

# Recent Updates to our Benchmarks

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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 (**40 percent of NEOS**)

We maintain the following NEOS solvers (8 categories)

Combinatorial Optimization \* CONCORDE [TSP Input]

Global Optimization \* ICOS [AMPL Input]

Linear Programming

\* bmpnd [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][ZIMPL 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-c [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 5/1/07-4/30/08

- **BPMPD 10368**
- **SCIP 8674**
- **FEASPUMP 2241**
- **CONCORDE 1211**
- **SDPA 788**

## NEOS solver usage statistic for 5/1/07-4/30/08

- **QSOPT-EX 569**
- **BNBS 434**
- **CSDP 270**
- **CONDOR 247**
- **PENBMI 207**

## NEOS solver usage statistic for 5/1/07-4/30/08

- **SEDUMI 167**
- **PENSDP 131**
- **NSIPS 129**
- **SDPT3 112**
- **ICOS 97**

NEOS solver usage statistic for 5/1/07-4/30/08

- **SDPLR 73**
- **DDSIP 12**
- **SDPA-C 10**

# Overview of Talk

- **Current and the Discrete Benchmarks**
  - Concorde-TSP with different LP solvers
  - Parallel CPLEX on MIP problems
  - Feasibility Benchmark
  - MILP benchmark (free codes)
  - MI(QC)QP Benchmark
- Conclusions

## SERIAL vs PARALLEL OPTIMIZATION

Parallel CSDP on SDP problems (8-22-2006)

\* Parallel CPLEX on MIP problems (4-10-2008)

\* Parallel CPLEX and MOSEK on LP problems (3-24-2008)

## COMBINATORIAL OPTIMIZATION

\* Concorde-TSP with different LP solvers (4-12-2008)

## LINEAR PROGRAMMING

Benchmark of commercial LP solvers (2-17-2008)

Benchmark of free LP solvers (8-7-2007)

\* Large Network-LP Benchmark (commercial vs free) (4-16-2008)

## NONLINEAR PROGRAMMING

Benchmark of commercial and other (QC)QP Solvers (5-6-2008)

AMPL-NLP Benchmark, IPOPT, KNITRO, LOQO, PENNLP & SNOPT (4-18-2008)

## 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 (4-10-2008)

## MIXED INTEGER PROGRAMMING

\* MILP Benchmark - free codes (4-19-2008)

\* Feasibility Benchmark - FEASPUMP vs CPLEX (2-17-2008)

\* MI(QC)QP Benchmark (4-10-2008)

## PROBLEMS WITH EQUILIBRIUM CONSTRAINTS

MPEC Benchmark (4-11-2008)

## **Important features of all our benchmarks**

- Links to codes given
- Links to test problems given
- Links to full logfiles given

## Reasons for updates

- New commercial software
  - CPLEX-11.01 (SCIP, Feaspump, Bonmin, Concorde)
  - MOSEK 5.0.0.79, KNITRO-5.2
- New free software
  - CLP-1.7\*, CBC-2.1, GLPK-4.2\*, SDPA-7.1
  - IPOPT-3.4.\*, SeDuMi (64-bit), Boncouenne
- New multicore hardware

## Benchmarks still in need of updates

- LP Benchmark, commercial/free
- MINLP Benchmark, nonconvex/Boncouenne
- MINLP Benchmark, not only MIQCQP
- Benchmarks in new areas
  - Compressive Sensing, other sparse optimization
  - Derivative free/nonsmooth optimization etc

# Overview of Talk

- Current and the Discrete (+2 cont.) Benchmarks
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24 Mar 2008

First continuous benchmark

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=====  
Parallel CPLEX and MOSEK on LP problems  
=====
```

H. Mittelmann (mittelmann@asu.edu)

Logiles at [http://plato.asu.edu/ftp/cpx\\_msk\\_logs/](http://plato.asu.edu/ftp/cpx_msk_logs/)

The barrier methods of CPLEX-11.01 and MOSEK-5.0.79 were run on 1, 2, 4 processors of a 2.667 GHz Intel Core 2 Quad (64-bit, Linux) on large LP problems from here.

Times given are elapsed CPU times in seconds.

Large LPs on 1, 2, 4 processors of a 2.667GHz Intel Core 2 Quad

```
=====
```

problem	CPLEX1	CPLEX2	CPLEX4	MOSEK1	MOSEK2	MOSEK4
nug08-3rd	299	171	104	481	365	215
nug20	770	485	311	880	711	415
nug30	40955	15551	9708	30799	25885	14225
pde_1	765	410	269	2316!	1333	1037
pde_2	7071!	8759	2701!	1803	1499	1151
qap_1	1143	484	306	1949	1359	1205
qap_2	661	327	217	930	676	519

```
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```

! non-optimal

```
=====
```

5 Feb 2008      Second continuous benchmark

=====  
Large Network-LP Benchmark (commercial vs free)  
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Logfiles of these runs at: [http://plato.asu.edu/ftp/net\\_logs/](http://plato.asu.edu/ftp/net_logs/)

This benchmark was run on a 2.4 GHz AMD Opteron (64 bit, Linux, 12GB)

The MPS-datafiles are here.

The network resp. dual simplex versions of these codes were tested:

<http://www.cplex.com/> ILOG-CPLEX-11.01

<http://www.mosek.com/> MOSEK-5.0.0.79

<https://projects.coin-or.org/Clp/> Clp-1.6

<http://www.isye.gatech.edu/~wcook/qsopt/> QSopt-1.0 (32 bit binary)

Times are user times in secs including input. 3 hour time limit.

```

=====
problem      nodes      arcs      CPLEX  MOSEK      CLP  QSOPT
=====
16_n14      16381     261873     258    203        79   140
i_n13       8181     739733     163    272        264  211
lo10        23728     383578      93     71         53   123
long15      32767     753676     330     24         38  1894
netlarge1   45774     7238591    706    383        403   t
netlarge2   39893     1158027    226     31        230   t
netlarge3   38502     4489009    449    132       1124   t
netlarge6    8000    15000000    126    284       3230   m
square15    32760     753512     339     22         52  1746
wide15      32767     753676     328     24         48  1217
=====

```

"m": out of memory, "t": time limit exceeded

12 Apr 2008

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Concorde-TSP Benchmark (excerpt)

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problem	Cplex-11.0	QSopt-1.0\$	GLPK-4.11	MOSEK-5.0.0.79
d1655	55	100	1360	129
f11400	415	11368	2518	1186
f13795	3582	>50000		28474
nrv1379	70	126	462	109
pcb3038	19309	33706		31424
r11304	87	112	>64000	154
r11889	1406	6710	fail	6136
u1817	32746			
vm1748	247	536	2030	813

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10 Apr 2008

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Parallel CPLEX on MIP problems  
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Logfiles at [http://plato.asu.edu/ftp/ser\\_par\\_logs/](http://plato.asu.edu/ftp/ser_par_logs/)

CPLEX-11.01 was run in default mode on a single and a 2-processor 2.4GHz Opteron (64-bit, Linux), as well as on 1, 2, 4 processors of a 2.667GHz Intel Core 2 Quad (64-bit, Linux) on problems from

<http://plato.asu.edu/ftp/milpf.html>

<http://plato.asu.edu/ftp/miqp.html>

Times given are elapsed CPU times in seconds.

10 Apr 2008

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Parallel CPLEX on MILP problems  
=====

elapsed CPU sec on AMD Opteron resp Intel Core2 (64-bit, Linux)

"c": problem convex

=====  
class problem c Opter-1 Opter-2 Intel-1 Intel-2 Intel-4  
=====

MILP	bienst2	y	205	81	155	61	32
	lrn	y	102	62	55	24	90
	mas74	y	499	410	304	129	69
	neos13	y	155	509	71	100	372
	neos5	y	257	548	186	104	32
	seymour1	y	293	230	159	106	68

Parallel CPLEX on MIQP and MIQCQP problems

```

=====
class  problem  c  Opter-1 Opter-2 Intel-1 Intel-2 Intel-4
=====
MIQP   ibienst1      1696   1448   1124   519   243
       inug08  y   8315   4849   3013   1516   1821
       iqap10      1619    464    641   188   194
       isqp  y   5662   3603   1662   1028   2202
-----
MIQCQP ibienst1      131     90     98     63     31
       imisc07      176    120    105     79     39
       imod011  y   9456   8401   5025   3602   3105
       inug06-3rd y   7814  15480   4168   3260   3148
       inug08  y   4477   4308   2710   1519   1086
       iran13x13     37     46     26     11     6
=====

```

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17 Feb 2008

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Feasibility Benchmark - Feaspump vs CPLEX  
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The following codes were run on a 2.67GHz Intel Core2 under Linux:

CPLEX-11.01: <http://www.ilog.com/cplex/>

"h"/"f": emphasis on hidden feasible solutions/feasibility

FEASPUMP: [www.or.deis.unibo.it/research\\_pages/ORcodes/FP-gen.html](http://www.or.deis.unibo.it/research_pages/ORcodes/FP-gen.html)

"ab"/"bfl": Achterberg-Berthold/Bertacco-Fischetti-Lodi variants  
free use at NEOS: <http://neos.mcs.anl.gov/> (utilizes CPLEX)

SCIP-1.0: <http://scip.zib.de/> (uses CPLEX for LP)

Times given are user times in seconds. Time limit of 2 hrs.

Column "o" indicates the ranking wrt quality of the objective.

### Feasibility Benchmark (excerpt)

problem	CPLEX-h	o	CPLEX-f	o	FP-ab	o	FP-bf1	o	SCIP
atlanta-ip	241	4	837	2	56	1	21	5	505
core4872-1529	1	3	1	3	497	1	58	2	57
ds	1	3	1	3	-	-	6531	2	24
germanrr	26	4	267	3	22	2	5	5	243
momentum1	1	2	1	2	25	2	16	2	5012
momentum2	4003	2	323	1	67	3	62	5	4315
momentum3	3	2	2	2	516	1	253	2	-
msc98-ip	353	2	271	1	23	3	22	5	447
neos16	118	2	298	2	633	3	74	4	72
neos-506428	-	-	-	-	4470	1	-	-	2481

### Feasibility Benchmark (continued)

problem	CPLEX-h	o	CPLEX-f	o	FP-ab	o	FP-bf1	o	SCIP
neos-595925	3	1	1	2	141	4	83	5	14
net12	50	2	939	1	14	2	67	2	263
ns808444	-	-	-	-	56	1	-	-	2914
ns894236	2693	2	2001	2	160	2	88	2	2885
ns894244	4856	2	-	-	543	2	591	2	1976
ns894786	-	-	-	-	-	-	-	-	-
ns894788	-	-	-	-	47	1	908	1	-
ns897005	158	1	360	1	175	1	59	1	384
ns897642	7	2	5	2	504	2	19	2	345
ns903616	281	1	-	1	154	1	144	1	6806
ns930473	320	1	-	-	1076	2	45	3	-

Feasibility Benchmark (continued)

problem	CPLEX-h	o	CPLEX-f	o	FP-ab	o	FP-bfl	o	SCIP
ns1061051	557	4	1632	2	4	1	4	1	3993
ns1116954	-	-	-	-	2070	1	364	1	-
ns1208400	681	1	6753	1	2653	1	729	1	2728
ns1219534	34	3	109	1	85	1	97	2	2670
ns1405304	-	-	927	2	981	1	27	3	-
ns1425622	5280	1	373	3	74	5	8	4	159
ns1456591	3	3	-	-	127	2	-	-	1947
NSR8K	392	3	279	3	6154	1	594	4	886
protfold	39	3	201	2	145	2	32	1	-
ramos3	1	3	1	3	383	1	179	2	70
rd-rplusc-21	180	2	19	2	632	4	1199	3	1676
van	2035	2	1109	2	695	1	458	4	525

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1 Apr 2008 =====  
Mixed Integer Linear Programming Benchmark (free codes)  
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The MPS-datafiles for all testcases are in one of

<http://miplib.zib.de/>

<http://plato.asu.edu/ftp/fctp/>

<http://coral.ie.lehigh.edu/mip-instances/>

<http://plato.asu.edu/ftp/milp/>

<http://www.ps.uni-sb.de/~walser/acc/acc.html>

<http://www.ieor.berkeley.edu/~atamturk/data/>

CBC-2.1: <https://projects.coin-or.org/Cbc>

GLPK-4.26: <http://www.gnu.org/software/glpk/glpk.html>

MINTO-3.1: <http://coral.ie.lehigh.edu/~minto/>

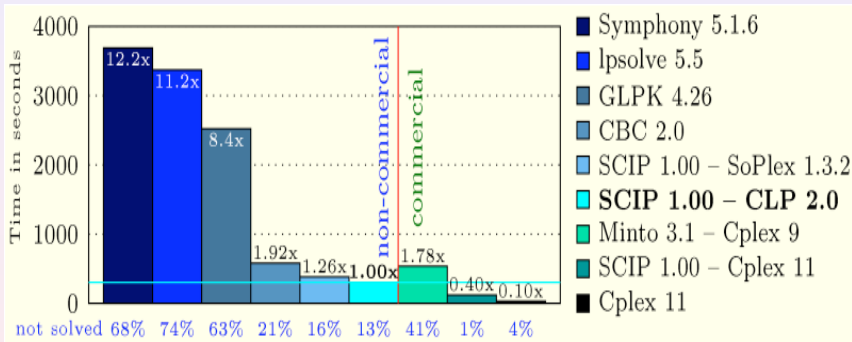
SCIP-1.0: <http://scip.zib.de/>

SYMPHONY-5.1.6: <https://projects.coin-or.org/SYMPHONY>

CPLEX-11.01: (for comparison purposes; mipgap=0, absmipgap=1e-9)

## Graphical summary of our MILP benchmark

From The SCIP webpage [scip.zib.de](http://scip.zib.de):



Geometric mean of results taken from the homepage of Hans Mittelmann (2/22/2008)

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10 Apr 2008

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Mixed Integer (QC)QP Benchmark  
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MIQP cases from [http://plato.asu.edu/ftp/ampl\\_files/miqp\\_ampl/](http://plato.asu.edu/ftp/ampl_files/miqp_ampl/)  
also solved as MIQCQP with

CPLEX-11.01: <http://www.cplex.com/>

Bonmin-0.1.4: <https://projects.coin-or.org/Bonmin>

(Bonmin: default hybrid algorithm. with Clp)

(B-OA-C: outer approx. with CPLEX)

FilMINT: currently only at NEOS

LaGO-0.3: <https://projects.coin-or.org/LaGO>

on a 2.4GHz Opteron (Linux). "t" > 3 hrs, "f" fail

Mixed Integer (QC)QP Benchmark (convex cases)

	QP					QCQP			
problem	Bonmin	B-0A-C	CPLEX	FilMINT	Bonmin	B-0A-C	CPLEX	FilMINT	
ibell3a	48	6	11	t	55	6	6	1600	
ibienst1	1466	6237	1697	t	1285	5838	131	t	
icap6000	3315	29	18	1961	t	32	11	1065	
ilaser0	f	4	2443	f	f	14	967	f	
imod011	7954	t	124	8134	t	t	t	f	
inug08	t	t	7760	f	t	t	4521	t	
iqiu	389	t	217	1510	1528	t	171	2758	
isqp0	(1)f	10	115	f	(2)f	f	t	f	

(1) B-BB solves in 4408 s

(2) B-BB solves in 4485 s

Mixed Integer (QC)QP Benchmark (nonconvex cases)

QP

|

QCQP

```

=====
problem  Bonmin B-0A-C CPLEX FilmINT  Bonmin B-0A-C CPLEX FilmINT
=====
  iair04   3387    992    388    2188    5475    1358    115    5151
  iair05   1812    168    113         f    1628    118     67    1218
  ieild76   845    166     31    3122    1032    150     27     910
  imas284   806      9     21     87     845      9      6     562
  imisc07   974   4541    309    7627    1054   5332    176         t
  iqap10   5591   2163   1488    3691    9086   4638   2575         t
iran13x13  3739     89     63    2515    4971    124     37    2026
iran8x32   257     45     12    3680     546     68     18    5856
  iswath2  (3)t    396    383         t    (4)t    283     f         t
  ivalues  1396         t     f         t    1658         t     f         t
=====

```

(3) B-QG solves in 3770 s

(4) B-0A solves in 4066 s

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Mixed Integer (QC)QP Benchmark  
=====

- 25 MI(QC)QP cases total
- MIQP cases solved:
  - CPLEX 22, Bonmin 17, FilmINT 10, LaGO 5
- MIQCQP cases solved:
  - CPLEX 15, Bonmin 16, FilmINT 9, LaGO 4

## Conclusions

- Parallel CPLEX effective most of the time, MOSEK competitive
- FEASPUMP competitive with CPLEX
- SCIP-CPLEX competitive for MILP with CPLEX except for speed
- SCIP-SOPLEX/CLP best free MILP solver, then CBC, MINTO
- BONMIN competitive with CPLEX for MIQCQP, much slower for MIQP

**Thank you for your attention**