

A Reference Model for Process-Oriented Software Development Organizations*

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Abstract. In this paper, a proposal of a generic model for process-oriented software development organizations is presented. Additionally, the respective way of managing the process model, and the instantiation of their processes with RUP (Rational Unified Process) workflows, whenever they are available, or with other kind of processes is suggested. The proposals made in this paper were consolidated based on experiences from real projects.

1 Introduction

Systems using new technologies, developed and concluded in time and in budget, may not have a full usage or even not being used at all, if, for example, the client's requirements were not understood and included in the final applications.

Visual and semi-formal information models lead to a better communication among software engineers and clients. One example is UML (Unified Modeling Language), which allows the visualization, specification, construction, and documentation of the components of a software system. It is also important to adopt processes that use this language with added-value to the final client, like RUP.

Currently, organizations are moving from a hierarchical structure, sub-divided by departments where the activities are performed by collaborators with a limited view of the organization, to a model where multi-skilled teams run horizontal business processes that cross all the organization, and may affect suppliers and clients. Thus, to develop software systems for those organizations two aspects must be addressed: (1) the development process must be adequate and controlled; (2) the platform where the organizational processes will run must be modeled and considered, both in the software development organization and in the target organization.

This paper presents a proposal for a reference model for processes in a process-oriented software development organization, based on a generic model of organization. We also propose the way of managing it, and the instantiation of its processes with RUP workflows, whenever they are available.

The structure of the paper is the following. In section 2 the concept of a process-oriented organization that focus its activities towards the needs of the clients is introduced. In section 3 we propose a generic model for a process-oriented organization

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and in section 4, based on that model and in the RUP workflows, we detail it in order to describe the specific case of organizations that develop software (the main scientific contribution of the paper is described in these two sections). The Business Process Modeling is explained in section 5.

2 Process-Oriented Organizations

The concept of a process-oriented organization [1] is a way of focusing the activities of an organization towards the clients' needs. These activities are oriented towards and validated by the clients. The necessities of a client must be satisfied efficiently and with quality. Reengineering, and its process-orientation, must be applied to anticipate change and not as a corrective procedure when bad indicators occur.

The typical pyramids-like hierarchies constitute a real obstacle to satisfy the clients, since the functions and skills are distributed among several departments. Each of these departments has internal aims, which may create inter-departmental conflicts due to their divergences and threaten the clients' needs. Thus, in traditional organizations (fig. 1.a), the clients' needs may collide with the internal interests.

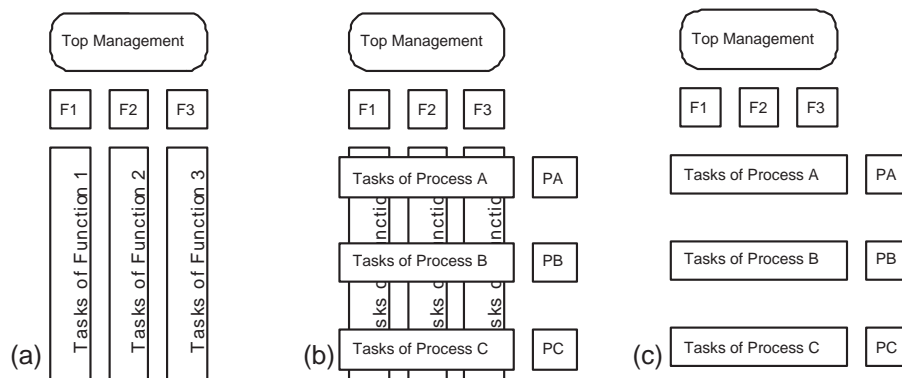


Fig. 1. Functional and process-oriented organizations.

A process-oriented organization tackles these conflicts by creating structures that assume for themselves the needs of the clients. Thus, as illustrated in fig. 1.c, a process that incorporates all the functions is created and whose objectives match the client's ones. Similarly, in functional organizations with integration of processes (fig. 1.b), the aims of the processes should have priority over the departments' ones.

In client-oriented and, consequently, process-oriented organizations, it is mandatory an easy adaptation to changes, so that the clients' needs are continuously satisfied. This necessity favors the continuous improvement of every aspect of the enterprise, being it process-, product-, or organizational-related.

Information technologies are among the principal factors to permit a process-based restructuring of a given organization [2]. Thus, the software engineering processes must

model the organization structure, during the requirements' capture. With this model, the system becomes more useful to the organization, and maintenance is facilitated since changes were already considered to occur in the product life-cycle.

Software is often the realization of the business rules [3]. Whenever these rules change, the software must also change accordingly. Nevertheless, the mere computer-based implementation of the business processes that already exist in an organization does not show all the advantages that that implementation could offer [4]. It is desirable that, in parallel with the implementation activities, there exist actions to redefine and optimize the way work is done. The performance of an organization will be better if both the automation of the old processes, and the constant improvement of its business processes are considered.

The validation of process improvements must always take into account the business perspective and must be evaluated according to the creation of value to the client of that process [2]. The use of object-oriented (OO) techniques to conceptually model an organization and its processes permits the analysis of information systems and the re-engineering of the business processes to become a unique activity [5], which requires a common set of artifacts [4]. The adoption of the OO paradigm and UML, both in the organization and in the information system models, is also supported by RUP.

3 Generic Model for a Process-Oriented Organization

Business processes can be viewed as a set of related tasks executed to achieve a given business goal. Within the business process, human resources, raw material, and internal procedures are combined and synchronized towards a common objective. An enterprise can be viewed as a group of competence centers, which share the same goal, whenever there is an instance of a process [1] (fig. 2).

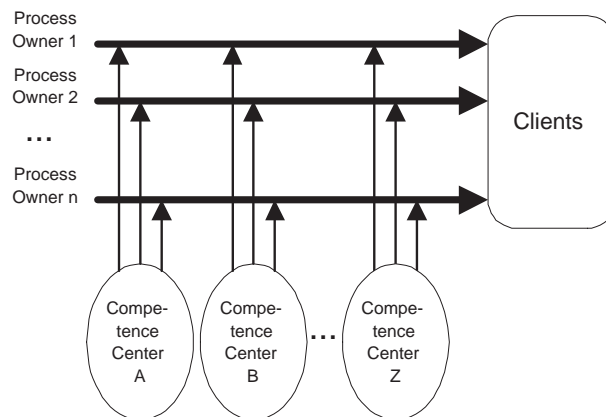


Fig. 2. Generic structure of a process-oriented organization.

For each competence center, a coach must be attributed, whose mission is to manage the members and provide them training, and assure the uniformity of technologies related with his center. The coach is also supposed, when requested, to assign members of his center to the processes being created. The owner of a process is responsible for the success of his process, according to the clients' objectives.

In this type of organizations, the members are no longer dependent on an hierarchical chain of command. Each member must have expertise in one area where he perform his functions. For that, he is helped by a coach to improve his capacities/skills and by a process owner to coordinate his activities with those of the other team members.

The career within an organization does not follow the typical promotion to higher positions in the hierarchy, thus reducing the problem of transforming a good technician into a bad chief. Instead, an element progresses within his area of competence, and he does not need to become a chief, since other elements are responsible for managing persons and processes.

Generically, an organization exists to supply a set of products or services to its clients. To achieve this, the organizations need to execute a set of internal activities. Actually, organizations do not exist isolated, but are part of markets, where other organizations can be their competitors, suppliers or clients. The creation of wealthy, within private organizations, or the supplying of products or services with social impact, within non-profit organizations, follow the same underlying principle: the fulfillment of the clients' needs. Thus, these needs and the expectations of the clients must be considered vital for defining the internal structure of an organization.

A process inside an organization can be viewed as a set of activities that has as inputs a set of services and/or materials and has as outputs also a set of services and materials. This view must be oriented towards the necessities of the client and the creation of added-value. This implies that the clients' requirements must always be considered, both in the design and in the performance of the system.

In an organization, there are other processes rather than those that provide added-value to the clients. The existence of different types of processes are necessary, to assure, for example, the strategic planning for the organization, the recruitment of the human resources, or the fiscal duties. As illustrated in fig. 3, these processes are instantiated in Management and Support Processes.

Within an organization, the management by processes requires a structure that differs from the typical functional hierarchy. It is mandatory to synchronize the processes among them and to fulfill the strategic objectives of the organization. Thus, for a process-oriented organization, a structure with the following components should exist:

Process Management Top Team: This team includes the top managers and all processes owners. Its mission is to revise all the processes according to the strategic objectives of the organization, to analyze the effectiveness of the process-oriented management (by changing, for example, the process owners), and to decide about unsolved problems at the processes' interfaces. This team is supposed to meet once a year.

Process Godfather: For each process one godfather, which must be a top manager, should be designated. His mission is to help and instruct the process owner, to decide when there is a problem of interface among processes, to determine the strategic orientation of the process (e.g. to decide that the development process of a given product has higher priority over another one), and to assure that the process is uniform within

the organization, i.e., that the development process of a new product is similar to the development of other products.

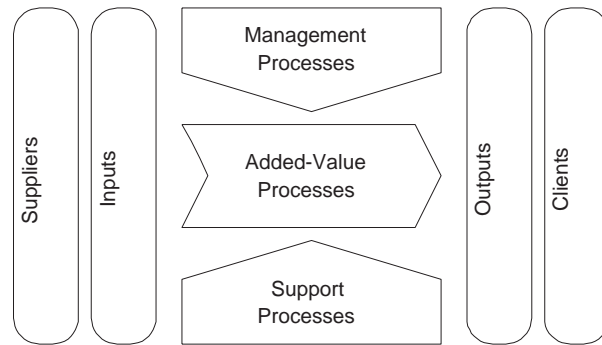


Fig. 3. Framework for an organization's processes.

Process Owner: For each process, an owner is needed. He must have know-how on managing processes and persons, but also competency in the areas associated with the process. His mission is to lead the process' multi-disciplinary team, being also responsible for the process design, measurement, improvement, and efficiency. The process owner and the godfather should designate the members of the multi-disciplinary team. This team must be constituted by elements with proven expertise on the several sub-processes and activities, and its cardinality must allow an effective management.

Multi-Disciplinary Team: These teams must be created for each added-value process, since they represent the most critical processes for the clients. For management and support processes and considering the organization size and its strategic objectives, multi-disciplinary teams may also be established. This decision must be taken by the process owner and godfather. The mission of this team is multiple: to monitor its process, to define and analyze the key indicators and the process objectives, to ensure that the process documentation is updated, to decide when and how to use improvement teams and coordinate them, to manage the process execution teams (e.g. to define the number of teams, the criteria of segmentation, the members validation). This team must meet in a weekly or monthly basis.

Execution Teams and Team Leaders: These teams and their leaders represent the instances of a given process. Therefore, during the execution of a process, some teams will use it with a specific focus. For example, for a given production process, one team may be responsible for producing parts for industrial clients, while other team may produce them for individual clients. This partitioning must be managed by the process' multi-disciplinary team, but the team leader is supposed to suggest its composition. Each leader must obey the definitions and use the indicators of the process for which he is responsible for. It is possible that some processes have only one execution team, whose members are the same as those of the multi-disciplinary team. The execution teams must meet each week, since they execute activities and tasks daily.

To align a process-based organization with its strategic objectives, it is crucial that the goals are based on the organization's mission and vision, and also on its principles and values. Based on those strategic objectives and in the business plan, the priority when deciding the key processes within the organization can be perceived.

After completing these stages, highly connected to the top management, we propose the following pragmatic procedure, to introduce the processes in an organization: (1) Define the processes: identify the collection of processes in an organization and decide on the relative importance of each one; (2) Define the sub-processes and tasks: each process is decomposed into sub-processes, until we reach a level of detail where only primitive activities remain; (3) Identify the interfaces among processes; (4) Assign the owner and godfathers to the processes and the members to the multidisciplinary teams; (5) Define the goals of the processes; (6) Define the key indicators; (7) Define the processes' team leaders and executing teams; (8) Measure and monitor the processes; (9) Execute corrective actions; (10) Review and continuously improve the processes.

The identification of the key processes within an organization must be accomplished with the help of criteria. Some of those criteria are: (1) Identify if the process traverses several functions; if this is not the case, we might have an activity or a task; (2) Verify if the process is measurable and is integrated in the business plan; otherwise, the process must be terminated, since it is not aligned with the organization's strategy; (3) Verify if there is a focus towards the clients and their requirements; when this does not happen, the process may be inefficient; (4) Determine the importance of the process for the final quality of the product; (5) Determine the importance of the process for the fulfillment of the organization's mission; (6) Verify if the process is multi-disciplinary; if that is not the case, we may have an activity or a task; (7) Find out the importance of the process to the success of the organization.

Based on these criteria, we can select which processes of a given organization will have a process-oriented management and the activities and tasks they will be composed of. Some processes, activities, and tasks will be eliminated since they do not add any value to the clients, neither to the organization. These eliminated (or redefined) processes, activities, and tasks and their respective consequences in terms of reorganization and impact in human resources are the essence of re-engineering [1].

Besides this general framework (fig. 3), inside each process category (management, support, and added-value), there are several processes that define with more detail the types of activities that exist inside organizations (fig. 4.a). The business processes are designed with the aim of bringing value to the organization. This value must be quantified to serve as a basis to trace the process state and possible improvements. Some general indicators for each process were proposed [6]: productivity, added value, cycle time, queue size, quality indices.

In the management category (top of fig. 4.a), 3 business processes are proposed:

- Global Strategy (GS): within this top-level management process, potential clients are evaluated, the innovations are planned, and the general policy for the enterprise, such as its mission, its vision, its principles, its values, and its long-term objectives, is defined;

- Policy Deployment (PD): the organization’s policy and short-term objectives, usually defined in an annual basis, are unfolded and delivered to the competence centers and processes;
- Business Plan (BP): the planning and the budgeting of the activities and their distribution among processes and competence centers are defined. Normally, these activities are planned with an annual scope; the activities for controlling the execution of the plan are also defined.

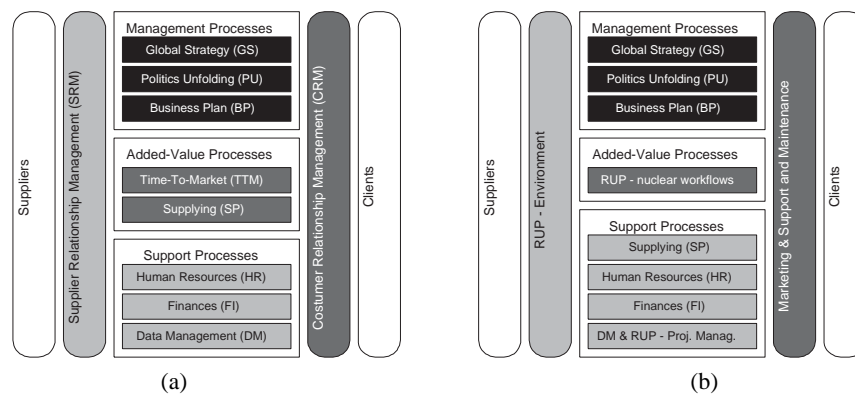


Fig. 4. (a) General composition of the processes within a generic organization; (b) General framework for the processes of organizations that develop software.

In the added-value category (center of fig. 4.a), there are 3 business processes:

- Time-To-Market (TTM): This represents the development process associated to a new product and the environment needed to produce it. Usually, this process occurs between the discovery of a business opportunity in the market and its complete development;
- Supplying (SP): This process occurs normally after the TTM for the same product, and starts with a request from the client, or with a decision of production, and ends with the deliver of a product to the client with the fulfillment of the required schedules and quality levels;
- Customer Relationship Management (CRM)³: This process includes activities such as marketing, after-sales service, management of clients’ accounts, and generally all activities that allow clients to be satisfied with products or services supplied to them.

In the support category (lower part of fig. 4.a), 4 business processes are suggested:

³ Although the CRM process is mainly seen as an interface process, it was also included in the added-value category, because client-oriented organizations must address the customer needs.

- Supplier Relationship Management (SRM)⁴: This includes activities such as the selection of the materials' suppliers, the execution of audits to verify the quality, or the establishment of agreements for just-in-time delivers;
- Human Resources (HR): This process includes activities related to hiring people, salaries management, and generically all issues associated with the well-being and qualifications of the organization's collaborators;
- Finances (FI): All the activities related to fiscal issues belong to this process;
- Data Management (DM): This process includes activities associated to data quality and the indicators of the organization, the security of data, the priority of computer related projects and their budget control, data-warehousing and data-mining.

It is important to indicate that if the processes are described in great detail, it will be difficult to implement them. The idea is to maintain the processes as generic and abstract as possible, to allow their instantiation to a broader class of organizations. The emphasis and priority, and also the specific activities of each process, depend primarily on the type of organization where they will run, and secondly on the strategic objectives of the top management. The activities related to the continuous improvement, to the quality and environment management (including certification tasks), are all examples of activities that tend to be confused with processes. These activities are part of all processes, such as those of fig. 4.a), and should not have a separate management.

4 Model for an Organization that Develops Software

Since the process model presented in fig. 4.a describes a generic organization, it can also serve as a basis for modeling an organization that develops software. Being a more specific type of organization, we can add more details and propose processes already existent to the processes presented in the generic model.

In this section, we analyze and compare the specific aspects of the model in fig. 4.b with the model in fig. 4.a that was in its origin, highlighting those topics that differentiate them, namely indicating how the RUP workflows can be used. This constitutes the main contribution and innovation of this paper and next, we propose the instantiations of the business processes within the organizations that develop software.

Any type of organization needs management processes. Therefore, the processes named Global Strategy (GS), Policy Deployment (PD), and Business Plan (BP) are equivalent to those of any other organization, although we must take into account the particularities of the software market, such as the rapid changes in technology and the competition in world-wide markets.

Since software is an intangible product, it is obvious that no raw materials are needed to produce it. For organizations that develop software the SRM process is instantiated in RUP's Environment Workflow, since it furnishes the working environment (e.g. development tools), which will be used by the teams, and the development guidelines to be followed by the teams within the organization.

⁴ The SRM process is mainly classified as an interface process, but it was also included in the support category, because it generates inputs for added-value processes.

The Supplying (SP) process consists essentially in creating copies of an application. In contrast with more traditional industries, where it represents probably the most important process, in software, due again to its intangible nature, this is an easy process. Usually, the kind of materials used to support it, DVD and printed manuals, imply that external suppliers are hired. The outsourcing of this process comes from the fact that it is considered to be secondary for an organization that develops software. Therefore in this kind of organization, this process is a support one.

The Time-To-Market (TTM) process is mapped into the set of nuclear workflows of RUP: Business Modeling, Requirements, Analysis and Design, Implementation, Test, and Deliver. This set of activities, or sub-processes, run in parallel for the same development project [7]. In our opinion, this is the most critical process for an organization that develops software.

The Human Resources (HR) process for software factories is the same as for other types of organizations. We must however point out that software development requires highly-specialized people, being their hiring a critical issue for the success of the organization. It is impossible to produce quality software without skilled people.

The Finances (FI) process is the typical fulfillment of the fiscal obligations, which is common to all types of organizations.

The Customer Relationship Management (CRM) process is decomposed into the sub-processes: Marketing, and Maintenance and Support. This ensures that, when a software application is delivered to the final clients, its life-cycle does not end, but instead continues with this process, incorporating changes and corrections and providing training to the users, until the application is no longer used by the client. The Marketing assumes, in this case, a form similar to that observed in other types of organizations.

The Data Management (DM) process, in what concerns the data related to the nuclear RUP workflows, is mapped into the RUP's workflow 'Project Management'. In this workflow, some activities lead to the production of indicators of the project status. Its existence is the foundation to take decisions based on facts, related to the advance of the project and also to adjust and improve the software development process.

To reach the highest CMM levels, the continuous improvement of the development processes must be part of each process, instead of being a single autonomous process.

The nuclear RUP workflows, that in fig. 4.b implement the added-value process, are sub-divided in activities, which can be viewed as sub-processes. The description of those sub-processes is made with UML activity diagrams (an example is presented in fig. 5), complemented optionally with other type of diagrams, such as interaction diagrams, and business object diagrams. This representation is also valid for all other processes of a generic organization, as illustrated in fig. 4.a. Whenever an organization that develops software executes a development process, the TTM process will be executed. Since we are proposing this process to be implemented by the six nuclear RUP workflows, it implies that the workflow 'Business Modeling' will also be executed. This workflow strongly recommends the usage of activity diagrams (and other complementing diagrams) for modeling purposes. Therefore, the target organizations, as proposed in fig. 4.a, will be modeled with a collection of these diagrams. In parallel, within the organization that develops software, since the workflow 'Business Modeling' is a sub-process of the TTM process, it can also be modeled by activity diagrams (fig. 5).

5 Business Process Modeling

In this section we concentrate on 'Business Modeling', because of the six RUP nuclear workflows (Business Modeling, Requirements, Analysis and Design, Implementation, Test, and Deliver), it is the one most directly related to the client's needs. During the development of software, all the stakeholders must have a common understanding of the business processes that exist in the target organization. This reality is not circumscribed to the obvious organizational information systems, but can also include real-time embedded systems if they affect the business processes.

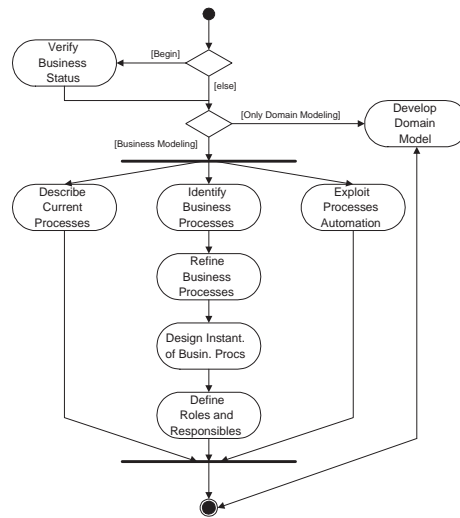


Fig. 5. Activity diagram in the business modeling in RUP.

If the development of applications does not take into account the current business processes (or those to be implemented), the result will be unsuccessful. This may be caused by the fact that the end users are not using correctly the application, since it does not model and support directly the activities under their responsibility. Within RUP, the business processes model is obtained in the 'Business Modeling' workflow (fig. 5). The main activities in this workflow are centered around the identification, refinement, and realization of the business processes and in the definition of the roles of people associated to the business. Each role in this RUP's workflow (e.g. the agent that executes some activity within the organization that develops software) has under its responsibility the execution of several activities that will have as deliverables several artifacts (tab. 1). It is important to note that the activities of tab. 1 are at a higher level of detail than those of fig. 5. For example, the activity 'Refine Business Processes' includes the activities 'Structure the business use case model', 'Review the business use case model', and 'Detail business use cases'.

Among all the activities and their respective artifacts, only some are mandatory. This flexibility permits the configuration of RUP, so that it can be adapted to a specific

project executed in a specific organization. Thus, taking into account the options made when choosing the artifacts, the following set allows modeling business processes [7].

Business Vision: This artifact captures the goals of a particular business modeling activity. It should be stated 'Why' and 'What' are to be modeled. It also serves as an oracle to all future high level decisions.

Role	Activity	Artifact
Analyst of the Business Process	Verify target organization Establish and adjust objectives Capture the vocabulary of the business Find business actors and use cases Maintain the business rules Structure the business use case model Define the business architecture	Business rules Business use case model Business Glossary Business object model Business vision Supplementary business specification Target organization verification Business architecture
Reviewer of the Business Model	Review the business use case model Review the business object model	
Designer of the Business	Detail business use cases Find business workers and entities Define the automation requirements Detail business entities Detail business workers	Organizational units

Table 1. Roles, activities and artifacts for business modeling in RUP.

Business Glossary: In this artifact all business terms and expressions are kept.

Business Rules: The business rules correspond to policy statements and conditions that should be fulfilled, from the business perspective. They are similar to systems' requirements, but they focus on the business core, expressing rules related to business, but also its architecture and style. Its modeling must be rigorous, being one possibility the usage of the Object Constraint Language (OCL) as specified in UML [8]. Alternatively, using a natural language in a structured form is also admissible, since even though there are clear advantages in using a more formal approach, the need to allow its understanding by all the stakeholders is usually paramount.

Business Use Case Model: The main goal of this artifact is to show how the business is being used by all stakeholders. This is achieved by modeling the business processes and their interactions with external parties, based on use case diagrams (with stereotypes for business use cases and business actors) [9]. The business processes are associated to a workflow that needs to be modeled, and that specify how added-value is created for the business actors. This modeling can be supported by activity diagrams, possibly extended with the representation of organizational units interfering in the business process and with the distribution of the activities by those organizational units.

6 Conclusions

In this paper, we have presented a generic model for process-oriented organizations, which serves as a foundation for modeling organizations. This model is adequate for modeling target organizations. Based on this model, we have also proposed a process model for organizations that develop software, the corresponding way of managing it, and the instantiation of their processes with RUP workflows. These concepts and ideas were used in two case studies, where the usage of UML and RUP, to develop software for a process-oriented organization, were experienced.

Based on the experience from these two projects, we believe that the modeling capabilities of a graphical modeling language, such as UML, and the understanding that it offers to all the stakeholders is a crucial factor to avoid interpretation errors and to improve the solution's utility and correctness.

The existence of a process, within an organization that develops software, that ensures control over the activities being carried out and guarantees the quality of the final solution is of major importance.

Whenever the target organization is a process-oriented organization, with the structure depicted in fig. 4.a, RUP can handle its modeling and the transformation of the business processes into computer applications supporting them. Finally, RUP can be used for systems already in execution, developed without a process-oriented perspective, allow their integration in a new system, by re-engineering the business process, through the business use case diagrams for the current and future situations.

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