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published in
Proceedings 26th International Conference on Software Engineering (ICSE 2004)
2004

document version
Publisher's PDF, also known as Version of record

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Abstract

Based on interviews with a number of architects and managers from a wide range of organizations, we characterize how architecture is perceived in practice. We identify three groups of organizations that differ with respect to their level of architectural thinking and the alignment of business and IT on architectural issues. Analysis of the interviews further indicates that these three groups differ in the architecture aspects and critical success factors they emphasize. Our results provide a starting point for assessing architecture maturity and alignment within organizations, and can be used to help harmonize different architectural tunes played within organizations.

1 Introduction

The business community has been using architecture in the context of a wide range of organizational and technological problems, from building large software and information systems to abstracting complex organizational situations. This diversity in use easily results in incomprehension and misunderstandings between different architecture users, for example between business management and the IT department of an organization.

The software engineering community has spent much time trying to define software architecture. Though there is a plethora of definitions around (see [2] for a compilation), these definitions do have a lot in common. Other architecture disciplines, however, like infrastructure and business architecture, show less consensus. For instance, there is a large variety in the types of information included in architecture frameworks [9]. Also, little research is done on the practical perception of architecture and problems encountered when applying it.

The objective of our research is to get a better idea of how architecture is perceived in practice by various organizations, mostly large organizations like banks, insurance companies, but also government agencies and supplying parties like consulting firms and IT vendors. Our hypothesis is that different organizations have a different perspective on what architecture entails. These differences manifest themselves in different architectural issues being emphasized.

This is an exploratory study, based on 41 semi-structured interviews with architects and managers, conducted at 27 different organizations within the Netherlands. Using these data, we characterize how architecture is seen in practice. We do so by applying Grounded Theory. This results in the identification of three key aspects of architecture, and three critical success factors for applying architecture. The key aspects identified are that architecture is: a means of abstraction, a means of communication, and a management instrument. The key critical success factors are: the need for acceptance of organizational changes, the availability of effective means, and the proper usage of architecture.

We next characterize the organizations with respect to their level of architectural thinking and the alignment of business and IT on architectural issues, and visualize the results in our Architecture Alignment Model. This visualization allows us to identify and characterize different types of organization with respect to architecture maturity and alignment. These types of organization turn out to also differ considerably in the architecture aspects and critical success factors they emphasize.

In a few organizations where we interviewed more than one person, these persons voiced quite different issues and concerns. In many organizations also, we interviewed one person only. So, the views expressed need not reflect those of the whole organization, but might only hold for the organizational unit whose representatives we happened to have interviewed. Since architecture affects not only the IT department, but cuts across the whole organization, it is important that different views on what architecture is and what it is good for be understood and bridged. Only then will architecture mature and truely become successful. Viewed

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this way, our results provide a starting point for assessing architecture maturity and alignment within organizations, and can be used to help harmonize different architectural tunes played within an organization.

This paper is organized as follows. In the next section we describe the data that our research is based on. In section 3 we apply Grounded Theory to discern the major issues that accrue from the set of interview data. In section 4, we introduce our Architecture Alignment Model and use this model to characterize the organizations interviewed. In section 5, we analyse the differences in perception of the major issues between different types of organization. Section 6 discusses related work, and section 7 contains our concluding remarks.

2 Data Collection

Our analysis is based on interview data that were gathered during a course in software architecture in the fall of 2002. The general aim of the course was to let the students get acquainted with software architecture as it was perceived and applied across organizations in the Netherlands. The students had to interview practitioners (software architects, enterprise architects, project managers and the like) from a variety of organizations. In total, 27 different companies were visited, ranging from industrial and government organizations to banks, IT vendors and consulting firms. 28 master level students (computer science as well as business informatics) enrolled in the course.

After a general introduction in software and business architecture, the students received a training in interview techniques. Since the focus of the course was to get an inventory of how architecture is perceived in practice, we used semi-structured interviews, so that unknown architecture-related topics would not be excluded. Semi-structured interviews are an accepted method for filling the dataset in Grounded Theory (see section 3). To make sure certain topics were addressed, we spent several meetings to get consensus on a set of topics to be addressed in the course of each interview. This set of topics was:

- The working situation and role of the interviewee
- The use of architecture within the company
- The role of an architect within the company
- The methods and techniques used for composing an architecture
- The personal experience of the interviewee with architecture

The 14 pairs of students were each given three persons to interview. One interview had to be cancelled because of time constraints. The analysis thus is based on 41 interviews.

The interviewees were selected by the course supervisors using their contacts. Most of the interviewees were knowledgeable in the field of architecture, had attended workshops on the topic, the national architecture conference, or similar meetings. The students prepared a report of each interview. These reports were in many cases – though not always – sent to the interviewee for approval. The reports varied in length from a mere two to over five pages.

The students of course were inexperienced in the field. This is in itself not a problem. Grounded Theory prefers interviewers that are not very experienced, because they need to set aside, as much as possible, theoretical ideas and notions, so that the analytic, substantive theory can emerge [3]. Experts as interviewer are more likely to directly analyze the observations during the interviews, which will influence the resulting theory. The variability between the interviewers is partly mitigated by the effort taken to get a consensus on topics to be addressed, but cannot be fully ruled out.

3 Applying Grounded Theory

While going through the interviews, the frequency with which two issues recurred in the interviews – aspects of architecture, and critical factors for successfully using architecture – caught our attention. In order to further underpin this observation, we applied Grounded Theory. The Grounded Theory method is a qualitative approach to inductively distil theory from a dataset [8], [7]. This approach is not fit to test an existing hypothesis, but provides a method for emerging a theory from collected data. The basic idea of Grounded Theory is to read and reread some textual database, and iteratively 'discover' and label a set of concepts and their interrelationships. Next, these findings are compared with existing theory from the field.

In our case, we started with two concepts: aspects of architecture, and critical success factors for using architecture. These concepts were selected as core categories. We used these core categories to bring structure in and reduce the enormous amount of data. For each core category we constructed a tree structure with subcategories, sub-subcategories, etc.

While going through all the interview notes, the trees slowly expanded. During this growth stage of both trees, a new category was added to the tree in question whenever a new topic was mentioned. Whenever an existing category was mentioned in an interview, the name of the interviewee was linked to that category. This way, we were able to count the number of occurrences of each category in the set of interview notes. These numbers are later used to analyze differences between groups of organizations and the concepts they emphasize.

After several iterations over the set of interview notes, both tree structures stabilized. We interpret the contents of

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Means of Abstraction	Business	Vision, mission and strategy Organization Processes Information needs
	Alignment	—
	IT	Strategy Requirements Application portfolio Coupling of components Infrastructure
Means of communication	Explain something Give advice Exchange ideas	
	Stakeholder communication	Intern (inside the organization) Extern (outside the organization)
Management instrument	Knowledge	Methods and techniques Solutions
	Development process	Rules Guidelines Principles
	Planning Decision Making Quality Control Audit Consistency Constraints	

Figure 1. Tree with Architecture Aspects

both tree structures below. In section 5, we discuss how the attention paid to the various concepts differs between the clusters of organizations identified.

3.1 Aspects of architecture

The tree of aspects of architecture that we encountered in the data is depicted in figure 1. In the following, we give our interpretation of the contents of the various subtrees of the aspects category and relate this to existing views in the field. Overall, the aspects encountered match existing literature pretty well.

3.1.1 Means of Abstraction

Large organizations often have difficulties organizing their complex internal and external situations. By abstracting reality in models and descriptions, architecture has an important role in organizing and structuring these complex situations [4], [1]. In abstracting reality, architecture focuses on three areas:

1. the business situation (business architecture),
2. the use of information systems facilitating the business situation (IT architecture),
3. the alignment of the information systems to the business goals.

A business architecture gives a description of the organizational goals, particularized in the vision and mission statement, the business strategy, and the information an organization requires to reach its goals. The IT architecture describes the IT goals to help the organization reach its information requirements, and the strategy for meeting these IT goals. It also gives an overview of the present and future information systems and the infrastructure for being able to reach the IT goals, together with the planning for their development [1].

Aligning the information provision of IT systems with the information requirements and business goals of an organization — also called business-IT alignment — is one of the main goals architecture tries to achieve [11], [20].

Our findings indicate that at present relatively little is known about how to realize alignment, since this category does not have any subcategories, meaning that our respondents did not articulate more detailed information about what alignment entails, or how to achieve it. Yet, alignment is generally considered an important issue [17].

3.1.2 Means of Communication

Clear communication between technicians and business experts is critical for business and IT alignment. Without clear communication, they cannot exchange ideas or come to unambiguous requirements. By abstracting a complex situation in models and descriptions, it becomes more manage-

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able. This improves communication and the decision making process. Architectural models and descriptions form a central reference point; they act as a contract between stakeholders [4].

3.1.3 Management Instrument

Large organizations often have no central strategy for implementing the desired information systems and meeting the organizational information requirements. Information systems are developed piece by piece, which results in systems that do not fit together and are not able to interoperate. Architecture provides a central strategy and a long-term planning of all information system development projects. Structuring the information system development process and making it more efficient, is a problem in many organizations. Architecture structures this development process by prescribing rules and guidelines [1].

By managing development knowledge and experience, architecture enables the reuse of knowledge from the past. This makes it possible to develop information systems in less time and against lower costs, making the development process more efficient.

3.2 Critical Success Factors

The success of using architecture depends on a lot of factors. We again applied Grounded Theory to our set of 41 interviews to determine which factors are most important in making architecture work in practice. From this analysis, it appears successful use of architecture mainly depends on the following three factors:

1. acceptance of organizational changes initiated by architecture,
2. availability of effective means, and
3. proper usage of architecture.

The tree of topics related to success factors is depicted in figure 2.

3.2.1 Acceptance of Architecture-Driven Changes

Changes initiated by the use of architecture generally affect the entire organization, especially its employees. Full acceptance of all organizational changes is important in making successful use of architecture. The acceptance of changes through architecture has many similarities with Kotter's eight stage process to achieve successful change [15]. As a change process, architecture is not all that different from other change processes.

3.2.2 Availability of Effective Means

The interviewees consider skilled architects more important than effective methods. A good method can be misused by a bad architect. Architects should have practical experience and have knowledge about the problem domain. Also, communicative and social skills are important in spreading architectural knowledge, and explaining the urgency of architecture within an organization [12, Ch. 12].

Although skilled architects are important, they should also have effective tools at hand: methods that fit the specific requirements and situation of a company. These methods should not constrain the architect in his work and creativity. The architectural models and descriptions an architects produces, should be understandable and unambiguously interpretable by all stakeholders [14]. It is also important that these models and descriptions are practical, easily translatable to the practice of software development and implementation. Otherwise the architecture will exclusively be used by the architects.

3.2.3 Proper Usage of Architecture

Architecture is a means which should be used properly. Often, a lot of time is spent on finding the best methods and modeling languages, which takes the attention away from the real purpose of architecture. This way architecture becomes a goal, though it should be used as a means. Another threat is to focus too much on getting positive results on the short term. This is important in convincing board-room members that the use of architecture pays off, but could make an organization loose track of its long term concerns.

In order to perform their tasks properly, architects should not be subordinate to project managers who have to defend the planning and budget of individual information system development projects. If this happens, the quality improvement of information systems — one of main goals of architecture — will likely not be achieved.

Standardizing architecture methods, descriptions, and terminology within an organization is important in improving the adjustment of different projects to each other, and making sure information systems fit together, and into the entire architecture. By making decisions about interfaces, security, the integration with legacy systems, usability, and maintenance, this central architecture makes the entire set of information systems within an organization interoperate properly [1].

4 Architecture Alignment Model

The amount of data available calls for a compact visualization of the results. We looked for a simple visualization that would highlight the differences in architecture maturity

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Acceptance of architecture-driven changes	Create and explain urgency of changes	
	Involve leading parties	Management
		Authorized to make changes
	Vision and strategy	Develop it
		Communicate it
	Create support	Amongst developers
		Amongst users
	Make results visible Cost decrease	Short term Long term
	Let architecture evolve	
	Anchor architecture	In development process
		In management process
		In innovation process
	Anticipate future changes	
Effective means	Architects	Knowledge
		Skills
		Responsibilities
		Qualities
	Methods & techniques	Practice-oriented
		Situational
		Top-down and bottom-up
		Prescriptive
		Widely usable
		Reasonable costs
	Architecture (models and descriptions)	Comprehensible
		Satisfy requirements
		Based on standards
		Complete
Proper usage	Room for creativity	
	Maintain architecture	
	Focus on	Alignment
		Quality
		Not just cost reduction
		Simplicity through abstraction
		Long term
		Contents
	View on architecture	More than just description
		Prescriptive, not descriptive
		Inter-organizational
		Means, not a goal in itself
		Management instrument
	Deployment	Not in small projects
		Only when needed
		Only for what it's for
		On all organizational levels
	Responsibilities	Assign properly
		State clearly
	Centralize	Terminology
		Architecture methodology
	Account for	User requirements
		Legacy systems
		Modifiability, flexibility
		Security
		Standardization
		Maintainability

Figure 2. Tree with Critical success factors

of all the organizations visited. Wagter et al [19] describes one such model, where the level of architectural thinking is contrasted with organizational embedding; see figure 3.

Although these two aspects are important, this representation ignores an important aspect that struck us in the interviews. The origin of the 'architecture lobby' within an organization turned out to play an important role. An organization where architecture awareness originates with business

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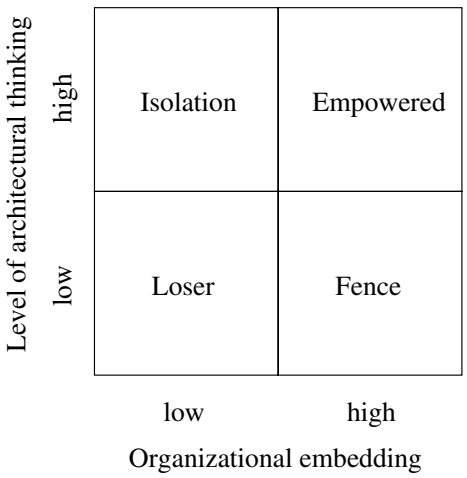

Figure 3. A simple architecture maturity model

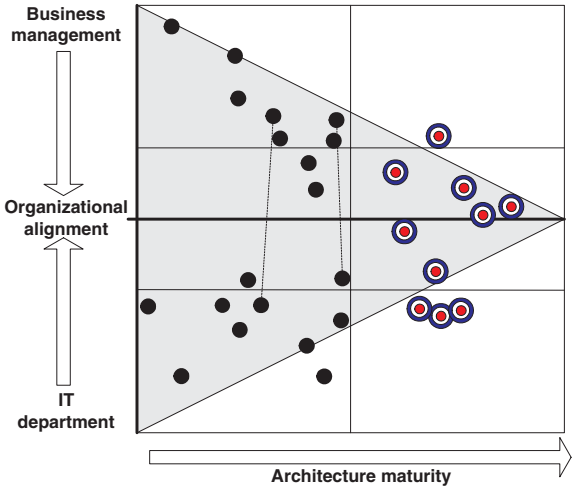

Figure 4. The Architecture Alignment Model

management has different ideas about architecture and faces different problems than an organization where architecture awareness starts in the IT-department. We visualized these differences in our Architecture Alignment Model; see figure 4. This model not only visualizes architecture maturity, but also the alignment of business and IT on architectural issues.

The Architecture Alignment Model relates architecture maturity on the horizontal axis with organizational alignment on the vertical axis. It is important to note that the vertical optimum is at the midpoint of the axis. Only fully aligned organizations will appear on the middle 'horizon' of this model. In organizations which are positioned above this horizon, architecture awareness started from business management, while architecture awareness originated with the IT-department in those organizations that are positioned below the horizon. The optimum of this model is the middle-right point. Here, full alignment is combined with a high level of architecture maturity. The shaded triangle in the model represents an area in which almost all interviewed organizations are positioned; apparently some sort of growth path can be defined. We construe that architecture awareness originates from either the business or the IT-department, with no alignment yet. When architecture maturity increases, alignment becomes more important, and organizations get 'on the move' towards the point that indicates full alignment and architecture maturity.

All 27 organizations are positioned in the model in figure 4. Two of the authors independently did so. We did not have objective measures to rate organizations with respect to their level of architectural thinking or alignment. We assessed them based on our global impression as it accrued from the interview notes. The differences between the assessments were minor; one of the authors consistently assessed the level of architectural thinking a bit higher than the other. Most organizations are represented by a single dot in figure 4, indicating that we interviewed one person from that organization, or a few persons that told a similar story. Two (big) organizations are represented by two dots, one above and one below the middle horizon; in figure 4 these dots are connected by a dotted line. Apparently, different tunes are being played by different units within these organizations.

The y-axis depicts organizational alignment. Organizations where employees see architecture as being imposed by business management make up the business management segment of this axis. Business management uses architecture to give structure to the organization, emphasizing the business aspects of architecture. They have difficulties convincing employees of the benefits of architecture. The other extreme on this axis is the type of company where the awareness of architecture starts at the IT department, which uses architecture to structure the development process and the information systems it produces, focusing on the IT aspects of architecture. The IT department has difficulties convincing the business management to use architecture. The middle point of this axis represents the type of company where the focus of architecture lies evenly on the IT and business aspects, resulting in the alignment of business and IT goals.

The x-axis depicts architecture maturity. Architecture has many aspects which are meant to solve various business and IT problems. Companies using only one or a few aspects of architecture have a low maturity level. They often use certain architecture aspects separately and uncon-

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sciously to address specific problems. When the number of architecture aspects being used increases, companies start to realize they should be connected, which shifts their focus to making it a unity. Also they try to spread the use of architecture to other parts of the company. These companies make up the middle segment of the maturity axis in our model. The companies where the full range of architecture aspects forms a unity and is being used company wide, have the highest level of maturity.

What strikes most in figure 4 is that there seem to be three obvious clusters: there are clearly discernable groups of organizations where architecture awareness starts with either business management or the IT department. And there is a third group which runs in front of the herd. This latter group turned out to contain all IT service providers we interviewed. The latter are indicated by a $\odot$.

5 Comparative Analysis

The three main groups of organizations distinguished in section 4 each have a different perspective on architecture. Each group emphasizes certain aspects and critical succes factors. To determine those emphases, we counted the number of times the different aspects and critical success factors for the respective groups of organizations as identified in figure 4 are mentioned in the interviews. Our assumption is that a higher frequency implies more emphasis. See figures 5 and 6. The analysis below is based on these numbers, as well as on the number of times subordinate nodes in the respective trees are mentioned.

5.1 Aspects

IT service providers emphasize architecture as a means of abstraction. They do not pay much attention to the communication and management aspects. The two user groups, with their use of architecture originating from either business management or the IT department, mainly emphasize architecture as being a management instrument and to a slightly lesser extent its abstraction aspect.

5.1.1 Means of Abstraction

The IT service providers emphasize the abstraction aspect of architecture most often. They give attention to abstracting both the business and IT parts of an organization. This is often part of the architectural framework they advocate. The two groups where architecture awareness started with business management or the IT department mainly focus on abstracting the business and IT part of the organization, respectively.

5.1.2 Means of Communication

It is striking that communication, essential for realizing business and IT alignment, is mentioned least often by all three groups. This is especially so for organizations where architecture awareness has its origin in business management.

5.1.3 Management Instrument

Organizations where the use of architecture has its origin with business management emphasize the management aspects of architecture predominantly. They want to make the organization, and its complex internal and external situation, more controllable and manageable. The group where architecture has its origin in the IT department tries to make the software development process, and the information systems they develop, more manageable by using architecture.

5.2 Critical Success Factors

Service providers and organizations where architecture has its origin in the IT department have much in common where it comes to mentioning the critical factors for successfully reaching the goals set for using architecture. See figure 6. Organizations where architecture has its origin with business management differ predominantly in that they put more emphasis on change management as opposed to the availability of effective means.

5.2.1 Acceptance of Architecture-Driven Changes

Organizations where the use of architecture started with business management emphasize the acceptance of organizational changes. They have to make the results of using architecture visible to themselves and to the employees that depend on these changing circumstances. Firstly, to ensure themselves architecture is reaching its goals. Secondly, to convince the rest of the organization architecture does work, which improves the support of the company policy by the employees.

Regarding acceptance of architecture-driven changes, IT service providers differ from the other two groups. They less often mention the forming of a leading coalition to carry through changes. On the other hand, they indicate the importance of composing and communicating a vision and strategy for implementing an architecture more often than the other two groups. This is probably because they want to differentiate themselves from competing IT service providers through their vision and strategy for using architecture.

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	awareness with business	awareness with ICT	IT service providers
total # of occurrences	42	86	81
means of abstraction	43%	41%	60%
means of communication	7%	15%	15%
management instrument	50%	44%	25%

Figure 5. Number of occurrences of different aspects for different groups of organizations

	awareness with business	awareness with ICT	IT service providers
total # of occurrences	64	124	114
architecture-driven changes	42%	24%	23%
effective means	27%	38%	40%
proper usage	31%	38%	37%

Figure 6. Number of occurrences of different critical success factors for different groups of organizations

5.2.2 Availability of Effective Means

IT service providers and organizations where the origin of using architecture is with the IT department emphasize the availability of proper means, such as architects and architecture methods. This is not surprising, since they are responsible for composing the architecture. Organizations where the origin of architecture is with business management find it less important to have skilled architects at their disposal. They instead emphasize the comprehensibility of architectural models and descriptions, for it is their job to make sure their ideas and decisions are properly reflected in these models and descriptions.

5.2.3 Proper Usage of Architecture

Overall, the different user groups put the same emphasis on the proper use of architecture. IT service providers and organizations in which the use of architecture started at the IT department emphasize that the quality of information systems should not be subordinate to budget and planning issues of the development projects that realize those systems. Those two groups are responsible for composing the architecture and ensuring its quality. Because of this responsibility, these two groups also point out that an organization should focus on the long term benefits of architecture, like improving quality and alignment. Also, the technical aspects of architecting information systems — their interfaces, security, integration with legacy systems, usability, maintainability, and adaptability — is very important to them.

6 Related Work

Overall, there is very little research that addresses the practice of applying architecture in organizations.

Grinter [10] focuses on the work of the architect in the telecom domain, and highlights the communicational and political skills required of such persons. Architecture as a means of abstraction is mentioned, architecture as a management instrument is relatively absent. Managing change is mentioned as one of the core elements of the architect's work.

Kruchten [16] also focuses on the work of the architect, based on his own extensive experiences. He also stresses the communicational aspect. As traps and pitfalls, he mentions issues like lack of authority, ivory tower, and procrastination, which well fit our success factor termed 'effective means'.

Beznosov [5] discusses practical problems of architecture, based on results reported on in the literature. This research focuses on differences between practitioners and researchers in developing architectures and not between different groups of practitioners.

Smolander [18] discusses four metaphors of architecture as he found them in different organizations. These metaphors, and their relation to our findings, are:

- architecture as blueprint, which fits our category "means of abstraction",
- architecture as literature, which fits our category "means of communication",

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- architecture as language, which also fits that category, and
- architecture as decision, which fits our category "management instrument".

The architecture as literature metaphor emphasizes documentation for future readers, whereas the architecture as language metaphor emphasizes understanding of the present. There thus is a big consensus between these metaphors and our major architecture aspects.

7 Concluding Remarks

In this paper, we analyze a set of 41 interviews with architects and managers from a variety of organizations in the Netherlands. We applied Grounded Theory to determine the major aspects and critical success factors of architecture as they accrue from these interviews. These match existing literature well.

We positioned all organizations in a two-dimensional model, thus visualizing architecture maturity and the alignment of business and IT on architectural issues. From this model, we observe that there are three obvious clusters of organizations:

- organizations where architecture awareness starts with the business,
- organizations where architecture awareness starts with the IT department, and
- IT service providers.

This latter group seems to run in front of the herd, where it comes to alignment and architecture maturity. Apparently, it is easier to preach the gospel than to actually sing it. A kind of IST and SOLL situation, where it is as yet unclear whose SOLL situation it is.

Interesting observations can be made when we analyze how the different clusters of organizations stress the major aspects and critical success factors:

- IT service providers emphasize architecture as a means of abstraction, and pay less attention to communication and management aspects.
- The groups where architecture awareness starts with either business management or the IT department, emphasize architecture being a management instrument.
- IT service providers and organizations where architecture has its origin in the IT department emphasize the availability of proper means, such as architects and architecture methods.
- Organizations where architecture has its origin with business management stress the importance of change management.

There is a potential bias in our study. We may distinguish people-oriented and task-oriented leadership styles [6]. In organizations in the Netherlands (and, e.g., also in Scandinavia), the prevalent leadership style is people-oriented. This means employees in the Netherlands can participate more in decision-making and management than employees in other countries, like for instance the US [13]. To realize changes in an organization in the Netherlands, the majority of the employees need to accept them. So the acceptance of architecture-driven changes is an important issue, quite likely more so than in some other countries.

Our results provide a means to assess organizations with respect to their architecture maturity and alignment. The classification as presented in this paper is still rather subjective, and the instrument needs considerable refinement. The global separation into three distinct clusters has a merit of its own, especially where it comes to the differences between those clusters. Assessing different units within an organization that have a stake in architecture using this model may help harmonize different architectural tunes being played. We are currently developing and testing a questionnaire for that purpose.

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Proceedings of the 26th International Conference on Software Engineering (ICSE'04)
0270-5257/04 $20.00 © 2004 **IEEE**