A MULTIMEDIA WORKFLOW-BASED COLLABORATIVE ENGINEERING ENVIRONMENT

Integrating an Adaptive Workflow System with a Multimedia Collaboration System and a Collaborative Virtual Environment for Petroleum Engineering

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Keywords: Collaborative Engineering, Workflow Systems, Collaborative Virtual Environments.

Abstract: In this paper we discuss the scenario of Petroleum Engineering projects of Petrobras, a large Brazilian governmental oil & gas company. Based on this scenario, we define a set of requirements and system architecture to guide the construction of a Collaborative Engineering Environment for assisting the control and execution of large and complex industrial projects in oil industry, specifically tailored for Petroleum Engineering. The environment is composed by the integration of three different technologies of group work: Workflow Management System, Multimedia Collaborative System and Collaborative Virtual Environments.

1 INTRODUCTION

The present work is motivated by the necessity to find effective solutions for collaboration of team workers during the execution of large and complex Petroleum Engineering projects at Petrobras. The necessity of collaboration is especially acute in oil & gas industry, where techniques such as immersive virtual environments with large display walls, stereographics projection systems, videoconference tools and auditory display systems are pushing the limits of teamwork activities.

In this paper we introduce a set of application requirements and define the system architecture of a Collaborative Engineering Environment (*CEE*), tailored for assisting the control and execution of large and complex industrial projects in oil & gas industry. The proposed *CEE* is composed by the integration of three different technologies of distributed group work: Workflow Management System (*WfMS)*, Multimedia Collaborative System (*MMCS)* and Collaborative Virtual Environments (*CVE*). It is intended to control the execution of engineering projects involving many geographically distributed teams. It also allows an easy integration of different applications providing the teamworkers with means of information exchange, aiming to reduce the barriers imposed by applications with limited or no collaboration support. This environment needs to be *extensible*, *flexible* and *platform-independent*, allowing a transparent flow of information among different teams and their models.

In the following section we present some aspects for our solution and discuss related works. Then, in section 3, we present the problem and the solution requirements. In section 4, the system architecture is discussed. Conclusions finish the paper.

2 RELATED WORK

Workflow Management Systems (*WfMS*) assist in the specification, modeling, and enactment of structured work process within organizations. These systems are a special type of collaboration

H. F. Santos I., Valle C., B. Raposo A. and Gattass M. (2004).
A MULTIMEDIA WORKFLOW-BASED COLLABORATIVE ENGINEERING ENVIRONMENT - Integrating an Adaptive Workflow System with a Multimedia Collaboration System and a Collaborative Virtual Environment for Petroleum Engineering.
In *Proceedings of the Sixth International Conference on Enterprise Information Systems*, pages 259-262
DOI: 10.5220/0002656702590262

technology which can be described as *"organizationally aware groupware"* [Ellis, 96]. According to the Workflow Management Coalition [WfMC, 95] there are different types of workflows, which suits different organizational problems. The type of workflow used in this work follows the definition of *"adaptive workflow"*. This kind of workflow enables the coordination of different types of exception, dynamic change problem and possibilities of late modelling and local adaptation of particular workflow instances. The support for managing partials workflows present in an "adaptive workflow" is very attractive for our purposes because processes in engineering domains have a very dynamic nature which means that they cannot be planned completely in advance and are under change during execution. Furthermore, in contrast to well-structured business processes, they are characterized by more cooperative forms of work whose concrete process steps cannot be prescribed.

MMCS such as Videoconferencing Systems (*VCS*), contain no knowledge of the work processes, and therefore are *not "organizationally aware"*. These systems are best suited for unstructured group activities once that audiovisual connectivity and shared documents enable flexible group processes. The drawback is that all coordination tasks are left to the conference participants. The combination of *MMCS* and *VCS* can support problems which cannot be well supported by each one of them isolated. Embedding synchronous teamwork as part of the workflow produces a complementary way of conducting project activities. Such integration would enable a continuous stream of tasks and activities in which fast, informal, ad-hoc, and direct actions can be taken through conferences within the workflow.

Collaborative Virtual Environments (*CVEs*) are a special case of Virtual Reality environment systems, where the emphasis is to provide distributed teams with a virtual space where they can meet as if face-to-face, co-exist and collaborate while sharing and manipulating in real-time the virtual artifact of interest [Goebbels, 03]. *CVEs* are becoming increasingly used due to a significant increase in cost-effective computer power, advances in networking technology, as well as database, computer graphics and display technologies. They have been used mainly by automotive and aircraft manufactures aiming to improve the overall product's quality and to reduce project's life cycle, cutting down costs and time to market new products.

The integration of *MMCS* systems into a *WfMS* is not new; [Weber, 97] proposed the integration of a *VC* tool into a *WfMS* in order to furnish a synchronous collaboration work. To allow the coordination of the conference by the *WfMS* he suggests the creation of new entity in the workflow model, called "*conference activity*". Another important aspect is the time dimension. Conferences that are already planned at the time of the creation of the workflow are called *pre-scheduled*, while an *ad-hoc conference* is the one that was not foreseeable at the time when the workflow model is specified. This implies that in the former case some of the steps can be formally prescribed in the *WfMS* providing a tighter control of the results and documents generated during the conference section by the workflow engine, while in the later the results of the section should be updated by the users in the system.

In the literature there are a lot of proposals concerning integration of a *WfMS* and other technologies. [Joeris, 97] proposes the combination with a *Document Management System (DMS)*. He suggests the creation of a new data-oriented perspective for the *WfMS*, centered on the documents and data produced during the execution of tasks, in order to improve the coordination and cooperation support for engineering processes. [Weske, 98] proposes the junction with a *Geographic Information System* to combine a data-oriented view with a process-oriented view aiming to support the complex cycle of process and data modeling in environmental-related geoprocessing applications. This integration is very suitable for our solution because many activities in Offshore Engineering require the use of geo-referenced data.

Sevy, [Sevy, 00] proposes the creation of a *CEE* called *Collaborative Design Studio* to enhance the design engineering process through the integration of a Computer-Aided Design and engineering tools (CAD/CAE), a *MMCS*, and archiving functions.

3 PROBLEM DEFINITION

In this work we will focus our attention to Offshore Engineering projects. The project of a new production unit is a very lengthy and expensive process. Usually projects involve not only geographically distributed teams but also teams of specialists in different areas using different software tools. The interoperability of those tools is still an issue in the industry and is a mandatory requisite for any viable collaborative solution.

Due to their huge complexity projects are divided into smaller interrelated subprojects where each one deals with an abstract representation of the others. To cope with the problems that usually happens to such a division, we propose the creation of an Agent-based Awareness mechanism to help users identify and solve conflicts. Another difficulty presented in those projects is that, although the specialists deal with the same artifacts (platforms, mooring systems, etc.) they usually have different data representations for those objects according to the needs of each application requiring from the solution some support for *multi-resolution representation of the data*. For example, in structural and naval engineering the models usually have dense polygonal meshes, with a few objects representing the outline of the artifacts, suitable for static and dynamic stability studies with numerical methods. In CAD/CAE the models usually have objects with coarse grid meshes suitable for good visual representation, but the problem is that all objects that comprise the artifact should be represented yielding huge models. For real time visualization those models are almost intractable and, even today, represents a great challenge for computer graphics.due

3.1 *CEE* Requirements

Based on previous works in the related areas and on an analysis of the domain of our scenario, we define a set of requirements for our *CEE*.

Communication support - *CEE* should provide different communication support possibilities: synchronous, asynchronous, and enabled in various media types. These supports should be provided in a seamless way, so that users can start a communication of one or of another type while they are interacting with the *CEE*, or they should be able to plan certain time for a specific communication interaction. The communication support should be integrated to the other tools in the *CEE* and provide means of recording conversation and retrieving old ones. This requirement helps user solve their project's problems in critical situation, with fast interaction and negotiation, and it allows the recovery of useful pieces of communication used to solve similar problems in the past.

Coordination support – at the project management level, multiple and different visions of the on-going project must be provided. Users have different background and need different types of information to execute their duties. Project management should also be feasible in a *CEE*.

Cooperation and flexibility support – there should be process model flexibility support, like dynamic change of process instances during run-time to support dynamically evolving processes, possibility of executing rollback of processes (reset, redo, undo, recover, ignore, etc) and reuse of process fragments. The cooperation support must provide different levels of data access: local and distributed, shared, public and private access, versioning control of engineering models and related data, concurrency control and synchronization. It is also necessary to provide support for different types of data interchange, concurrent work on shared copies, change propagation. Different types of visualization should also be available at the *CEE*, like real-time simulation and visualization of 3D models; walkthroughs in the managed models; object interaction and manipulation; edition and planning and lately, access to organizational work history.

Awareness – in our scenario the most important types of awareness are: *event monitoring* – to observe what is going on in all separate parts and provide active notification to the right person, at the right time and the right sub-system; *workspace awareness in the VE* – to provide control of collaborative interaction and changing of the user location; *mutual awareness* – to allow users see each other's identity and observe each other's actions; *group awareness* – to facilitate the perception of groups of interest connecting people who need to collaborate more intensely.

Integration Management Infrastructure – at this level, several services should be available in order to guarantee the data and modeling persistency, and the different levels of access control to different user roles in our scenario. Here we include the shared workspace and results service, access control service, user management service, data synchronization service and security service.

CVE specific requirements – high performance and *scalability* to support execution of large shared virtual worlds, which varies widely in size and number of participants, over long periods of time; *a persistence mechanism* to save and restore world state between activations; *version-safe* updating mechanisms, because large and long-lived virtual worlds tend to incorporate different versions of the same components; *composability*, so that one may easily and effectively combine worlds and world components developed by different organizations; *dynamic extensibility*, the architecture must permit the seamless run time extension and replacement of any part of its hosted application.

4 PROPOSED SOLUTION

Our *CEE* has component based architecture (Figure 1) to facilitate the reuse of elements. The architecture of the *CEE* uses a *WfMS* as its kernel while the *MMCS*, *CVE* and the other components are seamlessly accessed according to the collaborative necessities of the team workers.

The integration of the *WfMS* with other components is done in a seamless way through the Collaboration Bus (*CBus*) in a way that the user always interacts with the same interface independent of the environment he is currently using. This is a very important aspect of the solution to keep the user conscious of what he is doing and what should be the next steps of the current task being executed. The *CB*us represents the collaborative infrastructure provided by the CEE core functions to fulfill the requirements discussed throughout the paper. The *CVE* is being constructed on top of *Avango* [Tramberend, 99], an object-oriented framework for distributed VR applications.

All the consistency, adequacy and compatibility of the shared data among its users should be done by the kernel in conjunction with the *SDMS*, in order to avoid, or at least to diminish, non useful iterations during the project's life cycle. The ability of reusing partial workflows, which were previously stored in the system with some guidelines, will provide an optimized usage of the available computational resources and also a better control of the costs and the time scheduling. We use OpenORB to implement the architecture of the system with the following CORBA^{TM} services: *Persistence*, *Life Cycle*, *Trading, Event* e *Relationship* (Figure 2). The user interacts with the system through its GUI and from there the *WfMS* guides the execution accessing the other components accordingly.

In this architecture the requirements are fulfilled by different association of the components, Communication: *MMCS and Collaborative Support Service;* Coordination: *WfMS;* Cooperation: *WfMS, DMS, SDMS; Collaboration: CVE; Awareness: Agent-based Awareness Service.*

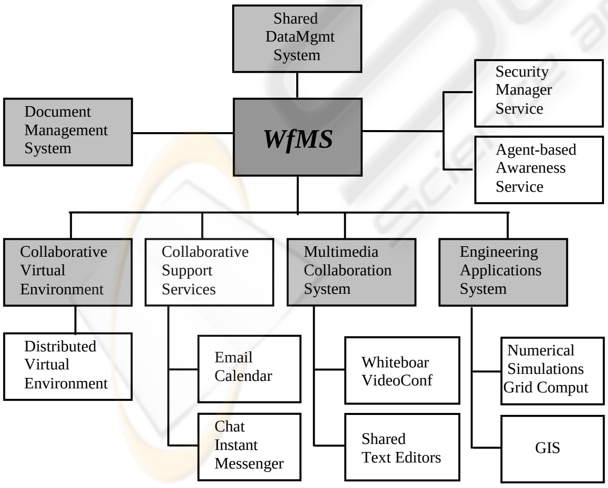

Figure 1: Components of the *CEE*.

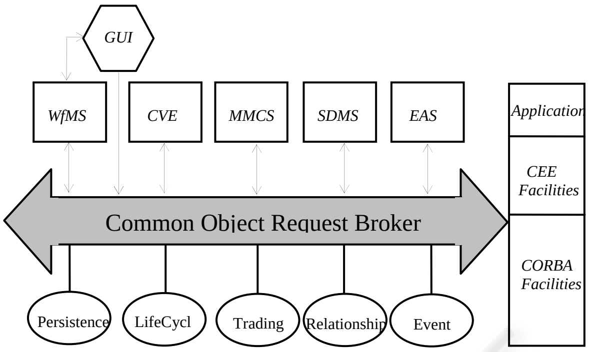

Figure 2: CORBA architecture of the *CEE*.

5 CONCLUSIONS

This paper presented a set of requirements and system architecture of the *CEE* that we are currently undertaking. As next steps of this work, we plan to continue refining the architecture of the *CEE*, and as a proof of concept we intend to develop a prototype that will be used at Petrobras and usability studies will follow afterwards. Through the use of the CEE we expect that users easily mitigate their problems during the execution of projects. We also intend to improve the effectiveness of the use of VR technology once that is now seamless integrated in the workflow of the team workers. Although this work is focused on a solution for Offshore Engineering projects, we believe that the *CEE* could also be used in other areas as well.

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