Show me the Money!

Optimize your business with JBoss BRMS Business Resource Planner

Geoffrey De Smet
OptaPlanner lead

Duncan Doyle
Technical Marketing Manager

2017-05-02

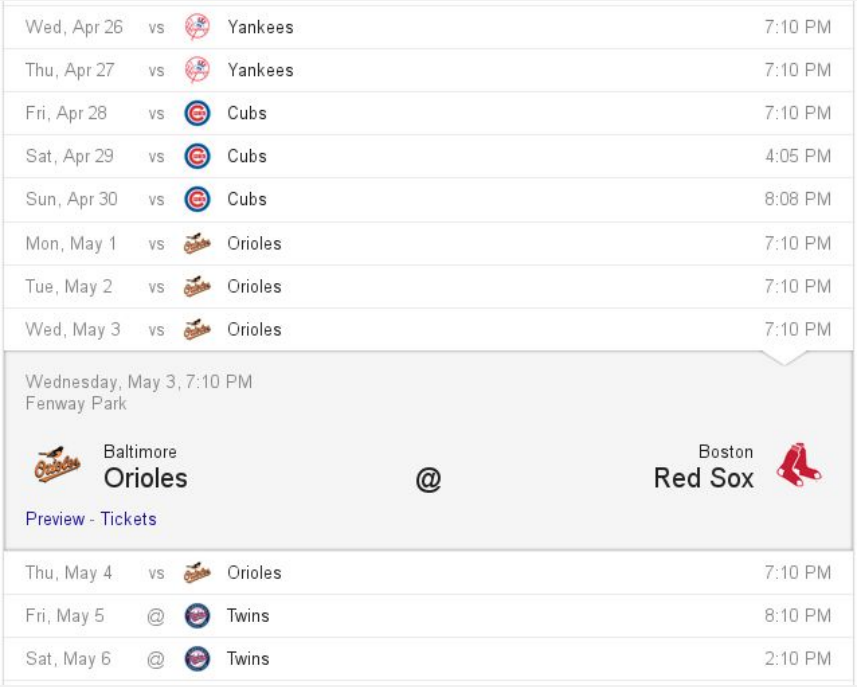
redhat.

Baseball

redhat.

Baseball schedule

Wednesday: Red Sox party at Fenway Park



Wed, Apr 26	vs	Yankees	7:10 PM
Thu, Apr 27	vs	Yankees	7:10 PM
Fri, Apr 28	vs	Cubs	7:10 PM
Sat, Apr 29	vs	Cubs	4:05 PM
Sun, Apr 30	vs	Cubs	8:08 PM
Mon, May 1	vs	Orioles	7:10 PM
Tue, May 2	vs	Orioles	7:10 PM
Wed, May 3	vs	Orioles	7:10 PM

Wednesday, May 3, 7:10 PM
Fenway Park

Baltimore Orioles @ Boston Red Sox

Preview - Tickets

Thu, May 4	vs	Orioles	7:10 PM
Fri, May 5	@	Twins	8:10 PM
Sat, May 6	@	Twins	2:10 PM

How hard is it to create a schedule for Major League Baseball?

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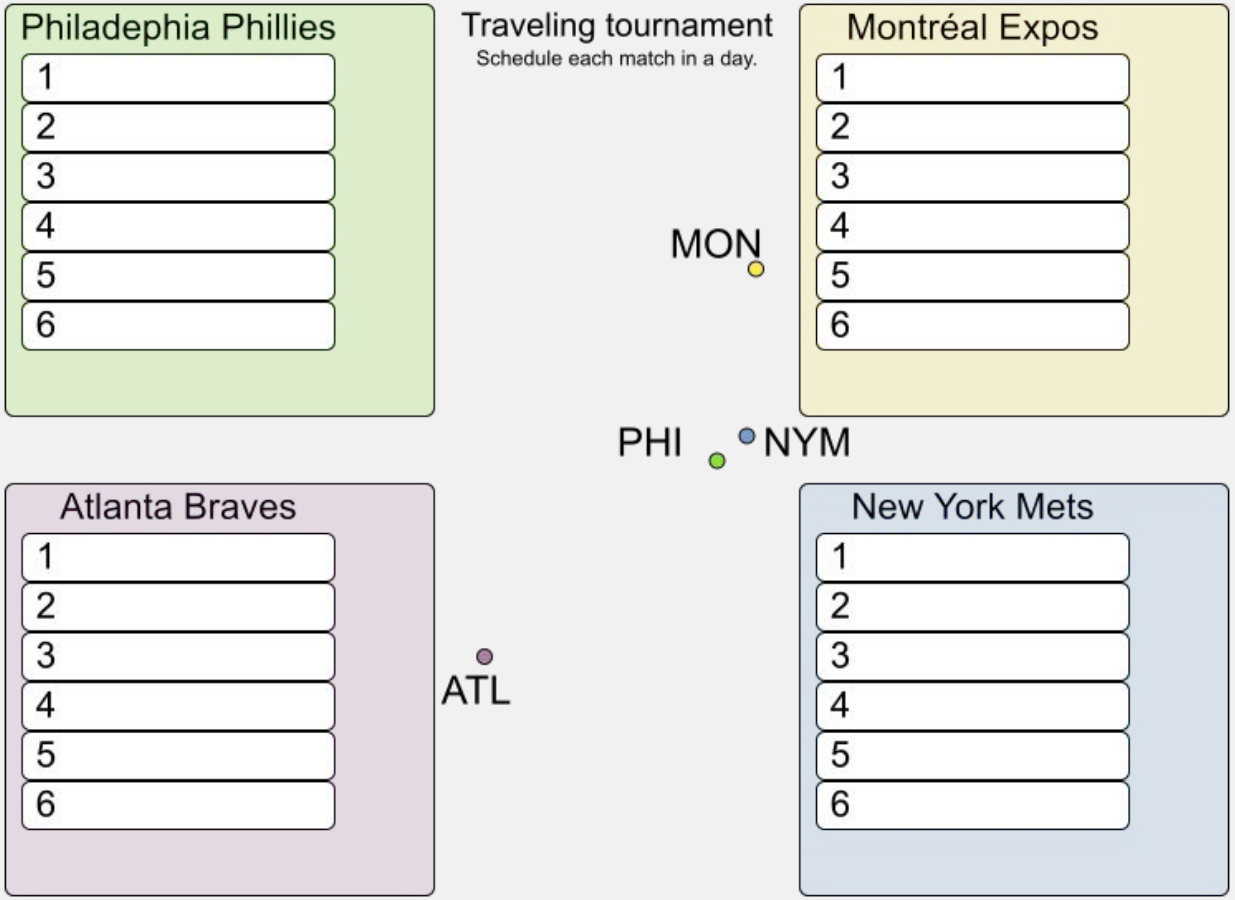
Philadephia Phillies
1
2
3
4
5
6
Traveling tournament
Schedule each match in a day.
Montréal Expos
1
2
3
4
5
6
MON
PHI
NYM
Atlanta Braves
1
2
3
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6
ATL
New York Mets
1
2
3
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5
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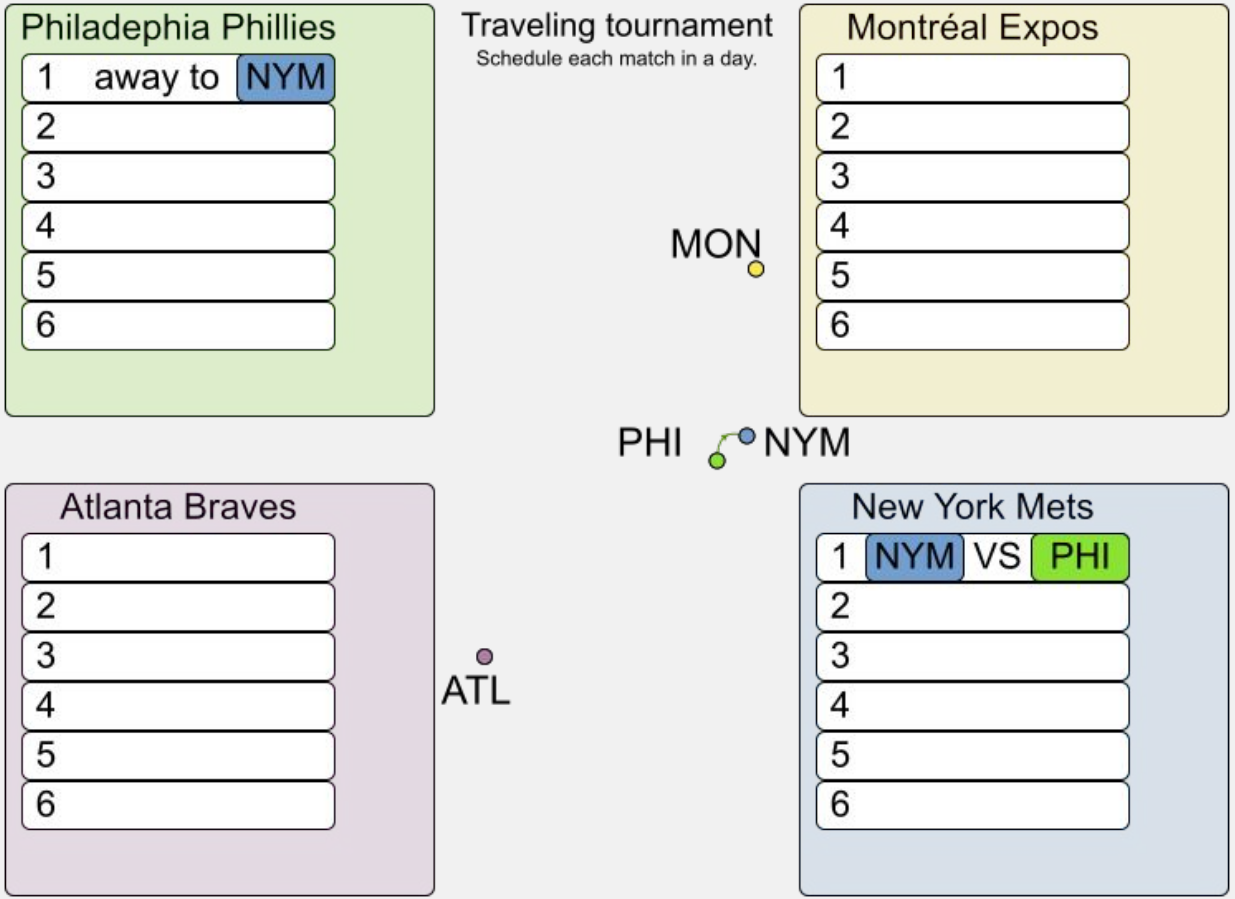
redhat.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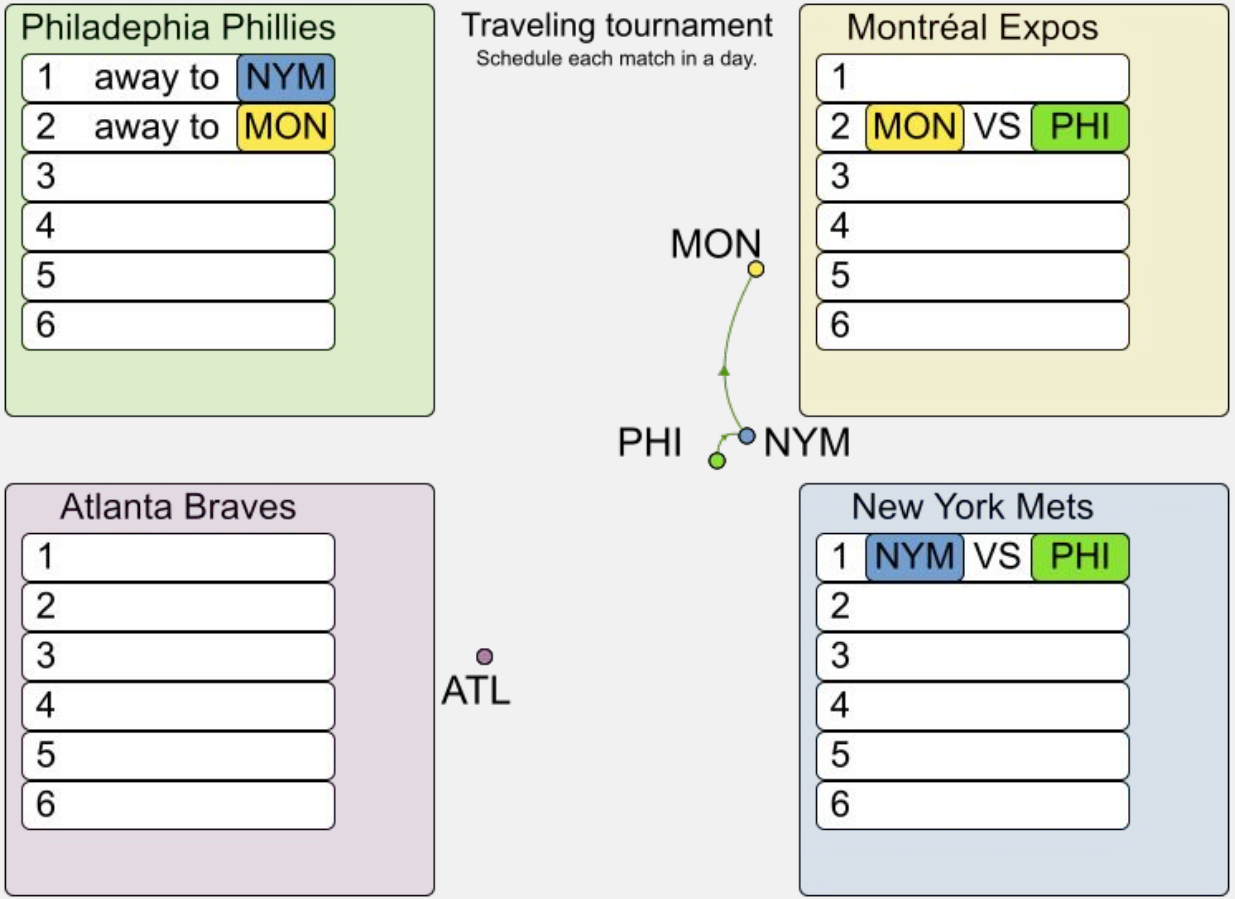
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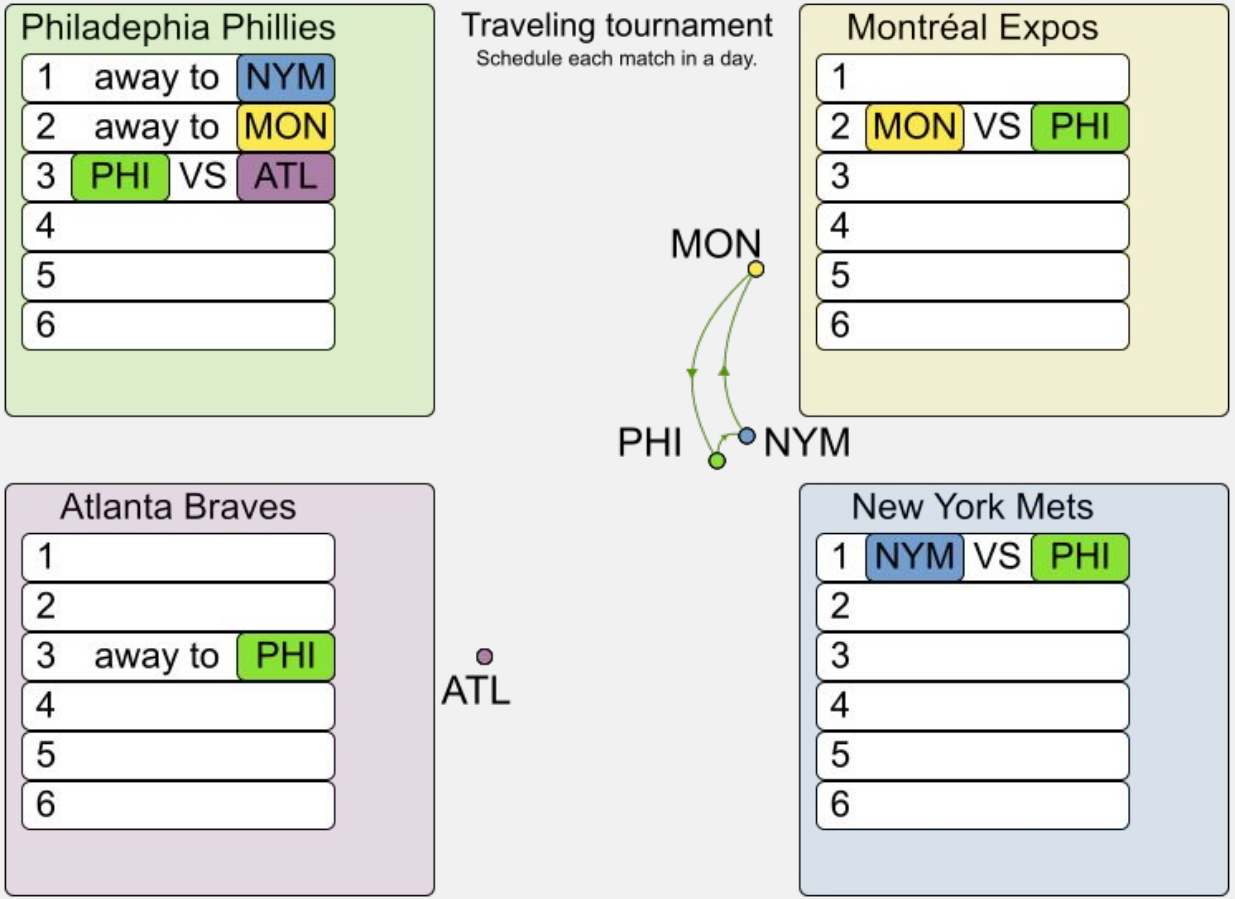
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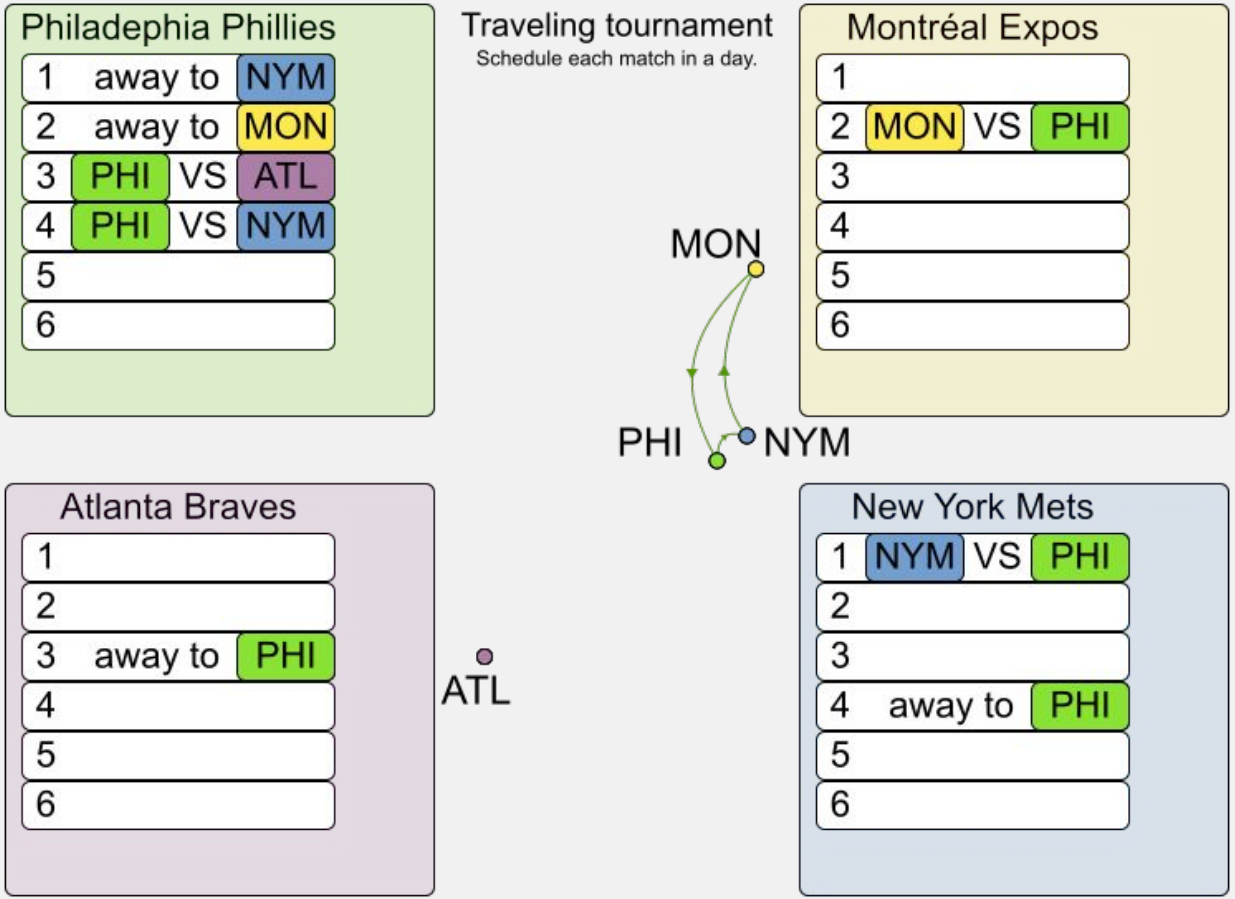
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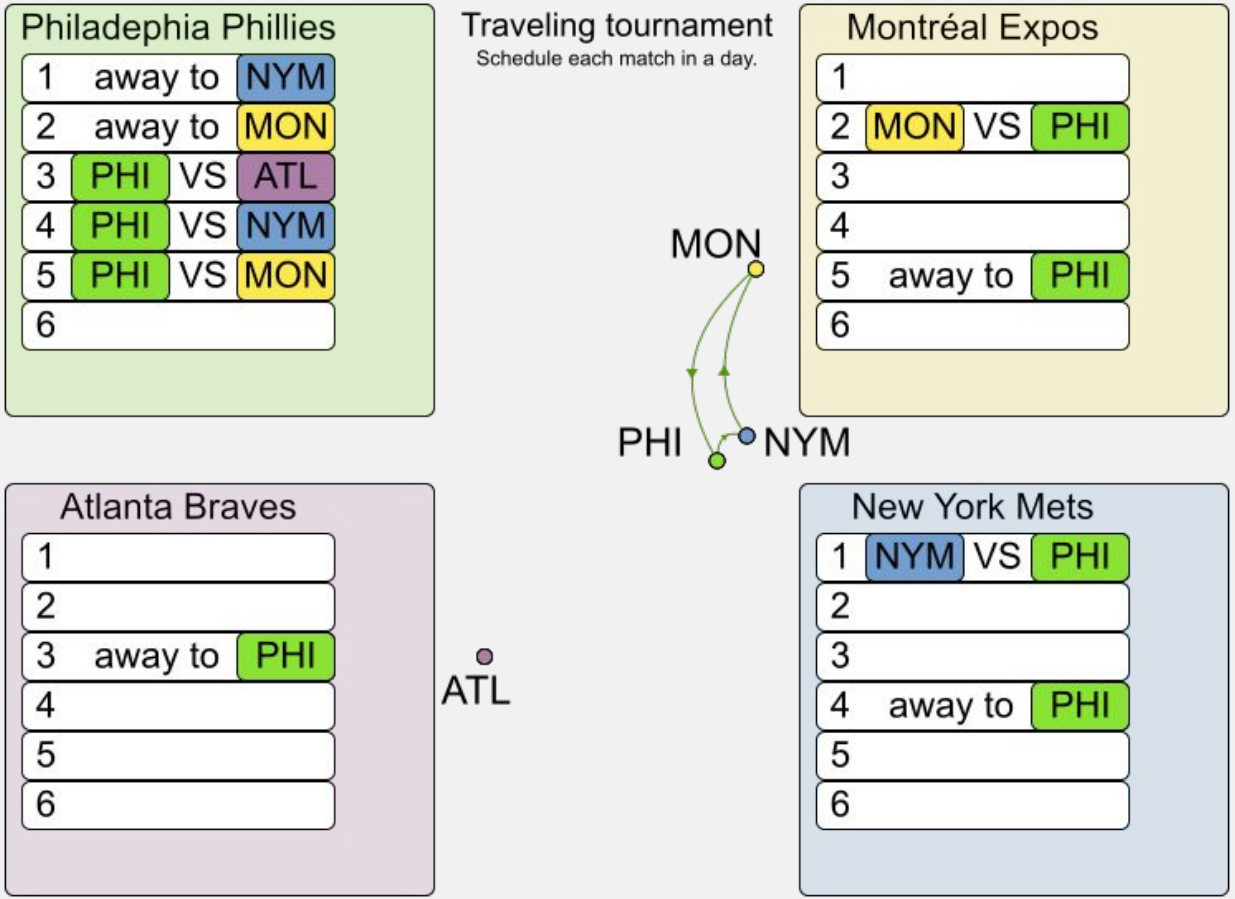
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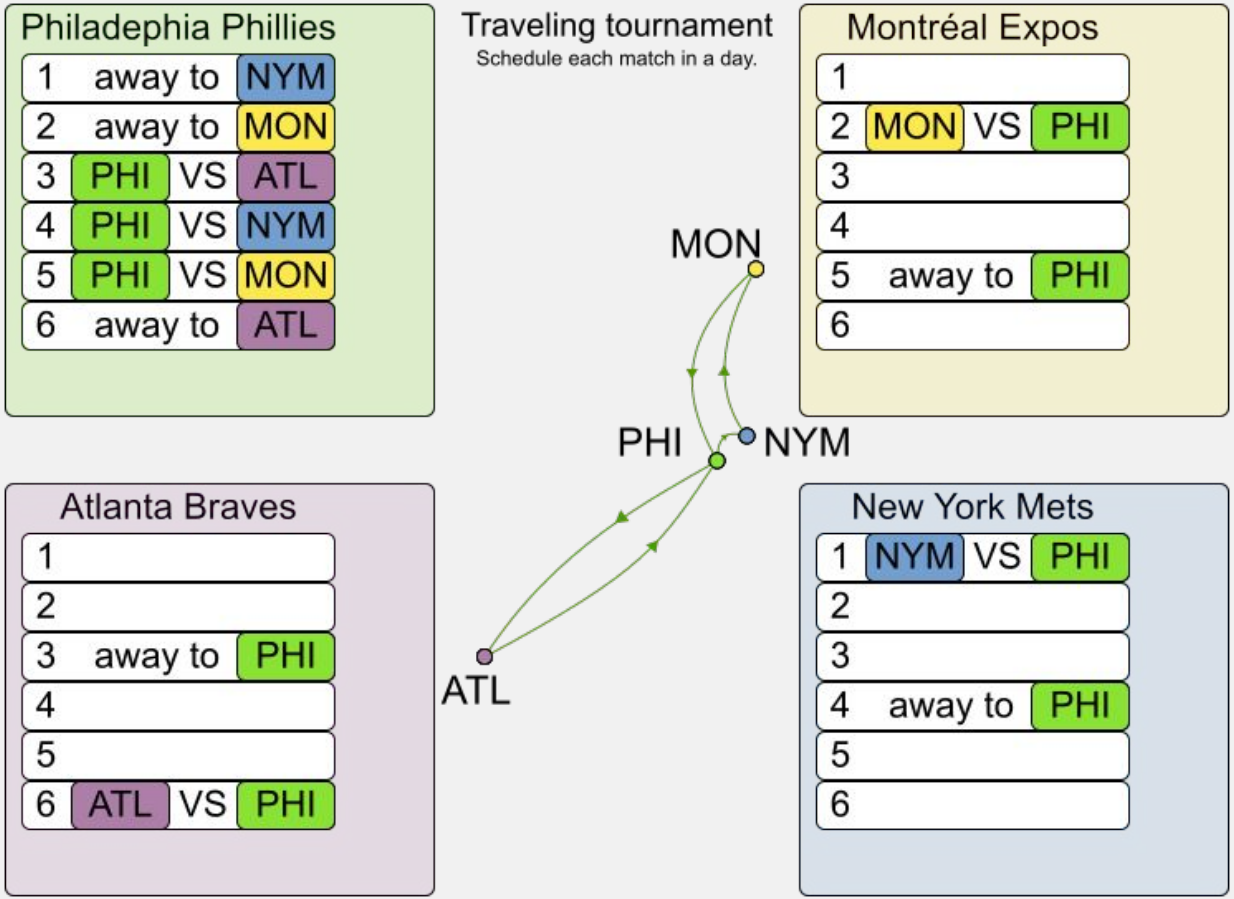
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5
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redhat.

Traveling tournament

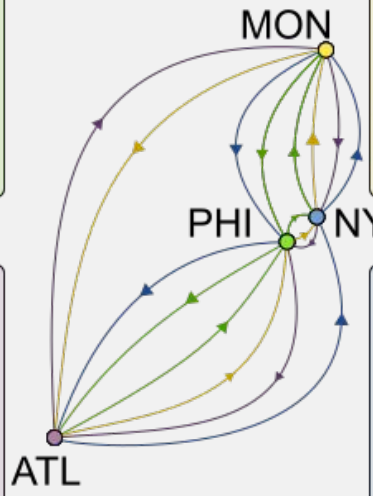
Schedule each match in a day.

Philadephia Phillies

1	away to		NYM
2	away to		MON
3	PHI	VS	ATL
4	PHI	VS	NYM
5	PHI	VS	MON
6	away to		ATL

Montréal Expos

1	MON	VS	ATL
2	MON	VS	PHI
3	MON	VS	NYM
4	away to		ATL
5	away to		PHI
6	away to		NYM



Atlanta Braves

1	away to		MON
2	away to		NYM
3	away to		PHI
4	ATL	VS	MON
5	ATL	VS	NYM
6	ATL	VS	PHI

New York Mets

1	NYM	VS	PHI
2	NYM	VS	ATL
3	away to		MON
4	away to		PHI
5	away to		ATL
6	NYM	VS	MON

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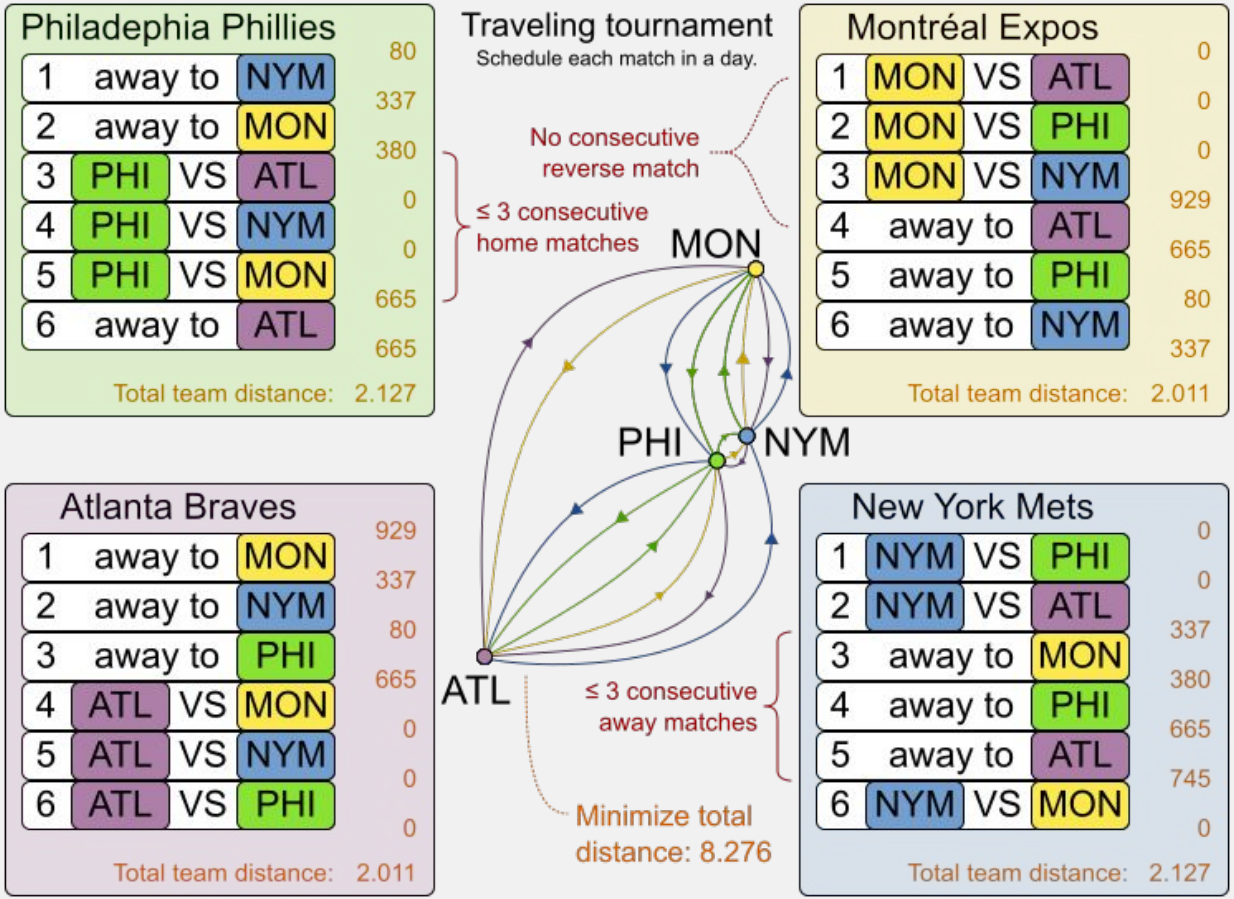
Philadephia Phillies
1 away to NYM
2 away to MON
3 PHI VS ATL
4 PHI VS NYM
5 PHI VS MON
6 away to ATL
80
337
380
0
0
665
665
Total team distance: 2.127
Traveling tournament
Schedule each match in a day.
No consecutive reverse match
≤ 3 consecutive home matches
Montréal Expos
1 MON VS ATL
2 MON VS PHI
3 MON VS NYM
4 away to ATL
5 away to PHI
6 away to NYM
0
0
0
929
665
80
337
Total team distance: 2.011
MON
PHI
NYM
ATL
Atlanta Braves
1 away to MON
2 away to NYM
3 away to PHI
4 ATL VS MON
5 ATL VS NYM
6 ATL VS PHI
929
337
80
665
0
0
0
Total team distance: 2.011
≤ 3 consecutive away matches
Minimize total distance: 8.276
New York Mets
1 NYM VS PHI
2 NYM VS ATL
3 away to MON
4 away to PHI
5 away to ATL
6 NYM VS MON
0
0
337
380
665
745
0
Total team distance: 2.127

redhat.

Traveling Tournament Problem (TTP)

http://mat.tepper.cmu.edu/TOURN/

- Academic simplification
- Small datasets
- Heavily researched
  - Since 1999
  - 26k results on scholar
- Still suboptimal solutions

Teams	Matches	Optimal (proven)
4	12	✓
6	30	✓
8	56	✓
10	90	✗
12	132	✗
14	182	✗
16	240	✗

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Planning Problems

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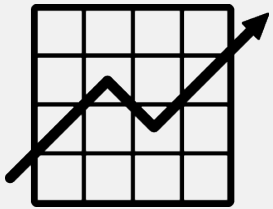
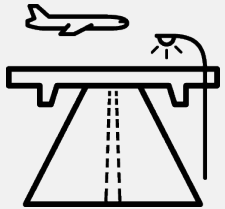
What is a Planning Problem?



Optimize **Goals**



With limited **Resources**

Under **Constraints**

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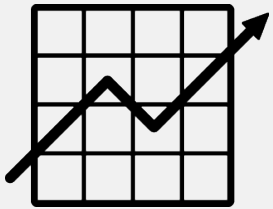
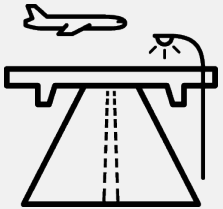
Vehicle Routing

Assign the delivery order more efficiently



Goals

Minimize fuel consumption
Minimize driving time
Minimize required vehicles



Resources

Vehicles (capacity, fuel)
Deliveries (location, packages)

Constraints

Max 8 hrs consecutive driving
Arrive before due time
Max vehicle capacity

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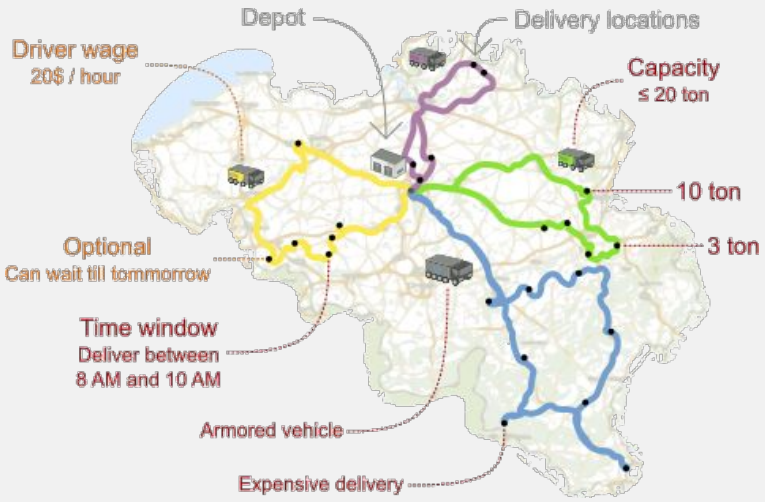
Vehicle Routing

Assign the delivery order more efficiently



Business Value

-15% Driving Time

(based on real benchmark versus traditional algorithms, Belgium datasets)

Users:

Supermarket & Retail Stores

Freight Transportation

Buses, Taxi's & Airlines

Technicians on the road

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Demo

http://planner-ddoyle.rhcloud.com/optaplanner-webexamples

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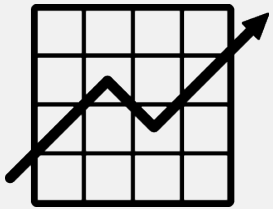
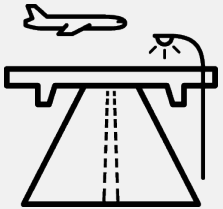
Employee Rostering

Assign shift to employee more efficiently



Goals

Increase Employee well-being



Resources

Nurses

Constraints

Work 1 shift per day
Max consecutive working days
Requested days off

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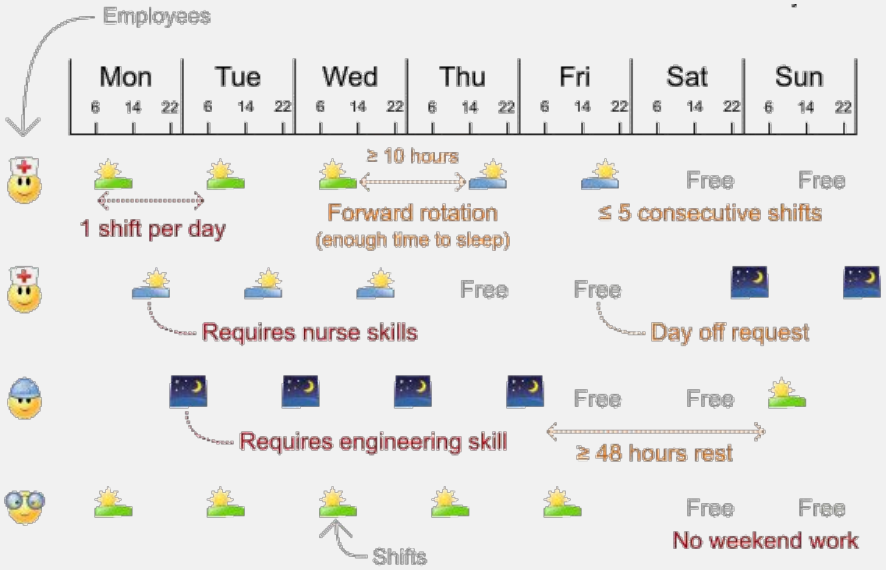
Employee Rostering

Assign shift to employee more efficiently



Business Value

+53% Employee well-being

(average on real benchmark versus traditional algorithms, Nurses case)

Users:

Hospitals

Call Centers

Police and Fire Departments

Courts of Justice

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Show Me The Money

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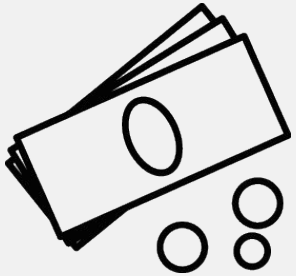
Where is the Money?

Lower Costs

Less wages
Less fuel consumption
Less vehicles required

Improve Customer Satisfaction

Better consecutive rest time
Reduced waiting time
Comply with requests (holidays)



Increase Turnover

More deliveries
More flights/busses/trains
More passengers

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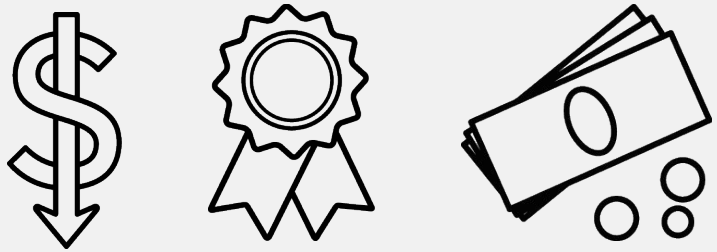
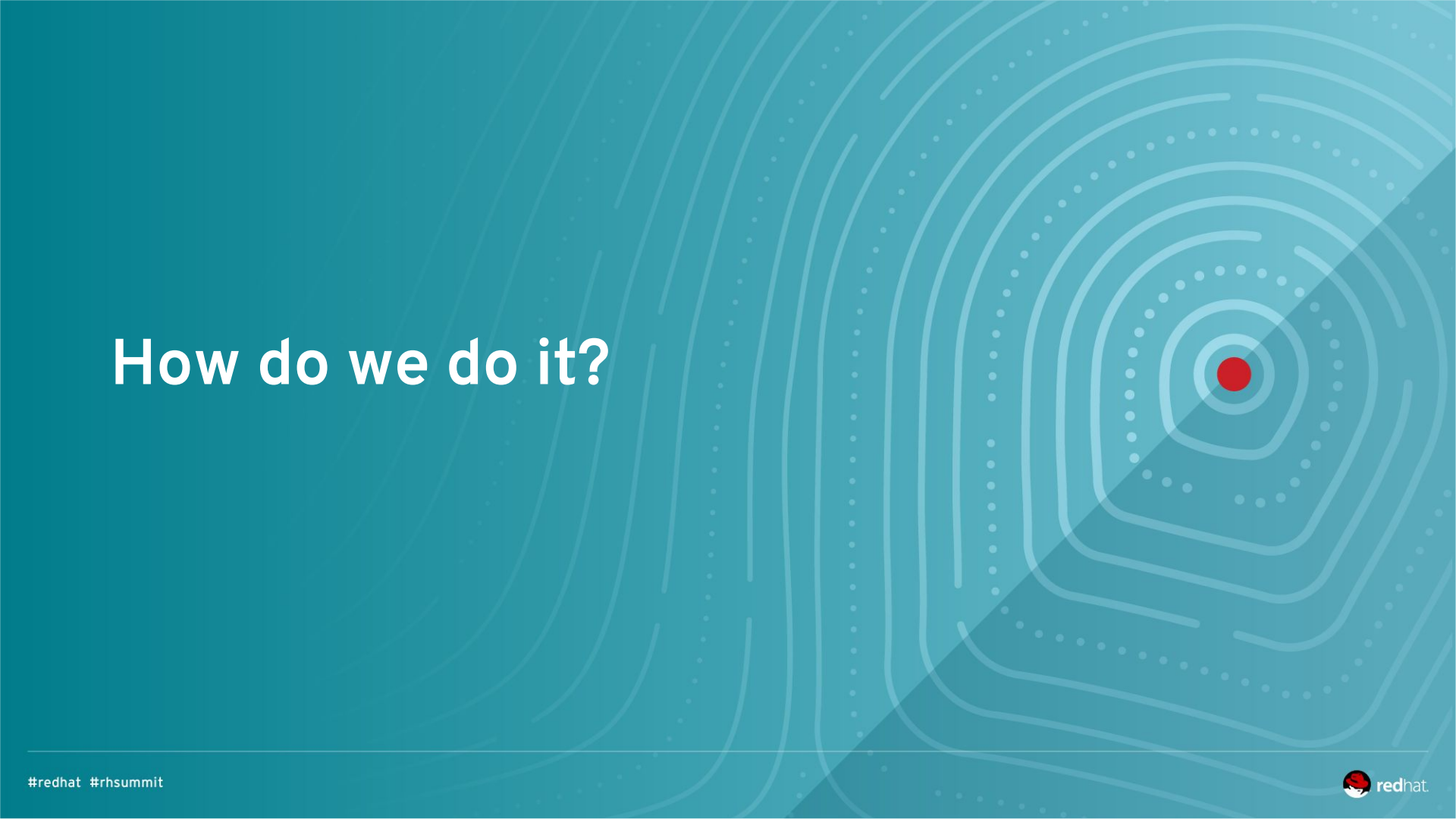
Show me the Money!



- **-15% Driving Time**
  - Supermarket & Retail stores, Freight transportation, Buses, Taxis, Airlines
- **+53% Employee well-being**
  - Hospitals, Call centers, Police & Fire Departments,
- **-18% Cloud Hosting Costs**
  - Datacentre automation
- **-31% Travel Distance**
  - Tournament scheduling

How do we do it?



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Two Types of Constraints

Hard Constraints must be satisfied by any solution (for it to be a feasible solution)

- Crew must not exceed 8 hours in 24
- Truck must not be overloaded
- Every shift must have a full complement of nurses

Soft Constraints should be satisfied as much as possible (better solutions satisfy more soft constraints)

- Crews should return home every 5 days
- A nurse's time preference should be honored

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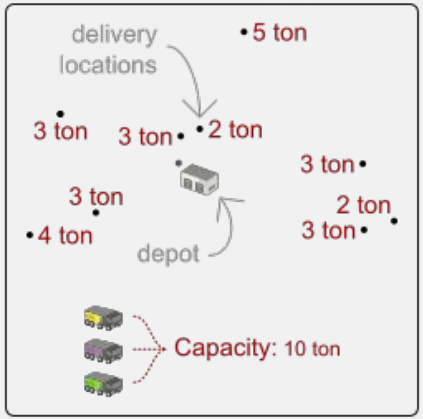
Score Comparison Vehicle Routing

Hard constraints always outweight soft constraints.



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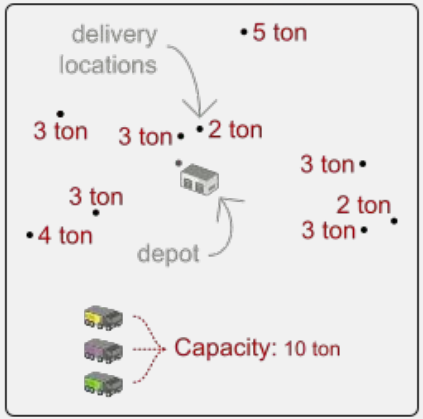

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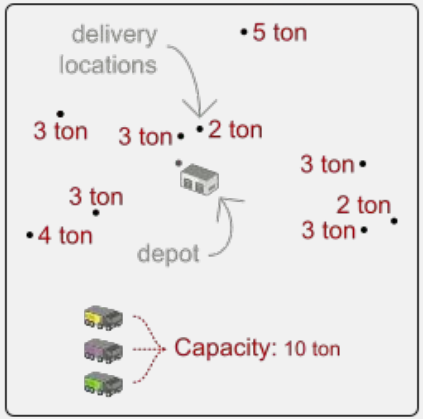

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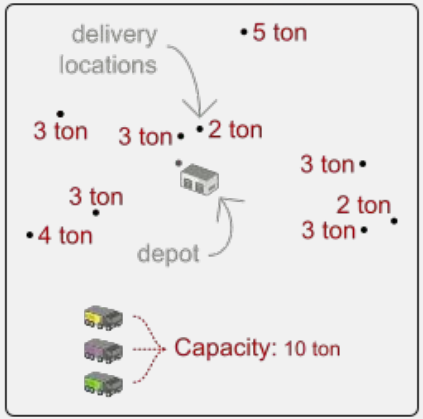

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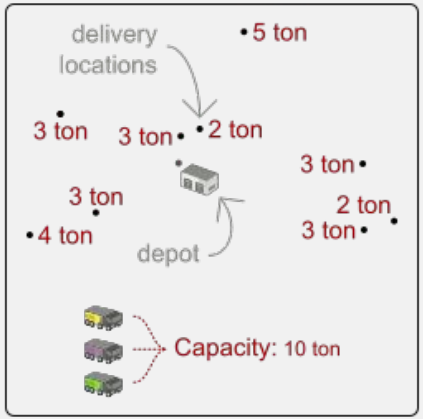

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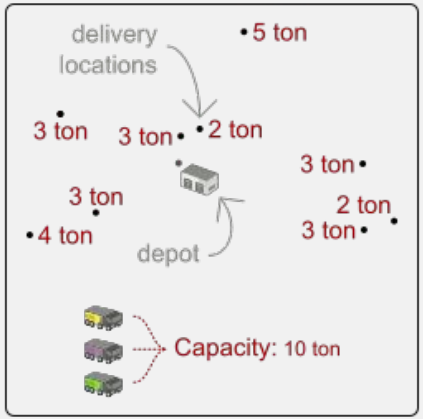

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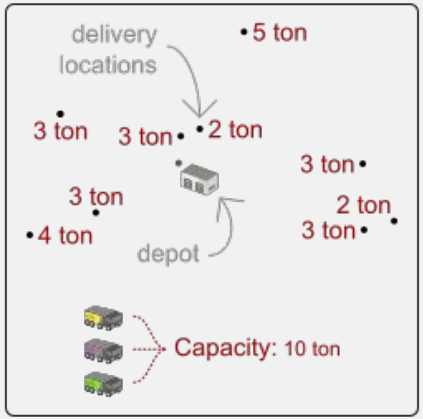

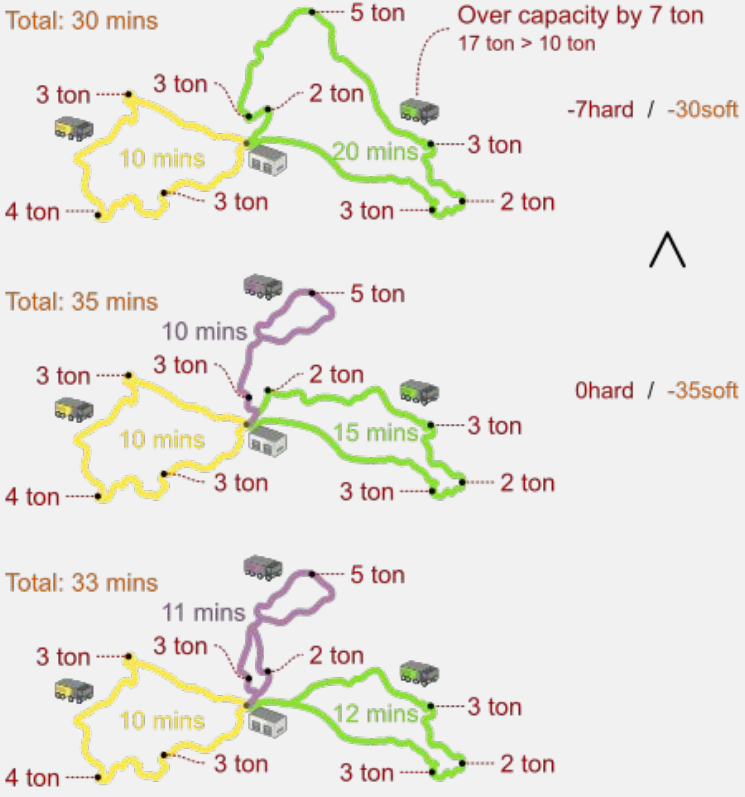

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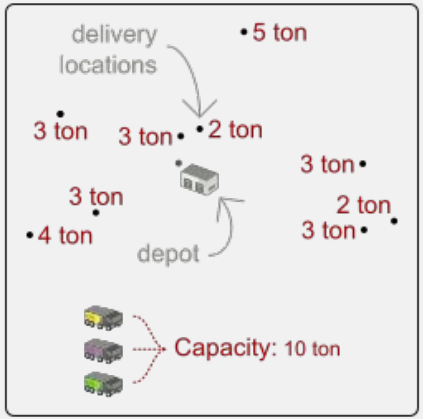

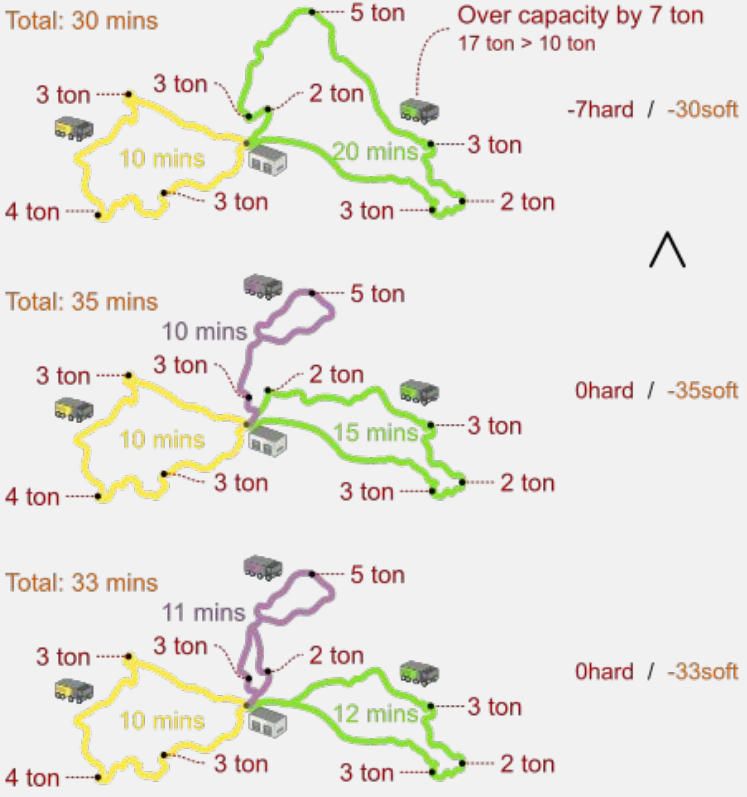

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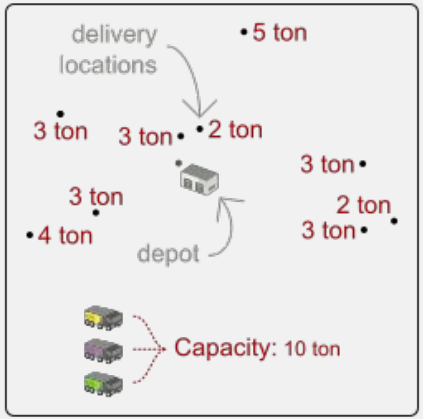

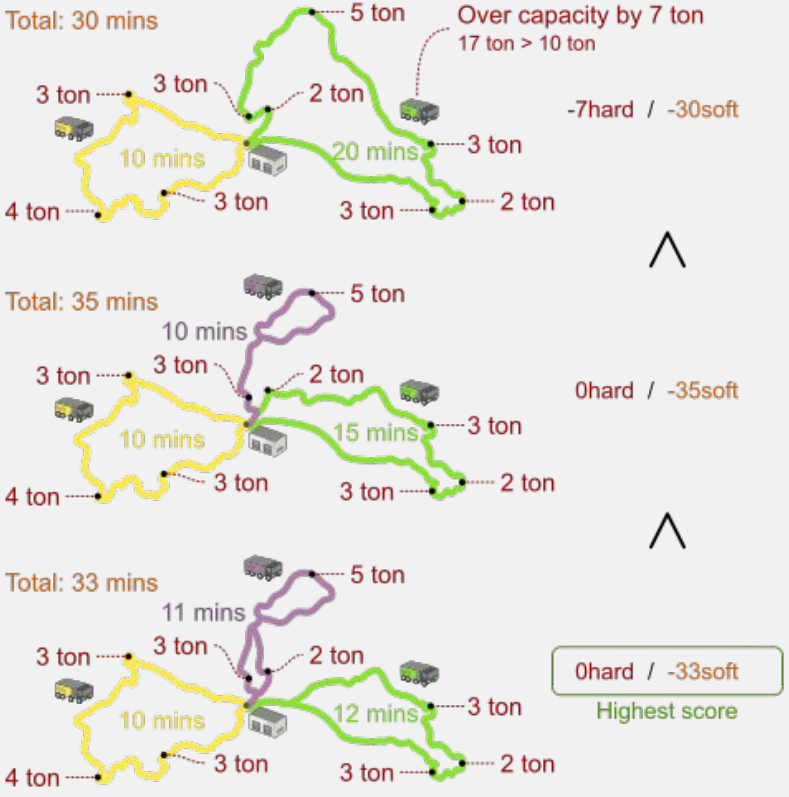

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Planning problems are hard to solve

Well … very hard actually …

- Exploring all potential solutions takes millions of years.
- Software optimization engines are expensive.
- Expertise is expensive (mathematicians, Operations Research specialist).

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Let’s do some math …

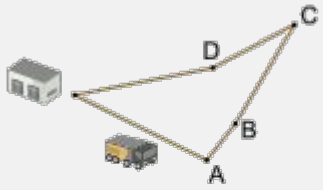
In how many combinations
can **100** locations be assigned
into **10** vehicle trips?

10^{170} ways

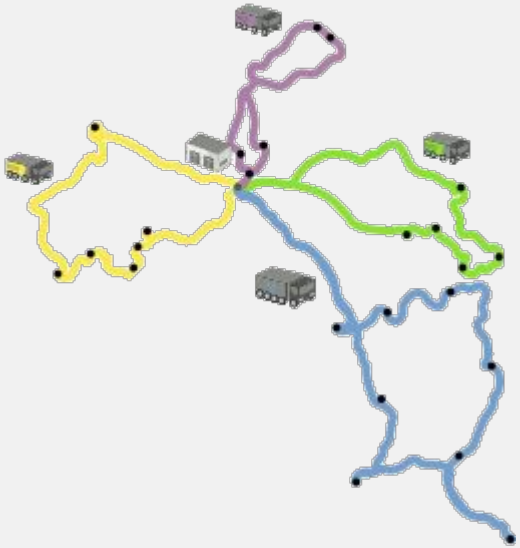
Number of atoms in the observable universe:

10^{80}

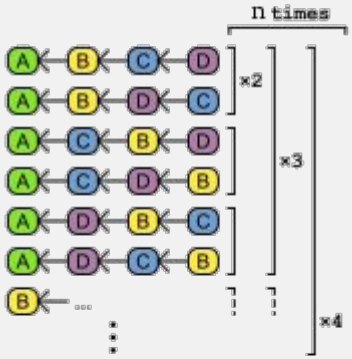
One vehicle



Vehicle Routing



Model: linked list



Search space: **n!**

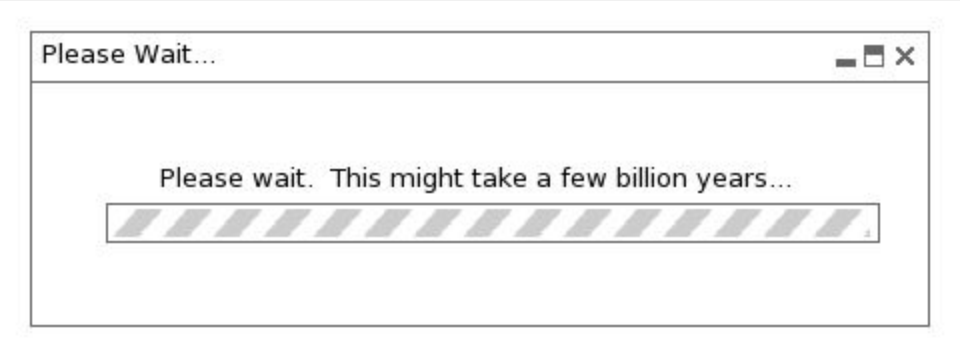
# locations	search space
4	24
100	10^{157}
1000	10^{2567}
10000	10^{35659}

(n+v-1)!/(v-1)!

# locations	# vehicles	space
10	2	39916800
50	10	10^{79}
100	10	10^{170}
200	20	10^{401}

redhat.

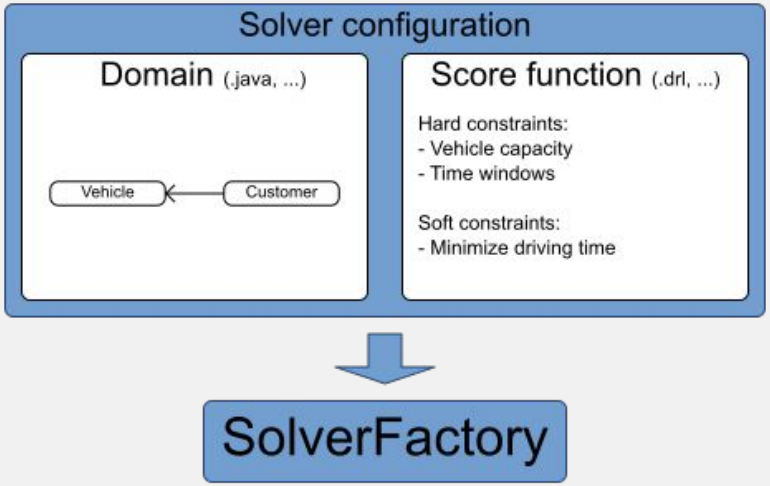
Please Wait...



redhat.

Input/Output overview vehicle routing

Use 1 SolverFactory per application and 1 Solver per dataset.



redhat.

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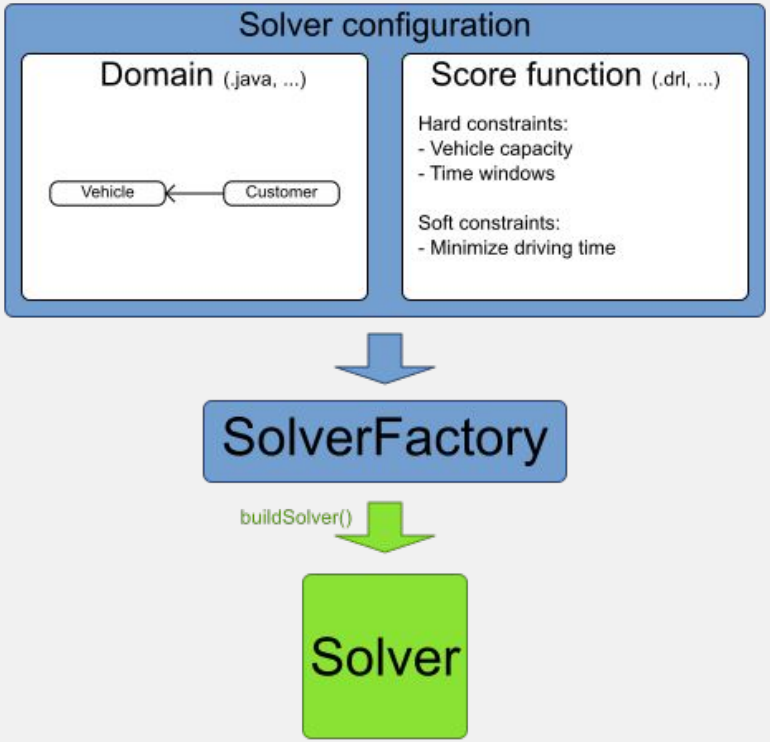

redhat.

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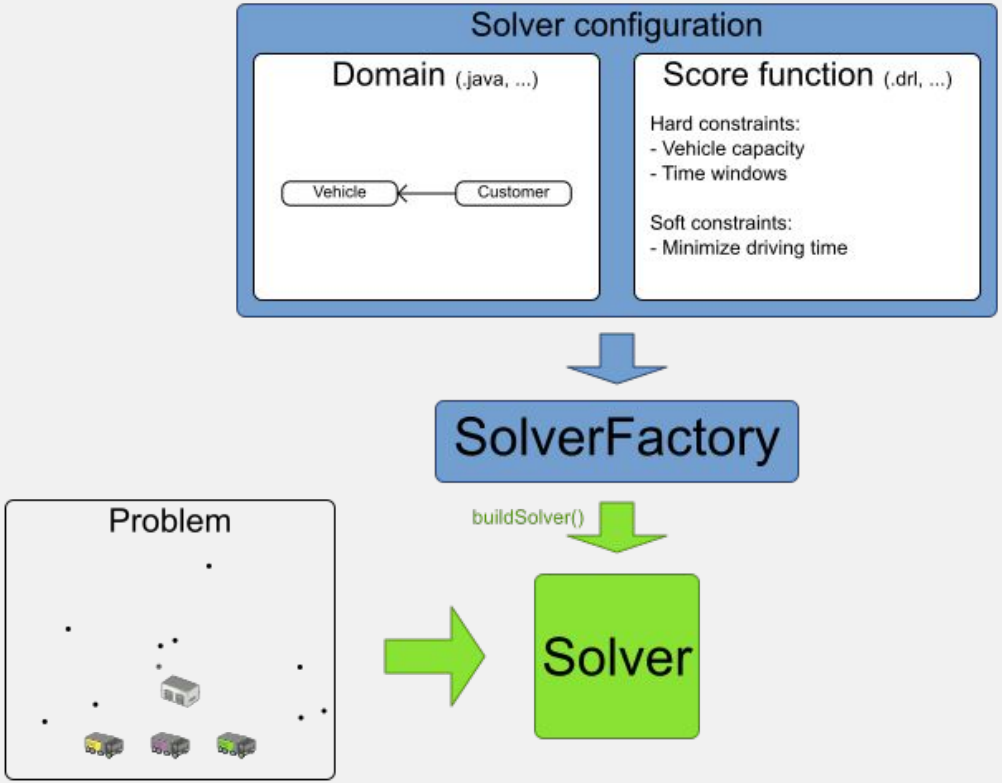

redhat.

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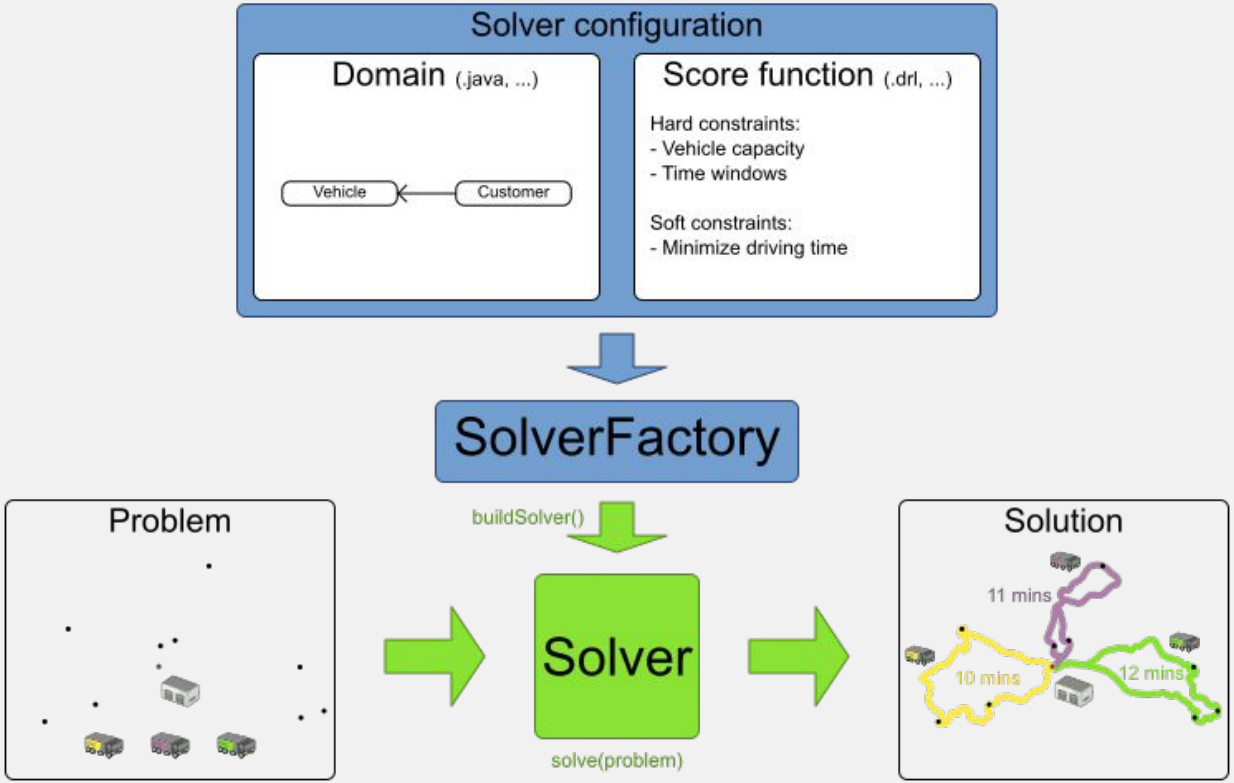
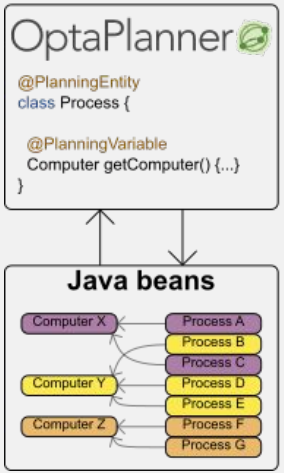


redhat.

Integration overview

OptaPlanner combines easily with other Java and JEE technologies.



redhat.

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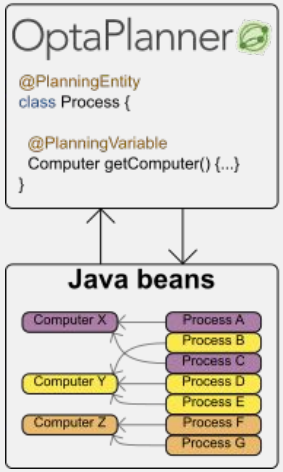

XML file

```
<cloudBalance>
  <computerList>
    <computer id="1">...</computer>
    ...
  </computerList>
  <processList>
    <process>
      <name>A</name>
      <computer ref="1"/>
    </process>
    ...
  </processList>
</cloudBalance>
```


redhat.

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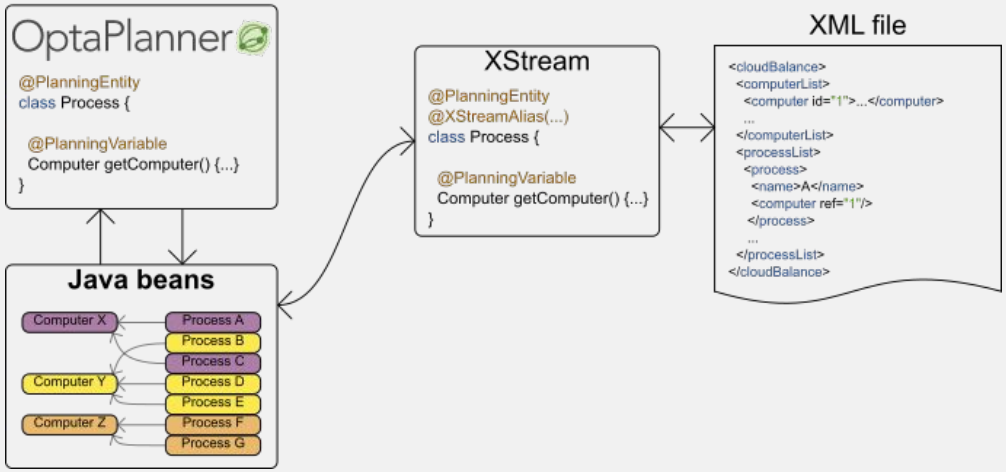

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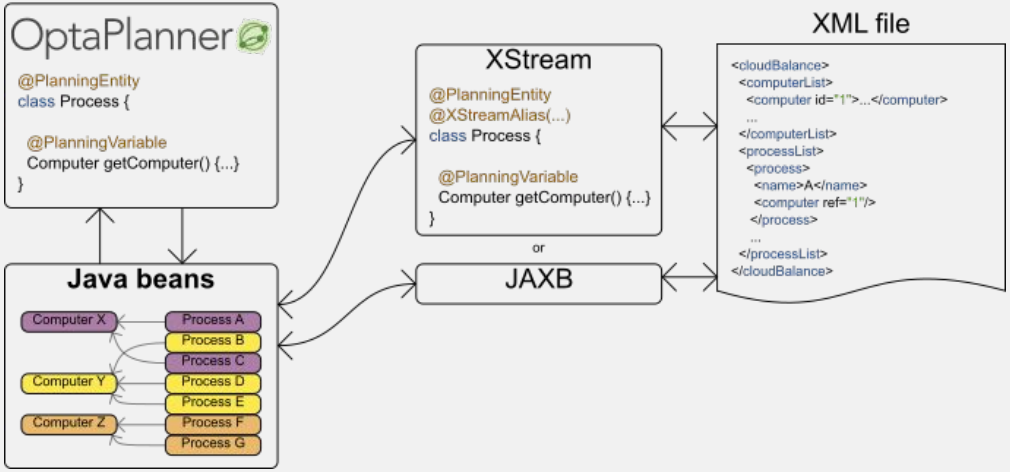

redhat.

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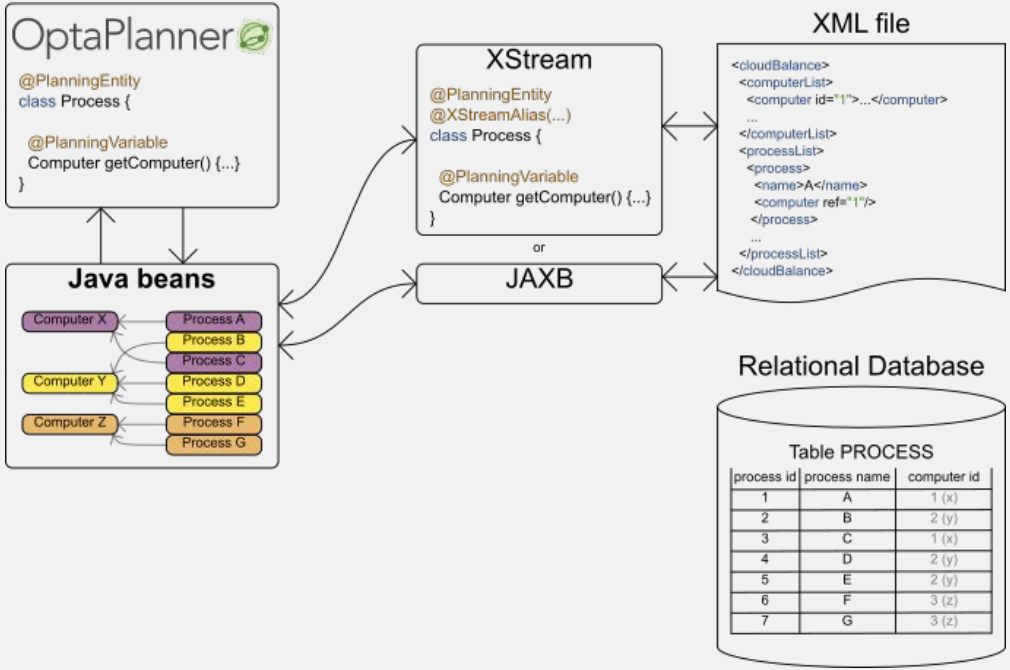

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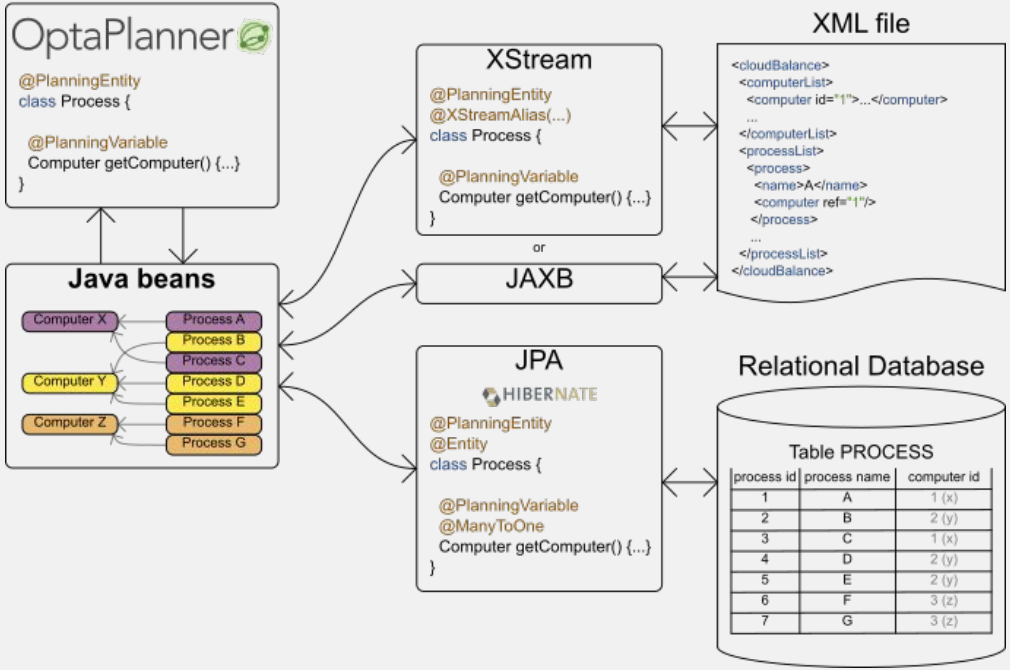

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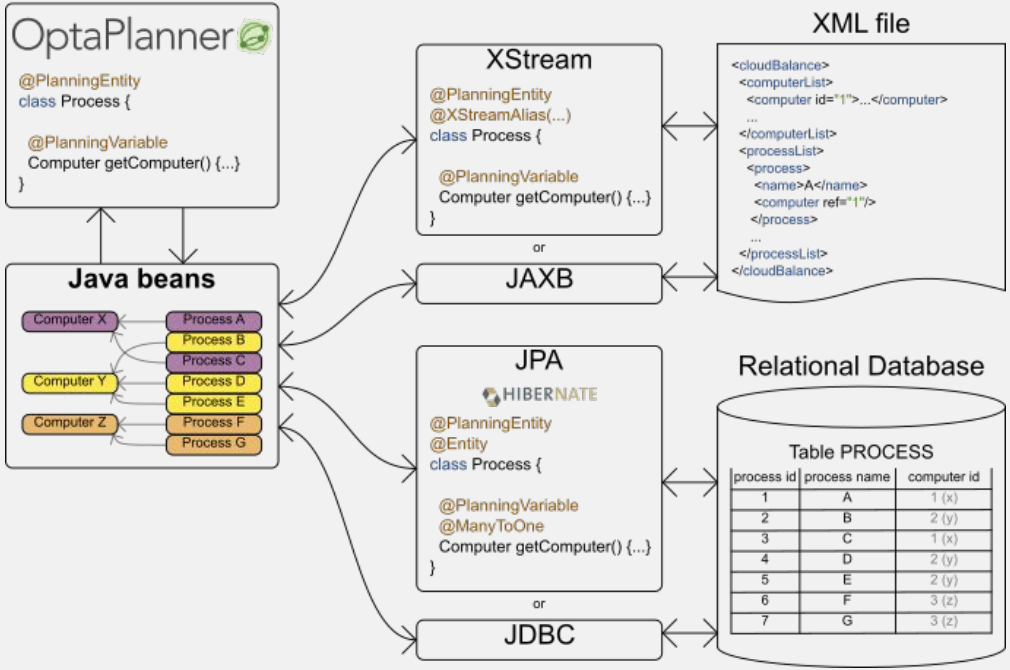

redhat.

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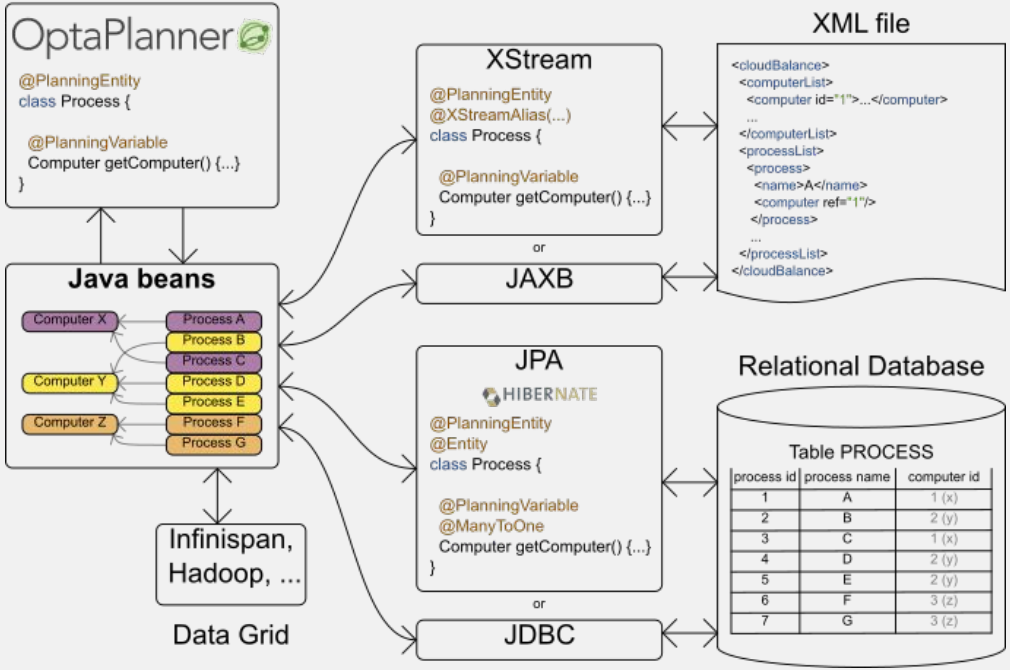

redhat.

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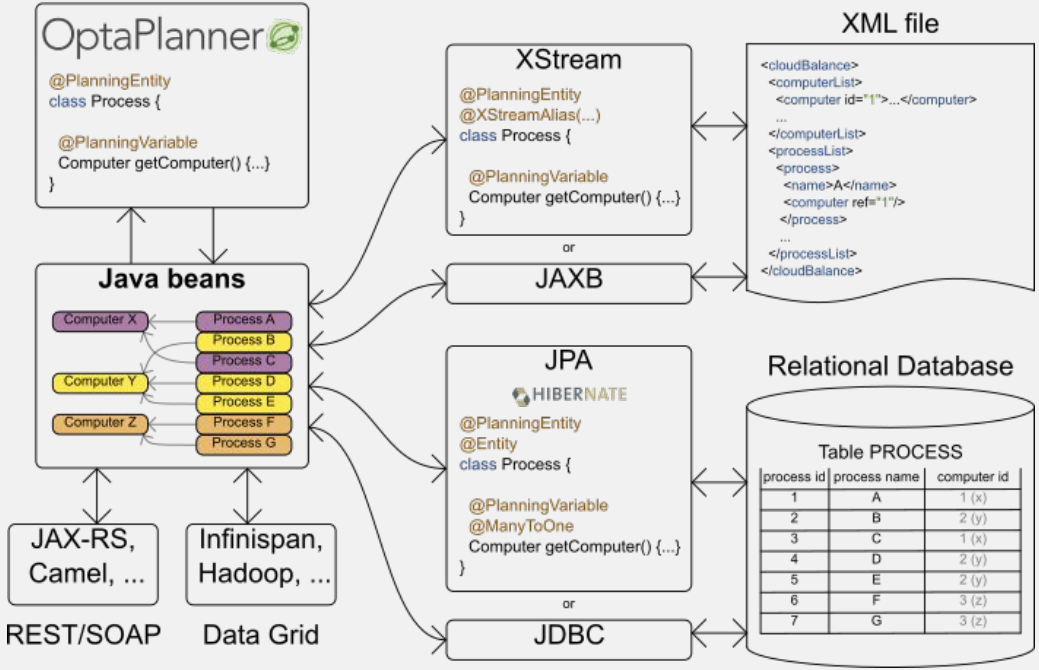


redhat.

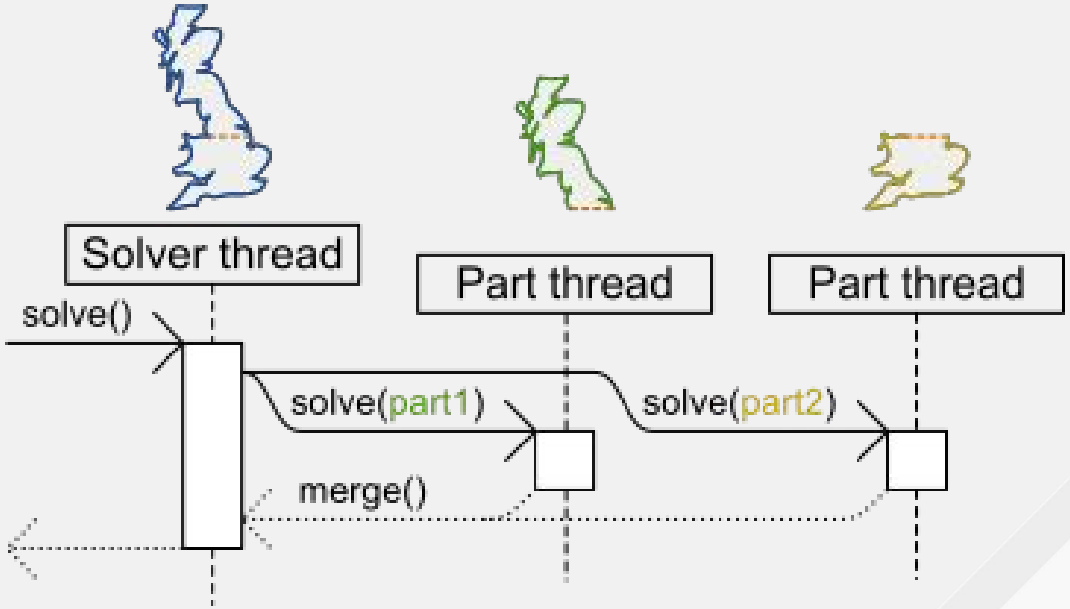
New and Noteworthy 7.x

redhat.

Multi-threaded Partitioned Search

Already in OptaPlanner 7.0.0.CR1

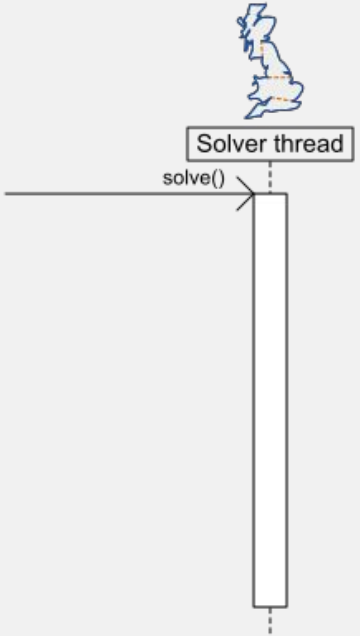
- Split up
  - Custom Partitioner code
  - Generic Partitioners (TODO)
- Merge
  - No code
- Multi-threaded
  - Progress reporting
  - Fast forward (anti-OOME)
  - Anti-starvation



redhat.

Partitioned Search Threading

The main Solver transparently delegates to and aggregates from the child solvers.



redhat.

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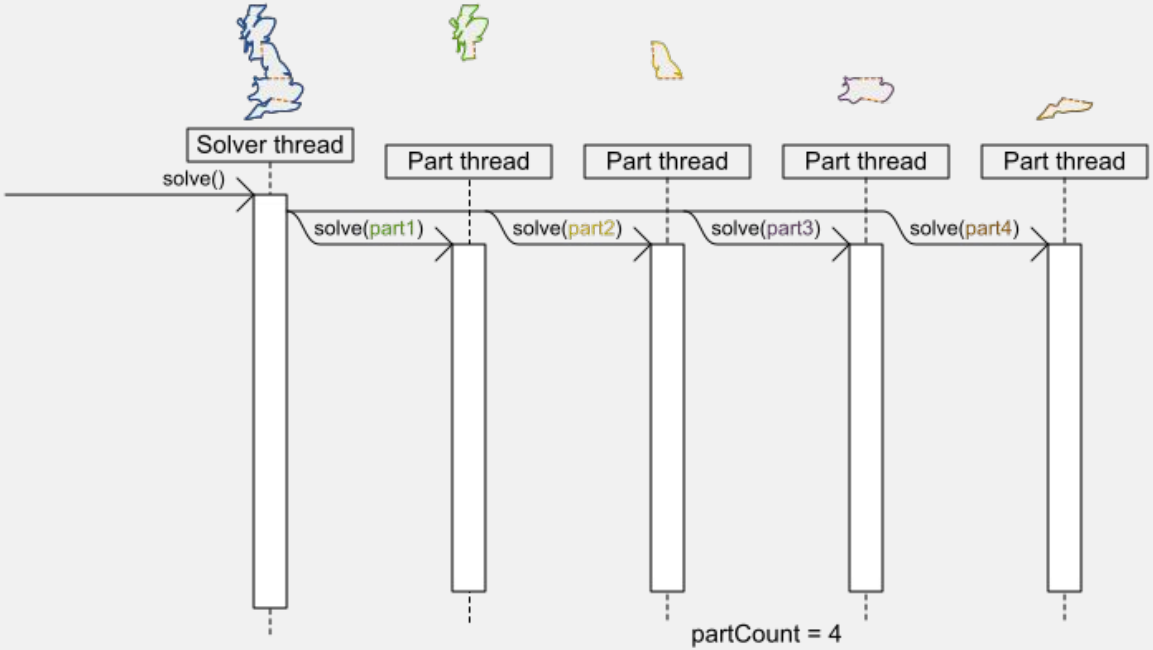


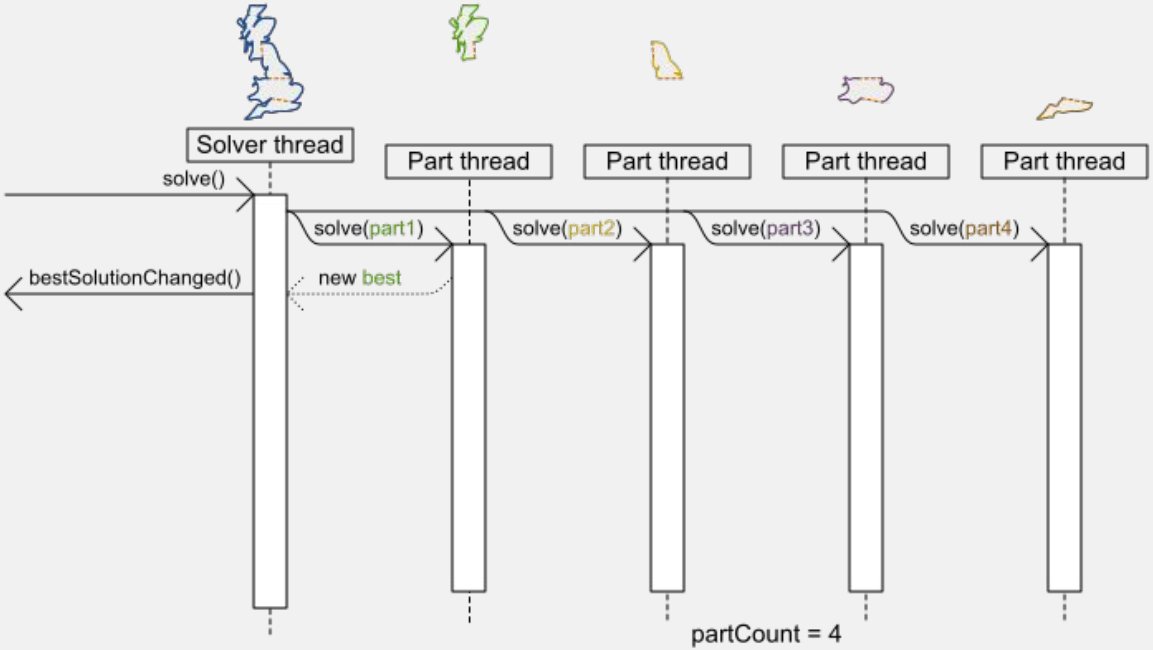
Can I get intermediate results?

redhat.

Partitioned Search Threading

The main Solver transparently delegates to and aggregates from the child solvers.

Progress reporting of the whole



redhat.

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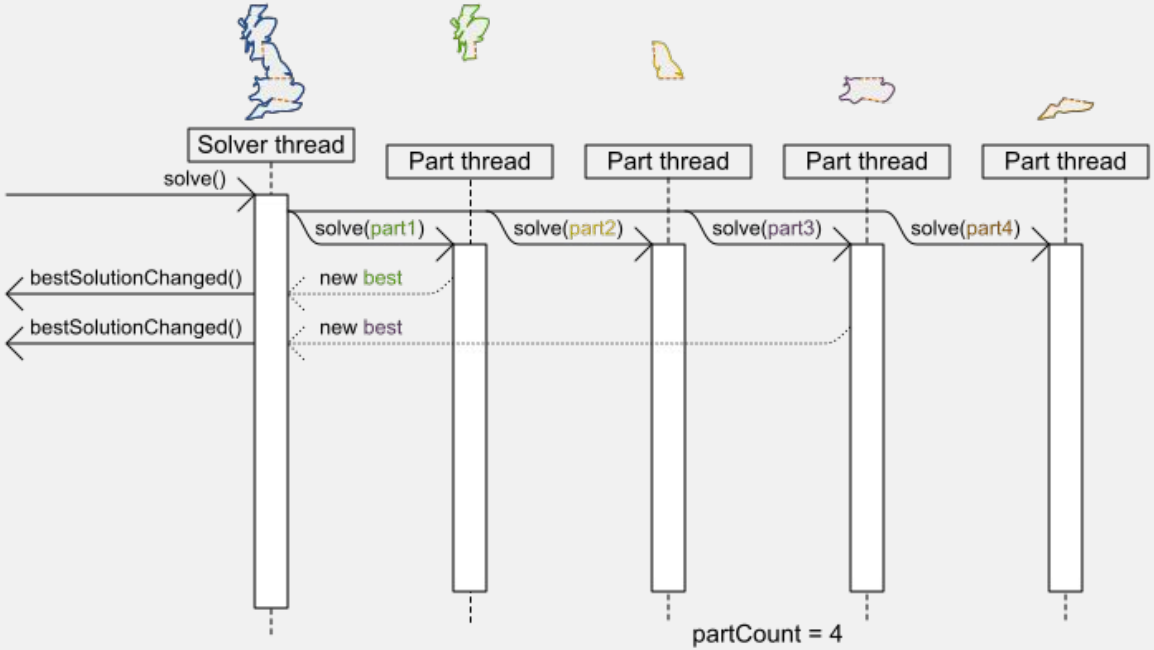

redhat.

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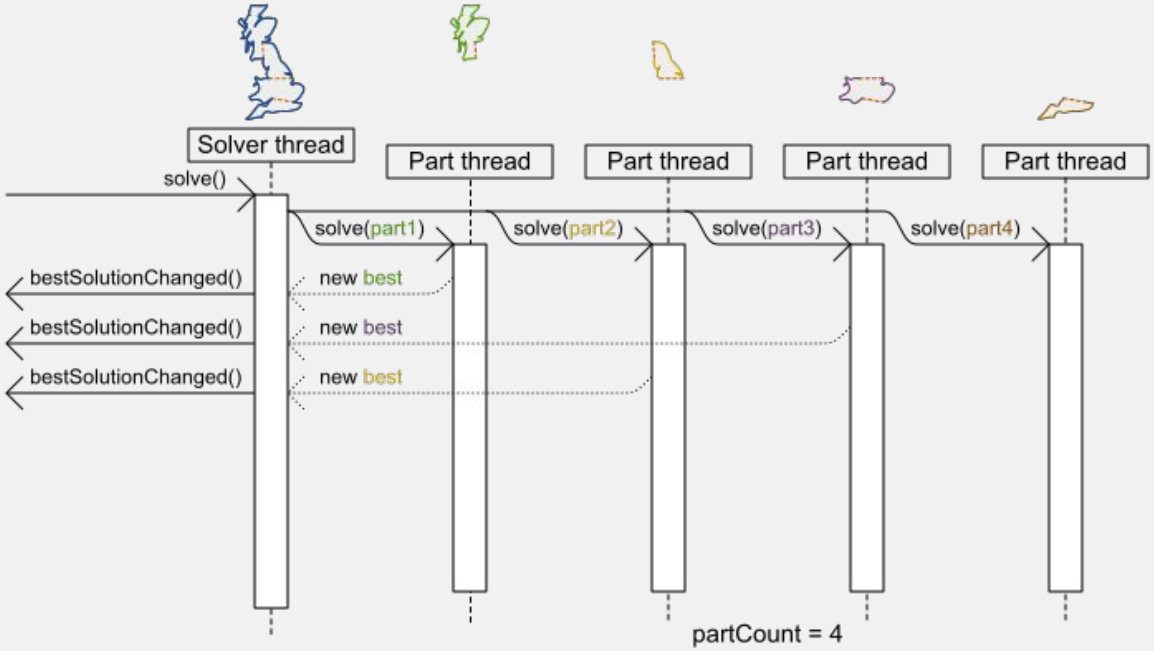

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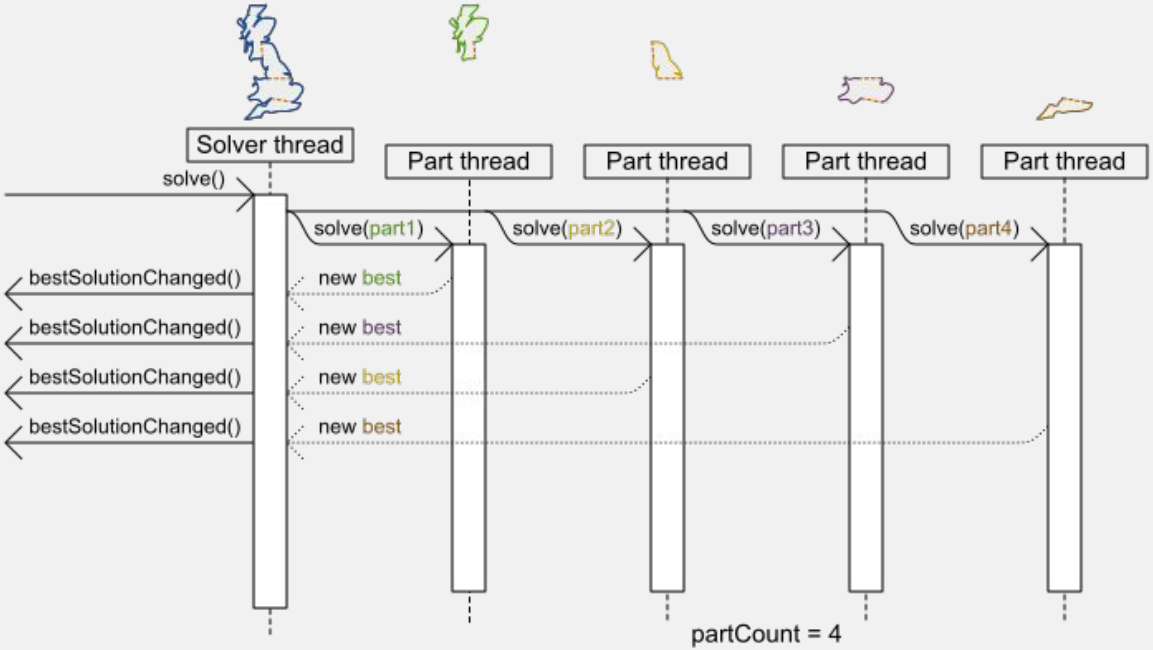

redhat.

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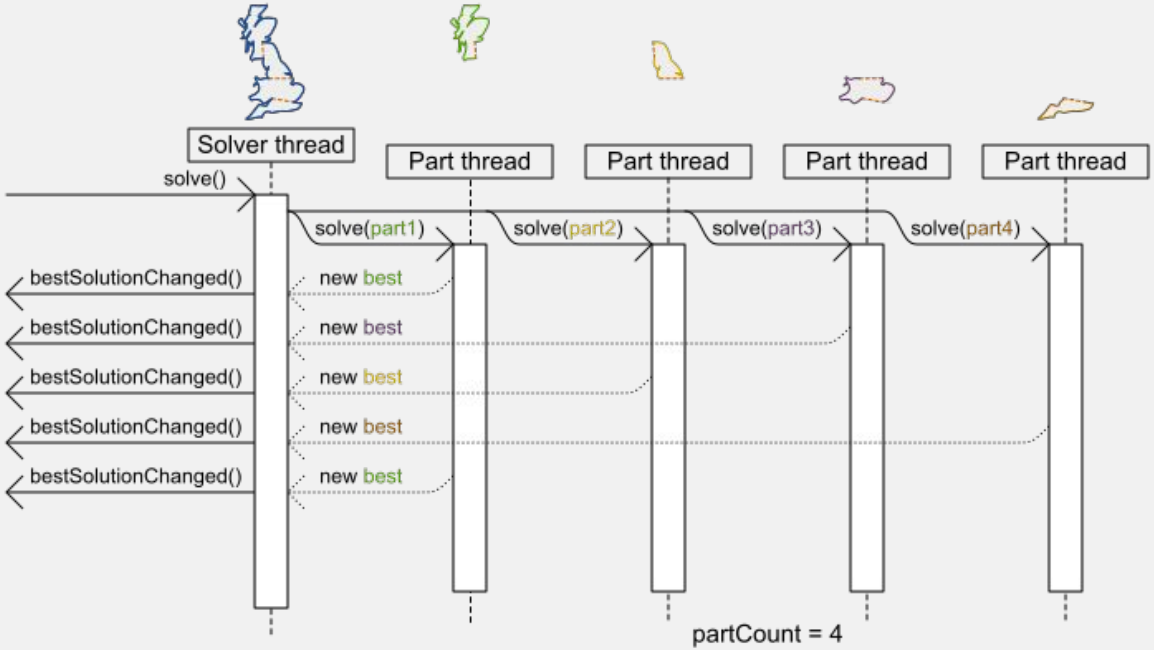

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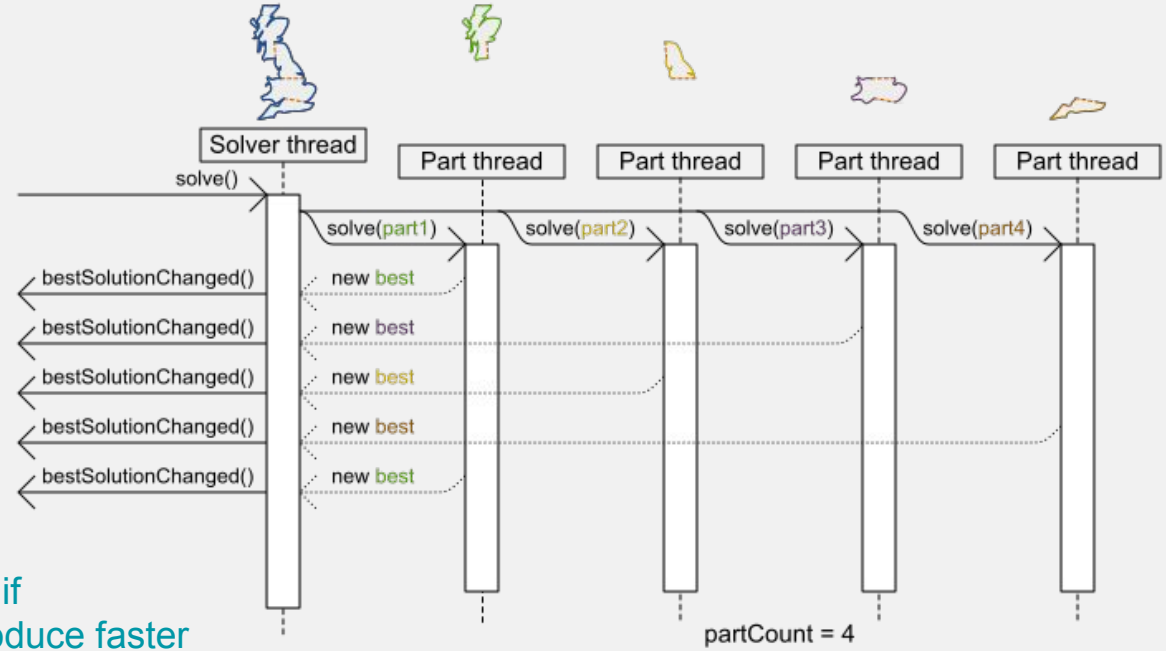

What if
Part threads produce faster
than Solver thread consumes?
Blocks or OOME?

redhat.

Partitioned Search Threading

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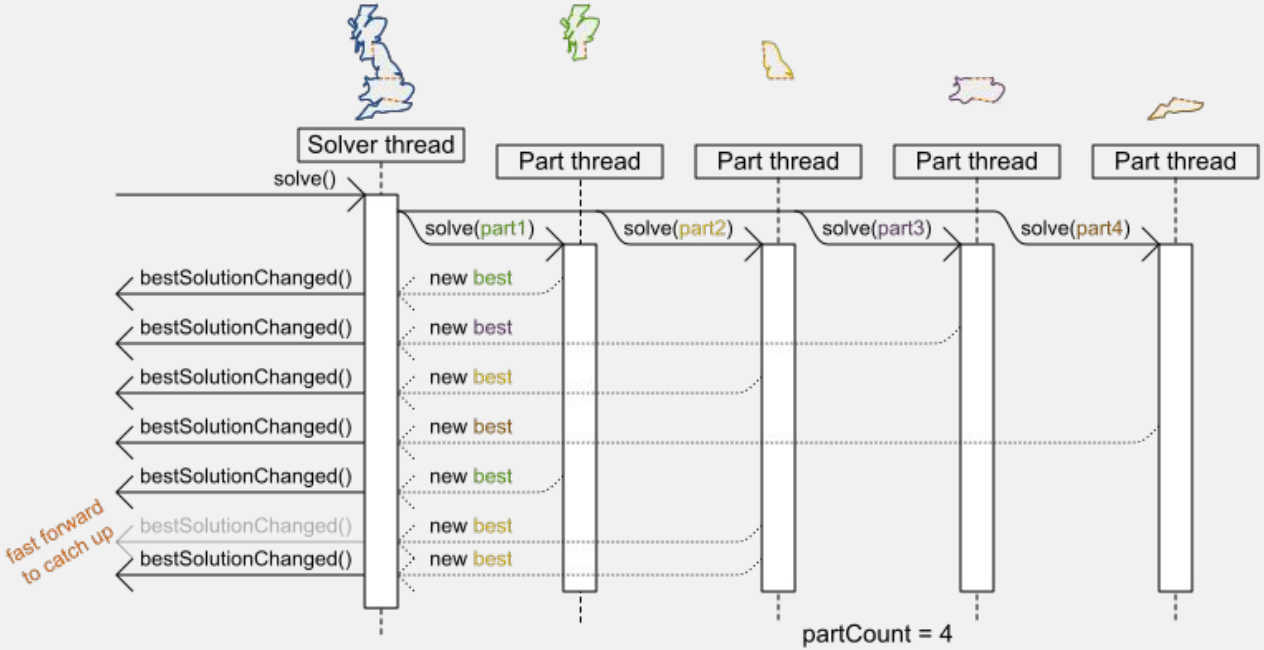
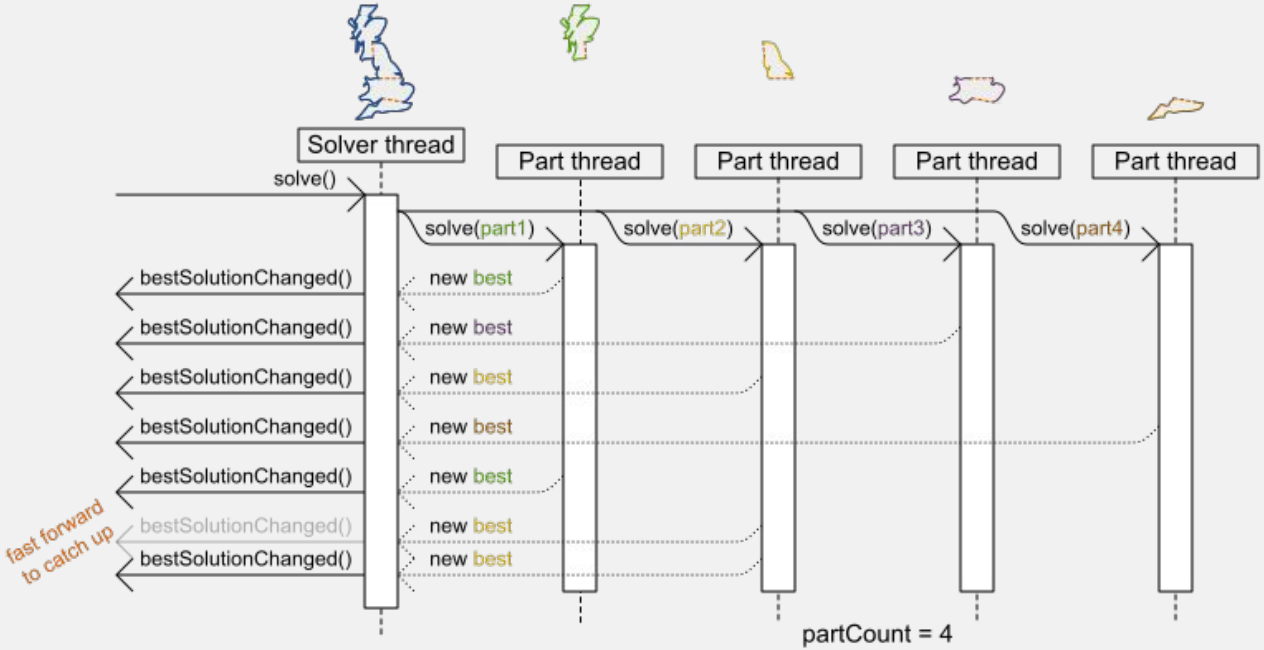


It skips forward!
No blocking and no OOME.

redhat.

Partitioned Search Threading

The main Solver transparently delegates to and aggregates from the child solvers.



What if
there are only 4 CPU's?
Starvation of other threads?

redhat.

Partitioned Search Threading

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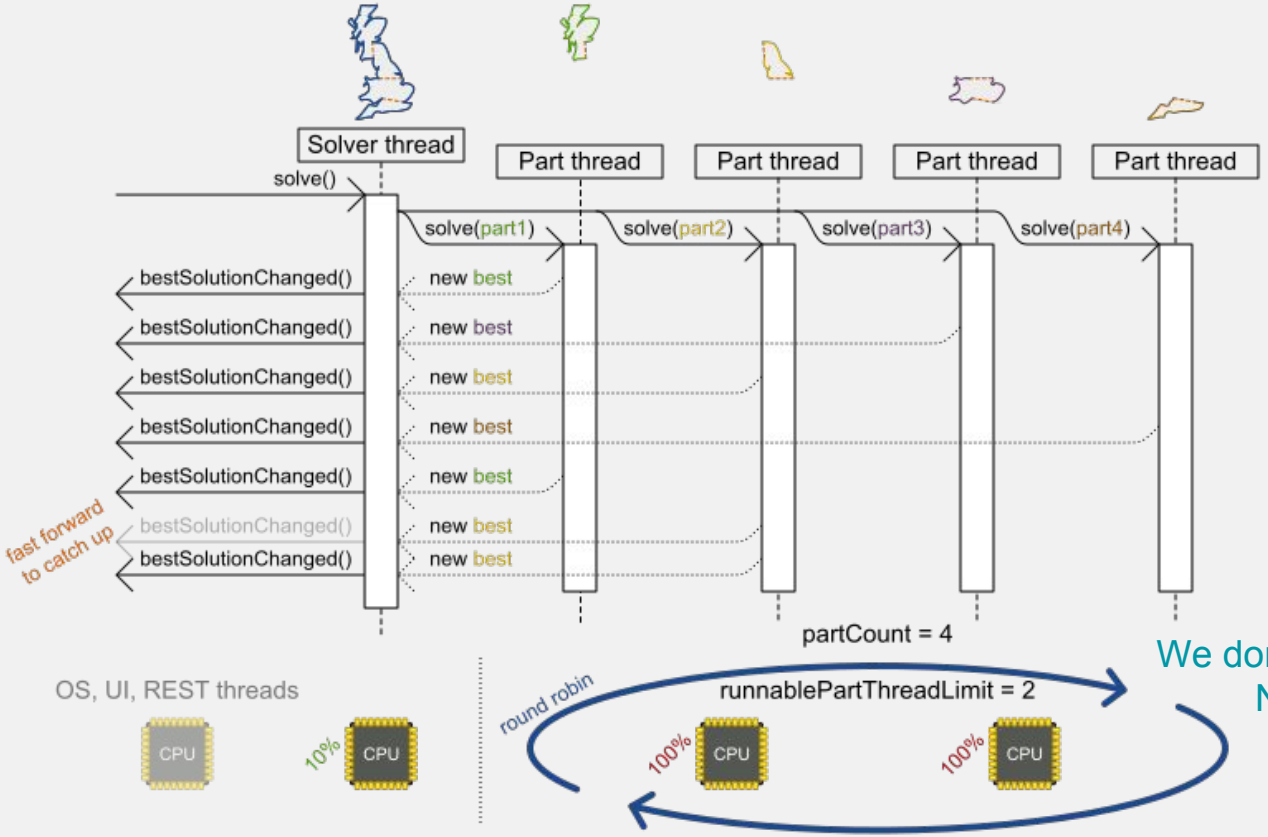


We donate only 2 CPU's.
No starvation

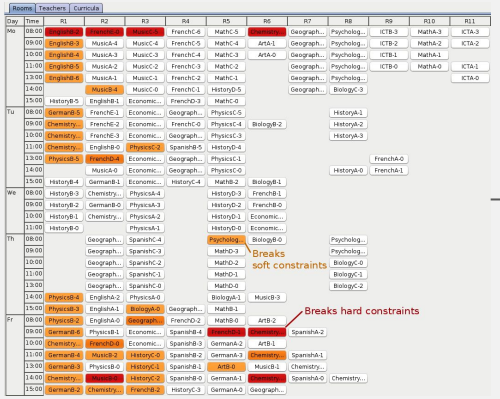
redhat.

Constraint heat map

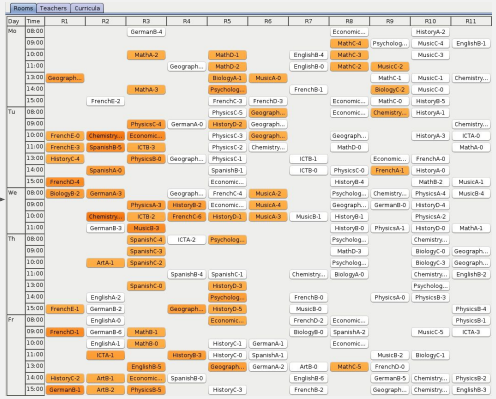
Where are the pain points in my schedule?

Influence per entity on score

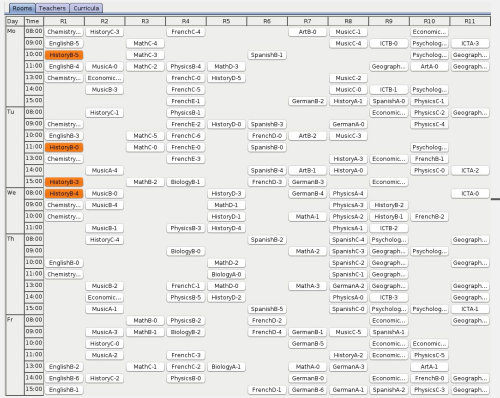
- Involved in hard constraint match
- Involved in soft constraint match



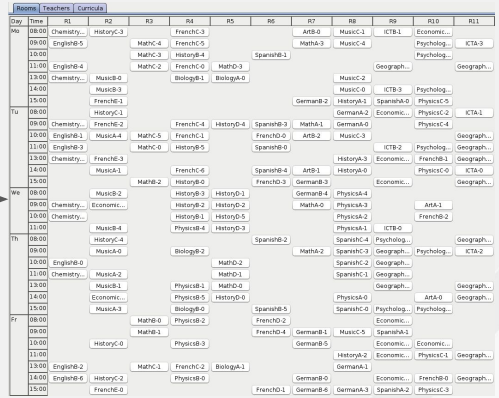
-4hard/-18soft



0hard/-68soft



0hard/-1soft



0hard/0soft

Demo

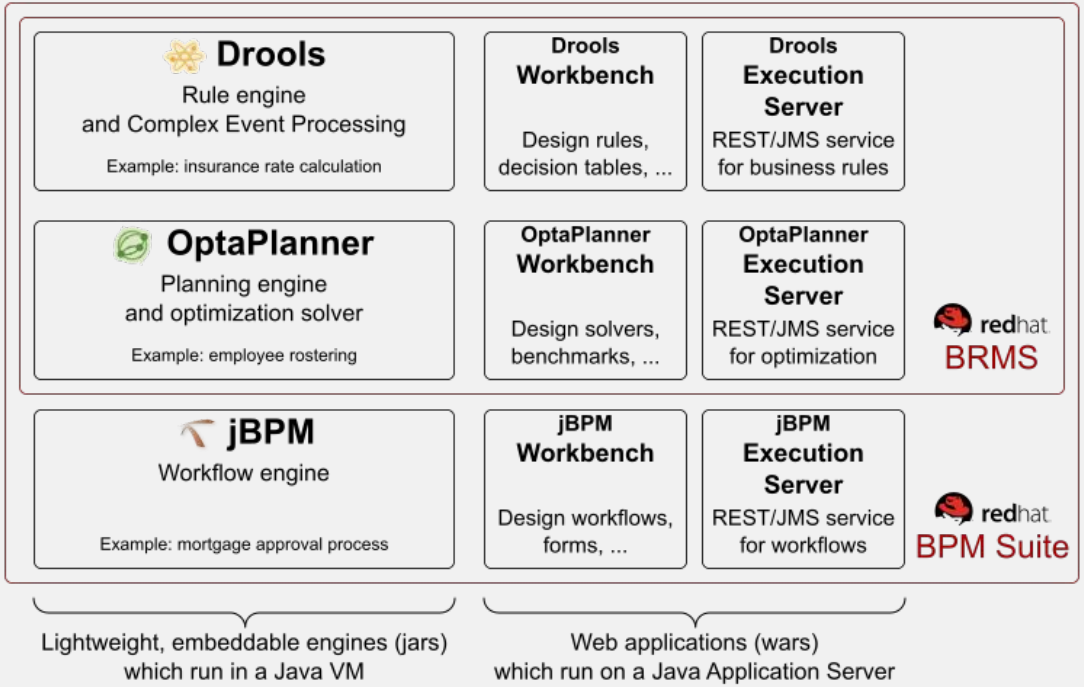
Traveling Tournament Problem
Baseball dataset nl14

redhat.

BRMS / BPM Suite

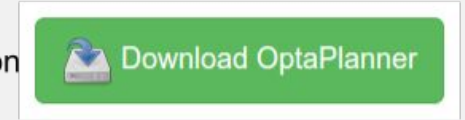
JBoss Business Resource Planner (AKA OptaPlanner) is part of

- BRMS
- BPM Suite

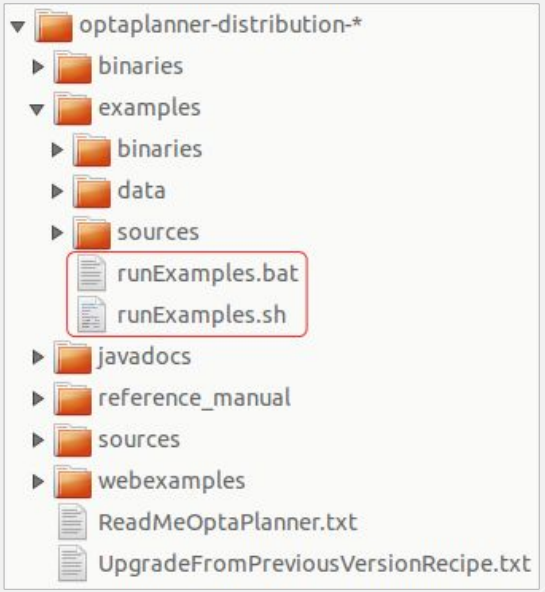


Try it now

www.optaplanner.org

1. Surf to www.**optaplanner.org**
2. Click on 

3. Unzip optaplanner-distribution-*.zip
4. Open the directory `examples` and double click on `runExamples`



redhat.

RED HAT SUMMIT

THANK YOU

Homepage:	www.optaplanner.org
Slides:	www.optaplanner.org/learn/slides.html
User guide:	www.optaplanner.org/learn/documentation.html
Feedback:	@GeoffreyDeSmet @DuncanDoyle

redhat.