VRE for the Integrative Biology Research Consortium (IB VRE)

Introduction

Project Overview

This proposal requests funding to develop a large-scale Virtual Research Environment (VRE) demonstrator to investigate the utility of existing collaboration frameworks to support the entire research process of a large-scale, international research consortium - the EPSRC-funded Integrative Biology (IB) e-Science Pilot Project. This project requires a rich and complex environment, demanding a very comprehensive range of research-support and grid-enabled tools and services. Hence, it provides an ideal test-bed for evaluating and developing existing and planned VRE middleware. The project will take as its starting point the Sakai open source and open standards portal framework, and will incorporate the wide range of tools and services required to support the chosen research community, including Grid-based tools and services from the OGCE project, and from a wide range of existing UK JISC and e-Science projects.

The key deliverables from the project will be: (1) a robust integrated VRE demonstrator supporting the work of a major multi- and inter-disciplinary research consortium at the interface between the physical and the life sciences; (2) detailed reports on the requirements, specification, design, and implementation stages of the development of a fully-functioning VRE to support this leading international research community; and (3) detailed evaluation studies based on extensive user- and developer-experience of the use and extension of existing VRE middleware to support large-scale collaborative research.

The project will form part of a comprehensive IT strategy within the University of Oxford aimed at supporting and promoting large scale collaborative, interdisciplinary and inter-institutional (both national and international) research and learning. This is being achieved through provision and development of a University-wide e-Research, virtual learning and research support infrastructure, and extensive participation in national and international developments in these areas.

Integrative Biology Project Background and Utility as a Test-bed for a VRE

The Integrative Biology (IB) project is a second-round EPSRC e-Science Pilot project which commenced in February 2004. It received initial funding of £2.4M to support the research of nine post-doctoral researchers, and to provide training for 10 PhD students1, across seven UK Institutions (the Universities of Oxford, Nottingham, Leeds, UCL, Birmingham and Sheffield, and CCLRC), IBM, and the University of Auckland (see section D for further details of project partners). Interest in the project is such that this has already been extended to several further experimental groups both within the UK and overseas (see section D). These researchers are currently drawn from a wide range of disciplines (including computer science, mathematics, medical engineering, biophysics, biochemistry, physiology, genetics and several areas of clinical medicine).

The primary aim of the IB project is the development of the Grid Infrastructure required to support post-genomic research in integrative biology. Integrative or systems approaches to research in biology are evolving very rapidly, driven by a pressing need to understand how the components that make up a biological system interact across multiple spatial and temporal scales to allow biological function to emerge, and to express that understanding in quantitative terms. It is now widely accepted that this can only be achieved by an iterative interplay between experimental data (both in vitro and in vivo), mathematical modelling, and computer simulation. The IB project is building the IT infrastructure to support this cycle: from experimental data, through the model-building process and HPC-enabled simulation, to experimental and simulation data capture, storage and analysis, and on to model validation and the subsequent design of new wet lab and in-silico experiments. This infrastructure is being built using a service-oriented Grid architecture, and is utilising many of the middleware developments within the UK e-Science Programme and in the wider Grid community, and within the JISC Middleware programmes.

The requirements for the Grid middleware development are being determined by considering the needs of two clinical areas, cardiovascular disease and cancer, which together account for over 60% of all UK deaths. Internationally leading experimental groups in each of these areas are members of our consortium. These application areas are complementary in terms both of modelling - each involves multiscale modelling of a complex biological system - and in terms of the required Grid infrastructure. Since the modelling of complex systems has become a priority area across the physical and life sciences, the generic Grid infrastructure that we propose to develop should also serve as a blueprint for a wide range of application areas.

Contribution to the needs of the Community

Initial research within the IB project has focused on developing a set of early demonstrators to evaluate the utility of existing tools and services developed by first-round e-Science projects to meet the aims of this diverse research project. The project will form part of a comprehensive IT strategy within the University of Oxford aimed at supporting and promoting large scale collaborative, interdisciplinary and inter-institutional (both national and international) research and learning. This is being achieved through provision and development of a University-wide e-Research, virtual learning and research support infrastructure, and extensive participation in national and international developments in these areas.

The key deliverables from the project will be: (1) a robust integrated VRE demonstrator supporting the work of a major multi- and inter-disciplinary research consortium at the interface between the physical and the life sciences; (2) detailed reports on the requirements, specification, design, and implementation stages of the development of a fully-functioning VRE to support this leading international research community; and (3) detailed evaluation studies based on extensive user- and developer-experience of the use and extension of existing VRE middleware to support large-scale collaborative research.

The project will form part of a comprehensive IT strategy within the University of Oxford aimed at supporting and promoting large scale collaborative, interdisciplinary and inter-institutional (both national and international) research and learning. This is being achieved through provision and development of a University-wide e-Research, virtual learning and research support infrastructure, and extensive participation in national and international developments in these areas.

Integrative Biology Project Background and Utility as a Test-bed for a VRE

The Integrative Biology (IB) project is a second-round EPSRC e-Science Pilot project which commenced in February 2004. It received initial funding of £2.4M to support the research of nine post-doctoral researchers, and to provide training for 10 PhD students1, across seven UK Institutions (the Universities of Oxford, Nottingham, Leeds, UCL, Birmingham and Sheffield, and CCLRC), IBM, and the University of Auckland (see section D for further details of project partners). Interest in the project is such that this has already been extended to several further experimental groups both within the UK and overseas (see section D). These researchers are currently drawn from a wide range of disciplines (including computer science, mathematics, medical engineering, biophysics, biochemistry, physiology, genetics and several areas of clinical medicine).

The primary aim of the IB project is the development of the Grid Infrastructure required to support post-genomic research in integrative biology. Integrative or systems approaches to research in biology are evolving very rapidly, driven by a pressing need to understand how the components that make up a biological system interact across multiple spatial and temporal scales to allow biological function to emerge, and to express that understanding in quantitative terms. It is now widely accepted that this can only be achieved by an iterative interplay between experimental data (both in vitro and in vivo), mathematical modelling, and computer simulation. The IB project is building the IT infrastructure to support this cycle: from experimental data, through the model-building process and HPC-enabled simulation, to experimental and simulation data capture, storage and analysis, and on to model validation and the subsequent design of new wet lab and in-silico experiments. This infrastructure is being built using a service-oriented Grid architecture, and is utilising many of the middleware developments within the UK e-Science Programme and in the wider Grid community, and within the JISC Middleware programmes.

The requirements for the Grid middleware development are being determined by considering the needs of two clinical areas, cardiovascular disease and cancer, which together account for over 60% of all UK deaths. Internationally leading experimental groups in each of these areas are members of our consortium. These application areas are complementary in terms both of modelling - each involves multiscale modelling of a complex biological system - and in terms of the required Grid infrastructure. Since the modelling of complex systems has become a priority area across the physical and life sciences, the generic Grid infrastructure that we propose to develop should also serve as a blueprint for a wide range of application areas.

Contribution to the needs of the Community

Initial research within the IB project has focused on developing a set of early demonstrators to evaluate the utility of existing tools and services developed by first-round e-Science projects to meet the aims of this diverse research

1 Training will be provided at the EPSRC-funded Life Sciences Interface Doctoral Training Centre (DTC) at the University of Oxford, see http://www.lsi.ox.ac.uk. The DTC provides a comprehensive four-year training and research programme leading to a D.Phil which enables physical sciences graduates to obtain the skills necessary to work in leading research projects at the interface with the life sciences. Several new modules are in development as part of the IB project. All teaching is underpinned by comprehensive on-line learning support tools, including provision of a VLE (currently Bodington).
community, and to act as a basis for the requirements gathering process. A range of user-interfaces to these tools are utilised, with the longer-term intention of developing a suitable Grid portal to the underlying infrastructure, leveraging extensive experience at CCLRC. However, as outlined above, the IB architecture provides an ideal test-bed for development of a comprehensive VRE to support a very large-scale, complex research project undertaken by a geographically distributed and interdisciplinary community. This project therefore aims to provide to the IB community a single, integrated environment to support the entire research process from experimental and simulated data generation, acquisition, analysis and curation, through access to IT, HPC and experimental resources, to project management, administration, and learning and teaching support tools. The distributed and collaborative nature of all of the research undertaken by this community ensures that there is widespread support (see details of the IB consortium in section D) for this project which aims to meet the pressing need for a comprehensive and integrated environment to support their research programme.

Project description

Project Summary

It is proposed to extend the IB infrastructure to become a Virtual Research Environment. This VRE will focus on support for the "research process" - accessing, managing and combining facilities provided by the IB and other projects in order to achieve their research objectives (in the widest sense of objectives, including identification of research area, building and managing projects and consortia, disseminating results, and provision of training to new researchers entering the field). The main objective of this proposal is to evaluate the utility of current generation VRE technologies, and extensions to those technologies developed through this and other current programmes, to extend this Grid infrastructure to achieve this aim of supporting the entire research process of this geographically distributed and interdisciplinary research community.

Proposed Framework

The Roadmap document (http://www.jisc.ac.uk/uploaded_documents/VRE%20roadmap%20v4.pdf) produced for this call defines a VRE as "a set of applications, services and resources integrated by a standards-based, service-oriented framework which will be populated by the research and IT communities working in partnership", reflecting existing plans for the IB architecture and component tools and technologies. However, as pointed out later in the Roadmap document, this definition must be extended if it is support a usable VRE to include one of the key factors in any IT infrastructure – it must seamlessly integrate and support the pattern of work demanded by the domain and which is familiar to the users. In other words, it must support the “research process” in which the user is engaged. The IB project is engaged in developing a range of Grid-based services and facilities for its user communities and will provide direct support for the “in-silico” experiment process. This process support will provide tools to allow the user to compose the necessary set of required services to achieve the objectives of the experiment. The proposed VRE will extend this support to encompass the entire “research process” allowing the user to compose and manage underlying services to streamline and enhance the research cycle undertaken by this community of researchers.

Building a VRE requires three distinct activities: collecting suitable tools; ensuring these tools inter-operate; and providing a tool management (or process support) layer. To achieve our goal we will require a suitable implementation framework to provide the necessary interfacing and interworking between the component tools. Such a framework must be portable across all major platforms, comply to the emerging standards in the VLE and VRE communities, be extensible, have an appropriate level of built-in functionality, ideally be open source, and meet the usual generic middleware requirements of being reliable, scalable, adaptable and so on (see JISC Technical Review by Bill Oliver, June 2004 available at http://www.jisc.ac.uk/index.cfm?name=programme_vre). Following discussions with the authors of the JISC-funded evaluation report of the Sakai framework for a VRE (see http://lardis.dl.ac.uk/ReDReSS/sakai.pdf), we will take as our starting point the Sakai environment to provide the initial underlying VRE infrastructure. The Sakai infrastructure provides a comprehensive suite of collaboration tools (see http://sakaiproject.org/presentations/UM_SakaiTalk_1-15-04.ppt for detailed examples) to support diary, interactive working, and e-mail, amongst many others. Since it is a collaborative project between four US HE institutions (Michigan, Indiana, MIT and Stanford) together with the uPortal Initiative (http://www.uportal.org) and the Open Knowledge Initiative (OKI) (see http://web.mit.edu/oki/), it is committed to producing open source software to support the development of collaboration and learning environments. This approach is predicated upon an underlying service-based architecture, and is strongly committed to the use of the WSRP (Web Services for Remote Portlets) and JSR168 (Java Specification Request) standards. Since the IB project has also adopted a service-based architecture, this will allow the component application tools to be readily incorporated into the VRE framework. In the Annex we list these application-specific tools and services that will be provided through the IB project, to support the chosen research community. These tools will be further supplemented by incorporation of relevant Grid-based tools and services from the current round of UK e-Science projects, the OGCE project (see http://www.collab-ogce.org/nmi/index.jsp), and from a wide range of existing UK JISC Middleware2. A key, and innovative, part of this proposal is the support provided for the "research process": one of the central facilities of a VRE must be the ability to capture and reuse processes. In an IB “in-silico experiment”, the process takes the form of workflows, and, working with the myGrid project, we are developing tools to allow this workflow information,

---

2 For example, current JISC projects involving development work in Oxford include the DCOCE, ESPGrid, SPIE, and MDC projects (see http://www.jisc.ac.uk/index.cfm?name=programme_middleware#CMI).

2 For example, current JISC projects involving development work in Oxford include the DCOCE, ESPGrid, SPIE, and MDC projects (see http://www.jisc.ac.uk/index.cfm?name=programme_middleware#CMI).
including provenance, to be saved, and that allow this information to be annotated, categorized and retrieved for reuse.
In addition we are also capturing outcome information – was the workflow successful or not? This body of information is
important because the knowledge of the experimental process is itself used to interpret and validate the results
obtained. However, by capturing the workflow information we can also allow new users, or users with new
requirements, to build upon a knowledge base of previous workflows. Coupled with an intelligent scoring or
recommendation system based on machine learning techniques (such as those being developed within the e-DiaMoND
project in Oxford, see http://web.comlab.ox.ac.uk/oucl/research/areas/softeng/eWLM/), these captured workflows can
therefore be used to represent best practice, and used either as the basis for future experiments (perhaps undertaken
by less expert users), or as part of a collaborative or learning environment where colleagues or new researchers can
learn by observation and re-enactment. We will evaluate within this proposed project the utility of implementing such a
workflow layer over a service-oriented architecture in facilitating job-composition by less IT-literate members of the
research community within a VRE.

Proposed Architecture
In extending the service oriented IB infrastructure, the proposed VRE will adopt a layered or tiered architectural
framework: presentation; front end; business logic; and resources. This is illustrated in the following diagram.

![Proposed Architecture Diagram]

**Presentation layer:** The user client must be lightweight, ideally just a web browser. However early experience within
the IB project suggests that some of the more sophisticated user interface capabilities, in particular interactive
visualization of complex result sets, will demand additional client-side assistance. In addition, personalisation and
scaling requirements may also require client-side assistance. This assistance must not be mandatory (ie users should
be able to access and exploit the core VRE functionality with only a web browser). Behind the user client will be a portal
server running on the IB infrastructure and providing access via coordinated portlets to the underlying facilities/services.

**Front end layer:** IB portlets, also running on the IB infrastructure, provide access to the core IB functionality: Resource
Location, Job Composition, Job Submission, Computational Steering, Data Management (inputs and results), and
Visualization. In addition, a Workflow portlet allows the user to merge and manage this functionality in terms of
coherent in-silico experiments. (One of the key highlights of the IB system is capture of the workflow underlying the
experiment, together with other automatically gathered metadata to provide full provenance information attached to the
experimental results). To this set will be added Portlets giving access to the extended range of domain-specific
functionality described in the Annex.

**Business logic:** Behind the portlets are the underlying services. These can be internally layered in three strata, the
coordination/orchestration layer, the functional services layer, and the base service layer. The latter services provide
direct access to the computational and data resources, and will generally be hosted remotely. The middle layer
aggregates and presents these as functional services relevant to and understandable by the user. Most of the work of
the system occurs in this layer and the user interacts directly with these services via their portlets and the portal. The
upper layer helps the user manage these functional services, i.e. it supports the “experimental process”. It is in this
layer that the major work of creating the VRE will lie, moving the process support up from managing jobs to managing
the user’s research environment.

**Resource layer:** The underlying resources in IB are computational, modelling and data storage systems (see Annex).
Through the VRE, many other resources will be made available. In particular, access to published and unpublished
information (such as e-journals, e-print archives and raw data archives), project management tools (including project
wikis and code repositories), Personal Information Management tools (diaries, contact lists, task management, etc), conference and messaging management, and teaching learning tools will be supported. In addition the project will include tools for managing and tracking the development process including project management and administration tools, and bug tracking and enhancement request tools, i.e. our aim is that as it is developed VRE functionality will itself be used to maintain and develop both the VRE.

**Security:** We will make use of the underlying IB security infrastructure. The security layer will be provided through the IB security work package which is closely monitoring the work being carried out under the recent JISC security call. This work is being led by Dr Andrew Martin, who is playing a leading role within the e-Science Security task force. As stated above (see footnote 2), Oxford developers are also playing a leading role in the JISC Middleware Programme including the DCOCE, SPIE and ESPGrid projects.

**Underpinning Technologies and Components**

The IB Portlets described within the above diagram will be written to conform to the WSRP 1.x standard (Web Services for Remote Portlets) where possible to ensure that the tools can be deployed within a portlet-based VRE environment. The initial development and testing environment will be based on the Sakai framework and the project will re-use tools already developed for the Sakai framework where appropriate, as well as making use of planned tools (for example workflow management). Where limitations with the WSRP standard are identified which may hinder the types of tools needed by the IB project, the requirements will be presented to the OASIS WSRP Technical Committee for discussions for inclusion within the WSRP 2.0 standard. Where the development environment is based on Java, the IB Portlets will be written to conform to the JSR-168 Java Portlet API standard, and exposed as WSRP via the JSR-168/WSRP producer in the Apache WSRP4J project.

Overall, the VRE framework is illustrated in the following diagram. Tools are located via a local or central registry (for example using the Web Service for Remote Portlets – Publish, Find, Bind profile). Tools expose their functionality to the end user through a portal interface using a standard Portlet interface such as WSRP or JSR-168. Authentication will be handled via an authorisation framework such as Shibboleth and PKI (Public Key Infrastructure).

The Sakai framework provides such an infrastructure as well as some of the generic tools applicable for a VRE. However by developing tools which can be exposed via WSRP, the VRE will be accessible through any WSRP compliant framework. The IB VRE portlets will require the following components:

- Ability to represent processes and information in both graphical formats (for end users) and textual machine readable formats (for computer interpretation and execution)
- Ability to create, locate, interact and control background processes
- Workflow creation and management (working closely with the Sakai development of these tools)
- Component discovery (working with the WSRP-PFB – WSRP Publish Find Bind – Profile)

The IB VRE will work closely with projects already investigating security frameworks within a portal/WSRP context within the JISC Middleware Programme such as the SPIE Project lead by Oxford University. It will also work closely with other VRE projects developing security infrastructures. The Research Technologies Service within OUCS (see section D) is already working closely with related portal based VLE projects such as the MDC project, and this will allow integration of learning tools (see footnote on page 1) into the IB VRE.

---

3 The project will have representation on this Committee through Matthew Dovey (see section E).
Example of User Interaction with the VRE

An example of user interaction with the VRE might be as follows. User logs into the VRE through a single, secure sign-on, gaining access to all tools and resources to which he/she is authorised. User checks e-mail and diary. User sets up a new in-silico experiment to look at a possible mechanism for the initiation of arrhythmias in a 3D model of the whole heart by editing an existing workflow with the aid of intelligent workflow support tools. User submits workflow, and the IB infrastructure then initiates a job on remote HPC facility, together with steering, visualisation and data management client. User, waiting for results to be generated, edits on-line teaching material on VLE (via VRE). User notified that interim results are ready for visualisation, and contacts colleague in United States via instant messaging to initiate collaborative visualisation and steering session making use of AccessGrid. Pattern of working continues, alternating between interactive monitoring and control of simulation, and other tasks, all supported by VRE tools. Job completes and all relevant simulated data, provenance data, and metadata are securely stored at a remote storage facility.

Annex: Integrative Biology Architecture, Tools and Services

The IB infrastructure is based on a Service Oriented Architecture, and focussed on sharing resources or access to shared resources. From a software engineering perspective, the project is utilising an object-oriented component-based toolkit to provide a layer of abstraction above our application codes and the middleware (web services) that directs the resource management software.

In developing a distributed, collaborative, computational modelling infrastructure to support in silico experimentation for whole organ models of the heart and cancer, the IB project will develop component tools and Web/Grid services to support the research processes listed below. This toolkit will be incorporated into the VRE Resource Layer, as described in section B. Where these tools are being built upon first round e-Science projects, this is indicated.

1. Implementation of the necessary simulation codes on appropriate platforms, including HPCx, CSAR, the data and compute clusters of the National Grid Service (NGS), the Atlas Data Store at the Rutherford Appleton Laboratory, and a range of local HPC resources.
2. Integration of the different model components, and development of tools to manage execution of the distributed simulations.
3. Development of mechanisms to assimilate experimental and clinical data with simulation results.
4. Development of mathematical modelling tools and services (including incorporation and extension of the Grid-enabled Matlab environment as developed in the GEOIDISE project).
5. Provision of fault-tolerance by regularly checkpointing the simulations during execution. (RealityGrid)
6. Ensuring efficient and secure data transfer, storage and management of the individual datasets produced in each simulation together with a metadata catalogue containing information about all simulations.
7. Analysis and visualisation of the results of the simulations, both individually and comparatively, including exploration of very high dimensional (>50) multi-parameter spaces. (gViz, RealityGrid)
8. Provision of real-time interaction with running simulations so the user can monitor their progress, observe their developing state and to steer the subsequent course of the simulation. (gViz, RealityGrid)
9. Ability to allocate and co-allocate one or several resources, including pre-emptive access to resources in the second case.
10. Management of accounts and authentication across all resources in the testbed, to enable monitoring and migration across the heterogeneous network (networks of workstations, clusters, CSAR and HPCx).
11. Provision of performance control by optimising the deployment of resources in a dynamically varying grid environment (requiring the monitoring of progress and performance-based decision algorithms to utilise efficient checkpoint/restart and the ability to migrate across architectures), and to monitor operational parameters to enable optimisation of performance.
12. Support of advanced reservation and co-allocation of heterogeneous resources to prevent barriers to the routine use of computational steering.
13. Provision of a simple-to-use interface which focuses on the physiological processes involved and can either expose or hide as many of the implementation features as is appropriate for the user’s task.
14. Provision of a comprehensive set of tools to support workflow. (myGrid)
15. Provision of tools to support sharing of the interactive features of the environment and audio/visual communication (e.g. AccessGrid) between researchers at different locations working either concurrently or at different times.

Resources requested

We request resources for three project workers to undertake the workpackages described below.

A senior project officer (SPO) based in the Oxford University Computing Services (OUCS) within the Research Technologies Services (RTS). The RTS already have experience in developing to portal based infrastructures using the WSRP and JSR 168 standards, for example within the Subject Portals Project and the CREE Projects. They also have experience in linking these standards to Virtual Learning Environments through the MDC project. As part of the OUCS five year vision the RTS strategy includes VRE development. The RTS contains the Oxford e-Science Centre (OeSC) (see Section D), and the SPO will report to the OeSC Technical Manager, Matthew Dovey. The SPO will oversee the
management of the project, and have expertise in the development of online support services, and will take responsibility for building the overall VRE infrastructure.

A project officer (PO1) working within the IB project in the Oxford University Computing Laboratory (OUCL) on user requirements analysis, usability and interface design, and system testing and validation. OUCL, through the Software Engineering Programme (SEP), has extensive experience of all stages of system development. OUCL also plays a leading role within the OeSC, providing PIs for the many of the current e-Science projects. The PO1 will report to Andrew Simpson who is an SEP lecturer with extensive e-Science research experience (see section E).

A project officer (PO2) working within the IB project at OUCL and liaising closely with project staff based at CCLRC (Rutherford Appleton Laboratory (RAL)) on incorporation of the IB component toolkit into the VRE, and acquisition and integration of resource layer tools into the VRE. OUCL and CCLRC staff are working very closely together on all Grid and e-Science aspects of the IB project. CCLRC staff have very extensive experience of all aspects of the UK's e-Science Programme. Current or former CCLRC staff involved in the IB project and their roles are outlined in section D. The PO2 will report to the project PI, David Gavaghan, and to the project architect, Damian Mac Randal, who is based at RAL but also spends a large proportion of his time overseeing IB project development at OUCL.

Key Personnel

David Gavaghan is Professor of Computational Biology, Director of the EPSRC-funded Life Sciences Interface Doctoral Training Centre, and Deputy Director of the Oxford e-Science Centre at the University of Oxford. He received his D.Phil in parallel scientific computation from Oxford University in 1991. From 1992-1994 he held the Esme Fairbairn Junior Research Fellowship at New College, Oxford, from 1993-1997 a Wellcome Trust Biomathematics Fellowship, and from 1997-2001 a Medical Research Council Career Development Fellowship. His research interests are in the application of mathematical and computational techniques to problems in the life sciences and associated basic sciences, and he has over 75 publications in refereed journals. He has been fully engaged in the UK e-Science Programme since its commencement, and is the Principal Investigator on both the Integrative Biology EPSRC second-round e-Science Pilot Project and the Grid workload management project, and a co-investigator on the flagship e-DiaMoND project, and the gViz, NeuroGrid, and two EU DataGrid projects.

Andrew Simpson: is a Lecturer in Software Engineering and Associate Director of the Oxford e-Science Centre at the University of Oxford. He received his D.Phil. in Computation from the University of Oxford in 1996. He lectures on the University’s Software Engineering Programme and in that role teaches applied and theoretical software engineering principles to practising software engineers from around the world. His particular specialisms are database design and software specification and design, which fit with his research interests. He is an investigator on the e-DiaMoND, Integrative Biology, Neuro-Grid, and ESLEA (Exploitation of Switched Lightpaths for e-Science Applications) projects.

David Boyd: recently retired from CCLRC where he was the Deputy Director of the e-Science Centre. He is currently employed as a part-time consultant both to the Integrative Biology project and to the UK e-Science Core Programme. He is a member of the JISC Committee for the support of Research, and chaired the recent JISC VRE Working Group. He brings to the project a wealth of experience of all aspects of e-Science and of the application of new technologies in the advancement of research.

Damian Mac Randal (CCLRC) has over 20 year’s experience of research at national and international level in a number of fields including intelligent user interfaces, computer aided design, business process support, ambient computing, web and grid services. He also has experiences in the design and implementation of commercial systems for business process support and web-based e-learning systems. He has been scientific coordinator for several large multinational EU projects and overall coordinator of several national and international research consortia. He is currently involved in several Grid related projects, Grasp and e-LeGE projects funded under IST, the DyCom project funded by JISC and the Integrative Biology eScience pilot and IB-MyGrid best practice projects funded by EPSRC. He is the System Architect for the Integrative Biology project.

Sharon Lloyd is currently the project manager on both the e-DiaMoND and Integrative Biology e-Science projects. She has over 17 years of project management experience of scientific and commercial IT development projects both in the UK and overseas. Her previous posts include Operations Director and European Projects Manager at Integra, and Business Development Manager at Blackwells.

Matthew Dovey. Technical Manager, Oxford E-Science, where he is responsible for technical advisory on GRID and Service Oriented Architectures. He is a member of a number of web service standards committees including the OASIS WSRP and UDDI Technical Committees and the SRW Editorial Board. Mr Dovey is involved in a number of relevant projects within the Research Technology Service at Oxford University including the SPIE and ESP-Grid projects investigating the use of Shibboleth for authentication within portal and GRID frameworks and the CREE and MDC projects developing portal channels for retrieval and teaching.

Paul Jeffreys is currently Director of Oxford University’s Computer Services and Director of the Oxford e-Science Centre (OeSC). Earlier positions held include being Director of the Central Laboratories Research Council’s e-Science Centre, and Head of the Particle Physics Department’s Computing and Resource Management Division at the
Rutherford Appleton Laboratory. He has been very active in the e-Science arena in recent years and has prepared cases which won funds from the Government for both the CCLRC and the Particle Physics and Astronomy Research Council e-Science programmes. He was responsible for taking the UK into the EU framework 5 funded DataGrid project. He set up the OeSC as one of the nodes on the national e-Science Grid. He holds a BSc in Physics, and a PhD in Particle Physics. He is a member of the JISC Committee for Networking, the e-Science core programme Technical Advisory Committee, the e-Science core programme Grid Network Team, two research council e-Science Steering Committees, the Wellcome Bioinformatics Committee, and the PPARC Grid Oversight Committee. He is a professorial fellow at Keble College.