Chapter XVI
A Grid Aware Large-Scale Agent-Based Simulation System

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ABSTRACT

The emergence of Grid technologies provide exciting new opportunities for large scale simulation over Internet, enabling collaboration and the use of distributed computing resources, while also facilitating access to geographically distributed data sets. This chapter presents HLA_Grid_RePast, a middleware platform for executing large scale collaborating RePast agent-based models on the Grid. The chapter also provides performance results and analysis on Quality of Service from a deployment of the system between UK and Singapore.

INTRODUCTION

The last decade has witnessed an explosion of interest in distributed modelling and simulation techniques, not only for speeding up simulations but also as a strategic technology for linking simulation components of various types (e.g., discrete or continuous, numerical or discrete event, etc.) at multiple locations to create a common virtual environment (e.g., battlefields, virtual factories and supply chains, agent-based systems, games etc). The culmination of this activity, which originated in military applications where battle scenarios were formed by connecting geographically distributed simulators via protocols such as DIS (DIS Steering Committee, 1994), has been the advent of the High Level Architecture (HLA), a framework for simulator interoperability (Dahmann, 1998). The HLA for modelling and simulation was developed as an IEEE standard to facilitate interoperability among simulations and promote reuse of simulation models. Using the HLA and the associated executable middleware, namely Run Time Infrastructure (RTI), a large-scale simulation can be constructed by linking together a number of simulation components (or federates) distributed geographically into an overall simulation (or federation).
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Such simulation systems often require huge computing resources and the data sets required by the simulation may also be geographically distributed. For example, in a supply chain simulation involving different companies, the most up-to-date data will be in the individual companies. Furthermore, the development of such complex simulation applications usually requires collaborative effort from researchers with different domain knowledge and expertise, possibly at different locations. A typical example is simulations of systems biology, which are extremely challenging in requiring the modelling of many complex phenomena at multiple spatial and temporal scales (Lees, 2007).

In order to support collaborative model development and to cater for the increasing complexity of such systems, it is necessary to harness distributed resources over the Internet. The emergence of Grid technologies provides an unrivalled opportunity for large-scale distributed simulation. While HLA enables the construction of large-scale distributed simulations using existing and possibly distributed simulation components, Grid technologies enable collaboration and provide mechanisms for the management of distributed computing resources where the simulation is being executed, while also facilitating access to geographically distributed data sets.

In the last few years, there has been an increasing interest in taking advantage of Grid technologies to execute HLA simulations over the Internet. Contributing to this global effort, this chapter presents HLA_Grid_RePast, a prototype platform for executing large-scale agent-based distributed simulations on a Grid.

HLA_Grid_RePast integrates two different middleware systems. At the bottom end, lies HLA_Grid, which has been developed as a middleware to support HLA simulations on the Grid (Xie, 2005); at the top sits HLA_RePast, which can support the execution of multiple interacting instances of RePast agent-based models within the HLA (Minson, 2004). The RePast system (Collier, 2007) is a Java-based toolkit for the development of lightweight agents and agent models. It has become a popular and influential toolkit, providing the development platform for several large multi-agent simulation experiments, particularly in the field of social phenomena. RePast has been assessed by (Railsback, 2006; Tobias, 2004) as the most effective development platform currently available for large-scale simulations of social phenomena. HLA_Grid_RePast allows large scale RePast simulation systems to benefit from the advantages of both HLA and Grid technologies.

The rest of this chapter is organized as follows: Section 2 summarises related work. Section 3 introduces HLA and provides a short summary of the two existing constituent systems, namely HLA_Grid and HLA_RePast. Section 4 presents the architecture of HLA_Grid_RePast and outlines the steps required for the deployment and execution of HLA_Grid_RePast systems on the Grid. Section 5 presents a quantitative performance evaluation of the system. Section 6 discusses future research directions based on this study. Finally, section 7 concludes this chapter and provides some ideas to further improve the system’s performance.

RELATED WORK

Recent years have witnessed an increasing interest in taking advantage of Grid technologies to execute distributed simulations over the Internet. This section outlines some representative work along this research direction.

An influential initiative in this area is the Extensible Modelling & Simulation Framework (XMSF, http://www.movesinstitute.org/xmsf/xmsf.html). XMSF makes use of Web-based technologies, applied
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