



Open-source Quality Assurance and Performance Analysis Tools

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Welcome/Agenda

SQA at GAMS

Effective Testing

Performance Analysis Tool Paver

Examples



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Examples

Solver/Platform availability - 24.1 May 30, 2013

	x86 MS Windows	x86_64 MS Windows	x86 Linux	x86_64 Linux	Sun Sparc SOLARIS	Sun Sparc64 SOLARIS	Sun Intel SOLARIS	IBM RS-6000 AIX	Mac x86_64 Darwin
ALPHAEC	✓	✓	✓	✓	✓	✓	✓	✓	✓
ANTIGONE 1.0	✓	✓	✓	✓					
BARON 12.3	✓	✓	✓	✓					
BDMLP	✓	✓	✓	✓	✓	✓	✓	✓	✓
COIN-OR	✓	✓	✓	✓			✓		✓
CONOPT 3	✓	✓	✓	✓	✓	✓	✓	✓	✓
CPLEX 12.5	✓	✓	✓	✓	✓	✓	✓	✓	✓
DECIS	✓	✓	✓	✓	✓	32bit			
DICOPT	✓	✓	✓	✓	✓	✓	✓	✓	✓
GLOMIQO 2.2	✓	✓	✓	✓					
GUROBI 5.5	✓	✓	5.0	✓				✓	✓
KNITRO 8.1	✓	✓	✓	✓			✓		✓
LINDO 8.0	✓	✓	✓	✓			✓		✓
LINDOGLOBAL 8.0	✓	✓	✓	✓	6.0	6.0	✓		✓
LGO	✓	✓	✓	✓	✓	✓	✓		✓
MILES	✓	✓	✓	✓	✓	✓	✓	✓	✓
MINOS	✓	✓	✓	✓	✓	✓	✓	✓	✓
MOSEK 7	✓	✓	✓	✓					✓
MPSGE	✓	✓	✓	✓	✓	✓	✓	✓	✓
MSNLP	✓	✓	✓	✓	✓	32bit			✓
NLPEC	✓	✓	✓	✓	✓	✓	✓	✓	✓
OQNLP	✓	32bit	✓	32bit					
PATH	✓	✓	✓	✓	✓	✓	✓	✓	✓
SBB	✓	✓	✓	✓	✓	✓	✓	✓	✓
SCIP 3.0	✓	✓	✓	✓			✓		✓
SNOPT	✓	✓	✓	✓	✓	✓	✓	✓	✓
SOPLEX 1.7	✓	✓	✓	✓			✓		✓
SULUM 2.0	✓	✓	✓	✓					
XA	✓	✓	✓	✓					
XPRESS 24.01	✓	✓	✓	✓	✓	✓	✓	✓	✓

For backward compatibility we maintain older versions of operating systems and solvers. Please call.



Motivation

Quality Assurance

- Essential component in most industries
- Important in most software engineering sectors

Mathematical Programming

- Less attention to quality assurance (small community)
- Specific QA issues for modeling systems (initially expensive)
- Different focus for industry and academia





Software Quality Assurance at GAMS

- Software configuration management
- Quality control and tests of the product
- Client model testing
- Performance Analysis tools: PAVER
- Solution verification tool: Examiner
- Model converter and “encryption” tool: Convert



Quality Test Models Library

- Include tests to verify proper behavior of the system
- More than 600 quality test models, each containing numerous pass/fail tests:

```
...  
abort$card(delta) 'time routines have an error';  
...
```

- Check basic functionality of the solver and the link:

```
...  
abort$( abs(cost.m-cost_m) > tol) 'bad cost.m';  
...
```

- Gives developer and users assurance about the basic functionality of the link and the solver
- Automatic generated test summaries with different level of information



Latest GAMS System Builds and Test Results

Monday 01Jul13 19:36 (UTC)

[[Latest Builds](#) | [Alpha Builds](#) | [Beta Builds](#) | [Nightly Builds](#) | [Glossary](#)]

[Comments?](#)

NOTE: The (nightly) alpha builds are internal development versions of the GAMS system. They may have known bugs, unfinished features, beta versions of third-party software, or may not function at all! Not for production use!

nightly α	System	Libraries	Build	Rev	Status and Time (UTC)	Initial Tests	Full Tests
Thursday	Inx	Download	24.2.0	41150	Test started 28Jun2013 01:43:36	918 runs 1 failures (q=1,s=0)	Report results pending
Monday	leg	Download	24.2.0	41173	Test done 01Jul2013 17:15:28	777 runs 0 failures (q=0,s=0)	Report 2141 runs 1 failures (q=0,s=0,a=1) Report
Friday	vs8	Download	24.2.0	41164	Test started 29Jun2013 01:06:54	920 runs 0 failures (q=0,s=0)	Report results pending
Friday	wei	Download	24.2.0	41166	Test started 29Jun2013 03:23:50	917 runs 1 failures (q=1,s=0)	Report results pending
nightly β	System	Libraries	Build	Rev	Status and Time (UTC)	Initial Tests	Full Tests
Thursday	Inx	Download	24.1.2	41150	Test done 01Jul2013 18:58:07	897 runs 0 failures (q=0,s=0)	Report 16714 runs 3 failures (q=0,s=3) Report
Thursday	vs8	Download	24.1.2	41150	Test done 28Jun2013 07:47:08	761 runs 0 failures (q=0,s=0)	Report 11107 runs 0 failures (q=0,s=0) Report
Friday	wei	Download	24.1.2	41166	Test done 01Jul2013 13:32:22	896 runs 0 failures (q=0,s=0)	Report 16768 runs 1 failures (q=0,s=1) Report
alpha	System	Libraries	Build	Rev	Status and Time (UTC)	Initial Tests	Full Tests
20130427	aix	Download	24.1.0	39956	Test done 27Apr2013 22:18:39	387 runs 1 failures (q=1,s=0)	Report 3427 runs 5 failures (q=1,s=1,e=3) Report
20130627	deg	Download	24.2.0	41138	Test done 27Jun2013 12:50:22	706 runs 0 failures (q=0,s=0)	Report 10171 runs 0 failures (q=0,s=0) Report
20130627	leg	Download	24.2.0	41138	Test done 27Jun2013 21:15:39	778 runs 0 failures (q=0,s=0)	Report 11666 runs 0 failures (q=0,s=0) Report



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Effective Testing

- Test cases
 - Widely available collection of standardized test instances
- Data collection tools
 - Automatic collection of solution and statistics
 - Capture test environment setting (hardware, software)
- Data analysis tools
 - Standard quality and performance measurements
- Give the tools in the hand of the user.
Make your own benchmarks!

GAMS



GAMS World

The Worlds
CONE
GLOBAL
MINLP
MPEC
MPSGE
Performance
Translation
Search
Contact

Welcome to the GAMS World

This is the home page of the GAMS World, a web site aiming to bridge the gap between academia and industry by providing highly focused forums and dissemination services in specialized areas of mathematical programming.

Substantial progress was made in the 1980s and 1990s with the development of algebra based modeling systems, algorithms, and computer codes to solve large and complex mathematical programs. The application of these tools, however, was less than expected. The abstraction, expression, and translation of real world problems into reliable and effective operational systems requires highly specialized and domains specific knowledge. The process of acquisition and dissemination of this knowledge is complex and poorly understood and the number of "good modelers" is much less than we all hoped for. Similarly, the process of transforming a new algorithm into a reliable and effective solution system is a slow and expensive process and there are few "good implementers". This web site hopes to address some of these problems by helping with the collection and dissemination of domain specific information and knowledge that is outside the established channels because of its content or form.

For example, model structures and results get published in commercial and academic papers but it is virtually impossible to reproduce any of those results or lift model components and data from one study to be used in some other study. Algorithm implementers face a similar dilemma when trying to get their hands on real world data models and data to test and refine their systems. This web site offers a few, well focused and maintained services to help with the dissemination of problems and solutions.

The GAMS World Google discussion group is associated with GAMS World.

Subscribe to the GAMSWORLD Newsgroup	
 Google Groups	
Email:	Subscribe
Browse Archives at groups.google.com	



Performance World

Welcome to the Performance World!

Performance World is a forum for discussion and dissemination of information and tools about all aspects of performance testing of solvers for mathematical programming problems. This world has been established in response to user demands for independent and reproducible performance results.

Overall performance highly depends on problem formulation, solver, and tuning parameters. Our performance tools are designed to serve the different needs of our user community. One user may be interested in finding the most reliable way to solve a proprietary or classified model. On the other hand, an academic researcher may be interested in testing a new algorithm against a set of existing test problems and competing approaches. The main features are:

- Uniform access to a comprehensive set of established and new test problems
- Automation tools for collecting performance measurements
- Tools for analyzing and visualizing test results

What's New:

- Experimental [PAVER 2.0 Server](#) is on-line.
- The paper [PAVER 2.0: An Open Source Environment for Automated Performance Analysis of Benchmarking Data](#) is available.
- Several new libraries ([Fixed Cost Network Flow](#) and the [Princeton NLP](#) collection) have been added to the [Performance Libraries](#).
- A collection of quadratically constrained programs (QCP) have been added to the LINLIB set of models.
- The paper [A Server for Automated Performance Analysis and Benchmarking of Optimization Software](#) is available which includes an NLP benchmark using PAVER. See the results on ([all models](#) or a [subset of models](#)).
- Presentations on benchmarking and performance testing from the INFORMS 2002, San Jose conference have been added to the [related links section](#)
- Try our online [PAVER Server](#) for automated performance analysis and visualization, batch file creation and model translation
- New tools for [analyzing non-convex or discrete models](#) (quality of solution information)
- MINLP type models from the [MINLP World](#) have been added to the [PerformanceLib](#)

Editorial Board

PerformanceLib

Performance Tools

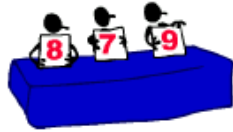
PAVER Server

Performance List

Related Links

Search

Contact



MacMOOP - A Collection of Multiobjective Optimization Testproblems

MacMOOP is a collection of multiobjective optimization testproblems from Sven Leyffer. See the [MacMOOP Collection](#). The GAMS models were translated by Andre Savitsky as is from the [original AMPL source](#).

The raw GAMS models were converted into GAMS scalar format using the CONVERT facility. For models with multiple solves, only the first solve instance is translated.

Download

Download [MacMOOPLib.zip](#)

Total number of models: 14

Original Source: [My AMPL Collection of Multiobjective Optimization Testproblems \(Sven Leyffer\)](#)

Name	Type	#Eqns	#Vars	#NZ	#NNZ	Bestknown Objective	GAMS Scalar	AMPL Source	GAMS Source
abc-comp	NLP	4	3	9	4	17.96428571	gms	ampl	raw gms
ex001	NLP	4	6	21	11	0.55508075	gms	ampl	raw gms
ex002	NLP	3	6	13	3	8.00000000	gms	ampl	raw gms
ex003	NLP	3	3	7	5	7.25098758	gms	ampl	raw gms
ex004	LP	4	3	7	0	2.00000000	gms	ampl	raw gms
ex005	NLP	1	3	3	2	-4.00000000	gms	ampl	raw gms
hs05x	NLP	4	6	13	5	0.14049587	gms	ampl	raw gms
liswetm	NLP	3	9	13	7	-3.41233322	gms	ampl	raw gms
molpg_1	NLP	9	9	51	0	-26.01668874	gms	ampl	raw gms
molpg_2	NLP	17	13	67	0	-13.37500000	gms	ampl	raw gms
molpg_3	NLP	15	11	55	0	-13.40000000	gms	ampl	raw gms
moqp_1	NLP	14	24	102	60	-57.29327326	gms	ampl	raw gms
moqp_2	NLP	13	24	102	60	-13.16755651	gms	ampl	raw gms
moqp_3	NLP	14	24	101	60	-24.54193065	gms	ampl	raw gms

```

* MINLP written by GAMS Convert
Variables
b1,b2,i3,i4,i5,i6,i7,i8,x9;
Binary Variables b1,b2;
Integer Variables i3,i4,i5,i6,i7,i8;
Equations
e1,e2,e3,e4,e5,e6,e7,e8,e9,e10,
    e11,e12,e13;

e1.. 0.1*b1 + 0.2*b2 + i3 + i4 - x9
=E= 0;
e2.. 460*i5 + 570*i7 =L= 1900;
e3.. 460*i6 + 570*i8 =L= 1900;
e4.. 460*i5 + 570*i7 =G= 1700;
e5.. 460*i6 + 570*i8 =G= 1700;
e6.. i5 + i7 =L= 5;
e7.. i6 + i8 =L= 5;
e8.. i3*i5 + i4*i6 =G= 8;
e9.. i3*i7 + i4*i8 =G= 7;
e10.. b1 - i3 =L= 0;
e11.. b2 - i4 =L= 0;
e12.. - 15*b1 + i3 =L= 0;
e13.. - 15*b2 + i4 =L= 0;

* set non default bounds
i3.up = 15; i4.up = 15; i5.up = 5;
i6.up = 5; i7.up = 5; i8.up = 5;

Model m / all /;
Solve m using MINLP minimizing x9;

```

```

# MINLP written by GAMS Convert
var b1 binary;
var b2 binary;
var i3 integer >= 0, <= 15;
var i4 integer >= 0, <= 15;
var i5 integer >= 0, <= 5;
var i6 integer >= 0, <= 5;
var i7 integer >= 0, <= 5;
var i8 integer >= 0, <= 5;

minimize obj:
    0.1*b1 + 0.2*b2 + i3 + i4;

subject to

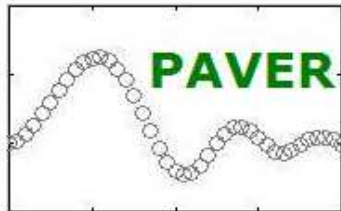
e2: 460*i5 + 570*i7 <= 1900;
e3: 460*i6 + 570*i8 <= 1900;
e4: 460*i5 + 570*i7 >= 1700;
e5: 460*i6 + 570*i8 >= 1700;
e6: i5 + i7 <= 5;
e7: i6 + i8 <= 5;
e8: i3*i5 + i4*i6 >= 8;
e9: i3*i7 + i4*i8 >= 7;
e10: b1 - i3 <= 0;
e11: b2 - i4 <= 0;
e12: - 15*b1 + i3 <= 0;
e13: - 15*b2 + i4 <= 0;

```

minlp;



GAMSWorld Translation Service



[[Home](#) | [Tools](#) | [Links/Other](#) | [Performance World](#)]

PAVER - GAMS Model Translation Web Submission Tool (GMS2XX)

The PAVER GAMS model translation web-submission tool runs the [GAMS/CONVERT](#) "solver" to translate GAMS models into the following supported languages:

- AlphaECP
- AMPL
- AmplNLC
- BARON
- CoinFML
- CplexLP
- CplexMPS
- Dict
- FixedMPS
- GAMS (scalar)
- Jacobian
- Lago
- Lgo
- LindoMPI
- LINGO
- MINOPT
- NLP2MCP
- ViennaDag



Data Collection – GAMS Trace Files

```

C:\Users\Michael\Desktop\Nurses\gams\transport.lst
transport.gms | transport.lst

+ Compilation
+ Equation Listing
+ Equation
+ Column Listing
+ Column
+ Model Statistics
- Solution Report
+ SolEQU
+ SolVAR
+ Execution
+ Display

GENERATION TIME      =      0.000 SECONDS      4 MB  24.1.2 r40979 WEX-WEI

EXECUTION TIME       =      0.000 SECONDS      4 MB  24.1.2 r40979 WEX-WEI
GAMS 24.1.2 r40979 Released Jun 16, 2013 WEX-WEI x86_64/MS Windows 06/27/13 05:15:08
A Transportation Problem (TRANSPORT,SEQ=1)
Solution Report      SOLVE transport Using LP From line 66

          S O L V E      S U M M A R Y

MODEL  transport          OBJECTIVE  z
TYPE   LP                 DIRECTION MINIMIZE
SOLVER CPLEX              FROM LINE 66

**** SOLVER STATUS      1 Normal Completion
**** MODEL STATUS       1 Optimal
**** OBJECTIVE VALUE    153.6750
  
```

* Trace Record Definition

* GamsSolve

* InputFileName, ModelType, SolverName, OptionFile, Direction, NumberOfEquations,

* NumberOfVariables, NumberOfDiscreteVariables, NumberOfNonZeros,

* NumberOfNonlinearNonZeros, ModelStatus, SolverStatus, ObjectiveValue,

* ObjectiveValueEstimate, SolverTime, ETSolver, NumberOfIterations, NumberOfNodes

*

30n20b8, MIP, SCIP, 1, 0, 577, 18381, 11098, 109709, 0, 1, 1, 302, 302, 186.80, 189.833, 464659, 466
acc-tight5, MIP, SCIP, 1, 0, 3053, 1340, 1339, 16136, 0, 1, 1, 0, 0, 366.28, 367.651, 1788064, 1971
afLOW40b, MIP, SCIP, 1, 0, 1443, 2729, 1364, 8148, 0, 1, 1, 1168, 1168, 1411.99, 1425.472, 5232401, 3773

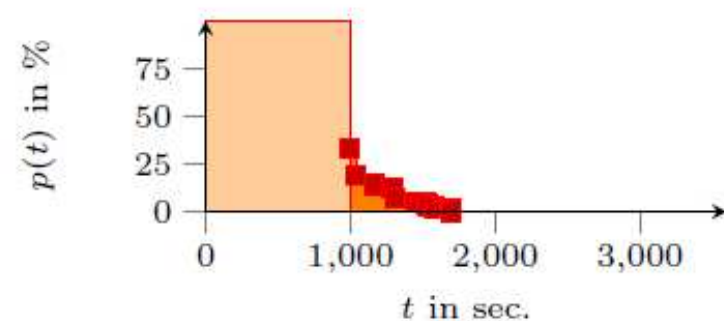
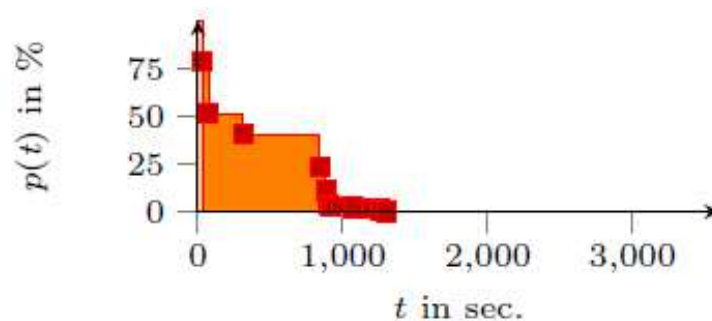


More Data Collection – MIP|SolveTrace

Timo Berthold: Measuring the impact of primal heuristics

$$P(T) := \int_{t=0}^T p(t),$$

```
* solvetrace file SCIP.miptrace: ID = SCIP 3.0.1
* fields are lineNum, seriesID, node, seconds, bestFound, bestBound
1, S, 1, 0, 260614197.6, 216717059.8
2, T, 3, 1.1205, 260614197.6, 217028062.2
...
63, E, 2550, 38.3884, 220249516.8, 217928729.7
* solvetrace file closed
```





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PAVER Server

- PAV~~E~~R server (**P**erformance **A**nalysis and **V**isualization for **E**ffortless **R**eproducibility)
- 2013: Complete rewrite PAV~~E~~R 2.0(Python):
 - New functionality:
 - consistency checks
 - comparison against solution database
 - many more metrics
 - Easily extendable
 - Open source (COIN-OR project)



PAVER 2 – Web Submission

PAVER 2 SERVER - Performance Analysis Web Submission Tool

The PAVER web-submission tool runs the PAVER perform

- [paver.zip](#). See the [README](#) for details.

Users can input their data in the form of trace files, which c
format.

If you find this tool useful, please consider citing the paper
M. Bussieck, S. Dirkse, S. Vigerske (2013). PAVER 2.0: A

Note: there is a maximum total file size limit of 1Mb.

Submit trace files:

- | | | |
|----------------|--|-------------------|
| Trace 1 | <input type="button" value="Browse..."/> | blitzen.trc |
| Trace 2 | <input type="button" value="Browse..."/> | comet.trc |
| Trace 3 | <input type="button" value="Browse..."/> | cupid.trc |
| Trace 4 | <input type="button" value="Browse..."/> | No file selected. |
| Trace 5 | <input type="button" value="Browse..."/> | No file selected. |
| Trace 6 | <input type="button" value="Browse..."/> | No file selected. |
| Trace 7 | <input type="button" value="Browse..."/> | No file selected. |
| Trace 8 | <input type="button" value="Browse..."/> | No file selected. |

Submit solution files (optional):

- | | |
|--------------------|--|
| MINLPLib | ☐ |
| GlobalLib | ☐ |
| LinLib | ☐ |
| MIPLIB 2010 | ☐ |
| Solutions 1 | <input type="button" value="Browse..."/> No file selected. |

Optional Settings:

- | | | |
|---|-------------------------------------|--|
| Relative Tolerance on Bounds: | <input type="text" value="1e-6"/> | (Consistency Checks) |
| Absolute Tolerance on Bounds: | <input type="text" value="0.0001"/> | (Consistency Checks) |
| (Primal) Feasibility Tolerance: | <input type="text" value="2e-6"/> | (Consistency Checks w.r.t. Examiner computed val |
| Optimality (Dual Feasibility) Tolerance: | <input type="text" value="2e-6"/> | (Consistency Checks w.r.t. Examiner computed val |
| Reference Solver (Name): | <input type="text"/> | (Performance Evaluation) |
| Shift for Time (s): | <input type="text" value="10"/> | (Performance Evaluation) |
| Shift for Number of Nodes: | <input type="text" value="100"/> | (Performance Evaluation) |
| Minimal Time: | <input type="text" value="1"/> | (Performance Evaluation) |
| Time in case of failure: | <input type="text"/> | (Performance Evaluation) |
| Number of Nodes in case of failure: | <input type="text"/> | (Performance Evaluation) |
| (Relative) Gap Tolerance: | <input type="text" value="1e-6"/> | (Performance Evaluation) |
| Threshold for being relatively faster: | <input type="text" value="0.1"/> | (Performance Evaluation) |
| Threshold for relatively better obj. value: | <input type="text" value="0.1"/> | (Performance Evaluation) |
| Regard Dual Bounds (if available): | ☒ | (Performance Evaluation) |
| Number of ticks (points): | <input type="text" value="40"/> | (Performance Profiles) |
| Extended Performance Profiles: | ☐ | (Performance Profiles) |
| Include virt. best solver: | ☒ | (Performance Profiles) |
| Option file name is runname: | ☐ | (Reading) |

For questions or comments please contact the [PAVER 2 author](#).



PAVER 2 – Output

Analysis Results

Your data was successfully submitted to the PAVER - Performance Analysis and Visualization Environment

- <http://www.gamsworld.org/performance/paver2/analysis>

You can also download the results at

- <http://www.gamsworld.org/performance/paver2/analysis>

Submit data:

Date/Time Mon Jul 1 16:02:46 EDT 2013

[Log file](#)

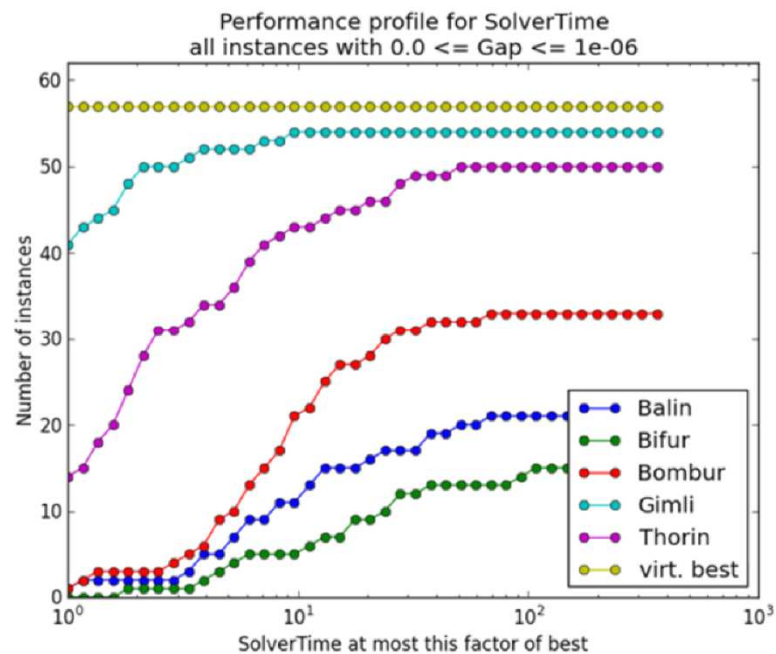
Solver Runs

- Thorin
- Gimli
- Bombur
- Balin
- Bifur

[Solving Data](#)

[Statistics \(Counts and Means\)](#)

Performance Profiles





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PAVER Example

- 5 MIP Solvers
 - Thorin, Gimli, Bombur, Balin, Bifur
 - Models from MIPLIB 2010 (Benchmark set)
 - Time limit: 1 hour

```
python src/paver/paver.py \  
    balin.trc bifur.trc bombur.trc gimli.trc thorin.trc \  
    solu/miplib2010.solu \  
    --failtime 3600 --refsolver Gimli --writehtml mip
```