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THE CONCEPT OF PDM AND AGENT SYSTEM INTEGRATION FOR DESIGN MANAGEMENT IN VIRTUAL ENVIRONMENT

Z. WEISS, E. DOSTATNI, J. DIAKUN

Poznań University of Technology
Institute of Mechanical Technology
Division of Industrial Information Systems
e-mail:
Zenobia.Weiss@put.poznan.pl
Ewa.Dostatni@put.poznan.pl
Jacek.Diakun@put.poznan.pl

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Abstract: *In the paper the current trends in design and manufacturing were outlined. The role of PDM-class systems in design was presented. The design process from the point of view of task coordination and the nature of managing a design process viewed as an organisational and technical undertaking were characterized. Agent system as method for developing decentralised information and decision-making systems was proposed and the computer system based on this technology was presented. Finally the conception of integration of both presented systems for creation of information management solution for design purposes in Intranet environment was proposed..*

1. INTRODUCTION - CURRENT TRENDS IN DESIGN AND MANUFACTURING

The requirements of contemporary market enforces searching for new ways of project execution. The features of modern manufacturing, latest trends in this area such as: outsourcing, strong cooperation between producers, geographical dispersing of company's departments, and impact of computer technologies cause often and often moving design into virtual space. In this case a key role is played by communication platform.
The term "virtual" may be perceived in two general meanings:

- in a context of a product's model, which is not real object, but virtual one. This virtual model (e.g. Digital Mock-Up - DMU) is processed during individual design stages until achieving of the product that fulfills customer's requirements,
- in the context of organization or team which in specific conditions may become a virtual one.

The carrying out of the projects requires using of appropriate IT environment, which basic functions should:

- support participants' work,
- deliver mechanisms of collaboration and communication,
- enable management of design process.

The area of tools that supports participant's works are usually formed by computer tools and systems already used in organization. In case of technical design this group consists mainly of software belonging to CAx area. The role of data management in this area often and often is entrusted to specialized class of computer systems – PDM (Product Data Management).

2. THE ROLE OF PDM SYSTEMS IN DESIGN AND MANUFACTURING

Contemporary PDM systems have a set of common functionalities. Nowadays to this group belongs:

- product data and document management,
- product structure and configuration management,
- classification and part family management,

- process and workflow management
- viewing, mark-up and image services,
- classification and retrieval,
- configuration management,
- user management,
- tools for administration, configuration and customising.

A term "product data" is very broad one and it may include such data as: product's configurations, part definitions, design data, specifications, drawings, engineering analysis models, manufacturing process plans, NC programs, etc. Typical PDM is dedicated to work with digital documents (files) and is characterized by multi-tier architecture (Figure 1). It includes:

- a database management system (typically relational) for metadata,
- a set of application-independent functions which delivers core functionality (used by other modules),
- a set of functional modules which delivers functions specific to concrete application,
- a user interface (nowadays rather graphical) of various types (OS native or web-browser client),
- an electronic vault – one from logical point of view place where all documents (files) are stored.

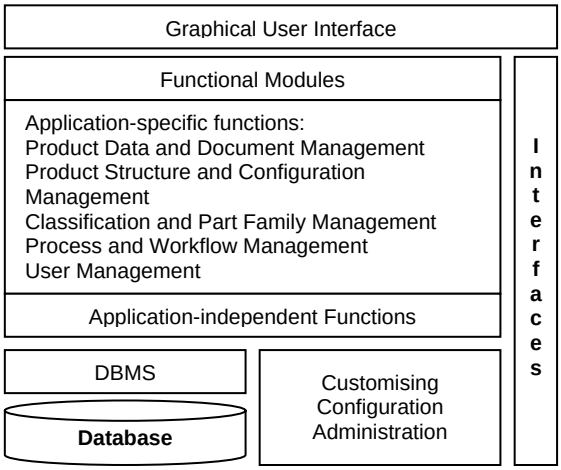

Figure 1. PDM system architecture [1]

Modern systems have usually additional groupware functions for collaboration. Most PDM systems provides notification services for all users via internal electronic mail service (which may be integrated with general-purpose e-mail), including process oriented information and links to the appropriate data.Use of PDM as collaboration platform usually changes the character of communication between team members, from spontaneous data and information exchanging. Thanks to the internal system's mechanism elimination of several minor tools is possible (it concerns mainly clients of popular Intranet and Internet services). Implementation of PDM changes the way of use of organisation's IT infrastructure - particular stands become the places of data processing; data storing is handled by the PDM system.

From point of view of project management PDM enables organizing of team working within the frames of particular project, reflects the structure of organization (team and its members) and the roles of particular members within the team and project (i.e. designer, approver, etc.). It may be achieved mainly by user management functionality. Specific to PDM systems data and document management ensures reflecting processes characteristic for design (i.e. approving or rejecting of document or project's stage).

PDM-based project management tools are typically graphics programs based on scheduling and action network techniques. These tools make it possible to correlate various tasks, modify them rapidly, allow for multi-criterion-based optimisation of tasks with regard to their timing, human, material and financial resources. They also enable monitoring of project progress and task status.

Nevertheless, these schedule and activity network based systems do not enable the self-acting modification of the activity plan as well as feedback creation between tasks. Because of the complexity of design processes and frequent changes in planned project tasks, the network of actions developed for such processes have to be verified and modified very frequently, allowing design team members to access project status information at demand from different locations. Therefore while managing a design undertaking consisting of a number of partial actions and involving many people, it is advisable to use a tool that makes it possible to control the work schedule at any stage of the project and to automatically collect information from individual design engineers.

3. DESCRIPTION OF DESIGN PROCESS FROM THE POINT OF VIEW OF TASK CO-ORDINATION

During each design process, the status of the work is subject to constant changes. As a result, it is very difficult to obtain accurate data on the progress of such projects because they change dynamically. Very often, there are a number of design engineers working on the same project in different places and information about the tasks and progress achieved must be sent to various locations.Because of the high level of variation in design tasks and differences in task complexity, it is often necessary adjust design procedures to every single task. When designing new products it is difficult to foresee the result of a design process. As a result, it is equally difficult to prepare a detailed action plan. In such a situation it is necessary to create a dynamic work plan, which only defines the sequence of design stages, rather than their timing. The content of subsequent process

steps is determined only after the results from previous steps have been obtained. Alternatively subsequent steps are selected depending on any changes in problem area defined, in accordance with the design method.
When one analyses a design process, one can determine a number of characteristic properties, which may be defined as follows:

- separability – processes are shared into partial tasks and carried out on a few levels, i.e. they are carried out by a few design engineers simultaneously, sometimes at different locations,
- parallelism – processes are carried out in parallel to one another,
- poor structuralisation – processes are only loosely determined, with no clearly defined action path,
- self-organisation – the task plan to be executed during a design process is subject to constant changes and has to be adjusted to a current situation,
- communications – information has to be exchanged among design team members.

A product design process also has to take into account information and communication technologies and a network worked enterprises.
In the construction design process, it should be possible to make rapid adjustments of the design process plan by providing updates on the status of a current piece of work and informing project managers about work progress. The complexity of the construction design process and the increased use of computer technology results in the need to use appropriate process management methods.
When managing a design process, one has to remember that developing a design for a new product is a creative process. That is why it is difficult in advance to estimate the time and budget needed to carry out such a project. Standard software is not efficient to fully meet the requirements of a given design office, mainly because it does not have the ability to enable complex planning of the design process.

4. 4. THE NATURE OF MANAGING A DESIGN PROCESS VIEWED AS AN ORGANISATIONAL AND TECHNICAL UNDERTAKING

A design process is a set of tasks to be carried out with a clearly defined start and end. It is a multi-subject undertaking involving a certain number of people, organisational units or independent institutions or enterprises. To realize such an undertaking requires an appropriate task structure. Tasks have to be ordered in terms of preparation, procedures and actions carried out. Furthermore, appropriate human, material, financial and informational resources have to be assigned to each set of actions.
Managing such an undertaking involves all basic management functions i.e. planning, organisation and supervision. Planning consists in identifying and analysing external and internal factors that influence the design process, including the available resources (human, material and financial), preparing checklists of project actions and estimating duration. The organisation stage is focused on co-ordinated actions in time, to ensure the fastest and cheapest realization of a design process that lead to the creation of a modern, high quality product.
As such, it is appropriate to design and provide a system that would aids task management in the design process, with a decentralised information and decision-making structure.

5. AGENT SYSTEM AS METHOD FOR DEVELOPING DECENTRALISED INFORMATION AND DECISION-MAKING SYSTEMS

The concept of Decentralised Artificial Intelligence, or DAI, and the related term of agent was first written about in the literature in the 1980s. However, computer systems employing these concepts only began to flourish in the mid 1990s.
The development of decentralised information and decision structures was put into practice as Autonomous Agents, sometimes know as Active Agents. This led to the development of the multi-agent system concept (short agent system).There are different approaches to interpreting the role of the properties of agents [2,4]. However, they do share certain common characteristics. Three of the most characteristic features of agents are:

- observation – thanks to its ability to observe (via receptors), an agent perceives dynamic environmental conditions in which it operates, reacts to change in these conditions and determines suitable actions to achieve its defined goals
- autonomy – agents operate autonomously in a complicated and dynamic environment, achieving goals or performing tasks for which they have been designed; they perform certain actions on behalf of the user or some other program either independently or autonomously, using knowledge representing the user's goals
- mobility – agents are able to move within the network and co-operate with other agents.

Application of the agent system method for task management in a design process seems appropriate given these properties. There are usually a number of design engineers working on one project, making it necessary to synchronize work and change tasks assignments dynamically. This forces the task management system to constantly adjust the plan to react to progress achieved.

6. PROJECT OF THE SYSTEM SUPPORTING THE TASK MANAGEMENT DURING THE DESIGNING PROCESS

The system was programmed using the RETSINA [3] package, which was developed for multi-level programming of intelligent agents. RETSINA contains two main parts: AFC (Agent Foundation Classes) and MAS (Multi-Agent Infrastructure), and enables semi-automatically creation of agents and their interactions. The proposed task management agent system is presented on figure 2.
Each agent is programmed using the inner agent scheme, and have the ability to move and communicate. They can negotiate among themselves in order to perform mutual tasks, or perform independent tasks autonomously. Organization of the agent system operation is blended into already existing communication systems.
The following agents were designed to fulfill different functions in the system:

- KnowBase_Agent – Info Agent,
- Designer_Agent – Interface Agent,
- Manager_Agent – Interface Agent,
- Middle_Agent – Middle Agent,
- BestDesigner_Agent– Task Agent.

KnowBase_Agent makes required information available in the database, and is responsible for updating the project knowledgebase. Designer_Agent assigns the tasks to designers and sends information about the progress of tasks. Manager_Agent manages the information about the relationships between employees, projects and tasks. Middle_Agent mediates between the Manager_Agent and Designer_Agent, controls the progress of work on-line and keeps the Manager_Agent and the Designer_Agent informed. BestDesigner_Agentassigns specific tasks to individual designers, according to criteria (e.g. shortest time, lowest costs and current project situation etc.).

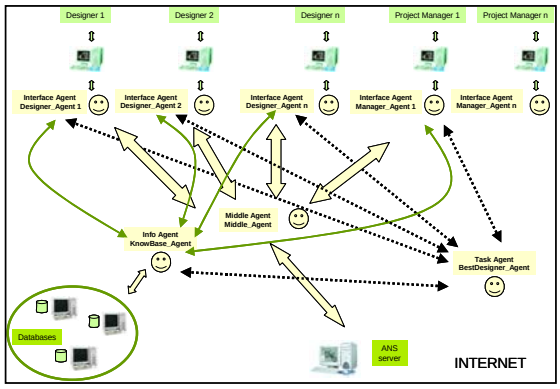

Figure 2. Chart of the agent system for the task management aiding

Each agent must be registered in the system. ANS (Agent Name Server) is responsible for storing the names of agents, addresses and port numbers of host machines, and allows all registered agents to be located.
The Data Base stores all project process planning data: list of designed elements, work stands, staff, schedule of planned project works and current state of work progress.
The main aim of this system is to provide all the functionality required to manage the design process by:

- sharing project tasks (based on the structure of a designed product and information about already realized projects base),
- planning the realization time of each task and the whole project (basing on previously performed tasks and taking account of the complexity of the designed element),
- assigning designers to individual tasks, based on their individual characteristics and experience,
- automatic notification of particular tasks to individual designers,
- current monitoring of progress (reminding designers to provide updates on progress achieved), receiving and registering progress in the data base,
- estimation of project costs, including working time of a designer.

The system also provides information about:

- ongoing projects – their progress, workers involved, estimated completion time,
- finished projects – start and end of separate project tasks, time difference, the causes of delays; designers involved in the realization of the project,
- designers – character features which may influence of the realization of the project; information, concerning elements which a given designer designed, results of the design, disposition.

Knowledge base is a source of information, which is used by the system to manage project tasks, estimate time and assignment particular tasks to a particular designer.
This system widens the functions of standard project management systems and the decision-making elements, making it easier to observe work in progress, and automatically notifying the responsible project manager about any problems encountered.

7. CONCLUSIONS

The both systems presented before (PDM and agent system) work independently and fit into various areas of design management. On the one hand PDM systems ensures functionality connected with data management, but existing in this class of systems tools dedicated for project execution supervising don't allow, according to the opinion of the authors, performing this process at appropriate level of details. On the other hand the agent system presented

above enables task management at advanced level, but doesn't take into account the matter of data management.
The authors propose hereby the idea of establishing comprehensive information management solution for design purposes. This idea bases on connection the functionality of both presented systems in order to create comprehensive collaboration platform.
The crucial role in proposed integration plays the consistency of data in both systems' databases. A change in one of the systems should be reflected and taken into account in the second and vice versa. The authors propose use of another agent for this task, which role will consist in monitoring the changes in each system's database and make the appropriate changes in the second one (Figure 3).
The designing process should be treated as not just one of the steps in creating a new product, but as a complicated organisational-technical process which is critical path for the entire organisation, and as such requires proper methods and tools to work effectively.

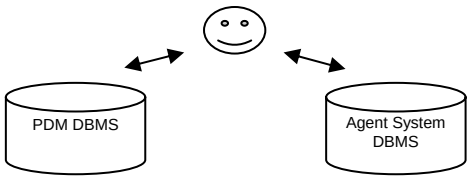

Figure 3 The agent monitoring changes in both systems' databases

Standard project management systems do not enable the self-reinforcing modification of activities and internal task feedback loop required. The agent based system described solves, many of the problems encountered using standard solutions, and can be used in both intranet and internet based working environments. The programmed agents manages the work of designers (especially in assigning tasks, forwarding designing tasks and gathering progress information). Application of the agent method to manage tasks in the design process, enables real-time management of all the activities of the design team by the project manager. Use of the system can be particularly efficient where project work is distributed, tasks may be carried out between many designers or the design process involved the use of external resources (whether people, or special equipment).
In today's working environment, where increasingly virtual and extended enterprises are becoming an important way for organisations to work together to achieve common goals, any tools that support distributed management of the design process are to be welcomed. In this type of environment, real-time management and coordination of design tasks is critical, especially where decentralised information sharing and decision making structures are in place. Therefore the use of the agent method to support distributed task management in the design process enables the proper functioning of the system.
The proposed conception may be treated as powerful extension of contemporary PDM's functionality, giving the project manager the possibility of more advanced, in comparison to standard ones, tool for project management. The presented concept is to be developed within the frames of research works of Poznan University of Technology VIDA (Virtual Design and Automation [5]) Center.

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