



# Challenge 2024

Peter J. Stuckey

# Challenge 2024



20 benchmarks \* 5 instances = 100 instances

20 minutes time limit

## Scoring system:

each instance compares each pair of solvers

1 point for every solver you beat

If both prove optimality/satisfiability/unsatisfiability in time  $t_1$  and  $t_2$

Solver 1 gets  $t_2/(t_1 + t_2)$  points

## Five categories:

**single engine fixed search:** single solving algorithm, must follow given search strategy

**single engine free search:** search however you want

**single engine parallel search:** free search on 4 threads

**local search:** free search for local search (nominated) solvers

# Entry System



## Docker based solver installation

- solver writers install solver in docker image
- upload docker image in online system
- test script automatically run, checks rule compliance
- Feedback on crashes, no solution, wrong solutions
- Challenge is automatically scheduled using a competition system compute server
- Machine: Intel Xeon 8260 CPU (24 cores)
  - sequential: 1 core, 16GB RAM limit
  - par+open: 4 cores, 32GB RAM limit

# 2024 Benchmarks



## NEW

- aircraft-disassembly scheduling real-world, MIN
- compression optimising compression patterns combi, MIN
- graph-clear planning robots combi, MIN
- harmony music harmony generation puzzle, MIN
- monitor-placement-1id network monitoring real-world, MIN
- network\_50\_cstr chemical reaction plans real-world, MIN
- portal ascii portal game planning puzzle, MIN
- tiny-cvrp VRP problem real-world, MIN
- train-scheduling complex train scheduling real-world, MIN
- word-equations solving word equations combi, MAX

## OLD problems (mostly new instances)

accap, cable-tree-wiring, community-detection, concert-hall-cap, fox-geese-corn, hoist-benchmark, neighbour, peaceable-queens, triangular, word-equations, yumi-dynamic

# Globals



- alldifferent, alldifferent\_except\_0
- all\_equal
- count\_eq
- circuit
- cumulative
- diffn
- disjunctive
- element
- global\_cardinality, global\_cardinality\_low\_up
- increasing, strictly\_decreasing
- inverse
- lex\_lesseq
- nvalue
- regular
- table
- value\_precede, value\_precede\_chain

# The official contestants



<b>atlantis:</b> New CBLS solver.	New
<b>choco-cp:</b> Java based trailing FD solver	
<b>choco-cpsat:</b> experimental LCG choco solver	New
<b>gecode-dexter:</b> portfolio based on Gecode	New
<b>izplus:</b> Mysterious local search hybrid solver	
<b>jacop:</b> Java based trailing FD solver	
<b>optimathsat:</b> translation to SMT solver	
Three versions: <b>bv</b> (bit vector) and <b>int</b> and <b>int-smt</b> (New)	
<b>or_tools LCG:</b> C++ LCG based FD solver	
<b>or_tools LCG LS:</b> C++ local search solver	New
<b>picat-SAT:</b> translation to SAT approach to FD solving	
<b>pumpkin:</b> Rust based LCG solver	New
<b>sicstus-prolog:</b> prolog based trailing CLP(FD) solver	
<b>yuck:</b> local search solver for MiniZinc (Scala)	

# The unofficial contestants



**cbc:** open source MIP solver

**chuffed:** C++ based trailing lazy clause generation solver

**cplex:** commercial MIP solver

**cp\_optimizer:** IBM commercial CP solver

**gecode:** C++ based copying FD solver

**gurobi:** commercial MIP solver

**highs:** open source MIP solver

**scip:** open source MIP solver

# The hard worker(s)



## Jason Nguyen

- Handling submitted problems
- Managing entrants, communication
- Running preliminary round checking
- Checking submitted models
- Running the competition
- Setting up new competition infrastructure

## Peter Stuckey

- Selecting problems and instances

Thank you Jason for all your hard work!



# Fixed search category



# Fixed search category



# Fixed search category



**choco-fd: 279.00**

# Fixed search category



**choco-fd: 279.00**

**jacop-fd: 280.46**

# Fixed search category



**choco-fd: 279.00**

**jacop-fd: 280.46**

**gecode-fd: 303.09**

# Fixed search category



**choco-fd: 279.00**

**jacop-fd: 280.46**

**gecode-fd: 303.09**

**pumpkin-fd: 308.30**

# Fixed search category



**choco-fd: 279.00**

**jacop-fd: 280.46**

**gecode-fd: 303.09**

**pumpkin-fd: 308.30**

**sicstus-fd: 324.06**

# Fixed search category



**choco-fd: 279.00**

**jacop-fd: 280.46**

**gecode-fd: 303.09**

**pumpkin-fd: 308.30**

**sicstus-fd: 324.06**

**choco-cpsat-fd: 354.42**



# Fixed search category



**choco-fd: 279.00**

**jacop-fd: 280.46**

**gecode-fd: 303.09**

**pumpkin-fd: 308.30**

**sicstus-fd: 324.06**

**choco-cpsat-fd: 354.42**

**chuffed-fd: 459.69**

# Fixed search category



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**pumpkin-fd: 308.30**

**sicstus-fd: 324.06**

**choco-cpsat-fd: 354.42**

**chuffed-fd: 459.69**

**or\_tools-fd: 471.48**

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**BRONZE Medal**

SILVER Medal

**GOLD Medal**

# Local search category



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**atlantis-free: 4.00**



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**yuck-free: 158.22**



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**yuck-free: 158.22**

**yuck-par: 166.72**





# Local search category



**atlantis-free: 4.00**

**yuck-free: 158.22**

**yuck-par: 166.72**

**or\_tools-ls-free: 285.45**

# Local search category



**atlantis-free: 4.00**

**yuck-free: 158.22**

**yuck-par: 166.72**

**or\_tools-ls-free: 285.45**

**or\_tools-ls-par: 299.11**

# Local search category



**atlantis-free: 4.00**

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**yuck-par: 166.72**

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**BRONZE Medal**

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SILVER Medal

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<i>Positions on 20 problems</i>	<i>1st</i>	<i>2nd</i>	<i>3rd</i>
optimathsat-int			<b>1</b>
scip-free			<b>1</b>
sisctus-free			<b>1</b>
highs-free			<b>2</b>
cp_optimizer-free			<b>4</b>
or_tools-ls-free		<b>1</b>	
pumpkin-free		<b>1</b>	
choco-free		<b>2</b>	
optimathsat-smt	<b>1</b>		
cplex-free	<b>2</b>	<b>5</b>	<b>1</b>
chuffed-free	<b>3</b>	<b>3</b>	<b>2</b>
picat-SAT – free	<b>4</b>	<b>1</b>	<b>4</b>
or_tools-free	<b>4</b>	<b>2</b>	<b>4</b>
gurobi-free	<b>6</b>	<b>5</b>	

# Parallel search category



# Parallel search category

atlantis-free: 14.00



# Parallel search category



atlantis-free: 14.00

cbc-par: 677.08

**-2 (but better than free)**



# Parallel search category



atlantis-free: 14.00

cbc-par: 677.08

optimathsat-bv: 679.85

-2 (but better than free)

+1

# Parallel search category



atlantis-free: 14.00

cbc-par: 677.08

optimathsat-bv: 679.85

yuck-par: 690.50

-2 (but better than free)

+1

+1

# Parallel search category



atlantis-free: 14.00

cbc-par: 677.08

-2 (but better than free)

optimathsat-bv: 679.85

+1

yuck-par: 690.50

+1

optimathsat-int: 864.74

# Parallel search category



atlantis-free: 14.00

cbc-par: 677.08                    -2    (but better than free)

optimathsat-bv: 679.85            +1

yuck-par: 690.50                   +1

optimathsat-int: 864.74

optimathsat-smt: 864.77

# Parallel search category



atlantis-free: 14.00

cbc-par: 677.08                    -2    (but better than free)

optimathsat-bv: 679.85            +1

yuck-par: 690.50                   +1

optimathsat-int: 864.74

optimathsat-smt: 864.77

choco-cpsat-free: 976.21

# Parallel search category



atlantis-free: 14.00

cbc-par: **677.08**                    **-2**    **(but better than free)**

optimathsat-bv: 679.85                    **+1**

yuck-par: 690.50                    **+1**

optimathsat-int: 864.74

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choco-cpsat-free: 976.21

gecode-par: 976.22

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**atlantis-free:** 14.00

**cbc-par:** 677.08      **-2**      **(but better than free)**

**optimathsat-bv:** 679.85      **+1**

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**optimathsat-int:** 864.74

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**choco-cpsat-free:** 976.21

**gecode-par:** 976.22

**jacop-free:** 991.83

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**cbc-par:** 677.08      **-2**      **(but better than free)**

**optimathsat-bv:** 679.85      **+1**

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**optimathsat-bv:** 679.85      **+1**

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**sisctus-fd:** 1014.90

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**yuck-par:** 690.50      **+1**

**optimathsat-int:** 864.74

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**sisctus-fd:** 1014.90

**or\_tools-ls-par:** 1075.82

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highs-par: 1086.91

# Parallel search category



**atlantis-free:** 14.00

**cbc-par:** **677.08**      **-2**      **(but better than free)**

**optimathsat-bv:** 679.85      **+1**

**yuck-par:** 690.50      **+1**

**optimathsat-int:** 864.74

**optimathsat-smt:** 864.77

**choco-cpsat-free:** 976.21

**gecode-par:** 976.22

**jacop-free:** 991.83

**pumpkin-free:** 997.68

**sisctus-fd:** 1014.90

**or\_tools-ls-par:** 1075.82

**highs-par:** 1086.91

**cp\_optimizer-par:** 1196.95

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**cplex-par: 1353.75**

**gurobi-par: 1431.00**

**chuffed-free: 1549.09**

**picat-SAT-free: 1553.99**

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izplus-par: 1198.82                    **-1**    **(but better than free)**

choco-par: 1311.01                    **+1.**                    **BRONZE Medal**

cplex-par: 1353.75

gurobi-par: 1431.00

chuffed-free: 1549.09

picat-SAT-free: 1553.99                    **SILVER Medal**

or\_tools-free: 1699.44                    **GOLD Medal**

# Open search category



atlantis-free: 15.00

cbc-par: 716.40

optimathsat-bv: 719.98

yuck-par: 727.00

optimathsat-int: 915.20

optimathsat-smt: 915.25

choco-cpsat-free: 1031.74

gecode-par: 1026.64

jacop-free: 1045.67

pumpkin-free: 1053.82

sisctus-fd: 1068.47

or\_tools-ls-par: 1140.48

highs-par: 1086.91

**gecode-dexter-open: 1222.47**      +6 compared to gecode

cp\_optimizer-par: 1265.62

izplus-par: 1266.03

choco-par: 1386.86

cplex-par: 1431.93

gurobi-par: 1504.66

chuffed-free: 1628.72

picat-SAT-free: 1635.01

or\_tools-free: 1787.21

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Honorable Mention

BRONZE Medal

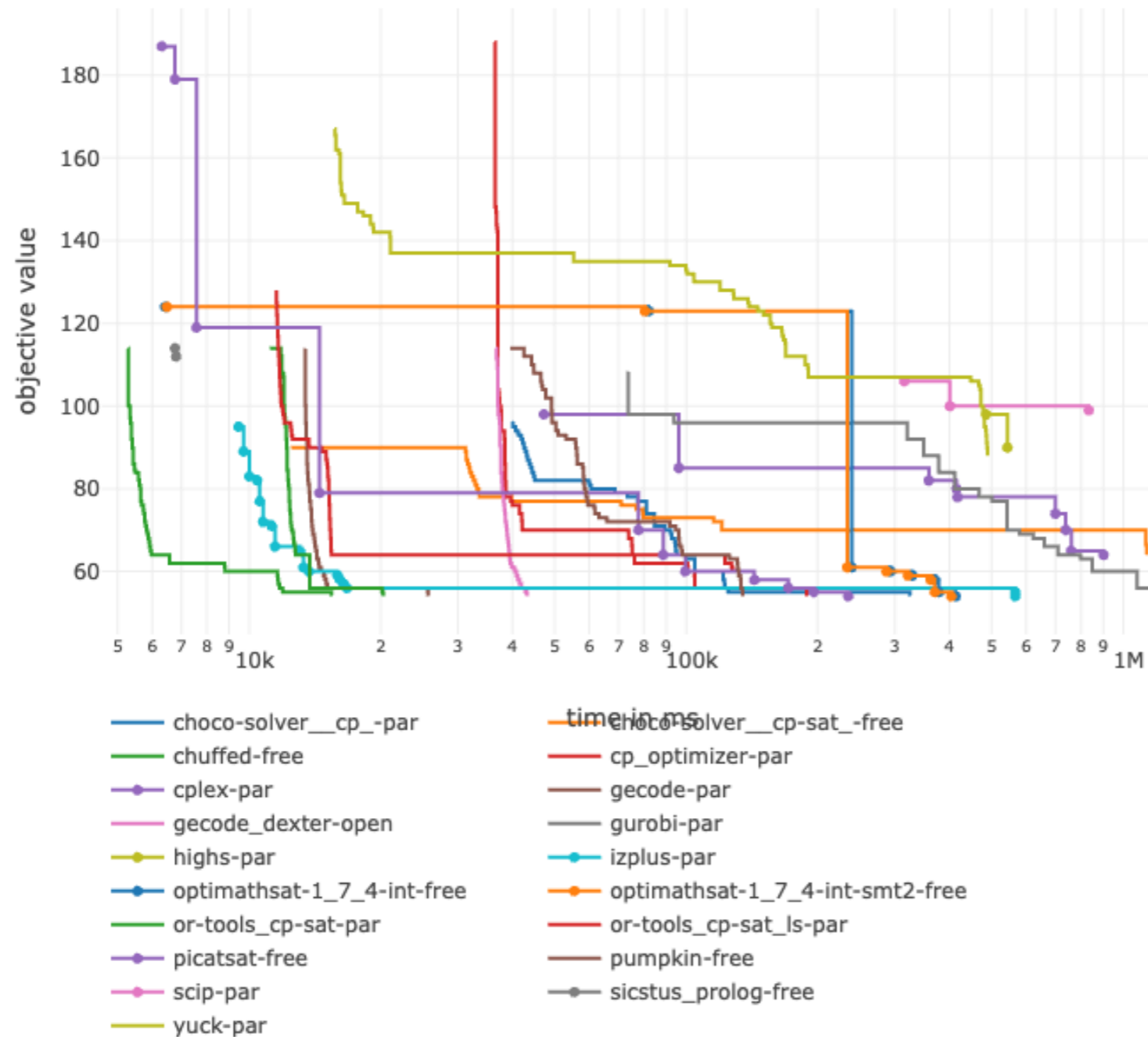
SILVER Medal

GOLD Medal

# Example plot



graph-clear planar\_n20\_seed2022\_14



# Summary



One dominating solver

## OR-tools

- includes learning/LCG + MIP + LS
- Added a pure LS approach for one more medal!

More local search solvers! More FD solvers

Most solvers support parallelism

- but not a lot of speedup
- now **ALL** par versions are better than free

Please send us more **real world** benchmarks



# Conclusions



Congratulations to the winners

	Fixed	Local	Free	Par	Open
<b>GOLD</b>	<i>OR_tools</i>	<i>OR_tools</i>	<i>OR_tools</i>	<i>OR_tools</i>	<i>OR_tools</i>
<b>SILVER</b>	<i>Choco</i>	<i>Yuck</i>	<i>picat-SAT</i>	<i>picat-SAT</i>	<i>picat-SAT</i>
<b>BRONZE</b>	<i>Sicstus</i>	<i>Atlantis</i>	<i>iZplus</i>	<i>Choco</i>	<i>Choco</i>
<b>HonMent</b>					<i>Dexter</i>

Full details: [www.minizinc.org/challenge2024/results2024.html](http://www.minizinc.org/challenge2024/results2024.html)

Enter [your solver](#) next year, send us some [problem instances](#)!

# final word



## Learn MiniZinc

- <https://www.coursera.org/learn/basic-modeling>
- <https://www.coursera.org/learn/advanced-modeling>
- <https://www.coursera.org/learn/solving-algorithms-discrete-optimization>
- All 3 available as a Coursera specialization

## Use MiniZinc

Make all your benchmarks available in MiniZinc

- and [add them to CSPLib](#) (after the challenge!)

## MiniZinc 2.8.5 is here

- OR\_tools is now bundled with MiniZinc