XCSP3 Competition 2018
– Results –

http://www.cril.fr/XCSP18/

Christophe Lecoutre and Olivier Roussel

24th International Conference
Principles and Practice of Constraint Programming

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XCSP3 is:

- an XML-based format designed to represent instances of combinatorial constrained problems
- an *intermediate* integrated format preserving the structure of models

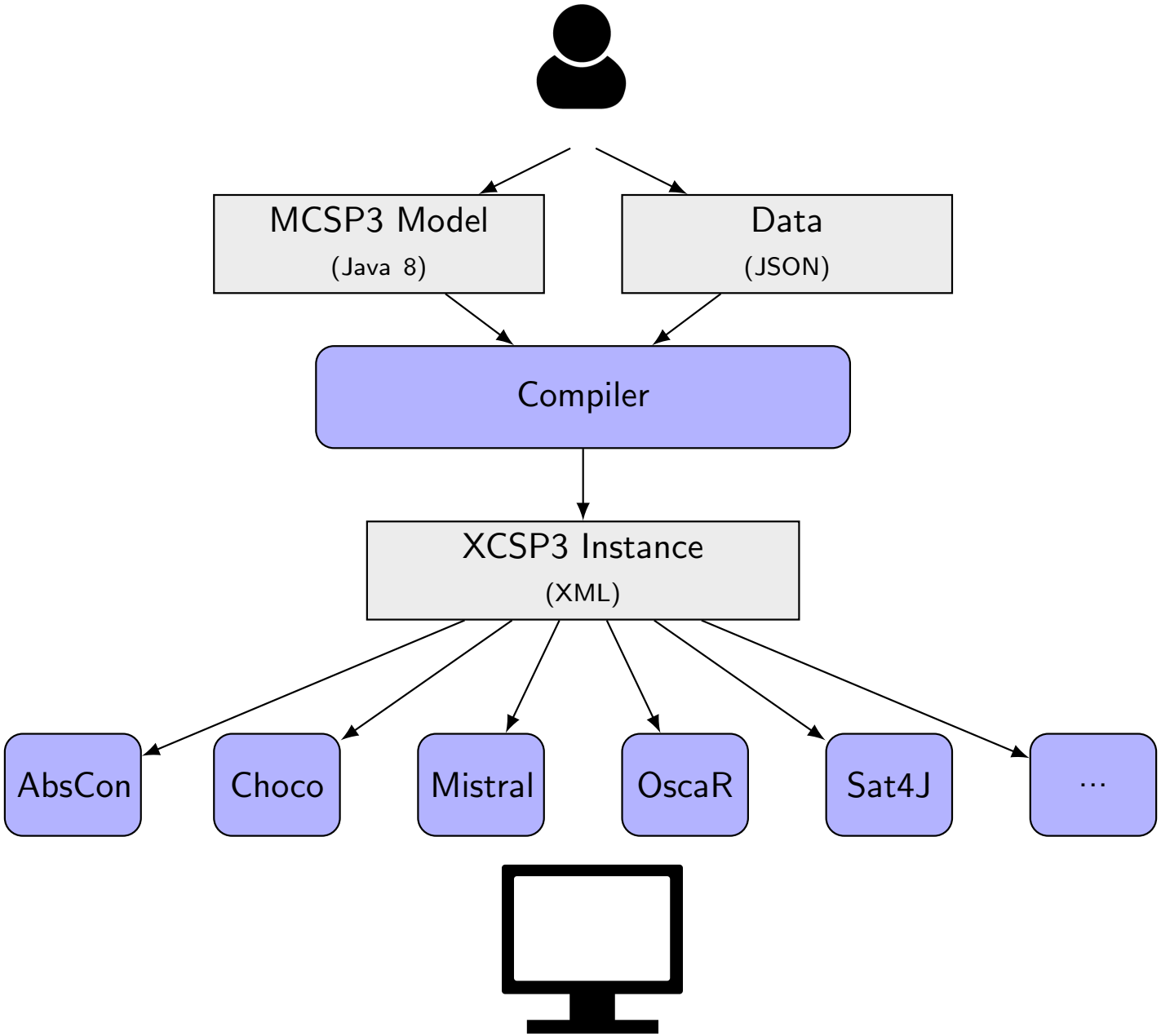
XCSP3 is a major extension of XCSP 2.1 since it allows us to deal with:

- mono/multi optimization
- many types of variables
- cost functions
- reification and views
- annotations
- variable quantification
- distributed, probabilistic and qualitative reasoning

XCSP3: an Intermediate Format

www.xcsp.org

XCSP3: the central piece of a Modeling/Solving process



XCSP3: Available Tools and Benchmarks

Many tools are available on github:

https://github.com/xcsp3team/

Parsers available on github:

- Java 8 Parser
- C++ 11 Parser

Various tools for:

- checking solutions and bounds:
  org.xcsp.parser.callbacks.SolutionChecker
- checking the validity of an instance for a competition track:
  org.xcsp.parser.callbacks.CompetitionValidator

Many series of CSP/COP instances that can be downloaded from `www.xcsp.org` by means of our selection engine!

Outline

Purpose of Competitions

The goal of a competition is to:

- evaluate solvers in the same conditions
- help collecting publicly available benchmarks and data (results, traces, ...)
- help the community identify good ideas and strange results: the goal is to raise questions and get new ideas!

Competitions should not be misunderstood:

- The results are not an absolute truth: they depend on the benchmark selection, experimental conditions, ...
- A competition is not limited to a ranking: rankings are just an over-simplified view, but still relevant to motivate authors
- Competitions must be driven by the community: benchmark submission/selection advices, suggestions for improvements, ...

Perimeter of Constraints (mainly, XCSP3-core)

For the standard tracks:

- `intension`, `extension`
- `regular` and `mdd`
- `allDifferent`, `allEqual`, `ordered` and `lex`
- `sum`, `count`, `nValues` and `cardinality`
- `maximum`, `minimum`, `element` and `channel`
- `noOverlap` and `cumulative`
- `circuit` and `instantiation`
- `slide`

For the Mini-solver tracks:

- `intension`, `extension`
- `allDifferent`
- `sum`
- `element`

Tracks for the 2018 XCSP3 Competition

There are 6 Standard tracks and 2 Minisolver tracks.

Problem	Goal	Exploration	Timeout
CSP	one solution	sequential	40 minutes
CSP	one solution	parallel	40 minutes
COP	best solution	sequential	4 minutes
COP	best solution	sequential	40 minutes
COP	best solution	parallel	40 minutes

Table: Standard Tracks.

Problem	Goal	Exploration	Timeout
CSP	one solution	sequential	40 minutes
COP	best solution	sequential	40 minutes

Table: Mini-Solver Tracks.

Main Novelties in 2018

1. Constraint `extension`. Short tables (i.e., tables with '*') allowed.
2. Constraint `allDifferent` and `sum`, handling view extensions. For example:

```
<allDifferent>
  add(x1,1) add(x2,2) add(x3,3)
</allDifferent>
```

3. Constraint `element`. It is possible to have a vector of integers (instead of variables).
4. Constraint `channel`. It is possible to have two lists of different sizes.
5. Constraint `circuit`. This constraint is introduced in 2018.
6. For some instances (series), the set of decision variables are specified, by means of annotations.

Remark.

The XCSP3 Competition essentially remains a blackbox solving competition.

Computer Infrastructure

- The cluster we used is provided by CRIL and is composed of nodes with two quad-cores (Intel @ 2.67GHz with 32 GiB RAM).
- Hyperthreading was disabled.
- Sequential solvers were run on one processor (4 cores) and were allocated 15500 MiB of memory.
- Parallel solvers were run on two processors (8 cores) and were allocated 31000 MiB of memory.

Organisation

Selection of instances by Christophe Lecoutre (good knowledge in modeling with MCSP3):

- Standard tracks: 236 CSP and 346 COP instances
- Mini-solver tracks: 176 CSP and 188 COP instances

Remark. AbsCon didn't enter the competition.

Remark. 4 discarded instances (computations requiring 64 bits).

Olivier Roussel managed the experiments.

Ranking. Based on the number of times a solver is able to prove a result (satisfiability, optimality). For COP, another viewpoint given with the number of times a solver gives the best known answer (satisfiability, optimality, best known bound).

Problems (36.5% are new, displayed in italic font)

Problem	Optimization	Constraints
Auction	max SUM	`count`, `sum`
BACP	min MAXIMUM	`intension`, `extension`, `count`, `sum`
BIBD		`sum`, `lexMatrix`
Car Sequencing		`extension`, `sum`, `cardinality`
Coloured Queens		`allDifferent`, `allDifferentMatrix`
Crosswords		`extension`
Crosswords Design	max SUM	`extension` (∗)
Dubois		`extension`
Eternity		`intension`, `extension`, `allDifferent`
FAPP	min SUM	`intension`, `extension`
FRB		`extension`
Golomb Ruler	min VAR	`intension`, `allDifferent`
Graceful Graph		`intension`, `allDifferent`
Graph Coloring	min MAXIMUM	`intension`
Haystacks		`extension`
Knapsack	max SUM	`sum`
Langford		`intension`, `element`
Low Autocor.	min SUM	`intension`, `sum`
Magic Hexagon		`intension`, `sum` and `allDifferent`
Magic Square		`allDifferent`, `sum`, `instantiation`
Mario	max SUM	`intension`, `extension`, `sum`, `circuit`

Problem	Optimization	Constraints
Mistery Shopper		`intension`, `extension`, `allDifferent`, `lexMatrix`, `channel`
Nurse Rostering	min SUM	`intension`, `extension`, `sum`, `count`, `regular`, `instantiation`, `slide`
Peacable Armies	max SUM	`intension`, `sum`, `count`
Pizza Voucher	min SUM	`intension`, `count`
Pseudo-Boolean	min SUM	`sum`
QAP	min SUM	`extension`, `allDifferent`
QuasiGroup		`intension`, `allDifferentMatrix`, `instantiation`, `element`
RCPSP	min VAR	`intension`, `cumulative`
RLFAP	min NVALUES	`intension`, `instantiation`
Social Golfers		`intension`, `instantiation`, `cardinality`, `lexMatrix`
Sports Sched.		`intension`, `extension`, `instantiation`, `allDifferent`, `count`, `cardinality`
Steel Mill Slab	min SUM	`intension`, `extension`, `ordered`, `sum`
Still Life	max VAR	`intension`, `extension`, `instantiation`, `sum`
Strip Packing		`intension`, `extension`, `noOverlap`
Subgraph Iso.		`extension`, `allDifferent`
Sum Coloring	min SUM	`intension`
TAL	min SUM	`intension`, `extension`, `count`
Template Design	min SUM	`intension`, `ordered`, `sum`
Traveling Tour.	min SUM	`intension`, `extension` (∗), `allDifferent`, `element`, `cardinality`, `regular`
Travelling Sal.	min SUM	`extension`, `allDifferent`

Generating Instances – 1. Model

```
class Knapsack implements ProblemAPI {
  int capacity;
  Item[] items;

  class Item {
    int weight;
    int value;
  }

  public void model() {
    int[] weights = valuesFrom(items, item -> item.weight);
    int[] values = valuesFrom(items, item -> item.value);
    int nItems = items.length;

    Var[] x = array("x", size(nItems), dom(0, 1),
      "x[i] is 1 iff the ith item is selected");

    sum(x, weightedBy(weights), LE, capacity)
      .note("the capacity of the knapsack must not be exceeded");

    maximize(SUM, x, weightedBy(values))
      .note("maximizing summed up value (benefit)");
  }
}
```

Generating Instances – 2. Data

```
{
  "capacity": 10,
  "items": [
    { "weight": 2, "value": 54 },
    { "weight": 2, "value": 92 },
    { "weight": 1, "value": 62 },
    { "weight": 2,"value": 20 },
    { "weight": 2,"value": 55 }
  ]
}
```

Generating Instances – 3. Compilation

```
java  org.xcsp.modeler.Compiler  Knapsack  -data=knap10.json
```

Generating Instances – 4. Instance

```
<instance format="XCSP3" type="COP">
  <variables>
    <array id="x" note="x[i] is 1 iff the ith item is selected"
      size="[5]"> 0 1 </array>
  </variables>
  <constraints>
    <sum>
      <list> x[] </list>
      <coeffs> 2 2 1 2 2 </coeffs>
      <condition> (le,10) </condition>
    </sum>
  </constraints>
  <objectives>
    <maximize type="sum">
      <list> x[] </list>
      <coeffs> 54 92 62 20 55 </coeffs>
    </maximize>
  </objectives>
</instance>
```

Outline

Teams/Solvers (in alphabetic order)

BTD, miniBTD	P. Jegou, H. Kanso and C. Terrioux
BTD_12, miniBTD_12	P. Jegou, D. Habet, H. Kanso and C. Terrioux
Choco-solver	C. Prud'homme and J.-G. Fages
Concrete	J. Vion
cosoco	G. Audemard
GG's minicp	A. Gellens and S. Gustin
macht, minimacht	D. Habet and C. Terrioux
MiniCPFever	V. Joos and A. Vanderschueren
Mistral-2.0	E. Hebrard and M. Siala
NACRE	Gaël Glorian
OscaR	OscaR Team
PicatSAT	N.-F. Zhou and H. Kjellerstrand
Sat4j-CSP	D. Le Berre and E. Lonca
scop	T. Soh, D. Le Berre, M. Banbara, N. Tamura
slowpoke	A. Gerlache and v. vandervilt
Solver of Schul & Smal	X. Schul, Y. Smal
SuperSolver	F. Stevenart Meeus and J.-B. Macq
The dodo solver	A. Dubray

Mini-solvers, COP

Total number of instances: 188

	#solved		%inst.	%VBS
Virtual Best Solver (VBS)	48	48 OPT	26%	100%
1 cosoco	46 (122)	46 OPT	24%	96%
2 Solver of Schul & Smal	35 (44)	35 OPT	19%	73%
3 GG's minicp	3 (22)	3 OPT	2%	6%
4 MiniCPFever	0 (50)		0%	0%
5 SuperSolver	0 (23)		0%	0%
6 The dodo solver	0 (18)		0%	0%
7 slowpoke	0 (12)		0%	0%

Between parentheses, the number of times, the solver gives the best known result (not necessarily, a proved optimal one).

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Mini-solvers, CSP

Total number of instances: 176

	#solved		%inst.	%VBS
Virtual Best Solver (VBS)	113	53 SAT, 60 UNSAT	64%	100%
1 NACRE	86	43 SAT, 43 UNSAT	49%	76%
2 miniBTD_12	79	36 SAT, 43 UNSAT	45%	70%
3 miniBTD	75	32 SAT, 43 UNSAT	43%	66%
4 cosoco	72	42 SAT, 30 UNSAT	41%	64%
5 minimacht	69	37 SAT, 32 UNSAT	39%	61%
6 GG's minicp	56	37 SAT, 19 UNSAT	32%	50%
7 Solver of Schul & Smal	54	23 SAT, 31 UNSAT	31%	48%
8 MiniCPFever	54	34 SAT, 20 UNSAT	31%	48%
9 slowpoke	38	38 SAT	22%	34%
10 SuperSolver	31	31 SAT	18%	27%
11 The dodo solver	25	25 UNSAT	14%	22%

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Standard solvers (sequential), COP

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Virtual Best Solver (VBS)	146	146 OPT	42%	100%
1 PicatSAT *2018-08-14*	132 (132)	132 OPT	38%	90%
2 Concrete *3.9.2*	105 (148)	105 OPT	30%	72%
3 Choco-solver *4.0.7b seq*	102 (154)	102 OPT	29%	70%
4 OscaR-Conf. Ordering+restarts	99 (132)	99 OPT	29%	68%
5 Concrete *3.9.2-SuperNG*	99 (139)	99 OPT	29%	68%
6 cosoco *1.12*	64 (112)	64 OPT	18%	44%
7 OscaR - Hybrid *2018-08-14*	61 (132)	61 OPT	18%	42%
8 Sat4j-CSP	54 (86)	54 OPT	16%	37%

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3 PicatSAT *2018-08-14*	138	85 SAT, 53 UNSAT	58%	84%
4 Mistral-2.0	116	80 SAT, 36 UNSAT	49%	71%
5 Choco-solver *4.0.7b seq*	115	77 SAT, 38 UNSAT	49%	70%
6 Concrete *3.9.2*	92	64 SAT, 28 UNSAT	39%	56%
7 OscaR-Conf. Ordering+restarts	90	62 SAT, 28 UNSAT	38%	55%
8 Concrete *3.9.2-SuperNG*	84	55 SAT, 29 UNSAT	36%	51%
9 Sat4j-CSP	83	40 SAT, 43 UNSAT	35%	51%
10 OscaR - Conflict Ordering	81	51 SAT, 30 UNSAT	34%	49%
11 cosoco *1.12*	79	53 SAT, 26 UNSAT	33%	48%
12 BTD_12	76	32 SAT, 44 UNSAT	32%	46%
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14 macht	66	33 SAT, 33 UNSAT	28%	40%

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2	scop *both+MapleCOMSPS*	140	87 SAT, 53 UNSAT	59%	85%
3	PicatSAT *2018-08-14*	138	85 SAT, 53 UNSAT	58%	84%
4	Mistral-2.0	116	80 SAT, 36 UNSAT	49%	71%
5	Choco-solver *4.0.7b seq*	115	77 SAT, 38 UNSAT	49%	70%
6	Concrete *3.9.2*	92	64 SAT, 28 UNSAT	39%	56%
7	OscaR-Conf. Ordering+restarts	90	62 SAT, 28 UNSAT	38%	55%
8	Concrete *3.9.2-SuperNG*	84	55 SAT, 29 UNSAT	36%	51%
9	Sat4j-CSP	83	40 SAT, 43 UNSAT	35%	51%
10	OscaR - Conflict Ordering	81	51 SAT, 30 UNSAT	34%	49%
11	cosoco *1.12*	79	53 SAT, 26 UNSAT	33%	48%
12	BTD_12	76	32 SAT, 44 UNSAT	32%	46%
13	BTD	76	31 SAT, 45 UNSAT	32%	46%
14	macht	66	33 SAT, 33 UNSAT	28%	40%

Standard solvers (sequential), CSP, 236 Instances

	#solved		%inst.	%VBS
Virtual Best Solver (VBS)	164	104 SAT, 60 UNSAT	69%	100%
1 scop *order+MapleCOMSPS*	146	92 SAT, 54 UNSAT	62%	89%
2 scop *both+MapleCOMSPS*	140	87 SAT, 53 UNSAT	59%	85%
3 PicatSAT *2018-08-14*	138	85 SAT, 53 UNSAT	58%	84%
4 Mistral-2.0	116	80 SAT, 36 UNSAT	49%	71%
5 Choco-solver *4.0.7b seq*	115	77 SAT, 38 UNSAT	49%	70%
6 Concrete *3.9.2*	92	64 SAT, 28 UNSAT	39%	56%
7 OscaR-Conf. Ordering+restarts	90	62 SAT, 28 UNSAT	38%	55%
8 Concrete *3.9.2-SuperNG*	84	55 SAT, 29 UNSAT	36%	51%
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Standard solvers (sequential), CSP, 236 Instances

		#solved		%inst.	%VBS
	Virtual Best Solver (VBS)	164	104 SAT, 60 UNSAT	69%	100%
1	scop *order+MapleCOMSPS*	146	92 SAT, 54 UNSAT	62%	89%
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4	Mistral-2.0	116	80 SAT, 36 UNSAT	49%	71%
5	Choco-solver *4.0.7b seq*	115	77 SAT, 38 UNSAT	49%	70%
6	Concrete *3.9.2*	92	64 SAT, 28 UNSAT	39%	56%
7	OscaR-Conf. Ordering+restarts	90	62 SAT, 28 UNSAT	38%	55%
8	Concrete *3.9.2-SuperNG*	84	55 SAT, 29 UNSAT	36%	51%
9	Sat4j-CSP	83	40 SAT, 43 UNSAT	35%	51%
10	OscaR - Conflict Ordering	81	51 SAT, 30 UNSAT	34%	49%
11	cosoco *1.12*	79	53 SAT, 26 UNSAT	33%	48%
12	BTD_12	76	32 SAT, 44 UNSAT	32%	46%
13	BTD	76	31 SAT, 45 UNSAT	32%	46%
14	macht	66	33 SAT, 33 UNSAT	28%	40%

Standard solvers (parallel), COP

Not enough contestants for being relevant, but Choco-solver *4.0.7b par* has made a good job.

Standard solvers (parallel), CSP

Total number of instances: 236

	#solved		%inst.	%VBS
Virtual Best Solver (VBS)	168	104 SAT, 64 UNSAT	71%	100%
1 scop *order+glucose-syrup*	151	95 SAT, 56 UNSAT	64%	90%
2 scop *both+glucose-syrup*	138	82 SAT, 56 UNSAT	58%	82%
3 Choco-solver *4.0.7b par*	134	88 SAT, 46 UNSAT	57%	80%
4 OscaR - Parallel with EPS	89	56 SAT, 33 UNSAT	38%	53%

Standard solvers (parallel), CSP

Total number of instances: 236

	#solved		%inst.	%VBS
Virtual Best Solver (VBS)	168	104 SAT, 64 UNSAT	71%	100%
1 scop *order+glucose-syrup*	151	95 SAT, 56 UNSAT	64%	90%
2 scop *both+glucose-syrup*	138	82 SAT, 56 UNSAT	58%	82%
3 Choco-solver *4.0.7b par*	134	88 SAT, 46 UNSAT	57%	80%
4 OscaR - Parallel with EPS	89	56 SAT, 33 UNSAT	38%	53%

Standard solvers (parallel), CSP

Total number of instances: 236

	#solved		%inst.	%VBS
Virtual Best Solver (VBS)	168	104 SAT, 64 UNSAT	71%	100%
1 scop *order+glucose-syrup*	151	95 SAT, 56 UNSAT	64%	90%
2 scop *both+glucose-syrup*	138	82 SAT, 56 UNSAT	58%	82%
3 Choco-solver *4.0.7b par*	134	88 SAT, 46 UNSAT	57%	80%
4 OscaR - Parallel with EPS	89	56 SAT, 33 UNSAT	38%	53%

Standard solvers (parallel), CSP

Total number of instances: 236

	#solved		%inst.	%VBS
Virtual Best Solver (VBS)	168	104 SAT, 64 UNSAT	71%	100%
1 scop *order+glucose-syrup*	151	95 SAT, 56 UNSAT	64%	90%
2 scop *both+glucose-syrup*	138	82 SAT, 56 UNSAT	58%	82%
3 Choco-solver *4.0.7b par*	134	88 SAT, 46 UNSAT	57%	80%
4 OscaR - Parallel with EPS	89	56 SAT, 33 UNSAT	38%	53%

Standard solvers (parallel), CSP

Total number of instances: 236

	#solved		%inst.	%VBS
Virtual Best Solver (VBS)	168	104 SAT, 64 UNSAT	71%	100%
1 scop *order+glucose-syrup*	151	95 SAT, 56 UNSAT	64%	90%
2 scop *both+glucose-syrup*	138	82 SAT, 56 UNSAT	58%	82%
3 Choco-solver *4.0.7b par*	134	88 SAT, 46 UNSAT	57%	80%
4 OscaR - Parallel with EPS	89	56 SAT, 33 UNSAT	38%	53%

Standard solvers (sequential), COP – fast (4 minutes)

Total number of instances: 346

	#best	%inst.	%VBS
Virtual Best Solver (VBS)	316	91%	100%
1 Concrete *3.9.2*	151	44%	48%
2 Choco-solver *4.0.7b seq*	146	42%	46%
3 OscaR - Hybrid	139	40%	44%
4 OscaR - Conflict Ordering with restarts	133	38%	42%
5 Concrete *3.9.2-SuperNG*	129	37%	41%
6 Mistral-2.0	123	36%	39%
7 cosoco	107	31%	34%
8 Sat4j-CSP	78	23%	25%

For this fast track, we consider the number of times the solver gives the best known result (not necessarily, a proved optimal one).

Useful Data

On http://www.cril.fr/XCSP18/, many tables/diagrams and plots can be found.

Also, you can get the traces of any solver.

Forthcoming

- Proceedings with descriptions of:
  - problems and models,
  - solvers,
  - analysis of the results.

  Not done in 2017 (sorry), but this year proceedings already include detailed descriptions of all models.
- 2019 XCSP3 Competition
- MCSP3, Version 1.1, release in October 2018 $\Rightarrow$ it is **important** to propose new series for the 2019 Competition.
- Update of the website
- Publications of 100 problems/models in Fall 2018