Welcome on Board!

Flight Gate Scheduling with Multiple Objectives

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Take off...

Narita, Japan 29.05.2009
Partners and Collaborators

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Airport Layout

Terminal

In

Gate 1

Out

Gate

... Gate

... Gate m

Apron
The Classical Model: Objectives

\[ z_1 = \sum_{i=1}^{n} \pi_{i,m+1} \]

\[ z_2 = \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{k=1}^{m+1} \sum_{l=1}^{m+1} f_{i,j} w_{k,l} \pi_{i,k} \pi_{j,l} + \sum_{i=1}^{n} \sum_{k=1}^{m+1} f_{i,0} w_{k,0} \pi_{i,k} \]

\[ z_3 = \sum_{i=1}^{n} \sum_{k=1}^{m+1} \nu_{i} u_{i,k} \pi_{i,k} \]
The Classical Model: Restrictions

\[
\sum_{k=1}^{m+1} \pi_{i,k} = 1 \quad 1 \leq i \leq n
\]

\[
\pi_{i,k} \pi_{j,k} (d_j - a_i)(d_i - a_j) \leq 0 \quad 1 \leq i, j \leq n, \quad k \neq m + 1
\]

\[
\pi_{i,k} \in \{0, 1\} \quad 1 \leq i \leq n, \quad 1 \leq k \leq m + 1
\]
The Advanced Model: Gantt Chart

\[ S_i = t_i^a \quad S_i + p_i^{\text{min}} \]

\[ M_i \]

\[ p_i^{\text{min}} \quad C_i \]

\[ S_k \quad t_k^d - p_k^{\text{min}} \quad C_k = t_k^d \]

\[ M_j \]

\[ p_k^{\text{min}} \]

\[ d_{ij}^{\text{low}} \quad d_{jk}^{\text{low}} \]

\[ M_k \]

\[ S_j \quad p_j^{\text{min}} \quad C_j \]

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The Advanced Model: Restrictions

Find a schedule \((S, C, M)\) satisfying the restrictions

**Minimal processing time**
\[ S_i + p_i^{\text{min}} \leq C_i \quad \forall i \in V \]

**Continuous processing**
\[ C_i + d_{iM_i,jM_j}^{\text{row}} = S_j \quad \forall (i, j) \in E^{\text{row}} \]

**Disjunctive activities and setup times**
\[ C_i + d_{iM_i,jM_j}^{\text{setup}} \leq S_j \quad \forall i, j \in V \]
\[ C_j + d_{jM_j,iM_i}^{\text{setup}} \leq S_i \quad \exists (i, M_i, j, M_j) \in E^{\text{shadow}} \]

**Start and completion time**
\[ S_i = t_i^a \quad \forall i \in V^a \]
\[ C_i = t_i^d \quad \forall i \in V^d \]
\[ S_i, C_i \in \mathbb{N}_0 \quad \forall i \in V \]

Mode selection:
\[ M_i = M_j \quad \forall i \in V \]
The Advanced Model: Objectives

\[ z_1 := \sum_{i \in V} w_i u_i M_i, \]

\[ z_2 := |(i, j) \in \varepsilon^{tow} : M_i \neq M_j|, \quad \text{and} \]

\[ z_3 := \sum_{i \in V: M_i \neq M_i'} w_i. \]
Pareto Simulated Annealing (A. Jaszkiewicz, 1998)

**Standard characteristics of PSA**

- Neighborhood concept
- Cooling schedule
- Temperature dependent acceptance probability
- Termination criterion

**Special features of PSA**

- The concept of generating solutions or agents
- Use of aggregation function-based probabilities
- Management of the population of generating solutions or repulsion
- Updating the set of potentially Pareto optimal solutions
- Normalization of objectives

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Typical output of PSA


Concluding remarks

Taking into account two aspects – multicriteriality and robustness – makes mathematical models more realistic and closer to reality
Multicriteria Flight Gate Scheduling

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Landing...

Narita, Japan
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Thank you for your interest!

Questions and Answers