Collaborative Engineering Virtual Teams in a Grid Environment Supporting Consortia in the Construction Industry

John Miles[1], Liviu Joita[2], Jaspreet Singh Pahwa[2], Pete Burnap[2], Alex Gray[2], Omer Rana[2]

[1]Cardiff School of Engineering, Cardiff University
Queen's Buildings, The Parade, PO Box 925, Cardiff,
CF24 0YF, Wales, UK.

[2]School of Computer Science, Cardiff University,
Queen's Buildings, Newport Road, PO Box 916,
Cardiff, CF24 3XF, Wales, U.K.

(MilesJC@cardiff.ac.uk ,{L.Joita, J.S.Pahwa, P.Burnap, W.A.Gray, O.F.Rana}@cs.cardiff.ac.uk)

Summary

In the AEC (Architecture / Engineering / Construction) industry a number of individuals and organisations collaborate and work jointly on a construction project. The resulting consortium has large pool of expertise and experience and can be defined as a Virtual Organisation (VO) formed for the duration of the project. VOs are electronically networked organisations where IT and web based communication technology play an important role in coordinating various activities of these organisations.

This paper describes the design, development and implementation of a Grid enabled application called the Product Supplier Catalogue Database (PSCD) which supports collaborative working in consortia. As part of the Grid-enabling process, specialised metadata is being developed to enable PSCD to effectively utilise Grid middleware such as Globus and Java CoG toolkits. We also describe our experience whilst designing, developing and deploying the security service of the application using the Globus Security Interface (GSI).

1 Introduction

In the Architecture/ Engineering/ Construction (AEC) industry, large projects are tackled by consortia of companies and individuals, who work collaboratively for the duration of the project. Such projects are complex and consortia members contribute a range of skills to the project from its inception to completion. Increasingly, the planning, implementation and running of these AEC industry projects requires the formation of secure VOs to enable collaboration between its members. An important feature of the VOs is that they are dynamic and are formed only for the project lifetime. Members can participate in several consortia at the same time and can join or leave a consortium as the project evolves.

This is a complex situation to support with software and the Grid will be an important (vital) infrastructure in such future systems. The Grid is perceived as providing additional functions to the existing functionalities of the Internet. As well as high speed networks, it offers features such as an enhanced security infrastructure including a single sign-on capability, simple setting up of networks to support VOs, distribution of computationally intensive jobs across multiple distributed processors and resource information sharing.

This paper describes the design, development and implementation of a Grid-enabled solution to the Product Supplier Catalogue Database (PSCD) application, an ActivePlan Solutions Ltd (APSL)[1] software package, which brings together clients, designers, contractors, suppliers and product manufacturers to work collaboratively in multiple consortia in a virtual environment. Collaboration occurs between: (1) product suppliers and VOs for procurement of supplies; (2) product specification designers for defining building industry standards to describe available

[1] ActivePlan Solutions Ltd – http://www.activeplan.co.uk

products; and (3) members of a VO working on a particular construction project which require information on the products.

In this paper we describe our experience whilst developing and deploying (Grid) services and components of the PSCD application such as: the Security Management Service using the Globus Security Infrastructure (GSI) (Grid Security Infrastructure 2004) and Java CoG Toolkit 1.1 (Commodity Grid Kits 2004), the Product Classes Databases (PCD) system and the Grid Service based Multiple Databases Search Service (MDSS) system. The Grid enabled MDSS system is an important component of the PSCD application build using Globus Toolkit 3 (core) Grid middleware.

The paper is organised as follows: in Section 2 we discuss the background information identifying the need to support collaborative work from the point of view of the AEC industry. Section 3 discusses security, user and data management respectively - describing the design, development and implementation of the Grid Service oriented architecture for the PSCD application. Conclusions and further work follow in Section 4.

2 Background on collaborative aspects between users supported by the PSCD application

Collaboration in a construction project takes place in various ways. This section looks at how this can be supported using PSCD. Product suppliers and purchasers have to collaborate to procure items for a given project. Currently the search for potential suppliers is done from experience and by using trade journals and other forms of advertising. The suppliers are then contacted by telephone or email and asked for quotes. With such a mechanism it is difficult to get a comprehensive search of all possible suppliers and the process is time consuming. PSCD provides a mechanism for a network based search of all relevant, registered suppliers. The application thus serves as a platform to bring together a large number of suppliers and contractors to negotiate and procure the necessary supplies for construction projects. As AEC industry products are normally prototypes and have large number of components, procurement is a significant activity and so any increase in efficiency is beneficial.

Three types of users can be involved with PSCD:

Industry Specifications Designers. These are high level users who can update and edit data within the central PSCD database. These users work collaboratively to design and review Product Classes (see Section 3.2.1) for use within the PSCD application.

Project Consortia Members. Project consortia members have read only access to system information. Consortia members work together to create project designs and perform searches for products and supplies. Procurement managers, a specific type of consortia member, have to analyse search results and communicate with the Product Suppliers to fix purchase prices.

Product Suppliers. Product Suppliers subscribe to the Product Classes created by the Industry Designers. They download Product Class specifications that are relevant to their own products and populate their own databases with product information in the format of the Product Class data structure.

3 The PSCD application architecture and its various modules and services

PSCD supports the collaboration described in Section 2 using three functional modules: Security Management, User Management, and Data Management.

The Security Management module defines a security framework for the PSCD application using the Globus Security Infrastructure (GSI). GSI is based upon Public Key Infrastructure (PKI) and requires users to have a private key and an X.509 certificate used to authenticate to Grid services. An important feature of GSI is the single sign-on capability and the ability to perform delegation, known as a proxy, the authentication to PSCD's resources on a user's behalf. The proxy can be enabled on the user's machine or on a designated MyProxy Server (MyProxy Online Credential Repository 2004) machine within the PSCD application site. This facility is incorporated in the Globus and Java CoG toolkits. The Security Management service also provides the capability of role-based privileges within the VO.

User management deliverables are concerned with the privileges of users either as single users or members of a consortium. Within PSCD there are levels of authority associated with different types of user and it is important to have a robust authority schema to ensure this information is kept structured, consistent and secure.

The Data Management area of the PSCD application describes how the data is managed within the application and at the supplier's end. Data Management incorporates an infrastructure which we call the Product Class Database (PCD) system. The PCD System functions within the overall PSCD application and serves its data needs. PCD makes available to members of the project design consortium, information about products which can be acquired from external suppliers so that availability, delivery and cost can be considered.

3.1 Security Management

Security aspects rely on keeping important information in the hands of authorized users. There are four issues to deal with: authentication – being able to verify identities; authorization – limiting access to resources to selected users or programs; confidentiality – ensuring that only the parties involved can understand the communication; integrity – being able to verify that the content of the communication is not changed during transmission (Grid Security Infrastructure 2004).

Without strong authentication, an unauthorized user can access PSCD's web resources. The challenge to build a secure access to PSCD web resources is to require the integration of the Security Management Service of PSCD into a single user-friendly service using the capabilities of GSI. Since the user accesses PSCD web resources remotely, it must be possible to establish the user's identity, the user's role and the VO the user belongs to with certainty.

GSI uses PKI as the basis for its functionality. PKI relies on two keys which can be used in such a way that if one key is used to encrypt a message, the other must be used to decrypt the message. One key is available publicly (i.e. *public key*). The other key is private (*private key*). A person can prove they hold the private key simply by encrypting a message. If the message can be decrypted using the public key, the person must have used the private key to encrypt the message.

Currently, Web browsers and Web servers do not support the concept of *delegation.* This means the creation of a limited lifetime private key and a certificate pair known as a proxy which can be used to authenticate access to PSCD web resources. GSI provides the security mechanism for a user to delegate his/her credentials to the Web resources. This can be done using either a Globus service or Java CoG toolkit version 1.1.

PSCD offers the user two methods of being authenticated and authorized: (1) a proxy certificate which has been previously enabled on his/her local machine or (2) a proxy certificate that resides on the MyProxy credential repository (MyProxy Online Credential Repository 2004) located at the PSCD application site. The user has to provide the username and password that protect his/her proxy certificate on the MyProxy credential repository.

In both scenarios users are authenticated and authorized to use the resources of the application against their proxy certificate, their role and the VO they belong to. If users don't provide either one or all of these credentials they are not authorized to use the PSCD resources and services. For both security scenarios a Tomcat Web server is used to host the Security Management module and to handle the connections to the PSCD application via an HTTPS protocol.

3.2 Data Management

The VOs are interested in the procurement of supplies such as building materials, furniture, electrical equipment, etc from suppliers. For the members of the consortiuum to reach a large number of suppliers and to identify what products and services would best suit their requirements taking into consideration facts such as materials cost, delivery time, etc, an infrastructure is required to enable VO members to search across a large number of product supplier databases. At present no such infrastructure exists. The prevalent means by which a VO can reach product suppliers is through product catalogues published by the product suppliers, personal recommendations and other forms advertisement. Procurement of supplies for construction projects is increasingly globalised. There are large numbers of product suppliers operating in both regional and international markets but there is no single integrated mechanism for reaching them. Current procurement procedures are time consuming and so only a limited search of potential suppliers is made resulting in an less than satisfactory process.

A further complication is that there is no standard mechanism by which the suppliers store and publicise information about their products. Some suppliers have complex IT Systems in place to manage information about products whereas others store information as .pdf or .doc files. So there is a large degree of heterogeneity in the way suppliers manage information about their products. Unless suppliers adopt a standard mechanism to store information about their products and services, it will not be possible to search their databases using a single and integrated mechanism. Therefore the problem is twofold. In the first place an infrastructure is needed to define a common mechanism that could be adopted by all the suppliers to supply information about products and services in their databases and secondly a search mechanism is needed that is designed to search such information sources for required products and services.

The Data Management area of PSCD describes the design and development of systems that have been created to support the infrastructure in which product suppliers can use a standard mechanism to store information about their products so that the members of a VO can search for the products they require using predefined search criteria. The Product Class, the Grid enabled Multiple Database Search Service (MDSS) System and Supplier Database (SD) Systems are three important components of the PSCD Application that are being developed as part of this research to provide the required infrastructure.

In PSCD, the PCD System supports the creation of Product Classes which are subscribed to by the suppliers to create products in their SDs. The products created in the SDs are then available to be searched and procured by VOs in civil engineering projects. The search takes place using the MDSS System deployed in the Grid environment. Both the PCD and SD Systems are linked via XML based Web Services technology (Graham et al. 2002). The development of the PCD and the SDs is concerned with making available to the members of the VO information about products so that availability, delivery and cost can be taken into account.

The Grid enabled MDSS System queries a dynamic selection of relevant supplier databases to extract, in real time, detailed information about the products which a VO wishes to acquire, using the Grid infrastructure. Suppliers manage their own databases and provide an interface between these and MDSS or they can use the SD System which is being designed to be MDSS complaint. Section 3.2.1 describes the design of the PCD System from the point of view of the product class, its composition, product class specification types, versioning of product classes and its specifications and product class release and Section 3.4 describes the MDSS architecture.

3.2.1 The Product Class

The creation of product classes is the first fundamental task required before creating products in the SD Systems. To enable all the product suppliers to adopt a standard mechanism of storing product information, the idea of the Product Class was conceived. A product class can be defined as a standard product definition which can then be used by product suppliers for creating and storing products in their SDs. It acts as a template and provides all the necessary information required to create actual products in an SD System. Each product has a corresponding product class using which, information about the product can be provided by the product supplier. For example a supplier dealing in furniture can subscribe to product classes such as Chair Product Class, Filing Unit Product Class, Desk Product Class, etc. Using a product class a number of products conforming to it can be described in the SD System. For example using Desk Product Class different kinds of desks (product) such as roll top desk, office desk, study desk, computer desk, pedestal desk, etc can be created.

3.2.2 Composition of Product Class

A product class is made up of a number of specifications. The specifications can be of several types and are created as part of creating a Product Class. The specifications are created from pre-defined specification types and provide the mechanism for defining the properties a product class can have. For example, a window product class can have specifications (properties) such as width, height, weight, frame material, panel shape, glazing configuration etc. Specifications can also have constraints on them. For example there can be a constraint on the "width" which should lie within a given range or on the "weight" which should not exceed some limit etc. A particular type of product can conform to only one product class at a given time. A product is said to conform to a product class when it uses the specifications defined as a part of a Product Class. Defining a product class requires the definition of its specifications and constraints. Figure 1 shows the five different specification types that have been identified so far. Some specification types can be further decomposed into sub specification types as also shown in Figure 1.

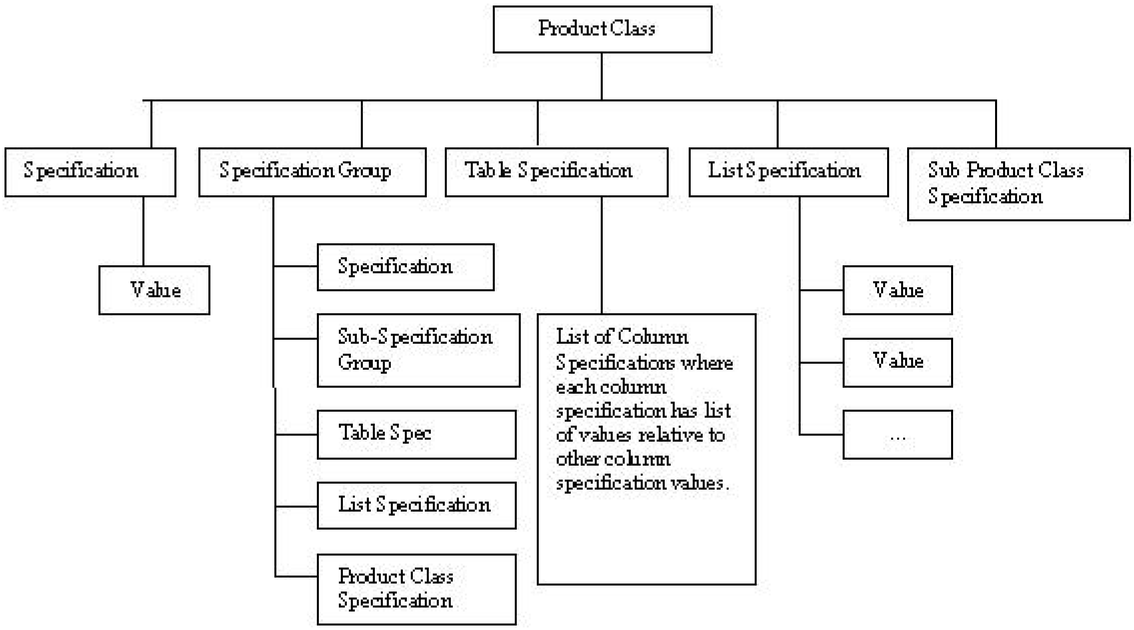

Figure 1 - The Product Class and its various specification types

The specification types of a product class are described below.

Specification: This is a unit specification type that holds only a single value. For example a specification "Manufacturer's Name" holds the name of the manufacturer. The value of a specification can correspond to a measurement unit for identifying its size, quantity, degree etc.

Specification Group: This specification type is used when a number of different specification types need to be grouped. The need for grouping specification types may arise when a number of specification types, as a part of industry standards needs to be addressed as a single unit or when they are commonly used across more than one product class. A specification group can be made up of individual specifications, sub specification groups, product class specifications, list specifications and table specifications. The following example describes a simple specification group. The name of the specification group is "Performance Criteria" and is made up of a list specification and a number of individual specifications.

Performance Criteria:

Electrical Supply	240v, 1ph, 50 hz
Chilled Water Flow Temp	6 Degrees C.
Chilled Water Return Temp	12 Degrees C.
External Static Pressure	30 Pa.

List Specification: A list specification can have a number of values. For example in the above "Performance Criteria" specification group "Electrical Supply" is a list specification which contains three values with their corresponding measurement units.

Table Specification: A table specification is made up of a number of column specifications where each column specification has a list of values. Specification values in each row are part of a collection where each value describes some aspect of a product. Table specifications can be used in a product class to represent technical details of the product in the form of rows and columns. A table specification can also be used for comparison of specification values of a product range. For example the table specification in Figure 2 represents specification values of a series of fan coil units.

Cheetah HBWS Series 200	GUIDE NR	AIR FLOW RATE (L/S)	MAX DUTY AVAILABLE		AIR OFF 12°C		AVAILABLE HEATING DUTY (KW)	F.L.C. (A)
			TOTAL COOLING DUTY (KW)	SENSIBLE COOLING DUTY (KW)	TOTAL COOLING DUTY (KW)	SENSIBLE COOLING (KW)		
201	30	110	1.71	1.45	1.56	1.35	1.80	0.72
	32	115	1.77	1.50	1.64	1.42	1.85	0.74
	35	130	1.95	1.67	1.85	1.60	1.99	0.78
	37	140	2.07	1.77	1.99	1.72	2.08	0.80
	40	165	2.39	2.06	2.35	2.03	2.33	0.86

Figure 2 - Table Specification

Sub Product Class Specification: The sub product class specification type is in fact a complete product class. It is so called in order to distinguish between a product class and other product classes which are defined within the product class. For example a Chair Product Class can include a Wheel sub product class. Here a Wheel sub product class is a complete product class in itself but it is called a sub product class in context to the Chair product class. A sub product class can be made up of one or more specifications of each type. There is no limit on how many levels a product class can include. For example a door set product class can be made up of a door closer sub product class, door lock sub product class, door handle sub product class, etc. These sub product classes can themselves be very complex entities and can be further made up of a number of specifications of different types.

3.2.3 Versioning of Product Class

New products or a new range of existing products are introduced by suppliers on a regular basis as they enhance features and functionality. These changes to products cannot be defined within the scope of the existing product classes which cannot support these extra features. With the evolution of the products, the product classes need to evolve as well. For this, versioning of product classes is required so that new versions of existing product classes can be created. A new version of a product class allows product suppliers to describe new products with enhanced features. Versioning support is provided for a product class to support such evolution.

Versioning of a product class requires versioning of its specifications as they are made up of specifications of different specification types. However, only those specifications that are altered to include extra features need versioning. This allows reuse of existing specifications and new versions are only required when creating new product classes. For example a list specification "Wood Type" with version ID 1.0 can have a number of values such as alder, cherry, fir, hemlock and mahogany. Once "Wood Type" version 1.0 list specification is created it should remain persistent throughout its lifetime. There could be more than one door, window or other furniture product classes using "Wood Type" version 1.0 list specification. When a need is identified to expand the "Wood Type" list specification a new version is created with enhanced values. The new version of "Wood Type" list specification can have the values of its previous version plus additional values such as maple, oak, pine etc.

New product classes or new versions of product classes are released to subscribing suppliers. Products are added to the SD System by the suppliers using the product classes as templates. This involves supplying values for the specifications defined within the product class whilst populating product information in the SD System. The constraints associated with the specifications ensure that only valid values are entered by the product supplier. Therefore, in this way products can be rapidly added once their product classes are available. It is envisaged that suppliers will subscribe to the product classes that correspond to their products. Product classes are currently undergoing a testing phase. Product classes are created in the PCD System and subscribed to by the SD Systems. A product class is released as an XML document. Subscribing to a product class requires parsing the XML document at the supplier's end and populating the SD System with the information contained in the XML document. The PCD and SD Systems are described in section 3.3.

3.2.4 Product Class Subscription

As illustrated in Figure 3 the product classes are subscribed to by product suppliers / manufacturers for their products.

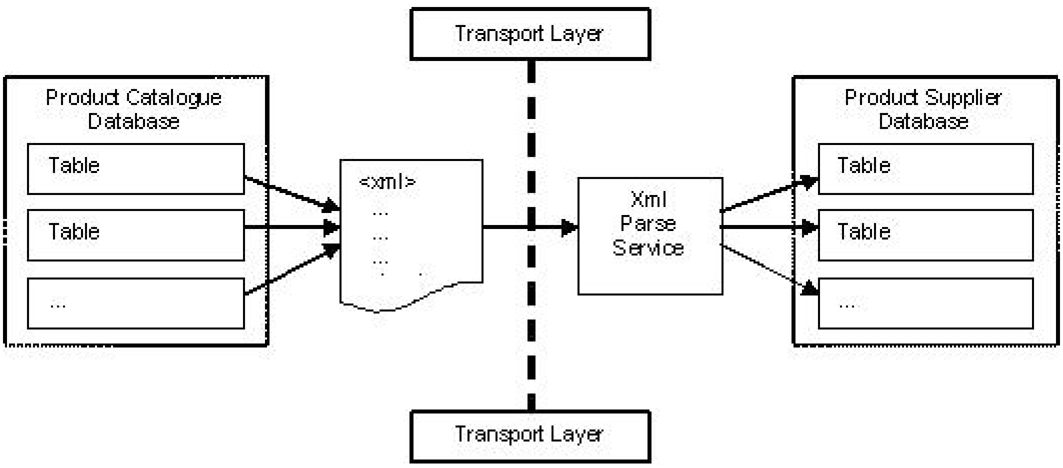

Figure 3 - Product Class subscription architecture

They are provided with the industry defined data structure for that class, allowing them to populate their own internally maintained databases with details about their own products that fall under the category of the subscribed class.

The application comprises a two way information retrieval system. First the product supplier has to subscribe to the product classes; this involves pulling and merging data from several different tables within the main PCD database into a single XML file for transportation via the Internet to the supplier side. The XML file is then parsed at the supplier side and split into chunks to be put back into the relevant tables of the PSCD. For a product supplier to be included in a user search, they have to first have subscribed to the relevant class. When a user conducts a search, metadata within the system determines which suppliers' databases to search based on which suppliers have subscribed to the product class(es) identified in the search.

3.2.5 Product Searching

Collaboration takes place when a search is made across a large number of supplier databases to retrieve products matching a criterion set by the purchasers. VO members collaborate on the specifications and range of products that they require. The search string is then broadcast to all suppliers and matching products are returned in a similar way to which they are subscribed to, all the data about the product is pulled and merged from several tables within the PSCD and returned to the search service for display to the user.

The grid enabled MDSS enables searching for the required products across a large number of supplier databases by the VO. It accepts criteria set by the VO and searches for the products based on the criteria across the supplier databases registered with the PSCD application. MDSS has been designed and developed using the Globus Toolkit 3 based on the Open Grid Services Architecture (OGSA) model. MDSS is discussed in detail in sub-section 3.4.

3.3 The Product Class Database (PCD) and Supplier Database (SD) Systems

As part of the PSCD application, the development of a prototype database centric tool called the Product Class Database (PCD) has occurred. It enables its users (the independent industry specification designers) to create the Product Classes described in sub-section 3.2.1. The PCD System enables specification designers to create new product classes/specifications and new versions of existing product classes/specifications. It is expected that where possible industry standards will be used and where these are not available standards will have to be developed. Once a product class is created, it is released so that relevant product suppliers can subscribe to it. A product class can be used by a large number of product suppliers to create and list products in their SD Systems. The SD Systems are used by large number of contractors/VOs for the procurement of goods (e.g. doors, windows) for construction projects. The supplier databases store product information. They are managed autonomously by independent suppliers. It is anticipated that the suppliers will subscribe to the product classes distributed by the APSL. The product classes will enable them to create products in their databases. The supplier databases will be designed to provide an interface to the MDSS, so that the products stored within them can be effectively searched. The prototype PCD and SD Systems are currently being tested with the MDSS System.

3.4 Grid enabled Multiple Database Search Service (MDSS) Architecture

The MDSS System was created as a result of investigating the applicability of Grid Technology in the sphere of AEC projects. MDSS is based on the Open Grid Services Architecture (OGSA) (Foster et al. 2002) model and provides a grid service solution for processing a large amount of data. MDSS is oriented towards the specific purpose of serving the needs of the members of a VO within an AEC industry community. It is anticipated that the VOs will use the MDSS

System as part of the PSCD application for searching large numbers of supplier databases for the products required in the project.

MDSS searches for products based on the criteria submitted by a contractor or a VO. The architecture is shown in Figure 4. Searching for products requires the searching of all the supplier databases that have subscribed to the corresponding product classes. The database search is divided into two parts. In the first part the VO specifies the search criteria in PSCD. This is then analysed to identify the suppliers that meet the requirements of the VO. The search criteria serve as the underpinning means for the dynamic creation of an XML document which contains the list of all the SD Systems that need to be searched in response to user's request. For example a VO may be interested in searching for air conditioning units. Therefore only those SD Systems that have subscribed to the air conditioning unit product class need to be searched. Also at this stage the Grid resources that are available to deploy the search are identified. There can be more than one grid machine running the MDSS software in the local area or wide area network. Searching a large number of SD Systems typically takes place using a cluster of Grid machines which work collaboratively and invoke supplier databases to retrieve product information in the form of XML documents. The Grid resources that are available for undertaking the search are dynamically identified and an XML document is created on the fly containing a list of Grid Service Handles (GSH) which is a permanent network pointer to a particular Grid service instance (Open Grid Services Infrastructure Version 1.0 2003) - in this case the MDSS instance.

In the second part, the two XML documents: a list of suppliers in the form of supplier web service URL and a list of GSHs is submitted to the Master Grid Service (MGS) which divides the total work to be done into equal proportions and allocates each proportion to individual Grid machine running an MDSS instance. The collaboration between the Grid machines helps to undertake database search jobs faster as the work load is equally distributed among them. A single MDSS instance in the Grid cluster can be required to search a number of SD Systems. Product information retrieved from the SD Systems by the MDSS instance is aggregated to form one XML document which is submitted to the Master Grid Service. The MGS also performs the service of collating results submitted by the individual MDSS instances to form a complete picture containing information on all the products for which the search was propagated. The MGS accesses MDSS instances using the GSH of the instances. The GSH is resolved to the Grid Service Reference (GSR) by the handle resolution service that implements HandleResolver PortType (Web Services Description Language (WSDL) Version 1.2 2003). The MGS creates a single proxy for all MDSS instances using its service description which is a Web Services Description Language (WSDL) document defining the bindings, messages, type definitions, etc required to invoke a service (Web Services Description Language (WSDL) Version 1.2, 2003). The proxy is created once and is used to gain access to any number of MDSS instances. Communication between the MGS, MDSSs and SD Systems takes place via XML based SOAP messages (see Figure 4).

MGS distributes search jobs to the Grid cluster running MDSS instances that perform the actual work of invoking SD Systems and requesting appropriate data. SOAP messages are created by the MDSS instances using an Apache Axis SOAP Server (Apache Axis User's Guide 2004). The SD Systems provide an XML based Web Service interface for the operations that can be performed by the MDSS (Graham et al. 2002). Instances of MDSS are created by the MDSS Factory implementing the Factory PortType. They are registered with and receive a GSH from the handle resolution service (Web Services Description Language Version 1.2 2003). The SD Systems subscribe to product classes created in the PCD System.

The MDSS System provides a data access mechanism only. It does not provide other database operations such as data definition, data insert, data update, data delete, etc as these are not needed for this application. There is scope to incorporate other database operations in MDSS as a part of future research. MDSS investigates the issues that need to be addressed when implementing OGSA based grid services to enable a search paradigm where data is retrieved from a large number of autonomously managed databases. Since it implements this search paradigm, it has a different set of basic operations than those provided by the OGSA-DAI (Antonioletti and Jackson 2004) and the Spitfire approaches ((Description of Spitfire 2003), (EU DataGrid WP2 2003), (Bell et al. 2002)) which have different objectives.

The MDSS System is designed to integrate with the PCD System in the PSCD Application. The PCD System enables the creation of product classes that are subscribed by the product suppliers in their SD Systems. These product classes can only be deployed in database schemas that can supply data structures which are identical to the schema of the PCD System. Therefore it is a requirement of the PCD System that all the resource provider database schemas should be able to provide identical data structures. A standard SD System is being designed to be identical in structure to the PCD System. Since the MDSS System collaborates with the PCD System to perform user tasks, it is optimised to search only those database systems which are registered with the PCD System and provide data conforming to the required schema. As part of the current research we are also investigating how the architecture of the MDSS System can be extended to support data search operations in the Grid environment in general supporting different database schemas.

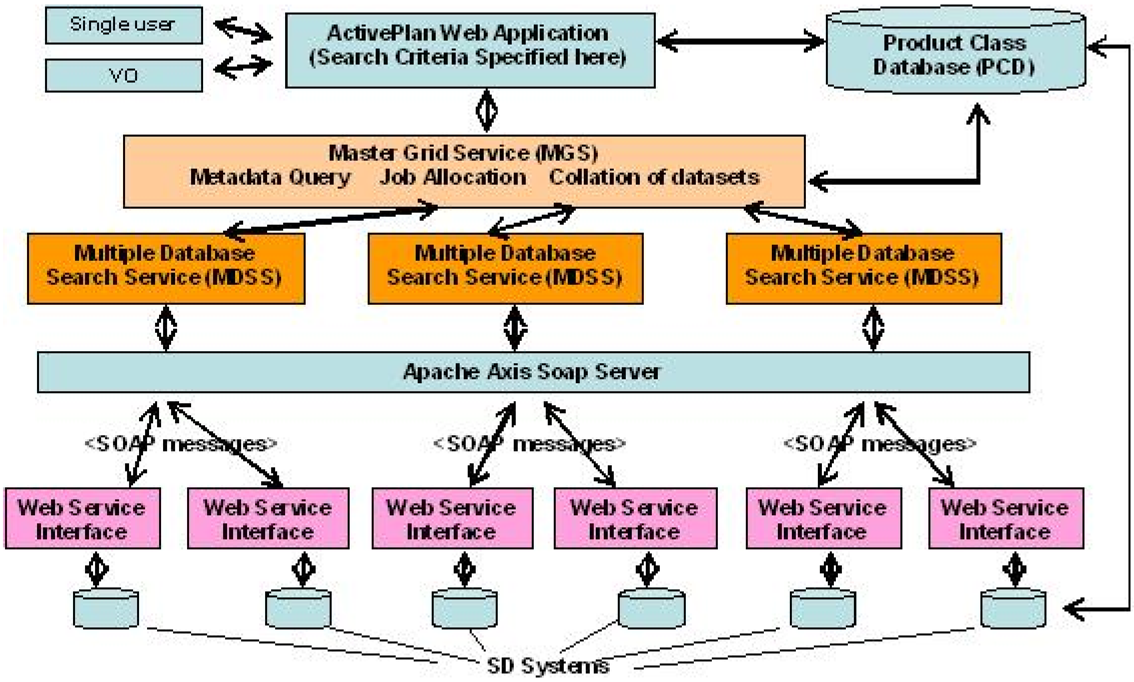

Figure 4 - The Grid Enabled MDSS System Architecture

3.5 Project Design & Virtual Meetings

If collaborative virtual teams are going to take off and be a part of the future there needs to be some way of teams of people taking part in virtual meetings and conferences. At the moment there are many conferencing tools such as VIC[2] and RAT[3] that are used with the access grid to provide a virtual interactive meeting environment where project teams can have video and audio

[2] Videoconferencing Tool (VIC), Network Research Group
http://www-mice.cs.ucl.ac.uk/multimedia/software/vic/
http://www-nrg.ee.lbl.gov/vic/

[3] Robust Audio Tool (RAT)
http://www-mice.cs.ucl.ac.uk/multimedia/software/rat/index.html

contact but this is a very limited form of interaction. For example, if a team attending a project proposal meeting start with a blank piece of paper, there will be an initial struggle to get people to say anything and there will be a limited constructive output from the meeting, whereas, if there are with some proposed ideas on paper, people will read them and add their own contribution. A web conference with only audio and video facilities is much the same as turning up to a real meeting with a blank bit of paper. In real project meetings, teams interact with diagrams, plans and graphics, therefore to create a complete conferencing environment all these things will have to be included in a virtual meeting application.

Some computer system developers might argue that computers are extremely complex products to design and make and that the demand for the services that computers can provide has always exceeded the demand for ease-of-use. In the case of this project there is the belief that ease-of-use is of utmost importance, mainly due to the fact that the users of the system may not feel particularly comfortable using computers for something they have become accustomed to doing manually or in person. The idea of a virtual meeting is ridiculous to some people who would much rather meet in person. However, the cost saving factor alone should convince people to change to virtual meetings. Given a user friendly virtual environment in which meetings could be held, plans could be drawn up, edited and reviewed, possible products could be discussed, compared and ordered and all the principles of real life business logic could be implemented, many more people would be open to this option.

4 Conclusions and further work

A Grid based system for the procurement of products has been described. Although the system is currently aimed at the AEC industry it could be applied universally to any complex project. The usage of the Grid provides a secure access facility, a vital feature if suppliers are to have confidence in the system, and provides a high speed, distributed search for products.

The PSCD application includes a login interface using the security infrastructure based on GSI.. Two scenarios have been developed: first, users use their local proxy certificate, and second, users use a username/password pair in order to be authenticated and authorized to access the server resources. This mechanism is implemented over an HTTPS connection. Further development will be done in regards to a secure integration with the PSCD .NET web development environment and the applicability of the new emerging technology of Web Services Security Framework.

A recent extension of the PCD has been to incorporate a peer review system for the creation of Product Classes. Before a new Product Class version is released, it has to be reviewed and accepted by all members of the specification design team; this will involve dynamic tagging and editing of Product Class information within the PCD.

The data management aspect of the PSCD Application involves creation of Product Classes, subscription to these by the product suppliers, creation of products based on Product Classes, and Grid enabled search by a VO or individual contractors for the required products. The prototype PCD System and the MDSS are developed to support data management. Implementation of the supplier database is still at a conceptual stage. The prototype components developed so far are currently undergoing testing, and the outcome of this activity will influence any changes to their architecture.

5 References

Antonioletti, M. and Jackson, M. (2004). OGSA-DAI Product Overview. <http://www.ogsadai.org.uk/docs/current/OGSA-DAI-USER-UG-PRODUCT-OVERVIEW.pdf> (6 April 2004)

Apache Axis User's Guide (2004). <http://ws.apache.org/axis/java/user-guide.html> (6 April 2004)

Bell, W., Bosio, D., Hoschek, W., Kunszt, P., McCance, G. and Silander, M. (2002). Project Spitfire - Towards Grid Web Service Databases. Technical report, Global Grid Forum Informational Document, GGF5, Edinburgh, Scotland, July 2002.

Commodity Grid Kits (2004). <http://www-unix.globus.org/cog/> (6 April 2004)

Description of Spitfire (2003). <http://edg-wp2.web.cern.ch/edg-wp2/spitfire/index.html> (6 April 2004)

EU DataGrid WP2. (2003) <http://cern.ch/grid-data-management> (6 April 2004)

Foster, I., Kesselman, C., Nick, J. and Tuecke, S. (2002). The Physiology of the Grid: An Open Grid Services Architecture for Distributed Systems Integration. Open Grid Service Infrastructure WG, Global Grid Forum, June 22, 2002, <http://www.globus.org/research/papers.html> (6 April 2004)

Graham, S., Simeonov, S., Boubez, T., Davis, D., Daniels, G., Nakamura, Y. and Neyama, R. (2002). Building Web Services with Java: Making sense of XML, SOAP, WSDL, and UDD. Sams Publishing 2002.

Grid Security Infrastructure (2004). <http://www-unix.globus.org/security/> (6 April 2004)

MyProxy Online Credential Repository (2004). <http://grid.ncsa.uiuc.edu/myproxy/> (6 April 2004)

Open Grid Services Infrastructure (OGSI) Version 1.0 (draft) (2003). Global Grid Form Open Grid Services Infrastructure WG 5 April 2003. <https://forge.gridforum.org/docman2/ViewProperties.php?group_id=43&document_content_id=176> (6 April 2004)

Web Services Description Language (WSDL) Version 1.2, W3C Working Draft (2003), World Wide Web Consortium. <http://www.w3.org/TR/2003/WD-wsdl12-20030303> (6 April 2004)