# Realise e-Research through Virtual Research Environments

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*Abstract:* Scientists today are tackling increasingly difficult challenges. More and more advanced technologies are required to support such kinds of research activities. With recent innovations in information technology it is now possible to perform research activities within virtual research environments (VRE). In this paper we describe a Sakai-based VRE system aiming at providing an improved platform for supporting research. In addition to benefiting from the existing collaboration tools like chat and discussion, our VRE system extends the Sakai e-Learning framework by providing additional functionalities for integration of existing web components, JSR-168 portlets, and managing documents.

*Key–Words:* Virtual research environments, e-Research, Portlets, Document management

## 1 Introduction

Research activities today normally involve more than one individual/group. This naturally demands collaboration among researchers who are geographically distributed so that they can focus on tackling a shared challenge. With the development of today's information technology, in particular, the Internet, such kinds of research activities can be performed online. We define these activities as *e-Research* activities. While e-Learning systems are widely adopted and deployed for helping education, e-Research systems are still at their early stage. Starting from 2004, the UK Joint Information Systems Committee (JISC) has funded a set of projects investigating virtual research environments (VRE) under different circumstances aiming at helping *"researchers in all disciplines manage the increasingly complex range of tasks involved in carrying out research"* [1]. Although there does not exist a precise definition of VRE, according to this JISC statement, a VRE system can be treated as a flexible framework which is equipped with collaborative services for supporting research process across all disciplines.

Naturally such a VRE system can be constructed on top of existing e-Learning systems. While e-Leaning systems are designed to support learning activities, they can also be *borrowed* to support research with proper extensions. The key of VRE relies on efficient collaboration and relevant information provided to researchers. First, a VRE system should be able to act as a communication platform, which typically provides services such as instant messaging and online discussion. Furthermore, services like audio and video conferencing are also required. This requirement is aiming at providing researchers with an efficient environment so that they can easily share/exchange ideas, knowledge and data, work plans, etc. Second, a VRE system should at the same time act as an information provider. For example, making use of the portal technology, a VRE system can collect user preferences and therefore it is possible to filter information retrieved from various sources, e.g. via RSS, and provide end users with information they are likely to be most interested in.

To support research, VRE systems are not limited to solely research-related activities mentioned above. They also need to support administrative tasks involved in project management, e.g. risk assessment, progress monitoring, financial monitoring and task assignments. Therefore a typical VRE system provides both research and administrative support.

In this paper, we are going to present our recent research progress at the CCLRC Daresbury Laboratory on building up a general purpose VRE system to realise e-Research by making use of an existing advanced e-Leaning system called Sakai [2], which is a Collaboration and Learning Environment (CLE) developed by the University of Michigan *et al.* targeting the higher education market. The JISC funded Sakai VRE Demonstration Project [3] led by the University of Lancaster is a joint project with three other partners – the University of Oxford, the University of Reading (previously Portsmouth) and Daresbury Labora-

tory. While at different sites different tools are under development, for example at Lancaster and Reading, audio/video conference, blog tools and portlet bridges are being developed; at Daresbury we are focusing on groupware services and portal/portlet integration.

The rest of the paper is organised as the following. First some related work is described and our understanding of VRE systems is elaborated. After that, our Sakai-based VRE system is described with a focus on integration of existing web components, JSR 168 portlets and document management. In the last section, concluding remarks and possible future work are presented.

## 2 Related Work

A VRE system typically has a web-based front-end which makes it available with only a web browser required on the client side, it is thus a pervasive tool to access research-related services. This could be from a desktop or mobile devices like PDA. The development of the web highlights ideas of e-activities including e-Research. Therefore in this paper, when we talk about VRE systems they are all assumed to be web based.

In [4] web-based research support systems (WRSS) are proposed as a specific type of web-based support systems (WSS) [5] for supporting research activities for scientists. In [4], Yao examined the principles and issues of WRSS by going through the general research process and methods. Functionalities like resource and data/knowledge management are pointed out for designing such a WRSS system.

Whilst there is no implementation in [4] but with only guidelines, CUPTRSS, a prototype WRSS system, was discussed by Tang *et al.* focusing on management support [6]. CUPTRSS aims at providing researchers with accurate and up-to-date information, improving research management and integrating public research resources at the Chongqing University of Posts and Telecommunications in China.

Recently with the concept of the Grid emerging [7, 8], virtual organisations (VO) are built up around the world to construct and maintain activities of dynamically extensible research groups. These VOs are aiming to link research resources including not only facilities such as instruments, computing and data resources but also research staff. The key of the grid is its ability to plug-in/ remove resources dynamically if required across a multi-institutional platform. This brings VOs great flexibility to meet today's always changing grand challenges in research.

NEESit [9] is such an example which links earthquake research scientists together across USA by providing them with a virtual research laboratory. NEESit makes use of the grid technology so that geographically distributed computing resources and engineering facilities can be combined together to support collaborative research activities.

According to our understanding, WRSS systems have the same objective as VRE systems, that is, to improve research quality and productivity by providing research support systems; while the grid technology can be used to implement such a VRE system. Since 2004, JISC in the UK funded a set of VRE projects to investigate the development of an infrastructure to support research activities in various disciplines. These projects are aiming at four different aspects as stated on JISC VRE Programme web site [1]: *a) building and deploying VRE systems based on currently available tools and frameworks; b) assessing their benefits and shortcomings in supporting the research process; c) improving and extending them to meet the future needs of UK research; and d) developing or integrating new tools and frameworks where appropriate solutions do not yet exist.* The Sakai VRE Portal Demonstration Project [3] we meets the first criteria to investigate the possibility of building up VRE systems using existing frameworks.

## 3 Build up a VRE System Based on Sakai

### 3.1 VRE Architecture

VRE systems should be designed to be as flexible as possible because the user requirements are dynamically changing. Furthermore, there is always demand for re-usage of existing components. Therefore we adopt a service-oriented architecture (SOA) for VRE systems. As depicted in Fig. 1, a VRE system contains a bundle of services that meet stated and tacit user requirements, for instance, authentication and authorisation service, communication service. Besides these core services, this VRE system should be able to be extended to meet new requirements. This could be done by plugging in new services or making use of external services as shown in Fig. 1. Ideally, a VRE system can be built up with many services integrated from external (VRE) systems.

In general VRE systems also follow a three-tier architecture. Typically, web portals act as the presentation layer while business logic and data layers are sitting behind it. A web portal provides a single entry point for end-users to access all kinds of resources either inside or outside of the VRE system. In particular, portals provide users with customisable gateways for retrieving and rendering information. A VRE system can make use of the latest portal technologies with

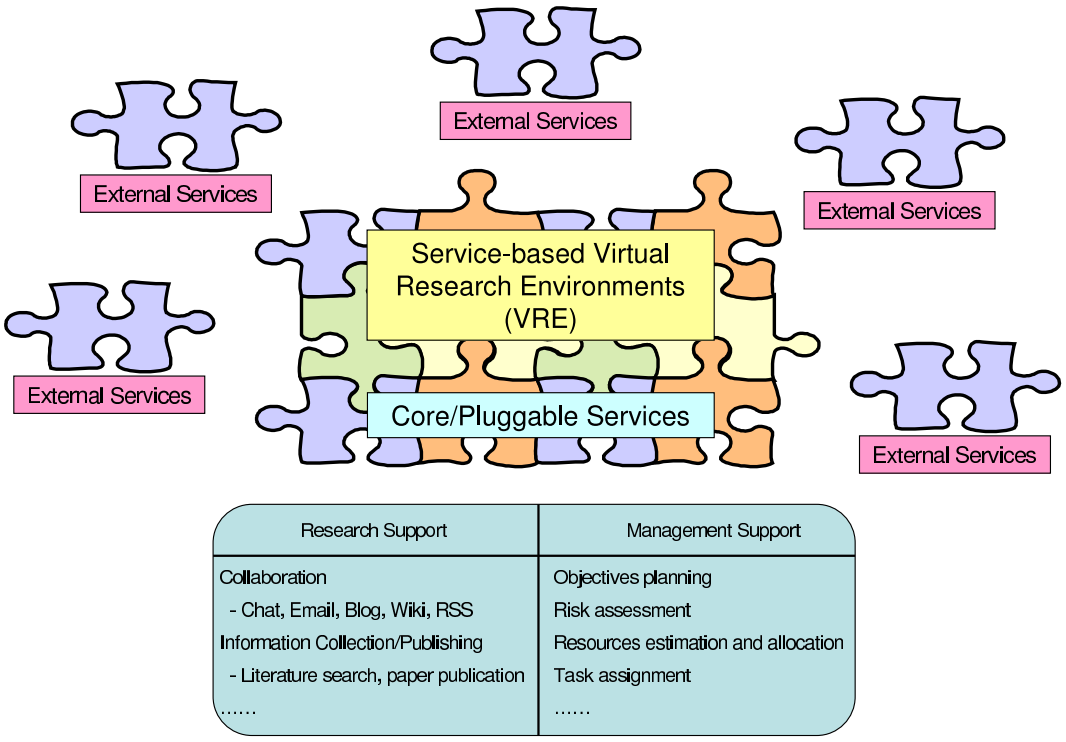


Figure 1: Service-based VRE architecture.

additional services added, like information filtering. Today's web portals are standards based – in the Java community, there are two portal standards; Java Portlet Specification 1.0 (JSR 168) [10]; and Web Services for Remote Portlets (WSRP) 1.0 [11]. We will talk about them later in the following section.

According to our experience in grid portal development over the past several years, we realised that although general purpose functionalities such as remote job submission and file transfer can be packaged as reusable services, ideally these services should act as templates only. This means that if different projects have specific requirements they can be customised, even for execution of standard services. For example, research scientists from various background are making use of the UK National Grid Service (NGS). They all want an user-friendly interface to submit jobs remotely, but they will have their own specific applications. For example, a researcher in the computational fluid dynamics field is interested in locating and partitioning geometry meshes pre-defined for numerical simulation while in bioinformatics it is more likely that a researcher will search for a workflow to apply to a new gene sequence.

Only when such requirements are met are scientists likely to be happy to continue using VREs as they are perceived to meet their subject-specific requirements. Hence when we talk about the VRE architecture we are focusing on services for supporting research, i.e. without touching *real* research. That's why in Fig. 1 only collaboration services are listed in "Research Support". This leaves space for techniques like portal to provide services such as information filtering as mentioned above to better fit end user requirements.

### 3.2 Sakai

As aforementioned, Sakai is an open-source e-learning system initially developed at the University of Michigan and targeting the higher education market.

The Sakai architecture obeys our proposed VRE structure very well – Sakai consists of two parts: the Sakai framework and Sakai tools [12]. The framework provides presentation and common services to form a basic system while tools are designed for specific purposes like chat room and discussion. Tools can be treated as components and can be plugged-in or removed from Sakai dynamically. Tools can make use of common services such as retrieving current user information.

In the past two years, a world-wide community has gradually been built up which involves deployment and development of Sakai at universities all over the world, see http://www.sakaiproject.org/sakai-map/. Sakai provides generic collaboration tools such

as announcement, chat room, email archive, as well as learning and teaching tools, for example, assignments, grade book and module editor. Inevitably, many universities have their own requirements to meet demands from their end-users. For example, internationalisation is a common issue outside of English-spoken countries. Hence there are many tools such as blog and wiki being developed by the community rather than the USA based core Sakai development team. In fact, the growth of Sakai around the world itself proves the power of this collaboration.

### 3.3 Extensions to Sakai

Because of its flexible architecture and well developed tools/service for collaboration, Sakai was selected as the basis of our VRE system. Over the two years of our project this architecture has evolved, but continues to meet our needs. In this paper, we describe part of the work done at Daresbury Laboratory for the Sakai VRE Portal Demonstrator Project.

#### 3.3.1 Integration of JSR 168 Portlets

Portlets are web components that can be composed in a full web page. Through portlet technology, portals can be equipped with various pre-defined portlets such as weather forecast and stock price query (the typical examples). The JSR 168 specification standardises communication between a portlet and its container which enables development of re-usable portlets. These web components can now be deployed under different portlet containers if both of them conform to this specification.

Currently however, Sakai does not provide support for JSR 168 portlets. As shown in Fig. 2, there are basically two approaches to make Sakai support this standard: a) to develop a portlet container for Sakai; and b) to develop a WSRP (Web Services for Remote Portlets) [11] consumer for Sakai and consume JSR 168 portlets published by a remote WSRP producer. The first approach provides the best support for portlets but will involve a lot of work on Sakai itself. Moreover, portlets are required to be deployed inside Sakai locally. This work has now started in the USA with the core team working to integrate Pluto 1.1, an open-source JSR 168 reference implementation by Apache, into the kernel. The second approach relies on the WSRP specification, and external WSRP producers are required to deploy JSR 168 portlets. The benefit of this method is that there is no requirement to maintain 3rd-party portlets inside Sakai. They can simply be used on demand while hosting, upgrade and maintenance of these portlets are the duty of their providers.

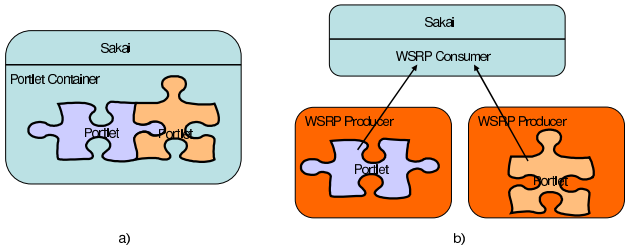


Figure 2: Two approaches for Sakai to support integration of JSR 168 portlets.

As grid technology gains more and more attention, we have developed the UK National Grid Service (NGS) Portal [13] for researchers to seamlessly access the UK NGS computing and data grid. The second release of the NGS Portal is portlet based, but still provides mostly generic services. A set of grid portlets have been developed to perform tasks like proxy credential management, job submission and file transfer. To make use of these portlets inside our VRE system, they are published as remote portlets and a WSRP consumer has been written for Sakai so that it can consume these portlets remotely. Obviously, with the help of this consumer, Sakai can also consume other 3rd-party portlets. For example, besides our grid portlets, a research library search portlets from the previous JISC-funded CREE project, Contextual Resource Evaluation Environment, have been successfully tested. This greatly extends Sakai's capabilities. For more information about WSRP support of JSR 168 portlets in our Sakai based VRE system, see [14].

Unfortunately support of WSRP 1.0 in different open-source portal frameworks is still not mature, as we discovered in earlier tests [15]. As WSRP becomes more mature, this will be a promising approach for integration of portlets in information systems including VRE systems. Fig. 3 gives a screenshot of a remote JSR 168 portlet called proxy manager running inside Sakai through WSRP. This portlet is used to retrieve a proxy credential from a MyProxy server. The credential can then be utilised to perform grid tasks like job submission and file transferring through GridFTP.

#### 3.3.2 Document Management System

The document management system (DMS) is a tool developed for Sakai which provides support for organising conferences/ workshops. Conferences are good platforms for researchers to share their ideas and knowledge, it is a very important part of research. To help organise conferences, the DMS tool has been proposed and is now under development in Sakai.

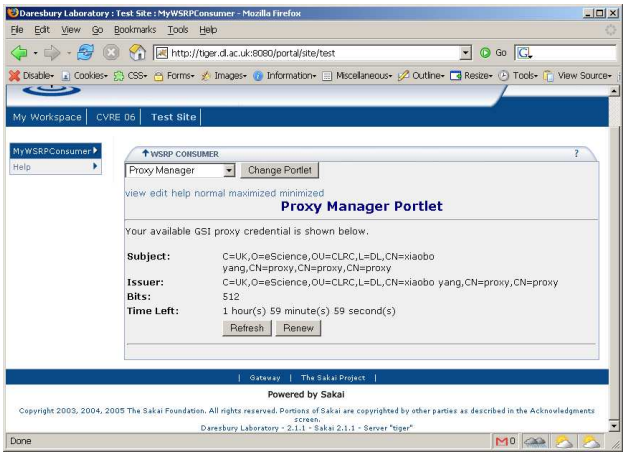


Figure 3: Proxy manager portlet running inside Sakai through WSRP.

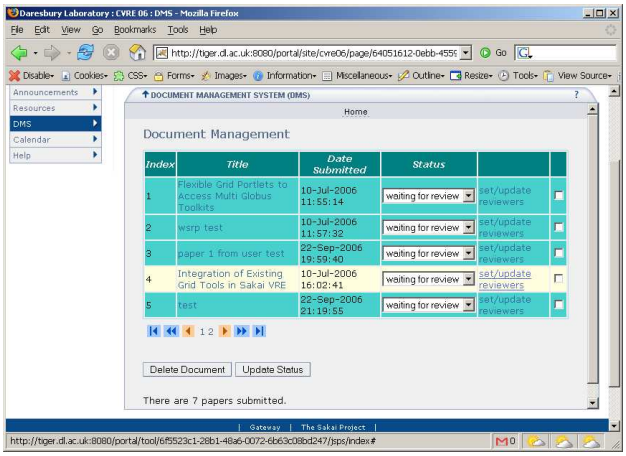


Figure 4: Document management of the DMS tool.

From the beginning to the end of a conference, there are a lot of communications among conference organisers, authors, reviewers, etc. The DMS tool aims to make such kind of communications easier.

Benefits from Sakai's existing collaboration tools, DMS is focusing on paper/review submission, and communications mentioned above. Within Sakai, for each conference, a work site can be created. This work site has its own calendar which can be shared by all members of the site. There are other tools such as announcement and resource that can be used to advertise announce and store documents.

DMS first provides authors with the ability to upload their papers, check paper status, etc. It also provides reviewers with a platform to submit their reviews easily. Moreover, DMS makes it easy for authors, reviewers, and organisers to communicate through email besides the existing chat tool inside Sakai. During the above interactions, meta-data may be recorded behind the scenes which can then be utilised for analysis purpose.

A prototype of the DMS tool has some services to handle database operations while the tool itself focuses on providing a presentation layer using JavaServer Faces (JSF) and business logic. A screenshot of this tool is illustrated in Fig. 4. This page is provided so that a conference organiser can manage submitted papers, e.g. to set/update reviewers of a paper, to change paper status.

Other work of groupware integration by accessing Microsoft Exchange server through WebDAV is reported in [16]. Integration of Sakai calendar and Microsoft Exchange server calendar has been discussed in that paper.

# 4 Conclusion Remarks and Future Work

Scientists today are tackling more and more complex challenges. Collaboration among them is becoming increasingly important. To provide better support for research, we describe virtual research environments (VRE) for realising e-Research. In particular, a general purpose VRE system has been built up on top of Sakai, an open-source e-Learning framework. Sakai has been extended to support JSR 168 portlets which makes it possible to consume 3rd-party portlets like the grid portlets developed for the UK NGS Portal. A document management tool has also been proposed and is now under development which provides help for organising conferences.

Service-based VRE systems are ideal candidates for sharing services. In the future, we will investigate how to make use of SOA for integration of existing resources. One interesting point is to realise single sign-on (SSO) among different VRE systems. This may involve adoption of technology like Shibboleth.

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