FRAMEWORK TO SUPPORT COLLABORATION AND KNOWLEDGE MANAGEMENT IN THE PRODUCT PRE-DEVELOPMENT

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Abstract. *Best practices for product pre-development aren't clear because the information available for designers in this phase are still instable and too abstract. Portfolio management highlights reasons, restrictions, tendencies and impacts, using competitive intelligence concepts insights on a knowledge management perspective, in order to classify project proposals in accordance with the organizational strategy. Usually this work is much dependent of the senior professional's opinions. Also it is common the ideas imposition, with few interactions between the involved people. An agreement about what is really important to organizational strategy, along with a right team appointment, can contribute to empower portfolio management decisions. To achieve such an agreement, it is necessary to understand the different viewpoints in the negotiation process. There is a lack in support mechanisms for collaboration and knowledge management in this context. In order to contribute for solve this claim, is deed an argument about some requirements and is defined a preliminar architecture to implement an information and communication technology infrastructure (middleware), based in web services, that will articulate the relation between modules of existing groupware tools, preferentially using free software. For that are necessary indicatives about the quality of the available information for decision-making in the product pre-development, supporting product innovation management. It's expected more endorsement and proper decisions taken with more people's commitment in the portfolio management, enabling coherence on similar situations. A collaborative product pre-development can extend the organizational capacity to obtain competitive advantages, because results in minor deviation on subsequent phases of the new product development.*

Keywords*: product pre-development, strategic product planning, project planning, collaborative portfolio management, collaborative knowledge management.*

1. INTRODUCTION

New product development (NPD) is each more surrounded by collaboration and knowledge management requirements. Globalization and the technology evolution urge for adaptive organizations. Product lifecycles are increasingly reduced, requiring more agility and flexibility from project teams in NPD. Analyzing this scenario, Kim et al. (2004) observe that the great challenge is in how to make feasible the collaboration in early NPD phases, when vague and incomplete information make collaboration hard.

First stages in the product definition are insufficient supported by computer tools (Huang and Mak, 2003) because they are nonfigurative processes, and it is difficult to model the concept generation. Great impact decisions are taken without the right comprehension of the context, by experience absence or even by ideas imposition.

It is in the pre-development that the relationship between ideas is established. Engineering, sales, directors, distributors, as well as call centers are involved. Ideas are evaluated in terms of money, technologies and competences, and also risk management; considering financial, production, human and market capacity; is performed. Usually it's difficult to evaluate and quantify some parameters in portfolio management, such as the project links with organizational strategy, to define how many information is necessary to decision making, to suppose how will be the marketplace, and to understand the customer tendencies.

New collaborative methodologies to solve problems and maximize knowledge workers creativity in project teams on NPD, also consider cognitive and social aspects of the collaboration. The problems in collaborative project involve areas from information technology to sociology, combining anthropology, software engineering, linguistic, and human-computer interaction, among others.

Empowered decisions with effective involvement are linked to the different viewpoints comprehension. To minimize impositions and dependences, it is required a full understanding about how people collaborate and also by discovering performance measurements that transform intangible in tangible.

In order to obtain successful computing tools to support product pre-development, the technology should look to identify best practices in knowledge reuse and wisdom application. This article presents a preliminary architecture proposal intended to improve collaboration conditions in the product pre-development.

2. COLLABORATION, CSCW AND GROUPWARE

The idea behind the collaboration concept is to add efforts, competences and abilities, aiming a determined goal; for example, to obtain a product innovation. Some projects could be only feasible with an effective collaboration between interested people, inside or outside the organization.

Computer Supported Cooperative Work in Design (CSCW-D) involves studies about the use of computer technology to support collaboration between project teams, distributed or not, in order to create a favorable environment to quality improvement, conflicts resolution, and to reduce time and money spent on NPD.

CSCW definitions vary according application nature. Usually, it's an environment where computers support people groups to do a common task. As user requirements are not properly considered in the conception of computer systems, continuous changes in the system are required by the users (Orlikowski, 1992).

Huang and Mak (2003) remember that many efforts have been conducted to develop computer mechanisms to support teamwork, being that important initiatives in collaborative product development adopt Web technology as Collaborative Engineering infrastructure, because it provides favorable conditions for information sharing between distributed project teams. CSCW systems can improve the efficacy on collective decision-making, offering facilities to information retrieve, share and use, which stimulate interactions, reducing problems as disorganized activities, member's domination, social pressure, and inhibition (Monplaisir and Singh, 2002).

For Santoro and Bifulco (2006), environments that enable all people to fully express their creative potential, making them feel part of a shared intention (social dimension), will increase the knowledge creation (collaborative knowledge) and will obtain the economic benefits from the achievement of the goals (business dimension).

The term groupware is used to describe the technology resulting of CSCW researches. These resources make ideas sharing more efficient and accurate, simplifying processes and supporting parallel tasks execution, increasing knowledge and expertise sharing on teamwork (Cormican and O'Sullivan, 2004).

Groupware tools were presented like adequate mechanisms for overcoming obstacles that exists in work environments. However, many of those obstacles are due to human characteristics, and justify more attention in their management, for example: low performance in group activities; work processes ill-documented; nonexistence of data from everyday definitions; rejection of new truth; difficulties in the communication and the expression of ideas; concerns about function loss (strategic competence preservation); concerns about opportunities loss (facts suppression); absence of a vision about the benefits in sharing.

3. COLLABORATIVE PRODUCT DEVELOPMENT

Also know as Collaborative Engineering, the Collaborative Product Development tries the application of team collaboration to the product development efforts. It's a systematic approach that associates the collaboration in new product development and a consensus making strategy to satisfy more fully the user needs.

According Monplaisir and Singh (2002), Collaborative Product Development has been considered by researchers and professionals on industry as the key for cycle time reduction and improvement related to product quality and reliability. Huang and Mak (2003) affirm that some success factors in this area involve teamwork, communication improvements, project management, information sharing and consistency.

Analyzing some kinds of advanced manufacture systems, as product data management, supply chain management, enterprise resource management, manufacturing execution system, customer relationship management, demand chain management, among others, Ming et al. (2005) perceive that such systems do not consider adequately the collaboration support needs during product lifecycle, because they aren't designed according to the current business requirements, and they focus specific activities in the companies.

Several models have been proposed to identify those requirements in business environment, but just for certain collaborative functions, including product portfolio management, collaborative product customization, collaborative product development, collaborative product manufacturing, collaborative component supply, and also extended product service. Ming and Lu (2003) remember that although each one of those models involves a certain collaboration function, they don't act in an integrated way on product lifecycle context. Beyond the difficulty to model, project, integrate, automate, monitor and optimize processes in product lifecycle management, the ability to support collaboration in different levels is a challenge to be pursued (Ming et al., 2005).

There is a perception that a large amount of collaborative effort is required from project teams during product lifecycle, but these efforts should start before the beginning of the development phase, already in pre-development. And the intangible nature of the pre-development requires from CSCW-D researchers an even more attentive regard.

3.1. Product pre-development

Product pre-development is characterized basically by the definition of the projects that will be developed in the organization. According Rozenfeld et al. (2006), the pre-development mission is to guarantee that strategy direction, stakeholder's ideas, opportunities and restraints, can be systematically mapped and transformed in a project portfolio.

Analyzing the product innovation management, Cooper et al. (2001a) say that portfolio management represents the business strategy expression, defining where and how resources will be put in the future. Project selection can involve value measurement approaches as well as other decision criteria – for example, a competence creation in a strategic area that can be important for the organization to survive (Project Management Institute, 2004).

According Huang and Mak (2003), the complexity involved in the product pre-development requires know-how and wisdom accumulation, and making tools that can adequately support designers in the initial phases of new product development is highly desirable.

It's possible to understand that the portfolio management efficacy can be improved using collaborative systems in product innovation, by overall visibility offered in decision-making, or by the stimulus to share ideas, increasing commitment and minimizing domination.

The standards for portfolio management and program management were published in May 2006 by Project Management Institute (PMI), what allow perceive an opportunity window involving the use and repercussion analysis about portfolio management, considering that this theme is actual and prominent in NPD and CSCW-D context.

4. FRAMEWORK OVERVIEW

A framework for collaboration support in product innovation management should have its focus on portfolio, and need to be able to prepare a dynamic structure for incentive the generation and capture of abstract ideas, whose expression can be concrete functional specifications (Cormican and O'Sullivan, 2004). However, it's imperative that requirements for collaborative systems incorporate the needs of real user in your own work context.

4.1. System requirements

An ideal framework to support collaboration and knowledge management in the product pre-development need to include the following characteristics:

- **Recording, classifying and integrating the information**: treated matters in meetings, lessons learned in previous projects, ideas, customer and partners suggestions, are mainly important for decision-making in the portfolio management, but the information need to be structured in a way that easily can be useful;
- **Looking for the implementation of the organizational strategy**: distinguish the information stored in the system in order of his relevance level for the strategy ("quality of the managed information");
- **Enabling dynamic criteria for the projects selection**: the mechanism that define the criteria in function of the organizational strategy should be dynamic (need to permit adaptations and process adjusts);
- **Showing the information level about each project**: the system need to present indications about the availability or not of sufficient information for the decision-making;
- **Having flexibility**: the framework should be adaptable to the use context (e.g. time availability, different complexity level of the projects, user affinity with the system);
- **Permitting the capture of abstract ideas**: tools as mind maps can help to define abstract ideas, to clarify and spread out those ideas with more people involvement, and to empower the team when the ideas are showed to the administration staff;
- **Stimulating the self-involvement for problems solution**: depending of the information details about the circumstances of a problem, and how was the procedure during similar situations in the past, the user can feel more confident and supported upon taking a decision;
- **Enabling synchronous and asynchronous collaboration by the Web**: the user should obtain rights to access the system in any place, at any moment, using a conventional Web browser;
- **Having service orientation**: the system need to permit resource sharing by the Web, and need to have modularity and compatibility with the new tendencies for NPD support;
- **Without being invasive**: the system need to facilitate the user collaboration without impose practices that modify radically its work form.

These requirements helped to define a preliminary architecture for a middleware infrastructure based in web services, who can manage the relations between modules of existing groupware tools based in free software.

In order to emphasize the collaborative nature that is necessary in portfolio management, from now will be used the terminology "collaborative portfolio management". Figure 1 shows the main elements (input, output, support and control) for the collaborative portfolio management process.

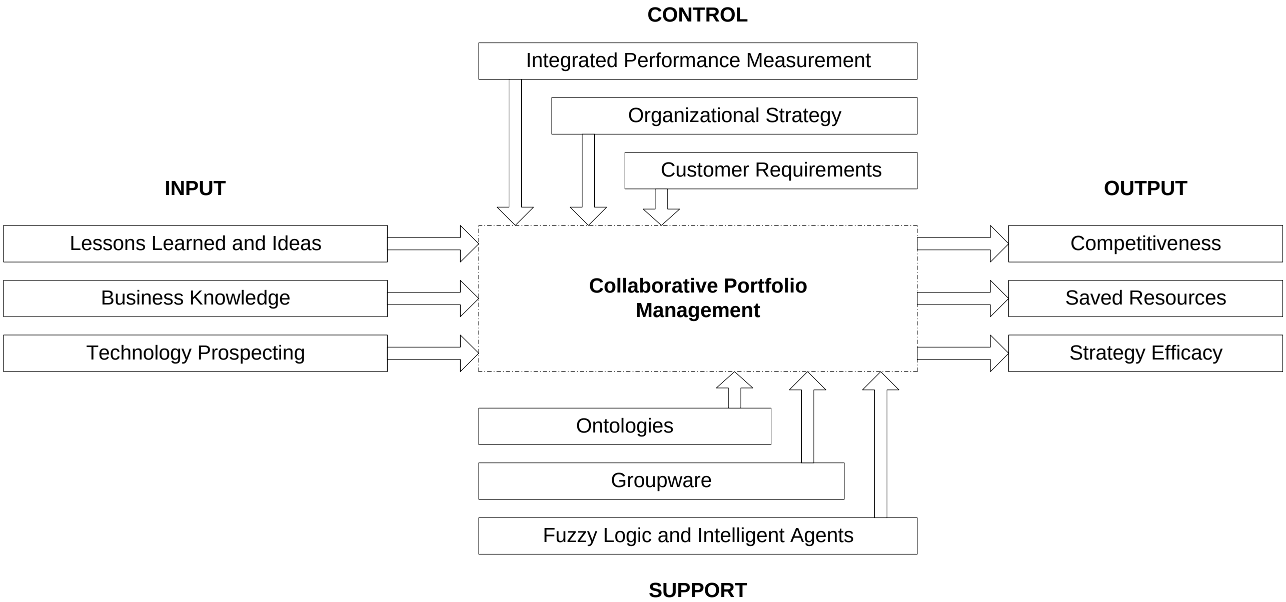

Figure 1. Collaborative portfolio management process

Inputs are based in information of marketing and strategic planning areas: ideas and lessons learned by the planning team (effect of its experience), the strategic knowledge of the business and the feedback obtained in technology prospecting (using patent basis, scientific publications and events).

Controls that drive the process involve integrated performance measurement (R&D performance linked to the product performance in the market), the organizational strategy and the customer requirements.

Support mechanisms should involve: resources to make feasible the knowledge representation and use (based in ontologies); groupware application modules based in free software to support the collaboration; and Fuzzy Logic and Intelligent Agents application in order to estimate the quality of the available information for decision-making in product pre-development, as a way to add tangibility and make easy the consensus.

The expected outputs are improves in organizational competitiveness, increases on profits with the saved resources (time and money) and increases on strategy efficacy.

4.2. Proposed architecture

For an effective product innovation management, it is necessary an articulation on the information flow resulting of the technology prospecting, performance measurements, lessons learned and ideas, and improvement suggestions of customers, partners and suppliers. It is necessary that this information can be considered in product new concepts, market trends, customer requirements and business opportunities (Moeckel and Forcellini, 2007).

In order to support collaboration and knowledge management in the product pre-development, Monplaisir and Singh (2002) consider that the framework should have a universal workspace, accessible by the Web, with integrated resources to project management, document management, project agenda and calendar, among others.

The merge between Internet and Web technology, known as Web services, has great potential to collaboration support (Ming and Lu, 2003; Camarinha-Matos and Afsarmanesh, 2005; Ratti and Gusmeroli, 2006). It’s a new paradigm in distributed systems, where tasks are performed through networked computers, each one dedicated to attend an objective, involving accessible remote programs using Internet protocols, encoded in XML, and platform independent (Tramontin Jr, 2006).

Beyond to support portfolio management, the architecture should incorporate techniques and best practices aiming to stimulate the project goals alignment, the effective knowledge and information use, and the increase on decision-making ability (Cormican and O’Sullivan, 2004). Figure 2 illustrates a general view of the proposed architecture.

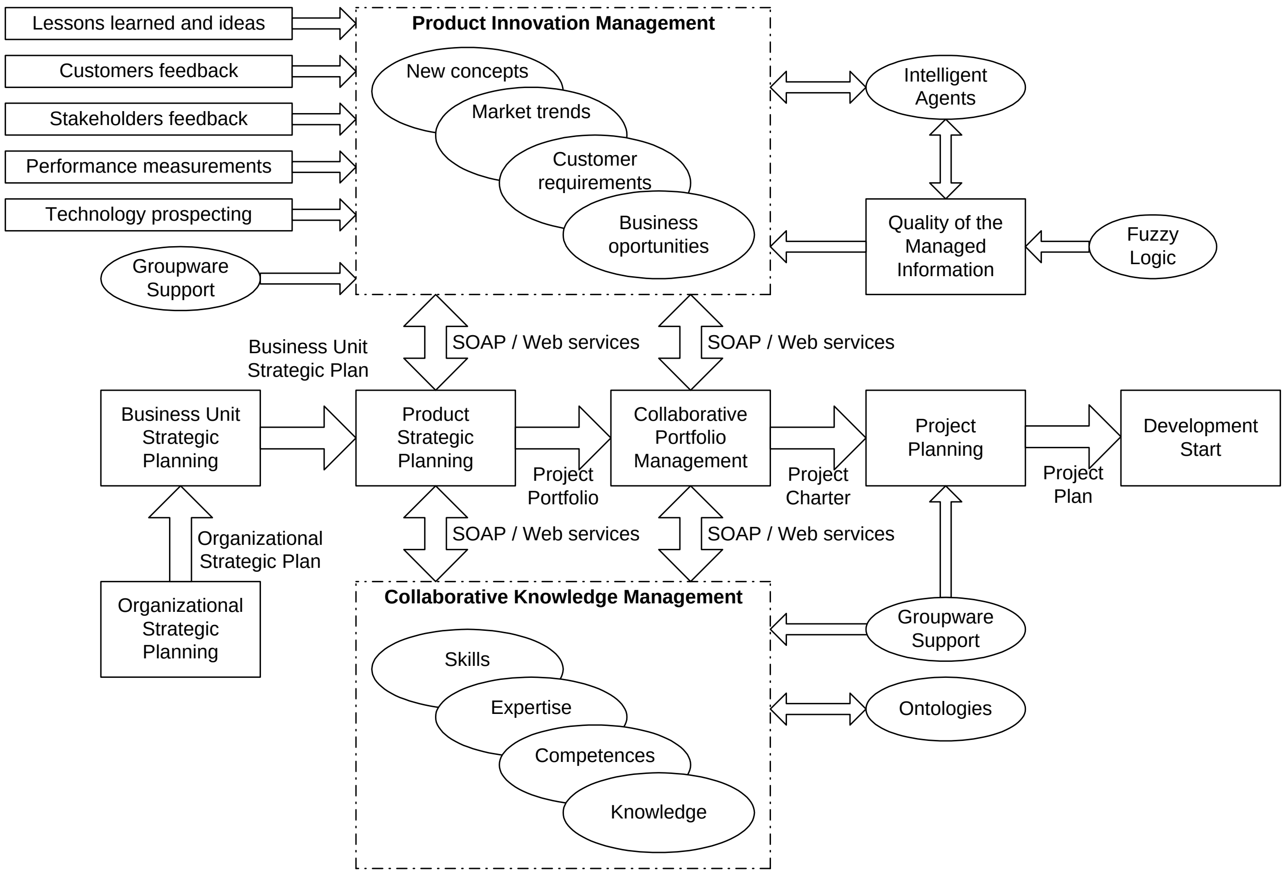

Figure 2. Architecture for collaborative product pre-development

The proposed architecture is based in Web technology, it is modular and service orientated, incorporating best practices in groupware systems. It was considered that SOA (Service Oriented Architecture) approach is indicated to Web resource sharing in collaborative product development (Kim et al., 2004). According Rabelo (2006), an SOA application has several small modules of specialized software, which can be implemented in any programming language; it is distributed, remotely accessible, interoperable, and reusable, by adopting standardizations. SOAP, or Simple Object Access Protocol, is a standard protocol to exchange messages between computer programs, used in Web Services creation. Messages SOAP are XML documents based on W3C specifications.

The problems solution should not occur only in a reactive mode, but also in an active one. Product strategic planning should be aligned with business unit strategy, which is backed by organization strategy. Product innovation management, collaborative knowledge management and project planning have groupware support, to improve collaboration and communication, which can be integrated using Web Services.

4.3. Quality of the managed information

After the absence of resources, Cooper et al. (2001b) recognize that information poor quality is the most important problem in portfolio management. These authors say that sophisticated methods for portfolio management are not sufficient if the process input hasn't qualified data.

Considering the literature review for this work, we can understand that the earned value for portfolio management is directly associated with the quality of the information available for decision making and the capacity of the team in use this information with intelligence (his experience), and is inversely proportional to the cost of the technology necessary to support the decision process and the time interval until the team reach the decision making. The metaphoric Eq. (1) showed below intends to describe the notion of earned value for portfolio management in new product development.

$$\text{Value}_{\text{Portfolio Management}} = \frac{\text{Quality}_{\text{Information}} \text{ x } \text{Experince}_{\text{Team}}}{\text{Cost}_{\text{Process}} \text{ x } \text{Time Interval}_{\text{Decision Making}}} \quad (1)$$

For portfolio management, information quality is related to actuality (new information), precision (objectivity) and relevance for decision making (importance), and this quality is proportional to the degree of rights decisions enabled in the next steps of new product development.

Hu and Feng (2005) observe the absence of approaches to classify information structures with quality indicators, saying that is important to analyze problems involving data and information using the semantic of the information, aiming to show the essence of the problems. Based in the perspective of Information Theory, these authors appreciate that data quality can be associated with the intrinsic quality of the data, and information quality with the form in what the information is represented and can be perceived and accessed.

According Brela et al. (2004), improves on information quality requires time, efforts and money, imposing restrictions to the organizational structure and his processes, making necessary specific management skills. This context brings a tendency in erroneously minimize problems about information quality to the database community scope.

4.4. Fuzzy logic and intelligent agents application

Considering the complexity involved in the portfolio management, are needed methodologies to evaluate inexact information about product characteristics. According Bilalis et al. (2002), the Fuzzy Logic employs approaching and interpretation (instead accuracy) in order to incorporate subjective and linguistic values in the decision-making criteria.

The Fuzzy Logic is based in the principle that human thinking is structured in object classes, and not in numbers. It permits to capture intangible or inexact information, generally described in natural language, and convert them in a numerical format, that can be processed by computers. Therefore, its application in computer systems to collaboration support in product pre-development is promising, taking into account that in this context it is necessary to work with hardly quantifiable parameters, as the "quality" of the available information for decision-making, the project adherence into competitive strategy, the ratio in which the users are attended in their needs, the product market placement in relation to competitors, the market trends, among others.

Autonomy is the main characteristic of the intelligent agents. They possess an explicit representation, a model, in that decisions are taken by means of symbolic reasoning (Tacla and Barthès, 2003). However, that kind of system is capable to perceive and do modifications in an environment.

The advantage of using agents is the possibility to structure intelligent environments using abilities collection, and also the fact that their autonomy can make them work in independent way in any task, in a proactive posture, that differentiates them from systems based on client-server architecture (Tacla and Barthès, 2003).

Among several applications involving intelligent agents are finding, filtering and retrieving information, which can be presented in a format that facilitates the users' comprehension. This can be the case, for example, of the information manipulated in product strategic planning, or in the use of lessons learned in previous projects. Therefore, it's promising to apply intelligent agents in computer systems used to support innovation management.

4.5. Groupware resources to support the framework

Is suggested, preliminarily, that an ideal framework to support the collaboration and the knowledge management in the product pre-development contemplate the following resources:

- **Voting mechanisms**: in order to facilitate the decision-making in group;
- **Matrices for support**: pre-defined structures to include score and attributes, aiming to facilitate the value analysis and the decision-making in group;
- **Mind maps**: to facilitate the ideas generation and register, lessons learned, the expression of the meetings results and the information that can be moved out because the structuring absence;
- **Synchronous communication**: instant messages, voice and/or video among team members and/or collaborators geographically distributed;
- **Asynchronous communication**: email, voice-email and multimedia messages (voice, image and graphic resources) for interaction in differentiated schedules;
- **Forums and discussion lists**: to facilitate the information and wisdom sharing, beyond the register of lessons learned;
- **Shared workspace**: to storage files and URLs, versions control, and to make possible the register of the evolution from the ideas and discussions;
- **Meetingware**: to plan meetings and to create agendas;
- **Collaborative workflow management**: to facilitate the representation and the dynamic change of the processes involved in the decision-making, in a way that contribute for the consensus and continuous improvement of the strategy;
- **Project data and information management**: support mechanisms to classify, register, search and make the reuse of project documents;
- **Mechanisms for technology prospecting**: to make easier the search for patents and scientific publications, with the use of keywords and other criteria.

It is recommended that the structure can offer redundancy in the support mechanisms for collaboration, aiming to satisfy different expectations. The choice of the groupware resource by the users can vary according a prior knowledge, training, affinity, or easily to use. For example, the register of lessons learned can be made through forum, wiki or discussion fields in a shared workspace. The system need to manage that diversity, looking for the user preference.

4.6. Approaches, models and standards to be considered in the implementation

Aiming to adequately represent the product pre-development complexity, it is necessary the back of approaches, reference models and formalities. The system framework need to present interoperability with the business processes that north the organizational strategy. For this is recommended the use of Business Process Modelling.

Also it is suggested the study of the Enterprise Knowledge Development (EKD) approach, in order to analyze the feasibility of the system modeling and the requirements identification can be done in accordance with this approach. In addition, is recommended the consideration of the following norms: ISO 14258 (Concepts and rules for enterprise models); ISO 15704 (Requirements for enterprise-reference architectures and methodologies); ISO 15745 (Open systems application integration frameworks); ISO 19439 (CIM systems architecture - framework for enterprise modelling); and ISO 19440 (Enterprise integration - constructs for enterprise modelling).

For the definition of aspects related to usability and user interaction with the system, is recommended the consideration of the norms ISO 9241-11 (Ergonomic requirements for office work with visual display terminals - part 11: guidance on usability) and ISO 13407 (Human-centred design processes for interactive systems).

In the choice of the programming language, is recommended the analysis of alternatives as Business Process Modeling Language (BPML) and Unified Modeling Language (UML), taking into account the following criteria:

- Compatibility with existing systems, based in free software;
- Technical possibilities and resources offered;
- Facility and time to training;
- Time to conclude the job.

Considering the interest in obtain a system who can be modular and interchangeable with other project management support tools, based in free software or open source, is recommended that his implementation follow specifications for data exchange. Among the existing specifications, it is opportune to cite OPMEF (Open Project Management Exchange Format), ProjectXChange XML DTD and TaskJuggler XML DTD.

4.7. Related works

Huang et al. (2001) presents POPIM (Pragmatic Online Project Information Management), a collaborative management system to extended environment product development projects. Its structure offers a shared workspace to improve team communication, sharing, and collaboration on projects, accessing on-line information. The system supports collaboration and knowledge management during the project development phase, but does not contemplate the pre-development.

Bilalis et al. (2002) and Montoya-Weiss and O'Driscoll (2000) involve computational systems based in Fuzzy Logic to establish criteria for project selection in portfolio management, but do not consider collaboration between the people on decision-making during the criteria ranking.

Cormican and O'Sullivan (2003) adopt the collaborative knowledge approach on product innovation management to conceive the eProduct Manager, a Web system prototype for portfolio management. The authors claim that the final version will be built in a structure that integrates four modules: goals, actions, teams and results. Forms are used to store the organization goals, setting out knowledge that before was tacit, and also to record problems and ideas, in which the user does a strategic alignment ranking for each new product concept. In Cormican and O'Sullivan (2004) is described its architecture main elements: controls (consumer requirements, strategic impulses and performance measurement); mechanisms (individuals, teams and revisers); entrances (ideas, problems); and exits (project revisions, scorecards and exception reports). It seems that a new prototype would use intelligent agents and Web semantic.

Ming and Lu (2003) propose a business model called "collaborative product services in virtual enterprise", based in Web Services, which is going to integrate the majority of the functions related to collaboration on product lifecycle. The authors defend the application of PLM systems to collaboration support during all product lifecycle, but don't clearly define the requirements of such a system (based itself in a classification of the nature of the collaboration process) and don't consider pre-development peculiarities.

Zhang et al. (2004) presents the WS-EPM (Web Services for Enterprise Project Management), a service oriented architecture to business projects management. In what it refers to the product pre-development, there is an operation to project prioritization named Prioritization Web Service (PWS), which considers, as criteria to conduct different projects coordination, the following factors: tangible value, intangible value, project scope, required time to market, convenience to develop the project inside or outside the company. The PWS appears graphically associated with all WS-EPM operations in product lifecycle, hinting that the system is used in the entire new product development process, and not only in pre-development.

5. CONCLUSION AND FUTURE PERSPECTIVES

Communication is one of the most forgetful aspects during the project planning, and the absence of care with that aspect is the biggest problems cause during the NPD. In order to obtain an effective communication, is necessary a favorable environment to collaboration.

There is a lack of support mechanisms to stimulate collaboration in product pre-development and to improve the impartiality and the repeatability in the portfolio management. Efforts dedicated to solve this problem will result in effectiveness on competitive strategy. A comprehension about how people can be able to collaborate, associated with investments on technology infrastructure, can help to transform intangible aspects in tangible.

This work highlights the importance of computer systems to support planning, accompaniment, control and decision-making processes that should be centered in the requirements of the collaboration among professionals involved in product pre-development, in order to facilitate the conversion of the experience acquired into structured knowledge for new challenges.

The proposed architecture should facilitate the understanding about different viewpoints, focusing in what is important on product innovation management: all the people involved on collaborative portfolio management, contributing to reach convergence on decision-making.

Considering that the technological innovation is a survival factor for the organizations, well coming are the investments in information and communication technology infrastructure to support the process of product innovation management in the pre-development.

6. ACKNOWLEDGEMENTS

The authors are grateful to Millennium Factory Institute (IFM) by the support given to the Product and Process Engineering Group (GEPP) of the Federal University of Santa Catarina (UFSC), where this research is in development.

7. REFERENCES

Bilalis, N; Lolos, D; Antoniadis, A and Emiris, D (2002) A fuzzy sets approach to new product portfolio management. In: Proceedings of the IEEE INTERNATIONAL ENGINEERING MANAGEMENT CONFERENCE (IEMC '02). Cambridge, UK, August 18-20, 2002. pp. 485- 490.

Brela, B; Stokalski, B and Walesiak, P (2004) Information quality management in a real-time world. Cutter IT Journal. 17(9):32-41.

Camarinha-Matos, LM and Afsarmanesh, H (2005) Collaborative networks: a new scientific discipline. Journal of Intelligent Manufacturing. 16(1):439-452.

Cooper, RG; Edgett, SJ and Kleinschmidt, EJ (2001) Portfolio management for new product development: results of an industry practices study. R&D Management. 31(4):361-380.

Cooper, RG; Edgett, SJ and Kleinschmidt, EJ (2001) Portfolio management for new products. New York: Basic Books.

Cormican, K and O’Sullivan, D (2003) A collaborative knowledge management tool for product innovation management. International Journal of Technology Management 26(1):53-67.

Cormican, K and O’Sullivan, D (2004) Groupware architecture for R&D managers. International Journal of Networking and Virtual Organisations. 2(4):367-386.

Hu, W and Feng, J (2005) Data and information quality: an information-theoretic perspective. Computing and Information Systems 9(3):32-47.

Huang, GQ and Mak, KL (2003) Internet applications in product design and manufacturing. Berlin: Springer.

Huang, GQ; Feng, XB and Mak, KL (2001) POPIM: Pragmatic online project information management for collaborative product development. In: Proceedings of the 6th International Conference on COMPUTER SUPPORTED COOPERATIVE WORK IN DESIGN. London, Ontario, Canada, July 12-14, 2001. pp. 255-260.

Kim, K-Y; Wang, Y; Muogboh, OS and Nnaji, BO (2004). Design formalism for collaborative assembly design. Computer-Aided Design 36(9):849-871.

Ming, XG and Lu, WF (2003) A framework of implementation of collaborative product service in virtual enterprise. In: SMA ANNUAL SYMPOSIUM - Innovation in Manufacturing Systems and Technology. Singapore–MIT Alliance: Singapore, Malaysia, January 17-18, 2003.

Ming, XG; Yan, JQ; Lu, WF and Ma, DZ (2005) Technology solutions for collaborative product lifecycle management – status review and future trend. Concurrent Engineering. 13(4):311-319.

Moeckel, A and Forcellini, FA (2007) Collaborative product pre-development: an architecture proposal. In: Loureiro, G and Curran, R (Org.) Complex systems concurrent engineering: collaboration, technology innovation and susteinability. London: Springer, pp. 471-478.

Monplaisir, L and Singh, N (Eds.) (2002) Collaborative engineering for product design and development. Stevenson Ranch: American Scientific Publishers.

Montoya-Weiss, MM and O'Driscoll, TM (2000) From experience: applying performance support technology in the fuzzy front end. Journal of Product Innovation Management. 17(2):143-161.

Orlikowski, WJ (1992) Learning from notes: organizational issues in groupware implementation. In: Proceedings of the 4th Conference on COMPUTER SUPPORTED COOPERATIVE WORK. ACM: Toronto, Canada, October 31 - November 4, 1992.

Project Management Institute (2004) A guide to the project management body of knowledge (PMBOK® Guide), Third Edition. ANSI/PMI 99-001-2004. Newton Square, PA: Project Management Institute.

Rabelo RJ (2006) Arquiteturas orientadas a serviços. Florianópolis: Universidade Federal de Santa Catarina, Curso de Engenharia de Controle e Automação.

Ratti, R and Gusmeroli, S (2006) An advanced collaborative platform for professional virtual communities. In: Proceedings of the 12th International Conference on CONCURRENT ENTERPRISING. ESoCE-Net: Milan, Italy, June 26-28, 2006.

Rozenfeld, H; Forcellini, FA; Amaral, DA; Toledo, JC; Silva, SL; Alliprandini, DH and Scalice, RK (2006) Gestão de desenvolvimento de produtos: uma referência para a melhoria do processo. São Paulo: Saraiva.

Santoro, R and Bifulco, A (2006) The concurrent innovation paradigm for integrated product/service development. In: Proceedings of the 12th International Conference on CONCURRENT ENTERPRISING. ESoCE-Net: Milan, Italy, June 26-28, 2006.

Tacla, CA and Barthès, J-P (2003) A multi-agent system for acquiring and sharing lessons learned. Computers in Industry. 52(1):5-16.

Tramontin Jr, RJ (2006) Web services. Florianópolis: Universidade Federal de Santa Catarina, Grupo de Sistemas Inteligentes de Manufatura.

Zhang, L-J; Cai, H; Chung, J-Y and Chang, H (2004) WS-EPM: web services for enterprise project management. In: Proceedings of the IEEE International Conference on SERVICES COMPUTING (SCC'04). Shanghai, China, September 15-18, 2004.

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