Simplifying the Design of Complex, Large Scale Systems
(like the Air Transportation System)

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The Air Transportation System

- Everything involved in transporting cargo / passengers by air
- One of the most huge, complex and expensive artificial system
Aggregated ATS into Airline Service Route Network

- Compound effect of airline, PAX demand, regulations, etc.
- Topology = layout of the network
- Airport => node, Airline route => link
- How to define different network topologies?
- What are the pros and cons?
- What is a good topology for the congested airspace of today?
Network Structure vs. ATS Performance

Operational & Fuel efficiency trade-offs wrt topology

AC Design & Fleet assignment wrt network topology

Higher operational efficiency

Higher fuel efficiency

(Above Right & Left) Each dot on plot represents a different service route network topology

(Above Right): Preferred AC spec if airlines can assign any aircraft to routes without constraint (total of three AC types)
Modeling all details of the Transport Network may be too time consuming – is there a way to aggregate?

Each dots represent an airport

Model based on linear regression (annual delays + cancellations)

Equation variables are network characteristics of the airport

Model validation for calendar year 2007

\[
\text{Delayed Ops / year} = (\text{const.} + c_{\text{deg}} \times \text{degree} + c_{\text{cc}} \times \text{CC} + c_{\text{evc}} \times \text{EVC} + c_{\text{pop}} \times \text{population})^2 \times n_{\text{ref}}
\]
Service route network dynamics

- Investigate how service network topology changes over time (for future forecasts)
Simplifying the ATS for Design/Analysis

- Aggregate ATS components into service route network topology (network of airports connected by routes provided by airline)
- Each ATS component influences how the service route network topology is structured, and how it evolves