Chapter 11

DISTRIBUTED AND OBJECT-ORIENTED COMPUTATIONAL ELECTROMAGNETICS ON THE GRID

D. Caromel\textsuperscript{1}, F. Huet\textsuperscript{1}, S. Lanteri\textsuperscript{2} and N. Parlavantzas\textsuperscript{1,*}
\textsuperscript{1}INRIA-I3S-CNRS, project-team Oasis, 2004 route des Lucioles, BP 93, 06902 Sophia Antipolis Cedex, France; \textsuperscript{2}INRIA, project-team CAIMAN, 2004 route des Lucioles, BP 93, 06902 Sophia Antipolis Cedex, France

Abstract: Grids raise new challenges for programming, composing, and deploying numerical applications. Heterogeneity, medium to high latency, various underlying systems and protocols call for new paradigms and techniques. Within this framework, the development of high performance numerical methods for the solution of systems of PDEs (Partial Differential Equations), must integrate these factors, representing both new difficulties and new opportunities. In this chapter, we describe an open source middleware for the Grid, ProActive, featuring distributed objects and components. Using ProActive, we demonstrate how to design and implement an object-oriented (OO) time domain finite volume solver on unstructured meshes for the 3D Maxwell’s equations modelling the propagation of electromagnetic waves. We also present some experimental results obtained on an experimental Grid, Grid’5000, running on more than 400 processors.

Key words: Grid Computing; PDEs; Finite Volume Solver.

1. INTRODUCTION

The availability of powerful computers and high-speed network technologies as low-cost commodity components is changing the way we use computers today. These technological opportunities have led to the

\textsuperscript{*} This work was carried out for the COREGRID IST project n° 004265 funded by the European Commission.

\textsuperscript{L. Turricone and A. Esposito (eds.), Advances in Information Technologies for Electromagnetics, 327–343. © 2006 Springer. Printed in the Netherlands.}
possibility of using distributed computing platforms as a single, unified resource, leading to what is popularly known as Grid computing. However this emerging grid computing concept also brings additional constraints on the development of large-scale distributed applications such as heterogeneity (both in terms of CPUs and interconnection networks) and multi-localization. We present here the results of a collaborative effort between computer scientists and applied mathematicians towards the use of modern programming languages and libraries (Java and ProActive\textsuperscript{7}) for the design and implementation of an object-oriented time domain finite volume solver on unstructured tetrahedral meshes for the 3D Maxwell’s equations modelling the propagation of electromagnetic waves.

Section 2 presents the main characteristics of the ProActive library and in particular, the object-oriented group communication paradigm. Section 3 is dedicated to the description of the object-oriented distributed solver at the heart of this study. Section 4 presents performance results for various experimental test beds, including Grid'5000\textsuperscript{8}. Finally, section 5 discusses ongoing and future work, and section 6 concludes the chapter.

2. DISTRIBUTED OBJECTS: PROACTIVE

ProActive is a Java middleware for parallel, concurrent and distributed programming which features high level services as weak migration, group communication, security, deployment and components. As ProActive is built on top of the Java standard API, it does not require any modification to the standard Java execution environment, nor does it make use of a special compiler, pre-processor or modified virtual machine.

2.1 Basic Model

A distributed or concurrent application built using ProActive is composed of a number of medium-grained entities called active objects. Each active object has one distinguished element, the root, which is the only entry point to the active object. Each active object has its own thread of control and is granted the ability to decide in which order to serve the incoming method calls that are automatically stored in a queue of pending requests. Method calls sent to active objects are asynchronous with

\textsuperscript{7} ProActive is available in LGPL at http://ProActive.ObjectWeb.org.

\textsuperscript{8} The Grid'5000 initiative is described at http://www.grid5000.org.