Airline planning & airline scheduling with Unified Optimization

SchedulAir

the only system with Unified Management & Optimization of:

flights  aircraft  crew
Overview

- Unified Optimization
- Benders decomposition
- decisal
Airline planning & scheduling

Long-Term

Fleet Planning
- Which aircraft types and how many aircraft?

Network Planning
- Which flights?

Fleet Assignment
- Which fleet for each flight?

Medium- & Short-Term

Aircraft Rotations
- Which schedule for each aircraft?

Crew Scheduling
- Which schedule for each crew?
SchedulAir unified management & optimization

Long-Term

Fleet Planning
Network Planning
Fleet Assignment
Aircraft Rotations
Crew Scheduling

Medium- & Short-Term

Plan Unified
Sched Unified
SchedulAir

Unified Optimization | Benders decomposition | decaisal
PlanUnified: comparison with other products

PlanUnified
unified optimization

Fleet Planning
Network Planning
Fleet Assignment

Other Products
sequential optimization

Fleet Planning
Network Planning
Fleet Assignment
SchedUnified: comparison with other products

- **SchedUnified**
  - unified optimization
  - Fleet Assignment
  - Aircraft Rotations
  - Crew Pairing

- **Other Products**
  - sequential optimization
  - Fleet Assignment
  - Aircraft Rotations
  - Crew Pairing
Users report savings of **USD 300 / flight**
within a month of using our system
Benders decomposition

\[
\begin{align*}
\min & \quad c^T \cdot x + c(y) \\
A \cdot x + y &= b \\
x &\geq 0, y \in Y
\end{align*}
\]
Benders problems

\[
\begin{align*}
\text{Master Problem} & \\
\min & \quad c(y) + ? \\
\text{Subproblem} & \\
\min & \quad c^T \cdot x \\
A \cdot x & = b - \hat{y} \\
x & \geq 0
\end{align*}
\]
Benders subproblem given a MP solution

\[
\begin{align*}
\text{Master Problem} & \\
\min & \quad c(y) + ? \\
\text{s.t.} & \quad y \in Y
\end{align*}
\]

\[
\begin{align*}
\text{Subproblem} & \\
\min & \quad c^T \cdot x + c(y) \\
\text{s.t.} & \quad A \cdot x + y = b \\
& \quad x \geq 0, y \in Y
\end{align*}
\]
Dual Benders subproblem

min $c^T \cdot x + c(y)$

$A \cdot x + y = b$

$x \geq 0, y \in Y$

Master Problem

min $c(y) + ?$

$? ? ?$

$y \in Y$

Subproblem

min $c^T \cdot x$

$A \cdot x = b - \hat{y}$

$x \geq 0$

Dual of Subproblem

max $(b - \hat{y})^T \cdot \pi$

$A^T \cdot \pi \leq c$

Unified Optimization | Benders decomposition | decisal
Duality theorem

Master Problem
\[ \min \ c(y) \]
\[ y \in Y \]

Subproblem
\[ \min \ c^T \cdot x \]
\[ A \cdot x = b - \tilde{y} \]
\[ x \geq 0 \]

Dual of Subproblem
\[ \max \ (b - \tilde{y})^T \cdot \pi \]
\[ A^T \cdot \pi \leq c \]
Duality theorem

\[
\begin{align*}
\min & \quad c^T \cdot x + c(y) \\
A \cdot x + y &= b \\
x \geq 0, y \in Y
\end{align*}
\]

Master Problem
\[
\begin{align*}
\min & \quad c(y) + \text{?} \\
\text{???} & \quad (b - \tilde{y})^T \cdot \pi \leq z \\
y \in Y
\end{align*}
\]

Subproblem
\[
\begin{align*}
z &= \min \quad c^T \cdot x \\
A \cdot x &= b - \tilde{y} \\
x &\geq 0
\end{align*}
\]

Dual of Subproblem
\[
\begin{align*}
\max & \quad (b - \tilde{y})^T \cdot \pi \\
A^T \cdot \pi &\leq c
\end{align*}
\]
Benders algorithm

Master Problem
\[ \min \ c(y) + z \]
\[ \cdots \]
\[ (b - y)^T \cdot \pi_i \leq z \]
\[ \cdots \]
\[ y \in Y \]

Subproblem
\[ \min \ c^T \cdot x \]
\[ A \cdot x = b - \hat{y}_i \]
\[ x \geq 0 \]

Dual of Subproblem
\[ \max \ (b - \hat{y}_i)^T \cdot \pi_i \]
\[ A^T \cdot \pi_i \leq c \]
decisal

making decisions optimal

Unified Optimization | Benders decomposition | decisal
• Born from cutting edge research at Imperial College London
• Based in London, UK
• IBM partner
IBM Global Entrepreneur Success Stories UK & Ireland 2013

Looking for Global Entrepreneurs who want to build a Smarter Planet

Business Analytics

VoiceSecure
developed a solution for disasters – from fires in apartment blocks to nuclear attacks – and a voice biometrics solution to help identify callers to customer care and help desks.

Constructive
developed a flexible, scalable mobile and web-based reporting solution within the small business space that provides customised business insights and projections.

Hiwayman
enabled a UK address to be captured quickly and accurately and developed a solution to ensure that an account number is valid for a given sort code.

Decisal
provided a new system that allows unified optimisation of air network aircraft maintenance rotation, as well as crew and fleet assignment planning.
Conclusions

Fleet Planning

Network Planning

Fleet Assignment

Aircraft Rotations

Crew Scheduling

Unified Planning

Unified Planning

Unified Planning

Unified Planning

Air Schedule

Medium- & Short-Term

Medium- & Short-Term

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