Gurobi 6.5 Performance Benchmarks

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Thank You for Your Interest in Gurobi

The Gurobi Optimizer was designed from the ground up to be the fastest, most powerful solver available for your LP, QP, QCP, and MIP (MILP, MIQP, and MIQCP) problems.

▸ In industry standard public benchmark tests[1] Gurobi has the…

   ◦ Fastest overall solve times for MIP models
   ◦ Fastest overall solve times for LP models
   ◦ Fastest overall solve times for QP models

   And, as problems get harder, our relative performance gets even better.

[1]Industry standard public benchmarks maintained by Hans Mittelmann at Arizona State University

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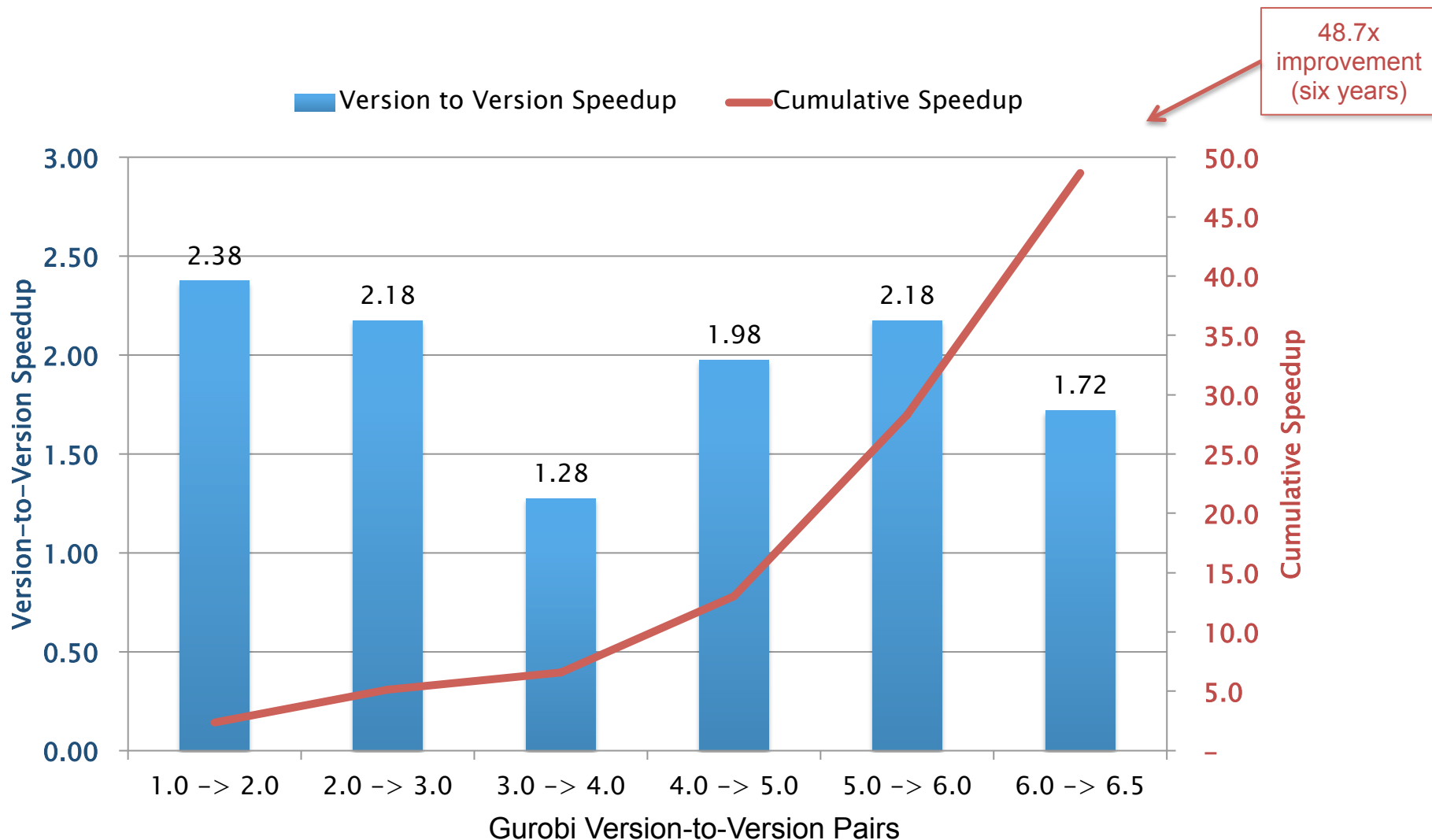OPTIMIZATION

Two Types of Benchmark Testing

Internal

- Primary Objectives
  - Robustness testing
  - Compare version-to-version improvements

- Test Bank
  - Internal library of over 10,000 models from industry and academia

Public

- Primary Objective
  - Competitive benchmarks against other solvers

- Test Bank
  - Maintained by Hans Mittelmann
    - http://plato.la.asu.edu/bench.html
  - Based upon MIPLIB 2010

- On the next slides we'll share some specific results as well as results from our own internal testing.

- Of course, every model is different so we invite you to try Gurobi for yourself or contact us with any questions.

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Gurobi Keeps Getting Better

48.7x improvement (six years)

Version to Version Speedup — Cumulative Speedup

Gurobi Version-to-Version Pairs	Version-to-Version Speedup
1.0 –> 2.0	2.38
2.0 –> 3.0	2.18
3.0 –> 4.0	1.28
4.0 –> 5.0	1.98
5.0 –> 6.0	2.18
6.0 –> 6.5	1.72

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MILP Competitive Benchmarks
Gurobi 6.5.0 vs. CPLEX 12.6.3 vs. XPRESS 7.9.0
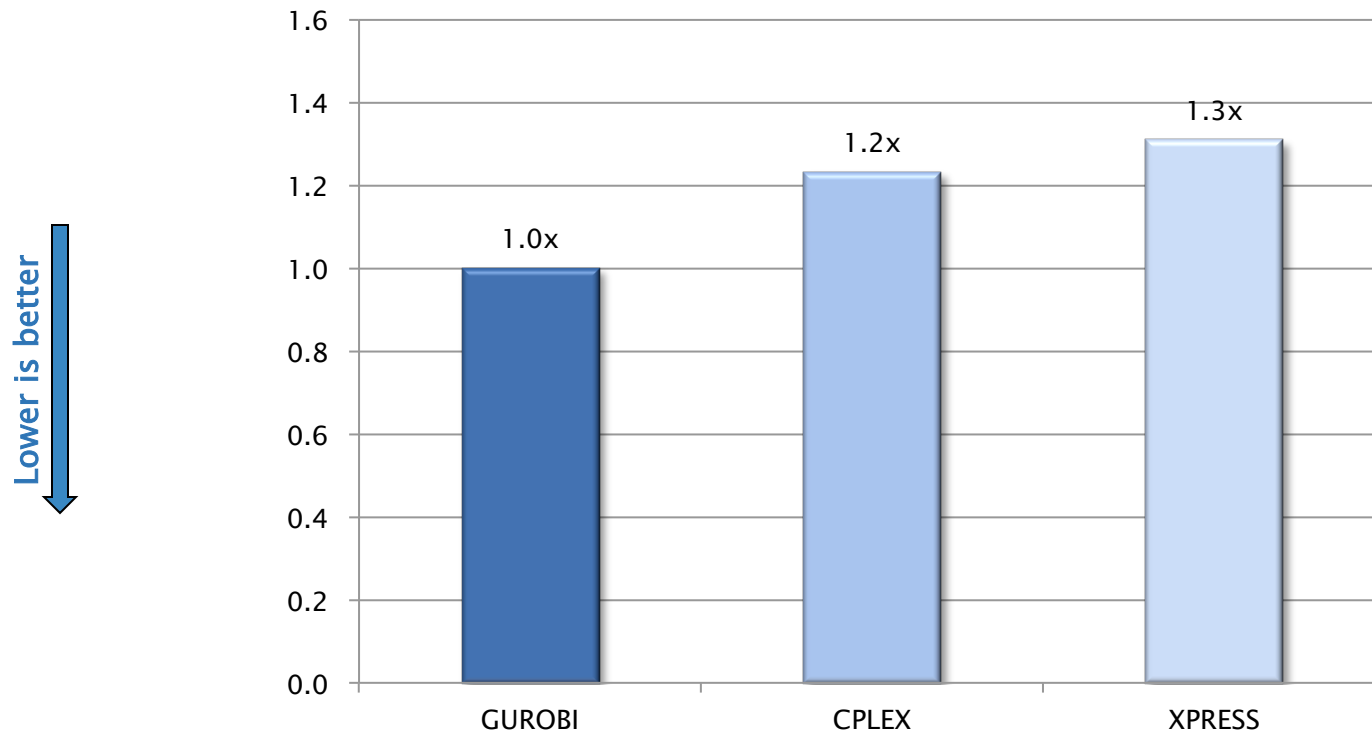### (Maintained by Hans Mittelmann)

Fastest to Optimality

Fastest to Feasibility

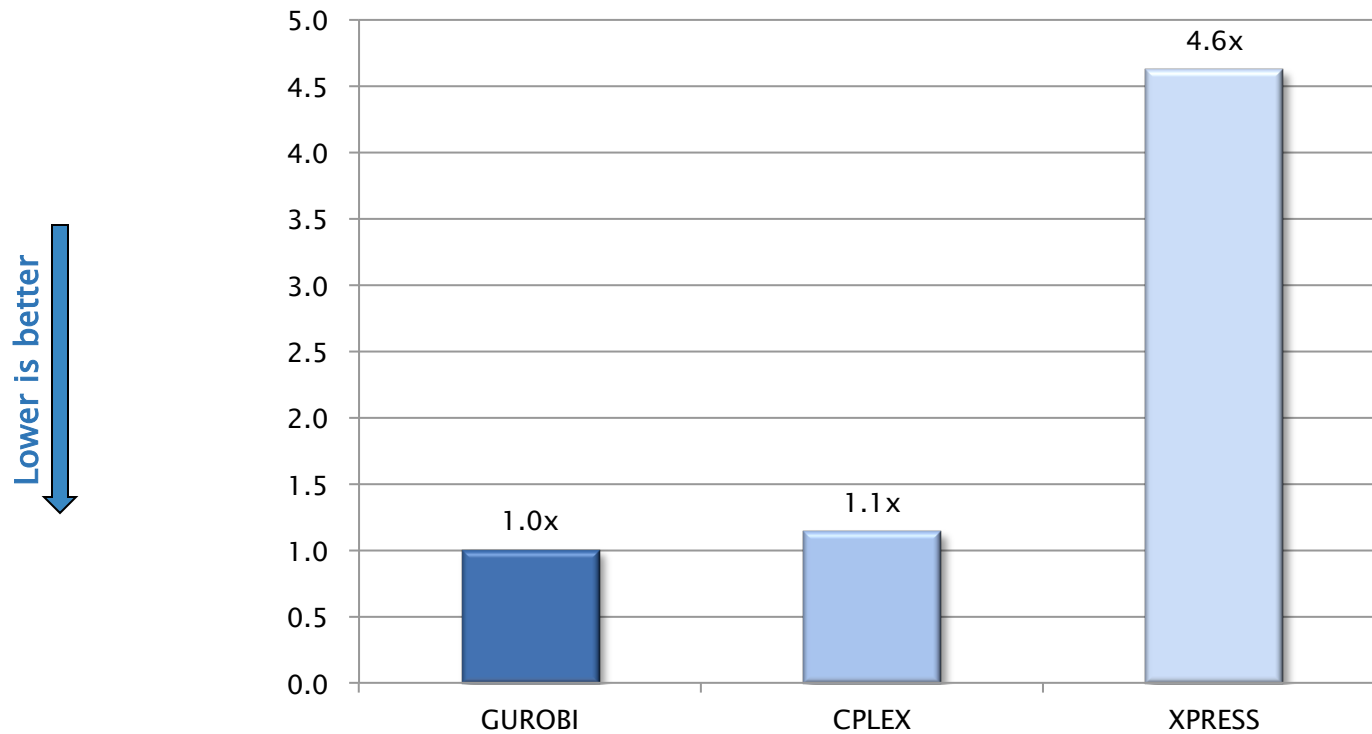Fastest to Detect Infeasibility

Fewest Time Limits Hit

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Gurobi is the Fastest Overall MIP Solver

Geometric mean times across 1, 4 and 12 thread tests

Complete test data available here: http://plato.asu.edu/ftp/milpc.html
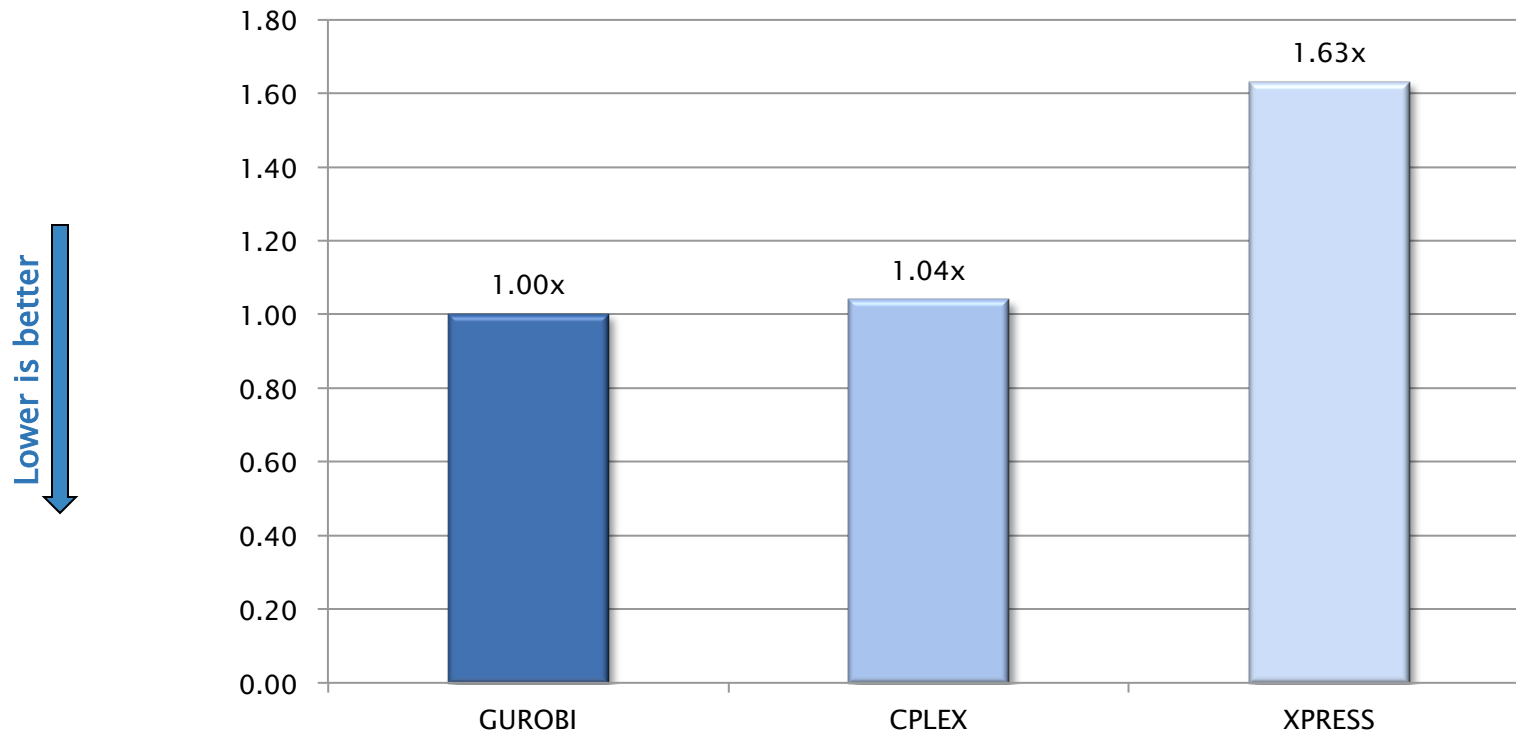
Gurobi is Fastest to Feasibility

Complete test data available here: http://plato.asu.edu/ftp/feas_bench.html

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Gurobi is Fastest to Detect Infeasibility

Lower is better ↓

GUROBI	CPLEX	XPRESS
1.00x	1.04x	1.63x

CPLEX takes on average 4% longer to detect infeasibility
Complete test data available here: http://plato.asu.edu/ftp/infeas.html

Gurobi wins on the broadest public benchmark test set
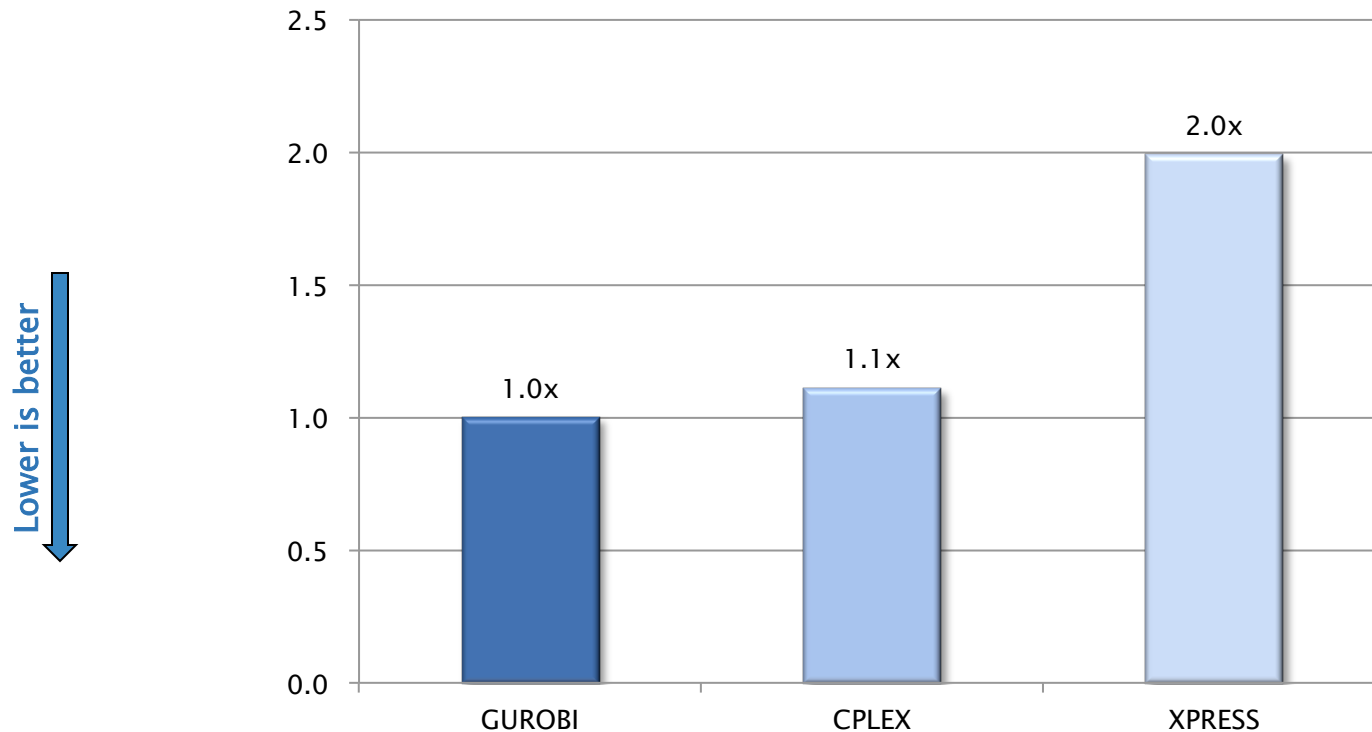
▸ Notes:
  ◦ Broader than the 87 model core MIPLIB test set usually used, this is a set of 212 models in the MIPLIB library where at least one solver has been able to solve the model.
  ◦ Since this is a new to the benchmarks, it is believe this is a better, less-tuned to, representation of relative solver performance.
  ◦ Complete test data available here: http://plato.asu.edu/ftp/easy.html

Gurobi hits time limits less frequently

Gurobi 6.5 vs. Competition: Hit time limit

Benchmark	Gurobi	CPLEX	XPRESS
Optimality	2	4	3
Feasibility	0	0	3
Infeasibility	0	1	1
"Easy" -- Optimality	9	13	41

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LP Competitive Benchmarks

Gurobi 6.5.0 vs. CPLEX[tm] 12.6.3 vs. XPRESS[tm] 7.9.0 vs. Mosek 7.1.0.44 (Maintained by Hans Mittelmann)

Gurobi Has The Fastest Solve Times

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Gurobi is the Fastest Overall LP Solver

Lower is better
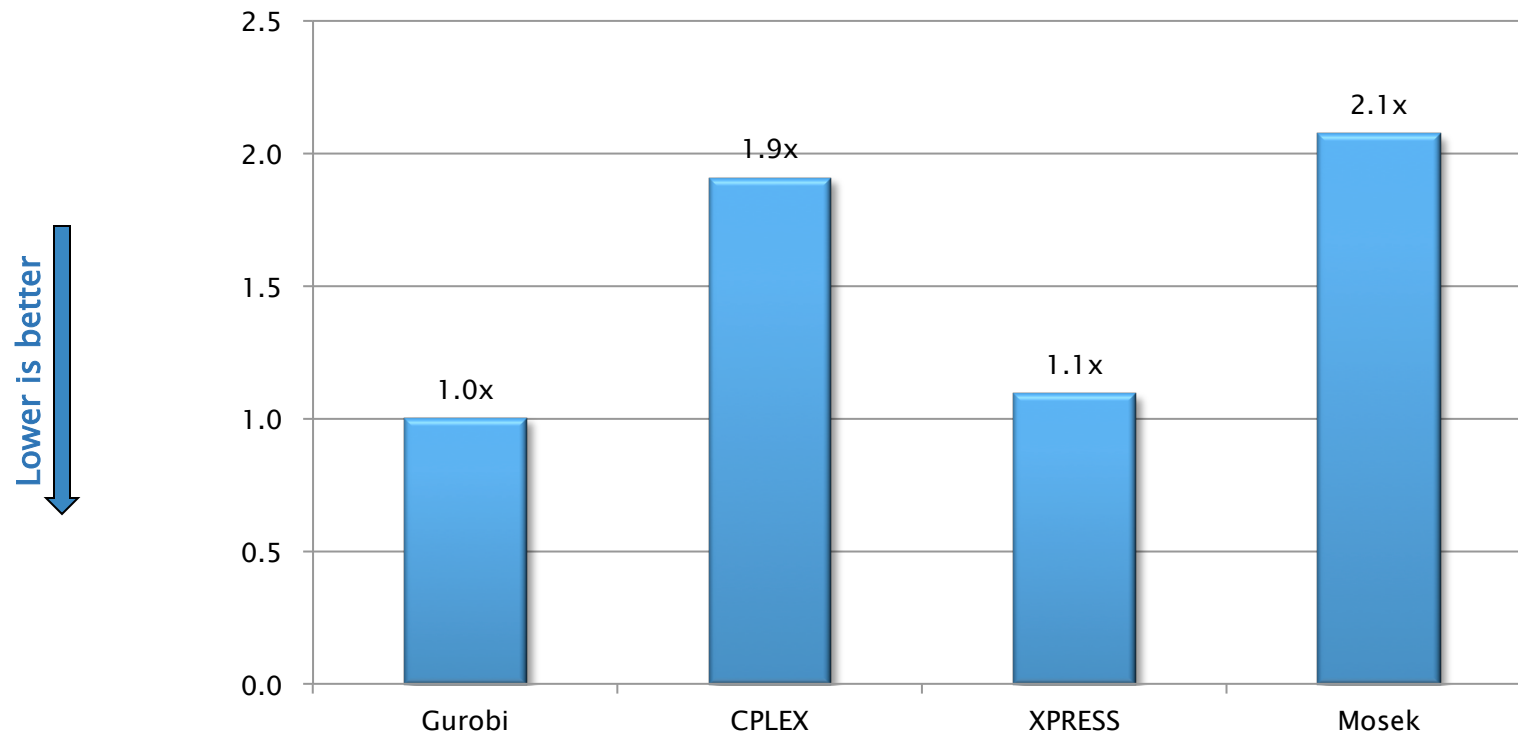
Geometric mean times across Dual, Barrier and concurrent

1.9x means than overall CPLEX takes almost twice as long to solve the set of benchmark models as Gurobi

Complete test data available here: http://plato.asu.edu/ftp/lpcom.html

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Gurobi is Overall the Fastest LP Solver

Competing LP Solver Performance

Lower is better

Geometric mean times across models in the benchmark set

1.9 means than overall CPLEX takes almost twice as long to solve the set of benchmark models as Gurobi

Complete test data available here: http://plato.asu.edu/ftp/lpcom.html

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Gurobi Is NearlyTwice as Fast Overall…
… and 3.5X Faster on the Hardest Models

CPLEX vs. Gurobi (Dual Simplex)

Make sure to not just test us *on* easy test models.
Our best performance will *likely* be *on* your real-world, hardest, models.

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QP Competitive Benchmarks

Gurobi 6.5.0 vs. CPLEX 12.6.3 vs. XPRESS 7.9.0 vs. MOSEK^{tm} 7.1.0.44
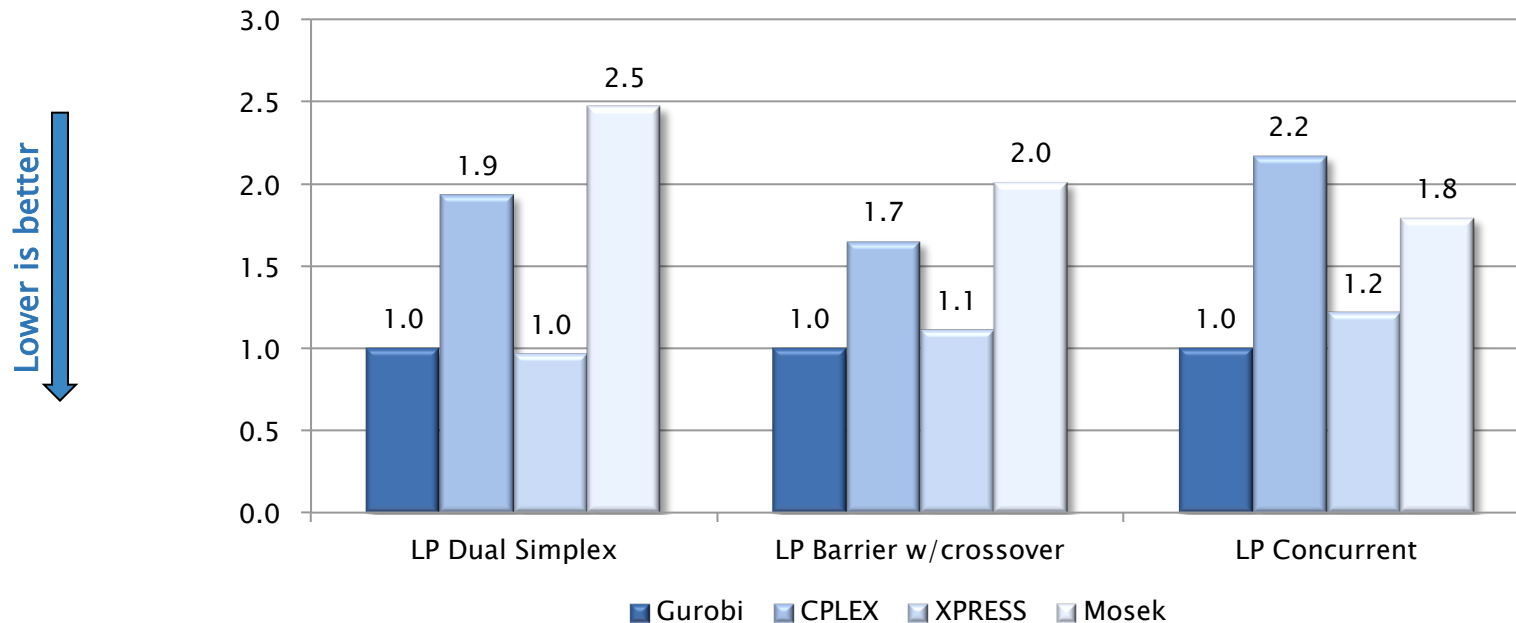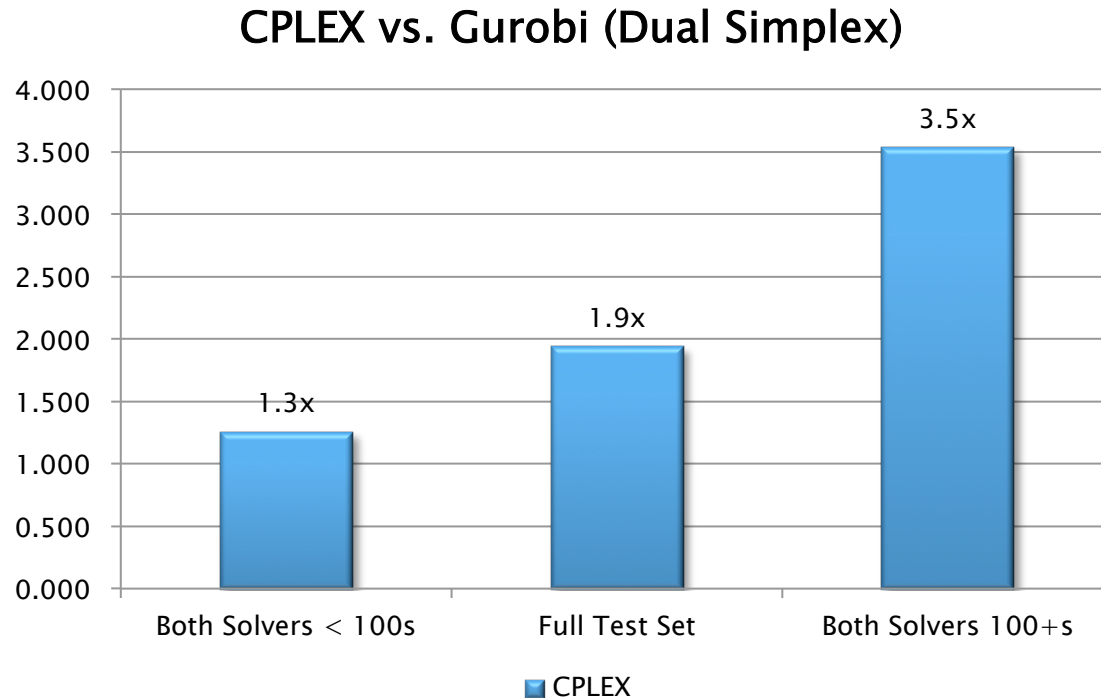(Maintained by Hans Mittelmann)

Gurobi beats the recognized leaders across QP, MIQP, SOCP, and MIQCP benchmarks

Gurobi is Fastest Across QP Benchmarks

(> 1.0 means Gurobi is faster)

Benchmark	CPLEX	XPRESS	MOSEK
MIQP	1.33X	1.36X	–
MIQCP	1.47X	1.61X	–
MISOCP	2.46X	4.82X	10.5X
SOCP	2.32X	1.22X	0.97X

- Results comparing geometric mean runtimes of the models in each benchmark
- Results with a "–" indicate no test data available for that combination
- Complete test data available here:
  - http://plato.asu.edu/ftp/miqp.html
  - http://plato.asu.edu/ftp/socp.html

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Benchmarks vs. Open Source Solvers

Benchmarks – Open Source MIP

▸ Mittelmann MIPLIB2010 tests, P=1 (>1X means Gurobi wins):

	January 2012	January 2013	January 2015	November 2015	% Solved
CBC	10X	13X	17X	26X	55%
SCIP	6X	7X	7X	9X	80%
GLPK	22X	27X	–	–	1%
LPSOLVE	19X	24X	–	–	6%

▸ GLPK and LPSOLVE are not currently tested in the public benchmarks
▸ CBC is the only open-source solver in the feasibility benchmark tests
  ◦ CBC scores 64x slower than Gurobi at finding a feasible answer.
  ◦ Importantly, Gurobi found a feasible answer prior to the time limit in all 33 models. CBC failed to find a feasible answer in 14 models

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Pushing Performance Even Higher:

Taking advantage of Gurobi's Parameter Tuning and Distributed Optimization capabilities

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Tuning can have a significant positive impact on performance results

▸ Test Set: MIPLIB 2010 benchmark, 87 models
  ◦ Default tuning run with TuneTrial=1
    · It uses 10X of default solving time
  ◦ Two tuning runs, one with a single machine, one with 5 machines

▸ Results: (> 1 means faster)
  ◦ Mean improvement from the best settings:
    · A single machine: 1.68X
    · 5 machines: 2.52X

Gurobi gives you industry-leading out-of-the-box performance. However, you can take that performance up even higher by tuning Gurobi's parameters for your model(s).

To help you do that we provide an automatic tuning tool you can run on just one machine (the 1.68X performance improvement you see above across the test set), or on a number of machines (the 2.52X improvement in the five machine example above.

Note, obviously the performance gain on your particular model could be higher or lower than the test results above. We are always happy to assist our commercial users in tuning and evaluating Gurobi's performance.

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Using distributed optimization can further improve Gurobi's performance

▸ MIPLIB 2010 (87 models)

  ◦ Note: This test set was not designed for testing distributed optimization. Because of this, the results below understate the potential gains.

  ◦ Models that take >1 second to solve

Machines	Distributed
4	1.43X
8	1.53X

  ◦ Models that take >100 seconds to solve

Machines	Distributed
4	2.09X
8	2.87X

Models suited for distributed optimization can see significantly greater speed-ups

▸ Model *seymour*

  ◦ Hard set covering model from MIPLIB 2010

  ◦ 4944 constraints, 1372 (binary) variables, 33K non-zeroes

Machines	Nodes	Time (s)	Speedup
1	476,642	9,267s	–
16	1,314,062	1,015s	9.1X
32	1,321,048	633s	14.6X

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Isn't it time you considered upgrading to Gurobi?

1. You can get a free academic license at www.gurobi.com.
2. You can request a free commercial evaluation license. Simply contact us at: info@gurobi.com.

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