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A complementary generic architecture for PLM system to control collaborative work

Implementation and Deployment

S. El Kadiri, M. Delattre, P. Pernelle, and A. Bouras

Abstract— This research work aims at analyzing the problems related to the collaborative work using a PLM system. The principal objective is to reduce risks of dysfunctions that may occur by reacting in a “real time”. This paper follows up our proposal of the methodological aspects for the control of collaborative activities. A brief description of these aspects is presented, and then we focus on the development of a complementary architecture supporting the proposed methodology. The overall system architecture based on services technology is described, as well as the associated prototype developed using an industrial PLM system.

Index Terms— PLM, SIP, collaboration, observation, monitoring indicators, IS analysis and design, generic architecture

I. INTRODUCTION

THE intensification of the competition and, simultaneously, the technology evolution have resulted in an unprecedented complexification of the conception, development and launch of products. The companies have therefore to concentrate on their competences keys, and to subcontract the supplementary expertise subcontracting required to support the innovation and reactivity asked by customers [1]. Consequently, the product and its development are no longer the result of a single team or of a single business, but the result from a multidisciplinary team coordinated around the objectives of the realization of this product.

The needs of the collaborative work (product development cycle reduction and fostering the collaboration between the different implied actors) have contributed to share information between the different stakeholders. The data integration initiated by PDM systems (Product Data Management) had

been extended throughout the integration of processes and organization.

In fact, the development of PDM has strongly contributed to the appearance of a domain related to Information Systems that treats specific problems for product development: Product Lifecycle Management. One of the objectives of the PLM to reduce the product lifecycle is to foster the collaboration between the actors in the different business processes.

Organizational complexity

In a context where the organizations are in a constant seek of balance facing up to more and more constraints of the competitive environment; organizational methods remain characterized by their instability, their uncompleted and relative incoherencies of the rules that govern them. A continues reorganization process or a permanent adaptation seems necessary to maintain a level of suitable coupling between the management of activities and human resources. Usually, such strategy of product lifecycle management (PLM), necessitates to manage the whole business and functional processes as well as the methods of their synchronization with the Information system of the Product lifecycle (called also Product Information System) [2].

Technical complexity

PLM system fosters the cover of the whole transverse processes [3] (product development, purchases, production, quality management, etc.). The rigidity of models structuring the system makes its synchronization difficult with the organizational schema. The issues are multiple (importance of the impacted domains) and sometimes vital for the company. The difficulties related to the implementation (human resources, stability through time, distribution of the responsibilities, etc.) could result in a very complex.

The conditions and the methods of introduction of such systems can be diverse, but the effects are determining on the quality of functioning of the concerned structure. Needs in terms of technical flexibility are necessary to facilitate the

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coupling with the organizational "reality".
Behavioral complexity

The influence of the context on the individual behaviors regarding to the collective work in PLM system is a source of constraints. It's linked, in one hand, to the actors facing the adaptation to the new methods of management; in the other hand, to the company with respect to the information sharing with its different stakeholders. In fact, the reorganization of the whole processes leads most often to reduce actors' autonomy spaces to the profit of the system implementation. Nevertheless, we observe that the actors just move these autonomy spaces and recreate them [4].

A. Problematic

Considering the three categories of issues: organizational, technical, and behavioral complexities; these have major consequences on the company functioning:

- Local and/or global ruptures of the collective production;
- Many impacts:
 - short term, on the quality of the collaborative work (stability, durability, ...);
 - medium term, on the system and on the organization set up (through the misappropriation of the processes hindering to the prescribed running);
 - long term, on company's performances.

The research of a more and more global performance, seen with methods and new principles linked to the perspectives of a sustainable development (ecology or global cost estimation associated to the whole lifecycle of the system) becomes insufficient regarding to the current challenges and futures caused by:

- 1) organizational changes of the companies,
- 2) evolution of society and economy,
- 3) emergence of new strategies and management methods based principally on the reduction of development cycles.

It's important to take into consideration the local performance: local effectiveness and local gains in terms of time, which is considered here from the standpoint of collaborative process and management of interactions "actor/actor" and "actor/system", not from the standpoint of functioning optimization of a sub-system.

A local control of processes and constraints linked to the collaborative work (and organizational evolutions) within the PLM system offer in fact gains in terms of time, that are not negligible regarding to the requirements of a competitive environment that exercises a strong pressure.

B. Research questions

These research works focus on instrumentation problematic of the collaboration in PLM system; starting from the principle that such problems hinder the system quality and effectiveness, the collaboration itself and consequently the organization.

Our research questions are:

- How to make cartography of the brakes and sticking points of the collaborative work within the PLM system?
- How can the PLM System be « instrumented » in order to analyze the collaborative activities and to reveal the brakes causes?
- How to enable the proposition of actions in order to minimize their scope and impacts?

C. The proposed approach

In previous works ([5], [6], [7], [8]), we had adopted a **bottom-up** logic, where our starting point is at a micro level and consists in the analysis of the operational activities (resulted activities from the decomposition of collaborative processes). Then we had proposed an approach that consists of two principal actions:

- **The observation of activities** conducted within the PLM system in order to detect and reveal the brakes causes that can be of a technical order (such as repeated bugs), or organizational order (instabilities of data and process models), etc. This observation is done through the analysis of tracks generated by the system; we mean LOG files completed by data from the databases.
- **The construction of monitoring indicators**, in order to assure a regular control of activities and to limit brakes causes. The principal task is to define specific indicators that will able the control of collaborative activity around the following key idea: anticipating problems by setting up monitoring indicators.
- **The extension of process models**. A regular monitoring of activities can lead to the redefinition of tasks and of new rules (and their reinjection in the methods of work).
- **The definition of a complementary architecture** adapted to the environment of PLM system; and the implementation of the proposed architecture. In fact, the realization of an experience of observation necessitates an important architectural work in appropriateness with existing models. This architecture will have to take into account the generic dimension of PLM system.

This paper aims to propose an analysis and conception of an architecture responding to our research objectives.

II. SPECIFICATIONS OF THE FUNCTIONAL NEEDS

The studied system presents a controlling tool completely

configurable offering different functionalities:

- 1) Specify the data sources by defining probes that collect data and structure them in a standard format.
- 2) Set up monitoring indicators (elementary and fuzzy logic based).
- 3) Realize dashboards that consolidate the defined indicators.
- 4) Manage the notification.

We develop hereafter the presentation of all these functionalities.

A. Probes management

Two sources of observation are used in order to set up the process of observation:

The log files

In a PLM system, all operations carried out by every user are tracked in the log files. In these files we can find pertinent information concerning the activities that sometimes cannot be found in the database (such as information seeking). Our system has therefore to collect the data from these files and to structure them in exploitable schema. From the log file structure, the probes will scan these files to pinpoint the concerned data and to put them in a suitable format.

The database

Objects and processes of the PLM are stored in the database, as well as the historic of activities performed on objects and processes. Our system must take into account several DataBase Management Systems (Oracle, MySQL, Ingres...) to manage probes. A database probes is defined by an SQL request such as " Select ... From ...". The probes can perform only simple measures.

The two types of probes generate XML flows that facilitate the process of indicators measuring. Thus, it is necessary to construct probes that can be reused for several indicators.

B. Management of indicators and dashboard

The user must be able to manage two sorts of Indicators:

Elementary Indicators

All indicators are defined by its formula for calculation and the probes that it uses. Our system must give the access to the constructed probes to allow the formula of calculation; this formula is defined by a succession of arithmetic operations that transforms the probe results to quantitative value.

Fuzzy indicators

Our system must integrate the concepts of the fuzzy logic in order to construct indicators based on fuzzy logic. These indicators use the results of the elementary ones (previously

defined, considered as input variables). Every input variable is characterized by a membership function and a linguistic term. The fuzzy indicator is defined by an output variable, a conclusion of a basis of rules.

Our system must put at the disposal of the user a configurable dashboard. This dashboard posts the indicators according to their type in a suitable format, specified by the user (a graph, an expression...).

C. Management of notification actions

To assure the monitoring of activities, the system must launch the measure of indicators periodically; this period is defined by the user of the system. Thresholds must be associated to the indicators. When a specific threshold is reached, the notification is performed by sending automatically e-mail to the user.

The settings of probes, indicators, dashboards and actions of notification will be saved in a file XML for system portability. The measure results also are stocked in a file XML and will be updated periodically or well to the request of the user.

III. TECHNICAL SPECIFICATIONS

The technical specifications allow detailing the use cases of the system and proceed to a first distribution of the system behavior within various objects.

A. Actors and data of the system

We identify two principal actors of the system:

- The manager: takes charge of the administration of the PLM, having a good knowledge of the architecture and the internal structure of the PLM and ability to construct probes and indicators. It is supposed that the manager has a thorough knowledge of fuzzy logic.
- The User of the PLM: he can use dashboards to realize a continuous monitoring of his activities within the PLM.

Our system leans on two kinds of source of data:

Log files

In log files, data are easily accessible. We had been obliged to analyze these files and to study their structures to find a method that allows extracting them under an exploitable format. Generally, these files contain the activity tracks. Every activity takes up a bloc in the file that it is necessary to scan to extract information.

Database

Data are divided up between several tables of the database and the access to these data is done with SQL requests.

The choice of the data source and the of the probes type to use depend on the indicator to be constructed.

B. Use Cases of the system

From the study of the specifications of the functional needs, we specified six use cases (UC) of the system:

- 1) Manage the probes
 - 1.1. Manage the probes on the database
 - 1.2. Manage the probes on the log files
 - 1.3. Manage the sources of the database
 - 1.4. Manage the sources of the log files
- 2) Manage the notification actions
- 3) Manage the indicators
 - 3.1. Manage the elementary indicators
 - 3.2. Manage the fuzzy indicators
- 4) Manage the dashboards
 - 4.1. Setting up the dashboards
 - 4.2. Visualize the dashboards
 - 4.3. Personalize the dashboards

We present in the table below an extract of the descriptive one the whole use cases of the system, their objectives, their associated conditions, and the responsible actor.

TABLE I
EXTRACT OF USE CASES DESCRIPTION

Use case	Objective	Conditions
Manage the probes on the log files Actor: Manager	To be able to add, modify, eliminate the probes on the log files	Pre: It exists at least a source of log files. Post: the probes that exist are operational.
Manage the sources of database Actor: Manager	To be able to add, modify, eliminate the sources of database	
Manage the elementary indicators Actor: Manager	To be able to add, modify, eliminate the elementary indicators	Pre: It exists at least a probe. Post: The indicators that exist are operational.
Visualize dashboards Actor: User of the PLM	To be able to visualize the dashboard elements	Pre: It exists at least an element.

C. Class diagrams

The functional study of our system “**PLM Monitoring**” leads to its decomposition to three increments: Observation Measure and Visualization. This party defines the static structure of the three increments. We present bellow the class diagram associated to the subsystem "Observation".

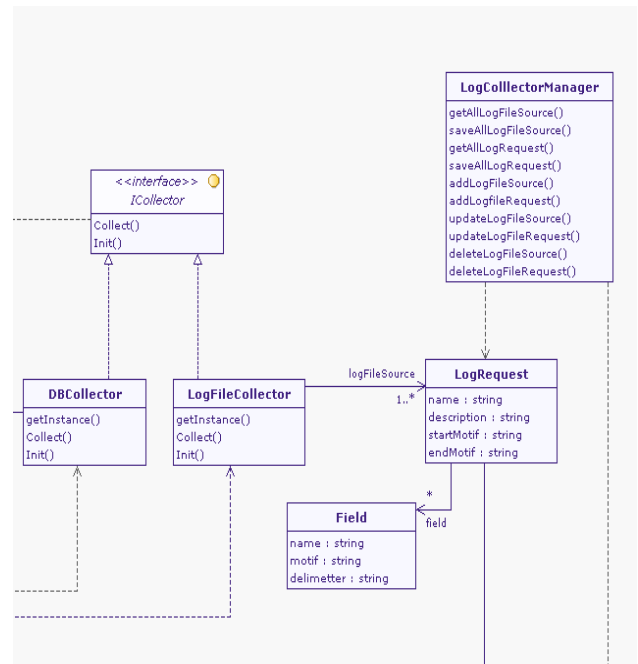


Fig. 1. Class diagram of the layer "Probes" (Part 1)

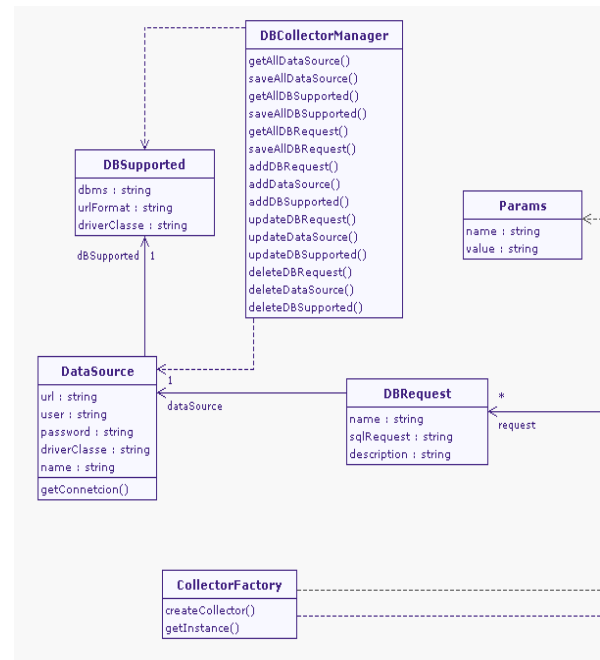


Fig. 2. Class diagram of the layer "Probes" (Part 2)

IV. ARCHITECTURE OF IMPLEMENTATION

The functional architecture of the application corresponds to the different increments. We propose then three functional layers:

1) *Observation layer* (Collect and Structure): charged of the collection and the structure of information from the PLM. It allows the access to the probes in different way (continuous, factual).

2) *Indicators layer*: aims at constructing and measuring the indicators (both elementary and fuzzy indicators) based on the observation layer. This layer also integrates notification actions since it's based on the measures previously carried out.

3) *Dashboards layer*: aims at generating graphs.

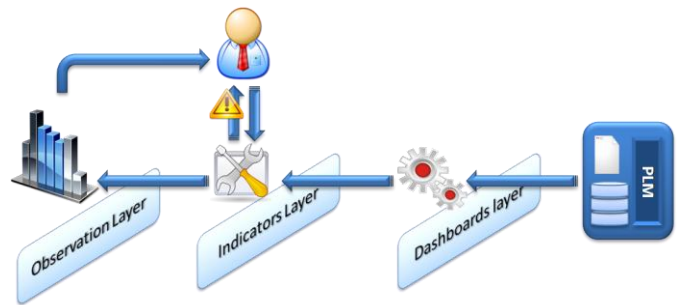


Fig. 3. Functional architecture of PLM Monitoring

For a better deployment, we used a 4-tier technical architecture. We present below a description of the components of the proposed architecture.

TABLE II
DESCRIPTION OF THE TECHNICAL ARCHITECTURE

Layer	Description
Client	<ul style="list-style-type: none"> - generally a navigator having access to <i>Flash Player</i> - it does not necessitate any specific installation on the local machine
Presentation	<ul style="list-style-type: none"> - represents the Human-Machine Interface layer - allows the settings of the business layer and the visualization of dashboard in an interactive way - receives HTTP requests from the client layer - communicates with the business layer by sending http requests and receiving XML flow - implemented in Flex and can be accommodated in a web container such as Tomcat
Business	<ul style="list-style-type: none"> - This layer contains the logical applicative of the system - measures are carried out within this layer, as well as the management of the settings files - Implemented in Java, and the services offered by this layer are exposed using the JSP. It integrates also the fuzzy logic part - receives http requests from presentation layer and sends back XML flow - communicates with the other adjacent layer through XML flow - can be accommodated in a container of JSP/Servlet such as Tomcat
Physical	<ul style="list-style-type: none"> - represents the directory for the storage of the whole XML files - accessible thanks to a Java API for XML

V. CONCLUSION

This paper discussed the problems of collaboration within PLM systems. The analysis of industrial companies' issues lead to highlight many problems related to technical, organisational and behavioural constraints. This analysis highlights a need of a local control of collaborative activities. Therefore, we proposed a methodology for improving collaboration that consists in the observation of activities. This observation process leans on the analysis of tracks generated by the system, completed by data from the databases. The proposed approach leans also on the construction of monitoring indicators.

This paper focused on the analysis and design of a *complementary* architecture supporting the proposed approach. This architecture takes into account the generic

dimension of PLM system. We had then implemented this architecture using an industrial PLM.

Some perspectives of this research works concern the implementation of the system, to enable the setting of dashboards for PLM users as well, and to finish the development of fuzzy indicators. We intend to experiment this system in an industrial company in the Rhône-Alps Region.

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