Gurobi 7.5 Performance Benchmarks

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 MIP (MILP, MIQP, and MIQCP), LP and QP problems.

- In industry standard public benchmark tests[*] 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.

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

Two Types of Benchmark Testing

Internal

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

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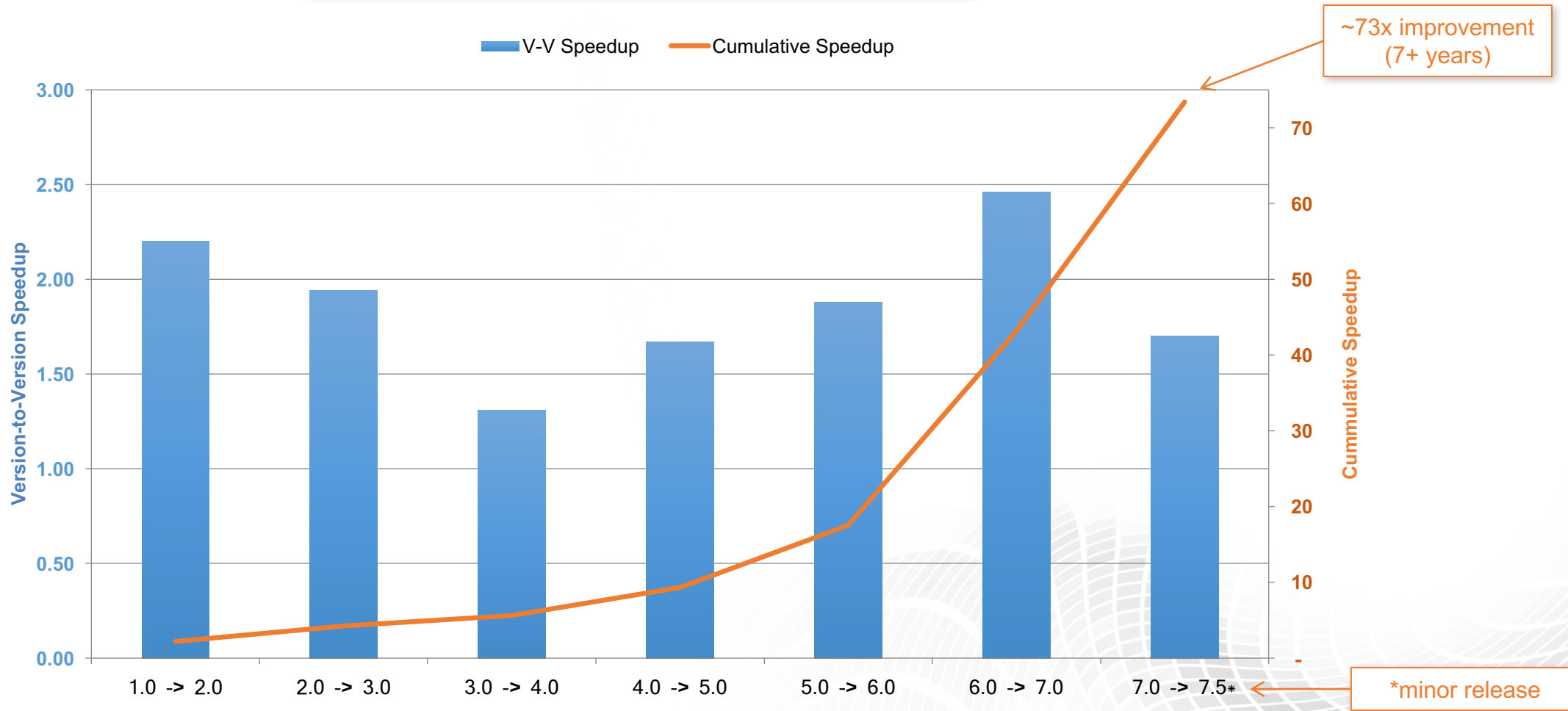 - Internal library of over 10,000 models from industry and academia

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.

Continual Performance Improvements

Nearly a 2x average improvement per major release

Legend: V-V Speedup, Cumulative Speedup

~73x improvement (7+ years)

*minor release

Gurobi Version-to-Version Pairs

X-axis: 1.0 -> 2.0, 2.0 -> 3.0, 3.0 -> 4.0, 4.0 -> 5.0, 5.0 -> 6.0, 6.0 -> 7.0, 7.0 -> 7.5*

Time limit: 10000 sec.
Intel Xeon CPU E3-1240 v3 @ 3.40GHz
4 cores, 8 hyper-threads
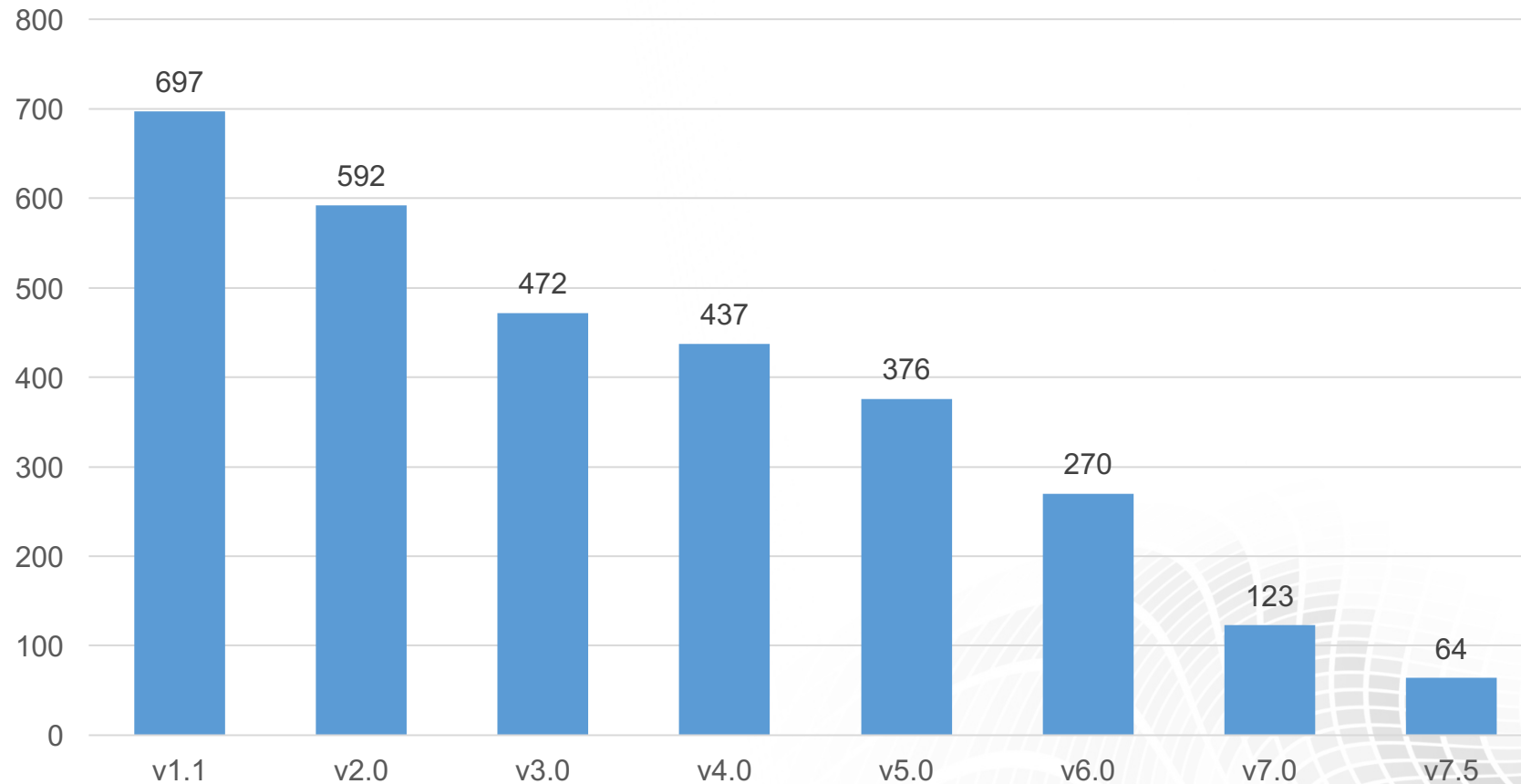32 GB RAM

Test set has 3740 models:
- 229 discarded due to inconsistent answers
- 908 discarded that none of the versions can solve
- speed-up measured on >100s bracket: 1227 models

Continual Performance Improvements


Number of unsolved models

Version	Unsolved models
v1.1	697
v2.0	592
v3.0	472
v4.0	437
v5.0	376
v6.0	270
v7.0	123
v7.5	64

Time limit: 10000 sec.
Intel Xeon CPU E3-1240 v3 @ 3.40GHz
4 cores, 8 hyper-threads
32 GB RAM

Test set has 4378 models:
- 305 discarded due to inconsistent answers
- 1081 discarded that none of the versions can solve
- speed-up measured on >100s bracket: 1486 models

Broad Performance Improvements in v7.5

- Consistent with prior releases, the Gurobi Optimizer v7.5 delivers performance improvements over v7.0 across a broad range of model types:

  - MIP – 32% faster (70% faster on models that take >100 seconds to solve)
  - LP
    - Concurrent – 15% faster (47% faster on models that take >100 seconds to solve)
    - Dual Simplex – 19% faster (42% faster on models that take >100s to solve)
    - Barrier – 9% faster (34% faster on models that take >100s to solve)
  - MIQP – 220% faster (too few models >100s to compare)
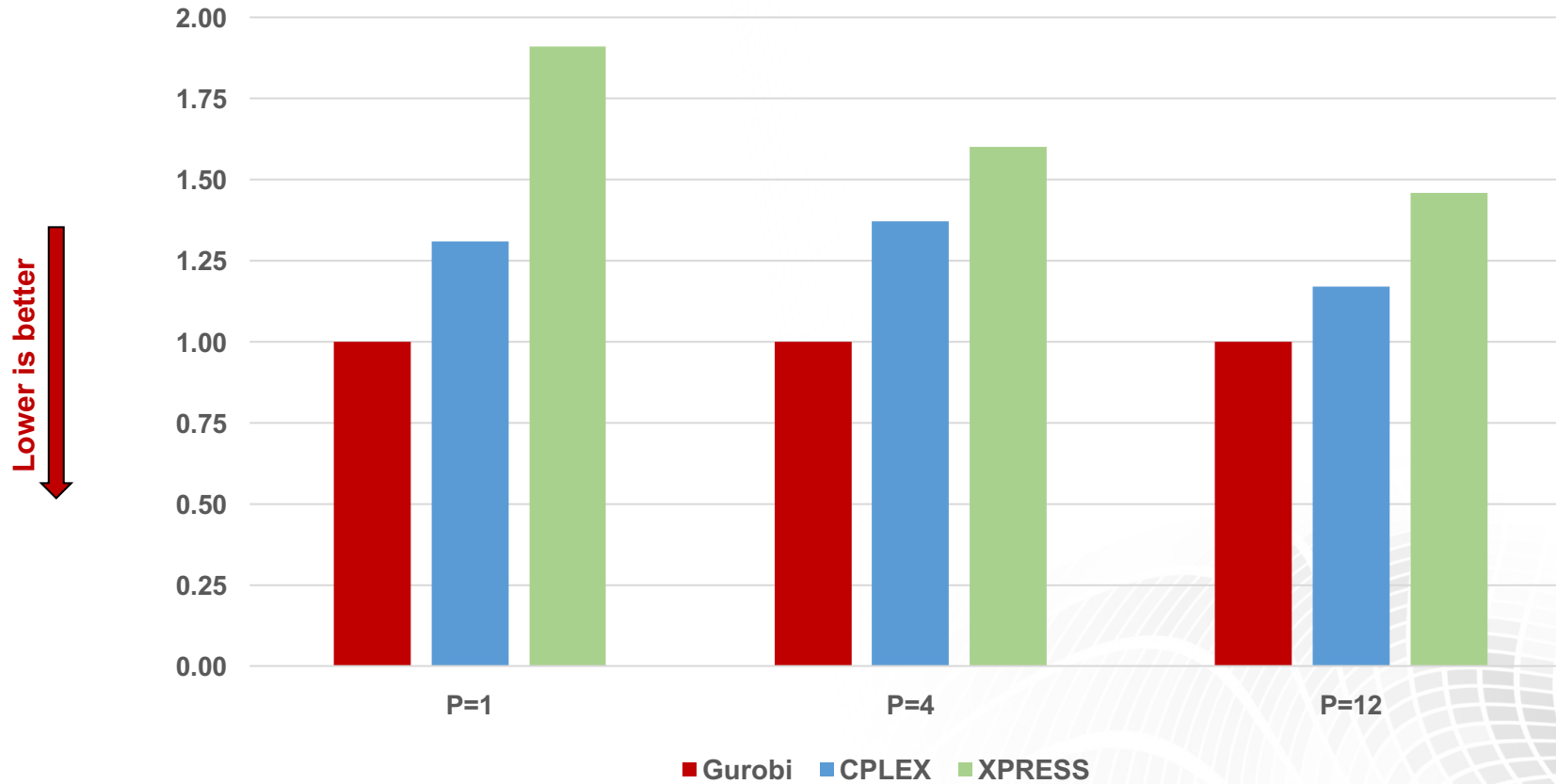 - SOCP – 17% (too few models >100s to compare)
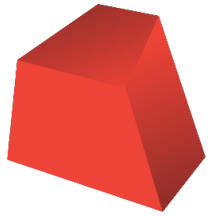
MILP Competitive Benchmarks

Gurobi 7.5 vs. CPLEX 12.7.1 vs. XPRESS 8.2.1
(Maintained by Hans Mittelmann)

Gurobi is…
- *Fastest to optimality*
- *Fastest on the broadest test set*
- *Fastest to feasibility*
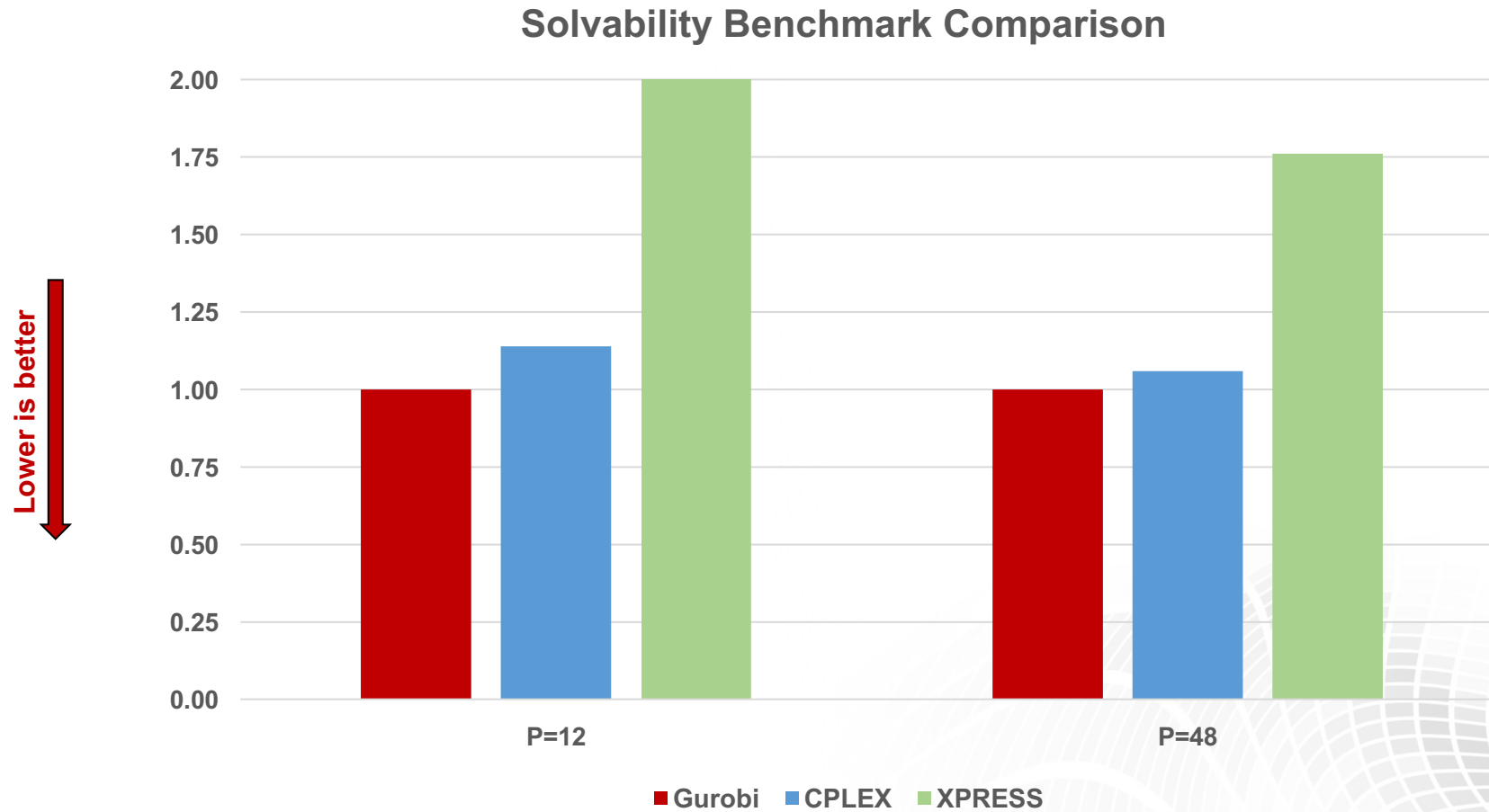- *Fastest to detect infeasibility*

Gurobi is Fastest Optimality

Optimality Benchmark Comparison

Lower is better

Gurobi | CPLEX | XPRESS

For example, on this Mittelmann speed to optimality benchmark (87 models) using 12 threads (P=12), CPLEX was 17% slower (1.17) and XPRESS was 46% slower (1.46) than Gurobi.
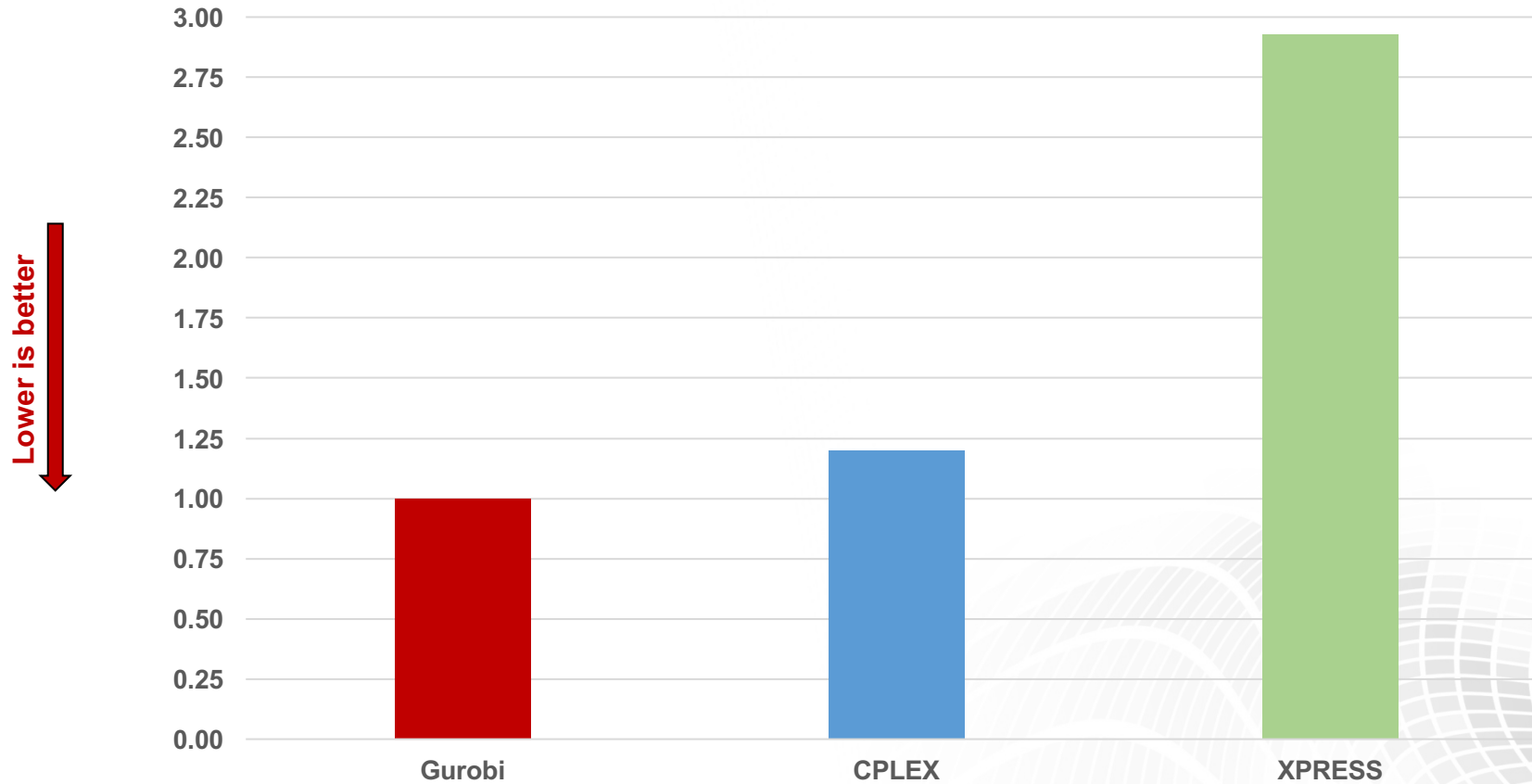
Gurobi is Fastest on the Broadest Test Set

Solvability Benchmark Comparison
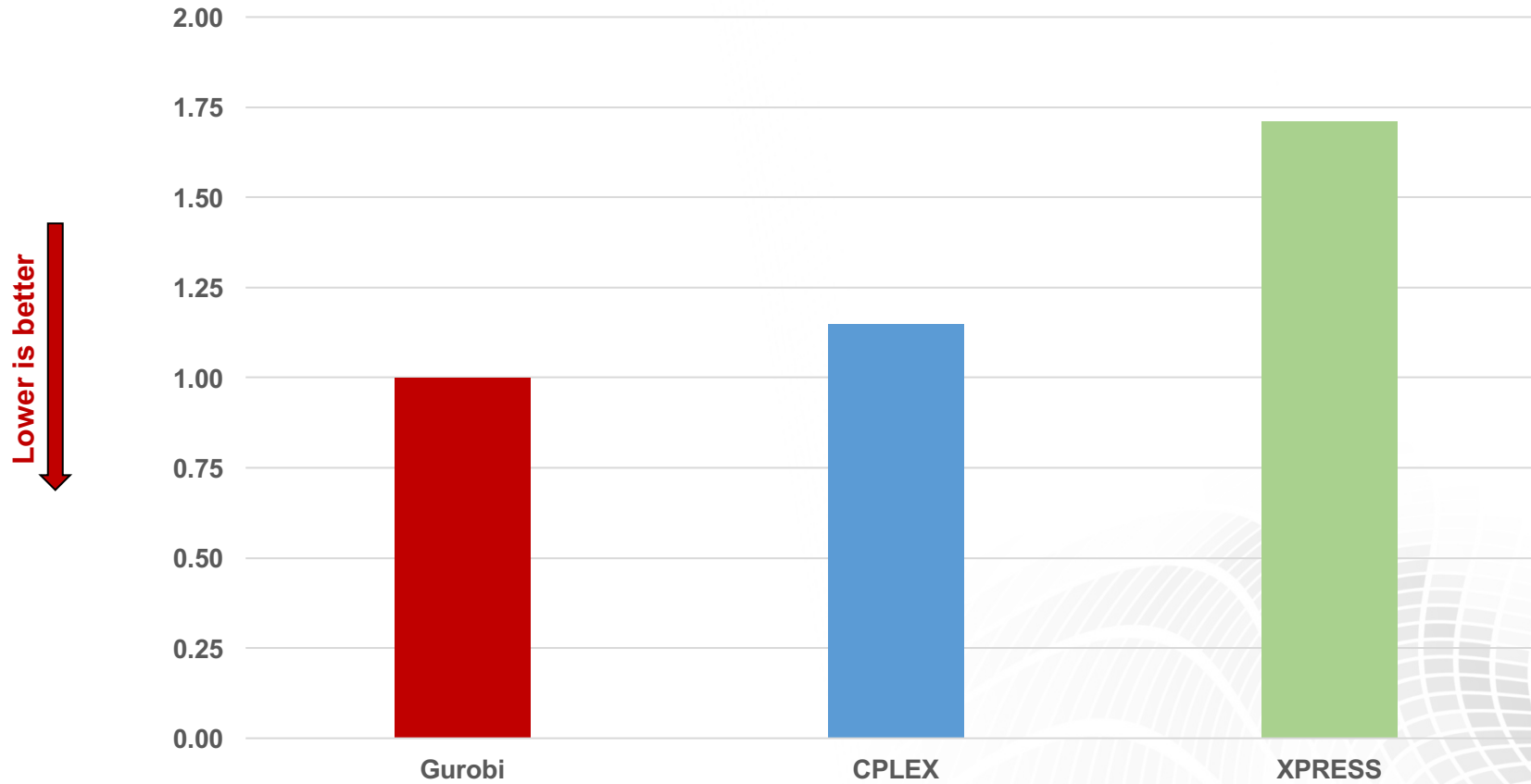
Lower is better

Legend: Gurobi, CPLEX, XPRESS

X-axis: P=12, P=48

Gurobi is Fastest to Feasibility

Feasibility Benchmark Comparison (P=4)
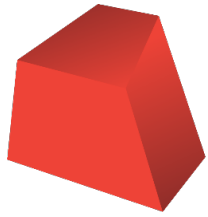
Lower is better

Gurobi   CPLEX   XPRESS

Gurobi is Fastest to Detect Infeasibility

Infeasibility Benchmark Comparison (P=8)

Lower is better
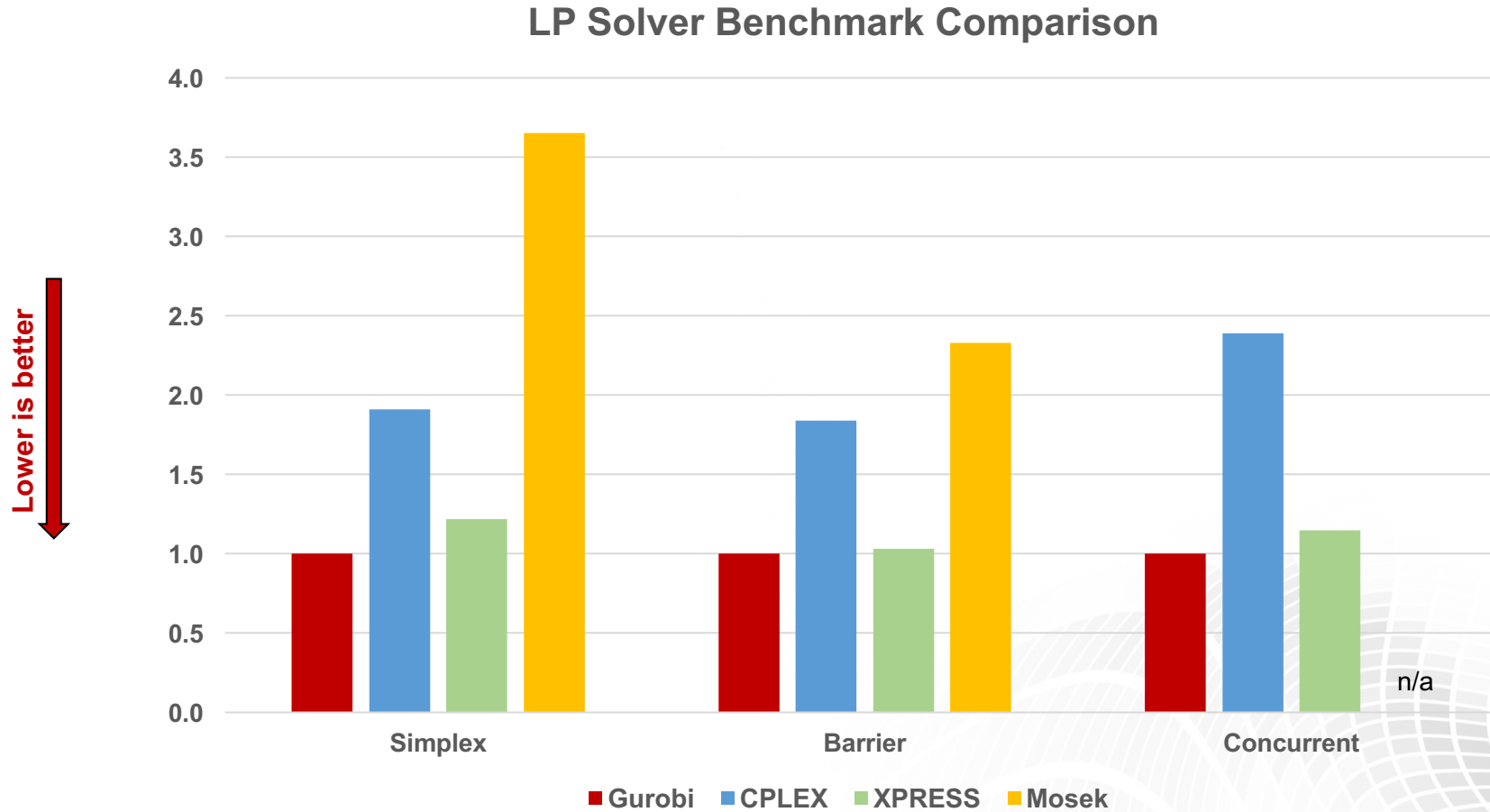
LP Competitive Benchmarks

Gurobi 7.5 vs. CPLEX 12.7.1 vs. XPRESS 8.2.1 vs. Mosek 8.0.0.74
(Maintained by Hans Mittelmann)

Gurobi has the fastest solve times

Gurobi is Fastest Across All LP Benchmarks

LP Solver Benchmark Comparison

Lower is better

Legend: ■ Gurobi ■ CPLEX ■ XPRESS ■ Mosek

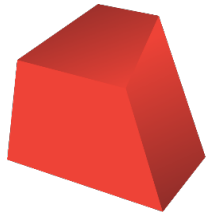Copyright 2017, Gurobi Optimization, Inc.

QP Competitive Benchmarks

Gurobi 7.5 vs. CPLEX 12.7.1 vs. XPRESS 8.2.1 vs. Mosek 8.0.0.64
(Maintained by Hans Mittelmann)

Gurobi has the fastest solve times
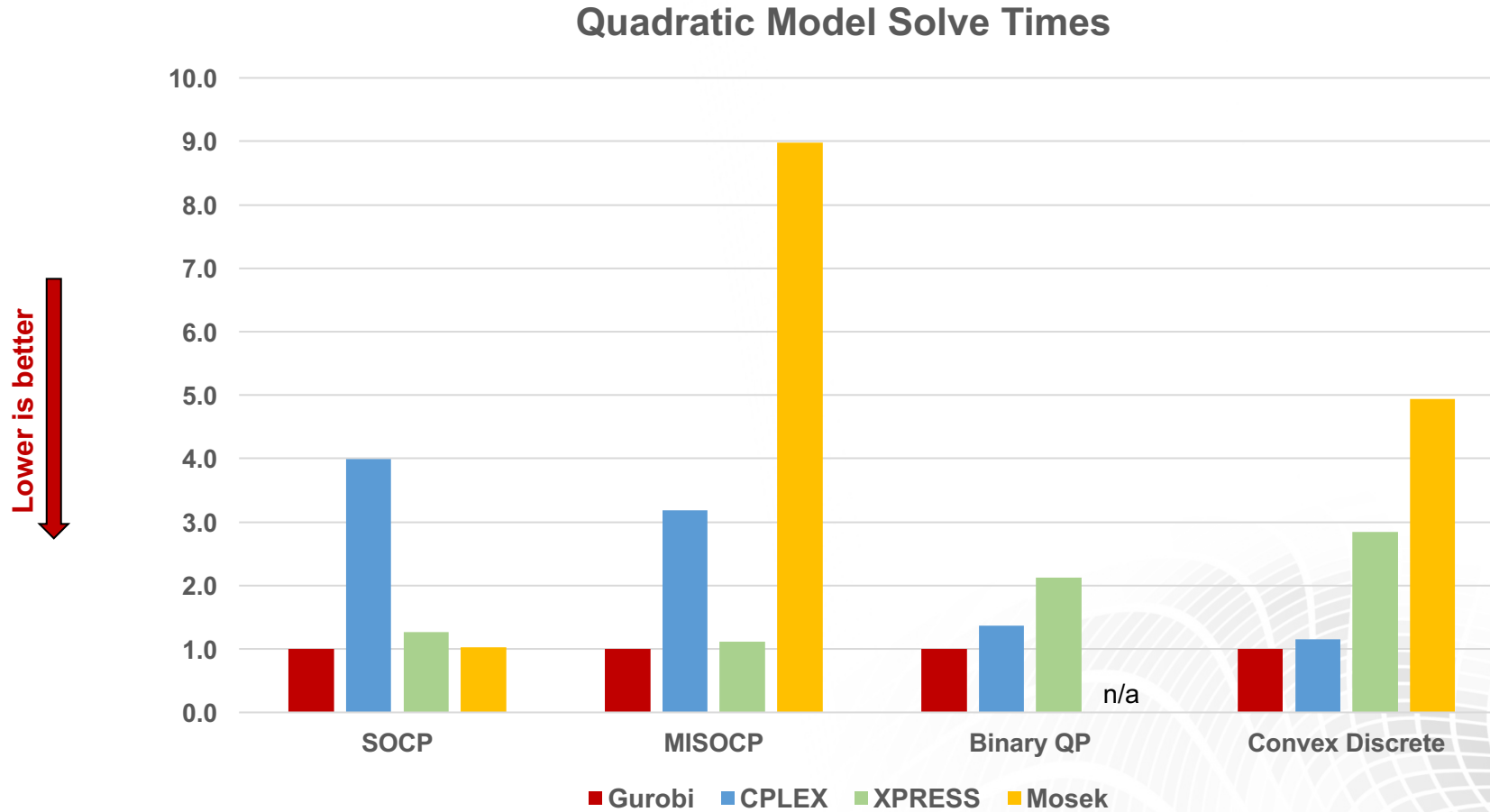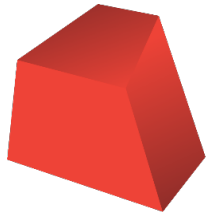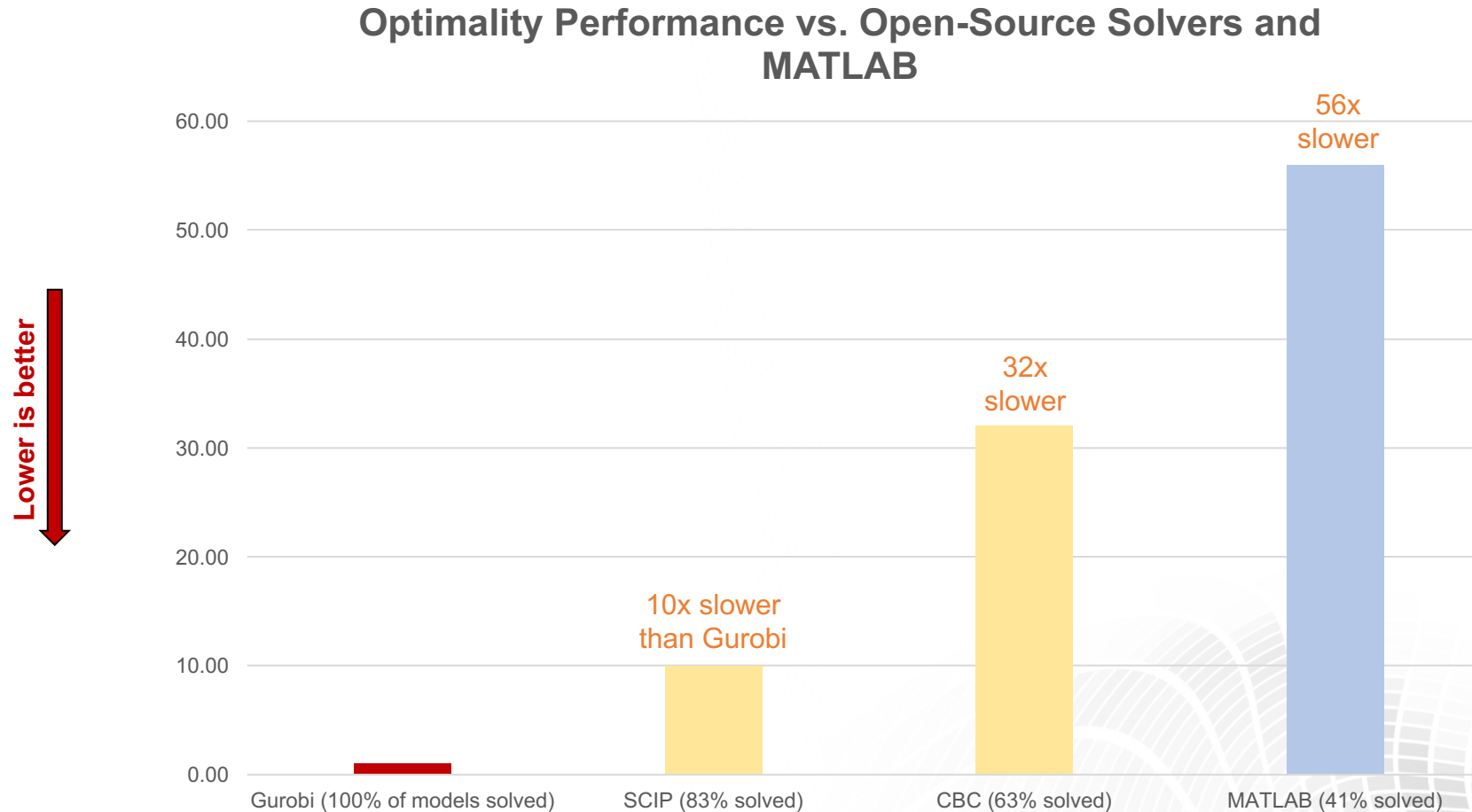
Gurobi is Fastest Across All QP Benchmarks

Quadratic Model Solve Times

Open Source Solvers and MATLAB Benchmarks

GUROBI OPTIMIZATION

Benchmarks – Open Source MIP and MATLAB

Optimality Performance vs. Open-Source Solvers and MATLAB

Lower is better

- 60.00
- 50.00
- 40.00
- 30.00
- 20.00
- 10.00
- 0.00

10x slower than Gurobi

32x slower

56x slower

Gurobi (100% of models solved) | SCIP (83% solved) | CBC (63% solved) | MATLAB (41% solved)

- Gurobi, SCIP, CBC and MATLAB data from current MIPLIB test results (http://plato.asu.edu/ftp/milpc.html). LPSolve and GLPK are not included in benchmark results as they solved too few models (five and zero respectively) to calculate useful performance comparisons.
- Test set includes 87 models. Open-source and MATLAB solver performance is worse than shown as unsolved models are treated as solved at max time limit.
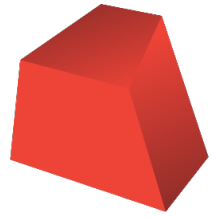
Tuning can have a significant positive impact on performance results

- 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.

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

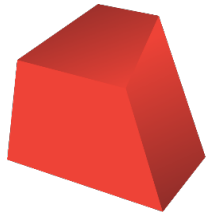| Machines	Distributed
4	2.09X
8	2.87X

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

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 by contacting us at: info@gurobi.com.
3. We are happy to assist with benchmarking your own models