6
Conclusions and Future Work

6.1.
Conclusions

This thesis presented the conceptualization (the SOA architecture) and implementation of a CPSE we devised for OE projects. As a proof of concept we have developed CEE, a collaborative environment to optimize the execution of Large Engineering Projects such as Offshore Engineering projects developed at Petrobras. Through the use of the CEE we have build an effective collaborative environment that allow users to easily mitigate their problems that usually happen during the execution of large and complex engineering projects. We also believe that the goal of creating a user-friendly workflow system operating in a collaborative environment was achieved.

Upon the integration of VR technologies into the workflow of the teamworkers we expect to improve the use of VR in OE projects, which is unfortunately just used in very few areas of Petrobras nowadays. It is clear that visualization resources improve the quality of engineering projects as we have pointed out in Chapter 2, but users do not want to spend their time preparing the content to be visualized in other system, like an immersive multi-projection environment. In this concern CEE is already showing its value, upon simplifying the daily job of the engineers, from running simulations on a Grid through visualizing its results on an immersive environment or on a desktop. Now everything can be done through the *CEE Portal* just accessing a web page and sending commands to CEE server.

In addition, we argue that SOA offers E&P companies a number of compelling benefits. It allows organizations to be able to respond efficiently to changes in the business and competitive landscape, preservation of legacy system while enhancing integration, lower technology development costs by leveraging functions already built into legacy system services, by re-using services developed for other process, and by simplifying maintenance and support through elimination of redundant applications.

We believe that the main contribution of this thesis is the junction of approaches and technologies from different areas composing a CPSE suitable for LSEP (more specifically, OE projects), with distinguishable characteristics, when compared to similar systems as was pointed out at the end of Chapter 2.

From the OE point of view, the introduction of a Scientific Workflow in the project life cycle and the use of a CPSE are important contributions in the sense of providing a more structured way to solve the problems and the creation of tools more widely used.

From the VR and Visualization point of view, CEE approach treats them as first class tools, exploring their potential for facilitating information exchange and common understanding of complex problems. It was not possible to find any other approach complete as presented here in the academic literature or in any oil & gas company in the world.

The perspectives for the future is that many other organizations are going to start to use Scientific Workflows and this will become a common solution in high complex enterprises that have several areas that must be integrated and synchronized.

Although this work is focused on a solution for Offshore Engineering projects, we believe that the proposed CEE could also be used in other areas. There are many important Petroleum Engineering activities ([SCL+01], [RRF+04]) that would benefit with the implementation of the CEE as defined in this thesis, such as:

- Collaborative real-time visualization, walkthrough and fly-over offshore facilities modeled with massive CAD models;
- Project of ultra-deep water riser and mooring systems;
- Oceanographic model visualization;
- Stability analysis of oil platforms;
- Controlling and monitoring of the construction process of large production units. Estimation of the progress based on the differences between the captured 3D “as-built” model and the "as-planned";
- Design, planning and optimization of marine installations and sub-sea layout arrangement of production equipments;
- Simulation and evaluation of the performance of remote teleoperations and interventions on submarine equipments in deep waters;

- Change Management Planning Systems - execution of interference and visibility checks to elaborate maintenance and inspection plans for production units;
- Planning oil pipeline installation and monitoring;
- Training and safety simulations applied to emergency scenarios;
- Integrated Oil Reservoir Management;
- Immersive Well-path planning and Geosteering;

6.2.
Future Work

There are a lot of important future works that could be developed in many directions. Considering the CEE SOA architecture and its components we can propose future works for each environment of CEE, the *Project Management Environment,* the *Scientific Workflow Environment* and the *Collaborative Visualization Environment*. The following subsections present the current main ideas.

6.2.1.
Project Workflow Environment

For this environment we mainly suggest as future works the topics that we have not addressed in this thesis for this environment.

- *Introduction of Project Management System with an Integrated Data Management System tor control all documents and artifacts generated during the project lifecycle ;*
- *Close and functional integration with ERP systems, like SAP, providing better accountability of resources when executing engineering simulations;*

6.2.2.
Scientific Workflow Environment

For this environment we mainly suggest as future works the topics that we have not addressed in this thesis, which are Data Provenance and Ontology.

- *Implementation of the Open Provenance Model [OPM] for BPEL workflows;*

- *Usage of an Ontology inference engine to help the creation of new workflows in the context of Offshore Engineering;*
- *Support for data replication. once CEE supposes that the data is already replicated or centralized there is no mechanism for data distribution in CEE;*

6.2.3. Collaborative Visualization Environment

In the visualization area, there are also many additional resources that may be addressed in the context of CEE, such as:

- *Multimedia Communication System with a more powerful tools, such as instant messages, better audio / video tools, etc;*
- *Agent Based system for improving collaboration among users during a collaborative visualization session;*

We believe that CEE is a step towards a new frontier in CPSE, which is the use of a computation steering approach in tele-immersive CPSE (Figure 2.1).

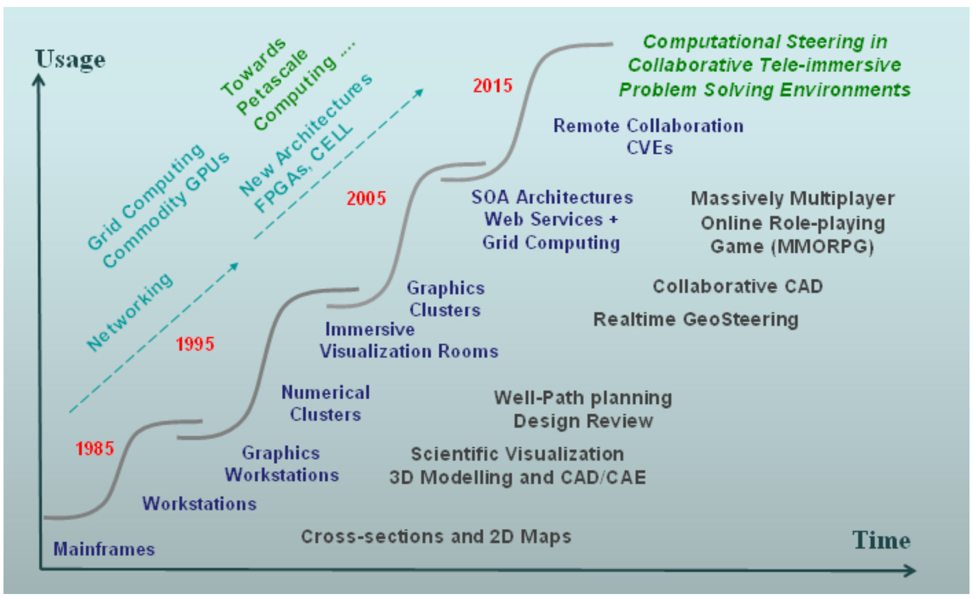

Figure 6.1: Towards tele-imersive CPSEs.

Following this line of thought, two additional lines of research can be envisioned for CEE:

- *Implementation of Computational Steering approach*

Computational steering is the practice of manually intervening with an otherwise autonomous computational process, to change its outcome. Abstractly, we can think of it as an API for Interactive Application Control, furnishing interesting tools for data exploration visualization such as:

- Modify Parameters While (Long) Running – helps to eliminate wasteful cycles of ill-posed simulation. Drive simulation to more interesting solutions; enhance convergence of Numerical Algorithms;
- Allows “What If” Explorations – closes loop of standard simulation cycle. explore non-physical effect;

The steering approach is a very valuable feature for any CPSE for Science and Engineering.

- *Tele-immersive CPSE*

Tele-immersion is a technology that will enable users in different geographic locations to come together in a simulated environment to interact. Users will feel like they are actually looking, talking, and meeting with each other face-to-face in the same room. This kind of environment will improve collaborative work, which is essential for a CPSE like the proposed CEE in this thesis.

In the oil & gas industry projects for building inhabited production plants would have a great benefit for such a tele-immersive CPSE.