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Optimization in the aviation industry

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Agenda

- Introduction to Jeppesen and aviation business
- Fleet planning
- Applied optimization

The presenters

Mattias Lindby

- Master’s in Engineering Mathematics
- 2 Years at Jeppesen
- Product Owner Rostering Optimization

Moa Samuelsson

- Master’s in Engineering Mathematics
- 2 Years at Jeppesen
- Client Solution Owner Tail Assignment

BOEING

QANTAS
Spirit of Australia

The New Kangaroo Route 2018 | Qantas and the 787 Dreamliner

ORIGINAL ROUTE 1947	NON-STOP ROUTE 2018
55 HOURS IN THE AIR	17 HOURS IN THE AIR
4 DAY JOURNEY	1 DAY JOURNEY

Crew & Ops Management customers

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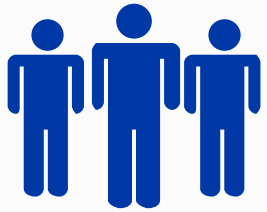
Product suite



Manpower

Crew pairing

Crew rostering

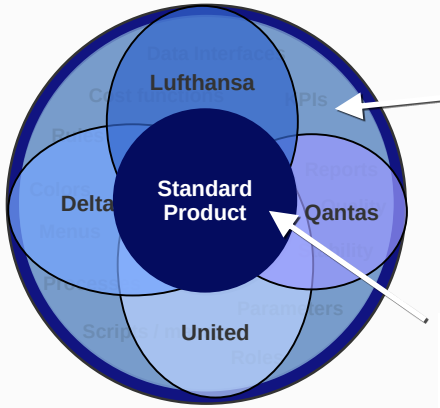
Crew tracking

Tail assignment

Ops control

Time

Change Management



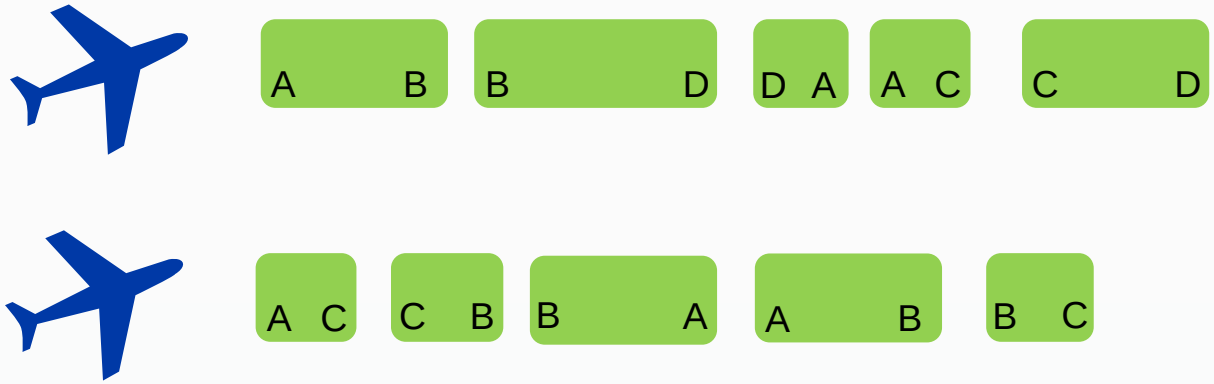
Configuration layer
The configuration layer makes it possible to update the business logic whenever necessary.

Standard Product
The standard product make all clients benefit from new features.

Tail assignment – the optimization problem

- Operational restrictions
- Aircraft restrictions

- Improve aircraft utilization
- Improve maintenance utilization
- Reduce fuel cost
- Increase passenger/payload revenue



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What we actually do

```
rule minimum_turn_time =
%turn_time% >= %minimum_turn_time%;
remark "Minimum turn time";
end

export %minimum_turn_time% =
parameter 0:35;
remark "Minimum turn time";
end

%turn_time% = next(leg(chain),
%departure%) - %arrival%;
```

- The minimum turn time is 35 minutes
- Would it be **impossible** to turn in 34 minutes?
- Ehm no.. It could work but should be avoided!
- Okey, so what is the **actual** minimum turn time?

Applied Optimization

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Model

In general:

Minimize

objective function

Such that

All given restrictions are respected

Volume of a soda can

Use as little material as possible

Minimize *area*

Such that: *volume = V*

Minimize $2\pi r^2 + 2\pi rh$

Such that: $\pi r^2 h = V$

$r \geq 0, h \geq 0$

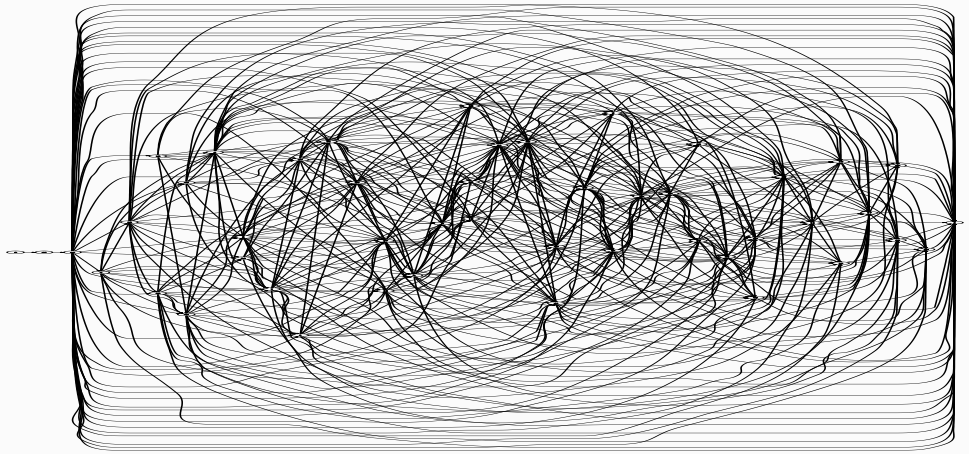
Problem types and solution techniques

- Set partioning problems
- Network flow style problems
- General Mixed Integer Programs
- Shortest path problems

➢ Column generation

➢ Local Search

➢ Constraint programming



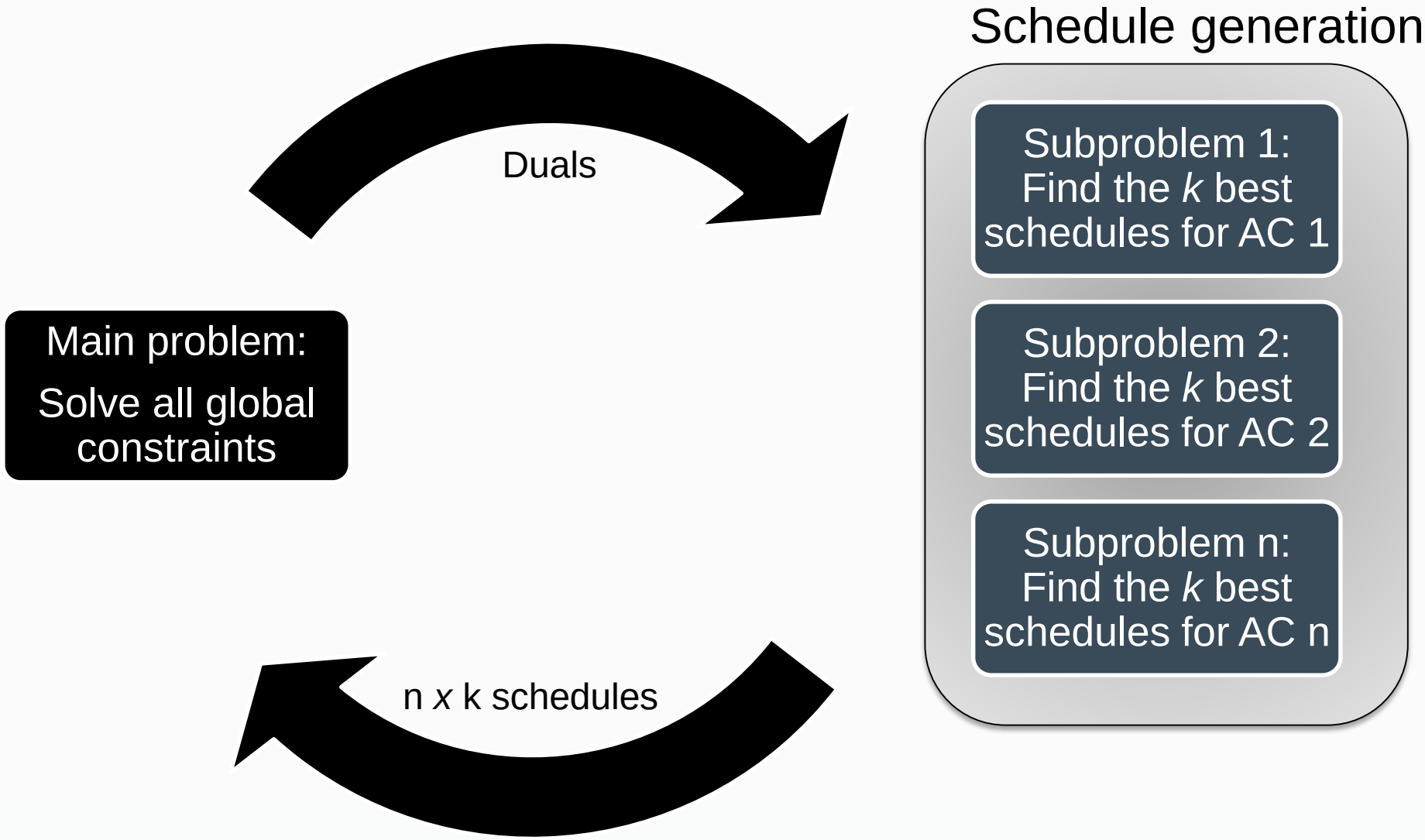
min	C_1	C_2	C_3	C_4	C_5		
task 1	1	1	0	1	0	=	1
task 2	1	1	0	0	0	=	1
task 3	0	0	1	0	1	=	1
task 4	0	1	1	1	0	=	1
task 5	1	0	1	1	1	=	1

Tail assignment example

- Optimization problem

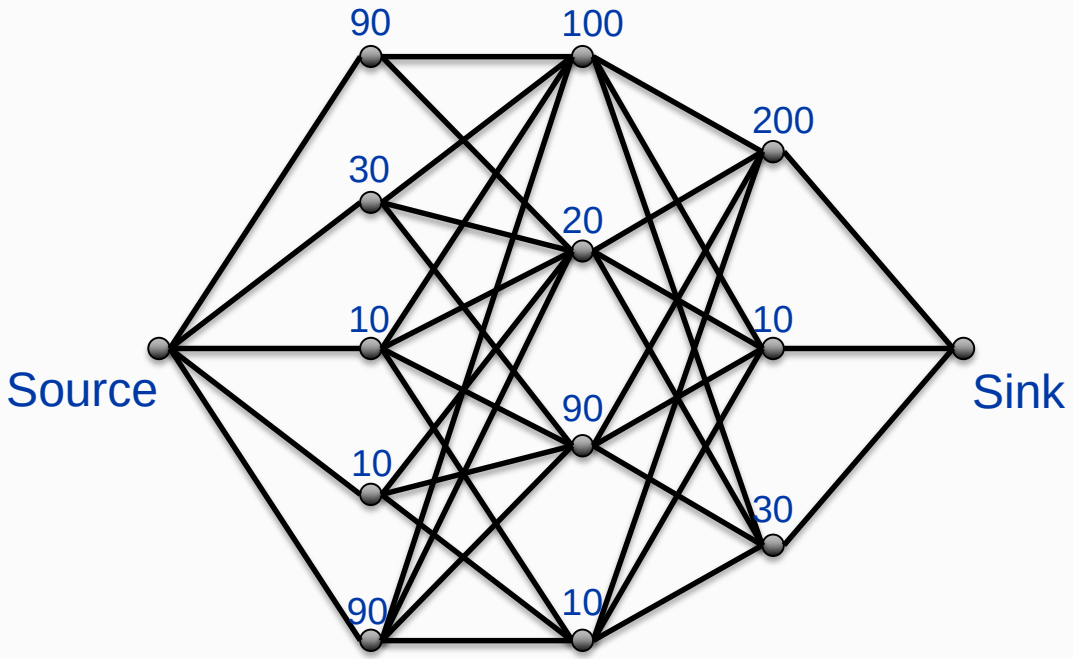
- Objective
  - $z^* := \min\{c^t x : Ax = e,\ x \in \{0,1\}^n\}$
  - $x \in \{0,1\}^n$ is a decision variable whose jth entry is 1 if schedule R_j is chosen.
- Solution method
  - Solve it iteratively through Column generation
    - Two step process
      - Many subproblems
      - One master problem

Column Generation



Subproblem: Generating schedules

- Find the best possible schedule based on cost modelling and duals from master problem.



- Nodes are flights
- Add edges
- Remove illegal flight-flight connections
- Append costs in graph
  - Cost = schedule cost – duals
- Find shortest path
  - Nodes in the path are flights on the schedule

Solve the puzzle!

- Each optimial solution per aircraft is not a global feasible solution.
  - **One** flight can only be on **one** schedule
  - Some flights can only be operated by certain aircraft subtypes