Multi-agent-based conception of modern aircraft design

Dmytro Konotop[1], Ivana Budinska[2], Valeriy Zinchenko[1], Emil Gatial[2]

[1] National Technical University of Ukraine "Kyiv Polytechnic Institute", Peremogy ave, 37, 03056 Kyiv, Ukraine.
konotop.dmitriy@gmail.com
[2] Institute of Informatics, Slovak Academy of Sciences, Dubravska cesta, 9, 84507 Bratislava, Slovakia.
budinska@savba.sk

1 Introduction

An airplane design is undoubtedly an extremely complex technical problem. The complexity of the problem is hundred times over a complexity of e.g. T.V. and a car design. Manufacturers have to consider many different customers´ requirements. Practically it means that every piece of manufactured aircraft has specific and different requirements. In an aircraft design the changes usually involve substitution, not just omission of a simple part. Manufacturers try to adopt a certain level of standardization to cope the complexity problem. However, an aircraft design process is still exhausting and extremely complex process that involves many designers working together on one aircraft design. Recently there exist numbers of collaborative tools to support aircraft design. The designing process afford knowledge, both formalized (standards, rules, etc.) and un-formalized (experiences). That is why many collaborative design tools contain also some kind of knowledge management. The problem is what kind of knowledge can be and how to formalize knowledge obtained and required in the process of an aircraft design.

2 An aircraft design as a knowledge intensive process

The main stages of an aircraft design (AD) using modern computer information technologies are shown in Fig.1.1. The final result of an AD is the automated execution of work documentation (WD) and the formation of programs for the machine tools with programmed numerical control (PNC) and then transferring it to the manufacture [1].

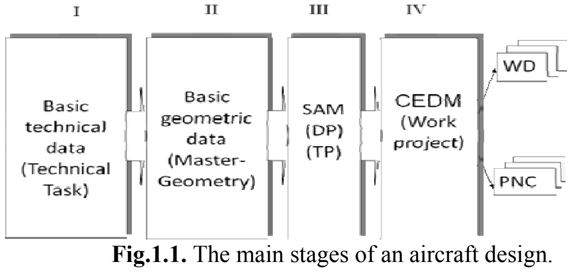

Fig.1.1. The main stages of an aircraft design.

Space allocation mock-up (SAM) is the basic design stage, the bridge between the technical task, master geometry and complete electronic definition of model (CEDM). SAM includes the following stages: the draft project (DP) and the technical project (TP). And first of all we will work with this stage. A SAM structure tree of an airplane An-NNN is shown in Fig. 1.2. There is presented the structure of the all aircraft systems and equipment, and power plant at this tree [2].

For example: NNN.01.0000.000.000a is a key of a main assembly, which means, that it is the first modification of an An-NNN aircraft machine. And it includes the all assemblies with constructive and power set, systems and equipment.

NNN.01.5600.000.000a is the assembly of a hydraulic system in an aircraft which includes the assemblies of all hydraulic system parts. For example: NNN.01.5610.000.000a is a hydraulic system in a fuselage, which includes the parts with real 3D-models.

```
|NNN.01.0000.000.000a
        |NNN.01.0000.010.000a
                 |NNN.01.0000.100.000a
                        |NNN.01.0001.000.000a
                        |NNN.01.2000.000.000a
                        |NNN.01.2300.000.000a
                        |NNN.01.3000.000.000a
                        |NNN.01.4000.000.000a
                 |NNN.01.0000.200.000a
                        |NNN.01.6100.000.000a
                        |NNN.01.6400.000.000a
                        |NNN.01.6500.000.000a
                        |NNN.01.6600.000.000a
                        |NNN.01.6700.000.000a
                        |NNN.01.6900.000.000a
                        |NNN.01.6099.000.000a
                 |NNN.01.0000.300.000a
                        |NNN.01.5000.000.000a
                        |NNN.01.5600.000.000a
                        |NNN.01.5800.000.000a
                        |NNN.01.7000.000.000a
                        |NNN.01.7100.000.000a
                        |NNN.01.7200.000.000a
                        |NNN.01.7400.000.000a
                        |NNN.01.7500.000.000a
                        |NNN.01.7550.000.000a
                        |NNN.01.7600.000.000a
                        |NNN.01.7650.000.000a
                        |NNN.01.7700.000.000a
                        |NNN.01.7800.000.000a
                        |NNN.01.7900.000.000a
                        |NNN.01.8005.000.000a
                        |NNN.01.9000.000.000a
                        |NNN.01.9600.000.000a
```

Fig.1.2. A SAM structure tree of the An-NNN airplane.

The main problem of a modern AD is handling large volumes of created 3D-models, data exchange among designers and control for the new data from designers to design environment. To solve this problem, the conception of an AD based on the multi-agents has been developed and is presented at this paper.

3 Knowledge formalization in AD

There were several basic knowledge concepts determined in the aircraft design process. A formal representation of knowledge for an aircraft design process was made in ontology. The suggested AD ontology is shown in Fig. 2. It describes the basic concepts and relations among the basic parts of AD process.

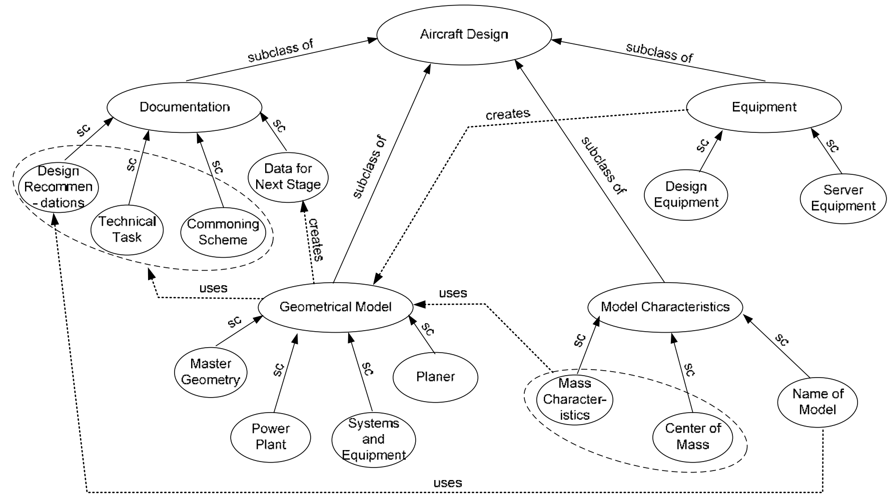

Fig. 2. AD ontology.

An AD process includes the four basic parts. The subclasses of AD are: documentation, equipment, geometrical model and file characteristics. The subclasses of the basic concepts are depicted in the fig. 2.

A Documentation concept includes the basic document information before this SAM stage and after this simulation. An Equipment concept shows the programs, which are used at the AD process. A Model Characteristics concept describes the basic characteristics of every real 3D model. Every txt-file with these model characteristics is located with real 3D model file. A Geometrical Model concept contains the 3D models according to the SAM stage.

4 A conception of a multi-agent-based aircraft design

The concept of an aircraft design based on multi-agents and ontology has been developed and realized with a help of the JADE-environment, using information about characteristics and geometry of 3D-models from CAD-program Catia v.5.

Because of the complexity of application development for the multi-agent system and the PDM system as well as their technical characteristics, their integration is difficult [3]. We have developed the simplified multi-agent system (MAS) architecture for aircraft design, which is shown in Fig.3. A Changes Analysis Agent receives new 3D-file from designers. It requests information about the state of the AD process from an AD information Base, which is represented by ontology. Then it receives an old file, analyzes the differences and sends the tasks to the Design Changes Agent. The Design Changes Agent handles the files according related tasks. The information with changed file is returned to the AD Information Base. The Design Changes Agent stores information about these changes for different users.

For the example, the assembly of an aircraft hydraulic system (key: NNN.01.5600.000.000a), which was simulated in Catia v.5, was chosen. The structure was checked in Protégé 3.4.4 and has been realized in JADE-environment according to described scheme.

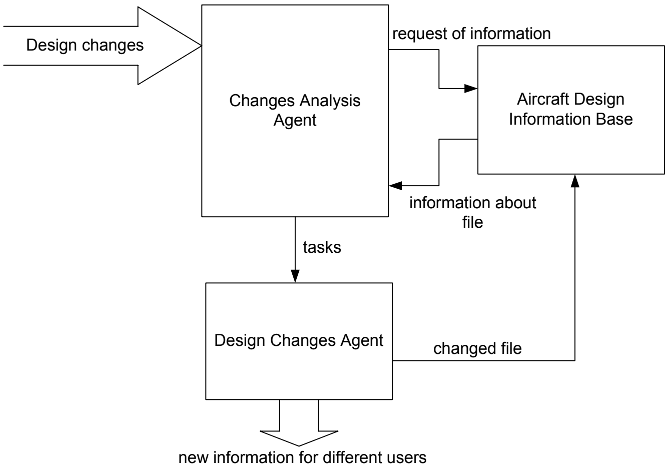

Fig.3. Simplified AD MAS architecture.

5 Conclusions

The advantages of a suggested multi-agent-based AD are: a high quality design of CTO; quick response of AD to aircraft product change; an AD project punctuality; reduction of material and labor costs; improvement of ergonomics of the engineer-designers.
The work started on the basis of the beginning cooperation between II SAS and Kyiv Polytechnic Institute during a stage of a PhD student at II SAS.

Acknowledgement The authors would like to express their sincere thanks to the Slovak Academy Information Agency (SAIA) for the financial support.
The work was partially supported by the grant agency VEGA by a contract No. VEGA 2/0197/10.

References

[1] Eger, S. M., Mishin, V. F.: Aircraft design. “Mashinostroenie”, Moscow (1983) (in Russian).
[2] Zinchenko, V. P., Konotop, D. I.: Using of modern computer information technology for the complex technical object design // Book of Abstracts of Conference “Information technology and computer engineering”, 19-21 May 2010, Vinnitsa, Ukraine, p.50–51 (in Ukrainian).
[3] Yingguang Li, Jianbang Jian, Ruijie Yan and Wenhe Liao: Aircraft Tooling Collaborative Design Based on Multi-agent and PDM. SAGE Publications 2009.