TOWARDS A GRID-BASED COLLABORATIVE PLATFORM FOR E-LEARNING

Wang GuiLing, Li YuShun, Yang ShengWen, Miao ChunYu, Xu Jun, Shi MeiLin
Computer Networking & CSCW Lab, Department of Computing Science & Technology, Tsinghua University

Keywords: Grid, CSCW, e-Learning, Web Services

Abstract: Large-scale cooperation support for learners becomes even more important, when e-Learning is implemented in scalable, open, dynamic and heterogeneous environment. This paper presents how to realize collaborative learning support in distributed learning environments based on grid technology. Our approach fills the existing gap between current cooperative platform and complex, cross-organization infrastructure. We propose the grid architecture for establishing collaborative platform for e-Learning, where grid middleware and *CSCW* services are provided. A Learning Assessment Grid, abbreviated as *LAGrid*, is built on top of these services and provides collaborative learning in large-scale cross-organization environment.

1 INTRODUCTION

It is still an unsolved problem in e-Learning research that supporting collaborative learning in scalable, open, dynamic and heterogeneous environment. The scenario is a large-scale connected environment of learning management systems, learning content management systems and virtual classroom systems of different organizations. Such an environment may support various services such as widely collaborative learning on top of kinds of collaborative tools, collaborative usage of learning resources, monitoring the learning activity of others, feedback and notification of learning activity etc. The target environment is scalable, by which we mean that infrastructure and services can be decoupled from their users and expanded on demand.

Grid Computing has its origins in wide-area distributed computing, and extends to a large-scale "flexible, secure, coordinated resource sharing among dynamic collections of individuals, institutions, and resources" (Foster, 2001). Modern grids also focus on scalability and openness. Therefore Web Services technologies are introduced and adopted. The implementation of *OGSA* (Foster, 2002) which is actually based on Web Services with specific extensions has combined grid computing and Web Services technology. Grids are typically implemented as a form of middleware which provides all grid-related services and can also use the Internet as a communication infrastructure (Atkinson, 2004).

Collaborative learning is taken as a fundamental and essential learning activity (Cowie, 1988). Application in which such activities are supported is perceived as "collaborative platform for e-Learning" in our view. *CSCW* technology is adopted to support collaborative learning, and it is more and more widely used such as in BSCW (http://bscw.gmd.de/bscw/bscw.cgi/) and ANTS (Lopez, 2001) recently. However, up to now, complex e-Learning applications which support large-scale, cross-organization and collaborative learning in an open, dynamic and heterogeneous environment have rarely been considered in the context of e-Learning or in *CSCW*, mainly due to technical feasibility problems or high costs. Now rapid evolution of grid computing gives us a chance to integrate the technology into collaborative platform for e-Learning.

As a result, in the *"Grid-based Collaborative Platform for e-Learning"* project, we are working on solutions for collaborative learning in grid environment in the context of cooperation work platform. We investigate both the impact of grid infrastructure on *CSCW* theory and technology and the requirement of *CSCW* application for grid infrastructure. In particular, we investigate how to make collaborative platform grid-enabled with grid

GuiLing W., YuShun L., ShengWen Y., ChunYu M., Jun X. and MeiLin S. (2005).
TOWARDS A GRID-BASED COLLABORATIVE PLATFORM FOR E-LEARNING.
In *Proceedings of the First International Conference on Web Information Systems and Technologies*, pages 510-517
DOI: 10.5220/0001227705100517

techniques employed in the infrastructure, especially methods and techniques developed for collaborative learning. In the first phase of this project, we developed "*Distance Learning Assessment Grid" (LAGrid)* for learning assessment which is a critical aspect in e-Learning.

In this paper we are to describe an approach of building a grid-based collaborative platform in distributed, dynamic and heterogeneous e-Learning environment. In particular, we will employ the Web Services and Services Oriented Architecture (SOA) technologies to build grid middleware, combine groupware technology with grid computing to develop generic *CSCW* services, and study a layered open architecture.

The organization of this paper is as follows: First, we motivate our work by a scenario of open e-Learning requirements. We propose the grid architecture for domain application which contains five layers: Infrastructure Layer, Basic Service Oriented Architecture Layer, Grid Middleware Layer, CSCW Layer and Domain Specific Services & Application Layer. The detailed functions of each layer are introduced in section 3. Section 4 shows the implementation mechanisms of the main components in Grid Middleware Layer, CSCW Layer and Learning Assessment Layer. The paper ends with conclusion and remarks on future work.

2 MOTIVATION SCENARIO

"*Grid-based Collaborative Platform for e-Learning*" aims to develop a scalable collaborative environment to meet the increasing requirement of national education by integrating the learning resources, software resources and educator resources from above 40 autonomous organizations in *China Central Radio & TV University (CRTVU)* (http://www.crtvu.edu.cn/) which are distributed in location or network.

Based on grid infrastructure, the platform can help educators work in collaboration more widely by controlling, sharing and employing resources in virtual organization which is composed of dynamic autonomous organizations, so they can provide better service quality for learners and more flexibility for the collaboration learning process compared with the independent system serving their own users.

Development of such a platform is motivated by a practical problem, which is to provide learning assessment services with collaboration for large-scale, dynamic learners and educators group.

In the first phase, we built "*Distance Learning Assessment Grid"(LAGrid)* targeting to solve the problems as follows:

To begin with, three basic grid problems should be resolved. The first one is its distribution. For resources in *CRTVU* are distributed in the country, *LAGrid* is a large-scale, distributed platform serving the whole nation's business process. The second one is the dynamic and openness. *CRTVU* is an organization serving learners not only from universities but also from companies or other organizations. The last one is the cross-organization problem. The platform should support the cross-organization collaborative business process. The connected resources are from different organizations, and the control flow and the data flow of business process both cross organization boundary. In a word, these three problems propose the important requirement for building scalable grid architecture.

Secondly, there are various collaboration patterns ranging from collaborative processes to discrete collaborative activities. The learning assessment task from different locations and organizations is transparent to teachers and learners. Users can customize a global monitoring view anytime. Learners can access the learning resources from various locations and organizations they need. At the same time they can attend group learning activities such as discussions or conferences. In addition, managers can expand the scale of platform, including the varieties of the business. These applications bring higher level requirements, so we should build a set of advanced services.

3 SOA-BASED ARCHITECTURE

We propose the architecture to meet the requirements of domain application as presented in figure 1. The architecture contains five layers from bottom to top. Firstly, at the lowest layer, the infrastructure layer supports basic networking environment, including computing devices, network and networking protocols etc. Secondly, the basic service oriented architecture layer supports the run time environment for implementing the basic web services related protocols such as HTTP(S)、XML/XMLS、UDDI/SOAP/WSDL、BPEL4WS、OWL-S etc. This layer provides the elementary connectivity, interoperation, reliability and flexibility for the layers on top of it. Thirdly, the grid middleware layer is the core of the architecture where the basic grid problems such as distribution, dynamic, openness and cross-organization are resolved. By using SOA technology, we can design

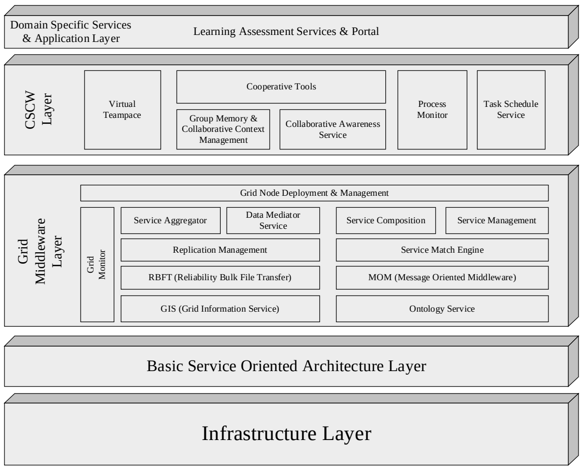

Figure 1: LAGrid Architecture

this layer when application functionality can be provided and consumed as sets of services. The CSCW layer is on top of grid middleware layer to provide collaborative work/learning services. Lastly, the domain specific service and application layer supports domain specific collaboration application. New collaborative interaction services can be published in the environment so that a customized domain cooperation platform can be built up.

For LAGrid, the top layer is learning assessment service and application including learning assessment task assignment, task submission, e-Portfolios etc. *LAGrid* emphasize the grid middleware layer and the CSCW layer. A brief introduction of them is as follows.

3.1 Grid Middleware Layer

This layer is a crucial layer to build a grid environment. To resolve the basic grid problems such as distribution, dynamic, openness and cross-organization, some relatively universal services should be developed to provide and consume the application functionality as sets of services. Though the services are somewhat domain related, they are universal to generic grid-based platform, and can be used in other grid-based platform for e-Government, e-Business etc. So we can categorize them as grid middleware layer. Message Oriented Middleware (MOM), Services Aggregator, Grid Information Services and Reliable Bulk File Transfer Services construct the essential components of this layer. The main functions of them are listed below:

As a new distribution communication paradigm, MOM, in particular its Publish/Subscribe event-driven messaging paradigm may gradually be more and more mature (MSMQ, 2000; Sun, 2004). MOM supports the function of awareness events routing, reliable transferring, and storing as the basis for collaborative awareness in *LAGrid*. It has the following functional features:

①The capability of message routing based on *LAGrid*'s organization ID; ② Support message unicast, multicast, and broadcast; ③ Provide the messaging reliability mechanisms; ④Implement events of publishing and subscribing functions by Web Services technology so that the components of MOM can be expanded flexibly.

Service Aggregator provides the function to aggregate many services as a new service so that the complexity of distribution, dynamic and heterogeneous of the services can be transparent to the users.

Grid Information Service (GIS) is a kind of directory service (Karl, 2001). We adopt a dynamic and scalable architecture for it. It has the following functional features:

① Describe information based on XML, implement Web Services standards; ② Support dynamic organization construction; ③Support the scalability of *LAGrid* and the consistency in deployment of grid runtime environment and maintenance of grid information; ④ Provide the function of discovery and registration of services; ⑤ Dynamically resolve message routing address for MOM.

We develop middleware services such as Service Management and Grid Monitor components in this layer for reliability, stability and maintainability of the platform. Grid Monitor is responsible for monitoring the runtime status of grid including the working status of grid middleware, invoking status of Web Services instances, running status of grid nodes etc. Service Management can support management of the change of the service binding address and the out of work of service.

Further in this layer we develop Ontology Service, Service Match Engine and Service Composition for the sake of new generation knowledge-intensive cooperation environment based on knowledge grid in the future (Cannataro, 2004). *LAGrid* makes use of Ontology Service to query and process the learning resources, services and cooperative context. Service Match Engine matches query conditions with services' description based on service ontology. Service Composition dynamically composes services and invokes them with different granularity. Thus the business process can be composed automatically.

Replica management service in grid middleware layer provides guarantee for better quality of resource sharing, which implements functions of transparent data transfer/copy, transparent copy selection in grid.

Grid Node Deployment & Management is another important component in this layer to support the flexible scalability of grid. For example, if new business organization joins in, a new grid node supporting it can be created and joins in *LAGrid*. If the business supported by a grid node expands, it can be migrated to a new grid node. New grid node integrates with original environment seamlessly in both cases. As a result, grid nodes in *LAGrid* can be expanded on users' demand and adaptive to scale of its business.

Now, a grid infrastructure is enacted, and it is supported by grid middleware and is scalable. Moreover, business service can be developed and deployed on demand.

3.2 CSCW Layer

The cooperation work environment is the important infrastructure built on the top of grid middleware.

In *LAGrid*, we mainly focus on the research of large-scale collaboration, which includes monitoring of cooperative process, scheduling of task in wide area. We also consider providing team-space for group of different sizes, where group members can work together with groupware tools and other business functions binding to the virtual workspace. These groupware can support various cooperative patterns for different cooperative tasks.

Collaborative Awareness Service provides the facility for naturally cooperation, and it is used in many scenarios in the cooperative environment (Ramduny, 1998). Cooperative interactive tools also provide communicative media in grid, and they are categorized to common interactive tools and domain-related cooperative tools.

Group Memory and Collaborative Context management are used for knowledge building in collaborative learning too (Prinz, 1993). Group Memory is used to capture knowledge or information within an organization and distribute it to the workers/learners who need it (Klemke, 2000), and context has been recognized by a wide range of researchers as being an important concept to consider in enhancing individual's access to organizational information. In *LAGrid*, they are used to enhance the awareness and sharing of cooperative information. For example, automatically deliver documents according to context, review or reference the learning process, assemble cooperative information about some person, place or task etc.

Monitoring Service monitors the whole collaborative process through a unified global view in a real-time and on-demand manner. The monitoring information concerns with various statuses of users such as numbers of learners who have or have not submitted their job, number of teachers who have completed their tasks.

Task Scheduling Service schedules resources on the grid nodes globally. For example, selects the available task and distributes it to users all around the platform. Thus the performance of the whole grid can be improved.

3.3 Learning Assessment Services & Portal

On one hand, Learning Assessment Layer creates the assessment environment in grid environment to provide the functions of creation, publishing, processing and feedback of assessment tasks. On the other hand, this layer makes it possible for sharing of learning resources.

LAGrid portal is the unified entry for all grid users. Users from different organizations who logon it could share learning resources without knowing where they come from.

4 IMPLEMENTATION

4.1 Grid Middleware Layer

4.1.1 Message-Oriented-Middleware (MOM)

MOM consists of three main modules as presented in Figure 2. The Core Module is composed of message sending and receiving web services. The Message Queue Management Module maintenances messages in and out. The Common Service Module is composed of message addressing service, message routing service, security service, protocol transforming service and application notifying service etc. Most of the functions are implemented as web services which can be invoked, published, discovered and composed. As a result, the flexibility of MOM can be enhanced by employing such SOA-based technology in MOM design, especially in message addressing and routing.

There are three modes of sending message which are uni-casting, multicasting and broadcasting. The message addressing of the three modes is through GIS, but their mechanisms are not the same. The message receiver for uni-casting is an organization's ID, but for broadcasting, it is a domain's ID which represents global domain or local domain. As for multicasting, the receiver is several IDs from different organizations or domains.

It is very important for MOM to guarantee the reliability of message. Therefore, multi-fold methods are used in *LAGrid* to support the reliability. Multi-message-queues are employed to tackle performance bottleneck. Error tolerance mechanisms are considered to avoid message losing due to application failure. Also message receipting mechanism is used to validate message receipt.

4.1.2 Grid Information Service (GIS)

Grid Information Service of *LAGrid* manages four kinds of grid entity metadata: metadata of grid nodes; metadata of organizations, domains and department; metadata of service interface and metadata of services.

Since relation model better meets the demands of the dynamic feature of grid environment (Dinda, 2000), it is used in GIS of *LAGrid*. We extend the organization, domain and grid node entity based on those defined in UDDI specification.

TModel structure is one of the most important data structures in UDDI (UDDI, 2002). It represents the category of entity with a unique global key value. To improve the query efficiency of GIS, more than ten tModels are created. These tModels can be divided into two categories, one of which represents the category tree of *LAGrid*, and the other represents the categories of service interface. There are three kinds of category tree in *LAGrid*: virtual organization tree representing the structure of virtual organization, organization tree representing organizations in *LAGrid* and message transmitting tree representing the logic structure of grid nodes catering for message transmitting. When new grid node joins in, the organization it belongs to should be given. GIS maps the organization onto the virtual organization tree and message transmitting tree. Based on the mapping information, grid nodes form different logic layered structures. The categories of service interface include message receiving service interface and tens of business-related service interface. Other new service interfaces can be further added dynamically.

Information publishing service, information discovering service, metadata schema service and information cache service are key services in GIS as presented in Figure 3. GIS has close relationship with MOM. Information changes of GIS on portal node are synchronized to cache of every grid node.

4.1.3 Service Aggregator

This component is implemented as a compound web service. It is designed according to a basic layered data model that consists of three layers such as data entity service layer, service aggregate layer and cross-organization aggregate layer. Encapsulation of data entity is completed in data entity service layer; Aggregation of services from common organization is completed in service aggregate layer; while aggregation of services from different organizations is completed in cross-organization aggregate layer.

When an aggregating request comes in, services are discovered and selected at run time invoking grid

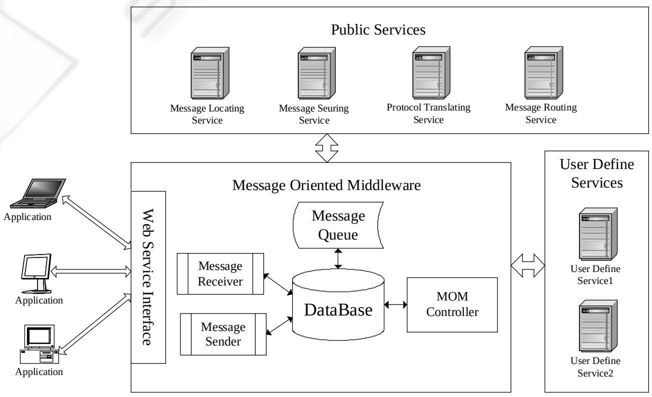

Figure 2: Architecture of MOM

information services. Then they are filtered based on aggregating policy. Before invoking it, service consumer negotiates security policy with the service providers using *LAGrid* security component. Then the request is distributed to service providers on different grid nodes. The instances of services are generated dynamically and are invoked in parallel. At the end of aggregating process, results returned from service providers would be transformed and aggregated.

In *LAGrid*, data sources such as learners' score, users' attachment in e-portfolio from different organizations need to collected real time. This brings more complexities in aggregating them. Figure 3 shows how GIS and Service Aggregator are used in aggregating such business data distributed in wide-area network environment.

4.2 CSCW Layer

CSCW layer of *LAGrid* provides collaborative awareness service, collaborative context service, monitor service, task scheduling service and so on, based on the grid middleware layer.

Collaborative awareness service consists of three parts, which are event generation component, event processing component and awareness mediation component.

Event generation component is to capture and publish related events. Events in *LAGrid* can be categorized into grid metadata synchronization events, grid maintenance events and business events. Upon update of grid nodes or services, synchronization events are generated. Grid maintenance events are caused by grid exception. Business events are triggered by time, users or some specific activity.

Event routing, transferring, and storing are implemented based on MOM. Event processing component on every grid node is an independent windows process. Those validated events can be presented at online message notification interface, or sent to email server or processed automatically by specific agent.

Awareness mediation component functions as an enhanced module to support personalized event subscription and redirection. Users of *LAGrid* can subscribe interested events and redirect the events to suitable event processing component. For example, teachers may subscribe exercise finishing event of specific student and get the notification by email.

Collaborative context service consists of two parts which are group memory service and context management service. Group memory service acts as a store of collaborative information relevant to a user performing a task in *LAGrid*. Context management service models the collaborative context from various dimensions and provides means of query/reasoning of collaborative context.

Collaborative context service is implemented based on Ontology Service, Service Match Engine of grid middleware. Metadata of collaborative tools such as server's port, task type supported, group size permitted etc. is encapsulated as collaborative service. Collaborative service publishing and discovering are implemented based on top-level collaborative ontology and collaborative service ontology model. Details will be discussed in the other papers.

Monitor Service is implemented based on Service Aggregator. Task status on every grid nodes is encapsulated as web service, and a unified monitoring view is generated based on Service Aggregator. Task Scheduling Service implements a global scheduling algorithm.

Email, online message tool are integrated in this layer and new interaction tools such as threaded

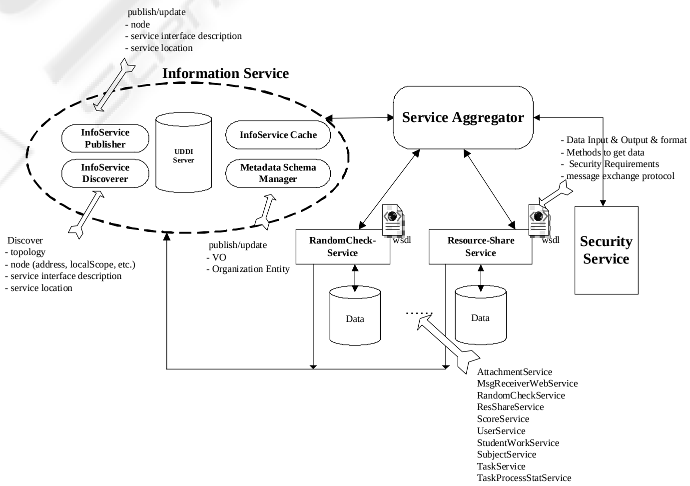

Figure 3: The Mechanism Scheme of Data Aggregating

discussion tools and whiteboard will be integrated in plug-and-play manner.

4.3 Learning Assessment Services & Portal

Learning Assessment Layer provides almost all functions in assessment task process on top of other layers. They are task creation, publishing, delivering, retrieving, submitting, and statistics etc. Figure 4 shows the main assessment actions *LAGrid* supports.

Sharing of assessment results and learning resources are implemented. The sharing process can be divided into three phases. In the phase of resources publishing, when resource providers publish resources, the metadata of resources are generated and encapsulated in a message. Then it is broadcasted on the whole system. In the phase of resources delivering, metadata of resources be subscribed are delivered through MOM. Service Aggregator of grid middleware is used in the phase of resources query.

In addition, various business messages notification and feedback are implemented based on Publish/Subscribe mechanisms.

Collaborative learning is also supported through team-space where various collaborative tools based on services provided by CSCW layer.

The Single Sign On (SSO) component implements *LAGrid* portal by providing grid user security, grid node security and web services security in an unified manner.

5 RELATED WORK

Large-scale cross-organization e-Learning environment is also investigated by some national projects. The *National Grid for Learning* (NGfL, http://www.ngfl.gov.uk) is a Government initiative to help learners and educators in the UK benefit from information and communications technology (ICT). *NGfL* collects many website links into a single portal by hyperlink. It is based on traditional web technologies rather than service-oriented architecture. *NGfL* integrates website links rather than data or function. Although learners and educators can access resources on different websites, data and processes of different organizations remain independent and can't be orchestrated efficiently. Some approaches such as *Access Grid* (http://www.accessgrid.org), which aims to support wide area, real-time, and computer-mediated communication in large-scale distributed conference and training, and *ELENA* (http://www.elena-project.org), which focuses on providing personalization, openness, and interoperability in the context of smart spaces for learning by using semantic web technology and adaptive learning management technology have different focus with *LAGrid*. *GECSR(Grid- Enabled Collaboratory for Scientific Research)* (GECSR, 2004), which aims at building new generation of global-scale collaboration infrastructure and focuses on integration of distributed collaborative tools, agent based monitoring and decision support system according to a proposal submitted to NSF, is somewhat similar to our work. However, further development progress and more detailed technologies have not been reported yet.

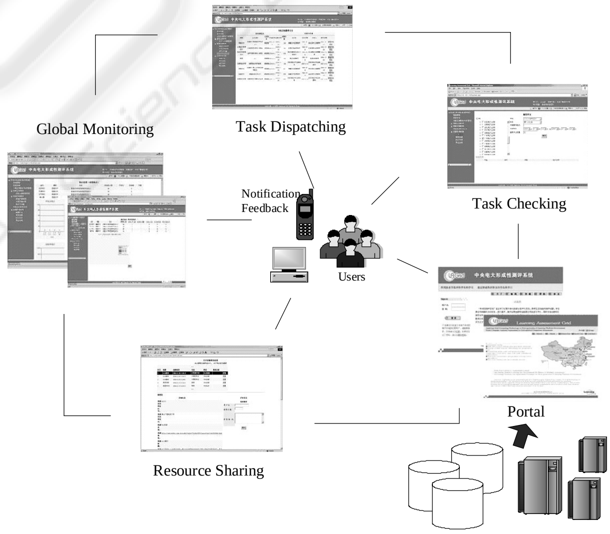

Figure 4: Learning Assessment Actions Supported by LAGrid

6 CONCLUSION AND FUTURE WORK

Grid-based collaborative environment architecture of domain oriented application is proposed based on research on combination of grid computing and *CSCW*. Grid middleware and *CSCW* services are developed which are MOM, GIS, Service Aggregator, Collaborative Awareness Service, Collaborative Context Service, Monitor Service and Task Scheduling Service etc. Collaborative process in distributed, dynamic, open, cross-organization environment is supported by those services. Furthermore advanced collaborative learning service can be developed for the learning assessment task in e-Learning. Therefore, our work fills the existing gap between current cooperative platform and complex, cross-organization infrastructure.

Services of *LAGrid* have been deployed in five cities (http://www.lagrid.cn) supporting assessment task of three courses for *CRTVU*. The next phase of the project "*Grid-based Collaborative Platform for e-Learning*" will aim to promote perfect development of grid middleware and *CSCW* services. More flexible *CSCW* services will be delivered together with the more robust and flexible grid middleware components. Various collaborative resources can be reused and composed according to context. Various cooperation-intensive groups in different sizes may coexist with each other orderly and may be evolved in a natural way.

ACKNOWLEDGEMENTS

Our project is supported by the National Natural Science Foundation of China under grant No. 90412009. The authors would like to acknowledge the other members of the *LAGrid* team for their contributions.

REFERENCES

GECSR, 2004, 'ITR: A Global Grid-Enabled Collaboratory for Scientific Research', <http://pcbunn.cacr.caltech.edu/Collaboratory/GECSR_Final.pdf>

M. Atkinson, D. DeRoure, A. Dunlop, 2004, 'Web Service Grid: An Evolutionary Approach'. UKeS-2004-05, TAG revised version, < http://www.omii.ac.uk/paper_web_service_grids.pdf>

H. Cowie and J. Ruddick, 1988. *Cooperative Group Work, an overview*, BP Educational Service, Sheffield University.

Lopez, P. G. & Molla, R. R., 2001. ANTS : a new Collaborative Learning Framework. *In EuroCSCL'2001, European Conference on Computer Supported Collaborative Learning.*

Foster, I., C. Kesselman, S. Tuecke., 2001. The Anatomy of the Grid : Enabling Scalable Virtual Organizations, In t. J. of Supercomputer Applications and High Performance Computing ,15(3) 2001,pp.200-222

Foster, I., C. Kesselman, J. Nick, S. Tuecke., 2002. The Physiology of the Grid: Open Grid Services Architecture for Distributed Systems Integration, In *Proc. 4th Global Grid Forum (GGF) Workshop 2002*, <http://www.globas.org/research/papers/ogsa.pdf>

Microsoft Message Queue (MSMQ) Center, 2000. <http://www.microsoft.com/windows2000/technologies/communications/msmq/default.asp>

Sun, Java Message Service Specification, 2004. <http://java.sun.com/products/jms/>

Karl Czajkowski, Steven Fitzgerald,Ian Foster,Carl Kesselman, 2001. Grid Information Services for Distributed Resource Sharing, Proc. 10th IEEE International Symposium on High-Performance Distributed Computing (HPDC-10), IEEE Press.

M. Cannataro and D. Talia, 2004. "Semantics and Knowledge Grids: Building the Next-Generation Grid," *IEEE Intelligent Systems*, vol. 19, pp. 56-63.

Ramduny, D., A. Dix and T. Rodden, 1998. Exploring the Design Space for Notification Servers", in *Proc. of CSCW'98 : ACM Conference on Computer Supported Cooperative Work*, Seatle, ACM Press, pp. 227-236.

Klemke, R., 2000. Context Framework - An Open Approach to Enhance Organisational Memory Systems with Context Modeling Techniques. In *Proceedings of the International Conference on Practical Aspects of Knowledge Management - PAKM 2000 (Oct. 30-31, Basel, Switzerland*).

W. Prinz., 1993. TOSCA – Providing organizational information to CSCW Applications, In *Proceedings of Int'l Conference on Computer supported Cooperative Work (ECSCW'93)* Kluwer Press.

P. Dinda and B. Plale, 2000. A Unified Relational Approach to Grid Information Services, Grid Forum Informational Draft GWD-GIS-012-1.

UDDI Version 2.03 Data Structure Reference UDDI Committee Specification, 19 July 2002, <http://uddi.org/pubs/DataStructure-V2.03-Published-20020719.htm>