

PARALLEL GRID COMPUTING FOR LUBRICATION

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LAURENCE SCALES, SHELL GLOBAL SOLUTIONS

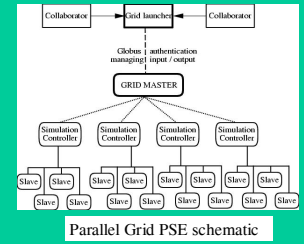
Lubrication of Journal Bearings and Gears

- Surface areas in contact are very small
- Surfaces are rotating very quickly
- Resulting pressures are up to 2 or 3 GPa.
- Under such high pressures the surface will deform
- This is called **elastohydrodynamic lubrication (EHL)**



EHL and the Grid

- The computational power needed exceeds most resources
- When running multiple simulations, such as optimisation, then the number of simulations are multiplied
- Each simulation may itself be run in parallel



Optimisation

- Rheological parameters are hard to ascertain experimentally
- Real experiments at different **physical conditions** (load, speed, temperature) performed and **friction** measured
- Numerical solutions performed at same physical conditions – allowing the rheological parameters to be optimised for best friction
- Global residual of difference between experimental and numerical results is the criteria governing parameter-set ‘quality’

$$R_F = \sum_{j=1}^{36} (F_j^{num} - F_j^{exp})^2$$

- Typically ten or more rheological parameters optimised at once

PSEs and the Grid

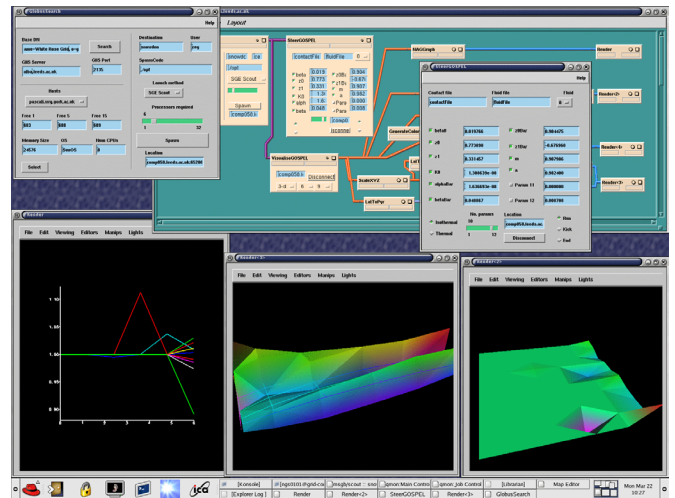
- **Globus** allows secure job launching onto a Grid machine
- Socket connections then formed between desktop PSE and Grid simulation using **gViz**
- Steering can still be done from the desktop, and visualisations returned
- Users can join whilst the simulation is running
- The users need not all use the same environment

Problem Solving Environments

- Interaction with complex numerical software
- Experimentation with “What if...?” questions
- Powerful visualisation techniques available
- Computational steering to guide simulations
- Ease of use for e-Scientists – not just computer scientists

Collaboration

- Often teams working on a project are geographically disparate, e.g. Utah and Leeds or across sites within Shell
- Sharing visualisation of a simulation is useful
- Very useful when combined with Access Grid
- Computational steering can now also be shared through generic libraries, such as **gViz**
- Different users can contribute their own expertise to guide a simulation



Multivariate visualisation

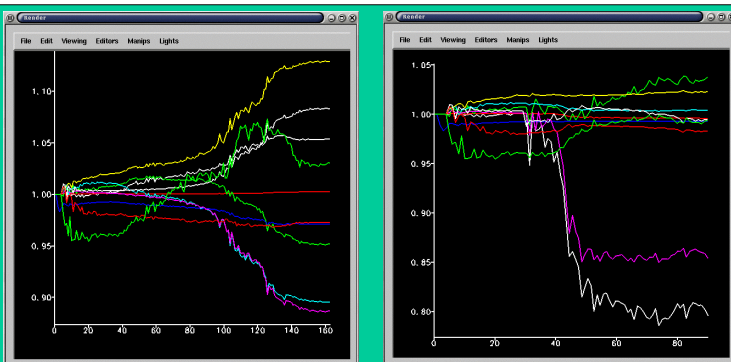
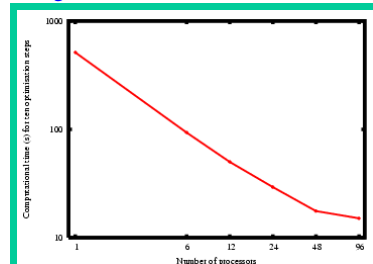
- In this problem there are many different sets of variables requiring visualisation:
- 10+ rheological parameters being optimised
 - global friction residual being reduced
 - 36 different friction residuals
 - progression of the optimiser through parameter space

Parallel Computing

- High resolution cases require many gigabytes of computational memory and vast CPU resources
- Global deformation makes it communication intensive.
- Large memory requirements mean distributed machine...
- ...therefore use **MPI** rather than shared memory
- Parallel **multigrid** for pressure solution
- Parallel **Multilevel Multi-Integration** for deformation

Performance

- Speed-up excellent for individual like-for-like cases
- Optimiser performance limited by slowest continuation run
- 2-d optimisation runs performed for first time



Effect of a computational steering (adding the temperature model) on optimised parameters after 30 iterations of the optimiser



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