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Objective and Methodology

Objective: to optimize sector boundaries over multiple periods while addressing demand variability by varying sector controller staffings at each period.

The target airspace is decomposed into contiguous hex-cells. A mixed integer program groups hex-cells into sectors that align with traffic flows and minimize total controller hours.

Model Formulation

- Flow Conservation Constraints
  \[ \sum_{j \in I} x_{ij} + x_{ij} = \sum_{j \in J} x_{ij}, \quad \forall i \in I, \forall t \in T \]
- Link Usage Constraints
  \[ \sum_{i \in I} x_{ij} = M_{ij}, \quad \forall i \in I, \forall j \in J, \forall t \in T \]
- Step-wise Sector Capacity Constraints (on Dummy Links)
  \[ M_{ij} = \sum_{k \in K} M_{ijk} \]
- Outbound Flow Constraints
  \[ \sum_{i \in I} x_{ij} = 1, \quad \forall i \in I, \forall j \in J, \forall t \in T \]
- Objective Function
  \[ \min \sum_{i \in I} \sum_{j \in J} \sum_{t \in T} c_{ijt} x_{ijt} \]

Decision Variables

- \( x_{ijt} \): continuous variable of link flow at each time period.
- \( M_{ij} \): binary variable on whether link is chosen.
- \( M_{ijk} \): binary variable on which sector capacity value is chosen at each time period.
- \( d_{ij} \): demand at each hex-cell, measured as TZ radar hits.

Objective Function

\[ \min \left( \sum_{i \in I} \sum_{j \in J} \sum_{t \in T} c_{ijt} x_{ijt} \right) \]

Cost Coefficients

- \( c_{ijt} \): variable link cost, defined as the inverse of aircraft crossings between two hex-cells.
- \( M_{ij} \): fixed cost on dummy links, capitalizing controller usages.

Our model significantly reduces controller-hours!

Contribution and Future Works

- Given the time-varying nature of traffic, the sectorizations from this model not only accommodate the multi-period demand but also consider the overall efficiency of controller staffing requirements.
- Further investigation is required to specify how the capacity values link to controller staffing.
- Other non-controller resources that impact sector capacity could also be included to reflect those resource constraints.