Benchmarking of Optimization Software

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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)

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Combinatorial Optimization  * concorde [TSP Input]
Global Optimization         * icos [AMPL Input]
Linear Programming
  * bpmpd [AMPL Input][LP Input][MPS Input][QPS Input]
  * qsopt_ex [LP Input][MPS Input]
Mixed Integer Linear Programming
  * feaspump [AMPL Input][CPLEX Input][MPS Input]
  * scip [AMPL Input][CPLEX Input][MPS Input][ZIMPL 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 2006 (1/1-10/31)

- BPMPD **5324**
- SCIP **3116**
- FEASPUMP **1819**
- SDPA **1237**
- CONCORDE **1190**

NEOS solver usage statistic for 2006 (1/1-10/31)

- SDPT3 **218**
- CSDP **192**
- CONDOR **183**
- SEDUMI **142**
- BNBS **141**

NEOS solver usage statistic for 2006 (1/1-10/31)

- PENBMI **133**
- ICOS **87**
- SDPLR **71**
- DDSIP **59**
- PENSDP **42**

Overview of Talk

- **Current and some recently updated Benchmarks**
  - Parallel Benchmarks (CSDP on SDP, CPLEX on MIP)
  - SDPs with free variables (more at 4:30 in MD07)
  - MILP benchmark (free codes)
  - MI(Q)QP Benchmark
  - Commercial and other (QC)QP Solvers
- Conclusions

SERIAL vs PARALLEL OPTIMIZATION

* Parallel CSDP on SDP problems (8-22-2006)
* Parallel CPLEX on MIP problems (9-9-2006)

COMBINATORIAL OPTIMIZATION

Concorde-TSP with different LP solvers (8-8-2006)

LINEAR PROGRAMMING

Benchmark of commercial LP solvers (7-12-2006)

Benchmark of free LP solvers (8-3-2006)

NONLINEAR PROGRAMMING

* Benchmark of commercial and other (QC)QP Solvers (11-3-2006)

AMPL-NLP Benchmark, IPOPT, KNITRO, LOQO, PENNLP & SNOPT (10-27-2006)

SEMIDEFINITE/SQL PROGRAMMING

* Several SDP-codes on SDP problems with free variables (10-17-2006)

Several SDP codes on problems from SDPLIB (7-19-2006)

SQL problems from the 7th DIMACS Challenge (8-8-2002)

Newer SDP/SOCP-codes on the 7th DIMACS Challenge problems(7-18-2006)

Several SDP codes on sparse and other SDP problems (7-19-2006)

SOCP (second-order cone programming) Benchmark (10-28-2006)

MIXED INTEGER LINEAR PROGRAMMING

* MILP Benchmark - free codes (9-25-2006)

MIXED INTEGER NONLINEAR PROGRAMMING

* MI(Q)QP Benchmark (8-2-2006)

PROBLEMS WITH EQUILIBRIUM CONSTRAINTS

MPEC Benchmark (9-12-2006)

Important features of all our benchmarks

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

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22 Aug 2006

Parallel CSDP on SDP problems

A partly Open-MP parallelized version of CSDP was run on a 24-proc Sun E6500 HPC server. Given is the speedup for 2 to 16 processors. The problems are taken from our Sparse SDP Benchmark (more in MD07)

problem	var	cons	2	4	8	16
trto-4	1,200	1,874	1.57	2.53	3.64	4.52
taha1b	1,610	8,007	1.80	3.36	6.01	11.18
mater-4	4,807	12,498	1.74	2.82	3.84	5.25
mater-5	10,143	26,820	1.90	3.43	5.66	8.81
mater-6	20,463	56,311	1.94	3.71	6.34	11.57

9 Sep 2006

Parallel CPLEX on MIP problems

elapsed CPU seconds on 2.4GHz Opteron (64-bit, Linux)

class	problem	Opter-1	Opter-2	Opt-dual
MILP	bienst2	2529	608	762
	lrn	114	85	356
	mas74	897	441	483
	neos13	2073	1694	2266
	neos5	1169	>40000	
	seymour1	669	449	526

"c": problem convex

MIQP	ibienst1		2742	1330	1105
	inug08	c	7973	4761	10209
	iqap10		1679	457	687
	isqp	c	4755	2824	8827
MIQQP	ibienst1		3132	1878	2644
	imisc07		6460	3255	3445
	imod011	c	7348	9463	10014
	inug06-3rd	c	6588	6890	7833
	inug08	c	4221	2336	2768
	iran13x13		8756	3876	4278
	CLay0304M	c	1278	630	1329

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Several SDP-codes on SDP problems with free variables
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Thirty problems, first twenty were generated for [1]
Last ten were generated with [3] (solveMaxCut.m)

[1] M. Anjos, S. Burer, On Handling Free Variables in
Interior-Point Methods for Conic Linear Optimization
technical report 1456, University of Iowa (2006)

[2] K. Kobayashi, K. Nakata and M. Kojima, A Conversion
of an SDP Having Free Variables into the Standard Form SDP
June 2005. Revised April 2006. to appear in COAP

[3] http://www.is.titech.ac.jp/~kojima/SparsePOP/

SDP-codes on problems with free variables (summary)

Accuracy (vanilla/default codes)

code	best	sec best
CSDP	16	9
SeDuMi	7	9
SeDuMif	6	5
SDPT3	1	7

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25 Sep 2006 ==========

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-1.01:	https://projects.coin-or.org/Cbc
GLPK-4.11:	http://www.gnu.org/software/glpk/glpk.html
MINTO-3.1:	http://coral.ie.lehigh.edu/~minto/
SCIP-0.90:	http://scip.zib.de/
SYMPHONY-5.1a:	https://projects.coin-or.org/SYMPHONY
CPLEX-10.01:	(for comparison purposes; mipgap=0, absmipgap=1e-9)

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Mixed Integer Linear Programming Benchmark (free codes)
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Solved of 67 total cases in 2 hrs on 3.2GHz P4:

   CPLEX-10:       64
   SCIP-CPLEX:     63
   SCIP-MOSEK:     58
   SCIP-SOPLEX:    53
   CBC:            40
   MINTO:          30      (with CLP, with CPLEX: 39)
   GLPK:           22
   SYMPHONY:       18
```

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Mixed Integer Linear Programming Benchmark (free codes)
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60 cases solved by both CPLEX and SCIP-C
   CPLEX faster by 5 or more:  25
   SCIP-C faster by 5 or more:  4
   CPLEX solves, SCIP-C not:    4
   SCIP-C solves, CPLEX not:    3

38 cases solved by both CBC and SCIP-S
   CBC faster by 3 or more:     8
   SCIP-S faster by 3 or more: 15
```

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2 Aug 2006

Mixed Integer (Q)QP Benchmark

MIQP cases from http://plato.asu.edu/ftp/ampl_files/miqp_ampl/
also solved as MIQQP with

CPLEX-10.01: http://www.cplex.com/
Bonmin-0.9: https://projects.coin-or.org/Bonmin
(Bonmin: default hybrid algorithm. with Clp)
Bonmin-0.9: https://projects.coin-or.org/Bonmin
(B-OA-C: outer approx. with CPLEX)

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

Mixed Integer (Q)QP Benchmark (convex cases)

	QP			QQP		
problem	Bonmin	B-OA-C	CPLEX	Bonmin	B-OA-C	CPLEX
ibell3a	48	8	9	53	8	607
ibienst1	1482	6304	2668	1615	7636	3129
icap6000	3250	51	14	t	156	t
ilaser0	f	28	741	f	58	t
imod011	8122	t	124(?)	t	t	8629
inug08	t	t	8426	t	t	4102
iqiu	807	t	417	781	t	t
isqp0	(1)f	f	99	(2)f	f	t

(1) B-BB solves in 4273 s (2) B-BB solves in 4487 s

Mixed Integer (Q)QP Benchmark (nonconvex cases)

	QP			QQP		
problem	Bonmin	B-OA-C	CPLEX	Bonmin	B-OA-C	CPLEX
ivalues	2010	t	f	1767	t	f
iair04	3460	1043	196	4986	1584	t
iair05	1846	181	202	1690	124	t
ieilD76	859	131	27	1032	113	f
imas284	780	13	22	798	14	t
imisc07	986	3489	162	1044	3356	6511
iqap10	5485	2084	1637	t	4830	f
iran13x13	3766	126	55	3808	231	8839
iran8x32	257	61	18	525	210	t
iswath2	(3)t	148	245	(4)t	132	f

(3) B-QG solves in 3627 s (4) B-OA solves in 2853 s

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Benchmark of commercial and other (QC)QP solvers

3 Nov 2006

Given below is the number of successful runs.
B: dir BRUNEL (46), C: dir CUTE (76), M: dir MISC (16)

	QP				QCQP			
dir	BPMPD	CPLEX	KNITRO	IPOPT	MOSEK	CPLEX	KNITRO	IPOPT	MOSEK
B	46	46	46	46	46	45	37	46	46
C	76	74	76	76	75	67	62	74	65
M	16	15	16	16	16	14	16	15	15

Benchmark of commercial and other (QC)QP solvers

	QP					QCQP			
no	BPMPD	CPLEX	KNITRO	IPOPT	MOSEK	CPLEX	KNITRO	IPOPT	MOSEK
1	8	8	427	239	10	34	499	252	11
2	58	18	599	f	22	25	786	f	f
3	10	9	46	451	19	23	243	505	34
4	31	24	231	1644	65	41	1031	2293	92
5	39	157	388	1926	f	774	1475	5032	467
6	27	58	121	675	29	332	474	807	53
7	59	287	766	3261	509	968	3102	8851	4825
8	23	138	367	219	17	362	30202	249	20
9	1	1	1	2	1	1	f	31	1
10	1	1	4	6	1	1	2600	22	1

Problem statistics for the QPs

no	example	var	bounds	equal	nz(A)	nz(Q)
1	BOYD1	93261	93261	18	802156	93261
2	BOYD2	93263	93263	186531	423784	2
3	CONT-201	40397	40397	40198	199199	10400
4	CONT-300	90597	90597	90298	448799	23100
5	CVXQP1_L	10000	10000	5000	14998	69968
6	CVXQP2_L	10000	10000	2500	7499	69968
7	CVXQP3_L	10000	10000	7500	22497	69968
8	EXDATA	1500	1500	3001	7500	2250000
9	QSHELL	1476	1476	487	2958	2165
10	QSHIP08L	3149	3149	520	9346	34495

Conclusions

- Parallel versions effective in continuous and discrete optimization
- Sufficient accuracy on SDPs with free variables with SeDuMi and CSDP
- SCIP-CPLEX competitive for MILP with CPLEX except for speed
- good free MILP solvers: SCIP-SOPLEX, CBC

Conclusions (cont.)

- free BONMIN competitive with CPLEX for MI(Q)QP, can handle MINLP
- convex QP: BPMPD, CPLEX, MOSEK, KNITRO, IPOPT (in order)
- convex QQP: MOSEK/CPLEX, IPOPT, KNITRO (in order)

Thank you for your attention