

HiGHS

High-performance open-source software for linear optimization

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What's in a name?

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

Team HiGHS

- Julian Hall: Reader (1990–date)
- Ivet Galabova: PhD (2016–date)
- Qi Huangfu
 - PhD (2009–2013)
 - FICO Xpress (2013–2018)
- Michael Feldmeier: PhD (2018–date)



Linear programming (LP)

- Dual simplex (Huangfu and Hall)
 - Serial techniques exploiting sparsity
 - Parallel techniques exploiting multicore architectures
- Interior point (Schork)
 - Highly accurate due to its iterative linear system solver
 - Crossover to a basic solution

Mixed-integer programming (MIP)

Prototype solver

Features

- Model management: Load/add/delete/modify problem data
- Presolve
- Crash

Interfaces

• Language

- C++ HiGHS class
- Load from .mps
- Load from .lp
- C
- C#
- Julia
- FORTRAN
- Python

• Applications

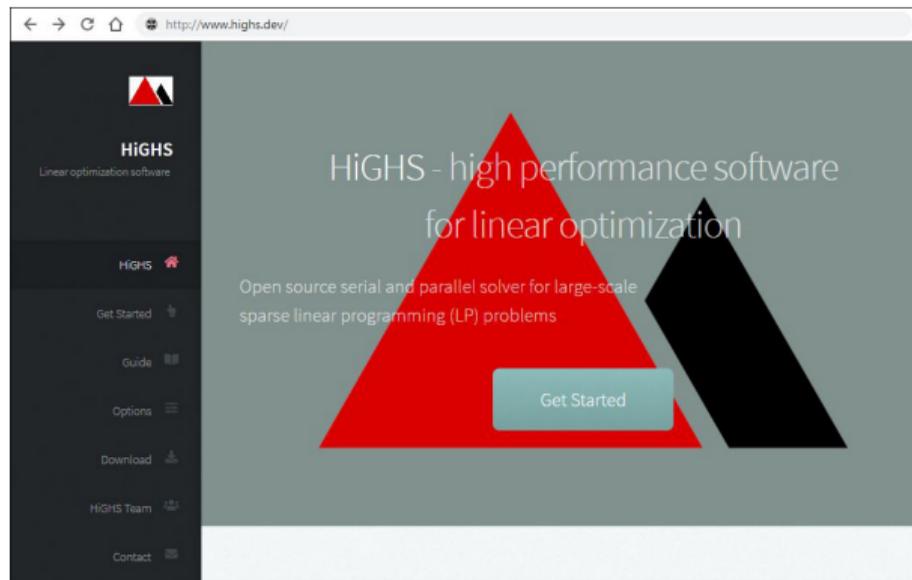
- GAMS
- JuliaOpt
- OSI
- SCIP
- SciPy

• Future

- AMPL
- MATLAB
- Mosel
- PuLp
- R

Suggestions?

- Open-source (MIT license)
 - GitHub: [ERGO-Code/HiGHS](https://github.com/ERGO-Code/HiGHS)
 - COIN-OR: Successor to C1p?
- No third-party code required
- Runs under Linux, Windows and Mac
- Build requires CMake 3.15
- Parallel code uses OpenMP
- Documentation:
<http://www.HiGHS.dev/>



HiGHS: Simplex benchmarks (14 August 2020)

Commercial

- COPT
- Gurobi
- Matlab
- MindOpt
- Mosek
- SAS

Open-source

- Clp (COIN-OR)
- Glop (Google)
- Soplex (ZIB)
- Glpk (GNU)

Solver	MindOpt	Gurobi	COPT	Clp	Mosek	SAS	HiGHS	Glop
Time	1	1.1	1.4	3.0	6.0	6.1	10	14
Solved	40	40	40	40	38	37	37	35

Solver	Matlab	Soplex	Glpk
Time	16	16	54
Solved	33	39	31

HiGHS: Comparison with Clp

Solver	MindOpt	Gurobi	COPT	Clp	Mosek	SAS	HiGHS	Glop
Time	1	1.1	1.4	3.0	6.0	6.1	10	14
Solved	40	40	40	40	38	37	37	35

Why is the HiGHS score so bad?

- HiGHS parallel code not used
- HiGHS triangular crash not used
- Clp has a better presolve
- Clp has the Idiot crash
- Clp has a primal simplex solver
- Clp has “sprint” (“sifting”) variant

Development

- Speed of HiGHS relative to Soplex motivates writing a HiGHS interface to SCIP
- Prototype interface now complete, but lacks
 - Primal ray for unbounded LPs
 - Farkas proof for infeasibility
 - Full efficiency when hot-starting nodes
- Passes 94% of the SCIP unit tests

Initial results: Time limit 3600s

	Solves	Timeout	Fails	Faster	M-time
SCIP-Soplex	89	5	1	41	105
SCIP-HiGHS	65	22	8	7	242

95 MIPLIB problems that Mittelmann's SCIP-Soplex test solves in 1000s

LP

- Improve presolve (Galabova)
- Add primal simplex solver and sifting (Hall)
- Improve simplex performance (Hall)
- Add Idiot crash and crossover (Galabova and Hall)
- Improve Idiot crash (Galabova)

QP

- Active set QP solver (Feldmeier)

MIP

- Develop successor to Cbc?

Further interfaces

- AMPL
- MATLAB
- Mosel
- PuLp
- R



HiGHS

- High performance LP solvers: simplex and IPM
- Reads: .mps and .lp
- Language interfaces: C++ (native) C, C#, Julia, FORTRAN, Python
- Application interfaces: GAMS, JuliaOpt, OSI, SCIP, SciPy
- Permissive license and no third-party code
- Available for research and consultancy

HiGHS: <http://www.HiGHS.dev/>



I. L. Galabova and J. A. J. Hall.

The 'Idiot' crash quadratic penalty algorithm for linear programming and its application to linearizations of quadratic assignment problems. *Optimization Methods and Software*, 35(3):488–501, 2020.



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Novel update techniques for the revised simplex method. *Computational Optimization and Applications*, 60(4):587–608, 2015.



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Parallelizing the dual revised simplex method. *Mathematical Programming Computation*, 10(1):119–142, 2018.



L. Schork and J. Gondzio.

Implementation of an interior point method with basis preconditioning. *Mathematical Programming Computation*, pages 1–33, 2020.