Open-source Quality Assurance and Performance Analysis Tools

Michael Bussieck MBussieck@gams.com
Steven P. Dirkse SDirkse@gams.com
Stefan Vigerske SVigerske@gams.com

GAMS Development Corp • GAMS Software GmbH

EURO|INFORMS MMXIII
26TH EUROPEAN CONFERENCE ON OPERATIONAL RESEARCH
ROME 1-4 JULY, 2013

Welcome/Agenda

- SQA at GAMS
- Effective Testing
- Performance Analysis Tool Paver
- Examples

Agenda

- SQA at GAMS
- Effective Testing
- Performance Analysis Tool Paver
- Examples

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 academic

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	lnx	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	lnx	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

Agenda

- SQA at GAMS
- **Effective Testing**
- Performance Analysis Tool Paver
- Examples

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 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.

Google Groups

Subscribe to the GAMSWORLD Newsgroup

Email: Subscribe

Browse Archives at groups.google.com

Performance World

Editorial Board
PerformanceLib
Performance Tools
PAVER Server
Performance List
Related Links
Search
Contact

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.

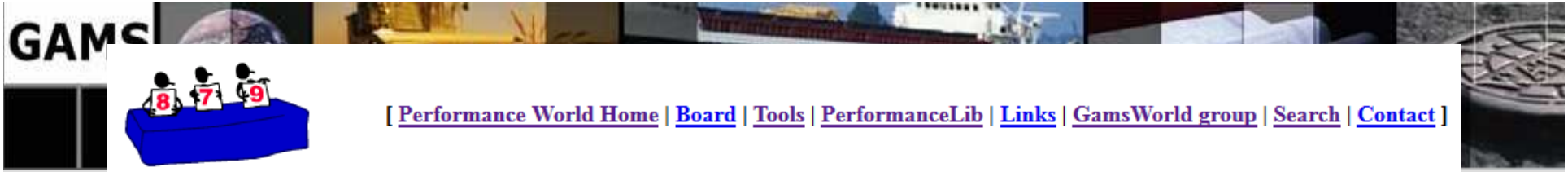
Overall performance highly depends on problem formulation, solver, and tuning parameters. Our performance tools are designed to serve the different needs of our user community. One user may be interested in finding the most reliable way to solve a proprietary or classified model. On the other hand, an 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 resuls 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

Performance World is featured by GAMS World



[Performance World Home | Board | Tools | PerformanceLib | Links | GamsWorld group | Search | Contact]

MacMOOP - A Collection of Multiobjective Optimization Testproblems

MacMOOP is a collection of multiobjective optimizatin testproblems from Sven Leyffer. See the MacMOOP Collection. The GAMS models were translated by Andre Savistky 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 gams
ex001	NLP	4	6	21	11	0.55508075	gms	ampl	raw gams
ex002	NLP	3	6	13	3	8.00000000	gms	ampl	raw gams
ex003	NLP	3	3	7	5	7.25098758	gms	ampl	raw gams
ex004	LP	4	3	7	0	2.00000000	gms	ampl	raw gams
ex005	NLP	1	3	3	2	-4.00000000	gms	ampl	raw gams
hs05x	NLP	4	6	13	5	0.14049587	gms	ampl	raw gams
liswetm	NLP	3	9	13	7	-3.41233322	gms	ampl	raw gams
molpg_1	NLP	9	9	51	0	-26.01668874	gms	ampl	raw gams
molpg_2	NLP	17	13	67	0	-13.37500000	gms	ampl	raw gams
molpg_3	NLP	15	11	55	0	-13.40000000	gms	ampl	raw gams
moqp_1	NLP	14	24	102	60	-57.29327326	gms	ampl	raw gams
moqp_2	NLP	13	24	102	60	-13.16755651	gms	ampl	raw gams
moqp_3	NLP	14	24	101	60	-24.54193065	gms	ampl	raw gams

```
*  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;
```

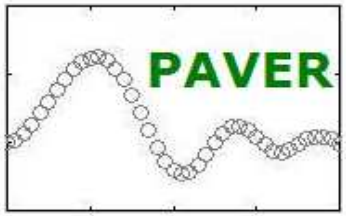
```
#  MINLP written by GAMS Convert
var b1 binary;
var b2 binary;
var i3 integer >= 0, <= 15;
var i4 integer >= 0, <= 15;
var i5 integer >= 0, <= 5;
var i6 integer >= 0, <= 5;
var i7 integer >= 0, <= 5;
var i8 integer >= 0, <= 5;

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;
```

GAMSWorld Translation Service



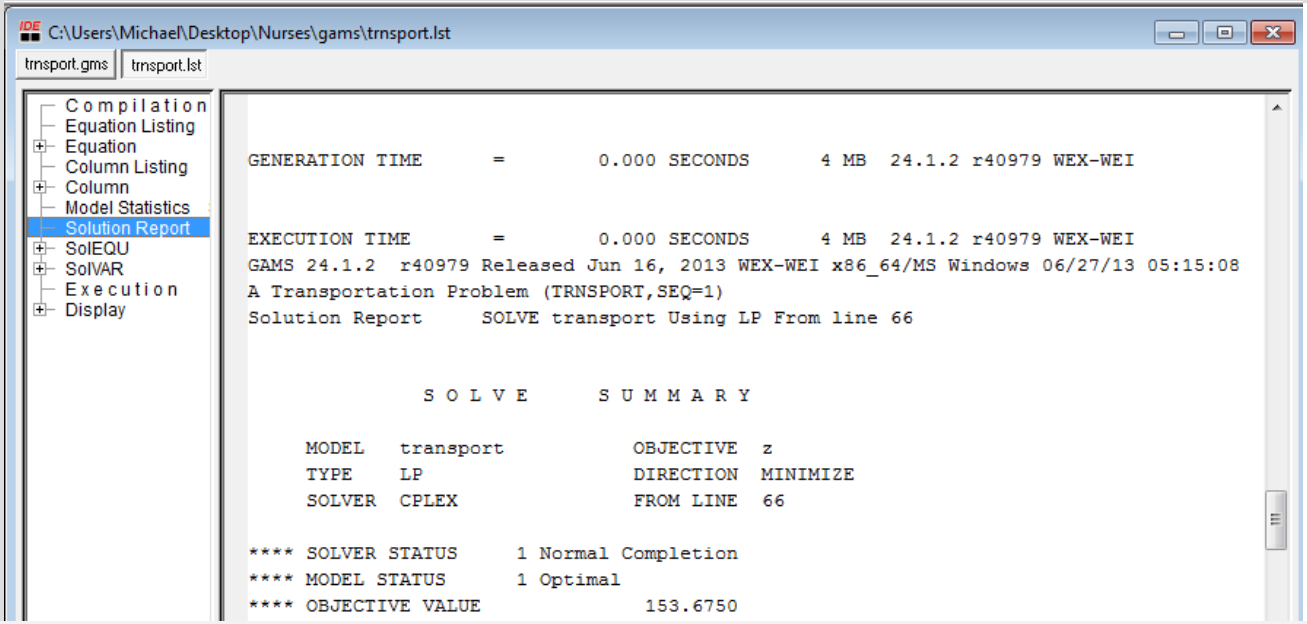
[Home | Tools | Links/Other | Performance World]

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



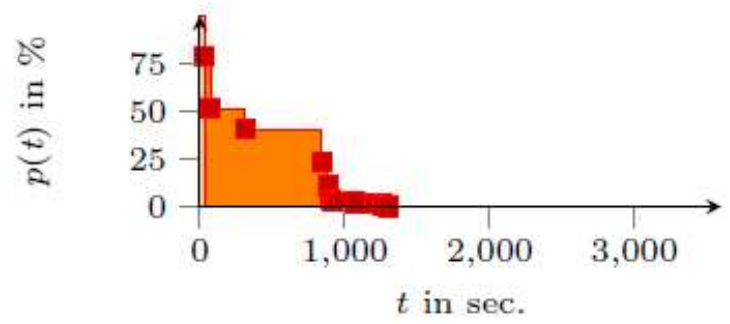

```
* Trace Record Definition
* GamsSolve
* InputFileName,ModelType,SolverName,OptionFile,Direction,NumberOfEquations,
* NumberOfVariables,NumberOfDiscreteVariables,NumberOfNonZeros,
* NumberOfNonlinearNonZeros,ModelStatus,SolverStatus,ObjectiveValue,
* ObjectiveValueEstimate,SolverTime,ETSolver,NumberOfIterations,NumberOfNodes
*
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
```

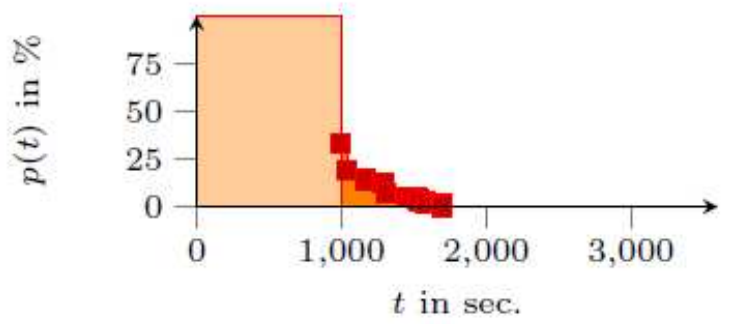
More Data Collection – MIP|SolveTrace

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
```





Agenda

- SQA at GAMS
- Effective Testing
- **Performance Analysis Tool Paver**
- Examples

PAVER Server

- PAVER server (**P**erformance **A**nalysis and **V**isualization for **E**ffortless **R**eproducibility)

- 2013: Complete rewrite PAVER 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	Browse...	blitzen.trc
Trace 2	Browse...	comet.trc
Trace 3	Browse...	cupid.trc
Trace 4	Browse...	No file selected.
Trace 5	Browse...	No file selected.
Trace 6	Browse...	No file selected.
Trace 7	Browse...	No file selected.
Trace 8	Browse...	No file selected.

Submit solution files (optional):

MINLPLib	☐
GlobalLib	☐
LinLib	☐
MIPLIB 2010	☐
Solutions 1	Browse... No file selected.

Optional Settings:

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

Run PAVER RESET

For questions or comments please contact the PAVER 2 author.

PAVER 2 – Output

Analysis Results

Your data was succesfully submitted to the PAVER - Perfo

- http://www.gamsworld.org/performance/paver2/anal

You can also download the results at

- http://www.gamsworld.org/performance/paver2/anal

Submit data:

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

Log file

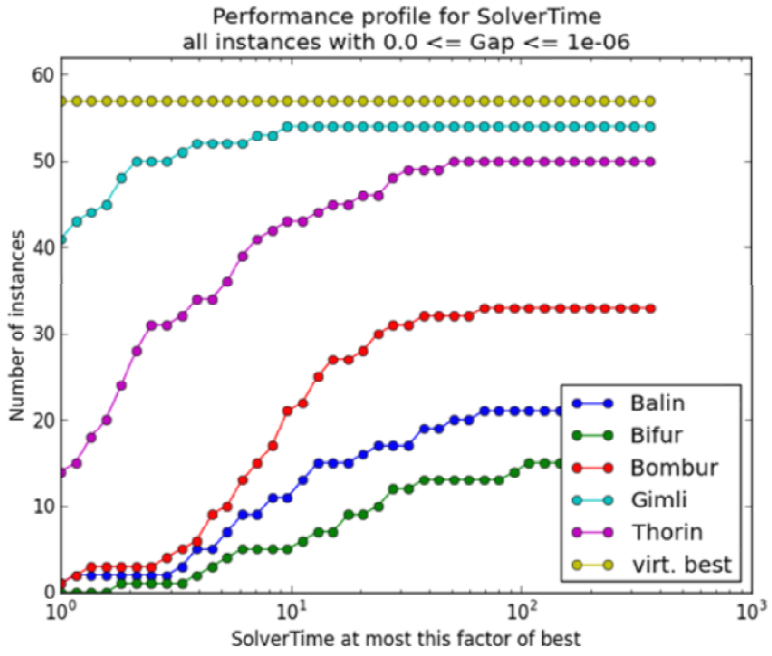
Solver Runs

- Thorin
- Gimli
- Bombur
- Balin
- Bifur

Solving Data

Statistics (Counts and Means)

Performance Profiles



Agenda

- SQA at GAMS
- Effective Testing
- Performance Analysis Tool Paver
- Examples

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
```