Traffic Engineering for ISP Networks
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Internet Service Provider (ISP) backbones
- Wide-area network with multiple Points of Presence
- Shortest-path link-state routing between edge routers
- Optimizing routing given a topology and traffic matrix
  - Local search to select the integer link weights

Tomography: Inferring the traffic matrix
- Estimating traffic matrix from routing and link loads

Conclusion and ongoing work
Example Backbone: Abilene Internet2 Network
Points-of-Presence (PoPs)

- **Inter-PoP links**
  - Long distances
  - High bandwidth
  - Short cables between racks or floors
  - Aggregated bandwidth

- **Links to other networks**
  - Wide range of media and bandwidth
Routing Inside an Internet Service Provider

- Routers flood information to learn the topology
  - Routers determine “next hop” to reach other routers…
  - By computing shortest paths based on the link weights

Diagram:

[Diagram showing a network topology with routers and links, illustrating the routing process.]
Optimization: Tuning Routing to the Traffic
Link Weights Control the Flow of Traffic

- **Routers compute paths**
  - Shortest paths as sum of link weights

- **Operators set the link weights**
  - To control where the traffic goes
Heuristics for Setting the Link Weights

- Proportional to physical distance
  - Cross-country links have higher weights than local ones
  - Minimizes end-to-end propagation delay

- Inversely proportional to link capacity
  - Smaller weights for higher-bandwidth links
  - Attracts more traffic to links with more capacity

- Tuned based on the offered traffic
  - Network-wide optimization of weights based on traffic
  - Directly minimizes key metrics like max link utilization
Why Are the Link Weights Static?

◆ Strawman alternative: load-sensitive routing
  – Link metrics based on traffic load
  – Flood dynamic metrics as they change
  – Adapt automatically to changes in traffic load

◆ Reasons why this is typically not done
  – Delay-based routing unsuccessful in the early days
  – Oscillation as routers adapt to out-of-date information
  – Most Internet transfers are very short-lived

◆ Research and standards work continues…
  – … but operators have to do what they can today
Big Picture: Measure, Model, and Control

- Network-wide "what if" model
- Topology/Configuration
- Offered traffic
- Changes to the network

Operational network

Measure

Control