GRID ENABLED OPTIMISATION AND DESIGN SEARCH (GEODISE)

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Key words to describe the work: Computer aided design and analysis tools, optimisation methods, distributed computing and data resources, data archives, knowledge capture and reuse tools, design search, optimisation.

Key Results: Delivering a design optimisation tool demonstrator for fluid dynamics problems, exploit grid computing technology for the simulation and optimisation computation, enhance the design process through the adoption of knowledge management and ontology techniques.

How does the work advance the state-of-the-art?: The Geodise project integrates and improves design optimisation processes in a Grid environment.

Motivation for the work: Assist engineers in the process of optimisation and design search.

Abstract

During the process of optimisation and design search, the modelling and analysis of engineering problems are exploited to yield improved designs. The engineer explores various design parameters that he wishes to optimise and a measure of the quality of a particular design (the objective function) is computed using an appropriate model. A number of algorithms may be used to yield more information about the behaviour of a model, and to minimise/maximise the objective function, and hence improve the quality of the design. This process may include lengthy and repetitive calculations to obtain the value of the objective function with respect to the design variables.

The issue of design optimisation with regard to fluid dynamics is relevant, amongst others, to the aerospace, automotive and oil industries. Computational Fluid Dynamics (CFD) allow the engineer to analyse the properties of a design. However detailed analysis is computationally expensive. To perform the numerous solutions required for extensive parameter exploration during a design search in this domain normally requires access to significant computational resources.

The Geodise project [1] aims to aid the engineer in the design process by making available a suite of design optimisation and search tools, CFD analysis packages integrated with distributed Grid-enabled computing, data, and knowledge resources [2]. These resources will be exposed to the user via a web based portal. The user will be guided through the design search process by an integrated knowledge base.

The current version of Geodise has the following features:

A sample application which optimises the aerodynamic profile of a jet engine nacelle. The nacelle geometry is parameterised with 6 design variables which may be optimised. The CFD solver used is a lightweight potential flow solver for 2D axisymmetric problems developed for the project.

The Geodise demonstrator portal provides the tools required to sample this objective function, build a Response Surface Model (RSM) that describes the behaviour of the objective function over all of the design variables. The RSM may be searched to generate an optimal nacelle design.

The portal automatically databases the input and output from the various services. This database may be searched to retrieve patterns in the use of the portal and to retrieve the results of the simulations for post-processing and visualisation.

Client certificates are used to authenticate users to the portal and distributed components within the demonstrator. Secure communication between components is achieved through SSL encryption.

The architecture of the Geodise project is based upon a number of distributed components exposed

through XML web services. This approach allows components to be authored and managed at a number of locations within a Virtual Organisation (VO). The computational resources used by the Geodise demonstrator are exposed to the user via a web service interface to a Condor Pool [3].

Current research activities within the Geodise project include:

- Exposing the state of computational jobs as Grid Services compliant to the OGSA Grid Services Specification [4] in ASP.NET [5].
- Exploring solutions that allow users to compose workflow solutions to design search problems from the components made available within the Geodise toolkit. In addition we are developing knowledge based support to guide workflow composition.
- Investigating the use of ontologies that describe the conceptual hierarchy within the engineering domain to annotate workflows, with a view to their use in future knowledge based support.
- Incorporation of commercial CAD packages (e.g. ProEngineer [6]) and CFD tools (e.g. Gambit and Fluent [7]). We are developing state of the art adjoint-based CFD solvers that, in addition to performing CFD analysis, also return gradient information, which is important in optimisation calculations.
- Adopting UK Grid Certificates as the ticket for user authentication effectively outsourcing the activities of the Registration Authority (RA) to a national infrastructure [8].

References

[1] The Geodise Project.
http://www.geodise.org/

[2] I. Foster, C. Kesselman, J. M. Nick, and S. Tuecke. 2002. *The Physiology of the Grid: An Open Grid Services Architecture for Distributed Systems Integration.*
http://www.globus.org/research/papers/ogsa.pdf

[3] The Condor Project.
http://www.cs.wisc.edu/condor/

[4] S. Tuecke, K. Czajkowski, I. Foster, J. Frey, S. Graham and C. Kesselman. 2002. *Grid Service Specification (Draft 2, 6/13/2002).*
http://www.gridforum.org/ogsi-wg/drafts/GS_Spec_draft02_2002-06-13.pdf

[5] Microsoft .NET Home Page.
http://www.microsoft.com/net/

[6] Pro/Engineer Home Page.
http://www.ptc.com/products/proe/index.htm

[7] Fluent Home Page.
http://www.fluent.com/

[8] UK e-Science Grid CA
http://www.grid-support.ac.uk/ca/