Performance of Optimization Software - an Update

EURO-INFORMS 2013
Rome, Italy
2 July 2013

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School of Math and Stat Sciences
Arizona State University
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
   * bpmpd [AMPL Input][LP Input][MPS Input][QPS Input]
Mixed Integer Linear Programming
   * FEASPUMP [AMPL Input][LP Input][MPS Input]
   * SCIP [AMPL Input][LP Input][MPS Input] [ZIMPL Input][OSIL Input]
   *** also in global category and mixed-int nonlin constrained cat.***
   * qsopt_ex [LP Input][MPS Input] [AMPL Input]
Nondifferentiable Optimization  * condor [AMPL Input]
Semi-infinite Optimization   * nsips [AMPL Input]
Stochastic Linear Programming * bnbs [SMPS Input]
   * DDSIP [LP Input][MPS Input]
   * SD [SMPS 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]
* sdplr [MATLAB_BINARY Input][SDPLR Input][SPARSE_SDPA Input]
* sdpt3 [MATLAB_BINARY Input][SPARSE_SDPA Input]
* sedumi [MATLAB_BINARY Input][SPARSE_SDPA Input]
Overview of Talk

• Current and Selected(*) Benchmarks
  – Parallel LP/QP/SOCP benchmarks
  – MILP benchmark (MIPLIB2010)
  – Feasibility/Infeasibility Detection benchmarks (MIPLIB2010)
  – slightly pathological MILP cases
  – MIQ(C)P benchmark

• Conclusions
COMBINATORIAL OPTIMIZATION

Concorde-TSP with different LP solvers (3-6-2013)

LINEAR PROGRAMMING

Benchmark of serial LP solvers (6-27-2013)
* Benchmark of parallel LP solvers (5-24-2013)
* Parallel Barrier Solvers on Large LP/QP problems (5-26-2013)
Large Network-LP Benchmark (commercial vs free) (6-12-2013)

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 (6-22-2011)
* MISOCPS and large SOCP Benchmark (6-18-2013)
MIXED INTEGER LINEAR PROGRAMMING

* MILP Benchmark - MIPLIB2010 (5-25-2013)
* MILP cases that are slightly pathological (5-31-2013)
* Feasibility Benchmark (5-22-2013) (MIPLIB2010)
* Infeasibility Detection for MILP Problems (5-24-2013) (MIPLIB2010)

NONLINEAR PROGRAMMING

Benchmark of commercial and other (QC)QP Solvers (8-15-2012)
AMPL-NLP Benchmark, IPOPT, KNITRO, LOQO, PENNLP, SNOPT & CONOPT (11-9-2011)

MIXED INTEGER QPs and QCPs

* MIQ(C)P Benchmark (6-22-2013)

MIXED INTEGER NONLINEAR PROGRAMMING

MINLP Benchmark (1-28-2013)

PROBLEMS WITH EQUILIBRIUM CONSTRAINTS

MPEC Benchmark (11-28-2012)
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
  - CPLEX, GUROBI, XPRESS, KNITRO-8.1, MOSEK-7

- New versions of free software
  - CBC, CLP, SCIP,
  - BONMIN, COUENNE, IPOPT

- More multicore hardware
Overview of Talk

• Current and Selected(*) Benchmarks
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  – MILP benchmark (MIPLIB2010)
  – Feasibility/Infeasibility Detection benchmarks (MIPLIB2010)
  – slightly pathological MILP cases
  – MIQ(C)P benchmark

• Observations and Conclusions
This benchmark was run on a Linux-PC (i7-2600).
The MPS-datafiles for all testcases are in one of (see column "s")

miplib.zib.de/ [1]
plato.asu.edu/ftp/lptestset/ [2]
www.netlib.org/lp/data/ [3,7]
www.sztaki.hu/~meszaros/public_ftp/lptestset/
(MISC[4], PROBLEMATIC[5], STOCHLP[6], INFEAS[8])

The (dual) simplex, barrier, and concurrent methods were tested of:

CPLEX-12.5.1pre CPLEX
GUROBI-5.5.0 www.gurobi.com/
MOSEK-7.0.0.55 www.mosek.com
XPRESS-7.5.0: XPRESS

Scaled shifted geometric mean of runtimes (A automatic) (40 instances)

4.44 2.65 4.63 3.49 1.15 1 1.54 1.01 1.40 1.28 1.34 1.27
==============================================================================
26 May 2013

Parallel Barrier Solvers on Large LP/QP problems

H. Mittelmann (mittelmann@asu.edu)

Logiles at plato.asu.edu/ftp/barrier_logs/

CPLEX-12.5.1pre CPLEX
GUROBI-5.5.0: GUROBI
MOSEK-7.0.0.65: MOSEK
XPRESS-7.5.0: XPRESS

The barrier methods (w/o crossover) of the above solvers were run on a 3.47 GHz Intel Xeon X5690 (6 cores, 48GB) on large LP problems from here. Times given are elapsed times in seconds.
<table>
<thead>
<tr>
<th>problem</th>
<th>CPLEX</th>
<th>GUROBI</th>
<th>MOSEK</th>
<th>XPRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1_250</td>
<td>59015</td>
<td>103</td>
<td>98</td>
<td>slow</td>
</tr>
<tr>
<td>L1_500</td>
<td>m</td>
<td>2529a</td>
<td>3608a</td>
<td>m</td>
</tr>
<tr>
<td>in</td>
<td>172</td>
<td>164</td>
<td>428</td>
<td>283</td>
</tr>
<tr>
<td>pde_1</td>
<td>2525</td>
<td>2034</td>
<td>7934</td>
<td>6267</td>
</tr>
<tr>
<td>pde_20</td>
<td>1790</td>
<td>2016</td>
<td>16088</td>
<td>2867</td>
</tr>
<tr>
<td>pde_2</td>
<td>4920</td>
<td>15403</td>
<td>53447</td>
<td>6486</td>
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<tr>
<td>qap_2</td>
<td>slow</td>
<td>fail</td>
<td>2082</td>
<td>1156</td>
</tr>
<tr>
<td>splan1</td>
<td>2577</td>
<td>4186</td>
<td>5632</td>
<td>6308</td>
</tr>
<tr>
<td>srd300</td>
<td>9723</td>
<td>&gt;35000</td>
<td>11762</td>
<td>10809</td>
</tr>
<tr>
<td>zib01</td>
<td>6520</td>
<td>8461</td>
<td>14982</td>
<td>6433</td>
</tr>
<tr>
<td>L2CTA3D</td>
<td>3236</td>
<td>6379</td>
<td>fail</td>
<td>1545a</td>
</tr>
<tr>
<td>bdry2_0</td>
<td>1930a</td>
<td>1046</td>
<td>5247a</td>
<td>1521</td>
</tr>
<tr>
<td>bdry2_1</td>
<td>9689a</td>
<td>6831</td>
<td>fail</td>
<td>7541</td>
</tr>
<tr>
<td>cont5_2_0</td>
<td>515</td>
<td>1049</td>
<td>36a</td>
<td>626a</td>
</tr>
<tr>
<td>cont5_2_1</td>
<td>1803</td>
<td>4308a</td>
<td>68a</td>
<td>1550a</td>
</tr>
<tr>
<td>cont5_2_2</td>
<td>7326</td>
<td>fail</td>
<td>148a</td>
<td>5465a</td>
</tr>
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<td>twod_00</td>
<td>2460</td>
<td>8785</td>
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<td>2701</td>
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<tr>
<td>twod_0</td>
<td>12429</td>
<td>46410</td>
<td>&gt;10000</td>
<td>12056</td>
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</table>

"a": red. accuracy, "m": out of memory
<table>
<thead>
<tr>
<th>problem</th>
<th>constraints</th>
<th>variables</th>
<th>nonzeros</th>
<th>MPS-file</th>
</tr>
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<tr>
<td>L1_250</td>
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<td>428032</td>
<td>4280320</td>
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</tr>
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<td>L1_500</td>
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<td>790746</td>
<td>7907460</td>
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<td>6813128</td>
<td>561 MB</td>
</tr>
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<td>pde_1</td>
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<td>9005998</td>
<td>80970001</td>
<td>4.1 GB</td>
</tr>
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<td>pde_20</td>
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<td>8824196</td>
<td>39669001</td>
<td>2.2 GB</td>
</tr>
<tr>
<td>pde_2</td>
<td>26993999</td>
<td>18005996</td>
<td>80970001</td>
<td>4.5 GB</td>
</tr>
<tr>
<td>qap_2</td>
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<td>14400</td>
<td>203040</td>
<td>70.7 MB</td>
</tr>
<tr>
<td>splan1</td>
<td>572800</td>
<td>1317382</td>
<td>5233840</td>
<td>374 MB</td>
</tr>
<tr>
<td>srd300</td>
<td>1101467</td>
<td>2052911</td>
<td>59170079</td>
<td>1.6 GB</td>
</tr>
<tr>
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<td>12471400</td>
<td>49877768</td>
<td>2.5 GB</td>
</tr>
<tr>
<td>L2CTA3D</td>
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<td>10000000</td>
<td>30000000</td>
<td>1.8 GB</td>
</tr>
<tr>
<td>bdry2_0</td>
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<td>4003997</td>
<td>19991999</td>
<td></td>
</tr>
<tr>
<td>bdry2_1</td>
<td>12253498</td>
<td>12256997</td>
<td>61235999</td>
<td></td>
</tr>
<tr>
<td>cont5_2_0</td>
<td>1959681</td>
<td>1961081</td>
<td>11749904</td>
<td></td>
</tr>
<tr>
<td>cont5_2_1</td>
<td>3999656</td>
<td>4001656</td>
<td>23986126</td>
<td></td>
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<tr>
<td>cont5_2_2</td>
<td>8999641</td>
<td>9002641</td>
<td>53979959</td>
<td></td>
</tr>
<tr>
<td>twod_00</td>
<td>505284</td>
<td>511446</td>
<td>4856046</td>
<td></td>
</tr>
<tr>
<td>twod_0</td>
<td>989604</td>
<td>999306</td>
<td>9586066</td>
<td></td>
</tr>
</tbody>
</table>
18 Jun 2013 =======================================
MISOCP and large SOCP Benchmark
=======================================
Hans D. Mittelmann (mittelmann@asu.edu)

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

MOSEK-7.0.0.65 www.mosek.com/
CPLEX-12.5.1pre CPLEX
GUROBI-5.5.0 GUROBI

These codes were tested on a selection of the (MI)SOCP problems from the forthcoming CBLIB2013.

The codes were run in default mode (except mipgap=0 for the MISOCP problems) on an Intel i7-2600. Given are total CPU seconds. Time limit 2 hrs.
<table>
<thead>
<tr>
<th>problem</th>
<th>CPLEX</th>
<th>GUROBI</th>
<th>MOSEK</th>
</tr>
</thead>
<tbody>
<tr>
<td>pp-n100-d10</td>
<td>6228</td>
<td>4562</td>
<td>t</td>
</tr>
<tr>
<td>uflquad-nopsc-20-100</td>
<td>1135</td>
<td>667</td>
<td>246</td>
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<tr>
<td>uflquad-nopsc-20-150</td>
<td>6453</td>
<td>980</td>
<td>1064</td>
</tr>
<tr>
<td>uflquad-nopsc-30-100</td>
<td>t</td>
<td>902</td>
<td>1909</td>
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<tr>
<td>uflquad-nopsc-30-150</td>
<td>t</td>
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<td>3981</td>
</tr>
<tr>
<td>uflquad-nopsc-30-200</td>
<td>t</td>
<td>5211</td>
<td>t</td>
</tr>
<tr>
<td>uflquad-psc-30-150</td>
<td>25</td>
<td>1011</td>
<td>5</td>
</tr>
<tr>
<td>uflquad-psc-30-200</td>
<td>89</td>
<td>5572</td>
<td>6</td>
</tr>
<tr>
<td>uflquad-psc-30-300</td>
<td>292</td>
<td>t</td>
<td>24</td>
</tr>
<tr>
<td>dsNRL</td>
<td>707</td>
<td>296</td>
<td>318</td>
</tr>
<tr>
<td>firL1</td>
<td>597</td>
<td>379</td>
<td>101</td>
</tr>
<tr>
<td>firL1Linf alph</td>
<td>1087</td>
<td>526</td>
<td>232</td>
</tr>
<tr>
<td>firL1Linf eps</td>
<td>331</td>
<td>48</td>
<td>101</td>
</tr>
<tr>
<td>firL2L1al ph</td>
<td>85</td>
<td>99</td>
<td>33</td>
</tr>
<tr>
<td>firL2L1eps</td>
<td>573</td>
<td>371</td>
<td>104</td>
</tr>
<tr>
<td>firL2L1inf alph</td>
<td>500</td>
<td>529</td>
<td>661</td>
</tr>
<tr>
<td>firL2L1inf eps</td>
<td>290</td>
<td>152</td>
<td>113</td>
</tr>
<tr>
<td>firL2a</td>
<td>388</td>
<td>800</td>
<td>811</td>
</tr>
<tr>
<td>firLin</td>
<td>672</td>
<td>420</td>
<td>664</td>
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<tr>
<td>wbNRL</td>
<td>324</td>
<td>131</td>
<td>35</td>
</tr>
</tbody>
</table>

't': timelimit exceeded
Overview of Talk

• **Current and Selected(*) Benchmarks**
  
  – Parallel LP/QP/SOCP benchmarks
  
  – **MILP benchmark (MIPLIB2010)**
  
  – Feasibility/Infeasibility Detection benchmarks (MIPLIB2010)
  
  – slightly pathological MILP cases
  
  – MIQ(C)P benchmark

• Conclusions
The following codes were run on the MIPLIB2010 benchmark set with the MIPLIB2010 scripts on an Intel Xeon X5680 (32GB, Linux, 64 bits, 2*6 cores), with one, four and twelve threads. (deterministically) and a time limit of 1 hour. These are updated and extended versions of the results produced for the MIPLIB2010 paper.

CPLEX-12.5.1pre CPLEX
GUROBI-5.5.0: GUROBI
ug[SCIP/cpx/spx]-3.0.1: Parallel development version of SCIP (SCIP+CPLEX/SOPLEX/CLP on 1 thread)
CBC-2.8.0: CBC
XPRESS-7.5.0: XPRESS
GLPK-4.49: GLPK
LP_SOLVE-5.5.2: LP_SOLVE

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.
Scaled geometric means of times

All non-successes are counted as max-time. The fastest solver is scaled to 1. The second line lists the number of problems (87 total) solved.

<table>
<thead>
<tr>
<th>1 thr</th>
<th>CBC</th>
<th>CPLEX</th>
<th>GLPK</th>
<th>GUROBI</th>
<th>LPSOLVE</th>
<th>SCIPC</th>
<th>SCIPL</th>
<th>SCIPS</th>
<th>XPRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>scaled</td>
<td>11.3</td>
<td>1</td>
<td>22.8</td>
<td>1.01</td>
<td>20.3</td>
<td>4.05</td>
<td>6.77</td>
<td>5.23</td>
<td>1.30</td>
</tr>
<tr>
<td>solved</td>
<td>35</td>
<td>81</td>
<td>3</td>
<td>79</td>
<td>5</td>
<td>62</td>
<td>52</td>
<td>62</td>
<td>78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4 thr</th>
<th>CBC</th>
<th>CPLEX</th>
<th>FSCIPC</th>
<th>FSCIPS</th>
<th>GUROBI</th>
<th>XPRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>scaled</td>
<td>15.1</td>
<td>1.10</td>
<td>7.30</td>
<td>11.8</td>
<td>1</td>
<td>1.47</td>
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<tr>
<td>solved</td>
<td>52</td>
<td>84</td>
<td>67</td>
<td>63</td>
<td>87</td>
<td>84</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12 thr</th>
<th>CBC</th>
<th>CPLEX</th>
<th>FSCIPC</th>
<th>FSCIPS</th>
<th>GUROBI</th>
<th>XPRESS</th>
<th>GUROBI5</th>
<th>CPLEX5</th>
</tr>
</thead>
<tbody>
<tr>
<td>scaled</td>
<td>13.3</td>
<td>1</td>
<td>10.2</td>
<td>17.6</td>
<td>1.19</td>
<td>1.49</td>
<td>0.71</td>
<td>0.86</td>
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<tr>
<td>solved</td>
<td>57</td>
<td>86</td>
<td>68</td>
<td>64</td>
<td>87</td>
<td>85</td>
<td>87</td>
<td>86</td>
</tr>
</tbody>
</table>

CPLEX5/GUROBI5: best of 5 runs with 12 threads and random seeds 1001-5.
Overview of Talk

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  – MIQ(C)P benchmark

• Conclusions
26 Jun 2013 === Feasibility Benchmark ===

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

MILP problems mostly from MIPLIB2010 were solved for a feasible point

The following codes were run on an Intel i7-2600 (3.4 GHz, 16GB, Linux, 4 cores) with 4 threads:

CPLEX-12.5.1pre CPLEX
FEASPUMP2: as implemented for interactive use at NEOS (utilizes CPLEX)
GUROBI-5.5.0: GUROBI
XPRESS-7.5.0: XPRESS
CBC-2.8.2: CBC

Times given are elapsed times in seconds. A time limit of 1 hr was imposed.
Shifted geometric means of the times are listed. For objective values see logfiles.

=================================================================
problem(30 tot) CPLEX FP2 GUROBI XPRESS CBC
=================================================================
| geometric mean | 1  | 3.59 | 1.91 | 3.57 | 84 |
| problems solved | 30 | 28   | 28   | 27   | 12 |
=================================================================
24 May 2013  Infeasibility Detection for MILP Problems

The following codes were run on the infeasible problems from MIPLIB2010 with the MIPLIB2010 scripts on an Intel Xeon X5680 (32GB, Linux, 64 bits, 2*6 cores).

CPLEX-12.5.1 pre CPLEX
GUROBI-5.5.0: GUROBI
ug[SCIP/spx/cpx]: Parallel development version of SCIP
CBC-2.8.0: CBC
XPRESS-7.5.0: XPRESS

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

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

Shifted geometric means of times

<table>
<thead>
<tr>
<th></th>
<th>CBC</th>
<th>CPLEX</th>
<th>FSCIPC</th>
<th>FSCIPS</th>
<th>GUROBI</th>
<th>XPRESS</th>
</tr>
</thead>
<tbody>
<tr>
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<td>55.8</td>
<td>1</td>
<td>26</td>
<td>31.3</td>
<td>1.38</td>
<td>1.55</td>
</tr>
</tbody>
</table>

solved of 19: 7 18 10 11 18 18
Overview of Talk

- **Current and Selected(*) Benchmarks**
  - Parallel LP/QP/SOCP benchmarks
  - MILP benchmark (MIPLIB2010)
  - Feasibility/Infeasibility Detection benchmarks (MIPLIB2010)
  - slightly pathological MILP cases
  - MIQ(C)P benchmark

- Conclusions
31 May 2013 MILP cases that are slightly pathological

CPLEX-12.5.1pre CPLEX
GUROBI-5.5.0: GUROBI
ug[SCIP/cpx]: FSCIP-Parallel development version of SCIP
CBC-2.8.0: CBC
XPRESS-7.5.0: XPRESS
SCIP-3.0.1: serial SCIP with CPLEX

These codes were run with the MIPLIB2010 scripts in default mode on an Intel Xeon X5680 (32GB, Linux, 64 bits, 2*6 cores) on problems from here. Times given are elapsed CPU seconds. Time limit 3 hrs. Available memory 24GB. This benchmark is not giving a representative impression of the relative performance of the codes.

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

Scaled shifted geometric mean of runtimes and problems solved (25 total)

<table>
<thead>
<tr>
<th></th>
<th>CBC</th>
<th>CPLEX</th>
<th>FSCIP</th>
<th>GUROBI</th>
<th>SCIP</th>
<th>XPRESS</th>
<th>CPLEX-5</th>
<th>GUROBI-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>8.79</td>
<td>1</td>
<td>9.27</td>
<td>1.65</td>
<td>7.64</td>
<td>2.53</td>
<td>0.69</td>
<td>0.75</td>
</tr>
<tr>
<td>10</td>
<td>23</td>
<td>14</td>
<td>24</td>
<td>15</td>
<td>17</td>
<td>25</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

GUROBI/CPLEX-5: Best of 5 runs with random seeds 1001-1005
Overview of Talk

- Current and Selected(*) Benchmarks
  - Parallel LP/QP/SOCP benchmarks
  - MILP benchmark (MIPLIB2010)
  - Feasibility/Infeasibility Detection benchmarks (MIPLIB2010)
  - slightly pathological MILP cases
  - MIQ(C)P benchmark

- Conclusions
The following codes were run in default mode on a 2.66GHz Intel Core2 Quad, For accuracy reached, see logfiles. In the second table are results for the QCQPs obtained by rewriting the QPs as: min t, subject to quadratic obj <= t plus constraints. SCIP does this transformation itself. SCIP uses relgap=0;

CPLEX-12.5.1pre: CPLEX
Bonmin-1.6.0: projects.coin-or.org/Bonmin (Bonmin: hybrid algorithm. with Cbc)
Couenne-0.4.3: projects.coin-or.org/Couenne
MOSEK-7.0.0.65: mosek.com
Gurobi-5.5.0: gurobi.com (convex only!)
Minotaur-0.1.1: http://wiki.mcs.anl.gov/minotaur/
SCIP-3.0.1: scip.zib.de (with CPLEX and IPOPT)
XPRESS-7.5.0: XPRESS
CBC-2.8.2: CBC

Times given are user times in seconds. A time limit of 10,800 seconds was imposed. "t" time limit exceeded, "f" fail, "c" problem convex.
QP
==
Scaled shifted geometric means of runtimes

120  205  1.04  -  1  12.4  2.29  35.1  30.4
=====================================================================  
problem Bonmin Couenne CPLEX MOSEK GUROBI SCIP XPRESS MINOTAUR CBC
=====================================================================  

QCQP
===
Scaled shifted geometric means of runtimes

70.7  62.4  1.03  4.13  81.9  1
=====================================================================  
problem Bonmin Couenne CPLEX XPRESS Minotaur GUROBI
=====================================================================  

Conclusions: **Declare Winners?**

- **Parallel LP**: Gurobi, XPRESS, CPLEX
- **(MI)SOC**P: Gurobi, MOSEK, CPLEX
- **MIPLIB-bench**: CPLEX, Gurobi, XPRESS
- **MIPLIB-feas**: CPLEX, Gurobi, XPRESS
- **MIPLIB-infeas**: CPLEX, Gurobi, XPRESS
- **Pathological**: ( CPLEX, Gurobi, XPRESS )
- **MIQ(C)P**: Gurobi, CPLEX, XPRESS, MOSEK
Thank you!