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Publication Date

2001

Peer reviewed

AIT-VEPOP: VIRTUAL EARLY PROTOTYPING

A means for supporting the work of Distributed Virtual Teams in Concurrent Engineering Environments

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KEYWORDS

Cooperative Problem Solving, Digital Mock-Up, Rapid and Virtual Prototyping, Data Handling, Distribution and Transformation, Distributed and Co-operative Product Development, Product Life Cycle Management

ABSTRACT

AIT-VEPOP (IST-1999-13346) is a European Research Project within the IST Programme of 5th Framework. The project is scheduled from July 2000 to June 2002. Members of the AIT-VEPOP consortium are EADS CCR (co-ordinator), Airbus GmbH, Astrium GmbH, Flowmaster Ltd., CNAM, University of Oulu, and DFKI. AIT-VEPOP deals with issues of co-operative work and concurrent engineering with respect to the use of virtual prototypes in the early design phases of an aircraft.

The here presented paper is a position paper. It focuses on the AIT-VEPOP project objectives and describes the requirements and characteristics of a common platform for early virtual prototyping. The requirements result from use case scenarios that are stated in this paper.

INTRODUCTION

In the future, world-wide co-operation needs efficient support of co-operative work practice. A major issue is the organisation of a distributed workflow over large distances. The federal system of the European Union leads to more and more trans-national (European) companies, which incorporate skills and experience of a widely spread workforce. Also on global scale markets, companies and organisations become increasingly multi-sited, operating with partners and customers around the globe. In particular for the area of product design, accuracy and timeliness of communication is vital.

Conceptual design is a critical activity in the life cycle of complex engineering products. During the conceptual design phase, most of the design decisions defining performance and cost of the future product are fixed. Later corrections of these decisions are time consuming with an increase in cost with each following development stage.

There have been several attempts to use information technology to decrease the amount of face-to-face meetings, like video conferencing and special conferencing systems based on some sort of electronic whiteboards. However, these systems have had only minimum impact on the concept design phase due to a lack of support for easily sharing visual data of a 3D-design. Distributed virtual early prototyping will change design practice by opening new communication channels and providing new ways of co-operative and concurrent computer interaction.

AIT-VEPOP OBJECTIVES

The project main objective is to provide methods and tools for supporting the design of complex engineering products during the concept phase.

Concept design activities are performed in project-oriented teams. Due to product complexity and a high degree of supplier specialisation, beside large organisations also small and medium sized enterprises (SME) are involved in collaborative design activities. In order to respond to market competition and economies of scale, they have to manage very tight deadlines on a geographically distributed European scale.

Geographical distribution of project teams requires efficient communication between designers, the responsible program managers (decision makers), and the customers. Misunderstandings based on communication problems are considered to be the main bottleneck in the current co-operative design process.

Within AIT-VEPOP, a virtual early prototyping demonstrator for distributed co-operative work will be designed, implemented, and evaluated, which will enhance common understanding and eliminate the main source of communication problems. Using state-of-the-art web technology for content management and virtual reality technology for interactive visualisation of highly complex technical systems, designers will be performing real-time collaborative design. They can communicate with other designers on the same shared design using the virtual early prototyping framework.

APPROACH

The AIT-VEPOP approach is based on realistic industrial scenarios and concrete use cases from the aerospace industry (e.g. aircraft section integration). This leads to an efficient requirements elaboration as well as a user-centered implementation and evaluation of two framework prototypes for a high efficient interactive co-operative design.

We expect that new metaphors for real-time 3D co-operative design and parallel work within virtual shared worlds will be introduced while preserving the consistency of the structure and the system design with a number of designers working in parallel. Such a framework will enable new ways of co-operative work, where session participants can co-operate in real-time when designing a product prototype.

Designers will be aware **in real-time** of modifications performed by remote participants. They will be able to modify **in parallel** their prototype while keeping it consistent. In addition to these shared meeting phases, it defines, still consistent, private pre- or post-meeting phases that currently are missing in many research proposals.

Virtual reality (VR) will be used to manipulate conceptual geometric data, which can be handled easily by engineers not familiar with specific CAD systems. Real-time consistent protocols for distributed virtual reality will be used which will not limit the ability of parallel working or degrade the quality of animation. In order to avoid bottle-necks and allow a scalability of the framework, these protocols will be suited for fully distributed architectures.

In addition, the project considers the integration of different simulators with the 3D-world. Depending on the performance of the simulators and the level of integration, we can reach either real time co-simulation or at a first level maintaining consistency between simulation models and the 3D-models. Considering the last, 3D-scenes can be used to reproduce animated presentations of simulation results

For the integration of simulators new efficient methods for sequencing activities of different simulators and their causal ordering of exchanged events in order to satisfy the repeatability and correctness of the distributed simulations are expected. Thus through interactive visualisation and simulation capabilities, designers, contractors, and end-users co-operate simultaneously and directly when designing, reviewing, and testing the concepts of the future product. This will facilitate the assessment of multiple design alternatives and the conclusion of trade-offs.

USE CASE SCENARIO IN STRUCTURE AND SYSTEMS ENGINEERING

During early design phases, workshops are periodically organised to conciliate the various 3D architecture proposals established by engineers of different domains / disciplines. The aim of these meetings is to eliminate inconsistent global architectures, select and amend the most promising solutions.

Thus, an important part of the work is acheived by the definition of frontier/interface models. They describe the interface between at least two models that were designed under different responsibilities, belong to different assembly structures and that were eventually assembled in consideration of compliance with:

- all functional requirements,
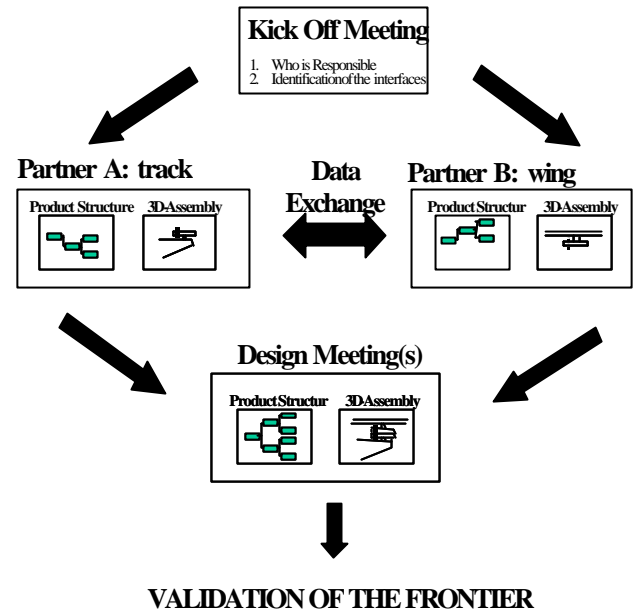- defined physical data, and
- geometry data and tolerances.

Figure 1: Frontier Process

The above figure 1 shows the principle structure of the frontier/interface process for conjunction of track and wing structure.

For example, the aircraft Airbus A340-600 tracks and flaps of wings were designed by EADS Airbus in Bremen, Germany, wing box which assimilate tracks and flaps were designed by BAe System in Filton, England, and fuselage section 15/21, which assimilates the wings was designed by EADS Airbus in Toulouse, Farnce.

Particularly design tasks for frontier/interface-models of aircraft structure-/system-interfaces require:

- a very high level of distributed work sharing and thus,
- a lot of co-ordination between the designing partners.

So within the frontier/interface design review process, the use of a virtual environment connecting all participated front-end visualizer would be a great benefit in respect to improve the communication for concurrent and distributed engineering and to satisfy requests of the designers like:

- improve the availability,
- upgrade the clearness,

- reduce the failure-rating,
- decrease the running time / iteration loops

of design information like visualised data.

ENCOUNTERED PROBLEMS

These meetings are necessary collocated which is not always feasible. In this context, teleconferencing is only useful if distributed 3D models or distributed VR are accessible to assess and validate design alternatives.

In collocated meetings, the 3D geometry and functional models including structure and system components are manipulated by a single person only.

Therefore, it is necessary to provide visibility, for example, by projections during the meeting but also to provide direct feedback and interaction for every participant in order to capture design rationale.

In systems engineering, for example, the safety segregation rules (e.g.: minimum distance between fuel and electric systems) have to be checked in order to prevent any interference between different systems. Therefore, the minutes of the meeting describe what have to be done to conciliate the system.

LOCAL MODE: USER 1   **LOCAL MODE: USER 2**
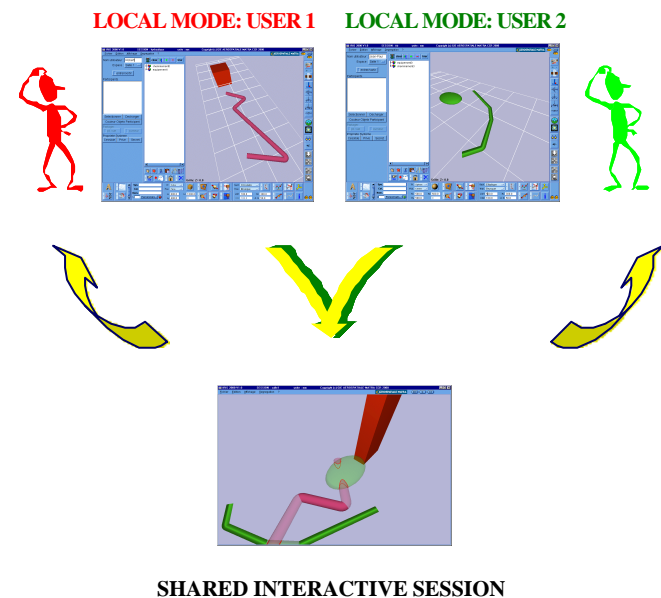
SHARED INTERACTIVE SESSION

Figure 2: Collaborative Design and Conflict Solution

Figure 2 illustrates this kind of collaborative and conflict resolution, where two local users can check and reach consistency of their locally generated models in a shared interactive session.

In addition, it is difficult to take decisions and to find trade-offs without access to different views, for example, functional, geometric or behaviourals and the possibility to switch between them, easily and consistently. The capability

of integrating different multi-physic simulation models and 3D geometry would leverage decision making.

There are dedicated tools for building the behavioural models. However, these tools have no common standardized interface. Consequently, 3D-models once designed cannot be used to create or to update a behavioural model without the development of specific interfaces. Conversely, a change in the behavioural model cannot directly or incrementally be transmitted to the spatial model.

FUTURE SCENARIOS

Meetings will be held either remotely when only restricted analysis are necessary or jointly when a synthesis effort is required. A shared session will be built up starting from individual contibutions and a support for multiple alternative exploration will be provided.

Every participant will be able to interactively manipulate objects (3D components or behaviours) within the shared session in order to propose new or modified concepts. Easy access to first order simulations will enable to quickly validate the performances of these proposals.

Interactive design and first order simulations will increase the quality of meeting results. Minutes will be available at the end of the meeting including the justified action items and commonly agreed design results linked to 3D and functional representations.

AIT-VEPOP REQUIREMENTS

The first set of requirements deals about the communication between design engineers:

- to share the different virtual representations of the product,
- to share documents,
- to support interactivity during conciliation meetings and design reviews.

To support and review 3D modeling- and configuration-processes and of course for working with digital mock-ups (DMU) designers nowadays use different 3D visualizers like dVISE or DMU-Navigator merely local in their own team without any possibilities to involve participated and locally distributed design partners.

To improve the use of 3D visualizer with respect of performing design reviews between distributed design teams, first of all it is necessary to connect all visualizers of participated designing teams via Internet or other network-systems. Therefore all participated designers would be able to communicate to each other via their own visualizer. Every participant should be able to speak about the same design information in the same 3D representation at the same time during one distributed design review.

Users must be able to initiate and start a new session or to enter and leave an already running session. On the other hand all basic functions of currently existing visualisers must be available, for example, object selection and object transformation.

3D-CAD data must be exchanged automatically between all locations when starting a new "virtual review session", so that all partners start with identical databases before

visualized data are generated. Data exchange for visualisation can be perfomed in a neutral format like VRML so that everyone is able to easily convert his own data.

A module that supports audio and video conferencing as well as chat rooms within the virtual environment is the objective of an extended and advanced version of the AIT-VEPOP prototype.

The second set of requirements deals about system engineering. Tools will enable to manage the consistency between 3D-representation of systems and their behavourial counterparts.

For large and complex multi-functional systems, other tools will provide a way to define a layered system diagram. This structured schema will be used to combine different simulators in order to perform a global multi-physic simulation simulation.

Any possibilities of communication between front-end systems and the virtual communication environment via the provided API have to be checked in the next project steps.

The DMU will act as an common 3D display as it will be possible to display and replay in 3D the simulation results and animate moveable parts following simulation results.

During these global simulations, real-time issues needed for integrating immersive virtual aircraft cockpits issues will be also investigated.

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BIOGRAPHIES

MARKUS DURSTEWITZ studied aerospace engineering at the University of Stuttgart and ENSAE Toulouse (Diploma 1993). Then, PhD thesis work in the field of Cognitive Science and Engineering at EURISCO and Airbus in Toulouse. In 1998, project coordinator at Lufthansa Technik in Hamburg – Logistic process and information systems. Since 1999, project manager for new IT methods at Airbus GmbH in Hamburg. This includes responsibility for research and technology projects in the fields of engineering knowledge management and virtual product development.

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CHRISTOF NUBER studied computer science and computer graphics at the University of Kaiserslautern and obtained his B.S. in 1991 and his M.S. in 1995. Since 1995 he has been working at Astrium GmbH, Space-Infrastructure, Bremen in the field of virtual reality and space-related VR-applications.