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A Cross-disciplinary Collaborative Research Platform - Study on Qinghai Lake Joint Research Environment

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Abstract—**By constructing e-Science projects, we have explored that the creation of a collaborative research platform, is in great demand. This paper explores the requirements and approaches to build a collaborative research platform named Duckling for e-Science projects. Our case study is the e-Science project in joint research center of the Chinese Academy of Sciences and the Qinghai Lake National Nature Reserve, where many scientists from different areas and various backgrounds form virtual teams to study migratory bird protection and avian flu problems. This paper studies collaborative characteristics and requirements of virtual scientific communities. It introduces the framework of Duckling and applies it to the Qinghai Lake case, which helps to construct a real-time collaborative environment for scientists and promotes e-Science activities.**

Keywords- e-Science, collaborative research platform, information sharing, Web2.0, Grid

I. INTRODUCTION

With the rapid development of the Internet, and the exceptional increase in computing power, storage capacity and network bandwidth, information sharing and collaboration have widely taken place, especially for scientific researchers. The changing scale and scope of experimental science also require a new research paradigm, i.e. e-Science, where researchers collaborate with each other globally via virtual communities, which is now under construction in many countries for various disciplines [1].

Most of traditional work focused on building cyber-infrastructures to facilitate accessing to the geographically distributed and heterogeneous resources, such as computational resources, scientific instruments, databases, and applications. However they put little concern on communication and collaboration between scientists, which are of great importance in scientific research. For example, when doing research online, scientists may need messaging (email, calendar and scheduling), team collaboration (file sharing, task management), real-time collaboration and communication (application / desktop sharing, voice, audio and video conferencing), and community authorization. Scientists may also need collaboration on data analyzing and sharing. Currently there has some work conducted to build collaborative platforms for e-Science, but functions simply focus on communication, and lack of support to cross disciplinary research. Communication and collaboration between researchers from various backgrounds become more difficult as they need some common information context for information sharing and require multi-layered and different point of view of data display. Thus, they need a more intelligent collaborative platform to support their online scientific activities within and between virtual communities.

This paper was motivated by the scientific work carried out by joint research center of Chinese Academy of Sciences and Qinghai Lake National Nature Reserve (short for Qinghai Lake Joint Research Base). The lake becomes a focus in global concerns of avian influenza (H5N1), as a major outbreak could spread the virus across Europe and Asia, further increasing the chances of a pandemic. Many scientists from different organizations and various disciplines come to study the bird protection and avian flu problems. In order to support cross-disciplinary, cross-cutting, cross-unit and international collaborative research, we have established a collaborative research platform named Duckling, by means of which, scientists, wherever they are, could carry out research and communicate on line. In this paper, we focus more on how to develop a collaborative environment for real scientific application. We would firstly study on the collaborative characteristics and requirements of the virtual scientific communities in Qinghai Lake Joint Research Base. We would emphasize Duckling architecture which takes advantages of Grid and Web 2.0 technologies making collaborative work online. Furthermore, we would introduce customized realization and effectiveness achieved in the Qinghai Lake case, which helps to construct a real-time collaborative environment for scientists and promotes e-Science activities.

This paper is organized as follows: The second section describes the related work. The third section introduces e-Science work in Qinghai Lake Joint Research Base and summaries the characteristics of collaborations and requirements in cross-disciplinary scientific research. The fourth section introduces the architecture of Duckling and its core components. In section V, we introduce the real applications and collaboration enhancement in the Qinghai Lake case. Section VI concludes this paper and outlines our topics for further research.

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II. Related Works

We reviewed two lines of work which are closely related to the concept we will propose: e-Science related projects and collaborative application in e-Science.

The TeraGrid [2] integrates high-performance computers, data resources and tools, and high-end experimental facilities. Currently, TeraGrid resources include more than 750 teraflops of computing capability and more than 30 petabytes of online and archive data storage, with rapid access and retrieval over high-performance networks. Researchers can also access more than 100 discipline-specific databases, which make TeraGrid one of the world's largest, most comprehensively distributed cyberinfrastructures.

OSG (Open Science Grid) [3] is a distributed shared cyberinfrastructure for domain scientists, computer scientists, technology specialists, and providers in more than 70 U.S. universities, national laboratories, and organizations providing resources, tools and expertise. The OSG consortium also partners with campus and regional grids, large projects such as TeraGrid , Earth System Grid, Enabling Grids for e–Science (EGEE) in Europe and related efforts in South America and Asia to facilitate interoperability across national and international boundaries.

The Biomedical Informatics Research Network (BIRN)[4] is a geographically distributed virtual community of shared resources offering tremendous potential to advance the diagnosis and treatment of disease. BIRN is changing how biomedical scientists and clinical researchers make discoveries by enhancing communication and collaboration across research disciplines. BIRN hosts a collaborative environment rich with tools that permit uniform access to hundreds of researchers, enabling cooperation on multi-institutional investigations. BIRN synchronizes developments in wide area networking, multiple data sources, and distributed computing.

The VL-e [5] is a Dutch e-Science project. The goal of the VL-e project is to bridge the gap between the technology push of high performance networking of the Grid and the application pull of a wide range of scientific experimental applications. It will provide generic functionalities that support a wide class of specific e-Science applications and set up an experimental infrastructure for the evaluation of ideas. The mission of VL-e is to boost e-Science by creating an e-Science environment and carrying out research on methodologies. Its strategy is to carry out concerted research along the complete e-Science technology chain, ranging from applications to networking, focusing on new methodologies and re-usable components. The essential components of the total e-Science technology chain are: 1) e-Science development areas, 2) a Virtual Laboratory development area, 3) a large-scale distributed computing development area, consisting of high performance networking and grid parts.

The "CyberBridges" project [6] is a model collaboration infrastructure for e-Science, designed to complement the technical infrastructure with a socio-organizational service-oriented infrastructure. It offers the potential of creating a community of scientists and researchers capable of collaborating with their counterparts across the network by fully integrating cyber-infrastructure into their educational, professional, and creative processes.

III. E-SCIENCE in Qinghai Lake Joint Research Base

Our studies were conducted at the Qinghai Lake National Nature Reserve, Qinghai province, China. Qinghai Lake, the largest salt lake in China with an area of 525 km2, is located in the middle of Qinghai Province. From 2001, the Chinese Academy of Sciences (CAS) has been aware that e-Science has played a very important role in online scientists' collaboration. CAS initiated the e-Science program in Qinghai Lake Nature Reserve, which is a virtual organization, that many other groups (e.g. Scientific Research Institutes, Qinghai Lake Reserve Government, USGS) utilize. These groups make full use of resources to build small or large research-driven virtual teams to work on migratory bird protection and avian flu problems, such as identification of important migratory bird species, spatial distribution patterns, and disease monitoring and risk assessment.

A. Characteristics

In this section, we describe the characteristics of e-Science work in Qinghai Lake Joint Research Base that arise from four areas of concern –organizations, research collaboration, resources, and information-sharing.

1) Organizations are research -driven

Like many e-Science projects, Qinghai Lake Joint Research Base was formed for specific scientific research problems with clear overall common goals and objectives in mind. All members have agreed on these goals and objectives and contribute to the realization of the goals.

2) Collaboration runs through whole research activities.

As institutes participating in this program are distributed geographically and the research problems are interdisciplinary, collaboration always runs through all research activities from experimentation, data analysis, and results-publishing and most of the other collaborative activities to IT, technology, and support, such as real-time communication tools, collaborative document editing, and virtual community management.

3) Experiment and the research process are resource intensive.

As scientific activities become larger and more complicated, researchers have to handle larger amounts of data generated in e-Science such as experimental data generated by the migratory experimental instruments, paper data from digital library, documents, reports, patents and so on. As many of the resources are dispersed, researchers needed to locate each resource and query through their own interface, as well as finding the unknown relationship.

4) Information sharing need

Information providers are also in demand thus encouraging information sharing. However, different stakeholders' require different types of information. And people from various disciplines have different perspectives of the same information.

B. Requirements

Collaborative environments in e-Science are a dynamic mix of organizations (people), research activities, and resources. Current research communities focus on one or, at best, two of the three aspects as described in section II. During our investigation of Qinghai Lake Joint Research Base, there was an urgent need to develop informative and collaborative systems capable of supporting and advancing new modes of research activities. The detailed requirements of the collaborative environment in Qinghai Lake Joint Research Base are:

- Research projects can be used as "virtual organizations" (VO) in the collaborative platform. Researchers could participate in the VO corresponding activities and project, such as meetings, paper reviews, inspections and acceptances, and inspection activities, use the corresponding service and communicate with peers or find a partner.
- Data and information could be shared and reused by different virtual organizations, with a good authentication and authorization management.
- Collaborative platforms should facilitate access to many kinds of heterogeneous resources like experiential instruments, computing, storage, databases, literature as well as domain-specific applications. These resources should not be isolated and their relationship should be uncovered.
- Collaborative platforms should support the ongoing process of scientific discovery and development from experimenting, data analyzing to results publishing.
- The communication such as email, video conferences should also be enabled.
- Researchers share all kinds of electronic documents with projects / virtual partner or other person, in an efficient safe and easy way and writing documents collaboratively.

IV. ARCHITECTURE OF DUCKLING

We focus more on how to develop a collaborative environment for real scientific application. The implementation of Duckling is based on an architecture that is extensible and supports, but does not restrict, the resources such as databases, instruments and mobile devices required by virtual communities. Fig.1 presents the Duckling architecture. The resources are created by e-Science projects which are widely distributed in different institutes in CAS. Also the types of resources are heterogeneous. The large-scale, distributed resources are universally integrated by a Resource Service in the Duckling architecture. The Resource Service includes different plug-ins aimed to provide pipelines for different types of resources, like Computing Resources Plug-in, AV Plug-in, Device Plug-in, Database Plug-in, Digital Library Plug-in and others. We also provide a scientific workflow over these resources, which can easily draft complex business logic and consume resources to generate scientific knowledge. To help integrate, share and manage the large scale and distributed resources, we also built three core toolkits for online collaboration, including VO management, document collaboration, and activity collaboration. VO management toolkit is designed for scientific virtual organization management, helping scientists to organize the communities with the same interests. Document collaboration toolkit is designed for document sharing and searching with the support of a text search engine. Activity collaboration toolkit helps to organize Internet-based activities, such as project review and conferences. Also we design a Virtual Work Console to help access, organize and manage resource easily and transparently and integrate resources from CAS, such as computing, storage, database, and digital library. To assist scientists in accessing the resources needed, we provide a CA engine that helps them to use the correct resource.

We will describe core work components in the following sections.

A. Research and Protocols

As an ultimate goal, Duckling is to help scientists in different domains to manage their complex, long-term and wide-spread research activities online. To realize this goal, we would carry out our research from three aspects:

- Solve the collaboration problem for scientific activities i.e. support the process of the collaborative scientific activities. This includes integrating scientific resources, publishing, creating and maintaining cross-disciplinary and cross-organizational collaboration, and organizing and managing academic conferences.
- Solve the management problem for scientific resources. The scientific resources are distributed and heterogeneous, which also makes the Duckling a distributed environment. We need to provide a loose-coupled architecture that will manage these resources and services, thus supporting the interoperation for upper scientific collaboration.
- Solve the availability and accessibility problem for scientific activities. Scientists can access the collaborative research platform portal to carry out scientific activities anywhere, anytime and on any device.

The first step of research is to investigate the advanced technologies for Duckling architecture, including Grid, Web 2.0, Web services, JSR-268 portal and so on. The architecture must be scalable and extensible enough to make different kinds of plug-ins be loaded easily. The architecture should also enable scientists to create and maintain scientific workflow. We would firstly investigate the requirements of workflow for scientific activities, analyze the workflow like KEPLER, Condor DAGMan, Globus, Pegasus, Chimera, Unicore, Triana and so on, and finally customize a suitable workflow engine and applications for different types of activities.

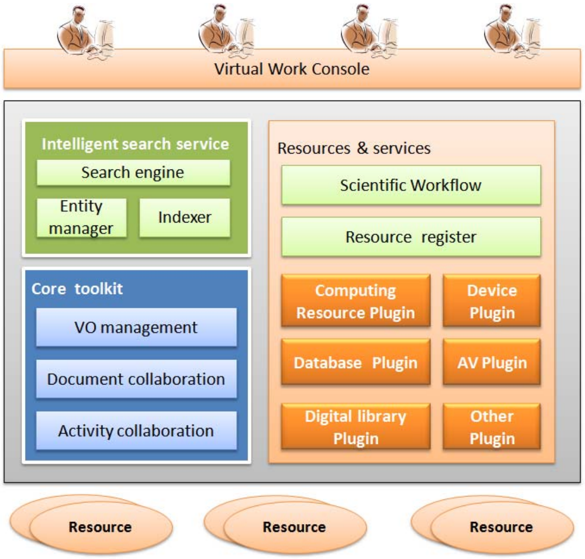

Figure 1. The architecture of Duckling

B. *Virtual Work Console*

Virtual Work Console is a portal based Web UI, which provides an EASY-TO-USE interface and a universal access point for different resources and services. It is an open, scalable, flexible integrated platform for different resources based on Portal, Grid and SOA technologies. The Web UI is based on open source portal architecture, which enhances other portals like uPortal, GridSphere, and Liferay. Grid and SOA are used to integrate heterogeneous and distributed resources and provide universal services for upper Web interfaces.

C. *Core Toolkit*

1) *Document Collaboration Tool*

Document Collaboration Tool (DCT) is a collaborative writing, document-sharing and management tool for virtual communities, which supports concurrent editing for proposal- planning, schedule tracing, project summary. DCT provides two basic functions: 1) Online collaborative document-writing among group users. Traditional collaborative document-writing is always based on e-mail, which is not real-time and cannot provide document segment modification. DCT is a wiki-based collaborative tool that can support document editing with different granularity. 2) Online document sharing. Scientists can share their scientific documents to members of related communities. We provide a search engine to index the documents for easy searching by other persons. We also provide a semantic mechanism to tag documents from users' viewpoints.

2) *Activity Tool*

Scientific activities not only include the academic conference, but also the out-side investigation, real time observation. Activity Tools (AAT) provides a communication channel from national discussions to international conferences. Activity Tools can easily complete tasks like arranging conferences including calling for papers, making activities schedules, activities resources sharing, video conference and so on.

3) *User Management Tool(VO Management Tool)*

User Management Tool (UMT) is also a VO management tool which helps to provide a universal VO management and authentication solution. Different applications share the same user system, but provide different privileges for their specific requirements. Through a single sign-on solution, each user can log-in once, and access all applications provided in Duckling. Users are organized in different communities according to their interests, and thus possess their own profiles and access to control. Applications based on VO Management Tool utilize the user/group information to address their specific needs.

D. *Resources Manager*

We have implemented JSR286 Portlet framework in the platform - a portlet container to offer an easy deployment environment for plugging-in the portlet application implemented for domain applications. Resources and application plug-ins enrich the platform as a collaborative environment for different requirements while keeping the application autonomous.

E. *Intelligent Search Service*

This component supports searching rich content in context, by indexing content, such as data and information, generated by core toolkits or some plug-ins in Duckling, and providing a uniform search interface for searching these contents. Above all, we have implemented an entity management, including an entity recognizer and entity extractor to discover the linkage between the resources and information [7].

F. *Duckling Advantages*

Duckling aims to provide a system which presents easier usage than current systems. It provides the following advantages over previous systems:

- Resources integration. Duckling is a resource integrator that provides users with a single operating environment where many kinds of resources, such as supercomputers, mass storage facilities, scientific databases, digital libraries, high bandwidth link, scientific equipment, and etc. could be accessed in a seamless way.
- Customized service. Duckling provides a user with what he or she wants completely and exactly. Each user may have a specific workbench individually. Users may choose different services at different times.
- Ubiquitous research. Duckling benefits from state-of-the-art technologies on mobile computing and related technologies so that users could use the collaborative research platform at anytime and anywhere.
- Collaborative work. Duckling enables a lot of scientists, who are from multiple independent institutions, from multiple sites across the world, and from different professional backgrounds, to work

together on a collaborative project or a common problem.

- Scalability. Duckling supports hundreds of users from many institutions, but should work just as well for three or five users.

Duckling is such a common collaborative platform that it can be applied to many fields. We think collaborative research platform is most suitable for scenarios that satisfy the following conditions: 1) A national important plan or proposal. 2) Need for high-performance computing, high-speed network and scientific database. 3) Cross-disciplinary and cross-organizational collaboration among several institutes.

Also we should customize Duckling for different purposes and provide consultation. In next Section we will introduce the applications we have been developing to enhance scientific collaborations in Qinghai Lake Joint Research Base, a real scientific research application scenario.

V. COLLABORATION ENHANCEMENT IN QINGHAI LAKE

In this section, we demonstrate implementations and the effectiveness Duckling has achieved in supporting the collaborations and information sharing in Qinghai Lake Joint Research Base.

A. Supporting Resource Sharing Between VO with UMT

There are several ongoing research-driven projects in Qinghai Lake Joint Research Base, which may have more than one institutes participated. With UMT of Duckling, the project leader could create a research VO corresponding to a project, identify collaborators, and customize the resources and applications needed in the virtual team. Common users could apply to join the specific projects according to their own interests. The project leader could allow or deny their applications in UMT. Once the application is allowed, the user could join the VO and use the customized service and resources.

B. Supporting Scientific Research Collaboration.

The process of scientific research in Qinghai Lake Joint Base includes field experimenting, data analyzing, results publishing and reusing. In order to support observing, data collecting and experimenting, we set up a monitoring system (Fig.2) in Qinghai Lake [8], as well as a mobile-device based outdoor data collection system and data application , enabling scientists to observe and analyze the activities of birds in real-time. As we making these tools plug-ins in Duckling, scientists could carry out the e-experiment in one platform. Furthermore, the data generated by these applications such as video clips or pictures could be saved in the platform, based on which, scientists could maintain their workflow , carry out analyzing and data mining [9], and publishing results for further study or other related projects reuse.(Fig.3,Fig.4).

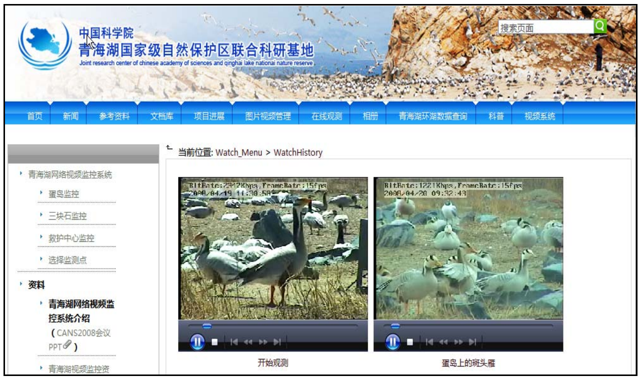

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Figure 2. Monitoring migratory bird remotely

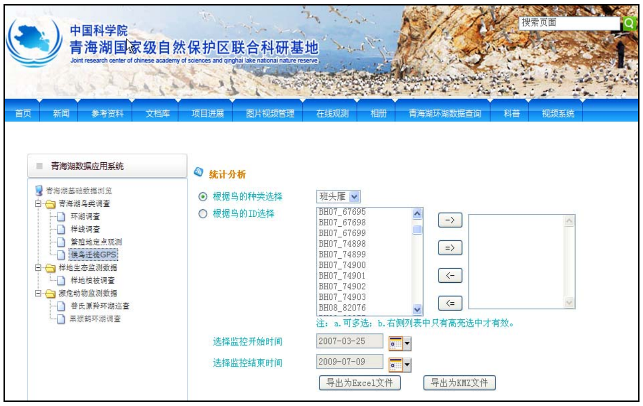

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Figure 3. Qinghai Lake scientific data application

C. Providing Access to Rich Content

The research carried on Qinghai Lake may use various data generated in the experiment period, such as observed and experimental data, scientific data and working documents, or from other outer sources, like paper data from digital libraries. We have implemented plugging-ins for many applications so that their metadata could be obtained and managed in our system. We also designed an e-Scholar [7] that is a metasearch engine to investigate the metadata from various data sources. Fig.5 shows a search case when a researcher use e-Scholar searches for paper on Avian Influenza with general search engines, he/she may find some paper on bar-headed geese (Anser indicus) ,which have suffered badly from influenza in Qinghai Lake, as well as data on the features and activity of bar-headed geese on Qinghai Lake, which was provided by searching interface of Qinghai Lake databases. With this service, relevant data could be connected and searching for distributed and autonomous resources is no longer isolated, which may help scientists find new scientific issues.

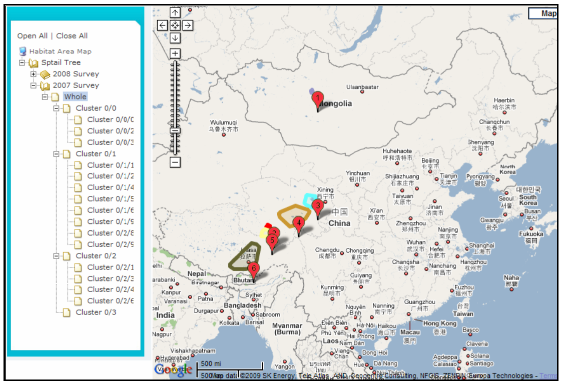
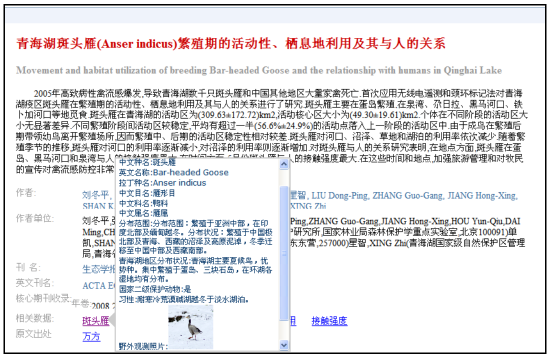


Figure 4. Discovering migration habitats and routes application



青海湖斑头雁(Anser indicus)繁殖期的活动性、栖息地利用及其与人的关系

Movement and habitat utilization of breeding Bar-headed Goose and the relationship with humans in Qinghai Lake

2005年高致病性禽流感爆发,导致青海湖数千只斑头雁和中国其他地区大量家禽死亡.首次应用无线电遥测和颈环标记法对青海湖疫区斑头雁在繁殖期的活动性、栖息地利用及其与人的关系进行了研究.斑头雁主要在蛋岛繁殖.在泉湾、尕日拉、黑马河口、铁卜加河口等地觅食.斑头雁在青海湖的活动区为(309.63±172.72)km2,活动核心区大小为(49.30±19.61)km2.个体在不同阶段的活动区大小无显著差异.不同繁殖阶段间活动区较稳定,平均有超过一半(56.6%±24.9%)的活动点落入上一阶段的活动区中.由于成鸟在繁殖后期带领幼鸟离开繁殖场所,因而繁殖中、后期的活动区稳定性相对较差.斑头雁对河口、沼泽、草地和湖泊的利用率依次减少.随着繁殖季节的推移,斑头雁对河口的利用率逐渐减小,对沼泽的利用率则逐渐增加.对斑头雁与人的关系研究表明,在地点方面,斑头雁在蛋岛、黑马河口和泉湾与人 人的接触强度最大.在这些时间和地点,加强旅游管理和对牧民的宣传对禽流感防控非常

中文种名:斑头雁
英文名称:Bar-headed Goose
拉丁种名:Anser indicus
中文目名:雁形目
中文科名:鸭科
中文属名:雁属
分布范围:分布范围：繁殖于亚洲中部，在印度北部及缅甸越冬。分布状况：繁殖于中国极北部及青海、西藏的沼泽及高原泥淖，冬季迁移至中国中部及西藏南部。
青海湖地区分布状况:青海湖主要夏候鸟，优势种。集中繁殖于蛋岛、三块石岛，在环湖各湿地均有分布。
国家二级保护动物:是
习性:耐寒冷荒漠碱湖越冬于淡水湖泊。
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Figure 5. Accessing to paper and the relevant data

VI. CONCLUSIONS AND FUTURE WORK

While more e-Science projects are being implemented, scientific research mode has undergone new paradigms and researchers are more dependent on information and collaborative systems. In this paper, we demonstrate the requirements of collaboration and information-sharing by exploring the frontline e-Science project Qinghai Lake Joint Research Base), which was a typical case of cross-disciplinary, cross-cutting, cross-unit and international collaborative research and poses many difficult problems for enabling researchers to collaborate efficiently. We designed the architecture and realization of the collaborative research platform-Duckling.

As we have implemented and deployed the collaborative platform, currently, we focus our work on developing the following tools to advance the platform.

A. *Semantic Enhancement*

We intend to build subject ontology and collaboration ontology to enhance the semantic navigation and search. Currently, we have had user tags, metadata, entities which are all private semantic information, but are not sufficient in scientific research which needs more accurate and standard semantic information.

B. *Social Network for Virtual Community*

Virtual Community is composed of people with the same interests. A social network is a social structure made of nodes (which are generally users or groups in Virtual Lab) that are tied by one or more specific types of interdependency. Research in a number of academic fields has shown that social networks operate on many levels, from families up to the level of nations, and play a critical role in determining the way problems are solved, organizations are run, and the degree to which individuals succeed in achieving their goals. So we use social network analysis to show the relationship of users, and discover people with the same interests and so on.

In conclusion, e-Science needs more international collaborations on cyber-infrastructure. E-Science applications are able to merge scientific domains and IT not only in IT technology and scientific knowledge, but also in human, e.g. e-Scientist.

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