code	Requirement	Motivation
R_f1	The efforts of the architectural practice must be related to the goals of the organization.	This requirement is a direct consequence of the formulation of the goal. To show the contribution of architecture to the business goals the two must be related in a way that is recognizable.
R_f2	It must be possible to show the contribution of the architectural practice to the business goals over the years.	Many organizations want to set targets and then to measure them, or to measure progress.
R_f3	It must be recognized that there are non-architectural factors contributing to the goals of the organization.	If the influence of other factors is not allowed for, the realization of business goals may always be contributed to other factors than architecture. It should

		therefore be made explicit that architecture is only one of the factors contributing.
R_f4	The formulation of the intended contribution of the architectural practice to the business goals must be tuned to the organization.	If the contribution of architecture is stated in general terms only, it is very difficult to make the connection to what is actually happening in the organization.
R_f5	Measurement of the contribution of the architectural practice to the business goals must be allowed for if desired.	This is necessary to make explicit the actual contribution. However, the instrument must also be usable if no measurements are intended as not every organization is geared towards measuring.
R_u1	The line of reasoning from architecture to business goals must be transparent	The instrument must be crystal clear as architecture is often considered rather abstract.
R_u2	The instrument must be applicable by the organization itself.	The organization itself is the only party that can determine the objectives of enterprise architecture.
R_c1	Integration of the instrument with existent business effectiveness measurement instruments must be possible.	For those organizations that have business effectiveness measurement instruments in place, architectural effectiveness measurements should be integrated in the overall organization performance measurements to ground the measurements in the organization and to stimulate use and acceptance.

Besides the requirements two assumptions were made.

Table 3-2: Assumptions for an AEM.

Code	Assumption	Motivation
A_u1	The organization can articulate the purpose it wants to serve with enterprise architecture.	If not, some other steps should be taken first.
A_c1	The organization can articulate its business objectives.	If not, some other steps should be taken first.

3. *Structural specifications*

   Requirements and Assumptions led us to develop the graph based model linking the architectural practice with the business goals described in this paper, with the following Specifications [S]:

Table 3-3: Specifications of an AEM.

Code	Specification	Motivation
S1	A cause-effect chain must be built from the enterprise architecture to the ultimate business goal by a set of intermediate effects.	By building a step by step ‘contributes to’ chain, the distance between the architectural practice and the business goals can be bridged. By using the term ‘contributes to’ other factors are allowed for. Linking all effects to the ultimate business goal provides justification for all intermediate effects.
S2	All architectural efforts are to be included in the cause-effect chain.	To provide a complete picture of all architectural efforts and their contribution to the business goals, all efforts must be included in the cause-effect chain.
S3	All architectural efforts must be ultimately related to the ultimate business goal.	If architectural efforts are not linked to the ultimate business goal it is not clear how they contribute to this goal and then the instrument does not fulfil its purpose.
S4	The result of the instrument is recognized by the organization.	This differentiates it from an abstract intellectual exercise. It makes for the fit with the organization’s reality.
S5	Key performance indicators can be defined for selected efforts.	This provides the choice to measure or not, and to what extent.
S6	Key performance indicators from the chain can be embedded in Balanced Score Card approaches.	The Balanced Score Card is widely accepted as a performance measurement instrument.

After stage 3, a goal based plan evaluation was performed, evaluating each element as to its own separate value (shown as motivation in tables 3-1, 3-2 and 3-3) as well as evaluating the way they relate to each other. The latter is depicted in table 3-4.

Table 3-4: the relation between Goal, Requirements, Assumptions and Specifications.

Goal	Requirement	Assumption	Specification
Make explicit…	R_f1, R_f4, R_u1, R_u2		S1, S4
…the intended…		A_u1	S3
…or actual contribution…	R_f2, R_f3, R_f5		S5
…of the architectural practice…			S2
…to the organization goals.	R_c1	A_c1	S6

The process of defining requirements, assumptions and specifications was mainly done by logical reasoning from the goal of the AEM instrument. The formulation of the specifications was aided by the use of graph theory.

Support for the approach of building a graph was also found in its occasional use by practitioners in the field. To arrive at the requirements, assumptions and specifications as formulated in the tables took a number of iterative cycles. Especially stages 2 and 3 were not clearly separated from each other.

4. *Prototype*

   A paper and pencil prototype was made. The brown paper session not only delivered a preliminary instantiation of the AEM, it also proved the feasibility of building one.

5. *Implementation*

   Implementation was done by building an instantiation of the AEM together with the stakeholders from the organization. Validity was striven for by involving stakeholders from various backgrounds. The building of an AEM for the municipality showed that it was feasible to build an AEM for a specific organization. The stakeholders involved in the building process indicated, when asked at the end of the workshop by the researcher, that they found both the exercise and the result useful. Proven moderation techniques were used in a workshop setting to ensure participation of all stakeholders in building the AEM (Kwakman and Postema 1996). The conclusions that could be drawn from the AEM, like the internal focus of the municipality, were recognized by the organization. The AEM was found useful in formulating KPIs.

6. *Evaluation*

   This stage is still to be completed, as the AEM instrument has only recently been developed. Use of the AEM in the municipality will show whether it does indeed support the organization in setting priorities and delivering real value to the business goals.

We can conclude that the process of developing the AEM instrument can be mapped onto the six stages of the designing cycle of Verschuren and Hartog. However, the stages were not always sharply demarcated. Especially stages 2 and 3, as well as stages 4 and 5 were closely intertwined. Evaluation was done on the one hand on stage 1-3, in the form of a goal based plan evaluation and on the other hand on stage 4-5 in the form of a formative process and product evaluation by building an AEM for a municipality. The evaluations performed are indicated by the tick marks in table 3-5.

Table 3-5: The constructive perspective applied to the AEM design.

Stages / Evaluation types	First hunch	Requirements and assumptions	Structural specifications	Prototype	Implemen-tation	Evalu-ation
Plan	√	√	√			
Process				√	√	
Product				√	√	
Formative				√	√	
Summative						
Ex ante						
Ex post						
Goal based	√	√	√	√	√	
Goal free						

As can be noticed not all types of evaluation mentioned by Verschuren and Hartog were applied. Summative evaluation is still to be done. As the stages were closely intertwined no explicit ex ante or ex post evaluations were performed. Goal free evaluation was not deemed relevant as goal based evaluation was available.

3.4.3 Discussion

Applying both Hevner et al. (2004) and Verschuren and Hartog (2005) to our AEM research, we found that the two are complementary and can be applied in combination.
The guidelines of Hevner et al. provided us with an overall framework to guide and evaluate our research. The prescriptive perspective gave us a wider view on design research than merely designing the artifact.

Verschuren and Hartog provided us with concrete and useful practices to give substance to Hevner et al.'s guidelines on problem relevance, design evaluation, research rigor and design as a search process. Verschuren and Hartog provide an extensive discussion of the various evaluation methodologies that can be used in fulfilling these guidelines.

As table 3-5 illustrates, Verschuren and Hartog provide a comprehensive overview of the possible moments and objects of evaluation during the designing cycle. In a particular case like our AEM research the researcher has to decide whether to apply all forms, or, if not, which ones to select. It would be interesting to investigate whether criteria for selection can be formulated.

3.5 Comparison of the two perspectives

In this section the perspectives of Hevner et al. (2004) and of Verschuren and Hartog (2005) are compared by looking at the framework they work in, as well as at the take on evaluation they each have.

Looking at the framework from which the approaches work, we see that the prescriptive perspective of Hevner et al. places relative emphasis on contributing to research while the constructive perspective of Verschuren and Hartog places relative emphasis on delivering the desired artifact. Verschuren and Hartog concentrate on the designing cycle and how to conduct and evaluate this in a way that ensures the quality of the end product. They discuss in detail the six stages of the designing cycle. Their aim is improvement of the process and product of designing. Hevner et al. pay more attention to the variety in research contributions design science can offer. Their aim is to inform the community of IS researchers and practitioners of how to conduct, evaluate and present design-science research. The artifact itself is not the only purpose, the contribution to the knowledge base is important as well.

The criteria of heretofore unsolved problems mentioned by Hevner et al. is not explicitly mentioned in Verschuren and Hartog. The examples used by Verschuren and Hartog (aircraft and helpdesk system) might not be considered design science (as opposed to routine design) by Hevner et al.

Both Hevner et al. and Verschuren and Hartog distinguish a build stage and an evaluate stage in design. They both define the evaluate stage in terms of establishing the utility of the designed artifact. In addition Verschuren and Hartog divide the build stage into five sub stages.

Table 3-6 presents an overview of the main differences and similarities between the two perspectives.

Table 3-6: The two perspectives compared

Aspect	Hevner et al. (2004)	Verschuren and Hartog (2005)
Research contribution of paper	The aim of the paper is to inform the community of IS researchers and practitioners of how to conduct, evaluate and present design-science research. The guidelines present how to ensure a valid and valuable research contribution.	The aim of the paper is the improvement of the process and product of designing. Operations, guidelines and criteria are given for evaluating the designing cycle. The guidelines present how to achieve the quality of the end product.

Aspect	Hevner et al. (2004)	Verschuren and Hartog (2005)
Research contribution of design science	Design science can contribute to the research knowledge base in three ways: by delivering design artifact, design foundations or design methodologies.	Design science contributes to research by providing the solution of a construction or inventive problem.
Framework	The key elements of the framework used are: Environment, IS Research, Knowledge Base (see figure 3-1).	The key elements of the framework used are: Designing cycle, Evaluation (see figure 3-2).
Subjects of Evaluation	Subjects of evaluation are both the process of designing and the designed product.	Subjects of evaluation are the design plan, the process of designing and the designed product.
Process	The designing process consists of the two subprocesses build and evaluate.	The designing process consists of the six stages first hunch, requirements and assumptions, structural specifications, prototype, implementation and evaluation.
Artifact	The artifacts to be designed are: constructs, models, methods or instantiations. Examples are methodologies, tools, prototype systems, formalisms, problem representations.	The artifacts to be designed are: tangible or intangible products. Examples are a new type of aircraft, a helpdesk system.
Paradigm	Design science is a problem-solving paradigm. It creates and evaluates IT artifacts intended to solve heretofore unsolved organizational problems.	Design-oriented research aims at solving construction or inventive problems, i.e. at the creation of a new artifact.
Evaluation	The artifacts (prescriptive theories) must be evaluated with respect to the utility provided for the class of problems addressed. Design evaluation should include an assessment of the artifact's style.	Each stage of the designing cycle should be evaluated with respect to designing rules and research methodology on the one hand, and to the results of this stage on the other. Evaluation is an integral part of the designing process.
	Design evaluation methods mentioned are observational; analytical; experimental; testing; descriptive.	Design evaluation methods mentioned are test of empirical research in terms of validity, reliability, researcher independence and verifiability; logical test; application of design guidelines; application of decision making guidelines; use of triangulation; use of research methodology; case study.

As of the two, Hevner et al. provide more clearly a set of guidelines, we took these as a starting point and searched how these are addressed by Verschuren and Hartog. The result of this comparison is presented in Table 3-7.

Table 3-7: Comparison of guidelines

Hevner et al. (2004)	**Verschuren and Hartog (2005)**
Guideline 1: Design as an Artifact	Design oriented research aims a the creation of a new artifact.
Guideline 2: Problem relevance	The designer should check whether the design goal really covers the desires of the stakeholders. The designer should be knowledgeable.
Guideline 3: Design Evaluation	Extensive discussion of how the design artifact (and its intermediate results) should be evaluated.
Guideline 4: Research Contributions	Emphasis on the design artifact as the main research contribution.
Guideline 5: Research Rigor	Extensive discussion of evaluation methods to evaluate the construction of the design artifact.
Guideline 6: Design as a Search Process	Stage three includes looking for structural alternatives and selecting a 'satisficing' solution.
Guideline 7: Communication of Research	Not addressed.

It can be concluded that Verschuren and Hartog (2005) address five of the seven guidelines by Hevner et al. (2004), while their discussion of evaluation methods can be regarded as an elaboration of especially guidelines 2, 3, 5 and 6. Guideline 7 is not addressed by Verschuren and Hartog. The two papers differ in the area of guideline 4, the intended contribution of design science. This is a direct consequence of the two different perspectives.

3.6 Conclusions and further research

Both the prescriptive perspective of Hevner et al. (2004) and the constructive perspective of Verschuren and Hartog (2005) provide guidelines and evaluation criteria for the design-science researcher. The prescriptive perspective supports the researcher in making a scientifically sound contribution to the IS research knowledge base. The constructive perspective supports the researcher in arriving at well-validated solutions to construction problems. The constructive perspective can contribute to the right designs, the prescriptive perspective can stimulate that the knowledge developed making these designs is spread to the scientific and practitioners community, so others can derive benefits from them as well.

If contribution to the scientific knowledge base is one of the aims of a design project, we recommend that Hevner et al. (2004) is taken as a leading framework. It provides support in formulating the overall research design. Verschuren and Hartog (2005) we recommend especially for preparing the actual design process within the overall research plan. It provides very specific aid in rigorously conducting and evaluating the designing cycle, contributing to the overall rigor of the research. Together, Hevner et al. (2004) and Verschuren and Hartog (2005) provide a comprehensive basis for adding rigor to relevance in design-science research. The listing of similarities and differences in table 3-6 can be used to strengthen the justification of research methodology used in a specific design-science research case.

The findings seem to be supported by the application of both perspectives to the same design-science research case. In applying the two perspectives we found that Hevner et al. (2004) provided us with a broader context that was very helpful in thinking about the scientific value of our AEM research, while Verschuren and Hartog (2005) provided us with instruments for structuring and executing the design of the AEM.

Enterprise architecture is a young discipline which has to establish a solid scientific foundation yet. As literature on the use of enterprise architecture is still limited, our research is very much explorative in nature. We feel that the papers discussed here will help improve rigor in future research.

We think it worthwhile to study the prescriptive and constructive perspectives further and to develop their combined or even integrated usage. For one thing, the use of Verschuren and Hartog to instantiate the guidelines of Hevner et al. can be enhanced further if selection criteria can be developed concerning the various evaluation types Verschuren and Hartog discuss in their paper (as depicted in table 3-5). We leave it to further research to develop such selection criteria. In addition, it will be interesting to apply both perspectives to other applications of design-science research.

Part III

Measuring the Maturity of the Enterprise Architecture Practice

Chapter 4

A Balanced Approach to Developing the Enterprise Architecture Practice

Enterprise architecture is a relatively young field. Many organizations are still engaged in implementing and developing a fully mature enterprise architecture practice. In this paper we introduce an architecture maturity model that enables us to identify strong and weak points in an organization's architecture practice and to consequently set priorities for improvement. The model distinguishes 18 factors that are relevant to developing an architectural practice. Each of these factors has its own maturity development path that is balanced against the maturity development paths of the other factors. In this respect, the model differs from other existing models that adhere to a generic 5-level approach. Two industrial case studies are presented to illustrate the use of the model[1].

4.1 Maturity in Enterprise Architecture

Increasing complexity in the overall information systems portfolio of an organization, and especially in the integration of information systems, requires enterprise architecture as a guiding principle. For this to work, sound architectural practices have to be implemented.

Enterprise architecture, however, is a relatively young field (Bucher et al. 2006; Lankhorst et al. 2005). Architectural practices still have to be established. There appears to be a need for an instrument to support and accelerate this.

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In this paper we will introduce such an instrument. We will start with distinguishing three basic types of architecture maturity models: the staged 5-level models, the continous 5-level models and the focus area oriented models. Enterprise architecture being a relatively young discipline, we feel that at the moment most organizations benefit best from the focus area oriented model. We will therefore introduce an architecture maturity matrix that falls into this category. By architecture maturity we mean the degree of development of the architectural practice, i.e. the whole of activities, responsibilities and actors involved in the development and application of enterprise architecture within the organization.

Most maturity models are concerned with software development and maintenance. The most widely used is CMM and all its variants (CMMI 2002). Recently some architecture maturity models have been developed. These models are all based on the generic 5-level maturity model used by CMM. Two variants can be distinguished.

1. *Staged 5-level models*. These models distinguish five levels of maturity. For each level a number of focus areas are defined specific to that level. These focus areas have to be implemented satisfactorily for the organization to achieve that particular level.
2. *Continuous 5-level models*. These models also distinguish five general maturity levels and a number of focus areas. The difference with the first kind of models is that the focus areas are not attributed to a level, but within each focus area the 5 levels are distinguished.

Searching for models that were not build around the standard five maturity levels, we also looked at other process maturity models and found a third type of model from test process improvement (Koomen and Pol 1999):

3. *Focus area oriented models*. These models depart from the idea that there are five generic maturity levels. Instead each focus area has its own number of specific maturity levels. The overall maturity of an organization is expressed as a combination of the maturity levels of these focus areas.

The differences between the types of models is illustrated in figure 4-1: (a) in the staged 5-level models a number of focus areas is associated with each maturity level; (b) in the continuous 5-level models each focus area has the same 5 generic maturity levels; (c) in the focus area oriented models each focus areas has a number of specific maturity levels.

	1	2	3	4	5
FA 1	X				
FA 2	X				
FA 3		X			
FA 4		X			
…					

a

	1	2	3	4	5
FA 1	X	X	X	X	X
FA 2	X	X	X	X	X
FA 3	X	X	X	X	X
FA 4	X	X	X	X	X
…					

b

	1	2	3	4	5	6	7	…
FA 1	X				X			
FA 2		X		X				
FA 3	X		X			X		
FA 4				X			X	
…								

c

Figure 4-1: Three kinds of architecture maturity models.

Looking at the three model types, we prefer the focus area oriented model because it allows a more fine-grained approach, making it more suitable to our purpose of developing and improving the architectural practice, rather than merely assessing its current maturity:

- The focus area oriented model makes it possible to distinguish more than five overall stages of maturity. This results in smaller steps between the stages, providing more detailed guidance to setting priorities in developing the architectural practice.
- Departing from the five fixed maturity levels makes the focus area oriented model more flexible in defining both focus areas and interdependencies between focus areas. In our opinion this better fits the current state of maturity of the architectural practice, where complex combinations of many different factors determine its success.

The application of the first two kinds of models to architectural processes can be found in the literature in various forms. The US Government Accountability Office uses a staged model (GAO 2003). Examples of the continuous model can be found in Appel (2000), METAGroup (2001), NASCIO (2003) and Westbrock (2004). The continuous model may also be found as foundation for various kinds of organization readiness assessments like for instance the Net Readiness Scorecard that measures the preparedness of an organization to make use of the internet-based economy (Hartman et al. 2000).

Application of the third kind of model to architectural practice we have not encountered yet. This is why we decided to develop a model based on the third type ourselves, the architecture maturity matrix.

Another approach to organizational improvement is the balanced scorecard approach (Kaplan and Norton 1992). The balanced scorecard is used to evaluate corporate performance, not only on financial aspects but also on customer perspective, internal processes and learning capability. The balanced scorecard concept has also been applied to the IS function (Martinsons et al. 1999) and to enterprise architecture (Schelp and Stutz 2007). The main difference between the balanced scorecard approach and the model presented in this paper is that the balanced scorecard is concerned with setting specific perfomance goals, while our approach is concerned with how to reach such goals.

4.2 Architecture Maturity Matrix

The development of the architecture maturity matrix is part of a wider program, called Dynamic Architecture (DYA), of building a vision on how to develop and improve an effective architectural practice (Wagter et al. 2005; Van den Berg and Van Steenbergen 2006). We have been using the maturity matrix over the last six years in about 20 large organizations in different sectors. In the remainder of this paper we will discuss two of these cases, a manufacturing company and a semi-governmental organization. We will discuss major findings and lessons learned of the cases studied. But first we will explain the architecture maturity matrix in more detail.

4.2.1 Structure of the Architecture Maturity Matrix

Key element of our approach is the realization that many factors determine the success of enterprise architecture, but that at different points in time, different aspects need attention. So we searched for a model that would support this differentiation in factors. We adopted the model from the Test Process Improvement (TPI) model (Koomen and Pol 1999). We adopted the structure of the TPI model, but translated it from test processes to architectural processes. We based this translation on the DyA model, a model that distinguishes the main processes relevant to developing and applying enterprise architecture (Wagter et al. 2005; Van den Berg and Van Steenbergen 2006). Firstly, we could transfer some of the factors directly from test processes to architectural processes as they are generic in nature: *budgeting and planning, commitment and motivation, roles and training, use of a method, consultation*. Secondly, some factors could be translated to factors relevant to enterprise architecture: *test strategy* became *use of architecture, life-cycle model* became *development* *of architecture*, *moment of involvement* became *alignment with business, alignment with the development process* and *alignment with operations*, *test specification techniques* and *static test techniques* became *use of an architectural method*, *metrics* became *quality management*, *test automation* became *architectural tools*, *testware management* became *maintenance of the architectural deliverables* and *test process management* became *maintenance of the architectural process*. Thirdly, some factors were specific to testing and we left them out: *test environment, office environment, reporting, defect management, evaluation, low-level testing*. Finally, we added four factors that are specific to architectural processes and of which we knew from experience that they are relevant to success in enterprise architecture: *relationship to the as-is state, roles and responsibilities, coordination of developments, monitoring*. Table 4-1 presents the 18 resulting factors.

Table 4-1: 18 key areas of the enterprise architecture practice.

Key area	**Description**
Development of architecture	The development of architecture can be undertaken in various ways, varying from isolated, autonomous projects to an interactive process of continuous facilitation. The more that architectural design is incorporated as a continuous process within an organization's trajectory of change, the greater is the chance that real value will be added.
Use of architecture	In practice, the uses of architecture can vary. It may merely be a conduit for information, or it may be a means of governing individual projects or even a tool for managing the entire organization.
Alignment with business	Architecture is justified insofar as it supports and facilitates business goals. Alignment with business is concerned with the degree to which the architectural process is in tune with what the business wants and is capable of.
Alignment with the development process	Architecture needs to channel changes in such a way that the business goals are achieved in the most effective manner. The relation between the architectural process and the development process has to support this, no matter whether process, organization or IT development is concerned.
Alignment with operations	The alignment with operations and maintenance (O&M) works reciprocally: principles and guidelines that are important from an operations perspective have to be included in the architecture, and based on that architecture, parameters must be imposed on O&M activities.
Relationship to the as-is state	In assessing the suitability of the architecture, it should be realized that a set of circumstances already exists, which has its own range of possibility and impossibility. If this relationship to the as-is state is ignored, there is a danger that the organization will be able to do little with its elegantly drafted scenarios for future architecture.

Roles and responsibilities	If the roles and responsibilities concerning architectural thinking and taking action are clearly and unambiguously outlined to everyone, discussions and differences of opinion about architecture are prevented from falling into limbo.
Coordination of developments	In an organization, a (large) number of developments take place in all sorts of areas at more or less the same time. Some of these developments are interrelated. Architecture is the control instrument to make sure that the content of such developments is coordinated.
Monitoring	It is generally insufficient to just state that projects must comply with the architecture. A control mechanism is needed.
Quality management	The successful employment of the architecture depends partly upon its quality.
Maintenance of the architectural process	Like every other process, the architectural process needs to be maintained. This is the only way to safeguard the effectiveness and efficiency of architecture.
Maintenance of the architectural deliverables	It is not enough to issue architectural products (such as standards, guidelines and models); they must also be maintained. Maintaining architectural deliverables means updates are provided and outdated products eliminated, as necessary.
Commitment and motivation	Commitment and motivation by the architecture stakeholders is critical in bringing the architecture up to speed and making it successful. These stakeholders include not only the architects but also, and especially, senior business and IT management, plus project management.
Architectural roles and training	Architects not only need to possess the skills to develop architectures, they also need to have the knowledge and understanding for process development, systems development and technical infrastructures. In addition, high demands are made on their social and management skills.
Use of an architectural method	The method to develop architecture must be sufficiently versatile and generic that it can be reused, but it also must be sufficiently particularized to be effective.
Consultation	A great deal of communication with various stakeholders is required in developing architecture. Stakeholders like business managers, process owners, information managers, project managers and IT specialists are involved.
Architectural tools	Working with architecture can be aided by architectural tools. Using tools in an integrated manner, preferably with the support of a repository, maximizes their efficiency and effectiveness.
Budgeting and planning	Careful budgeting and planning helps de-mystify architecture. It also shows the organization what it can expect. Budgeting and planning can range from drafting occasional plans to collecting past experiences with architecture.

As figure 4-2 shows, each of the 18 key areas has its own maturity growth path consisting of two to four maturity levels, depending on the actual key area. These maturity levels per key area are depicted by the letters A to D in the matrix. For example the key area *use of architecture* has three maturity levels *architecture used informatively* (A), *architecture used to steer content* (B) and *architecture integrated into the organization* (C).

Scale / Area	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Development of architecture		A			B			C						
Use of architecture			A			B				C				
Alignment with business		A				B				C				
Alignment with the development process			A				B		C					
Alignment with operations					A			B			C			
Relation to the as-is state					A				B					
Roles and responsibilities				A		B					C			
Coordination of developments							A			B				
Monitoring				A		B		C		D				
Quality management								A		B			C	
Maintenance of the architectural process							A		B		C			
Maintenance architectural deliverables					A			B					C	
Commitment and motivation		A					B		C					
Architecture roles and training				A		B			C			D		
Use of an architectural method				A						B				C
Consultation			A		B				C					
Architectural tools							A				B			C
Budgeting and planning				A							B		C	

Figure 4-2: Architecture Maturity Matrix.

The position in the matrix of the letters indicating the maturity levels for each key area is fixed. It indicates the relative priorities of the 18 key areas. The matrix should be read from left to right. The first A's to be encountered are the first key areas to pay attention to if one wants to develop an architectural practice. Figure 4-2 shows that these are the key areas *development of architecture*, *alignment with business* and *commitment and motivation* (the A's in column 1). These key areas should be developed to their first maturity level (A), before work is done on the key areas *use of architecture*, *alignment with the development process* and *consultation* (the A's in column 2). And so on. Only if all A's in columns 1 to 3 have been achieved, is it advisable, according to the matrix, to develop the key area *development of architecture* to the next level (the B in column 4). In this way the matrix can be used to set priorities in developing the architectural practice.

Each level of each key area is associated with one to four checkpoints. For instance level A of key area use of architecture has as one of its checkpoints whether the architecture is accessible to all employees. The matrix is used as an assessment instrument by scoring the checkpoints. All checkpoints belonging to a level have to be scored positively to achieve that level. In total there are 137 checkpoints.

Each level of each key area is also associated with one to three suggestions for improvement. They represent best practices that may help an organization to satisfy the checkpoints. For an extensive explanation of the matrix we refer to Van den Berg and Van Steenbergen (2006).

4.2.2 Use of the Architecture Maturity Matrix

The architecture maturity matrix is an assessment instrument to be used by an outside party to evaluate the current state of the architectural practice of an organization. Usually, an assessment is commissioned by the person responsible for the architectural function. This may be the head of the architects, the head of the IT function or the CIO. The assessment is often the first step in a structured improvement process.

The assessors, usually as a team of two, complete the matrix by scoring all 137 checkpoints. They do this on the basis of interviews, studying architectural documents, and making use of a questionnaire. The interviews are with all relevant stakeholders, being senior management, business managers, project managers, system developers, operations and architects. This is required because a successful architectural practice depends on the measure in which the various disciplines in the organization understand and accept the purpose and content of the architecture. This relation of architecture to other disciplines is therefore reflected in the key areas the matrix contains. Study of the documentation is primarily meant to gauge the width and depth of the architectural artefacts. To support the picture the assessors build for themselves, a questionnaire can be issued to architects, project managers and line management. However, this has to be regarded with care, as the questions are open to interpretation. The authors use the questionnaire for two purposes:

- to validate the picture they receive from the interviews; if the questionnaire outcome differs greatly from the findings from the interviews, the assessors have to dig deeper.
- To gain insight in possible differences in perception from the different stakeholders. By distinguishing the overall scoring of different disciplines differences in perception may occur. This provides clues to the measure of general acceptance and the extent to which views on architecture are shared throughout the organization.

Differences in perception between stakeholders are thus one of the indications of the level of architecture maturity and are as such reflected in the outcome of the matrix. The completed matrix is included in an assessment report, together with a discussion of the key findings as well as recommendations for improvement.

Some organizations choose to perform an assessment each year, using the results to feed a continuous improvement process. Reported results from such an improvement process include lower IT costs, better cooperation between business and IT and shorter response times of IT.

4.3 Case Studies

In the period of 2002 to 2007 the maturity matrix has been used in different organizations. The matrix has been applied to about 20 organizations in the private and public sector: finance, government, healthcare, industry, utility, telecommunications and retail. The size of the organizations ranges from a couple of hundred to tens of thousands of employees. Both national, international and multinational companies have been assessed.

In this section we present two case studies: first we give a brief description of the kind of organization we are looking at, followed by the basic approach to architecture we encountered. Then we present the matrix we completed for the organization and discuss how the scores on the key areas can be related to its basic approach to architecture. For completion's sake we will also say a few words on the kind of advice that we gave based on the outcomes of the assessments.

4.3.1 Case Study 1: A Manufacturing Company

The first case is of a multinational manufacturing company. The company has plants in various parts of the world and has about 23,000 employees worldwide. The IT department consists of about 600 employees. The architectural team is positioned within the IT department which consists of an American branch and a European branch. Architects are positioned both at headquarters in the US and in Europe. In total the architectural team consists of about six enterprise architects. Architecture has been worked on for about three years.

The basic approach taken to architecture is a technology-oriented approach. Architecture development is being done primarily from an IT perspective and concentrates on technical infrastructure. Standardization in the technological field is an important aim. About 30 practitioners are each laying down the standards and roadmaps for their specific technological areas. These standards are made available to all by means of the company intranet.

As a consequence of this approach architecture is very much a collection of technological standards. There is no overall, comprehensive vision of business choices, processes and information systems. Also, among the persons writing the standards, there is no common understanding of what architecture entails and what goals it has to achieve.

The director of architecture in the US asked for an assessment of the architectural processes to provide input for next year's architecture development plan and strategy. The assessment was performed within four intense days. One day was reserved for interviews and studying documentation, one day and a half for analysing the data and one day and a half for presenting and discussing the results. Beforehand the enterprise architects had completed the questionnaire, which was used as background information to the assessment. The matrix that resulted from completing the checkpoints is given in figure 4-3. The matrix shows that the key areas to focus on for this organization are *alignment with business*, *use of architecture* and *consultation*.

Scale **Area**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Development of architecture		A			B			C						
Use of architecture			A			B				C				
Alignment with business		A				B				C				
Alignment with the development process			A				B		C					
Alignment with operations					A			B			C			
Relation to the as-is state					A				B					
Roles and responsibilities				A		B					C			
Coordination of developments							A			B				
Monitoring				A		B		C		D				
Quality management								A		B			C	
Maintenance of the architectural process							A		B		C			
Maintenance of architectural deliverables					A			B					C	
Commitment and motivation		A					B		C					
Architecture roles and training				A		B			C			D		
Use of an architectural method				A						B				C
Consultation			A		B				C					
Architectural tools							A				B			C
Budgeting and planning				A							B		C	

Figure 4-3: Maturity matrix for the manufacturing company.

The low score on *alignment with business* is caused by the fact that no clear link can be established between the architectural products and the business strategy and goals, as well as by the fact that the architecture is not evaluated in terms of the business goals. The checkpoints 'Is there a clear relationship between the architecture and the organization's business goals?' and 'Is the architecture evaluated in terms of the business goals?' are answered negatively. This reflects the fact that architecture has emerged from individual expertise, not from a company-wide vision. The key area *use of architecture* failed on the checkpoint whether the architecture provides a clear picture of the organization's goals and demands. The low score for *consultation* is caused by the fact that though meetings of the architects were being held, no outcomes or decisions were being recorded.

Striking in the matrix is the relatively high score for *alignment with the development process*. The fact that the standards were being developed by the practitioners themselves resulted in a strong buy-in from the technical community. This made for a strong embedding of the architecture principles in the development process. Which helped a lot in getting projects to adhere to the architecture. Hence the high score for this key area.

The scores of the key areas can be straightforwardly explained from the basic approach to architecture. The specialist technology-oriented approach is directly reflected in the low scores for *alignment with business*, *use of architecture* and *consultation*, but also leads to the relatively high score for *alignment with the development process*.

The advice given to the company on the basis of the assessment (with the related key areas between brackets) was to:

- Strengthen the business - IT alignment by explicitly linking the architectural choices to the business goals (*alignment with business*; *use of architecture*).
- Create an architecture community of enterprise and domain architects that work together, exchange ideas and share a common framework (*consultation*).
- Strengthen the efforts in information architecture to start closing the gap between technology and business goals (*alignment with business*).

The matrix proved a useful instrument in providing input to the architecture development plan and strategy. It helped the organization to focus on the right measures to improve their overall maturity. Its major contribution lay in the integral approach to architecture reflected in the balance between the levels of the 18 key areas. The matrix helped to show the overall picture and gave clear insight in the strengths and weaknesses of the architectural practice so far. These strengths and weaknesses were, once they were exposed, clearly recognizable to the organization: the lack of a shared vision, partly because of the missing link to the business strategy, which prevented the move from individual technology standards to a comprehensive view on the right information structure for the company.

4.3.2 Case Study 2: A Semi-governmental Organization

The second case concerns a Netherlands semi-governmental organization. The organization has about 500 employees. At the moment of assessment, the organization underwent a transition from a purely government funded organization to an organization that was commercially active on the free market.

This transition had a huge impact on the culture and processes of the organization. Internal processes and products became commercially exploitable services. This asked for greater standardization and flexibility. The organizational thinking had to be turned from internal product oriented to external process oriented.

The organization had been working on architecture for a year before they approached one of the authors. They had appointed three consultants from the IT staff department to act as architects. One of these three clearly functioned as the frontman. Architecture was mainly associated with his name. The rest of the IT department was not actively involved in the architectural efforts.

The basic approach chosen by the organization was a project-driven one. As they put much value on commitment from the organization the architects had focused primarily on providing support to business projects. In this way they had built, over the year, a number of process and application models. These were delivered to the projects. The need-based, just enough, just in time approach ensured a clear link between the architectural models and the business goals. They also engendered awareness of architecture, especially with management. However, the architecture products were not consolidated into an enterprise architecture, nor were they made easily accessible to the rest of the company. Because of the lack of an overall enterprise architecture to relate the various models to, the architecture as a whole was rather fragmented. There were architectural products, there was no overall, comprehensive enterprise architecture.

As the architects were uncertain how to proceed they asked one of the authors to perform an assessment and provide recommendations for improvement. We performed eight interviews with project managers, team managers, directors and architects and fifteen employees completed the questionnaire. The assessment took six days over a period of four weeks. The resulting matrix is shown in figure 4-4. The matrix in figure 4-4 shows the organization is at scale 1. The key areas to work on in order to reach the next maturity level are *use of architecture* and *consultation*.

Scale Area	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Development of architecture		A			B			C						
Use of architecture			A			B				C				
Alignment with business		A				B				C				
Alignment with the development process			A				B		C					
Alignment with operations					A			B			C			
Relation to the as-is state					A				B					
Roles and responsibilities				A		B					C			
Coordination of developments							A			B				
Monitoring				A		B		C		D				
Quality management								A		B			C	
Maintenance of the architectural process							A		B		C			
Maintenance of architectural deliverables					A			B					C	
Commitment and motivation		A					B		C					
Architecture roles and training				A		B			C			D		
Use of an architectural method				A						B				C
Consultation			A		B				C					
Architectural tools							A				B			C
Budgeting and planning				A							B		C	

Figure 4-4: Maturity matrix for the semi-governmental organization.

Alignment with business scores relatively high. This can be explained from the fact that architecture development was project, and hence business goal, driven. However, the results of these project-driven development activities were not consolidated into a readily accessible enterprise architecture. Hence the low score on *use of architecture*. This key area failed on the checkpoints whether there is an architecture that is recognized by management as such, whether the architecture gives a clear indication of what the organization wants and whether the architecture is accessible to all employees. The fragmentation of the architecture was also shown in the lack of teamwork indicated by the low score for the *consultation* key area: there are no regular meetings of the architects, nor are any decisions made properly documented.

In this case too, the scores on the various key areas can be traced back to the basic approach taken to architecture.

The advice given to the organization on the basis of the assessment was to:

- Develop an overall enterprise architecture (*use of architecture*).
- Spread architectural awareness and involvement throughout the organization (*consultation*).
- Publish the architecture (*use of architecture*).
- Bring all projects under architecture (*monitoring*).

Again, the matrix proves useful in bringing the message home, especially because it shows the relations between the various aspects relevant to the architectural practice. The scores were recognizable and the matrix helped in the communication about the strengths and weaknesses and their consequences. The assessment stimulated the organization to start work on the overall framework to position their individual architectural artefacts and to broaden the base for architectural thinking and acting from essentially one person to employees from all parts of the organization.

4.4 Discussion

The identification of the key areas, their levels and their positioning in the matrix was initially based on practical experience. From our work in various organizations establishing architecture practices we distilled the key areas and their relative priorities. In this section we discuss some adjustments we made on the basis of applying the matrix and lessons learned.

4.4.1 Results and Matrix Adjustments

The first version of the matrix stems from 2001 and was published in 2003 (Van den Berg and Van Steenbergen 2003). Validation of the matrix took place primarily by applying the instrument to about 20 real-life cases. In all cases the results of the completed matrix met with much recognition from both management and architects. The strengths and weaknesses that emerged were recognized, as well as the priorities that were suggested by the matrix.

Secondly, as illustrated in the case studies, the scores on the key areas in the matrix could typically be traced back to the basic architectural approach of the organizations investigated. In the manufacturing company the low and high scores of the key areas could be recognizably linked to the individualistic technology-oriented approach. The same is the case for the relation between the scores of the semi-governmental matrix and its project-driven approach.

Finally, application of the first version of the matrix for two years led to a number of adjustments. The fact that these adjustments presented themselves and could be motivated can be seen as an indication of the relevance of the key areas chosen. The following changes were made:

- We changed the focus of the key area *maintenance of architectural process* from quality improvement to more general management of the process. This was motivated by the realization that we had focused too strongly on quality management, which is a separate key area, while neglecting more basic process management aspects like describing and communicating your processes.
- We moved level B for the key area *maintenance of architectural deliverables* from column 6 to column 7. This is a minor change, prompted by the wish to

bring a bit more balance in the matrix as a whole. The other letters in column 6 had higher priority in our eyes than level B of this key area.

- We moved level B for the key area *use of an architectural method* from column 11 to column 9. This move is motivated by the increasing need felt for having architects throughout the organization working together. This is made easier when they share a common approach to architecture.
- We moved level A for the key area *architectural tools* from column 8 to column 6, and level B from column 11 to column 10. While we remain wary of introducing tools into an organization at too early a stage, causing the organization to focus on the tool instead of on the content required, this move is motivated by the fact that tools are beginning to appear that are less daunting and more flexible in use. This reduces the risk of the tool dictating the architecture.
- We moved level A for the key area *budgeting and planning* from column 6 to column 3, and level C from column 13 to column 12. This move sprang from our experience that architects may tend to keep working on their architecture until perfection, without a sense of having to deliver in time. Therefore we stress the importance of drawing up a plan of approach before embarking on an architecture development project. We found it such an important aspect in making architects more effective that we moved the levels for this key area forward.

For the last four years the matrix has been stable and we do not anticipate any major changes. However, as the enterprise architecture field matures, minor adjustments may be called for sometime in the future.

4.4.2 Lessons Learned

From applying the maturity matrix in about 20 organizations in the course of six years, we learned the following lessons:

- *The scope of an assessment has to be clearly defined beforehand.* Within an organization several architectural practices may be distinguished. For instance, large organizations may have architectural teams within the various divisions, as well as a global architecture team. These architectural practices may differ substantially. In this case it is advisable to apply the maturity matrix to each of the architectural practices separately.
- *Using the checkpoints as a questionnaire may provide additional insight.* The checkpoints are meant as a formal instrument to complete the matrix. However, in the course of time we found that when they are converted to a questionnaire they may fulfil additional purposes. For one thing we have

encountered a number of times the fact that the various stakeholders in an organization differ in their view of the architectural practice. These are valuable clues to interpreting the actual situation. Another use of the checkpoints as questionnaire is to have a delegation of the organization complete the questionnaire together. This kind of self assessment appears to provoke very useful discussions and sharing of experiences and best practices. Completion of the questionnaire by a group of about six persons takes about an hour and a half. We frequently use it as an instrument in awareness and improvement workshops for architectural teams.

- *Using the checkpoints as a questionnaire is not reliable as single input for an assessment*. This lies mainly in the fact that situations and perceptions differ throughout the organization. For instance, some projects may be monitored by architects while others are not. As the checkpoints ask for a clear yes or no, different people may provide different answers. It is therefore to be left to the assessors to do the final scoring of the checkpoints if a formal assessment is asked for.
- *The assessment is organization independent, but the improvement suggestions are not*. The completion of the checkpoints is done in a standard way for each organization. Thus the identification of strengths and weaknesses does not differ from organization to organization. The actual advice for improvement, however, is very organization specific. The scoring of the matrix provides insight into the aspects that have to be addressed and improved. The best way to go about improving these aspects is very much driven by factors like culture, size, business and overall process maturity of the organization.

4.5 Conclusions and Further Research

The matrix has held, apart from a few adjustments motivated by changes in the field, for six years now, being applied to organizations of different branches and different sizes. Most organizations, however, have scored in the lower regions of the matrix (levels 0 to 3). It is imaginable that, when maturity grows and organizations get higher scores, the matrix will receive another update. The authors see this as a strength of the matrix, rather than a weakness.

The matrix provides insight and support to improve the architectural practice of an organization. It is aimed at making architectural practices run more smoothly and making them better accepted by the rest of the organization. What remains to be done is to measure whether these better running practices do indeed lead to better performance of the organization as a whole, or in other words, whether the contribution of architecture to the business goals improves as well.

The focus of the matrix has grown to be more on guiding improvement than on measuring maturity. In a field as young as enterprise architecture we think this is a justified choice. As a rule, an assessment is followed by formulating and implementing an improvement plan. A topic for further research is to investigate how organizational and cultural factors influence the formulation of actual improvement actions.

So far the matrix seems to be a very useful instrument in assessing the strengths and weaknesses of the architectural practice of organizations and in providing direction and priorities for improvement. Use in practice shows that the results are recognizable and the improvement suggestions feasible. A number of organizations have even used the matrix to give direction to an improvement trajectory of years, performing a yearly assessment to monitor progress.

Chapter 5

The Dynamic Architecture Maturity Matrix: Instrument Analysis and Refinement

The field of enterprise architecture is still very much in development. Many architecture teams are looking to improve their effectiveness. One of the instruments to do so is the Dynamic Architecture Maturity Matrix. In the past the DyAMM has been applied to many architecture practices to assess their architecture maturity level. In this paper we present an analysis of these assessments. This provides us with an overview of common strengths and weaknesses in existing architecture practices. In addition, we use the set of assessments to analyze the DyAMM instrument for four types of anomalies[1].

5.1 Introduction

Enterprise architecture, the application of principles and models to guide the design and realization of processes, information systems and technological infrastructure, is seen by many as a means to make complexity in IS manageable (Lankhorst et al. 2005; Ross et al. 2006; Versteeg and Bouwman 2006). For this promise to come true, sound architectural practices, by which we mean the whole of activities, responsibilities and actors involved in the development and application of enterprise architecture, have to be implemented (Van der Raadt et al. 2007; Van Steenbergen et al. 2007). As an aid in developing these architectural practices architecture maturity models have been introduced in the past. These maturity models are used to assess the maturity of

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architecture practices and to suggest improvements to these practices. In Van Steenbergen et al. (2007) three types of maturity models are distinguished. The main distinction is between *fixed-level models* that distinguish a fixed number of maturity levels, usually five, like in the well-known CMM (Appel 2000; CMMI 2002; GAO 2003; Luftman 2000; METAGroup 2001; NASCIO 2003; Westbrock 2004) and *focus area oriented models* that depart from the idea that there is a fixed number of generic maturity levels and instead define for each focus area its own number of specific maturity levels. To still be able to show incremental growth, the overall maturity of an organization is expressed in terms of combinations of the maturity levels of these focus areas. Focus area oriented models have been applied to testing (Koomen and Pol 1999) and software product management (Van de Weerd et al. 2010).

As enterprise architecture is still a field in development, a focus area oriented model is the most appropriate as it allows for a more fine-grained approach (Van Steenbergen et al. 2007). The Dynamic Architecture Maturity Matrix (DyAMM) is such a focus area oriented model. The DyAMM is developed as part of the DyA program in which an approach to enterprise architecture is developed, called Dynamic Architecture (DyA), that focuses on a goal-oriented, evolutionary development of the architectural function (Van den Berg and Van Steenbergen 2006; Wagter et al. 2005). The first version of the DyAMM, version 1.0, was developed in 2002 by a group of experts on the basis of many years of practical experience in the field of enterprise architecture. The format of the DyAMM was taken from the Test Process Improvement (TPI) Model [13]. Based on the first few applications, the DyAMM underwent one update in 2004, which consisted of the repositioning of some of the maturity levels, resulting in DyAMM 1.1. DyAMM 1.1 has been qualitatively validated by applying it to a number of cases (Van Steenbergen et al. 2007).

The DyAMM has been applied to many organizations in the last couple of years from many sectors in various countries in Europe as well as in the US. Thus a substantial dataset of assessment results has been accumulated. This dataset not only provides an insight into the state of the architecture practice, but it may also be used to quantitatively analyze and refine the DyAMM as is presented in this paper. We defined four types of instrument anomalies that might occur in focus area oriented models and used the dataset to investigate the extent to which the DyAMM exhibits these four types of potential anomalies. We found only few actual anomalies, thus supporting the validity of the DyAMM instrument.

The contribution of this paper is twofold. On the one hand it provides a view on the state of the architecture practice. On the other hand it provides a way to analyze and fine-tune focus area oriented maturity models. In the next section we will present the DyAMM in more detail. This will be followed in section 5.3

by an overview of the assessment results collected in the last few years. In section 5.4 we further analyze the assessment results with the purpose of fine-tuning the DyAMM. In section 5.5 we provide our conclusions.

5.2 The Dynamic Architecture Maturity Matrix

In this section we briefly discuss the DyAMM. For a full description of the DyAMM we refer to Van den Berg and Van Steenbergen (2006).

5.2.1 Structure of the DyAMM

The DyAMM is an instrument to incrementally build an architecture function. It distinguishes 18 architecture practice focus areas that have to be implemented. These focus areas are derived from practical experience in the field of enterprise architecture. The definitions of the architecture practice focus areas are provided in table 5-1.

Table 5-1: The architecture practice focus areas of the DyAMM.

Focus area	**Definition**
Development of architecture	The approach to architecture development, varying from isolated, autonomous projects to an interactive process of continuous facilitation.
Use of architecture	The way architecture is used: merely as a conduit for information, as a means of governing individual projects or even as a tool for managing the entire organization.
Alignment with business	The extent to which the architectural processes and deliverables are in tune with what the business wants and is capable of.
Alignment with the development process	The extent to which architecture is embedded in the existing (business and IT) development processes of the organization.
Alignment with operations	The extent to which architecture is both used in and built on the operations and maintenance discipline.
Relationship to the as-is state	The extent to which the existing situation is taken into account by the architecture processes and deliverables.
Roles and responsibilities	The distribution of responsibilities concerning both architecture processes and deliverables within the organization.
Coordination of developments	The extent to which architecture is used as a steering instrument to coordinate the content of the many developments that usually take place concurrently.
Monitoring	The extent to which and the manner in which compliance of projects with the architecture is guaranteed.
Quality management	The extent to which quality management is applied to the architecture practice.
Maintenance of the architectural process	The extent to which the architectural process is actively maintained and improved.

Maintenance of the architectural deliverables	The extent to which and the manner in which the architectural deliverables are kept up to date.
Commitment and motivation	The extent to which commitment is attained from and shown by the organization.
Architectural roles and training	The acknowledgement and support of the architectural roles and the extent to which architects can educate themselves.
Use of an architectural method	The extent to which a (common) architectural method is used.
Consultation	The extent to which communication among architects and between architects and their stakeholders takes place on a structural basis.
Architectural tools	The extent to which architects are supported by tools.
Budgeting and planning	The extent to which architectural activities are budgeted and planned.

Each focus area can be divided into a number of maturity levels. By positioning these maturity levels against each other in a matrix, as shown in figure 5-1, the DyAMM presents the order in which the different aspects of the architecture function should be implemented. The maturity levels of each focus area are depicted by the letters A to D, indicating increasing levels of maturity. As each focus area has its own specific maturity levels, the number of maturity levels may differ for each focus area, varying from two to four. Most focus areas distinguish three levels. For example the focus area *use of architecture* has three maturity levels A: *architecture used informatively*, B: *architecture used to steer content* and C: *architecture integrated into the organization*. The position of the letters in the matrix indicates the order in which the focus areas must be implemented to incrementally build an architecture practice in a balanced manner. The thirteen columns define progressive overall maturity scales, scale 0 being the lowest and scale 13 being the highest scale achievable. If an organization has achieved all focus area maturity levels positioned in a column and in all columns to its left, it is at that maturity scale. This is depicted by coloring the cells in the matrix up to and including the maturity level that has been achieved, for each of the focus areas.

The organization depicted in figure 5-1 for illustrative purposes shows an unbalance in that some focus areas, like alignment with the development process, are quite advanced, while others, like use of architecture, are not yet developed at all. Thus despite the development of some of the focus areas, on the whole the organization in figure 5-1 is still only at scale 1. Its first step would be to develop use of architecture to maturity level A.

Area / Scale	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Development of architecture		A			B			C						
Use of architecture			A			B				C				
Alignment with business		A				B				C				
Alignment with the development process			A				B		C					
Alignment with operations					A			B			C			
Relation to the as-is state					A				B					
Roles and responsibilities				A		B					C			
Coordination of developments							A			B				
Monitoring				A		B		C		D				
Quality management								A		B			C	
Maintenance of the architectural process							A		B		C			
Maintenance of architectural deliverables					A			B					C	
Commitment and motivation		A					B		C					
Architecture roles and training				A		B			C			D		
Use of an architectural method				A						B				C
Consultation			A		B				C					
Architectural tools							A				B			C
Budgeting and planning				A							B		C	

Figure 5-1: The Dynamic Architecture Maturity Matrix.

An organization that still has to build its architecture practice, starts with developing the focus areas positioned in scale 1 to their first maturity levels: *development of architecture*, *alignment with business* and *commitment and motivation* (the A's in column 1). To get to the next stage, the first maturity levels of the focus areas *use of architecture*, *alignment with the development process* and *consultation* have to be achieved (the A's in column 2). And so on. Once all A's in columns 1 to 3 have been achieved, is it time to develop the focus area *development of architecture* to the next level (the B in column 4). In this way the matrix can be used to set priorities in developing the architectural practice.

5.2.2 Use of the DyAMM

Each maturity level of each focus area is associated with one to four yes/no questions. Focus area level determination is done by answering these questions. Only if all questions associated with a maturity level can be answered confirmatively for an organization, the associated maturity level can be said to be achieved. Table 5-2 shows as an example the questions associated with level A of the focus area *use of architecture*. In total there are 137 questions associated with the matrix.

Table 5-2: Questions to measure maturity level A of focus area Use of architecture.

Nr.	Question
9	Is there an architecture that management recognizes as such?
10	Does the architecture give a clear indication of what the organization wants?
11	Is the architecture accessible to all employees?

The DyAMM can be applied in two distinct ways: as an *independent assessment* or as a *self assessment*. The primary use of the DyAMM is as an assessment instrument to be used by independent assessors. Usually, an assessment is commissioned by the person responsible for the architectural function, most often the head of the architects, the head of the IT department or the CIO. The assessment may be the first step in an improvement process. The assessors, usually as a team of two, complete the matrix by answering all 137 questions. They base their answers primarily on interviews with relevant stakeholders, like senior managers, business managers, project managers, system developers, operations personnel and architects. In addition, documentation is studied to support the findings from the interviews and to establish width and depth of the architectural artifacts. The second use of the DyAMM is as a self assessment to be completed by individuals for their own organization. Architects can answer the 137 questions for themselves, which leads to a completed matrix. This latter use of the DyAMM is offered as a service to the architectural field (DYA 2009).

5.3 Analysis of DyAMM Assessments

We collected 56 assessments conducted in the context of the DyA program over the period 2005 – 2008. This set includes independent assessments performed by DyA experts as well as self assessments executed in the context of courses or workshops. The assessments were collected directly from the DyA experts involved, which enabled us to establish their origins. In some assessments the authors were involved. The assessments are distributed over various industry sectors. Financial intermediation (23.2%), public administration (21.4%), transport, storage and communications (16.0%) and manufacturing (14.3%) are best represented. The high representation of financial intermediation in our set corresponds with a general high enterprise architecture awareness that can be noticed in this sector and that is evidenced for instance by the frequent representation of this sector at enterprise architecture conferences. The high percentage of public administration is in line with an increasing demand by government to apply enterprise architecture practices.

5.3.1 Overall Maturity Distribution

After establishing the dataset we conducted a number of analyses. First we determined the distribution of the 56 cases over the 13 maturity scales (Table 5-3). We looked both at the minimum scale and at the average scale. The minimum scale is the scale for which an organization has achieved all focus area maturity levels positioned in that column and in all columns to its left. The average scale was calculated for each case by adding the scales for each focus area and dividing this by 18, e.g. for the case in figure 5-1 this is 1 for *development of architecture,* 0 for *use of architecture,* etc.

Table 5-3: Overall maturity distribution.

		Minimum			**Average**
Scale	**Frequency**	**Percentage**	**Scale**	**Frequency**	**Percentage**
0	50	89.3	0	8	14.3
1	4	7.1	1	18	32.1
2	2	3.6	2	16	28.6
≥ 3	0	0.0	3	7	12.5
Total	**56**	**100**	4	5	8.9
			5	1	1.8
			6	0	0.0
			7	1	1.8
			≥ 8	0	0.0
			Total	**56**	**100**

The distribution shows that the vast majority of organizations is still at scale 0 and that none has a scale of 3 or higher. Looking at the average scores, we see more spread. This indicates that various organizations score high on some focus areas, while at least one of the focus areas needed for the first few scales is underdeveloped. This is indicative of an unbalance in the development of the 18 focus areas, some focus areas being well developed, while some essential areas seem to be neglected.

5.3.2 Distribution of Focus Area Maturity Levels

Drilling down, we next investigated the maturity level distribution of the 56 cases on each of the 18 focus areas of the DyAMM. This is presented in table 5-4.

Table 5-4: Distribution of organizations over focus area maturity levels.

Focus area	0	A	B	C	D	Total
Development of architecture	60.7	26.8	3.6	8.9	-	100
Use of architecture	82.2	7.1	10.7	0	-	100
Alignment with business	75	10.7	8.9	5.4	-	100
Alignment with the development process	23.2	41.0	32.2	3.6	-	100
Alignment with operations	66.1	19.6	12.5	1.8	-	100
Relationship to the as-is state	66.1	21.4	12.5	-	-	100
Roles and responsibilities	42.8	5.4	46.4	5.4	-	100
Coordination of developments	51.8	30.4	17.8	-	-	100
Monitoring	89.2	1.8	5.4	1.8	1.8	100
Quality management	92.8	5.4	1.8	0	-	100
Maintenance of the architectural process	76.8	14.3	7.1	1.8	-	100
Maintenance of the architectural deliverables	73.2	21.4	1.8	3.6	-	100
Commitment and motivation	34.0	57.1	7.1	1.8	-	100
Architectural roles and training	10.7	34.0	46.4	7.1	1.8	100
Use of an architectural method	67.8	30.4	1.8	0	-	100
Consultation	42.9	48.2	7.1	1.8	-	100
Architectural tools	48.2	37.5	12.5	1.8	-	100
Budgeting and planning	53.6	41.0	5.4	0	-	100

The focus area maturity level distribution in table 5-4 shows for each of the maturity levels of each focus area what percentage of the organizations in the dataset score that particular level. Thus, for the focus area *use of architecture* it is shown that 82.2% of the organizations score level 0, 7.1% scores level A, 10.7% scores level B, and 0% scores level C. It is clear from the focus area maturity level distribution that level 0 has a relatively high score on most of the focus areas. This implies that on many aspects the maturity of the architecture practices assessed is rather low. A few focus areas have a better distribution of organizations over the maturity levels, like *alignment with development* and *architectural tools*. Apparently there is a difference between organizations in maturity for these aspects of the architecture practice. This may indicate that some organizations pay more attention to them, either because they deem them more important or because they are relatively easy to achieve.

Translating the focus area maturity level distribution into the average maturity score for each focus area enables us to rank the focus areas according to maturity level found in the dataset (figure 5-2). The average maturity score is calculated by attaching a score of 0 to 4 to the maturity levels 0, A, B, C and D respectively. The fact that not all focus areas distinguish exactly five levels is corrected for in calculating the average score, by translating all focus areas to a number of four levels. This gives a range of potential scores between 0 and 3.

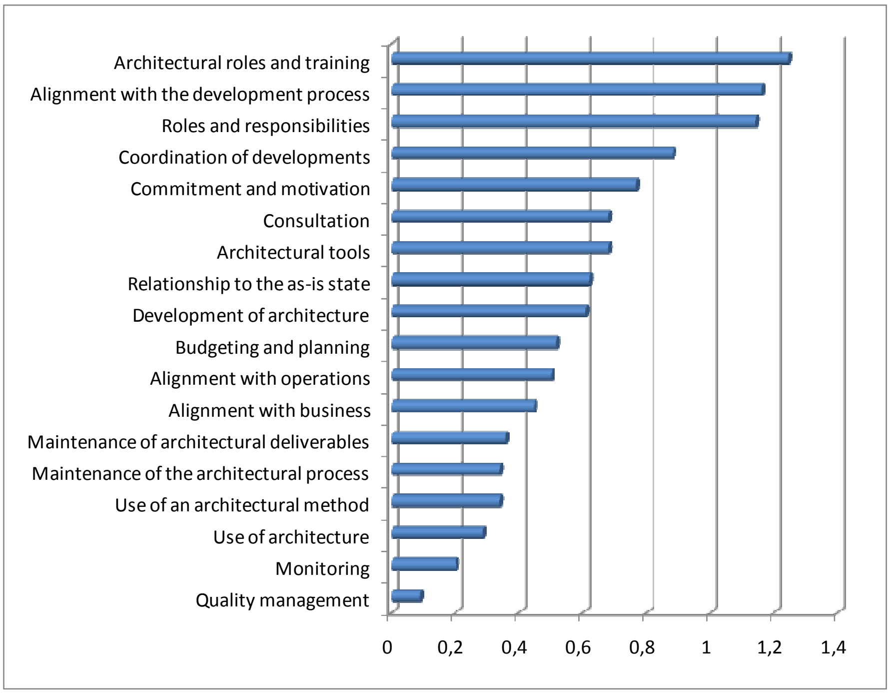

Figure 5-2: The average score for each of the focus areas.

The average maturity scores show that there is a clear difference in maturity between the focus area scoring lowest, *quality management* and the focus area scoring highest, *architectural roles and training*. If we relate the average score to the positioning of the focus areas in the DyAMM we see that the following focus areas that, according to the DyAMM, should be addressed at an early stage (scales 1 and 2), score relatively low on actual maturity: *development of architecture* (scale 1), *alignment with business* (scale 1) and *use of architecture* (scale 2).

If we look at the focus areas of scale 3, we see the following focus areas scoring low: *monitoring*, *use of an architectural method* and *budgeting and planning*. Of these, *monitoring* scores especially low. *Monitoring* seems to be a common weakness in the architecture practices analyzed. Maturity level A of the focus area *monitoring* is positioned at scale 3 in the matrix. The low score on this focus area apparently prevents organizations from attaining scale 3. This explains the fact that none of the assessed organizations score scale 3 or higher.

Looking at the top 3 focus areas in figure 5-2, we see that the following focus areas score highest: *architectural roles and training* (scale 3), *alignment with the development process* (scale 2) and *roles and responsibilities* (scale 3).

Of all three, maturity level A is positioned within the first three scales, i.e. relatively early in the maturity development process. Thus, the attention to these focus areas is justified. The focus areas *architectural roles and training* and *roles and responsibilities* are both concerned with structural aspects of the architecture practice. It seems that it is common to have these structural aspects in place. The high score of *alignment with the development process* is striking, especially when compared with the much lower scores of *alignment with operations* and *alignment with business*. It seems that most organizations are more mature in the relation between architecture and projects, than in the relation between architecture and operations or business. The immaturity of the alignment with the business may be a consequence of the fact that architectural thinking most often originates in the IT department. This does not explain, however, the low score on alignment with operations.

On the whole we may conclude that the architecture practices assessed are still in the early stages of architecture maturity. Architecture as an instrument for providing guidance to projects is relatively well developed, though follow up in the sense of compliance monitoring is strikingly lacking. The alignment of the architectural choices with the business goals and the existence of an interactive dialogue between architects and business is still underdeveloped.

5.4 Analysis and refinement of the DyAMM Instrument

The dataset not only gives us a picture of the EA practice, it can also be used to analyze and fine-tune the DyAMM, by using it to detect anomalies that might point to flaws in the DyAMM.

5.4.1 Approach

To fine-tune the DyAMM we defined four kinds of potential instrument anomalies, which we then searched the dataset for. The anomalies found we further explored in an expert panel, after which we decided on whether the anomaly should lead to an adaptation of the DyAMM. Thus our approach consisted of four steps: (1) Definition of instrument anomalies, (2) Quantitative analysis of the dataset, (3) Discussion in Expert Panel, (4) Decision making.

The first step was to define instrument anomalies that might distort the result of an assessment. What we looked for were elements that did not fit the concept of incremental growth, elements that were superfluous and elements that showed interdependency. With this in mind, we identified four kinds of potential instrument anomalies: blocking questions, blocking levels, undifferentiating questions and correlations (table 5-5).

Table 5-5: Potential instrument anomalies.

Anomaly	Definition
Blocking question	A question that in at least 10% of the cases was answered with “No”, while if it were answered with “Yes” by these organizations, they would move up at least two levels for the focus area concerned.
Blocking level	A focus area maturity level that is not achieved by at least 10% of the cases, while if these organizations would achieve the level, their overall score would be 2 scales higher.
Undifferentiating question	A question that at least 85% of the assessments answered with “Yes” and that thus does not differentiate between organizations.
Correlation	A dependency between two focus areas with a significance of 0.05.

Blocking questions may indicate that a question or level should be moved to a higher maturity level. Blocking levels may indicate that the level concerned should be moved to the right in the matrix. Undifferentiating questions seem to be superfluous and might possibly be removed, making the use of the matrix more efficient. Correlations indicate a dependency between two focus areas. This may indicate that focus areas should be combined.

Quantitative analysis of the dataset provided a few anomalies that required further investigation. These anomalies were discussed in an expert panel consisting of seven experts with 4 to 17 years of experience in the field of enterprise architecture, from organizations differing in size from 600 to 65.000 employees. The expert session consisted of three parts: (1) discussion of the blocking questions found, (2) rating the importance of the focus areas and (3) discussing the correlations found. In the session we checked whether the blocking questions were understandable, whether they were relevant to the architecture practice and, if so, at what level of maturity they are most relevant. We also asked the participants to rate the importance of each of the focus areas for an architecture practice in the starting-up phase. Finally, we asked whether they had any explanations for the correlations found. The expert session was organized in a group decision room at Utrecht University (DeSanctis and Gallupe 1987; GroupSystems 1990).

Based on the discussion in the expert panel, we made a final decision on how to deal with the anomalies found.

5.4.2 Blocking Questions

Quantitative analysis. Quantitative analysis provided three blocking questions (table 5-6). There are three possible responses to a blocking question: (1) the question should be moved to a higher level, (2) the question should be rephrased or (3) the question represents a genuine weakness in today's architecture practices and should remain as it is.

Table 5-6: Blocking questions.

Nr.	Question	Focus area	Percentage blocked
18	Is there a clear relationship between the architecture and the organization's business goals?	Alignment with business	10.7
44	Has a policy been formulated concerning the as-is state (existing processes, organizational structures, information, applications and technical infrastructure)?	Relationship to the as-is state	12.5
48	Does the architecture have an official status in the organization?	Roles and responsibilities	14.3

Expert panel. To determine our response to the blocking questions we used the opinion of the experts on the blocking questions, as presented in table 5-7. To determine whether questions should be rephrased we asked for the understandability and relevance of the questions. To determine whether the questions should be moved to a higher level, we asked for the maturity phase in which the questions become relevant.

Table 5-7: Expert opinion on blocking questions.

Nr	Question	Understandable?	Relevant?	Phase?
18	Is there a clear relationship between the architecture and the organization's business goals?	Yes (6) No (1)	Yes (7) No (0)	1 (4) 2 (3) 3 (0)
44	Has a policy been formulated concerning the as-is state (existing processes, organizational structures, information, applications and technical infrastructure)?	Yes (7) No (0)	Yes (7) No (0)	1 (5) 2 (2) 3 (0)
48	Does the architecture have an official status in the organization?	Yes (7) No (0)	Yes (6) No (1)	1 (3) 2 (3) 3 (1)

The numbers in brackets in table 5-7 show the number of respondents giving the answer indicated. The rightmost column shows the maturity phase in which according to the experts the question mentioned becomes relevant. Phase 1 translates to scale 0-3 in the matrix, phase 2 to scale 4-8 and phase 3 to scale 9-13. Table 5-7 shows that the questions are well-understood and relevant. This indicates that the questions need not be removed or rephrased in order to be understood. Regarding the position of the question, there is more deviation between the experts. Most consensus is about question 44. Most participants agree that the question is relevant in the early stages of an architecture practice. For the other two questions about half of the participants place them in the early stages, and the other half place them in the middle stage, when architecture is more or less on its way. In the matrix this would mean between scale 4 and 8 which would indicate a move of the questions to a next level. The difference in opinion regarding question 48 concentrated on the fact that in some organizations a formal approval at an early stage is important, while in others it is not. This seems organization dependent. Question 18 is one of the two questions that are associated with level A of the focus area *alignment with business*. Interestingly, the other question, question 19, 'Is the architecture evaluated in terms of the business goals?', serves as a blocking question for 7% of the assessments. This suggests two possibilities: (1) level A might be positioned too early in the matrix and should be moved to a higher scale or (2) the questions are not appropriate to level A and must be reconsidered. As the experts rank *alignment with business* as the second most important focus area in the early stages, we may conclude that the positioning of level A of *alignment with business* at scale 1 needs no reconsideration.

Decision making. Question 44 is well-understood and deemed relevant to the early stages of an architecture practice, thus we leave this question as it is (response option 3). Question 48 is well-understood and deemed relevant to the early stages of an architecture practice for formally oriented organizations. As the present version of the DyAMM is generic for all organizations, we opt to leave this question too as it is (option 3). Question 18 is well-understood, but the discussion indicates that it might be too advanced for the early stages. This goes for its companion question 19 as well. Which leaves us to consider whether other questions would be more appropriate to this level. We put reconsideration of questions 18 and 19 as an item on the improvement list for version 1.2 of the DyAMM to be further investigated (option 2).

5.4.3 Blocking Levels

Quantitative analysis. Quantitative analysis provided three cases that contained a level preventing them from moving up two scales. Two organizations scored 0 on the focus area *development of architecture*, preventing them from moving from scale 0 to scale 2. One organization scored 0 on the focus area *alignment with business*, preventing it also to move up from scale 0 to scale 2. These numbers are too small to consider these levels blocking levels, as the threshold of 10% is not reached by far. Thus we may conclude that the DyAMM does not contain any blocking levels.

5.4.4 Undifferentiating Questions

Quantitative analysis. Two undifferentiating questions were found.

Table 5-8: Undifferentiating questions.

Nr.	Question	Focus area	Percentage Yes
95	Are money and time allocated to architecture?	Commitment and motivation - A	87.5
102	Does the role of architect exist in the organization?	Architectural roles and training - A	87.5

Decision making. The fact that these two questions have such a high percentage of Yes score, can be partly explained by the fact that not many organizations will perform an architecture assessment if they do not allocate any time or money to architecture, or in some way or other recognize the role of architect. It might be worthwhile, however, to reconsider these two questions. As question 2 is the only question for level A of *architectural roles and training*, this also explains the high percentage of level A for this focus area. We decided to put the reconsideration of questions 95 and 102 on the improvement list for DyAMM 1.2.

5.4.5 Correlations

Quantitative analysis. Analyzing all relationships between the 18 items, we found one (Pearson, two-sided) correlation that complies with a significance level of 5%: between *alignment with the development process* and *commitment and motivation* (r=.37; p=.04), and two correlations that meet a significance level of 1%: between *commitment and motivation* and *architectural roles and training* (r =.55; p=.00) and between *architectural roles and training* and *alignment with the development process* (r=.43; p=.01).

Expert panel. We presented the three significant correlations found to the experts, asking them whether they could explain the correlations. This generated some suggestions, like the idea that when management shows commitment to architecture, projects will be more inclined to take architecture into account and more attention will be paid to the function of architect. Or, when architects are better trained, they will generate commitment more easily. An explanation offered for the third correlation was that as functions and roles are important in many development processes, alignment is easier when the function of architect is formally established. Not one explanation emerged as being the most likely, however.

Decision making. Further research is needed to investigate why these correlations were found, and no significant correlation between other items. The potential application of factor analysis or scale analysis to explore this, however, is not feasible due to the number of observations (N=56).

5.4.6 Overall conclusion

Taking all into account, not many instrument anomalies were found (table 5-9).

Table 5-9: Instrument anomalies found with the dataset.

Type of anomaly	Anomalies found	Action
Blocking question	Questions 18, 44, 48	Reconsider questions 18, 19
Blocking level	None	None
Undifferentiating question	Questions 95, 102	Reconsider questions 95, 102
Correlation	Three significant correlating focus areas	Further investigate explanation of significant correlations

Though the analyses lead to the reconsideration of a few questions, they do not lead to a shifting of maturity levels within the matrix. The correlations found do not lead to immediate changes in the DyAMM, but they do ask for further investigation on the interdependencies between various aspects of the architecture practice.

5.5 Conclusions and Further Research

This paper presents the analysis of 56 assessments of architecture practices executed with the DyAMM. From this analysis we get, on the one hand, a view of the current strengths and weaknesses of architecture practices and, on the other hand, a quantitative validation of the assessment instrument used, the DyAMM, a focus area oriented maturity model. For the latter purpose, we defined four types of potential instrument anomalies that might occur in focus area oriented maturity models.

As for the current status of the architecture practice, we may conclude that most practices are still in the early stages of maturity, and that on the whole there is much room for improvement. The aspects most underdeveloped but of great importance to young architecture practices, are the alignment of the architecture with the business goals, the use of architecture as a guiding principle to design and the monitoring of projects on compliance with the architecture. These are aspects architects should definitely work on. Better developed are the structural aspects of architectural function descriptions and education and the assignment of architectural responsibility. Also, the alignment with projects is well developed. Commitment and motivation are reasonably well realized within the organizations assessed.

As far as the DyAMM itself is concerned, the analysis does not give rise to fundamental changes in the matrix, though it provides some input to fine-tune the matrix. This fine-tuning consists primarily of reformulating some of the questions. The fact that so few anomalies were found is additional support for the validity of the DyAMM and quantitatively strengthens previous qualitative validation. We intend to use the results of our analysis in formulating version 1.2 of the DyAMM. We will also retain the dataset to test future suggestions for improvement from other assessors.

The expert panel discussion indicates that some of the questions of the DyAMM are organization-dependent, like the importance of the architecture being formally approved. It might be interesting to investigate whether there might be cause for different matrices for different types of organizations.

The correlations found need further investigation into interdependencies between various aspects of the architecture practice. Of course, this may in turn lead to further refinement of the DyAMM in future.

An interesting area for future research is the cause of the discrepancy in maturity between alignment with the development process and the consequent monitoring of this same development process.

There are limitations to the research presented here. In our dataset we combined assessments that were conducted in various ways, independent assessments as well as self assessments being included, to increase the number of assessments contained in the set. Preliminary analysis of the assessment results, comparing the average focus area scores, gives no indication that these two types of assessments differ substantially, though. A second limitation is that all cases score in the first three scales. This means that we cannot draw definite conclusions yet on the validity of the higher scales in the DyAMM. As the execution of assessments continues, we hope to repeat and extend the analyses in the future with a larger set. This paper provides a first quantitative validation of the DyAMM, in addition to previous qualitative validation. To fully establish validity of a maturity model like the DyAMM is complex, however, and will require additional research like for example empirical testing of the relation between maturity level and organization outcomes or applying factor analysis to further test construct validity.

Chapter 6

Improving IS Functions Step by Step: The Use of Focus Area Maturity Models

Within the field of IS new functions keep emerging, like portfolio management, sourcing, software product management and enterprise architecture. Maturity models are used to assess and support the development of these functional domains. The existing literature is strongly dominated by studies of fixed-level maturity models, i.e. maturity models that distinguish a limited set of generic maturity levels, like the well-known CMM. We argue that, while fixed-level maturity models are well-suited to assessing the maturity of functional domains, another form of maturity model, the focus area maturity model, is better suited to the incremental improvement of a functional domain. We define the concept of focus area maturity model by approaching it from three different perspectives: we provide a formal definition of focus area maturity model including a mathematical formalization, we illustrate its use in the fields of enterprise architecture and software product management and we present a generic method for developing focus area maturity models. We use a design-science research method, basing our work on both extensive industrial experience and scientific investigation[1].

[1] An earlier version of this work was published as: Steenbergen, M. van, Bos, R., Brinkkemper, S., Weerd, I. van de and Bekkers, W. (2010). The Design of Focus Area Maturity Models. In Winter, R., Zhao, J. L. and Aier, S. (Eds.), *Proceedings of the 5th International Conference on Design Science Research in Information Systems and Technology*, LNCS 6105, 317–332. Springer-Verlag, Berlin Heidelberg.

6.1 Introduction

Several new IS functions have emerged over the last decades. Examples are portfolio management, sourcing, software product management and enterprise architecture. New functions like these take many years to develop, both from a generic perspective and from the perspective of a specific organization. As is evidenced by the number of practitioners conferences, practitioners are often keen to seek guidance in this development process. Maturity models may provide this guidance.

Within the IS community the concept of maturity models is well-known, not only within the research community, but also with practitioners. If the abundance of maturity models that have been developed in the past years is any indication, there is a great need for this kind of models (De Bruin et al. 2005; Davenport 2005; Mettler and Rohner 2009). Maturity models may assist organizations in developing a new functional domain to a level that fits their objectives. They are not only instrumental in supporting the practical development of a functional domain, but also in building a better scientific understanding of new functional domains by making IS capabilities measurable (Santhanam and Hartono 2003). By functional domain is meant the whole of activities, responsibilities and actors involved in the fulfillment of a well-defined function within an organization. As the field of IS is still developing as a whole, it is to be expected that organizations will continue to be faced with implementing new functions. And thus the need for support in developing these functions will continue too.

6.1.1 Types of Maturity Models

The basic components of a maturity model are (i) a number of overall maturity levels, (ii) a number of aspects or areas (henceforth called focus areas) that can be developed along a predefined evolutionary path to achieve the defined maturity levels and (iii) descriptions of each step on the evolutionary path. In addition, a maturity model may contain suggestions on how to perform the various steps in terms of improvement actions. We can divide the existing maturity models into three basic types (Van Steenbergen et al. 2007).

1. *Staged fixed-level models*. Staged fixed-level models distinguish a fixed number of generic levels of maturity, usually around five. Each maturity level contains a number of focus areas that have to be implemented for the organization to achieve that particular level. The best-known staged fixed-level maturity model is the Capability Maturity Model for Software (CMM) and its successors (Paulk et al. 1993).

2. *Continuous fixed-level models*. Continuous fixed-level models also distinguish a fixed number of generic maturity levels. They differ from the staged fixed-level models in the fact that in the continuous models, focus areas are not attributed to a level, but the generic maturity levels are distinguished within each focus area. The Capability Maturity Model Integration (CMMI), which is developed to solve the problem of applying various capability maturity models by providing a single improvement framework, distinguishes both a staged and a continuous representation (CMMI 2002a; CMMI 2002b).
3. *Focus area models*. Focus area models do not distinguish a fixed number of generic maturity levels, but instead define specific maturity levels for each focus area. The overall maturity of an organization is expressed as a combination of the specific maturity levels. Focus area models are much less common than fixed-level models. Examples are the Test Process Improvement (TPI) model developed by Koomen and Pol (1999) and the models for enterprise architecture and software product management studied in this paper.

The differences between the three types of models is illustrated in figure 6-1: (a) in the staged fixed-level models with each maturity level (denoted by a number) a number of focus areas (denoted by ‘FA’ followed by a number) is associated; (b) in the continuous fixed-level models within each focus area the same generic maturity levels are distinguished; (c) in the focus area models within each focus area maturity levels are distinguished that are specific to that focus area. The number of maturity levels may differ per focus area.

	1	2	3	4	5
FA 1	X				
FA 2	X				
FA 3		X			
FA 4		X			
…					

(a) Staged fixed-level model

	1	2	3	4	5
FA 1	X	X	X	X	X
FA 2	X	X	X	X	X
FA 3	X	X	X	X	X
FA 4	X	X	X	X	X
…					

(b) Continuous fixed-level model

	1	2	3	4	5	6	7	…
FA 1	X				X			
FA 2		X		X				
FA 3	X		X			X		
FA 4				X			X	
…								

(c) Focus area model

Figure 6-1: Three types of maturity models (van Steenbergen et al. 2007).

The vast majority of maturity models encountered in the literature are fixed-level models, based on the generic 5-level maturity model used by CMM (Hansen et al. 2004). The fixed-level model has some limitations, however, which makes it less suitable to support incremental development of a functional domain. First of all, the use of generic maturity levels restricts the model to addressing just one dimension of a functional domain. In most cases this is the process dimension. Developing a new functional domain in general, however, requires not only processes to be implemented, but also people to be educated, rules to be agreed upon and relationships to be established. Secondly, the use of generic maturity levels for all focus areas makes the model relatively coarse-grained, limiting its ability to provide guidance in setting priorities in developing a functional domain. Several authors argue that CMM models are too large to implement, or even comprehend (Kuilboer and Ashrafi 2000; Reifer 2000). It also requires large resources and long term commitment, which can be a problem for small and medium companies (Zahran 1997). Small and medium companies often not only lack the funds required to implement many of the practices from CMM, but also have to base their improvement initiatives on practices that do not apply to them (Brodman and Johnson 1994).

6.1.2 Focus Area Maturity Model

The focus area maturity model originates in the domain of software testing (Koomen and Pol 1999). Subsequently, focus area maturity models were developed for the domains of enterprise architecture (Van den Berg and Van Steenbergen 2006; Van Steenbergen et al. 2007; Van Steenbergen et al. 2010) and software product management (Bekkers et al. 2010a; Van de Weerd et al. 2010). A focus area maturity model defines for each of its focus areas a series of progressively mature capabilities. A capability is the ability to achieve a certain goal, making use of the available resources (cf. Bharadwaj 2000). The capabilities are specific to the focus areas they are related to. An incremental development path is defined by juxtaposing all capabilities of all focus areas relative to each other in a matrix. An example of a focus area maturity model for the domain of enterprise architecture is given in figure 6-2 (Van Steenbergen et al. 2010). The focus areas are in the left column. The letters (A to D) to the right of the focus areas, stand for the progressively mature capabilities related to each of the focus areas. For example, the focus area *Development of architecture* has the capabilities A: *Architecture undertaken as project*, B: *Architecture as a continuous process* and C: *Architecture as a facilitation process*, representing a progression in maturity. The focus area *Use of architecture* has three capabilities A: *Architecture used informatively*, B: *Architecture used to steer content* and C: *Architecture integrated into the* *organization*. The positioning of the letters in the matrix indicates the order in which the capabilities of the different focus areas can be implemented to develop the enterprise architecture functional domain in a balanced manner.

Maturity Level **Focus Area**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Development of architecture		A			B			C						
Use of architecture			A			B				C				
Alignment with business		A				B				C				
Alignment with the development process			A				B		C					
Alignment with operations					A			B			C			
Relationship to the as-is state					A				B					
Roles and responsibilities				A		B					C			
Coordination of developments							A			B				
Monitoring				A		B		C		D				
Quality management								A		B			C	
Maintenance of the architectural process							A		B		C			
Maintenance of architectural deliverables					A			B					C	
Commitment and motivation		A					B		C					
Architectural roles and training				A		B			C			D		
Use of an architectural method				A						B				C
Consultation			A		B				C					
Architectural tools							A				B			C
Budgeting and planning				A							B		C	

Figure 6-2: A focus area maturity model for the functional domain of enterprise architecture (Van Steenbergen et al. 2010).

The fourteen columns in the matrix of figure 6-2 define the overall maturity levels, with level 0 being the lowest level and level 13 the highest. The rightmost column for which an organization has achieved all focus area capabilities positioned in that column and in all columns to its left, indicates the overall maturity level of that organization. This overall maturity level can be visualized by coloring the cells of each row up until the first capability that has not been implemented yet by the organization, giving a maturity profile of the organization. The rightmost column that does not contain any non-colored cells, indicates the maturity level of the organization assessed. Thus, the organization in figure 6-2 is at maturity level 1, as the capability A of *Use of architecture* in column 2 has not been achieved. It also shows an unbalance: the focus area *Alignment with the development process,* is fully developed, while others, like *Use of architecture* and *Monitoring*, are not yet developed at all. To get a balanced enterprise architecture function, this organization first has to develop the focus area *Use of architecture* to its first capability (the A in column 2), achieving overall maturity level 2. The next step would be to develop *Monitoring* to the first capability (the A in column 3), progressing to level 3.

For the purpose of developing a functional domain, the focus area maturity model seems more appropriate than the fixed-level maturity model, because it allows a more fine-grained approach. Because the nature of the focus area maturity model enables it to distinguish more levels of maturity, it allows for defining smaller steps between the levels and for expressing more interdependencies between focus areas. Thus practitioners receive more guidance in setting priorities when developing their functional domain.

In this paper we formally define the concept of focus area maturity model, illustrate its use in the fields of enterprise architecture and software product management, and present a generic development method for focus area maturity models for other functional domains. By doing so we enable researchers to develop a focus area maturity model for new functional domains and consequently support practitioners in developing these domains in a balanced, well-founded manner. Our research contributes to the scientific knowledge by providing a handle on how to understand and describe a specific functional domain in a manner that is not only relevant to practitioners having to implement the domain, but also to researchers wanting to understand the domain.

We start in the next section with providing the theoretical background to maturity models and motivating the need for focus area maturity models. Next, we present the research method used, which is an instantiation of design-science research. We illustrate the application of focus area maturity models in two areas, enterprise architecture and software product management. To better understand the nature of the focus area maturity model, we need a more precise definition of what exactly constitutes a focus area maturity model. We provide this by precisely defining the various concepts included in the model, as well as providing a mathematical formalization. Finally, we present a development method for new focus area maturity models. We conclude with some general observations.

6.2 Related Work

The origins of maturity models lie in Crosby's Quality Management Maturity Grid (Crosby 1979). The best-known maturity model within the field of IS, and the one that was an inspiration to the development of many more maturity models, is SEI's Capability Maturity Model for Software (CMM) with its successors (Paulk et al. 1993) and the alternative model ISO-IEC 15504, known as SPICE or BOOTSTRAP (Haase et al. 1994; Kuvaja 1999).

CMM was developed as a response to the needs of the US Defense Department for better techniques for the selection of contractors (Rout et al. 2007). In response to the increasing number of subsequent assessment approaches the UK Ministry of Defence initiated a series of studies resulting in a proposal to develop a Standard. The SPICE project was started to support the development of the Standard. The first version of this Standard was released as a Technical Report in 1998. It was published as a full International Standard over the period 2003-2006 (ISO/IEC 15504). Over the years, both CMM and SPICE have broadened their scope: CMMI has moved beyond software development processes to a broad systems engineering view, while SPICE has gradually moved to a defined set of requirements suitable for many human organized activities with defined goals. BOOTSTRAP is based both on CMM and on the international standards ISO 9001, ISO 9000-3, ISO 12207, ISO/IEC 15504 (SPICE), ESA PSS-05-0 (Kuvaja 1999).

Over the past years more than a hundred maturity models have been developed for domains as varied as corporate data quality management (Hüner et al. 2009), e-learning (Marshall and Mitchell 2004), e-government (Andersen and Henriksen 2006) and offshore sourcing (Carmel and Agarwal 2002; Strutt et al. 2006), to name just a few. Benefits expected from maturity models are, among others, providing a roadmap to improve processes, stimulating management into more long term commitment, enhancing support for institutional planning by the ability of benchmarking and providing a means of organizing the diverse collection of ideas and heuristics (Marshall and Mitchell 2004).

6.2.1 Distinguishing characteristics of maturity models

The research literature reveals a number of distinguishing characteristics of existing maturity models. First of all, the nature of maturity models may be descriptive, prescriptive or comparative (De Bruin et al. 2005). This is directly related to the purpose of the model: whether it is meant purely to assess an organization’s current state (descriptive), whether it is meant to suggest improvement actions (prescriptive), or whether it is aimed at comparison with other organizations (comparative). A maturity model may evolve from descriptive to prescriptive to comparative. In their review of six maturity models that are described in some detail in the research literature, Becker et al. (2009) found that these models tend to put the objective of evaluation and comparison of businesses to the foreground, i.e. the descriptive and benchmarking purposes. Niazi et al. (2003), however, mention that studies show that 67% of Software Process Improvement (SPI) managers want guidance on how to implement SPI activities, rather than what SPI activities to actually implement, which pleads for a prescriptive maturity model.

A second characteristic is the dimension the model applies to. Most maturity models, including the original CMM, focus on only one dimension, often the process dimension. In general, however, performing a specific function involves more dimensions, like people and objects (Bharadwaj 2000; Feeney and Willcocks 1998; Mettler and Rohner 2009; Niazi 2003; Ravichandran and Rai 2000).

A third characteristic is the maturity growth structure. Many models adopt the five maturity levels defined by CMM, with or without adaptations. Other models define their own maturity levels. Usually the number of levels is somewhere between three and six. Each level has a label and, usually, a description of the characteristics of the level as a whole. Achievement of a level is measured either by having an aspect of the domain fully implemented (staged approach) or by having an aspect of the domain implemented to the extent required by the maturity level (continuous approach). The nature of the levels differs according to the focus of the model. In CMM, for instance, the levels are defined in terms of the degree of process management, i.e. initial, repeatable, defined, managed, optimizing. In other maturity models, the levels are defined in terms of resulting situations, for instance the Public Sector Process Rebuilding model contains the levels catalogue, transaction, vertical integration and horizontal integration (Andersen and Henriksen 2006), while Gottschalk and Solli-Saether (2006) present a maturity model for IT outsourcing that distinguishes the stages cost, resource and partnership. In the domain of enterprise architecture, Ross et al. (2006) discuss four stages that an organization passes through, making increasingly effective use of enterprise architecture: business silo, standardized technology, optimized core and business modularity.

6.2.2 Underlying rationale of maturity models

The choices made in an actual maturity model to a great extent depend on the underlying rationale and conceptual model on which the maturity model is based. Making explicit the underlying rationale for a maturity model is essential to obtaining theoretical rigor. The rationale defines what constitutes progressive maturity for the scoped functional domain as a whole as well as for each of the distinguished focus areas constituting the functional domain. For instance, the underlying rationale for CMM is that maturity is directly associated with the degree to which a process is institutionalized and effective: the more structured a process is, and the more transparent in terms of measurability of performance, the better (Lockamy and McCormack 2004; Maier et al. 2009), though some authors express doubts as to the theoretical foundation for this rationale (Hansen et al. 2004; Ravichandran and Rai 2000). The use of a conceptual framework and the explicit statement of the underlying rationale of the maturity model are even more important as in practice, certainly with new models, most organizations score in the lower regions. This implies that there is not much empirical evidence for the higher maturity levels. Because of the normative nature of prescriptive maturity models great care has to be taken in defining the various levels. If the design sticks to currently available techniques a maturity model may hinder innovation. Prescriptive models, because of their prescriptive nature, require careful consideration and continuous updating to new developments (Andersen and Henriksen 2006).

6.2.3 Maturity growth structure

Several authors describing a fixed-level maturity model express the need for further detailing of the overall maturity levels. De Bruin et al. (2005) argue that there is a need to further differentiate within the overall maturity levels in actual assessments, in order to be able to perform separate maturity assessments for a number of discrete areas, in addition to the overall assessment. To this aim they introduce additional layers to their maturity models: domain components and domain sub-components. Reporting can be done on each level, depending on the audience. Targeted improvement actions can be defined on the sub-component level. Other researchers have expressed the need for assessment on a level more detailed than the overall maturity levels (Haase et al. 1994; Kuvaja 1999; Strutt et al. 2006; Visconti and Cook 1998). Using a limited number of fixed overall maturity levels also provides little support in prioritizing improvement efforts as prioritization within levels is not supported by the model (Kuvaja 1998; Marshall and Mitchell 2004).

Only a few models, however, depart from the idea of a fixed number of maturity levels. One example is the Corporate Data Quality Maturity Model (CDQ MM) by Hüner, Ofner and Otto (2009). Hüner et al. distinguish a number of maturity dimensions with each dimension having its own specific set of progressive maturity levels, the number varying between three to six levels. A similar example that departs from the fixed number of maturity levels is the IS/ICT Management Capability Maturity Framework (Renken 2004). This model distinguishes seven IS/ICT management capability maturity indicators, each consisting of between three and five competency levels or maturity stages. A third example is the E-Learning Maturity Model (Marshall and Mitchell 2007). Marshall and Mitchell replace in this model the idea of maturity levels that are moved through progressively, by the idea of maturity dimensions or perspectives that are simultaneously relevant to process maturity. Each process has associated with it a number of practices for each dimension. Each practice is rated from not adequate to fully adequate, depending on a combination of whether or not the practice is performed, how well it appears to be functioning, and how prevalent it appears to be. The dimension for a process is rated by averaging the results of the practice assessments.

6.2.4 Context dependency in maturity models

Several authors argue for the need for situational application of a maturity model (Kuvaja 1999; Maier et al. 2009; Mettler and Rohner 2009; Renken 2004). Because of their greater flexibility, focus area maturity models are more amenable to situational application than fixed-level maturity models. Conceptually, there are three approaches to making a focus area maturity model situation specific. The first approach is to make a selection of focus areas and/or capabilities that are relevant to the situation, i.e. disabling some focus areas and/or capabilities that are deemed not applicable in the situation at hand. This is the approach followed by Mettler and Rohner (2009), who identify certain focus areas or capabilities as being not applicable to certain types of organizations. They distinguish five scenarios of coordination forms in hospitals and derive five configurations in terms of a selection of their maturity model for these five scenarios. In their Corporate Data Quality Maturity Model (CDQ MM) Hüner et al. (2009) allow for companies to configure and specialize dimensions and to assign weightings in calculating maturity levels. Not all capabilities, however, can just be disabled, without damaging the balance of the model as a whole. For instance, capabilities that are a prerequisite for other capabilities can only be disabled if the dependent capability is also disabled.

A second approach is not to disable focus areas or capabilities but to vary the order in which they are addressed, i.e. the relative positioning of the capabilities in the matrix. This is possible for those capabilities that are ordered for practical reasons only. For instance one ordering can be defined for large organizations and another one for small organizations.

A third approach is not to configure the model itself, i.e. disabling some focus areas or capabilities or changing their order, but to configure the improvement actions associated with the capabilities to the organization specifics. This is feasible as the capabilities are defined in terms of goals or results instead of in terms of specific activities (Hüner et al. 2009; Marshall and Mitchell 2007; Rout et al. 2007; Visconti and Cook 1998). The same goal can be achieved in various ways. Indeed, the improvement actions have been identified as being the part of the maturity model that is most prone to being outdated by new developments. Also, when a field matures, it may provide additional insight into how to achieve certain capabilities (Mettler 2009). Such new insights should be incorporated into the suggested improvement actions.

The objective of our research is to provide organizations with a step by step development path for a specific functional domain until a desired state has been reached. This objective is best supported by a prescriptive, multidimensional approach distinguishing maturity levels per focus area.

6.3 Research Method

Our research approach fits in the tradition of design-science research. It is in fact a two-level design-science research approach. At the first level, we applied the design-science research approach in two separate instances of developing a focus area maturity model, one for the domain of enterprise architecture and one for the domain of software product management. At the second level, we applied the design-science research approach to design a generic focus area maturity model development method, using among others the knowledge gained from the two earlier development studies. In doing so, we made use of the IS research framework presented in Hevner et al. (2004) and extended with the three research cycles of relevance, rigor and design in Hevner (2007), which is depicted in figure 6-3.

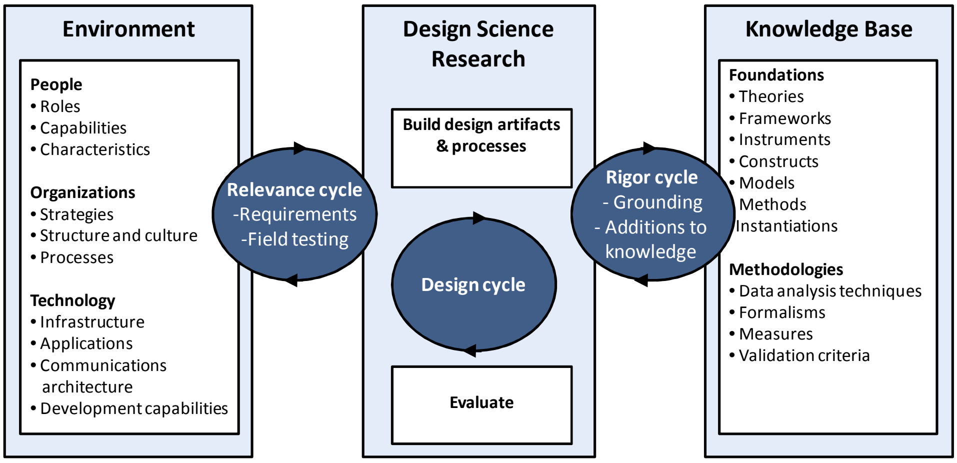

Figure 6-3: The IS research framework (Hevner et al. 2004; Hevner 2007).

The framework distinguishes environment, design-science research and knowledge base. The environment provides relevance to the research. The effective use of the knowledge base provides rigor to the research (by appropriately applying existing foundations and methodologies). The three research cycles connect environment, design-science research and knowledge base. The design cycle iterates between building and evaluating design artifacts and processes. The relevance cycle connects the environment with the design-science activities and the rigor cycle connects the existent scientific knowledge with the design-science activities. These latter two cycles are concerned with both providing input to the design-science research and receiving output from the design-science research (Hevner 2007).

We used the IS research framework to structure the design processes of an EA maturity model (the Dynamic Architecture Maturity Matrix or DyAMM) and a SPM maturity model (the Software Product Management Matrix or SPMM). We combined the knowledge thus gained with existing literature on developing maturity models (Becker et al. 2009; De Bruin et al. 2005; Maier et al. 2009; Mettler and Rohner 2009). As all literature on developing maturity models is concerned with fixed-level maturity models, we had to transform and adapt it to focus area maturity models. We structured the process of designing the development method, i.e. the execution of the design cycle, using the design-science research process presented in Peffers et al. (2008). Peffers et al. distinguish six activities:

1. **Problem identification and motivation**. The problem motivating our research is how to develop capabilities in a given functional domain in an incremental, balanced manner. In their quests for continuous improvement, practitioners and researchers are looking for well-founded development paths. This is, among others, illustrated by the large interest in the DyAMM and SPMM by the practitioners’ field.
2. **Define the objectives for a solution.** The objective of our solution is to provide a method to develop a step by step improvement approach for any specific functional domain. This method must be well-founded and enable practitioners and scientists to design an optimal and feasible improvement path to a fully mature function. As argued in the introduction, focus area maturity models can provide such development paths.
3. **Design and development.** The focus area maturity model development method is derived from both literature review and practical experience. The research literature on developing maturity models is limited to fixed-level maturity models. This meant that we could draw fairly well upon the overall steps identified but only partly on the prescriptions of implementing the steps. From the literature we could derive a number of common process phases: 1) scope, 2) design model, 3) develop instrument, 4) implement & exploit. To detail these phases for the development of focus area maturity models we also draw on the experiences gained from the development of the DyAMM and the SPMM. To structure these experiences we used the IS research framework as presented in table 6-3.
4. **Demonstration.** The use of the development method is demonstrated by retrospectively applying it to the two development studies of the DyAMM

and the SPMM. This showed that the two cases are complementary in some respects and that both might have profited from the availability of the development method.

5. **Evaluation.** The development method is evaluated by applying the requirements for the development of maturity models defined by Becker et al. (2009), which were derived from the seven guidelines presented by Hevner et al. (2004).
6. **Communication.** Besides communication of the development method in the scientific community by publication in conferences and journals, the method will be published in practitioners' forums.

Peffers et al. (2008) distinguish four different entry points to the design-science research process: problem-centered, objective-centered, design and development-centered and client/context initiated approaches. Our aim is to design a generic focus area maturity development method to support functional domain development and thus we applied an objective-centered approach: "an objective-centered solution (...) could be triggered by an industry or research need that can be addressed by developing an artifact." (Peffers et al. 2008). The need in this case, is the need for support in incremental functional domain improvement and we addressed this need by designing a focus area maturity model development method.

6.4 Application of Focus Area Maturity Model

We independently developed focus area maturity models for the functional domains of enterprise architecture and software product management. These two applications of the concept of focus area maturity model are briefly presented here.

6.4.1 A Focus Area Maturity Model for Enterprise Architecture

The DyAMM is the application of the focus area maturity model in the field of enterprise architecture (figure 6-1). Development of the DyAMM is embedded in a larger program developing an approach to enterprise architecture that focuses on a goal-oriented, evolutionary development of the architectural function, called Dynamic Architecture (Wagter et al. 2005). The DyAMM was developed in 2002, in 2004 it was slightly adjusted based on the first few applications. This version was qualitatively validated in a case study in 2005/2006 and quantitatively analyzed on a dataset of 56 applications in 2009 (Van den Berg and Van Steenbergen 2006; Van Steenbergen et al. 2007; Van Steenbergen et al. 2010). The DyAMM has been applied to over 70 organizations. A number of organizations use the DyAMM to give direction to an improvement program of years, performing a yearly assessment to monitor progress.

Besides the definition of focus areas, each with their own progressively mature capabilities, the DyAMM also contains an assessment instrument. Each capability is associated with one to four yes/no assessment questions to assess its implementation and one or more improvement actions that may support achieving it. Maturity is assessed by answering the yes/no questions. A capability is considered achieved, only if all questions associated with it are answered confirmatively. Table 6-1 shows as an example the questions associated with capability A of the focus area *ùse of architecture*. In all, there are 137 assessment questions.

Table 6-1: Questions to measure maturity level A of focus area Use of architecture.

Nr.	**Question**
9	Is there an architecture that management recognizes as such?
10	Does the architecture give a clear indication of what the organization wants?
11	Is the architecture accessible to all employees?

The DyAMM assessment instrument is primarily meant to be applied by independent assessors. The assessors fill the matrix by answering all 137 questions, basing their answers on interviews with relevant stakeholders and studying documentation. However, the DyAMM is also used as a self assessment to be completed by individuals for their own organization. Organizations can answer the 137 questions, which are available on-line, for themselves, and acquire a maturity profile as depicted in figure 6-1.

6.4.2 A Focus Area Maturity Model for Software Product Management

The second field of application is software product management (SPM). Many software companies have made a shift from developing custom-made software to developing product software. To cope with this shift, software companies need to introduce the right SPM processes. The SPM matrix (SPMM) was developed to support analysis and incremental improvement of SPM processes. It is based on the previously developed SPM Competence Model, that presents 14 SPM processes divided over four business functions: Portfolio management, Product planning, Release planning and Requirements management (Bekkers et al. 2010a; Van de Weerd et al. 2006). The SPMM was tested in 12 case studies in companies of varying sizes. Evaluation of these case studies led to a refinement of the capabilities and their positioning. Since then, the improved matrix has been evaluated in 45 more cases. In addition, a survey was conducted to validate the positioning of the capabilities (Bekkers et al. 2010b; Van de Weerd et al. 2010).

The focus areas of the SPMM correspond directly with the SPM processes in the earlier published SPM Competence Model. They are divided into four groups, corresponding to the four business functions identified in the SPM Competence Model. For a capability to be achieved it must be institutionalized and documented. In Figure 6-4, the SPMM is presented.

	0	1	2	3	4	5	6	7	8	9	10
Requirements management											
Requirements gathering		A		B	C		D	E	F		
Requirements identification			A			B		C			D
Requirements organizing				A		B		C			
Release planning											
Requirements prioritization			A		B	C	D			E	
Release definition			A	B	C				D		E
Release definition validation					A			B		C	
Scope change management				A		B		C		D	
Build validation					A			B		C	
Launch preparation		A		B		C	D		E		F
Product planning											
Roadmap intelligence				A		B	C		D	E	
Core asset roadmapping					A		B		C		D
Product roadmapping			A	B			C	D		E	
Portfolio management											
Market analysis					A		B	C	D		E
Partnering & contracting						A	B		C	D	E
Product lifecycle management					A	B			C	D	E

Figure 6-4: The maturity matrix for Software Product Management (Van de Weerd et al. 2010)

The amount of capabilities within a focus area varies from three (A-C) to six (A-F). Each capability has five attributes:

1. **Name**. A name describing the capability in a few words.
   Example: Requirement dependency linking (capability C of the focus area Requirements Organizing).
2. **Goal**. The goal describes what purpose the capability serves and it indicates the advantage of executing the capability.
   Example: The existence of requirements interdependencies means that requirements interact with and affect each other. Requirement dependency linking prevents problems that result from these interdependencies, and therewith enables better planning of the development process.

3. **Action**. The action describes what must be done in order to meet the requirements of the capability.
   Example: Dependencies between market and product requirements are determined and registered. A dependency exists when a requirement demands a specific action of another requirement. E.g. a requirement demands that another requirement be implemented too, or that another requirement is not implemented in case of conflicting requirements. The linkage can be supported by using advanced techniques, such as linguistic engineering.
4. **Prerequisite(s)**. Some capabilities require that one or more other capabilities be achieved first. This relation is described by listing all the capabilities that have to be implemented first.
   Example: Requirements Gathering: A.
5. **Reference(s)**. This optional attribute describes related literature which can aid in understanding and implementing the capability, thus having a supporting role.
   Example: Dahlstedt & Persson (2003).

With the SPMM a Situational Assessment Method (SAM) is associated (Bekkers and Spruit 2010). The SAM adds situationality to the SPMM by allowing for the fact that not all capabilities apply to every form of organization. It disables capabilities that do not apply based on the situational factor (SF) values of that organization.

Another form of situationality is enabled by the prerequisite(s) attribute of the capabilities. The prerequisite attribute separates mandatory ordering from ordering that is imposed for practical reasons. Whereas the matrix presents a best practice ordering, i.e. an ordering that experience has shown as being effective, the prerequisites indicate the mandatory ordering within this best practice ordering, by indicating which capabilities must mandatorily be implemented before the capability in question can be implemented.

The third type of situationality entails distinguishing in the manner of implementation of the capabilities. This is realized by a selection stage in the SAM in which method fragments that fit the organization are selected and suggested to the organization. The method fragments are stored in a Knowledge Base, organized according to the capabilities they cover and to the SF restrictions under which they apply. The SAM can select the best suited method fragments by looking at the method fragments which cover those capabilities, and comparing the results from the situational context of the organization to the SF restrictions of the method fragments (Bekkers and Spruit 2010).

6.5 Focus Area Maturity Model Defined

In order to provide a rigorous foundation for focus area maturity models, we need to abstract the commonalities from the application cases into a mathematical formalization. To achieve this formalization, we first have to precisely define the fundamental concepts underlying the focus area maturity model.

6.5.1 Definition of concepts

We first provide an informal description of the focus area maturity model and its constituent parts in their mutual relations. After having sketched this overall picture we present precise definitions of each of the concepts mentioned (table 6-2).

A focus area maturity model is used to establish the *maturity* of an organization in a specific functional domain. A focus area maturity model must have a well-defined scope in the sense of the functional domain it applies to. A *functional domain* is described by the set of *focus areas* that constitute it. With each focus area a set of *capabilities* is associated. The capabilities are positioned against each other in a *maturity matrix*. Based on the positioning of the capabilities in the maturity matrix a number of *maturity levels* can be distinguished. To establish the actual maturity of an organization in the functional domain, an *assessment instrument* based on the maturity matrix is used. The assessment instrument contains *assessment questions* linked to the capabilities. Answering the assessment questions for a specific organization produces a *filled-in assessment*. The filled-in assessment can be translated into a *maturity profile* for the organization, depicted by the colored cells in the maturity matrix. To guide the organization in incremental development of the functional domain, *improvement actions* are associated with the capabilities. All of this together constitutes the *focus area maturity model*.

Table 6-2: Definitions of concepts of the focus area maturity model.

Concept	Definition
Maturity	Maturity indicates the degree of development.
Functional Domain	A Functional Domain is the whole of activities, responsibilities and actors involved in the fulfillment of a well-defined function within an organization.
Focus Area	A Focus Area is a well-defined coherent subset of a Functional Domain. The total set of focus areas is a partition of the functional domain, i.e. different focus areas are disjoint and the union of all these focus areas is the complete functional domain.

Capability	A Capability is the ability to achieve a predefined goal.
Maturity Matrix	A Maturity Matrix provides a partial ordering of Capabilities within a Functional Domain across Focus Areas over a sequence of Maturity Levels.
Maturity Level	A Maturity Level is a well-defined evolutionary plateau within a Functional Domain.
Assessment Instrument	An Assessment Instrument is a tool to determine Maturity within a Functional Domain.
Assessment Question	Assessment Questions are used to determine the current or target Maturity Level of an organization within a Functional Domain.
Filled-in Assessment	A Filled-in Assessment is the set of Assessment Questions together with their answers as provided during a particular assessment.
Maturity Profile	A Maturity Profile is a specific set of Capabilities within a Functional Domain that has been achieved by an organization.
Improvement Action	An Improvement Action is the description of an activity that is expected to result in achieving a specific Capability.
Maturity Model	A Maturity Model is an instrument to assess and develop the ability of an organization to perform within a Functional Domain.

Now that the elements of the focus area maturity model are defined, a further specification can be made by mathematical formalization.

6.5.2 Mathematical formalization

To thoroughly penetrate the concept of focus area maturity model, it helps to try and develop a precise mathematical formalization. We start with the concept of functional domain, which we will consider as a set *FD* of otherwise unspecified elements (representing activities, actors and responsibilities). This set is made up of all focus areas, so a focus area is a subset of *FD* and in fact *FD* can be partitioned into a number of focus areas: $FD = \dot{\bigcup}_{FA \in I} FA$.

Here *I* denotes the set of all focus areas related to *FD* and the dot on top of the union symbol denotes that the union is disjoint, i.e. different focus areas have no elements in common. The size of *I*, i.e. the number of focus areas, depends on the functional domain, e.g. 18 for the domain of enterprise architecture and 16 for software product management. Another fundamental concept comes from the assessments organizations have to pass in order to reach a certain maturity level for a specific focus area. To keep terminology straight, we will distinguish the term ‘(overall) maturity level’ related to the complete functional domain from the term ‘level’ related to a focus area. We therefore introduce a totally ordered set $(L, \leq_L)$ of levels and since an assessment is specific for a pair consisting of a focus area and a level, we are interested in the Cartesian product $I \times L$. We abstract away from the ‘assessment’ and concentrate on the set $I \times L$. Since not every element of *I* needs to have the same number of levels, this Cartesian product is in general too large. For the general definition of maturity matrix we allow subsets *C* of $I \times L$. In the two example matrices, *C* denotes the set of capabilities and the pairs $(FA, l) \in C$ correspond to the cells in the matrix that are filled with a capital letter. From these examples we derive that *C* is not just a set, but a partially ordered one. The columns in the example matrices are the final concept we need and are formally described by a specific mapping *ML* from *C* to the natural numbers. Putting it all together gives the following definition.

A maturity matrix consists of

1. A triple $(I, (L, \leq_L), (C, \leq_C))$ where *I* is a set, $(L, \leq_L)$ is a completely ordered set and $(C, \leq_C)$ is a partially ordered set with $C \subseteq I \times L$. Moreover, the ordering on *C* respects the ordering on *L* in the sense that if $c_1 = (FA, l_1), c_2 = (FA, l_2) \in C$ and $l_1 \leq_L l_2$ then $c_1 \leq_C c_2$.
2. An order preserving mapping $ML\colon C \to \mathbb{N}$ with $\mathrm{Im}(ML) = \{1, ..., m\}$ for some $m \in \mathbb{N}$.

As an example take the SPMM where *I* is the set of 16 focus areas, *L* = {A,B,…} is the set of 6 levels (so $I \times L$ consists of 96 elements), and *L* is totally ordered in the obvious way (A < B <…). Furthermore, *C* is the set of 63 capabilities, consisting of specific pairs (FA, l) where $FA \in I, l \in L$ and *C* is partially ordered by the intra- and inter-process capability dependencies, e.g. relations of the form (*FA*,A) < (*FA*,B) (intra-process) and relations of the form $(FA_1, l_1) < (FA_2, l_2)$ where $FA_1 \neq FA_2$ (inter-process). Finally, the mapping *ML* assigns every capability to one of the numbers 1 through 12 while preserving the order (so if $c_1 \leq c_2$, then $ML(c_1) \leq ML(c_2)$).

The overall maturity level of an organization can now be defined. Since an organization that just started the development of a functional domain could very well have none of the capabilities defined for this domain, it makes sense to allow a zero maturity level. Even if they have some capabilities of maturity level 1, but not all of them, we still define their overall maturity level as zero. Only if they have all capabilities of maturity level 1 (i.e. all capabilities of the set $ML^{-1}(1)$), then their overall maturity level will be 1 or higher.

In general, if C_A is the set of capabilities of the organization (C_A is a subset of *C*), then the *maturity level* of that organization is the maximum value *l* for which $ML^{-1}(\{1, ..., l\}) \subseteq C_A$. Note that if we substitute $l = 0$ the set

$ML^{-1}(\{1,...,l\}) = ML^{-1}(\varnothing) = \varnothing$ is a subset of C_A, so this definition also holds if C_A is empty or if C_A does not contain all capabilities with maturity level 1 (in both cases the maturity level of the organization will be 0).

We still need to formalize the concepts dealing with assessments. To every capability *c*, a set Q_c of yes/no questions is related (e.g. in DyAMM, these sets have 1 to 4 elements). The assessment instrument consists of the set of all these questions together. If we denote this set by *Q*, then $Q = \bigcup_{c \in C} Q_c$. A filled-in assessment is then a mapping $\mathsf{F} : Q \to \{yes, no\}$ and this mapping determines the maturity profile of an organization as the set $\{c \in C \mid \mathsf{F}(Q_c) = \{yes\}\}$. So a capability *c* belongs to the maturity profile if *all* questions related to *c* are answered with 'yes'.

Formalizing the focus area maturity model concept contributed to our understanding of the concept. First of all, it made us aware of the fact that there is a distinction in ordering of capabilities between a mandatory ordering and a best practice ordering. The mandatory ordering represents an ordering engendered by the fact that one capability does not make sense if another capability has not been realized before. The best practice ordering represents an ordering that is engendered by practical reasons and based on industrial experience. It is a recommended order, but capabilities could be achieved in parallel or even maybe in the opposite order. Secondly, the formalizing supported the validation of the focus area maturity model development method in the sense that all elements of the formalization had to be addressed in the method. Thus it helped in ensuring the completeness and precision of the development method.

6.6 Development of Focus Area Maturity Model

With the focus area maturity model well-defined, we can design a generic method for developing focus area maturity models for new functional domains.

6.6.1 Design science cycles in focus area maturity model development

The development method presented here is based on both the experiences with building the DyAMM and SPMM, and research literature on developing fixed-level maturity models. The experiences from building actual focus area maturity models were structured by relating them a posteriori to the three research cycles described in Hevner (2007) as presented in table 6-3.

Table 6-3: The SPMM and DyAMM design activities related to the design science cycles.

Area	Relevance	Design	Rigor
SPM	- Identifying requirements in the field ("need for body of knowledge and guidance in SPM") - Expert interviews with domain experts - Field testing: carrying out SPM assessments & advice for product managers - Using the matrix as a structure for professional courses on SPM	- Building the maturity matrix based on identified capabilities - Evaluating the focus areas and capabilities with expert interviews - Validating the capability positions with a survey - Evaluating the whole matrix in 57 case studies - Refining the matrix based on the evaluations/validation	- Grounding the maturity matrix concept on existing work (DyA/TPI, software process improvement) - Grounding the capabilities on existing work (deliverable hierarchy, SPM competence model) - Ensuring research rigor by using established research method: questionnaire - Formalization of maturity matrix concepts - Addition to the knowledge base (knowledge on SPM, knowledge on creating and using maturity matrices)
EA	- Identifying requirements in the field: need for guidance in EA function development - Field testing: carrying out DyAMM assessments & advice for EA managers - Field testing: periodic assessments - Providing a public service to freely access the DyAMM questionnaire and receive a maturity profile - Self assessments by organizations - Using the matrix in EA courses - Inclusion of the matrix in a book for EA practitioners	- Building the maturity matrix based on identified focus areas - Evaluating the focus areas and capabilities with expert interviews (consultants) - Validating the capability positions with a case study - Evaluating the whole matrix in a number of case studies and by statistical analysis of 56 assessments - Refining the matrix based on the evaluations/validation	- Grounding the maturity matrix concept on existing work (TPI) - Grounding the focus areas and capabilities on existing work (TPI, DyA model) - Ensuring research rigor by using established research methods: case study, statistical analysis - Formalization of maturity matrix concepts - Addition to the knowledge base: knowledge on EA function, knowledge on creating and using maturity matrices

The rigor cycle and the relevance cycle can be easily recognized in both cases. The rigor cycle is present for instance in basing both maturity models upon existing conceptual models. Thus, in the SPMM, the focus areas are deducted from the previously developed Reference Framework for Software Product Management (Van de Weerd et al. 2006). The main activities that are carried out by a product manager identified in this framework are directly transformed into focus areas for the maturity matrix. The DyAMM, in turn, has its base in the DyA model, developed in the DyA program (Van den Berg and Van Steenbergen 2006; Wagter et al. 2005). Also, in developing the models, use is made of well-founded research methods like questionnaires, case studies and statistical analysis. The DyAMM was validated firstly by applying it in a few cases. This led to an adjustment of the model in a very early stage. After this adjustment the model was validated in a number of new cases (Van Steenbergen et al. 2007), which did not lead to further adjustments. Finally, the DyAMM has been quantitatively validated on a repository of 56 assessments that was collected in the period 2005-2008. This led to a few adjustments in the assessment questions (Van Steenbergen et al. 2010).

The relevance cycle is exhibited in the extensive field testing performed for both models, in some cases even in the form of repeated assessments of the same organization over a period of many years. The effectiveness of the DyAMM is illustrated by companies that have been using the model over the years to evolve their architecture practice and consequently established greater effectiveness of the practice. The field has also been involved in developing the models. For the SPMM, the capabilities were identified in a brainstorming session with four SPM experts. After the brainstorming session, the results were compared with the existing SPM literature and, if necessary, refined or redefined. Finally, the capabilities were iteratively refined in expert interviews until agreement was reached. Finally, the maturity models are made available to practitioners in various ways. Thus, the DyAMM is published in a practitioner book (Van den Berg and Van Steenbergen 2006) as well as in the form of an on-line self-assessment service (DYA 2009).

6.6.2 Focus area maturity model development method

Using Peffers' design-science research process, we drew upon table 6-3 and on existing literature about developing fixed-level maturity models (Becker et al. 2009; De Bruin et al. 2005; Maier et al. 2009; Mettler and Rohner 2009) in defining and describing the steps for the focus area maturity model development method. This led to the following development method, graphically depicted in figure 6-5. We use the notation presented by Van de Weerd and Brinkkemper

(2008), which is based on standard UML conventions, with some minor adjustments.

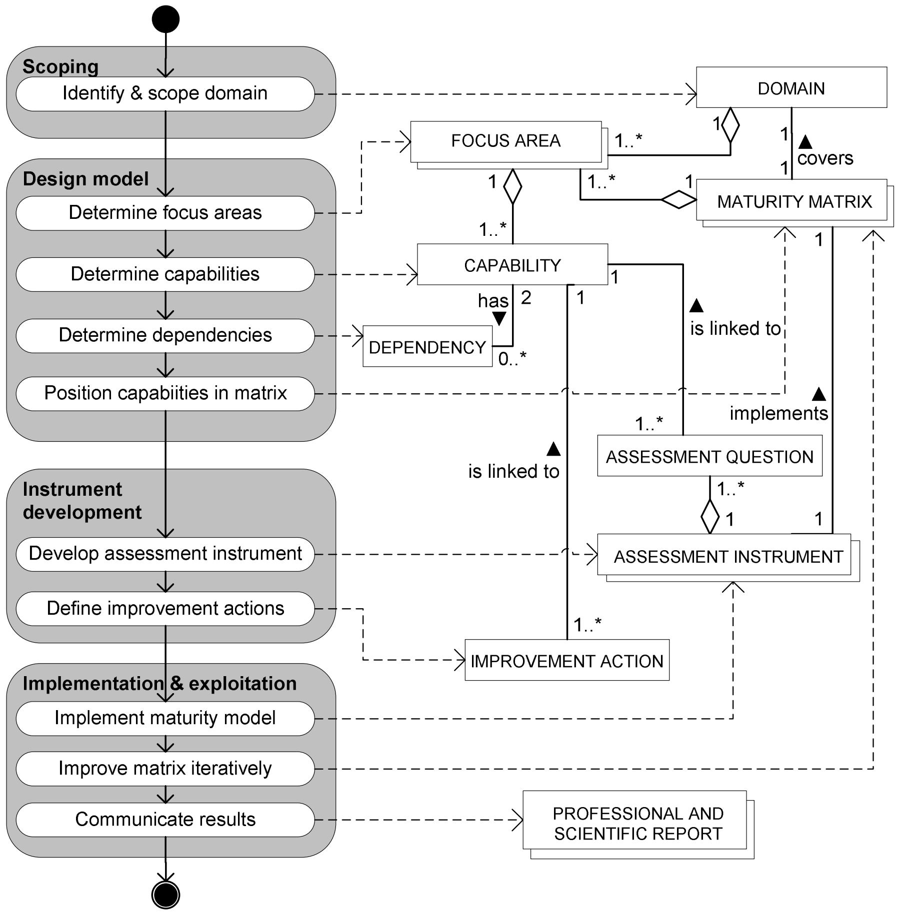

Figure 6-5: The development method for focus area maturity models.

The method steps are depicted on the left, the deliverables on the right. The steps are structured into four phases, derived from the literature on fixed-level maturity model development: scoping, design model, instrument development and implementation & exploitation. The steps are briefly described below.

Scoping

Step 1: Identify and scope the functional domain. In order to develop a well-founded and balanced model, the domain must be scoped properly. This starts with making explicit the underlying rationale and conceptual framework concerning the functional domain in terms of relevant dimensions and evolutionary growth of the functional domain. It also means deciding on what to include and what to exclude. Existing maturity models for the same or similar domains are identified in order that they may be used as a starting point for further development (Becker et al. 2009).

Design model

Step 2: Determine focus areas. Within the chosen domain, the focus areas must be identified, i.e. set *I* is defined. In a relatively new field, literature review will provide a theoretical starting point which has to be followed by exploratory research methods like expert groups or case studies (Becker et al. 2009; De Bruin et al. 2005, Maier et al. 2009; Mettler and Rohner 2009). Critical success factors found in previous research may be a useful source for identifying focus areas (De Bruin et al. 2005). Grouping the focus areas into a small number of categories may add to the accessibility of the model and is also a means of validating completeness.

Step 3: Determine capabilities. Each focus area consists of a number of different capabilities representing progressive maturity levels, i.e. set *C*, which is a subset of the Cartesian product of *I* and *L*. Per focus area the evolutionary path of capabilities is defined, based on the underlying rationale of how the focus area can be incrementally developed in an evolutionary way. There are two ways of defining maturity levels: top down from literature review and bottom up from experimental data (De Bruin et al. 2005). In a relatively new field, the top down approach is more suitable. This implies first identifying the capabilities from literature and then detailing them into descriptions of how these capabilities present themselves in practice.

Step 4: Determine dependencies. In this step dependencies between capabilities are identified, providing the partial ordering of *C*. This regards both the dependencies between the capabilities of the same focus area, representing progressive maturity levels, and the dependencies that may exist between capabilities of different focus areas.

Step 5: Position capabilities in matrix. In this step the capabilities are positioned in the matrix, i.e. the mapping *ML* from *C* to $\mathbb{N}$ is defined. Capabilities that are dependent on other capabilities are always positioned further to the right. Capabilities that are not dependent on each other may be put at the same level. For reasons of practicality, however, if many capabilities are contained in one level, they may be divided over a number of levels to get a more balanced matrix. This assignment is based on past experiences on preferences of implementation order. By this positioning the number of levels of the matrix is revealed.

Instrument development
Step 6: Develop assessment instrument. Measures must be defined for each of the capabilities, in order to be able to use the focus area maturity model as an instrument to assess the current maturity of a functional domain. This can be done by formulating control questions for each capability and combining them in a questionnaire that can be used in assessments, i.e. the set *Q* is defined. Formulation of the questions is usually based on the descriptions of the capabilities and on experience and practices.
Step 7: Define improvement actions. For each of the capabilities improvement actions can be defined to support practitioners in moving to that capability. Improvement actions are usually based on experience and practices. The usefulness of specific improvement actions will very much depend on the actual situation of an organization. Therefore it is advisable to present them as suggestions, rather than as prescriptions (Andersen and Henriksen 2006).

Implementation & exploitation
Step 8: Implement maturity model. Implementation can be done in various ways. A questionnaire can be distributed by electronic means which allows for collecting many assessments in a relatively short timeframe (De Bruin et al. 2005). The assessment can also be performed by independent assessors, basing their assessment on discussion in workshops or individual interviews.
Step 9: Improve matrix iteratively. The initial applications of the model can be used to evaluate the model qualitatively. Once enough assessments have been collected, quantitative evaluation becomes possible. To evaluate how the model assists in incremental improvement interventions should be tracked longitudinally. A repository must be kept to collect assessment results.
Step 10: Communicate results. To further the field, the results of the design should be communicated to practitioners as well as to the scientific community.

The fourth phase of *implementation & exploitation* is an important part of the relevance cycle in the IS research framework. Both the DyAMM and the SPMM are used for educational purposes, as well as being used as an improvement instrument in organizations. Feedback from these usages is input for the iterative improvement step. The second and third phases, *design model* and *instrument development* require the right balance between relevance and rigor, grounding model design and instrument development in both industrial experience and scientific knowledge. In phase one, *scoping*, the rigor cycle is especially important.

6.7 Conclusions

In this paper we present the focus area maturity model as a means to incrementally improve new functional domains within the field of IS. We argue that there is a need for focus area maturity models, as they provide more guidance to incremental improvement than the fixed-level maturity models mostly encountered in the existing literature. As in the field of IS new functions are still emerging, it is to be expected that the need for guidance in developing new functional domains will continue. Existing research literature, however, is strongly dominated by studies of fixed-level maturity models. A gap we aim to fill with the research presented in this paper.

After discussing the concept of maturity model in general, we further developed the concept of focus area maturity model. We approached the subject from a number of different perspectives: we provided a formal definition of the focus area maturity model including a mathematical formalization, illustrated its use in the areas of enterprise architecture and software product management and designed a generic focus area maturity model development method. Studying the focus area maturity model from these three angles provided a more thorough understanding than only one perspective would have and enabled us to provide a firm scientific grounding for the focus area maturity model. The applications in the industrial field yielded the necessary balance between rigor and relevance. The mathematical formalization ensured completeness and precision. The design of the development method gave structure to the future application of the focus area maturity model in other functional domains. The combination of real-life application, mathematical formalization and development method firmly establishes the concept of focus area maturity model, enabling its use and further development by the scientific community at large. We feel that the focus area maturity model approach provides researchers with a valuable, scientifically grounded, instrument to better study and understand functional domains in the field of IS.

We used a design-science research approach to achieve our results, in particular the IS research framework with the three research cycles by Hevner et al. and the design-science research process model by Peffers et al. The design-science research process model helped to structure the design cycle while designing the development method. Applying the IS research framework a posteriori to the development of the two existing focus area maturity models, DyAMM and SPMM, provided insight into how the balance between relevance and rigor can be ensured in developing focus area maturity models. These insights are used in the design of the generic development method. Both the relevance and the rigor cycle were well identifiable in the development processes of the DyAMM and SPMM. Thus we provide additional empirical evidence for the existence of the three research cycles.

The implication of our work for practitioners is the availability of an instrument that not only establishes the current state of a functional domain, but above all provides detailed guidance for incremental development of the domain. The wide application of the DyAMM and SPMM illustrate the demand for such guidance.

Part IV

Shaping the Practice of Enterprise Architecture

Chapter 7

The Architectural Dilemma: Division of Work versus Knowledge Integration

In this paper we investigate the tension that exists in many large organizations between the need for division of work among architects and the requirement of developing an integrated set of architectural principles and models spanning all aspects of the organization. Two types of division of work are presented that set different requirements on knowledge integration. Drawing from insights of the fields of IS research (business-IT alignment), organizational theory (knowledge-based theory of the firm) and sociology (boundary objects) we arrive at a conceptual model linking knowledge integration mechanisms to types of division of work. We test this conceptual model in three cases. The results show that the concepts of boundary objects and of interconnectedness are relevant in realizing the integration required[1].

7.1 Introduction

Enterprise architecture is a growing discipline within the field of Information Systems. Awareness is increasing that large organizations need some kind of direction-giving frameworks to manage information systems development in order to prevent an unmanageable increase in IT complexity. Enterprises, and with them the management of information, are changing so fast and becoming so complex that some kind of reference framework is needed to keep in control.

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[1] This work was originally published as: Steenbergen, M.van and Brinkkemper, S. (2009). The architectural dilemma: division of work versus knowledge integration. In Weigand, H., Werthner, H. and Gal, G. (Eds.), *Proceedings of the Third International Workshop on Business/IT Alignment and Interoperability*, 46-60.

Enterprise architecture provides such a framework (Lankhorst et al. 2005; Ross et al. 2006; Versteeg and Bouwman 2006).

We define enterprise architecture as a consistent set of rules and models that guide the design and implementation of processes, organizational structures, information flows, and technical infrastructure within an enterprise (Wagter et al. 2005). Enterprise architecture provides an integrated set of direction-giving architectural principles and models concerning all aspects of the enterprise: products, processes, organization, data, applications, technical infrastructure. The value of enterprise architecture lies in the fact that it provides an integrated view taking all these aspects into account, instead of the isolated view on only one aspect that may be provided by specialists.

As enterprise architecture takes all aspects of the enterprise into account, it becomes too all-encompassing to be assigned to one or just a few architects. With architecture, as with other functions (Buchanan 2004; Ditillo 2004; Grant 1996a), we see forms of functional specialization emerging with different types of architects. In large organizations the number of architects may easily run up to more than a hundred. These architects represent various roles that can be distinguished along two dimensions, as depicted in figure 7-1. The first dimension is the management level the architect operates on. In practice we see architects act on all of the well-known levels of strategic, tactic and operational management (Van den Berg and Van Steenbergen 2006; Foorthuis and Brinkkemper 2007; Van der Raadt and Van Vliet 2008). At strategic level the architect interacts with senior management on fundamental strategic choices for the organization. These fundamental strategic choices are translated by the architect into high-level designs and design principles, usually called the enterprise architecture. These high-level designs and principles are further developed at the tactical level into directions and designs per business line and per technical domain, the so-called domain architectures. At the operational level the directions from strategic and tactical level are translated into specific rules for projects in the project start architectures (Van den Berg and Van Steenbergen 2006; Wagter et al. 2005).

The second dimension against which types of architects can be distinguished, is the dimension of content. Architects may have their own field of expertise like business architect, application architect, data architect, middleware architect, etc. Which exact domains are distinguished differs between organizations. Often a division is made in business domains per business line (for instance retail, wholesale, production) plus technical domains per technical aspect (for instance software development, middleware, network). This distinction is particularly clear at the tactical level in the form of various domain architectures. Thus we see that the architecture of an enterprise usually consists of many documents covering different aspects of the enterprise and authored by different architects.

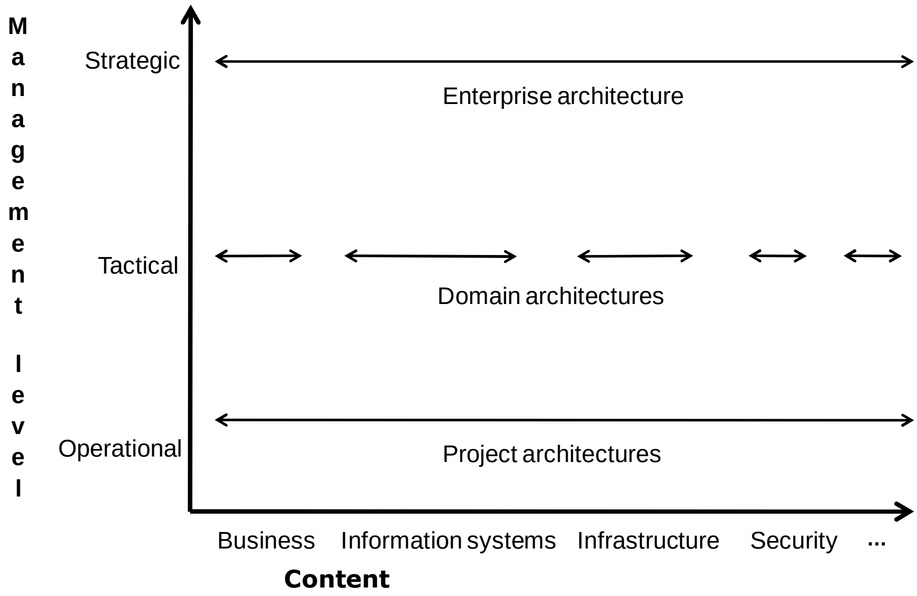

Figure 7-1: Division of architectural work.

This division of work is necessary because no single person or team can grasp all aspects anymore. However, as the purpose of architecture is to provide guidance to changes in the organization by setting a coherent set of rules and models spanning all aspects of the organization, the various types of architects cannot work in isolation each on their own subject, but the rules and models they develop must be aligned with each other. Thus a principle like 'core data are maintained in only one place' at strategic level translates to a tactical level principle 'customer data are only maintained in our customer database'. And if an enterprise adopts a service oriented architecture, the services identified at application level should match the services identified at process level. Real life shows that this kind of alignment, however, is hard to achieve. The number of architects is too large to trust upon spontaneous collaboration. This is evidenced by the emergence of contradictions between the rules of the different management levels, by gaps in the coverage of the models and by discrepancies between the rules for different aspects.

Management is thus faced with the question how to achieve the integration that is needed to ensure that though a great number of architects are at work, each with his or her own special focus, together they produce a coherent set of architectural principles and models. In this paper we investigate how within the context of division of work among architects, the cohesion of the architectural content can be maintained. In doing so, we draw upon ideas about alignment and integration already developed in the fields of organization, sociology and IS theory. The contribution of this paper is twofold: it applies existing theory on knowledge integration to the new field of enterprise architecture, and in doing so, it combines theoretical concepts from various domains in one conceptual model.

The research approach followed is that of a theory testing case study as described by Dul and Hak (2008). As not much theory has been built yet concerning the division and integration of architecture, our research concerns initial theory-testing. Whereas the research question emerged from observations in the field of architecture, the first step in answering it was done by investigating how existing theories might apply. This led to the building of a conceptual model combining concepts from various fields of research. This model is presented in section 7.2. From this conceptual model a number of propositions were formulated and tested in three different organizations. The results from these case studies are discussed in section 7.3. Evaluation and conclusions are given in section 7.4.

7.2 Architectural Knowledge Integration

7.2.1 The Conceptual Model for Architectural Knowledge Integration

The division of work among architects requires a manner of knowledge integration in order to ensure integrated architectural deliverables. The concept of knowledge integration has been thoroughly investigated in organizational theory, especially the knowledge-based theory of the firm (Grant 1996a; Grant 1996b). Four integration mechanisms are distinguished: rules and directives, sequencing, routines and group problem solving and decision making (Grant 1996b). These mechanisms differ, among others, in the intensity and mode of interaction. The extent to which the required knowledge integration is achieved depends on whether the organization is able to employ the right integration mechanisms. The successful employment of specific integration mechanisms is greatly influenced by organizational characteristics (De Boer et al. 1999; Ditillo 2004; Ravasi and Verona 2001).

Based on these ideas we developed the conceptual model of architectural knowledge integration presented in figure 7-2 and explained below.

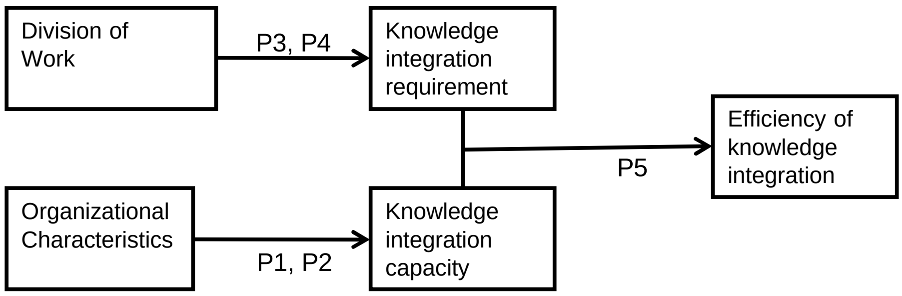

Figure 7-2: The conceptual model for architectural knowledge integration.

The model reflects the idea that the efficiency of knowledge integration depends on the match between the integration requirement set by the type of division of work and the integration capacity that depends on organizational characteristics (see De Boer et al. (1999) for a comparable model for the multimedia domain). We explain the concepts of the model below. In section 7.3 we elaborate the model into a number of propositions.

Division of work we define as the manner in which the architectural work is divided over a number of different architectural roles. As shown in figure 7-1 we distinguish two kinds of division of work: division along management levels, which we will refer to as vertical division of work and division along content, which we refer to as horizontal division of work. The division of work leads to the need for some kind of knowledge integration: the knowledge integration requirement. *Knowledge integration requirement* we define as the kind of knowledge integration that is required in an organization because of division of work over more than one person. *Knowledge integration capacity* is the kind of knowledge integration that an organization is capable of achieving. The capacity is partly dependent on organizational characteristics. By *organizational characteristics* we mean both fixed and changeable characteristics of an organization, like structure and modes of collaboration. If the knowledge integration capacity matches the knowledge integration requirement it is possible to achieve efficiency of knowledge integration. The *efficiency of knowledge integration* is the extent to which the organization accesses and utilizes the specialist knowledge held by individual organizational members (Grant 1996a). In the case of architectural knowledge integration the efficiency is evidenced by the measure in which an integral, coherent and consistent set of architectural principles and models is available for use to the organization.

7.2.2 Dependencies between the Concepts

The next step is to see whether it is possible to say anything about the relations between the concepts in the model. Using ideas from the fields of IS research, organizational theory and sociology we will arrive at a number of propositions.

We start with investigating *the relation between organizational characteristics and knowledge integration capacity* to answer the question what organizational characteristics influence the knowledge integration capacity.

First of all we should further elaborate the concept of knowledge integration capacity. For this we turn to the knowledge-based theory of the firm which distinguishes four mechanisms for integrating knowledge: rules and directives, sequencing, routines and group problem solving and decision making (Grant 1996b). *Rules and directives* are written down directions. They are suitable for communicating explicit knowledge among specialists and between specialists and non-specialists. Integration is done by ensuring that one's own rules are compliant with the ones written down by others. The second integration mechanism is sequencing. *Sequencing* is characterized by organizing activities in a time-patterned sequence. In this way each participant can do his own piece of work, based on a prescribed input. This kind of integration requires a minimum of communication. The third integration mechanism, *routines*, requires a bit more communication, but communication is still very much restricted to a minimum. In contrast to sequencing, routines allow the participants to perform their tasks simultaneously. It also allows for more variation during execution than sequencing. Like sequencing, routines can only be developed for repetitive tasks in which it can be predefined how the various participants are to react to certain events (Becker 2004; Cohendet and Llerena 2003; Pentland and Feldman 2008). The fourth and final integration mechanism mentioned by Grant (1996b) is *group problem solving and decision making*. This mechanism requires the most interaction and communication of the four mechanisms. It is suitable to non-standardized tasks characterized by task complexity and task uncertainty.

According to Grant (1996a) three factors are important in determining the success of knowledge integration: the level of common knowledge, the frequency and variability of task performance, and structure. Frequency and variability of task performance are more or less a given, but common knowledge and structure are organizational characteristics that can be manipulated. The first factor mentioned by Grant is the level of common knowledge. To be able to integrate knowledge some kind of common ground is needed, without the participants having to share all their specialist knowledge. From sociology we learn that *boundary objects* can provide such common ground (Star and Griesemer 1989). When people from different perspectives work together this can be facilitated by boundary objects. A boundary object is an artifact that has different meanings in different social worlds but that has a structure that is common enough to more than one world to make it recognizable. This makes boundary objects into means of maintaining coherence across intersecting social worlds. Examples of boundary objects are shared concepts, repositories, frameworks and templates, for instance the use of maps by ecologists (Star and Griesemer 1989) and the use of layered plans and ordering lists by physical architects (Schmidt and Wagner 2002). The work of physical architects is described as “individual, team-based and multi-disciplinary, enlisting multiple professional competences and perspectives, at the same time” (Schmidt and Wagner (2002), p.262). In this world boundary objects play various roles of integration. This is reminiscent of the world of ‘digital’ architects. Which leads to our first proposition.

Proposition 1*. The use of boundary objects is a viable way of achieving knowledge integration in the field of architecture.*

The second organization dependent factor to influence knowledge integration mentioned by Grant (1996a) is structure, especially the extent to which the structure enables the right amount of communication. In Ravasi and Verona (2001) interconnectedness is mentioned as one of the relevant structural factors. *Interconnectedness* is defined as the richness and frequency of contact and information exchange among the different parts of a system (Ravasi and Verona 2001). The importance of interconnectedness for alignment between disciplines is also shown by research into business-IT alignment (Campbell 2005; Chan and Reich 2007; Van Eck et al. 2004; Huang and Newell 2003; Kearns and lederer 2003). Though in this paper we do not look at business and IT alignment as such, we investigate alignment between the various architects, who, besides, may be concerned either with business aspects or IT aspects. Business-IT alignment research indicates that cross-participation and sharing of knowledge is important in achieving alignment. Interconnectedness seems to be especially relevant for the relatively unstructured integration mechanism of group problem solving and decision making (Huang and Newell 2003). This gives us our second proposition.

Proposition 2. *Interconnectedness is an important factor in achieving knowledge integration by way of group problem solving and decision making in the field of architecture.*

The second relation in the model to discuss is *the relation between division of work and knowledge integration requirement*. Vertical and horizontal division of work each put specific requirements on how the knowledge of the participants is to be integrated. Vertical integration is concerned with setting directions and constraints on the level below. The issue here is to provide clear, unambiguous directions, guidelines, fundamental choices and high level design rules. In terms of knowledge complexity as defined by Ditillo (2004), vertical division of work causes computational knowledge complexity: the knowledge of the strategic level is to be spread to many agents that are to use this knowledge in many kinds of activities. According to Ditillo, computational complex knowledge can be integrated by documents and codification. This all points in the direction of using the mechanism of rules and directives for vertical integration. This leads to our third proposition.

Proposition 3*. Vertical division of work requires rules and directives for knowledge integration.*

Horizontal division of work is quite different. Though it may be argued that there is some kind of order in specifying the various aspects, with processes dictating choices in the supporting applications, in practice the specification of the aspects is a matter of mutual interaction. It is a matter of bi-directional integration rather than uni-directional. This requires more face-to-face interaction discussing the impact of choices in one aspect on the other aspects. The architects have to work together to design a coherent framework in which the knowledge of all the different domains comes together in an integrated whole. Often tacit knowledge is involved: each participant applying his or her knowledge to arrive at a consistent and effective set of directions. Each participant is autonomous in his/her own domain, but within limits because of the interdependencies with the other domains. The knowledge complexity involved is of a technical and cognitional type (Ditillo 2004).

As horizontal integration is concerned with tacit knowledge and bi-directionality, rules and directives are less suitable. This leaves us with sequencing, routines and group problem solving and decision making. Sequencing does not seem to be appropriate because of the strong bi-directional nature of the integration. Routines might be a suitable integration mechanism. However, the present maturity of the architectural field may not allow for routines as yet. The frequency of task performance may be moderately high for full time architects, but the variability is usually high too. For efficient routines a high frequency and a low variability are best. Which leaves us with group problem solving and decision making: solving architectural issues together in face-to-face communication. Face-to-face communication is also the integration mechanism suggested by Ditillo (2004) for cognitional complex knowledge.

Proposition 4*. Horizontal division of work requires group problem solving and decision making for knowledge integration.*

Binding everything together is the third relation in the model, the *relation between the knowledge integration requirements and knowledge integration capacity and the efficiency of knowledge integration* as expressed in our final proposition.

Proposition 5. *The measure in which the integration capacity matches the integration requirements determines the efficiency of architecture knowledge integration.*

To summarize the model, the type of division of work (vertical or horizontal) determines the knowledge integration requirements. For an efficient integration of knowledge, these requirements must match the integration mechanisms chosen (rules and directives, sequencing, routines or group problem solving and decision making). The capacity for choosing an integration mechanism is determined by organizational characteristics like the use of boundary objects and the extent of interconnectedness.

7.3 Case Studies

To seek support or rejection for our conceptual model, we analyzed three cases. We think the choice for a case study is appropriate as we are dealing with a 'how' question regarding a contemporary event over which the researcher has little control and in which the borders between the phenomenon of interest and its context are not clear (Yin 2003). Besides, the nature of our research is strongly exploratory and we are seeking initial support.

7.3.1 Validity

The three cases, two financial institutions and one semi-governmental agency, were partly chosen because of practical reasons. All three had been subject to an assessment, in which one of the authors participated, on the architecture practice. The assessments consisted of interviewing architects and their stakeholders and studying documentation. At the interviews two investigators were present, one of them taking notes. The interviews were semi-structured, based on an existing architecture maturity assessment instrument (Van Steenbergen et al. 2007), thus providing greater reliability. Construct validity is supported by using multiple sources and by having the results of the assessments reviewed by the interviewees either in an interactive session or by commenting on the assessment document. The object of analysis of the assessments was the entire architecture practice, i.e. the whole of activities, responsibilities and actors involved in the development and application of architecture within the organization. The material resulting from the assessments, consisting for each case of interview notes and an assessment report approved by the architecture manager, provided the data for our study. As the assessments had a wider scope than the object of analysis of our study, we mined the material for data that was relevant to our study in the sense that it provided evidence for or against our propositions. We provided focus by using our conceptual model as a framework, thus supporting internal validity (Yin 2003).

7.3.2 Background of the Case Organizations

The cases we selected are two banks and a semi-governmental institution. BANK1 is a multinational bank with more than 40,000 employees. The some 150 architects are divided over various departments but reside mainly in the Operations division (14,000 employees). The architects are divided both vertically and horizontally. Vertically a distinction is made between (1) enterprise architects with a global scope, (2) information systems (IS) architects with a business line scope and information technology (IT) architects with an IT scope, (3) domain architects with a business or technical domain scope and (4) application and solution architects with a project scope (see figure 7-3a).

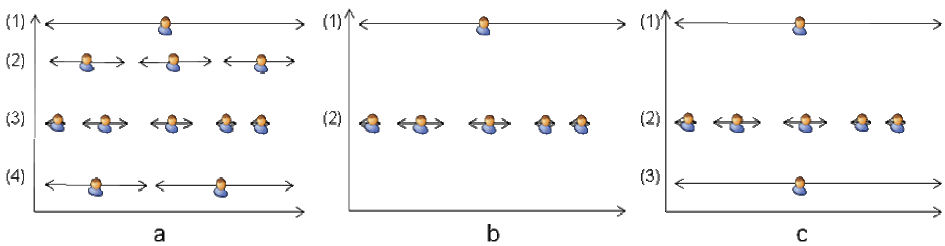

Figure 7-3: Division of work in BANK1 (a), BANK2 (b), GOVERNMENTAL (c)

Horizontally at the levels of IS/IT architects and domain architects in BANK1 a division is made according to business aspect or technical aspect. The main type of architectural deliverable is the enterprise architecture (EA) at strategic level and the project start architecture (PSA) at operational level. The architects have an advisory task concerning project design choices. Decision making is done by line management.

BANK2 is a national bank with some 40,000 employees. The 80 architects reside in the IT department and are vertically divided into (1) enterprise architects and (2) domain architects (figure 7-3b). The domain architects also function as project architects. The domain architects represent various business domains. The enterprise architects represent information or technical aspects. The top-level architecture is the enterprise architecture. All other architectural documents must be in line with the EA. Each project has a project start architecture made at the start. For many domains there is a domain architecture. The architects have an important say in project design choices. Only in cases of disagreement between architect, project manager and business line manager is senior management involved in decision making.

GOVERNMENTAL is an independent semi-governmental institution of some 1000 employees that works primarily for the ministry of education. Its architects reside in the Operations department. There are three types of architects: (1) enterprise architects, (2) domain architects and (3) project architects (see figure 7-3c). Enterprise architect and domain architect is a function, project architect is a role. The domain architects are assigned to a specific business domain or are technical architects. The enterprise architects may have their specialism as well. In all there are some 20 employees working as architect, with some six of them being full time architect (the enterprise architects). There is an enterprise architecture and there are project start architectures. The first domain architecture is still under construction.

7.3.3 Data Analysis

An overview of the integration mechanisms found in the cases is given in table 7-1.

Table 7-1: Case findings concerning integration mechanisms.

Case	Vertical integration	Horizontal integration	Boundary objects	Inter-connectedness	Fit
BANK1	High level EA; Sporadic guidelines; Lack of DA's	At operational level by sequencing; At tactical level by individual architects	Templates at tactical and operational level; No framework	Architects work individualis-tically: no architectural community over departments; Initiatives to increase interconnected-ness	Lack of integration at tactical level; Gap between strategic and operational level
BANK2	Enterprise architecture; Great variety in domain architectures	Informal network; By review at strategic and operational level	Framework and templates at strategic and operational level; No boundary objects at tactical level	Architecture community meeting four times a year	Lack of integration at tactical level; No insight in interde-pendencies
GOVERN-MENTAL	Enterprise architecture; DA's to be developed yet	Only at strategic and operational level, tactical level still being developed; Informal network	Framework; Templates at all levels	Active architecture community meeting once a week	Lack of structural integration at tactical level

Vertical integration. In all cases both vertical and horizontal division of work are found. As figure 7-3 shows, the levels of architects vary from two to four levels. In the case of two levels, the operational task of supporting projects is performed by architects at the tactical level or, less frequently, the strategic level. In all cases architects that support projects are expected to conform to rules and directions laid down in an enterprise architecture and domain architectures where available. Thus all cases confirm that there is some form of vertical knowledge integration required. The extent of the rules and directives, however, varies between the cases.

BANK1 has but few direction-setting architectural documents. There is a high-level enterprise architecture, but this is regarded by many as too abstract. It is not fully understood and is not always considered useful. Much architectural effort is spent on the operational level, providing projects with a project start architecture. Between the PSA and the EA there is a gap. As a consequence, the architects do not work from a common background and there is no overall view of how the various sub domains are related to each other. Each architect has to establish the relations to other programs and domains anew and has to find the appropriate persons to ensure alignment. In some sub domains guideline documents are produced, like integration guidelines and principles for customer relation management. These types of documents are considered very valuable and useful by program managers.

A source of tension between the IS architects and the IT architects of BANK1 is the difference in assignment for the two. IS is focused on supporting the dynamics of the business while IT is focused on standardization and industrialization. There is no overarching architecture to solve this difference in goal.

BANK2 and GOVERNMENTAL both have an enterprise architecture that sets directions and guidelines for the other levels. BANK2 in addition has lower levels of architectural documents. Counting all levels of architecture, starting at holding level and all the way through to project level BANK2 distinguishes 4 levels of architecture.

Horizontal integration. Horizontal division of work is seen especially at the tactical level, where in all three cases a division in domains is made, with architects being assigned to a specific domain and architecture being split up in various domain architectures. Domain architectures may be business line oriented (processes and applications) or technical oriented (aspects of technical infrastructure). This is a difference with the strategic and operational level where the various aspects and domains are integrated into one document, the EA respectively the PSA. As one person is usually end responsible for EA or PSA, even though more architects may be involved, integration of the various specialized knowledge domains is guarded by this person. At the tactical level this end responsibility is less evident and less easily fulfilled. This is illustrated in all cases, as each case is wrestling with the tactical level, though in different ways. Whereas BANK1 and GOVERNMENTAL deal with a lack of domain architectures, BANK2 deals with a wide variation of domain architectures of differing scope, content and format. One way of addressing the issue of integration we found in BANK2 and GOVERNMENTAL is to educate the architects in frameworks and concepts and to form a kind of architecture community that convenes regularly.

Within the IT department of BANK1 a few architects are assigned the task of guarding the coherence of the domain architectures over the various technical domains. They find this a very hard task to do. Only recently they changed tack from discussing issues with each domain architect separately to getting the domain architects together. This is felt as an improvement, but is still in its infant stage.

At operational level a tension is felt in BANK1 by some solution architects between the application part and the technical infrastructure part of the PSA. These two parts fall under different responsibilities and the processes of approval are not always aligned. This shows that at the operational level too, horizontal integration may be an issue. Also, some technical architects feel their involvement in writing a PSA is not timely enough. They are involved at too late a stage. Many feel that in this process, IT could be involved at an earlier stage and that a more collaborative mode of operation is desirable. BANK1 tends to use sequencing at the operational level, business talking with IS and IS talking with IT, but this is not found very satisfactory by IT: the last in the line keeps running after the facts.

In BANK2 domain architects are found to be of differing success in defining domain architectures. Those efforts that are perceived as being the most successful are the ones in which there is a close collaboration between the various parties involved and in which the domain architect is also involved in the programs that are to realize the domain architecture.

GOVERNMENTAL is still in the process of implementing the tactical level. There is an EA as well as a PSA process. As a gap is felt between EA and PSA, initiatives have started to appoint domain architects that are to develop business domain architectures. A template for domain architectures has been defined. The boundaries of the domain architectures are defined in the EA.

Boundary objects. The use of boundary objects can be encountered in various ways in the cases. Both BANK2 and GOVERNMENTAL make use of an architectural framework to support integration. Horizontal integration is supported by the sharing of concepts from the framework. It provides a common ground that facilitates integration. Besides, in GOVERNMENTAL the EA defines the boundaries of the domains at the tactical level. Vertical integration is supported by reflecting the framework in templates for enterprise architecture, domain architectures and project start architectures. By using the structure of the framework as the outline for the architectures at the different levels, it is easier to check the alignment of the levels.

At BANK2, however, there have been a number of initiatives recently to develop new kinds of domain architectures, using other architectural frameworks and templates. These initiatives emerged bottom up. This undermines the use of frameworks and templates as boundary objects. The result is that it has become increasingly difficult to identify interdependencies between domains. This was identified as problematic by program managers.

Interconnectedness. The cases also differ in how interconnectedness between the architects is realized. In BANK2 interconnectedness is large, primarily because collaboration and using one's informal network is a basic part of the organizational culture. Much architecture emerges in what the architects themselves call an organic fashion: there is much collaboration and many regard their informal network as an important success factor. All architects are part of the architectural community that meets for a day at least four times a year. When asked about responsibilities the answer frequently is that responsibility is shared among the stakeholders. Architectural documents are approved by having them reviewed by a large number of stakeholders.

In GOVERNMENTAL too, interconnectedness is large. The architects know each other. A kernel team meets weekly, mainly to discuss architectural issues but topics concerned with methods and processes can also be put on the agenda. A lot of knowledge integration is thus done in an informal manner.

In BANK1 the architects work very much individualistically, though there are differences between the business lines. On the whole there is no architecture community to speak of, nor is there a common language. This applies especially to the tactical level. Architects at this level mainly work with analysts and project managers. If architects work with other architects, this is because the project requires it. There is little discussion on meta level about methods, best practices, joint architectural products or architecture vision. In some business lines, however, architects are starting to engage in sharing knowledge in regular meetings. Not long after our case study, the IS architects of the different business domains decided to convene regularly to exchange knowledge and experiences and to align decisions, as they felt that this was missing in the formal structure. Also one of the architects responsible for the resilience of the architecture changed tack from having bilateral meetings with various domain architects to getting all domain architects together to discuss interdependencies. These developments illustrate a need for interaction among architects at tactical level.

Fit between requirements and capacity. As for the fit between requirements and capacity, we see that BANK1 seems to have something of a mismatch with regard to horizontal integration at tactical level. The large amount of domain architects in this case asks for explicit integration efforts, but the only integration mechanism offered is that of templates. Interconnectedness was not encouraged or facilitated in the past and is only now being developed. Thus group problem solving and decision making as integration mechanism is not implemented yet. As for vertical integration, a gap exists between the strategic level and the operational level, which makes it more difficult for the project architects to formulate the guidelines for projects.

Though interconnectedness in BANK2 is much larger, in BANK2 too, integration at tactical level is problematic. Though interconnectedness is better developed than in BANK1, as there are regular meetings and as there is a large informal network, what seems to be lacking is the full use of a framework and templates as boundary objects. It is felt by many that the cohesion between the many architectural documents is unclear and that nobody knows the whole picture anymore.

At GOVERNMENTAL integration issues are limited to strategic and operational level, as the tactical level is not implemented yet. Horizontal integration is mainly realized by interconnectedness. This is sufficient for GOVERMENTAL at the moment because the number of architects is still small. Most issues are solved at the weekly architecture meeting. Vertical integration is implemented by way of an enterprise architecture. Gaps between the enterprise architecture and the project start architecture are solved through interconnectedness.

7.3.4 Discussion

The cases seem to largely support our conceptual model. The suitability of rules and directives as integration mechanism for vertical integration is supported by all cases, in the form of architectural documents at the different management levels (enterprise architecture, domain architectures and project start architectures). Where there is a lack of architectural documents, integration between strategic, tactical and operational level is less efficient. The cases also support the statement that rules and directives are not suitable to horizontal integration. Horizontal integration appears to be a tough issue, especially at the tactical level. The cases seem to support the proposition that group problem solving and decision making is needed.

Architectural documents regularly function as boundary objects. Templates can be regarded standardized forms and an architectural framework provides coincident boundaries (vertical integration). Both the use of boundary objects and sufficient interconnectedness are found to facilitate group problem solving and decision making at the tactical level, though neither seems sufficient in itself. It appears that it is important to find the right balance between the use of boundary objects and interconnectedness. If this mix is not present, we see a mismatch with the integration requirements of tactical integration and a consequent lack of successful integration.

The horizontal integration needs explicit attention especially at the tactical level, as at this level there is no one single document that is being worked on as is the case at the strategic and operational level.

7.4 Evaluation and Conclusions

In this paper we investigated the tension that exists in many large enterprises between the need for division of work among architects and the requirement of developing an integrated set of architectural principles and models spanning all aspects of the enterprise. We found that there are two types of division of work that set different requirements on knowledge integration. Making use of results from the fields of IS research, organizational theory and sociology we arrived at a conceptual model of architectural knowledge integration linking knowledge integration mechanisms to types of division of work. We tested the propositions derived from this conceptual model in a case study. The cases confirm that forms of integration among architects are needed and that the use of boundary objects and the measure of interconnectedness are important factors in achieving this integration.

There are limitations to our research. Though the conceptual model of architectural knowledge integration seems to be supported by the cases, our research represents initial theory-testing and a series of replications is needed to enhance the theory's generalizability as well as to further investigate whether other factors may be relevant to our model. The results so far, however, are promising.

Our research suggests some additional areas of investigation. The apparent importance of interconnectedness in realizing the knowledge integration mechanism of group problem solving and decision making warrants further investigation in how this interconnectedness might be stimulated. One of the areas of research that seems a promising venue to further investigate this, is research into communities of practice (Brown and Duguid 1991; Lesser and Storck 2001) and epistemic communities (Cohendet and Llerena 2003). A community of practice is a group whose members regularly engage in sharing and learning, based on their common interests. Communities of practice develop connections among practitioners, fostering relationships that build a sense of trust and mutual obligation and creating a common language and context. The common ground for architects would be the architectural discipline, even if the domain of architecture differs. An epistemic community is a group of agents that share a common goal of knowledge creation. Where they are self-organized they share some characteristics with communities of practice.

Another direction that in our view merits further investigation is that of routines. A question that remains to be answered is whether the field of architecture has just not matured enough to make routines feasible, especially for horizontal knowledge integration, or whether this will never be the case because of the nature of architecture. In other words: is the lack of routines in present day architecture work a matter of time (architecture being still a relatively immature field) or is architecture work inherently too diverse to ever be supported by routines.

The implications of our research for practitioners are twofold. First our research suggests that practitioners should invest in building an architecture community in which architects exchange ideas, experiences and best practices, and discuss the interdependencies between their respective areas of expertise. An important part of best practices is the effective use of boundary objects. Practitioners should invest in choosing a common framework and in developing usable templates that can bind the various domains together.

Chapter 8

A Cultural Impact Model for Enterprise Architecture

Organizations have to manage increasingly complex IS portfolios. To manage this complexity many organizations have implemented an enterprise architecture (EA) practice. EA provides a framework to guide decision-making in IS development and acquisition. As EA involves decision making at all levels of the organization, it is important for the EA practice to tune its processes and methods to existing organizational practices. In this paper we present the results of a multiple-case study into how the choice and effect of EA techniques used by the EA practice is impacted by the cultural values of an organization. Based on the case study data we develop a Cultural Impact Model that links cultural values to EA techniques by way of an intermediate construct, the EA condition. We found that of the eight cultural dimensions examined, especially the three cultural dimensions of autonomy, collaboration and process/result orientation influence the use of specific EA techniques. These findings are elaborated into thirteen propositions linking specific EA techniques to specific cultural values. The propositions provide guidance to practitioners in deciding on which EA techniques to use in a specific organizational situation[1].

8.1 Introduction

Enterprise Architecture (EA), the practice of developing and applying a consistent set of rules and models that guide the design and implementation of processes, organizational structures, information flows, and technical

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[1] This work was recently submitted for journal publication.

infrastructure within an organization, is receiving increasing attention, both in practice and in research. Organizations today face an increasing complexity in their IS portfolio, especially with regard to integrating information systems. Awareness is growing that organizations need some kind of direction-setting frameworks to manage information systems development. Enterprise architecture provides such a framework (Lankhorst et al. 2005; Ross et al. 2006). As the EA discipline develops, awareness also increases that effectively employing EA is not only a matter of producing the right deliverables, but also of embedding the EA practice in the existing processes and operations of the organization (Aier and Schelp 2010). The EA practice is becoming a fully integrated part of the organization. Consequently, it may be expected that there is no ‘one size fits all’ approach to EA, but that effectiveness of particular EA techniques will depend on organizational aspects (Riege and Aier 2009). This is confirmed by Winter et al. (2010) in a survey among practitioners. Though they formulated, on the basis of the existing research literature, the hypothesis that adapting the EA approach to the organization is not important, the survey results made them reject this hypothesis: 82.1% of the respondents indicated that their approach used company-specific terminology and 73.2% indicated that the EA artifacts were tailored to the company’s and stakeholders’ needs. Apart from showing the need for adaptation to the organization specifics in practice, this study also indicates a gap in the research literature concerning the organization specific aspects of EA. An exploratory survey by Nakakawa et al. (2010) also shows differences between respondents in EA techniques used, but they do not provide an explanation for these differences.

In this paper we investigate the influence of organizational culture on the techniques used in EA practices, using a multiple-case study approach. Examples of such techniques are engaging in extensive communication with stakeholders, making explicit the added value of EA and applying time boxing to EA development. In previous research organizational culture has been found to influence organizational performance or actions in other areas (Alavi et al. 2006; Denison and Mishra 1995; Jones et al. 2006; Swidler 1986). To date, however, not much research has been done into the precise dependency of EA techniques on organizational culture (Leidner and Kayworth 2006). Though there is some research indicating a relation between contextual factors and EA performance (Aier and Schelp 2010; Riege and Aier 2009), the influence of organizational culture on EA practices is a topic that has not been extensively researched yet.

The objective of the study presented in this paper, is to contribute to the knowledge regarding the impact of organizational culture on how EA practices can be effectively implemented by employing specific techniques. By EA practice we mean the whole of activities, responsibilities and actors involved in the development and application of EA within the organization. This includes the application of EA at all levels: corporate, divisional and project. The underlying assumption is that different organizational cultures require different choices in the way the EA practice is formed. The study seeks to confirm this assumption and to investigate the nature of the influence of organizational culture on the EA practice. Our main research question is:

> *How does organizational culture impact the way the enterprise architecture practice is implemented?*

As we will show in this paper, the impact of organizational culture on the EA practice appears to work indirectly, by necessitating certain conditions to be fulfilled for architects to be effective.

The contribution of this paper is threefold. First of all, we develop a Cultural Impact Model as a framework to understand the relation between cultural dimensions and EA techniques, introducing condition as a mediating construct. Secondly, we instantiate this model for EA, showing which cultural dimensions impact the use of EA techniques most, and in what way. At a third level, we formulate a number of propositions predicting dependencies between specific cultural values and the employment of specific EA techniques.

The results of the study are expected to provide tools to practitioners in matching the implementation of their EA practice to the culture of the organization and, by doing so, in being able to improve the effectiveness of the EA practice.

In section 8.2 we present the theoretical background to our research. This is followed in section 8.3 by a discussion of the research method applied in this study: theory building from cases. Next, we describe the results of the within-case analysis and the cross-case analysis in sections 8.4 and 8.5, providing an extensive discussion of the resulting Cultural Impact Model in section 8.6, and the propositions that emerged from the data in section 8.7. Section 8.8 is reserved for conclusions.

8.2 Theoretical Background

Organizational culture has been regarded in various manners over the last decades. In terms of Smircich (1983), we adopt, in this paper, the corporate culture view. This view regards culture as functioning as an adaptive-regulatory mechanism that unites individuals into social structures and organizations as adaptive organisms existing by process of exchange with the environment. We do not assume, however, that organizational culture is easily changed. Instead we are looking for how to adapt EA practices to the existing organizational culture.

Much research in organizational culture draws upon Schein’s well-known three-level model of culture, which distinguishes basic assumptions, values or espoused beliefs and artifacts like technology, behavior patterns, myths and rituals. Study of the relation between organizational culture and group’s behaviors usually focuses on the level of values. One reason for this is the fact that values are easier studied than basic assumptions that are invisible and artifacts that may be hard to decipher (Alavi et al. 2006).

As we are in the process of theory building, we are looking for a framework that allows us to distinguish between various cultural aspects. In our study we therefore make use of the framework developed by Detert et al. (2000) and used by others to study the relation between organizational culture and organizational behavior and performance (Jones et al. 2006; Zahra et al. 2004). This framework is a synthesis of previous research into culture and it focuses on the level of values and beliefs. It distinguishes eight dimensions that are derived from a qualitative content analysis of the existing literature on organizational culture, including the well-known competing values framework (Quinn and Rohrbaugh 1983) and the organizational culture dimensions distinguished by Hofstede et al. (1990). Furthermore, we adopt the definitions and the values representing the polar extremes of each dimension used by Jones et al. (2006) in their application of the framework to knowledge sharing in ERP projects (table 8-1).

A point that has been debated in the literature is the extent to which organizational culture can be seen as a homogeneous whole of uniform values or whether an organization consists of various subcultures that may possibly contain conflicting values (Alavi et al. 2006; Myers and Tan 2002). In our study we focus on the cultural values as encountered and experienced by the architects and EA stakeholders. Though we found certain nuances in how cultural dimensions are experienced, we did not encounter strongly conflicting values. We took the nuances into account in our explanation of the relationships found.

Table 8-1: The cultural dimension framework (Detert et al. 2000, as used by Jones et al. 2006).

Cultural dimension	**Description**	**Polar extremes**
Basis of truth and rationality	Extent to which organizations seek truth through systemic, scientific study using hard data or through personal experience and intuition	Hard data vs. personal experience
Nature of time horizon	Extent to which organizations focus on the long-term or the short-term	Short term vs. long term
Motivation	Extent to which organizations deem that individuals are motivated by an internal desire to perform well or by external rewards and encouragement	External vs. internal
Orientation to change	Extent to which organizations have a propensity to maintain a stable level of performance that is 'good enough' or a propensity to seek to always do better through innovation and change	Stability vs. change
Orientation to work	Extent to which individuals in organizations focus on work as an end (results) or to which they focus on the process by which work is done as a means to achieve other ends	Process vs. results
Orientation to collaboration	Extent to which organizations encourage collaboration among individuals and across tasks or encourage individual efforts over team-based efforts	Isolation vs. collaboration
Control, coordination and responsibility	Extent to which organizations have decision making structures centered around a few vs. decision making structures centered around dissemination of decision making responsibilities throughout the organization	Concentrated vs. Autonomous decision making
Orientation and focus	Extent to which organizational improvements are driven by a focus on internal process improvements or by external stakeholder desires	Internal vs. external

To measure the EA practice dimensions we used the Dynamic Architecture Maturity Matrix, an EA maturity model developed by Van Steenbergen et al. (2010) that has been applied to over 50 EA practices. It distinguishes 18 focus areas that together constitute the EA practice. For feasibility reasons we had to make a selection of the 18 focus areas distinguished in the framework. We decided to restrict our study to those dimensions that are expected to be most influenced by organizational culture. To determine these dimensions we used an expert group. We interviewed five experts, asking them to score all 18 dimensions on the degree of culture dependency, using a five point scale, and to elaborate on their scores. The following dimensions were indicated by the experts as being most likely to be influenced by organizational culture and were included in the study: development of architecture, use of architecture, alignment with business, roles and responsibilities, monitoring, and consultation. The dimensions are described in table 8-2.

Table 8-2: EA practice dimensions studied (Van Steenbergen et al. 2010).

EA practice dimension	**Description**
Development of architecture	The approach to architecture development, varying from isolated, autonomous projects to an interactive process of continuous facilitation.
Use of architecture	The way architecture is used: merely as a conduit for information, as a means of governing individual projects or even as a tool for managing the entire organization.
Alignment with business	The extent to which the architectural processes and deliverables are in tune with what the business wants and is capable of.
Roles and responsibilities	The distribution of responsibilities concerning both architecture processes and deliverables within the organization.
Monitoring	The extent to which and the manner in which compliance of projects with the architecture is guaranteed.
Consultation	The extent to which communication among architects and between architects and their stakeholders takes place on a structural basis.

Figure 8-1 presents the overall research framework used in the study. It depicts a general impact of cultural dimensions on EA practice dimensions.

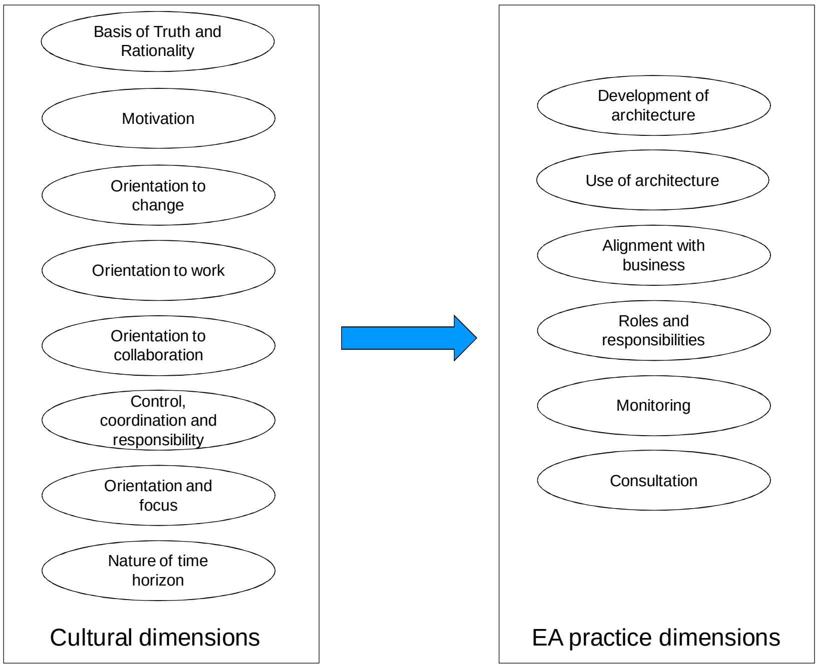

Figure 8-1: Theoretical Framework for cultural impact

The objective of our study is to explore whether this impact does indeed exist and to further investigate the nature of the relations that may be found. Our research is exploratory in nature as the existing literature does not provide enough knowledge yet, to formulate hypotheses about these relations from the research literature. The purpose of our study, therefore, is to generate new propositions from case data (cf. Alavi et al. 2006).

8.3 Research Method

8.3.1 Theory building from case studies

As little is known about the relation between organizational culture and EA practices, we decided on a theory-building case study approach. Theory building from case studies is extensively discussed in the literature (Benbasat et al. 1987; Carroll and Swatman 2000; Eisenhardt 1989; Eisenhardt and Graebner 2007; Runeson and Host 2009; Seaman 1999; Smith 1990; Yin 2003; Woodside and Wilson 2003). Building theory from case studies is an approach in which cases are not used to confirm hypotheses, but instead are used to generate new hypotheses. Thus, the hypotheses, and potentially even theory, emerge from the data. To allow theory to emerge in this way, the researcher does not start out with a fixed a priori theory, but at most with a few high-level concepts to direct data gathering.

As we want to study the effect of variation in cultural dimensions on the EA practice, we opted for a multiple-case study. In conducting the case study we applied the approach presented in Eisenhardt (1989) which synthesizes and extends work on qualitative methods (Miles and Huberman 1984), the design of case study research (Yin 1984) and grounded theory building (Glaser and Strauss 1967). Eisenhardt distinguishes eight steps.

1 Getting started. Theory-building research starts with formulating a, usually broad, research question and possibly some a priori constructs to guide data collection. Our research question is “How does organizational culture impact the way the EA practice is implemented?” and our a priori constructs are the eight cultural dimensions and six EA practice dimensions.

2 Selecting cases. As our purpose is theory building, we applied theoretical sampling to the case selection, selecting cases for theoretical, not statistical, reasons. In particular we were looking for EA practices that differ in (some aspects of) organizational culture but not too much in other aspects. Therefore we used the following criteria: (1) the cases must represent (partly) different cultures; (2) the cases must have an established EA practice that is comparable in maturity; (3) the cases must share a comparable context. A way to satisfy these criteria is to select EA practices that belong to the same economic sector, but to different companies within this sector. As in general EA has been practiced for quite some years in the financial sector, we decided to select the cases from the financial field. In the end, we investigated five cases. This is within the limits mentioned by Eisenhardt, who indicates 4-10 cases as a reasonable number in theory-building multiple-case studies (Eisenhardt 1989).

3 Crafting instruments and protocols. To guide the execution of the case study a case study protocol was developed beforehand. Also, based on the definitions of the cultural and EA practice dimensions, an interview guide was drafted to be used as a checklist during interviews.

4 Entering the field. Data was collected by means of interviewing architects as well as stakeholders of EA on each of the case sites. In addition, existing documents were viewed, both internal reports and external publications like public websites, presentations and articles in magazines. Per case 4 to 19 interviews were held, with both architects and EA stakeholders like project managers, business managers and IT managers. The total number of interviews is 62, performed over the period October 2009 – May 2010 (table 8-3). The small number of interviews in case C is compensated for by studying background material like publications, presentations and internal documents.

Table 8-3: Descriptives of data collection.

	Company A	**Company B**	**Company C**	**Company D**	**Company E**
Number of interviews	10	19	4	14	15
Roles interviewees	Architect (8) Buss. mgr. (1) Project mgr. (1)	Architect (13) Arch. mgr (2) Business (2) IT mgr. (1) Portfolio mgr. (1)	Buss. mgr. (1) IT mgr. (1) Arch. mgr. (1) Information mgr. (1)	Business mgr (3) IT mgr (2) Architect (9)	Business mgr. (2) IT mgr. (1) Information mgr. (3) Architect (3) Analyst (3) Project mgr. (3)
Period of data collection	Oct – Nov 2009	Nov 2009 – Jan 2010	Apr 2010	Apr – May 2010	May 2010

The interviewees were interviewed about the organizational culture as well as the implementation of the EA practice. Interviewees were encouraged to talk about actual EA techniques. The interviews were semi-structured. All interviews were conducted by the first author who was assisted by a scribe making extensive notes. As soon as possible after the interview the notes were transferred by the first author to a template distinguishing the cultural dimensions and the EA practice dimensions. In this way the interview notes were ‘coded’ according to the dimensions of the theoretical framework. All data collected is stored in a case study database. A total of 91 EA techniques were identified in the interviews.

5 Analyzing data. *Within-case analysis (5a)* was conducted by synthesizing the interview notes into a case study report describing the cultural values of the company as well as the EA techniques identified. In addition, we included potential improvements that were mentioned by the interviewees, a tentative preliminary analysis of the relations between cultural values and EA techniques, and some overall conclusions and recommendations. The latter were primarily meant as a ‘thank you’ to the participating companies. However, the formulation of conclusions and recommendations were also conducive in better understanding the cases. The case study report was sent to all interviewees with the invitation to comment on our findings. We made sure that at least our primary contact, in all cases the lead architect, validated the case study report explicitly. In addition, we received some comments from the interviewees. The comments only concerned refinements. No controversies did emerge.

Cross-case analysis (5b) was done by looking for the similarities and differences between the EA techniques, making extensive use of the technique of tabulating the data in several ways. We entered the cases into a spreadsheet and used this as a basis for sorting the cases and associated techniques in several ways according to (combinations of) cultural values. The similarities we found within sets and the differences between sets were the basis for further investigation. This process is explained in more detail in section 8.5.

6 Shaping propositions. We built propositions (Eisenhardt (1989) speaks of hypotheses) by trying to explain the links found during the cross case analysis between the cultural values and the EA techniques. This was an iterative process in which we kept going forth and back between data and emerging constructs and their relationships, further sharpening our ‘theory’ with every round. The propositions thus were checked against each case. This is a case of replication logic instead of sampling logic, i.e. treating the cases as a series of independent experiments where each case confirms or disconfirms the proposition.

7 Enfolding literature. In order to embed our findings in the existing research knowledge, we searched the research literature for related findings. Most of the concepts emerging from the data could be related to previous research. We found little literature, however, on specific causal relations the concepts. In that sense our results extend the existing knowledge.

8 Reaching closure. We reached closure when the iteration between data and theory and literature no longer resulted in new insights.

8.3.2 Case descriptions

We included five cases in our study. Two companies that are active on the insurance market, one company working in the banking sector, one company in the pension market and one company in the financial market. Most companies had many years of experience with EA. Company E has, with four years, the shortest history of EA of the five cases. A brief sketch of the participating companies is given below.

Company A. Company A is a large insurance company with 22.000 employees that provides insurances in healthcare, damages, pension and life, but also offers banking and mortgage products and services. It offers products under various labels. The company is divided into a number of divisions that until recently enjoyed much autonomy. Lately, however, a move was initiated towards a more centralized governance structure. Company A has a variety of architects, positioned either in the central IT department or in the divisions. Architecture development takes place primarily at central level, while the application of the architecture in projects takes place at division level.

Company B. Company B is a bank with about the same number of employees as company A, 22.000, 3000 of which are employed abroad. It offers services in savings, investments, mortgages, loans, insurance, payments and financial planning. The bank wants to build a longstanding relationship with its clients, both private and corporate. Company B has architects both within the central IT department and in the divisions. The divisions have great autonomy. Both architecture development and application take place primarily at division level.

Company C. Company C is a pension administration company with 1000 employees. It is divided into six divisions. The divisions have great autonomy. The development of processes and IT takes place within the divisions. Only generic IT services are placed centrally. These services are financed by the divisions, however. The architects are all positioned within the central IT department, there is no distinction between central architects and division architects. Architecture development takes place at central level, application takes place within the divisions.

Company D. Company D is an insurance company with 5000 employees that offers products in damages, life and income insurances, pensions, healthcare insurances and travel insurances. Company D is making a move towards a more centralized governance. The divisions still have autonomy, but within centrally set boundaries concerning for instance IT, human resource management and accounting. The architects are positioned centrally, primarily in the IT department. There are several kinds of architects, divided according to

IT aspect. Business architects are positioned separately from the IT architects. Architecture development takes place primarily at central level and there is a well-defined architecture compliance process in place.

Company E. Company E, with 1800 employees, is active in the financial sector. Company E consists of a number of divisions that have great autonomy. Employees are professionals with much expertise and relative independence. The architects are all positioned together in the central IT department. Architecture development and application takes place at division level. Ownership of the architecture lies with the divisions.

An overview of the case characteristics is given in table 8-4.

Table 8-4: Characteristics of the five cases.

	Company A	Company B	Company C	Company D	Company E
Number of employees	22.000	22.000	1000	5000	1800
Number of architects	60	50	5	60	7
Type of business	Insurance	Banking	Pension	Insurance	Financial

The cases differ considerably in size, which entails the risk of contributing certain effects to culture which should be contributed to size. The differences in size do not seem to be directly correlated to the cultural values found, though, which lessens the above mentioned risk. Company D contains a strikingly large number of architects. About 35 of these are full-time enterprise architects or solution architects, the other 25 possess the part-time role of domain architect.

8.3.3 Validity of the results

To ensure rigor in our study, the four types of validity described by Yin were taken into account (Yin 2003): construct validity, internal validity, external validity and reliability.

Construct validity *is satisfied when the concepts being studied are operationalized and measured correctly*. The constructs measured in the case study are derived from previous research and as such are well-defined. Measurement of each construct is supported by a set of pre-defined questions derived directly from the specifications of the constructs. In addition, for data collection multiple sources were used: interviews, internal documentation and publications. The case study report is reviewed by the lead architect, reducing the risk of crucial oversights or misinterpretations.

Internal validity *is defined as establishing a causal relationship and distinguishing spurious relationships*. Explanation building is used to identify possible causal relationships between cultural dimensions and EA techniques. This is supported by the extensive use of tables linking cultural values to EA techniques. All cases belong to the financial world, which provides a relatively similar background to the study and reduces the risk of unaccounted for factors influencing the results.

External validity *is defined as establishing the domain to which a study's findings can be generalized*. Case studies rely on analytical generalization, i.e. generalizing specific findings to a broader theory. External validity is striven for primarily by relating the findings from the data to the existing research literature and building a model and propositions based on both data and literature. To be able to make firmer claims of external validity, however, the theory developed in this study should be further supported by applying additional replication logic.

Reliability *is satisfied if the study can be repeated with the same results*. Having a case study protocol and case study database both contribute to the reliability of the case study, as well as the use of tables to represent and analyze the results. Also, the interviews are based on a predefined list of questions that are explicitly related to the dimensions investigated.

We believe that by taking these four types of validity into account from the onset of the case study, a satisfactory level of validity is achieved.

8.4 Within-case Analysis

The purpose of the within-case analysis was to establish the cultural values for each of the cases as well as identify the EA techniques successfully employed within the cases.

8.4.1 Within-case analysis method

The within-case analysis (step 5 in the overall approach) consisted of the following sub-steps, which were executed for each case.

5a1: Template coding. The notes from the interviews were categorized according to a predefined template containing the eight cultural dimensions and the six EA practice dimensions.

5a2: Cultural analysis. Based on the interview notes the values of each of the cultural dimensions were established. We positioned each case in a six-scale culture table. The introduction of a six-scale instead of the original two-scale was decided upon because the two-scale appeared not to be expressive enough to do justice to the cultural nuances of the cases. The results of this step are summarized in table 8-5.

5a3: Identifying EA techniques. From the interview notes the EA techniques were identified. As the interviewees did not only mention successful techniques, but also discussed techniques they thought should be implemented or improved, we decided to not only identify realized techniques in our study, but also ‘wished for’ techniques. Of course both types of techniques were clearly distinguished. The results of this step are summarized in the appendix.

5a4: Drafting case study report. The results of step 5a1 to 5a3 are recorded in a case study report containing the following elements: introduction, cultural values, techniques (both realized and wished for), preliminary relation between cultural values and techniques, conclusions and recommendations.

5a5: Validation. The case study report was submitted for review to the interviewees. The review comments received were integrated in the final case study reports. In addition, explicit approval of the report was asked for and obtained from the lead architect.

8.4.2 Within-case analysis results

Based on the interview data, for each company, the cultural value for each of the eight cultural dimensions was first described in text. As the cultural dimensions constitute a continuous spectrum between two polar extremes, each company was positioned on this spectrum based on the textual description. Thus, company E was described as being primarily result oriented, though processes are not unimportant. The focus, however, is on the result. Hence, company E was positioned to the left side of the spectrum of the dimension orientation to work, though not to the extreme left. It appeared that dividing the spectrum into six parts provided enough distinction to express the relative differences in cultural value between the cases investigated. Hence we introduced a six-scale value representation. Both description and position were validated by the organizations. The cultural values of the organizations, as derived from the data, are presented in table 8-5.

All cultural dimensions, except for motivation, show cases on both sides of the midpoint. The dimension of motivation shows a large concentration of cases on the internal motivation side of the spectrum. This may be related to the fact that the study deals with highly educated employees. As a consequence of this concentration of values, we could not link specific EA techniques to the cultural dimension of motivation. This is matter of further research.

Table 8-5: The cultural dimension values for each case.

Cultural dimension		**1**	**2**	**3**	**4**	**5**	**6**	
Basis of truth and rationality	Hard data			B,E	A,C,D			Personal experience
Nature of time horizon	Short term		A,E	B	D	C		Long term
Motivation	Internal	A,B,C,E	D					External
Orientation to change	Stability		E			B,D	A,C	Change
Orientation to work	Result		E		C,D	A,B		Process
Orientation to collaboration	Collaboration		C	E	B,D		A	Isolation
Control and coordination	Concentrated			D	A	E	B,C	Autonomous
Orientation and focus	Internal		A,B,E	C	D			External

The EA techniques that emerged from the interviews were described in the case study report, categorized according to EA practice dimension. An overview of all EA techniques that emerged as either being a good technique or a desirable technique can be found in the appendix.

8.5 Cross-case analysis

The purpose of the cross-case analysis was to provide insight into the relations between cultural values and the use of EA techniques.

8.5.1 Cross-case analysis method

The cross-case analysis (step 5b) consisted of the following sub-steps (cf. Eisenhardt 1989).

5b1: EA technique table construction. First of all, from the five case study reports all EA techniques were taken, categorized by EA practice dimension. This yielded 69 used techniques and 22 wished for techniques, a total of 91 techniques. Examples of techniques are *developing just enough architecture*, i.e. no more prescriptions than needed, *embedding EA in the organization*, i.e. integrating the EA process with the existing decision-making and development processes, and *architect in management team*, i.e. making sure the lead architect is positioned close to the decision-making powers. Next, overlap in techniques was identified, i.e. techniques that may have been called differently by the respective organizations, but are essentially the same technique. For instance, company C talks about *business being responsible*, while company E mentions *business being accountable*. Both techniques refer to the business feeling ownership for the EA, instead of referring EA to the architects or the IT department. These two techniques are therefore both labeled under *ownership with business*. This exercise yielded 48 distinct techniques. The resulting EA technique table, included in the appendix, was the basis for cross-case analysis. Table 8-6 shows an excerpt of the EA technique table.

Table 8-6: Excerpt from EA technique table.

Common technique	Company A	Company B	Company C	Company D	Company E
Alignment with business					
Added value	- Added value to business	- Business case	- Working from a supportive perspective	- *Alignment with business needs*	
Architecture as part of strategic chain				- Architecture as part of strategic chain	
Pro-activity		- *Pro-activity*	- *Pro-activity*	- *Pro-activity*	
Ownership with business			- Business responsible		- Business account-able

The excerpt shows the EA techniques for achieving alignment with the business. The techniques in italics denote techniques that are not implemented, but mentioned as being desirable in one or more interviews. For example, interviewees in company D indicated that they felt the architects, in defining the EA, might take into consideration more the fact that not all divisions share the same needs. Hence, the EA technique alignment with business needs is indicated in the table as a ‘wished for’ practice for company D. Techniques, found in more than one case, that are similar, are placed in the same row. In the first column a generic label for these techniques is given.

5b2: Set comparison table construction. Next, we sorted the five cases in different ways, according to their cultural values, providing us with sets of cases that differed in one or two specific cultural dimensions. For each of these combinations of sets we identified the techniques found in all members of one set while not found in any member of the other set(s). This step was done in preparation to the next step, looking for patterns. As an example, an excerpt of one of the set comparison tables is given in table 8-7.

Table 8-7: Example of a set comparison table (excerpt).

Cultural value	**Isolation**			**Collaboration**	
Common technique	**Company A**	**Company B**	**Company D**	**Company C**	**Company E**
Sharing knowledge	- Use common tool	- *Common body of knowledge*	- Registration of best practices		
Alignment with client perspective				- Alignment with client perspective	- Alignment with business perspective
Monitoring market develop-ments				- Presentations of market develop-ments	- Platform for monitoring market developments
Visibility				- Visibility	- Extensive communica-tion
Ownership with business				- Business responsible	- Business accountable

5b3: Looking for patterns. We investigated the sets generated by step 5b2 by looking for patterns and trying to explain these (Eisenhardt 1989; Eisenhardt and Graebner 2007; Seaman 1999). The first step in this approach was to take two sets with opposing cultural values, for instance organizations geared to collaboration and organizations geared to isolation and look for techniques found in all members of one set while not found in any member of the other set (cf. table 8-7). The techniques we found in this way acted as our starting point. We tried to explain these patterns, from the cultural values of the organizations. Sometimes this was straightforward, often we found there were more values that had to be taken into account. Some patterns we could not explain from a cultural perspective. We went through a process of formulating explanations, reading them over again, going back to the case reports, refining the explanations, going back again to the case reports, refining the explanations until we reached closure.

8.5.2 Cross-case Analysis Results

The process of going forth and back to data and explanations resulted in the end in eleven identified patterns which relate EA techniques to (combinations of) cultural values. An overview of all patterns identified is given in table 8-8. The codes within parentheses refer to the propositions that are formulated further on in this paper. Note that P1 and P7 are missing from table 8-8. These propositions are additionally derived from studying the patterns in table 8-8, but not directly related to one of the EA techniques. The fact that almost all patterns identified are related to the value of *autonomy* (upper half of table 8-8), and only one to the value of *concentrated control* can be explained by the nature of EA. EA looks at the enterprise as a whole and as such is easier incorporated in concentrated organizations where decision making is central, than in autonomous organizations where decision making is distributed over many parties. Hence the larger number of specific EA techniques encountered in autonomous organizations.

Table 8-8: EA technique patterns derived from the data.

<table>
<tr><th></th><th></th><th colspan="2">Orientation to collaboration</th><th colspan="2">Orientation to work</th></tr>
<tr><th rowspan="4">Control</th><th></th><th>Isolation</th><th>Collaboration</th><th>Process</th><th>Result</th></tr>
<tr><th rowspan="2">Autonomous</th><td colspan="4">- EA budget (P9)
- Independency (P10)</td></tr>
<tr><td>- Added value (P5)
- Knowledge sharing by tools (P8)</td><td>- Visibility by communication (P2)
- Ownership with business (P3)
- Alignment with client perspective (P4)</td><td>- Hooking into development process (P13)</td><td>- Time boxing (P12)
- Transparency of approach (P6)</td></tr>
<tr><th>Concentrated</th><td colspan="4">- Architecture in strategic chain (P11)</td></tr>
</table>

We found that patterns of techniques primarily emerged for three of the eight cultural dimensions: *control, coordination and responsibility* (the extent to which divisions, projects and employees are autonomous), *orientation to collaboration* (the extent to which divisions, projects and employees are inclined to collaborate) and *orientation to work* (the extent to which divisions, projects and employees put emphasis on the process rather than on the result).

During the process of looking for patterns, we also found that while sometimes cultural dimensions can be directly related to a technique, in most cases it is the combination of cultural dimensions that determines the technique. Thus, we find that organizations with great autonomy for divisions, projects and employees (cultural dimension *control, coordination and responsibility*) employ various kinds of techniques that on closer inspection are concerned with the architects getting themselves accepted by division management. What specific techniques they employ to this end is related to the fact to what extent their organization is inclined to collaboration (cultural dimension *orientation to collaboration*). In a collaborative organization, for instance, the technique of *aligning the EA format to the client perspective*, i.e. presenting the EA in a form that is understood and appreciated by the stakeholders, is used to gain acceptance, while in less collaborative organizations the technique of *making explicit the added value* for the division, i.e. showing the business the benefits certain EA choices generate, is used to gain acceptance. It appears that the influence of cultural dimension on the EA techniques works through certain conditions that the architects need to achieve in order to be effective. In other words, we find a mediating construct between cultural dimension and EA technique, the *EA condition*. We define *EA condition* as ‘a prerequisite that has to be fulfilled for architects to effectively develop and apply EA within their organization’. Both the existence of EA conditions and the way in which EA conditions can be met are partly determined by (different) cultural dimensions.

8.6 Cultural Impact Model

As explained above, the relation between cultural values and the use of EA techniques is not primarily a direct one, as we assumed at the start of our study (cf. figure 8-1), but is mediated by a third construct, the EA condition. Generalizing these concepts gives the Cultural Impact Model (figure 8-2).

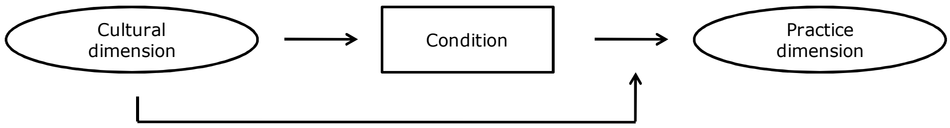

Figure 8-2: Cultural Impact Model

Cultural values necessitate certain conditions that can be achieved by employing certain practice techniques. Which techniques are most suitable to achieve these conditions is also influenced by (other) cultural values.

This finding is in line with earlier findings that cultural values interact and that models depicting cultural influence are often more subtle than directly linking values with outcomes (Alavi et al. 2005; Leidner and Kayworth 2006).

Instantiating the Cultural Impact Model for the case of EA, provides the *Cultural Impact Model for EA* depicted in figure 8-3. The figure illustrates that the cultural dimension of control, coordination and responsibility necessitates four EA conditions to be fulfilled and that the two cultural dimensions of orientation to collaboration and orientation to work influence with what EA techniques these conditions can be fulfilled. The EA techniques mentioned in table 8-8 are represented in the model by the EA practice dimensions they belong to (cf. the EA technique table in the appendix). Note that figure 8-3 is not to be read as depicting causal relations between independent, intermediate and dependent variables, but merely as visualization of the role of cultural dimensions and conditions.

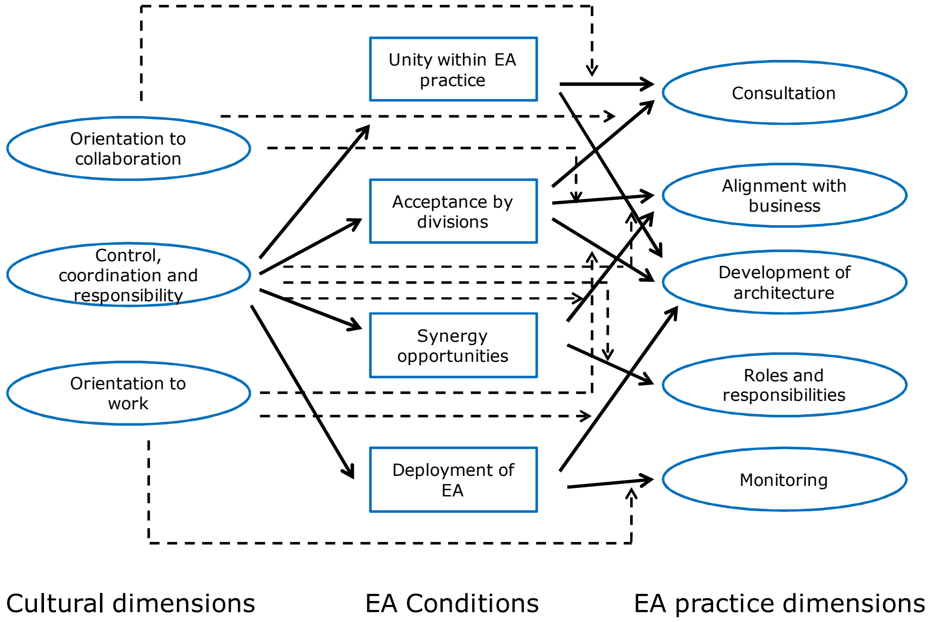

Figure 8-3: Cultural Impact Model for Enterprise Architecture

In the next section, a number of propositions are derived from the data that relate specific cultural dimensions, EA conditions and EA techniques.

The four EA conditions that emerged from the data and that are influenced by the degree of autonomy within the organization, are:

Condition 1: Acceptance by division management. In autonomous organizations much of decision making lies with the management of the individual divisions rather than with corporate management. Division management may have the power just to ignore the EA efforts. Without acceptance of the EA practice by management of autonomous divisions, it appears hard for architects to be effective. It is not only important that the concept of EA is understood and accepted, but also that the architects and their role are accepted. As the lead architect in company C formulated it:

"The attitude and competence of the architects are very important. A supporting attitude, not a preaching attitude. […] Architects are always asked for in person."

Condition 2: Unity within EA practice. In autonomous organizations architects will focus much of their efforts on the individual divisions or projects. Often, architects are dedicated to one specific division or transition program. They may even be partly positioned within the divisions. This leads to the risk of fragmentation in the EA. Thus, there is a need for the architects to pay attention to preserving unity within their EA practice. As a business architect within one of the divisions in company A said about the EA:

"There is a lot, but it is hard to see the consistency. […] Nothing is certain. Much is in the heads of people. [….]There is much, but the structure is lacking."

Company B, too, experiences the risk of fragmentation, according to one of the business architects:

"No transferable body of knowledge is created. […] There is no firmly established architecture. What is there, is very high level."

Condition 3: Identification of synergy opportunities. In autonomous organizations the focus of the individual divisions or projects will usually be on division or project results rather than organization-wide results. Also, division or project management may not be aware of opportunities originating from other divisions or projects. This carries the risk of sub-optimal choices. Thus, the architects must find a way to enable the identification and realization of synergy opportunities. A business manager of company D expressed his appreciation of the architects looking beyond his own division:

“Their thinking with us, is positive. The architects often are involved in more than one business line. Because of this, they can identify problems already solved elsewhere and solutions that can be reused.”

Condition 4: Deployment of EA. In autonomous organizations whether or not EA is actually deployed lies much within the power of the individual divisions or projects. Thus, the architects should look for ways to stimulate conformance to the EA. In company B, for instance, the degree of deployment of EA differs very much per domain. A business architect:

“There is a number of domains in which the architects are very effective. These domains have a good architect or a line manager who believes in architecture and enables them to do their job. […] In a large number of domains, architecture plays no role.”

Of course, reality is more subtle than might be suggested here. We find that autonomy is a gradual matter. None of the cases exhibits either complete autonomy or complete centralization. Thus the need for the four conditions mentioned is present in all five cases, but to a more or lesser extent. The fact that the dimension of *control, coordination and responsibility* appears to be the most dominant factor in generating EA conditions can be explained by the fact that EA is about organization-wide coherence, which exhibits a natural tension to autonomy. The relevance of degree of autonomy for EA is supported by findings from a multiple-case study into EA implementation by Aier and Schelp (2009). They found that strong divisional separation inhibited the emergence of a favorable EA culture.

The findings are in line with the view expressed by Swidler (1986) of culture defining and restricting the available range of *strategies of action*. Architects perform certain kinds of activities because the organizational culture requires them to fulfill particular conditions. As Swidler argues, cultural values “do not shape action by defining its ends, but rather fine-tune the regulation of action within established ways of life” (p.282). This leads to our first proposition:

Proposition 1*. The degree of autonomy in an organization strongly influences the necessity of four conditions to make EA effective: acceptance by division management of the architects, unity of content and method within the EA practice, synergy identification between divisions or projects and deploying EA throughout the organization.*

8.7 Cultural Impact Model elaborated

In this section the Cultural Impact Model for Enterprise Architecture is further elaborated. Based on the study of the case data, as well as related literature, thirteen propositions linking EA techniques to cultural values are formulated. The discussion of the data is structured according to the four EA conditions that emerged from the data. The way the four EA conditions are addressed by specific EA techniques can be explained by considering the cultural dimensions of *orientation to collaboration* and *orientation to work*.

8.7.1 Condition 1: Acceptance by division management

We find that the cases employ different techniques that address the challenge of the architects getting acceptance from the divisions. The two collaborative companies, C and E, employ three EA techniques related to this issue, that are not employed by the other companies: ensuring visibility by way of extensive communication, putting ownership of the EA with the business and aligning the architecture format to the recipients of the EA. All three techniques have been identified in previous research (Aier and Schelp 2010; Basselier and Benbasat 2004; Nakakawa et al. 2010; Reich and Benbasat 2000), though not related to specific cultural values.

The importance of *communication* is expressed in many research studies, both in aligning business and IT (Basselier and Benbasat 2004; Chan 2002; Chan 2007; Hu and Huang 2005; Reich and Benbasat 2000) and in EA management (Aier and Schelp 2009; Nakakawa et al. 2010; Winter et al. 2010). Hu and Huang (2005) stress the importance of relationship management. Reich and Benbasat (2000) indicate that high levels of shared domain knowledge between IT and business management at the same management level leads to mutual understanding and respect, which might even mitigate the negative effects of failed IT projects and prevents situations of finger-pointing. This effect is also mentioned by one of the division managers of company E:

“Architects must be good communicators.[…] Architecture must show its added value to the business. Then, people will be prepared to suffer a little bit of pain, occasionally. It is like going to the dentist.”

Chan (2002) concludes from a case study involving eight business units with high levels of alignment that the informal, relationship-based structure is more important to alignment than the formal structure. A division manager in company C:

“Trust. There is intensive collaboration [between architects and business information management], it is a whole: the architect and the information manager say the same things.”

The information manager also stresses the collaboration:

“The approach is to tackle things together, to collaborate. There is no imposed architecture. No parochialism. Consensus culture.”

The importance of personal relationships is also illustrated by the following remark of a project manager in company A:

“Whether I have confidence in what is written in the Project Start Architecture, also depends on the architect. A Project Start Architecture is nice, but talking is more important. Then you can get an impression of the person you are dealing with.”

The data from the cases suggest, however, that the influence of communication is situation dependent. This is in line with findings that IT personnel are not always in a position that allows them to communicate with business management, for instance because of low status of the IS unit (Campbell 2005). Reich and Benbasat (2000), too, indicate that a certain amount of integrative perspective on business and IT is necessary for communication to be fully productive. As an IT manager in one of the divisions of company A formulated it:

“The Business Information Plan is made by the business architects. Is being regarded as an ‘IT thing’. […] I come from the business part of the organization, but got an IT stamp very quickly.”

His colleague, a business architect says:

“It is difficult to deal directly with management. You deal with the project manager and the business analist.”

Our study shows a relation between the role of communication and the collaborative nature of organizations. It seems to be the case that communication is especially effective when the recipients of the communication are prepared to act upon what is being communicated. Where organizations are geared to 'doing their own thing' instead of to collaboration for a common goal, the tendency to act upon the communication of the architects will be much less. In that case, more is needed than extensive communication, to make people cooperate. This leads to the following proposition:

Proposition 2. *In a collaborative organization extensive communication by the architects has a stronger positive influence on the architects being accepted by division management than in a less collaborative organization.*

Companies C and E also place *ownership of the EA with the business*. Where people collaborate, they are aware of their mutual dependencies and more inclined to look for shared opportunities. As EA is an important instrument to achieve common interests, architectural thinking will be more easy to get support for in the business. Business will be more aware that all aspects of the organization, including IT, are to be considered integrally. And that this is the responsibility of the business itself. They will be less inclined to regard EA as purely IT and thus to delegate it fully to the IT department. Thus, in company E the business has formal accountability for the EA. As a division manager of company C expressed it:

"IT architecture is not different from other policy like human resources and quality management. […] One of the lessons I learned is that the business should be in the lead."

By placing ownership of the EA with the business, this integral responsibility of business management is formally confirmed.

Proposition 3. *In a collaborative organization placing ownership of the EA with the business has a stronger positive influence on the architects being accepted by division management than in a less collaborative organization.*

Thirdly, C and E both indicate that *approaching EA from a client perspective*, i.e. expressing EA models in a format that is aligned with the way of thinking of the stakeholders, is a good technique. The architects of E started off with high-level global visualizations, which, however, were not well received by the organization consisting mainly of well-educated professionals. Only when they started making precise models using a formal modeling language did they gain acceptance. As a business analyst in company E expressed it:

“The [modeling language] models are better received than my earlier high over slides. The models look professional and provide more detail. They better align with the environment here: people want to know precisely how things are.”

The fact that this aspect is not mentioned by the less collaborative companies might again be explained by a lack of receptive climate in these cases. Which leads to our fourth proposition:

Proposition 4. *In a collaborative organization aligning the format of the architecture description to the recipient of the EA has a stronger positive influence on the architects being accepted by division management than in a less collaborative organization.*

A technique that is mentioned by the two less collaborative autonomous companies, A and B, is *making added value explicit* to the divisions. Where organizations are more concerned with ‘doing their own thing’ it is not unexpected that ‘what’s in it for me’ is a prevalent attitude. Hence the relative importance of stressing the value of EA for each stakeholder individually. An IT architect in company A about a successful project:

“I built a bridge between the differences in interest. Key was the fact that [all parties] saw results. A target architecture was developed that profited their business.”

The relation between orientation to collaboration and making added value explicit is expressed in the fifth proposition:

Proposition 5. *In a less collaborative organization architects explicitly delivering added value to the divisions has a stronger positive influence on the architects being accepted by division management than in a collaborative organization.*

Company E is the only case with an orientation to work focusing on results rather than processes. It exhibits one EA technique that seems related to this aspect: *transparency of the EA approach*, i.e. being able to keep explaining step by step how the EA has come into being and how it is going to be applied. The importance of this transparency might be caused by the fact that because of the lack of clearly defined processes, the organization cannot rely on such processes ensuring a correct result. At the same time, a result is only accepted if it is correct. An architect:

"The architecture must be a hundred percent correct. Because they are going to disseminate it completely. If you assert something, it must be correct."

By ensuring that the approach that leads to the result is transparent, the architects can gain people's trust in the result.

Proposition 6. *In a result oriented organization transparency of the EA development approach has a stronger positive influence on being accepted by division management than in a process oriented organization.*

8.7.2 Condition 2: Unity within EA practice

A second condition made necessary by autonomy, is preserving the unity within an EA practice that may be divided over many divisions and projects, answering to many managers. The data show that especially the less collaborative companies are challenged by this condition. Thus we see that company A successfully uses an architecture tool to share models among architects, while company B is still in the process of choosing such a tool. One of the architects in company A explains some of the benefits of the new tool:

"The shared use of [the architecture tool] is very useful. Registering models uniformly at one place. This enables me to see what others are doing, look at examples from others, it works as a tool for exchanging things. Works much better than searching for examples in PSA documents."

Company D successfully uses a registration tool to share best practices among architects. Companies C and E are collaborative organizations with the architects working closely together. Thus sharing a common methodology and experiences is fairly natural and firmly established. The lead architect in company C:

“An architect never does his job on his own. He always collaborates with others in the organization. There is a checklist whom to involve. Within the team ideas are exchanged.”

A, B and D have a greater diversity of architects that are spread over the organization, which makes sharing less a matter of course. A technical architect in company D mentions his difficulties in finding the right colleague:

“The scope of the architectural domains is not the same as the scope of the teams. That makes it difficult to find the right domain architect. The technical infrastructure department is large. The group of domain architects is very diverse.”

Hence the need for explicit measures. In other words, preserving unity within the EA practice is needed in all cases, but requires more effort where collaboration is less. One manifestation of this observation is that in the less collaborative cases instruments like a project start architecture document (PSA), are also seen as a means to ensure communication among architects. The PSA, which is an EA deliverable that is embedded in the development process, is a reason for the architects to come together and discuss the issues. As an architect in company D says:

“The PSA is a standard part of projects: business as usual. PSA is effective, looking for collaboration…”

And another architect about the PSA:

“Nowadays they are all involved from an early stage. Having sessions together.”

An architect in company A also praises the use of the PSA:

“Architecture in the development process is something we do well: first looking at how things are structured, discussions over the domains.”

Interesting, too, is that only the less collaborative cases employ architecture review boards that exist solely of architects. The fact that such a board is only found in these three cases may be related to the fact that in these three cases architecture is distributed over more architects at various positions in the organization, combined with the fact that these cases incline to working in isolation. Thus the board might be a means of getting architects with their different perspectives together and regard architectural issues in collaboration. Company C, too, employs an architecture review board, but this board contains not only architects, but primarily the information managers from the divisions. It is not used for discussing individual EA issues, but for overall monitoring and management. The finding that organizational culture influences the manner in which instruments are used in organizations has been established before. Alavi et al. (2005) find this effect in the deployment of knowledge management tools. This use of tools, architecture review boards and PSA's are manifestations of what Star and Griesemer (1989) term boundary objects (cf. Van Steenbergen and Brinkkemper 2009). This leads to:

Proposition 7. *In less collaborative organizations the use of certain techniques, like employing tools, installing architecture review boards and employing PSA's, will more often be directed to stimulating unity between architects than in a collaborative organization.*

Also related to preserving unity within the EA practice is the finding that two of the less collaborative cases, A and D, indicate a wish for more direction setting by EA. A business architect in company A would like more directions from the enterprise architects:

"I would like for the EA team to better communicate clear choices and for the business architects to receive more rules and directives to make decisions.[…] You don't want to make division boundary spanning decisions, but sometimes you are forced to."

Company B, which also has a less collaborative culture, however, does not mention direction setting. The explanation for this may be that B is more autonomous than A and D, and therefore concentrates more on the domain level instead of the corporate level. Which lessens the need for direction setting from corporate level. The lead architect in company B consciously allows the architects a lot of freedom in the domains:

"The architects have the explicit freedom to do their jobs from their own expertise. As long as they don't contradict each other."

We might conclude that explicit direction setting is especially needed in cases of working in isolation with autonomous divisions that, however, have some central directives put upon them. This conclusion supports research by Van Steenbergen and Brinkkemper (2009) into division of work among architects and the need for vertical integration by employing rules and directives.

Proposition 8. *In an autonomous organization having a central direction setting EA has a stronger positive influence on architects being effective when the autonomy is bound by some central directives.*

8.7.3 Condition 3: Identification of synergy opportunities

The third EA condition that emerged from the techniques related to autonomy is identifying and enabling synergy opportunities between autonomous divisions or projects. The relation between autonomy and the need for explicit horizontal strategies to achieve synergy has been established before by Ensign (1998). Ensign defines two concepts as important to synergy: *interrelationships*, the sharing of resources or skills in activities that have relatedness and *horizontal strategy*, developing those interrelationships that create value to achieve competitive advantage. Horizontal strategies are concerned with creating value at corporate level, supporting coordination projects (including funding) and identifying interrelationships with the greatest potential for competitive advantage. Ensign also argues that achieving synergy is also much dependent on the individual actors and their concerns. Research in the health care area reveals that the combination of teamwork and professional autonomy is an enabler of achieving synergy (Rafferty et al. 2001).

We find that the two most autonomous organizations, B and C, share the techniques of having an independent EA budget and of independency of the architects. The relevance of an *EA budget* may be explained by the fact that it provides the EA team with a means to invest in searching for synergies. Divisions may not be inclined to pay for such investigations unless it is clear beforehand that they will benefit from them. An enterprise architect in company B explains how he goes about gaining the chance to investigate an opportunity for synergy:

"The first step is to get a budget from [the lead architect] to make a proposal. With this proposal we want to get the organization to invest a couple of hundred thousand to do a feasibility study. That must be paid by IT management. Architects do a lot of this kind of studies."

Besides, not having to pay for the architects lowers the threshold for divisions to engage the architects. The manager of the IT department in company C explains:

"Two years ago the internal recharge of expenses was abolished. That was a good move. The internal recharge was a big obstacle for the involvement of architects in projects. By abolishing this, the architects were first tolerated and then gradually appreciated."

This finding supports previous research where the impact of budget on achieving synergy is established (Aier and Schelp 2010; Ensign 1998; Hope Corbin and Mittelmark 2008), though others find only a limited influence of budget (Nakakawa et al. 2010). Strikingly, company E made the explicit choice to have the architecture initiatives being funded by the divisions. This was prompted by the idea that it forces the architects to add value for the business. This difference in choice may be contributed to the fact that E does not explicitly aim at identifying synergy opportunities, other than what emerges from the domains themselves, combined with the fact that E stresses the fact that the business owns the architecture. The findings lead to our ninth proposition:

Proposition 9. *In an autonomous organization having an independent EA budget has a stronger positive influence on achieving synergy between divisions than in a centralized organization.*

Independency of position, too, is important if architects want divisions to be open to synergies. Independency is mentioned as an important technique by B and C. Company E did not mention it explicitly as a good technique, but the importance of an independent attitude was mentioned by our contact. Divisions will be more inclined to cooperate if they trust the architects not to have a hidden agenda. Trust is mentioned by many researchers as an important ingredient to cooperation and alignment (Hope Corbin and Mittelmark 2008; Nakakawa et al. 2010; Rafferty et al. 2001). Company A, the fourth autonomous case, does not mention independency at all. This may be explained by the fact that in this company part of the architects are employed by the divisions, which mitigates the risk of the divisions not trusting the architects. The central architects do not directly deal with the divisions. This is different for C and E. Company B, which also dedicates architects to specific divisions, does mention the importance of independency, but on closer inspection another kind of independency is meant, i.e. independency in projects. An enterprise architect:

“The domain architect guides the project, but is no part of it, he has his own responsibility.”

Independency in projects is concerned with architects being in a hierarchical position to be able to meet their responsibilities rather than with exhibiting an independent attitude that engenders trust. We conclude that to achieve synergy, exhibiting an independent attitude is particularly important for staff architects dealing with divisions.

Proposition 10. *In an autonomous organization ensuring an independent attitude without hidden agendas has a stronger positive influence on achieving synergy between divisions when staff architects deal with divisions.*

Company D is the only case with a concentrated governance. It is also unique in the fact that EA has gained its own place in the strategic chain. EA is part of the chain from strategy, via information policy to information plans. The architects are collaborating with the information managers on an information plan for the next few years. It is a cooperation between business architects, IT architects and portfolio management. The fact that this activity is only found in company D may be explained by the fact that only in a centralized organization, there is a real sense of strategic chain, from central to de-central, where EA can hook into. If so, this can indeed be seen as an important step to achieving effectiveness. This is in line with the distinction Ensign (1998) makes between vertical organizations and horizontal or portfolio organizations. In vertical organizations, with a high degree of centralization, sharing is much more frequent, albeit one-directional. By aligning high in the chain, EA automatically rides on the existing governance structures of the organization.

Proposition 11. *In a centralized organization achieving a position in the strategic chain has a stronger positive influence on achieving synergy between divisions than in an autonomous organization.*

8.7.4 Condition 4: Deployment of EA

The final EA condition that emerged from the data is the deployment of EA. Investigating the techniques associated with *orientation to work* we find that these are mostly concerned with how EA is deployed in the organization. An example is the technique of *time boxing*, which is employed by company E. Time boxing is a good technique for E because with the focus on result, there will always be some aspects that the result can be improved upon. Without time boxing the EA might never see daylight and hence never be deployed. As a business analyst explains:

"The use of a strict timeline was good. Otherwise you keep on analyzing, it continues on and on. People can always think of a few more questions. At a certain moment in time you have to put an end to it."

The relation between time boxing and orientation to work is expressed in the following proposition:

Proposition 12. *In a result oriented organization employing time boxing has a stronger positive influence on the EA being actually deployed than in a process oriented organization.*

Deploying EA entails that projects conform to the architectural prescriptions. Four of the five cases mention EA being embedded in the organization and timely involvement of architects in projects, as important techniques, while the fifth case (A) mentions them as desired improvements. This indicates that the integration of EA in the existing organization, at the right points, is always important, regardless of culture. This is supported by Aier and Schelp (2010) who found in a multiple-case study that in all six cases they investigated, support of projects was a major success factor for EA. We might expect, however, that in a process oriented organization integration of the EA may be easier to achieve than in a result oriented organization, as in a process oriented organization there will be more processes implemented, for EA to hook into. In our study we find various ways of *integrating EA in the organizational processes*. Companies B and C, for instance, use the concept of a building permit or architecture certificate, i.e. an explicit permission for projects to move to the next stage in the development process, to ensure that architects are involved in projects. As one of the enterprise architects in company B put it:

"The building permit process […] ensures that the architects are involved right from the start, because that gives the projects more certainty that they will receive the building permit."

And in the words of one of the business architects:

"Working with permits is good, but in an indirect way. It works as a stimulant to involve architects."

Projects engage the architects at an early stage to ensure that they will be issued a permit later on. The use of such constructs is only really possible if well-defined development processes are in place. Company D indicates that having a transparent governance procedure in place, is an important technique. The manager of the information management department formulates it as follows:

"The operational governance is a best practice. The architecture review board. Strict procedures, clarity, you know who they are."

Again, this is closely related to a process approach to work. Company A mentions as a good technique the fact that there are points in the development processes that enable checking on the EA, for instance when a purchase order has to be issued. Interestingly, we find that in company E, which is the only result oriented case, EA is being used as a catalyst to move towards a more process oriented way of working. The manager of the IT department:

"Planning of IT is already much improved. Good information plans are being made en portfolio management is being implemented. Architecture gives a strong basis for portfolio management. Less difficult to make choices. The result is a more mature way of dealing with information systems."

In order for the EA processes to be implemented, the development processes must be well-defined.

Proposition 13. *In a process oriented organization hooking architecture into the existent development process like using building permits and reviews on natural moments in the development process, have a stronger positive influence on EA being actually deployed than in a result oriented organization.*

8.7.5 Overview of results

An overview of the propositions formulated in this section is presented in figure 8-4.

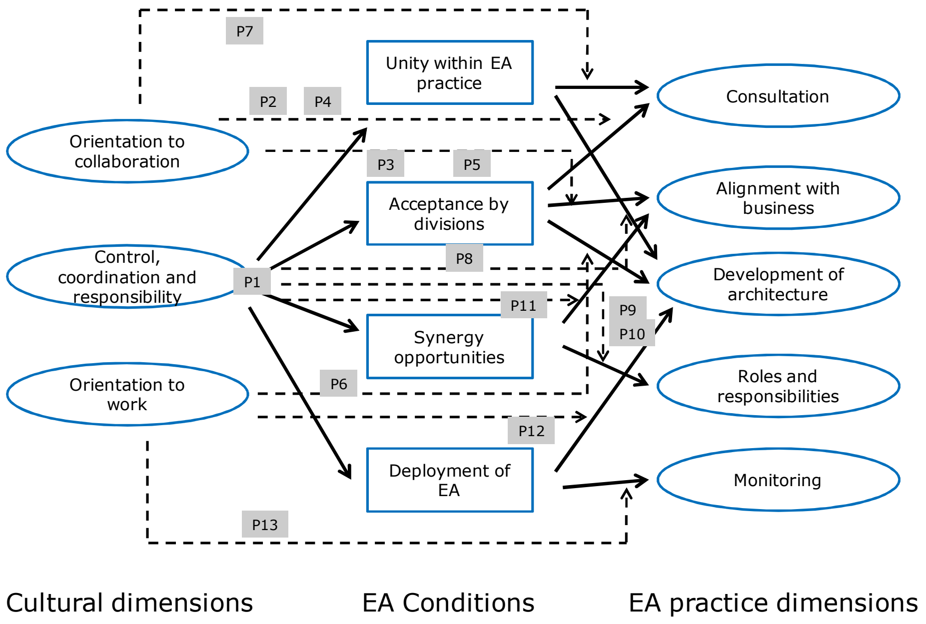

Figure 8-4: Propositions placed in Cultural Impact Model for EA

Summarizing, we have found that of the eight cultural dimensions distinguished in the framework of Detert et al. (2000), three account for the majority of patterns of EA techniques recognizable in the cases considered, i.e. the degree of autonomy within the organization, the attitude within the organization towards collaboration and whether the organization is more process oriented or result oriented. Of these three cultural dimensions, the degree of autonomy is special in the sense that it forces the architects to fulfill certain conditions, i.e. getting acceptance by division management, preserving unity in the EA practice, creating the opportunity to investigate potential synergies and ensuring deployment of EA throughout the organization. This specific impact of the degree of autonomy can be explained for a large part by the very nature of EA. EA is concerned with establishing coherence and consistency in decision-making throughout the organization and as such is susceptible to where the powers of decision-making lie within an organization. More surprising, perhaps, is the fact that cultural dimensions like basis of truth and rationality and nature of time horizon do not appear to have a clear impact. We did not find patterns of EA techniques associated with either dimension, though beforehand we expected them to have an impact, as the tension between short term and long term is often mentioned by architects, as well as the fact that the grounds for decision making often seem diffuse to them. This is a matter for further investigation.

8.8 Conclusions

In this paper we discuss the impact of organizational culture on EA practices. We investigated this impact by performing a multiple-case study among five financial institutions. We found that differences in organizational culture can indeed explain differences in the way EA practices are implemented. Furthermore, our study shows that three cultural dimensions in particular determine the implementation of EA practices: the amount of autonomy within an organization, the extent of collaboration found in the organization and the extent to which the organization is process or result oriented. We also found that to explain the influence of cultural dimensions on EA practices we needed a third construct, the EA condition. We combined these insights into a Cultural Impact Model. We formulated thirteen propositions reflecting the relations found between organizational culture and EA practice.

The emergence of the EA condition concept is interesting. Only when we recognized this concept in the data, were we able to build explanations around the relationships found in the cases between the cultural dimensions and the EA techniques used. It would be an interesting avenue for future research to investigate whether the applicability of the Cultural Impact Model can be extended to other IS domains such as business intelligence, IT governance or business process management.

Most of the EA techniques that emerged from the data can be found in the existing EA and IS research literature. What we contribute to this is that we relate these EA techniques to specific circumstances in terms of cultural values. In this way we sharpen the knowledge about the circumstances under which these EA techniques manifest themselves in organizations.

There are some limitations to our study. First of all, five of the eight cultural values were not equally divided over the cases, i.e. motivation, orientation to change, orientation to work, control, coordination and responsibility, and external focus. We mitigated this by looking for relative position on a six-scale instead of for a clear-cut yes or no. Secondly, all case studies are subject to the risk of bias (as indeed do empirical studies). We addressed this risk in two ways. First of all, we interviewed not only architects, but also various stakeholders of EA. Secondly, we kept going back to the validated case study reports as well as to the original interview notes while formulating our propositions. The third limitation is the difference in size among the cases. The two collaborative companies are smaller than the three isolated companies. Thus some effects might be attributable to size instead of collaboration. This does not emerge, however, from the analysis of the cases. If anything, we might accept that in smaller organizations collaboration is easier to generate than in larger organizations.

Our study has several implications for practitioners. First of all, it suggests that when tuning their EA practices to organizational culture, architects should focus on the three cultural dimensions that emerge from our study as having the most impact on the EA practice. Thus, when developing their approach on how to implement EA, they should establish the degree of autonomy, the measure of collaborative intent and the importance of processes in their organization and base their tactics on the outcomes. Secondly, the propositions formulated indicate for a number of EA techniques the cultural context in which these techniques might be effective, and conversely the context in which they might be less effective. For example, the combination of propositions 2 and 5 indicates that, where in a collaborative organization extensive communication about the purpose and underlying rationale of EA may be very effective, in less collaborative organizations this is not enough and architects should focus on making explicit the specific added value EA provides to the different parties in the organization.

Chapter 9

Achieving enterprise architecture Benefits: what makes the difference?

Enterprise Architecture (EA) is rapidly becoming an established discipline. However, this does not mean that the practice of EA is already fully standardized. Practitioners as well as researchers report various techniques being used in the EA practice. And although EA has various potential benefits, evidence of real benefits is only just emerging. This paper presents empirical evidence of the relations between EA techniques used and EA benefits perceived, as well as the influence of contextual factors. The evidence is based on the results of a survey (n=293) held among both architects and stakeholders of EA in a wide variety of organizations. Employing multivariate regression analysis we found that the combination of project compliance, EA choices being explicitly linked to business goals and organized knowledge exchange between architects is a strong predictor for EA being perceived as a good instrument. We also established that significant differences exist in EA practice effectiveness between different economic sectors. Government appears to reap less benefits from EA than other sectors. The empirical evidence furthermore shows only a small influence of organizational size and number of architects on EA effectiveness[1].

9.1 Introduction

Enterprise Architecture (EA) is rapidly becoming an established discipline. As the field is maturing, studies into its practices and benefits are starting to appear. Various benefits of EA are mentioned in the literature (Boh and Yellin 2007;

[1] This work was recently submitted for publication.

Gregor et al. 2007; Morganwalp and Sage 2004; Niemi 2006). Various techniques used to achieve these benefits are also mentioned (Boh and Yellin 2007; Foorthuis and Brinkkemper 2008; Nakakawa et al. 2010; Slot et al. 2009; Van Steenbergen and Brinkkemper 2009; Wagter et al. 2005). The research on EA techniques and benefits, however, is rather fragmented. A need for hypothesis testing on the direct relation between EA techniques and EA benefits, taking contextual factors into account, has been identified by several authors (Boh and Yellin 2007; Kappelman et al. 2008; Niemi 2006). This paper aims to contribute to addressing this need by conducting various statistical analyses on empirical data. Thus, we aim to answer the following main research question in this paper:

What EA techniques contribute most to achieving EA benefits and what is the impact of contextual factors on the EA practice?

We divide our main question into the following three research questions:

1. What EA techniques contribute to what EA benefits?
2. To what extent are EA techniques and benefits contingent upon economic sector?
3. To what extent are EA techniques and benefits contingent upon organizational size and number of architects?

This paper is the second in a series of studies based on an extensive set of empirical data derived from a survey among both architects and stakeholders of EA from a broad spectrum of organizations.

In section 9.2 we present the theoretical background and justification of our research. Section 9.3 discusses the research approach. In section 9.4 the research results are presented. In section 9.5, we discuss conclusions and suggestions for further research.

9.2 Theoretical Background

As mentioned in the introduction, various EA techniques and EA benefits are reported by different authors. Benefits of EA mentioned in the literature are better management of IT resources (Boh and Yellin 2007; Morganwalp and Sage 2004), cost reduction, reduction of development time, application and data integration (Morganwalp and Sage 2004; Niemi 2006), change management and risk management (Niemi 2006) and business – IT alignment (Gregor et al. 2007; Morganwalp and Sage 2004; Niemi 2006). EA techniques used to achieve these benefits mentioned are deploying key architecture roles, involving key stakeholders, institutionalizing monitoring processes and centralizing IT decision making (Boh and Yellin 2007; Nakakawa et al. 2010), translating general EA directives to project specific situations in so-called Project Start Architecture (PSA) documents (Foorthuis and Brinkkemper 2008; Wagter et al. 2005), providing assistance to projects (Foorthuis and Brinkkemper 2008; Slot et al. 2009) and creating an active community for EA knowledge exchange (Van Steenbergen and Brinkkemper 2009). The exact relation between all these techniques and benefits is still not fully established, however, as for instance reported by Boucharas et al. (2010) on the basis of an extensive literature review. In addition, the influence of contextual factors has not received much attention yet.

In this paper we test the hypothesis that the extent to which particular EA techniques are used is positively correlated with the extent to which particular EA benefits are experienced by the organization.

In accordance with Niemi (2006) and Kappelman et al. (2008) we will also take the influence of contextual factors into account. Though there are several indications that the approach to EA an organization takes is dependent on contextual factors, there is still much to be investigated into what these contextual factors are. Riege and Aier (2009) present three contingency factors, i.e. adoption of advanced architectural design paradigms and modeling capabilities, deployment and monitoring of EA data and services, and organizational penetration of EA. Winter et al. (2010) indicate that many organizations feel the need to adapt EA approaches to their situation, but do not provide answers as to what factors cause this need.

We investigate the influence of two types of contextual factors, economic sector and organizational size in terms of number of employees and number of architects. The influence of industry characteristics on various organizational functions or performance has been found before in other areas like human resource management (Datta et al. 2005), internationalization (Boter and Holmquist 1996) and diversification, size and divisionalization (Keats and Hitt 1988). The literature on the influence of organizational size is less clear. Studies by Keats and Hitt (1988) indicate that size does not play an important role in organizational performance. Aier and Schelp (2010) mention size of company as a potentially relevant contextual factor, but do not elaborate on this. Van Steenbergen et al. (2009) indicate that when the number of architects becomes large, knowledge integration becomes an issue (Van Steenbergen and Brinkkemper 2009), which suggests that size may play some role.

In this paper we test the hypotheses that both economic sector and organizational size influence the EA techniques used and the EA benefits experienced.

9.3 Research Approach

To answer the research questions formulated in the introduction, we used data from a survey study among a wide spectrum of organizations in the Netherlands. The survey was held among all stakeholders of EA, not only architects. This ensured that different perspectives on EA are represented in the response, not only that of the architects developing or applying the EA, but also of other employees being confronted with EA. Besides, both internal employees and external consultants were addressed. Potential respondents were approached primarily by email. As no register exists of the target population, use was made of contacts of some IT providers. In addition the survey was announced on a number of relevant sites and at several practitioner conferences. As our unit of analysis is the employee dealing with EA, more than one respondent per organization was allowed. This allowed for obtaining information from different perspectives (developers of EA and users of EA) and levels (organization level and project level).

The survey was presented as an online survey. It existed of three parts. The first part consisted of a number of factual questions like sector and size of the organization, number of architects and focus of EA, i.e. business and information or applications and infrastructure, or both. The second part asked about the extent to which specific EA techniques are used in the organization. The third part of the survey asked about the benefits experienced from EA which might be either benefits for the organization as a whole or benefits for projects and about the actual use of EA in the sense of whether projects actually conform to the EA and whether the EA prescriptions are clear and precise. The techniques and benefits asked about were derived from the EA literature. The questions regarding EA techniques and EA benefits were mostly presented with a 5-point scale ranging from e.g. *Very poor* to *Very good*. Respondents were also allowed the option of choosing a *No answer* category. The online survey was accessible to respondents from October 2009 till May 2010. A total of 293 valid responses was received. The responses came from a wide variety of organizations and economic sectors (table 9-1).

Table 9-1: Distribution of respondents across economic sectors (based on ISIC Rev.4)

Economic Sector		**Number of respondents**	**Percentage of respondents**
Govern-ment		91	31.1
Finance		89	30.4
Other	Education and research	5	1.7
	Energy & water supply and waste management	15	5.1
	Health and social work	8	2.7
	Trade, transportation, hotel, catering, real estate and other services	30	10.2
	Manufacturing and construction	16	5.5
	Information, communication, entertainment and recreation	36	12.3
	Agriculture	3	1.0
Total		**293**	**100.0**

The sectors best represented among the respondents are finance and government. This is as expected. The financial sector is a very IT-intensive sector that has been employing enterprise architecture for more than a decade now. The large response from the government sector can be related back to the increasing interest of the Netherlands Government in enterprise architecture which is related to a government-wide e-government program. The use of EA has been propagated by central government for a couple of years now. All in all the respondents seem to present a good representation of organizations employing EA. This is supported by the fact that the distribution of respondents over economic sector found in our survey is largely similar with distributions found in other surveys in the field of EA like Bucher et al. (2006) and Obitz and Babu K (2009).

For analysis of the data we used SPSS 17. Apart from simple descriptive statistics, we used a number of statistical techniques. To study whether statistically significant differences exist between economic sectors and between organizations of different size, we used chi-square tests. To build a model of the combination of EA techniques that best predicts EA effectiveness, we used a two-step approach. Firstly we used ordinal association (using Spearman’s rho) to find whether associations exist between individual EA techniques and the various EA benefits. Based partly on the results of this, we next used multivariate logistic regression to build a model of EA techniques combined. In all analyses we applied a significance threshold of p-value = 0.05.

9.4 Research Results

9.4.1 EA techniques contributing to achieving EA benefits

To answer our first research question, “What EA techniques contribute to what EA benefits?”, we took a two-step approach. We started with investigating whether associations exist between the EA techniques used on the one hand and the EA benefits perceived on the other hand. We did so by measuring ordinal association (using Spearman’s rho), between the EA techniques and each of the EA benefits.

Techniques asked about are whether the EA is formally approved by management (T1), the choices made in the EA are explicitly linked to the business goals of the enterprise as a whole (T2), management propagates the importance of EA (T3), projects are being explicitly assessed on their degree of compliance with EA (T4), knowledge is being exchanged in an organized manner between different types of architects (for instance enterprise, domain, project, software and infrastructure architects) (T5), knowledge is being exchanged in an organized manner between architects and other employees participating in projects that have to conform to EA (for instance instance enterprise architects or change managers helping a project to make a new design conform the EA) (T6), assistance is being offered in order to stimulate conformance to EA (for instance enterprise architects or change managers helping a project to make a new design conform the EA) (T7), projects make use of a Project Start Architecture (PSA) (T8), document templates are being used to stimulate conformance to EA (for instance templates that focus attention to the EA by asking for specific information) (T9) and financial rewards and disincentives are being used in order to stimulate conformance to EA (for instance by paying the IT costs of a project when the result is designed and built conform the EA or by imposing penalties in case of deviations from the EA) (T10).

With regard to the organization-wide benefits, respondents were asked whether EA turned out to be a good instrument to accomplish enterprise-wide goals instead of (possibly contradictory) local optimizations (B1), achieve an optimal fit between IT and the business processes it supports (B2), provide insight into the complexity of the organization (B3), control the complexity of the organization (B4), integrate, standardize and/or deduplicate related processes and systems (B5), control costs (B6), enable the organization to respond to changes in the outside world in an agile fashion (B7), co-operate with other organizations effectively and efficiently (B8), depict a clear image of the desired future situation (B9), enable different stakeholders to communicate with each other effectively (B10) and whether EA, in general, turns out to be a good instrument (B11).

Table 9-2 shows the results. It shows for each EA technique and each EA benefit the strength of the association in terms of Spearman’s rho and the significance of the association in terms of the p-value. A strength higher than 0.250 is underlined. An association that is not significant (p-value larger than 0.05) is printed in italics. An association with a p-value larger than 0.01 but smaller than 0.05 is marked with an *. All other associations have a p-value < 0.01.

Table 9-2: Association between EA techniques and EA benefits.

	B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**	**B11**
T1	*0.078*	*0.087*	*0.070*	*0.120*	*0.074*	*0.046*	*0.015*	*0.056*	*0.043*	*0.106*	*0.113*
T2	0.407	0.367	0.226	0.283	0.318	0.191	0.267	0.219	0.249	0.213	0.388
T3	0.347	0.302	0.126*	0.307	0.340	0.212	0.285	0.272	0.248	0.178	0.371
T4	0.344	0.285	0.202	0.193	0.330	0.275	0.277	0.210	0.258	0.282	0.401
T5	0.393	0.378	0.190	0.177	0.269	*0.186*	0.264	0.271	0.305	0.307	0.331
T6	0.336	0.349	0.193	0.232	0.297	0.140*	0.338	0.245	0.308	0.251	0.389
T7	0.372	0.236	0.207	0.307	0.249	0.273	0.253	0.199	0.252	0.216	0.333
T8	0.171	*0.087*	0.167	*0.062*	0.122*	0.140*	0.134*	*0.011*	0.140*	0.146*	0.141*
T9	0.143*	0.171	0.151*	*0.110*	0.134*	0.158*	*0.085*	*0.083*	0.132*	0.218	0.227
T10	*0.101*	*0.060*	*-0.006*	*0.116*	*0.061*	0.146*	*0.001*	0.161*	*0.024*	*0.084*	*0.046*

All EA techniques appear to have significant associations with at least some EA benefits, except for the EA being formally approved or not (T1). Three techniques, however, show markedly fewer and weaker associations: financial incentives (T10), using a PSA (T8) and using document templates (T9). The weak influence of the PSA (a document drafted at the start of a project, translating the EA prescriptions to the specific context of the project) is remarkable as the use of the PSA as a core EA governance document is widespread among the target population. In light of this widespread use, this outcome certainly warrants further investigation. It may be related to the struggle many organizations experience in precisely defining role and content of the PSA (Foorthuis et al. 2008). On the whole it seems as if formal techniques like using templates and getting formal approval are less effective than informal interactive measures like management propagating EA, providing assistance and organized knowledge exchange. The importance of informal aspects was also found by Aier and Schelp (2010). This may be related to EA still being a relatively young discipline.

Measuring ordinal associations as in table 9-2 shows the relations of the EA techniques to the EA benefits separately. The next step is to try and build a model combining various techniques, allowing also for the influence of contextual factors. To this end we conducted multivariate regression analysis. As the variables were measured on a five-point ordinal scale, we employed ordinal regression (cf. Chen and Hughes 2004; Weisburd and Britt 2007). Ordinal regression does not require a normal distribution or identical variance, but it does demand that the effects of the independent variables are constant across all categories of the dependent variable (the test of parallel slopes). Besides the EA techniques we also took into account the frequency of projects conforming to EA and the frequency of EA prescriptions being open to multiple interpretations.

After investigating a number of models, the model with T2, choices in EA are explicitly linked to business goals, and T5, knowledge exchange between various types of architects, together with project compliance, appeared to yield a good fit, giving a Nagelkerke R2 of 0.595. We applied the logit link function and combined the last two categories of the variable project conformance. We tested for the assumption of parallel lines, which was not violated (p-value of 0.774). Checking for the influence of contextual factors, we found that if we controlled for economic sector the strength of the prediction increases still a little to a Nagelkerke R2 of 0.606 (figure 9-1). The resulting model shows that a combination of project conformance with EA choices being explicitly linked to business goals and organized knowledge exchange between architects, strongly predicts EA being perceived as a good instrument.

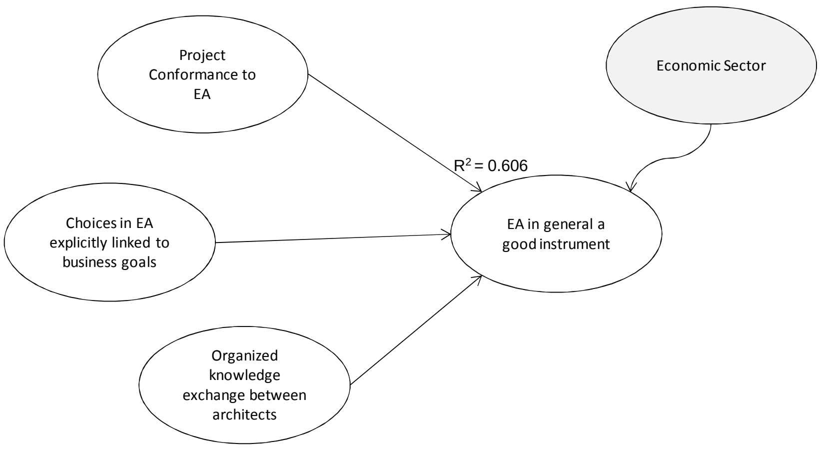

Figure 9-1: Empirical model for techniques contributing to EA being a good instrument.

The details of the model are given in figure 9-2. According to Garson (2010), for each variable at least one category must be significant. As the Sig. column shows, this is the case, with most variables having more than one significant category.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.
Threshold	[EAGoodInstrument= 1]	-25.952	3759.290	.000	1	.994
	[EAGoodInstrument = 2]	-6.565	.832	62.309	1	.000
	[EAGoodInstrument = 3]	-3.872	.741	27.265	1	.000
	[EAGoodInstrument = 4]	.377	.653	.333	1	.564
Location	[LinkBussGoals=2]	-2.677	.821	10.624	1	.001
	[LinkBussGoals =3]	-1.680	.544	9.544	1	.002
	[LinkBussGoals =4]	-.944	.483	3.817	1	.051
	[LinkBussGoals =5]	0[a]	.	.	0	.
	[KnowlExchArch=1]	-38.882	9090.909	.000	1	.997
	[KnowlExchArch =2]	-1.430	.717	3.975	1	.046
	[KnowlExchArch =3]	-1.548	.636	5.927	1	.015
	[KnowlExchArch =4]	-1.056	.607	3.025	1	.082
	[KnowlExchArch =5]	0[a]	.	.	0	.
	[ProjectsConform=2]	-2.641	.588	20.202	1	.000
	[ProjectsConform =3]	-1.434	.345	17.309	1	.000
	[ProjectsConform =4]	0[a]	.	.	0	.
	[Sector=1]	-.791	.374	4.471	1	.034
	[Sector=2]	-.328	.344	.906	1	.341
	[Sector=3]	0[a]	.	.	0	.

[a] This parameter is set to zero because it is redundant.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	304.354			
Final	141.371	162.983	11	.000

Link function: Logit.

Pseudo R-Square

Cox and Snell	.530
Nagelkerke	.606
McFadden	.364

Link function: Logit.

Figure 9-2: Ordinal regression model linking various factors to EA being a good instrument.

We might summarize the results by stating that the benefits of EA are most likely to be reaped if projects conform to an EA that is well-aligned: the architectural choices made in the EA are explicitly linked to the business goals (which may be seen as a form of business IT alignment) and the different viewpoints on the EA are shared by the architects developing and using it (internal consistency). It is the combination of quality of the EA with good governance that leads to effectiveness. The results also indicate that economic sector plays a role. This aspect is further investigated in the next section.

9.4.2 The influence of economic sector on EA practice and effectiveness

To answer our second research question, “To what extent are EA techniques and benefits contingent upon economic sector?”, we divided the respondents into three categories of economic sector: government, finance and all other sectors (see table 9-1). Next, we employed chi-square tests to see whether statistically significant differences exist between these three groups with regard to EA techniques used and EA benefits perceived. The results of these tests are shown in tables 9-3 and 9-4. Of the eleven possible EA benefits, seven were found to show significant differences between the sectors. Table 9-3 shows the percentages of respondents for each sector giving *Good* or *Very Good* as answer to the question whether EA is a good instrument to achieve specific benefits. The table also shows the number of non-responses and the p-value of a Pearson chi-square test with 2 degrees of freedom. In the table we included only the factors that exhibit a significant difference ($p < 0.05$).

Table 9-3: Differences in organizational benefits perceived between economic sectors

Perceived benefits for the organization	**Govern-ment: (very) good**	**Financials: (very) good**	**Other: (very) good**	**NR**	**p-value**
B1. Accomplish enterprise-wide goals, instead of (possibly conflicting) local optimizations	**41.0**	62.4	54.2	18	0.020
B2. Achieve an optimal fit between IT and the business processes it supports	**27.7**	47.0	51.4	22	0.003
B3. Provides insight into the complexity of the organization	**63.2**	78.2	79.8	10	0.018
B5. Integrate, standardize and/or undouble related processes and systems	**44.0**	58.6	62.3	16	0.034
B6. Control costs	**3.9**	17.1	17.6	32	0.014

B7. Enable the organization to respond to changes in the outside world in an agile fashion	**17.3**	34.1	24.5	28	0.045
B11. EA, in general, turns out to be a good instrument	**47.7**	65.1	68.5	13	0.008

As can be read from table 9-3, the respondents in government on the whole perceive less benefits from EA than in the other groups: for all EA benefits that show significant difference between sectors, the percentages *Good* or *Very good* are lowest in government. Somehow, government seems to experience difficulties in reaping the benefits from EA. This difference between government and the other economic sectors in benefits perceived cannot be fully explained by differences in the use of EA techniques (table 9-4).

Table 9-4: Differences in techniques used between economic sectors

Techniques	**Govern-ment: Freq./ always**	**Financials: Freq./ always**	**Other: Freq./ always**	**NR**	**p-value**
T4. Projects are being explicitly assessed on their degree of compliance with EA	46.2	**73.0**	58.7	4	0.001
T8. Projects make use of a PSA (Project Start Architecture)	47.1	**85.1**	41.0	14	0.000
T9. Document templates are being used to stimulate conformance to EA	37.6	**65.9**	47.2	12	0.001

Table 9-4 shows the percentages of respondents for each sector giving *Frequently* or *Always* as answer to the question whether specific EA techniques are being used in their organization. The table shows that government does not differ that much from the other non-financial sectors with respect to EA techniques used.

This suggests that other factors play a role. These factors may be related to project compliance, as government does score significantly lower on this aspect (table 9-5). In government projects comply with the EA less frequently than in the other sectors. This is consistent with the predictive power of project conformance with regard to EA being a good instrument as discussed in the previous section.

Table 9-5: Differences in use of EA between economic sectors

Use of EA	**Government: Freq./ always**	**Financials: Freq./ always**	**Other: Freq./ always**	**NR**	**p-value**
Projects that are required to conform to EA turn out to actually conform to the architectural principles, models and other prescriptions	**50.8**	71.6	70.0	56	0.015
Principles, models and other architectural prescriptions turn out to be open to multiple interpretations	**41.8**	31.0	**21.0**	30	0.011

Table 9-4 also shows that the financial sector scores higher on the more structural, formal techniques: assessing projects on compliance, using document templates to stimulate conformance and making use of the PSA. This might be related to the fact that the financial sector is especially subject to strict regulations and compliance rules, necessitating a formal governance. As far as project compliance is concerned, however, the financial sector is on a par with the other, non-government sectors (table 9-5). This suggests that these structural techniques alone are not decisive in achieving project conformance. This is supported by the fact that the category of ‘other’ sectors reports less frequently formal approval of the EA (69.2% versus 84.3% in government and 87.4% in finance), while still reporting comparable compliance percentages as the financial sector.

Taken together, the results of the comparison between sectors suggest that a differentiation in EA approach might be in order, where different sectors may require different approaches. Of course, this needs further investigation. It is worthwhile to investigate whether these differences can be related to underlying factors like organizational culture. This latter conjecture is supported by earlier studies (Chatman and Jehn 1994; Gordon 1991; Parker and Bradley 2000).

9.4.3 The influence of organizational size on EA practice and effectiveness

To answer our third research question, “To what extent are EA techniques and benefits contingent upon organizational size and number of architects?”, we conducted chi-square tests with respect to number of employees and number of architects. With regard to number of architects we distinguish between architects developing EA, i.e. enterprise and domain architects and architects applying EA in projects, i.e. project and software architects. For reasons of brevity, we will henceforth refer to the first group as enterprise architects and the second group as project architects.

As is to be expected the number of architects is related to the size of the organization. To test this hypothesis we performed chi-square tests on number of employees versus number of enterprise architects (figure 9-3) and on number of employees versus number of project architects (figure 9-4). The tables show the actual count as well as the count that would have been expected if number of employees and number of architects were totally unrelated. Both tests yielded a p-value of 0.000.

NumberOfEnterpriseArchitects * Size Crosstabulation

			Size			Total
			< 2000	2000-5000	> 5000	
NumberOfEnter-priseArchitects	<5	Count	65	43	32	140
		Expected Count	40.6	37.4	62.0	140.0
		% within SizeGroup	85.5%	61.4%	27.6%	53.4%
	6-20	Count	11	24	52	87
		Expected Count	25.2	23.2	38.5	87.0
		% within SizeGroup	14.5%	34.3%	44.8%	33.2%
	21-50	Count	0	2	19	21
		Expected Count	6.1	5.6	9.3	21.0
		% within SizeGroup	.0%	2.9%	16.4%	8.0%
	>50	Count	0	1	13	14
		Expected Count	4.1	3.7	6.2	14.0
		% within SizeGroup	.0%	1.4%	11.2%	5.3%
Total		Count	76	70	116	262
		Expected Count	76,0	70.0	116.0	262.0
		% within SizeGroup	100.0%	100.0%	100.0%	100.0%

Figure 9-3: Relation between organizational size and number of enterprise architects

Not surprisingly, the majority of organizations have up to 5 enterprise architects. In addition, a substantial portion of organizations with more than 2000 employees have between 6 and 20 enterprise architects. More than 20 enterprise architects is rare. As is to be expected, the numbers of project architects are on the whole higher than the number of enterprise architects and increasing with organizational size (figure 9-4).

NumberOfProjectArchitects * Size Crosstabulation

			Size			Total
			< 2000	2000-5000	> 5000	
NumberOfProjectArchitects	<5	Count	40	16	10	66
		Expected Count	18.9	17.9	29.2	66.0
		% within SizeGroup	55.6%	23.5%	9.0%	26.3%
	6-20	Count	26	33	27	86
		Expected Count	24.7	23.3	38.0	86.0
		% within SizeGroup	36.1%	48.5%	24.3%	34.3%
	21-50	Count	3	15	28	46
		Expected Count	13.2	12.5	20.3	46.0
		% within SizeGroup	4.2%	22.1%	25.2%	18.3%
	>50	Count	3	4	46	53
		Expected Count	15.2	14.4	23.4	53.0
		% within SizeGroup	4.2%	5.9%	41.4%	21.1%
Total		Count	72	68	111	251
		Expected Count	72.0	68.0	111.0	251.0
		% within SizeGroup	100.0%	100.0%	100.0%	100.0%

Figure 9-4: Relation between organizational size and number of project architects

To investigate the influence of number of employees, number of enterprise architects and number of project architects on EA practice and effectiveness, we again performed chi-square tests. Though we found some significant differences, we could not detect any strong patterns. Respondents from organizations of up to 2000 employees report less frequently the use of document templates (35.1% versus more than 50% for the other categories), respondents from organizations of 2000 to 5000 employees report more frequently that assistance is being offered in projects (57.3% versus less than 40%) and that projects having to conform to EA get initialized slower (65.6% versus less than 50%), and respondents from organizations of more than 5000 employees report more frequently that EA leads to standardization (63.6% versus around 50%).

Looking at the differences with regard to number of architects it is interesting to establish that the percentage of respondents from organizations with up to five project architects reporting benefits is slighter higher than of organizations with more project architects (table 9-6). This may be due to many factors like for instance the effect that with an increasing number of project architects the chance increases that they are not sufficiently educated (as they are frequently recruited from the population of analysts and designers that are not educated in EA), that they are more inclined to take over project work or that mutual alignment is more difficult.

Table 9-6: Differences in benefits between numbers of project architects

Number of project architects	<5	6-20	21-50	>50		
Perceived benefits for the organization	**(very) good**	**(very) good**	**(very) good**	**(very) good**	**NAR**	**p-value**
Achieve an optimal fit between IT and the business processes it supports	**52.5**	43.2	26.1	50.0	59	0.037
Provides insight into the complexity of the organization	**85.9**	66.3	83.0	80.8	47	0.020
Perceived benefits for projects	**(much) more often**	**(much) more often**	**(much) more often**	**(much) more often**	**NAR**	**p-value**
Deliver the desired functionality more often than projects that do not have to conform to EA	**66.7**	39.4	36.7	46.7	128	0.031
Perceived benefits for projects	**(much) quicker**	**(much) quicker**	**(much) quicker**	**(much) quicker**	**NAR**	**p-value**
Projects that have to conform to EA turn out to get initialized faster than projects that do not have to conform to EA.	**17.6**	2.8	15.0	14.3	95	0.041

Another difference that emerged from the data is that with an increase of architects an increase in the use of document templates is associated. This can be explained by the fact that document templates can function as a means of communication and alignment between architects (boundary objects, cf. Van Steenbergen and Brinkkemper 2009), which is of course needed more when the number of architects increases.

On the whole, however, we can state that, though there are a few significant differences, the relation between organizational structure and EA practice does not exhibit very strong patterns with regard to size of organization and number of architects.

9.5 Conclusions and Further Research

In this paper we investigated the question of what EA techniques contribute to what EA benefits and what is the impact of contextual factors on the EA practice. Analyzing the data of a survey study (n=293) utilizing various statistical techniques we found a number of interesting relations.

First of all, we found that the techniques strongest associated with EA benefits are choices in EA being explicitly linked to business goals, management propagation of architecture, assessment of projects on compliance with the EA, organized knowledge exchange among architects, organized knowledge exchange between architects and stakeholders and assistance being offered to projects. Formal approval of the EA, use of a PSA, use of document templates and use of financial incentives show much weaker associations or no significant association at all. It appears as if interactive measures are more effective than formal techniques. This may be related to the fact that EA is still a relatively young field where architects still have to prove their value to the organization.

Employing multivariate regression analysis we found that the combination of project compliance, EA choices being explicitly linked to business goals and organized knowledge exchange between architects is a strong predictor for EA being perceived as a good instrument. We conclude that EA effectiveness is best achieved by projects complying with an architecture that shows internal consistency and alignment between the various aspects of the organization.

We found a number of significant differences between economic sectors. Especially, respondents from government experience more difficulties in reaping the benefits of EA than respondents from the other sectors. Also, in government less projects comply with EA. The financial sector is distinguished from the other sectors by the more frequent use of structural, formal EA techniques. This may be related to the strict regulations the financial sector is subject to.

Finally, we found that organizational size and number of architects do not make a large difference for EA techniques used and EA benefits perceived. The few significant differences we found do not exhibit any strong patterns, though it is food for thought that an increase in number of project architects is slightly negatively associated with experiencing EA benefits.

There are some limitations to our research. Firstly, the survey asked for perceptions of the use of EA techniques and the benefits EA engenders. However, asking for perceptions in surveys is an established approach and has been found to lead to reliable results (Wall et al. 2004). Besides, responses represented different perspectives, both from EA developers and EA users, and from both an organization level and a project level. Secondly, the scope of the survey was limited to the Netherlands. In particular the results concerning the differences between economic sector may not be directly transferable to other countries. The fact that differences exist, however, is in our opinion also relevant outside the scope of the Netherlands.

Our research has several implications for practice. First of all, it provides an indication of what EA techniques to focus on, in order to reap the benefits of

EA. In addition, the relatively weak contribution of the use of the PSA to EA benefits merits a fresh reflection on the way this instrument is deployed in practice at the moment. The results concerning the difference between economic sector suggest that a variation in approach to EA according to economic sector is appropriate.

An interesting avenue for further research suggested by our results is the further investigation of the differences between economic sectors. How these differences can be explained and to what extent these differences are related to cultural differences are research questions that merit further study. The results concerning the influence of number of project architects on EA benefits indicates it may be worthwhile to investigate whether there is an optimum in number of architects, related to organizational size.

Part V

Conclusion

Chapter 10

Conclusion and Outlook

The main research question in this dissertation is:

MRQ: How can an enterprise architecture practice achieve effectiveness?

Underlying this question are three concepts we elaborated in the three main parts of this dissertation: EA effectiveness, EA maturity and EA context. We studied EA effectiveness and EA maturity by designing and formalizing the Architecture Effectiveness Model (AEM) and the Dynamic Architecture Maturity Matrix (DyAMM), using the research paradigm of design science. The behavioral-science paradigm was used to study the concept of EA context. In our study of the impact of EA context on the EA practice, we looked at organizational culture, organizational structure and economic sector. The study resulted in the Cultural Impact Model, a model of knowledge integration and an empirical model of the relation between EA techniques and EA benefits. In the following sections the findings of the research presented in this dissertation are related to these research questions.

10.1 Formalizing EA effectiveness

The first research question concerned EA effectiveness:

RQ1: How can the effectiveness of an EA practice be determined?

To answer this question the Architecture Effectiveness Model (AEM) was developed in the first part of this dissertation (chapters 2 and 3). EA effectiveness was defined as the degree to which the EA practice produces the desired results. The AEM makes this concept explicit by building a cause-effect network between having an EA practice and achieving the business goals of the organization. RQ1 was divided into two sub-questions.

SQ1.1: What constitutes EA effectiveness? Although much existing research focuses on EA effectiveness in financial terms, it was proposed that this is too limited a view of EA effectiveness. Instead EA effectiveness was operationalized as the degree to which the EA practice contributes to the organizational goals. By applying the AEM to three very different organizations, a financial institution, an institute of higher education and a municipality, it was shown that organizations differ in their goals and hence that the desired EA effects are situation dependent. Only in the AEM of the financial institution, explicit financial results , like reduced costs, increased income and profit, were included.

SQ1.2: In what way are EA practice activities related to organizational benefits? The application of the AEM to the three cases showed that it was feasible to establish the intended contribution of the EA practice to the organizational goals, by building an AEM with architects and other stakeholders of EA. By relating the results of EA activities to benefits for the organization, the AEM charts how the efforts of the EA practice should contribute to the achievement of the business goals. Participants in this exercise experienced the joint development of the AEM as very valuable. The AEM structured the discussion and stimulated the participants to be specific in expressing the EA contribution. The three cases suggest that the effect of EA on the organizational goals is indirect. EA practices can contribute to better organizational performance, which in turn contributes to the achievement of organizational goals. This indirectness may in part explain the difficulty that architects sometimes experience in expressing the value of their EA work. The AEM can also be used to set priorities concerning the EA activities and to define key performance indicators for the EA practice, in order to measure actual effectiveness.

10.2 Measuring the maturity of the EA practice

The second research question concerned the maturity of the EA practice.

RQ2: How can an EA practice grow in maturity?

In the second part of this dissertation, a Dynamic Architecture Maturity Matrix (DyAMM) was developed to assist practitioners in improving their EA practice (chapters 4, 5 and 6). The DyAMM distinguishes 18 focus areas that have to be implemented in a balanced manner to achieve a well-functioning EA practice. The DyAMM is an instantiation of a so-called focus area maturity model. Focus area maturity models are better suited to supporting incremental development of a functional domain than the better known fixed-level maturity models. RQ2 is divided into two sub-questions.

SQ2.1: How can an instrument be developed to guide the development of EA practices? The maturity of an EA practice can be determined by performing an assessment with the DyAMM. The DyAMM contains a questionnaire of 137 questions that when completed translates into an architecture profile for the organization. The architecture profile shows the strengths and weaknesses of the EA practice assessed. The DyAMM can be used not only for assessing the maturity of an EA practice, but also for setting priorities in further development of the EA practice. The positioning of the capabilities of the focus areas in a matrix provides a preferred implementation order of the focus areas. This implementation order has been validated by both case studies and statistical analysis. Improvement suggestions are associated with the capabilities to support practitioners in implementing them.

SQ2.2: What are the strengths and weaknesses of current EA practices? By collecting assessments performed in the period 2005-2008 a dataset of 56 assessments was assembled. By performing statistical analysis on this dataset common strengths and weaknesses were revealed. An interesting outcome is the observation that EA practices appear to be more involved in the execution of IS development projects than in business strategy formulation. This may be related to the fact that EA practices often originate from the IS/IT department. The involvement with projects, however, is mainly focused on the start-up phase of the project: the focus area of monitoring whether projects actually comply with the EA prescriptions scored very low among the 56 cases.

10.3 Shaping the practice of EA

The third research question concerned the impact of contextual factors.

RQ3: What is the impact of contextual factors on the EA practice?

Contextual factors definitely impact the EA practice, as is shown in the third part of the dissertation (chapters 7, 8 and 9). Three types of contextual factors were investigated: organizational culture, organizational structure and economic sector. This research question was broken down into three sub-questions.

SQ3.1: How does organizational culture impact the way the EA practice is implemented? In a theory-building comparative case study among five financial institutions three cultural dimensions were shown to lead to recognizable patterns in EA practice: the degree of autonomy of employees and divisions, the attitude towards collaboration and the extent of process versus result orientation. An important finding is also that the impact of cultural dimensions on EA practices seems to work indirectly. The degree of autonomy impacts the need for architects to meet certain conditions, i.e. getting acceptance by division management, ensuring unity within the EA practice, elaborating synergy opportunities and ensuring deployment of EA throughout the organization. The two cultural dimensions of orientation to collaboration and orientation to work impact the manner in which these four conditions are realized. This is generalized in a Cultural Impact Model. Thirteen hypotheses were formulated expressing relations between cultural dimensions and EA techniques.

SQ3.2: To what extent does organizational structure impact the way the EA practice is implemented? A survey among architects and EA stakeholders with a response rate of 293 valid responses revealed that organizational structure in terms of size (number of employees) does not have a direct correlation to EA techniques used or EA benefits perceived. An increase in number of project architects, however, correlated with slightly fewer respondents reporting EA benefits. A multiple case study revealed that where the number of architects increases, resulting in a certain amount of specialization among architects, the implementation of knowledge integration mechanisms to retain coherence and consistency among the architects is very important. This importance of knowledge integration is supported by the survey study, which showed that organized knowledge exchange between architects is a relatively strong predictor of EA being perceived a good instrument. Knowledge exchange becomes especially relevant at the tactical level, where EA is often divided into a number of domain architectures. Knowledge integration mechanisms that are most relevant to the EA practice are the use of rules and directives and group decision making and problem solving. Useful techniques to implement these mechanism are enabling interconnectedness and introducing boundary objects, as defined in sociology.

SQ3.3: To what extent does the economic sector impact the way the EA practice is implemented? The survey among architects and EA stakeholders revealed that the public government sector perceives fewer EA benefits than the financial sector and other economic sectors. In EA techniques used, however, government does not differ much from other economic sectors. The lack of EA benefits perceived might be explained, though, by the finding that projects in the government sector comply less frequently with the EA prescriptions. The financial sector appears to more frequently employ formal EA techniques like the use of instruments, than the other sectors. Why this is the case, has to be further investigated.

10.4 Contributions

The research presented makes three main contributions of both scientific and practical relevance.

Architecture Effectiveness Model. The AEM is an instrument that, by charting the relation between EA efforts and organizational goals, and attaching key performance indicators to related efforts, can be used in practice to support EA practices in setting course and priorities. The AEM provides insight into how EA can add value to a particular organization.

Since publication of the research described here, the AEM has been included in the toolkit of EA consultants. A guideline has been written regarding how to conduct a workshop to establish the AEM of a particular organization. The intention is to accumulate a substantial set of AEM’s that can be used for further analysis. It would be interesting to be able to generalize such a set of AEM’s to some kind of industrial branch models. Also, the underlying concept of the AEM has been recognized by practitioners as an instrument applicable to other functional domains like testing.

Dynamic Architecture Maturity Matrix. The DyAMM is an instrument to measure and improve EA maturity. It is based on the concept of the focus area maturity model, originally developed for the field of software testing. The DyAMM is thoroughly tested in practice and used by many organizations to focus their EA practice improvement efforts. In addition, by formalizing the underlying concept of the focus area maturity model and extending it with a focus area maturity model development method, we also contribute a generic instrument for investigating and developing new functional domains within IS.

The DyAMM is still being used extensively in EA management improvement programs. As the number of assessments executed with the DyAMM is still growing fast, it is hoped that a new dataset of sufficient size can be assembled to make it possible to compare EA practices from the period 2005 – 2007 with the period 2008-2010. This would provide insight into whether and where progression has been made in the field of EA. A program has also been started to actualize the DyAMM in a number of respects. Study will be made whether the positioning of the capabilities needs adjustment because of new developments in the field. Also, in addition to the current assessment questions, that were formulated for the purpose of being used by assessors, the assessment instrument will be extended with questions that are better tuned to use in a questionnaire. A possible future development is the construction of separate questionnaires for different stakeholder groups.

Cultural Impact Model. The Cultural Impact Model provides a handle on the study of the impact of organizational culture on the EA practice. It shows that of the eight cultural dimensions studied, three dimensions provide the main explanation for differences in EA techniques used. The Cultural Impact Model is of relevance both for focusing further research into EA effectiveness and for focusing the efforts of practitioners.

Taken together, the findings of this dissertation provide insight into what factors impact the choice of EA techniques used, to achieve the capabilities needed, for the EA practice to be effective in terms of contributing to the business goals. Key capabilities for the EA practice that are identified, are aligning the architectural choices with the business goals, monitoring whether projects keep complying with the architecture and knowledge exchange between architects. The cultural dimensions having the greatest impact on the way these capabilities are best achieved are the degree of autonomy in the organization, the attitude of the organization towards collaboration and whether the organization is process oriented or result oriented.

10.5 Implications, limitations and future work

Besides providing answers to the research questions, the research presented here has some additional implications. Several of the artifacts and theories developed in trying to understand the EA practice, may have applicability outside the domain of EA. The structure of the AEM can be easily translated to other functional domains like testing or quality management. Likewise, the concept of focus area maturity models can be, and is, applied to other functional domains. Finally, it is worth investigating whether the tripartite structure of the Cultural Impact Model is also valid for other IS functions. Thus, while fulfilling the purpose of studying the domain of EA, we built instrumentation that may be applied to the study of other functional domains as well. We think it would be worthwhile to further develop this instrumentation in an integrated approach for researchers to study functional domains.

A theme that emerges from the work done here, is the importance of interaction among architects. Where the number of architects increases, fragmentation of the EA becomes a real threat and communication between architects becomes an important issue. In organizations where collaboration is not a cultural value, instruments may acquire the additional purpose of supporting this communication. A case in point is the Project Start Architecture document (PSA). Intended as an instrument to bridge the gap between the often high-level enterprise-wide rules and directions and the very specific choices a project is confronted with, in some organizations the PSA is most appreciated for its role in stimulating communication among architects. Likewise, the architecture review board, intended as a governance instrument, in some organizations functions additionally as a platform for communication among architects. These examples illustrate a tendency to match available instruments to experienced needs, even if these instruments are not originally designed for these needs. An interesting avenue of research might be to study in more depth the actual application of EA instruments as a means to identify underlying gaps in the existing EA methodologies and instrumentation.

The statistical analysis of the dataset of 56 DyAMM assessments reveals a number of weaknesses, notably monitoring projects on compliance and aligning the choices made in the EA with the business strategy and goals. This is a worrying result as the survey study conducted reveals that monitoring projects and relating EA choices to business goals are determining factors in achieving EA benefits. Further study into the origins of these common weaknesses is not only scientifically interesting, but has high practical relevance as well.

It is evident from the work presented in this dissertation that contextual factors impact the EA practice. The research also presents various handles to deal with these factors, like the AEM and the theories on cultural values and on knowledge integration among architects. How these various types of contextual factors interact, however, and the precise nature of the impact of economic sector, is still to be explored further. A next step would be to integrate and extend the present results into a situational approach to achieving EA effectiveness. First priority in developing this approach should lie with addressing the common weaknesses of the current EA practices revealed in this research.

The research presented in this dissertation has a number of limitations. Though the DyAMM has been applied in several countries, both in Europe and in the USA, the other case studies and the survey are conducted only in the Netherlands. So far, we cannot be sure that the results can be transferred to other countries.

The main research question was deliberately formulated as a relatively broad question. This was motivated by the fact that the knowledge about the EA practice is still very limited. Also, the EA discipline is a very diverse discipline. It was felt that there was a need for studying EA effectiveness in a comprehensive way, looking at it from several perspectives. The trade off for this broad set up is that a number of aspects are only yet touched upon. Thus, until now, the AEM and the Cultural Impact Model are applied to a limited number of cases. Further confirmation of these models is needed. Also, the differences found between economic sectors in the survey conducted, merit further investigation as to the underlying causes. The research into knowledge integration, too, leads to further questions regarding the use of boundary objects and the feasibility of routine mechanisms in the field of EA.

Though EA research belongs to the field of IS research, the work presented in this dissertation profited much from the use of theories from other research disciplines. Especially where shaping the EA practice was concerned, concepts from organizational theory as well as sociology contributed much to the understanding of the phenomena observed. We think our research is an example of the fruitfulness of crossing disciplinary boundaries and would like to argue for more multi-disciplinary research.

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Appendix

This appendix shows the EA techniques that emerged from the case study described in chapter 8. It is the result of step 5b1 of the theory-building process. The techniques in italics denote techniques that are not implemented, but mentioned as being desirable in one or more interviews. The labels for the techniques are the labels used in the case study reports. Techniques that are similar, are placed in one row. In the first column a generic label for these techniques is given. The techniques are ordered according to the EA practice dimensions development of architecture, use of architecture, alignment with business, roles and responsibilities, monitoring and consultation.

Table A-1: EA technique table.

Common technique	Company A	Company B	Company C	Company D	Company E
Development of architecture					
Architecture known		Architecture known			
To the point architecture			Just enough architecture	*To the point architecture*	
Position architects		Business and enterprise architects in same department	Business consultants and architects in same department	Business architects in separate department	
Architecture concepts	Concepts: domains, layers, services				
Level of architecture development					Starting at domain level
Sharing knowledge	Use common tool	*Common body of knowledge*		Registration of best practices	
Alignment with client perspective			Alignment with client perspective		Alignment with business perspective
Insight				As-is landscapes	

Common technique	Company A	Company B	Company C	Company D	Company E
Transparant approach					Clear and transparent approach
Monitoring market developments			Presentations of market developments		Platform for monitoring market developments
Workshops	Workshops with business		PSA workshops	PSA workshops	
Involvement organization					Organization involved in architecture development
Multidisciplinary architecture development	*Common multi-disciplinary architecture development*				
Attention to costs				Attention to cost	
Time boxing					Time boxing
Securing architecture					*Securing architecture*
Use of architecture					
Boundary object	Architecture framework PSA as means of communi-cation BIP				
Realism		Fitting ambition level			
Architecture embedded	*Architecture embedded in business*	Domain teams	Architecture process embedded in organization	Architecture embedded in organization	Architecture embedded in professional-ization
Setting direction	*Unity in rules and directives* *PSA embedded in architecture rules and directives*			*Coherence in architecture* *Setting direction with architecture*	
Expertise		Expertise	Expertise	Collaborative thinking from overview	

Common technique	Company A	Company B	Company C	Company D	Company E
Architecture as quality attribute			Architecture as quality attribute		
Maintenance under architecture					*Maintenance under architecture*
Alignment with business					
Added value	Added value to business	Business case	Working from a supportive perspective	*Alignment with business needs*	
Architecture as part of strategic chain				Architecture as part of strategic chain	
Pro-activity		*Pro-activity*	*Pro-activity*	*Pro-activity*	
Ownership with business			Business responsible		Business accountable
Roles and responsibilities					
Transparency in process	*Simple and transparent approval process*			Transparent governance *Clear responsibili-ties*	Clarity in responsibili-ties
Independency		Architect independent role in project	Trust		
alignment architecture domains	*Alignment architecture domains and responsibili-ties*	*Alignment architecture domains with organization model*			Alignment architecture domains with organization model
Architect close to decision making		Architect in MT			
Formal decision making					Formal decision making
Benefits for generic solutions		Benefits for generic solutions			
Architecture budget		Architecture budget as catalyst	Architecture budget		
Monitoring					
Principles	Architecture principles				

Common technique	**Company A**	**Company B**	**Company C**	**Company D**	**Company E**
Building permit		Building permit	Architecture certificate		
timely involvement	*Architect remains actively involved in project*	Architecture definition document	Fitting involvement in projects	Early involvement *Continued involvement*	Involvement with specialists
Check on natural moments	Check on natural moments				
Check in architecture board	Check on project in architecture board				
Joint process development	Joint architecture process development				
Translation to design					Translation to design
Escalation			Escalation		
Consultation					
Collaboration	Collaborating on a common goal			Architecture community	
Common methodology				Common methods	Common methodology
Education	Architecture academy	Architecture course			
One team	*Operating as one team*				
Information exchange		Architecture content meeting			
Visibility			Visibility		Extensive communica-tion

Summary

Because of the need for continuous change, many organizations face an increasing complexity in their information systems portfolio. This increase in complexity leads to high IT costs, difficulties in ensuring reliability of data and in data sharing, and lack of flexibility in offering products and services to customers. One of the answers to this increase in complexity, which has become widely accepted, is the introduction of enterprise architecture (EA): the development and application of a consistent set of principles and models to guide the design and realization of processes, information systems and technological infrastructure from a holistic perspective. The application of a holistic view is expected to make complexity manageable and to prevent further increase in complexity, thereby freeing much needed resources for development and innovation. For this promise to be made true, however, sound EA practices have to be in place. This means that EA processes are to be implemented, responsibilities assigned, rules of conduct agreed upon, deliverables defined and employees educated. Though organizations are becoming progressively aware that they need EA to manage the complexity of their processes and IS, there are still many questions to be answered as to how to implement and maintain an effective EA practice. This research aims to contribute to the knowledge about how to achieve an effective EA practice.

First of all, the research focuses on how to determine the effectiveness of an EA practice. Effectiveness of an EA practice is defined as the extent to which the EA practice contributes to the achievement of the business goals of the organization. Using a design-science research approach, a model is developed with which organizations can chart the intended contribution of their EA practice to their business goals. The model can be used by organizations to set coherent priorities for their EA practice and to define key performance indicators for measuring its effectiveness.

Once it is determined how an EA practice can contribute to the realization of the business goals, the next question to be answered is how the activities, responsibilities and actors concerned with defining and applying EA can be developed to achieve this desired contribution. To answer this question a maturity model for EA practices is presented. The maturity model is used to assess EA practices and subsequently define improvement paths. Application of the maturity model to 56 organizations provides insight into the common strengths and weaknesses of EA practices in general. This may help focus future research efforts. Besides applying the maturity model to the domain of EA, its underlying structure is precisely defined and described making it also applicable for other researchers and other functional domains.

As EA aims to guide the design of processes, information systems and technical infrastructure from an enterprise-wide point of view, many stakeholders are involved. Therefore, it is important that the EA practice is fully integrated in the organization. This suggests that organizational factors like organizational culture and size may influence the techniques architects can use to achieve effectiveness. By using both case studies and statistical analysis of survey data the impact of such contextual factors is investigated. From the case studies it appears that especially the cultural dimensions of central control versus autonomy, extent of collaboration, and process or result orientation, influence the use of EA application techniques. Case studies also show the importance of interaction between architects, especially at the domain or tactical level. The survey shows that EA techniques used and EA benefits experienced differ among economic sectors.

This dissertation looks at the EA practice from several perspectives, thus extending the overall knowledge about the use of EA in practice. It provides both instruments for developing the EA practice, like the architecture effectiveness model and the architecture maturity model, and insights in the influence of contextual factors. Practitioners can use the results to better focus their EA efforts. Researchers can use the results to better understand the field of EA, but also to study other functional domains.

Nederlandse Samenvatting

Door de noodzaak van continue aanpassingen, hebben veel organisaties te maken met een toenemende complexiteit in hun informatievoorziening. Deze toenemende complexiteit leidt tot hoge IT kosten, problemen bij het garanderen van de betrouwbaarheid van gegevens en bij het uitwisselen van gegevens, en gebrek aan flexibiliteit in het aanbieden van nieuwe producten en diensten aan klanten. Een inmiddels breed geaccepteerd antwoord op deze toenemende complexiteit, is de introductie van enterprise architectuur (EA): het opstellen en toepassen van een consistente verzameling principes en modellen die richting geven aan ontwerp en realisatie van de processen, informatiesystemen en technische infrastructuur vanuit een overkoepelend perspectief. De verwachting is dat de toepassing van de door EA geleverde holistische blik complexiteit beheersbaar maakt en verdere toename in complexiteit voorkomt. Waardoor middelen vrijkomen voor nieuwe ontwikkelingen en innovatie. Om deze belofte waar te maken is er wel een goed werkende EA functie nodig. Dit betekent dat EA processen moeten worden ingericht, verantwoordelijkheden worden belegd, werkwijzen en gedragsregels worden afgesproken, op te leveren producten bepaald en medewerkers opgeleid. En hoewel organisaties zich steeds meer bewust worden van de noodzaak van EA om de complexiteit van hun processen en informatievoorziening te kunnen beheersen, zijn er nog veel vragen over hoe een effectieve EA functie kan worden geïmplementeerd en onderhouden. Het onderzoek in dit proefschrift wil bijdragen aan de kennis over hoe een effectieve EA functie bereikt kan worden.

Om te beginnen, richt het onderzoek zich op de vraag hoe de effectiviteit van een EA functie kan worden vastgesteld. De effectiviteit van een EA functie wordt gedefinieerd als de mate waarin de EA functie bijdraagt aan het bereiken van de bedrijfsdoelstellingen van de organisatie. Gebruikmakend van een design-science benadering, is een model ontwikkeld waarmee organisaties in kaart kunnen brengen wat de beoogde bijdrage is van hun EA functie aan de bedrijfsdoelen. Het model kan door organisaties gebruikt worden om op een samenhangende wijze prioriteiten te stellen voor de EA functie en om prestatie indicatoren te definiëren waarmee de effectiviteit kan worden gemeten.

Als bepaald is hoe een EA functie kan bijdragen aan de realisatie van de businessdoelen, is de volgende vraag hoe de activiteiten, verantwoordelijkheden en spelers betrokken bij het ontwikkelen en toepassen van de EA zich kunnen ontwikkelen om de gewenste bijdrage te kunnen leveren. Om deze vraag te beantwoorden is er een volwassenheidsmodel voor EA ontwikkeld. Het volwassenheidsmodel is gebruikt om EA functies te evalueren en op basis daarvan verbetertrajecten te definiëren. Toepassing van het volwassenheidsmodel op 56 organisaties geeft inzicht in de sterkten en zwakten van EA functies in het algemeen. Dit kan gebruikt worden om toekomstige onderzoeksinspanningen te richten. Het volwassenheidsmodel is niet alleen toegepast op het terrein van EA, maar de onderliggende structuur is precies gedefinieerd en beschreven zodat het ook gebruikt kan worden door andere onderzoekers en voor andere functionele domeinen.

Aangezien EA richting geeft aan de processen, informatiesystemen en technische infrastructuur van de gehele organisatie, raakt het veel partijen in de organisatie. Daarom is het belangrijk dat de EA functie goed is geïntegreerd in de organisatie. Dit suggereert dat organisatorische factoren als organisatiecultuur en omvang mede bepalen welke werkwijzen architecten het best kunnen gebruiken om effectief te zijn. Met behulp van zowel case studies als statistische analyse van survey data is de invloed van dergelijke omgevingsfactoren onderzocht. De case studies laten zien dat met name de culturele dimensies met betrekking tot mate van autonomie, mate van samenwerking, en of de organisatie proces- of resultaatgericht is, het gebruik van specifieke EA werkwijzen beïnvloeden. Case studies laten ook het belang zien van interactie tussen architecten, met name op het domein- of tactische niveau. De survey laat zien dat er verschillen zijn tussen economische sectoren met betrekking tot de EA werkwijzen die gebruikt worden en de voordelen van EA die men ervaart.

Door de EA functie vanuit verschillende invalshoeken te bekijken, vergroot dit proefschrift de algehele kennis over EA in de praktijk. Het levert zowel instrumenten om de EA functie te verbeteren, zoals het architectuur effectiviteitsmodel en het architectuur volwassenheidsmodel, als inzichten in de invloed van omgevingsfactoren. Architecten in de praktijk kunnen de resultaten gebruiken om betere focus aan te brengen in hun EA inspanningen. Onderzoekers kunnen de resultaten gebruiken om het domein van EA beter te begrijpen, maar ook om andere functionele domeinen te bestuderen.

Curriculum Vitae

Marlies van Steenbergen was born on May 16, 1962 in The Netherlands. From 1980 to 1987 she studied Linguistics (Generative Grammar) at the University of Groningen. After graduating Cum Laude she started work at the Dr. Neher Laboratory of KPN, moving after six years to the Telecom division of KPN. At the Dr. Neher Laboratory she worked on the topics of Natural Language Processing and Knowledge-Based Systems. During her years at KPN Telecom she studied Technical Informatics at Delft University of Technology, graduating in 2000. In the same year she changed jobs to Sogeti Netherlands, where she is still employed as principle consultant enterprise architecture. In the year 2006 she started to work on her PhD research at Utrecht University. She successfully finished her PhD research in 2011.

The main research areas of Marlies van Steenbergen are the practice of enterprise architecture, maturity models and the impact of organizational culture. She has co-written a number of books on enterprise architecture and provides training, coaching and workshops in this area.