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MSC IN E-SCIENCE

INDIVIDUAL RESEARCH PROJECT: DISSERTATION

REFINING OGSA-DAI INSTALLATION FOR RAPID DEPLOYMENT OF DISTRIBUTED DATA SERVERS SUPPORTING GENE THERAPY CLINICAL TRIALS IN CYSTIC FIBROSIS

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(s0792469)

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ABSTRACT

Cystic fibrosis is a debilitating disease and affects over 8,000 people making it the UK’s most common life-threatening inherited disease. Currently there is no cure for this disease and treatment is targeted at managing the symptoms and slowing down its progress. There are currently clinical trials being run at the Molecular Medicine Centre to try and develop a gene therapy to combat this disease. These trials are producing larger amounts of data that must be stored and analysed. The idea behind this project is to simplify the set of remote data servers to aid in this storage and analysis. The project developed a graphical installer which would install a Tomcat web service with a Globus Toolkit web service core onto which OGSA-DAI could be deployed. The installer also installs a database designed to store the trial data and access to the database is controlled via OGSA-DAI.

ACKNOWLEDGEMENTS

I would like to express my great thanks to Rob Kitchen and Jano van Hemert for all there help with this project, it would not have possible without them.

I would also like to thank Craig Thomson, not only for the original software I have adapted but also the help he gave me during implementation.

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1.1.Overview

The aim of this project was to assist in the data management of the Gene Therapy clinical trials in Cystic Fibrosis. The data produced from these trials is not only financially valuable (the cost of running the experiments) but scientifically valuable, as it is hoped these results could one day lead to a cure for Cystic Fibrosis. It is the value of this data that motivated this project, as this project will lead the way to being able to set-up quick and reliable backup systems to protect the trial data. Another major motivation for this project is that if the data can be stored and managed it can then be shared and analysed over a distributed network of institutions running similar studies. A system was developed to simplify the process of setting servers to store the trial data. The system has a simple user interface to encourage its use by the biologists running the trials. At the same time the system also addresses some of the major concerns of system administrators, namely the security aspects of distributed data storage.

1.2.Background

1.2.1. Cystic Fibrosis

Cystic Fibrosis (CF) is a hereditary disease that affects both the lungs and the digestive system. It is the UK's most common life-threatening inherited disease affecting over 8,000 people. According to the Cystic Fibrosis Trust(1) the current average life expectancy for a CF sufferer is around 31 years. CF is a genetic condition caused by a mutation in the Cystic Fibrosis Transmembrane Conductance Regulator (CFTR) gene on chromosome 7. It is an autosomal recessive disease, meaning that for a child to be born with CF it must inherit a pair of defective genes from the parents. If only one defective gene is inherited then the child is said to be a carrier of CF, but is otherwise completely healthy. Therefore, a child born to two carriers has a 25% chance of inheriting both defective chromosomes and developing the disease. The various permutations are illustrated in Figure 1. Around 1 in every 25 people in the UK and 1 in 22 Europeans is a carrier of the mutated gene; carriers however show no symptoms of the disease but can be tested for the mutation.

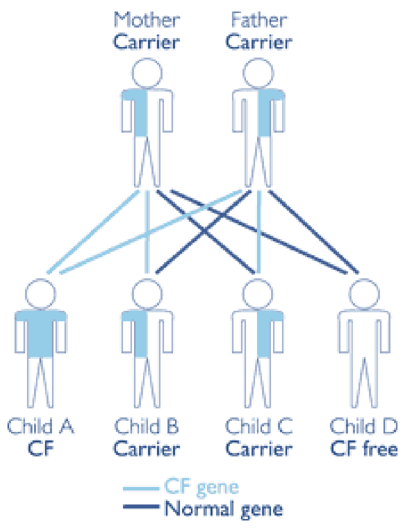


Figure 1 CF Autosomal inheritance (1)

The CFTR gene produces a protein which creates ion channels which help the salt move across the cell membrane. The mutated CFTR proteins do not carry out this transfer as effectively as healthy CFTR proteins, leading to dehydration and consequently the production of thick mucus surrounding affected organs such as lungs, pancreas, and digestive system. This thick mucus provides an excellent environment for the widespread growth of bacteria, resulting in the CF sufferer developing repeated infections in these organs. The lungs are commonly the most severely affected, and repeated lung infections are the primary cause of mortality in CF sufferers.

Currently there is no cure for CF and most treatments are targeted at managing the disease and slowing down its progress. Typical treatments include physiotherapy (to clear the thick mucus), antibiotics (to combat infections), and dietary supplements. Towards the end of the disease lung transplantation often becomes necessary.

One treatment which is being developed looks to cure the disease, rather than alleviate symptoms. This treatment is gene therapy; which is where a normal copy of the mutated CFTR gene is inserted into affected cells.

1.2.2. Microarrays

One aspect in the development of gene therapy for CF sufferers is the ability to measure the activity of CFTR gene, known as its ‘expression’ level. It is currently predicted that only a 5% restoration of function could prevent the lungs from developing CF (2). The researchers at the MMC are developing a solution to the problem using CF biomarkers, in that they are analysing the differences in gene expression between those with CF and healthy controls.

Biomarkers are identified as genes which are consistently, and significantly, differentially expressed between groups of CF patients and controls. The efficacy of the gene therapy will be monitored, as a time-course experiment, by measuring changes in the expression of these biomarkers and of all other genes. It is hoped that gene therapy will bring the expression of the biomarkers in CF sufferers closer to that seen in the healthy controls. The researchers employ microarray technology to monitor this gene expression.

DNA microarrays are a new research tool for analysing the expression of thousands of genes simultaneously. Microarrays are made up of thousands of gene specific probes arranged in a known order on a solid background. As mentioned above microarrays are used to quantify gene expressions in a cell, where a gene's expression is a measurement of its activity in the nucleus. A gene is a strand of DNA and acts as the blueprint for protein production. First the gene is transcribed to create messenger RNA (mRNA), the mRNA then produces proteins which affect the surrounding cells, and the cells affect the body. To measure the gene expression the amount of mRNA in the cell is measured as, this is thought to influence the amount of proteins made, which in turn affects the body/cell.

Each probe on the array is made up of a large number of copies of a single, unique, DNA strand. In a microarray experiment, mRNA is extracted from sample tissue, in this case either CF or control, and tagged with a fluorescent dye. The tagged strands of mRNA are washed over the microarray and each will bind specifically to one of the DNA probes on the array. Once the binding has taken place the array is washed to remove any unbound mRNA. The probes on the array are individually scanned with a laser, causing the bound mRNA to fluoresce. By measuring and recording the intensity of the light emitted from each probe the amount of mRNA bound to each probe can be quantified (the more bound mRNA the greater the light intensity). This technique allows for the direct comparison of gene expressions between CF patients and controls.

As the laser scans the microarray chip, the fluorescence is recorded using a photomultiplier tube. The resulting output from the experiment is a TIFF image of the entire chip. In order for useful biological analyses, software algorithms transform this image into an array of numbers representing the average signal recorded for each probe. This array is called a gene expression matrix and is the base for all further statistical investigations on the genes.

1.2.3. Real-time PCR

Another method of analysing gene expression is real-time PCR. Real time Polymerase Chain Reaction (real-time PCR) is commonly used to confirm microarray results. PCR uses the same principles of RNA to DNA binding as microarray analyses. The major difference between the two processes is that while microarrays simultaneously analyse thousands of gene expressions, real-time PCR concentrates on just one. Before undergoing real-time PCR, mRNA must be reverse-transcribed to complementary DNA (cDNA). Once converted to cDNA it is then amplified using DNA polymerase (an enzyme that replicates DNA). Once amplified the resulting amount of DNA is measured, like in the microarray experiments the DNA is tagged with a florescent marker, thus meaning the greater intensity of the fluorescence the greater the amount of DNA. This process of amplification and measurement is then iterated around 40 times and the results plotted on a graph. Using a number of controls the exact rate of amplification can be calculated and then, using this value, the researchers can extrapolate the original mRNA concentration in the sample, thus measuring the gene expression in the cell.

1.2.4. Current Procedures

The Molecular Medicine Centre(2) is currently researching the use of gene therapy to aid in the treatment of Cystic Fibrosis. The clinical trials currently running require the comparison of gene expressions in cells of affected patients versus controls. The current process for the analysis of gene expression in a single sample is listed below

1. Total RNA is extracted from the cells and the mRNA is separated
2. The mRNA is quality checked using an Agilent 2100 Bio analyser (3)
3. The mRNA is then amplified to become aRNA
4. The quality of the aRNA is again assessed, again using the 2100 Bio analyser
5. The aRNA is then used in a microarray experiment.

Once the results of the microarray experiment have been analysed, any genes shown to be significantly differentially expressed between disease and control are selected and re-tested using real-time PCR. In this process the first four steps are as above, then

5. The aRNA is reverse transcribed into cDNA
6. The quality of the cDNA is then assessed
7. The sample is used in the real-time PCR experiments

In these experiments, steps 2, 4, 5(in both microarray and real-time PCR) 6 and 7 all produce data that needs to be easily managed, stored, and processed. Currently a system has been developed by Rob Kitchen to manage the data output from these experiments(4). The current system is a desktop application, which takes the data produced from the experiments and stores it in a local database. This project aimed to simplify the process of backing up and sharing data remotely. The information gathered in these trials is subject to statistical analysis and it is anticipated that by increasing the sample size, the effect will be to produce more statistically significant results. Extrapolating to the situation where, if the data were pooled between multiple institutions, the effect on the significance of the results could be tremendous. Distributed data would not only increase the sample size, but also normalise it, as geographical anomalies could become apparent (for example, highlighting the differences in the data analysis procedures at different institutions).

1.2.5. Technology

Open Grid Services Architecture Data Access and Integration (OGSA-DAI) is a middleware product that allows data resources, such as relational or XML databases, to be accessed via web services (5). The OGSA-DAI project started in 2002 and is ongoing; the project has created 3 major releases so far.

The first problem encountered when sharing data resources is how to give users access. One way to do this is to expose the functionality of the data server in an application-specific web service. The benefits are that using the web service approach gives a platform-neutral solution and also provides a good security infrastructure. The problem arises when dealing with multiple databases of multiple types (see A in Figure 2). The solution developed by the OGSA-DAI team was to use generic, non-application-specific web services (see B Figure 2).

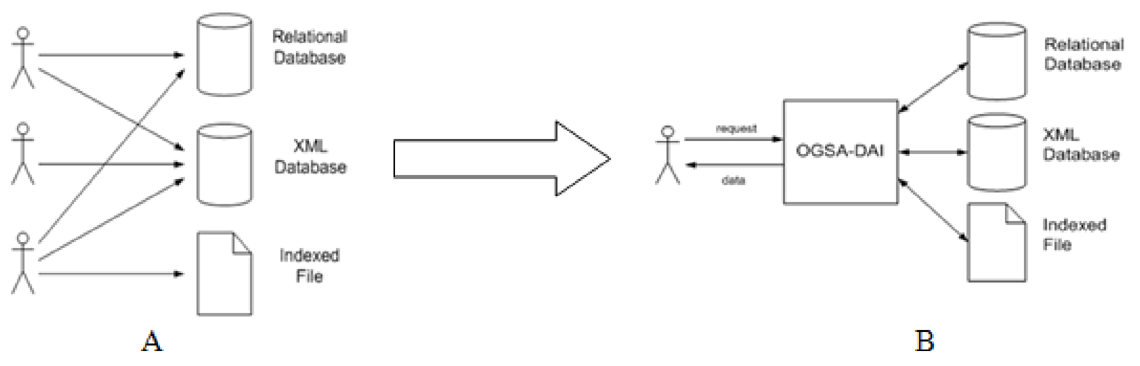


Figure 2 OGSA-DAI Generic Web Services (6)

OGSA-DAI not only provides a framework for exposing data resources on a grid it also provides support for the following:

- Data transformation.
- Data can be delivered to clients or other OGSA-DAI web services, URLs, FTP servers, GridFTP servers.
- Information about resources such as schemas can be accessed by clients.

1.2.5.1. Security

One of the focuses of this project is the OGSA-DAI security. The default security model in OGSA-DAI is based on the Grid Security Infrastructure and X.509 certificates. The X.509 certificates are used in authentication, ensuring the identity of a user. A certificate is an electronic document which binds together a user's identity with a public key (a number used in the encryption of information). Certificates are usually issued by a controlling body known as a certificate authority (CA). The purpose of the CA issuing certificates is so that the authenticity of the certificate is verified by a trusted third party, the CA. Once a user has a certificate this can be used as part of a secure conversation where both ends of the communication are verified before messages are passed between them. The public keys associated with the certificates are also used as part of the encryption algorithms protecting messages, which means only the intended party can decrypt the message.

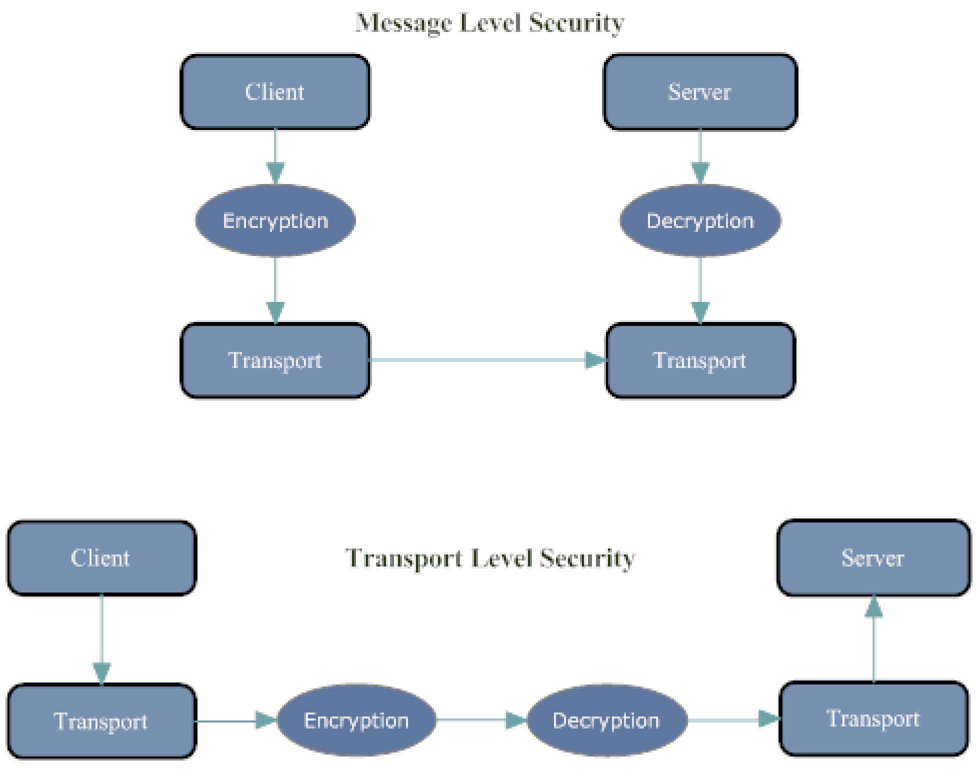


Figure 3 OGSA-DAI Security Levels

In OGSA-DAI, once the authentication is established there are two methods of communication security as seen in Figure 3. Message level security encrypts the contents of the message before it is transported, whilst transport level security encrypts the entire conversation.

1.2.5.2. Container

OGSA-DAI requires a web service container. This is an environment inside a web server where web services can be executed. OGSA-DAI supports two different containers: Globus Toolkit (GT) and Apache Axis. The Globus Toolkit is a fundamental enabling technology for the "Grid", letting people share computing power, databases, and other tools securely online across corporate, institutional, and geographic boundaries without sacrificing local autonomy (7). Apache Axis is an open source xml based web service framework. Both of these products provide the framework for and execution of web services, which includes the implementation of a SOAP server. SOAP is the messaging protocol at the heart of web services and concerns sending XML over the internet using standard HTTP. The two containers can be deployed in conjunction with an Apache Tomcat web server or the Globus Toolkit can be deployed as a standalone container.

1.2.5.3. Database

OGSA-DAI is used to expose the access to resources over the internet. The resource in question can be a multitude of things such as a file system or an XML database. In this report the resource in question is a relational database.

2. Design

2.1.System Overview

As described in the introduction, cystic fibrosis is a debilitating disease which affects a great many people. The researchers at the MMC are conducting many trials and experiments in a bid to create better methods of fighting this disease. These trials and experiments produce a great amount of data which must be processed and stored. This project has its roots in the organisation of this storage and the need for it to be reliable and remote. A system is being developed with a simple front end so that the biologists at the MMC are encouraged to use it. At the same time the system itself must be quick and easy to set-up by network administrators who do not necessarily have the experience in all the technologies involved. Figure 4 shows a high level view of the proposed system architecture detailing how the experimental data is inserted into the database across the internet.

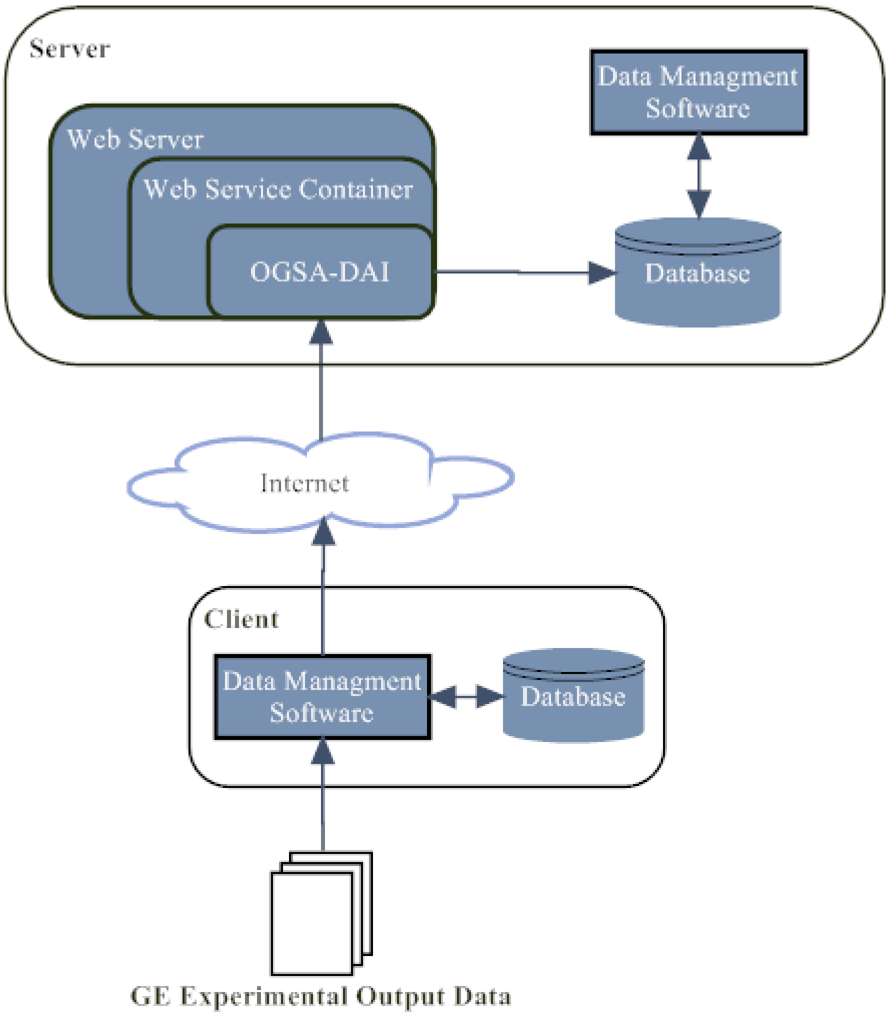


Figure 4 System Design for The Proposed System

2.1.1. Client

The client has been developed by Rob Kitchen (4) and is run on the scientist's local machine. The client collects and manages the data from the experiments and produces a number of SQL statements to commit this data to a remote database. These statements are then transported to the web server on the remote server machine, using http protocols on the internet, where they are processed and executed using OGSA-DAI and committed to the database. The data management software in the client is the same data management software on the server.

2.1.2. Server

The server consists of four components, firstly the web server which listens to a set port for the communications from the client. Then the web service container which creates the environment for the OGSA-DAI services to run. Thirdly the OGSA-DAI services' themselves which process the input from the client, so it can be passed to the final component, the database.

2.2. Design Aims

Each of the components in the server has their own installation procedures, some of which are very longwinded, using complicated command line arguments. Another drawback to these procedures is the set-up required on the host machine. As well as having the Java Development Environment (7) the machine must also have Apache Ant(8) and GNU Compiler Collection(9). All this makes the set-up very unfriendly and time consuming for an inexperienced user.

This project aims to simplify the set-up of a server. To do this the installation of the web server, web service container, OGSA-DAI and database must be simplified and incorporated into one easy-to-use installer. With this in mind the major design aims in this project are:

- A complete installer to set-up a server
- A simple user interface to facilitate the rapid deployment by non experienced users
- The flexibility and security to satisfy the requirements set by system administrators

To achieve these aims this project intends to expand on an existing program developed as part of the BEinGrid project (10). The program is a graphical user interface for the installation of OGSA-DAI 3.0.

2.3. Current Installer

The current installer is produced using IzPack which is an open source software project started in 2001. The software is a Java-based solution for packaging, distributing, and deploying applications. The software generates a single JAR file that only requires the Java runtime environment to operate, thus negating complex set-up on the host. This sole dependence on the Java virtual machine also makes it easy to produce a cross-platform compatible installer. This platform independence is of major benefit to the server set-up, as it gives flexibility to the choice of machines used. Izpack also provides integration with apache ant so is well suited for use in automating the OGSA-DAI deployment.

2.3.1. Structure of Current Installer

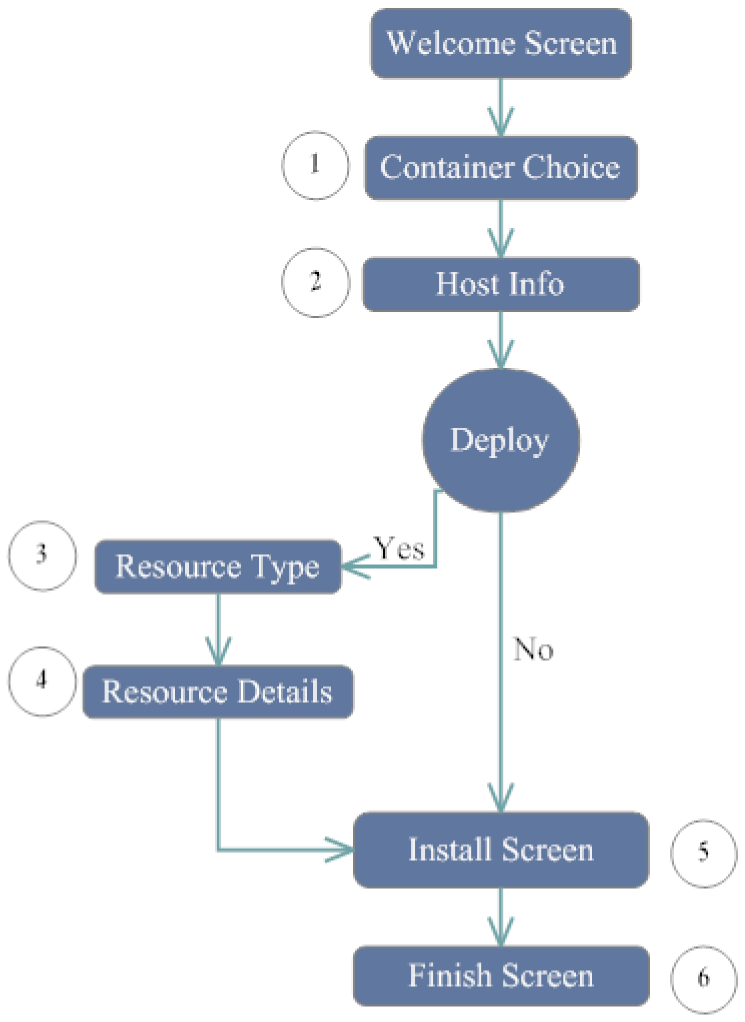
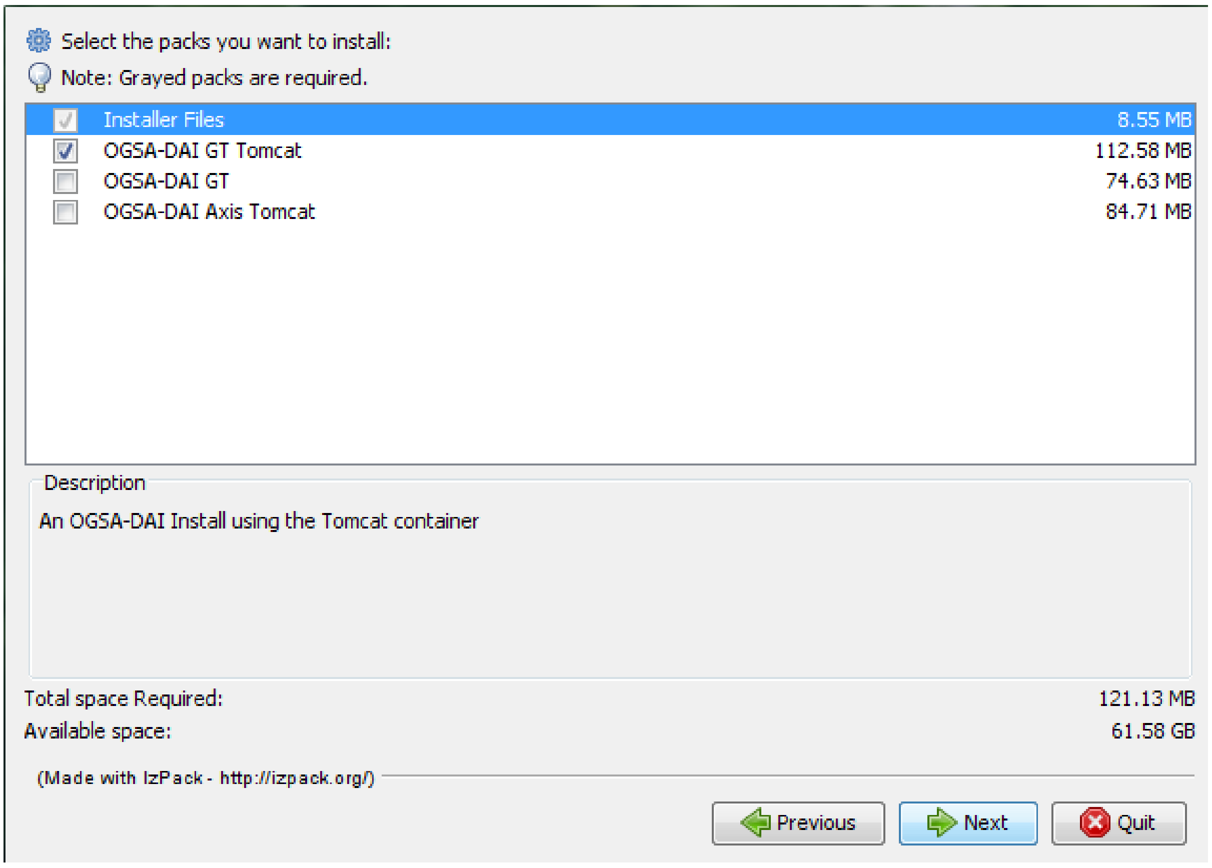


Figure 5 The Structure of the Original Installers User Interface

Figure 5 shows the structure of the current installer with each entity on the diagram representing a panel presented to the user. The panels are split into two categories: those that require user input and those that present installation information. The latter category will remain unchanged and includes the welcome screen, the install screen and the finish screen. There are five user input screens covering three areas of the setup:

- Container choice
- Web server setup
- Resource deployment



Select the packs you want to install:
Note: Grayed packs are required.

✓	Installer Files	8.55 MB
✓	OGSA-DAI GT Tomcat	112.58 MB
☐	OGSA-DAI GT	74.63 MB
☐	OGSA-DAI Axis Tomcat	84.71 MB

Description
An OGSA-DAI Install using the Tomcat container

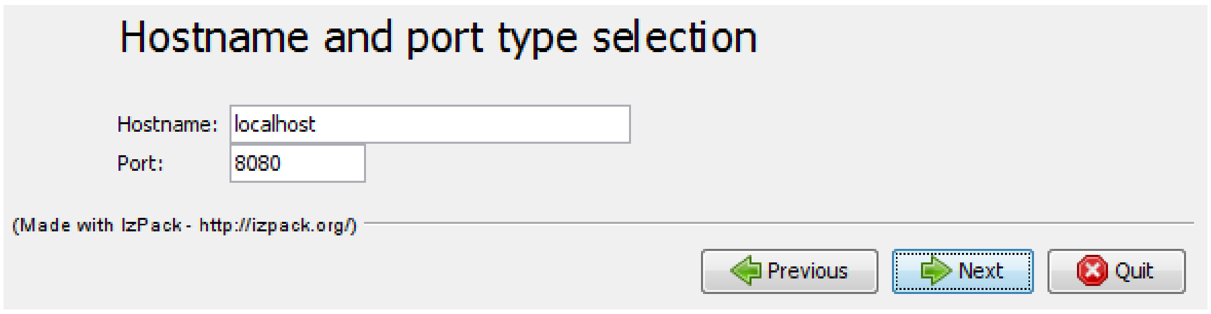
Total space Required: 121.13 MB
Available space: 61.58 GB

(Made with IzPack - http://izpack.org/)

Figure 6 Container Choice Panel from the Original Installer

The first input screen is screen one in Figure 5 and is shown in Figure 6, the container choice, where the user is asked to choose between the three distributions of OGSA-DAI

1. Globus
2. Tomcat with GT
3. Tomcat with Axis


Hostname and port type selection

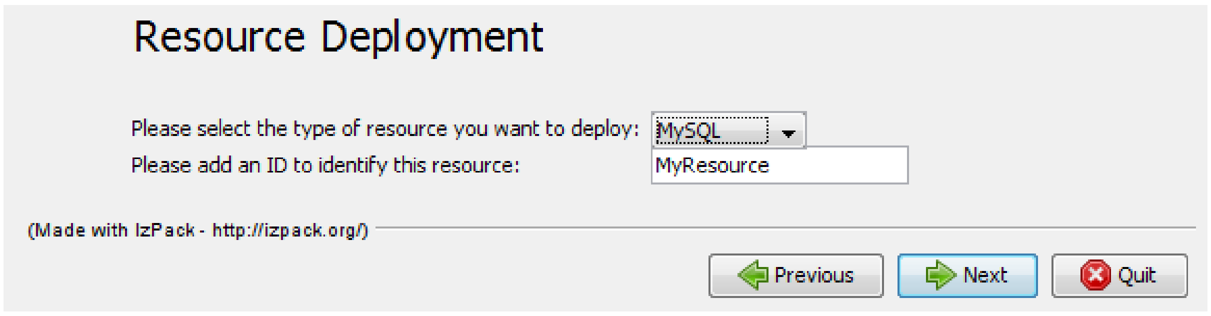
Hostname: localhost

Port: 8080

(Made with IzPack - http://izpack.org/)

Figure 7 Host Information Panel from the Original Installer

Screen two, host info shown Figure 7, requires input needed to set-up the web server this includes the host name and port number. The next three screens all deal with resource deployment, the first of these giving the user the option of whether to deploy a resource or not.


Resource Deployment

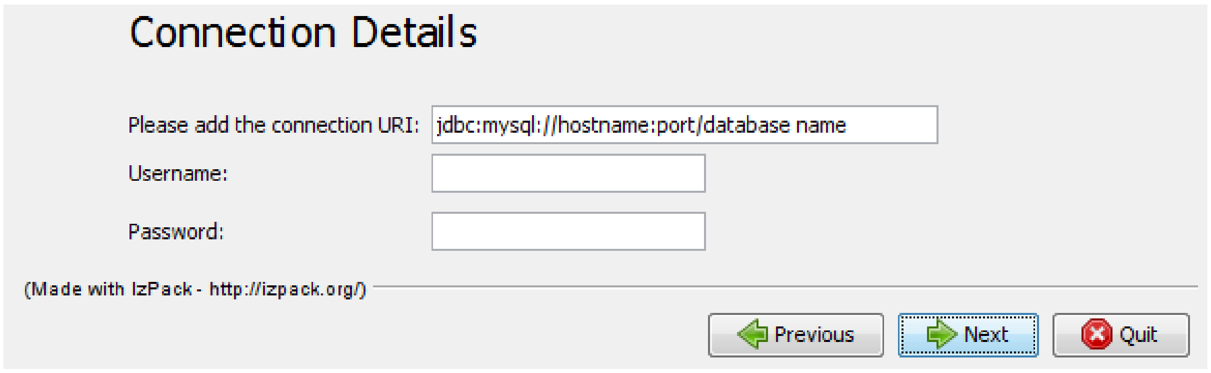
Please select the type of resource you want to deploy: MySQL

Please add an ID to identify this resource: MyResource

(Made with IzPack - http://izpack.org/)

Figure 8 Resource Deployment Panel from the Original Installer

If the user chooses to deploy a resource then screens three (Figure 8) and four (Figure 9) gather the information needed. Information gathered includes the type of resource, the URL of the resource (including database driver information) and user name and password for the resource.


Connection Details

Please add the connection URI: jdbc:mysql://hostname:port/database name

Username:

Password:

(Made with IzPack - http://izpack.org/)

Figure 9 Resource Details Panel from the Original Installer

Screen five (Figure 10) shows the user the progress of the install and presents any error messages that may occur. Finally screen six (Figure 11) is presented to the user if the install is successful.

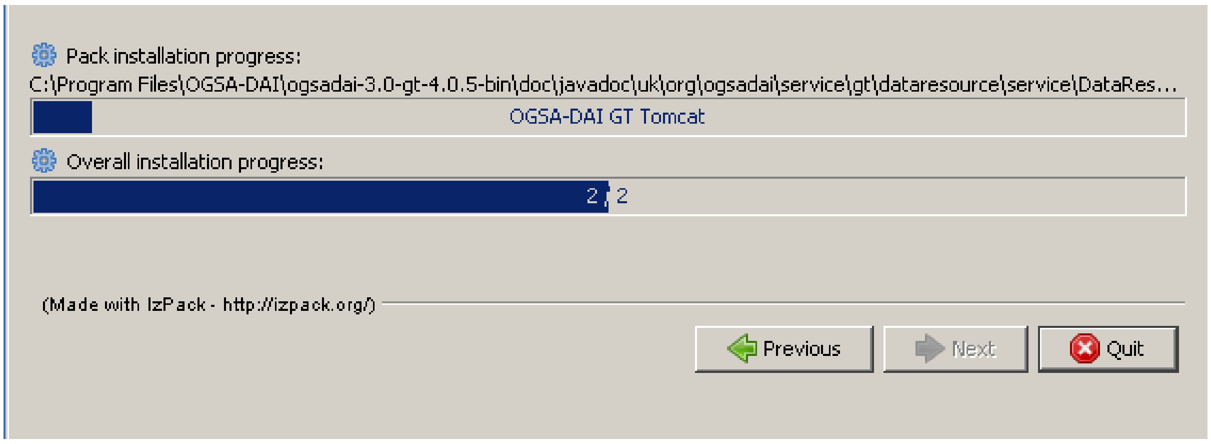

Pack installation progress:
C:\Program Files\OGSA-DAI\ogsadai-3.0-gt-4.0.5-bin\doc\javadoc\uk\org\ogsadai\service\gt\dataresource\service\DataRes...
OGSA-DAI GT Tomcat
Overall installation progress:
2 / 2
(Made with IzPack - http://izpack.org/)

Figure 10 Install Panel from the Original Installer

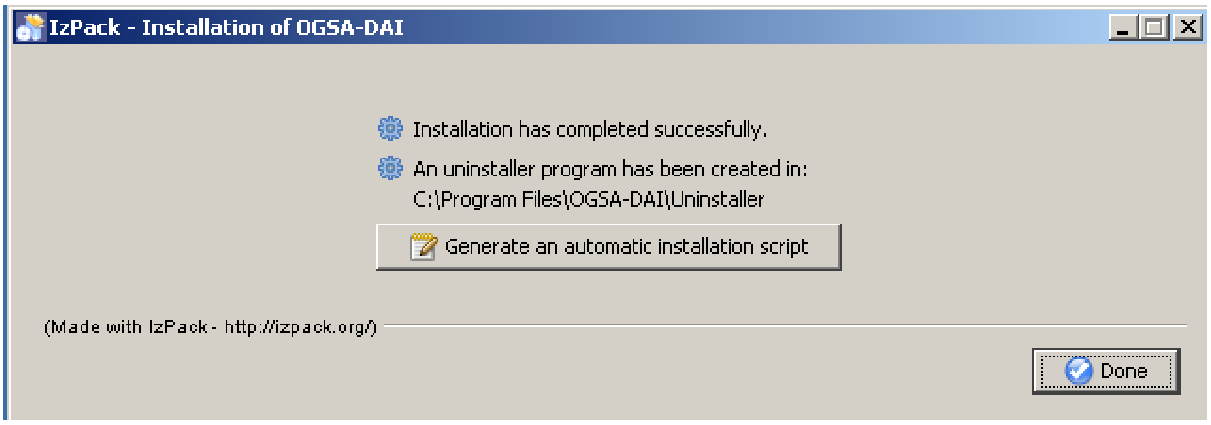

IzPack - Installation of OGSA-DAI
Installation has completed successfully.
An uninstaller program has been created in:
C:\Program Files\OGSA-DAI\Uninstaller
Generate an automatic installation script
(Made with IzPack - http://izpack.org/)

Figure 11 Finish Panel from the Original Installer

2.4. Design Choices

In light of the current installer the following goals must be addressed in the design

- A refined installer, minimising user input while maintaining enough freedom to satisfy network and system administrators
- The means of adding a database and exposing its resources
- The ability to enable the security infrastructure
- A platform independent installer

The first step is to simplify the installer and this simplification starts on the second screen. Rather than have an option of three different OGSA-DAI/container configurations, the container best suited to this project will be chosen and this will be the one presented to the user.

2.4.1. Refining Installer

2.4.1.1. Container Choice

2.4.1.1.1. Web server

The first aspect in choosing which OGSA-DAI set-up is right for this project is to choose which web server to use. There are two options

1. Apache Tomcat
2. Globus

The Globus web server is part of the Globus Toolkit and has one distinct advantage over the Tomcat option in that it is both the web server and the web service container. It being the complete package makes this a smaller option but only by about 10 mega bytes. Another major advantage to the Globus option is that OGSA-DAI was developed with the Globus Toolkit in mind. OGSA-DAI is in fact an off shoot of the Globus project.

The major drawback to using Globus as the web server is also the main selling point for Tomcat and that is brand power. Outside the grid world Globus is not very well known whereas Tomcat is synonymous with web servers in both the academic and business worlds. This familiarity will work as a major benefit when presenting the installer to system and network administrators. Another major benefit to Tomcat's popularity is that as an open source product, the more use of the system, the more likely bugs will be spotted and a solution devised. This means Tomcat is a very stable system which again makes it a very popular choice. Finally one of the major reasons why Tomcat was chosen for this project is its compatibility with operating systems. Tomcat is supplied with a number of features which aid in its deployment into an operating system, the main one of these is that the start up scripts also set the environment variables, unlike Globus which fails if the environment has not been set-up. One further feature of Tomcat is its easy integration with operating systems start up procedures which means it can be set to automatically start up when the system is initialised.

2.4.1.1.2. Web Service Container

Having chosen Tomcat as the web server of choice the next decision is what web service container to deploy inside of Tomcat. There are again two options

1. Globus Toolkit
2. Apache Axis

The Globus Toolkit is the larger of the two installations but only by 20 megabytes. As stated in 2.4.1.1.1 above, OGSA-DAI and Globus are high compatible as OGSA-DAI has been developed with Globus in mind. There is also extensive documentation available from the OGSA-DAI project detailing the set-up and usage of the Globus Toolkit with Tomcat.

Axis is developed by the Apache Software Foundation and as such is extremely compatible with Tomcat. Not only does the fact that Tomcat and Axis are developed by the same people lead to compatibly and stability, it also gives great benefit to the community and therefore the support that can be offered. However in this case it is the support that made the decision between the containers a lot easier. Whereas there is plenty of support available on the web for the integration of Axis into Tomcat, there is not that same level of support for the integration of OGSA-DAI into Axis. The OGSA-DAI Axis documentation does not cover the set-up of security. Given that security is one of the aims of the project the natural decision is to use the Globus Toolkit as the web service container.

2.4.2. Database

The second major design decision is the inclusion of a local database install into the set-up. The database is one of the most critical aspects in this system as this is where the data will eventually be stored. Of the many different database systems available, both commercially and freely, the MySQL database server was chosen. The reason for the choice of MySQL is that it is the system currently in use at the MMC(2) with Rob Kitchen's client(4). Another aspect in the addition of a local database is the need to deploy a database matching a set schema. The schema for this project is again provided from the current working system developed by Rob Kitchen. The schema sets out the format of the tables as well as the access rights for users. The schema in this project defines two databases; the first is an administrative database for user account management. The second is an individual database for the user, containing the tables required to store the data from the experiments. The first database is for administrative users and as such requires higher level access rights. This means two resources will need to be deployed, one for the user and one for the database administrator.

One feature in the implementation of this schema is the ease by which it can be updated or changed. Consideration is given to ensuring the schema definition is separated from the main installation so it can be readily changed or replaced.

2.4.2.1. New User Interface of the Installer

As discussed above the first design choice was to simplify the installation procedure by eliminating the choice of OGSA-DAI distributions. The next major design change to the installer is the addition of a database installation. Due to this addition the first decision now presented to the user is whether to include the installation of a local database or to proceed with either no resource or a remote resource.

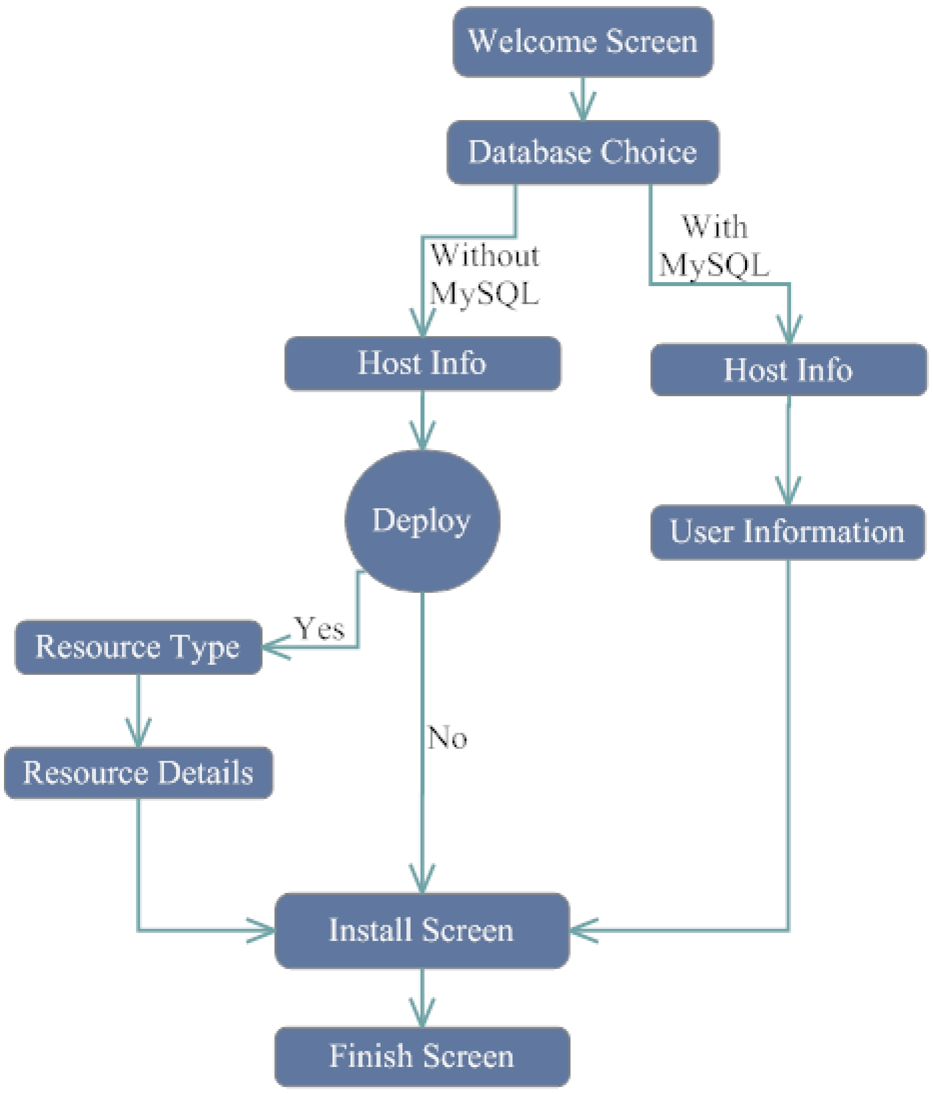


Figure 12 Updated Structure for the Installers User Interface

As can be seen from Figure 12 the installer has been stream-lined considerably when the user chooses to deploy a local database. Instead of being presented with four screens the user now is presented with only two. The first screen is the same as before, taking the host information of hostname and port number but the second screen is new, taking the username, password and a name for the resource. The reason this side of the installer has such minimal input is due to the fact that many variables are hard wired into the program. The hard coded variables all concern the database details, which can be set as the local database and its set-up is known. The left hand fork of the installer remains relatively unchanged to offer the flexibility of the remote resource deployment. The right hand fork is streamlined with the minimum user input as this is expected to be the default route for new users.

2.4.3. Security

The final design decision is what level of security to enable with the installer. As is mentioned in 1.2.5.1 above there are two possible levels of security

- Message Level Security
- Transport Level Security

Message Level Security (MLS) is a feature rich protocol supporting both GSI Secure Message and GSI Secure Conversation. Advantages include that because the encryption is done at message level separate portions of messages can be encrypted. This means if messages contain a mixture of sensitive and non-sensitive information only the sensitive information needs to be encrypted. Another advantage is the fact the MLS has a good integration with web service standards. However due to the fact that it is relatively new MLS has some performance issues which could lead to the slow transfer of data.

Transport Level Security (TLS) is used by default in the Globus Toolkit and has been a standard for years. Given that TLS has been around in various forms since 1994 its current incarnation has relatively good performance. Due to the large quantities of data being transferred through the server, performance will become an issue and therefore TLS was considered to be a better option.

Another OGSA-DAI security option is whether to enable integrity or privacy. Integrity guarantees that messages have not been altered by third parties, whilst privacy guarantees messages have not been altered by third parties and additionally encrypts the messages so that it cannot be read by third parties. Although enabling integrity would mean a high performance, the risk that third parties will be able to read the contents of the messages means it is unfit for this project. As there is sensitive medical information being transferred through the server, the privacy protection level must be enabled to encrypt all aspects of the message transfers, thus securing the message from third parties.

A further aspect of the security set-up is authentication, for this aspect there is no choice involved as the Globus Toolkit only supports the X.509 standard. This means using certificates to identify users.

Lastly with respect to the security infrastructure is the access to the database. This was only of concern when implementing a local database. The database is installed with a root user account; this account originally has no password and total access and control over all databases. This is account can only be accessed by the local host but still must still be secured with a password. It was decided to hardwire the password as only the database administrator would need to know it, not the users installing the system. The other issue with the database is user access for the deployed resource; this is controlled by the schema set by Rob Kitchen. In the database schema the access rights for the database and also individual tables are set.

2.4.4. Platform Independence

The final step to consider in the design of the system was keeping the platform independence. This issue was dealt with in the implementation phase of the project. Any additional functionality added to the installer must be implemented in such a way that it can run on multiple platforms. One of the reasons the Izpack software was chosen for this project is its cross-platform abilities. Izpack can determine the operating system it is being run on and therefore any installation process can be tailored for multiple operating systems.

2.5.Work plan

2.5.1. Methodology

This project is going to utilise an agile methodology inspired by extreme programming (XP) (11). The reason it is only inspired by XP is that not all the aspects of XP apply or can apply to a project of this size. The main reasons for choosing the agile methodology are

1. The primary aim of the project is to simplify the installer; once this is done the next steps are adding functionality. Using the XP method the primary objective can be designed, implemented, and tested before work starts on the extra features. Early feedback will be necessary, regarding whether the installer performs appropriately and if the correct level of complexity has been achieved. It will also be necessary to monitor the level of transparency of the installer so as to satisfy network and system administrators. If a more unified approach was used the system would not be available to the user until the end of the project, at which point changes to the basic implementation would be extremely difficult.
2. Due to the fact that this is a software evolution, it will be necessary to maintain a regime of continuous testing to ensure new additions to the code don’t compromise the integrity of the existing system.
3. Another reason for this agile approach is that the constant design, implementation, and testing will fit very well into the work plan. It will be a very realistic goal to produce

constant releases which can then be evaluated at the meeting with supervisors and contributors.

Areas where the methodology diverges from XP will be in the onsite customer and pair programming. To solve the problem of not having an onsite customer, regular meetings will be arranged to review each major development. As for pair programming given this is a solo project and not a large project it is unfeasible. The effectiveness of this methodology will be evaluated in Section 4.1 below.

2.5.2. Schedule

The time period between the 1st of June and the 22nd of August completion date conveniently breaks this project into 12 time periods of one week. One point that applies to all the stages of this work plan is the need to make notes and keep accurate records of work achieved. If this is done consistently it this will aid the report process. The development stage of the project will produce 3 prototype systems; each prototype will be the culmination of a complete development cycle (i.e. design implementation and testing). Once complete each prototype will be tested and any follow up work will then roll over to the second prototype. This could lead to time over runs but in the plan there is a built in period of grace between where development is completed and dedicated work begins on the report, labelled as the hand over period in Figure 13.

2.5.2.1. Tasks

Prototype 1 - A working installer for OGSA-DAI with the container of choice. This will include refactoring the current installer and simplifying it to meet users' needs.

Prototype 2 - Introduce security policies

Prototype 3 - Add functionality to deploy data resources. Investigate the possibility of the distributed data management.

Hand over period – in this period development will need to be wrapped up so work can start on the dedicated report writing.

The development period for each prototype is 2 weeks. It was reasoned that this is a generous enough time period for each deliverable while also keeping the project moving forward at a good pace.

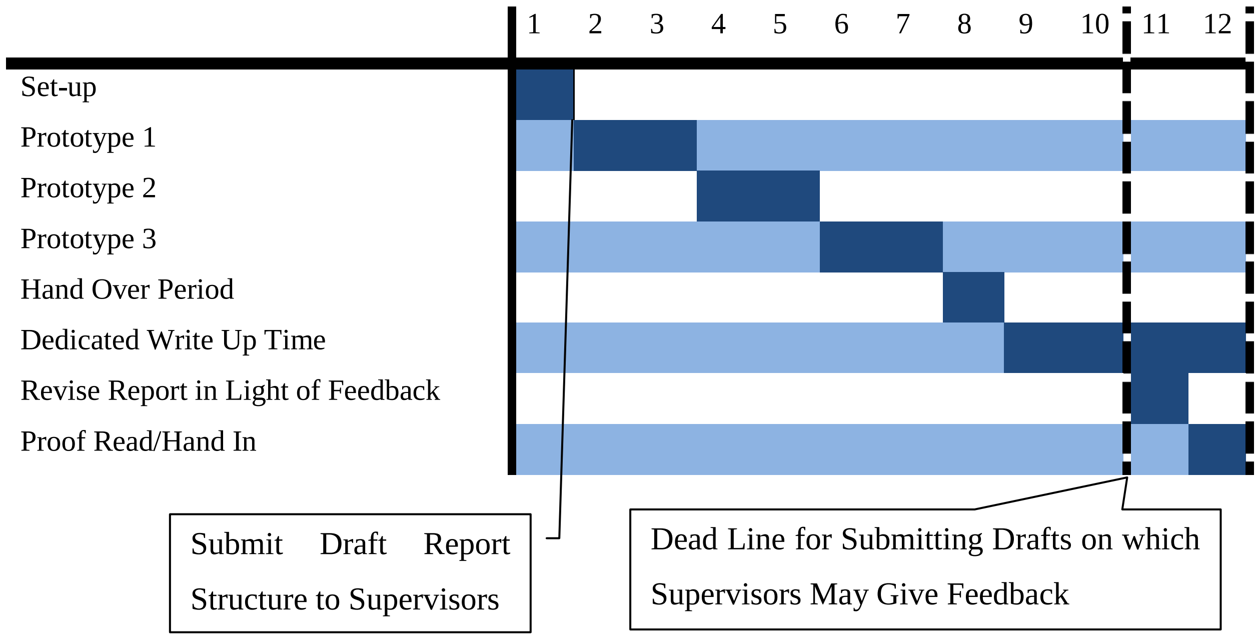


Figure 13 The Original Schedule of Work

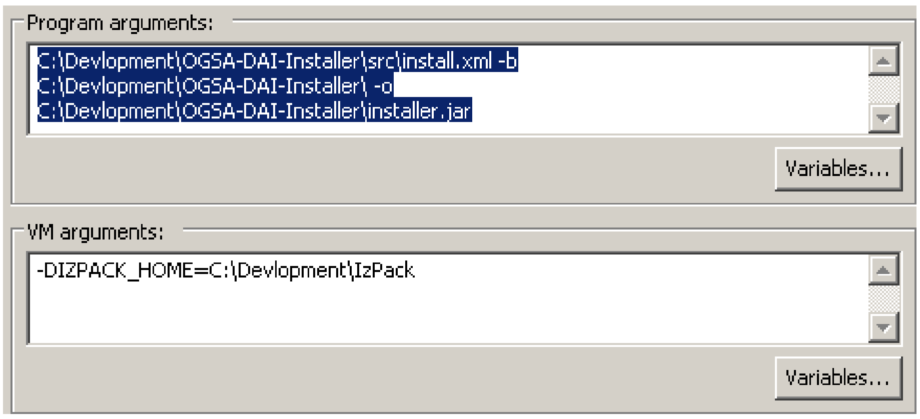
3. Implementation

3.1.Development Environment

The development environment used for the implementation of this project was a virtual machine using Microsoft Virtual PC 2007 (12). A virtual machine is a software implementation of a computer that executes programs like a real computer. Once the operating system had been installed onto the virtual system there are a number of environment variables that must be set-up. The first and most important aspect of the system setup is that of the Java development kit (JDK) (7). This kit includes the Java runtime environment (JRE) which is required to run the Izpack software as well as other Java programs. The JDK also includes a Java compiler which is needed to develop the Java based OGSA-DAI clients.

The second aspect of environment setup is to install the Izpack software. This software is provided in a jar file which must be unpacked to the working directory. Once unpacked the Izpack compiler must be set-up for use. In this project it was decided to use the compiler alongside the eclipse (13) integrated development environment (IDE) rather than set the operating systems class path and use the command line for compiling. By doing this, all the development such as XML and Java editing as well as the compiling could be carried out within the eclipse environment.

To setup the compile environment in eclipse the run dialog for the project must be created. Firstly the Izpack compiler must be added as the main class in the project. The program arguments must then be set; these are the settings used by the compiler to produce the installer and are shown in Figure 14.



```
C:\Devlopment\OGSA-DAI-Installer\src\install.xml -b
C:\Devlopment\OGSA-DAI-Installer\ -o
C:\Devlopment\OGSA-DAI-Installer\installer.jar
```

```
-DIZPACK_HOME=C:\Devlopment\IzPack
```

Figure 14 Program and VM arguments needed to setup eclipse

The first argument is the location of the main definition file of the installer, in this case install.xml, the –b indicates that this is the base path to be used for the installer. The second argument –o specifies that the next variable is the destination path for the program including the file name for the installer jar file. The final piece of eclipse setup is the VM argument; this is set to the location of the Izpack base directory.

The final aspect of setup needed on the test machine is the installation of the apache ant software. This is needed for manually testing the ant scripts created for the installer. Apache Ant is distributed as an archive which must be unpacked and its destination directory must be added to the class path by creating an environment variable ANT_HOME.

3.2.Initial Reverse engineer

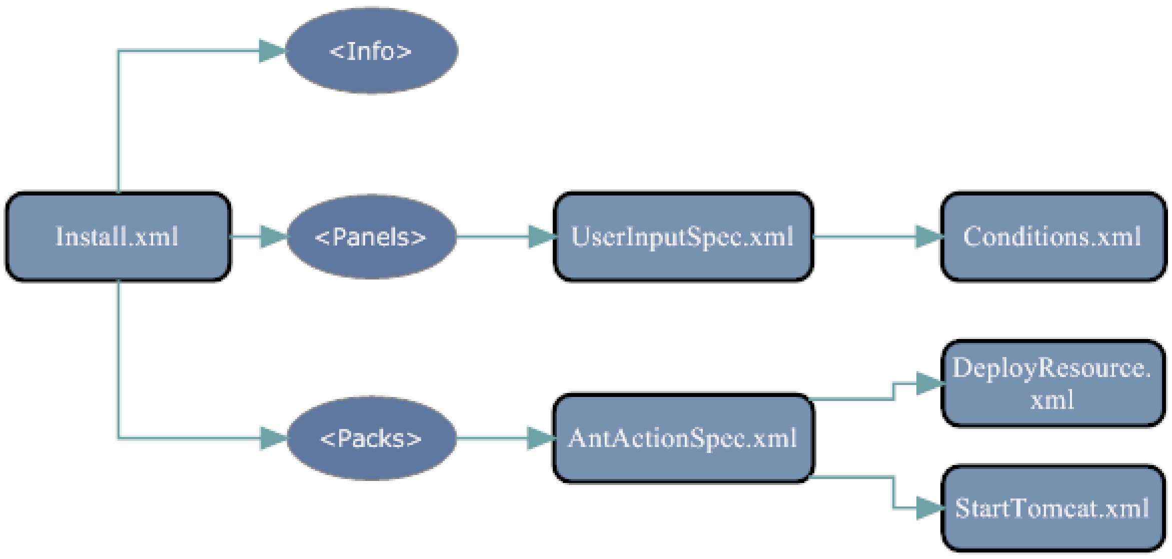


Figure 15 the Original Installers Source Files

The diagram in Figure 15 shows the original source files as well as some key XML elements, shown in the ovals. The main development process will be to edit the existing source files to configure the changes discussed in Section 2.4. This refinement of the current source files will be discussed in Section 3.3 below. One addition to the source files, shown in Figure 16, is the StartMySQL.xml file added to configure the local database install. This development is addressed in Section 3.4.

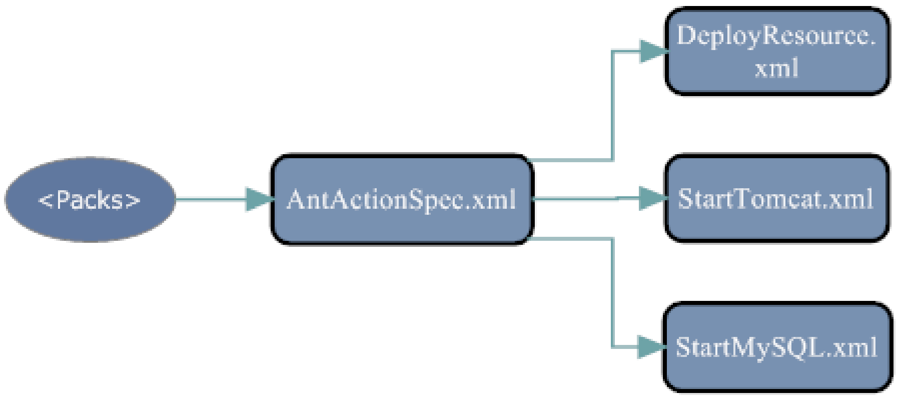


Figure 16 Changes to the Source Files

The start of the diagram in Figure 15 shows Install.xml, this file being the main configuration file used by Izpack to produce the installer. The file contains three main XML elements which define different aspects of the installer

3.2.1. Info

The <info> element is used to specify the general information for the installer. In this case the applications name and version number are both defined. The rest of the child elements are used to provide information on the author and the project.

```
<info>
    <appname>OGSA-DAI</appname>
    <appversion>3.0</appversion>
    <authors>
        <author name="Craig Thomson" email="c.thomson@epcc.ed.ac.uk"/>
    </authors>
    <url>https://gforge.beingrid.eu/gf/project/wp14/</url>
</info>
```

Figure 17 Info element from Install.xml

After the <info> element there are another couple of general information elements including the language information and the GUI preferences.

3.2.2. Panels

The <panels> element defines what screens will be seen by the users and in which order. As is laid out in Section 2.3.1 there are ten panels in the original installer.

```xml
<panels>
    <panel classname="HelloPanel"/>
    <panel classname="TargetPanel"/>
    <panel classname="PacksPanel"/>
    <panel classname="UserInputPanel"/>
    <panel classname="UserInputPanel"/>
    <panel classname="UserInputPanel" id="resourceDeploymentPanel"/>
    <panel classname="UserInputPanel" id="fileDeploymentPanel"/>
    <panel classname="UserInputPanel" id="dbDeploymentPanel"/>
    <panel classname="InstallPanel"/>
    <panel classname="FinishPanel"/>
</panels>
```

Figure 18 The panels element in Install.xml

As can be seen in Figure 18 the <panels> element has one child element, <panel> which has a mandatory attribute classname and an optional attribute of id. The first three and last two <panel> elements refer to standard Izpack classes and therefore require no further definitions. The other elements all refer to a classname UserInputPanel these panels are defined in the UserInputSpec.xml file.

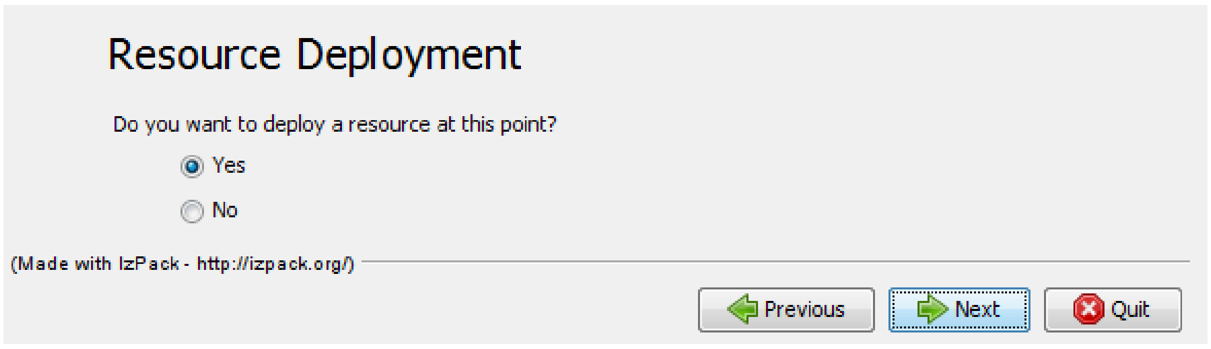
3.2.2.1. UserInputSpec.xml

This file contains the definitions for the custom panels created for this installer. One example panel is shown in Figure 19 and is the resource deployment panel, the result of which is shown in Figure 20. The only attribute of the <panel> element is the order; this number dictates the order in which the panels are shown to the user.

```xml
<panel order="1">
  <field type="title" txt="Resource Deployment"/>
  <field type="radio" variable="deployResource">
    <description align="left" txt="Do you want to deploy a resource at this point?"/>
    <spec>
      <choice txt="Yes" value="Yes" set="true"/>
      <choice txt="No" value="No" />
    </spec>
  </field>
</panel>
```

Figure 19 Panel number 1 from UserInputSpec.xml

As can be seen in the XML there are two fields defined, the first is the title and the second is for the radio buttons. The rest of the elements are used to define the layout and text used for the radio buttons and the result can be seen in Figure 20.


Resource Deployment

Do you want to deploy a resource at this point?

[✓ Yes] No

(Made with IzPack - http://izpack.org/)

Figure 20 The resource Deployment Panel defined in Figure 19

3.2.3. Conditions.xml

The panel shown in the example from Figure 20 also leads on to another important aspect of the installer and that is the conditions definitions. Whenever a choice is presented to the user a condition must be created to cope with the outcome of the decision.

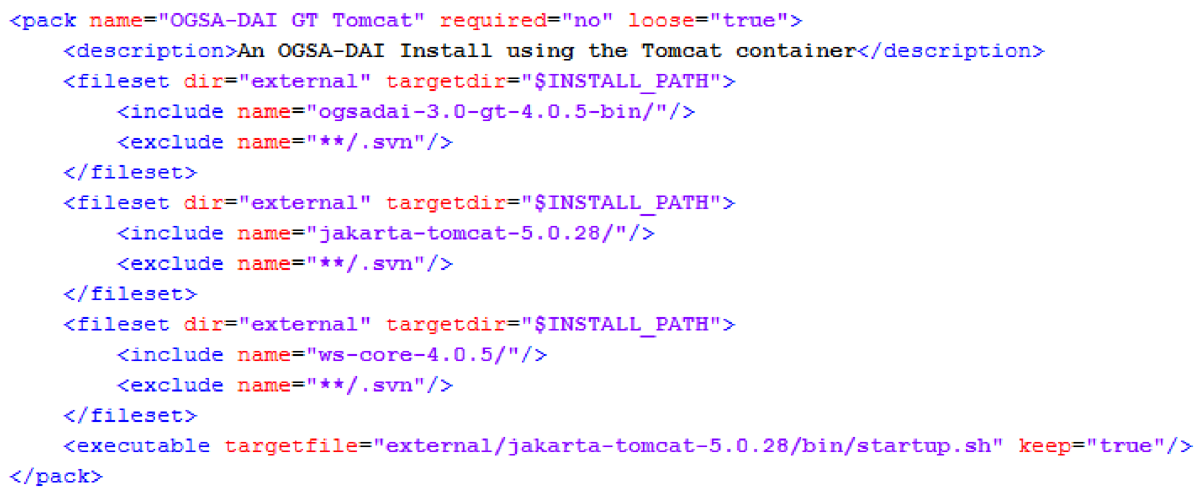
```
<condition type="variable" id="showDeployResource">
  <name>deployResource</name>
  <value>Yes</value>
</condition>
```

Figure 21 Deploy Resource Condition from Conditions.xml

The example shown in Figure 21 shows the condition needed to process the choice between deploying or not deploying a resource. The condition has a type variable which means that it is concerned with the value of a variable, in this case called deployResource as defined in the <name> element. The id variable for the condition is used to identify a condition so it may be called throughout the program. Finally the <value> element states what value the variable should have to pass the condition.

3.2.4. Packs

The <packs> element defines the files needed to complete the install. The packages defined here are also used as part of the PacksPanel, an Izpack standard panel which gives users the options of which packages to install



```
<pack name="OGSA-DAI GT Tomcat" required="no" loose="true">
    <description>An OGSA-DAI Install using the Tomcat container</description>
    <fileset dir="external" targetdir="$INSTALL_PATH">
        <include name="ogsadai-3.0-gt-4.0.5-bin/"/>
        <exclude name="**/.svn"/>
    </fileset>
    <fileset dir="external" targetdir="$INSTALL_PATH">
        <include name="jakarta-tomcat-5.0.28/"/>
        <exclude name="**/.svn"/>
    </fileset>
    <fileset dir="external" targetdir="$INSTALL_PATH">
        <include name="ws-core-4.0.5/"/>
        <exclude name="**/.svn"/>
    </fileset>
    <executable targetfile="external/jakarta-tomcat-5.0.28/bin/startup.sh" keep="true"/>
</pack>
```

Figure 22 <pack> Element from install.xml

As can be seen from the example in Figure 22 there are a number of attributes associated with each pack. The first attribute is the name; this is a unique identifier for the pack as well as the name displayed in the PackPanel. The second attribute shown is the required attribute, when set to yes this attribute means the pack is required for the installation and there is no option to remove it in the PackPanel. The final attribute is the loose attribute which sets whether or not to bundle the files in the package into the final jar file. The <pack> element then includes three child elements; the first is the <description> element which provides more information about the package. The second is the <fileset> element which defines the files that should be included with this package. This element has two attributes the first, dir, defines the base directory where the files can be located for packaging. The second attribute is the targetdir, which is the destination location for the files in the set. The value of this second attribute is $INSTALL_PATH this is a built-in variable of Izpack ,which is set by the targetPanel.

3.2.4.1. AntActionSpec.xml

Another area where the packs have an influence on the installer is in the execution of the ant scripts. Once a pack has been unpacked a number of ant calls are then made depending on which pack was selected, an example of which can be seen in Figure 23

```
<pack name="OGSA-DAI GT Tomcat">
    <antcall order="afterpack"
             buildfile="$INSTALL_PATH/jakarta-tomcat-5.0.28/startTomcat.xml"
             verbose="true">
        <target name="changePort"/>
        <property name="tomcat.dir" value="$INSTALL_PATH/jakarta-tomcat-5.0.28"/>
        <property name="port" value="$port"/>
    </antcall>
```

Figure 23 Ant call from antActionSpec.xml

In this example it can be seen that if the pack of name OGSA-DAI GT Tomcat is selected then the ant call is made after the files have been unpacked. The ant call in question is a call to the StartTomcat.xml file, which contains a target called changePort.

3.3. Refining the installer

3.3.1. Packs

The first aspect of refactoring the installer was to streamline the number of different OGSA-DAI distributions available for the installer. To do this the number of packs was edited; originally there were four packs:

- Installer Files
- OGSA-DAI GT Tomcat
- OGSA-DAI GT
- OGSA-DAI Axis Tomcat

The first contained the database drivers needed for resource deployment; the final three packs each represented a different OGSA-DAI install. As has been discussed previously it was decided this project would focus on the OGSA-DAI GT Tomcat distribution. With this decision in mind the last two packs were dropped from the installer and the installer files were integrated into the remaining OGSA-DAI pack, leaving just one pack and reducing the user input.

3.3.2. Ant Scripts

Once the packs had been dropped the next phase was to edit the ant calls in AntActionSpec.xml. The first change was to remove the ant calls associated with the dropped packs. The next change was to create an ant call to start the Tomcat server once the other calls were complete.

```
<antcall order="afterpack"
         buildfile="$INSTALL_PATH/jakarta-tomcat-5.0.28/startTomcat.xml"
         verbose="true">
    <target name="startTomcat"/>
    <property name="tomcat.dir" value="$INSTALL_PATH/jakarta-tomcat-5.0.28"/>
</antcall>
```

Figure 24 Ant call to start the tomcat server

Figure 24 shows the ant call used in the AntActionSpec.xml file, this calls an ant target named StartTomcat in the build file StartTomcat.xml.

```
<target name="startTomcat"
        description="start Tomcat">
  <echo message="Starting Tomcat"/>
  <chmod dir="${tomcat.dir}/bin" perm="u+rx" includes="**/*.sh"/>
  <exec executable="cmd" spawn="true" osfamily="windows">
    <arg value="/c"/>
    <arg value="&quot;cd ${tomcat.dir}\bin\&amp;&amp;service.bat install&quot;"/>
  </exec>
  <echo message="Installed service!"/>
  <exec executable="cmd" spawn="true" osfamily="windows">
    <arg value="/c"/>
    <arg value="&quot;cd ${tomcat.dir}\bin\&amp;&amp;tomcat5 //US//Tomcat5 --Startup=auto&quot;"/>
  </exec>
  <echo message="Made Service Auto!"/>
  <exec executable="cmd" spawn="true" osfamily="windows">
    <arg value="/c"/>
    <arg value="NET START Tomcat5"/>
  </exec>
  <echo message="Started service!"/>
```

Figure 25 Start Tomcat ant call StartTomcat.xml

Figure 25 shows the Windows implementation of this Tomcat start-up ant call. The call can be broken down into three commands

- Service.bat install – this command runs the service.bat script with the install argument. This script installs tomcat as a Windows service
- Tomcat5 //US//Tomcat5 –Startup=auto – this command edits the setting of the service installed previously so that the tomcat server starts automatically when the operating system is loaded.
- NET START Tomcat5 – this command starts the tomcat service.

The UNIX versions of these commands are shown in Figure 26. The first of these commands moves the Tomcat start up script into the operating systems automatic loading section so it will be run the next time the system is started. The second runs this script for the current session.

```
<exec executable="cp ${tomcat.dir}/bin/startup.sh /etc/init.d/tomcat" osfamily="unix">
<exec executable="${tomcat.dir}/bin/startup.sh" spawn="true" osfamily="unix">
```

Figure 26 Commands to Start Tomcat in UNIX

3.4.Database deployment

3.4.1. Database install

As has been discussed in previous Chapters the database used for this project is a MySQL community database server. The first aspect of installing the database with this installer was to include the necessary files into the installer jar. The files were downloaded from the MySQL website (14) and then added to a pack using the XML in Figure 27.

```
<fileset dir="external" targetdir="$INSTALL_PATH">
    <include name="MySQL/"/>
    <exclude name="**/.svn"/>
</fileset>
```

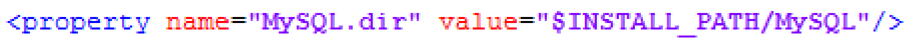
Figure 27 Figure 19 XML used to add the MySQL files to a pack

Once added to the pack the next step was to write the ant scripts needed to do the install and setup for the database. An ant script was created in StartMySQL.xml called StartMySQL and this was called in the AntActionSpec.xml after the unpacking of the files. The first aspect of the MySQL install is to modify the configuration file.

```
<replace file="${MySQL.dir}/my.ini"
         token="basedir=C:/OGSA-DAI/MySQL"
         value="basedir=${MySQL.dir}"/>
<replace file="${MySQL.dir}/my.ini"
         token="datadir=C:/OGSA-DAI/MySQL/data"
         value="datadir=${MySQL.dir}/data"/>
```

Figure 28 Ant Script to edit the MySQL configuration file

The two commands shown in Figure 28 both edit a line in the configuration file. The MySQL configuration file is my.ini and contains the details of the database server. The two key items of information that must be changed are the base directory of the MySQL program and the base directory of the data store. The commands in Figure 28 read in the file looking for the lines of text that match the token variable, once found these lines are replaced with a similar line containing the ${MySQL.dir}. The dollar sign indicates the string is a variable, the curly brackets indicate the variable was defined in the calling class, in this case AntActionSpec.xml. The XML tag for defining this variable is shown in Figure 29 as can be seen the value for this variable is the MySQL directory in the INSTALL_PATH (which is the path selected by the user).



```
<property name="MySQL.dir" value="$INSTALL_PATH/MySQL"/>
```

Figure 29 A variable definition in an Ant Script

The next part of the MySQL setup is concerned with configuring the MySQL server to initiate with the system start up. This setup is divided into two sections depending on the operating system the installer is being run on.

3.4.1.1. Windows

This section of the MySQL setup focuses on two commands:

```
mysqld --install MySQL --defaults-file=${MySQL.dir}\my.ini
```

This command installs the MySQL server as a windows service called MySQL and also sets the directory where the configuration file (as discussed above) is located. This command must be run from inside the bin directory of the MySQL install directory, so the first task when executing this command using the ant scripts is to change the location of execution.

```
NET START MySQL
```

The default service type for MySQL is automatic so it will start up at every system start, however the MySQL server must be started manually for the current session. The second command starts the MySQL service for the current operating system session.

3.4.1.2. UNIX

The UNIX version of the automatic set-up requires four commands.

```
cp my.ini /etc/my.cnf
```

The first command moves the configuration file changed above into the default position so the start up scripts can locate it and use the values stored in it.

```
scripts/mysql_install_db
```

The next command is the execution of the mysql_install_db script which is provided with the MySQL distribution. This script performs the installation of the database and the initial set-up. The third command is concerned with the automated start up of the database server. This command moves an automatic start up script from the support-files folder in the MySQL distribution to the init.d folder, where the operating systems automated start up scripts are stored.

```
cp /support-files/mysql.server /etc/init.d/mysql
```

The final command starts the database for the current operating system session. All these commands need to be run in the main folder of the MySQL distribution.

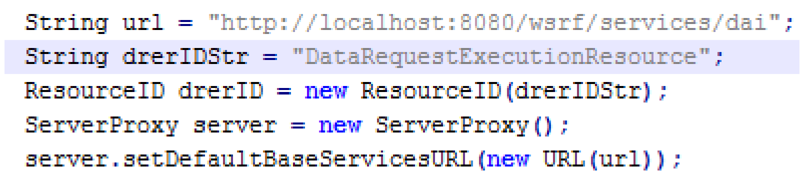
```
bin/mysqld_safe &
```

3.4.2. Schema Deployment

3.4.2.1. Java Deployment

3.4.2.1.1. Java Client

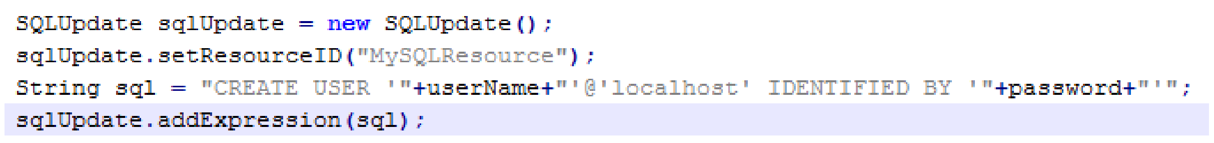
As has been addressed previously the original plan for schema deployment was to use a Java OGSA-DAI client utilising the deployed resources. The client itself is an adaptation of the SQLUpdate client provided with the OGSA-DAI distribution. The client can be divided into three main sections. The first of these shown in Figure 30 sets up the connection details including the URL of the OGSA-DAI services.



```
String url = "http://localhost:8080/wsrf/services/dai";
String drerIDStr = "DataRequestExecutionResource";
ResourceID drerID = new ResourceID(drerIDStr);
ServerProxy server = new ServerProxy();
server.setDefaultBaseServicesURL(new URL(url));
```

Figure 30 Connection Details for the Java OGSA-DAI Client

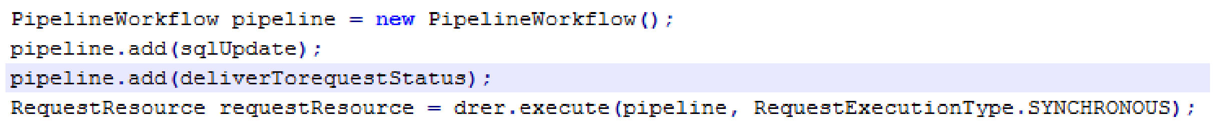
The next section is the creation of the SQL statements needed to apply the schema. This is shown in Figure 31, firstly the SQLUpdate class is created and then the id of the resource is set. In this case the resource id is a hard coded value MySQLResource, had development continued on the client this would need to have been set at runtime. The final two lines of code create one of the SQL statement needed. The other statements are created in the same way until all the statements have been added to the SQLUpdate class.



```
SQLUpdate sqlUpdate = new SQLUpdate();
sqlUpdate.setResourceID("MySQLResource");
String sql = "CREATE USER '"+userName+"'@'localhost' IDENTIFIED BY '"+password+"'";
sqlUpdate.addExpression(sql);
```

Figure 31 SQL Statement in the Java OGSA-DAI Client

Once each statement is added the SQL update can then be executed on the server and this process is shown in Figure 32.



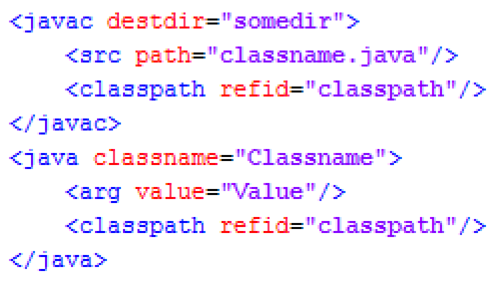
```
PipelineWorkflow pipeline = new PipelineWorkflow();
pipeline.add(sqlUpdate);
pipeline.add(deliverTorequestStatus);
RequestResource requestResource = drer.execute(pipeline, RequestExecutionType.SYNCHRONOUS);
```

Figure 32 SQL Statement Execution in the Java OGSA-DAI Client

Once the client had been developed the next challenge was to execute this with the installer and it was at this point that problems occurred.

3.4.2.1.2. Executing the Java Client

The standard method for executing java classes using Ant scripts is shown in Figure 33 the



```
<javac destdir="somedir">
    <src path="classname.java"/>
    <classpath refid="classpath"/>
</javac>
<java classname="Classname">
    <arg value="Value"/>
    <classpath refid="classpath"/>
</java>
```

Figure 33 Executing Java Program with an Ant Script

Firstly the class is complied using the source path and the classpath defined. The class is then executed with the defined classpath. When this was done with the client developed above the compile completed without error but when the execution was attempted a class not found error occurred. The problem with this execution could not be found it was thought it was most likley a problem with the classpath. As the problem could not be solved a solution was devised by adapting the setClasspath script that comes with OGSA-DAI. This script is design to set-up the system so OGSA-DAI clients can be run; therefore code was added to this to run the client from above. The code added to this script was simply:

Javac SQLClient

Java SQLClient

Once the Java client was developed and executed it highlighted problems with the database server's user account management. The schema dictates that the user be given access to a database called user_database (where database is the user's name); to do this a resource is deployed with OGSA-DAI with this database name. The problem occurs in that in that this resource cannot be used to create the user_database on the database server. The solution for this is to have a separate resource deployed to standard database from which the user database can be created. This second resource must have the correct privileges to create databases and user accounts; it was decided to use the default MySQL root account. MySQL is installed with one standard root account available for use from the local host. The OGSA-DAI resource required a second root account with the same privileges but accessible from a non local host. There is no non SQL method for creating this second user therefore the SQL statement must be executed in MySQL. It was decided that if scripts needed to be written to execute one SQL statement, they should be written to execute all the SQL statements. This decision meant the Java client was no longer needed.

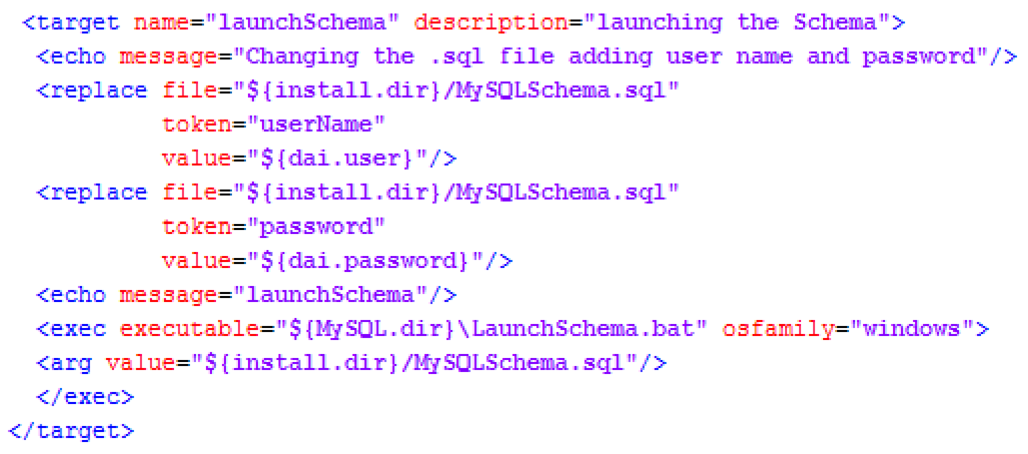
3.4.2.2. Scripts

Two scripts were need for deploying the schema one .bat script for the Windows execution and one .sh for UNIX systems. Both scripts contain the same commands; first the script changes the working directory to the bin folder in the MySQL installation folder.

```
cd bin
```

The second command takes the first argument, which in this case is the location to an .sql file containing all the SQL statements needed, and uses it with the mysql executable to load the schema onto the database server.

```
mysql -u root < %1
```



```
 <target name="launchSchema" description="launching the Schema">
  <echo message="Changing the .sql file adding user name and password"/>
  <replace file="${install.dir}/MySQLSchema.sql"
           token="userName"
           value="${dai.user}"/>
  <replace file="${install.dir}/MySQLSchema.sql"
           token="password"
           value="${dai.password}"/>
  <echo message="launchSchema"/>
  <exec executable="${MySQL.dir}\LaunchSchema.bat" osfamily="windows">
  <arg value="${install.dir}/MySQLSchema.sql"/>
  </exec>
</target>
```

Figure 34 Ant Script to Execute the Schema Script

Figure 34 shows the ant script written to launch the Windows version of the schema deployment scripts. Firstly the username and password in the SQL file are replaced with the values provided by the user in the installation. The LaunchSchema.bat script file can then be executed with the destination of the SQL file as a command line argument.

3.4.3. New User interface

It was decided with the addition of the local database install to have two package options; one which would include the local database files and one that would not. This was done so the packs panel would become a decision point for the user; pack one would lead to the new implementation including the local database, pack two would keep the old functionality of the remote database deployment. This decision panel can be seen in **Error! Reference source ot found.**

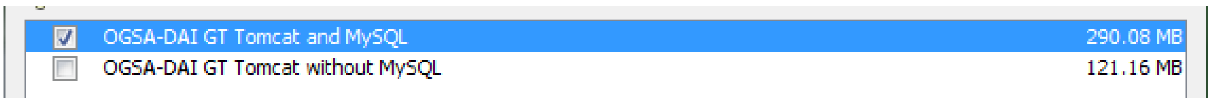

☑ OGSA-DAI GT Tomcat and MySQL 290.08 MB
☐ OGSA-DAI GT Tomcat without MySQL 121.16 MB

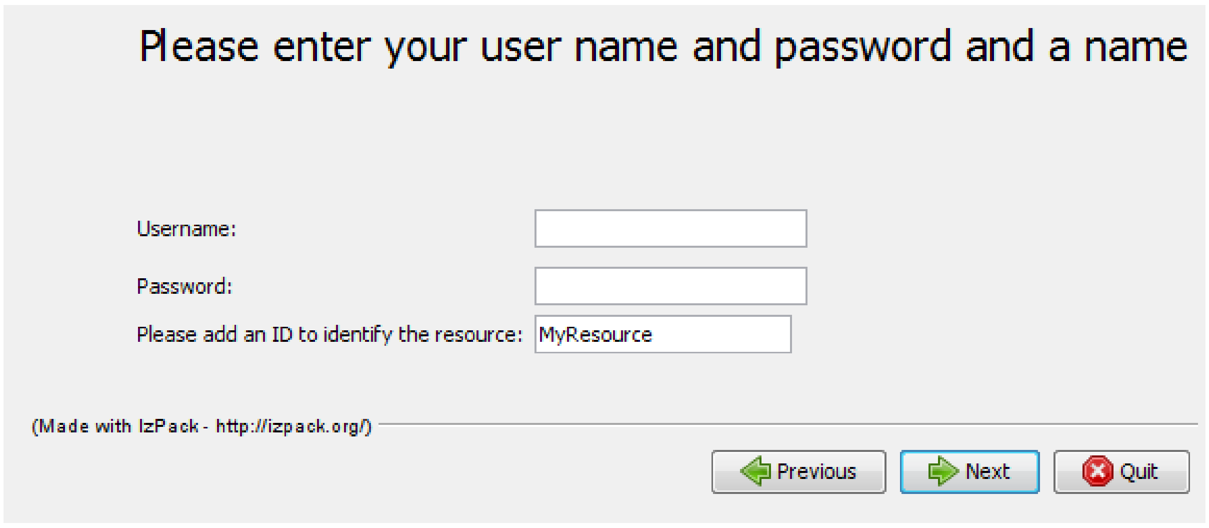
Figure 35 The New Pack Decision on the Packs Panel

As discussed in Section 2.4.2.1 when the user chooses an install including a local database they are presented with a new screen. The XML definition of this new screen can be seen in Figure 36.

```
<panel order="5">
  <field type="title" txt="Please enter your user name and password and a name for your resource"/>
  < variable="databaseType" value="mysql" />
  <field type="rule" variable="username">
    <spec txt="Username:" layout="O:16:U"/>
    <validator class="com.izforge.izpack.util.NotEmptyValidator"
           txt="You must supply a valid username" />
  </field>
  <field type="rule" variable="password">
    <spec txt="Password:" layout="O:16:U"/>
    <validator class="com.izforge.izpack.util.NotEmptyValidator"
           txt="You must supply a valid password" />
  </field>
  <field type="text" variable="resourceID">
    <spec txt="Please add an ID to identify the resource:" size="16" set="MyResource"/>
  </field>
</panel>
```

Figure 36 User Information panel XML definition

The XML defines three text fields, the first two are for the user name and password and the final one is for the resource id. To protect these fields against null inputs the username and password fields are monitored by a validator class, which will not allow the installer to continue without an input in these fields. To protect the final field a default value of MyResource is set. The resulting user input screen can be seen in Figure 37.


Please enter your user name and password and a name

Username:

Password:

Please add an ID to identify the resource: MyResource

(Made with IzPack - http://izpack.org/)

Figure 37 The User Input Panel Created For the Installer

3.4.3.1. Conditions

With the local database added the user is now presented with two main decisions as laid out in Figure 38.

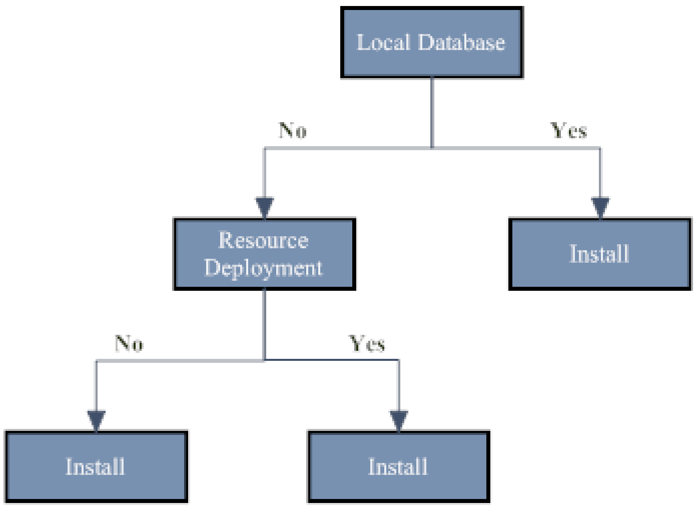


Figure 38 The Decision Tree for the Installer

These decisions affect which screens are presented to the user and each choice is governed by a condition. The condition that presents the user with the user information screen when the first pack is selected is shown in Figure 39. The condition checks if the pack with the id 1 has been selected.

```
<condition type="packselection" id="pack1selected">
  <packid>1</packid>
</condition>
```

Figure 39 Pack Selection Condition from Conditions.xml

The line in Figure 40 is a panelcondition element, this means that when a panel is due to be shown to the user it must satify the codition referenced here. In this case for the userNamePannel to be shown it must satisfy the pack1selected condition which is shown in Figure 39.

```
<panelcondition panelid="userNamePannel" conditionid="pack1selected" />
```

Figure 40 Panel Condition to decide whether to display the userName Panel

3.5.Security deployment

The security set-up is divided into two main areas, the first is authentication and the second is authorisation. The first change needed for a secure server is the deployment of a secure Globus Toolkit web service container; to do this the last line in Figure 41 needs to be changed to read deploySecureTomcat instead of deployTomcat.

```
<antcall order="afterpack"
        buildfile="$INSTALL_PATH/ws-core-4.0.5/share/globus_wsrf_common/tomcat/tomcat.xml"
        verbose="true">
    <target name="deployTomcat"/>
```

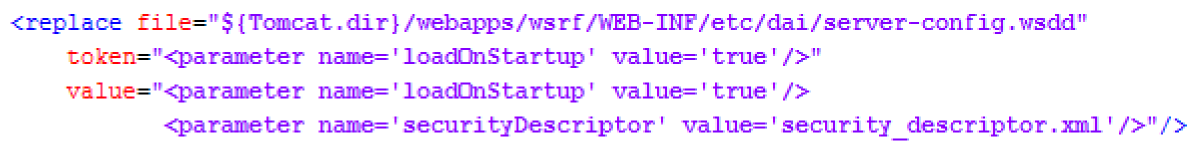
Figure 41 The Ant Script to Deploy GT onto Tomcat

The next stage is to write a security descriptor file for the OGSA-DAI services, the one written for this project can be seen in Figure 42. As discussed previously this descriptor sets out that transport level security should be enabled with full privacy encryption.

```
<?xml version="1.0" encoding="UTF-8"?>
<securityConfig xmlns="http://www.globus.org">
   <auth-method>
     <GSITransport>
        <protection-level>
          <privacy/>
        </protection-level>
     </GSITransport>
   </auth-method>
   <authz value="none"/>
</securityConfig>
```

Figure 42 A Security Descriptor for OGSA-DAI Services

The next stage of enabling this security is to link the services to the security descriptor file. This is done in the server-config.wsdd file and the commands needed are shown in Figure 43.



```
<replace file="${Tomcat.dir}/webapps/wsrf/WEB-INF/etc/dai/server-config.wsdd"
    token="<parameter name='loadOnStartup' value='true'/>"
    value="<parameter name='loadOnStartup' value='true'/>
           <parameter name='securityDescriptor' value='security_descriptor.xml'/>"/>
```

Figure 43 The Ant Commands to Secure the Services

The commands shown search the -config.wsdd file for the token loadOnStartup parameter, once found it is replaced with the value shown. The value contains both the loadOnStartup parameter and the securityDescriptor parameter. The reason it contains both parameters is to make this an insert rather than a replace. The loadOnStartup parameter is used as the token to search for as it is in each service descriptor.

The final part of the security set-up is the authorisation; this determines which users can have access to which services. The authorisation in OGSA-DAI is carried out using the X.509 certificates and unfortunately the development of these was not completed.

4. Evaluation

4.1. Evaluation of Implementation

4.1.1. Evaluation of Finished Installer

The main goal for this project was to produce a complete installer that could set-up a machine capable of storing clinical trial data; the machine also needed to be remotely accessible. This goal has been achieved; the installer sets up a local database with a schema designed to manage the trial data. The resource is exposed with a Tomcat web server and a GT web service core, into which OGSA-DAI is deployed.

In order to achieve this main goal of a complete installer four goals were set out

- A refined installer, minimising user input while maintaining enough freedom to satisfy network and system administrators
- The means of adding a database and exposing its resources
- The ability to enable the security infrastructure
- A platform independent installer

The first goal was achieved and the installation processes have been simplified. When deploying the server with a local database the user is confronted with only two input screens asking for simple host and user details. Also thanks to the IzPack software, and its sole dependency on the Java Virtual Machine, it means there is no complicated set-up before the installer can be run. This step, although one of the simplest to implement, was also one of the hardest to achieve. The balance between minimising user interaction, while still giving the flexibility in the set-up, was a fine line to tread. Information, such as the connection URI, could be hard coded to prevent errors but the resource name needed to be editable so users could change its value to match their clients. This process of refinement was ongoing throughout the project as each new feature created new issues in the balance of the installer. One way to avoid this constant iteration after each change would have been to implement this step last, once all the features had been added. An example of this is the addition of the local database. This was the second goal but its addition meant that three screens could be condensed into one, thus achieving progress with the refinement.

The second goal required the addition of a local database, which was realized by attaching a MySQL database server installation. Now, when a user chooses to, a MySQL database is installed and the schema specified by Rob Kitchen is applied to it. Once this is complete the database is exposed as an OGSA-DAI resource. One aspect in the database installation was the need for the flexibility to change the schema definition. By using an SQL file as part of the set-up scripts rather than hard coding the SQL statements, the schema can be updated or replaced without the need to modify the installer.

The third goal was the addition of security into the setup. Whilst securing the server was a relatively easy task, the problem came with the authorisation and authentication. To secure the server required changes to the OGSA-DAI configuration files and the server set-up as discussed in Section 3.5. The second stage of the security set-up is the addition of the authorisation, defining which user can have access to the server. As discussed previously the Globus Toolkit security model relies on the X.509 standard. This reliance on certificates caused problems in the development as a certificate infrastructure needed to be created, including a certificate authority, user certificates and host certificates. This implementation was unable to be completed mainly due to the complexity of the development and the short space of time allocated for it to be achieved.

The fourth goal of keeping the installer platform independent was achieved utilising the IzPack framework. By utilizing the ability of IzPack to distinguish the host operating system, different scripts and commands could be executed, on both Windows and UNIX systems, to achieve the same goals.

4.1.2. Robustness

4.1.2.1. Inputs

One problem that could arise with inputs is if the fields are left blank. An area where this would be a problem is in the user name and password fields. This problem has been avoided by utilising a validator class from the IzPack software. The class NotEmptyValidator checks that an input is placed into the field and will not let the installer proceed until it has been done. All the other fields combat this problem by having default inputs. If a user does delete the default and fails to replace it, the installer will fail. This problem could be solved simply by enabling the validator on all fields.

Another area where user input can cause errors in the program is the host port. If a non integer is placed in this field it will cause problems with the web server set-up. The installer itself will complete without error and the web server will run. However, when trying to access the applications and services on the web server, the requests will fail.

4.1.2.2. A space in install path

One problem identified with the installer is in the choice of target directory. If a space is included in the target directory such as “Program files” the installer fails when trying to deploy the resources. The error presented to the user is ogsadai-3.0-gt-4.0.5-bin\build.xml line 637: Java returned 1.

4.1.2.3. Multiple installs

The installer is not set-up for multiple installs and problems will arise when they are attempted. The main problem with a multiple install is automatic start up configuration. The host operating system can only have one program of a given name as an automatic start up program. As this installer has the names of the web server and database hard coded this causes a problem with multiple installs. Without this automated start up problem the only issue with running the installer multiple times on the same machine is the port number. So long as each set-up has a different port number then they can run side by side without problems.

4.1.3. Problems with the Development

As discussed in the implementation chapter the development environment used was a virtual machine (VM) using virtual pc 2007. This gave a lot of advantages to the development, the key one being that a clean operating system could be loaded each time the installer was tested. The use of a VM did however create some problems leading to delays in development. The major issue with the VM was the speed, the installer took around 15 minutes to complete on the VM which meant debugging took a lot of time.

Another problem was discovered with the network mapping on the VM. When the OGSA-DAI was deployed on the VM, although the web server could be accessed and a list of the OGSA-DAI services displayed, the services themselves could not be accessed. The exact fault could not be determined so instead the testing was moved on to a real operating system and the problem was resolved. The main reason for this problem not being resolved more quickly was due to difficulty in diagnosing what the problem was. When the problem first started it was still possible to access some of the services but not others therefore it was assumed (wrongly) that the problem was in the setup not in the operating system. It was not until the original services also stopped working that the installer was tried on a real machine and a solution was produced.

Another major problem with the development was in the schema deployment. It was originally thought the schema could be deployed using a Java client. As discussed in Section 3.4.2 to use a Java client to deploy the schema would require a user account on the database with total privileges that can be accessed from an unknown host. It was originally thought that just a local host account would be suitable but when this was implemented the OGSA-DAI resource failed. Once it was discovered that a separate multi host user would be needed, development was switched to scripts rather than Java clients. The main reason for the switch to scripts was that a script was needed to execute the SQL commands which were necessary to set-up the multi host user. Once it had been decided that this script was required it was felt unnecessary to then use a Java client to execute the other SQL statements. The change to scripts did have an advantage in that it meant the database could be better secured without the multi host user. However the change did slow development as the Java client had already been written before the problem was discovered.

4.2.Evaluation of the Original Work Plan

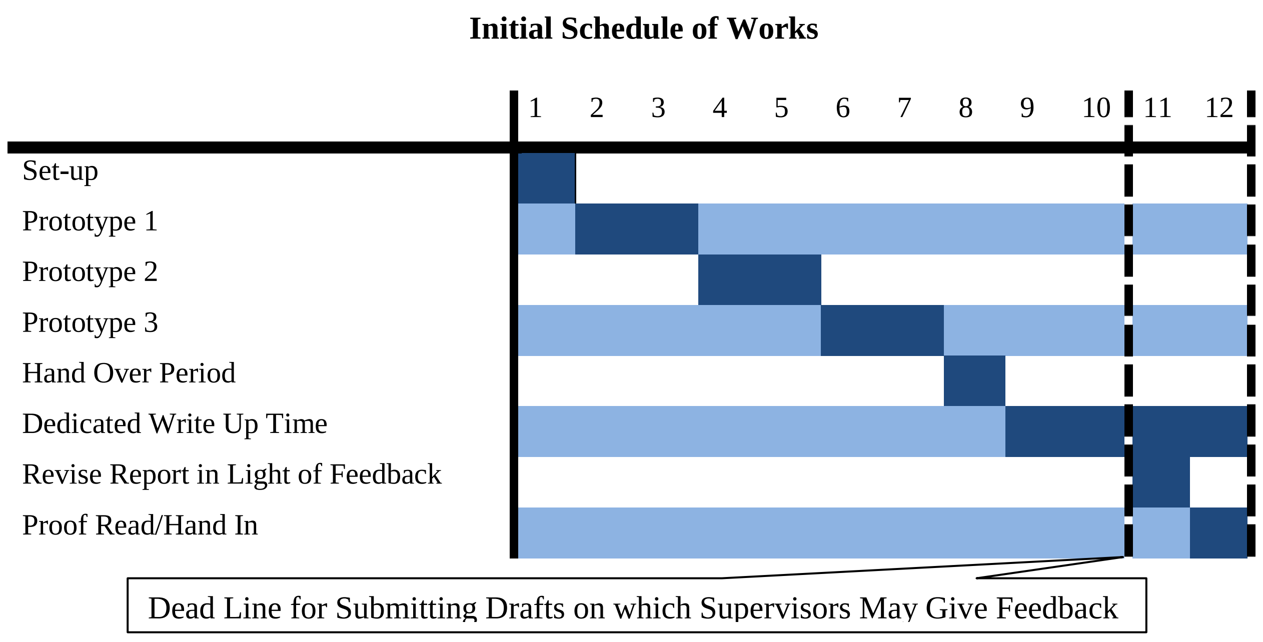
4.2.1. Evaluation of Chosen Software Engineering Methodology

The agile methodology as outlined in Section 2.5.1 worked well for this project. The structured breakdown of work led to an efficient development period. This structured breakdown was also a major benefit to the implementation as each stage of the program could be developed separately and then tested before moving on to the next phase.

One of the drawbacks to agile methodologies is the risk of repetition in development. Each phase is designed and implemented in the simplest manner without thought to later additional functionality. One area which was affected in this development was in the second phase: where the aim was to add a local database installer. The addition of the database installation had the side effect of also simplifying the interface; this had been the aim of the first phase but was much more effective with the addition of a local database.

4.2.2. Evaluation of the Schedule

The schedule of work changed in a number of ways, which can be seen in Figure 44. The most significant of these changes was the order of prototype releases. The second and third prototype releases were switched; the reason for this exchange was that it was felt that the third prototype was critical to fulfilling the primary goal of simplifying the installer. By adding a local database the user interface was cut by three screens and the complexity of user input was greatly reduced. Other changes to the schedule were mainly due to delays in development. As mentioned above a problem with the virtual machine caused the tests of database deployment to fail. These negative test results caused a delay which is shown in the extended development time of prototype three. This delay in prototype three had follow-on consequences, which led to the implementation phase continuing after the proposed cut off point. This implementation extension meant that instead of dedicated write up time in weeks 11 and 12 the final aspects of the report had to be finished concurrently with the final implementation.



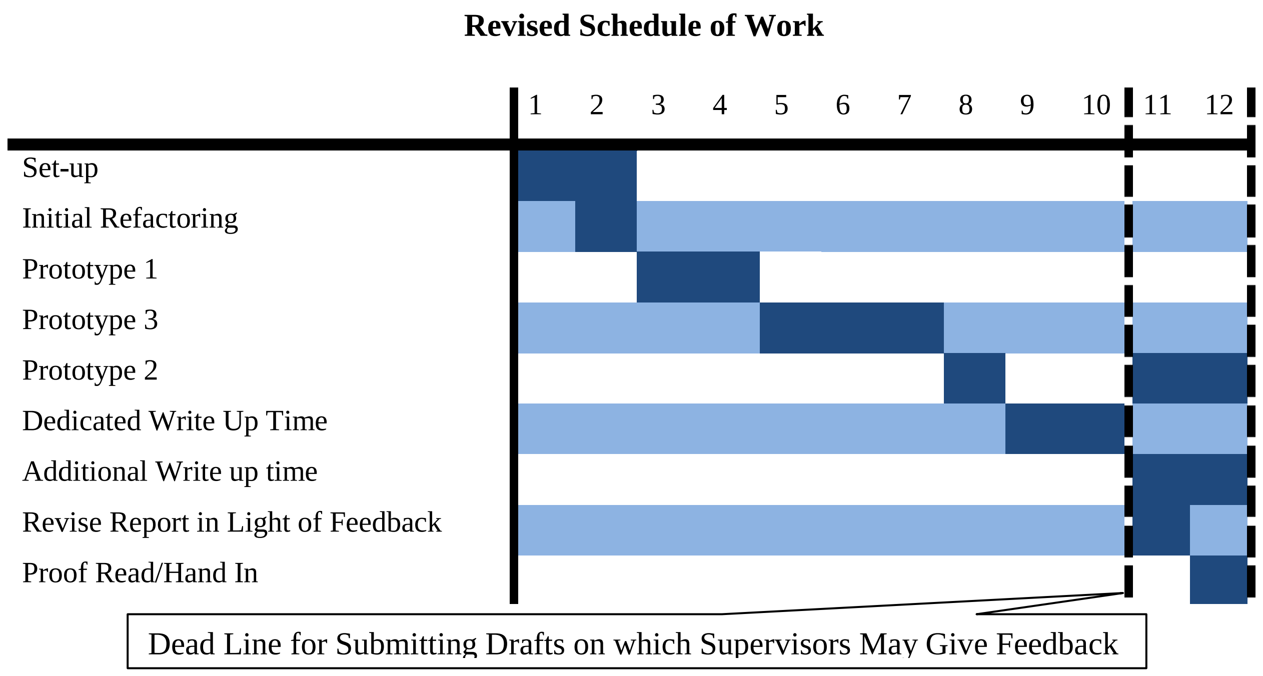


Figure 44 Schedule of Work

5. Conclusions and Future Work

5.1. Conclusions

As laid out in Section 2.2 the goals of this project were as follows

- To produce a complete installer to set-up a distributed data server

- To create a simple user interface to facilitate the rapid deployment of data servers by non experienced users
- To satisfy the requirements set by system administrators in terms of flexibility and security

The installer developed fulfils two of these goals and sets up a server with a Tomcat web server and a GT web service core, into which OGSA-DAI is deployed. The installer also installs a MySQL database server and exposes a schema defined database using OGSA-DAI. There is a simple user interface to facilitate the rapid deployment by non experienced users. When deploying the server with a local database the user is confronted with only two input screens asking for simple host and user details. Rapid deployment is achieved thanks to the IzPack software and its sole dependency on the Java virtual machine, meaning no complicated set-up before the installer can be run. Unfortunately the security component of the system has not been fully developed. As mentioned previously the X.509 certificate based security model provided many challenges. The process of securing the server has been completed but without proper authorisation it means that the task is not yet finalised.

The installer is fairly robust and can handle a number of common problems such as errors in user input. The problem of null fields is addressed with default values and a validator class checking for input. One area where the installer is not so robust is in multiple installs. The main problem is that the installer integrates the programs with the operating system and this can only be done once. However if the operating system integration is removed then the installer can be run multiple times on the same machine.

The success of this project is one further step towards the aim of providing distributed data sources able to contain the data from not only the Molecular Medicine Centre's cystic fibrosis clinical trials but also other clinical trials from other institutions across the globe.

5.2.Future Development

The first major piece of follow on work to this project should be the adaptation of the current client system to utilise the OGSA-DAI resources deployed using this installer. Once this modification is completed then the system envisioned in Figure 4 can be made a reality.

Further work to the installer will come in the form of firstly correcting the flaws identified in the robustness tests. Another area where the installer could be improved is in the automatic detection of current software. For example if a Tomcat server is already on the system this installer will have problems. One thing that could be done to improve this would be for the installer to detect this server and deploy OGSA-DAI and the Globus Toolkit onto it. More work will also be needed to finish the development of the security model. A certificate hierarchy will need to be developed and then this can be combined with the installer.

Lastly an extension to the project could come in the form of a different security framework. The current installer utilises the security model supported by OGSA-DAI. The X.509 certificate based security model may be too complex for the biologist to use in conjunction with the client system. A custom authentication and authorisation model could be constructed to simplify the users' involvement in the security process.

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7. Appendix