

Advanced Collaboration Tools To Support Integration & Steering of Multi-site Experiments

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Abstract

Our aim is to construct, refine and deploy a prototype Virtual Research Environment (VRE) to enable teams of material scientists, academic and industrial engineers and instrument scientists to work together in undertaking, compiling, analysing, interrogating and visualizing multiple experiments on components of high complexity at different sites. These proof of concept tools will support multidisciplinary and geographically distributed teams. They will facilitate: interactive steering of 24-hour experiments between post-doctoral and PhD students on-site with senior researchers at home, enhance the student learning/training experience and identify exciting opportunities that arise during the experiment that are currently sometimes missed and reducing the number of experimental errors. The "Shared Workspace" will be heavily based on the JSR 168 standard with the enabled features of Web Services to be consumed via Web Services for Remote Portlets (WSRP) by any JSR 168 compliant or non JSR 168 compliant, Java or .NET-based Web Portal. This allows extra portability between our developed web portlets and other web portal framework within the VRE community. We report our initial developments and findings in the deployment and analysis of the prototype VRE.

1. Background

Over the past decade, a number of complementary characterisation techniques have been developed capable of providing maps of structure and stress inside three dimensional engineering components. Some are available in specialised laboratory sites, such as the Stress & Damage Unit in Manchester, while others rely on specialised neutron and synchrotron X-ray beams as are available at International User Facilities such as ISIS (Rutherford Appleton Lab), SRS (Daresbury), ESRF & ILL (Grenoble). Taken together, this information becomes very powerful providing a picture of the state of the structure including any defects and internal stresses. This allows the integrity and lifetime of the structure to be predicted. The fact that the experimental methods are non-invasive means that the evolution of structure in response to service conditions (static loads, fatigue, stress corrosion environments, etc) can be followed in real time.

Experimenters at International User Facilities must work at speed throughout 24 hours/day experiments (Figure 1). Beam time is very precious and it may be months before another time slot is available to the team.

Limitations associated with travel mean that often post-doctoral researchers and/or PhD students travel to the site and must work in shifts alongside resident instrument scientists. Key decision points are often encountered late at night and without the benefit of a preliminary analysis of the data. Due to inexperience simple mistakes are sometimes made which are only revealed subsequently off-site upon detailed analysis. Currently, this community has little experience of VREs, with telephone calls being the primary method to support remote discussions between the experimental site and the home (university) site to explain the problems encountered and to utilise the expertise available at the home site. The use of the telephone has obvious limitations in explaining such situations. Email is also used and this is better than telephone calls in some ways, but worse in others. The asynchronous nature of this communication medium can often result in large delays between the exchange of ideas and the delay between messages makes brainstorming impossible.

While a supervisor may be prepared to log on to a computer at home in the middle of the night to give assistance, or receive a telephone call - a trip to the University to use the proposed VRE is not practicable! Whilst the

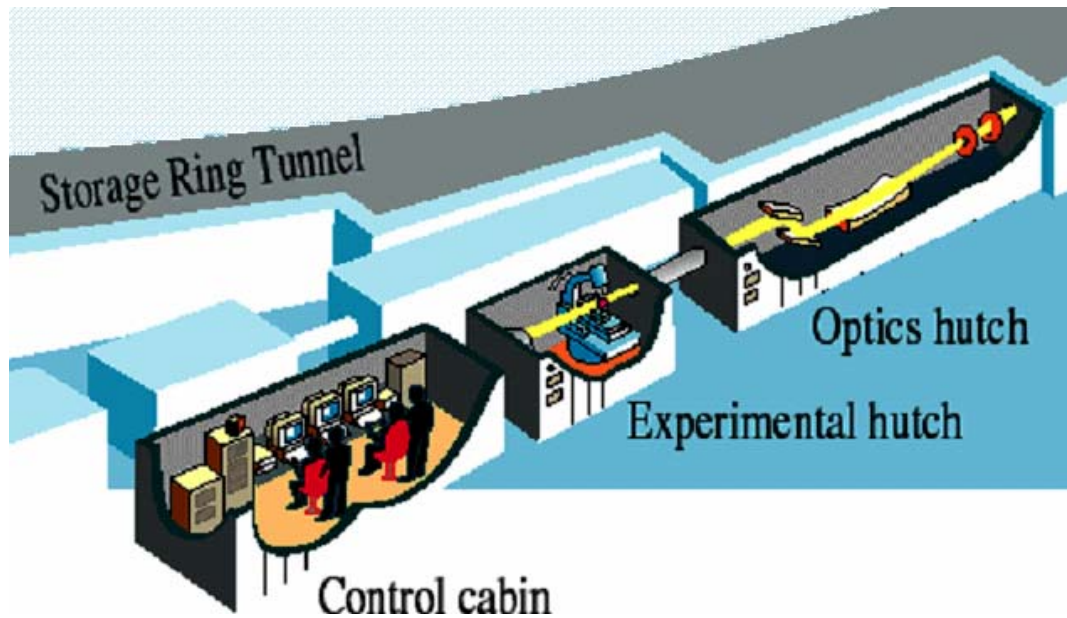


Figure 1: An instrument at an international facility (ESRF, France)

commonly available two party face-to-face video conferencing along with limited drawing board capabilities (via MSN or Yahoo! Messenger) may allow certain aspects of the experiment to be discussed, high quality video from more than one video feed (camera) is often required allowing the remote site (i.e. supervisor) to clearly appreciate the experiments going on inside the experimental hutch. Besides, discussions centred on the experimental results require more than just simple drawing board displays, but ideally require shared customised analysis applications (2D and 3D visualisation) and must be capable of handling the transmission of reasonably large file sizes. It is therefore, preferable to allow the various participants to log-into a shared server which hosts the required applications to support common analysis and discussions. Experimental thinking time is precious and so interaction infrastructures must be slim-line, natural and unobtrusive to gain wide-spread acceptance. This is of course balanced by the need and availability of communications bandwidth especially for users participating from domestic/home situations away from the host university.

2. Need for Advanced Collaborative Tools

It is common that different types of experiments are undertaken on the same component each involving sophisticated and demanding data analysis. Increasingly, the components are

complex (e.g. wide-chord fan blades from aircraft jet engine); each instrument at each experimental site has different measurement geometries, data acquisition and control systems, etc. Measurements are often undertaken using the laboratory frame, and the co-registration of data from different scans or instruments is very difficult [1]. This is especially important when data sets must be accurately combined, for example, at least 3 strains are required to calculate stress at a point. Combining the data is often a major undertaking simply because different co-ordinate systems have been used for the different sets. Furthermore, only rarely can a single experiment provide the complete picture (Figure 2). Carrying out experiments and measurements at different sites and combining them is thus a difficult task. Information is stored in different formats, on separate software using different co-ordinate systems. Data fusion requires the cooperative actions of engineers, materials scientists and instrument scientists at different sites. As a result, opportunities for bringing together results from different measurement techniques from multi-site experiments or remote sites are often missed.

Because large data sets must be processed, reconstructed and analysed, experiments are usually run blind, not just to team members at remote sites, but even to the experimenters on-site. As a result, the opportunity for real experimentation is lost. Ideally all team members should be able to steer the experimental strategy; to identify and focus on

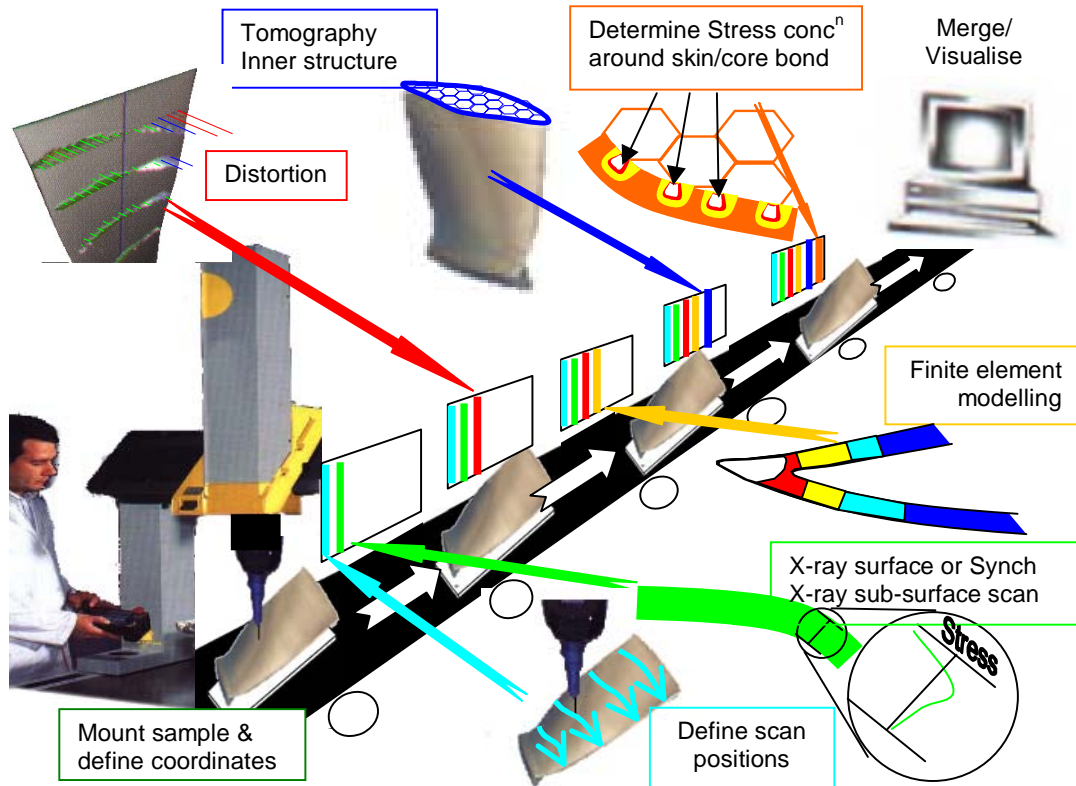


Figure 2: A complete experimental process on a single sample

regions of interest, to modify the conditions (loads, temperatures, etc), or to compare the results currently being acquired with complementary archived data.

With the analysis tools now available through an earlier EPSRC-funded Engineering Body Scanner project (GR/R38774/01); this provided all the site-specific sample registration, compilation, reconstruction and co-visualisation tools. At last year All-Hands Meeting 2004, we presented progress towards a grid enabled Engineering Body Scanner (EBS) project [2]. This project, Integrated and Steering of Multi-site Experiments for Engineering Body Scanner (ISME) is now funded as part of the JISC-VRE Programme. It commenced in November-2004 with the aim of integrating and refining these tools into a VRE to make them deployable by teams of instrument scientists, material scientists and engineers in a transparent and robust manner. It is helping to extend the culture and functionality of collaborative multi-site experiments.

Whilst this project is partly concerned with the technicalities of VRE-based development, the main focus is very much on the end-user engineering community and the usability of the developed VRE. Consequently it is end user led and focuses on lightweight unobtrusive

structures. Lessons learnt from applying these VRE tools to this specific focused group will have benefits for the wider science base using International User Facilities and further a field in other application domains.

The project targets two problems,

- the need for a mechanism/medium for experiment steering, to discuss progress, modify strategies, and to train and instruct students
- the need for a mechanism/medium for collaboratively analysing data and making available archival data collected elsewhere for immediate side-by-side comparisons

These two themes require separate, but connected, approaches. The latter can be viewed as “software interaction” under a Data Management Function, and the former “human interaction” to achieve a Strategic Experimental Steering Function.

The “human interaction” aspects are being pursued via the provision of Access Grid (AG) functionality at the remote sites while the “software interaction” activities involve embedding our previous developed EBS software within a portal service framework using toolsets such as GridSphere [3].

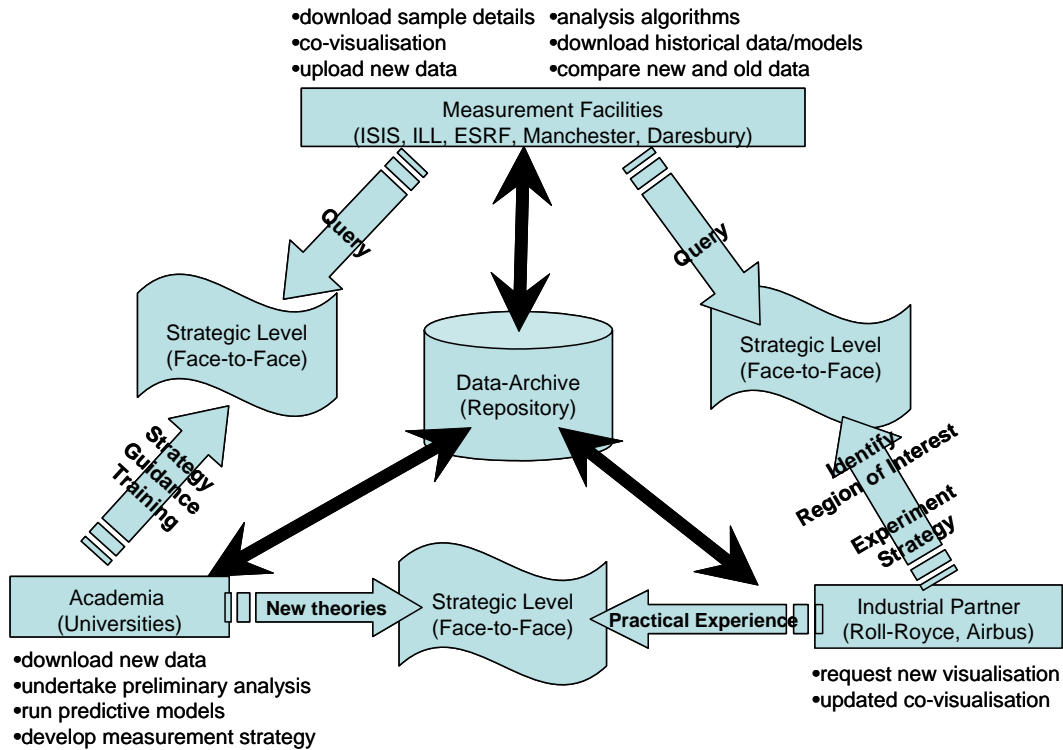


Figure 3: Schematic of the Strategic (large arrows) and Data Management (black) Pathways within the VRE

3. Experimental Steering Function (User to User)

Stress measurement often takes place at a remote experiment site and expert advice is often needed out-of-office hours. Intelligent discussion, training and steering requires a combination of three modality streams on screen:

- Group-based face to face contact, or at least voice to voice (via Access Grid)
- A shared view of the experimental set-up (using Access Grid)
- A common shared 'tablet' or 'workspace' to visualise results from the Data Management Function

Interactions via the multimedia resource should not be at the meeting room level but at the experimental level, whereby the whole team can 'meet' together bringing their own data, modelling predictions and discuss and develop an evolving experimental strategy with Grid middleware. It must allow student-supervisor interactions as well as analyst-experimenter interactions. Furthermore, this kind of guidance

support may be needed at anytime of the day or night. Due to the cost of instrumental time, the experimental problem must be resolved quickly and efficiently, errors in practical set-ups identified and key decision points resolved. Discussions would involve instrument scientists, the experimental team, project supervisor, modellers, owners of complementary data collected previously on the same component and industrialists with applied interests in the behaviour of the component. Consequently, this task is not one of teleconferencing, but rather a means of involving extended multi-disciplinary groups in the experimental steering process. This may be with regard to experimental set-up, the control of the environment to which the component is subjected (temperature, mechanical loading path, aqueous environment, etc) and the extent and locations of the regions of interest. In this respect the strategy can only be as good as the data on which the decisions have been based. This is the focus of the Data Management Function.

4. Data Management Function (User to Hub)

Some logistical problems only become apparent when the experimenter tries to sample on the instrument; these problems could be avoided or minimised by a virtual dry-run ahead of time. Once the experiment has begun the software required to assimilate the data can often not be run at the workcell, or remote facility (Figure 1) usually because of computing, software or time constraints. Only rarely is it possible to compare results with those collected previously elsewhere. As a consequence a picture of the quality and significance of the data is often not available until the scientist returns to their home institution and post-processes the collected data. Exciting pathways for the experiment are missed; key questions remain unresolved or worse of all mistakes made which invalidate the gigabytes of data collected.

Discussions at this point, with project supervisors, and potentially industrial engineers with live data analysed available to all, as well as complementary data previously collected will add real value to the experiments. With the whole database and all the analysis tools of the EBS project available to all members of the team, intelligent strategies can be devised. In effect all the collaborators will have opportunities to access and analyse the data and hence to offer their opinions on the particular measurement strategy. As a result the onus for experimentation and analysis can be more evenly shared amongst the group and a wider, multidisciplinary view brought to bear on the experiment. Hence the learning process for the PhD students can be much steeper and deeper. Of course access to these tools would not stop at the conclusion of an experimental phase; all the team would be able to continue to analyse, make presentations and share ideas after the experiment had finished.

Within the previous EBS project the appropriate software tools for material scientists and engineers have already been developed to assist them conduct physical experiments on large scale instruments, numerical modelling and to gain efficiencies and scientific insight. Although these tools have been disseminated to other groups at present they operate in a discrete unconnected manner. We will grid enable:

- Virtual running of experiment prior to travel
- Automated set-up and component mounting Access to data processing suite

(local or remote, using a variety of in-house and commercial codes)

- Data recording and archiving
- Download & uploading of data & analysis
- Visualization (either using local or remote resources and collaborative, 1D, 2D, 3D and 4D)
- Data co-registration & co-visualisation
- Presentation and interrogation of assimilated 3D data at remote sites (includes industry sites)

We aim to extend our present ontology to support the more complex workflows and interactions that need to take place in our multidisciplinary teams. It is envisaged that this will lead to a cultural change in the way experiments are undertaken. Most importantly, it will allow the experimenter to regain the initiative. Moving away from pre-determined experimental sequences to interactive experiments, in which developments are monitored during the experiment and strategies modified accordingly.

As noted from previous JISC supported projects, there are many software toolkits available from which to construct a VRE. This project will tailor these toolkits for the use for multi-site engineering experiments. The project will investigate the use of various common web portals to allow the VRE project to deploy the EBS toolkit at multiple sites.

5. Collaborative Tools to Use

For the Experimental Steering Function we have trialled Access Grid, focusing primarily on how best to configure it to optimise HCI and usability. To this end we have established our own 'virtual venue'. Due to the nature of our experiments and cost implications it is deemed more appropriate to use Access Grid predominantly on a computer with good quality webcam rather than non-portable traditional Access Grid studios. This is because firstly, for the experimenter, involvement must be seamless with the practical experimental function and secondly, because academics may need to enter into dialogue at home at unsociable hours. This necessitates the use of basic computing infrastructure. Connectivity between the two Functionalities will be achieved through the use of a shared virtual screen ("Shared Workspace") on which data analysed in the Data Functionality can be viewed on the web portal through the use of a standard web browser.

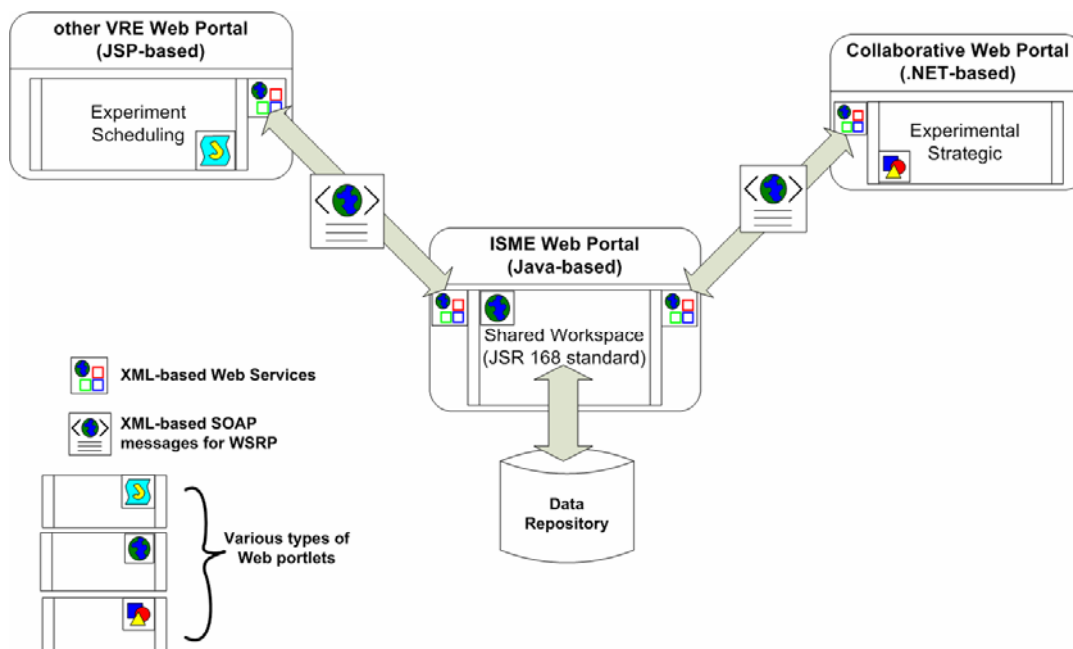


Figure 4: Integration of portlets within ISME Portal with web portals of others

JSR 168 Compliant Web Portals

Whilst the web portal concept can act as an efficient medium for our “Shared Workspace” (discussion), to download/upload information (achieving/restore) or even to retrieve previous experiment strategic (playback virtual running experiments), it is imperative that our web portal conform to a standard to allow efficient ways to deploy, share and even reuse portlets from various other VRE projects. It came to our attention that JSR 168 is a Java Specification Request (JSR) that establishes a standard API for creating portlets. One of our web portal choices, GridSphere is based on previous experience gained by our close project collaborators, the WeSC (Welsh e-Science) team, has been developed in close conformance to the JSR 168 standards. This brings benefits of interoperability achieved by standardisation between various web portal services. In general, it means that it brings the benefits that portlets developed from our web portal efforts are portable and could be deployed by other web portals associated with other VRE projects, and this standardization furthermore simplifies upgrading existing systems, as well as developing new ones.

Non-JSR 168 Compliant Web Portlets

With JSR 168 compliant web portlets able to plug directly into any Java-based portal framework, developers still need to source the portlet and run it locally on their web portal framework. In addition the ‘plug-n-play’

concept means that the portlets between web portals should also conform towards a non-Java-based portal framework or even non JSR 168 compliant web portals. It has been proven that .NET, a language independent API library for building web-based ASP.NET web portals (e.g. Open-source VB.NET-based DotNetNuke, C#-based Rainbow Web Portal or even forthcoming ASP.NET 2.0 Web Portal) can run on both Windows and Linux open source web servers (Apache with Mono plug-in). Furthermore, web portals such as the Sakai portal [4] which has achieved a certain level of maturity but is not JSR 168 compliant can be explored and exploited within our VRE project.

WSRP Web Portlets

While XML-based web services have been used in different API platforms to transfer data between them, a new concept, Web Service for Remote Portlets (WSRP) allows portlets to be exposed as Web services [5]. The resulting Web service will be user-facing and interactive among different web portals. Prior to the WSRP concept, even with JSR 168 compliant portlets, there was no concept of being able to access a remote portlet as if it was a local portlet. Portlets needed to be physically installed at a local web portal. As a result of this architectural limitation, enterprises wanting to bring remote content into their own portal typically faced a significant programming effort. They ended up having to run a portlet locally in their own portal infrastructure, which

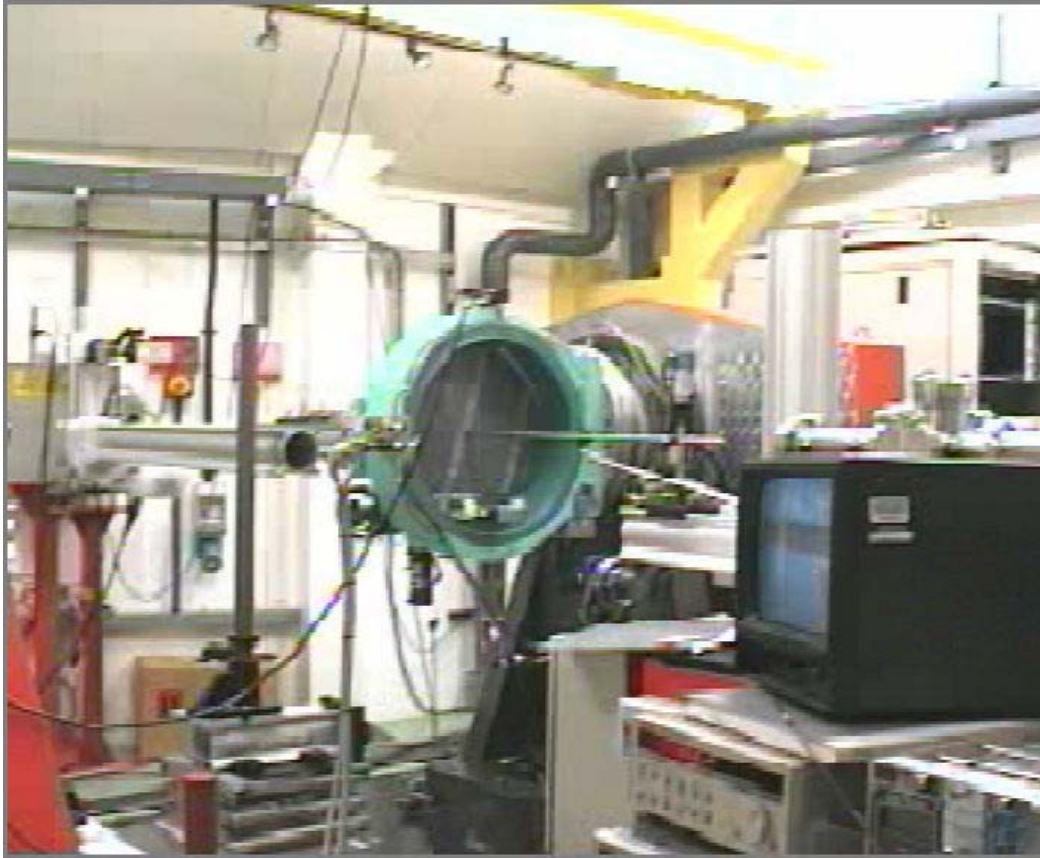


Figure 5: Daresbury experimental hutch viewed from an AG node.

often required a painful development and integration effort involving the redevelopment of a presentation layer. Unlike traditional Web services though, Web services for remote portals will carry both application and presentation logic that can be displayed by a consuming portal. To the end user, remote portlets will look like and interact with the user just as local portlets would.

When JSR 168 portlets can be deployed to any JSR 168 portal, these portlets are local to the portal itself. On the other hand, portlets exposed as Web services (using WSRP) run remote to the portal. They may or may not be JSR 168 compliant portlets. Our “Shared Workspace” JSR 168 portlets can be exposed as pluggable Web services for other portals to consume. The overall design architecture of the ISME web portal is shown in Figure 4. The consuming portal interacts with the remote portal service through a firewall proxy since it uses as a HTTP-based XML Web Services. Since we are still deploying it as Web services, we get the added benefit of being able to deploy our remote portlets in any programming language (.NET or any not JSR 168 compliant

Web Portal), given that the interface laws are laid down by the XML-based Web Service Description Language (WSDL) interface description. It is therefore, the job of a remote portlet Web service to deliver HTML, XML, or any content an end portal client might expect.

6. Access Grid Trial

For the Experimental Steering Function we have begun to trial Access Grid (AG) between Manchester Materials, The Daresbury Laboratory (Figure 5) and Cardiff University, focusing primarily on how best to configure it to optimise HCI and usability. The connectivity between the above two aspects of the problem mentioned in section 2, will be achieved through the use of a shared virtual screen on which data analysed in the Data Functionality can be viewed on the AG portal.

During this first phase of the AG configuration, the project has compared two AG software toolkits; inSORS and AGToolkit. inSORS [6] is commercial-ware having better usability to initiate from the web-based interface, whilst AGToolkit [7], an open source

toolkit, presently lacks user friendly features in its Windows-Python based interface which also can prolong the training for new users and impacts negatively on the familiarity and usability of the AG software.

Both software toolkits have been developed assuming normal office working environments. However when PIGs are deployed in experimental hutches there is often considerable background noise. In our first experiments conducted in Station 16.3 at Daresbury Laboratories, the inSORS toolkit failed to filter this background noise to an acceptable level, whereas the AGToolkit using RAT (Robust Audio Tool) appeared to cope well. In these experimental settings we are therefore presented with a greater challenge when choosing AG software capable of delivering good quality of video and audio in noisy science laboratory environments.

7. Future Work

At this stage of the project, we have developed a preliminary version of our “Shared Workspace” based on WSRP (shown in Figure 4) on using GridSphere web portal to be consumed in .NET-based web portals. Virtual Research Environments (VREs) are a relatively new technology especially in materials sciences field and we will collaborate closely with a wide-range of material scientists to determine an ontology and a workflow model. Our present work in this area has highlighted different terminology used at different experimental centres and we had planned to extend the work, which has been developed at ISIS using the XML file format using more sophisticated tools. We are looking into the potential of working with other VRE projects to embed certain advanced features (as part of our WSRP pluggable web portlet) such as Access Grid Recording Sections, Memetic [8] from Manchester Computing. In the future we will perform some usability studies using different experimental case studies to determine the potential of the project.

We are still at the initial stage of the project, however, at this year’s All-Hands Meeting we will present and demonstrate our first phase VRE featuring a prototype grid portal implementation of the “Shared Workspace” using WSRP and report our experiences involving AG deployment at the remote experimental sites.

8. References

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