Technical Evaluation

of selected

Open Source Repository Solutions

On behalf of

Version 1.3 approved

Project: **Open Access Repositories in New Zealand**
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Table of Contents

Revision History

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Max Maxwell	18-05-2006	Phase 1 Specifications	1.0
Jun Yamog	02-08-2006	Adding test information	1.1
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1. ABOUT THIS DOCUMENT

1.1 INTRODUCTION

The Technical Evaluation of Open Source Repositories report was commissioned as part of the Open Access Repositories in New Zealand (OARINZ) project. OARINZ is being undertaken by a collaboration of Tertiary Institutions lead by the Christchurch Polytechnic Institute of Technology.

The project targets the three key recommendations from the National Library's (2005) Institutional Repositories for the research sector report:

1. Establishment of a national network of Institutional Repositories
2. Support for individual institutional initiatives
3. Adoption of a "common road map"

Underpinning these objectives is the need to select best-of-breed Open Source Repository system/s for further enhancement and large-scale deployment across New Zealand.

To maximise the effectiveness of this evaluation, a significant effort has been made in gaining hands on experience with each software package, the documentation relating to each package has been assessed, and we have assessed each package's development community.

1.2 OBJECTIVES OF THIS EVALUATION

The objectives of this Technical Evaluation process are:

- To gain understanding of the design, architecture and implementation details of the short-listed Repositories.
- To evaluate the short-listed Repositories against an agreed set of criteria.
- To pay particular attention to the long-term development and maintenance lifespan of the short-listed Repositories.
- To engage members of the Open Source community in the process where relevant.
- To recommend the most suitable candidate Repository/s.
- To choose a system that can aggregate published metadata and offer a bureau/hosting service referred to here as The Hosted Solution and the National Hub. This would provide a federated search of the bureau and across the national network of separate and different repository systems.

- To select a system/s that offers institutions a repository system that is feature rich yet has low implementation and support overheads.
- To report our findings in a concise and complete manner.

1.3 MAJOR EVALUATION CRITERIA

Working with the *Evaluation of Open Source Technologies* paper as a guideline, and looking particularly for assurances that the selected repository/s had a secure future, the criteria selected for this evaluation were:

- Scalability.
- Ease of working on code-base, extensibility.
- Security.
- Interoperability (ability to integrate with other repositories - OAI-PMH compliance, and ease of integration with systems such as Learning Management Systems).
- Ease of deployment, ability to support multiple installations on a single platform (required for hosting facility).
- Ease of system administration (ability to configure for different uses).
- Internationalisation - multiple language interfaces.
- Open source (type of license).
- Quality and configurability of workflow tools.
- Strength of community.

1.4 EVALUATION METHODOLOGY

1.4.1 Repositories chosen to be evaluated (chosen from the Guide to Institutional Repositories[1])

The six Repositories chosen for evaluation were:

- DSpace
- Fedora
- EPrints
- ARNO
- CDSware
- i-TOR

1.4.2 Developing the Technical Evaluation Criteria

Major technical evaluation criteria were drafted and reviewed by Steering Committee members. Each selected criteria was given an importance rating to be used when evaluating the different Repository systems.

Major criteria were also broken down into sub-criteria with each sub-criteria also having an importance rating. The importance rating range is 0-4, with 0 being the lowest and 4 being of the highest importance.

Each sub-criteria was then rated using a range of 0-4, these ratings defined as:

0 – Failed or feature does not exist.

1 – Has poor support and/or it can be done but with significant effort.

2 – Fair support but needs modification to reach the desired level of support.

3 – Good support and needs a minimal amount of effort.

4 – Excellent support and meets the criteria out of the box, minimal effort.

[1] Sourced from Open Society Institute – A Guide to Institutional Repository Software 3rd Edition August 2004

1.4.3 Short-listing the systems

Out of the initial six repository systems to be reviewed three candidates were short-listed using the technical evaluation criteria.

The repository systems that were not short-listed were not evaluated further on the basis that a preliminary review of the systems showed they do not meet key technical evaluation criteria.

Section 3 offers further information on those systems that were not short-listed.

1.4.4 Deploy and evaluate each system

The short-listed systems were each deployed in a test-bed environment, where they were used and maintained for the duration of the review.

The deployment stage involved set-up, configuration, with some minor customisations being made to each system. Where possible, the evaluation criteria were checked against the actual performance of the system, rather than the published feature list.

Given a key project goal was that of understanding the challenges of long-term maintenance and development of any selected systems, the evaluation team applied significant focus to the ease and practicalities of making changes and developing extensions to each of the systems.

To test overall performance, workflow and scalability, approximately 100,000 digital objects, including metadata, were published in each of the systems as test data.

2. SHORT-LISTED SYSTEMS - OVERVIEWS AND FINDINGS

2.1 INTRODUCTION

The three short-listed systems were assessed as having significant differences in their design, their underlying architecture and process and complexity for how they are implemented.

While they all shared a common business function, the impact of these technical differences is important, and has had a significant bearing on their ratings and ultimately on the selection of the recommended packages.

It is also important to note that all systems were credible repository systems. At the end of our evaluations, to differentiate them in order to make recommendations we had to re-focus on 2 criteria:

- To choose a system that can aggregate published metadata and offer a bureau/hosting service referred to here as The Hosted Solution and the National Hub. This would provide a federated search of the bureau and across the national network of separate and different repository systems
- To select a system/s that offers institutions a repository system that is feature rich yet has low implementation and support overheads.

2.2 DSPACE

Platform: Any webserver, Java, PostgreSQL/Oracle.

Version: 1.4 Alpha 1

2.2.1 General Description

MIT's DSpace was expressly created as a digital repository to capture the intellectual output of multidisciplinary research organisations. MIT designed the system in collaboration with the Hewlett Packard Company between March 2000 and November 2002. Version 1.2 of the software was released in April 2004. The system is running as a production service at MIT, and a federation comprising large research institutions is in development for adopters worldwide.

DSpace integrates a user community orientation into the system's structure. This design supports the participation of the schools, departments, research centers, and other units typical of a large research institution. As the requirements of these communities might vary, DSpace allows the workflow and other policy related aspects of the system to be customised to serve the content, authorisation, and intellectual property issues of each. Supporting this

type of distributed content administration, coupled with integrated tools to support digital preservation planning, makes DSpace well suited to the realities of managing a repository in a large institutional setting in terms of its feature-set. DSpace is also focused on the problem of long-term preservation of deposited research material.[2]

2.2.2 Strengths of DSpace

DSpace scored well on the overall evaluation ratings, and has the most open development community of the three short-listed candidates.

2.2.3 Weaknesses of DSpace

DSpace has well documented scalability issues. The DSpace project team themselves are not addressing the scalability problem, and the code base is not easy to re-architect. This point alone makes DSpace the least desirable candidate for the OARINZ project.

There are no new significant developments planned for DSpace. The development community is there, but there are no new features on the horizon.

To address the scalability shortcomings of DSpace would be difficult as re-architecting any application is a high risk venture.

DSpace has a complex code base making it difficult to make low level modifications.

2.3 EPRINTS

Platform: Apache, PHP, MySQL.

Version: 2.3.13.1

2.3.1 General Description

The EPrints software has the largest—and most broadly distributed—installed base of any of the repository software systems described here. Developed at the University of Southampton, the first version of the system was publicly released in late 2000. The project was originally sponsored by CogPrints, but is now supported by JISC, as part of the Open Citation Project, and by NSF. EPrints worldwide installed base affords an extensive support network for new implementations. The size of the installed base for EPrints suggests that any institution can get it up and running relatively quickly and with a minimum of technical expertise. The number of EPrints installations that have augmented the system's baseline capabilities—for example, by integrating advanced

[2] Sourced from Open Society Institute – A Guide to Institutional Repository Software 3rd Edition August 2004

search, extended metadata and other features—indicates that the system can be readily modified to meet local requirements.[3]

2.3.2 Strengths of EPrints

EPrints is a good candidate for many institutions as it is the least complex of the three systems, and hence has the lowest skill level barrier of the three to implement and maintain.

EPrints has the widest install base, a significant factor in that it goes a long way to ensure its longevity as a fully supported system.

The Code base for Eprints is uniform and well documented making it easier to work on for low level customisation

2.3.3 Weaknesses of EPrints

The data model causes some scalability issues, although these could be addressed with some development effort. Its method of adding new digital content type can lead to disparate data models and compatibility issues if maintaining multiple systems.

The behaviour of the team at the University of Southampton can be described as a closed community in development and participation. They will not accept any contributions to the code base and retain the copyright to Eprints, and thereby raises concerns about collaboration (See **4.8.3**).

2.4 FEDORA

Platform: Apache, Java, MySQL/Oracle 8i

Version: 2.1.1

The Fedora digital object repository management system is based on the Flexible Extensible Digital Object and Repository Architecture (Fedora). The system is designed to be a foundation architecture upon which full featured institutional repositories and other interoperable web based digital libraries can be built. Jointly developed by the University of Virginia and Cornell University, the system implements the Fedora architecture, adding utilities that facilitate repository management. The current version of the software provides a repository that can handle one million objects efficiently. Subsequent versions of the software will add functionality important for institutional repository implementations, such as policy enforcement, and performance enhancement to support very large repositories. The system's interface comprises three web based services:

[3] Sourced from Open Society Institute – A Guide to Institutional Repository Software 3rd Edition August 2004

- A management API that defines an interface for administering the repository, including operations necessary for clients to create and maintain digital objects;
- An access API that facilitates the discovery and dissemination of objects in the repository; and
- A streamlined version of the access system implemented as an HTTP-enabled web service.

Fedora supports repositories that range in complexity from simple implementations that use the web service's "out of the box" defaults to highly customised and full featured distributed digital repositories.

Since Fedora is a web service and does not have a web UI front end, many UI applications have been built to front-end Fedora:

http://www.fedora.info/tools/.

For the purpose of this evaluation Fez was the User Interface used with Fedora and a limited amount of evaluation has been carried out. However Fedora is not totally constrained by using Fez. Alternative user interfaces may be developed as required as is suggested under the recommendations of this report.

Fez was developed using well understood technologies: PHP and MySQL. Fez is part of the Australian Partnership for Sustainable Repositories (APSR).

More information about Fez can be seen here:

http://sourceforge.net/projects/fez/

2.4.1 Strengths of Fedora

Fedora demonstrates the best scalability among the three short-listed systems, and stores multiple types of digital objects and collections particularly well.

It has a strong development team and development roadmap.

As foundation architecture with powerful API based interoperability features, Fedora is highly flexible and powerful, and has proven itself with large networked repositories similar to those envisaged with the OARINZ project.

With no set user interface, Fedora has true separation between the 'backend' and 'front-end'. Fedora provides good interoperability among different systems, with different options allowing for smart and flexible integration methods.

2.4.2 Weaknesses of Fedora

In a sense, a key strength could also be perceived as a weakness. With no user interface, Fedora can not offer a full repository service ‘out of the box’ and therefore provides a conceptual complexity which systems like EPrints do not.

Fedora’s code base is the largest of the three short-listed systems.

The Fedora development community can be described as closed. Currently it is a funded project, when this funded period is complete; the intention is to create a wider development community. When engaged as part of this evaluation they were happy to grant access to their code repository and were open to the suggestion of external Postgres support.

3. SYSTEMS NOT SELECTED FOR FURTHER EVALUATION

3.1 INTRODUCTION

The following three systems were excluded from the in-depth analysis phase through their not meeting key criteria.

3.2 ARNO

Platform: Apache, Perl, Oracle 8i

Version: 1.2

The ARNO project—Academic Research in the Netherlands Online—was developed to support the implementation of institutional repositories and link them to distributed repositories worldwide (as well as to the Dutch national information infrastructure). The project is funded by IWI (Dutch acronym for "Innovation in Scientific Information Supply"). Project participants include the University of Amsterdam, Tilburg University, and the University of Twente. Released for public use in December 2003, the ARNO system has been in use at the universities of Amsterdam, Maastricht, Rotterdam, Tilburg, and Twente.[4]

ARNO has been excluded from in-depth analysis on the basis that the data base management system is not open source compliant.

3.3 CDSWARE

Platform: Apache, PHP/Python, MySQL

Version: 1.2

The CERN Document Server Software (CDSware) was developed to support the CERN Document Server. The software is maintained and made publicly available by CERN (the European Organization for Nuclear Research) and supports electronic preprint servers, online library catalogs, and other web based document depository systems. CERN uses CDSware to manage over 350 collections of data, comprising over 550,000 bibliographic records and 220,000 full text documents, including preprints, journal articles, books, and photographs.

CDSware was designed to accommodate the content submission, quality control, and dissemination requirements of multiple research units. Therefore,

[4] Sourced from Open Society Institute – A Guide to Institutional Repository Software 3rd Edition August 2004

the system supports multiple workflow processes and multiple collections within a community. The service also includes customization features, including private and public baskets or folders and personalized email alerts.

CDSware was built to handle very large repositories holding disparate types of materials, including multimedia content catalogs, museum object descriptions, and confidential and public sets of documents. Each release is tested live under the rigors of the CERN environment before being publicly released.[5]

CDSware (now recently changed to CDS Invenio) has been excluded from the in-depth analysis for the following reasons

It has extremely complex installation steps. These steps can be seen here:

http://cdsware.cern.ch/download/INSTALL

CDSware also does not have a good community around it. The mailing list has had very limited traffic since 2002, which indicates that this project may have sustainability issues going forward:

http://cdsware.cern.ch/lists/project-cdsware-users/archive/date.shtml

3.4 I-TOR

Platform: Jetty, Java, MySQL,/Oracle,/SQL Server,/Berkeley database

Version: 1.2

iTor—Tools and technologies for Open Repositories—was developed by the Innovative Technology *Applied* (ITA) section of Netherlands Institute for Scientific Information Services (Dutch acronym: NIWI). i-Tor development concentrates on four areas: e-publishing; repositories; the content management system; and "collaboratories." NIWI offers i-Tor as a web-based technology by which users can present various types of information through a web interface, irrespective of where the data is stored or the format in which it is stored. i-Tor aims to implement a "data independent" repository, where the content and the user interface function as two independent parts of the system. In essence, i-Tor acts as both an OAI service provider, able to harvest OAI compatible repositories and other databases, and an OAI data provider.

Because i-Tor is able to publish data from a variety of relational databases, file systems, and websites, the system allows institution considerable latitude in the way it organises its repository. It can create new databases for the repository, but it can also use already existing relational databases. Further, i-Tor supports harvesting of data directly from a researcher's personal home page. The system's design allows an end user to add content via a web browser without a software developer acting as an intermediary. 4 See: <www.niwi.knaw.nl>. OSI Guide to IR Software 3rd ed.doc ▪ Page 13

[5] Sourced from Open Society Institute – A Guide to Institutional Repository Software 3rd Edition August 2004

Because of this design, i-Tor does not enforce a specific workflow on a group or subgroup. Rather, iTor gives an institution tools (for example, fine grained security, notification, etc.) to set up any required workflow required by the organisation, without integrating this workflow into the i-Tor system itself. i-Tor's design might make it an appropriate choice for an institution that wishes to impose a repository on top of an existing set of disparate digital repositories.[6]

i-Tor has been excluded from the in-depth analysis because it seems it has little or no community surrounding it. There is no clear roadmap. You can see the forum, mailing list and tracker have only had a couple of entries and the community appears dormant.

http://sourceforge.net/mail/?group_id=87240

http://sourceforge.net/forum/?group_id=87240

http://sourceforge.net/projects/i-tor/

[6] Sourced from Open Society Institute – A Guide to Institutional Repository Software 3rd Edition August 2004

4. REPOSITORY EVALUATIONS

4.1 SCALABILITY

4.1.1 **Scale Up –** Ability for the Repository to scale higher by adding more resources (CPU, ram, etc.)

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	2	3	3	3

4.1.2 **Scale out –** The repository supports caching, adding more instances, and other mechanisms to scale higher.

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	3	3	4	4

4.1.3 **Architecture -** The repository be separated into different local parts and put into different machines. (E.g. separate the database, data directory, components from the repository to distribute to different machines)

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	2	4	3	3

4.1.4 EPrints

With 100,000 digital objects, EPrints was able to handle it fairly well. EPrints uses Apache, mod_perl and MySQL. From this evaluation's testing and our experience, this platform is able to scale up as more resources are provided. The software architecture is simple and can be worked on if there is a major scalability issue discovered. Its architecture allows you to separate the web application from the database. Adding a reverse proxy to act as cache can be done with digital objects as they are published as static files.

It scales particularly well in accessing the digital objects. EPrints writes the published objects as static files on the server. Access to static files on a server is one of the quickest and simplest ways of making retrieval of objects.

The database layout is not normalised and it uses the database in a non-traditional way, as is evident when it is indexing content. With our test data, it took roughly around 5 hours to index approximately 100,000 objects. To compound the problem the indexer will re-index the 100,000 objects each time it runs, as EPrints does not yet support incremental indexing.

Documents on scalability for EPrints are not available.

4.1.5 DSpace

Preliminary evaluation of DSpace did not indicate any scalability problems. However after loading it with test data, there was obvious 'sluggishness' with DSpace. We searched for scalability reports and performance tuning and were able to get the following:

DSpace scalability issues report can be viewed at:

http://wiki.DSpace.org/ScalabilityIssues

DSpace performance tuning information can be viewed at:

http://wiki.DSpace.org/HowToPerformanceTuneForDSpace

However looking at the suggestions given to increase performance, the focus is on increasing the amount of resource (hardware) available to DSpace. There is no specific problem that is being addressed, which suggests an overall architecture scalability problem.

4.1.6 Fedora

Fedora scales well with the test 100,000 digital objects and it has been tested to scale up to 1 million digital objects the Fedora community is targeting to test storage and retrieval of 20 million to 30 million objects. Search, retrieval and management of the digital objects were still within an acceptable response time with the test repository loaded. Documentation of scalability tests undertaken with the Fedora project can be seen below:

http://www.fedora.info/resources/faq_old.shtml#scaling

http://www.fedora.info/download/2.1.1/userdocs/reports/performancetest.html

http://www.fedora.info/download/2.1.1/userdocs/reports/apim-performance/index.html

The retrieval of digital objects may be a possible scalability problem. It will depend on the type of dissemination methods exposed by a digital object. Unlike the other repositories reviewed which only support download of digital objects, Fedora supports adding operations to a digital object. An example of a complex operation is the ability to zoom digital images, or get text from a digital document through the use of OCR software. Fedora addresses this problem as it has the ability to proxy the complex operations to different machines.

4.2 EASE OF WORKING ON CODE BASE

4.2.1 **Add/Change digital object type -** The work involved in adding or changing a digital object type such as adding or changing metadata.

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
2	3	4	1	3

4.2.2 **Documentation of code and code consistency & style.**

EPrints	DSpace	Fedora *	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
4	2	4	3	3

4.2.3 **EPrints**

Eprint's documentation and code consistency is very good. As EPrints has been developed primarily by a single author the code has a consistent structure and standard.

Adding and changing content types looks to be straight forward when consulting the documentation given here:

http://www.EPrints.org/documentation/tech/php/howto.php#how_to__add_a_new_eprint_type

However more complex content types require database table changes. Due to the non-normalised nature of the database schema, one EPrints installation database schema will differ from another. Upgrading an EPrints installation that supports custom content types will not be straight-forward.

4.2.4 **DSpace**

Documentation is fair. The code is documented, but it could be more comprehensive. Examples of DSpace's documentation can be viewed at the following links:

http://www.DSpace.org/technology/system-docs/submission.html

http://wiki.DSpace.org/EndUserFaq#head-cd51bd76a37e678dfbd36e4d0245f361bf96b32c

DSpace has a user interface to add new metadata and namespaces. The database layout that stores the metadata supports adding new metadata.

DSpace supports adding different workflows to a collection that holds different digital objects

4.2.5 **Fedora**

Documentation and code consistency is very good. For many developers, it may be overwhelming as Fedora has more code than the other repository systems; however the quality of the code is high.

Adding a new content type is supported, a new content type is defined by a new XSD document. There is a current User Interface (UI) to add content types, although this is complex.

4.3 SECURITY

4.3.1 **Data Encryption -** Supports encryption of data while transmitting the content, such has using SSL/https.

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
4	4	4	3	3

4.3.2 **Server Security -** What does the repository require for installation? Does it follow good security practices e. g. proper file permissions, secure database connection?

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
2	3	4	4	4

4.3.3 **Authentication -** The authentication used by the repository to authenticate user

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	4	4	2	2

4.3.4 **Authorisation/Access Rights -** Support for different roles to properly manage the content and administer the system.

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
2	4	2	0	2

* Fedora is a web service designed for use in conjunction with other applications. Authorisation and access rights are implemented by the tools/application that integrate with Fedora.

4.3.5 **Ability to restrict access at repository item level (eg view metadata but not content).**

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
2	3	4	0	3

4.3.6 **EPrints**

EPrints supports SSL by reconfiguring Apache. Server security is not as good as desired. The Apache process must have write privileges in several areas in the file system. Authentication uses only basic authentication, although the upcoming EPrints 3.0 will support more authentication mechanisms. Currently, EPrints only supports fixed roles, contributors and editors.

4.3.7 **DSpace**

DSpace supports SSL and does practice good server side security for it to get installed. There is a configurable infrastructure for authentication in DSpace that currently supports web UI or LDAP authentication. DSpace supports different groups and roles. A web UI also allows you to edit the permission and policies.

4.3.8 **Fedora**

Fedora supports SSL. It requires a data directory that is not accessible from the outside and can be secured pretty well. Security is also given importance by Fedora as noted by several documents:

http://www.fedora.info/download/2.1.1/userdocs/server/security/securingrepo.html

http://www.fedora.info/download/2.1.1/userdocs/server/security/beSecurityConfig.html

Fedora only supports 2 types of access. Read and Management access, it was designed this way as a web service. Authorisation and Access rights are provided to the application that integrates with Fedora such as Fez.

4.4 INTEROPERABILITY

4.4.1 OAI-PMH Compliant (Essential)

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
4	4	4	4	4

4.4.2 SOAP, UDDI

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
0	4	4	0	3

4.4.3 SRU / SRW

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
0	4	0	0	3

* There are commercial applications that integrate with Fedora that provide an SRU/SRW interface.

4.4.4 Bulk Import and Export - Support for batch/bulk import and export of digital objects.

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
2	4	4	1	4

4.4.5 Institution exit mechanism to withdraw their content from the repository farm (Essential)

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	4	4	4	4

4.4.6 Authentication - Use an external authentication mechanism (ex. LDAP)

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	4	4	1	2

4.4.7 Standard metadata - Dublin core, METS.

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	4	4	4	4

4.4.8 EPrints

EPrints supports OAI-PMH, Dublin core "out of the box". There is support for a METS export through a modified version of the OAI exporter, contributed by one of the community developers. LDAP integration is possible as stated below:

http://wiki.EPrints.org/w/Integrating_EPrints_with_LDAP

There is no support yet for any web service API (SOAP or REST). The bulk 'export and import' only supports export of metadata but not the files related to a digital object.

4.4.9 DSpace

DSpace supports OAI-PMH, METS, and Dublin core. It also has support for both REST and SOAP web services. DSpace supports SRU/SRW. DSpace supports LDAP authentication as described here:

http://www.DSpace.org/technology/system-docs/configure.html#ldap

4.4.10 Fedora

Fedora, being a web service itself rather than a web application, naturally supports SOAP and REST web services. Fedora supports OAI-PMH, METS and Dublin core. It also has good bulk import and export scripts and supports FOXML and METS formats. Fedora supports authentication through LDAP.

4.5 EASE OF DEPLOYMENT

4.5.1 **Software and hardware requirements -** The repository only requires common/basic software and hardware

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	2	3	4	2

4.5.2 **Packaging and installation steps**

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
2	2	2	4	3

4.5.3 **Separate repository and branding for each institution (Essential)**

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
4	4	4	4	4

4.5.4 **EPrints**

EPrints will function on a modest PC installation. It is mod_perl based which normally does not require a lot of hardware resources. Packaging is only fair, as is evidenced by the need to install other software to make it run. As an example, there is a requirement to independently download additional Perl modules for a complete installation process. However installation steps are clear and not complex. The following link is a guideline to the EPrints installation process.

http://www.EPrints.org/documentation/tech/php/installation.php

EPrints requires:

- MySQL
- Apache with mod_perl
- Various perl modules

More details can be seen here:

http://www.EPrints.org/documentation/tech/php/reqsoftware.php

4.5.5 DSpace

DSpace will function on a modest PC installation. There are no exact minimum specifications; it just needs to be able to run PostgreSQL/Oracle and a java servlet.

DSpace requires the following software:

- Unix like OS
- Java 1.4 or higher
- Apache Ant 1.5 or higher
- PostgreSQL 7.3 or higher / Oracle 9i or higher
- Jakarta Tomcat 4.x or higher, or something equivalent

More details can be seen here:

http://DSpace.org/technology/system-docs/install.html

4.5.6 Fedora

Fedora does not require a lot of different software components, as the packaging includes all required software. It only needs the installation of a database if its internal database is not used. Fedora requires Sun Java SDK 1.4.2 or above. Fedora installation instructions can be found here:

http://www.fedora.info/download/2.1.1/userdocs/distribution/installation.html

Fez is more complex to install than Fedora. It requires the common software components of Linux, Apache, MySQL and php (LAMP). What makes Fez different from other LAMP software is that it requires a pre-installation of "tidy" and GD PHP extensions. It also needs Image Magick, Graphiz and JHOVE software to enable it to operate.

4.6 SYSTEM ADMINISTRATION

4.6.1 Ability to customise look and feel - change the header, theme, footer

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	2	3	4	2

4.6.2 Ease of Publishing - Inexperienced users of the repository can easily publish a content

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
4	3	3	4	3

4.6.3 EPrints

The EPrints web UI is clean and simple enough for a non-experienced user to use. EPrints web UI is developed using mod_perl which is relatively difficult to change. EPrints does support CSS and allows for the customisation of the header and footer.

4.6.4 DSpace

DSpace has a clean UI and is relatively simple for a non-experienced user. Configuration of the UI would need to be done by a developer. It uses JSP for its presentation layer and customisation is documented here:

http://DSpace.org/technology/system-docs/configure.html#customui

4.6.5 Fedora

Fedora is a web service; it does not have a web UI front end. However there are various applications that do integrate with Fedora here is a link to those.

http://www.fedora.info/tools/.

Fez is one of the tools we have evaluated in conjunction with Fedora. It uses a common and easy technology: PHP and MySQL. Fez is part of the Australian Partnership for Sustainable Repositories (APSR).

More information about Fez can be seen here:

http://sourceforge.net/projects/fez/

Fez is built using PHP templates and these templates can easily be changed. Some development effort could be applied to support the ability to change a theme. The publication UI of Fez is less complex than what Fedora is capable of, and it is a straight-forward process to publish to Fedora using Fez.

4.7 INTERNATIONALISATION

4.7.1 Localisable UI

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
4	4	4	4	4

* Fedora has no native UI. Fedora front-end applications, such as Fez, can be localised with relative ease

.

4.7.2 Unicode Text editing and storage

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
4	4	4	4	4

4.7.3 EPrints

EPrints supports localisation of the UI through language strings. Storage of metadata can be done in unicode.

4.7.4 DSpace

DSpace supports localising the UI; it even has downloadable language packs. Storage and metadata can be done in unicode.

4.7.5 Fedora

Tools such as Fez support localization of UI. Currently Fez supports different languages in terms of different PHP templates, rather than localisation of strings.

4.8 OPEN SOURCE

4.8.1 Open Source License (Required)

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
4	4	4	3	3

4.8.2 Defined roadmap for the future

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
4	2	4	3	3

4.8.3 EPrints

EPrints uses GNU Public License (GPL) and University of Southampton holds the copyright as explained here:

http://wiki.EPrints.org/w/Copyright_and_License_FAQ

This means that it is Open Source but any code contributions may not be accepted. Historically any contribution is kept outside the code base to retain copyright of the code base. EPrints 3.0 is on the development roadmap and may be released this year.

4.8.4 DSpace

DSpace uses the BSD license. It has a more open community in developing the software compared to the other repository systems evaluated.

The DSpace development roadmap seems to have slowed down as can be seen in the roadmap below:

http://wiki.DSpace.org/RoadMap

4.8.5 Fedora

Fedora uses the Educational Community License; a complete license list of the different components of Fedora is listed here:

http://www.fedora.info/download/2.1.1/userdocs/distribution/license/license.html

There is still funding for Fedora that will last until September 2007.

http://www.fedora.info/community/fedorafuture.shtml

4.9 WORK FLOW TOOLS

4.9.1 **Workflow integration -** Support to use different workflow tools

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
1	3	4	0	3

4.9.2 **Support for different workflows**

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
1	3	4	0	2

4.9.3 **EPrints**

The workflow of EPrints is integrated with its UI. Currently it is now supports only a fixed simple workflow. The ability to configure a workflow is planned for EPrints 3.0

4.9.4 **DSpace**

DSpace can be configured to support the workflow to be applied to publishing digital objects. It can also attach different workflows for publishing. The workflow system is described here:

http://DSpace.org/technology/system-docs/business.html#workflow

4.9.5 **Fedora**

Fedora does not support workflow natively. Its current design philosophy is to move workflow outside the repository. Fez, an application that uses Fedora, supports multiple configurable workflows.

The service framework of Fedora, viewable at the following address, illustrates how an application with workflow integrates:

http://www.fedora.info/download/2.1.1/userdocs/server/features/serviceframework.htm

The following link shows a screenshot of a Fez workflow template:

http://sourceforge.net/project/screenshots.php?group_id=148409

4.10 COMMUNITY KNOWLEDGE BASE

4.10.1 Quality and completeness of information on the product's web site

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
4	3	4	4	4

4.10.2 Size of and level of activity in the developer community

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
2	3	2	4	4

4.10.3 Size of and level of activity in the user community

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
2	3	2	4	4

4.10.4 Availability and use of a range of communication channels (email, forums, IRC, wiki, etc)

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	4	3	3	3

4.10.5 Software release history for evidence of sustainability and vitality

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
3	2	3	3	3

4.10.6 Documentation on how to set up and manage a repository farm (one code base, many independent repositories)

EPrints	DSpace	Fedora	Importance Rating DIY 0-4	Importance Rating Hosted/Hub 0-4
0	0	0	3	3

4.10.7 EPrints

EPrints documentation is of good quality and resides here:

http://www.EPrints.org/documentation/tech/php/intro.php

Relative to the other communities, its size is small, but it is currently active. There is little development activity outside University of Southampton possibly due to their maintaining sole copyright ownership.

The roadmap outlines the deliverables for EPrints 3.0., and the key development seen on this is the inclusion of a configurable workflow.

A Wiki page is available to the public at this address:

http://wiki.EPrints.org/w/Main_Page

The EPrints mailing list gets about 3-8 messages a day. Topics ranging from installation help and minor tweaking for EPrints.

Gmane activity graph can be seen here

http://dir.gmane.org/gmane.comp.web.eprints.devel

A paid community member will have more channels for collaboration and such a support services is provided by University of Southampton and more details can be read here:

http://www.EPrints.org/services/

4.10.8 DSpace

DSpace documentation is reasonable but appears dated:

http://www.DSpace.org/technology/system-docs/index.html

There is a fair amount of activity and community for DSpace. The Sourceforge project page can be found at this address:

http://sourceforge.net/projects/DSpace/

A public bug tracker and patches are available in the Sourceforge project space.

DSpace received approximately 9 messages a day over a span of 46 months. There is an active community around it. There was a noticeable jump of activity at the end of 2005 and until mid 2006 this then lowered to normal levels again. The jump looks to be attributed to the anticipated release of version 1.4 which was eventually released in July 2006.

There is a free mailing list for DSpace:

http://sourceforge.net/mail/?group_id=19984

Wiki pages for DSpace are available at this address:

http://wiki.DSpace.org/

DSpace also has an IRC channel at freenode.net #DSpace

4.10.9 Fedora

Fedora's documentation is of good quality.

Its documentation can be found here:

http://www.fedora.info/documentation/

The size and activity level of the community is small compared to other open source projects. The developers from University of Virginia and Cornell University primarily undertake all development. A wiki, mailing list, and bug tracker is provided for the public.

There are Fedora and other related projects conferences going on around the world

Wiki pages are available at this address:

http://www.fedora.info/wiki/index.php/Main_Page

Mailing list instructions are available at this address:

http://www.fedora.info/community/mailLists.shtml

A public bug tracker is available at this address:

http://www.fedora.info/bugzilla/

5. RECOMMENDATIONS

5.1 INTRODUCTION

It is important to note that all systems were credible repository systems. At the end of our evaluations, to differentiate them in order to make recommendations we had to re-focus on 2 criteria:

- To choose a system that can aggregate published metadata and offer a bureau/hosting service referred to here as The Hosted Solution and the National Hub. This would provide a federated search of the bureau and across the national network of separate and different repository systems
- To select a system/s that offers institutions a repository system that is feature rich yet has low implementation and support overheads.

5.2 DSPACE CAN BE ACCOMMODATED WITHIN THE NATIONAL NETWORK

Although DSpace scored well in the overall evaluation, the identified scalability issue is hard to overcome without a major re-write and therefore it is recommended that the project team does not use DSpace as the hosted solution and backend for the National Hub.

The less complicated software architecture of EPrints gives it the advantage over DSpace as the self-configuring institutional repository system for the OARINZ "DIY" deliverables.

DSpace is a good system, whose strengths lie in its interoperability and security. It can still be used by any individual institution as it will effectively integrate with our recommended centralised architecture based on Fedora.

5.3 FEDORA AS HOSTED SOLUTION AND BACKEND FOR NATIONAL HUB

Based from the total of the Technical Evaluation Criteria we can see Fedora is a strong contender for the hosted solution which is within the scope of outcome 2. of the OARINZ project.

Fedora offers OARINZ a good infrastructure foundation with scalability and interoperability in mind.

It is the strongest repository system to be used as the core of the national network for Outcome 1 of OARINZ: "Establish the infrastructure for a national network of Institutional Repositories". Fedora was designed as an infrastructure for institutional repositories, where multiple and disparate repositories co-exist and whose content is aggregated. This can be achieved by publication of metadata via an OAI harvester and full repository functionality

within the hosted solution using webservices.

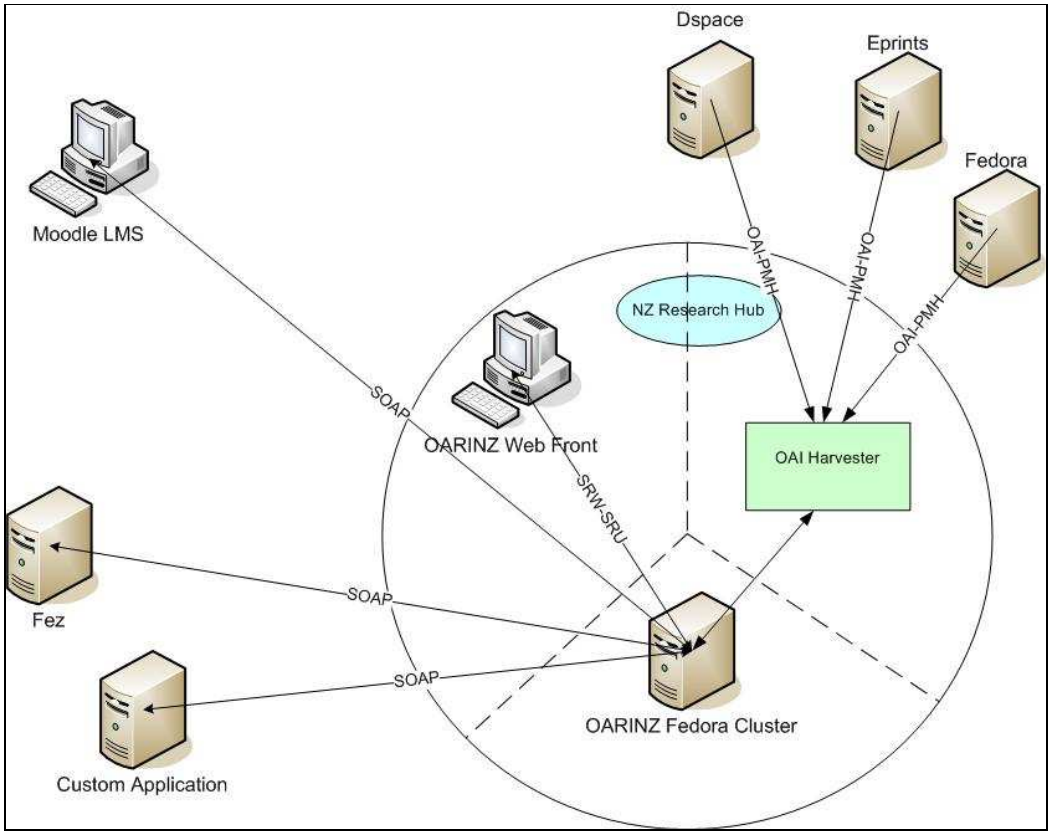
Custom development on Fedora itself will be harder than the other repository systems evaluated, however it is not foreseen that much development is needed on Fedora itself. Postgres support is the one potential development seen here. The User interface for those institutions using the hosted solution is where the most development would take place and an application such as Fez or other web service clients would be used as a basis here. This is not expected to be overly complex and should ensure each institution can have their own customised workflow and branding.

5.4 EPRINTS FOR SELF-CONFIGURING SOLUTION

EPrints is the best candidate for a self-configuring solution for institutions wanting to set up and host their own repository. Publication to the national network would be accommodated through the OAI harvester at the national hub retrieving the metadata from these institutions.

EPrints may have some scalability problems but, with less complicated software architecture; remedial development work can be done to resolve this issue. This work is not expected to be complex or risky.

5.5 POSSIBLE SCENARIO FOR USING FEDORA



A Fedora hosted 'cluster' architecture can be setup for the different institutions to publish and fetch digital objects.

Some applications will use webservices for two-way interaction with the Fedora cluster.

One directional interaction is also possible such as in the case of an OAI Harvester or for a non web services aware client such as an EPrints to publish its digital objects.

A summary of the technical work that must be done to support the architecture above:

Configuration of Fedora cluster

- Development of an OARINZ web front end, this front end is used to do a search in a web browser. Potential customisation of the existing web search user interface of Fedora.
- Potential development of a web service client if there are any institutions that want to directly integrate from 3rd party application software – e.g. Moodle Learning Management System. (**if scope and resources allow**)

- Development of custom applications (e.g. based on Fez) for institutions that do not find any of the Fedora tools suitable for their purpose.

- Development of EPrints export script to METS or FOXML format if there are any institutions that have an existing EPrints repository and wish to publish to the OARINZ Hub.

5.6 POTENTIAL AREAS OF DEVELOPMENT

During the evaluation several potential areas of development were identified:

- Development of a small PHP SOAP client to Fedora would be useful in 2 different areas. Firstly, a PHP SOAP Fedora client could be adopted by 3rd party applications - e.g. a Moodle module, thereby enabling users to directly source from a Fedora repository from within a Learning Management System environment. Secondly, using the same PHP SOAP Fedora client a simple PHP based front end can be developed for Fedora. This simple PHP Fedora front end could also be used as an alternative DIY solution.

- Improvement and customisation of Fez for the OARINZ project is another identified area of development. Fez was developed as part of UQ eScholarship Project and Australian Partnership for Sustainable Repositories, and therefore some aspects will likely not apply to the OARINZ project.

- Development of OARINZ web search and portal front end. This website will be the tool that will search the OARINZ repository. The website may also provide a portal and/or RSS feeds.

- Customisation and further development of an OAI Harvester. An evaluation of potential OAI Harvesters must also be undertaken.

- Development of prototypes on how to integrate with the OARINZ repository. The prototypes will give the different institutions a model to follow in integrating their respective repository.

- Fedora can be further enhanced to support PostgreSQL as its database backend. Currently it supports only MySQL and Oracle.

- Installation Packages (e.g. RPM and DEB Packages) for the self configuring solution and User Interface for the Hosted Solution.

6. APPENDIX 1 - EVALUATION MATRIX

Please note, the evaluation grades allocated are for guidance only and that there are two tables, one for the Self Configuring DIY solution the other for the Hosted/Hub solution, where the importance rating differs:

Self Configuring Solution (DIY)

Criteria	Importance	Rating	Eprints Evaluation	Eprints Total	Dspace Evaluation	Dspace Total	Fedora Evaluation	Fedora Total
4.1 Scalability								
4.1.1 Scale Up	3		3	**9**	2	**6**	3	**9**
4.1.2 Scale out	4		3	**12**	3	**12**	3	**12**
4.1.3 Architecture	3		3	**9**	2	**6**	4	**12**
Sub Total Scalability				**30**		**24**		**33**
4.2 Ease of working on Code Base								
4.2.1 Add/Change digital object	**1**		2	**2**	3	**3**	4	**4**
4.2.2 Documentation of code	**3**		4	**12**	2	**6**	4	**12**
Sub Total Ease of Working on Code Base				**14**		**9**		**16**
4.3 Security								
4.3.1 Data Encryption	**3**		4	**12**	4	**12**	4	**12**
4.3.2 Server Security	**4**		2	**8**	3	**12**	4	**16**
4.3.3 Authentication	**2**		3	**6**	4	**8**	4	**8**
4.3.4 Authorization/Access Rights	**0**		2	**0**	4	**0**	2	**0**
4.3.5 Ability to restrict access at repository item level	**0**		2	**0**	3	**0**	4	**0**
Sub Total Security				**26**		**32**		**36**
4.4 Interoperability								
4.4.1 OAI-PMH Compliant (Required)	**4**		4	**16**	4	**16**	4	**16**
4.4.2 SOAP, UDDI	**0**		0	**0**	4	**0**	4	**0**
4.4.3 SRU/SRW	**0**		0	**0**	4	**0**	0	**0**
4.4.4 Bulk Import and Export	**1**		2	**2**	4	**4**	4	**4**
4.4.5 Institution exit mechanism (Required)	**4**		3	**12**	4	**16**	4	**16**
4.4.6 Authentication - (e.g. LDAP)	**1**		3	**3**	4	**4**	4	**4**
4.4.7 Standard metadata - Dublin core, METS.	**4**		3	**12**	4	**16**	4	**16**
Sub Total Interoperability				**45**		**56**		**56**
4.5 Ease of Deployment								
4.5.1 Software and hardware requirements	**4**		3	**12**	2	**8**	3	**12**
4.5.2 Packaging and installation steps	**4**		2	**8**	2	**8**	2	**8**
4.5.3 Separate repository/branding each institution	**4**		4	**16**	4	**16**	4	**16**
Sub Total Ease of Deployment				**36**		**32**		**36**
4.6 System Administration								
4.6.1 Ability to customise look and feel	**4**		3	**12**	2	**8**	3	**12**
4.6.2 Ease of Publishing	**4**		4	**16**	3	**12**	3	**12**
Sub Total System Administration				**28**		**20**		**24**
4.7 Internationalisation								
4.7.1 Localisable UI	**4**		4	**16**	4	**16**	3	**12**
4.7.2 Unicode Text editing and storage	**4**		4	**16**	4	**16**	4	**16**
Sub Total				**32**		**32**		**28**
4.8 Open Source								
4.8.1 Open Source License	**3**		4	**12**	4	**12**	4	**12**
4.8.2 Defined roadmap for the future	**3**		4	**12**	2	**6**	4	**12**
Sub Total Open Source				**24**		**18**		**24**
4.9 Work Flow Tools								
4.9.1 Workflow integration	**0**		1	**0**	3	**0**	4	**0**
4.9.2 Support for different workflows	**0**		1	**0**	3	**0**	4	**0**
Sub Total Work Flow Tools				**0**		**0**		**0**
4.10Community Knowledge Base								
4.10.1 Quality of information on the product's web site	**4**		4	**16**	3	**12**	4	**16**
4.10.2 Size/Level of activity in the developer community	**4**		2	**8**	3	**12**	2	**8**
4.10.3 Size of and level of activity in the user community	**4**		2	**8**	3	**12**	2	**8**
4.10.4 Availability/Range of communication channels	**3**		3	**9**	4	**12**	3	**9**
4.10.5 Software release history-sustainability,vitality	**3**		3	**9**	2	**6**	3	**9**
4.10.6 Documentation on how to set up and manage a repository farm (one code base, many independent	**3**		0	**0**	0	**0**	0	**0**
Sub Total Community Knowledge Base				**50**		**54**		**50**
Totals for Self Configuring Repositories (DIY)				**285**		**277**		**303**

Hosted/Hub Solution

Criteria	Importance Rating	Eprints Evaluation	Eprints Total	Dspace Evaluation	Dspace Total	Fedora Evaluation	Fedora Total
4.1 Scalability							
4.1.1 Scale Up	3	3	**9**	2	**6**	3	**9**
4.1.2 Scale out	4	3	**12**	3	**12**	3	**12**
4.1.3 Architecture	3	3	**9**	2	**6**	4	**12**
Sub Total Scalability			**30**		**24**		**33**
4.2 Ease of working on Code Base							
4.2.1 Add/Change digital object	**3**	2	**6**	3	**9**	4	**12**
4.2.2 Documentation of code	**3**	4	**12**	2	**6**	4	**12**
Sub Total Ease of Working on Code Base			**18**		**15**		**24**
4.3 Security							
4.3.1 Data Encryption	**3**	4	**12**	4	**12**	4	**12**
4.3.2 Server Security	**4**	2	**8**	3	**12**	4	**16**
4.3.3 Authentication	**2**	3	**6**	4	**8**	4	**8**
4.3.4 Authorization/Access Rights	**2**	2	**4**	4	**8**	2	**4**
4.3.5 Ability to restrict access at repository item level	**3**	2	**6**	3	**9**	4	**12**
Sub Total Security			**36**		**49**		**52**
4.4 Interoperability							
4.4.1 OAI-PMH Compliant (Required)	**4**	4	**16**	4	**16**	4	**16**
4.4.2 SOAP, UDDI	**3**	0	**0**	4	**12**	4	**12**
4.4.3 SRU/SRW	**3**	0	**0**	4	**12**	0	**0**
4.4.4 Bulk Import and Export	**4**	2	**8**	4	**16**	4	**16**
4.4.5 Institution exit mechanism (Required)	**4**	3	**12**	4	**16**	4	**16**
4.4.6 Authentication - (e.g. LDAP)	**2**	3	**6**	4	**8**	4	**8**
4.4.7 Standard metadata - Dublin core, METS.	**4**	3	**12**	4	**16**	4	**16**
Sub Total Interoperability			**54**		**96**		**84**
4.5 Ease of Deployment							
4.5.1 Software and hardware requirements	**2**	3	**6**	2	**4**	3	**6**
4.5.2 Packaging and installation steps	**3**	2	**6**	2	**6**	2	**6**
4.5.3 Separate repository/branding each institution	**4**	4	**16**	4	**16**	4	**16**
Sub Total Ease of Deployment			**28**		**26**		**28**
4.6 System Administration							
4.6.1 Ability to customise look and feel	**2**	3	**6**	2	**4**	3	**6**
4.6.2 Ease of Publishing	**3**	4	**12**	3	**9**	3	**9**
Sub Total System Administration			**18**		**13**		**15**
4.7 Internationalisation							
4.7.1 Localisable UI	**4**	4	**16**	4	**16**	3	**12**
4.7.2 Unicode Text editing and storage	**4**	4	**16**	4	**16**	4	**16**
Sub Total			**32**		**32**		**28**
4.8 Open Source							
4.8.1 Open Source License	**3**	4	**12**	4	**12**	4	**12**
4.8.2 Defined roadmap for the future	**3**	4	**12**	2	**6**	4	**12**
Sub Total Open Source			**24**		**18**		**24**
4.9 Work Flow Tools							
4.9.1 Workflow integration	**3**	1	**3**	3	**9**	4	**12**
4.9.2 Support for different workflows	**2**	1	**2**	3	**6**	4	**8**
Sub Total Work Flow Tools			**5**		**15**		**20**
4.10Community Knowledge Base							
4.10.1 Quality of information on the product's web site	**4**	4	**16**	3	**12**	4	**16**
4.10.2 Size/Level of activity in the developer community	**4**	2	**8**	3	**12**	2	**8**
4.10.3 Size of and level of activity in the user community	**4**	2	**8**	3	**12**	2	**8**
4.10.4 Availability/Range of communication channels	**3**	3	**9**	4	**12**	3	**9**
4.10.5 Software release history-sustainability,vitality	**3**	3	**9**	2	**6**	3	**9**
4.10.6 Documentation on how to set up and manage a repository farm (one code base, many independent repositories)	**3**	0	**0**	0	**0**	0	**0**
Sub Total Community Knowledge Base			**50**		**54**		**50**
Totals for Hub & Hosted Repositories			**295**		**342**		**358**