Airline Network Design

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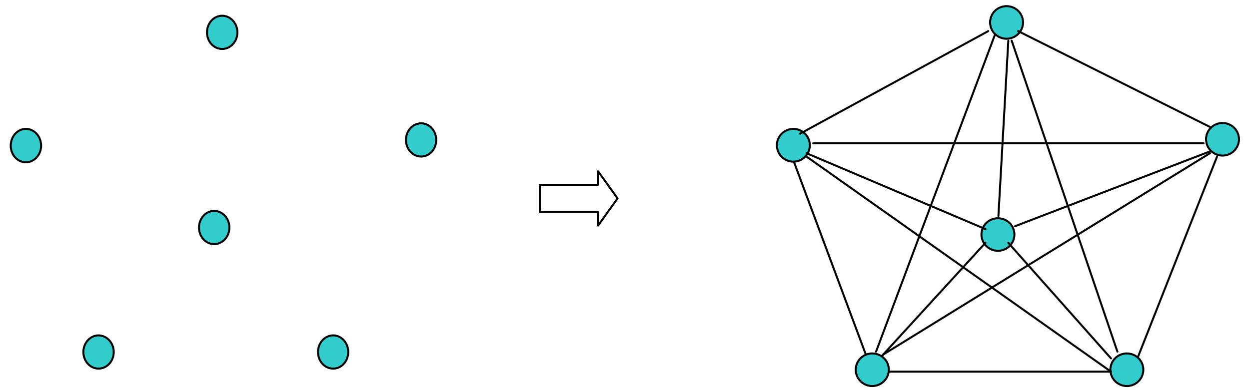
Airline Network Planning

- Airline Network planning tries to determine
  - Service network configuration
  - Flight route (delivering path)
  - Flow assignment

Network Configuration

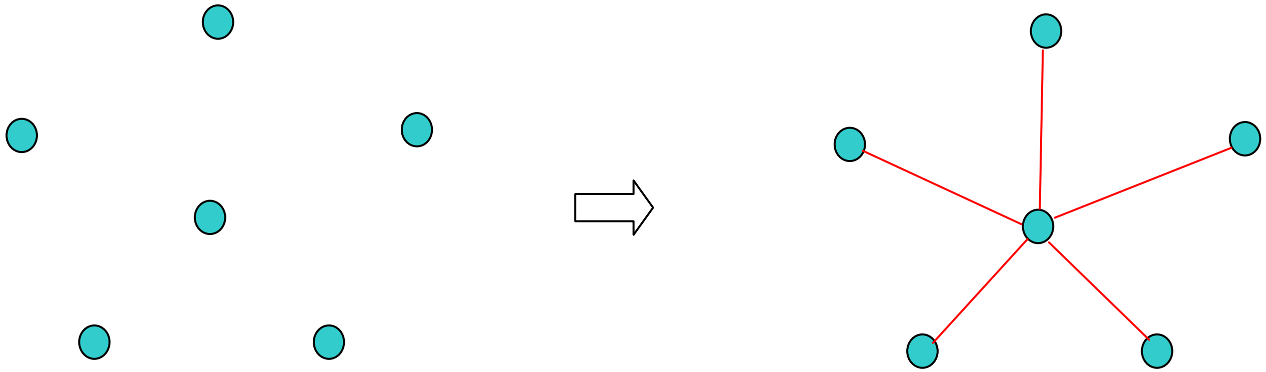
- Network configuration
  - Point-to-Point (direct flight)



15 linkages

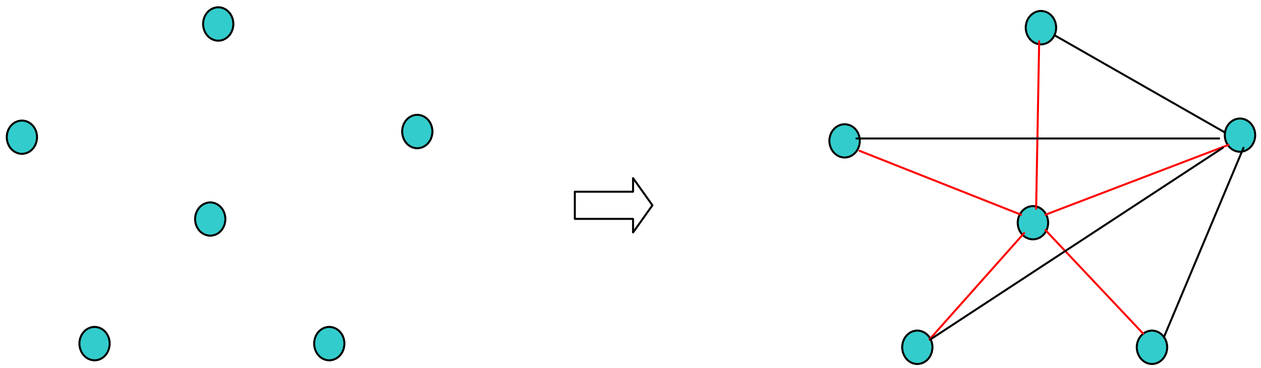
Network Configuration

- Hub-and-Spoke



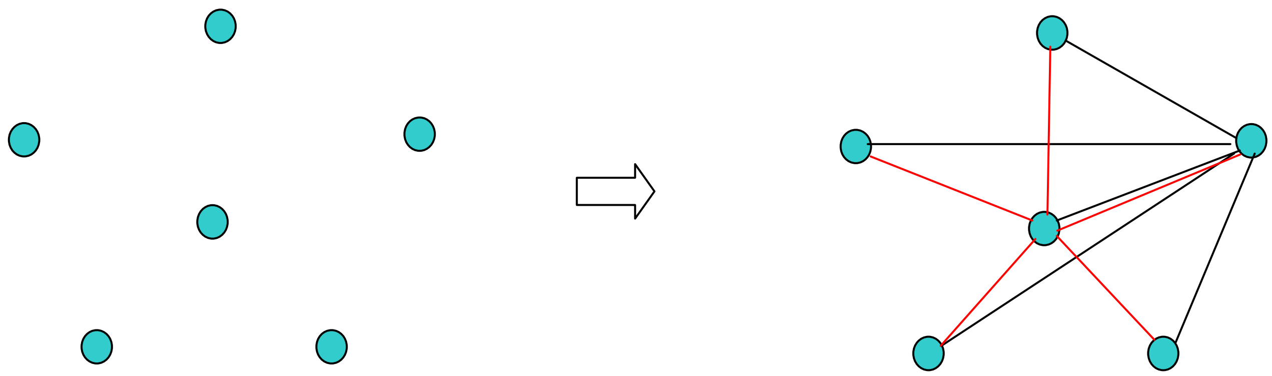
5 linkages

- Combination of both



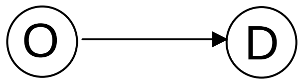
Network Configuration

- Coexistence of both



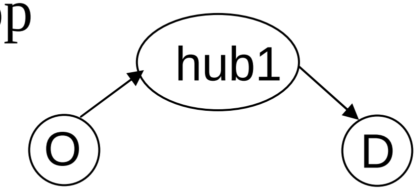
Flight Routes

- Flight route
  - Determine the routes (or paths) to deliver for every OD
  - Direct flight or non-stop flight

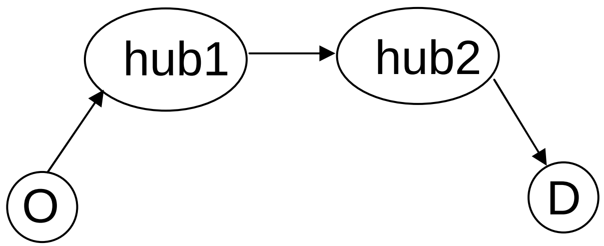


Flight Routes

- Hub-connected flight
  - rare to have more than two hub stops in practice, especially in the air passenger market
  - one-hub-stop



  - two-hub-stop



Tool for Airline Network Planning

- Tool: Mathematical Model
  - Objective: usually try to minimize the total cost
    - Cost
      - Fixed cost: hub setup cost
      - Variable costs: transportation cost and….
  - Maximize profit: more complicate because it would relate to pricing policy.
    - pricing in air market is dynamic and complicate task: Revenue Management.

Network Planning Model

- Given
  - nodes (airports): location
  - OD demand
  - Costs
  - Flight distance (if necessary)
- Determine
  - Network configuration
  - Number of hubs and location
  - Paths
  - Flows

$Minimize\ z = \sum_{i\in N}\sum_{j\in N:j\neq i} d_{ij}c_{ij}x_{ij} + \sum_{i\in N}\sum_{j\in N:j\neq i}\sum_{k\in N}\sum_{t\in N} d_{ij}c_{iktj}x_{iktj} + \sum_{k\in N} f_k s_k$	
$Subject\ \ to \quad x_{ij} + \sum_{k\in N}\sum_{t\in N} x_{iktj} = 1,\ \forall i, j : i \neq j$	Flow conversation
$\sum_{i\in N} x_{ik} + \sum_{i\in N} x_{ki} \leq V(1 - s_k),\ \forall k : i \neq k$	Differentiate non-stop flights in hubs
$\sum_{t\in N} x_{kkti} + \sum_{t\in N} x_{itkk} \geq 2s_k\ ,\ \forall i, k : i \neq k$	No two-hub-stop for hubs
$x_{kktt} \geq s_k + s_t - 1,\ \forall k, t : k \neq t$	Only non-stop between hubs
$v\left[\sum_{i\in N}\sum_{j\in N}\sum_{t\in N}(x_{iktj} + x_{itkj}) - \sum_{i\in N}\sum_{j\in N} x_{ikkj}\right] \geq s_k\ ,\forall k : i \neq k,\ j \neq k$	Hubs need transshipment flows
$\sum_{i\in N}\sum_{j\in N}\sum_{t\in N} d_{ij}(x_{iktj} + x_{itkj}) - \sum_{i\in N}\sum_{j\in N} d_{ij}x_{ikkj} \leq U_k s_k\ ,\forall k : i \neq j$	Capacity constraint
$0 \leq x_{ij} \leq 1,\ \forall i, j : i \neq j$	
$0 \leq x_{iktj} \leq 1,\ \forall i, k, t, j : i \neq j$	
$s_k \in \{0,1\},\ \forall k$	