

Performance of Optimization Software - an Update

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Services we provide

- Guide to Software: "**Decision Tree**"
- <http://plato.asu.edu/guide.html>
- Software Archive
- Software Evaluation: "**Benchmarks**"
- Archive of Testproblems
- Web-based Solvers (**1/3 of NEOS**)

We maintain the following NEOS solvers (8 categories)

Combinatorial Optimization * CONCORDE [TSP Input]

Global Optimization * ICOS [AMPL Input]

Linear Programming

* bmpd [AMPL Input][LP Input][MPS Input][QPS Input]

Mixed Integer Linear Programming

* FEASPUMP [AMPL Input][CPLEX Input][MPS Input]

* SCIP [AMPL Input][CPLEX Input][MPS Input]

* qsopt_ex [LP Input][MPS Input]

Nondifferentiable Optimization * condor [AMPL Input]

Semi-infinite Optimization * nsips [AMPL Input]

Stochastic Linear Programming * bnbs [SMPS Input]

* DDSIP [LP Input][MPS Input]

We maintain the following NEOS solvers (cont.)

Semidefinite (and SOCP) Programming

- * csdp [MATLAB_BINARY Input] [SPARSE_SDPA Input]
- * penbmi [MATLAB Input] [MATLAB_BINARY Input]
- * pensdp [MATLAB_BINARY Input] [SPARSE_SDPA Input]
- * sdpa [MATLAB_BINARY Input] [SPARSE_SDPA Input]
- * sdpa-gmp [MATLAB_BINARY Input] [SPARSE_SDPA Input]
- * sdplr [MATLAB_BINARY Input] [SDPLR Input] [SPARSE_SDPA Input]
- * sdpt3 [MATLAB_BINARY Input] [SPARSE_SDPA Input]
- * sedumi [MATLAB_BINARY Input] [SPARSE_SDPA Input]

NEOS solver usage statistic for 1/1/10-5/31/10

- CONCORDE **9811** second most used solver!
- SCIP **5130**
- BPMPD **1377**
- FEASPUMP **913**
- SEDUMI **789**
- QSOPT-EX **599**

NEOS solver usage statistic for 1/1/10-5/31/10

- **CSDP 473**
- **SDPA 243**
- **ICOS 209**
- **SDPT3 130**
- **PENSDP 48**
- **SDPLR 43**

NEOS solver usage statistic for 1/1/10-5/31/10

- **CONDOR 38**
- **NSIPS 24**
- **BNBS 19**
- **PENBMI 9**
- **DDSIP 5**

Overview of Talk

- **Current and Selected(*) Benchmarks**
 - Serial vs Parallel Optimization
 - Serial and Parallel LP Solvers
 - MILP benchmarks (serial/parallel)
 - Feasibility Benchmark
 - Infeasibility Detection Benchmark
- Conclusions

SERIAL vs PARALLEL OPTIMIZATION

Parallel CPLEX on MIP problems (7-18-2009)

Parallel CPLEX, GUROBI, and MOSEK on LP problems (6-15-2010)

* MILP cases that are difficult for some codes (6-15-2010)

COMBINATORIAL OPTIMIZATION

Concorde-TSP with different LP solvers (7-25-2009)

LINEAR PROGRAMMING

* Benchmark of serial LP solvers (11-29-2009)

* Benchmark of parallel LP solvers (4-30-2010)

* MILP Benchmark - serial codes (4-17-2010)

* MILP Benchmark - parallel codes (5-19-2010)

* Feasibility Benchmark - Feaspump, CPLEX, SCIP, GUROBI, CBC (6-8-2010)

* Infeasibility Detection for MILP Problems (4-22-2010)

Large Network-LP Benchmark (commercial vs free) (4-29-2010)

SEMIDEFINITE/SQL PROGRAMMING

Several SDP-codes on SDP problems with free variables (4-1-2008)
Several SDP codes on problems from SDPLIB (4-10-2008)
SQL problems from the 7th DIMACS Challenge (8-8-2002)
Newer SDP/SOCP-codes on the 7th DIMACS Challenge problems(4-7-2008)
Several SDP codes on sparse and other SDP problems (4-4-2008)
SOCP (second-order cone programming) Benchmark (1-6-2010)

NONLINEAR PROGRAMMING

Benchmark of commercial and other (QC)QP Solvers (7-20-2009)
AMPL-NLP Benchmark, IPOPT, KNITRO, LOQO, PENNLP, SNOPT & CONOPT (11-30-2009)

MIXED INTEGER NONLINEAR PROGRAMMING

MI(QC)QP Benchmark (3-1-2010)

PROBLEMS WITH EQUILIBRIUM CONSTRAINTS

MPEC Benchmark (7-22-2009)

Important features of all our benchmarks

- Statistics of problems (dimensions etc)
- Links to codes given
- Links to test problems given
- Links to full logfiles given
- Same selection for commercial/free codes

Reasons for updates

- New version of commercial software
 - GUROBI-3.0.1
- New versions of free software
 - CBC, CLP, SYMPHONY
 - BONMIN, COUENNE, IPOPT
 - FEASPUMP 2
- More multicore hardware

Benchmarks still in need of updates

- SDP Benchmark (parallel, iterative, nonlinear)
- MINLP Benchmark, not only MIQCQP
- Benchmarks in new areas
 - Compressive Sensing, other sparse optimization
 - Derivative free/nonsmooth optimization etc
 - More commercial codes

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15 Jun 2010

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MILP cases that are difficult for some codes
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Logfiles at http://plato.asu.edu/ftp/difficult_logs/

CPLEX-12.1 GUROBI-3.0.0 CBC-2.4.1 MOSEK-6.0.0.78
SCIP-1.2.0 (CPLEX or CLP as LP solver)

The codes were run in default mode on a 2.66 GHz Intel Core 2 Quad (64-bit, Linux) on problems from here. SCIP runs in serial mode. Times given are elapsed CPU seconds.

```
=====
```

problem	CPLEX4	GUROBI4	SCIPC	CBC4	MOSEK	SCIPL
bc	>50000	232	7681	>40000	>40000	6564
neos-849702	209	19583	1295	1864	>40000	3004
ns1952667	147	>60000	811	>60000	>40000	503
ns2017839	66	251	112	6902	18106	58
ns2034125	>65000	3501	>65000	>65000	>40000	fail
ns2070961	>80000	>40000	18279	>40000	>40000	>40000
ns2071214	>72000	32042	f	>40000	>40000	8260
ns2081729	>60000	363	11649	>40000	>40000	14329
ns2082664	5	4	5164	>40000	1	21
ns2082847	1	1	>5000	24	>40000	1

```
=====
```

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29 Nov 2009 ===== Benchmark of serial LP solvers =====

```

=====
s problem      BPMPD      CLP      PCX      QSOPT     SOPLEX     GLPK
=====
2 cont1         15      4011        22     13241     4127
2 cont4         20      2062        44      9682     3355
2 fome13        224       111     1343      2055      883     7099
2 neos          275        59           9503     2568     41065
2 neos1         53         9           293      325
2 neos2         26       204           496      532
2 neos3        369     1737           11078
4 nsct2         38         1       559         1         2         2
2 ns1687037     239     2416           >40000     17399
2 ns1688926     302     4151           376
4 nug15         298     33888     4186     9650     3132
2 nug20        11294     42729     >40000
2 sgpf5y6        18         6        13      805     1431     486
4 stat96v1       58       103           535      205
6 stormG2-125   857        16     5398      172      431     254
2 stormG2_1000  322     1420           20384
1 stp3d         855       493     1295     4047
=====

```

30 Apr 2010 ===== Benchmark of parallel LP solvers =====

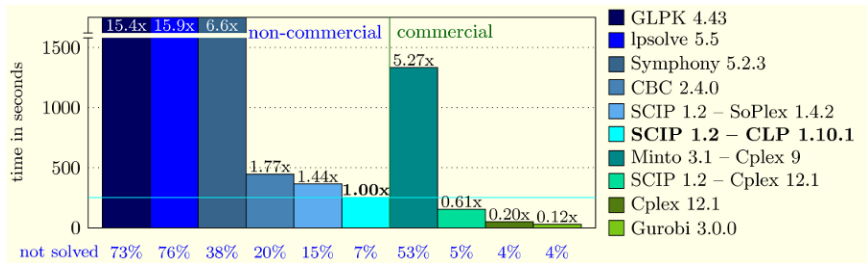
s	problem	CPLEX-S	GUROBI-S	MOSEK-S	CPLEX-B	GUROBI-B	MOSEK-B
2	cont1	1194	622	3228	1482	543	636
2	cont4	583	474	5270	1894	93	267
2	fome13	138	116	194	36	24	22
2	neos	10	107	160	37	34	54
2	neos1	264	16	3	8	5	5
2	neos3	987	2001	20	45	63	68
2	ns1687037	43182	2995	3099	17916	510	26057
2	nug20	54430	12174	>75000	265	1894	309
3	qap15	973	899	3539	16	23	24
2	rail4284	1725	3840	198	74	119	77
4	stat96v1	67	134	1046	384	46	117
6	storm-125	4	4	9	9	11	16
2	storm_1000	198	103	599	136	217	6870
1	stp3d	411	138	1738	40	55	39

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Graphical summary of our **serial** MILP benchmark

From The SCIP webpage scip.zib.de:



Geometric mean of results taken from the homepage of Hans Mittelmann (4/17/2010)

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8 Jun 2010 == Feasibility Benchmark - Feaspump,CPLEX,SCIP,GUROBI,CBC ==

```

=====
problem      CPLEX    FP-ab    FP-bf1    SCIP     GUROBI    CBC4
-----
atlanta-ip   848      24       17        213      41        1474
momentum2    6181     -         -         3307     69         -
net12        3093     5         3         129      1          69
ns1208400    5070    138      47        960     99         -
ns1758913    839     127      86        408     21         -
ns930473     1384    645      57         -       29        1930
=====

```

Objective values

```

=====
problem      CPLEX    FP-ab    FP-bf1    SCIP     GUROBI    CBC4
-----
atlanta-ip   115      96.01    148       102      194       120
momentum2    21521     -         -         14220.75 16824     -
net12        255      296      255       296      337       255
ns1208400     2         2         2         2         2         -
ns1758913   -290.2   -1454.67 -214.495  -1454.67 -395.2     -
ns930473    938734   1186540  1162340   -        1227168   935594
=====

```

Best objective in 34 cases: CBC/FP/SCIP 31, CPLEX/Gurobi 3

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22 Apr 2010 === Infeasibility Detection for MILP Problems ===

```
=====
problem      CPLEX4  GUROBI4  SCIP     CBC4
-----
neos788725   3711    279      75       436
neos820157   7504    78       1000000  1000000
neos858960   1312    653      1659     1804
neos859080    1       1        1        1
ns1158817    119     142      693     2179
ns1686196    213     38       338
ns1694849    661     896     1385
ns1702808    1150    173      308     4927
ns1745726    488     45       162
ns1766074    230     42      1057     336
ns1769397    1148    1084     7369
-----
```

Best times: Cplex 3, Gurobi 6, SCIP 1; time limit 64,000s

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Conclusions (free/NEOS red)

- Serial LP: **BPMPD** strongest IPM, **CLP** best Simplex
- MOSEK competitive for LP with CPLEX and GUROBI
- **SCIP-CPLEX** competitive for MILP (slower)
- GUROBI somewhat faster than CPLEX for MILP
- **SCIP-CLP** best free MILP solver, then **CBC, SCIP-SOPLEX**
- **CBC, FP, SCIP** competitive with CPLEX and GUROBI

Thank you for your attention