EUFORIA — Simulation Environment for ITER Fusion Research

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1 Introduction

A typical procedure in science can be described as follows: After preparing the theoretical and fundamental scientific work, scientific experiments to strengthen the new ideas are modeled, designed and parameterized at the computer. A virtual control room mimicking a real control room of real experiments serves as a user interface, manages all interactions of the scientist with the (virtual) experiments and visualizes the results graphically. After simulation success the real experiment can be built up, if still necessary, to produce (real) results. This procedure is generally advisable for nearly all physics experiments and indispensable for large experiments with high complexities and costs.

In reality this "optimum" procedure is inhibited by several problems: Modeling and simulation environments are insufficient or hard to operate, and resources are not available and expensive.

ITER is the next generation of fusion devices and is intended to demonstrate the scientific and technical feasibility of fusion as a sustainable energy source for the future. In the fusion scientific community detailed modeling codes exist to simulate different properties of plasma physics (e.g. plasma core and edge transport in interaction with material surfaces and geometries) at different timescales, but they are computationally complex, hard to operate and not well interfaced to explore complex relationships interactively.

2 Aims of the EUFORIA project

The EUFORIA [1] project aims to improve the situation for the ITER fusion reactor [2] in a number of ways such as setting up a framework to access the simulations easily, increasing the performance of existing codes and enabling a subset of the existing codes for use on computational Grids [3] and high performance computers (HPC). A novel aspect is the dynamic coupling of codes and applications running on a set of heterogeneous platforms. They have to be integrated into a single coupled framework through a workflow engine. This strongly enhances the integrated modeling capabilities of fusion plasmas and will at the same time provide new computing infrastructure and tools to the fusion community in general.

A selection of codes describing the different physics elements needed will be adapted to and optimized for different computational infrastructures as required by the different physics descriptions and numerical implementations.

The project is structured as following: Networking Activities are responsible for management, user documentation and training and dissemination. Service Activities de-

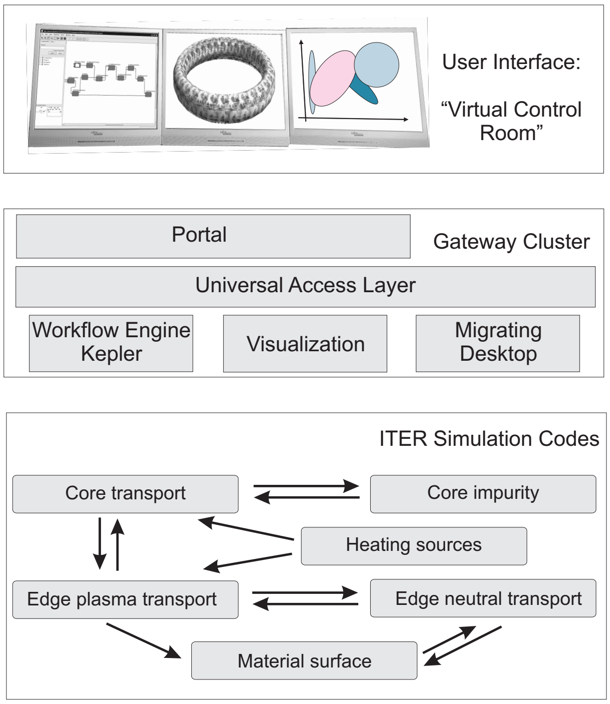

Figure 1. Euforia architecture: The virtual control room (top) provides the user interface to control the workflows and parameters of the simulations and to visualize the results. The intermediate gateway cluster (middle) consists of the workflow engine Kepler [6] with predefined simulation workflows and visualizations, the Universal Access Layer [7] to access the data structures and databases, the Migrating Desktop [8] to access Grid computing infrastructures and a user portal. The general workflow (bottom) describes the interactions between the different ITER simulation codes running on Grid and HPC infrastructures.

ploy and operate the Grid and HPC infrastructure and the user support. Joint Research activities adapt the fusion codes and tools for the Grid and HPC infrastructure and provide tools for workflow orchestration and visualization of the results.

3 Challenges

One of the core challenges is the adaption of codes to the different computing infrastructures and their optimization. Several codes have been identified [1] to be adapted to serial and parallel Grid computing environments based on the int.eu.grid [4] infrastructure running on gLite [5] and on HPC computing environments.

The codes are written in C and Fortran 77/90/95 and are partly engineered by physicists concentrating more on the physics than on the software engineering resulting in complex programs which are sometimes hard to analyze and to optimize. Close cooperations with the code–owners are indispensable to successfully adapt the codes.

Some codes requiring fast communication between computer processors are more suited to HPC infrastructures with massively parallel supercomputers to work efficiently, others requiring less or even no communication (e.g. for parameter sweeps) are more suited for Grid computing. The decisions which code will run on which infrastructure will be made after careful analysis.

The future plasma physics computations will involve mixed problems with the combination of Grids and HPCs. This EUFORIA project will provide the fundamental technologies to improve the results and to make them easier to use.

4 Acknowledgements

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