An Object-Oriented Framework for Goal and Process Modeling[†]

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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, presented as a UML Profile, for describing three organizational concerns: strategy and goals, business processes and information systems.

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 is 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.

In order to continuously improve its business knowledge and to identify problems and possible solutions, an organization needs to model its business processes. Business process modeling comprises the description of the structure and behavior of an organization's value adding activities. Although there is no universal definition of business process, we describe it as a collection of activities that take one or more inputs and create an output that is of some value to a costumer. Business processes have goals and are triggered by events occurring either internally or externally to the organization. Goals convey an organization's strategy and allow business processes to be qualitatively or quantitatively assessed. Therefore, the combined analysis and modeling of goals and processes is of great importance to the organization, allowing the strategy to

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be traced down to the business processes. However, the impact of combined goal and business process modeling is seldom considered.

In this paper, we present a framework for describing, linking and tracing organizational concepts at multiple levels of detail using three separate areas of concerns: strategy and goals, business processes and information systems. This 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 [1]. 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 [2] and the profile for scheduling and real-time [3]. However, UML does not provide suitable extensions to model business concepts. We are defining the required extensions as a UML Profile that includes the stereotypes, constraints, properties, tagged values and required meta-model elements [4, 5]. 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.

To represent the goal model, we propose applying the Balanced Scorecard approach and extending the concept of goal, problem and contradiction. This allows increasing the expressive power of goal models, capturing more knowledge about the overall business and strategic and operational goals. Business processes are represented as a hierarchic decomposition of activities that provide added value, contributing to the achievement of a goal. Moreover, separating core and supporting processes and providing traceability between goals and processes enables processes and strategy to be correlated. By applying the same approach to the information system level, system components supporting the business processes can be represented.

The remaining of this paper is structured as follows: the next three sections, 2, 3 and 4, detail the framework's major concepts, namely the goal, business and system levels. Section 5 presents the framework global meta-model and views, while section 6 presents a case study. Finally, in section 7 we set out our conclusions and work directions.

2 Goal Modeling

Business strategy is an integrated set of actions aimed at increasing the long-tem interests and strengths of an organization regarding its competitors [6]. 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 points 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 [7]. This is because the result of goal modeling process is the translation of strategy into goals and not of strategy itself.

According to Nilsson, there are three fundamental concepts behind goal capturing. [8]. Goals control the business behavior and contain the states of resources, while problems hinder goal achievement. Problems are related to goal modeling in the sense that they not only express negative conditions to the accomplishment of business purposes but also enable identifying new goals that mitigate these problems (these goals are usually sub-goals of the problem-related goal). Finally, contradictions arise when two mutually exclusive goals exist.

Goals are further classified as quantitative or qualitative. A quantitative goal is easily measured using a well-defined metric. A qualitative goal is difficult to measure in

quantifiable terms or applying a metric to, requiring human judgment to assess its status. Every goal must have a goal description. Quantitative goals, besides the goal description, also have a target value, a current value and a unit of measurement.

Goals can be hierarchically related or just linked to each other (such as contradictory goals), resulting in that (i) every sub-goal must be satisfied in order to satisfy the common parent goal; (ii) a goal can have multiple alternative sub-goals (iii) achieving a goal may positively or negatively contribute to the achievement of another goal. Problems, in the same way as goals, can be decomposed into sub-problems. Since a problem is always associated with a goal, the problem hierarchy can be mapped to the goal hierarchy (as stated before, a sub-goal is created in order to eliminate a problem associated with a parent goal).

2.1 Extending Goal Modeling Concepts

The Balanced Scorecard (BSC) is a tool for translating vision and strategy into action and measuring the effects of the chosen action considering the adopted strategy, and makes distinction between operational and strategic goals [9]. While operational goals are commonly associated with short-term returns, strategic goals concern long-term strategic purposes. The BSC also considers four different kinds of goals to express an organization's vision and strategy. These depend on each of the four different perspectives introduced by the BSC: financial, client, internal processes, and learning and growth. Therefore, in order to capture strategy, we must consider goals as well as its perspective.

In addition to the qualitative and quantitative goal classification, we add two other classification schemes: operational and strategic. Operational goals identify the business perspective and can be classified as either qualitative or quantitative. Strategic goals, just as operational goals, define the business perspective and a time frame representing the strategy's window of opportunity. Strategic goals can be specialized in qualitative and quantitative strategic goal.

There is no need for further classifying problems since they always depend on goals and have the required expressive power. However, since goals are specialized as strategic or operational, the goal contradiction classification scheme requires to be updated accordingly. Therefore, the following scenarios are possible: (i) a strategic contradiction arises from two inconsistent strategic goals. In this case, the involved strategic options must be assessed, possibly leading to a further evaluation of future scenarios and strategic positioning; (ii) inconsistent strategic and operational goals result in a strategic implementation contradiction. Since it causes short-term problems, measures enforcing the strategic path should be revised; (iii) finally, an operational contradiction exists between operational goals, requiring the involved goals to be revised in the supporting processes.

The purpose of discriminating apparently similar conditions is not to solve contradictions automatically but to draw attention to the strategic plan and to provide a basis for goal, process and strategic assessment.

2.2 Goal Modeling in UML

The UML stereotype for representing a goal is summarized on the following table. Problems can be represented as instances of UML Note.

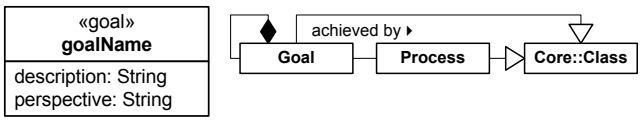
Stereotype	Goal
Extended meta-class	Core::Class
Semantics	Represents a goal that was originated by a specific business perspective of the organization's strategy.
Diagram notation	UML Class icon with the «goal» stereotype.
Icon and meta-model	
Predefined classes	Strategic Goal, Operational Goal, Qualitative Strategic Goal, Qualitative Operational Goal, Quantitative Strategic Goal, Quantitative Operational Goal.

Table 1 Goal stereotype.

3 Business Process Modeling

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 [10]. 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.

3.1 Process Modeling in UML

To represent processes and resources we use the following stereotypes.

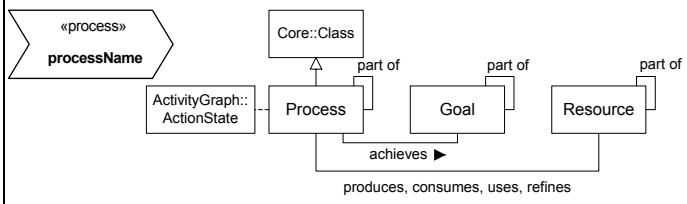
Stereotype	Process
Extended meta-class	Core::Class
Semantics	A Process represents a unit of work. Its execution may be connected to the execution of one or more Processes through Resource flows.
Constraints	(1) A Process must achieve at least one Goal. (2) A Process has a one-to-one association with the ActivityGraph::ActivityState
Notation	UML Class icon with the «process» stereotype or the alternative icon.
Icon and meta-model	
Predefined classes	Support processes are specialized into Management, Human Resources, Technology and Procurement. Core processes are specialized into Inbound and Outbound Logistics, Operations and Sales.

Table 2 Process stereotype.

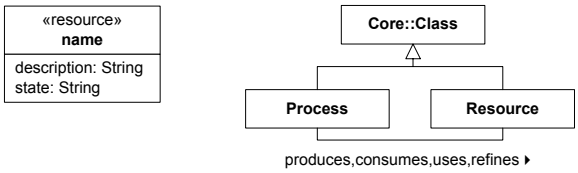
Stereotype	Resource
Extended meta-class	Core::Class
Semantics	Resources are produced, consumed, used or refined by Processes.
Constraints	Produced, consumed, used, or refined by at least one Process.
Notation	UML Class icon with the «resource» stereotype.
Icon and meta-model	
Predefined classes	Thing, Physical, People, Abstract, Information (v.Figure 1).

Table 3 Resource stereotype.

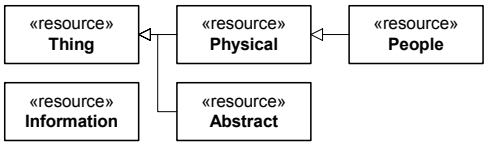


Figure 1 Predefined Resource classes.

4 Information System Modeling

An information system (IS) relies on a software architecture model that describes the structure of its components, their relationships and the guidelines governing their design and evolution [11]. 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 [12, 13, 14].

In today's business environment, organizations should ensure the IS architecture is business-driven, enabling it to support the business requirements and to be adjusted to changing business needs. However, fine-tuning the business strategy leads to business process rethinking. Thus, an organization must adjust the information system infrastructure to the way business processes are organized and enacted.

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 [13].

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 [15], accommodating other, more specific, component classifications, including, for example Herzum and Sims [16] and

Kobryn [17] 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.

However, 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.

4.1 Information System Modeling in UML

In this section, we describe the «extended component» stereotype. According to Herzum and Sims [16], a component may belong to three functional categories: utility, entity and process. A utility component comprises the supporting services required across different entity components. The entity component provides services that support the process component and the process component directly supports the business processes. However, an extended component may fit in more than one functional category. We refer to these as general components. We predefine four classes according to these four functional categories.

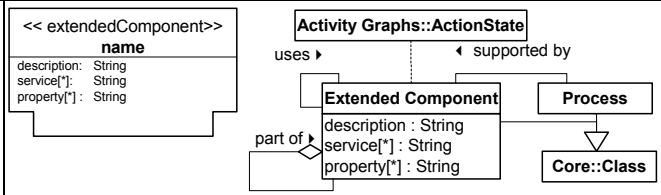
Stereotype	Extended Component
Extended meta-class	Core::Class
Semantics	An extended component represents a functional building block of an information system.
Constraints	An Extended Component has a one-to-one association with the UML ActivityGraph::ActivityState, representing the flow graph of its containing components.
Notation	UML Class icon with the «extended component» stereotype or the alternative icon.
Icon and meta-Model	
Predefined classes	General Component, Utility Component, Entity Component, Process Component.

Table 4 Extended Component Stereotype.

5 The Framework

As previously described, the object-oriented framework separates three types of concerns: goals, processes and information systems. The first level describes business strategy through a goal set. These goals must be achieved through one or more business processes. The business processes are described at the second level and exist in order to meet with the requirements of one or more goals. Business processes interact with resources in order to perform work and may be supported by information systems. The information systems layer aims at modelling how the system components

depend and are supporting the business. The dependencies between these levels are depicted in the simplified meta-model shown in Figure 2.

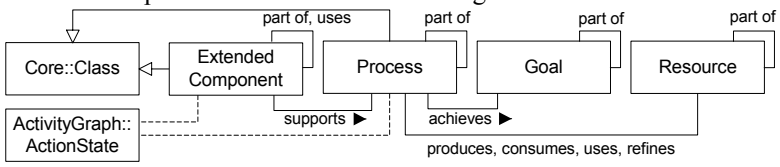


Figure 2. Simplified framework meta-model.

The framework can be further observed from different views, each revealing different abstraction details. We will now focus on two of these views: the structure and the behavior view. The structure view describes how goals, processes, resources and system components are structured and the dependencies between them. It comprises four UML object diagrams. The goal vision diagram describes the goal structure, problems and inconsistencies. The process structure diagram describes the process structure and dependencies. The goal, process and system (GPS) diagram describes the dependencies between goals, processes and system components. Finally, the system structure diagram describes the system as the breakdown of components into sub-components and the dependencies these.

Since goals, processes and components are inherently hierarchical, these concepts can be represented at more than one level of detail on each diagram, depending on the purpose and target audience. Therefore, a complete business and system description is only accomplished using multiple structure diagrams with different detail levels.

The behavior views makes possible to represent organization dynamics at system and business levels by describing the system behavior and the interactions between components and the behavior of processes and resources and theirs relations. This view is represented using the standard UML behavior diagrams (sequence, collaboration and state diagrams).

6 Case Study

To illustrate the usage of the framework, we model the purchase and sales operations of a retail store from the strategic, business process and information systems viewpoints. Then, using the "as-is" models, we show how these can be used to identify problems and possible solutions when the organization faces a strategic redefinition.

6.1 Current Situation

XYZ is a typical midsize retail store. Its core processes are Buy Supplies, Setup Store and Sell Product and its strategy derives from three goals: (i) providing costumers a good shopping experience, (ii) having 95% percent of its products ready for selling, and (iii) reducing stock levels to increase cash flow.

For the XYZ managers, the shopping experience relates to waiting time, service quality and product display. This leads to one inconsistency, triggered by lowering waiting time (i.e. having a larger number of counters) and better service quality (i.e. having clerks available for helping costumers). Both of these operational goals are difficult to achieve without hiring additional staff. Another problem arises from high product availability and low stock levels, since before adjusting product ordering rate and quantity, stock run-outs can occur. These concepts are depicted in Figure 3.

Operating the XYZ retail store consists of buying supplies, setting up the store and selling the products. Buy Supplies focuses on the supplier side of the retail value chain (buying, receiving and paying). Setup Store concerns the operations inside the store, including warehouse and shelf maintenance. Finally, Sell Products is responsible for attracting costumers and selling and delivering products to them (v. Figure 5). The Buy Supplies and Sell Products processes were adapted from MIT's Process Handbook [18].

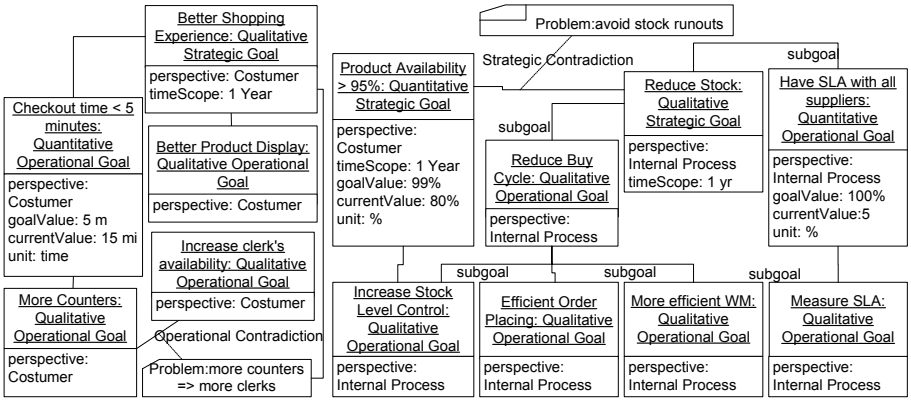


Figure 3. Goal diagram.

The XYZ store has three high-level information system components: procurement, back-office and front-office. All of these are general components since they are assembled from other extended components. Using the goal, process and system diagram, we get high-level view of the XYZ static organizational structure, showing the dependencies and realizations between business processes, goals and information system components, as depicted in Figure 4. This diagram allows tracing system and business dependencies. For instance, it is possible to notice that a failure in the Purchasing component influences the Submit Order process, hindering the successful accomplishment of the Product Availability goal.

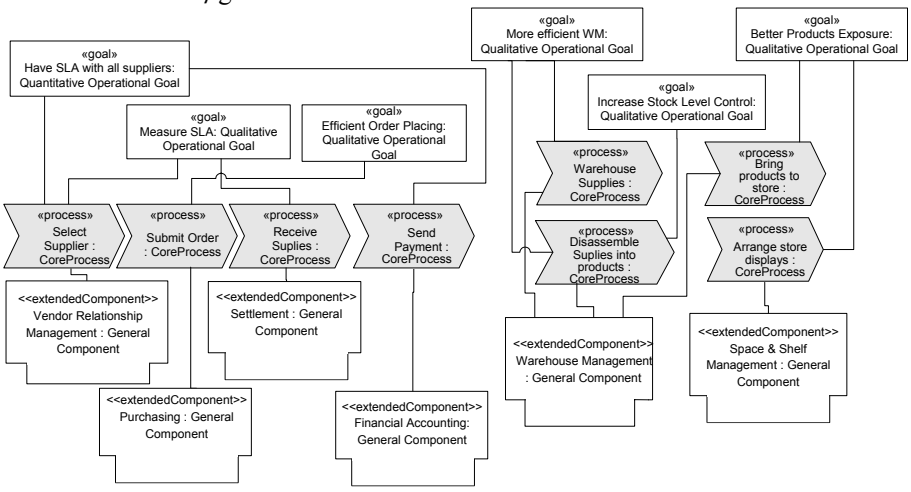


Figure 4 Partial Goal, Process and System diagram.

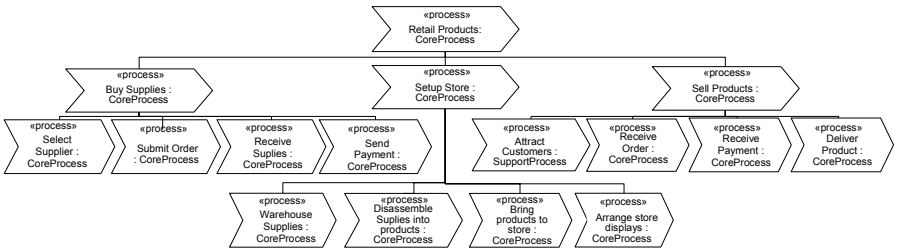


Figure 5 Process diagram.

6.2 Supporting a Strategic Redefinition

Aiming for a larger market share, the XYZ managers plan to use the Internet to sell products. However, it is not straightforward to identify which processes and information system components must be redesigned. Next, we will describe how this task can be simplified using the GPS diagram described in the previous section. The new strategy adds two additional goals: (i) consistent contact with the costumer, either in store or via the Internet, and (ii) delivering 99% of the products purchased on the advertised time. Another set of goals must also be set so that shopping the virtual store is flexible and suits the client's needs. The core processes remain unchanged since the core business remains the same. Nevertheless, the supporting processes may have to be changed so that they positively support the new goals.

To support the new business requirements, the system components supporting the Sell Products process must be redesigned. On the one hand, the POS and the Customer Relationship Management components must be redesigned in order to accommodate the B2C paradigm. On the other hand, a new component supporting product delivery ("last mile") must be introduced. The GPS diagram reflecting these changes is presented in Figure 6.

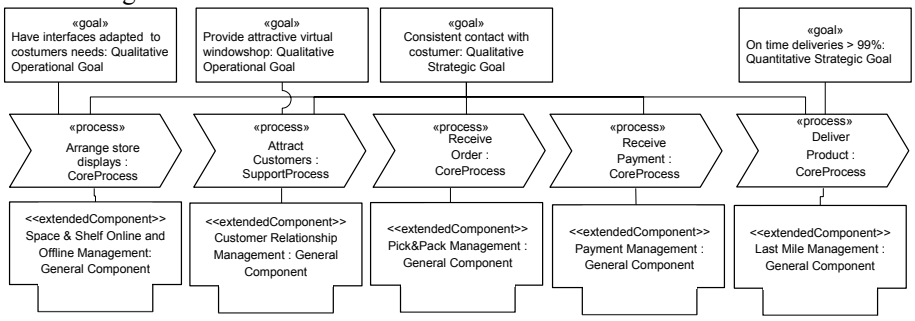


Figure 6 GPS diagram illustrating the B2C strategy.

7 Conclusions

We have presented a framework to describe organizational concepts so that understanding and communicating business, strategy and the supporting information system infrastructure is simplified. It makes use of a UML Profile to define a common language to describe these concepts and to provide a way to trace concept realizations from these areas of concern. We have embedded concepts from the Business Scorecard into goal modeling improving overall goal expressiveness. Business processes emerge as a middle tier between goals and system components, providing a means of repre-

senting workflow and the realization of strategy. The associations between process and system layers allow representing how information systems are supporting the business.

Future work includes specifying a methodology for capturing requirement into business models and a development process for traceable system design using business and strategic requirements as a starting point. Our current research involves modeling strategy, process and systems patterns using case studies from real organizations in different business sectors. In this setting, this framework sets a foundation for a representation of these patterns.

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