

Routing Repair Model

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1 Indices

s : index for commodities

i, j : indexes for flights

t : index for delay options

m : index for crew connection time options

2 Notations

S : set of commodities

A_r : set of real activities

A_b : set of beginning dummy activities

A_e : set of ending dummy activities

$A = A_r \cup A_b \cup A_e$: set of all activities

T_i : set of delay options for activity $i \in A_r$

Ω_s : set of acceptable links between activities for commodity $s \in S$

$CREW$: set of existing crew connections between activities

3 Parameters

ETD_{it} : departure time activity $i \in A_r$ for delay option $t \in T_i$

ETA_{it} : arrival time activity $i \in A_r$ for delay option $t \in T_i$

$MTAT_{sij}$: minimum TAT between activities $(i, j) \in \Omega_s$ for commodity $s \in S$

MCT_{ij} : minimum crew connection time between activities $(i, j) \in CREW$

M : big M

C_{swap} : unit cost of aircraft change

C_{cnx}^i : unit cost of activity i cancellation

C_{del}^{it} : unit cost of activity i delay option $t \in D$

C_{SB} : unit cost of overnight SB

C_{DCV} : unit cost of DCV

$C_{crewLink}$: unit cost of a broken critical (tech) crew connection (on same aircraft)

$C_{crewConnection}$: unit cost of a broken (tech) crew connection

$C_{overlap}$: unit cost of maintenance overlap

4 Decision Variables

ω_{sij} : 1 if activity $i \in A$ is before flight $j \in A$ for commodity $s \in S$, 0 otherwise

u_i : 1 if activity $i \in A$ is cancelled, 0 otherwise

d_{it} : 1 if delay option $t \in T_i$ is used for activity $i \in A$, 0 otherwise

b_{ij} : 1 if crew connection between activities $(i, j) \in CREW$ is broken, 0 otherwise

5 Objective Function

Minimize : $Cost_{swaps} + Cost_{cancellations} + Cost_{delays} + Cost_{overnightSB} + Cost_{DCV} + Cost_{crewLinks} + Cost_{crewConne}$
(1)

$$Cost_{swaps} = \sum_{\substack{i \in A \\ j \in CompF_i^A}} C_{swap} AF_{ij} \quad (2)$$

$$Cost_{cancellation} = \sum_{j \in F \cup M} C_{cnx}^j CF_j \quad (3)$$

$$Cost_{delays} = \sum_{\substack{j \in F \cup M \\ k \in D}} C_{del}^{jk} k DF_{jk} \quad (4)$$

$$Cost_{overnightSB} = \sum_{\substack{i \in A \\ j \in CompF_i^A}} C_{SB} LF_{ij} \quad (5)$$

$$Cost_{DCV} = \sum_{\substack{i \in A \\ j \in DCVForb_i^A}} C_{DCV} AF_{ij} \quad (6)$$

$$Cost_{crewLinks} = \sum_{\substack{i \in A \\ (j, \hat{j}) \in CritCrewLinks}} C_{crewLink} (1 - w_{ij\hat{j}}) \quad (7)$$

$$Cost_{crewConnections} = \sum_{\substack{(j, \hat{j}) \in CritCrewCnx \\ m \in C}} C_{crewConnection} (MCT_{j\hat{j}} - m) c_{j\hat{j}m} \quad (8)$$

6 Constraints

$$\sum_{s \in S} \sum_{i \in A_b \cup A_r} \omega_{sij} + u_j = 1 \quad \forall j \in A_r \quad (9)$$

$$\sum_{j \in A_r \cup A_e} \omega_{sij} \leq 1 \quad \forall s \in S, \forall i \in A_r \quad (10)$$

$$\sum_{j \in A} (\omega_{sij} - \omega_{sji}) = 0 \quad \forall s \in S, \forall i \in A_r \quad (11)$$

$$\sum_{s \in S} \sum_{i \in A_b \cup A_r} \omega_{sij} = 1 \quad \forall j \in A_e \quad (12)$$

$$\sum_{s \in S} \sum_{i \in A_r \cup A_e} \omega_{sij} = 1 \quad \forall j \in A_b \quad (13)$$

$$\sum_{t \in T_i} d_{it} = 1 \quad \forall i \in A_r \quad (14)$$

$$\sum_{t \in T_j} ETA_{jt} \cdot d_{jt} - \sum_{t \in T_i} ETD_{it} \cdot d_{it} + M \cdot (u_i + (1 - \omega_{sij})) \geq MTAT_{sij} \quad (15)$$

$$\forall s \in S, \forall (i, j) \in \Omega_s$$

$$\sum_{t \in T_j} ETA_{jt} \cdot d_{jt} - \sum_{t \in T_i} ETD_{it} \cdot d_{it} + M \cdot (b_{ij} + u_j + \sum_{s \in S} \omega_{sij}) \geq MCT_{ij} \quad (16)$$

$$\forall (i, j) \in CREW$$

7 Domain Of Variables

$$\omega_{sij} \in \{0, 1\} \quad \forall s \in S, \forall (i, j) \in \Omega_s \quad (17)$$

$$u_i \in \{0, 1\} \quad \forall i \in A \quad (18)$$

$$d_{it} \in \{0, 1\} \quad \forall i \in A, \forall t \in T_i \quad (19)$$

$$b_{ij} \in \{0, 1\} \quad \forall (i, j) \in CREW \quad (20)$$

8 Description

The objective function (1) is to minimize the cost of the operated routings (content of the routing and aircraft operating it), cancelled activities and broken crew connections.

Constraint (9) states that an aircraft can operate at most one routing.

Constraint (10) states that an activity can be present in at most one operated routing. This constraint also prevents a routing to be operated by more than one aircraft. If an activity belong to no operated routing then it is cancelled.

Constraint (11) states that a crew connection is broken in case the minimum connection time is not respected between the activities. If any activity of the connection is cancelled, the connection is not considered as broken. If both activities belong to the same operated routing, the connection is not considered as broken.

M can be set to the value of the recovery window end.