IBM ILOG CPLEX Optimizer performance benchmarks

Version-over-version speed comparisons on the proven, reliable and robust mathematical programming and constraint programming solvers

Try CPLEX Optimization Studio

CPLEX Optimizer performance

- IBM ILOG CPLEX Optimizer provides breakthrough improvements in performance with CPLEX Optimizer version 12.9.0 compared to previous version 12.8.0.

- Mixed integer programming models with linear terms are solved by the CPLEX MIP Optimizer 20% faster on average for large problems (>100s) than version 12.8.0. For models with convex quadratic terms, improvements on larger models (>10s) is 25% on average. On a special technique for decomposing models called Bender’s the speedup is +2.3x on average for large models (>100s).
CPLEX 12.8.0 vs. 12.9.0: MILP performance improvement

- MILP improvements summary
  - Presolve: 5%
  - Dynamic search: 3%
  - Heuristic manager: 3%
  - Cutting planes: 5%

Date: Mar/2019
Test-set: MILP 4001 models
Machine: Intel Xeon @ 2.80GHz, 24 GB RAM, 12 threads, deterministic
Time-limit: 10,500 sec
**CPLEX Optimizer**

**CPLEX 12.8.0 vs. 12.9.0: LP performance improvement**

- **Deterministic concurrent LP (12 threads)**

  - Time limits: 6 / 3

  - LP improvements summary
    - Presolve
    - LP folding
    - Improved Cholesky factorization (LP barrier)
    - Faster LU factorization for dense problems (simplex and crossover)

**CPLEX 12.8.0 vs. 12.9.0: LP (barrier) performance improvement**

- **Barrier LP (12 threads)**

  - Time limits: 2 / 0

- **Barrier LP with Crossover (12 threads)**

  - Time limits: 4 / 4

---

Date: Mar/2019  
Test-set: MILP-9581 models  
Machine: Intel Xeon E5-2650 @ 2.3GHz, 24 GB RAM, 12 threads, deterministic  
Time-limit: 10,000 sec
**CPLEX Optimizer**

**CPLEX 12.8.0 vs. 12.9.0: LP performance improvement**

- **LP primal simplex (1 thread)**
  - Time limits: 9 / 7

- **LP dual simplex (1 thread)**
  - Time limits: 6 / 5

**CPLEX 12.8.0 vs. 12.9.0: MIQCP performance improvement**

- **Convex MIQCP (12 threads)**

**MIQCP improvements summary (all for Outer Approximation, OA)**
- Better cone disaggregation: 1%
- Improved Lift-and-Project cuts: 5%
- Better integration between cone cuts and QCP relaxation for OA:
  - Improved strategies to solve QCP relaxation (at the root or in the tree),
  - to refine OA with cone cuts: 12%

---

**Date:** Mar/2019  
**Test set:** MILP 4902 models  
**Machine:** Intel X5650 @ 2.67GHz, 24 GB RAM, 12 threads, deterministic  
**Time limit:** 10,000 sec
**CPLEX 12.8.0 vs. 12.9.0: Benders B&C improvements**

![Benders MILP branch-and-cut (12 threads)](image)

- **Trial:** Try CPLEX Optimization Studio
- **Product Tour:** Solve an optimization problem
- **Video:** Introduction to ILOG CPLEX Optimization Studio
- **Webpage:** CPLEX Optimizer
- **Marketplace:** CPLEX Optimization Studio

**CPLEX 12.8.0 vs 12.9.0: Bender's performance improvement**

<table>
<thead>
<tr>
<th>Time Limit</th>
<th>CPLEX 12.8.0</th>
<th>CPLEX 12.9.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1s</td>
<td>1.56x</td>
<td>0.64</td>
</tr>
<tr>
<td>&gt;10s</td>
<td>1.83x</td>
<td>0.55</td>
</tr>
<tr>
<td>&gt;100s</td>
<td>2.36x</td>
<td>0.42</td>
</tr>
</tbody>
</table>

**Date:** Mar/2019  
**Test Set:** MILP 4651 models  
**Machine:** Intel X3435 @ 2.87GHz, 24 GB RAM, 12 threads, deterministic  
**Time Limit:** 10,000 sec
CP Optimizer
Performance Trends

• Test-cases are separated into two groups:
  1. Integer problems, which include rostering, matching, sports and other combinatorial problems.
  2. Scheduling problems, which include resource-constrained and job-shop scheduling problems (job-, flow-, etc).

• On performance of purely combinatorial/integer problems a breakthrough speed improvement has been achieved again with a nearly 2x, i.e. a more than 100% faster solve. On purely scheduling problems with COS 12.9, we have achieved a 1.5x speedup compared to 12.8.0. It is not just the speed up but the scaling achievement is staggering, i.e. significantly larger number of scheduling jobs are nearly linear in term of amount of time to schedule them.
Scheduling Performance – Overall

- Version to version performance on scheduling problems. The graph shows results on up to 2690 problems in 151 families.

Scheduling Performance
4 threads, problems taking over 1s

Scheduling Performance – Scaling

- The advantage of iterative diving is its performance on large scheduling instances.
- Here we compare CP Optimizer 12.9 against the previous version on the time to find an initial solution to RCPSP instances up to 500,000 tasks.

First solution time for large RCPSPs (automatic search with 4 workers)

CP Optimizer - scheduling performance evolution

CP Optimizer – integer/combinatorial performance improvements
Combinatorial Integer Performance – Overall

- Version to version performance on optimization and decision problems. The graph shows results on up to 1139 problems in 121 families.

CP Optimizer – integer/combinatorial performance improvements

- Trial: Try CPLEX Optimization Studio
- Tutorial: Create and run a scheduling model using Python
- Webpage: CP Optimizer
- Video: Introduction to ILOG CPLEX Optimization Studio
- Marketplace: CPLEX Optimization Studio