Capturing Internet traffic dynamics with graph distances

Towards a space-time model of Internet traffic

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COMPLEX'09, Shanghai, China, February 24, 2009

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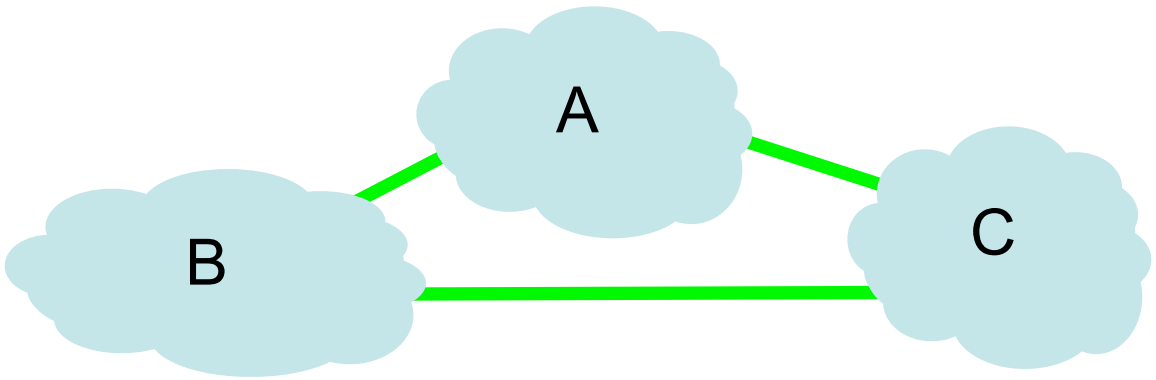
Background
Internet structure

- Internet topology
  - Network of 30,000 networks
- Implicit hierarchical structure
  - transit core: tier-1 providers
  - outer core: national and regional providers
  - edge: stubs
- Considered topology
  - A node is a network
  - A link represents connectivity between 2 networks



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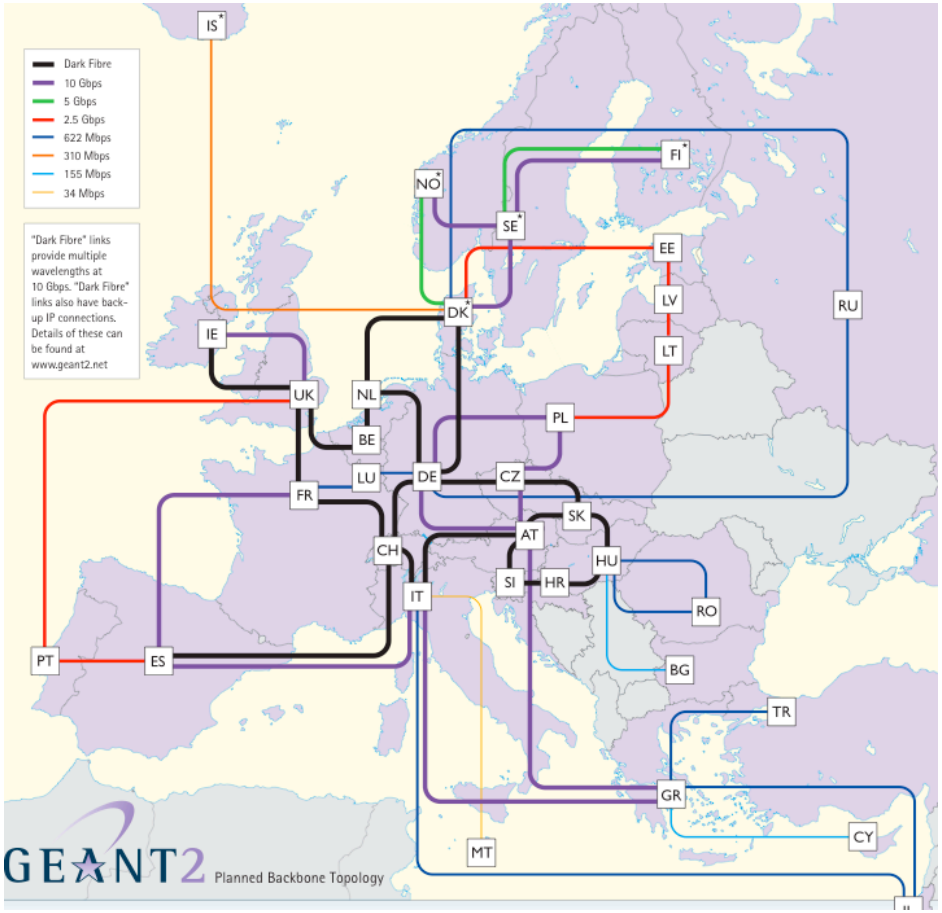
Data & methodology

- GEANT
  - European academic backbone: all EU academic institutions, CERN, several research centers
- Data
  - All traffic captured on ingress interfaces
  - Internet and external routing information
  - 26 days
- Methodology
  - Replay routing paths in CBGP simulator
  - Attribute traffic on routing paths



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Graph distances
Definitions

- Distance between two graphs:
  - $D(G_i, G_j) = 1 - \frac{I(G_i,G_j)}{U(G_i,G_j)}$

    where $I(G_i,G_j)$ denotes the intersection between graphs G_i and G_j and $U(G_i,G_j)$ its union.

- Distance between two "traffic-ed" graphs:
  - $D^{traf}(G_i, G_j) = 1 - \frac{I^{traf}(G_i,G_j)}{U^{traf}(G_i,G_j)}$

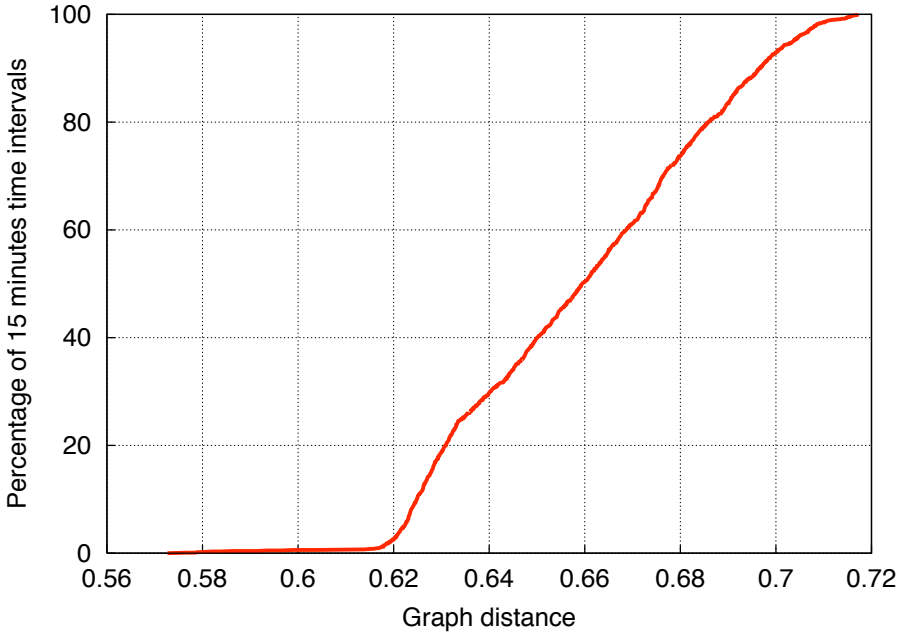
    where $I^{traf}(G_i, G_j) = \sum_{e \in I(G_i,G_j)} \min(traffic_e(G_i), traffic_e(G_j))$

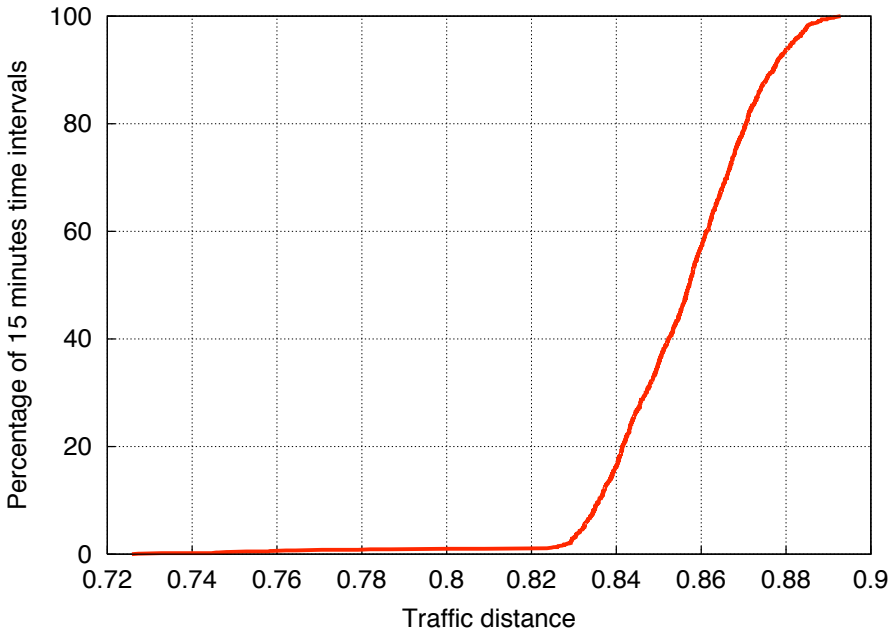
    and $U^{traf}(G_i, G_j) = \sum_{e \in U(G_i,G_j)} \max(traffic_e(G_i), traffic_e(G_j))$

Graph distances

Distances between local and global graph

- G_{global} : topology over the 26 days (G^{traf}_{global}: global averaged traffic)
- G_i, i=1,...,2592. Each graph represents a time interval of 15 minutes.

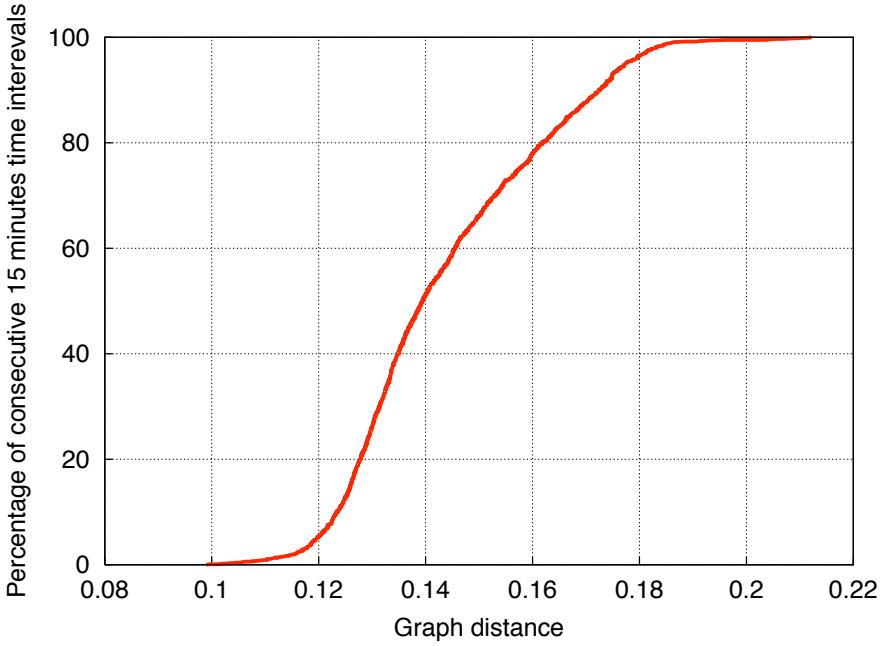


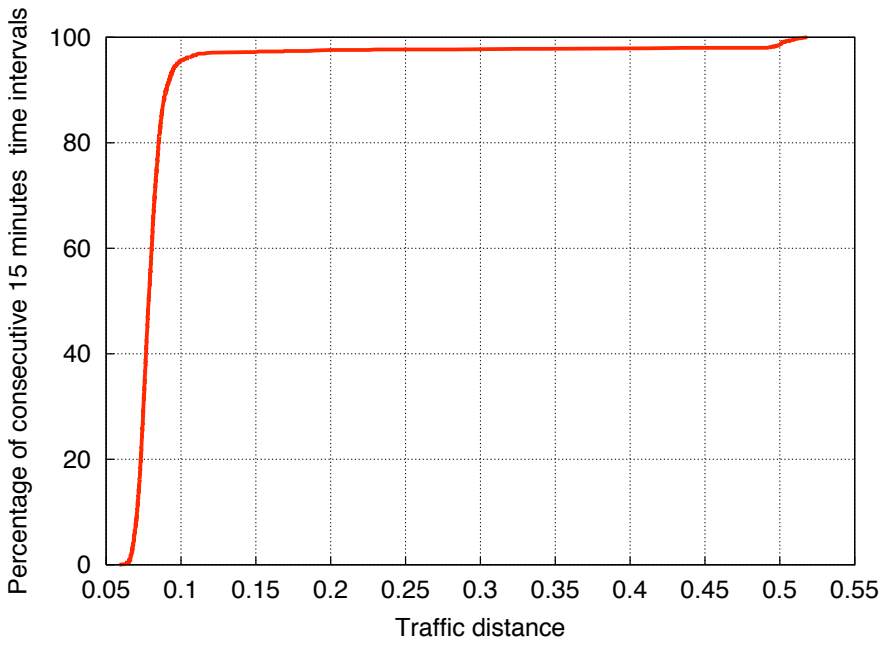


Graph distances

Distances between local graphs

- ΔG_i and ΔG_i^{traf} i=1,...,2591.





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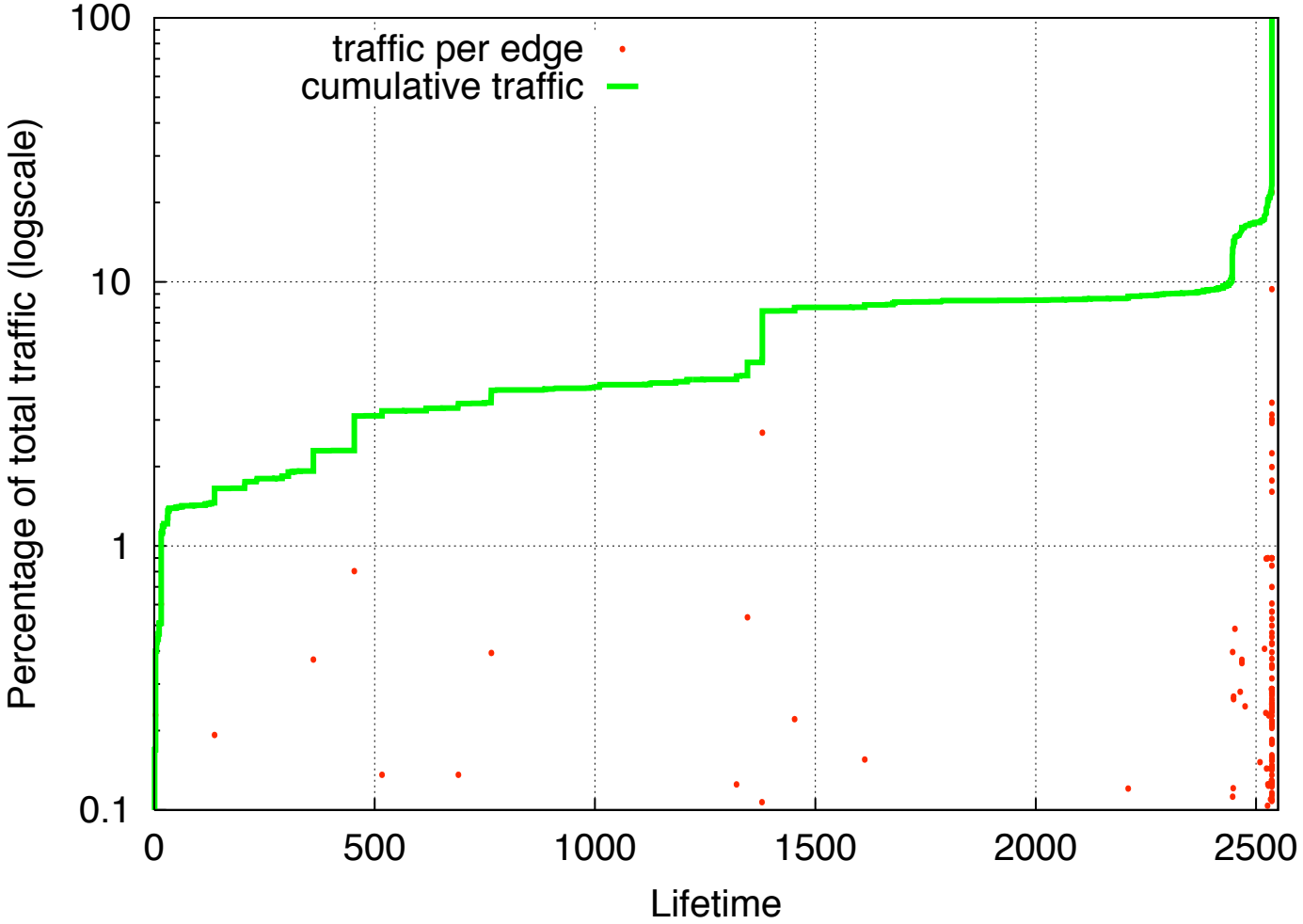
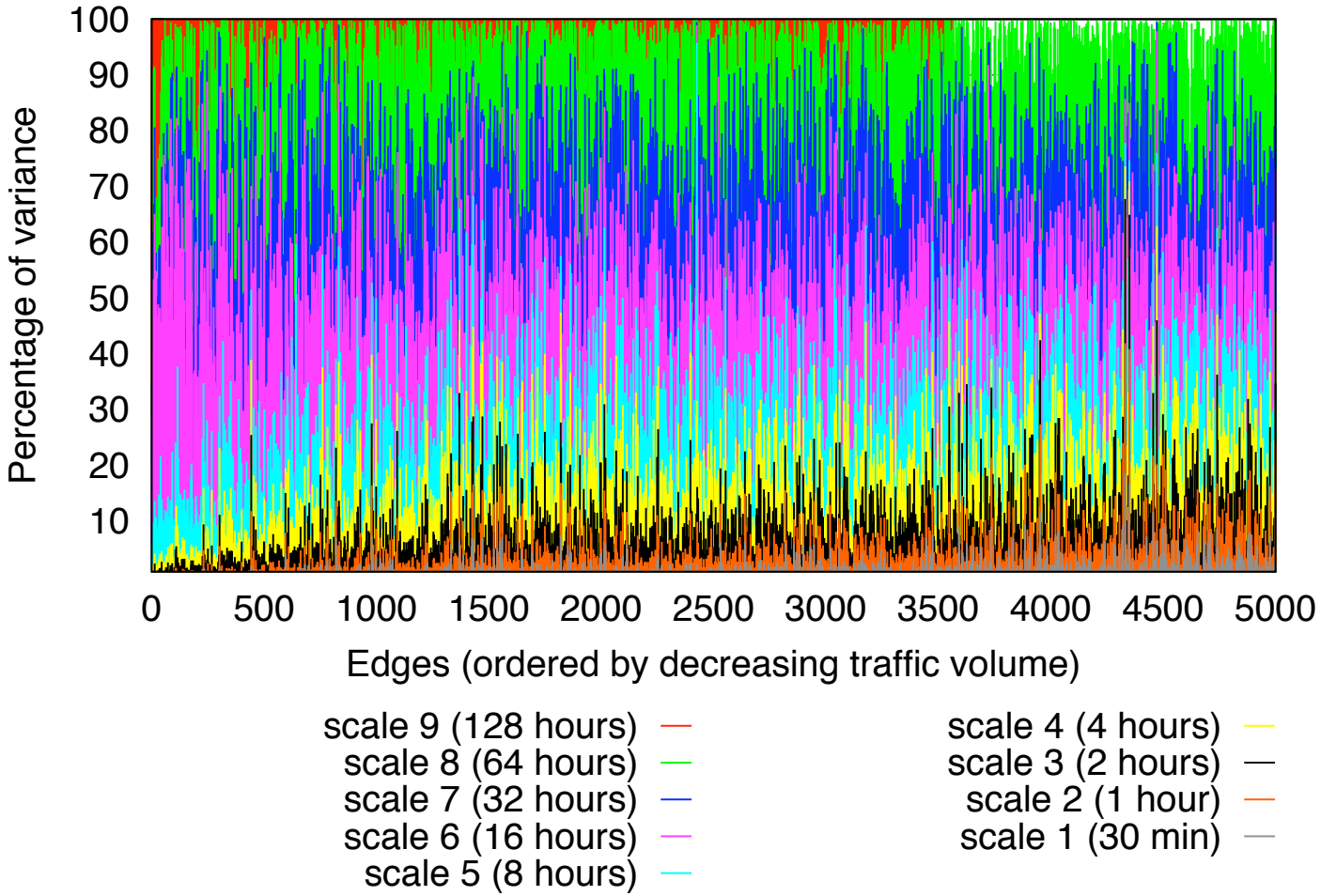
Traffic dynamics
Edge lifetime



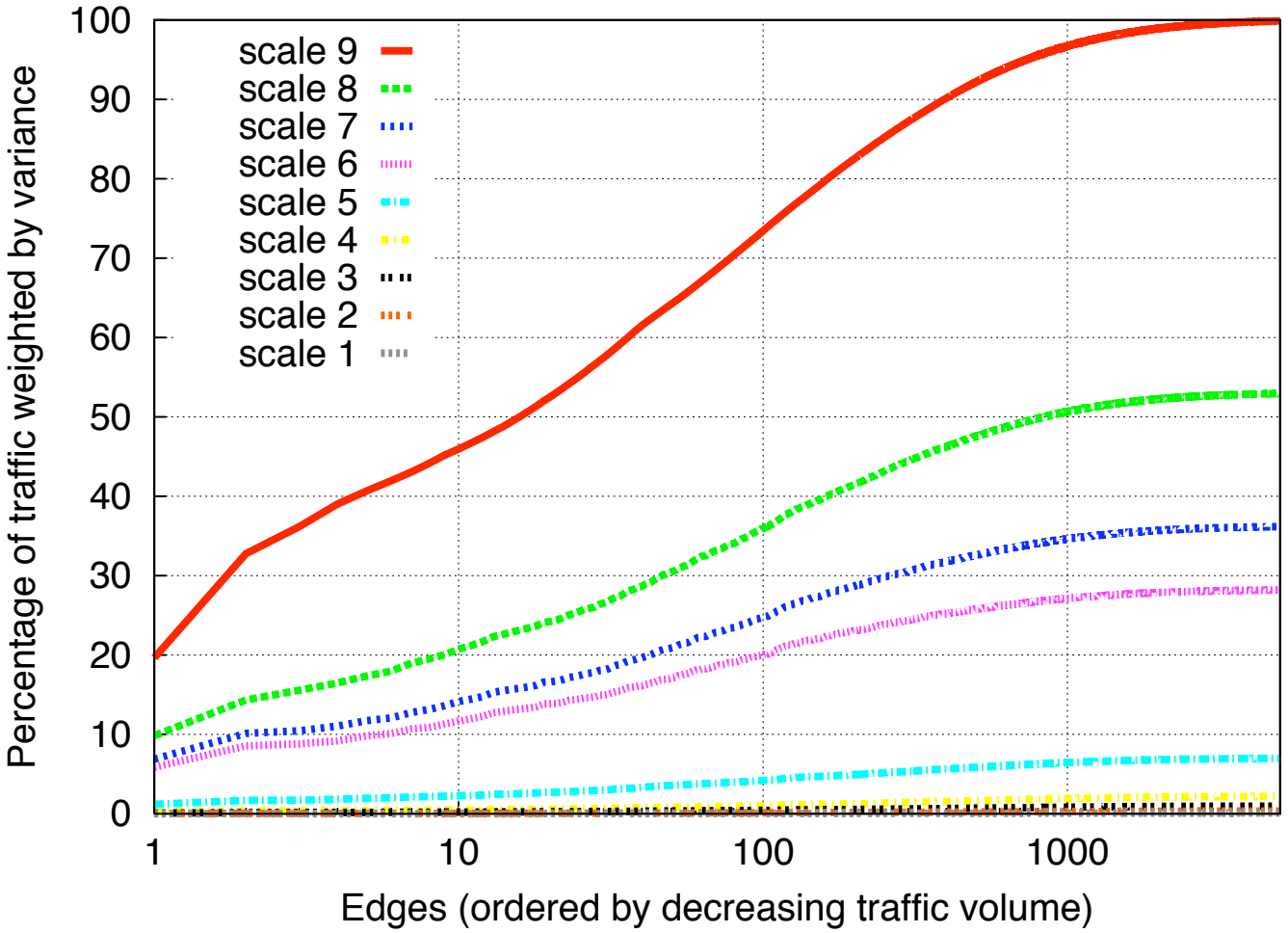
Traffic dynamics

Edge multi-scale dynamics



Traffic dynamics

Multi-scale cumulative variance



Contents

- Background
- Data and methodology
- Graph distances in Internet traffic
- Internet traffic dynamics
- Conclusions

Conclusions

- Learned initial constraints for a space time model of Internet traffic:
  - Traffic on small time-scales ≠ large time-scales
  - Possible simplifications: concentrate on large time-scales and largest edges in traffic
  - Still large weighted evolving topology to be considered
- I need your help to build a realistic space-time model of Internet traffic