



## Develop, License, Test, Curate – Optimization in the Real World



### SCIP Optimization Suite

Tools to model and solve a variety of mathematical optimization problems:

$$\min\{f(x) \mid x \in X, x_i \in \mathbb{Z}, i \in I \subseteq \{1, \dots, n\}\}$$

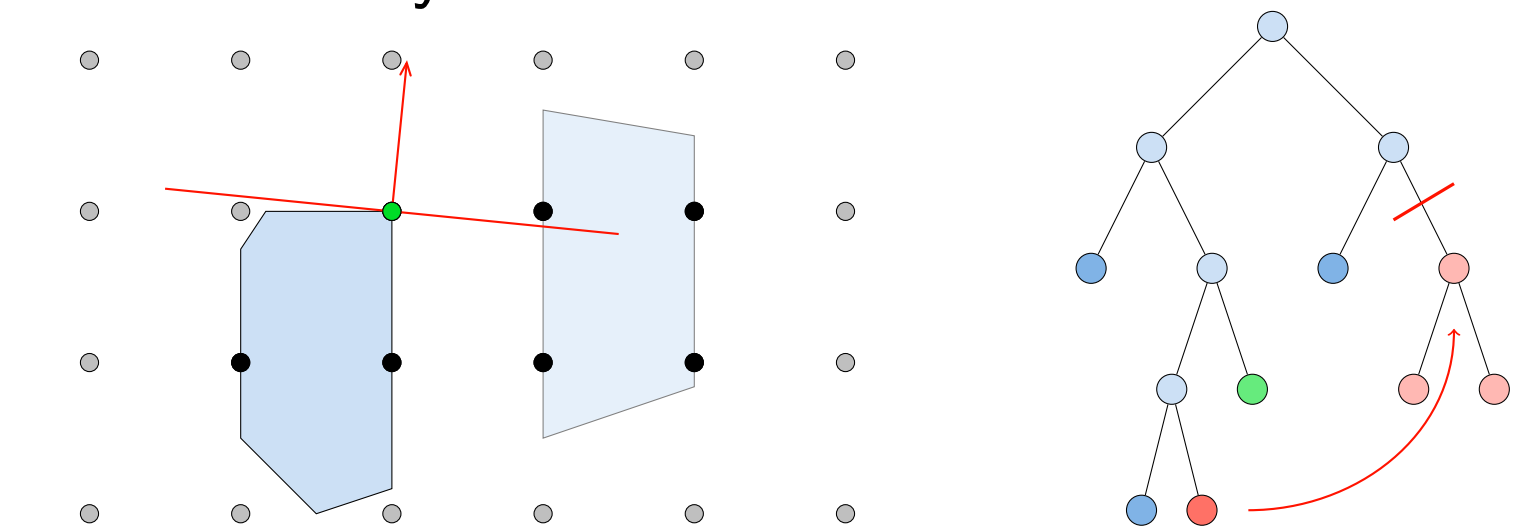
$$X := \{x \in \mathbb{R}^n, g_k(x) \leq 0, k = 1, \dots, m, x \in [\ell, u]\}$$

- ▶ Linear Programs
- ▶ Mixed-Integer Programs
- ▶ Mixed-Integer Non-Linear Programs
- ▶ Constraint Integer Programs
- ▶ SATisfiability problems
- ▶ Pseudo-Boolean Optimization

- ▶ Modular plug-in based structure allows researchers to implement new ideas
- ▶ APIs: C/C++, Python, Java, MATLAB, Julia, AMPL, GAMS
- ▶ Platforms: Linux, macOS, Windows, and more using CMake and Makefiles
- ▶ Support for massively parallel execution on supercomputers (80 000 cores)

### Core Algorithm: Branch-and-Bound

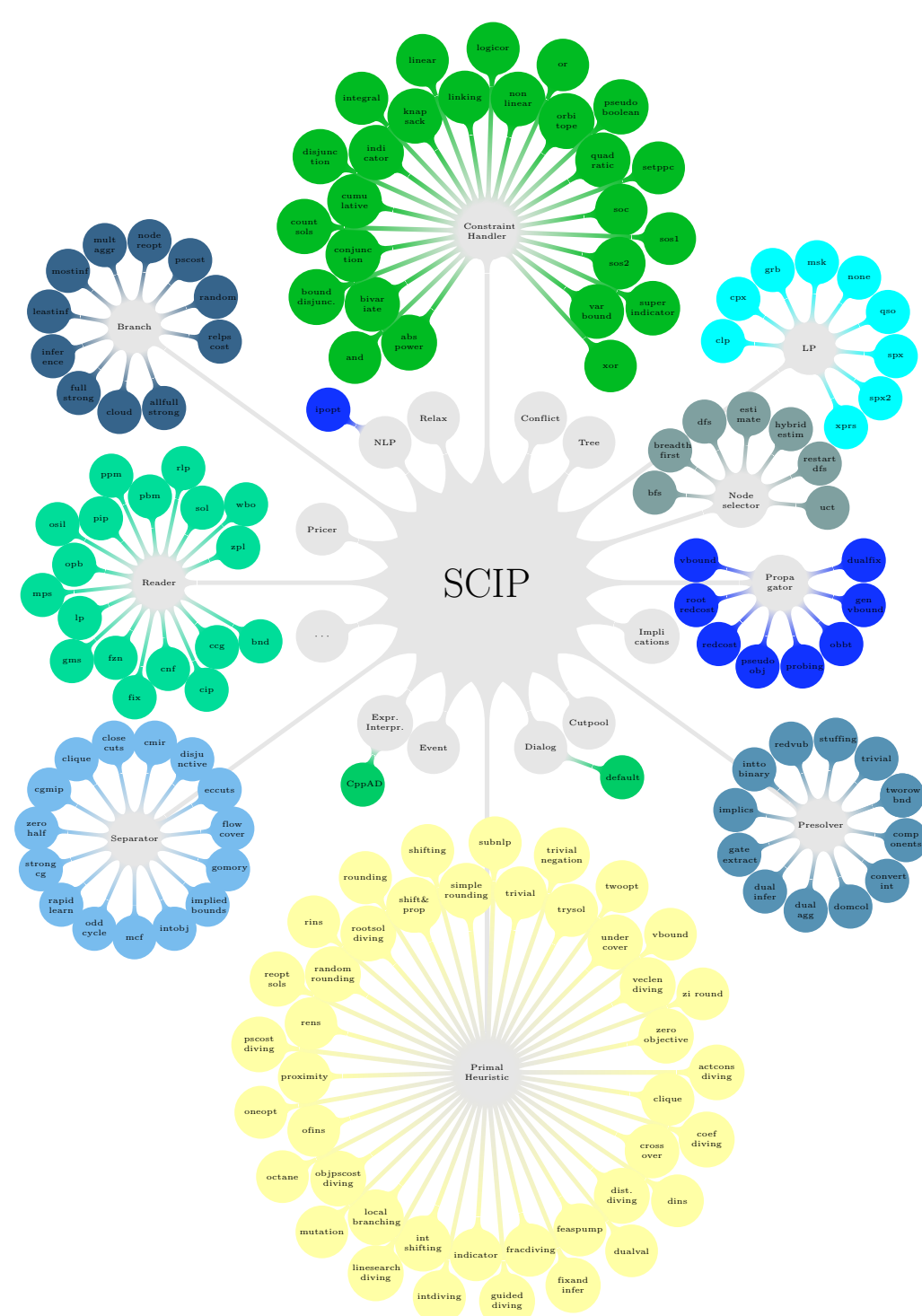
Divide-and-Conquer to iteratively reduce search space and eventually prove optimality or infeasibility:



- ▶ relaxation and bounding
- ▶ presolving
- ▶ cutting planes
- ▶ primal heuristics
- ▶ conflict analysis
- ▶ ...

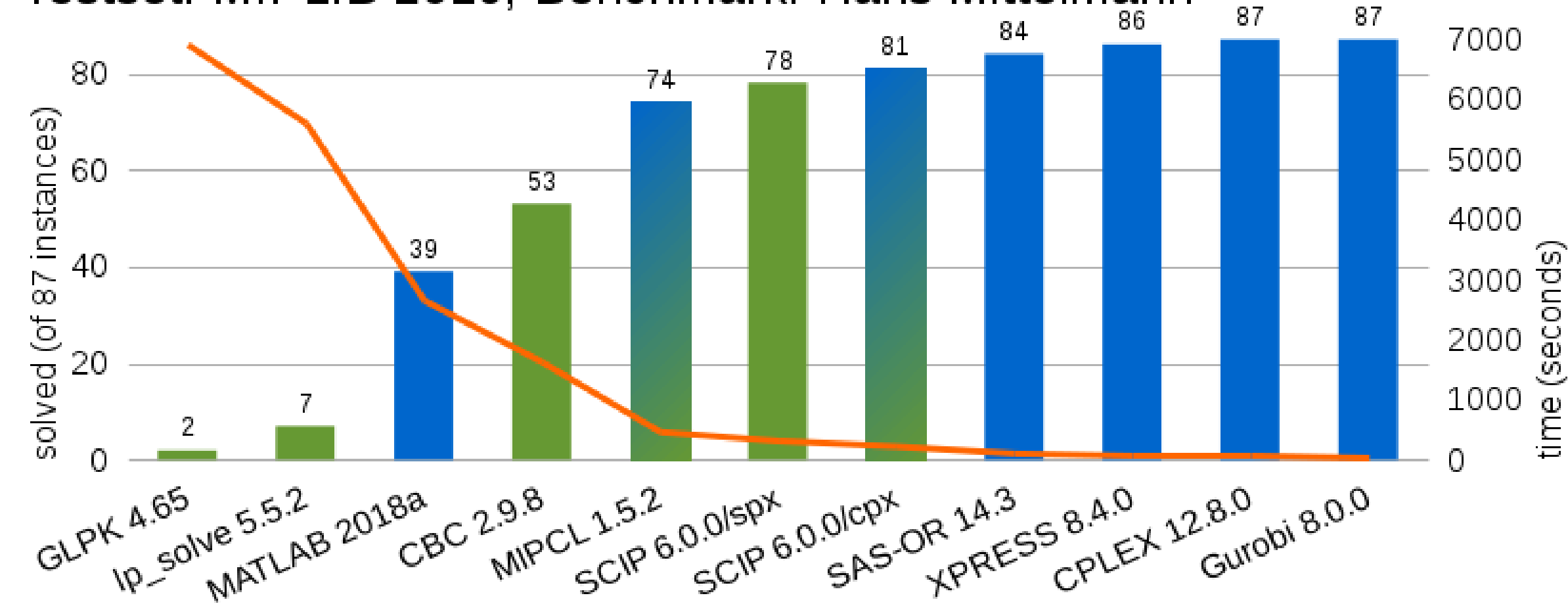
### 23 Years and Counting

- 1996 ▶ **SoPlex** – Sequential o.o. simplex (R. Wunderling [now at IBM])
- 1998 ▶ SIP – Solving Integer Programs (A. Martin [now at FAU Erlangen])
- 2002 ▶ Beginning of SCIP development (T. Achterberg [now at Gurobi])
- 2004 ▶ **ZIMPL** – Zuse Institute Math. Programming Language (T. Koch)
- 2005 ▶ First public version of **SCIP** – Solving Constraint Integer Problems
- 2007 ▶ SCIP 1.0 release, ZIB Optimization Suite (SoPlex, SCIP, ZIMPL)
- 2007 ▶ First SCIP Workshop at ZIB
- 2008 ▶ Development of **GCG** started (G. Gamrath)
- 2009 ▶ Beginning of **UG** development (Y. Shinano)
- 2009 ▶ Beale-Orchard-Hays Prize (T. Achterberg)
- 2010 ▶ Google Research Award
- 2011 ▶ Switch from CVS to Git
- 2012 ▶ SCIP Optimization Suite 3.0 release including GCG, UG, and SCIP-SDP
- 2012 ▶ Second SCIP Workshop at TU Darmstadt
- 2014 ▶ Google OR-Tools uses SCIP
- 2014 ▶ Third SCIP Workshop at ZIB
- 2015 ▶ SCIP-Jack release for Steiner Tree Problems
- 2016 ▶ PolySCIP release multi-criteria optimization
- 2018 ▶ Fourth SCIP Workshop at RWTH Aachen



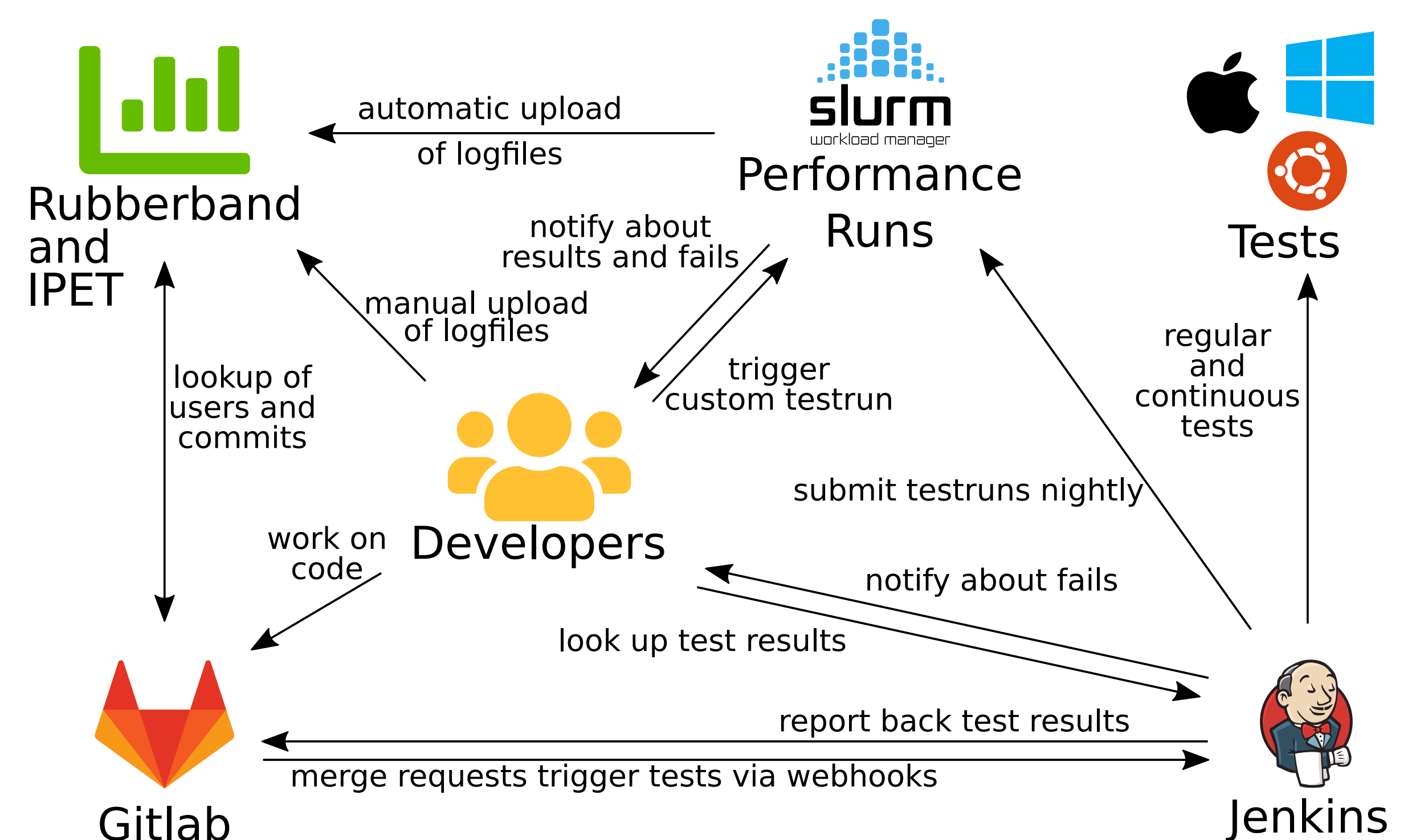
### Performance

Testset: MIPLIB 2010, Benchmark: Hans Mittelmann



- ▶ fastest MIP solver available in source code
- ▶ continuous progress over more than 20 years
- commercial solvers
- open source code

### Development Process – Continuous Integration



**Rubberband** ([github.com/ambros-gleixner/rubberband](https://github.com/ambros-gleixner/rubberband)):

- ▶ graphical online evaluation and analysis using Tornado and Elasticsearch
- ▶ compare results with hundreds of other runs from database using IPET

**IPET** ([github.com/GregorCH/ipet](https://github.com/GregorCH/ipet)):

- ▶ Interactive Performance Evaluation Tool using Python Pandas
- ▶ used as backend for data analysis in Rubberband

**GitLab** ([gitlab.com](https://gitlab.com)):

- ▶ user and repository management based on Git ([git-scm.com](https://git-scm.com))
- ▶ provides monitoring, testing, issue tracking, and documentation tools

**Slurm** ([slurm.schedmd.com](https://slurm.schedmd.com)):

- ▶ cluster management and job scheduling system for Linux clusters

**Jenkins** ([jenkins.io](https://jenkins.io)):

- ▶ testing and automatization server

### Keys to Success

- ▶ Attraction: welcoming environment for new users and developers
- ▶ Contact: ensure close contact to users
- ▶ Communication: weekly direct meetings, monthly online meetings with all developers
- ▶ Quality: code reviews and style guide for consistent appearance and readability
- ▶ Democracy: involve all developers on important changes
- ▶ Performance: keep up with competitors
- ▶ Usability: support different platforms and programming languages
- ▶ Support & Patronage: by acknowledged leaders in the field

### Publications, Visibility, Outreach, License

- 🎓 Bachelor's, Master's, and PhD theses promote and extend SCIP
- 📖 comprehensive release reports cover new features and developments
- 🌐 [scip.zib.de](https://scip.zib.de) lists related projects and publications
- 👥 in-depth, hands-on workshops for new and advanced users
- ✉️ mailing list with more than 400 subscriptions ([scip@zib.de](mailto:scip@zib.de))
- 🔖 StackOverflow tag `scip` watched by developers
- 🐛 online submission form for bug reports
- 🔗 interfaces open on GitHub for issues and pull requests ([github.com/SCIP-Interfaces](https://github.com/SCIP-Interfaces))
- 📖 extensive online documentation using Doxygen

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