Air Cargo Optimization

DDS - RWTH Business School

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Introduction:

Unit Load Devices (ULDs) are unloaded from an aircraft by the ground handling agent and placed in their respective drop zones. Each ULD has an arrival time. From the drop zone the ULDs need to be transported to a breakdown zone (BD zone), which are located at different places of the airport, have different capacity and handling times within the zone.

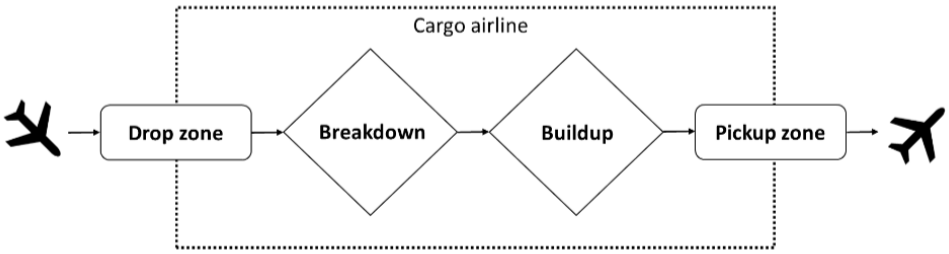


Figure 1: The processes that take place at a hub, with respect to air cargo

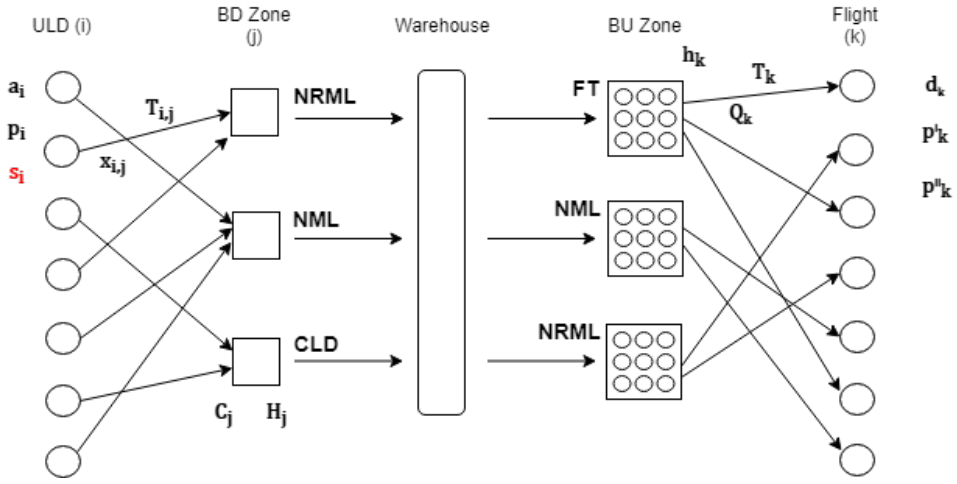


Table 1: Drop Zone

Name	Workstations	Sequence
DZ NRML-1	6	1
DZ NRML-2	4	2
DZ NML-1	3	3
DZ CLD-1	5	4

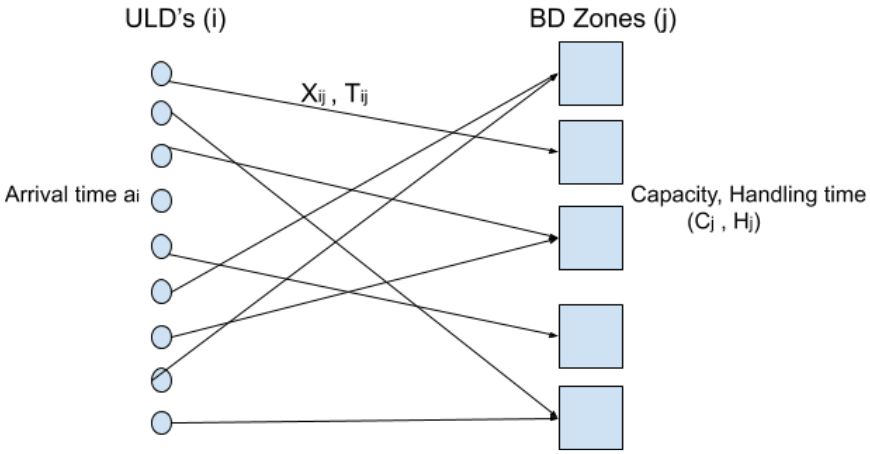
Table 2: Break Down Zone

Name	Workstations	Sequence	ToWH	HandTimePerULD
B BD NRML-1	33	1	0:30	0:24
B BD NRML-2	10	2	0:25	0:24
BD NML-1	4	3	0:40	0:13
BD CLD-1	8	4	0:30	0:17
BD NRML-1	5	5	0:30	0:20
BD NML-2	3	6	0:25	0:13
BD NRML-2	6	7	0:40	0:20
BD NRML-3	3	8	0:40	0:20
BD CLD-2	5	9	0:30	0:17
BD NML-3	5	10	0:25	0:20
BD NRML-4	3	11	0:30	0:13
BD CLD-4	1	12	0:40	0:15

Arrival:
Let each ULD $i \in I = \{1, 2, 3, \ldots, n\}$
a_i - Arrival time of each ULD i
s_i - Idle time spent by ULD i at drop zone
p_i - Priority of ULD i

Break Down (BD) Zones: $j \in J = \{1, 2, 3, \ldots, m\}$

From the drop zone the ULDs need to be transported to a breakdown zone (BD zone), which are located at different places of the airport, have different capacity and handling times within the zone.



$x_{ij} \in \{0, 1\}, \forall i \in I, j \in J$ - denotes if ULD i is assigned to BD zone j or not.
t_j - Time taken to transport an ULD to BD zone j
C_j - Capacity of each BD Zone j
H_j - Handling time of a ULD from in BD zone j
$a_i + s_i + \sum_{i,j \in E} x_{i,j} T_j$ - gives the Arrival time of ULD i to its BD zone j
$\sum_{i,j \in E} x_{i,j} \leq C_j \ , \forall j \in J$ - Capacity constraint needs to be checked from time to time

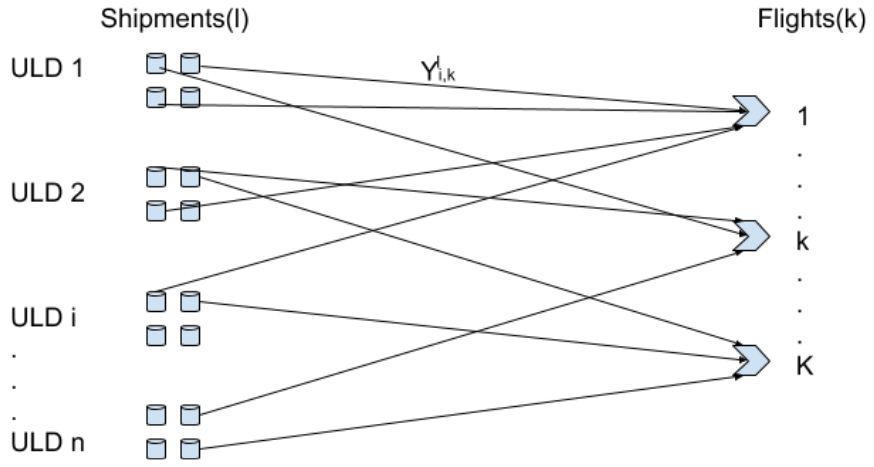
Warehouse:

When the shipments are unpacked, they are sent to the storage warehouse (WH) which is fully automated and with the assumption, that there are never capacity issues in the storage WH. In a next step the shipments are built up again to ULDs depending on their connecting flight. A departing aircraft type has a link to a specific BU zone, so with the provided information which aircraft the shipment should go on, the BU zone is known.

T'_j - Time taken to transport shipment from BD zone j to Warehouse
W_k - Time at which, all shipments for a new Flight k are requested
T'_k - Transport time from Warehouse to BU Zone for all shipments of Flight k

Build Up (BU) Zone:

B_k - Time taken to Build up ALL new ULDs for flight k
d_k - Departure time of a flight k must be ready (given)
T_k -Transport time from BU to Flight k (given)
p'_k - Default processing time of flight k (given)
p''_k - Pre processing time of flight k (given)
$W_k + T_k + T'_k + B_k + p'_k + p''_k \leq d_k$ //Constraint respecting Flight time



Let $Y_{i,k}^{l} \in \{0,1\}$ - depending on whether shipment l going to flight k is in ULD i or not.
w_l - Weight of each shipment l (given)
Q_k - Total weight of shipments going via flight k (summation of w_l)(given)
$\sum_{i \in I} \sum_{l \in L} Y_{i,k}^{l} w_l = Q_k$, $\forall k$ - Respecting assigned shipment weight to Flights k
$\sum_{i \in I} \sum_{l \in L} \sum_{k \in K} Y_{i,k}^{l}$ - N // Total no of shipments
All shipments of flight k, should reach be available before time W_k:
$a_i + s_i + \sum_{i,j \in E} x_{i,j} T_j + T'_j + H_j \leq W_k$ + (1-$Y_{i,k}^{l}$)M, $\forall i, k, l$ // Time constraint for every shipment.