Sequoia: Virtual-Tree Models for Internet Path Metrics

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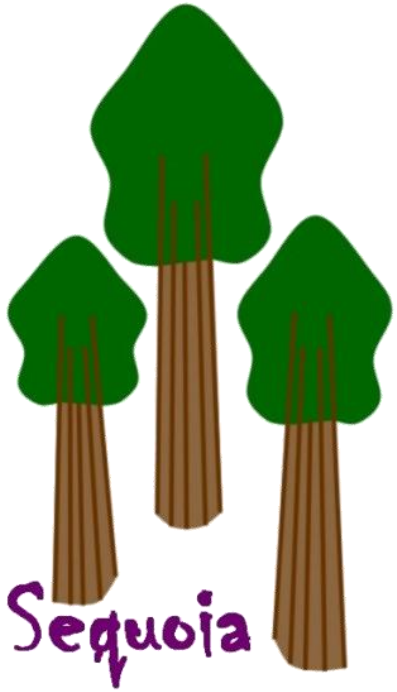
Goals

- Study "treeness" of Internet path metrics such as bandwidth and latency
- Construct tree models that represent network metrics
- Provide network-aware functionalities:
  - bandwidth and latency estimation
  - selection of "best" servers
  - topological clustering of peers

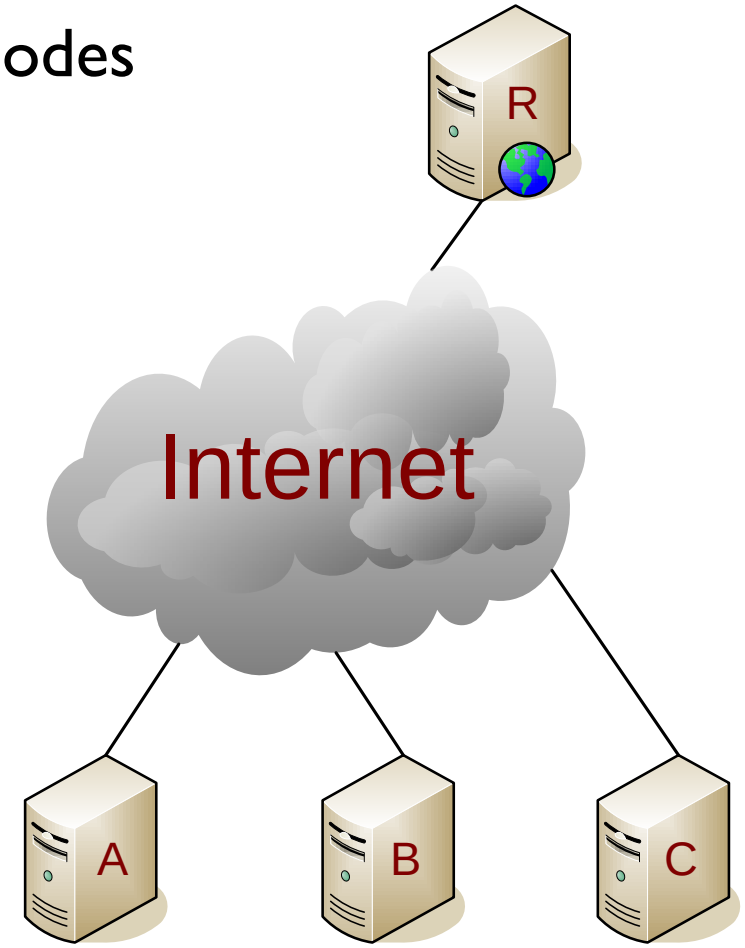


Applications

- *"what's the server with the largest bandwidth that a client can download content from?"*
  - *Content distribution*
- *"what's the closest peer that a host in a P2P network can connect to?"*
  - *P2P Neworking*
- *"what's the best game server to coordinate the online game between a set of players?"*
  - *Online gaming*

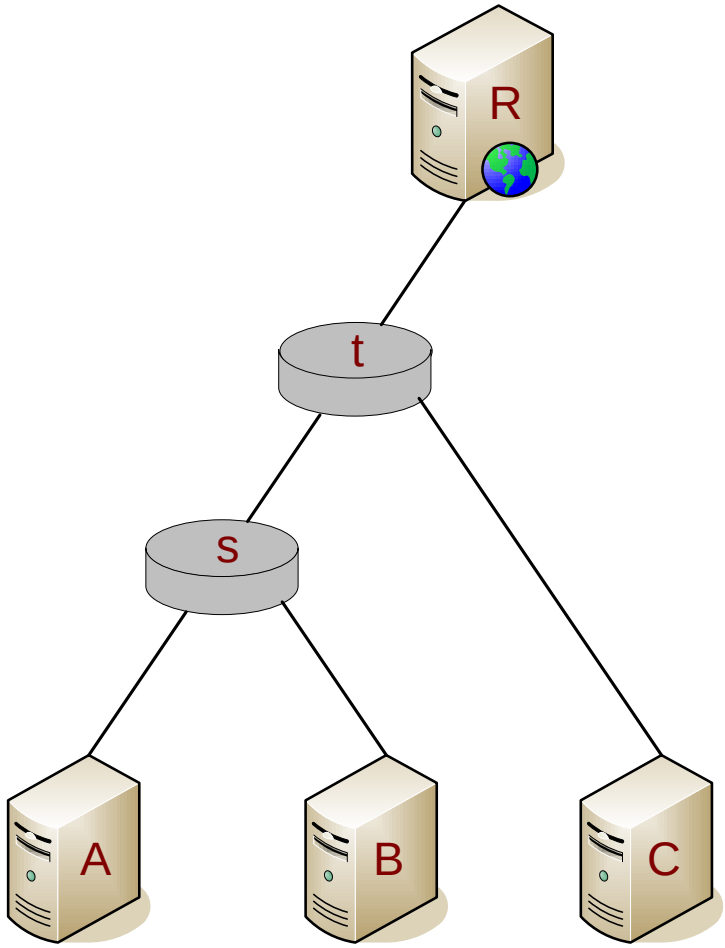
Approach: Metric Embedding into Trees

- End hosts (A, B, C, R) are leaf nodes



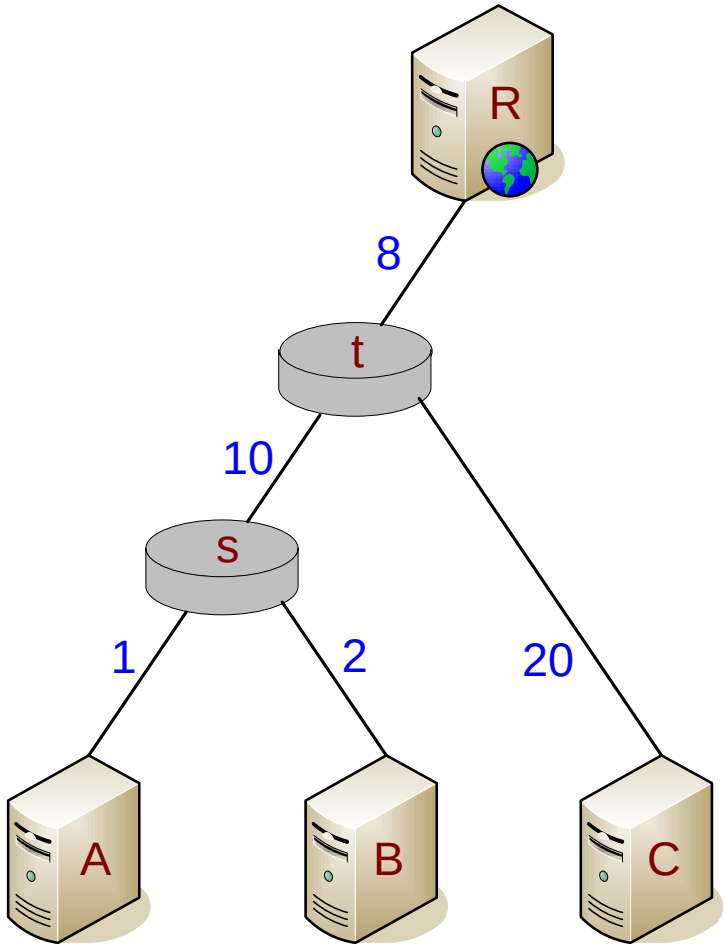
Approach: Metric Embedding into Trees

- Leaf nodes (A, B, C, R) are end hosts
- Inner nodes (s, t) are "virtual"



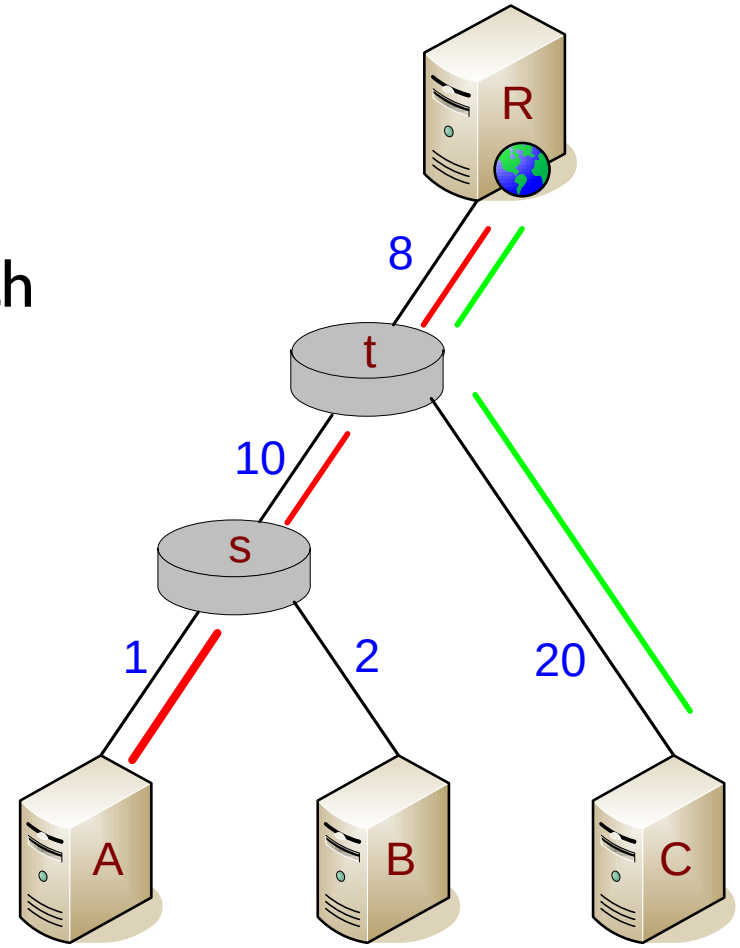
Approach: Metric Embedding into Trees

- Leaf nodes (A, B, C, R) are end hosts
- Inner nodes (s, t) are "virtual"
- Edge weights model network measure



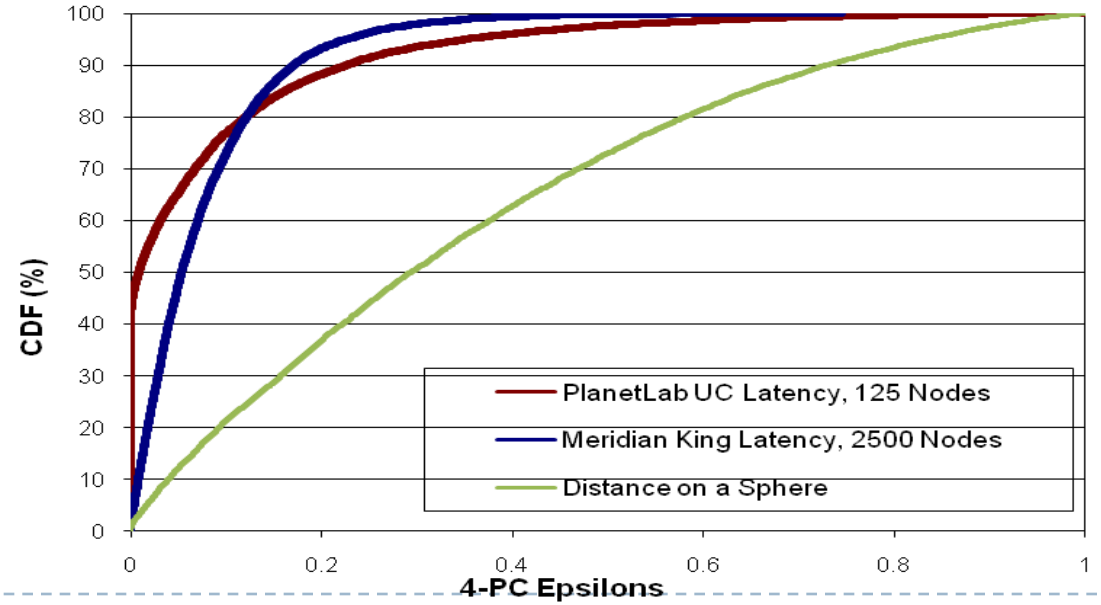
Approach: Sequoia and "Coordinates"

- Distance Label = path to the root
  - Example: A: (s,t,R) and C: (t,R)
- Estimated Metric = distance on path
  - Latency: d(A,C) = d(A,s) + d(s,t) + d(t,C)
- Same convenience as network coordinates

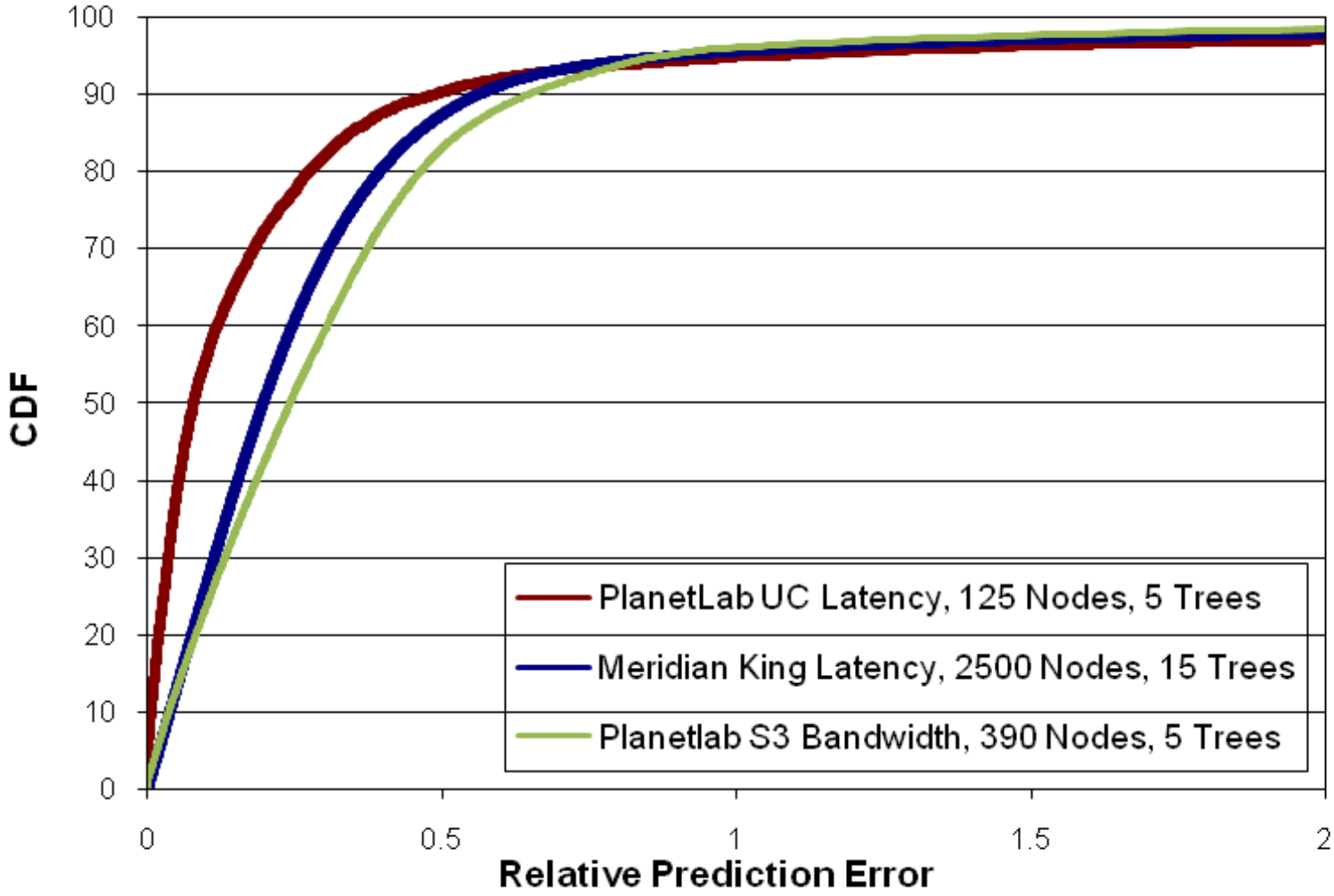


Intuition

- Internet is inherently hierarchical
  - ⇨end-to-end network measures are approximate tree metrics
- bottleneck-link bandwidth along the highest bandwidth path is a tree metric
  - ⇨bandwidth in a network bottlenecked at the edges is a tree metric

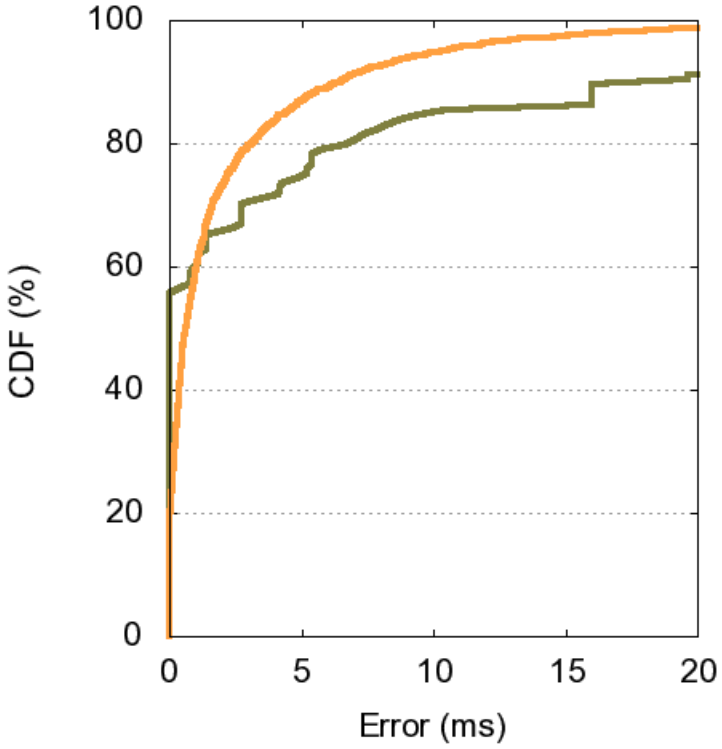


Results: Bandwidth/Latency Estimation

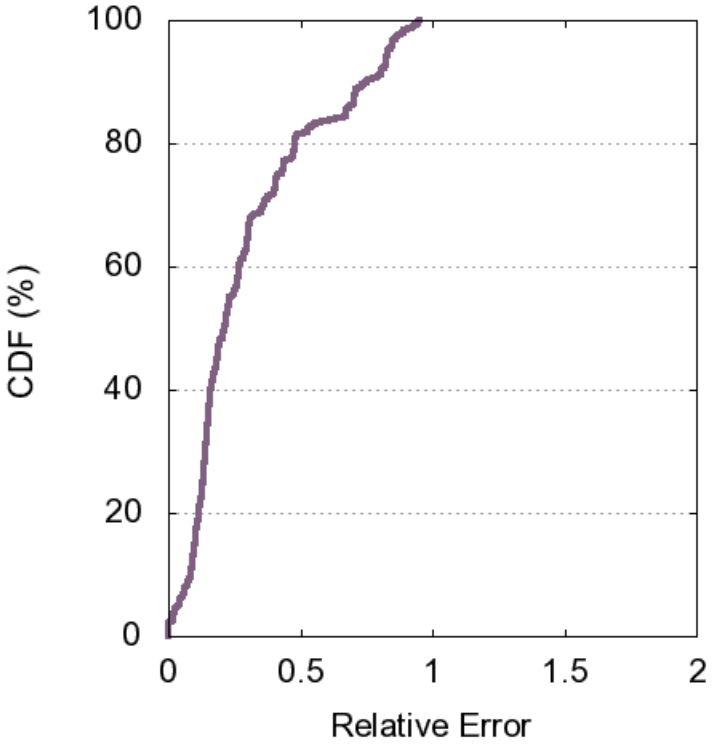


Results: Server Selection

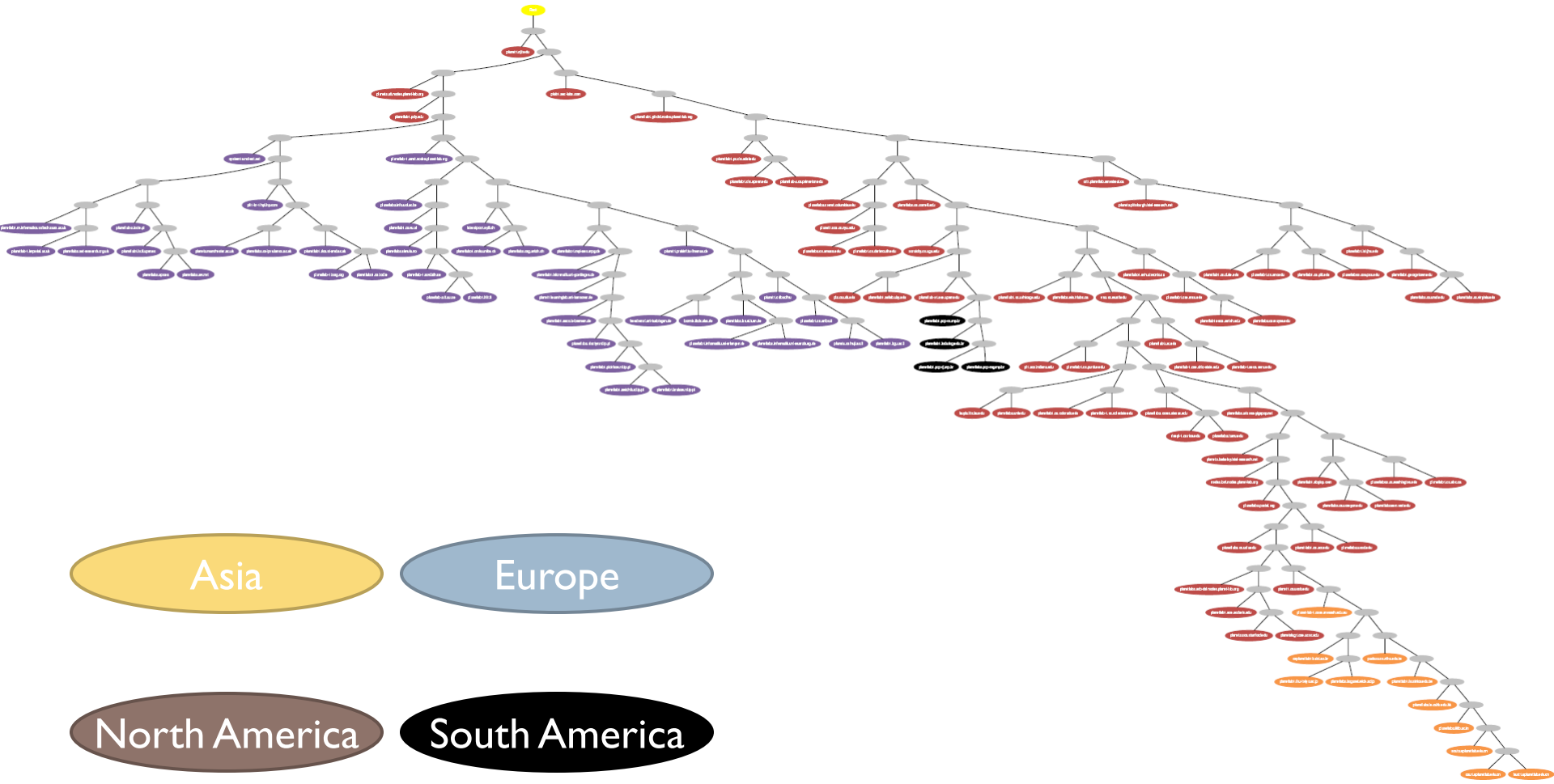
Closest Node



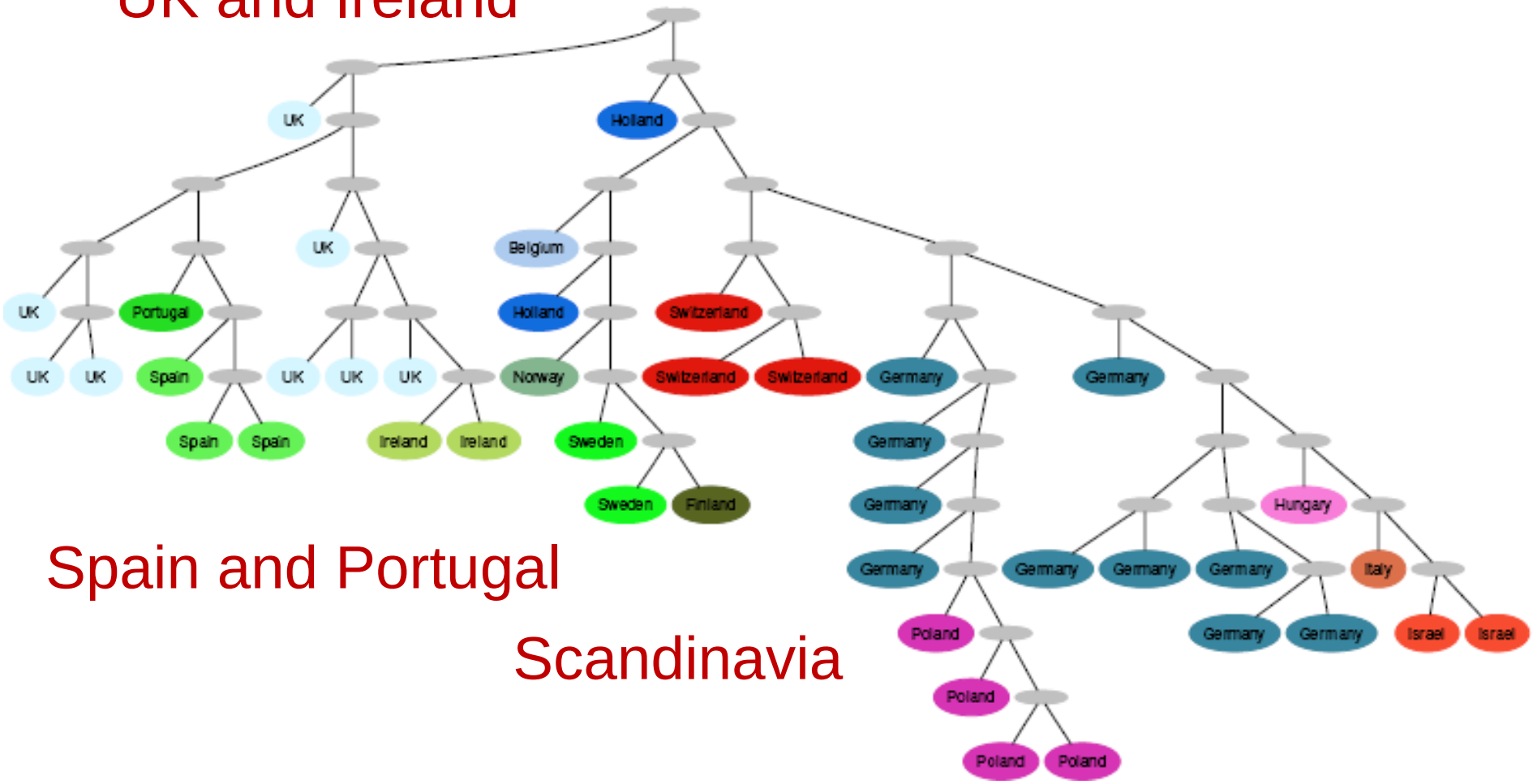
Best-Provisioned Node



Results:
Sequoia Tree for PlanetLab

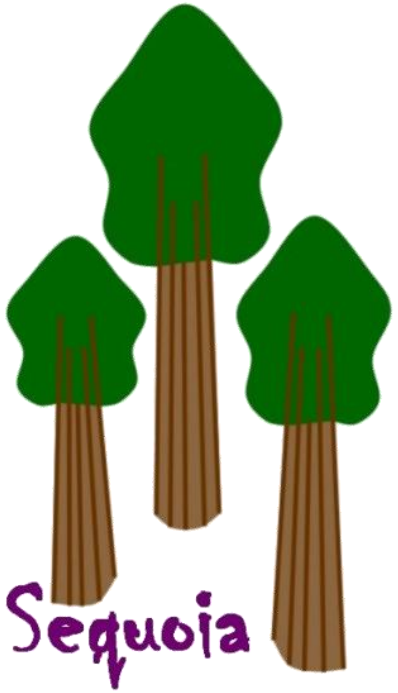


Results: Clustering of European Nodes



Summary: Virtual-Tree Internet Models

- Contributions
  - Represents both Bandwidth and Latency
  - Provides Convenient "Coordinates"
  - Shows Topological Correlations
- Properties
  - Light-weight end-to-end measurements
  - Tolerates triangle inequality violations
  - Adapts to changes in network measures



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