The edutain@grid Project*

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Abstract. edutain@grid is an exciting and ground breaking new project making use of Grid technology. The project will identify and define a new class of applications that are highly significant for Grid computing but have not been studied in the past, which we characterise as Real-Time Online Interactive Applications (ROIA). The distinctive features that make ROIA unique include large user concurrency to a single application instance, ad-hoc connections, competition-oriented Virtual Organisations, real-time interactive response, dynamically changing control and data application flows whilst maintaining high Quality of Service (QoS), user friendly security, and novel Business-to-Consumer market models. In order to meet these challenges, the project team will develop a new middleware layer that will allow ROIA to exploit Grid computing and validate the system using two pilot applications from online gaming and e-learning domains.

Keywords: Business models, E-learning, Grid computing, Online games, Quality of Service, Real-time Online Interactive Applications, Service Level Agreement, Scalability.

1 Introduction

For some years, Grid computing [1] has been successful in certain academic research disciplines, allowing researchers to share their computational resources or

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data to achieve an agreed research goal that none could pursue on their own. In industry, Grid computing has also been partially successful to improve time to market through rapid deployment of resources for new projects in areas such as pharmaceutical industries and risk analysis of financial services. However, Grid technology has yet to make an economic or societal impact similar to that achieved in the last 15 years by Web technologies. There are many reasons for this, including the lack of convergence of underlying specifications, the economic cost of porting applications, the inaccessibility of Grids from a usability perspective, especially with respect to Grid and Virtual Organisation security models, the high economic cost and static nature of Grid deployments and operation, the limited support for guaranteed performance, scalability, failover and recovery, or the lack of support for business models that provide an attractive balance of risks and rewards for both providers and consumers of services.

Possibly the most important (but rarely mentioned) reason for the slow pace of progress compared with Web technologies is the lack of any obvious "killer" applications for the Grid. In this project, we identify and define a new class of applications that are highly significant for Grid computing but have not been studied in the past, which we characterise as *Real-Time Online Interactive Applications (ROIA)*.

We classify ROIA as a new class of Grid applications with the following distinctive features that makes them unique in comparison to traditional parameter study or scientific workflows, highly studied by previous Grid research [2]:

- The applications often support a very large number of users connecting to a single application instance;
- The users sharing an application interact as a community, but they have different goals and may compete (or even try to cheat) as well as cooperate with each other;
- Users connect to applications in an ad-hoc manner, at times of their choosing, and often anonymously or with different pseudonyms;
- The applications mediate and respond to real-time user interactions, and typically involve a very high level of user interactivity;
- The applications are highly distributed and highly dynamic, able to change control and data flows to cope with changing loads and levels of user interaction;
- The applications must deliver and maintain certain QoS parameters related to the user interactivity even in the presence of faults.

The distinctive features that make ROIA unique include large user concurrency to a single application instance, ad-hoc connections, competition-oriented Virtual Organisations, real-time interactive response, dynamically changing control and data application flows whilst maintaining high QoS, user friendly security, and novel Business-to-Consumer market models. In order to overcome these challenges, the project team will develop a new middleware layer that will allow ROIA to exploit Grid computing and validate the system using two pilot applications from online gaming and e-learning domains.

2 Objectives

Grid technology still does not provide good support for all key features required by ROIA. The performance overheads of current Grid protocols and logically centralised resource management act against real-time interactivity, for example. Traditional Grids also do not provide good support for sharing application instances among communities of users with different (possibly conflicting) goals from each other or from resource providers. The edutain@grid project therefore seeks to overcome these barriers and implement Grid-based ROIA by having the following key scientific and technical objectives:

- To define ROIA as a new class of socially important applications and provide complete Grid support for their key features through well-chosen sample applications;
- To provide a QoS-enabled middleware for negotiation of Service Level Agreements (SLA) and ROIA provisioning that copes with dynamic Grid and highly populated user environments;
- To develop mechanisms that provide the necessary real-time performance, scalability, manageability, and QoS;
- To devise business models that make the provision of large-scale ROIA economically viable;
- To make the Grid accessible to large numbers of users of such applications by overcoming usability barriers including those associated with Grid security;
- To make the resulting technology cost-effective for application developers;
- To disseminate and promote exploitation and take-up of the technological results.

3 Pilot Applications

We consider many different classes of applications to be ROIA, like online games, online e-learning environments, training simulations, or synchronous collaborative work environments (engineering and science). The sample applications chosen to validate the scientific and technological developments are in multi-player online gaming and e-learning. By targeting these socially important sectors (education and entertainment), edutain@grid seeks to accelerate the emergence of killer Grid applications and promote accelerated take-up of the technology by European business and society.

ROIA are characterised by the tight immersive coupling of users to the application, the high rate of interactions between users and the frequent state computation and communication participating computers over the Internet. In some very responsive action computer games, the distributed processes exchange new application information at a very high rate of up to 35 updates per second. Users immediately notice a delay in this distributed computation and communication as a "lag" in the interactive flow and their immersion is abruptly disturbed. Because of this tight coupling of distributed processes, current ROIA run in a static way and do not allow dynamical adding, removing or migrating of the used resources.

Similarly the benefits to the e-learning community are expected to be significant where large numbers of geographically disparate students can interact with instructors making use of large operational data sets. In particular this will be relevant to online simulations in scientific modelling applications used in the energy, defence, transport and legal market sectors. Furthermore, edutain@grid is expected to attract new developers and development ideas that were not previously possible or simply cost prohibitive. One metric of the project being the generic support for ROIA, edutain@grid system will not be limited to the two domains of pilot applications. However, both online games and e-learning domain represent large classes of applications: online games as covered by edutain@grid refer to first person shooter games, action and adventure games and the game pilot application will only explore one of those. We will examine multiple scenarios by varying number of users and sessions, thus exploring in depth the nature of these applications and will provide tools and product open enough to support a wide variety of application domains, thus verifying the generality of edutain@grid.

4 Products

The outcome of the project will comprise the following elements:

- *A business infrastructure* supporting business models that make the provision of large-scale ROIA economically viable;
- *A management infrastructure* which handles the dynamic execution of ROIAs on the Grid with support for advanced configuration management;
- *A runtime framework* [3] which enables scalability and advanced Grid functionality within real-time applications.

These three elements address specific needs of the different user classes and their respective key challenges.

4.1 Client Products

The project will produce a so called client manager, providing a light-weight secure client application for distributing and installation a ROIA client application (application discovery, automatic installation and update), managing customer accounts (billing and personal information) and implementing basic community features (friends list, voice chat, user invitation).

4.2 Runtime Products

A runtime framework enables application developers to scale their application by distributing it among different hosts and to incorporate and support the advanced Grid functionality provided by the management infrastructure. Two components will be available to them:

- *Real-time framework* [3] is a middleware that provides scalable network communication within Grid systems and sophisticated mechanisms that enable ROIAs to be automatically distributed across multiple servers;

– *Portal* is a scalable request service enabling retrieval of user and session-related information, accessible either with the ROIA client manager or a Web browser.

4.3 Resource Management Products

At the resource management layer, edutain@grid will devise advanced services for automated resource allocation, monitoring, and predicted planning [4] tuned to the requirements of the highly dynamic ROIA. More precisely, the project will have the following outcomes:

– *Resource allocation service* deciding how to map business-oriented requirements to a local resource management policy at a Hoster site. Additionally, this service will aim to facilitate deployment, installation, and update of ROIA servers;
– *Resource monitoring and fault tolerance services* checking the health and availability of resources and detecting potential SLA violations;
– *Capacity management services* predicting future capacity to steer the negotiation strategy for new SLA;
– *Policy management services* maintaining security policies, enabling access rights, and enforcing restrictions for other actors consistent within the terms of existing SLA.

The services in the management layer will act as intermediaries between the business actors and the real-time layer and will enable the protocols for SLA negotiation and steering upon SLA violation.

4.4 Business Products

From the business point of view, edutain@grid will develop services that support economically viable business models, based on a balance of risks and rewards that is attractive to all participants, and supported by security mechanisms and trust models that are cost-effective as well as efficient [5]. The following components will be developed as products:

– *Market service* to support Market Broker operation, allowing offers from Hosters or application/content providers to be matched with requirements from Distributors - this will be a Web service implementation of standard auction models common in the agents community;
– *SLA negotiation services*, allowing the details of an SLA to be agreed with a Hoster – e.g. terms for handling faults or SLA violations, the provision of operational data;
– *User registration services* to support the operation of the ROIA session Coordinator, including business management of the Customer relationship, and access to security token services once business trust in the Customer is established;

– *Accounting services* supporting business-level accounting and micro-payment aggregation, in all the main service providers (Market Broker, Coordinator, Distributor and Hoster), enabling the creation, transfer and aggregation of usage and billing information by other actors.

As a whole, the edutain@grid platform will provide security features allowing cost-effective security, based on business trust relationships negotiated in the business layer, to be propagated across the management and real-time layers. The business layer will therefore support lightweight security procedures based on business trust decisions (e.g. customer credit checks), and capable of supporting pseudonymity and high levels of usability. These will be implemented using conventional WS-Trust services issuing SAML or X.509 security tokens.

5 Conclusions

The edutain@grid framework will offer to end-users unprecedented freedom of action, entertainment, adventure, training, etc. in a virtual world of unique dimensions on top of scalable and dynamic use of compute Grid resources. Facilitating rapid uptake of edutain@grid, the technology will be designed to be generic, scalable, and secure in nature. This will be achieved by providing sophisticated Grid middleware services, distributed real-time computation, and easy to configure user portals. The objective will be to allow both established Grid users and new applications developers to make use of this new technology at minimal cost. At present this has not been achieved in the market place and therefore has the potential to stimulate a whole new community of developers, service providers and end-users.

Within the edutain@grid project two demonstrator applications will be developed and validated including an on-line multi-player game and a multi-user e-learning application in search and rescue (natural environment). The project shall seek to meet the broader market needs through two user groups that will help define the requirements. Membership will be selected from a range of organisations that represent key potential user groups.

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