

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

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Department Mathematical Optimization,  
Zuse Institute Berlin

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- ▶ Non-university research institute and computing center of the state of Berlin
- ▶ Research Units:
  - ▶ Numerical analysis and modeling
  - ▶ Visualization and data analysis
  - ▶ Optimization: energy – traffic – linear and nonlinear IP
  - ▶ Scientific information systems
  - ▶ Distributed algorithms and supercomputing
- ▶ President: Prof. Christof Schütte



- ▶ *manufacturing*: sheet metal design
- ▶ *networks*: operation and design of water and gas networks
- ▶ *energy production and distribution*: plant design, power scheduling
- ▶ *logistics*: public transport, supply-chain management
- ▶ *industrial engineering*: mining with stockpiling constraints
- ▶ *biological engineering, chemical industry*, ...

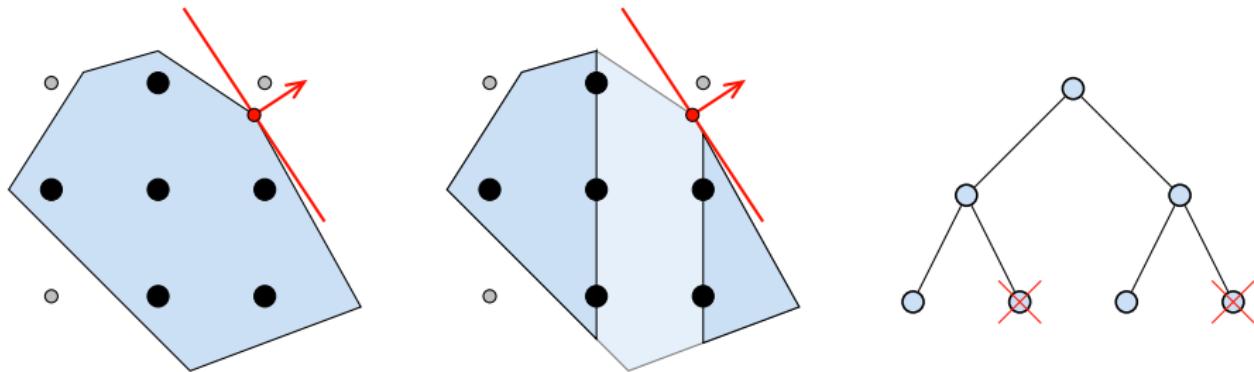


$$\min c^T x + d^T y$$

$$\text{subject to } Ax + By = b$$

linear constraints

$$x \in \mathbb{Z}^n, y \in \mathbb{R}^m$$



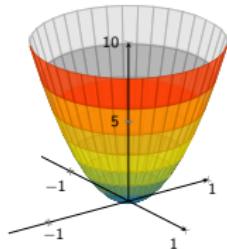
$$\min c^T x + d^T y$$

subject to  $Ax + By = b$  linear constraints

$G(x, y) = 0$  nonlinear constraints

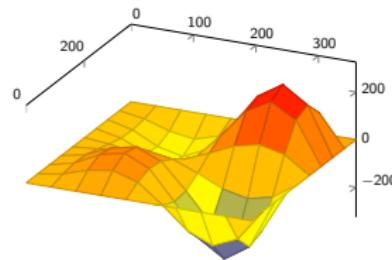
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The functions  $g_k \in G$  can be

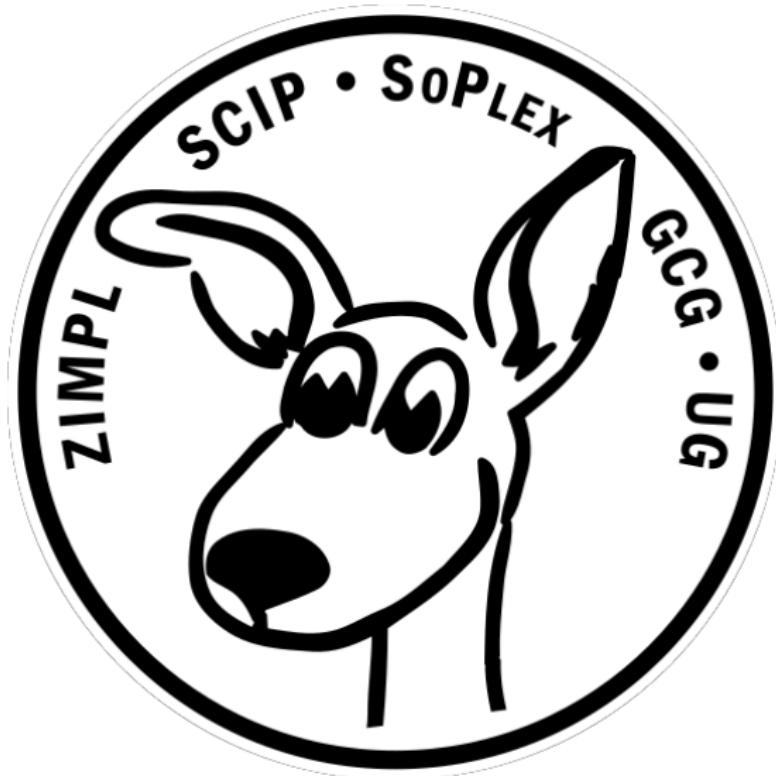


convex

or



nonconvex

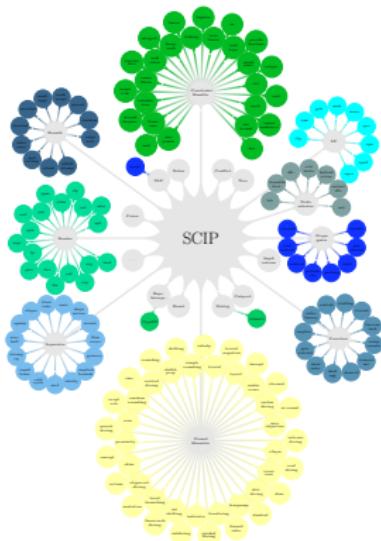


*SCIP is currently one of the fastest non-commercial solvers for mixed integer programming (MIP) and mixed integer nonlinear programming (MINLP).*

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### CODE

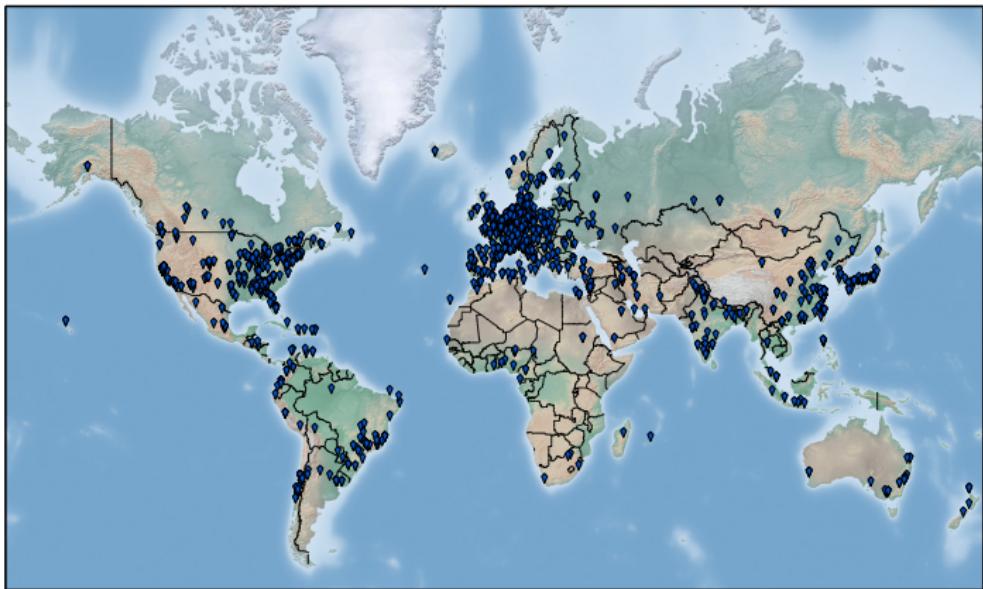
- ▶ more than 500 000 lines of C code
- ▶ plugin based design
- ▶ easily extendable and exchangeable



### DEVELOPERS

- ▶ approx. 20 active developers,  
  > 30 contributors
- ▶ most work at ZIB, some in  
  Aachen, Erlangen,  
  Darmstadt and Lancaster

- ▶ runs on Linux, Windows, macOS, ...
- ▶ free for academics, available in source code: <http://scip.zib.de>
- ▶ active mailing list with 400+ members: [scip@zib.de](mailto:scip@zib.de)
- ▶ 8000 downloads per year



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- ▶ first industry project: Chip design verification

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2016 First technical assistant without explicit research tasks

- ▶ stay attractive for new students, PhD candidates and postdocs
- ▶ establish an environment where everyone can grow and wants to stay
  - ▶ ZIB employs many PhD students and only few postdocs or professors
  - ▶ PhD students are usually employed for more than 5 years
- ▶ attract industry projects
  - ▶ forces code maturity, stability and performance
  - ▶ introduces challenging real world problems
  - ▶ finances development
- ▶ maintain communications
  - ▶ weekly meetings with all developers at ZIB
  - ▶ monthly online meetings with all developers

## Then and Now

## Take home messages / Lessons learned



# Source Code Management

# Source code management Infrastructure

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from the official website [git-scm.com](http://git-scm.com):

*"GIT is a free and open source distributed version control system"*

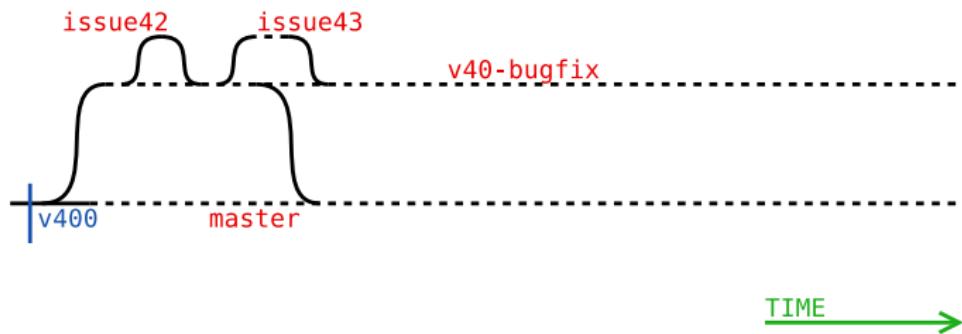
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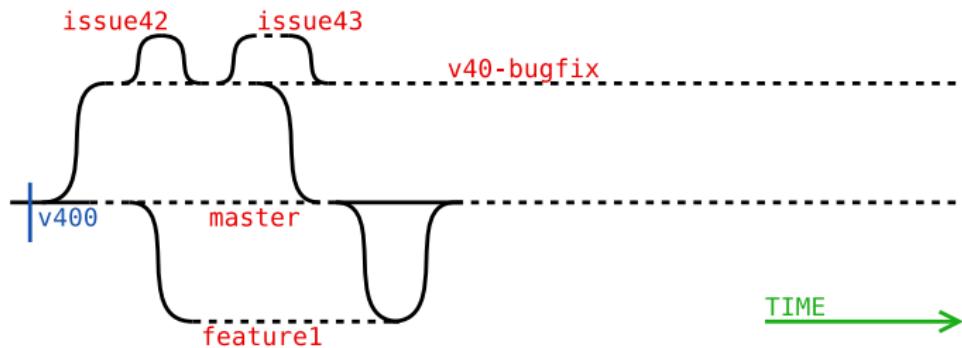
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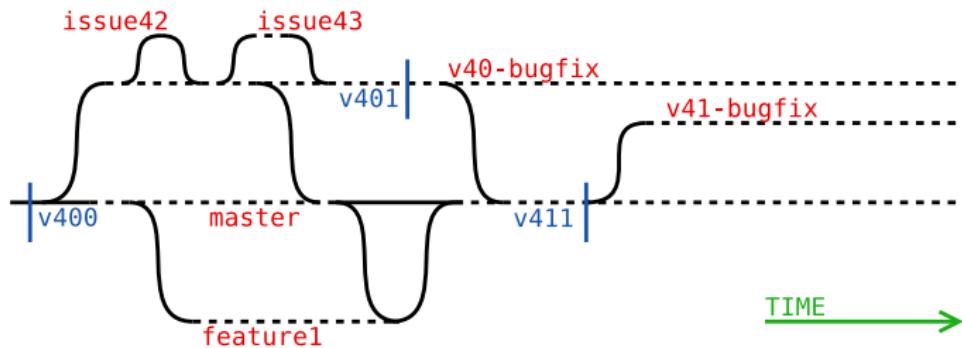
- ▶ Free and open source
- ▶ Distributed
- ▶ Snapshot based
- ▶ Staging Area
- ▶ Branches
- ▶ User system
- ▶ History/Evolution of code
- ▶ ...











GITLAB is an open-core self-hostable Git-repository manager, that provides Issuetracker, wiki, CI/CD and much more.

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- ▶ Issues
- ▶ Merge Requests
- ▶ Milestones
- ▶ integrates MATTERMOST (a messaging platform)
- ▶ ...

# Continuous testing

### Types of tests for SCIP

- ▶ Unit/end-to-end tests
- ▶ Different platform/compiler
- ▶ Code analysis
- ▶ Code Coverage

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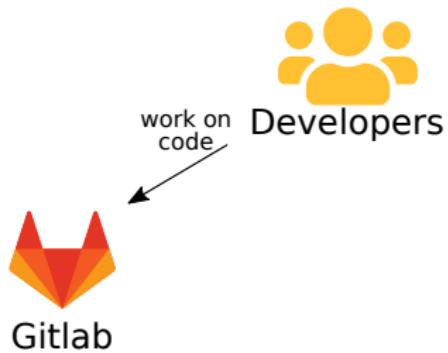
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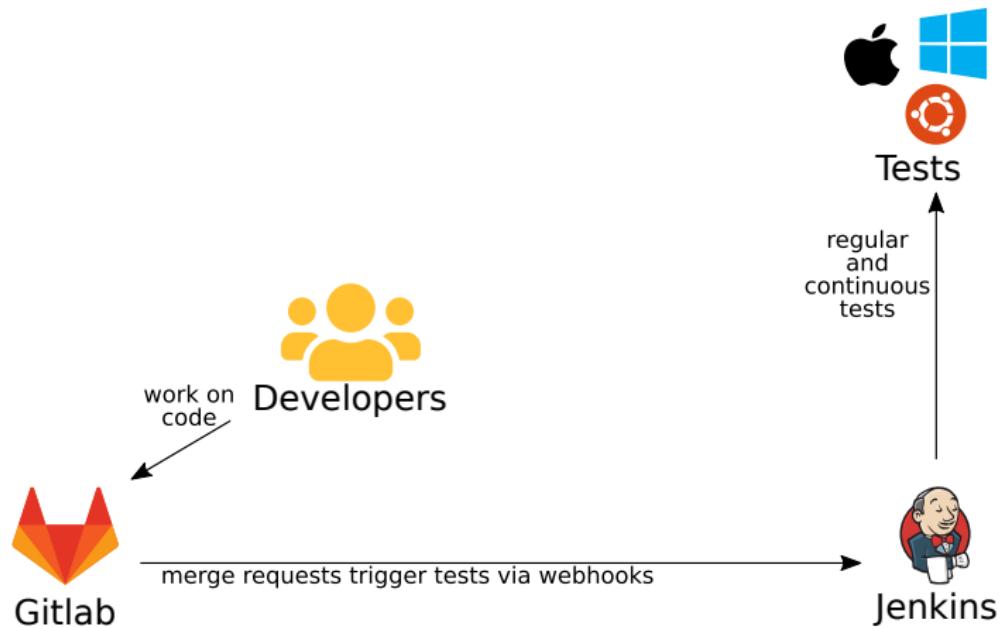
from the official website [jenkins.io](http://jenkins.io):

*"The leading open source automation server, JENKINS provides hundreds of plugins to support building, deploying and automating any project."*

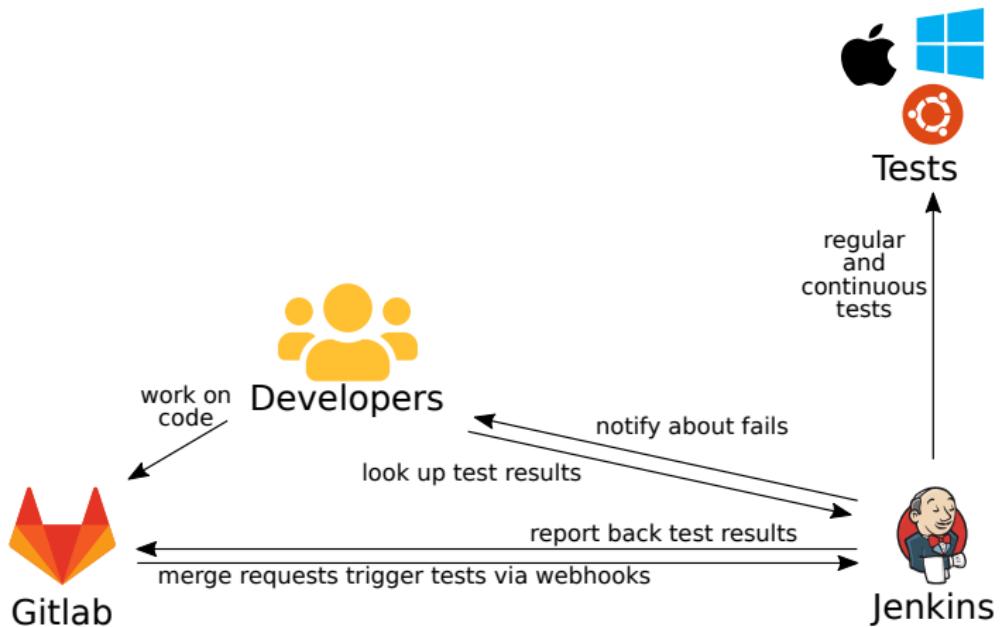
# Continuous testing Infrastructure



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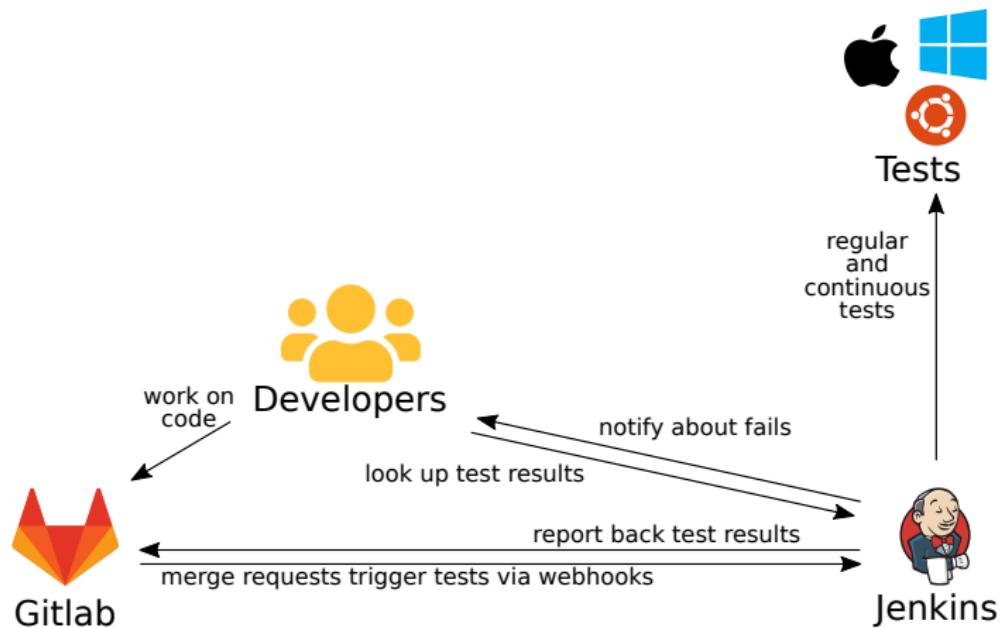
# Performance analysis

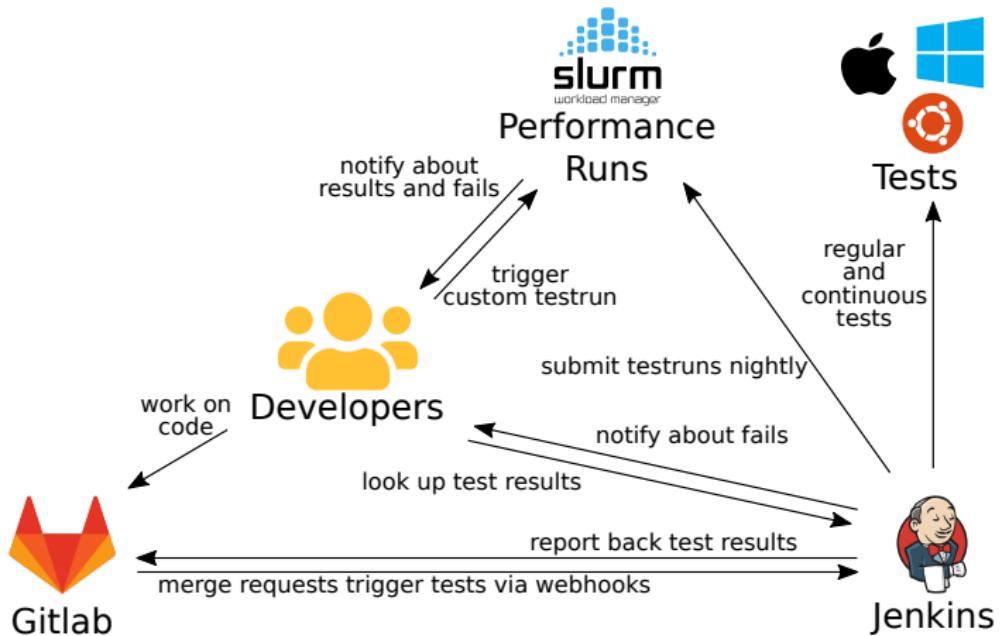
### What is a testrun?

- ▶ Run SCIP for a list of problem files (instances)
- ▶ Collect the output
- ▶ Concatenate output into big files

# Performance analysis

## Infrastructure







# Performance analysis

## Goal



Rubberband [Search](#) [Upload](#) [Help](#)

[schloesser@zib.de](#)

### Testruns



Repr.	Solver	LPSolver	Mode	Test Set	Setting	Seed	Pern	Timelimit	Host	Commit Timestamp	Uploader	Date Added
Ⓐ A sepaaggr (03. Nov 17)	(SCIP 4.0.2)	CPLEX 12.7.1.0	debug	short	sepaaggr	0	0	300.0s	opt-low	03. Nov 2017, 11:06	adm_time	05. Nov 2017, 03:48
Ⓑ B default (14. Feb 19)	(SCIP 6.0.2)	SoPlex 4.0.2	optimized	short	default	0	0	60.0s	mip-dbg	14. Feb 2019, 10:32	adm_time	14. Feb 2019, 11:40

[Details](#)

[Evaluation](#)

[Meta](#)

[Settings](#)

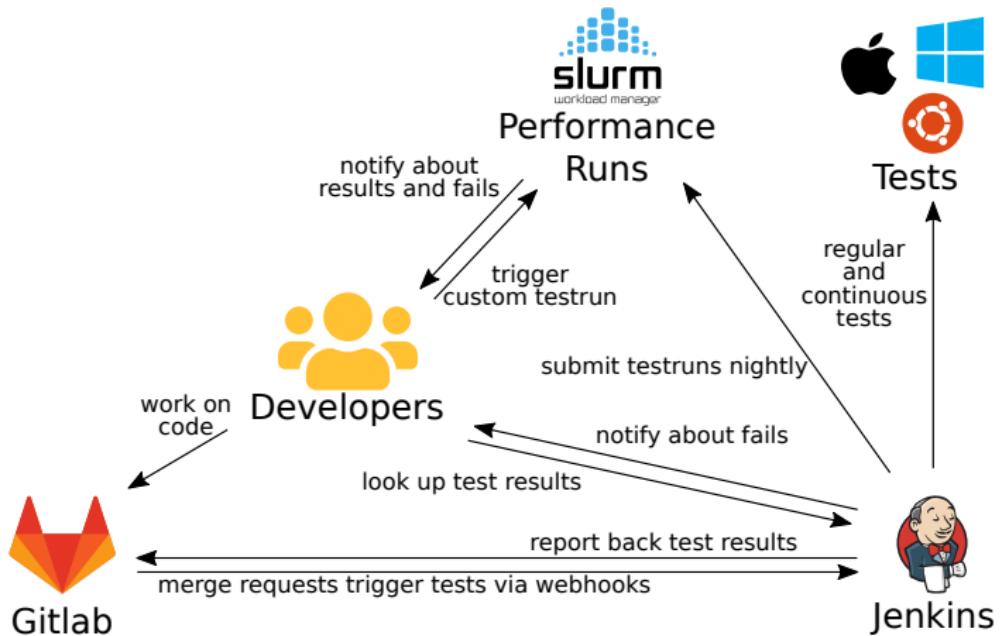
### Detailed data

Search:

Toggle columns:

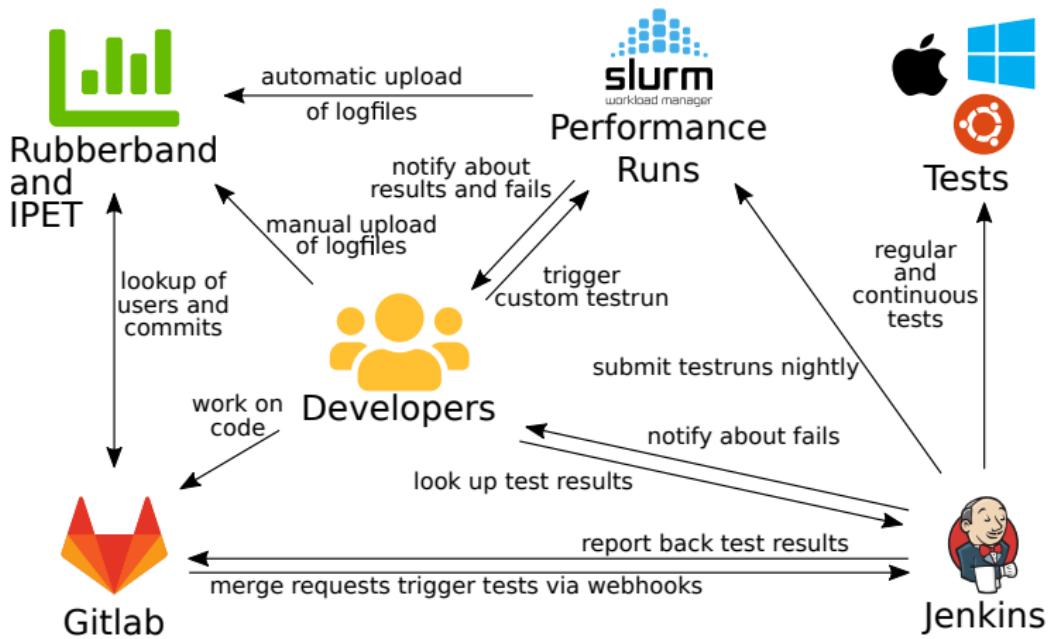
Nodes

Instance Name	Type	Original Cons	Original Vars	Presolved Cons	Presolved Vars	Dual Bound	Primal Bound	Gap	Iterations	Nodes	Solving Time	Total Time	Status
disj_conj_rail	CIP	63	53	56	50	1324.435574297	1324.435574297	0.0	54.0	27	0.03	0.03	ok
egout	MBP	98	141	37	49	568.1007	568.1007	0.0	54.0	1	0.02	0.02	ok
enigma	BP	21	100	21	100	0.0	0.0	0.0	3543.0	667	0.31	0.31	ok
ex1266	CIP	96	181	155	150	16.3	16.3	0.0	521.0	21	1.03	1.03	ok
factor-mod-si...6=307-B	CIP	505	640	405	529	3.0	3.0	0.0	15.0	1	0.05	0.05	ok
findRoot	CIP	3	101	3	101	1.0	1.0	0.0	10.0	11	0.0	0.0	ok
flugpl	IP	18	18	13	14	1201500.0	1201500.0	0.0	231.0	194	0.07	0.07	ok
gt2	IP	29	188	28	173	21166.0	21166.0	0.0	122.0	1	0.02	0.02	ok
j301_2	CIP	52	32	61	24	47.0	47.0	0.0	8.0	1	0.01	0.01	ok
linking	CIP	2	16	1	12	2.0	2.0	0.0	0.0	1	0.0	0.0	ok
lseu	BP	28	89	84	60	1120.0	1120.0	0.0	2903.0	382	0.67	0.67	ok
m3	MINLP	43	26	39	22	37.7999969901	37.7999969901	0.0	178.0	9	0.16	0.16	ok
MANN_n9.clq	BP	72	45	72	45	16.0	16.0	0.0	89.0	6	0.02	0.02	ok
mcf128-4-1	CIP	1832	2596	637	1566	14.0	14.0	0.0	759.0	1	0.17	0.17	ok
mcf64-4-1	CIP	928	1308	336	795	10.0	10.0	0.0	597.0	41	0.15	0.15	ok
meanvarxsc	CIP	43	36	38	23	14.3692318921	14.3692318921	0.0	66.0	5	0.16	0.16	fail_solution_infeasible
misc03	BP	96	160	95	138	3360.0	3360.0	0.0	1838.0	15	0.46	0.46	ok
normalized-bs...10_4_5	BP	97	66	31	20	-4.0	-4.0	0.0	127.0	1	0.03	0.03	ok
normalized-md...50_25_5	BP	1564	1514	84	23	3.0	3.0	0.0	968.0	4	0.23	0.23	ok
normalized-md...10_4_3	BP	72	62	8	7	2.0	2.0	0.0	4.0	1	0.0	0.0	ok
normalized-t2...1218308	BP	101	169	73	169	0.0	0.0	0.0	666.0	5	0.32	0.32	ok
normalized-t2...3-100-0	CIP	166	233	159	277	4.0	4.0	0.0	2434.0	53	0.68	0.68	ok
p0033	BP	16	33	13	28	3089.0	3089.0	0.0	58.0	1	0.01	0.01	ok



# Performance analysis

## Infrastructure



IPET

"Interactive Performance Evaluation

Tools for Optimization Software"

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Tools for Optimization Software"

- ▶ Extract and evaluate data from logfiles
- ▶ Flexible and customizable
- ▶ Commandline tool (plus rudimentary GUI)

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- ▶ Standardized interface to IPET for benchmark evaluation

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

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

Both python tools developed by members of the SCIP group at ZIB.

# Performance analysis RUBBERBAND and IPET

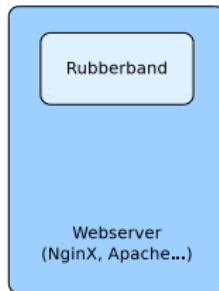
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Rubberband

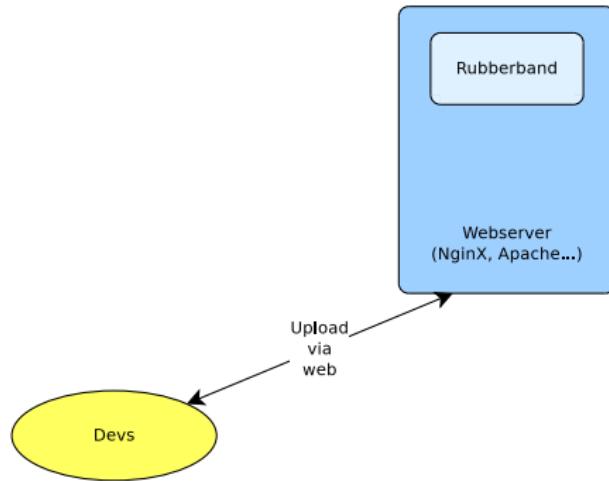
# Performance analysis

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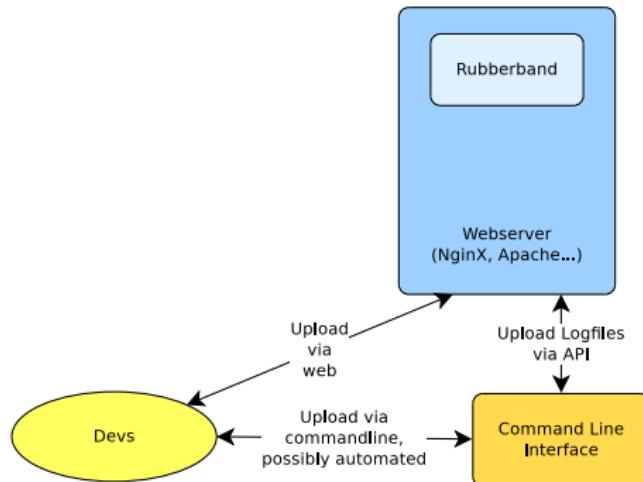


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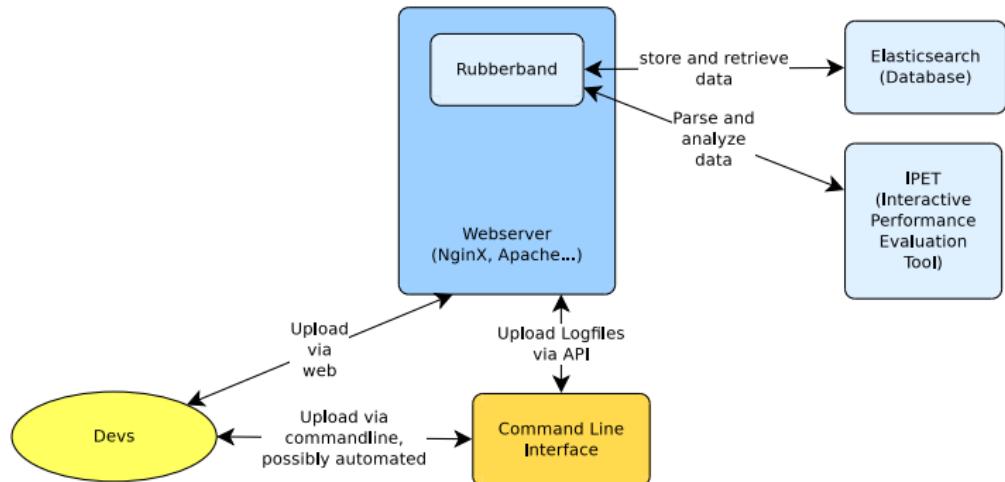
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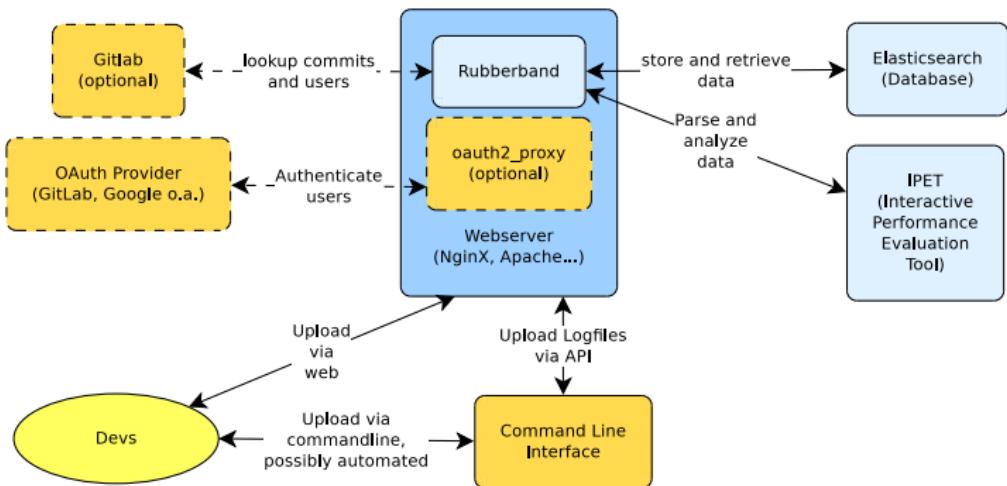


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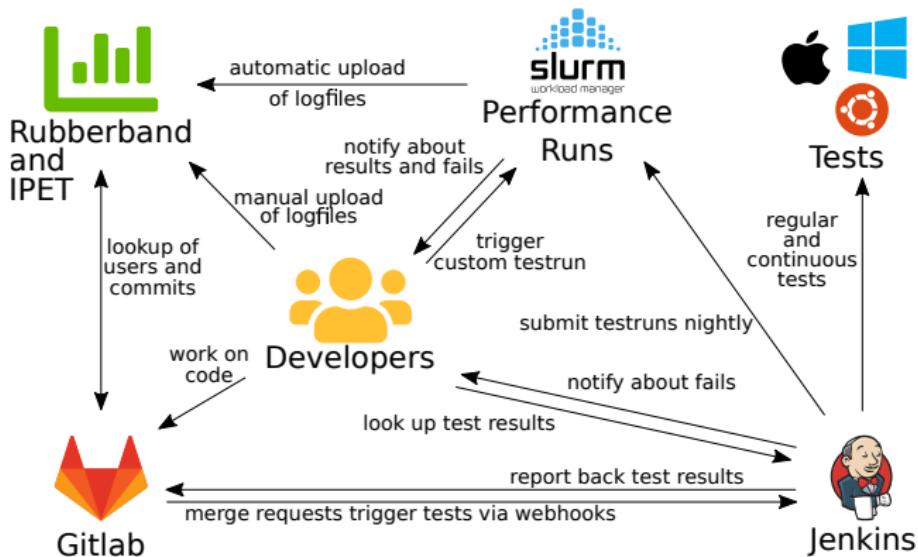


# Performance analysis

## RUBBERBAND and IPET



# Thank you for your attention! Questions?



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