

Operational Research and Optimization Group

Maths School, Edinburgh University
<http://www.maths.ed.ac.uk/ERGO/>

Our Strengths:

- 6 permanent staff – Cartis, Gondzio, Grothey, Hall, McKinnon work in computational optimization; Dagpunar works in reliability.
1 Post Doc, Colombo and 8 PhD Students.
2 visiting professors Fletcher and Gould, world leaders in nonlinear optimization.
- Our software is used in the energy, telecom and agriculture sectors to solve problems where no off-the-shelf software existed.
- We are interested in working with industry to developing new optimization methods for difficult problems.
- We run an Operational Research MSc with emphasis on optimization methods and we are starting a OR with Energy variant in 2008. We share courses with the Edinburgh Institute for Energy Systems.

World Class Software

We have developed world class software for

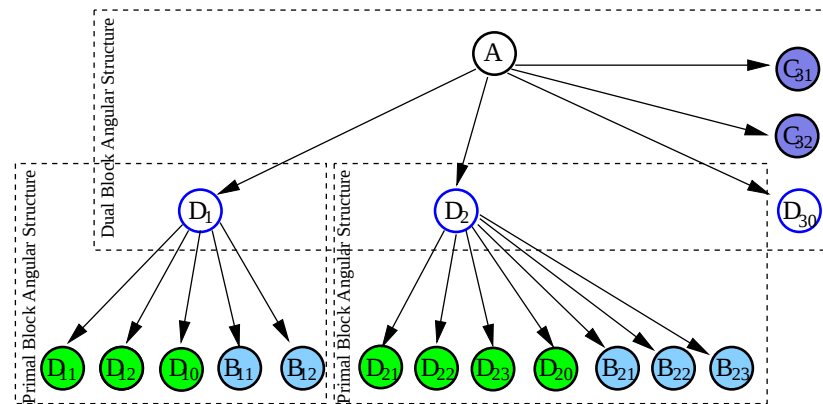
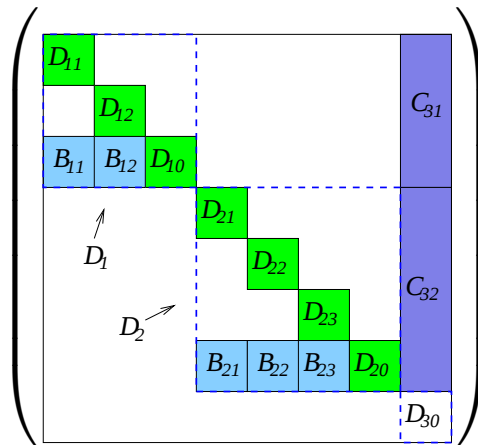
- Linear and quadratic optimization by interior point methods (best for huge problems).
- Linear optimization by the simplex method (best for families of problems).
- Decomposition methods for nonlinear and discrete optimization problems.
- Parallel solution of structured optimization problems.
- Optimization when the data is uncertain.

Common theme is Exploitation of Structure

- For small problems standard commercial solvers can usually cope.
- Large problems have a variety of different structures and different methods are needed to exploit this.

Exploiting Structure within Interior Point Methods (Gondzio, Grothey)

- Developed an Object-Oriented Parallel Solver (OOPS) for block-structured problems



- Beats commercial solvers by an order of magnitude on certain problem classes.
- Can solve problems with over 10^9 variables and constraints – a world record by a substantial factor.
- Currently developing an object oriented extension to a modelling language that passes the problem structure to the solver.

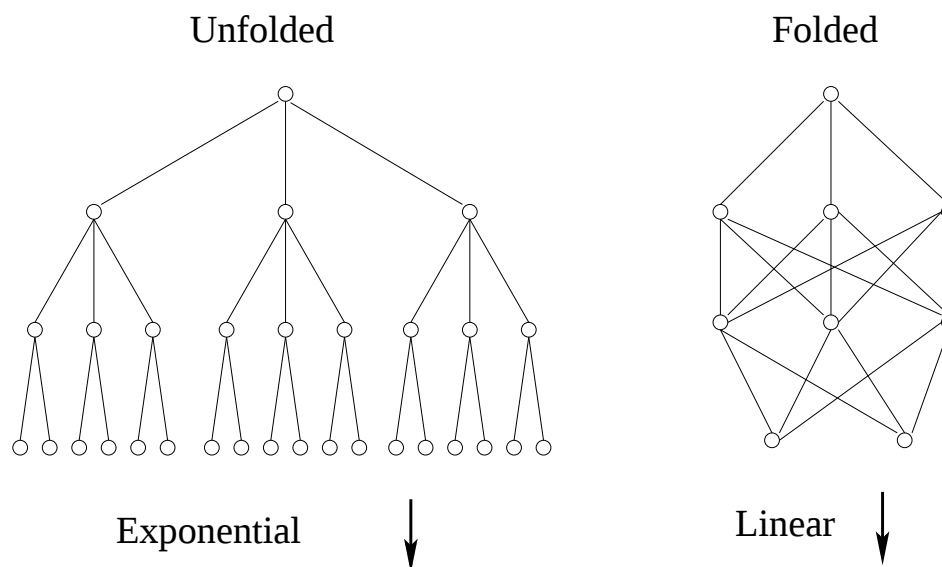
Exploiting Structure within Simplex Methods (Hall, McKinnon)

- Problems often start with few non-zeros but non-zeros increase rapidly during solution.
- Some of the biggest classes of problems don't have this behaviour (a property we called hypersparsity).
- Our simplex solver exploits hypersparsity and saves an order of magnitude on solution time.

Exploiting Structure by Decomposition

Above methods exploit structure within (the linear algebra of) a single large optimization problem. Alternative is to decompose the problem into several optimization problems.

- Lagrangian relaxation
- Benders Decomposition using Interior Point Method (Gondzio)
- Branch & Price and Danzig-Wolfe Decomposition (Grothey, McKinnon)
- Dynamic Programming with Nested Benders Decomposition for stochastic problems (McKinnon)



MSc in Operational Research (OR)

- There is family of MSc with a common core
 - OR
 - OR with Computational Optimization
 - OR with Finance
 - OR with Risk
 - OR with Energy
 - new for 2008-09 and in collaboration with the Institute for Energy Systems (Bialek)
- Students do 3 month industrial projects. (We are always looking for interesting new projects.)
- 45 students this year – half mathematicians, and the rest engineers, physicists, economists, computer scientists.
- Many students go into the energy sector.
- Many students go on for PhDs

Past energy related work

- IPM software was used for early studies of European carbon trading (Gondzio).
- Designed and implemented the model generation and nonlinear optimization core of what became the Edinburgh Petroleum Services REO product. This optimizes flow of oil and gas in pipe networks. (McKinnon)
- Used Dynamic Programming with Benders Decomposition for Hydro Thermal scheduling. Used by National Power to evaluate potential investments in Brazil. (McKinnon)
- Global gas flow models: Advised Wood MacKenzie on modelling the problem and selection of software (McKinnon) and independently provided a different company with an OOPS solver for a similar problem (Gondzio and Grothey).

Other Current and New Work

- Optimal routing of a fleet of LNG tankers with demand uncertainty. Uses branch and price.
- Optimal dispatch with wind variability and uncertainty. Uses stochastic optimization.
- Asset liability modelling using stochastic optimization.
- Hot starts for IPM for stochastic problems (EPSRC funded, Grothey, Colombo)
- Electricity dispatch with reliability constraints using OOPS. (Colombo, Dent, Grothey, Gondzio)
- We have a practical method for solving pooling problems, which is used worldwide for operating animal feed-mills. Mathematically the same problem occurs in operating tank farms in oil refineries.
- Multi-objective problems – Games – Optimization with equilibrium constraints.
- ... More suggestions please.

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