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Narrowing the gap of SME for IT innovation with enterprise architectures

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Abstract

Contemporary changes in market structures demands adequate response from Small and Medium sized Enterprises (SME). The rapid evolution of information-technology offers new challenges and exiting new opportunities for innovation. The approach presented in this paper will take the information system architectures of the enterprise as a starting point. It will be extended middle-out to a meta-level dealing with methodology issues and to a project level dealing with involved people, activities and results.

Keywords

information systems architecture, learning, method engineering, reference models

1 INTRODUCTION

It has been continuing difficult for Small and Medium sized Enterprises (SME) to innovate and to gain the benefits from the area of information technology. The introduction of innovative information technology is commonly hampered by:

- Incompatibility of newly introduced systems with the existing computer infrastructure, due to syntax, semantic or pragmatic differences.
- Rapid changes as SME are pressed the to react because the ever-shorter product-life-cycles, while IT projects might have a duration that is longer than expected.
- Lacking of professional IT specialists within the enterprise, with possibly as a consequence that individuals carry their personal wishes through in a craftsman culture.
- Limited resources available for starting innovative IT projects.

A challenge of major importance for the future is to enable SME, to master the growing complexity associated with the effective and efficient use of information technology for their information-related tasks. To our opinion more attention has to be paid to the fitting of information-technology within SME. Therefore we need a clear description of the enterprise architecture, because the concept is surrounded by much confusion and has yet no standard definition.

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This paper will focus on:

- the contex of various enterprise architectures and their interactions
- a methodology that emphasizes a reduction of the complexity to analyse and design systems for SME
- illustration of the advocated approach and an evaluation of project results in the dutch agriculture sector.

2 ENTERPRISE ARCHITECTURES

A clear picture of the various architectures and their interactions will improve the planning and implementation of IT projects. We distinghuish information system architectures focussing on the business characteristics, information needs, the technology and on the system applications.
A business architecture establishes a clear understanding of the mission and nature of the enterprise, reflecting the current management and control concepts and philosophy (e.g. TQM or JIT). It provides an overview of production, marketing and the logistics of goods or services. Further, it depicts the units, their employment and related responsibilities.

An information architecture is a personnel and technology independent profile of the major information categories used within an enterprise. It provides a way to relate business functions, data classes, decisions and control.

A systems architecture identifies applications needed to support the information needs of the enterprise, wheter they are computer based such as databases, expert systems, real-time microprocessors and spreadsheets, or non-computer based systems such as libraries, filing cabinets, microfilm, photocopiers or faxes.

The technology architecture consists of the computer infrastructure and digital networks that cooperate to provide support for computing and data communication.

Moreover, interactions among the (parts of) business architecture, information architecture, system architecture and technical architecture takes place as feedbackloops and feed forward loops. Thereover they cannot be carried out sequentially but they must be done in parallel, see figure 1. The planning of information systems should be no longer be separated from the business plan and vica versa.

2.1 Evolving enterprise architectures

Especially the enterprise architectures of SME are strongly influenced by changes in the market structure and the push of new technology.

Value chain
A value chain represents how businesses are linked to each other by the supply of goods and services and may be specialized to a product chain. Negotiations and contracts with suppliers and clients demands for quality of products, processes and information.
Emerging information technology
The processing of information is occupying an increasingly important strategic and economic role. For the introduction of emerging technologies in enterprise architecture, access to a wide range of information is needed.

Balancing with enterprise architectures
The dashed lines between the 4 architectures depicts the interactions. The already mentioned influences of the suppliers and buyers in the value chain and the emerging information technology are also included in the next picture.

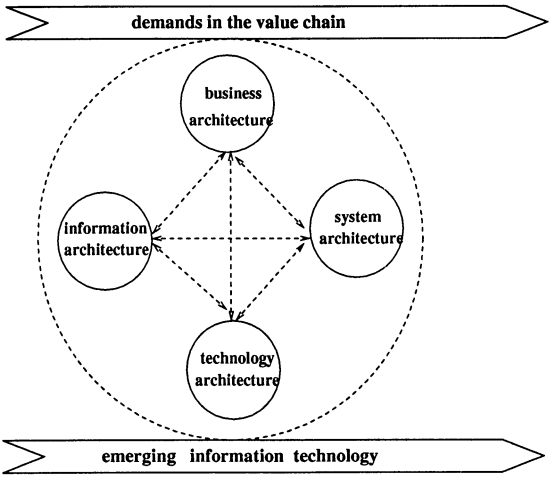

Figure 1 Alignment and balancing the enterprise architectures.

2.2 Reference models for building architectures

For SME the use of reference models appear to advantages. It is often economic impossible to carry out the whole life cycle of information system development, starting with a planning study eventually resulting to implementation and maintenance of tailor-made information systems. Enterprise wide data models are valuable for design [Scheer] (1992).

3 TOWARDS A FLEXIBLE FRAMEWORK

Various frameworks to model information systems have been proposed, among them are those of CRIS [Olle] (1988), CIM/OSA [Esprit] (1989), Zachman and Sowa [Sowa] (1992). A more flexible framework should offer help in the adaption of methods to specific situations in enterprises. Therefore we distinguish three levels in figure 2: the methodology level, the enterprise type level and the project type level.

Some distincions with other frameworks are:

- Both the number and choice of perspectives is open, in [Meijs] (1994) we extended the 2nd level with a chain architecture.
- The number of aspects is not fixed (as in [Sowa] e.g. data, function, time, network, people and motivation). This approach facilitates the decomposition and integration of aspects. Decomposition enables e.g. to split the motivation aspect into goals and constraints. The system archtitecture may contain templates of Abstract Data Types (ADT) that integrates data types and operations.
- The level of detail for describing components related to a perspective and aspect can be refined by hierarchies. Another level of abstraction is introduced by the reference models that creates extra genericity.
- The stages of the system development cycle do not have a dominant position in the framework, like in [Olle], because we want to include evolutionary information systems.

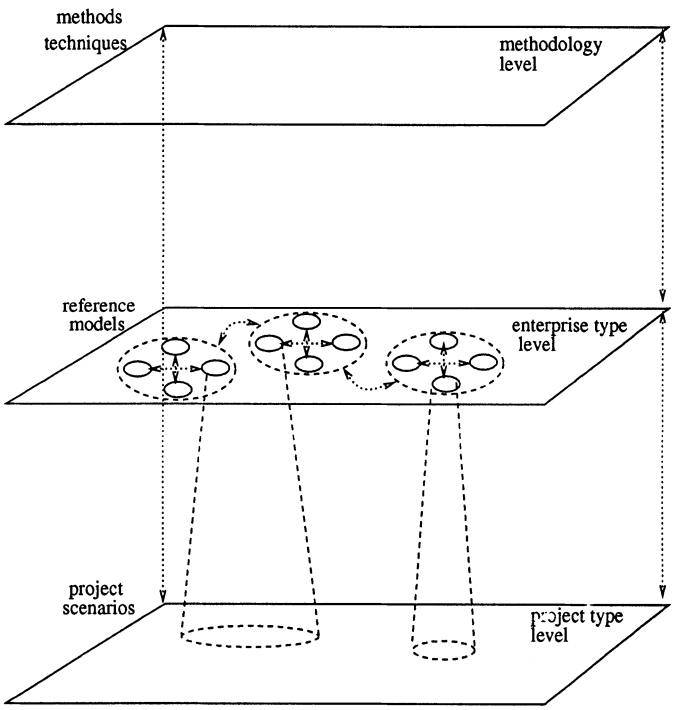

Figure 2 A flexible framework.

In the next paragraph more is said about the methodology level. The use of reference models on the middle level accelerates the planning and implementation of information technology. We will go in more detail for reference information models, that represent

generic components for clusters of enterprises. Finally an evaluation of some results at the project level will be presented, using adapted checklists in composing project scenarios. See also for project management [Uijttenbroek].

4 METHODS AN TECHNIQUES

There is a growing awareness that method and techniques cannot be applied unconditionally. Specific characteristics and particular circumstances of focused areas in the value chain of enterprises impact the methodology. Method engineering is considered as the design a methodology with the definition of steps to be conducted. At the 1st level of the framework we may recognize for a methodology a set of steps in the form of a triplet:
< SITUATION, DECISION, ACTION>.
The situation referers to the enterprise(s) type with involved architecture(s), and to the project type level: identified problems, opportunities, involved people and other project constraints. So the description of the situation can be specified and refined to get an adequate understanding of the context for taking decisions about needed actions. Action referes to one or more modelling aspects from the framework. Decisions are related to the intention of a step and may be atomic or compounded.

Decomposition can be decided to reduce complexity. It is then used to guide the modelling process. Integration of multiple specification fragments produced by conflicting basic components (e.g. relevant data may be modelled as a attribute or as entity type) may urge for a refinement with a sub-decision of view integration.

The feature of the framework that enables us to integrate aspects, is useful for putting the next object oriented template belonging to the system architecture into it.

```
Object ORDER
 attributes
   lines : set of (ORDER-LINE)
   creation_date, delivery_date: DATE
   state: {created, delivered, invoiced}
operations
   creation : order lines insertions
   delivery : change order state
   cancellation: delete order lines
constraints
   creation date <= delivery date
   delivery date <= invoice date
event
   pre-condition [quantity.old > replenishment level]
     out of stock
   post condition [quantity.new < = replenishment level]
```

5 REFERENCE INFORMATION MODELS

5.1 Characteristics

Reference models reflecting genericity are constructed for clusters of enterprises in a branch. These models need to be valid and stable for a line of business. Decisions related to control of the enterprise, functions of an enterprise and data classes are important components for the definition of so-called reference information models. Dynamic features may be incorporated by entity life cycle, petri nets, or state transition diagrams.

5.2 Roles of reference information models

- Identification of missing knowledge for learning purposes
  For innovation the involved individual employees of the SME are subjected to a process of change and learning. Effective learning means going through the following phases in a number of cyclic iterations: conceptualization, experimentation, action and reflection [Kolb] (1984).

- Standardization and as a basis for the development of software packages.
  Communication among interest groups is not primarly hampered by technical problems, but by a lack of broadly accepted definitions of products and processes. Different classifications and identification of objects may be prevented by unifying reference models.
  Software industry take some relevant parts of the models as a starting point, e.g. the definitions of entity types and derived indicators. This stimulates standardization of information technology, for instance the electronic data interchange (EDI).

- Selection of software packages.
  An available datamodel may be used to restrict the offered packages to a short list. Functionality of the package is tested by test-set.

- Benchmarking.
  Measuring the quality of business functions and comparing the actual indicators with other enterprises in the line of business, one gets a founded opinion about the performance of the enterprise.

6 EVALUATION AND RESULTS OF PROJECTS

It is estimated that in the Netherlands there are more than 500 000 SME, which may be classified into sectors and finally into one of the 600 branches. There are about 100 000 farms in the dutch agricultural sector, most of these farms employs only a few people. The number of farms belonging to a specific branch ranges from the smallest number for Mushroom cultivation farms (750) to the highest for Dairy farms (36 000).

6.1 Evaluation of projects in the agricultural sector

During the second part of the former decade several reference information models for the agricultural branches as dairy, potplant nursery, poultry and fruit were created in the Netherlands. For each type of farm an reference information model was constructed

mainly focussing on the data and process aspect, using the Information Engineering Methodology [Martin]. The construction of the models was a joined effort of the branch organizations, agricultural researchers and information engineers. Our evaluation of projects using these models recommends improvements of the methodology based on the framework of figure 2:

- The branch dimension is tentatively a good top-down criterium for clustering the different types of farms, but there are also branch crossing components on the next level. We need bottom-up techniques to define generic components that might be reused for different branches.
- The hierarchical decomposition of the data flow diagrams restricts the usability and reuse of components in different situational contexts. Related to other disadvantages for the hierarchical approach, especially for the business archictures, as noted in [Peters] (1992), this favours alternatives like object oriented techniques
- The data definitions of the reference models seems to be used most intensive. They are for example important for the introduction of EDI, because it might supports the standardization of exchanging data. However, only little attention was given to some issues about ownership, legization, maintenance of models.
- The decomposition that distinghuises management vs. technical functions results often in isolated systems for admiministrative applications and real-time computers that register data of continuous or discrete processes of the enterprise. Alternatively, we might unify some of the basic elements of both functions by elaborating a bottum-up approach. Interaction analysis improves the adjustments of selected aspects.

6.2 Project types and their scenarios

In co-operation with enterprises IT research projects are conducted by graduated students and supervised by the department of computer science.
- Reverse engineering
A software package for the semi-process industry that was installed at a medium sized enterprise in the food industry. Starting from the systems architecture consisting of several modules for purchasing, production, sales and financial administration, an reverse engineering traject resulted in a data model with Entity Relationship Diagrams.
- A software testing method was elaborated to enable the certification of software for pig farmers. The testing method uses definitions of entity types and ratios that are derived from reference information models for pig farms. The information and system architecture demarcates the boundaries of this project.
- Information resource management and security.
The main activities of this project scenario were: exploration of significant concepts of information resource management and security techniques, interviews with owners of SME, questionnaires to system managers and finally recommendations for auditing purposes of the business and technology architecture. The reference model was constructed after the exploration and validated during the visits to the more than fifty participating enterprises, that were selected across all branches. Confrontation of the concepts from information resource management and security techniques and the inventory of bottle-necks resulted in a handbook for information auditing.

7 CONCLUSIONS AND FURTHER RESEARCH

Reliable and actual information is a key issue for SME. This paper emphasizes in this era of all pervasive applications of information systems and technology the need for alignment of the various architectures. The advocated approach, creates a balance between market needs, via business functions of SME and the emerging information technology. Lessons learned from conducted projects show:
- how to put into practice the building of enterprise architectures, using the business functions and data classes defined in a reference models as a starting point.
- reference information models decrease complexity and cost of projects.
- communication and documentation should be well prepared, attention has to be paid to training and understanding of the involved people.
In the next future new research pojects with empirical results will enrich the methodology according the presented flexible famework.

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