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Representation, Assessment and Improvement of Information Systems Architecture

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ABSTRACT

This paper presents an alignment model for IS-architecture work that integrates previously separate lines of work. The model explains what it means to group IS-architecture elements into IS-architecture areas and thereby offers a systematic way to generate alternative future IS-architecture solutions. This aids IS-architecture work in several ways and offers possibilities for automated tool support. A major benefit is that the grouping principles used in the alignment model can act as high-level principles for IS-architecture evolution in the long term. The alignment model is embedded in a comprehensive methodology that also offers a representation framework, a position, a method and a modelling tool for IS-architecture work. The methodology results from several years of case and theory studies, tool development, industrial projects and consulting.

INTRODUCTION

Enterprises today have numerous computer-supported information systems in place. Each information system consists of one or several applications and other software systems, often including one or more databases. The information systems are related in many ways, e.g., they exchange data, store the same types of data and support the same types of operations. When the totality of information systems in an enterprise and the relations between them are not managed properly, a wide variety of problems occur, making it necessary to consider the *information systems (IS) architecture* of the enterprise as a phenomenon in its own right, where an IS architecture can be loosely defined as "the set of computerised ISs in an enterprise as well as the computerised communication paths between them. In a wider sense, [IS-architectures are] also related to human information systems and communication, as well as infrastructural and organisational issues" (Andersen and Opdahl 1996). This paper presents elements of a methodology for IS-architecture work.

IS-architecture work is the task of finding a satisficing IS-architecture for an enterprise in the long term. On the one hand, to be effective, the IS architecture must be well *aligned* with some of the (presumably most stable) aspects of the enterprise, e.g., its organisation structure, culture, degree of centralisation and philosophy (Davis and Olson 1984, chapter 20). On the other hand, to be flexible, the IS architecture must also be *decoupled* from the enterprise's (presumably most volatile) aspects. The balance between alignment and decoupling must be struck in the face of numerous other IS-architectural challenges. This paper focusses on the alignment issue in IS-architecture work.

IS-architectures and IS-architecture work have been central topics in both IS practice and research for several decades. Previous work includes Zachmann's (1978) seminal paper on information architecture, Nolan's (1973, 1977, 1979) *Information Resource Management (IRM)*, industrial methodologies such as IBM's *Business Systems Planning* (BSP, Gillenson and Goldberg 1984, chapter 5, Brancheau and Wetherbe 1986) and Andersen Consulting's *Method/1* (Flaatten 1986) and academic methods, e.g., by Wetherbe and Davis (1983), Vogel and Wetherbe (1984) and Leifer (1988), Hugoson's (1986) *Function-Based Systems Structuring (VBS)*, Kiewiet and Stegwee's (1992) clustering approach, Magoulas and Pessi's (1991), Petterson and Goldkuhl's (1994) and Axelsson's (1995) discussion and comparison of IRM and VBS, Axelsson's (1998) *process, activity and component-oriented* IS-architecture structuring (PBS and PAKS) and Päivärinta's (2001) and Päivärinta and Tyrväinen's (2001) work on *genres* and *genre systems* in IS-architecture work. Hackney, Burn and Dhillon (2000) have challenged many of the assumptions underlying current approaches to IS-architecture work.

This paper presents an *alignment model* (section 2) for IS-architecture work. An associated *representation framework* (section 3), *overall methodology* (section 4) and *practical experiences* from our research (section 5) are also outlined briefly. The methodology and its components result from several years of case and theory studies, tool development, industrial projects and consulting within the *RAISA project* (*R*epresentation, *A*ssessment and *I*mprovement of *IS-A*rchitectures, www.ifi.uib.no/projects/raisa/).

MODEL OF IS-ARCHITECTURE ALIGNMENT

Organisations and IS-Architectures

The alignment model views an organisation as a set of interrelated *organisational structures* and an IS-architecture as a set of *IS-architecture structures* that are both interrelated and related to the organisational structures. Both organisations and IS-architectures consist of *elements* that are related to one another in different ways (as described by the representation framework in the next section.) The elements in the organisational structures are instances of *organisational dimensions,* e.g., goals and strategies, organisation units, functions, locations, products and processes, all of them hierarchical. The elements in the IS-architecture structures are instances of *IS-architecture dimensions*, e.g., development *activities*, the low-level activities (operations) carried out by applications, physical data *resources*, procurement *guidelines* and *responsibilities* for applications. Opdahl (1996) surveys the IS-architecture dimensions found in the literature (including Allen and Boynton 1991, Brancheau and Wetherbe 1986, Gillenson and Goldberg 1984, chapter 5, Davis and Olson 1984, chapter 20, Earl 1993, Emery 1977, Goldkuhl and Pettersson 1994, Goodhue, Wybo and Kirsch 1992, Hart 1994, Warne and Hart 1996, Hugoson 1986, Iivari and Koskela 1987, Kiewiet and Stegwee 1992, Leifer 1988, Lundeberg, Goldkuhl and Nilsson 1978, Magoulas and Pessi 1991, Nolan 1973, 1977, 1979, Magoulas and Pessi 1991, Periasamy 1993, Sowa and Zachman 1992, Tardieu 1992; Vogel and Wetherbe 1984, Wetherbe and Davis 1983, Zachman 1987.)

The IS-Architecture Alignment Problem

According to the alignment model, the *IS-architecture alignment problem* is to group all the IS-architecture elements in an enterprise disjunctively into *IS-architecture areas* (Kiewiet and Stegwee 1992) that are suitable for the enterprise. An important type of IS-architecture area is *information systems*, which group elements like IS operations and physical data resources. There are also IS-architecture areas that group other kinds of IS-architecture elements, e.g., *responsibility areas* may group responsibilities for IS-architecture related

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activities and resources.

The elements in an IS-architecture area belong together because they are related to the same organisation element, the area's *grouping element*. For example, an information system may be *grouped by* the organisation function it supports, and a responsibility area may be *grouped by* the organisation unit that holds responsibility.

IS-architecture work starts with the enterprise's existing organisation and IS-architecture. The resulting *IS-architecture solution* comprises *blueprints* of an improved organisation and IS-architecture and a set of disjunctive, well-defined IS-architecture areas. The most fundamental component of the IS-architecture solution, however, is the set of *principles* used to group IS-architecture elements.

Grouping Principles: Organisational Dimensions and Hierarchical Levels

The elements in each IS-architecture dimension can be grouped — in principle independently of elements in other dimensions — according to a *grouping principle* which determines the organisation elements that will be used to group that dimension. A grouping principle is described in terms of an *organisational dimension* and a *hierarchical level*:

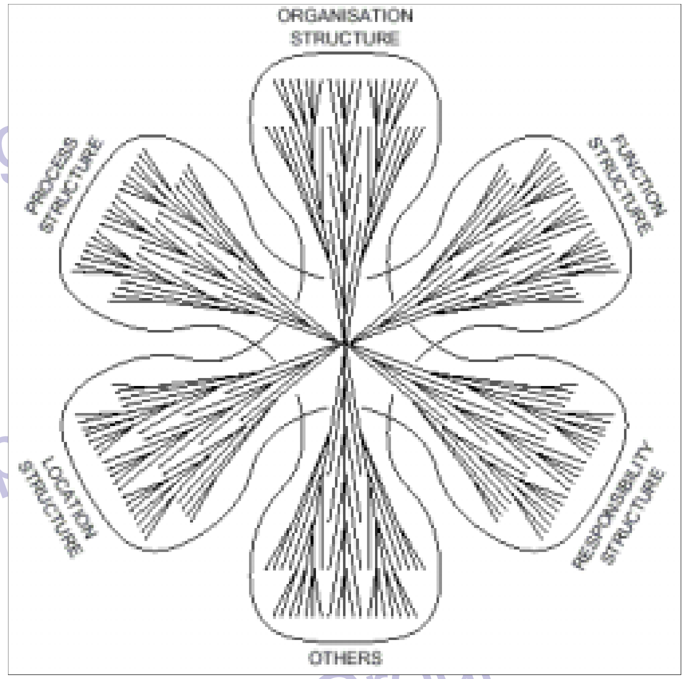
1. *Organisational dimension:* The elements of an IS-architecture dimension can in principle be grouped by elements from any organisational dimension, e.g., by goals, strategies, organisation units, functions, locations, products or processes. For example, physical data resources can be grouped either by the organisation units that use them or by the products they contribute to.
2. *Hierarchical level:* When an organisational dimension has been selected, the elements of an IS-architecture dimension can in principle be grouped by organisational elements at a higher or lower hierarchical level. For example, physical data resources can be grouped by low-level organisation units such as departments (or even individual employees for some applications) or by high-level units such as divisions (or — in the case of completely centralised ownership — even by the single, top-level enterprise element.)

The key contribution of the alignment model is that *the combination of organisational dimensions with hierarchical levels unifies two previously separate lines of work*: On the one hand, Kiewiet and Stegwee (1992) have discussed grouping by different organisational dimensions (they considered entity types, information processes, organisational units and physical locations), but without explicitly considering centralisation degrees. On the other hand, several authors have discussed centralisation degrees, but without explicitly considering organisational dimensions, e.g., Emery (1977), King (1983), Davis and Olson (1984, chapter 20), Magoulas and Pessi (1991) and Pettersson and Goldkuhl (1994a).

The alignment model combines organisational dimensions with centralisation degrees through *hierarchical levels* in the organisational dimensions. Different hierarchical levels correspond to different centralisation degrees. Opdahl (1996) offers the following example: "[…] the processes are first grouped after which organisation units that are responsible for them. Then, entity types are assigned to the processes that create them. In the first case, we represent the organisational-unit dimension as a single element only: the enterprise itself. As a result, all information processes and entity types end up in the same IS area, giving us a completely centralised IS architecture. In the second case, we represent the organisational-unit dimension at the highest possible level of detail with as many small organisational units included as possible. The result this time is a 'maximally' decentral IS-architecture. We can therefore regulate the centralisation degree of the IS architecture produced by choosing to represent the relevant organisational dimension in more or less detail."

Figure 1 shows the resulting *IS-architecture alignment petal*. Each IS-architecture dimension can be grouped by one of the petals (an organisational dimension) in this figure and with a particular centralisation degree within the petal (a hierarchical level in that organisational dimension.) When the same grouping principle is used

Figure 1: The IS-architecture alignment petal: Each IS-architecture dimension can be grouped by one of the petals (an organisational dimension) and with a particular centralisation degree inside the petal (a hierarchy levl in that organisational dimension)



for several IS-architecture dimensions, the resulting IS-architecture areas will comprise elements from all those dimensions. (Other IS-architecture areas may comprise elements from one dimension only.)

Using the Alignment Model

The model offers a precise explanation of what it means to group IS-architecture elements into IS-architecture areas. The model thereby offers a systematic way to generate alternative future IS-architecture areas for an enterprise. This should both aid generation of alternatives and offer possibilities for automated IS-architecture tool support. Assessing many alternative future solutions should also suggest improvements to the existing organisation and IS-architecture. The alignment model also offers a precise description of what an IS-architecture is and of how IS-architectures and areas are related to organisations. This should aid IS-architecture assessment.

In the end, an IS-architecture solution should be selected that harmonises, that leverages the enterprise's current IS-architecture and ICT-infrastructure and that is otherwise suited for the enterprise. The alignment model does not aid determining whether an alternative IS-architecture solution is satisficing for an enterprise, leaving this for human assessment and evaluation.

FRAMEWORK FOR IS-ARCHITECTURE REPRESENTATION

The representation framework is a *metamodel* of IS-architectures and the organisations that surround them. The framework can therefore be used as a *language* for modelling enterprises as part of IS-architecture work. The framework describes which information to collect and how to structure it in a way that matches the alignment model. The framework is also highly tailorable and provides concepts that can be adapted to enterprise terminology. For example, the framework defines a "Strategy" concept, which might be refined into enterprise-specific terms such as "Business strategy", "Principle", "Plan", "Standard" etc.

The representation framework comprises a core model that should be the starting point for most IS-architecture improvement processes. Figure 2 shows an ER-diagram of the core model. Depending on the circumstances, IS-architecture work may go in different directions. Therefore, a number of optional modules are provided to extend the core model, e.g., for describing business processes, products and locations.

The representation framework is tightly coupled to the alignment model in several ways: (1) It includes entity and relationships types to represent all the major *IS-architecture dimensions*, either directly or indirectly. (2) It includes entity and relationships types to represent all the major *organisational dimensions,* either directly or indirectly. (3) It includes relationship types to represent the organisation at different *hierarchical levels.*

METHODOLOGY FOR IS-ARCHITECTURE WORK

The alignment model and representation framework is embedded in a comprehensive methodology that also offers a *position*, a *method* and a *modelling tool* for representation, assessment and improvement of IS architectures. The *position* explains the underlying view of IS-architectures and IS-architecture work with emphasis on scalability, tailorability, adaptability and participative IS-architecture work. The *method* proposes a general way of thinking about and organising IS-architecture projects and is not a strictly prescribed way of working. It currently describes around 80 steps along two main paths. The *general path* may be run in parallel with the *modelling path*, but can also be run alone. The *tool* is implemented by a template for Computas' generic enterprise modelling tool METIS (www.metis.no). Using a generic tool ensures that local adaptations are always possible.

PRACTICAL EXPERIENCES

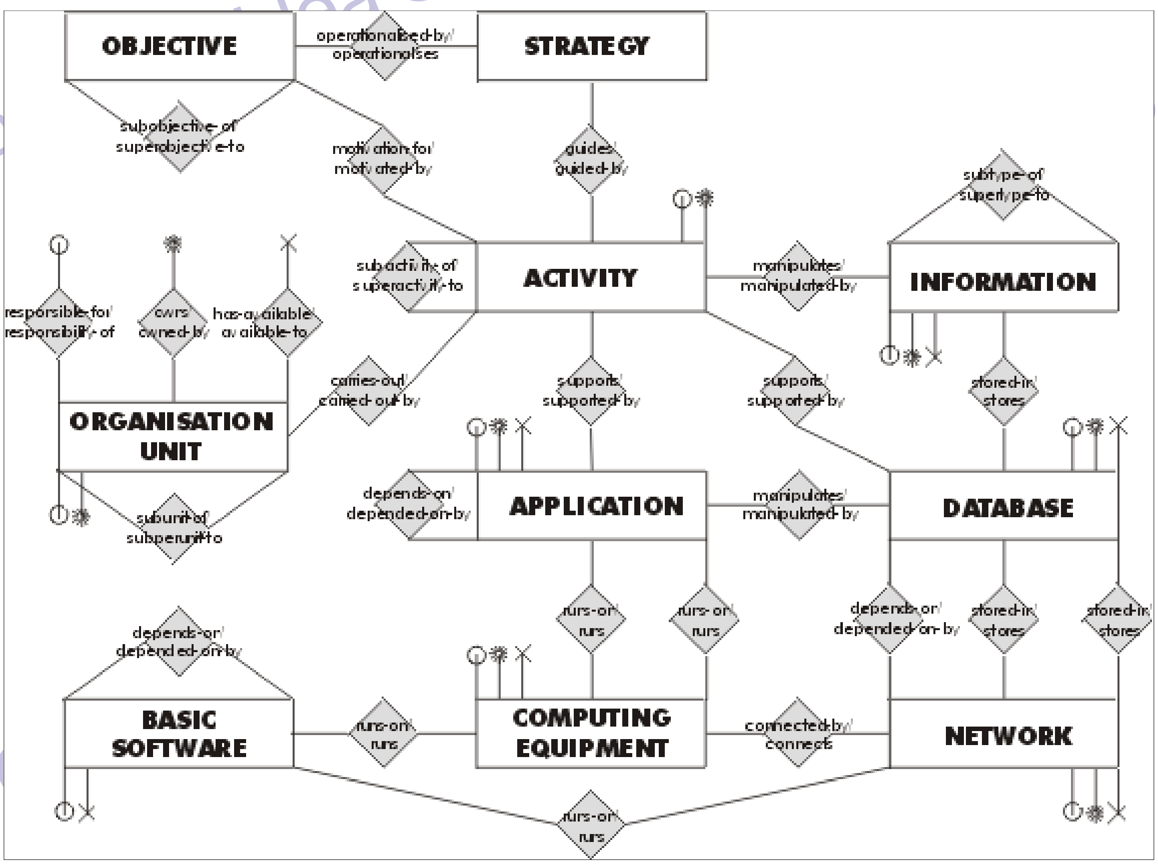
The methodology has been developed through several years of case and theory studies, tool development, industrial projects and consulting. Pettersvold (1996) focussed on the representation framework in her study of alignment at a regional Norwegian transport company. Lugenga (1997) used the representation framework and the *information ward model* (Hart 1994, Warne and Hart 1996) in a multi-case study of how to predict potential user resistance towards new systems. Netteland (1999) focussed on data collection methods in her study of a regional Norwegian college. In cooperation with IntraWeb AS, the author has studied how enterprise models can support IS-architecture evolution at Norway Post, resulting in a model of several thousand objects and links. The representation framework has been used in other commercial projects of similar size, one using the framework to represent the IS-architecture of a telecommunications company and to propose paths for further evolution. Several other studies are in progress.

CONCLUSION AND FURTHER WORK

The paper has presented an alignment model for IS-architecture work. The model is part of an integrated IS-architecture methodology. A major benefit of the model is that the grouping principles it produces can act as *high-level principles* (e.g., Richardson, Jackson and Dickson 1990) for IS-architecture evolution. Providing such a set of principles is preferable to relying on a *blueprint* of a future IS-architecture alone, because the principles are more abstract and may remain stable while the blueprint will slowly change.

Although the RAISA project (www.ifi.uib.no/projects/raisa/) is ended, the RAISA methodology is still being improved and extended. The most obvious path for further work is improved tool support.

Figure 2: The core of the IS-architecture representation framework shown as an ER-model. The core model can be extended with modules that represent other organisational dimensions, such as processes, products and locations.



Also, the limited *scope* of the approach should be made clearer: RAISA focusses on *modelling-oriented* approaches to IS-architecture work, as opposed to business-driven, method-driven, administrative and organisational approaches (Earl 1993). Also, RAISA leans towards *reactive* (as opposed to *proactive*) use of IT and on *alignment* of an IS architecture with (as opposed to *decoupling* the architecture from) the organisation. Extending the methodology with *genres* and *genre systems* (Päivärinta 2001, Päivärinta and Tyrväinen 2001) is another promising path for further work.

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