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APPLICATION OF THE AGENT SYSTEM METHOD IN MANAGING DESIGN PROCESS TASKS

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***Abstract**: In the paper design process at an angle organization and coordination of actions was characterized. The requirements for tasks management in design process were defined. On the base of carried out analysis characteristic properties of design process were determined. An agent system was proposed for aided management of tasks.*

1. INTRODUCTION

Widespread computerisation of enterprises results in the fact that engineers have to switch to new tools and adopt new work methods. In design offices, sheets of paper, pencils and drawing boards are being replaced with sophisticated computer systems.

A contemporary design office employs not only highly specialised computer tools but also modern work methods. There are many offices centred around the so-called dispersed design teams where engineers form a virtual project team whose members communicate with one another via electronic information networks.

This type of project work organisation requires a unique task management method to be adopted while carrying out a given design project.

2. CHARACTERISTICS OF A CONSTRUCTION DESIGN PROCESS WITH RESPECT TO TASK ORGANISATION AND CO-ORDINATION

During each construction design process, work progress status is subject to constant changes. Therefore, it is very difficult to obtain accurate data on project progress since they change dynamically. Very often, there are a number of design engineers working on the same project who do not occupy the same room or even the same building. Task information must be sent to various locations while project progress data and information on any disruptions must be collected from individual members of the design team. High level of design task variation and varying degrees of task complexity result in the need to adjust construction design procedures to every single task. In the case of designing new products it is difficult to foresee the result of such a design process. It is equally difficult to prepare a detailed action plan. In such a situation, it is only the sequence of design stages that is determined. The content of subsequent process steps is determined only after results from previous steps have been obtained, or is selected depending on the changing problem area in accordance, however, with the step system of a construction design process microstructure (e.g. in accordance with the LEMACH [8] design method). This type of project task planning is known as the dynamic plan.

When one analyses a construction design process, one can determine some of its characteristic properties which may be defined as follows:

- **separability** – processes are broken up into partial tasks and are 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 determined only loosely, there is no clearly defined action path,
- **self-organisation** – 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 account of computer technology and telecommunications developments that facilitate the implementation of a "network"-based enterprise model. Many authors use the "REACH AND RANGE" concept as proposed by Keen [3]. "REACH AND RANGE" means that each network node over a given area exerts influence on some other communications node – and in the case of limitations imposed on this principle it becomes a "nobody" – and that it has the capacity to convey information between identical platforms in the case of simple information systems but also that it can exchange data generated by computer systems based on different operating platforms. Appropriate tools that are now widely available make it possible to establish "dispersed" design offices where the structure of task management is decentralised. The extended reach of such a design office requires that the processes taking part within it be appropriately defined.

Construction design process management should allow for rapid adjustments of the design process plan to a current work progress status and for informing project managers about work progress. The complexity of a construction design process and the increased use of computer technology result in the need to employ appropriate processes management methods.

Advances in computer technology made it possible to develop various computer-assisted design tools. After analysing the methods and tools used in computer-assisted design one may conclude that current design systems are used mainly for computational and simulative purposes (e.g. CAE systems) and for modelling as well as graphic documentation preparation purposes (CAD systems). Existing EDM and PDM systems are used to manage product data and document circulation in a design office. These systems, however, are not intended to organise and co-ordinate various processes that take place while a given project is being carried out.

When managing a design process one has to remember that developing a construction design for a new product is a creative process. That is why it is difficult to estimate in advance the time (and also the cost) needed to carry out a given project. Standard software is not efficient enough to fully meet the requirements of a given design office. This also applies to the tools of the integrated enterprise management system class (including a production planning and control module) [12] that usually focus on material demand calculations and lack planning functionalities of a more general character that would take account of the complexities of a design project.

3. 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. The process has a clearly defined start and end and that is why, to a large extent, it may be approached as an organisational and technical undertaking which is in line with the definition stating that an undertaking is a one-off set of tasks with a defined start and end.

Design process is a multi-subject undertaking involving a certain number of people, organisational units or independent organisations (institutions, enterprises). Completing such an undertaking requires an appropriate task structure taking due heed of both material and action aspects of the process. Tasks have to be ordered, i.e. co-ordinated (from the point of view of procedures carried out, set of actions, elementary activities) in time and space. Furthermore, appropriate human, material, financial and informational resources have to be assigned to each set of actions [4].

Managing an undertaking such as a construction design process 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. It is meant to determine the purposefulness of a given undertaking. One should also analyse available resources (human, material and financial), prepare a checklist of project actions and estimate their duration. Having determined the set of project actions and having estimated their duration, one has to move to the organisation stage where actions are co-ordinated in time. Action network should be designed so that it ensures the fastest and cheapest completion of the design process and leads to creation of a modern high quality product.

Computer-based tools for undertaking management available on the market are usually graphics programs employing scheduling and action network techniques. Such tools make it possible to correlate various tasks, modify them rapidly, allow for multi-criterion-based optimisation of future tasks not only with regard to their timing but also taking account of the foreseen human, material and financial resources and, finally, enable their users to constantly monitor project progress status. Some of the best known computer tools used in undertaking management are "MS Project" by Microsoft, "Time Line" by Symantec, "CA-SuperProject" by Computer Associates, "PowerProject" by ASTA, "SureTrak Project Manager" and "Primavera Project Planner" by Primavera Systems [6].

Given the complexity of design processes and frequent changes in planned project tasks, action networks developed for such processes have to be verified and modified very often. Information on project progress status is obtained from design team members working at different locations. That is why, while managing a design undertaking consisting of a number of partial actions and involving many people, it is advisable to employ a tool that would make it possible to control work schedule at any given stage of the project and to automatically collect information from individual design engineers.

Given the above, it seems appropriate to design and provide software for a system that would aid task management in a design process and feature a decentralised information and decision-making structure.

4. *AGENT* SYSTEM AS A METHOD FOR DEVELOPING DECENTRALISED INFORMATION AND DECISION-MAKING SYSTEMS

The concept of Decentralised Artificial Intelligence, or DAI, and the term *agent* related to it appeared in literature in the 1980s. However, computer systems employing these concepts in practice began to flourish only in the second half of the 1990s [5].

Tendencies to decentralise decision-making centres and to make use of dispersed information resulted in the development of systems that would successfully support this type of activity.

The idea of creating decentralised information and decision-making structures was put into practice when the so-called *agents*, also known as Autonomous or Active Agents, were developed. This, in turn, led to the development of the *multi-agent* system concept (or *agent* system for short) [5].

There are different approaches to interpreting the role of *agent's* properties [3,7] which, nevertheless, share certain common characteristics. The following is a presentation of the three most characteristic features of *agents* [5]:

- **observation** – thanks to its ability to observe (via receptors), an *agent* perceives dynamic environmental conditions in which it operates, reacts to change these conditions and determines actions to achieve its own goals,
- **autonomy** – *agents* operate in a complex and dynamic environment, they perceive it and act within it in an autonomous manner, achieve goals or perform tasks for which they have been designed; they perform a certain set of actions on behalf of the user or some other program, independently or autonomously to a certain extent, while making use of a certain amount of knowledge that represents user's goals or intentions,
- **mobility** – *agents* are able to move within the network and co-operate with other *agents*.

Two *agent* types have been identified in the case of design process management:

- **information *agents*** – that collect information on tasks being performed and render this information available when subsequent tasks are performed,
- **task *agents*** – that monitor work progress and suggest next steps as well as point to missing information and render missing information available.

Application of the *agent* system method in task management during a design process seems to be appropriate given the above-described properties. There are usually a number of design engineers working on one project and that is why it is necessary to synchronise their work and assign tasks appropriately. Dynamic changes that occur while carrying out respective tasks related to designing a product force the task management system to constantly adjust the plan to work currently in progress.

5. APPLICATION OF THE AGENT SYSTEM IN AIDING TASK MANAGEMENT IN CONSTRUCTION DESIGN

5. 1. The concept of *agents* in a design task management system

Characteristic features of an *agent* outlined in the previous section combine into a certain type of architecture whose description is, in fact, a representation of an *agent's* internal structure. A classic *agent's* structure is presented in fig. 1.

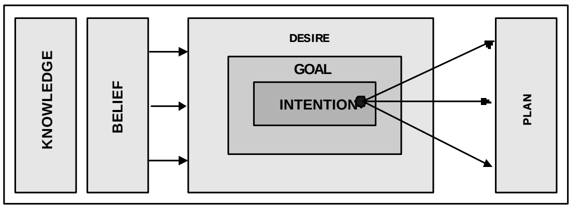

Fig. 1 Agent structure [7]

This chart presents basic functional modules of an *agent*. The level of complexity of the respective modules and their physical implementation depend on the purpose for which the *agent* (*agent* system) is intended and the technical solutions adopted.

The functional chart (*agent's* architecture) serves as a departing point for developing a formal description (internal model). There are certain works (e.g. [1,2,11]) that describe such model classes. Given, however, their high level of complexity and the large number of possible variations such model classes are usually discussed in highly abstract terms.

For the purposes of task management in a construction design process, we have selected an *agent* system method employing the concept of a BDI (Belief, Desire, Intention) *agent* whose operation, in form of a diagram, is presented in figure 2.

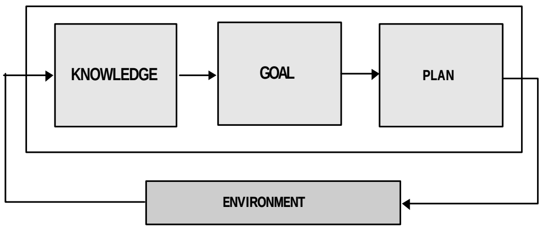

Fig. 2. A BDI agent operation diagram

A BDI *agent* is one of the widely recognised *agent* concepts [3]. *Agent's* beliefs **B** stem from its knowledge of the surrounding environment. Its desires (or pursuits) **D** correspond to the goals it intends to achieve. Its intentions **I** stand for its intended method of operation (strategy selection rules). It is often assumed that an *agent* has a "sense of social interaction" or, in other words, that its aim is, while putting its intentions into practice, to satisfy the needs of the environment in which it operates. The operation diagram presented in figure 2. is a dynamic one since it takes account of the results of *agent's* actions. Below you will find the formal model used to describe a BDI agent.

$$\left\langle E_i, B_i, I_i, A_i, i \right\rangle \qquad (1)$$

where: E_i – set of tasks, B_i – agent's knowledge (beliefs), I_i agent's intentions, A_i – agent's actions, i – number of the respective stage of system operation.

5.2. Agents' tasks

In a task management system employed in a construction design process, each of the planned program *agents* is provided with software on the basis of the *agent's* internal structure. A diagram of such an *agent* is presented in figure 3.

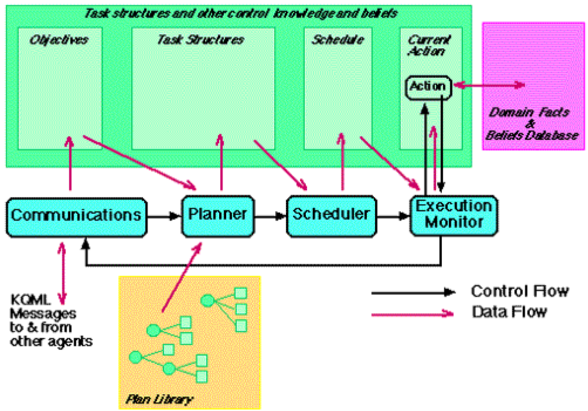

Fig. 3. Agent's functional diagram [9]

Respective *agents* will directly represent real users, or certain tasks (functions) they order, and artificial intelligence–based software used to aid decision-making processes. *Agents* will operate at network nodes and will have the ability to move and to communicate with one another. Agent communications will be effected at a different level than network communications proper. Negotiations may result in agents' joining their efforts to perform common tasks or in their remaining autonomous while performing mutually independent tasks (or mutually agreed tasks). The organisation structure of the *Agent* system operation will be integrated into the existing information system. In this case the system is the Internet.

The proposed system consists of a number of co-operating *agents* including:

- **Planner 1** – that assigns tasks to the respective team members working on the project,
- **Informant** – that sends queries to the respective project team members concerning work progress status (on the basis of the information contained in the DataBase),
- **Planner 2** – that updates work progress information in the DataBase,
- **Optimiser** – an *agent* responsible for planning the duration of respective design operations,

- **Manager** – that ensures the coherence of the system – it will be used to launch the entire system and to set parameters influencing its operation,
- **Communicator** – that is responsible for communications among *agents*,
- **Receivers** – respective terminals of the system for which tasks will be planned,
- **Administrator** – an *agent* entering basic data into the DataBase.

Respective *agents* directly represent real system users (**Receivers** and **Administrator**) or certain tasks ordered by them (program *agents*). The **DataBase**, used to define basic data with respect to design process planning such as the list of objects to be designed, workstations, personnel, planning calendar, planned design works schedule and current work progress status, is one of the main elements of the system.

Agents will operate in appropriate layers corresponding to their function. The planned system is composed of four basic layers:

- *core of the system* – the innermost layer of the system composed of agents performing mathematical computations; this layer will consist of agents responsible for adjusting the plan to a current situation,
- *input-output layer* – agents forming this layer will be responsible for user-system and agent-agent communications,
- *internal database management layer* – agents in this layer will be responsible for storage of appropriate data in the system and supplementing it using external sources,
- *security layer* – composed of agents responsible for system security (i.e. agents in charge of user authorisation, preventing illegal access, managing user rights, etc.).

6. CONCLUSIONS

The present paper outlines the purpose of applying an agent system in aiding task management in a construction design process. Application of an agent system should make it possible to constantly monitor design works, automatically collect work progress information from the design team and manage tasks in a virtual design office.

Application of the *agent* system method in task management in a construction design process opens up new possibilities in the area of task management.

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