The NEOS Benchmarking Service

Robert Fourer

Industrial Engineering & Management Sciences
Northwestern University

`4er@iems.northwestern.edu`

Liz Dolan, Jorge Moré, Todd Munson

Mathematics & Computer Science Division
Argonne National Laboratory

`[more,tmunson]@mcs.anl.gov`

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The NEOS Benchmarking Service

One of the "solvers" on NEOS 5 is actually a benchmarking service that runs a submitted problem on a selection of solvers on the same machine. In addition to output listings from the solvers, the service optionally returns an independent assessment of the quality of the results. It is particularly useful in choosing a solver for a particular application.

Benchmarking

Fundamentals
- Collection of test problems
- Collection of solvers & solver parameter settings

Performance measures
- Number of iterations
- Number of function evaluations
- Number of conjugate gradient iterations
- Computing time

Issues
- Running the solvers
- Verifying the results
- Comparing performance

Running Solvers

NEOS benchmarking tools
- User submits one problem to NEOS benchmark "solver"
- User selects solvers to be compared
- NEOS tries all solvers, using the same computer
- NEOS verifies reported solutions
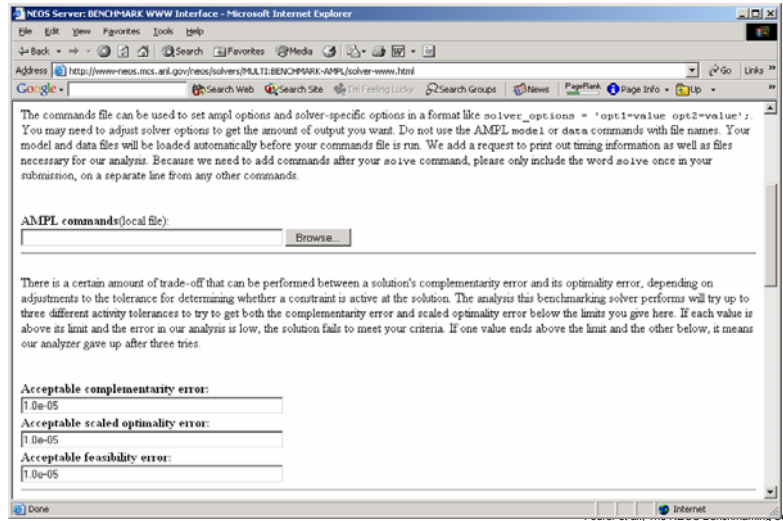- NEOS returns listing of results

Other current benchmarking resources
- Hans Mittelmann's benchmark pages,
  `plato.la.asu.edu/bench.html`
- PAVER performance analysis tool,
  `www.gamsworld.org/performance/paver/`
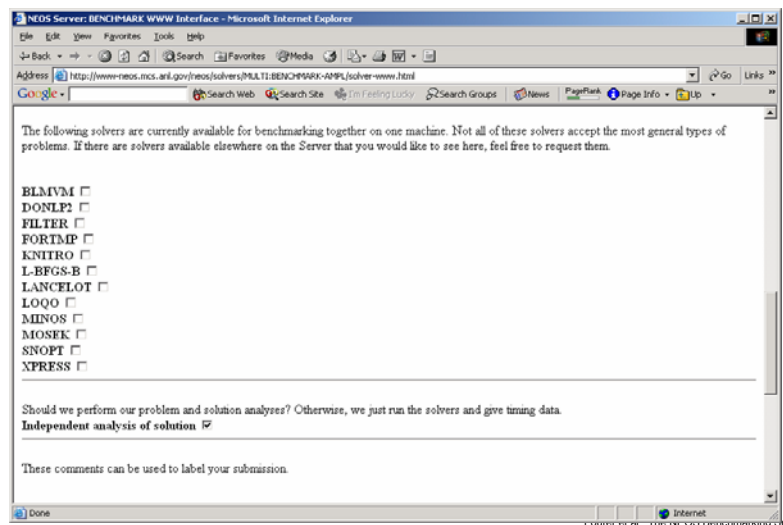
> *. . . access to numerous solvers is essential*

Benchmarking
NEOS Tools

Benchmarking web page (instructions)

Benchmarking
NEOS Tools *(cont'd)*

Benchmarking web page (solver choice)

Benchmarking

Verifying Results

Comparable running environments

➤ Same computer and operating system

➤ User's choice of solver parameters

➤ User's choice of tolerances for
feasibility, optimality, complementarity

Independent assessment of solutions

➤ Based only on solution returned

E.D. Dolan, J.J. Moré and T.S. Munson,
"Optimality Measures for Performance Profiles"
(available from www.optimization-online.org)

Benchmarking

NEOS Tools *(cont'd)*

Benchmark verification results

```
Solver lbfgsb.

feasibility error                    0.000000e+00
complementarity error                0.000000e+00
optimality error                     1.923416e-07
scaled optimality error              3.827304e-06
```

Solver solution optimality and complementarity found
acceptable.

```
Solver loqo.

feasibility error                    0.000000e+00
complementarity error                7.554012e-05
optimality error                     6.588373e-06
scaled optimality error              1.311233e-04
```

Solver solution not acceptable by this analysis because the
scaled optimality error is greater than your limit of 1.0e-05
and the complementarity error is greater than your limit of
1.0e-05.

Benchmarking
Comparing Performance

Average or cumulative totals of metric
   - ➤ Sensitive to results on a small number of problems

Medians or quartiles of a metric
   - ➤ Information between quartiles is lost

Number of k-th place entries
   - ➤ No information on the size of improvement

Number of wins by a fixed amount or percentage
   - ➤ Dependent on the subjective choice of a parameter

Benchmarking
Performance Profiles

Quantities to compute
   - ➤ For each solver *s* on each test problem *p*:
      ratio r_{ps} of that solver's metric to best solver's metric
   - ➤ For each solver *s*:
      fraction $\rho_s(\tau)$ of test problems that have $\log_2 r_{ps} \leq \tau$
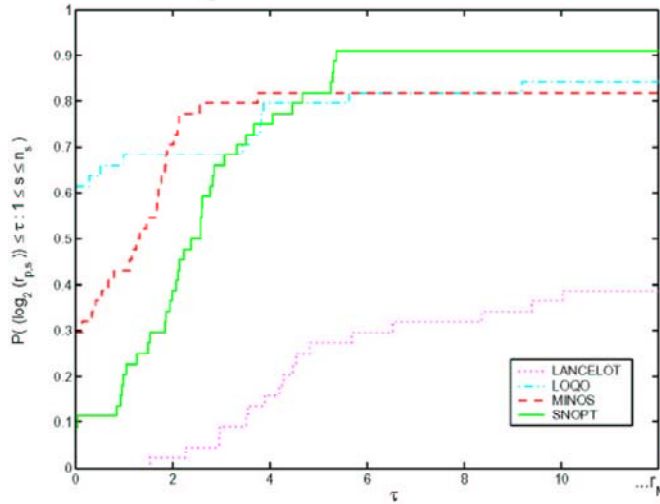
Values to display
   - ➤ Plot $\rho_s(\tau)$ vs. τ for each solver *s*
   - ➤ $\rho_s : \Re \to [0,1]$ is a non-decreasing, piecewise constant function
   - ➤ $\rho_s(0)$ is the fraction of problems on which solver *s* was best

      $\rho_s(\infty)$ is the fraction of problems on which solver *s* did not fail
   - ➤ Emphasis goes from performance to reliability
      as you go from left to right in the plot

E.D. Dolan and J.J. Moré,
"Benchmarking Optimization Software with Performance Profiles."
Mathematical Programming **91** (2002) 201–213.

Performance Profiles *(cont'd)*
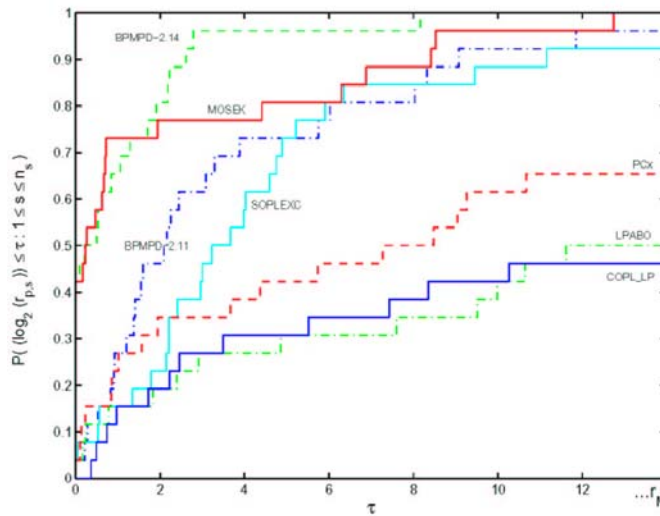
COPS optimal control problems

Performance Profiles *(cont'd)*

Mittelman test problems

Performance Profiles *(cont'd)*

Advantages

> ➢ Not sensitive to the data on a small number of problems
>
> ➢ Not sensitive to small changes in the data
>
> ➢ Information on the size of improvement is provided
>
> ➢ Does not depend on the subjective choice of a parameter
>
> ➢ Can be used to compare more than two solvers

Further research interests

> ➢ Multi-problem NEOS benchmarking tool
>
> ➢ Automated benchmark runs
>
> ➢ Automated generation of result tables & performance profiles