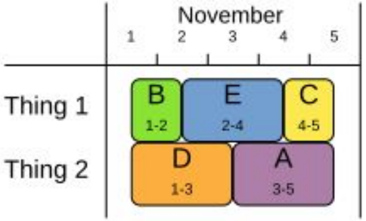
Back to school: create a timetable with OptaPlanner and Quarkus

Radovan Synek

Equipment scheduling

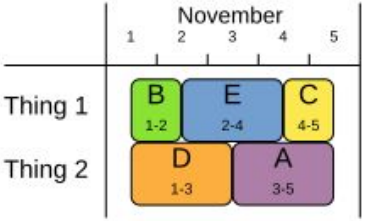


Higher utilization

OptaPlanner

*Optimize planning
with Artificial Intelligence*

Equipment scheduling



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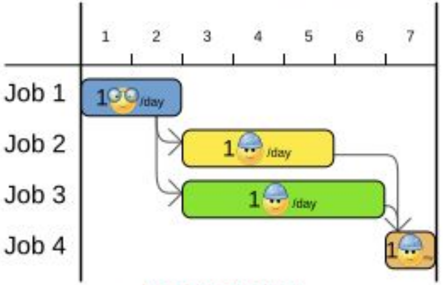
Job shop scheduling



Less makespan

OptaPlanner

Optimize planning
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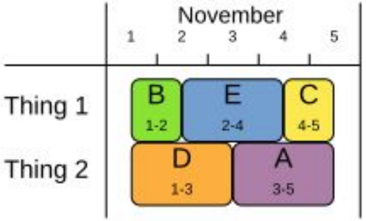

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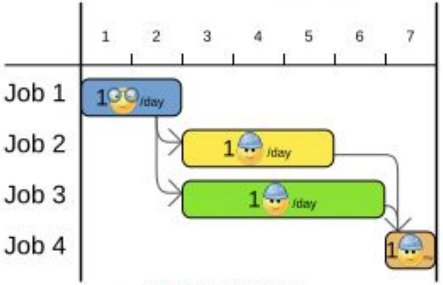

Less makespan

Vehicle routing

Less driving time

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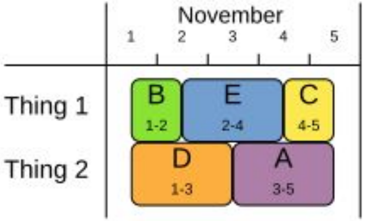

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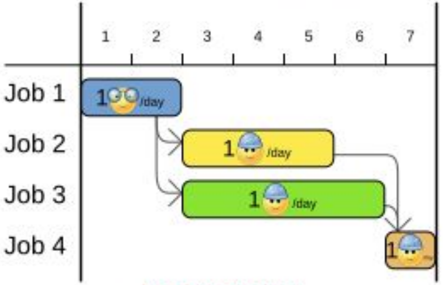

Less makespan

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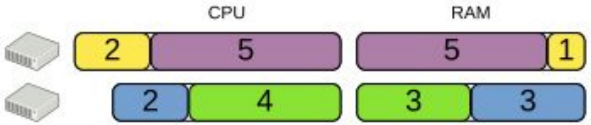
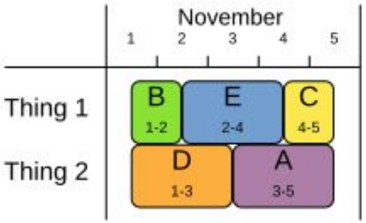
Less fragmentation

Bin packing



Equipment scheduling



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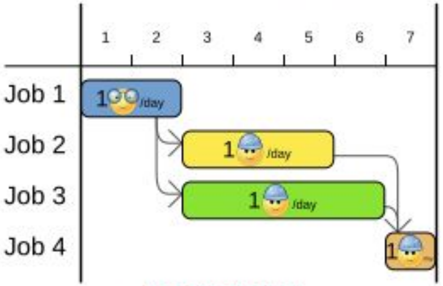

Less makespan

Vehicle routing

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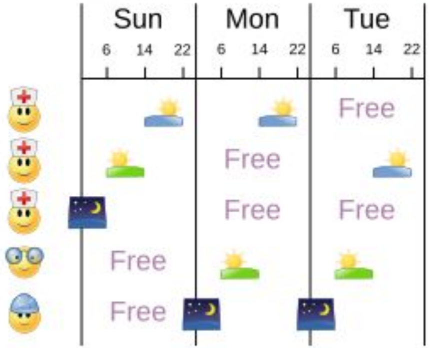
Happier employees

Employee rostering



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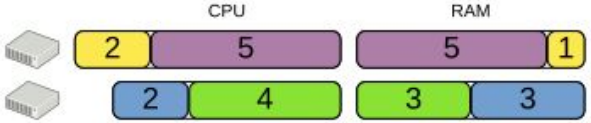
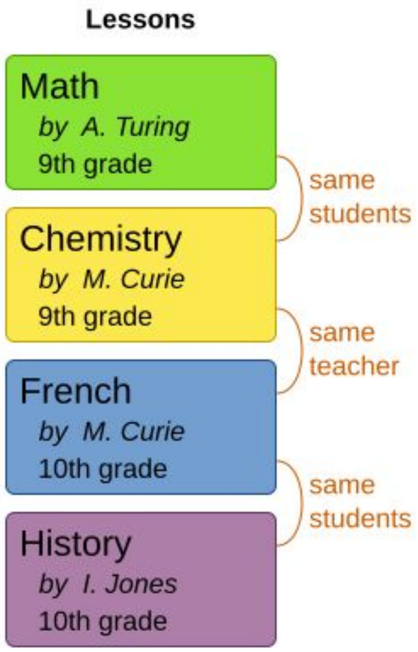


Image by Wokandapix from Pixabay.

School timetabling input/output

Assign each lesson to a time slot and a room.



Lessons

Math
by A. Turing
9th grade

Chemistry
by M. Curie
9th grade

French
by M. Curie
10th grade

History
by I. Jones
10th grade

same students

same teacher

same students

	Room A	**Room B**
08:30 - 09:30	?	?
09:30 - 10:30	?	?

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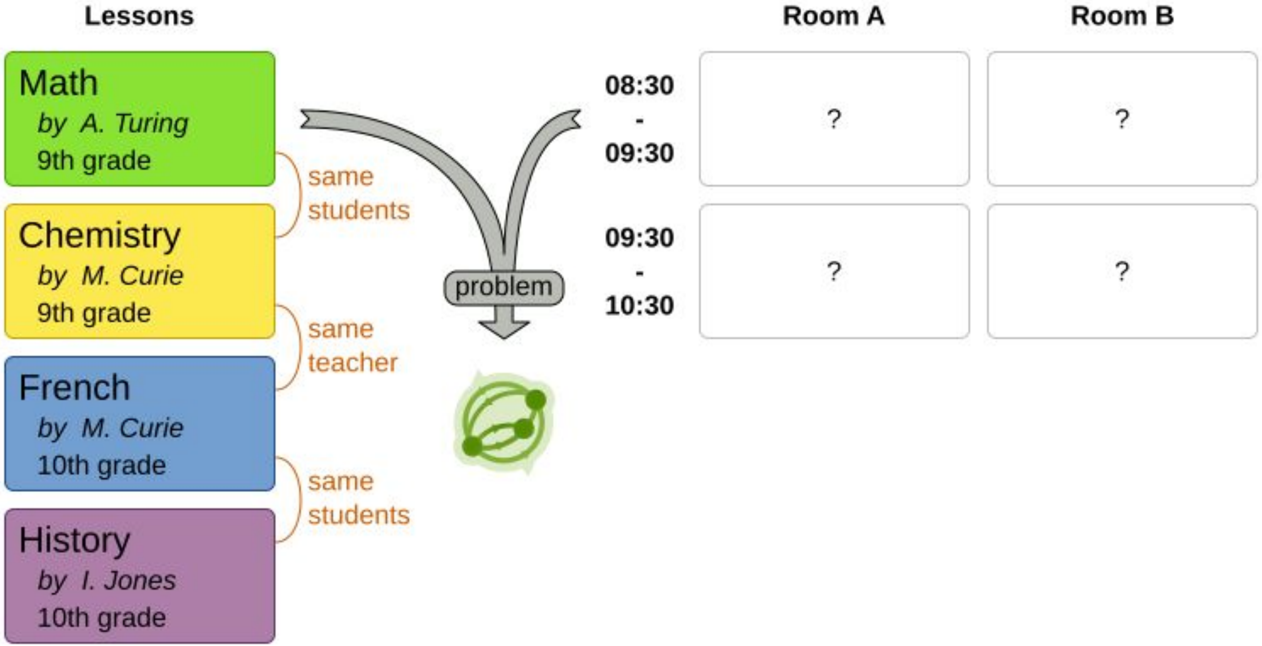

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problem

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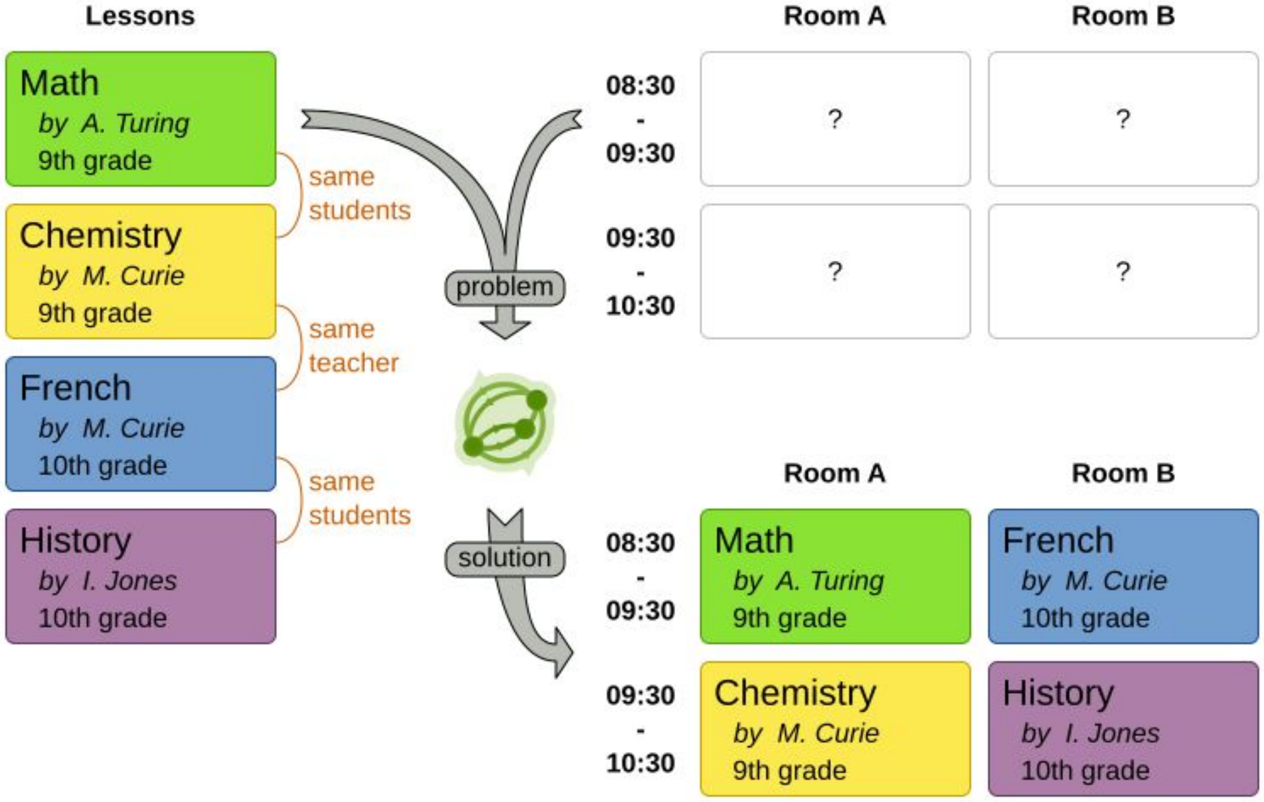

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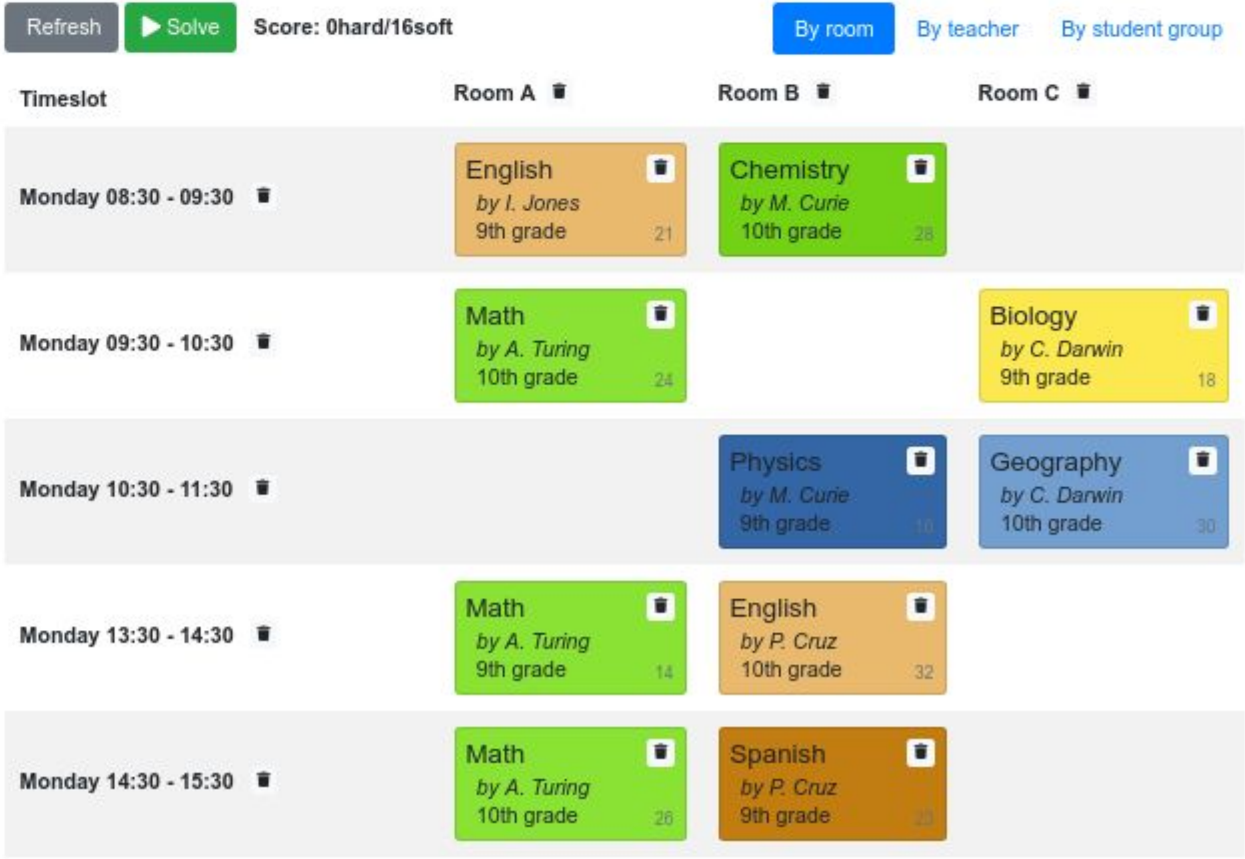
Spend less time in
a spreadsheet?

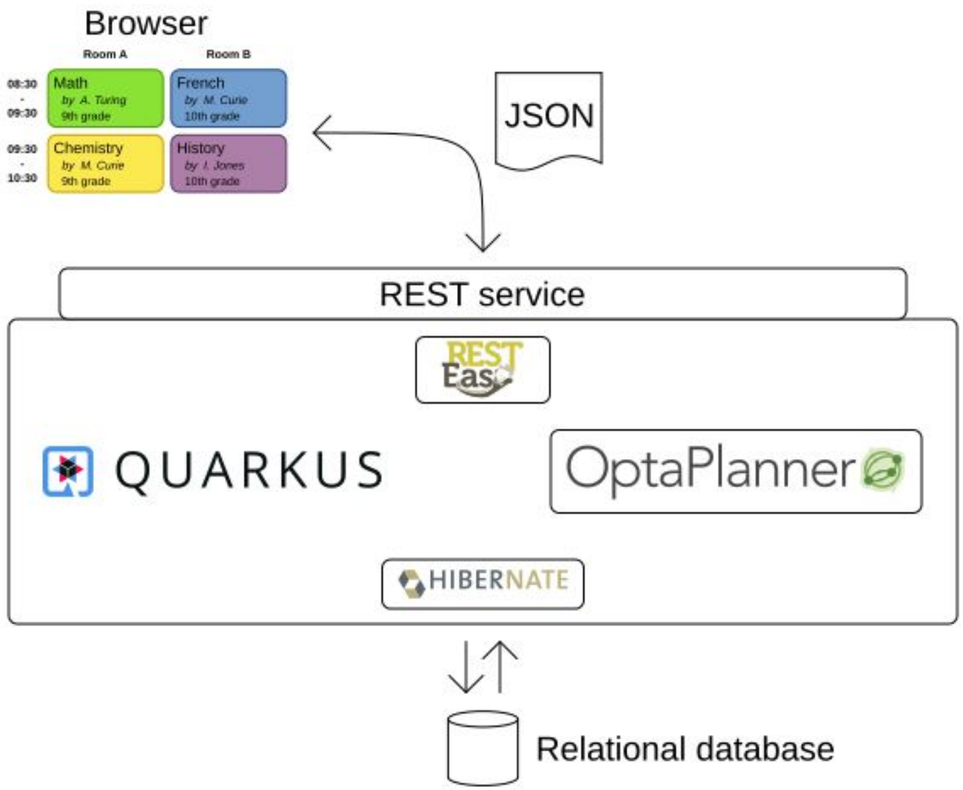


Score: 0hard/16soft

Timeslot	Room A	Room B	Room C
Monday 08:30 - 09:30	English *by I. Jones* 9th grade 21	Chemistry *by M. Curie* 10th grade 28	
Monday 09:30 - 10:30	Math *by A. Turing* 10th grade 24		Biology *by C. Darwin* 9th grade 18
Monday 10:30 - 11:30		Physics *by M. Curie* 9th grade 10	Geography *by C. Darwin* 10th grade 30
Monday 13:30 - 14:30	Math *by A. Turing* 9th grade 14	English *by P. Cruz* 10th grade 32	
Monday 14:30 - 15:30	Math *by A. Turing* 10th grade 26	Spanish *by P. Cruz* 9th grade 23	

School timetabling architecture

It's a Quarkus REST service using OptaPlanner on top of a database.



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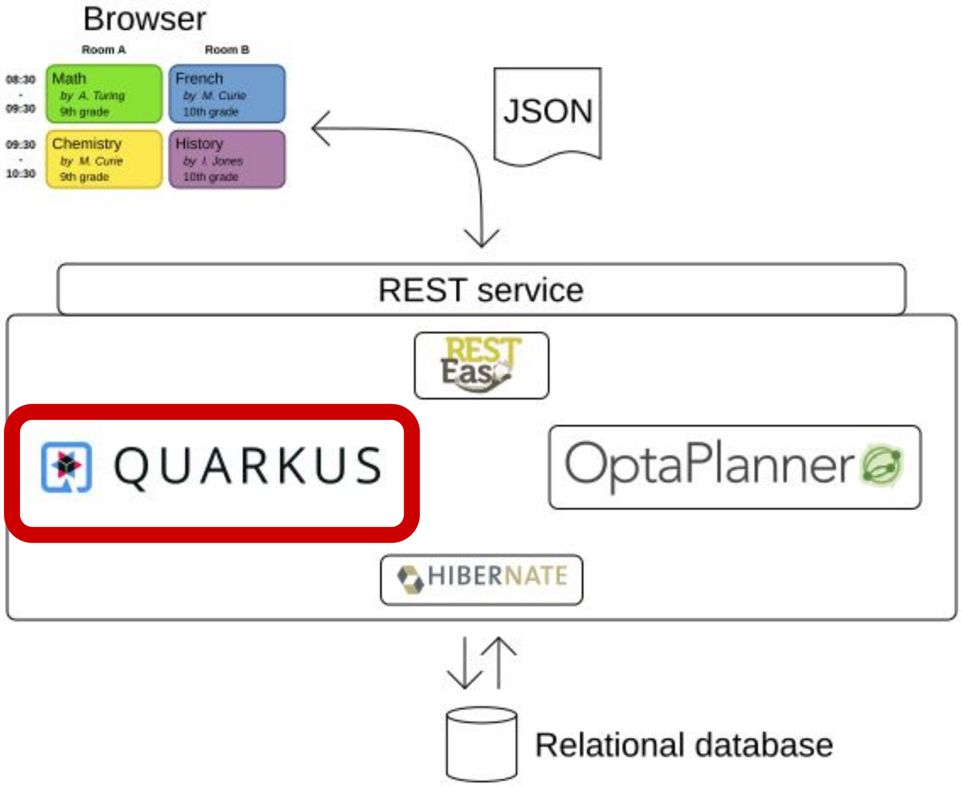
Quick redeploy

Minimal memory footprint

Native image



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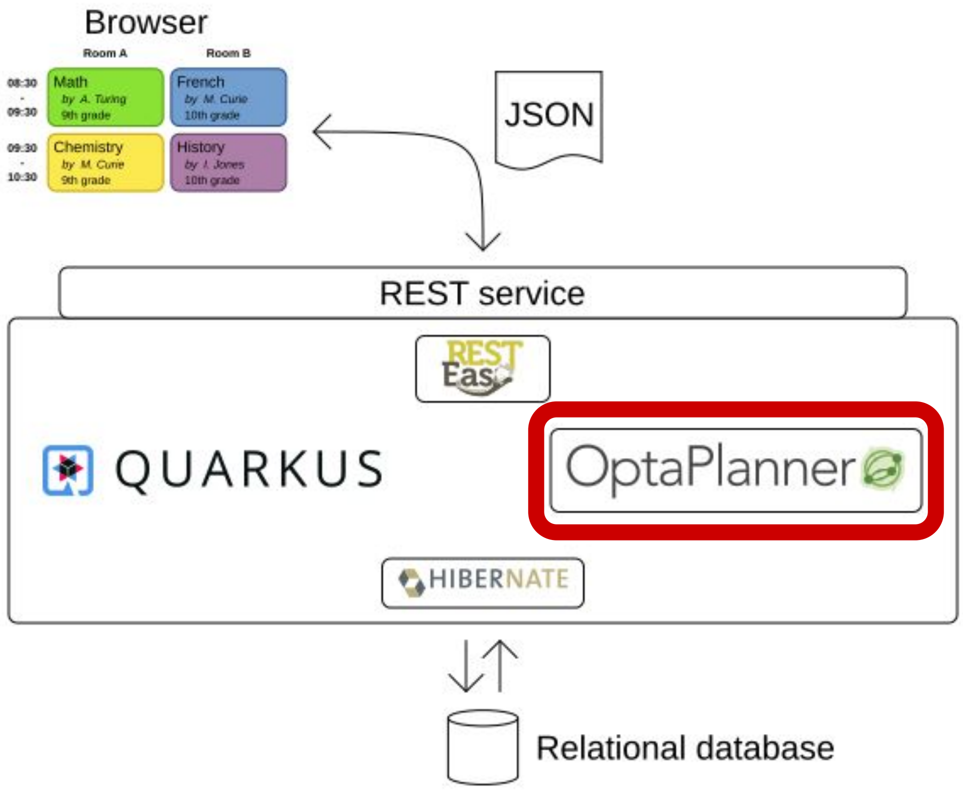

Browser

	Room A	Room B
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JSON

REST service

Relational database

OptaPlanner

OptaPlanner - Constraint satisfaction solver (Java™, Open Source)

“Lightweight, embeddable constraint satisfaction engine

which optimizes planning problems.”

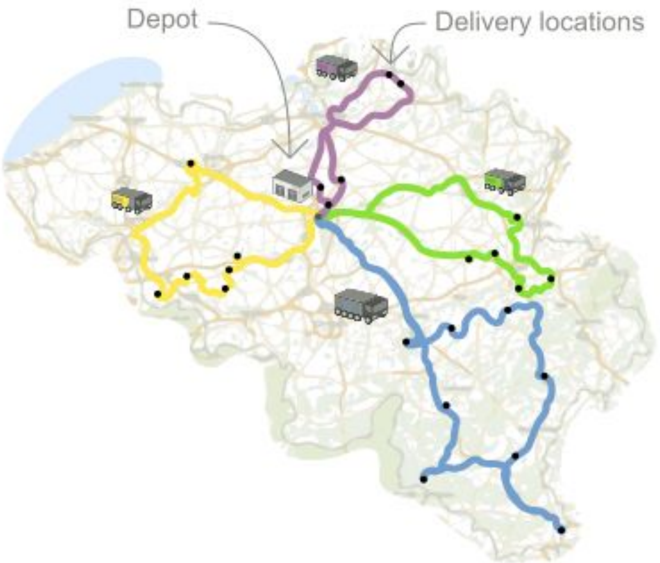
Planning problem

Goals

Minimize fuel consumption & ecological footprint

Resources

Vehicles



Constraints

Vehicle capacity

Distance

Planning problem

Bad news

No guarantee of finding the optimal solution in reasonable time

Planning problem

Good news

“Near-optimal” solution can be found

Quickly verifiable if the solution is satisfying

Is school timetabling a planning problem?

Is school timetabling a planning problem?

Goals

Make both students and teachers happy

Resources

Rooms

Time slots

Constraints

All lessons must be allocated

No teacher has multiple lessons at the same time

There can be up to a single lesson in a room at any moment

Minimize gaps between lessons

Is school timetabling a planning problem?

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Make both students and teachers happy

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✓

What OptaPlanner needs to know to optimize your planning problem?

The planning problem

The constraints

What OptaPlanner needs to know to optimize your planning problem?

The planning problem

What is the entity that changes during solving?

What references should the OptaPlanner change there?

What OptaPlanner needs to know to optimize your planning problem?

The planning problem

What is the entity that changes during solving?

`@PlanningEntity`

What references should the OptaPlanner change there?

`@PlanningVariable`

What OptaPlanner needs to know to optimize your planning problem?

The constraints

What is the score of the solution?

Which conditions must never be broken?

What OptaPlanner needs to know to optimize your planning problem?

Constraint Streams API

Hard vs. soft constraints

The constraints

What is the score of the solution?

Which conditions must never be broken?

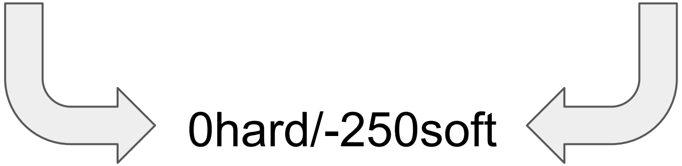
What OptaPlanner needs to know to optimize your planning problem?

Hard constraints

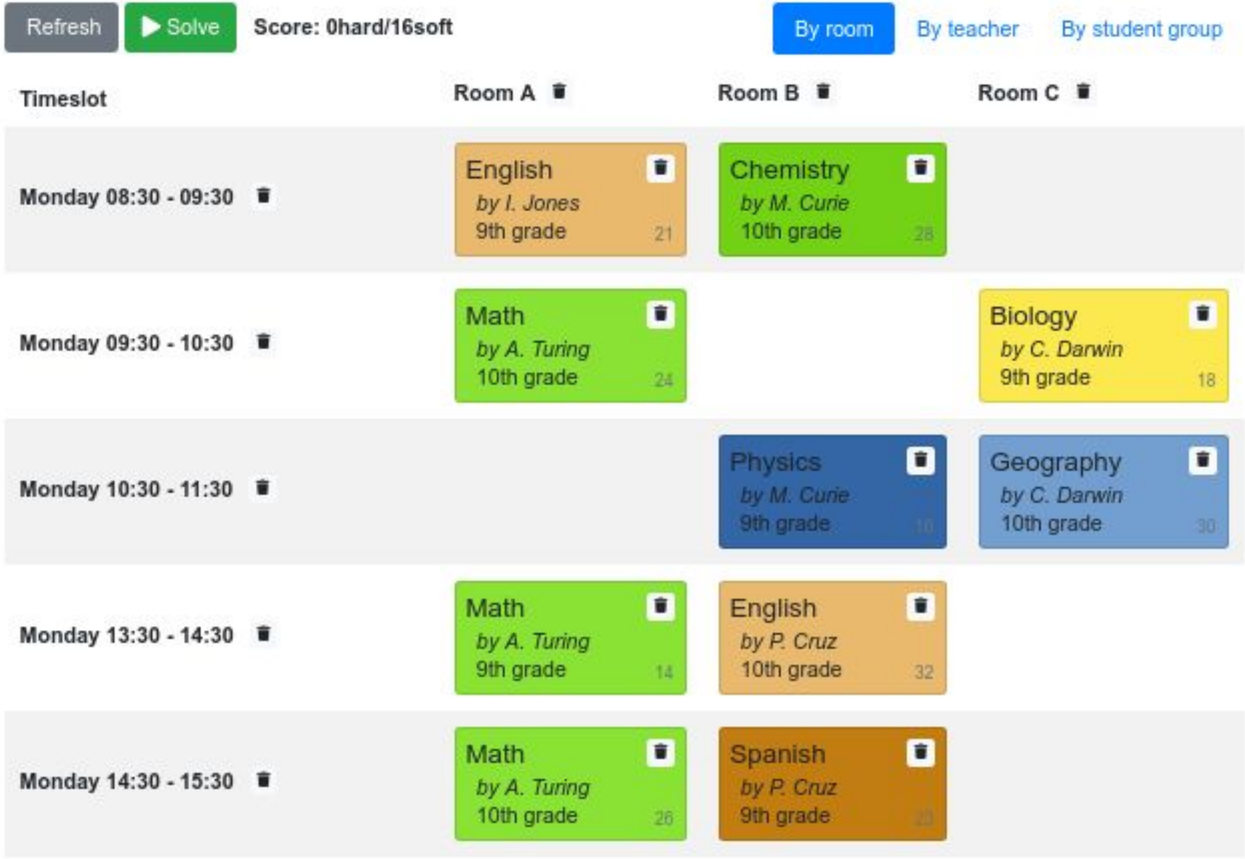
- Must not be broken
- in(feasible) solution

Soft constraints

- Cost
- Can be broken



0hard/-250soft



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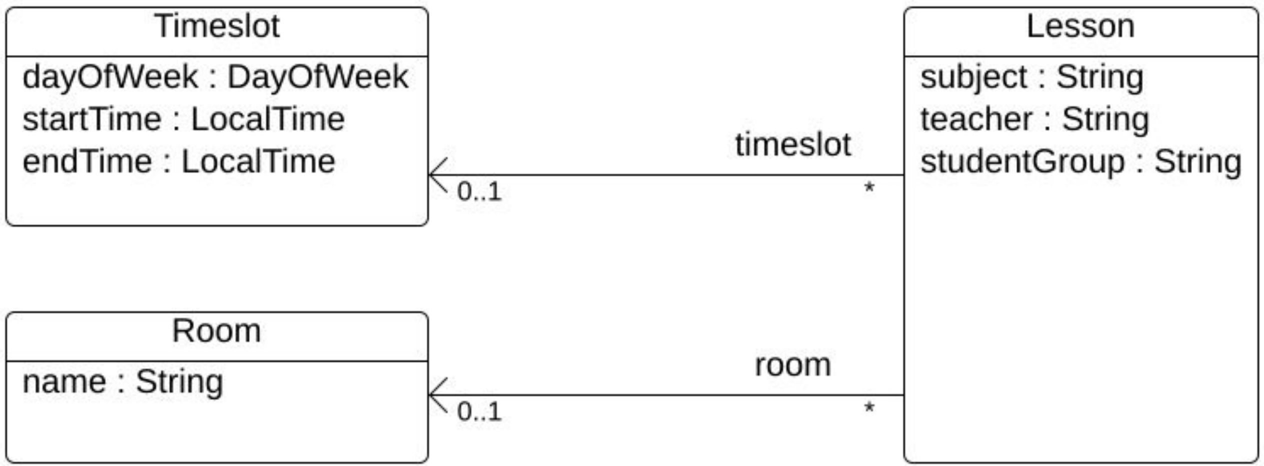
Time table class diagram



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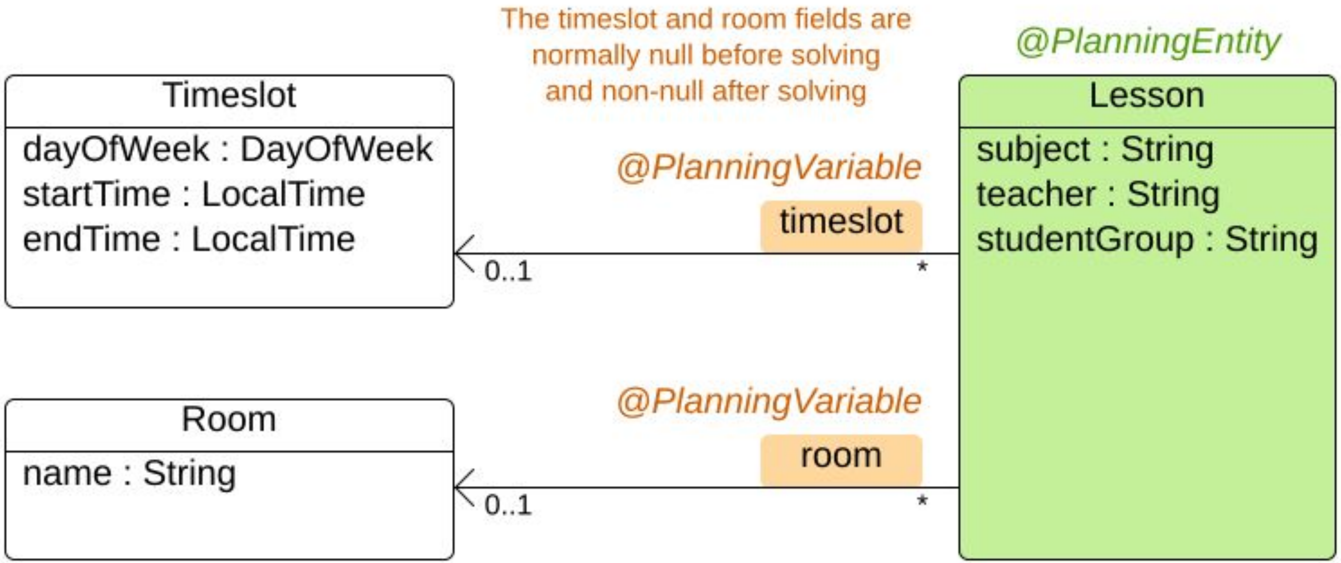
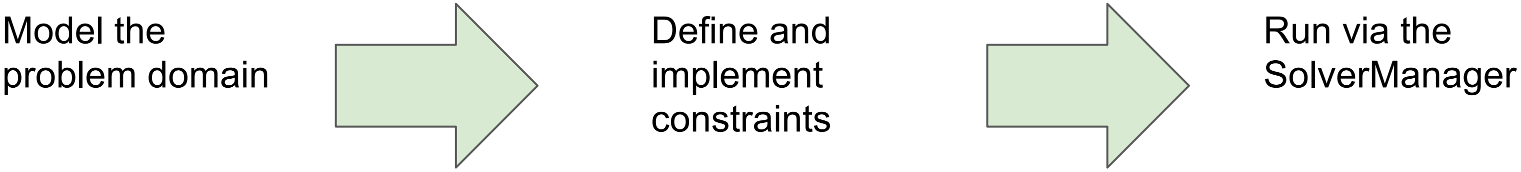


Demo

Summary



Model the problem domain

Define and implement constraints

Run via the SolverManager

```
@PlanningEntity

@PlanningVariable

@PlanningSolution
```

```
return constraintFactory
        .fromUniquePair(Lesson.class,
                ...
        .penalize("Teacher conflict",
                HardSoftScore.ONE_HARD);
```

```
solverManager
        .solveAndListen(...);
```

Q&A

Homepage: www.optaplanner.org

GitHub: optaplanner

Email: rsynek@redhat.com