Architectural Frameworks for Business Information System Analysis and Design

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Abstract. The paper makes the first steps towards a methodology to assess frameworks for business process analysis and information system design. The assessment instrument will be designed based on key elements of architectural frameworks such as Isa, Cim-Osa and Pera. Four major frameworks will be discussed: Isa-S95, Oagis, Scor and Cpfr.

1 Introduction

In the late 1980s and early 1990s various frameworks for business analysis and information system design were developed: for example Cim-Osa [1], Pera [2] and Grai [3]. Concurrently, in the 1990s a new generation of process oriented modelling methods emerged to analyse and redesign business processes. Examples of these are Event Process Chain, the Activity Chain Model and Grai Grids. These modelling methods reflect distinct, though complementary, dimensions of business (or supply chain-) management. For example, Event Process Chain focuses on time relationships, Activity Chain Model focuses on business process flow whereas Grai Grids focus on decision structures. The models were mostly applied to single business cases, although also supply chain applications have been made [4].

These frameworks and modelling methods can be considered predecessors of reference information models that were developed in the second half of the 1990s and later. Reference models were mostly developed to be used as a basis for software development and applications. Two examples are Baan Dem and Sap. Baan Dem was developed by Baan Company in the mid 1990s to support implementations of Baan's Erp-system. Major elements of Dem were business control models, decompositions of business functions (including predefined parameter settings) and detailed process models (including roles, work instructions and links to the specific Baan transactions). The Baan Dem reference models started as a single industry

model but moved to a multiple-domain reference model in the late 1990s. Sap also developed a reference model to support their implementation processes. Major elements of the model were process diagrams and data models. The Sap reference model is a multiple-domain model, i.e. set up for many industries [5].

In the last decade the development of (reference) frameworks to model inter-company relationships as a basis for inter-enterprise software development has emerged with examples such as Scor and Cpfr.

2 Architectural frameworks

Designing an architecture for a software system, especially for large-scale supply chain systems, is a complex process. A state-of-the-art review of the many proposals to system architectures does not show consistency in concepts.

Ieee 1471-2000 defines architecture as the fundamental organisation of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding in its design and evolution. Thus, architecture is about the manner in which the components of a specific product, system or an organisation are composed, organised and integrated and as such, an architecture determines the nature or essence of a product, system or organisation. In many contexts model and architecture are not really distinguished. Van Waes [6] states that the architecture is represented by a model and a system abstracts from an architecture (figure 1).

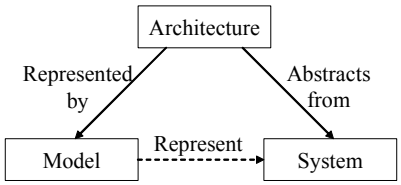

Fig. 1. Relationships between architecture, model and system [6]

Zwegers [7] and Williams [8] discuss the distinction between architecture in the art of science and architecture in model of structure meaning:

1) The structural arrangement (design) of a physical system such as the computer control system part of an overall enterprise integration system. Examples are the Nbs or Amrf reference models [9], the reference model for manufacturing planning and control [10], and the Factory Automation Model [11].
2) The structural arrangement (organisation) of the development and implementation of a project or program such as a manufacturing or enterprise integration or other enterprise development program. Examples are Cim-Osa's Open System Architecture for Computer Integrated Manufacturing [12], the Grai Integrated Methodology [13] and the Purdue Enterprise Reference Architecture [8].

These two views are unified in the following such that the first type is called reference architecture and the second type is called architectural framework (meta-architecture, i.e. architecture about architecture).

Architecture is based on a set of ontology concepts and principles. Chandrasekaran et al. [14] define ontologies as content theories about the sorts of objects, properties of objects and relations between objects that are possible in a specified domain of knowledge. Ontologies provide a clearer view on how

knowledge should be structured, thereby enabling sharing of knowledge. Benjamins [15] defines an ontology as "a shared and common understanding of some domain that can be communicated across computers and people". Thus, an ontology provides a common and shared representation platform. Accordingly, ontologies may, through meta architectures and reference architectures, support the design of information systems and be the basis of the unambiguous communication between people and information systems [16]. To arrive at operational business information systems it is of immanent importance that stakeholders commit to a shared ontology and shared architecture, including communication between people involved in designing information systems.

The architecture principles applied here are decomposition, abstracting, layering, hierarchy and nesting, and reference system for orthogonal arrangement. Early work on establishing so-called architectural framework for information systems are found in Zachman's framework [17, 18].

	Data	Function	Network	People	Time	Motivation
Scope						
Enterprise model						
System model						
Technology model						
Component						
Functioning system						

Fig. 2. Zachman's framework. The dimensions people, time, and motivation were added in 1992 [17, 18]

An architectural framework is a collection of principles, methods, or tools relevant for a given domain of application [19]. Such a framework is a real or conceptual structure intended to serve as a support or guide for the building of something that expands the structure into something useful. Other examples of architectural frameworks are Cim-Osa for computer-integrated manufacturing, Geram developed by the Ifip-Ifac task force group and synthesised from other frameworks (Cim-Osa, Grai, The Purdue Enterprise reference architecture, etc.).

The concepts of architectural framework, reference model or, as we will call it, reference architecture will be discussed. Architectural frameworks found in the literature are all established within a frame of reference given by two, three or more axes (a n-dimensional co-ordinate system). Fixing those axes is the essence of these frameworks. Within the framework the architectural descriptions are positioned.

Common to most frameworks are the following three axes:

- Instantiation is the degree of particularisation from the generic level, through partial level to particular level of architectures.
- Derivation is a level of abstraction corresponding to domains of the main phases/representation of the development process (requirements, design and implementation) representing a distinct, unique perspective of the Owner, Designer, Builder.
- Generation is a decomposition according to domains of views of describing the real world's objects/variables (data model, functional model etc).

In Zachman's terminology the axis of derivation establishes the scope/enterprise model, system model and technology model. Instead of model we prefer here the term architecture. As stressed by Zachman, these representations are not merely successive levels of increasing detail but are actually different representations/ domains – different in meaning, in motivation, in use, etc. [17]. Aerts et al. [20] describe the three domains for representation by

- Business architecture which defines the business system in its environment of suppliers and customers,
- Application architecture which details the software application components and their interaction and
- Ict platform architecture which is the architecture of computers, networks, operating systems, data base management systems etc.

A reference architecture (in literature often called reference model) is defined as "a generic manner to organise and integrate system components" [7]. A reference architecture is used for comparing something to a reference. Thus, it refers to the generic and partial level of the framework. It serves as a point of departure for the design of a large number of systems in a specific application area. Thus, a reference architecture is a generic/partial (architecture) which can be used as a basis for particular architectural developments or for evaluation of particular architectures. The relation between reference architecture and (particular) architecture is therefore one of instantiation. Examples of reference architecture/models are the Osi reference model, the Nbs or Amrf models [9], and Mrpii systems [21].

An adequate reference model can reduce development costs tremendously. From an economic point of view, reference models are attractive, since they promise to accomplish two goals which are usually in conflict: higher quality and lower cost. However, the development of high quality reference models is facing severe challenges. Usually, semantics compromises the chance of re-use: The more a particular model is specialised, the higher its comfort of re-use but the lower is the chance that it fits a certain case. In order to overcome this conflict, it is required to develop concepts that allow for adapting reference models to individual needs both conveniently and safely.

3 Current Models for Information System Analysis and Design

Four different frameworks will briefly be discussed in the following:

- Supply Chain Operations Reference-model (Scor) developed and endorsed by the Supply-Chain Council
- Collaborative Planning, Forecasting, and Replenishment (Cpfr) industry initiative based on the Voluntary Inter-industry Commerce Standards Association
- Isa-S95 standards for enterprise and manufacturing integration developed by the Instrumentation, Systems and Automation (Isa) Society Consensus Committee.
- Integration Specifications developed by Open Applications Group (Oag) which is widely supported by industry and software companies (e.g. Ibm, Sap, Oracle, Boing, Ford, Automotive Industry Action Group).

Scor has been developed as the cross-industry standard for supply-chain management [22]. The Scc was organised in 1996 by Prtm and Amr Research, and initially included 69 voluntary member companies (mainly in the U.S.). At the moment more than 800 companies are members of Scc and the model is internationally broadly acknowledged. The Scor-model focuses on the processes plan, source, make, deliver and return. It provides process models on three aggregation levels, standard process descriptions, performance metrics (in the categories Delivery Reliability, Responsiveness, Flexibility, Costs and Asset Management Efficiency), and best-practice descriptions. The Scc claims to support different supply chain configurations including "pure" Make-to-Stock, Replenish-to-Order and Make-to-Order. Cpfr has developed a set of business processes, which entities in a supply chain can be used for collaboration on a number of buyer/seller functions towards overall efficiency in the supply chain. Their Xml specifications have been integrated with the broader set of Ean•Ucc Xml specifications endorsed by the Global Commerce Initiative (Gci) to ensure full coverage of the Cpfr process without creating overlapping or redundant message formats. The existing core Ean•Ucc messages for item synchronisation, party (trading partner) synchronisation, purchase order, invoice, dispatch (shipment notice) and other information have been augmented with the Cpfr product activity, forecast and other transactions [www.cpfr.org].

Isa-S95 (Iec62264) addresses the interface or exchange of data within the enterprise systems (planning, scheduling and procurement) and the production management systems (production dispatching and execution). It consists of three parts: Models and terminology, Object model attributes and Models of Manufacturing Operations. The development is based on the work by Williams [23] on the Purdue Reference Model (Prm) for Computer Integrated Manufacturing (Cim), but two other works have also a great deal of influence, which are the Isa Sp-88 "Batch Control' committee and the Mesa International Mes context model.

Oag includes a broad set of Xml schemas for sharing business information. It addresses the needs of traditional Erp integration as well as supply chain management and e-commerce. This specification provides the structure of business documents and additional meta-data, which is required as a part of the application processing.

4 Positioning Current Frameworks and Reference Architectures

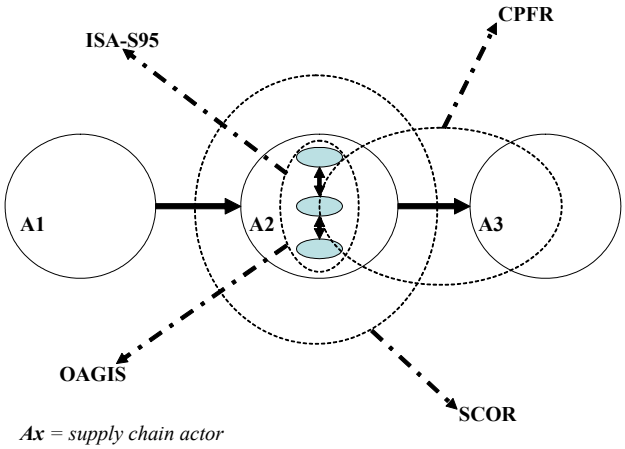

Fig. 3. Scope of four major frameworks/ reference architectures

In this section the frameworks and reference architectures described in the previous section are positioned using the basic architectural components described. Figure 3 depicts the scope of the four examples described in section 3. Scor focuses on the main company integrating demand and supply (deliver and source); Cpfr focuses on collaboration between buyer and supplier; whilst Isa and Oag focus on integration (standards) between in-company management and manufacturing layers. Figure 4 depicts domain of views of reference architectures. Scor and Isa/Oag describe the object system in terms of process, data and/or object networks and hierarchies. Cpfr focuses on how to approach the object system (e.g. collaborative forecasting) and what activities to undertake to arrive at a collaborative system. Scor also includes these two perspectives (e.g. benchmarks, best practices) whilst Isa and Oag focus less on the concrete design of systems. All four reference models pay less attention to company network and supply chain (wide) relationships, although Cpfr looks at buyer-supplier relationships and Scor at sourcing and delivering relationships. The role of people in (collaborative) processes has minor attention in all four models. Although the im-

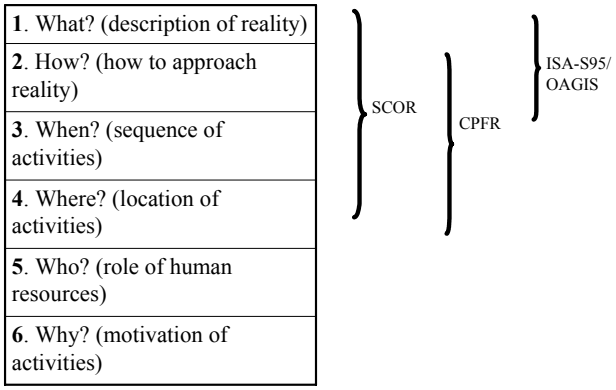

Fig. 4. Domains of views of reference architectures with different coverage areas

portance of trust and power relationships is recognised in both Scor and Cpfr, exact conditions or types of relationships in this regard are not defined. All four reference models pay no or very little attention to the companies' strategy.

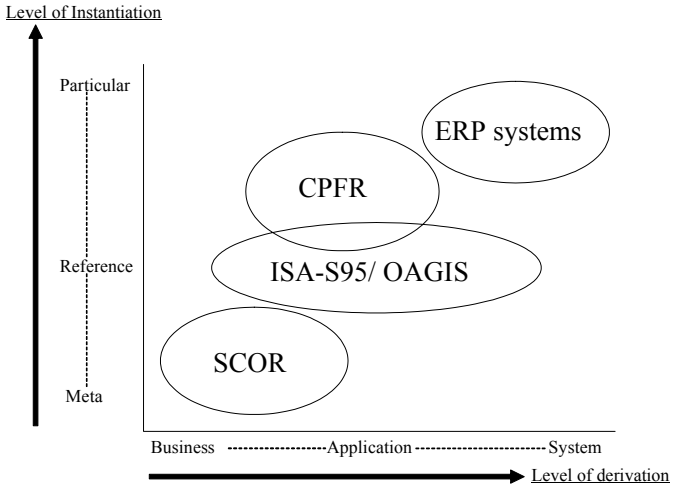

Fig. 5. Instantiation and derivation positioning of models

5 Conclusion

In this paper first steps to a method to assess information system architecture reference models have been made. We have discussed scope, coverage of different perspectives on the real-world and levels of derivation and instantiation of four current models. Future research will focus on an integrated methodology to assess these reference models. This also involves the degree to which functions are/are not supported by the models (e.g. quality control, resource management, etc.) and how well these models can be implemented in different sectors (electronics, machine and food industry) and in different dynamic business environments.

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