Selected Benchmark Results

INFORMS Annual Meeting 2016

Nashville, TN

16 November 2016

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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 in 9 categories

```
Combinatorial Optimization  * CONCORDE [TSP Input]
Global Optimization         * ICOS [AMPL Input]
  * scip [AMPL Input][CPLEX Input][MPS Input][OSIL Input][ZIMPL Input
Linear Programming
  * bpmpd [AMPL Input][LP Input][MPS Input][QPS Input]
  * SoPlex80bit [LP Input][MPS Input]
Mixed Integer Linear Programming
  * feaspump [AMPL Input][LP Input][MPS Input]
  * proxy [CPLEX Input][MPS Input]
  * qsopt_ex [AMPL Input][LP Input][MPS Input]
  * scip [AMPL Input][LP Input][MPS Input] [ZIMPL Input][OSIL Input]
Nondifferentiable Optimization   * condor [AMPL Input]
Semi-infinite Optimization       * nsips [AMPL Input]
```

Mixed Integer Nonlinearly Constrained Optimization
* scip [AMPL Input][CPLEX Input][MPS Input][OSIL Input][ZIMPL Input]

Semidefinite (and SOCP) Programming (also discrete)
  * csdp [MATLAB_BINARY Input][SPARSE_SDPA Input]
  * penbmi [MATLAB Input][MATLAB_BINARY Input][YALMIP Input]
  * pensdp [MATLAB_BINARY Input][SPARSE_SDPA Input]
  * scipsdp [SPARSE_SDPA Input]
  * sdpa [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]

Stochastic Linear Programming   * bnbs [SMPS Input]
                                 * DDSIP [LP Input][MPS Input]
                                 * SD [SMPS Input]

Overview of Talk

- **Current and Selected(*) Benchmarks**

  - Benchmark of Simplex and commercial LP solvers

  - Several SDP-codes on sparse and other SDP problems

  - MISOCP and large SOCP Benchmarks

  - MILP benchmarks (MIPLIB2010, SOLVABLE)

  - AMPL-NLP and MINLP benchmarks

- Observations and Conclusions

COMBINATORIAL OPTIMIZATION

Concorde-TSP with different LP solvers (11-30-2015)

LINEAR PROGRAMMING

* Benchmark of Simplex LP solvers (11-10-2016)
* Benchmark of commercial LP solvers (11-11-2016)
Parallel Barrier Solvers on Large LP/QP problems (11-11-2016)
Large Network-LP Benchmark (commercial vs free) (11-9-2016)

SEMIDEFINITE/SQL PROGRAMMING

SQL problems from the 7th DIMACS Challenge (8-8-2002)
* Several SDP codes on sparse and other SDP problems (10-13-2016)
Infeasible SDP Benchmark (10-18-2016)
* Large SOCP Benchmark (11-10-2016)
* MISOCP Benchmark (11-10-2016)

MIXED INTEGER LINEAR PROGRAMMING

* MILP Benchmark - MIPLIB2010 (11-11-2016)
* The Solvable MIPLIB Instances (11-11-2016) (MIPLIB2010)
MILP cases that are slightly pathological (11-8-2016)
Feasibility Benchmark (11-8-2016) (MIPLIB2010)
Infeasibility Detection for MILP Problems (11-8-2016) (MIPLIB2010)

NONLINEAR PROGRAMMING

* AMPL-NLP Benchmark (9-26-2016)

MIXED INTEGER QPs and QCPs

MIQ(C)P Benchmark (11-8-2016)

MIXED INTEGER NONLINEAR PROGRAMMING

* MINLP Benchmark (9-24-2016)

PROBLEMS WITH EQUILIBRIUM CONSTRAINTS

MPEC Benchmark (9-21-2016)

Important features of all our benchmarks

- NO PERFORMANCE PROFILES! (unreliable, TOMS 43)

- Statistics of problems (dimensions etc)

- Links to codes, problems and logfiles given

- Same selection for commercial/free codes

- many benchmark talks on personal webpage to
  TRACK PERFORMANCE OVER TIME

Reasons for updates

- New versions of commercial software

  - CPLEX-12.7, GUROBI-7

  - (KNITRO-10.2), MOSEK-8

  - MATLAB-2016b(linprog, intlinprog, fmincon)

- New versions of free software

  - MIPCL, SDPNAL, CBC, CLP, GOOGLE, SCIP, IPOPT

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```
10 Nov 2016    ==================================
                 Benchmark of Simplex LP solvers
               ==================================
                 H. Mittelmann (mittelmann@asu.edu)


This benchmark was run on a Linux-PC (i7-4790K, 4.0GHz, 32GB).


The simplex methods were tested of the codes:

 CPLEX-12.7.0     CPLEX
 GUROBI-7.0.0     www.gurobi.com/
 MOSEK-8.0.0.42   www.mosek.com
 XPRESS-8.0.0     XPRESS (1/8 threads)
 CLP-1.16.8       projects.coin-or.org/Clp (with openblas)
 Google-GLOP      LP with Glop
 SOPLEX-2.2.0     soplex.zib.de/
 LP_SOLVE-5.5.2   lpsolve.sourceforge.net/
 GLPK-4.60        www.gnu.org/software/glpk/glpk.html
 MATLAB-R2016a    mathworks.com (dual-simplex)


Unscaled and scaled shifted (by 10 sec) geometric mean of runtimes
```

problem	CPXS	GRBS	MSKS	XPR1	XPRS	CLP	GLOP	SOPLX	LPSLV	GLPK	MATL
	78.7	41.8	105	45.3	42.3	42.9	292	434	5068	1843	485
	1.88	1	2.52	1.08	1.01	1.03	6.98	10.4	121	44.1	11.6

```
10 Nov 2016    ===================================
               Benchmark of commercial LP solvers
               ===================================
               H. Mittelmann (mittelmann@asu.edu)


This benchmark was run on a Linux-PC (i7-4790K, 4GHz, 32GB).

The barrier(B) and deterministic automatic/concurrent(A) methods were tested of:

 CPLEX-12.7.0  CPLEX
 GUROBI-7.0.0     www.gurobi.com/
 MOSEK-8.0.0.42 www.mosek.com
 XPRESS-8.0.0    XPRESS
 MATLAB-R2016a   mathworks.com (interior-point, NO CROSSOVER!)


Unscaled and scaled shifted (by 10 sec) geometric mean of runtimes


          27.5  17.9    34    17.6  44.9  23.4  23.3    361
          1.56  1.01  1.95     1    2.55  1.33  1.32   20.5
=============================================================
45 probs   CPXB  GRBB  MSKB  XPRB  CPXA  GRBA  XPRA    MATB
=============================================================
```

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```
13 Oct 2016   =====================================================
              Several SDP-codes on sparse and other SDP problems
              =====================================================
                    Hans D. Mittelmann (mittelmann@asu.edu)


   CSDP-6.1.1:       www.nmt.edu/~borchers/csdp.html
   DSDP-5.8:         www.mcs.anl.gov/hs/software/DSDP/
   MOSEK-8.0.0.36:   mosek.com
   SDPA-7.3.8:       sdpa.sourceforge.net
   SDPT3-4.0:        www.math.nus.edu.sg/~mattohkc/sdpt3.html
   SeDuMi-1.32:      github.com/sqlp/sedumi/
   PENSDP-2.2:       www.penopt.com/pensdp.html
   SDPNAL-0:         www.math.nus.edu.sg/~mattohkc/SDPNAL.html


The codes were run in default mode on an Intel i7-2600 (16GB) under Linux. Given are total CPU sec

Scaled shifted geometric means of runtimes ("1" is fastest solver)
                 5.21      4.21       1      2.08     1.37     6.24      3.46     9.42
------------------------------------------------------------------------------------
count of "a"      6        22         2        21       10        6         4       13
solved of 90     82        73        87        83       84       79        81       56
====================================================================================
problem         CSDP      DSDP     MOSEK     SDPA     SDPT3    SeDuMi    PENSDP   SDPNAL
====================================================================================
"a": insufficient accuracy (DIMACS errors)
```

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```
10 Nov 2016     =========================================
                    Large Second Order Cone Benchmark
                =========================================
                  Hans D. Mittelmann (mittelmann@asu.edu)


Logfiles for these runs are at: plato.la.asu.edu/ftp/socp_logs/


MOSEK-8.0.0.42 MOSEK
CPLEX-12.7.0 CPLEX
GUROBI-7.0.0 GUROBI
XPRESS-8.0.0 XPRESS


These codes were tested on a selection of the SOCP problems from CBLIB2014.
The codes were run in default mode on an Intel i7-4790K (4.0 GHz, 32GB). Time limit 1 hr.


                          4.10         1.26          1         1.62
-----------------------------------------------------------------------
problem                  CPLEX        GUROBI       MOSEK      XPRESS
solved of 18                18           18          17          18
-----------------------------------------------------------------------
```

```
10 Nov 2016      =====================================
                     Mixed-integer SOCP Benchmark
                 =====================================
                 Hans D. Mittelmann (mittelmann@asu.edu)


Logfiles for these runs are at: plato.la.asu.edu/ftp/misocp_logs/


MOSEK-8.0.0.42 MOSEK
CPLEX-12.7.0 CPLEX
GUROBI-7.0.0 GUROBI
XPRESS-8.0.0 XPRESS
SCIP-3.2.0 SCIP


These codes were tested on a selection of the MISOCP problems from CBLIB2014 and from here.
The codes were run in default mode (except mipgap=0) on an Intel i7-4790K (4.0 GHz, 32GB).
Time limit 2 hrs.


Scaled shifted geometric means of runtimes (t/m counted as maxtime)
```

	3.40	1	9.66	1.37	54
problem	CPLEX	GUROBI	MOSEK	XPRESS	SCIP
solved of 47	37	46	32	45	23

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  - **MILP benchmarks (MIPLIB2010, SOLVABLE)**

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```
11 Nov 2016  ========================================================
            Mixed Integer Linear Programming Benchmark (MIPLIB2010)
            ========================================================
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The following codes were run with a limit of 2 hours on the MIPLIB2010 benchmark
set with the MIPLIB2010 scripts (exc Matlab) on two platforms.
1/4 threads: Intel i7-4790K, 4 cores, 32GB, 4GHz, available memory 24GB;
12 threads: Intel Xeon X5680, 12 cores, 32GB, 3.33Ghz, available memory 24GB


CPLEX-12.7.0: CPLEX
GUROBI-7.0.0 GUROBI
ug[SCIP/cpx/spx]-3.2.1: Parallel development version of SCIP (SCIP+CPLEX/SOPLEX on 1 thread)
CBC-2.9.8: CBC
XPRESS-8.0.0: XPRESS
MATLAB-2016b: MATLAB (intlinprog)
MIPCL-1.1.2: MIPCL


Table for single thread, Result files per solver, Log files per solver


Table for 4 threads, Result files per solver, Log files per solver


Table for 12 threads, Result files per solver, Log files per solver


Statistics of the problems can be obtained from the MIPLIB2010 webpage.
```

Unscaled and scaled shifted geometric means of run times

The third line lists the number of problems (86 total) solved.

```
-----------------------------------------------------------------
 1 thr   CBC    CPLEX   GUROBI   SCIPC    SCIPS    XPRESS    MATLAB    MIPCL
-----------------------------------------------------------------
unscal  1611     75      59.6     420      631       92       3117      849
scaled    27    1.26       1      7.04     10.6     1.54      52.2      14.2
solved    53     86       86       74       69       85        30        65
-----------------------------------------------------------------
```

```
 4 thr    CBC    CPLEX   FSCIPC   FSCIPS   GUROBI   XPRESS   MIPCL
-----------------------------------------------------------------
unscal    824    45.2     345      638      32.9     48.4     382
scaled   25.1    1.38    10.5       19        1      1.47    11.6
solved     65     86      74        68       86       85      74
-----------------------------------------------------------------
```

```
12 thr    CBC    CPLEX   FSCIPC   FSCIPS   GUROBI   XPRESS   MIPCL
-----------------------------------------------------------------
unscal    661    33.7     331      510      31.6      44      324
scaled     21    1.07    10.5       16        1      1.39      10
solved     68     86      73        69       86       85      76
-----------------------------------------------------------------
```

```
11 Nov 2016        ==========================================
                    The Solvable MIPLIB Instances (MIPLIB2010)
                   ==========================================
                      H. Mittelmann (mittelmann@asu.edu)


The following codes were run on the "green" problems from MIPLIB2010

CBC-2.9.8: CBC
CPLEX-12.7.0: CPLEX
GUROBI-7.0.0: GUROBI
XPRESS-8.0.0: XPRESS
FiberSCIP[cpx]-3.2.0: Parallel development version of SCIP


 no. of probs     CBC      CPLEX     GUROBI     XPRESS      FSCIP
-------------------------------------------------------------------
12 threads        1183      85.7       76        158         727
   211            15.5      1.13        1        2.07        9.56
  solved          118       201       207        178         142'
-------------------------------------------------------------------


 no. of probs   CPLEX    GUROBI    XPRESS
-------------------------------------------
48 threads       79.9     69.3       139
   213           1.19       1        2.07
  solved         206       210       181
-------------------------------------------
```

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  - **AMPL and MINLP benchmarks**

- Observations and Conclusions

```
26 Sep 2016       ====================
                  AMPL-NLP Benchmark
                  ====================
                  (mittelmann@asu.edu)


  IPOPT-3.12.3   projects.coin-or.org/Ipopt (MA97, also MA86 results, 4 threads)
  KNITRO-10.0    www.artelys.com/knitro/
  LOQO-7.03      www.princeton.edu/~rvdb/
  PENNON-0.9     www.penopt.de/pennlp.html
  SNOPT-7.5-1.5    www.scicomp.ucsd.edu/~peg/
  CONOPT-3.17A   www.conopt.com/
  WORHP-1.8        www.worhp.de/
  XPRESS-8.0.0(Nonlinear)   www.fico.com
  FMINCON-2016a   www.mathworks.com


For AMPL models see plato.asu.edu/ftp/ampl-nlp-source

The codes were run in default mode, except as indicated and with a CPU time
limit of 2hrs on a 16GB, 3.4GHz Intel i7-2600. Means for table instances only.

  Partial listing (123 instances; logfiles are complete)
===============================================================================
scaled shifted geom mean     3.1     1    21.2 17.7 24.3  33.6  11.6    1.05      15
src   problem              IPOPT KNIT  LOQO PENN SNOPT CONPT WORHP XPRESS FMNCON
===============================================================================
```

```
10 Oct 2016  =========================================================
             Mixed Integer Nonlinear Programming Benchmark (MINLPLib2)
             =========================================================
                       H. Mittelmann (mittelmann@asu.edu)


The following codes were run through GAMS-24.7.4 with a limit of 2 hours on these instances
from MINLPLIB2 and with one thread on an Intel i7-4790K, 32GB, 4GHz, available memory 20GB.


Description of selection process of benchmark instances. Statistics of the instances.


ANTIGONE-1.1, BARON-16.8.24, COUENNE-0.5, LINDO-9.0, SCIP-3.2


Table for all solvers, Result files per solver, Log files per solver,
Trace files per solver, Error files per solver


++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Scaled and shifted geometric means of run times


The second line lists the number of problems (72 total) solved.


The geometric mean is computed on the 54 instances for which no solver failed.
```

	ANTIGONE	BARON	COUENNE	LINDO	SCIP
geom mean	5.68	1	11.5	13.5	6.49
solved	39	58	24	19	35

- Observations and Conclusions: **Declare Winners?**

  - **Simplex LP**: CLP, XPRESS, Gurobi, ….CPLEX, MOSEK

  - **commercial LP**: XB, GB, ….XA,GA,CB, ….MB,CA

  - **SDP**: MSK, SDPT3, …SDPA, …PEN,DSDP,CSDP,SDPNAL

  - **SOCP**: MOSEK, …Gurobi, …XPRESS, …CPLEX

  - **MISOCP**: Gurobi, XPRESS, …CPLEX, ….MOSEK, ….SCIP

  - **MIPLIB**: Gurobi, CPLEX, …XPRESS, …SCIP,MIPCL,CBC

  - **MINLP**: BARON, ….ANTIG, SCIP, ….COU, LINDO

Thank you!