Communication and control modeling for collaborative engineering

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Abstract

Collaborative engineering requires a distributed computer environment in which each user has a work station or a personal computer and which enables parallel and interrelated execution of operations. We propose to define this environment by using OMT modeling and to implement it on internet network. We develop these concepts in a project financed by the French Research Ministry.

Keywords

Collaborative Engineering, Communication system, Control system.

1 INTRODUCTION

Today, the industrial enterprises use informatics in order to computerise many phases of a product development. It induces a lot of information generation by designers and engineers. The necessity to reduce the development delays, the collaborative engineering concept (Sohlenius, 1992) which imposes to simultaneously share information between each member of the same project, explain the increase of data. A new communication approach is necessary for industrial enterprises to be competitive. The traditional communication means such as telephone conversations, periodic meetings, textual message exchanges are not able to efficiently transfer information generated during the product development.

Truly effective co-ordination in collaborative design requires an integrated approach where dependencies across all the dimensions of design distribution are modeled and managed in a single computational framework (Klein, 1995). So a collaborative engineering requires a distributed computer support environment in which each user has a work station or a personal computer and which enables parallel execution and interrelated operations (Masui, 1995).

This paper describes an approach to define and implement a communication and control system for collaborative engineering. This approach is currently used in a French research project and is applied by using Internet network. At first, we give an overview of this project. We then present the communication aspect and finally its control aspect.

2 DSPT8 PROJECT

2.1 Introduction

The project entitled "Scenario of collaborative engineering for manufacturing integrated systems" is financed by the Technical and Scientific Mission (DSPT8) of the French Research Ministry and has begun at September 1994. This project deals with the process study for designing a manufacturing system in a collaborative engineering context. The project involves four geographically and organisationally distributed research teams : CRAN (Centre de Recherche en Automatique de Nancy), LAMIH (Laboratoire d'Automatique et de Mécanique Industrielles et Humaines), LAN (Laboratoire d'Automatique de Nantes) and LIRMM (Laboratoire d'Informatique de Robotique et de Micro électronique de Montpellier).

2.2 Objectives

The laboratories abilities are complementary and are used to study a design scenario for an assembly system. The specifications of this system are provided by the DASSAULT French society and represent an application for plane parts assembly by using riveting techniques. The different research axis which emerge from this approach are :

- to develop and to validate methods and tools for the analysis, design and project control;
- to define a communicating infrastructure supporting the information exchanges between the laboratories and to validate organisation allowing the collaborative engineering in a design process;
- to derive from a scenario observation, a set of "quality" procedures based on ISO 9000 requirements in order to ensure both the design process tracability and its control.

In this paper, we only detail the communication and control aspects and their implementation within a communicating infrastructure. Indeed, we propose to develop an HTML server which will gather in a same environment the whole of information processed in the project. This server has to allow : to have a global view of the project towards its actors and tasks but also outside of project members, to follow and to control the project, to connect all associated methodological tools,... In a first time, we specify the project communication and control models by using the OMT (Object Modeling Technique) method. This method allows to define the information system through object models and its management through behaviour models. We then represent these models in an HTML syntax.

3 COMMUNICATION SYSTEM FOR COLLABORATIVE ENGINEERING

3.1 Data representation

The integration of different activities assumes a distributed knowledge model, between each actor and task with respect to the information heterogeneity. The objective is to represent the whole of knowledge issued from specific tasks in a unique information system. Since individual engineering tools use specialised internal formats, there is a need to maintain portable by providing translation mechanisms into and out of shared representation (McGuire, 1993). All the dialogues between activities have to be translated into a neutral format which will be recovered in a specific format for a particular engineering discipline. Data-exchange standards provide a neutral format through which data can be exchanged between application programs. We have chosen the EXPRESS language (ISO 1030311, P.11) which is appropriated for describing the information produced by the interrelated activities. It is indeed used to interface different CAD/CAM tools in the STEP (STandard for Exchange of Product data model) project (ISO 10301-1) and in CALS (Computer aided Acquisition and Logistic Support or Continuous Acquisition Life cycle Support) project (Sandoval, 1995).

3.2 User Interface

The definition of a unique representation only solves a part of the communication problems because the actors in a project must be able to access to the models. For this, we use Internet network to transfer all the information and develop an HTML server allowing the project partners to work in a collaborative engineering environment. In opposition to the classical Web Servers where we only can access to fixed pages, our objective is to automatically update the Web server by querying a database. This database records the whole information generated during the design life cycle and the project development phases.

3.3 HTML pages structuration

The main difficulty to develop an HTML server concerns the structuration and the navigation between the pages which compose the hypertext document. At this present time, it does not exist methods to model, to generate and to validate HTML document structures. Thus, we propose to develop these hypertext documents by using OMT modeling (Rumbaugh, 1995) without taking into account the implementation target. We then derive HTML structures from the OMT models (Rondeau, 1996).

Enterprise organisation

Manufacturing enterprise goal is to achieve products that meet a given set of requirements and consequently which can be sold. For this, the enterprise needs both employees and manufacturing resources. We only consider in this modeling the human work process and define the interactions within the design life cycle. Three phases are defined : the project references a specification list established from a marketing; then the specification list has to be modeled by using different methods and finally the obtained models have be implemented to

manufacture the products. This description is sequential and not simultaneous. But it is only an easy manner to describe the product life cycle. The OMT object model (figure 1) is a flat model which does not prescribe a way to read this model. So the object model introduces three classes (project, model and product) without specifying how each class evolves. Dependencies and co-ordination which necessary appear in a collaborative engineering will be taken into account during the next phase which concerns the control system

Figure 1 OMT object model for enterprise organisation

This model also shows the set of actors working on the project and their responsibilities. They can be located inside or outside of the enterprise. Each actor, depending on its responsibility, interacts at different level of the design life cycle and with different representations.

HTML implementation

We want to generate a part of the Web server from the OMT model. Figure 2 shows the HTML graph obtained from the OMT model of enterprise organisation. The interest to define HTML server is to dispose of a work flow to share the whole information of a project and to exactly know all the actors, their responsibilities and work process towards this project.

Figure 2 HTML graph

4 CONTROL SYSTEM FOR COLLABORATIVE ENGINEERING

4.1 Introduction

Parallel and interrelated work process necessitates more than a simple communication support, it requires not only the co-operation but above all the co-ordination between the different project actors. Without co-ordination, the work could be done several times or inversely not at all, the decisions could be taken with incorrect or incomplete information, the conflicts could be hardly resolvable,... The optimal project functioning imperatively needs the synchronisation and control of the work process and the coherence of the different actions (Gupta, 1993).

Therefore, the previously defined communication system has to be completed by means of a control system which will be the server engine. This control system defines the procedures of management and control of the interactions between actors working in a same project. These procedures must be included in the elaboration of the communication system. However, their definitions imply to perfectly know the information flows and the organisation of the project. The project information flow is represented by a set of co-ordination services between actors. These services are then completed with the definition of the internal functioning of each actor in order to organise and to control in an adequate manner the project. The objective is to gather in the control system a set of co-ordination information and functions which can serve as a basis for a computational project control of a collaborative engineering.

4.2 Collaborative engineering constraints on project control

In the context of a collaborative engineering project, existing project control systems are limited in that they typically lay down a perfectly sequential design scheme and activities which are known in advance. Taking into account of collaborative engineering obliges to introduce lots of interactions, reviews and modifications, and consequently new working methods.

Consequently, the definition of a control system for a collaborative engineering project requires an exhaustive knowledge of each task and an accurate planning where explicitly appear the activities involved in the collaborative work process.

Definition of project co-ordination services

The objectives are to represent co-operation between actors and to store convenient scheduling of the project. The OMT object models have already allowed to define the functional and operational responsibilities and tasks of each actor. But, to measure and to control the project progress, these models must be completed by OMT behaviour models where we will explicitly identify all the interactions that occur in a collaborative design process. These interactions are represented by a set of co-ordination events or services. For this, the project is decomposed into a detail level sufficiently fine to highlight the implications of each actor towards an event occurrence.

Figure 3 shows an example of design dependencies between two different disciplines (a controller software designer and a mechanical designer) in case of a model modification. To change a model, this one is first of all downloaded to a particular designer (to its internal format). The designer then modifies the model as required (Modification procedures are defined for each actor in order to allow to the other actors to correctly identify these modifications. They are expressed by means of OMT behaviour models). Each modified model is sent to appropriate actors for validation. In case of overall validation, the modification is authorised, recorded in the project database and reported to all influenced actors.

Moreover, in order to check work progress and thus to control each project development phase, limit times could be assigned to a co-ordination service. The information that each co-ordination service has been completed must be reported before the assigned execution delay, otherwise an alarm is triggered to the responsible actor.

Figure 3 OMT Event Trace for a common model

Definition of internal functioning procedures

Once we have defined the detailed interactions during the different development phases, we must specify a set of internal functioning procedures for each actor within the project. These functioning procedures are represented by means of OMT behaviour models. They specify how each actor must respond to the occurrence of an event. The main procedures we have defined are related to the creation, access, modification and validation of a common

information, model or document to be recorded in the project database. Each functioning procedure imposes a regular reporting relating the present and future activities within the project.

5 QUALITY MANAGEMENT PERSPECTIVES

The proposed modeling allows to each project individual member to act in respect to his given privileges (connection, creation, modification, validation, ...) on a common information, models or documents. That means that each actor has always to know the responsibility of each other, the state of each information in the project database, the work in progress, ... This kind of modeling gives a global visibility of the project and of its history. In the same way, the definition of both co-ordination services and functioning procedures clarifies the project organisation and the dependencies between actors. Each one can visualise the who, what, where, when, why and how of his work or decision making as it affects the total scope of the project (Leung, 1995). This proposed modeling is in this fact a first step to obtain a framework for quality management in a distributed computer environment, in so far as the modeling provides an overall image of the project strategy and organisation and at the same time sufficient well-characterised information to access to all the necessary procedures in order to accurately accomplish a task.

6 IMPLEMENTATION

The implementation of the server is in progress. We use a Silicon Graphic computer to develop the HTML interface and ORACLE database to store the whole DSPT8 project information. The set of co-ordination services and internal functioning procedures can easily be implemented within the server. Each OMT behaviour model can indeed be directly translated into a software (C or C++) which is integrated to the server. These softwares will then be executed by the server at each connection, to control accesses to the server, to manage the interactions within the project and finally to allow an effective utilisation of the server. Thus, we have an integrated environment (Nékoui, 1994) where we can manage multimedia document, send electronic mails, dialogue through video-conferencing, exchange CAD files,...

7 CONCLUSION

The need of a communicating and co-operating system for managing activities between designer groups working on different sites and with different views on the same project constrains to organise and to control the work in a better way (Bourdichon, 1995). This organisation will clarify the work procedures allowing to lead to enterprise quality certification. The definition and the organisation of a communicating infrastructure for collaborative engineering project have to allow to control the work in progress and to trigger alarms when delays are not respected, to plan meeting in order to resolve a particular problem, to give more means,...

8 REFERENCES

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9 BIOGRAPHY

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