From Business to System Components: An Integrated Framework

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Abstract

To continuously improve its knowledge and to identify problems and possible solutions, an organization requires understanding of the way business is aligned with the organizational strategy and how information systems are supporting the business. This paper presents an object-oriented framework for modeling three separate organizational concerns (strategy and goals, business processes and information systems) while allowing top-down and bottom-up traceability between these concerns. The foundations of this framework are presented as an extension to the Unified Modeling Language. In this paper, we discuss several issues regarding organizational and information system modeling, including the impact of identifying traceable business/information system patterns, modeling business strategy, and analyzing how strategic redefinitions influence information systems components.

1 Introduction

The setting for business and information technology has been changing in the last decade. On the one hand, the widespread use of information technology and the connectivity granted by the Internet provide new methods for interconnecting organizations and customers, enabling transaction costs across organization boundaries to be driven down and making the traditional departmental or hierarchical structure less attractive either from a strategic or economical point of view. On the other hand, the growing competitive pressure is forcing organizations to rethink continuously the ways in which they do business and the type of business that they do, leading to a different way of managing. In this scenario, organizations are regarded in terms of business processes instead of functions, integrating activities from several organizational functions in a cross-functional value chain. An organization needs to be flexible enough so that it can cope with the complexity of its business systems while not disregarding all the

opportunities created by internal or external business changes. This means that an organization requires to have knowledge of how it operates at both business and supporting information system levels and to have a precise assessment of the dependencies between these.

To accomplish this task, an organization requires models of its strategy, business processes and information systems. However, creating a complete model of such a dynamic and highly non-deterministic entity as an organization is probably an unattainable task. Nevertheless, the creation of this abstraction is of fundamental importance in order to allow managers to abstract from irrelevant details and focus on the important problems. So how does one create a business model? Ideally, an organization model would consist of a single diagram that included all the important aspects of a business, but the complexity involved usually does not allow it [5].

In this paper, we discuss a framework for describing, linking and tracing organizational concepts at multiple levels of detail using three separate concern: strategy and goals, business processes and information systems. This framework is expressed as an extension to the Unified Modeling Language (UML) so that a common representation language is in both business and in software domains.

The remaining of this paper is structured as follows: the next section presents open issues in the areas of business and information system modeling. Section 3 describes some trends on business modeling. In section 4, the foundations of the modeling framework are discussed. Finally, in section 5 we set out our conclusions and work directions.

2 Open Issues

Although business modeling has been a challenge for business and information systems practitioners for more than one decade, expressing dependencies between business processes, goals and information system components is still a debatable issue. This section describes some of the problems related to these.

2.1 Goal Modeling

Business strategy is an integrated set of actions aimed at increasing the long-tem inter-ests and strengths of an organization regarding its competitors [28]. Strategy can be realized by a set of business goals driving the operations of an organization and must be accomplished by at least one business process. However, Kawalek and Kueng point out that, during business goal capture, the full goal set cannot be captured since some goals are disregarded when interviewing the stakeholders and that goals are not shared by the participants of business processes [10].

We sustain the same view because the output of the goal modeling process is usually the translation of strategy into goals and not strategy itself. By capturing and representing the strategy from which each goal was derived, a goal model delivers more knowledge about the business and is a more effective tool for communication between the business participants. In our approach, we aim at providing a form of representing this strategic information and therefore bringing the model closer to reality.

2.2 Business Process Modeling

In today's highly competitive global economy, the demand for high quality products manufactured at low costs with shorter cycle times has forced various industries to consider new product design, manufacturing and management strategies. To fulfill these requirements, organizations have to become process-centric so they can maximize the efficiency of their value chain. In order to take out the most of the reengineering efforts and from information technology, business processes must be documented, understood and managed. One way to do that is by modeling business processes. Modeling business processes includes not only the models of the processes and activities, but modeling and describing the resources involved in that processes.

Business processes are hierarchically decomposed in activities that bring value to a costumer. A process consumes or uses resources as input and produces or refines products (i.e. resources) as output. Additionally a process should support one or more strategic goals. Porter's value chain model is one of the most common models for business process analysis [22]. It highlights specific activities or processes that bring value to the products or services of an organization. Primary or core processes are directly related to the production and distribution of products or services. Supporting processes sustain the organization's core activities, including its infrastructures, people and technology.

It is accepted that business-oriented software should be aligned with the business processes of an organization. Thus, the specifications of the business software must not only derive from the resource modeling, usually accomplished though data modeling, but also with process modeling itself.

2.3 Information System Modeling

An information system relies on a software architecture model that describes the structure of its components, their relationships and the guidelines governing their design and evolution [6]. However, tracing which parts of the business are realized by which parts of the system is

not a straightforward task since this information is often embedded in the development process [11, 27].

In today's business environment, organizations should ensure the information system architecture is business-driven, enabling it to support the business requirements and to be adjusted to changing business needs. Current component technologies and standards (e.g. Microsoft .Net, Sun's EJB, CORBA Component Model) provide the basic means for reusing system components and simplifying its maintenance and evolution. In the context of business modeling, a notation and underlying formalism for expressing relationships between business and information systems that fulfills the new technological solutions and business demands is still lacking.

2.4 Matching Business and Information System Concepts

One of the major issues organizations face in a dynamic business environment, is the need for permanent change and innovation. However, adapting to a changing environment, i.e. tuning the business strategy, leads to business process rethinking. To sucessfully adapt, an organization must adjust the information system infrastructure to the way business processes are organized and enacted [15].

The impact of business changes in the software infrastructure can be established by identifying refinement from source to the target and feedback from target to the source. Realization between the software infrastructure and business concepts can be expressed as a generalization of the traceability concept. In this context, traceability means each construct should be traceable down to the system specification. Similarly, each construct in a system specification should be traceable up either to the business specification or to the business environment [11].

Current software component architectures are making easier for a business component marketplace to emerge. The trend is to use business and other commercial components off the shelf so that the task of evolving and maintaining an information system infrastructure is simplified, and, as a result, the software can follow the changing business requirements. Nevertheless, to cope with this trend, an organization requires a means to trace business specifications down to the information systems components.

The extended component concept, as described by Buschmann, is the foundation for defining the structure of an information system [3], accommodating other, more specific, component classifications, including, for example Herzum and Sims [8] and Kobryn [12] definitions. An extended component is defined as an encapsulated part of a software system, with an interface that provides access to its services, serving as a building block for structuring the system.

Therefore, a composition of components and the relationships between them allows describing the architecture of an information system.

As stated in the previous subsection, there is no common language to represent realizations between information system concepts, goals and business processes. Specifying a unified framework to address this matching issue will allow describing the structure and the associations between these concepts. This makes possible, for instance, to identify which components must be replaced or adapted when a business requirement changes.

3 Trends

Designing a framework allowing the representation and tracing of concepts from business to system intersects three broad areas of knowledge: business modeling, capturing information system requirements, and software tools supporting the modeling and design activities.

Business modeling is mainly focused on strategy and business process modeling. Strategy modeling is moving away from the traditional plain, informal, text format, to goal based modeling [10]. Modeling the way a business operates has evolved from describing its functional aspects to a value-chain oriented business process description. Several approaches exist addressing business process modeling, from workflow to event process chains [25]. Additionally, resources used and produced by business processes are also being included in process modeling.

Enterprise information systems requirements should be business driven to support the organization activities. Business modeling is essential to identify these requirements. Several approaches are used, including business objects [14]and business components [7], but lack an integrated vision from strategy to the system level. Other methods for specifying information system requirements do exist. For instance, in object-oriented software development the emphasis is on the functional specification and development, whereas the process part is either assumed to be already defined or simply disregarded [2, 4]. In the UML, use cases are the main method used to describe system functional requirements [16]. Several templates for requirements specification exist, such as the Volere Requirement Specification Template [24], which separates requirement in functional, non-functional, project constraints, project drivers and project issues that characterize the system needs.

Object modeling CASE tools should improve their support for mixed-language development. However, bringing together components implemented in different languages and connected using component interoperability standards is a challenge. CASE tools will move toward using standard repositories accessible from multiple tools. This promotes the exchange of information between tools that perform specific modeling tasks. The MOF (Meta Object

Facility) [17] is a specification for meta-model conformance, which allows the creation and sharing of model repositories.

4 The Framework

In this section, we present our vision towards the solution of some of the problems raised in the previous sections. Through an integrated framework, we aim at providing a model-driven approach for describing business goals, processes, information systems and the dependencies between them. This framework comprises three levels, corresponding to each of these concepts. The first level describes business strategy through a set of goals. These goals must be achieved through one or more business processes. The second level comprises the business processes, where each process exists to achieve one or more goals. Besides achieving goals, business processes interact with other processes and resources to perform work. These processes may be supported by information systems components. The third level describes the information system components that support the business. Although the framework presents a clear separation of concerns between business and system concepts, the dependencies and relationships between the different levels are easily described. The next subsections detail the framework concepts within each level.

4.1 Goal Modeling

The approach to goal modeling taken in this paper is mostly based on the goal patterns described by Nilsson [15]. In this approach, the fundamental concepts are goals, problems and contradictions. Goals control the behavior of the business and show the desired states of some resources in the business. Problems are obstacles that hinder the achievement of goals. They are related to goals, in the way that they not only express adverse conditions to the accomplishment of business purposes but also give way to the creation of new goals that aim at eliminating problems (these goals are usually sub-goals of the one associated with the raised problem). Contradictions between goals arise when two mutually exclusive goals exist.

In order to increase the expressive power of goal models, our approach introduces some of the concepts inherent to the Balanced Scorecard [9]. Balanced Scorecard is a management theory that aims at providing a system of goals and measures divided into strategic or operational and lined at four fundamental perspectives: financial, client, internal processes and growth and learning. Our approach introduces these concepts by classifying goals as strategic or operational and adding to each goal its original perspective of business. Goals are further classified as qualitative or quantitative. Strategic goals have time scope as an additional attribute in order to represent information about the strategy's time scope.

Since goals can be classified as strategic or operational, contradictions between goals can have different meanings. If a contradiction between two strategic goals is detected, a strategic contradiction should be created and the involved strategic options must be reviewed or properly weighted (possibly leading to further evaluation of future scenarios and strategic positioning). If a strategic goal and an operational goal are inconsistent, a strategy implementation contradiction is created and the measures applied to enforce the strategic path should be revised considering that it causes short-term problems. If two operational goals are inconsistent, an operational contradiction is raised and both goals should be revised or reflected in the supporting process. The purpose of making such distinctions between apparently similar conditions is not to help solving contradictions but to allow business participants to revise the strategic planning when facing such situations.

4.2 Business Process Modeling

The business processes are the activities performed within the business during which the state of the business resources changes. Processes describe how the work is accomplished within the business [5]. At the business level the most common model that allows the analysis of the business itself is the Porter's value chain model. The value chain model highlights specific activities, primary or support, which add value to an organization's products or services. It is on those activities, or processes, of business that competitive strategies can be best applied [22].

Primary or core activities are usually directly related to the production and distribution of products or services. Supporting activities are the ones that make the delivery of the results from the core activities possible. They comprise an organization's infrastructure, human resources, technology and procurement. Included in process modeling is resource modeling. Resources are objects within the business that are manipulated by processes. Resources can be arranged in an object-oriented structure, defining a resource taxonomy and the relations and dependencies between the resources. A resource is always related to at least one process that may produce, consume, use or refine it.

4.3 Information System Modeling

Components are the core concept supporting information system modeling, since they are the building blocks structuring the system. The extended component concept, as described by Buschmann, is the foundation for defining the structure of an information system [3], accommodating other, more specific, component classifications, including, for example Herzum and Sims [8] and Kobryn [12] definitions. An extended component is defined as an encapsulated

part of a software system, with an interface that provides access to its services, serving as a building block for structuring the system. Therefore, a composition of components and the relationships between them allows describing the architecture of an information system. A component may be classified at different granularity levels. Component composition allows creating higher-level, business-oriented, components.

A component, according to Herzum [8], may belong to three functional categories: process, entity or utility component. A utility component represents the supporting concepts that are broadly required across different components. An entity component provides services required by process components, and are reused by different process components. A process component represents business concepts and is used to implement the services of a business process.

4.4 Using UML to Represent the Framework Concepts

Representing such different concepts as business processes and system component requires using a common modeling language to facilitate the task of creating and communicating the models. The framework is expressed in the Unified Modeling Language (UML) primarily since it is simple to use and understand, and it can be adapted to different domains using its extension mechanisms [7]. Although the UML 1.3 is focused on modeling object-oriented software, the OMG is extending it with several domain-specific profiles, such as the profile for enterprise distributed computing [18] and the profile for scheduling and real-time [19]. However, UML does not provide suitable extensions to model business concepts. We are defining the required extensions as a UML stereotypes. This approach allows creating, tailoring or customizing new and existing meta-model concepts for a particular domain. In this way, a common representation language is used not only in the business but also in the software domain.

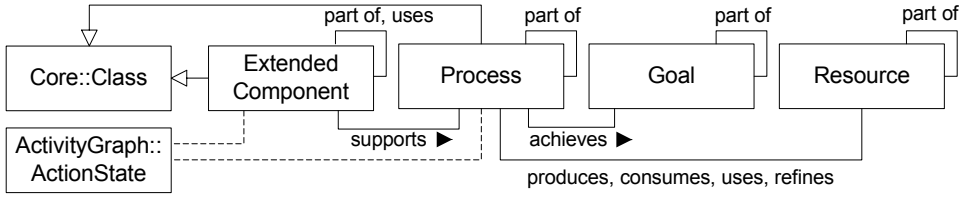

Figure 1. Simplified framework metamodel.

The strategic, business and system levels previously introduced are represented as UML stereotypes, and its relationships and dependencies expressed at the metamodel level. The simplified metamodel is depicted in Figure 1.

Following the classification lines previously introduced, we define a set of base classes supporting the concepts of Goal, Process and Extend Component. These are depicted in Figure 2, Figure 3 and Figure 4, respectively.

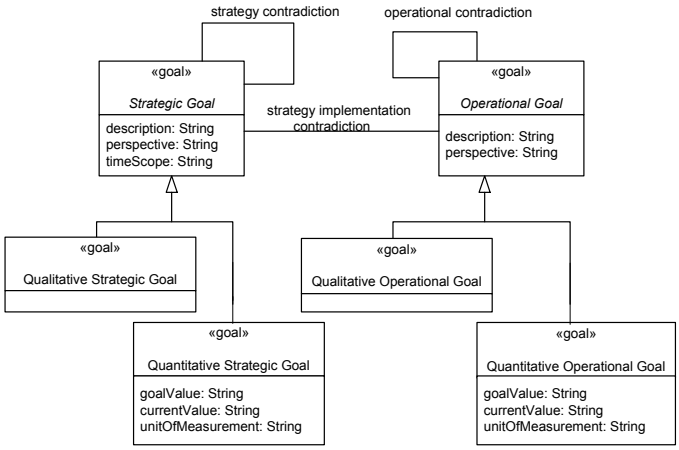

Figure 2. Predefined Goal classes.

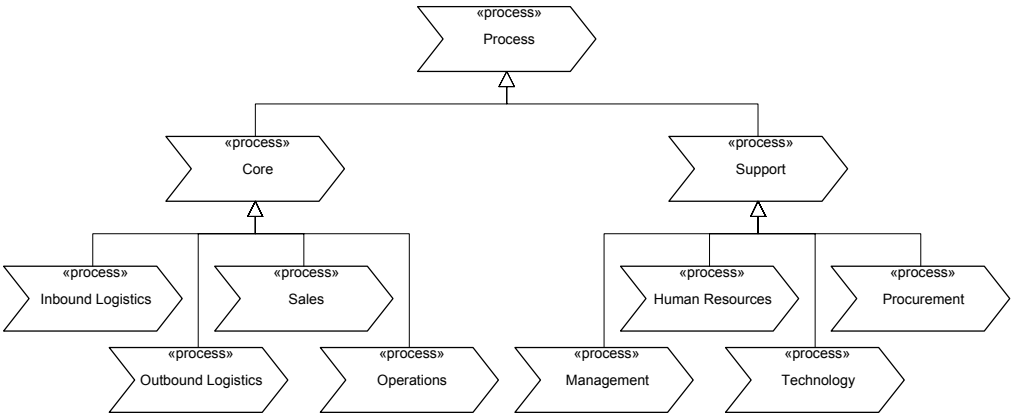

Figure 3. Predefined Process classes.

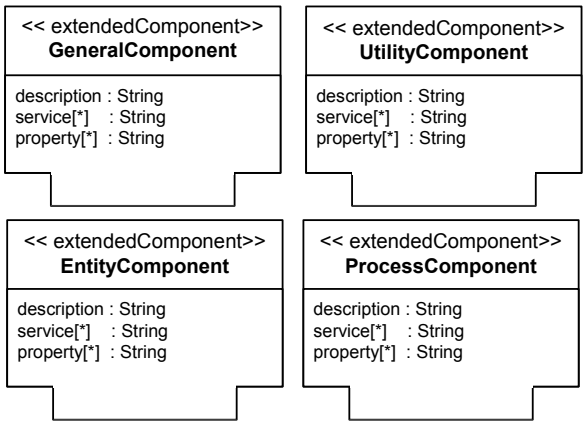

Figure 4. Predefined Extended Component classes.

4.5 Views

The framework, like a building's blueprint, may be observed from different points of view. The different views reveal different concerns and abstraction criteria. We propose two major views: the *structure view* that describes the goal structure, the process and resources decomposition, the system building blocks and theirs dependencies and the *behavior view*, which shows the processes, resources and system dynamics. The business models should be supported by a software tool, which may automatically generate these views from the base model.

4.6 Software Tools

The framework is built upon a set of standard UML extensions, so it can be supported by UML modeling tools. Softeam's Objecteering object-oriented CASE tool [26] has been used to successfully create models with this framework, since it allows defining UML extensions with its profile builder tool. Other tools, such as Proforma Corporation's ProVision Workbench [23] also support business modeling but it is not UML compliant. Tools as the PHIOS Corporation process repository [21], a tool based on an approach is based on the "Process Handbook" [13] from MIT Sloan School of Management, provide an extensive number of industry best-practices. Although it includes a variety of mechanisms to edit and view its knowledge repository, it lacks the models used to design and develop information system components. However, a tool, or even better, a set of independent but specialized tools interconnected through a common repository, which allow model-driven development of components from business concepts is still missing.

5 Conclusions and Research Directions

The framework discussed in this paper aims at solving some of the issues within business modeling. Having a single language to describe different aspects of business is fundamental to create a common ground for discussing both business and the supporting systems. The emphasis is on providing the basis for creating such a common representation and simultaneously providing a way for addressing the traceability between the different levels. At the first level of the framework, and considering the concepts from the Balanced Scorecard, goal modeling gains additional representation power. Business processes appear as a middle tier between goals and system components, providing a way of representing how work is done and how these activities contribute to goal achievement. The relations between the process and system levels are traceable, describing how information systems support business, which is one of the main issues in today's organizations. System modeling is addressed through the concept of extended component.

However, several questions are still left unanswered and different work directions might be followed. The first two questions concern methodology and the development process:

- What are the base features of a methodology for capturing the core organizational aspects into a model that addresses the strategy, processes and system levels?
- What are the requirements for a model-driven development process for system components based on business requirements?

As a tool supporting business modeling, one should make use of best practices to simplify and communicate the models and promote reuse. We are currently analyzing specific problems in real organizations and studying how to apply well-defined business and system patterns during business modeling [3, 5]. In vertical sectors, such as the retail sector, banking, and telecommunications it is possible to identify multi-level patterns, i.e. patterns addressing simultaneously the strategy, process and system levels. In this case, a pattern represents a industry best-practice. However, since the business model spans more than one dimension, two question arise:

- Is it possible to reuse the concepts of existing patterns (e.g. system patterns) at other levels of concern? What abstractions are required to do so?
- How to use and relate patterns at different levels of concern, namely at the strategy, business process and information system levels, while ensuring the integrity and traceability of the models?

Developing computer tools for representing goals, processes and system components, the simulation of different "what-if" scenarios, the comparative analysis of best practices and the detection of possible errors and optimizations (at business and system levels) are also important work directions.

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