Using AI to schedule US technicians, UK magistrates and Belgian healthcare

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October 2019
The Ultimate American Road Trip
A data genius computes the ultimate American road trip

By Ana Swanson  March 10, 2015  Follow @ansewanson

This post comes via Know More, Wonkblog's social media site.

Who needs an atlas when you have an algorithm? Data tinkerer Randy Olson, who previously developed the optimal search path for finding the bespectacled main character of the "Where's Waldo?" books, has used this same algorithm to compute the ultimate American road trip.
Road trip for 50 landmarks, monuments, etc.
Traditional algorithm: 271h 35m 16s
Is it optimal?
Olson's trip: 232h 43m 10s
⇒ 38h 52m 6s faster (14% faster)
Is it optimal?
Better algorithms

Olson
232h 43m 10s
Better algorithms

Olson
232h 43m 10s

OptaPlanner
231h 7m 30s

- 1h 35m 40s
Road are asymmetric

To location A
Road are asymmetric

To location A

From location A
Road are asymmetric

Use symmetric data

231h 7m 30s
(asymmetric calculation)
Road are asymmetric

Use symmetric data
231h 7m 30s
(asymmetric calculation)

Use asymmetric data
230h 17m 54s
- 49m 36s
Olson's trip: 232h 43m 10s
Not optimal
OptaPlanner's trip: 230h 17m 54s
⇒ Another 2h 25m 16s faster (1% ⇒ 15% in total)
Optimal, also 33km 710m (= 20.95 miles) shorter
15% less driving time
Now imagine this scenario ...
You got stuck in a bad traffic jam ...

https://themindcircle.com/abandoned-cars/
Your GPS suggests a faster route

Save 11 minutes?
Your GPS suggests a faster route

Would you take the suggested new route?

Save 11 minutes?
HOW WE RESPOND TO CHANGE

Pause

- Risk
- Insecurity
- We lose what we achieved so far

Pounce

- We could be the first!
- It’s worth the risk
- It’s an adventure
15% less driving time
Any enterprise with vehicles can use constraint solving AI to reduce their driving time by a significant margin.
The Vehicle Routing Problem (VRP)
Vehicle routing

Assign the delivery order of vehicles more efficiently.
Vehicle routing

Assign the delivery order of vehicles more efficiently.

- Driver wage: 20$ / hour
- Optional: Can wait till tomorrow
- Time window: Deliver between 8 AM and 10 AM
- Armored vehicle
- Expensive delivery

Capacity: ≤ 20 ton
- 10 ton
- 3 ton
Vehicle routing

Assign the delivery order of vehicles more efficiently.

Users

Supermarkets & retail stores

Freight transportation

Buses, taxi’s & airlines

Technicians on the road
Vehicle routing
Assign the delivery order of vehicles more efficiently.

- Users
  - Supermarkets & retail stores
  - Freight transportation
  - Buses, taxi’s & airlines
  - Technicians on the road

- VehicleRouting benchmark (Belgium datasets)
  - Driving time:
    - OptaPlanner versus traditional algorithm with domain knowledge
    - Average: -15%
    - Min/Max: -9% to -18%
    - # datasets: 5
    - Biggest dataset:
      - 2750 deliveries
      - 55 vehicles

Don't believe us? Run our open benchmarks yourself: http://www.optaplanner.org/code/benchmarks.html
Technician vehicle routing

- Major Digital Service provider

- Technician vehicle routing across US
  - In production since 2017
  - Constraints: Time windows, maximum shift duration, ...

- Savings: 25-30% reducing driving time (they expected 1-2%).
  - 25%+ lower CO² emissions
    - 11000 ton / year
  - 10k+ less technicians (same workload)
    - Results in $100M+ savings per year
OptaWeb Vehicle Routing Demo

https://github.com/kiegroup/optaweb-vehicle-routing
Available on RHPDS
Other planning problems?
Constraint solver AI
What is a planning problem?

- Optimize **Goals**
- With limited **Resources**
- Under **Constraints**
What is a planning problem?

**Goals**
- Minimize driving time
- Increase employee well-being
- Improve resource utilization

**Resources**
- Vehicles (capacity, fuel)
- Employees (skill, FTE’s)
- Time

**Constraints**
- Max 8 hrs consecutive driving
- Laws & Regulations
- Max vehicle capacity
Some of the Business Benefits

- **Reduce Costs**
  - Trucks
  - Fuel
  - Employee wages

- **Improve Customer Satisfaction**
  - Faster delivery
  - Assign employees with higher affinity

- **Improve Employee well-being**
  - Reduce travel time
  - Honor day-off requests
  - Improve resting periods

- **Save the planet**
  - Reduce CO² emissions
The right A.I. for the job

One Artificial Intelligence algorithm does not fit all use cases.
The right A.I. for the job

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Full text search

"cat"
The right A.I. for the job

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"cat"

The secret life of felines
felines.pdf
Felins, or cats as they are more commonly known, are carnivorous...
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Vehicle routing problem

Driver wage
20$/hour

Delivery locations
Capacity ≤ 20 tpm

Depot
10 ton

3 ton
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Full text search

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**Vector Space Model**
- Full text search
- "cat"
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  - felines.pdf
  - Felines, or cats as they are more commonly known, are carnivorous ...

**Neural Net**
- Image recognition
- "Dog"

**Constraint Solver**
- Vehicle routing problem
  - Delivery locations
  - Capacity ≤ 20 ton
  - Driver wage 20$ / hour
  - 10 ton
  - 3 ton
  - 15% less driving time
The right A.I. for the job

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**Neural Net**
- Image recognition
  - "Dog"
  - Other use cases include:
    - recommendations,
    - similarities,
    - voice recognition,
    - machine translation,

**Constraint Solver**
- Vehicle routing problem
  - 15% less driving time
  - Other use cases include:
    - employee rostering,
    - job scheduling,

Other algorithms for other use cases:
A* Search for pathfinding, Rete/Phreak for production rule systems, k-means for cluster analysis,
The right A.I. for the job

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**Neural Net**
- Image recognition
- "Dog"
- Other use cases include:
  - voice recognition,
  - machine translation,...
  - Implemented by:
  - TensorFlow,
  - Deeplearning4j

**Constraint Solver**
- Vehicle routing problem
- 15% less driving time
- Other use cases include:
  - employee rostering,
  - job scheduling,...
  - Implemented by:
  - OptaPlanner

Other algorithms for other use cases:
- A* Search for pathfinding, Rete/Phreak for production rule systems, k-means for cluster analysis,...
Maintenance scheduling
Machine maintenance scheduling

● 100K+ machines and 1000+ mechanics in North America
● Constraints
  ○ Maintenance frequency
  ○ SLA’s
● Benefits
  ○ Completed maintenance rose by 25%
  ○ Reduced contract cancellations
Employee rostering
For employees that don't work 9 to 5
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
Employee rostering

Assign shifts to employees more efficiently.

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Employees

Shifts

Free  Free
Free  Free
Free  Free
Free  Free
# Employee rostering

Assign shifts to employees more efficiently.

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- **1 shift per day**
- Requires nurse skill
- Requires engineering skill
- **No weekend work**
### Employee rostering

Assign shifts to employees more efficiently.

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- **1 shift per day**
- **≥ 10 hours**
- **Forward rotation** (enough time to sleep)
- **≤ 5 consecutive shifts**
- **Required nurse skill**
- **Free**
- **Day off request**
- **Free**
- **≥ 48 hours rest**
- **Free**
- **No weekend work**
Employee rostering
Assign shifts to employees more efficiently.

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≥ 10 hours
Forward rotation
(Enough time to sleep)

≥ 5 consecutive shifts

≤ 5 consecutive shifts

Day off request

Requires nurse skill

Requires engineering skill

≥ 48 hours rest

No weekend work

Users
Hospitals
Security
Guard firms
Call centers
Police and
Fire department

Nurse Rostering benchmark
Employee well-being +53%
OptaPlanner versus traditional algorithm with domain knowledge

Average Min/Max # datasets Biggest dataset
+19% +85% 26 752 assignments 50 employees

5 mins Tabu Search vs First Fit Decreasing

Don't believe us? Run our open benchmarks yourself: https://www.optaplanner.org/code/benchmarks.html
Business Benefits for Employee Rostering

- Improve Employee well-being
  Employee health and social life improved

- Improve Customer Satisfaction
  Right employee at the right time
Pharmacy on duty planning

- In use for all pharmacies in Flemish+Brussels (> 60% Belgium)
- Assigns night and weekend “waiting shifts” to pharmacies
  - So people can buy medication Saturday night at 3 AM.
- Constraints
  - Pharmacy availability
  - Location distribution

There's always an open pharmacy nearby
Shift rostering for anesthesiologists

- In use for Belgian hospitals (Saint-Jean UZ Brussel, OLV Aalst, ...)
- Implementation: MyStaff by Axians BE (Red Hat partner)
Schedule hearings

- 10K+ magistrates in UK
- Assigns all court cases to magistrates
- Constraints
  - Judge expertise
  - Holidays
  - Work hour preferences
  - Distance to court
OptaWeb Employee Rostering

https://github.com/kiegroup/optaweb-employee-rostering
Technology overview
Business Optimizer
Part of Business Automation portfolio

Complex event processing
Business rules
Business optimization

Process/Case management
Entando UX platform
Red Hat Application Development

CREATE THE APPLICATION LANDSCAPE YOU NEED

APPLICATION RUNTIMES
BUILD & MIGRATE APPS

INTEGRATION
COMPOSE & INTEGRATE APPS & DATA

PROCESS AUTOMATION
AUTOMATE & OPTIMIZE BUSINESS PROCESSES

Application Modernization and Migration

RED HAT® MIDDLEWARE

CONTAINER PLATFORM

PHYSICAL VIRTUAL PRIVATE CLOUD PUBLIC CLOUD
Conclusion
Real-World AI with Business Optimizer

● Deliver real-world value today with optimization technologies
  ○ Greatly reduce manual effort
  ○ Solve seemingly impossible problems
  ○ Drive competitive advantage

● BA’s have an important role to play:
  ○ Problem & domain definition is critical

● Don’t forget - this is also about change management
Want to learn more?

Homepage: www.optaplanner.org
Slides: www.optaplanner.org/learn/slides.html

See also Red Hat Decision Manager, our commercially supported product

Attend a 3 day Business Optimizer Bootcamp (in Kontich) provided by InfoFarm/The Campus.

Feedback: @GeoffreyDeSmet
LinkedIn: Ronald Meuwsen & Geoffrey De Smet
ReBoot
Customer Experience with Open Source

Virtual Hackathon September - December 2019
ReBoot Customer Experience with Open Source

How would you reinvent customer experience so users (like yourself) love it? Take the opportunity to compete against the best developers in EMEA, and stand to win awesome prizes!

Sky's the limit. You choose the area. You choose the app, service, frameworks or programming languages. Level up your game with the power of open source technology provided by Red Hat.

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