What's new in HiGHS, and thanks to JuMP for its support!

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HiGHS: What's new?

HiGHS: **H**all, **i**vet **G**alabova, **H**uangfu, **S**chork

- Simplex, interior point and first order solvers for LP
- Branch-and-cut solver for MIP
- Active set solver for QP
- Open-source (MIT license)
- https://HiGHS.dev/

What's new?

- HiPO: a new interior point solver: v1.12
- Enhanced MIP solver: v1.12
- Enhanced irreducible infeasible system (IIS) facility: WIP
- HiPDLP: a new first order solver: WIP

HiGHS–JuMP: Timeline

- JuMP first interested in HiGHS (2019)
- JuMP–HiGHS interface developed by Dowson and Galabova (2020)
- HiGHS has become the default solver in JuMP documentation (2020–date)
- JuMP maintains HiGHS binaries (2021–date)
- Dowson guided HiGHS through the adoption of `Documenter.jl` (2023)
- Funded by Breakthrough Energy, JuMP and HiGHS are working together to improve the open-source energy systems ecosystem (2024–date)

HiPO: A new interior point solver

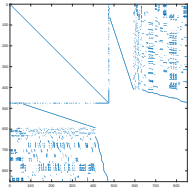
HiGHS has an interior point solver (IPX)

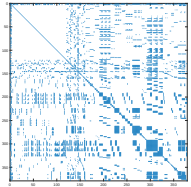
- Solves the normal equations using preconditioned conjugate gradient
- Preconditioner derived from "weighted" simplex-like basis (Schork 2018)
  - Best open-source IPM solver (Mittelmann)
  - Serial, and a big gap to commercial IPM solvers
  - Hard to predict solution time
  - Doesn't generalise to QP

HiPO

- Funded by Google
- Written by Filippo Zanetti (2023–25)
- Available in HiGHS v1.12
  - If you're building from source
  - If you're using JuMP!
- Python build is WIP

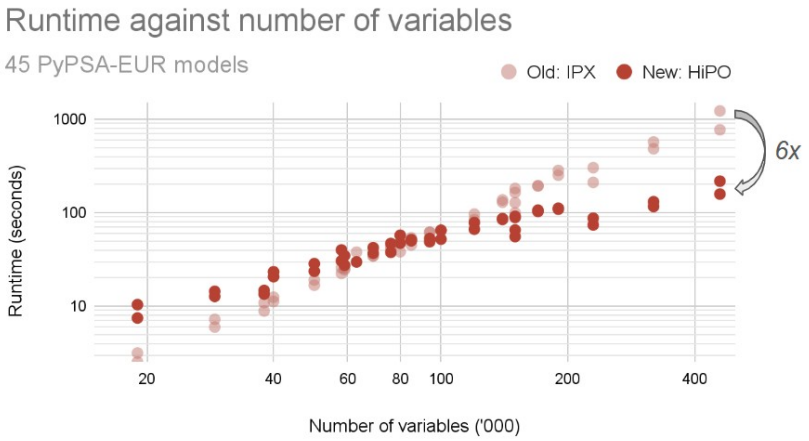
HiPO: A new interior point solver





- Determines an LDL^T decomposition to solve either
  - The augmented system $\begin{bmatrix} -\Theta^{-1} & A^T \\ A & \end{bmatrix} \begin{bmatrix} \boldsymbol{\delta x} \\ \boldsymbol{\delta y} \end{bmatrix} = \begin{bmatrix} \boldsymbol{g} \\ \boldsymbol{h} \end{bmatrix}$
  - The normal equations $A\Theta A^T \boldsymbol{\delta y} = \boldsymbol{f}$
- Uses `Metis` to producing a fill reducing ordering
  - Introduces a dependency into `HiGHS`
  - Best way to mitigate this is WIP
- Multi-frontal approach allows
  - Parallel processing of the elimination tree
  - Multi-threaded dense factorisation of frontal matrices
- Requires a good `BLAS` library

HiPO: A new interior point solver



- Up to 6X faster on LPs from energy systems
- Further significant performance enhancement expected

MIP solver

Solver	COPT	HiGHS	SCIPC	SCIP	Cbc	GLPK	cuOpt
Speed	1	6.61	7.02	8.83	12.0	35.9	?
Solved	218	157	145	128	107	23	?

Mittelmann results for the 240 MIPLIB 2017 benchmark problems (October 2025)

- Written by Leona Gottwald (2020–22)
- The world's best open-source MIP solver since 2021
- Used by MathWorks since 2024
- No performance improvement since Leona joined FICO
- No MIP expertise in the HiGHS team!

MIP developments

Building a MIP team (2024–date)

- Franz Wesselmann (MathWorks: 2024–date)
- Mark Turner (Funded by Breakthrough Energy: 2025–27)
- Ben Champion (PhD funded by Kraken: 2024–28)

No shortcuts to major performance improvement!

- Parallel tree search: Not as "oven ready" as Gottwald suggested!
- MIP race: Non-deterministic and horrible!
- Presolving the analytic centre calculation: Unwise!

Enhancements

- Wesselmann: Fixing presolve bugs and adding MIP solver enhancements
- Turner: Added flow cover cuts and working on parallel tree search
- Champion: Added feasibility jump and working on primal heuristics

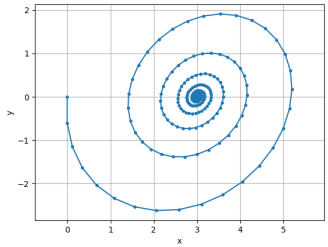
Irreducible infeasible system (IIS) facility

- Started work in 2024
  - Aimed for provable IIS
  - Needed enhancements to primal simplex solver
- IIS "light" (v1.12) checks for
  - Incompatible bounds
  - Infeasible row activity bounds
- Added option to find just an infeasible system (WIP)

What's coming?

- Extension to MIP
- "Timeout" facility
- Performance enhancement
  - Collaboration with MathWorks

HiPDLP: A new GPU-accelerated PDLP solver



What is PDLP?

- PDLP is a new method for LP
- Runs on GPUs
- HiGHS uses cuPDLP-C
  - On CPU since March 2024
  - On GPU since March 2025

Why develop HiPDLP?

- New features to add to PDLP
  - Feasibility polishing
    Applegate *et al.* (2025)
  - Halpern restarts
    Kaihuang Chen *et al.* (2024)
    Lu *et al.* (2025)
  - Reflection
    Lu and Yang (2024)
- New first order algorithms
  - Negative step size gradient descent-ascent
    Shugart and Altschuler (2025)
- New solvers
  - cuPDLPx
    Lu *et al.* (September 2025)

HiPDLP: A new GPU-accelerated PDLP solver

- Contract with NESO (September 2025 – February 2026)
- Research for PhD student Yanyu Zhou (funded by Google)
  - C++ implementation of cuPDLP-C is done
  - CUDA implementation of cuPDLP-C is WIP

Summary

- Developed a much better IPM solver
- Built a MIP team and enhancing the solver
- Enhancing the IIS facility
- Adding a new PDLP solver

Q. Huangfu and J. A. J. Hall.
Parallelizing the dual revised simplex method.
Mathematical Programming Computation, 10(1):119–142, 2018.

F. Zanetti and J. Gondzio.
A factorisation-based regularised interior point method using the augmented system.
arXiv: 2508.04370, 2025.