

■ Research Article

Knowledge-Oriented Process Portal With BPM Approach to Leverage NPD Management

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New product development (NPD) processes can be improved through change projects managed in a context of business process management (BPM). In order to fully characterize and implement NPD process change projects it is necessary to be able to identify and adequately describe “to-be” processes. These “to-be” processes should be based on best practices, which can be structured into NPD reference models and body of knowledge (BOK). Despite the availability of NPD BOKs today, they are not easily applicable to process improvement, since they are published in on- and off-line guidelines that are unsuitable for dynamic updating by a collaborative network such as a community of practice (CoP). A proposal is therefore put forward for the collaborative systematization of best practices through a two-level portal external and internal to an organization, enabling users to participate in creating generic and public NPD reference models and BOKs. The proposal allows for the selection of a specific reference model and an existing BOK as required. This paper presents the main concepts underlying the proposal and its methodology, which focuses on agile project management (APM). It also describes the portal vision and the main deliverables of this research, with emphasis on the concept of the knowledge-oriented process (KOP) portal. Three prototypes based on this concept are shown, which represent the evolutionary development of the KOP portal. Finally, the main results of the application are presented and discussed. Copyright © 2009 John Wiley & Sons, Ltd.

INTRODUCTION

New product development (NPD) is a business process (BP) aimed at converting market opportunities, technology, and customer needs into technical and commercial solutions. To apply new best practices and ensure the optimization of processes, NPD requires a management approach based on

integrated business process management (BPM). BPM, together with strategic planning, provides performance metrics that are used to monitor business and NPD processes (Costa *et al.*, 2007). The continuous improvement of a BP may, in turn, be based on a reference model. BP reference models comprise a collection of best practices that serve to define a specific BP (also known as a standard process) for an organization. This generic reference model can also be used to benchmark and define a new to-be model, so change projects may contribute to transforming an as-is into a to-be situation represented in the model. Thus, a NPD reference model promotes a single product-development

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vision for the benefit of all involved, placing all stakeholders at the same level of knowledge.

Existing reference-model elements (i.e., specifying work instructions, activities, information, tools, methods, templates, and best practices) must be adapted to the company's NPD maturity levels. These elements may involve materials such as instructional publications; guides for method application; case descriptions for benchmarking; books designed to teach the basics of groups of activities; specialist résumés or even technology suppliers who support firms in implementing best practices; descriptions and further resources (e.g., spreadsheet and software) related to the application of best practices, etc. These knowledge objects always represent explicit knowledge and may include descriptions of tacit knowledge. These are dynamic elements, subject to updating by members of an organization or a community of practice (CoP). All the participants contribute to collaborative creation and information sharing, which becomes the so-called body of knowledge (BOK). Linking an element of a BP model to a knowledge object and a specific best practice within a BOK gives people the opportunity to learn by themselves, which, in turn, may lead to process improvement within their organizations.

Few companies are aware of the advantages of such practices, few continuously improve their NPD processes, and most of them carry out change projects only occasionally. In addition to low levels of competence, the explanation for this is lack of tools that facilitate the integration of a specific reference model with a generic one. Furthermore, such situations reflect the absence of a dynamic and collaboratively created BOK linked to BP model elements.

The fundamental question that now presents itself is whether a feasible framework can be created upon which to support the management of BP reference models integrated in a knowledge management environment. This framework should support the development of an ICT (information communication technology) tool, e.g., a portal, to support knowledge sharing among partners in a BP. In this paper, we focus on a NPD process.

This work proposes a knowledge-oriented process (KOP) portal based on a generic framework, i.e., an environment that enables organizations to define and manage their own NPD reference models (standard process)—or even to use existing generic reference models—and to continuously update the associated BOK. The portal should enable access to reference models, their elements, and related knowledge insertions, to be shared by all stakeholders in a company; as well as lessons

learned and best practices related to the models. Furthermore, it would permit participation in a CoP that allows for knowledge sharing and contact with specialists.

It is important to emphasize that the use of this technology should be tailored to other business requirements and approaches, such as balanced score cards, knowledge management, organizational learning, human resources management, etc., all of which contribute to continuous process improvement.

In the balance of the paper Section 2 outlines BPM according to the aforementioned concept, describing NPD process management integrated with BPM. BPM features are referred to in creating a framework for continuous improvement of NPD processes. Section 3 then discusses the importance of NPD reference models and demonstrates how BOKs can aid in process improvement. In establishing reference models and corresponding knowledge sources we are proposing a tool to support collaboration and knowledge sharing, thus Section 4 describes the main concepts of knowledge sharing and CoP, and describes advanced web portals for this purpose. Section 5 presents the methodology, vision and conceptual model of the portal, as well as prototypes that have been developed and the results of practical applications. The paper closes with our conclusions, in Section 6.

BUSINESS PROCESS MANAGEMENT (BPM)

BPM is equally about business and technology (Smith and Fingar, 2003). From the vantage point of business, BPM is regarded as a best practice management principle to help companies maintain a competitive edge. From a holistic perspective, BPM combines total quality management (TQM), which is incremental, evolutionary and continuous in nature, and process re-engineering, which is radical, revolutionary, and regarded as a one-time undertaking suitable in most circumstances for performance improvement (Hung, 2006). A currently developing trend is the application of BPM to innovation and innovation processes (Smith and Fingar, 2003).

Several authors, however, see BPM as a technological tool, an evolutionary step beyond workflow management systems (Aalst *et al.*, 2003). From this perspective, the BPM life cycle has four phases: process design, system configuration, process enactment, and diagnosis. Traditional workflow management (systems) focus on the process design and BPM enactment phases of the BPM lifecycle

(Aalst, 2004). Although workflow technology should be considered when NPD process improvement is related to the introduction of product life cycle management (PLM) systems, this paper focuses on the business vision of BPM, since its objective is to integrate NPD process improvements within a broader BPM framework.

Hung (Hung, 2006) defines BPM as an integrated management philosophy and a set of practices that incorporate both incremental and radical changes in business processes, emphasizing continuous improvement, customer satisfaction, and employee involvement. BPM is a structured and systematic approach to the analysis, improvement, control, and management of processes to increase the quality of products and services. This approach depends on the alignment of business operations with strategic priorities, operational elements, the use of modern tools and techniques, human involvement and, most importantly, a horizontal focus that can best meet and satisfy customer requirements in an optimized way (Zairi, 1997; McKay and Radnor, 1998).

BPM, which manages company performance indicators, should be integrated into strategic plan deployment from which change projects are usually derived. These projects can be either small improvements (e.g., executing kaizens) or major changes (e.g., implementing new standard processes). An NPD process, currently recognized as one of the key processes by which to enhance competitiveness (Büyüközkan *et al.*, 2007), should be consistent with BPM strategies in order to meet a company's strategic goals. The next section discusses how reference models in BPM contribute to NPD improvements.

IMPORTANCE OF REFERENCE MODELS IN NPD

Ulrich and Eppinger (Ulrich and Eppinger, 2003) define the NPD process as a sequence of steps or activities employed by an enterprise in the conception, design and commercialization of a product. These activities permit the interchange of information (Browning and Eppinger, 2002).

NPD is a BP implemented by a group of people to transform data on market opportunities and technical possibilities into useful information for the design of a commercial product (Clark and Fujimoto, 1991). NPD is considered a critical BP to increase company competitiveness, diversity and product mix—especially on the international market—and to reduce the product life cycle (Büyüközkan *et al.*, 2007; Rozenfeld, 2007).

Product development requires interdepartmental cooperation, and involves people with different areas of expertise and varying levels of experience. Thus, effective communication is critical in implementing NPD as a continuous learning process (Söderquist, 2006; Bradfield and Gao, 2007).

Efficient management of product development depends on making the process visible to all stakeholders (Costa *et al.*, 2007), which results in a representation that describes the company's BP (Pernici and Weske, 2006). This representation is known as the *business process reference model*. A generic reference model is usually developed for individual industrial sectors. Companies within each sector can then create their standard process models by adapting the generic reference model to their own specificities. Thereafter, NPD projects can be mapped out. By means of a reference model, a single product-development-vision can be attained, bringing all the stakeholders participating in a specific development to the same level of knowledge (Rozenfeld, 2007).

Some examples of NPD reference models, with different levels of detail, are: Stage-gate Process (Cooper, 2001), Pahl & Beitz Model (Pahl and Beitz, 2003), Product Design and Development Model (Ulrich and Eppinger, 2004), CMMI (Software Engineering Institute, 2006), and PDPnet reference model (Amaral and Rozenfeld, 2007; Rozenfeld, 2007), which is adopted herein as a generic NPD reference model. This model synthesizes NPD best practices, which are structured into the following phases: strategic product planning, project planning, informational design, conceptual design, detailed design, production preparation, product launching, product and process follow-up, and product discontinuation (Amaral and Rozenfeld, 2007; Rozenfeld, 2007).

The PDPnet model highlights the integration of strategic planning and portfolio management; the incorporation of PMBOK concepts (Project Management Institute, 2004) into the planning phase; the definition of integrated iterative cycles (detailing product acquisition and product cycle optimization) in the detailed design phase; the insertion of optimization activities; and integration of the product launching phase, wherein other business processes such as technical assistance and sales processes are defined and implemented.

These reference models have been developed to capture processes and data abstractly and may represent the best practice solutions for a specific industry. The models usually cover the entire range of solution components such as product models, business rules, data models, and service models (Kuster *et al.*, 2006). Once developed, a reference

model for a specific problem domain may be utilized in different ways (Fettke and Loos, 2003):

1. To provide a framework for the identification, development, and coordination of related standards, while facilitating communication among stakeholders.
2. To develop more specialized models to support specific requirements and scenarios (standard processes).
3. To map onto a collection of software components and data flows between those components and to obtain a reference architecture that can be refined by adding sufficient implementation details, resulting in a system architecture.
4. To permit the use of an architecture-based development process. Architecture-based development is characterized by combining or integrating separately developed components into a functional entity, while respecting constraints and the organizational structure imposed by the system architecture (and the reference model). Such development is generally thought to increase quality and/or to be cost-saving, during both system development and normal operational life.

The benefits of reference models are widely recognized, but there is still a lack of understanding about the types of reference models that should be used for specific applications (Fettke and Loos, 2003). Moreover, existing reference models are limited and their content is somewhat static, i.e., they tend to represent a frozen collection of best practices rather than sources of alternative approaches and support for the improvement of NPD knowledge. As a result, they typically do not allow for updating, and hence, for continuous improvement through the sharing of structured NPD knowledge by an online community, nor are most of them open for free access. Sometimes the level of detail is insufficient to support the modeling of detailed activity procedures. Only some of them offer an integrated maturity model to support the smooth evolution of a company's specific model. Furthermore, it is not easy to find a flexible change method associated to a model that allows for the implementation of a to-be model within the BP. In the following section, some ways to share knowledge—knowledge sharing concepts and portals—are explained in the next section.

KNOWLEDGE SHARING, COMMUNITY OF PRACTICE, AND WEB PORTALS

Given that knowledge is a strategic resource for companies, researchers, and managers have sought

to determine new ways to efficiently gather and manage these resources to produce new knowledge (Hahn and Subramani, 2000).

However, the accumulated knowledge of an organization is only strategically useful when shared, synthesized, and used in unique ways (Zahra *et al.*, 2007). Hence, companies must implement specific practices to share and disseminate their knowledge so as to build and strengthen their technological capabilities or skill set to build upon and leverage in capitalizing on different technologies and systems.

There are two complementary viewpoints about knowledge sharing (Zahra *et al.*, 2007). The first, known as formalized knowledge sharing, considers knowledge as a collectable, storable, and retrievable artifact (Leonard-Barton, 1995). In this case, organizational knowledge can be packaged and transferred by means of structured and formal knowledge-sharing practices. The second, called informal knowledge sharing, regards knowledge as tacit, socially constructed, and collectively held by individuals throughout the organization (Nonaka and Konno, 1998).

Collective knowledge sharing can be supported and nurtured by communities of practice (Yoo *et al.*, 2007). Wenger (Wenger, 1998) describes communities of practice as the source of an evolutionary group-learning process. Such communities consist of three basic elements: domain, community, and practice (Wenger *et al.*, 2002). Domain refers to the subject selected by a community, the knowledge of which is shared and accumulated. Communities are comprised of interacting people who build relationships around a given domain. They create the possibility of collaborative learning about how to address and deal with issues that interest community members. A fundamental aspect of community is the effective information sharing, which is conducive to the construction of new accumulated knowledge.

The community's experience and collaboration are worked into "artifacts" (e.g., symbols, procedures, rules, technology, products, lessons learned, etc.) (Wenger *et al.*, 2002). Communities are cultural entities that emerge from virtual or non-virtual organizations. Virtual communities are groups that use networked technologies to communicate and collaborate across geographical barriers and time zones (Johnson, 2001).

Nowadays, markets demand higher quality and higher performance products, with shorter and more predictable life cycles and lower costs. Therefore, companies use information and communication technologies in NPD to accelerate the process, increase productivity, facilitate team

collaboration, communication and co-ordination, foster versatility, produce and share knowledge about new products, improve decisions about new products, and to develop superior products (Özer, 2004; Büyüközkan *et al.*, 2007).

For such purposes, portals can be profitably used to promote the integration of people, and for applications and services through a single access site. Portals allow for the collection, management, sharing, and utilization of information (e.g., textual documents, web pages, images, videos, sound, etc.) available in multiple sources, such as application databases (Benbya *et al.*, 2004; Smith, 2004). Therefore, portals can include administration, research, content management, and collaboration tools, among others.

Portals can be classified as environment-related (public or corporate) and function-related (decision support and/or collaborative) portals (Dias, 2001). Public portals, also known as internet portals, web portals or consumer portals provide a single interface for the entire network of Internet servers. Corporate portals, which have evolved from intranets, comprise new tools that enable the identification, capture, storage, retrieval, and distribution of vast amounts of information from multiple internal and external sources. Decision-support portals help executives, managers, and

analysts gain access to corporate information in order to unify business decisions. Collaborative portals deal with information from traditional supply chains stored and handled by corporate applications, as well as information produced by groups or individuals outside of these chains.

A knowledge portal (also called an enterprise information portal) can be classified as a decision support portal as well as a collaborative portal. Thus, we have outlined a proposal for the creation of a KOP portal for continuous NPD process improvement, which we present in the following section.

PROPOSAL OF THE KNOWLEDGE-ORIENTED KOP PORTAL

A hypothetical-deductive approach was adopted to develop a KOP portal. This methodological approach is more suitable for iteratively developed research projects, resulting in many prototypes that test new hypotheses individually. Whenever a prototype cannot be refuted, the concept is considered robust (Coughlan and Coughlan, 2002). The hypothesis in this case was the KOP itself. This portal facilitates both access to reference models and systematic knowledge sharing to improve NPD

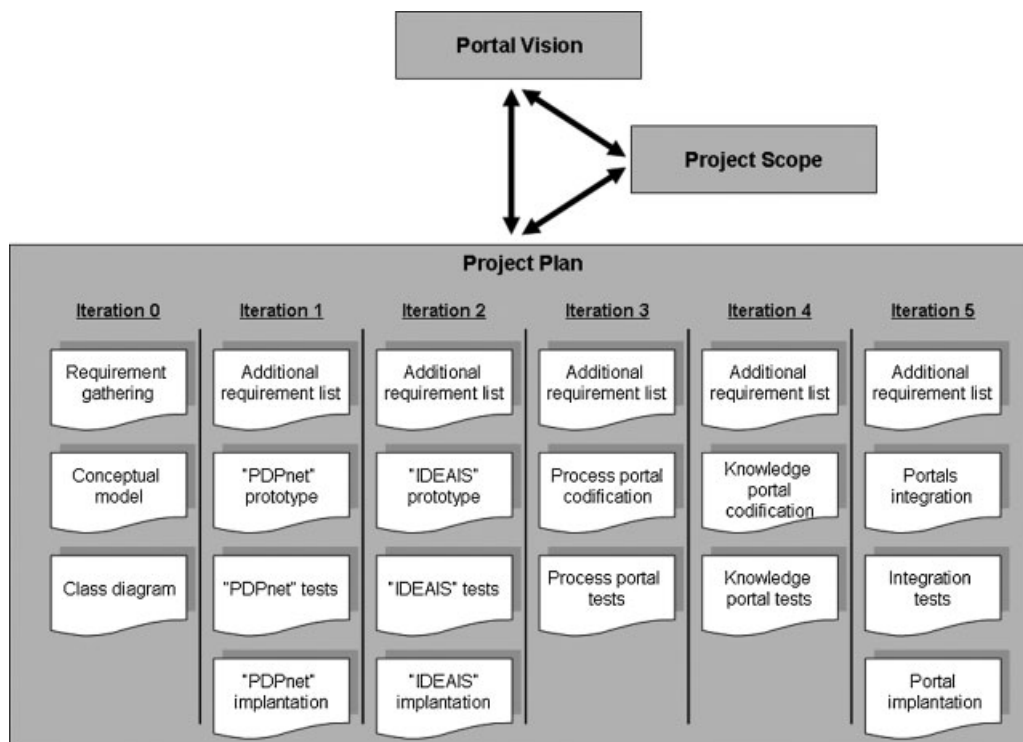


Figure 1 Project plan based on the agile approach

processes. In the first implementation, the KOP was divided into two portals, namely, “process” and “knowledge.” The first process portal prototype included a generic NPD reference model and was available to a CoP, called a PDPnet (Rozenfeld *et al.*, 2002). Subsequently, another prototype, named IDEAIS, was developed and adopted by a small company. In addition, a more flexible process portal was developed simultaneously with the knowledge portal. Both will be integrated in the fifth iteration.

In this work, we adopted the agile project management (APM) approach (Highsmith, 2005). The first phase involved the development of the portal vision. This was followed by the outline of the project’s scope, after which the project plan was executed. The software development method adopted here was the rational unified process (RUP) (Kruchten, 2003), which is based on iterative and incremental development involving the phases of conception, elaboration, construction, and transaction. This method is therefore in line with APM.

Figure 1 describes the iteration deliverables. The partial results obtained so far are associated with the fourth iteration. This paper presents the following deliverables: portal vision, the conceptual model, PDPnet and IDEAIS prototypes, and the implementation of the process and knowledge portals.

Portal vision

The portal’s mission is to offer an environment that enables organizations to define and manage their own NPD reference models (standard processes)—or even to use existing reference models—and to continuously update the BOK associated with their reference models. This mission was divided into two main objectives:

1. To manage the BOK associated with the NPD reference model. The BOK can be used collaboratively within a CoP which produces and shares knowledge about the model’s elements.
2. To offer an environment that enables organizations to manage, i.e., to create, read, update, and delete their own NPD standard process or

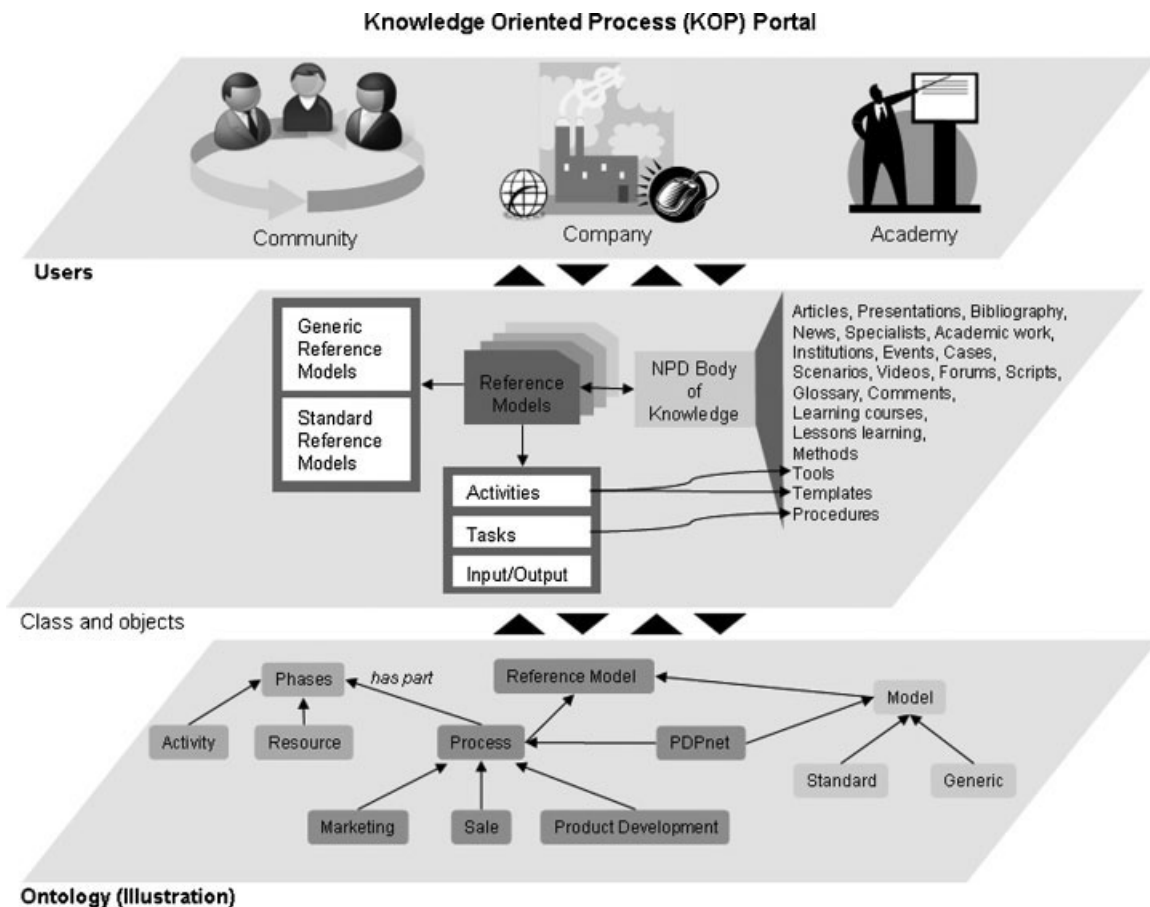


Figure 2 The conceptual model of the portal

to use existing reference models, provided that a system to manage reference models is available.

Five main groups of requirements were defined to ensure that these objectives are achievable:

1. That a mode of inserting and developing new reference models be provided. These reference models comprise best practices and describe activities, and information and resources used therein, including methods, techniques, and tools as well as roles played by people involved in element organization.
2. That portal users (organizations) be allowed to use available reference models as the basis to define their standard NPD processes. The users may adapt the reference model to their requirements, excluding or inserting model elements.
3. That exchange of reference models be allowed between the KOP portal and BP modeling tools.
4. That portal users be empowered to insert NPD knowledge objects and link them to any model elements, thereby facilitating continuous process improvement. To this end, lessons learned through the use of the model elements and knowledge about these elements is vital. Reported knowledge may include any BOK objects of knowledge (described below).
5. That portal users be entitled to participate in a CoP, since this enables management of the BOK

associated with reference models. Furthermore, users can access community comments relating to the BOK of a given reference model.

Based on these requirements, we elaborated a conceptual model of the portal, as described in the following section, and identified many project deliveries.

Portal conceptual model

Figure 2 shows the conceptual model of the portal. The user profile includes professionals, researchers, teachers, students, and all those interested in NPD. User privileges may be stated in the portal, as well as all viewing possibilities and also areas restricted to companies, research groups, projects, and communities.

The main categories of objects are related to knowledge processes. Reference models may be generic or standard. Models may include the following attributes: activities, tasks, input and output information, responsibilities, associated knowledge, methods and tools to be applied, and performance indicators. The BOK comprises a set of categories, called knowledge objects, such as papers, presentations, books, videos, tools, methods, concepts, systems, cases, best practices, and academic work. These objects may be accessed, commented on, and linked to reference model objects, since an activity can use a tool as a resource.

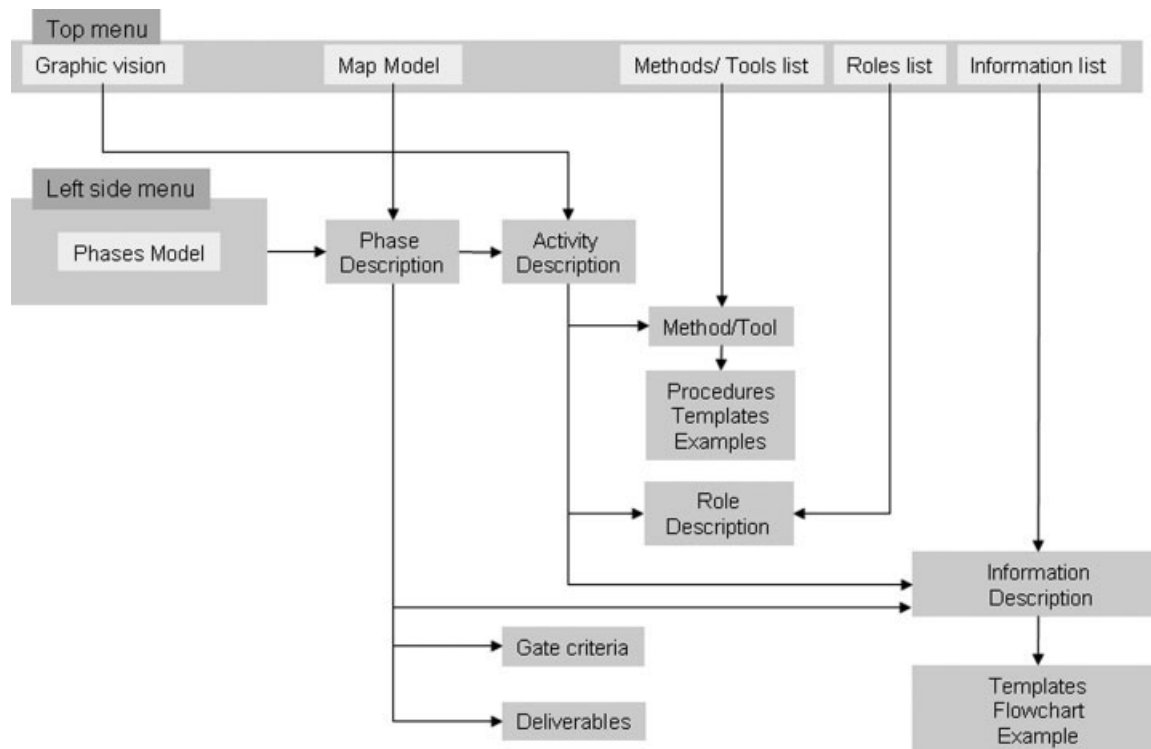


Figure 3 Navigation map model of the PDPnet portal

The information in the portal can be accessed in different ways according to the user's needs. The BOK or reference model contains detailed information on any object. However, dynamic knowledge insertion and updating depend on user commitment to the community.

This portal is based on a knowledge-management ontology, which contributes to the formalization of concepts about product development and relations among those concepts. Its aim is to help users retrieve and reuse knowledge available in the KOP. The KOP can also be applied in organizations that have their own specific model and BOK.

Reference models can be visualized through a tree structure. The models' structure is determined

by the information hierarchy, i.e., process, phases, and activities, and the latter can be associated to resources. For instance, a NPD tool such as QFD (quality function deployment) can be associated to an activity, enabling users to access additional information, such as real examples of application, best practices, etc. Work instructions of a specific organization may also be linked to that activity and to the people responsible for it.

Since the ability to import process models from other modeling tools is essential, models can currently be imported from ARPO[®] (Klug Solutions, 2007), a modeling tool. New modeling tools are now being evaluated with a view to integrating them into the KOP Portal. The next stage



Figure 4 Web pages of the PDPnet portal

will involve the incorporation of an imported XML representation of a Business Process Management Notation (BPMN) (Johannsen *et al.*, 2007).

A CoP may use and share information incrementally within the portal, i.e., by adding more knowledge to the BOK or contributing comments on existing knowledge.

The CoP will provide support for users to improve knowledge relating to standard process models. The CoP will enable users to contact NPD specialists, and to access links to pertinent websites, papers, books, and other important research material. Thus, users can add new experiences to the existing BOK.

Based on the methodology employed in this research, the definition of the aforementioned conceptual model was followed by project iteration development, whose results are shown in the following section.

Partial results

PDPnet and IDEAIS prototypes were developed in the 1st and second iterations, respectively. After these prototypes were implemented and tested, iterations 3 and 4 were carried out to develop two additional environments: a more generic process portal and a knowledge portal. These environments were developed and tested individually. After the

validation project, Iteration 5—portal integration—will commence.

The first prototype developed was named PDPnet. Its main goal was the rapid development of a simple site to publish a new reference model. The site's navigational model is illustrated in Figure 3.

This development met, and improved on, what had been stipulated in the initial requirements, which were related mainly to capabilities needed for reference models and to easy use by companies and researchers, in line with the APM approach.

This portal records about 50 000 visits and can be accessed at www.pdp.org.br. Among its visitors are undergraduate and graduate students and professionals seeking a site that provides reference material for product-development courses and company training courses. Figure 4 shows the main PDPnet pages.

In Iteration 2, a second prototype was created to support a software development process of a small company (Figure 5). All the information about this process (e.g., activities description, document templates, resources, rules, etc.) was published in the prototype.

The prototype was called "IDEAIS Site" (acronym in Portuguese for "Integration of Enterprises in Systems Application and Implementation"). All the information about the software development



Figure 5 First process portal prototype (IDEAIS)

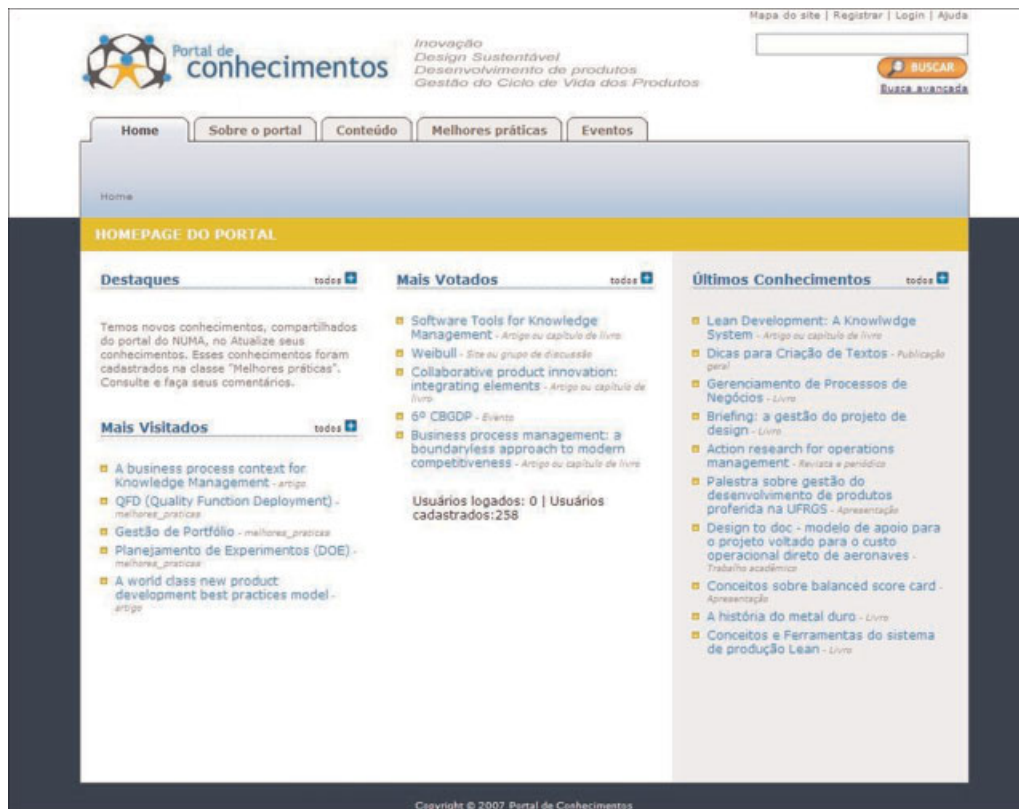


Figure 6 Home page of the Knowledge Portal

process should be managed through this prototype. Company collaborators were asked to view the process and to download the templates they use in their daily routines from the IDEAIS Site. Later, this prototype became the company's process guide.

After validating the two prototype requirements, Iteration 3 was initiated. An additional document requirement was developed to assure improvements sought in the prototype development. The technologies chosen for this new project were Java, AJAX, and Hybernate.

Iteration 3 was aimed at implementing the process portal, which has two main areas: management and public users. The management area enables its users to insert a process. The public users' area permits navigation through processes and instantiation of development project templates.

In Iteration 4 (knowledge portal codification deliverable), the following phases were established:

1. Development of knowledge taxonomy and the specification of each knowledge-type attribute.
2. Outline of system users' privileges.
3. Systematic evaluation of an open source, content management system (CMS), which is the basis for portal development. The selected system was

eZ Publish, which uses the MySQL data base Apache as server and PHP as the programming language (Ez Systems, 2008).

4. Implementation of the portal layout, considering usability and navigability issues (Figure 6).

The CoP currently has about 251 members, who have already inserted approximately 1200 knowledge objects into the portal. The second phase is aimed at internationalizing both portals.

In the first iterations, new requirements and problems were identified, including access speed and optimization of module updating, since the database is expected to store a large volume of information which should be promptly accessible. The next iteration will involve the development of a module that integrates the process portal prototypes and the knowledge portal.

CONCLUSIONS

NPD process management incorporated into a broader BPM framework allows for a systematic approach to create change projects designed to continuously improve the process. To leverage these projects, awareness of proven best practices is the *sine qua non*. The proposal described in this

paper provides a way of systematizing best practices on two levels, one external and the other internal to the organization. On both levels, best practices can be structured into reference models and BOKs. Although reference models can also represent a BOK, in this proposal these structural types are distinguished. A reference model allows for navigation throughout its phases, associated activities and information as required. A BOK is broader, enabling users to search for specific best practices and related knowledge objects.

External systematization is carried out through a collection of reference models and/or a public BOK. The models may be generic or specific. Associations or research institutions usually choose generic model structure processes, which may be used as a certification reference. The specific model may be made available to everyone who wants to share given experiences. The proposed public BOK is a virtual place where people can insert any knowledge object and/or best practices relating to business processes. In this proposal, any model element can be linked to a knowledge object.

This external systematization allows organizations or individual users to create communities of practice in order to share knowledge from which to learn. Thus, specific organizations may systematize their knowledge internally, i.e., they can consider generic models and the public BOK as a reference to build their own standard reference models and BOKs. Moreover, they can insert new knowledge. The proposed infrastructure can be instantiated for internal purposes, describing the internal level of knowledge systematization of this proposal.

The combination of the two levels is aimed at integrating people and providing collaborative access to information/knowledge within a cycle of knowledge retention, use, and sharing. The focus of this proposal is on NPD, where this cycle supports the generation of new knowledge, which is incorporated into NPD reference model activities, continually increasing company capabilities in product development.

The iterative approach adopted here allowed for validation of the concept, for the prototypes have been employed successfully by many users. The prototypes presented made it possible to identify new requirements and problems, which were considered in new development iterations.

The generic NPD reference model and the public BOK are becoming increasingly familiar within the community of NPD practitioners in Brazil. New cases have been reported of organizations adopting them as a reference to define their own models and BOK, but this information still has to be systematized in future research.

Since the hypothetic-deductive methodological approach employed here is based on refutation results, the present proposal has so far proved robust. That was the objective stated at the outset.

The framework behind the portal concept is generic and represents the main scientific contribution of this paper. In principle, the same approach could be implemented in other fields of knowledge, although this assumption should be evaluated through the development of new portals and the creation of new communities of practice.

In future, further actions will be taken to add more knowledge objects and reference models, increase the number of participants, release new versions of the web portal based on new technologies, and apply and test this proposal in diverse organizations.

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