Determining an Optimal Airport Slot Profile

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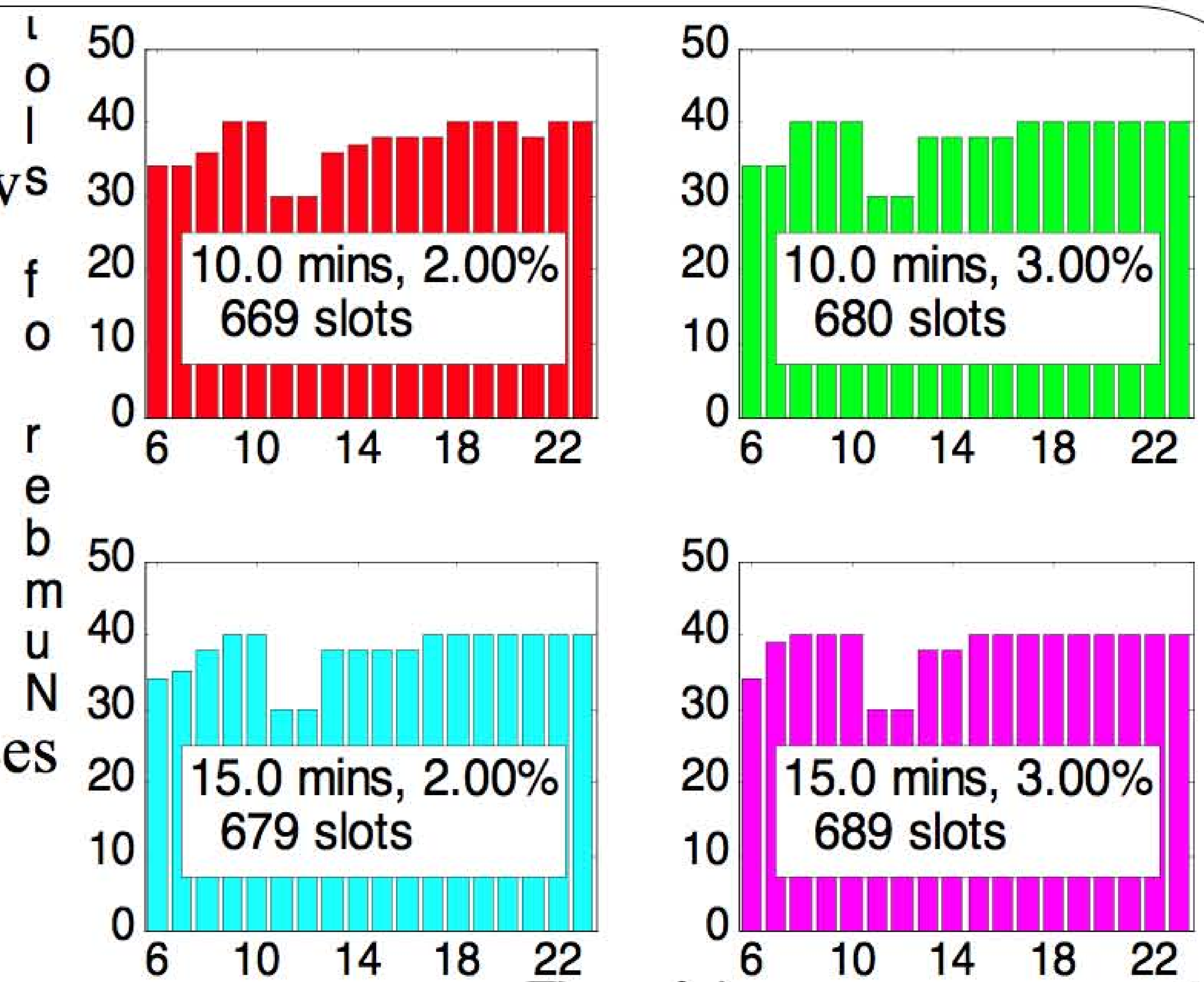
Problem: *How many* slots should exist in *different time periods* at an airport?

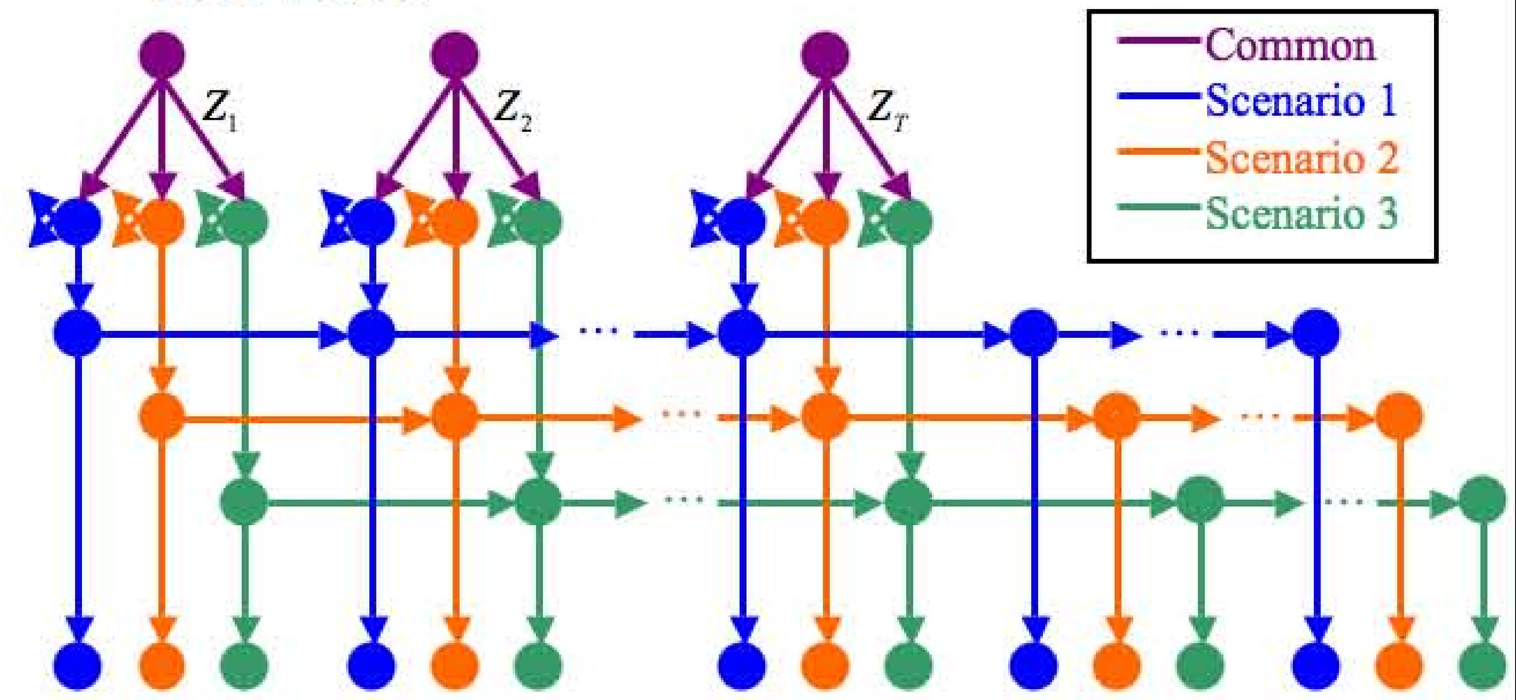
Background:
- A slot grants authority to schedule a landing or takeoff
- Few US (but most European) airports are slot-controlled
- In practice, slot profiles over a day are generally uniform

Motivation:
- Not necessary to assume a uniform slot profile
- Should not use good or bad weather capacity exclusively
- Balance level of service (delays/cancellations) against number of slots
- Certain time periods are naturally more valuable than others
- Create recovery periods after high utilization periods

Results:
- Case study using data for New York's LaGuardia Airport
- High-valued periods have more slots
- Model meets level of service targets (10/15 mins delay, 2%/3% cancellation rate)
- Forcing uniform profile reduces objective function 3–5%



Mathematical Formulation:
- Integer linear program (almost a network flow model)
- Stochastic optimization over a set of discrete capacity scenarios
- Maximize total value of slots
- Specify expected level of service



$$\max \left\{ \sum_t V_t Z_t \right\}$$

Subject to

$$Z_t - X_{t,q} - \sum_i \theta_{t,q}{}^i = 0 \qquad \forall t \in \{1,\ldots,T\},\ q \in \{1,\ldots,Q\}$$

$$X_{1,q} - Y_{1,q} \le C_{1,q} \qquad \forall q \in \{1,\ldots,Q\}$$

$$X_{t,q} + Y_{t-1,q} - Y_{t,q} \le C_{t,q} \qquad \forall t \in \{2,\ldots,T\},\ q \in \{1,\ldots,Q\}$$

$$Y_{t-1,q} - Y_{t,q} \le C_{t,q} \qquad \forall t \in \{T+1,\ldots,T+U-1\},\ q \in \{1,\ldots,Q\}$$

$$Y_{T+U-1,q} \le C_{T+U,q} \qquad \forall q \in \{1,\ldots,Q\}$$

$$D_{\min} \le Z_t \le D_{\max} \qquad \forall t \in \{1,\ldots,T\}$$

$$Y_{t,q} \le W_{t,q} \qquad \forall t \in \{1,\ldots,T+U-1\}, q \in \{1,\ldots,Q\}$$

$$\theta_{t,q}{}^i \le P_i \qquad \forall t \in \{1,\ldots,T\},\ q \in \{1,\ldots,Q\}, i \in \{1,\ldots,N\}$$

$$X_{t,q}, Y_{t,q}, Z_t, \theta_{t,q}{}^i \in {}^{+} \qquad \forall t \in \{1,\ldots,T\}, q \in \{1,\ldots,Q\}, i \in \{1,\ldots,N\}$$

$$\sum_q p_q \sum_t Y_{t,q} - \gamma \sum_t Z_t \le 0$$

$$\sum_q p_q \sum_i \sum_t \theta^i_{t,q} - \rho \sum_t Z_t \le 0$$

Where

$$W_{t,q} = \sum_{i=t+1}^{\min\{t+U,T+U\}} C_{i,q} \qquad \forall t \in \{1,\ldots,T+U-1\}, q \in \{1,\ldots,Q\}$$