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Grid-based platform for disaster response plan simulation over Internet ☆

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Abstract

Efficient emergency response for disasters need systematic response preparedness and plan. Distributed computer simulation drilling can help to perfect the disaster response plan. Since the disaster response simulation drilling participants are geographically distributed and subjected to different organizations, they need to communicate via the Internet. The HLA-based distributed simulation has been widely used, but presently it is difficult to implement a HLA-based distributed simulation application that needs resources from multi-organizations or communicates on the public Internet environment. The advantages of computational Grid in distributed resources collaboration and management provide a new development opportunity for distributed simulation. In this paper, a distributed simulation framework which realizes extending HLA/RTI to Internet based on Grid service is proposed. The framework aims to the advantage of Grid technology as well as the reusability and interoperability of simulation modules. The results of experiments of the prototype indicate the feasibility of the framework, which provide a platform for disaster emergency response drilling distributed simulation over Internet. At the end of paper, the future development plan has been discussed.

Keywords: Disaster response plan; Distributed simulation; Grid service; HLA; WS-Notification

1. Introduction

Disasters are broadly defined as emergencies of severity and magnitude resulting in deaths, injuries, illness, and or property damage that cannot be effectively managed by the application of routine procedures or resources [1]. Disasters such as floods, earthquakes, and outbreak of epidemics pose a greater risk to populations [2,3]. Efficient emergency response for both natural and man-made disasters can reduce the damage and

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casualties. Thus, it is important for emergency planners to take a broad approach to disaster preparedness and plan for the consequences from disasters [5,6]. However, the response plan is typically composed by the idea of diverse stakeholders and subject matter experts and it should be evaluated and revised through practical drilling repeatedly to be optimized. Computer modeling and simulation can help to ensure that the planning and evaluation process is systematic, logical, and complete in a low cost, risk-free setting.

Disaster preparedness planning operates in a convoluted, confused, and fragmented environment. It involves a variety of governmental and non-governmental agencies, including fire, emergency medical services, hospitals, police, and public health, with overlapping jurisdictions and competing agendas and interests [4–6]. These agencies, which involved in simulations of Disasters response, are commonly geographically distributed and subjected to different organizations. Since their private computer networks need not exchange large data, special net lines are seldom constructed. Therefore, the public Internet is the appropriate way if they are managed to interconnect to set up a distributed computer simulation.

Currently in most research projects of disaster emergency response simulation & practice, for convenient intercommunication between simulation model components of diverse agencies, they are centralized in a simulation center. However, since simulation drilling of disaster emergency response often refers human-computer interaction, it is inconvenient to assemble all related staff of multi-agencies every time when to organize a simulation drilling.

The High Level Architecture (HLA) is an IEEE standard for simulation and modeling and provides application developers with a powerful framework for distributed simulation reuse and interoperability. However, its design was not intended to support software applications that need to integrate instruments, displays, computational and information resources managed by diverse organizations [7]. In order to run a distributed simulation over the Wide-Area-Network (WAN) using the IEEE HLA/RTI directly, special arrangements have to be made beforehand to ensure the availabilities of the required hardware and software. Such arrangements are typically made with a centralized control or simply within an organization, because inter-organizational sharing of resources involves issues such as security [8].

The advent of computing Grid technology enables the use of distributed computing resources and facilitates the secure access of geographically distributed data. It provides an unrivalled opportunity for facilitating the large-scale distributed simulation.

The Open Grid Services Architecture (OGSA), developed by The Global Grid Forum, aims to define a common, standard, and open architecture for grid-based applications. Web services provide an approach to distributed computing with application resources provided over networks using standard technologies. It is based on a defined set of technologies, supported by open industry standards, that work together to facilitate interoperability among heterogeneous systems. Web Services Resource Framework (WSRF), a specification developed by OASIS, extends Web services to stateful services, which OGSA requires.

WS-Notification is a family of related specifications (including WS-BaseNotification, WS-BrokeredNotification, and WS-Topics) that define a standard Web services approach to notification using a topic-based publish/subscribe pattern and it had been approved to be OASIS standard in 2006. WS-BaseNotification defines the Web services interfaces for NotificationProducers and NotificationConsumers. WS-Topics defines a mechanism to organize and categorize items of interest for subscription known as "topics." WS-BrokeredNotification defines the Web services interface for the NotificationBroker. The Globus Toolkit 4.0 (GT4) is a software toolkit developed by The Globus Alliance. It is an implementation of OGSA and a sort of de facto standard for the Grid community. GT4 currently implements part of WS-Notification including effective topic-based notification [9].

In recent years, some remarkable research work focus on combining Grid Technology and HLA for simulations to take advantages of both. Katarzyna Zajac, etc. gave the idea of a three-level approach to building the Grid services for HLA-based applications. They also care about supporting execution of HLA distributed interactive simulations in a Grid environment and federate migration [7,10].

Stephen J. Turner, etc. propose a distributed simulation framework, called HLAGrid. The framework uses a Federate-Proxy-RTI architecture, which allows resources on the Grid to be utilized on demand by using Grid services. In HLAGrid, RTI services are exposed as Grid services and federates' RTIAmbassador call is translated to remote Grid service invocations. Correspondingly, federates' FederateAmbassador callback is also exposed as Grid services to be invoked by the RTI side [8]. Grid service invocation communicates