

Future Strategy for Irish Research, Development and Use of Virtual Research Environments

March, 2011

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About this Report:

The OJAX ++ Project is an ongoing exploration of Virtual Research Environments undertaken by the UCD School of Information and Library Studies in collaboration with the UCD School of Computer Science and Informatics. The project was funded by Science Foundation Ireland between September 2007 and February 2011. This report explores future strategy for Irish research, development and use of VREs.

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With special thanks to:

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Glossary:

ADONIS	Access Unifie Donnees et Document Numeriques des Sciences Humaines et Sociales
AICV	Artificial Intelligence and Computer Vision Unit
ANDS	Australian National Data Service
ARCS	Australian Research Collaboration Service
ARDC	Australian Research Data Commons
ASSDA	Australian Social Science Data Archive
BioGrid	Biological General Repository for Interaction Datasets
CeRcH	Center for e-Research in the Humanities
CASL	Complex and Adaptive Systems Laboratory
CERN	European Organisation for Nuclear Research
COIN	Collaboration Infrastructure
CSI	School of Computer Science and Informatics
DEFF	Denmark's Electronic Research Library
DFG	Deutsche Forschungsgemeinschaft
DHO	Digital Humanities Observatory
DRIVER	Digital Repository Infrastructure for European Research
ESF	European Science Foundation
FDI	Federated Data Integrator
FIN	Fishbase Information and Research Group
GUI	Graphical User Interface
HEA	Higher Education Authority
HEI	Higher Education Institutions
HISCO	Historical International Classification of Occupation
IADB	Integrated Archaeological Database
IISH	International Institute of History
INSPIRE	Interactive NASA Space Physics Ionosphere Radio Experiments
IRCHSS	Irish Research Council for Humanities and Social Sciences
JISC	Joint Systems Information Committee
NASA	National Aeronautics and Space Administration
NeCTAR	National e-Research Collaboration Tools and Resources
NCP	National Contact Point
NCRIS	National Collaborative Research Infrastructure Strategy
NDGF	Nordic Data Grid Facility
NDP	National Development Plan
NOTUR	Norwegian Metacenter for Computational Science
NSF	National Science Foundation
OGHAM	Online Group Historical and Archaeological Matrix
PfC	Platforms for Collaboration
RIC	Research Information Center
RIN	Research Information Network
RLUK	Research Libraries UK
SCONNUL	Society of College, National and University Libraries
SIF	Strategic Innovation Fund

SME	Small or Medium Enterprise
SoC	Science of Collaboratories
TCD	Trinity College Dublin
TGE	Tres Grands Equipments
TSR	Technology Sector Research
UCD	University College Dublin
VERA	A Virtual Research Environment for Research in Archaeology
VKS	Virtual Knowledge Studio
VLE	Virtual Learning Environment
VO	Virtual Organisation
VRC	Virtual Research Community
VRE	Virtual Research Environment

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1. Executive Summary:

The latest generation of research, E-Research, is characterised by its collaborative, multi-disciplinary nature, the increasingly large volumes of data it processes and generates, and the sophisticated infrastructure required to support it. This new generation of research requires new tools and technologies to underpin it. Virtual Research Environments (VREs) are evolving to fit these requirements.

VREs are an emerging concept and their definition is still evolving. The most recent definition from The UK Joint Information Systems Committee, states that “The term VRE is now best thought of as shorthand for the tools and technologies needed by researchers to do their research, interact with other researchers (who may come from different disciplines, institutions or even countries) and to make use of resources and technical infrastructure” (JISC, 2010).

This report investigates the future strategy for Irish research, development and use of VREs . It provides an overview of VREs, both locally and internationally and gives the views of experts, stakeholders and strategists. This research was conducted as part of the Science Foundation Ireland (SFI)-funded OJAX ++ Project.

The findings of this report can be summarised as follows:

- Future approaches to VRE development should be modular and phased, with incremental advances based on participatory development and the perpetual beta model.
- It is vital to consider how to build on and incorporate tools that are already used by researchers and how to support not just the technical but also the social aspect of collaborative research.
- There may be opportunities to link to resources already in place (such as Edugate, RiAN) and benefit from those.
- Development will inevitably involve reconciling contractual and data protection issues of cloud computing; the later is identified as a critical area for future research.

- A central issue is that of agreeing on common taxonomies and standards, a process that may find itself driven by collaborative activity.

VRE research, development and use is at a critical juncture, with researchers benefitting from new and increasing numbers of research support tools in online environments, and Irish institutions initiating a move towards cloud service provision. Further research will see efforts to reconcile the technical issues of cloud-based data storage, agreed data standards, along with the political issues of sustainability (funding and support) and advocacy.

2. Introduction:

With the increasing value of collaborative research in academia and in industry, it is important that information systems and services provide an environment for maximum efficiency in the creation, management, sharing and use of information. As the range of collaborative projects grows and research crosses geographical, organisational and disciplinary boundaries, new technologies are required to manage growing volumes of data, enhance work practices and adapt to meet future research challenges. The adoption of e-infrastructure, including advanced information and communications technologies, computer grids or clouds, workflow engines and semantic technologies to facilitate collaboration, represents a new generation of e-research. E-research is a collaborative activity that combines the abilities of distributed groups of researchers in order to achieve research goals that individual researchers or local groups could not hope to accomplish (Voss and Proctor, 2009: 175). As researchers increasingly depend on digital information, so consolidated tools to support collaboration and e-research become increasingly important. Virtual Research Environments represent the relatively novel concept of combining e-infrastructure, e-research, Web 2.0 and semantic web tools to support and enhance e-research and collaboration. Despite their current importance and increasing application in the context of e-research, an established definition of the term 'Virtual Research Environment' (VRE) has only recently begun to emerge. By exploring the VRE landscape locally and internationally along with interviewing experts in the field, stakeholders and strategists, this report, conducted as part of the OJAX ++ Project for Science Foundation Ireland (SFI), seeks to investigate the future strategy for Ireland in research, development and use of VREs.

3. History of the VRE:

The development of VREs has its roots in the earlier development of Virtual Learning Environments (VLEs) and there are some lessons to be drawn from the application, use and pedagogy of VLEs. "The notion of a VRE is based on the older concept of a virtual learning environment (VLE), such as Moodle, Sakai or Blackboard" (Voss and Proctor, 2009:176). While VLE platforms are extensively used to support education in

practice, there is evidence to suggest that the concept of VRE is novel to many researchers. In 2007, over half (50.5%) of UK researchers had never heard of VREs and while a further 31% had heard of VREs, they knew little about them (Brown and Swan, 2007: 54). A small proportion of researchers (13%) say they knew something about VREs but had no direct experience of using one. Just a very few researchers had actual experience of VREs: 1% were involved with developing and testing VREs; and 2% report that they had regularly used a VRE. (Brown and Swan, 2007: 54). While these figures indicate that VRE awareness, development and use was in its infancy in 2007, it is likely to have seen a boost in recent years with the increasing profile of e-research and major funding projects such as the UK's Joint Information Systems Committee (JISC) VRE Programme, the Netherlands-based SURFfoundation Programme and Germany's DFG funding. While the term may have its origins in the concept of a VLE to support e-learning, the VRE itself supports an entirely different type of user, one with more advanced and more complex and often specific research needs. As such, the VRE, by its nature, must be a more flexible and customisable tool. This is reflected in attempts to define the concept.

4. Defining the VRE:

Current dialogue on the definition of the VRE is diverse and offers a platform for further debate. The concept itself is evolving and while the term is increasingly used, it is also often associated with similar terms and occasionally misused, resulting in some ambiguity surrounding the exact definition of a VRE. "Definitions relating to VREs and analogous technologies are fluid and can be vague" (Wusteman, 2009: 170). The UK's Joint Systems Information Committee (JISC) defines a VRE as:

"The term VRE is now best thought of as shorthand for the tools and technologies needed by researchers to do their research, interact with other researchers and to make use of resources and technical infrastructures available both locally and nationally. The term VRE also incorporates the context in which those tools and technologies are used"

(Carusi and Reimer, 2010: 16).

The JISC definition reflects the nature of the VRE, as an evolving concept and at such early stages, being too prescriptive in definition may in fact stifle innovation (Carusi and Reimer 2010:13). Other definitions are similarly fluid and negotiable, emphasising the possibility of incorporating tools to facilitate collaboration and acknowledging the needs of researchers in the digital age:

“The aim of a VRE is to provide an integrated environment that supports the work of a community of collaborating researchers. That is, a VRE brings together previously separate tools needed for conducting the research and for collaboration, support for which is increasingly recognised as an integral aspect of researchers work rather than something that can be added as an afterthought”

(Voss & Proctor, 2009: 176)

The Netherlands based SURF Foundation and US-based Science of Collaboratories Projects refers to a collaboratory, a term often associated with the concept of a Virtual Research Environment:

“Collaboratories are virtual locations where researchers together on data and publish their results, in an ongoing process”

(Doove et al., 2010: 6)

“A collaboratory is a network-based facility and organizational entity that spans distance, supports rich and recurring human interaction oriented to a common research area, fosters contact between researchers who are both known and unknown to each other, and provides access to data sources, artifacts and tools required to accomplish research tasks”

(Science of Collaboratories, 2002)

Bos (2007) identifies a taxonomy of collaboratories, listing virtual learning communities (similar to VLEs) alongside more research orientated technologies such as shared instrument environments, community data systems, virtual communities of practice and distributed research centres. This emphasis on community in collaboration matches the purpose of a VRE. Voss and Proctor (2009: 175) suggest that VREs, collaboratories, cyberenvironments and science gateways can all be described as synonymous.

While the association with collaboratories is the most common among VRE definitions, the often-found correlation to gateways or even portals is somewhat tenuous. For instance, Dunn's (2009:207) explanation of what a VRE is not, citing Google Earth as an example, goes some way to outlining that not all cyberenvironments that pertain to support research can be considered VREs. Although potentially a useful component or tool, Google Earth does not display some of the more important characteristics or features of what Dunn considers a VRE. Notably, Google Earth does not provide a mechanism for managing or authenticating users, any data created by the user remains in the cloud and is not as such their data and finally, the scope of use is considerably broader than would be the case with a VRE. Wusteman also acknowledges misuse of the term, particularly in the increasing tendency to describe a digital library as a VRE or collaboratory and argues that this needs to be guarded against. Despite this misuse, Wusteman contends that as a relatively novel concept, there are cases of other related technologies "such as collaborative (or virtual) research communities, Web 2.0 tools and e-research tools" that "may constitute VREs or may be potential components of a VRE" (2009:170). Wusteman also states that a VRE remains "a young concept and is still making the transition from research product to real-world product" (2009:169). While it is important that the definition of a VRE remains fluid, with scope to organically evolve in conjunction with the technologies, it is equally important to set boundaries and be aware of what a VRE is not.

Despite the contention in defining a VRE, a review of these definitions provides a sense of cohesion as to purpose. The definitions emphasise the importance of access to resources, communication and the provision of tools to support the research process. Research exploring the efficacy and applications of VREs across disciplines often depicts how such a system should function and what types of components it should incorporate. VREs may provide remote access to scientific instruments and software, support interaction among researchers and include digital libraries and data archives and provide storage and retrieval of scientific documents and data. Any one VRE will typically support one or two of these goals (Sonnenwald et al., 2009: 192).

5. The VRE Landscape:

Funding has been central to development and application of the VRE to date, enabling working prototypes and leading to implementation and use of the environments. Funding strategies have fallen into three categories (Carusi and Reimer, 2010: 16). The first are dedicated VRE or similar programmes; the second are programmes which do not explicitly see themselves as promoting VREs as such but where there is an overlap and the third category are programmes that do not target VREs. The UK JISC (Joint Information Systems Committee) programme, along with the Dutch SURFshare programme and German DFG correspond to the first strand of funding.

The UK JISC-coordinated VRE Programme started in 2004 and is now in phase three and to date has included dedicated VRE projects and pilots testing the technologies in real-life settings. The Netherlands-based SURFshare programme, running from 2008-2011, promotes collaboration among higher education institutions on matters relating to ICT for education and research (Carusi and Reimer, 2010: 53). Half funded by Government and half by the institutions themselves, the programme has identified collaboratories as a major theme. To date, projects have included the development and deployment of collaboratories in the humanities and social sciences and the development of a collaboration infrastructure (COIN). The developed infrastructure links collaboration services set up by educational institutions, research organisations, commercial parties and SURFnet, thus enabling them to interact, supporting customised, flexible online collaboration. The DFG (Deutsche Forschungsgemeinschaft) is Germany's largest research funding organisation, with a mission to promote all fields in science and the humanities. The organisation has supported virtual research collaboration since 2000 and issued specific VRE calls in 2008 and 2009, with a view to funding development projects that develop new solutions and transfer projects that apply existing solutions (Carusi and Reimer, 2010, 46).

Ireland's UCD OJAX++ project and TCD Microsoft Softedge partnership also fall into this first category, having received dedicated funding. ADONIS in France and the Nordic Data Grid facility (NorGrid) in Scandinavia are not intended as explicit VRE-like structures but ultimately operate as such. Norgrid ensures that "researchers in Nordic countries can create and participate in computational challenges of scope and size unreachable for the national research groups alone" (NGDF, 2010). Examples of funding strategies in the third category are some of those in Spain and Italy, where high performance computing and e-science resources exist.

An example of a source of VRE-related funding is the US National Science Foundation (NSF) which has funded projects such as the Science of Collaboratories Project. The recent NSF Cyber-infrastructure Programme "fosters the development of a scalable, comprehensive, secure and sustainable cyber-infrastructure that supports potentially transformative research in science and engineering" (NSF, 2010). There is a current call for suitable projects pertaining to the acquisition, development, deployment, sustaining, research, and educational activities necessary to create or enhance current cyber-infrastructure and positively impact science and education, with potential scope for VRE-related projects. The EU Framework 7 Programme is committed to research into VRE-related infrastructure and tools, with a call for tender focussing on Virtual Research Communities projects. VRCs are considered part of the development of e-infrastructures in Europe (Doove et al., 2010: 28). In the thematic area of ICT, key challenges include future and emerging technologies, along with ICT in learning and technology-enhanced learning.

In the UK, the Economic and Social Research Council (ESRC) e-infrastructure project has been responsible for VRE-related funding, as has the UK e-Science Programme. The UK also has a joint Research Libraries UK (RLUK) and Society of College, National and University Libraries (SCONNUL) Scholarly Communications Group, with a more specific SCONNUL task force on e-research to promote related research in the library community. There are also a number of prominent dedicated and related research funded programmes running internationally, worth particular mention, as detailed below.

6. Case Studies:

6.1 BioGrid Australia

The Biological General Repository for Interaction Datasets (BioGrid) is a unique not-for-profit platform to enable life science research teams to access and share genetic and clinical research data across hospitals, research institutes and universities. It facilitates the linking of computers containing research and clinical data in an ethically approved, secure and controlled way, using the Web. “The Australian BioGrid Portal, a support project of the APAC Grid, is a Web portal that aims to provide the biotechnology sector in Australia with ready access to technologies that enable them to perform drug-lead exploration in an efficient and inexpensive manner using grid-based methods” (Gibbens et al., 2005: 2). It was developed with Bio21 Australia, a biomedical biotechnology research cluster supporting collaborative research and funded by the Victoria state Government, in close consultation with researchers (Carusi and Reimer, 2010: 65). The e-research environment enables biologists to perform their experiments through a Web portal and for deployment across the grid. Users access via the Web. The portal is divided into four components: user and project management, experiment composition, experiment execution, and visualisation and analysis (Gibbens et al., 2005: 5). The data is co-located in a virtual repository and can be linked with publicly available research and genetic profiling data. Thousands of records of patient data are record-linked across all the databases and institutions (BioGrid Australia, 2010). Source databases from various institutes are extracted, transformed and loaded nightly to their respective Local Research Repositories. Authorised researchers are then able to query and analyse the data via the Federated Data Integrator (FDI) using SAS enterprise (querying and analysis software) (BioGrid Australia, 2010b). Because of the sensitive nature of the data in a medical environment, the BioGrid designers were forced to pay rigorous attention to ethics and privacy requirements, with participating sites requiring ethics approval to join. The e-research environment also provides Virtual Organisation services to contain information about which resources the biologist has accessed to. The BioGrid also provides accounting and auditing

services to keep a record of what occurs in different experiments. BioGrid is currently expanding to the Australian Cancer Grid for cancer research.

6.2 VERA

The Virtual Environments for Research in Archaeology (VERA) was a joint venture of the School of Systems Engineering and Department of Archaeology University of Reading and the School of Library, Archive and Information Studies, University College London (user testing and analysis). The VERA project facilitated greater collaboration amongst the archaeological researchers, on-site teams and interested Internet community, providing them with the enhanced means of collaborating, collating, manipulating and managing data and information, as well as collective knowledge creation (JISC, 2010b). Funded by JISC Phase II and running from 2007-2009, the project built on the successful JISC VRE 1 project, Silchester Town Life, a research and training excavation of one part of the large Roman town at Silchester. The purpose of the excavation was to trace the site's development from its origins before the Roman Conquest to its abandonment in the fifth century A.D. The environment was populated with the diverse finds from the excavation (JISC, 2010b). Under the first VRE programme, a project called OGHAM (Online Group Historical and Archaeological Matrix) was funded. OGHAM's objectives included to establish full interoperability among datasets, improved real-time on-site data gathering including an assessment of the usefulness of handheld mobile devices and wireless networking, to develop a structured mechanism for classifying thematic Research Domains or Views and to develop a framework for the creation of real-time online conferences involving both on- and off-site project workers and remote specialists. (JISC, 2007b). VERA took the prototype solution produced in VRE I, along with the knowledge and experience gained, and deployed it in a full Portal Framework with portlets. The finds from the excavation had been logged for a decade into an Integrated Archaeological Database (IADB), an online database for managing records, data, archiving and online publication of excavations (Baker et al., 2008: 2). The VERA project investigated the tasks carried out to ascertain how and where technology can be used to facilitate information flow within a dig and to inform the designers of computational tools such as the IADB how it might be adapted to allow

integrated use of the tools in the trench itself. According to the Vera Project Plan, the work within VRE II was to allow greater customisation of the user environment, role-based security, enhanced integration of user tools, reusable components, and greater standards compliance (JISC, 2007).

6.3 TEXTvire

Funded by Phase 3 of the JISC virtual research environment programme and led by researchers at Kings College London, the TEXTvire project is a collaboration between the Centre for eResearch in the Humanities (CeRcH), the University of Sheffield, and the State and University Libraries at Göttingen, Germany (Kings College, 2009). The overall aim of TEXTvire is to support the complete lifecycle of research in e-Humanities textual studies by providing researchers with advanced services to process and analyse research texts that are held in formally managed, metadata-rich institutional repositories (JISC, 2010). The access and analysis of research data is supported by annotation and retrieval technology and will provide services for every step in the digital research lifecycle. TEXTvire builds upon the German TextGrid project, a collaborative environment for textual studies and a cornerstone in the emerging German e-Humanities agenda (JISC, 2010). According to JISC “TEXTvire will adopt, evaluate and expand TextGrid solutions to UK community needs, broadening its community of practice, and bringing together key organisations in the domain of e-Humanities textual studies in the UK. TEXTvire will take pains to embed the VRE within the day-to-day research practices at the institution, and will integrate it fully with institutional repository and data management infrastructures. The project will also interoperate closely with national infrastructures, in the form of the NGS” (JISC, 2010). The project started on 1 April 2009 and will end on 31 March 2011. The main deliverables of TEXTvire will be a working, exemplar VRE for textual scholarship. TEXTvire will be embedded within day-to-day research practices across disciplines at King’s College and interoperate with institutional and national infrastructures (Kings College, 2010).

6.4 DRIVER

The Digital Repository Infrastructure Vision for European Research (DRIVER) enhances the off-line capabilities underlying the DRIVER portal, which currently harvests, aggregates, and curates approximately 700,000 documents from 150 repositories in 20 countries, as well as the on-line services offered to its users (D4Science II, 2010b). The VRE is under development as part of the D4Science II e-infrastructure project, funded by the European Commission's Seventh Framework Programme for Research and Technological Development. The current DRIVER e-infrastructure from which the portal has been built, has neither the hardware nor software to support computationally-intensive or storage-heavy high-value and innovative end-user services (D4Science, 2010b). D4Science-II are creating a VRE supporting such services, including some interoperability services such as meta-data brokerage, data transformations, ontology-based mappings and enhanced publications, potentially linking DRIVER content to other data in the ecosystem. It also plans to incorporate the bibliometric data-mining and metrics-calculation services implemented for INSPIRE to provide more sophisticated information retrieval and personalisation functionality (D4Science II, 2010b)

6.5 eSciDoc

eSciDoc is an e-research environment developed in 2004 by the Max Planck-Institute and FIZ-Karlsruhe and funded by the German Ministry of Education and Research. It is developed specifically for use by scientific and scholarly communities to collaborate globally and across disciplines. The aim of eSciDoc is to ensure open and persistent access to research results and material from scientific institutions and research organisations, whilst also supporting scientific collaboration and interdisciplinary research in future e-science scenarios (eSciDoc, 2010). It utilises open source components where possible and supports open standards and Web 2.0 style mash-ups. It includes a Fedora repository and multi-disciplinary applications are built on top of the infrastructure ensuring it covers a broad range of generic and discipline-specific requirements (eSciDoc, 2010b). Services of the system include a

citation style manager, data acquisition handler, depositing interface, supplicate detection, JSPWiki Adapter, search and export and validation tools (eSciDoc, 2010c). The project was well received upon presentation at the European Conference for Digital Libraries in 2009 and promises advances in openness, modularity and the integration of specific discipline-oriented tools and solutions (Doove et al., 2010: 21).

6.6 Microsoft RIC

The Research Information Centre (RIC) is a virtual research environment framework, jointly developed by Microsoft External Research and the British Library. The first implementation of the RIC focused on the biomedical researcher, leveraging commercial, off-the-shelf software. The purpose of the project is “to support researchers in managing the increasingly complex range of tasks involved in carrying out research. Specifically, to provide structure to the research process, easy access to resources, guidance and tools to manage information assets, along with integrated collaboration services” (Barga et al., 2007: 31). The team modelled the research process as a series of phases or steps, where it is possible to identify and configure each project. A researcher can participate via a web browser and is assumed to be working on a number of projects. The system targets a set of specific design goals, namely to enable collaboration, provide access to rich content via a search query tool, support the publication life cycle, offer personalisation features and provide an architecture for participation. The RIC itself uses the Microsoft Office Sharepoint server and manages access to shared documents, tools, applications, data sets etc. The RIC specifications have also been used in other collaborative environments. In the Netherlands, the “Tales of the Revolt” SURFshare collaborator used the source code but installation was problematic and bugs meant that the project turned to “Plan B”, that of implementing on the basis of standard Sharepoint (Doove et al., 2010: 19). In Ireland’s Trinity College Dublin, Softedge (an Irish SME) and Microsoft have collaborated to build a VRE for Humanities Researchers. It involves the extension of known technologies to bring together existing collaboration, communication, search and social networking technologies. The VRE has been created by enhancing the core RIC framework for use by Humanities Researchers.

6.7 VKS Collaboratory

The Virtual Knowledge Studio (VKS) Collaboratory was designed to facilitate collaboration between the staff and partners of the VKS in the Netherlands. Logistically, the team of researchers at Amsterdam, Rotterdam and Maastricht required a tool for collaboration, communication and sharing of humanities and social sciences data (SURF Foundation, 2010). The VKS responded to a call by the SURF foundation and the collaboratory is a further development of SURFgroepen, an earlier platform based on Microsoft Sharepoint and supported by the SURFfoundation (Carusi and Reimer, 2010: 95). The project generated results in four areas: technical development, support, research and application. At a technical level, the system provided a link between the collaboratory and RePub, the institutional repository at Erasmus University Rotterdam. In terms of support, an introductory course was provided including webinars and instructional films. Research was carried out and published on the ways researchers carry out and experience online collaboration. From an application perspective, the team developed a tool to enhance thesauri and ontologies in the humanities and social sciences (SURFfoundation, 2010). The collaboratories used the SURFgroepen and Sharepoint technology, providing numerous functions such as document libraries, calendars, blogs, wikis, action lists, a reference management tool and the aforementioned link to RePub. The SURF Foundation found that all of these tools were not used; the collaboratories are mainly used for organising conferences and meetings and for sharing documents (SURFfoundation, 2010).

6.8 HubLab

This project is based at the International Institute of Social History in the Netherlands and is co-funded by the Institute, SURFfoundation's collaborator programme and the Virtual Knowledge Studio for the Humanities and Social Sciences (Carusi and Reimer, 2010: 76). Described as a user-friendly 'light' tool for communication, data gathering and data sharing, it uses the Liferay open source portal and collaboration software. The main objectives of the project complement the aims of the Institute, namely to be a world leader in new forms of research and to enable the writing of global

history (Carusi and Reimer, 2010: 75). The 2007 project saw the creation of a hub of five international laboratories in social and economic history (Doove et al., 2010: 22). HubLab aims to study the working practices of these labs. The labs vary in terms of users and needs. HISCO uses an historical international classification of occupations (HISCO) to combine various kinds of information on their tasks and duties in historical settings. *History of Labour Relations* provides an inventory of all types of labour relations worldwide, varying from slavery, indentured labour and share cropping, to free wage labour and self-employment from 1500 to the present day. *Historical Life Courses* aims to bring together the main users, developers and administrators of databases with historical life courses, utilising a growing number of large-scale, public databases of life histories from the past. Because of the nature of working with this type of data, developers work to create common data structures and software in this collaborator (IISH, 2010).

6.9 myExperiment (JISC) 2007

myExperiment is funded by the Joint Information Systems Committee (JISC) 'Virtual Research Environment' Programme. It is a web-based service enabling scientific researchers to share and discuss their experiments (RIN, 2010: 40). The resource supports the sharing of research objects, providing web-based social infrastructure similar to other social networking sites (DeRoure et al., 2008: 172). "For researchers it is both a social infrastructure that encourages sharing and a platform for conducting research, through familiar user interfaces. For developers it provides an open, extensible and participative environment" (DeRoure et al., 2008: 172). The platform is open and extensible. myExperiment was motivated by observing a clear need to share workflows, to reduce reinvention, propagate best practice and enable scientists, within a fairly decoupled community of workflow users, to concentrate on science. As of May 2010, myExperiment had over 3,500 registered users and 1,000 workflows (Goble et al., 2010: 677). "Motivated by the needs of scientists and inspired by popular social network websites such as Facebook, the myExperiment project has developed an open source Web 2.0 infrastructure that enables scientific artefacts including workflows to be shared within the life sciences community" (Goble et al, 2009: 678). The social model in myExperiment is supported by a number

of entities, namely the users who can register and contribute research objects. Users may be developers interested in contributing their workflows to the repository or scientists wishing to discover workflows to be reused in their own research. While some content is available to guests, registered users can benefit from a richer experience. There are other social metadata entities such as attributions, creditations, favourites, ratings, reviews, citations, comments and tags. Registration is via an OpenID URL, email address and registered users have a profile, providing a list of friends, workflows and other digital objects. The majority are currently Taverna workflows. There is also scope for external applications to access content by making use of its programming interface. The software base comprising the myExperiment VRE is now being extended in an open manner BioCatalogue project which provides service catalogues. It is also currently in use in the SKUA astronomy project. Since the project has begun, a number of lessons have been learned. These include the importance of sustainability, in terms of software, content and social networking; designing for integration into existing systems; understanding the different needs and motivations of scientists; understanding the complex socio-technical nature of a VRE and appreciating it as a system (Carusi and Reimer., 2010: 81).

6.10 arts-humanities.net

arts-humanities.net is an “online hub for research and teaching in the digital arts and humanities” that provides repository and online information services. It is managed by the Centre for e-Research (CeRCH) at King’s College London and funded by JISC (Rin, 2010, 41) and the Arts and Humanities Research Council (AHRC). The aim of arts-humanities.net is to support and advance the use and understanding of digital tools and methods for research and teaching in the arts and humanities. It does this by providing:

- Information on projects creating and using digital content
- Tools and methods to answer research questions
- Information on tools and methods for creating and using digital resources
- A listing of expert centres engaged in research and teaching using digital tools

- Methods, content and a library documenting lessons learned through case studies
- Briefing papers
- A bibliography

Membership is open to all; members are encouraged to contribute information about their own projects, tools and research, to publicise events, conferences, and job vacancies, and to set up and take part in discussion forums. Although these tools are similar to those offered by VREs, arts-humanities.net lacks the collaboration functionality supported VREs. However, it could be defined as a useful VRE component. Several projects currently contribute to arts-humanities.net, including the Network Expert of Centres, a group of UK research centres with expertise in fields such as digital curation and preservation and the Digital Humanities Observatory (DHO) in Ireland, which is developing classification systems (arts-humanities.net, 2010).

7. A National Perspective: Ireland

In order to foster academic awareness of and community support for VREs, it is essential that e-infrastructure and e-research projects supported by and in support of VREs become an integral part of national research strategies, with research undertaken, technologies prototyped and tested, and sustainability promoted. Development and use of VRE infrastructure and tools in Ireland are in their infancy. Despite this, there is evidence of activity through dedicated projects, spanning academia and industry.

Only a small number of funders in areas relating to research, e-research and e-infrastructure are currently supporting VRE-related projects in the Republic of Ireland. Potential funders include the European 7th Framework Programme which, to date, has called for tender for projects focussing on Virtual Research Communities and has funded projects such as D4Science (D4Science, 2010). As of February, 2011, there is currently an active call under Research Infrastructures within this FP7

Programme, with the current ICT challenge including calls for research exploring future and emerging technologies and ICT in learning.

In 2009, the European Science Foundation (ESF) promoted the EUROCORES Programme for European Collaborative Research Projects. As a signatory to the call for projects, the Irish Research Council for Humanities and Social Sciences (IRCHSS) encouraged applications from large collaborative projects (IRCHSS, 2009). IRCHSS also support applications towards the European Seventh Framework Programme. The IRCHSS is currently funding the Irish in Europe project.

The Higher Education Authority (HEA) in Ireland also promotes research, recently supporting the Technology Sector Research (TSR) initiative aimed at enhancing core research strengths at Institutes of Technology in Ireland. The HEA is also responsible for Ireland's Strategic Innovation Fund. The Strategic Innovation Fund (SIF) amounting to €510 million over the period 2006 – 2013, supports innovation in higher education institutions by encouraging new approaches to enhancing quality and effectiveness (HEA, 2010). Projects approved to date under SIF are aimed at enhancing collaboration between higher education institutions, improving teaching and learning, supporting institutional reform, promoting access and lifelong learning and supporting the development of fourth level education (HEA, 2010). A total of 31 projects have been approved under Cycle II from 2008, of which 30 are collaborative. Of the €97 million allocated in Cycle II €20.7 million was allocated for proposals seeking to extend the research capacity of the education sector, in line with the Strategy for Science Technology and Innovation (HEA, 2010).

The HEA is also responsible for the Programme for Research in 3rd level Institutions (PRTLII) from 1998, with financial support for institutional strategies, programmes and infrastructure in key areas of research spread across all disciplines (HEA, 2010b). Currently in its fifth cycle, funded programmes include e-Inis, the Irish National Infrastructure and the Geary Institute at University College Dublin (UCD). The HEA is also currently the National Contact Point (NCP) for calls to the Seventh EU

Framework Programme European Funding for Research Infrastructures strand, running from 2007-2013.

Dedicated VRE-related funding in Ireland can be attributed to Science Foundation Ireland (SFI), a key organisation in the implementation of the strategy for science, technology and innovation under the National Development Plan (NDP). SFI (2010) focus on biotechnology, ICT and sustainable energy technologies and provided funding for the OJAX ++ Project at UCD between 2007 and Feb 2011.

7.1 OJAX ++ Project

The OJAX ++ project is being developed at the UCD School of Information and Library Studies, with the collaboration of the UCD School of Computer Science and Informatics. Between 2007 and February 2011, it was funded by Science Foundation Ireland (SFI). The OJAX++ project aims to demonstrate how loosely coupled web 2.0 frameworks, enabling interoperability and integration of popular third party tools, can facilitate usable VREs. "Loosely coupled VRE" is a term coined by the OJAX ++ project to describe the concept of a VRE that is interoperable with a number of tools but does not explicitly rely on any one of these tools. A prototype VRE has been developed to explore and demonstrate the importance of these trends. This VRE acts as a hub or aggregation point for the data from third party applications and supports communication and collaboration. The OJAX ++ project draws on the Open Web and for inclusion, applications must provide access to their data, through a data feed, ideally Activity Stream format but potentially an RSS/Atom feed (Wusteman, 2010). Currently, users of the system also have the option of logging in to the VRE using common Web-based accounts such as Yahoo, Google and Open ID. Features include the ability to maintain a user profile, details of affiliation, a social graph or research contacts and group membership, access and privacy controls and private messaging. Users can also manage and control an activity stream of aggregated personal content. A typical project stream might contain bookmarks from Delicious, calendar events from Google Calendar, tweets from Twitter, citations from Connotea and workflows from MyExperiment. Regardless of which web applications researchers use to conduct their research, they can organise and collaborate on their work, in one place, using Ojax++ (Wusteman, 2010).

7.2 The Irish in Europe Project

In 2007, the Irish in Europe Project was awarded an Irish Research Council for the Humanities and Social Sciences thematic grant to elaborate a virtual research environment (VRE) for biographical data and other resources pertaining to Irish migrants to Europe in the early modern period. In 2010 it launched the Irish in Europe VRE. It currently hosts biographical information on about 40,000 Irish migrants to Europe in a format which permits rapid querying and flexible presentation of research results. The original information was collected by colleagues in Trinity College Dublin and the universities of Oxford, Toulouse and the Complutensian in Madrid. The VRE offers researchers a range of research functions including data import and export facilities. The VRE also features a pilot interactive sources feature, based on an account book from the Salamanca Papers in St Patrick's College, Maynooth (Irish in Europe, 2010). "The proposal is unique in paying equal attention to the requirements of historians, the exigencies of information technology and the expectations of the general public. Its flexible structure facilitates links with other cross-cultural and comparative research projects on Ireland's relationship with Europe" (Irish in Europe, 2010). It is difficult to discern if this 'VRE' provides enough functionality and tools to fall in line with more recent definitions of the VRE. While the system allows a user to register, manage a collection, save, import and export data, there is little evidence of tools of collaboration and communication in the system and no reports of Web 2.0 functionality.

7.3 TCD Microsoft-Softedge

Trinity College Dublin, Softedge (an Irish Small and Medium Enterprise (SME)) and Microsoft have collaborated to build a VRE for Humanities Researchers. The VRE has been created by enhancing the core Microsoft Research Information Centre (RIC) framework for use by Humanities Researchers (see Section 6.6). The project group identified four distinct elements to the project (Healey, 2009):

1. Development of an intuitive enhanced user interface, incorporating input from TCD humanities researchers

2. Creation of connectors to selected humanities digital content. (This stage included developing a federated search system within RIC.)
3. Integration of research groups into the process of developing the VRE.
4. A scoping document on the extension of RIC to a wider group of researchers and to external research collaborators.

In relation to element 3, three content groups were chosen, with templates designed for each group:

- Group 1: Oliver Cromwell's Letters and Papers required textual editing capabilities and image handling, along with the ability to search sources.
- Group 2: Oral History Project had similar requirements but also needed facilities for the handling of images, audio and video. For this group, the VRE also supported a funding application aiming to produce an accessible e-book programme for older people.
- Group 3: A general template for Classics and History. The aim in this group was to provide an environment for research students to engage interactively with primary and secondary digital sources, and to use these resources innovatively in individual and group project work. The intention was for the templates developed to be reusable by other groups in the humanities.

7.4 Related Activity:

Beyond specific VRE funding in Ireland, there is a certain amount of related activity, focussing on technologies and infrastructures to support research. For example, Feicim, a grid-computing tool for facilitating scientific collaboration is currently under development in the UCD School of Computer Science and Informatics (UCD CSI, 2010). The Feicim prototype presents the user with a simple interface and provides resource discovery of data-files, data-content and versions of algorithm implementation through a graphical user interface. The School of Computer Science and Informatics also hosts the Heystaks project that involves the development of a browser toolbar to facilitate more efficient search engine retrieval. The tool promotes collaboration by allowing users and organisations to promote and share

search experiences in 'staks' to avoid redundancy in future searches (UCD CSI, 2010b).

UCD is also responsible for The Complex and Adaptive Systems Laboratory (CASL), a dynamic multidisciplinary research community advancing scientific knowledge through mathematics and computation. The CASL encourages and fosters collaboration using a number of methods beyond collocation including; CASL Collaborative Demos, the CASL Common Room, CASL Cross-Disciplinary Seminars, CASL Problem of the Week and CASL TV (UCD CASL, 2010). The Artificial Intelligence and Computer Vision Unit (AICV) based in Institute of Technology, Carlow researches the intelligent use of image techniques, video analysis, and deployment of Artificial Intelligence within what they refer to as "Collaborative Virtual Environments". The emphasis is on, virtual reality, in the form of gesture recognition, three-dimensional reconstruction from stereoscopic images and scene indexing of video.

8. Opportunities and Challenges:

8.1 Web 2.0

Within the VRE community, there is widespread recognition of the need for customisable e-infrastructure and tools to support this infrastructure. Increasingly are publicly available. Web 2.0 tools that combine elements of communications technologies, data management and dissemination and the Social Web. Existing platforms for research management such as myExperiment facilitate collaboration and the sharing of workflows online. Reference management tools such as Cite-U-Like, Zotero and Connotea are being used by researchers as administrative support tools to share and manage citations and academic research. Network tools such as LinkedIn support communication and connection among professionals with mutual interests. Blogs and micro-blogging tools such as Twitter, alongside bookmarking tools such as Delicious and discovery engines such as Stumble Upon are used to disseminate news and connect with communities and content of shared interest. Communication tools such as Skype are used in video-conferencing and remote

collaboration. Even popular search engines, e-mail and video-sharing providers offer real potential as VRE tools.

A consensus is appearing that the momentum of academic research could benefit enormously from adopting Social Web ingenuity and functionality. Carusi and Reimer (2010: 30) found that of the different technologies being utilised in VREs, Web 2.0 technologies were seen as particularly interesting because of their ease of use and lightweight nature. The integration of Web 2.0 technology and infrastructure facilitates more lightweight and adaptable solutions (Carusi and Reimer, 2010:38). In addition, the Web 2.0 ethos of the 'perpetual beta' is of relevance to VRE development; early, simple versions of VREs can be made available to a user community which experiments and co-produces new tools, services and content in a more or less continuous process (RIN, 2010, 42).

An obvious advantage to incorporating Web 2.0 in VREs is that it offers researchers the possibility of continuing to use popular tools that they are already familiar with. This can foster support for a VRE. The RIN study (2010: 46) indicates that the majority of researchers are making at least occasional use of one or more Web 2.0 tools and services for purposes related to their research: for communicating their work, including work in progress, for developing and sustaining networks and collaborations, or for finding out about what others are doing (Rin, 2010: 46). Some surveys of the needs of researchers based in Ireland have been carried out to date (UCD Research IT, 2007, DCU Library Services, 2010). More such exploration is essential.

The addition of social Web ingenuity would produce what DeRoure et al. (2008) call the social research environment. This hybrid solution facilitates the management and sharing of research objects in the style of a VRE alongside supporting the social model, i.e. producers of research objects should themselves have incentives to make them available and consumers should be able to discover and use them and all will benefit from self and community curation. The collaborative experience is enhanced through real-time communication and productivity is increased. "For the VRE, it is

also important to incorporate the real social encounters and interactions that actually drive collaboration and make research happen” (Barry Hogan, CASL).

A further advantage of opting for lightweight Web 2.0 tools and applications lies in their architecture. Many are built on open extensible platforms and public APIs. This Open Web is a versatile enabler for VREs, allowing customisation from the bottom up. (Recent projects such as UCD’s OJAX++ Project have promoted this Web 2.0 integration).

8.2 Design Across Disciplines:

A major obstacle to sustainability in VREs is how approaches to research and information-seeking differ across disciplines. Development has often been discipline specific, with some disciplines not as well served as others. Research and development of VREs for the social sciences has lagged behind that of the natural sciences, engineering and business (Sonnenwald et al., 2009:192).

However, the notion of cross-disciplinary collaboration is central to e-research and thus to VRE functionality. So a challenge for VRE development is identifying the differences in approaches to research within different disciplines and to meet expectations and needs in a consolidated system. For instance, Dunn (2009: 214) contends that “the successful deployment of a VRE in the humanities or arts is contingent on recognising that workflows are not scientific objects in their own right. Workflows in these disciplines are highly individual, often informal and cannot be easily shared or reproduced”. Collaborative tools must reflect the complex nature of collaboration itself. This depends on researchers “creating a common language and learning to understand each other” and to “address more difficult sociological and cultural issues”. This includes identifying and articulating the need for a solution, concrete benefits of developing a system and clarity on the purposes it seeks to address (Doove et al., 2010:7). To date, many VREs have been project driven and strategic. A more useful approach might be to focus on developing systems responsively and incrementally, meeting the needs of end users as they arise (Dunn, 2009: 206).

8.3 The Cloud:

At this stage of VRE development, in particular where Web 2.0 tools are used, an additional area meriting further research is data storage in the cloud. Institutions are at the early stages of availing of cloud services. For example, UCD has extended its cluster into the cloud and have been working with the Amazon cloud for over a year. UCD has also built an internal UCD cloud on underutilised hardware. Although cloud solutions provide some advantages over grid alternatives (namely, free personal storage, the variety of tools available), there are some disadvantages to building a VRE using cloud data storage. Some experts (Prof Kechadi, UCD) argue that it may be too soon to build VREs using cloud solutions because of the complicated contract issues that can emerge. For instance, if an institutional VRE presents a suite of tools, the institution is implicitly endorsing them. Without this endorsement, it is difficult to reach a threshold level of active users. But encouraging researchers to store data in the cloud necessitates the security of that data (Niall O'Leary, DHO). This becomes further complicated when an institutional VRE incorporates Web 2.0 tools for which researchers use personal accounts; here, comeback is further limited should problems arise.

With cloud service provision, it is necessary for the institution to manage contracts with individual service providers. Depending on their jurisdiction, this can present challenges. For instance, Google operates under Californian law. Institutions may see the European data protection model as more desirable and attempt to negotiate a contract in this territory. They may often have a history of hosting a local mirror of data stored outside the institution itself (Fred Clarke, Ruth Lynch, Research IT, UCD). This issue is further complicated by the fact that the future existence of any particular Web application provider cannot be guaranteed. company (particularly in an economic downturn). If a company ceases trading, this could result in a loss of data by the institution. These are complex issues for Irish institutions intending to further utilise cloud storage provision and for developers hoping to roll out Web 2.0 based tools at institutional level.

8.4 Sustainability:

Sustainability is of critical concern in future VRE development and use, particularly in Ireland. As digital curation projects such as the Digital Humanities Observatory come to the end of a funding cycle and contracts for information service staff such as librarians stagnate, we face the unprecedented challenge of developing, deploying and advocating for vital tools for research productivity in the face of little or no funding. Finding support for relatively novel research tools such as VREs in the face of severe austerity measures across third and fourth level and funding cuts will be a major challenge in the coming years.

Sustainable VRE development can be supported by:

- Supporting researchers' use of existing tools
- Engaging in dialogue with teams who have build successful systems, thus avoiding potential pitfalls
- Building on and customising platforms with a proven record
- Avoiding proprietary options, instead incorporating open source applications that already have a critical mass of active users

The feasibility of integrating VREs into the current institutional Web-based research infrastructure merits investigation. This could tie in with existing plans to link institutional repositories to research management systems. Thus, advocacy for institutional repositories is also important. Reaching a critical mass of content in such respositories also facilitates the open access movement, the value of which is championed by experts in the field (Paul Sheehan, Director of Library Services, DCU). Supported by the Strategic Innovation Fund, RIAN is Ireland's open access portal, harvesting content from the Institutional Repositories of the seven University libraries. A potential useful link could be a tailored feed of relevant articles as part of an aggregated data stream in a VRE.

The potential to integrate VREs into larger projects also merits investigation. HEAnet Ireland has recently developed Edugate, the national access federation for the

academic sector. The federation comprises institutions with agreed policies for sharing information and resources using a single sign on. By becoming a federation resource, a VRE reaches a larger and more diverse potential user group. This facilitates not just the collaboration process itself but also the fostering of new collaborations. There are plans for the Edugate federation to expand laterally and ultimately become part of a pan-European federation.

Funding and infrastructure in third level institutions tend to follow projects, thus, there is scope to harness underutilised resources already in place. Researchers must be encouraged to share such resources where possible, rather than reinventing the wheel (Fred Clarke, Research IT). With this in mind, developers must be cautious to avoid the temptation of overfunctionality as this reduces the intuitiveness and flexibility of the resulting system.

8.5 Support:

A further issue in relation to sustainability is that of library support and service provision for fourth level researchers. In general, the more specialised the research need, the more difficult it can be to fulfil it successfully, particularly when there are increased demands on fewer resources. The role of the librarian in design, development and deployment of VREs is acknowledged. Cathal McAuley of NUIM suggests that “successful models would suggest embedding librarians within different departments and research teams” but adds that this is difficult in the current economic times. However, sustainability of VRE projects cannot be ensured without adequate service provision. According to Wusteman, the overlap with VLEs could offer a natural entry point to VRE activity for librarians. “As information specialists, librarians not only understand information and data management, they are also aware of the needs and interests of their respective subject communities. This gives them unique skills to act as interpreters between researchers and developers” (Wusteman, 2010:26). There are some examples of institutions appointing librarians with responsibility for research and research institutes (DCU, TCD). The remit for such librarians is often broad, possibly too broad to also include

expectations for VRE development, deployment and training. Nevertheless, this is an important move in service provision at fourth level.

8.6 Advocacy:

Fostering advocacy for VREs is of significant strategic importance for Ireland. Sustainability requires funding and successful deployment but ultimately, the product will not survive without a critical mass of active users who are willing to use the system. “It is about mapping onto the political landscape and getting that threshold of users” (Shawn Day, DHO). For Ireland, deployment and piloting of developed tools such as UCD’s OJAX ++ is key to this process. There is some discussion about how support for such systems could be fostered. “Actual involvement of (senior) researchers and local champions, and time spent by them on the project, is crucial” (Doove et al., 2010: 39). It is important to seek adoption by high-profile users, a strategy actively pursued, for example, by myExperiment. This approach can also help to generate use across national boundaries, which may otherwise be a challenge for nationally-funded projects. In addition, it may attract further funding or funding for new projects. It is also important to engage gatekeepers such as universities and leading research centres, learned societies, and the funders of research. “People move en masse in communities. There is a tipping point of when the community moves and everybody moves with it” (Faith Lawrence, DHO). Advocacy is crucial to sustainability of the VRE, once developed. “A major issue is to build that sense of community. If they feel they own it, then they use it. If they use it, then the issue of sustainability becomes less of a concern” (Cathal McAuley, NUIM).

8.7 Infrastructure:

A major challenge for VREs is interoperability: the functioning of collaborative tools across technologies, geographical boundaries and disciplines. While the trend towards the Open Web goes some way to meet this end, there are still many issues to overcome. The problem of creating common vocabularies, taxonomies and data standards is ongoing. Although there is agreement on the pressing need for international standards, commercial interests often dictate the adoption of

proprietary standards, rather than supporting open source and open standards. This is an area that merits further research.

9. Summary of Findings

Development of VREs is still at an early stage. Current implementations include discipline-specific and project-driven models. Although there has been limited VRE development in Ireland, examples include the HEAnet funded NUIM Irish in Europe Project for biographical data, the TCD Microsoft-Softedge VRE for Humanities Researchers based on Microsoft RIC and the SFI UCD OJAX ++ Project.

Drawing on current activity in the field and the need for information behaviour research, it is clear that any future approaches to VRE development should be modular and phased, with incremental advances based on participatory development and the perpetual beta model, allowing for systems that are sufficiently customisable to cross disciplines while avoiding the opacity of overfunctionality. An initial phase could see the development of broad generic tools. A second phase could focus on more discipline specific issues based on information behaviour research of user groups. A third phase could concentrate on the development of a hybrid, with some general and some specific functionality. Such an incremental approach would suit VRE development, where the discipline-specific, sometimes even project-specific nature of research makes deployment a challenge.

In times when funding and human resources are limited, the emphasis must be on encouraging advocacy while minimising resource impact. It is vital to consider how to build on and incorporate tools that are already used by researchers and how to support not just the technical but also the social aspect of collaborative research. There may be opportunities to link to resources already in place (such as Edugate, RiAN) and benefit from those. Institutional roll-out is more likely to bring together a critical mass of active users than is independent roll-out, and linking to related services will no doubt facilitate this process. This will inevitably involve reconciling contractual and data protection issues of cloud computing; the latter is identified as a

critical area for future research. A further central issue is that of agreeing on common taxonomies and standards, a process that may find itself driven by collaborative activity.

This is a crucial juncture for VRE research, development and use: researchers are benefiting from increasing numbers of research support tools in online environments; Irish institutions are initiating a move towards cloud service provision. Further research is needed to reconcile the technical issues of cloud-based data storage, the need for agreed data standards, issues of sustainability (funding and support) and the need to foster advocacy for such systems as relative newcomers to the field. Projects such as UCD's OJAX ++ have gone some way to harness changing trends in research service provision and uptake and pioneer the integration of Web 2.0 and cloud-based solutions but this process is very much in its infancy.

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