



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



Introduction

We solve Problems!



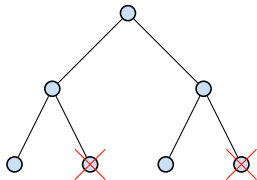
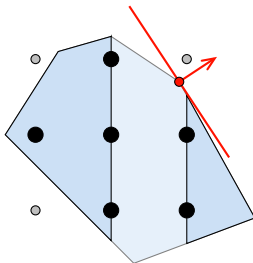
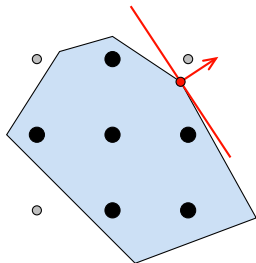
- ▶ *manufacturing*: sheet metal design
- ▶ *networks*: operation and design of water and gas networks
- ▶ *energy production and distribution*: plant design, power scheduling
- ▶ *logistics*: public transport, supply-chain management
- ▶ *industrial engineering*: mining with stockpiling constraints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



$$\begin{aligned} \min \quad & c^T x + d^T y \\ \text{subject to} \quad & Ax + By = b \end{aligned}$$

linear constraints

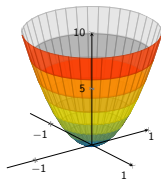
$$x \in \mathbb{Z}^n, y \in \mathbb{R}^m$$



$$\begin{aligned} \min \quad & c^T x + d^T y \\ \text{subject to} \quad & Ax + By = b \\ & G(x, y) = 0 \\ & x \in \mathbb{Z}^n, y \in \mathbb{R}^m \end{aligned}$$

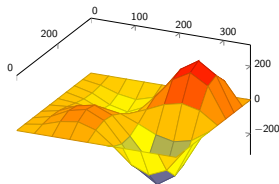
linear constraints
nonlinear constraints

The functions $g_k \in G$ can be



convex

or



nonconvex

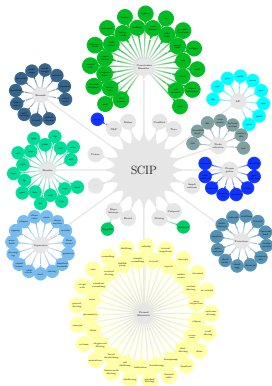


SCIP is currently one of the fastest non-commercial solvers for mixed integer programming (MIP) and mixed integer nonlinear programming (MINLP).

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CODE

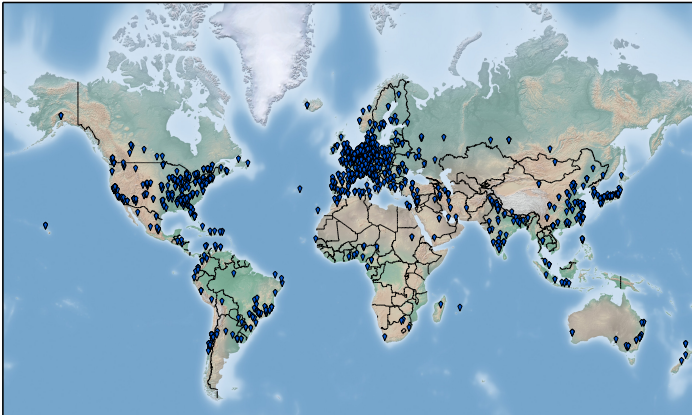
- ▶ more than 500 000 lines of C code
- ▶ plugin based design
- ▶ easily extendable and exchangeable



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
- ▶ 8000 downloads per year



Then and Now

How SCIP came to be



2002 Tobias Achterberg starts SCIP project

- ▶ 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



from the official website `git-scm.com`:

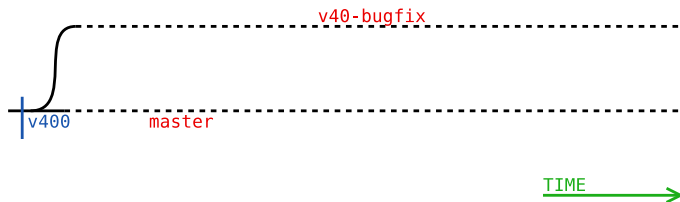
"GIT is a free and open source distributed version control system"

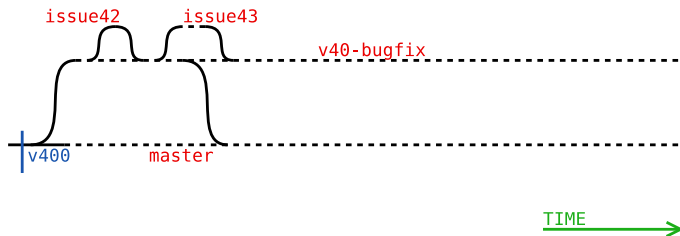
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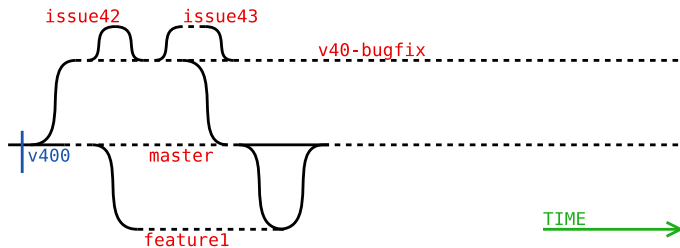
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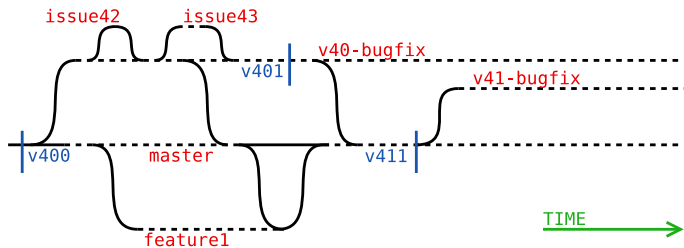
- ▶ Free and open source
- ▶ Distributed
- ▶ Snapshot based
- ▶ Staging Area
- ▶ Branches
- ▶ User system
- ▶ History/Evolution of code
- ▶ ...











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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Schedule

- ▶ Regularly (i.e. every night)
- ▶ run tests on Merge Request
- ▶ update websites/install software on code update

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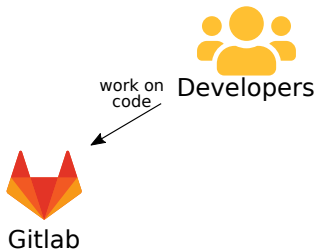
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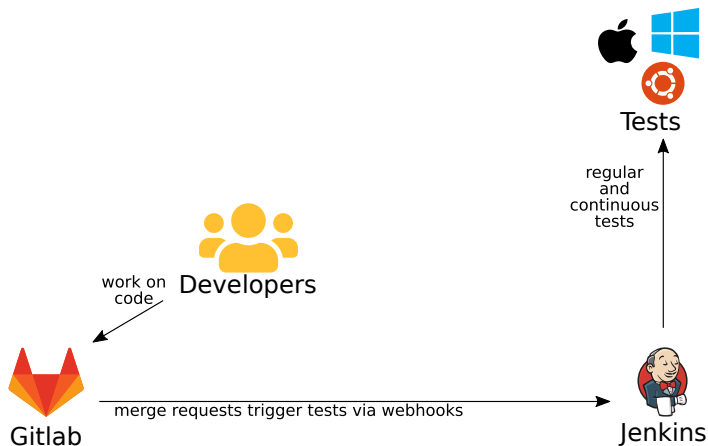
Schedule

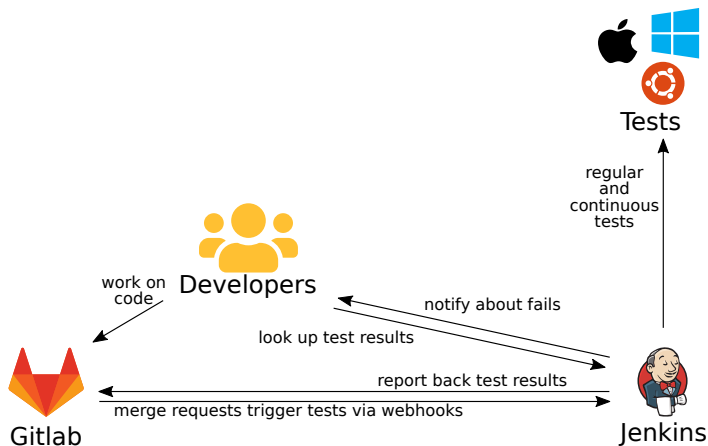
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from the official website `jenkins.io`:

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



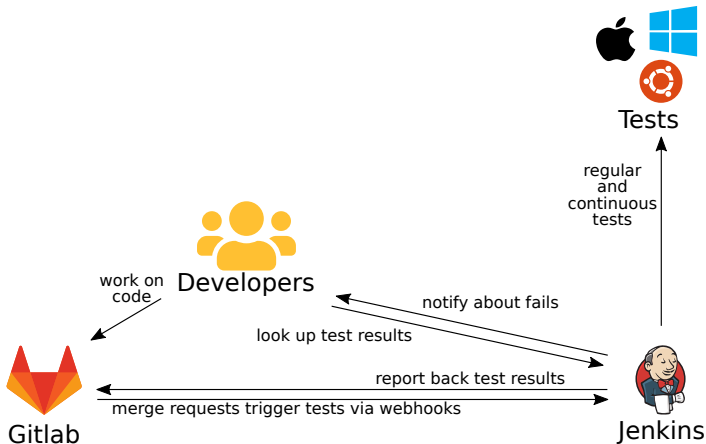


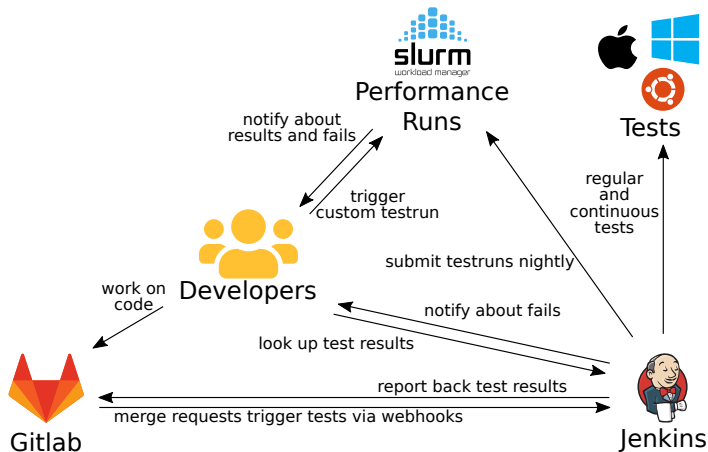


Performance analysis

What is a testrun?

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





Performance analysis

Goal



Rubberband 🔍 Search 📁 Upload ? Help

schloesser@zib.de

Testruns ▼



Repr.		Solver	LPsolver	Mode	Test Set	Setting	Seed	Perm	TimeLimit	Host	Commit	Timestamp	Uploader	Date Added
⊙ A sepaagr (03. Nov 17)	★	SCIP 4.0.2	CPLX 12.7.1.0	debug	short	sepaagr	0	0	300.0s	opt-low	03. Nov 2017, 11:06		ada_tino	05. Nov 2017, 03:48
⊙ B default (14. Feb 19)	★	SCIP 6.0.2	SoPlex 4.0.2	optimized	short	default	8	0	60.0s	nip-dbg	14. Feb 2019, 10:32		ada_tino	14. Feb 2019, 11:40

Details

Evaluation

Meta

Settings

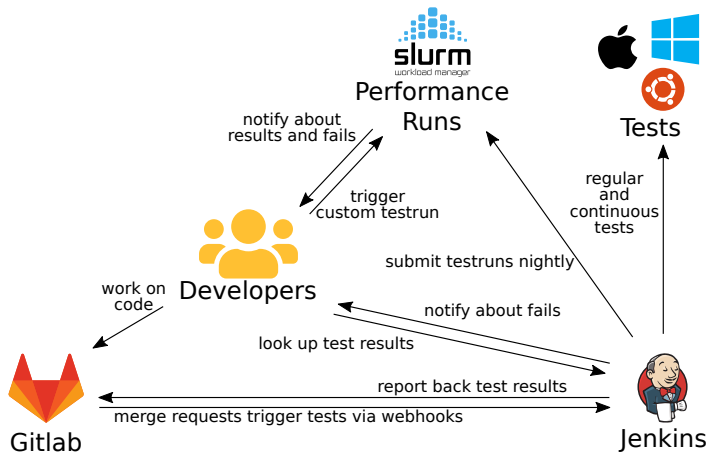
Detailed data

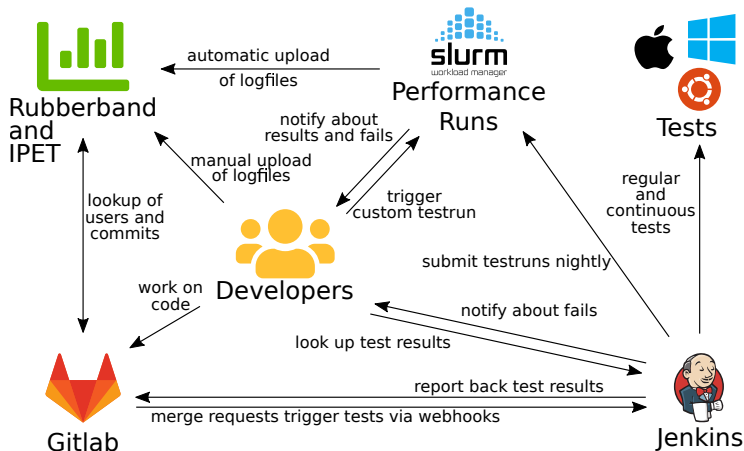
Search:

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	1324.4355742297	1324.4355742297	0.0	54.0	27	0.03	0.03	ok
egout	MBP	98	141	37	49	568.1807	568.1807	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	101	155	150	16.3	16.3	0.0	521.0	21	1.03	1.03	ok
factor-mod-si...6=307-B	CIP	505	648	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	108	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	0.0	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	302	0.67	0.67	ok
n3	MINLP	43	26	39	22	37.7999969901	37.7999969901	0.0	178.0	9	0.16	0.16	ok
MANI_a9.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	30	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	1038.0	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	960.0	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...1210308	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	20	3089.0	3089.0	0.0	58.0	1	0.01	0.01	ok





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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RUBBERBAND

is a flexible archiving platform for
optimization benchmarks.

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RUBBERBAND

is a flexible archiving platform for
optimization benchmarks.

- ▶ Archives the logfiles in `ELASTICSEARCH` database
- ▶ Accessible (browser based, unique links)
- ▶ Standardized interface to IPET for benchmark evaluation

IPET

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github.com/GregorCH/ipet/

RUBBERBAND

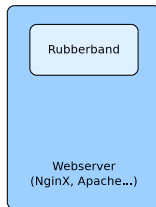
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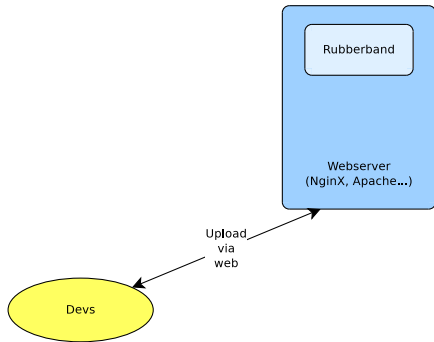
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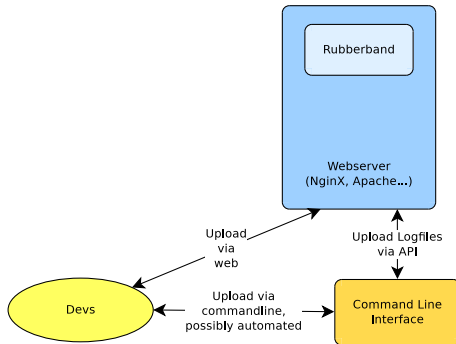
github.com/ambros-gleixner/rubberband

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

Rubberband

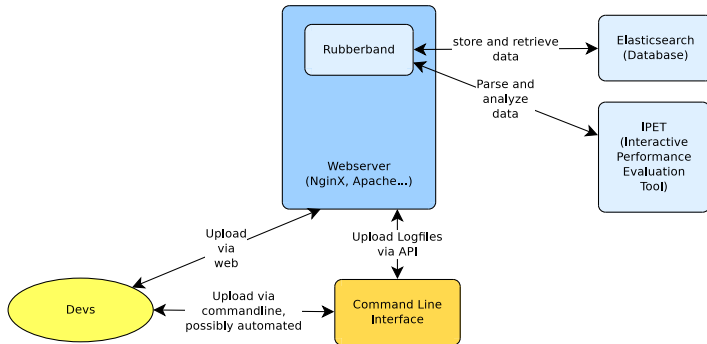






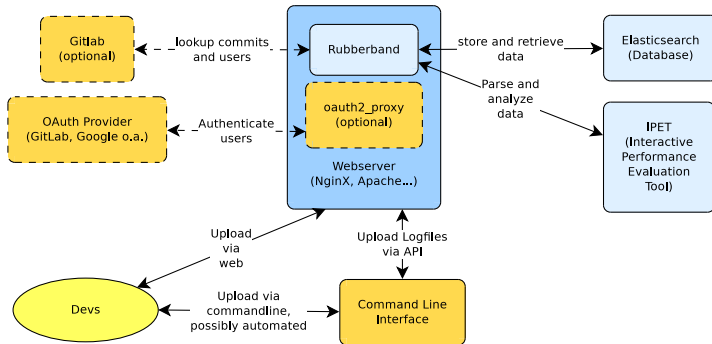
Performance analysis

RUBBERBAND and IPET

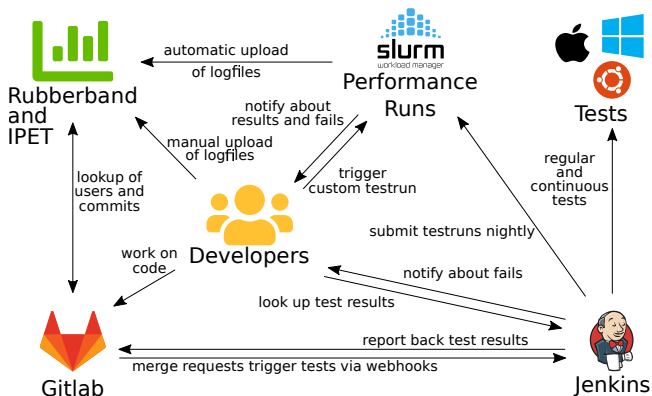


Performance analysis

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Thank you for your attention! Questions?



Interested? Come visit our poster!