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SIDION

Zuhören. Analysieren. Beraten.

CONSTRAINT SATISFACTION PROBLEMS –

NEVER CODE THIS AT HOME!

Matthias Koch I Java Forum Stuttgart I 07.07.2022

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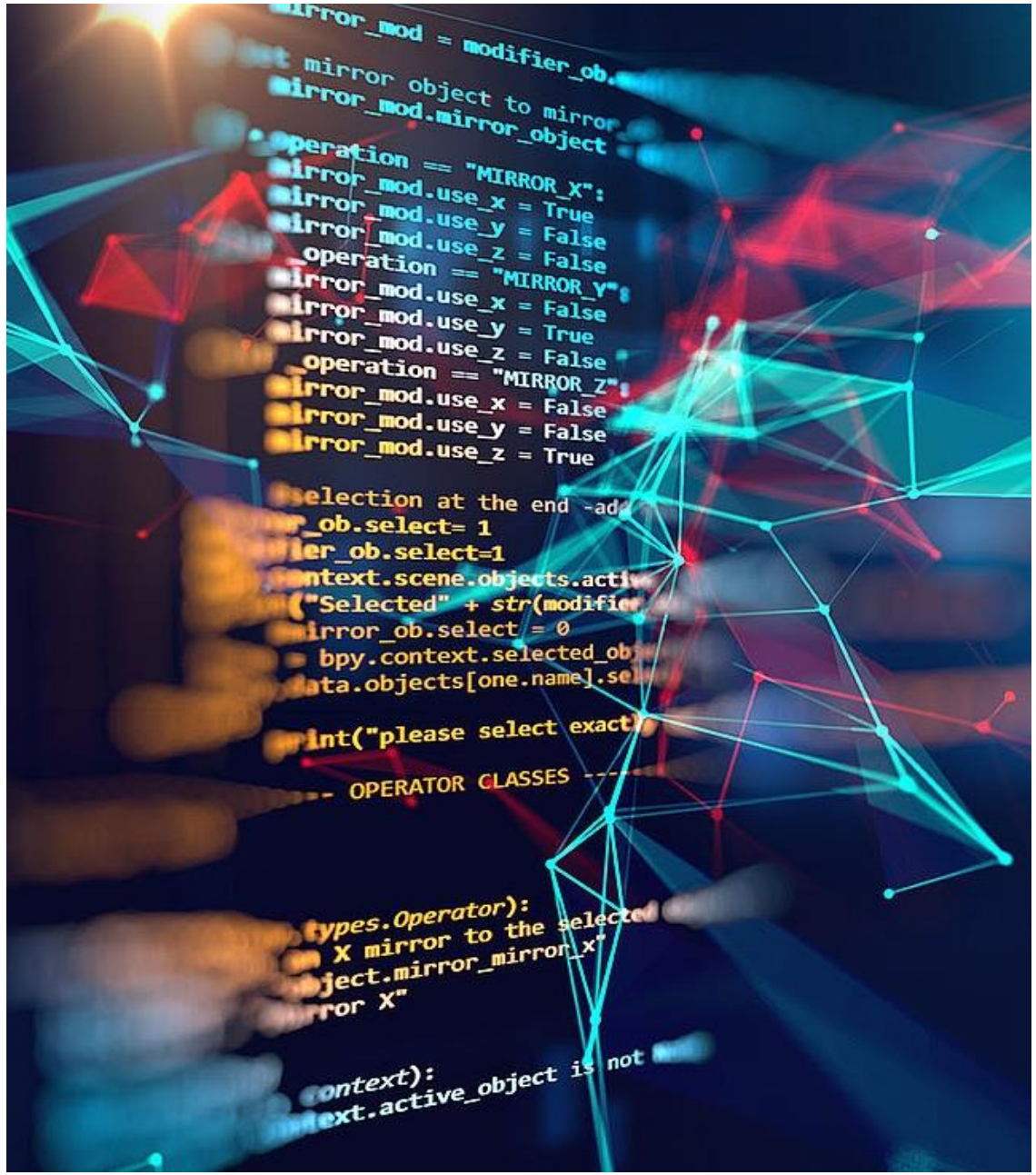

CONSTRAINT SATISFACTION PROBLEMS

Bedingungserfüllungsprobleme, CSPs

- Variablen
- Domänen (können für jede Variable unterschiedlich sein)
- Constraints

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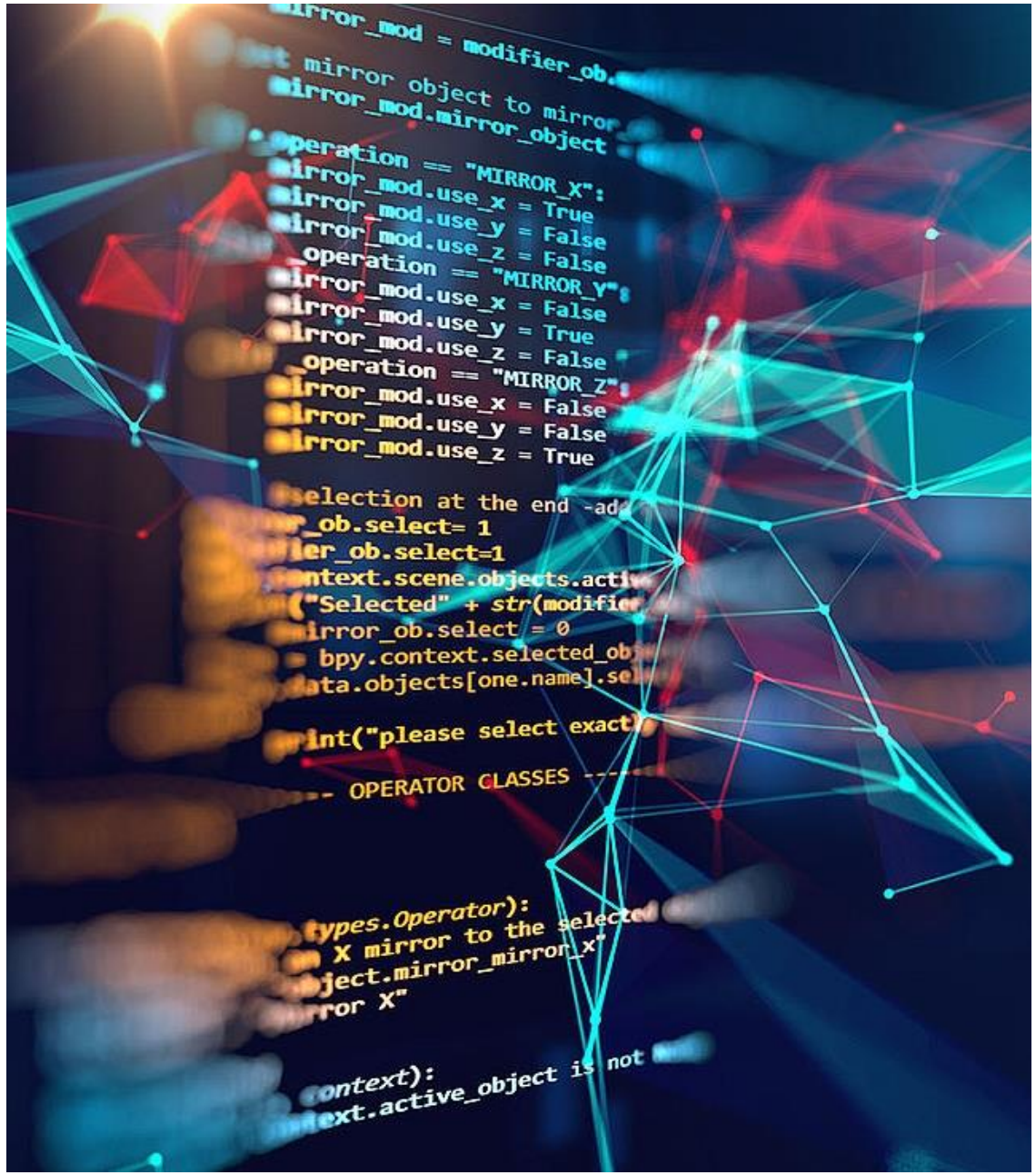

CONSTRAINT SATISFACTION PROBLEMS

- Sind schon sehr alt

  →AC-3 Algorithmus (Alan Mackworth, 1977)

- Es gibt sehr viele Anwendungsfälle dafür:
  - Operations Research (z.B. Travelling Salesman Problem)
  - Künstliche Intelligenz
  - Terminplanung
  - Spielpläne von Sportligen
  - Spiele
  - ...
  - SAT oder 3SAT → damit potentiell NP-vollständig

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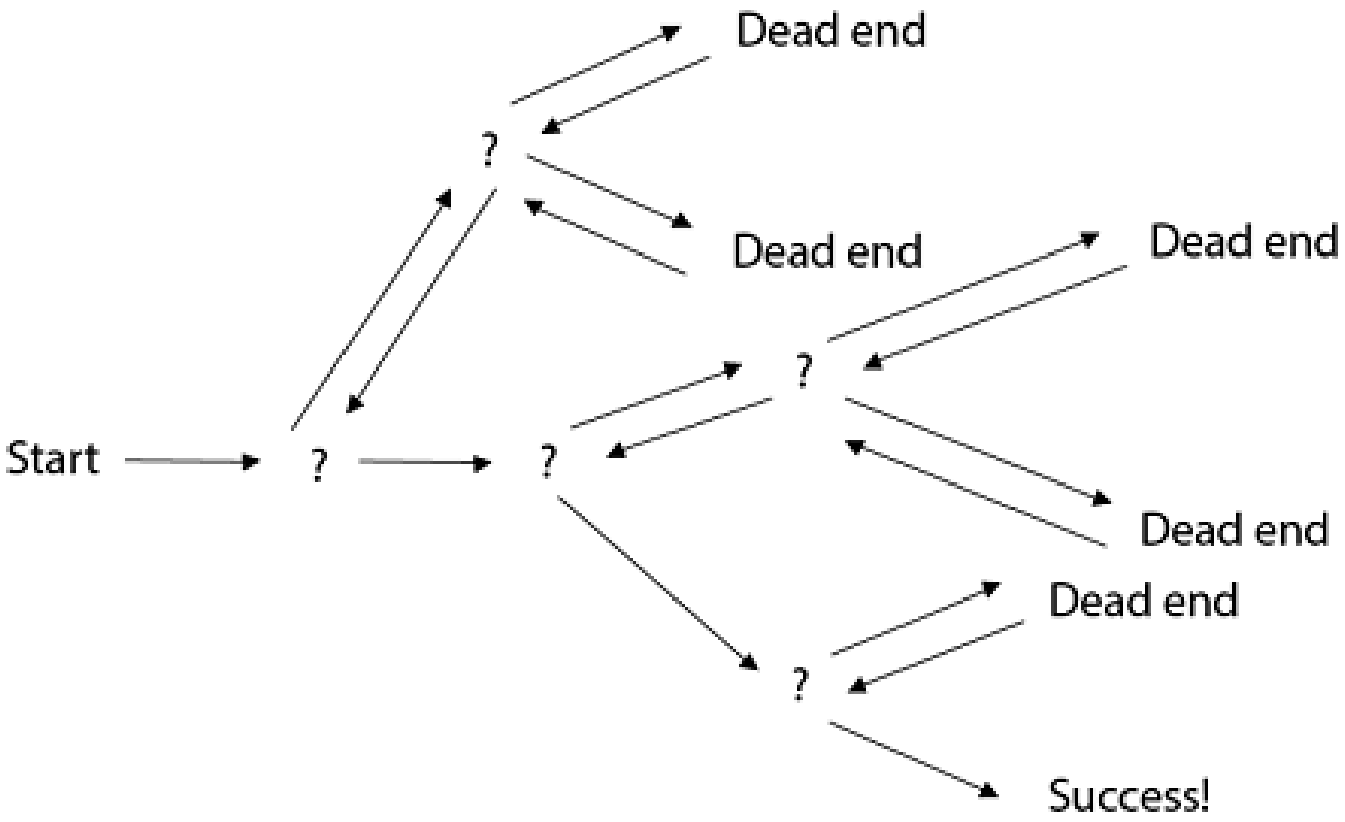
IMPLEMENTIERUNG EINER LÖSUNG

- Ein CSP kann immer durch Backtracking gelöst werden. Aber das ist nicht immer die schnellste Lösung!
- Es gibt Programmiersprachen wie Prolog und Picat, die Elemente zur einfachen Umsetzung eines Backtracking Algorithmus besitzen.
- In Programmiersprachen wie Java ist das explizit zu implementieren. Naive Implementierung: Eine Schleife über den Wertebereich jeder Variable.

BACKTRACKING PRINZIP



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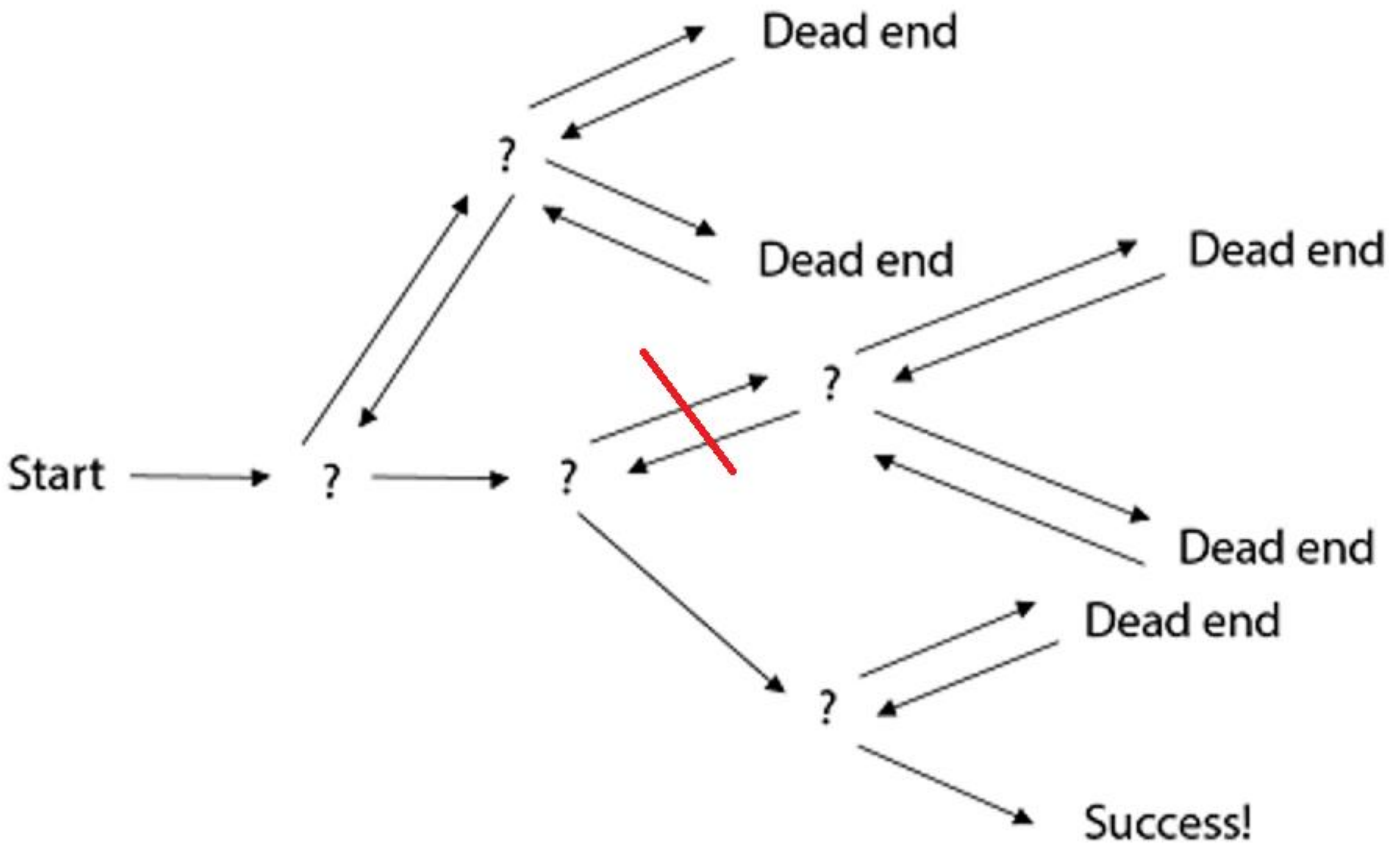
IDEE: PRUNING



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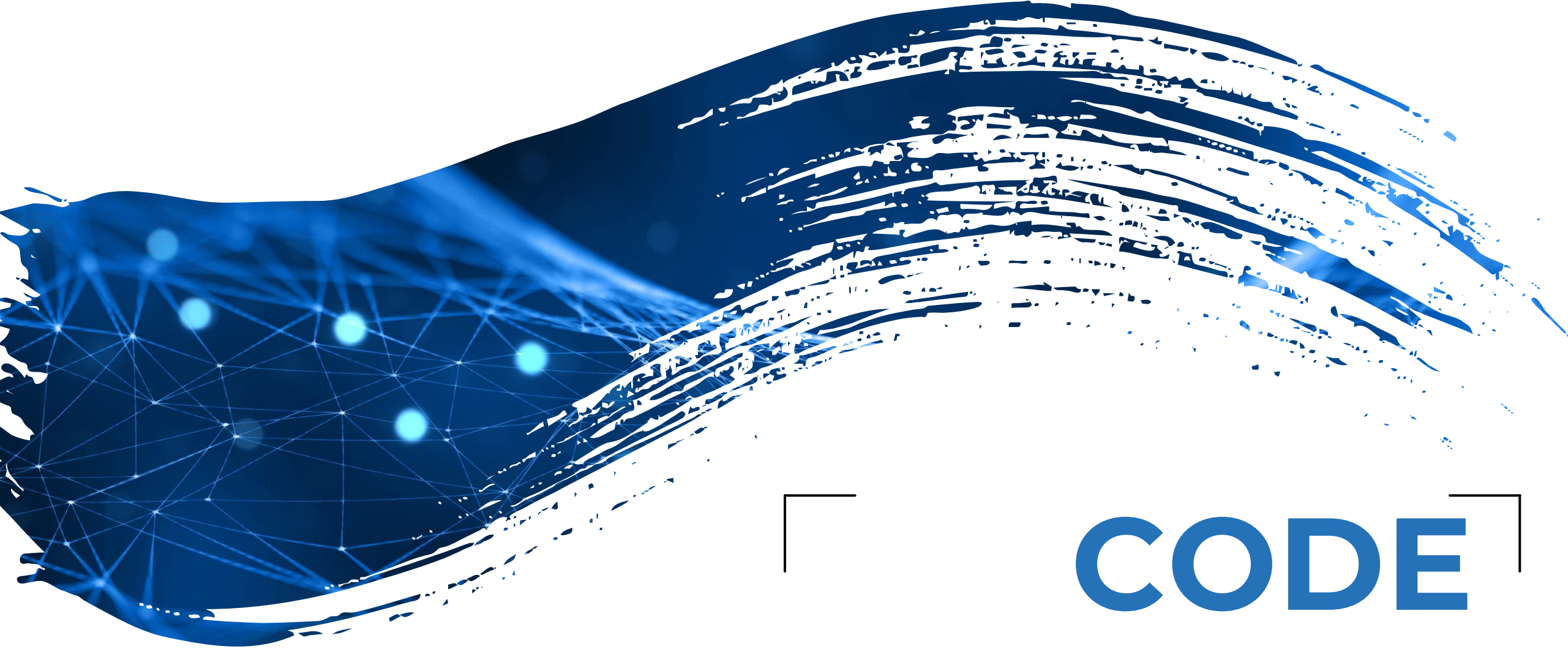

CODE DEMO

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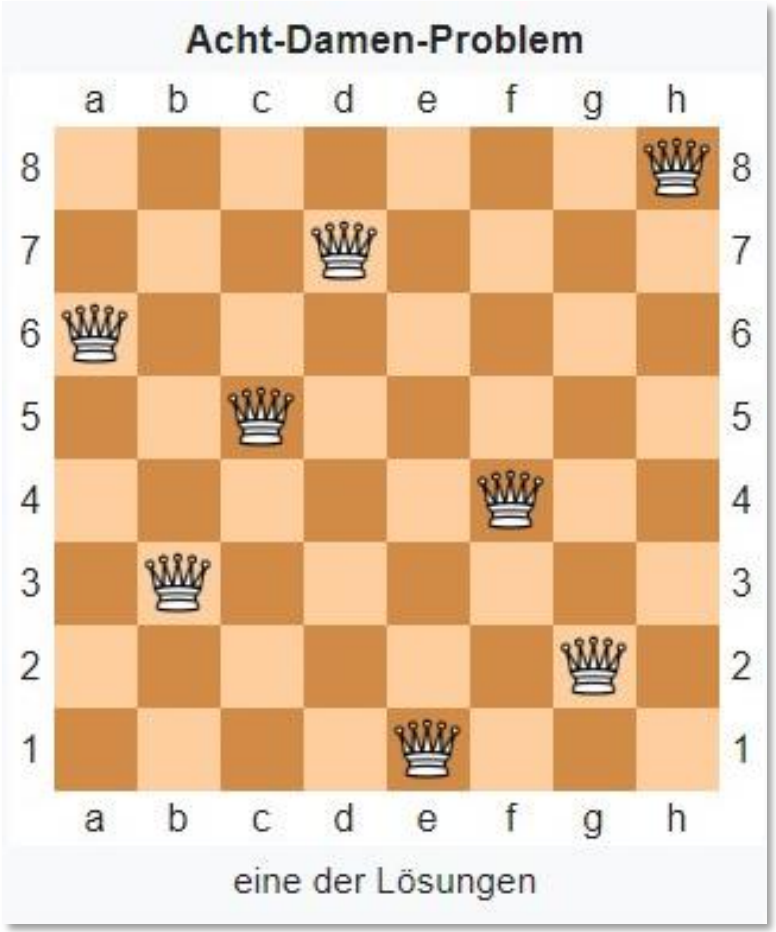
DAMENPROBLEM



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EINE MÖGLICHE IMPLEMENTIERUNG

```
public static Stream<List<Pos>> nQueens(int n) {
   return IntStream.rangeClosed(1, n)
     .mapToObj(i -> i)
     .sorted(Comparator.reverseOrder())
     .reduce( Stream.of(new ArrayList<Pos>()), (r, i) -> r.flatMap(qs -> IntStream.rangeClosed(1, n).mapToObj( j ->
       new Pos(j, i))
    . flatMap(p -> (qs.stream().allMatch( q -> (q.x != p.x && q.y != p.y && abs(q.x -p.x) != abs(q.y - p.y))) ?
       Stream.of(Stream.concat(qs.stream(), Stream.of(p))
    .collect(Collectors.toList())) : Stream.<List<Pos>> empty())))), Stream::concat);
}
```


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SUDOKU

	3							
			1	9	5			
		8					6	
8				6				
4			8					1
				2				
	6					2	8	
			4	1	9			5
							7	

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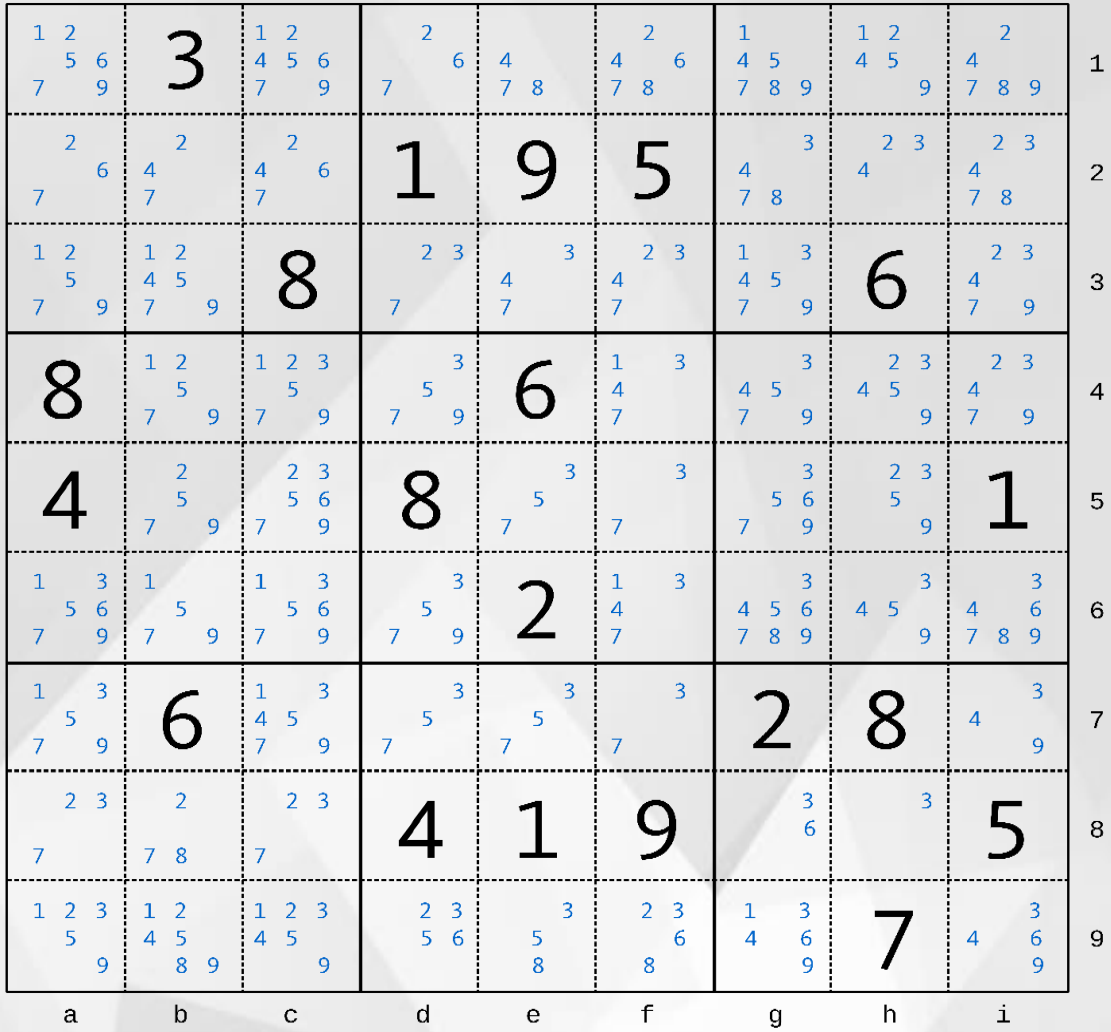
SUDOKU



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MAP OF AUSTRALIA

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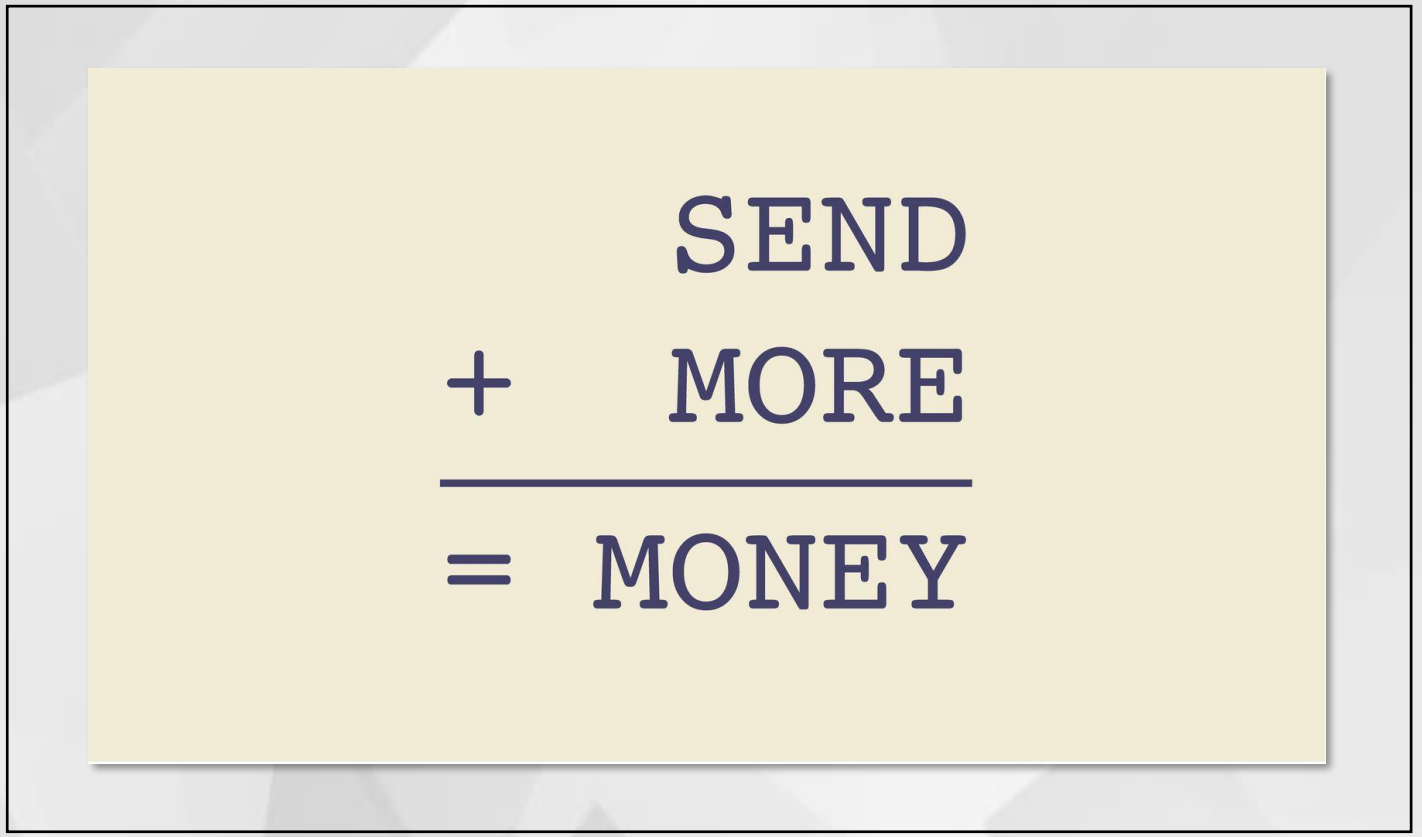
SEND + MORE = MONEY



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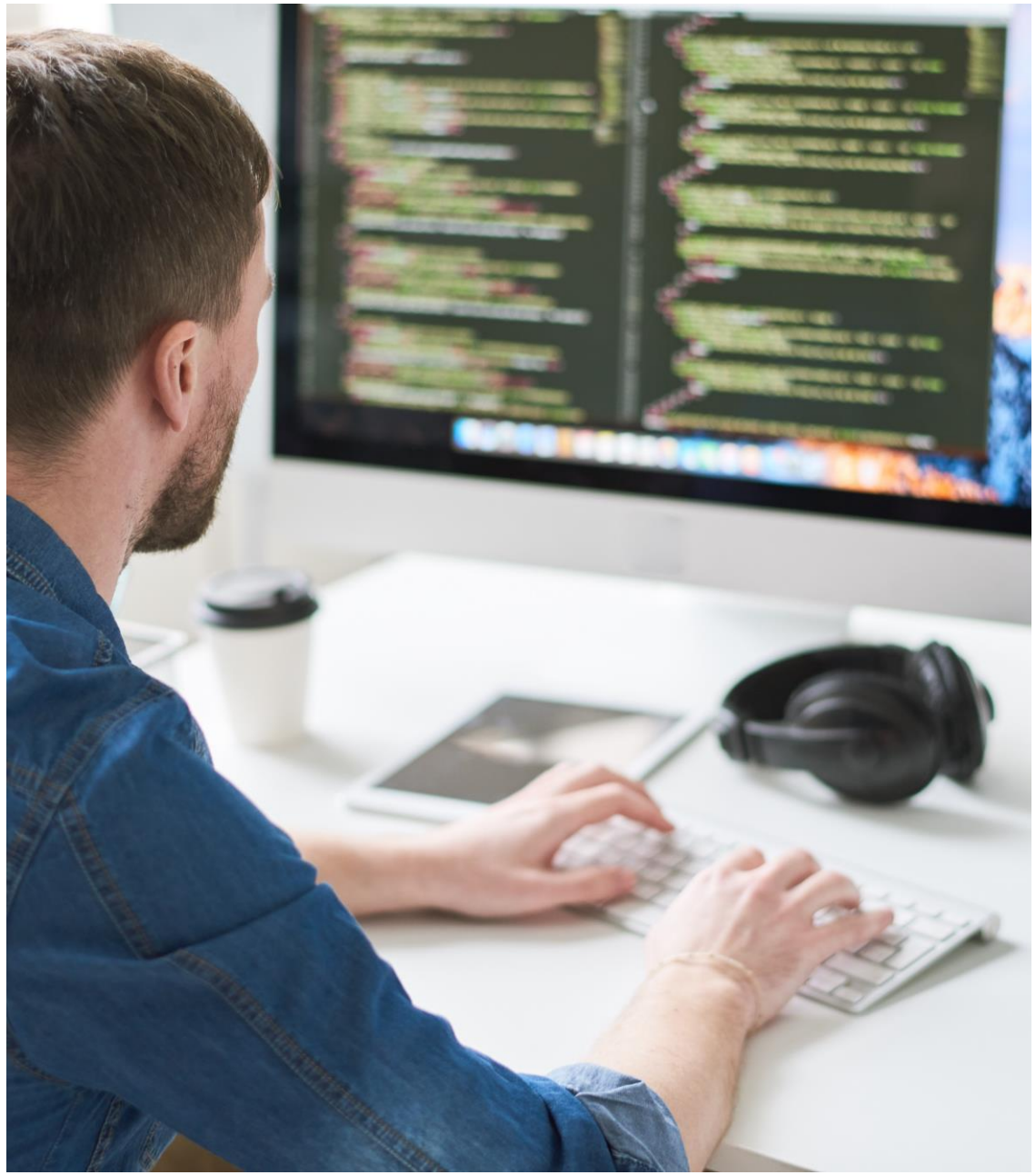

ERSTELLUNG VON SPORTLIGEN

- Einige kommerzielle Produkte vorhanden
- Optimierung des Spielplans nach folgenden Kriterien:
  - Heim- und Auswärtsspiele (approx.) alternierend
  - Ortskonflikte vermeiden
  - Top-Spiele gleichmäßig über die Saison verteilen
  - Minimierung der Reisewege

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CHOCO-SOLVER

Erster Release 2003!

Open Source (BSD4-Clause-Lizens)

IMT Atlantique

Choco-solver

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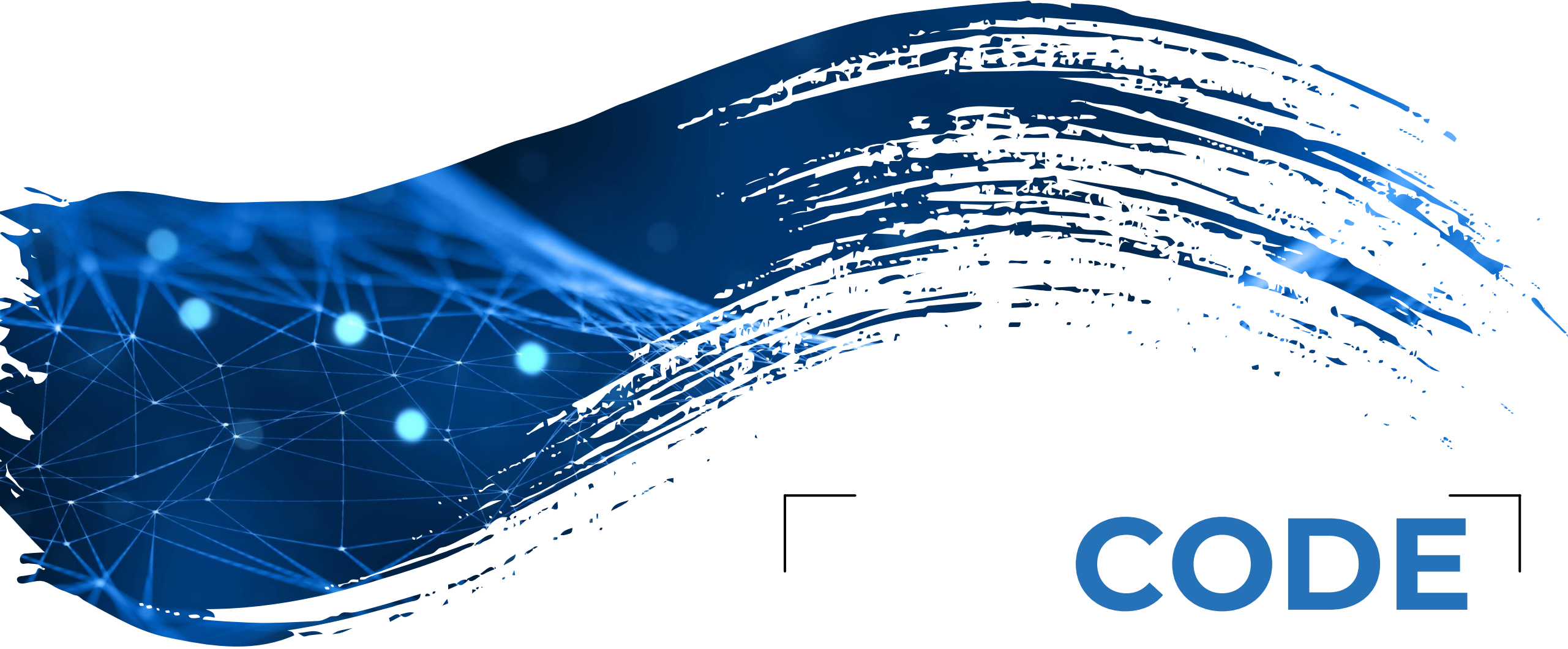

CODE DEMO

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CHOCO-SOLVER CHEAT SHEET

Model

- Model model = new Model („n-queens problem“);

Variables + Domains

- IntVar[] vars = model.intVarArray(“Q“, GRID_SIZE, 1, GRID_SIZE, false);
- Variablen gibt es vom Typ Integer, Boolean, Set und Real

Constraints

- model.arithm(vars[i], “!=“, vars[j], “-“, j – i).post();
- Es gibt arithmetische, relationale und logische Expressions

Solver

- Solver solver = model.getSolver();
- List<Solution> solutions = solver.findAllSolutions();
- Solver.showStatistics();

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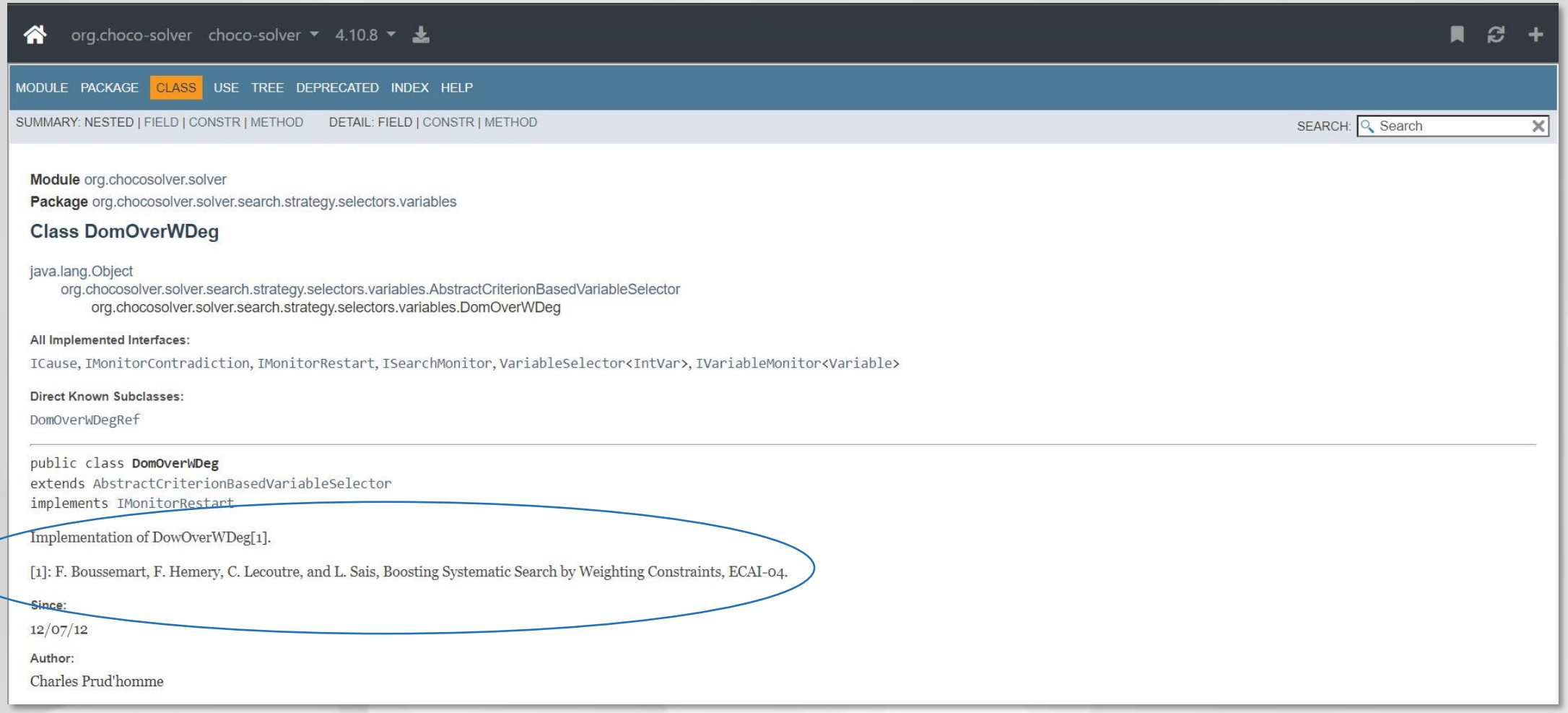
SEARCH STRATEGIES - BEISPIEL



org.choco-solver choco-solver 4.10.8

MODULE PACKAGE CLASS USE TREE DEPRECATED INDEX HELP

SUMMARY: NESTED | FIELD | CONSTR | METHOD DETAIL: FIELD | CONSTR | METHOD SEARCH: Search

Module org.chocosolver.solver
Package org.chocosolver.solver.search.strategy.selectors.variables

Class DomOverWDeg

java.lang.Object
org.chocosolver.solver.search.strategy.selectors.variables.AbstractCriterionBasedVariableSelector
org.chocosolver.solver.search.strategy.selectors.variables.DomOverWDeg

All Implemented Interfaces:

ICause, IMonitorContradiction, IMonitorRestart, ISearchMonitor, VariableSelector<IntVar>, IVariableMonitor<Variable>

Direct Known Subclasses:

DomOverWDegRef

```
public class DomOverWDeg
extends AbstractCriterionBasedVariableSelector
implements IMonitorRestart
```

Implementation of DowOverWDeg[1].

[1]: F. Boussemart, F. Hemery, C. Lecoutre, and L. Sais, Boosting Systematic Search by Weighting Constraints, ECAI-04.

Since:

12/07/12

Author:

Charles Prud'homme

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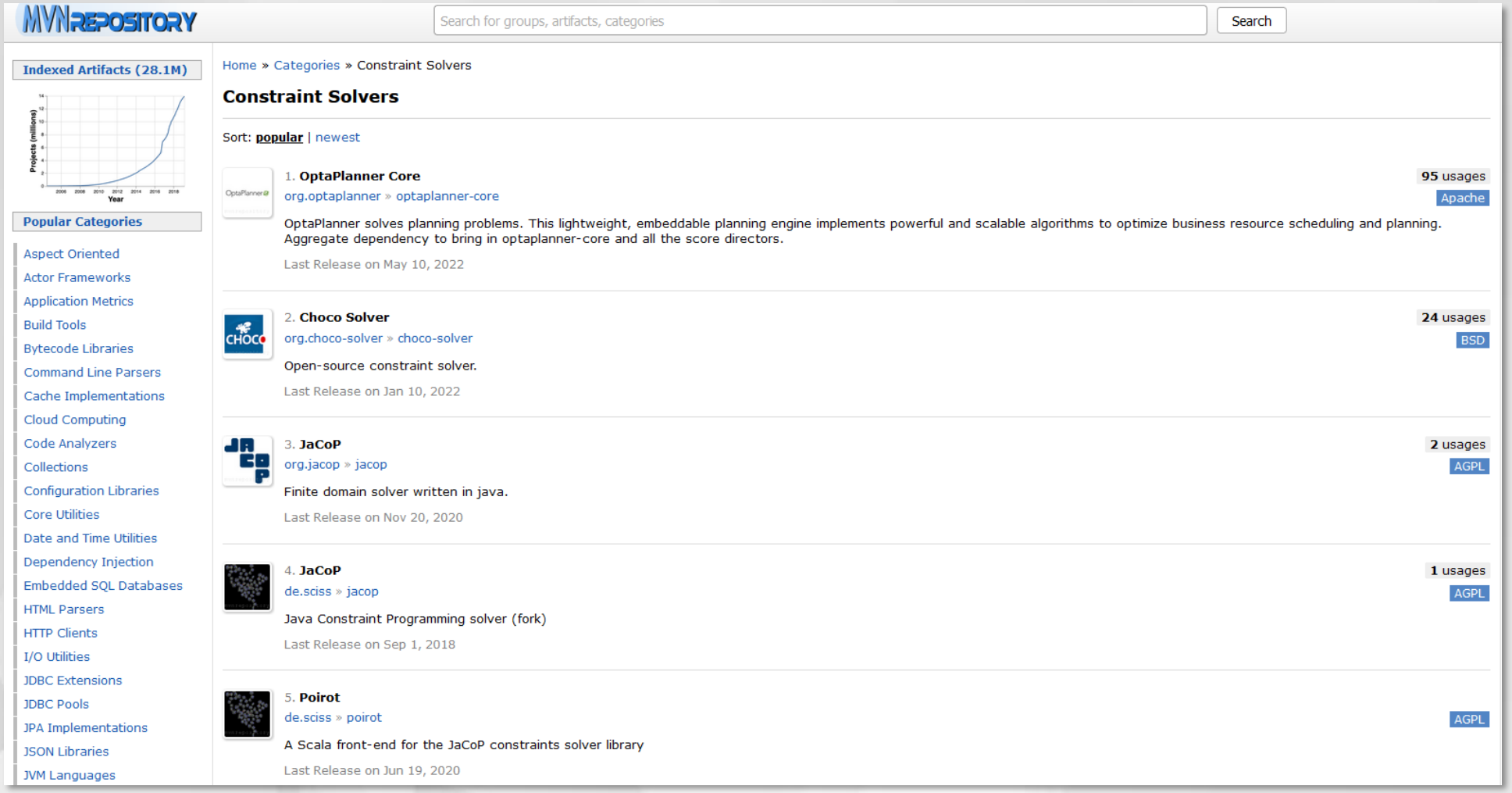
ALTERNATIVEN?



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SOFT CONSTRAINTS

What can OptaPlanner do?

OptaPlanner optimizes plans and schedules with *hard constraints* and *soft constraints*.
It **reduces costs** substantially, improves **service quality**, fulfills **employee wishes** and **lowers carbon emissions**.

Vehicle routing (VRP)
Quicker routes for a fleet of vehicles.

Learn more

Employee rostering
Assign shifts to employees by skills and availability.

Learn more

Maintenance scheduling
Timely upkeep of machinery and equipment.

Learn more

Conference scheduling
Schedule speakers and talks by availability and topic.

Learn more

School timetabling
Compacter schedules for teachers and students.

Learn more

Task assignment
Assign tasks by priority, skills and affinity.

Learn more

Cloud optimization
Bin packing and defragmentation of cloud resources.

Learn more

Job shop scheduling
Reduce makespan for assembly lines.

Learn more

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FRAGEN

Mitdenken

Mitgestalten

Mitarbeiten

bei sidion

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QUELLENANGABEN

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- David Kopec – Algorithmen in Java, Rheinwerk Computing, 2021
- https://www.javatpointom/backtracking-introduction
- https://de.wikipedia.org/wiki/Damenproblem
- https://de.wikipedia.org/wiki/Sudoku
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- https://javadoc.io/doc/org.choco-solver/choco-solver/latest/org.chocosolver.solver/org/chocosolver/solver/search/strategy/selectors/variables/DomOverWDeg.html
- https://www.optaplanner.org/

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VIELEN DANK