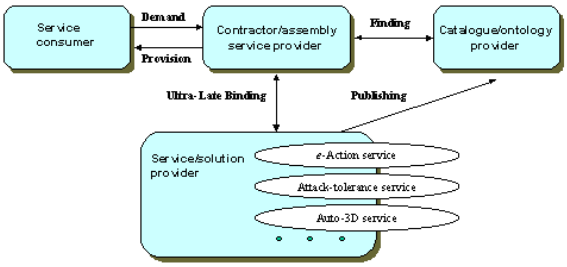
The **Department of Computer Science** at Durham has had for many years an established track record and an internationally leading reputation in service-based software architectures, dependable distributed computing and software visualisation. The **Durham Grid Consortium**, including experts from both academia and industry (including Sun, Sharp and Sparkle Computer Technology) is acting as a research team to lay the foundations for the project and develop solutions to the Grid problem.

The real problem underlying the Grid concept for advanced e-Science applications is coordinated resource sharing and problem solving in dynamic, multi-institutional virtual organisations. Previous attempts and existing approaches for such large-scale distributed applications are often tightly coupled, static, inflexible, and associated with specific protocols. The overall goal of the e-Demand project is to address this problem by developing a demand-led and service-centric architecture for building complex but dependable and secure Grid applications based on the notion of ultra-late binding and dynamically bound service components. This new architecture is protocol-independent, and able to wrap and package other applications and technology including existing Grid protocols and services.



The e-Demand Service-based Architecture

The e-Demand project is currently developing a number of generic services in order to enhance the proposed architecture, in the fields of Software Testing, Security, Fault Tolerance and Stereoscopic Visualisation. Our research interests include:

Grid Middleware Testing

We are developing a generic Grid service based on a fault injection tool called *OGSA-FIT (Open Grid Services Architecture Fault Injection Technology)* which aims to test Grid middleware by injecting faults at the network level – capturing, corrupting and re-transmitting network packets. We have modified the SOAP API so that we can inject faults before the signing and encryption of SOAP messages takes place, so that the injected faults are not immediately rejected by the receiving service.

We have developed an initial prototype tool, which is fully scriptable by the user and is compatible with Globus Toolkit 3. The tool has already generated a number of interesting results and has discovered a number of faults with the current Globus implementation. In addition to expanding the functionality of OGSA-FIT, we plan to test the other services under development at Durham and Newcastle.

Security

The Durham Grid Consortium is also developing an attack-Tolerant private Information Retrieval (TIR) service for Grid computing, which aims to protect the privacy of Grid users against potential (unauthorised) observers, detect corrupted results and retrieve correct results in the occurrence of failures and/or malicious attacks.

We found that our approach is viable and promising; experimental results have shown that our TIR scheme is particularly effective against a variety of malicious faults. Incorrect results reconstructed from corrupted data can be detected with a high probability and thus masked from the user. Our current implementation exhibits good performance: for example the service takes less than 32% extra processing time to reconstruct a correct result in the presence of two malicious servers from a total of five servers, in comparison with fault-free situations. The total processing time is

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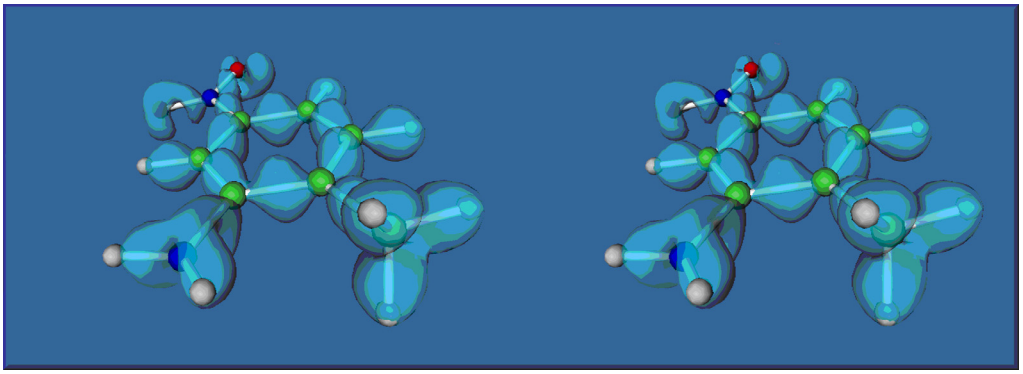

A Stereo Pair, Depicting a Molecule with Electric Field Isosurfaces

typically much less than one second, even in the presence of malicious attacks.

Fault Tolerance

As the individual nodes on a Grid may be potentially unreliable or insecure (for example, they may be owned by an outside organisation), job replication is an obvious way of reducing the chances of an erroneous or maliciously-altered result being received, as anomalous results should be caught in the voting procedure.

However, as different nodes in the Grid run at different speeds and have different loads at any one time, it is difficult to guarantee that a job will be finished within a given amount of time. In addition, many Grids are highly dynamic - nodes may join or leave at any time. Simple replication might therefore not be suitable; scheduling and prioritisation concerns need to be taken into account.

We are therefore developing a Grid service for providing fault tolerance - based upon an improved fault model that we have created - that combines a replication-based fault tolerance approach with both dynamic prioritization and dynamic scheduling in order to improve the confidence of jobs processed on the Grid.

Stereoscopic Visualisation

The use of stereoscopic visualisation can allow greater insights into the data being visualised. To display a stereoscopic visualisation, two images need to be generated, one for the left eye and one for the right. Different sizes and types of stereoscopic 3D displays vary in their ability to reproduce depth, which means a stereo image pair is generally not portable from display to display. This lack of portability makes the generation of stereoscopic visualisations a good candidate for the use of Grid services to allow just in time rendering for the target display.

In designing a Grid service framework to allow visualisation, we built upon the traditional data flow model of tools such as IRIS Explorer and AVS/Express. We have separated each stage of the pipeline: Data, Filter, Mapping, Render and Presentation, and built each into a Grid service. In addition to making each part of the pipeline separate, our design allows for a return flow of visualisation to provide configuration information and to control the flow of data to a service. The decoupling of both the visualisation design tool and also the end user interface allows an expert with domain knowledge and visualisation knowledge to build the visualisation before making it available to non-expert users who can then interact with the visualisation without needing to worry about the technical aspects of constructing the visualisation.

Our demonstration shows the current implementation of the Grid service framework for visualisation based upon an application in the field of Crystal X-Ray Diffraction - a branch of Chemistry.


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