Revisiting Internet AS-level Topology Discovery

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Outline

- Motivation and background.
- New topology discovery method.
- Experimental results.

Why we want to know the Internet topology?

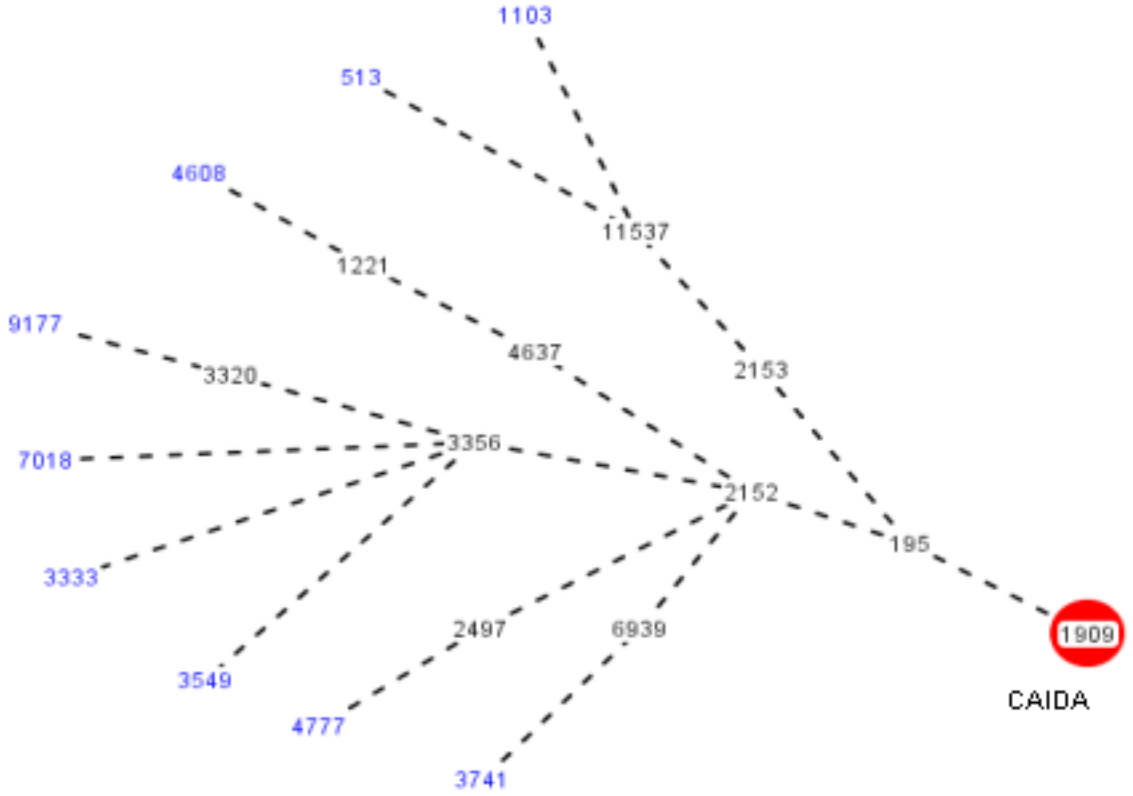
- Run realistic simulations.
- Fine-tune protocols' performance.
- Evaluate susceptibility to attacks.
- Model Internet topology.
- Predict Internet topology.

AS-level Topology Discovery from BGP table dumps (BTD)

Network	Next hop	AS path
192.172.226.0/24	134.12.127.3	1103 11537 2153 195 1909 i
	194.68.130.254	513 11537 2153 195 1909 i
	144.21.14.2	3741 6939 2152 195 1909 i
	194.63.247.208	4777 2497 2152 1909 i
	64.233.161.147	9177 3320 3356 2152 195 1909 i
	208.185.54.46	7018 3356 2152 195 1909 i
	193.92.28.32	3333 3356 2152 195 1909 i
	221.23.12.4	3549 3356 2152 195 1909 i
	83.138.128.168	4608 1221 4637 2152 195 1909 i

BGP tables dumps (BTD):

- are used widely by researchers to study the Internet topology.
- are available in RouteViews, RIPE, Route Servers (www.traceroute.org), CERNET, etc.
- lead to incomplete AS-level maps.



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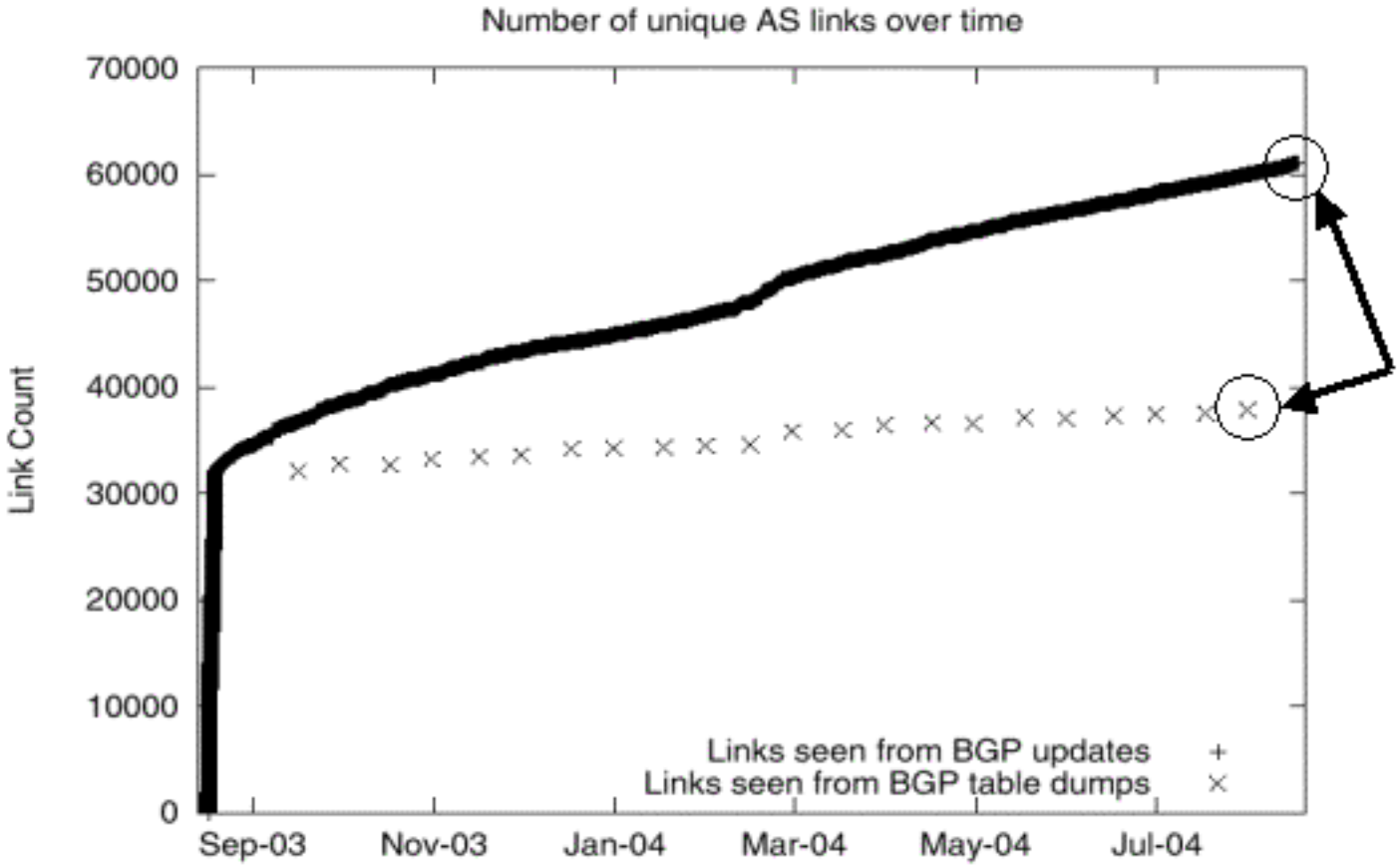
A new source of Internet AS level topological data.

- AS-paths change over time, but BTDs only reveal one AS-path per prefix/peer pair.
- During BGP "*path exploration*" numerous short-lived AS-paths appear for the same prefix/peer pair.
- Does "*path exploration*" reveal new topological data?

Experiment Methodology

- Collect BGP updates from RouteViews (route-views2.oregon-ix.net) over the period of a year (Sep. 2003 to Aug. 2004).
- Collect BTDs from RouteViews (route-views2.oregon-ix.net) over the same period in 15-day intervals.
- Count the unique AS-links we find from updates and BTDs.

AS links from BGP updates versus BTDs

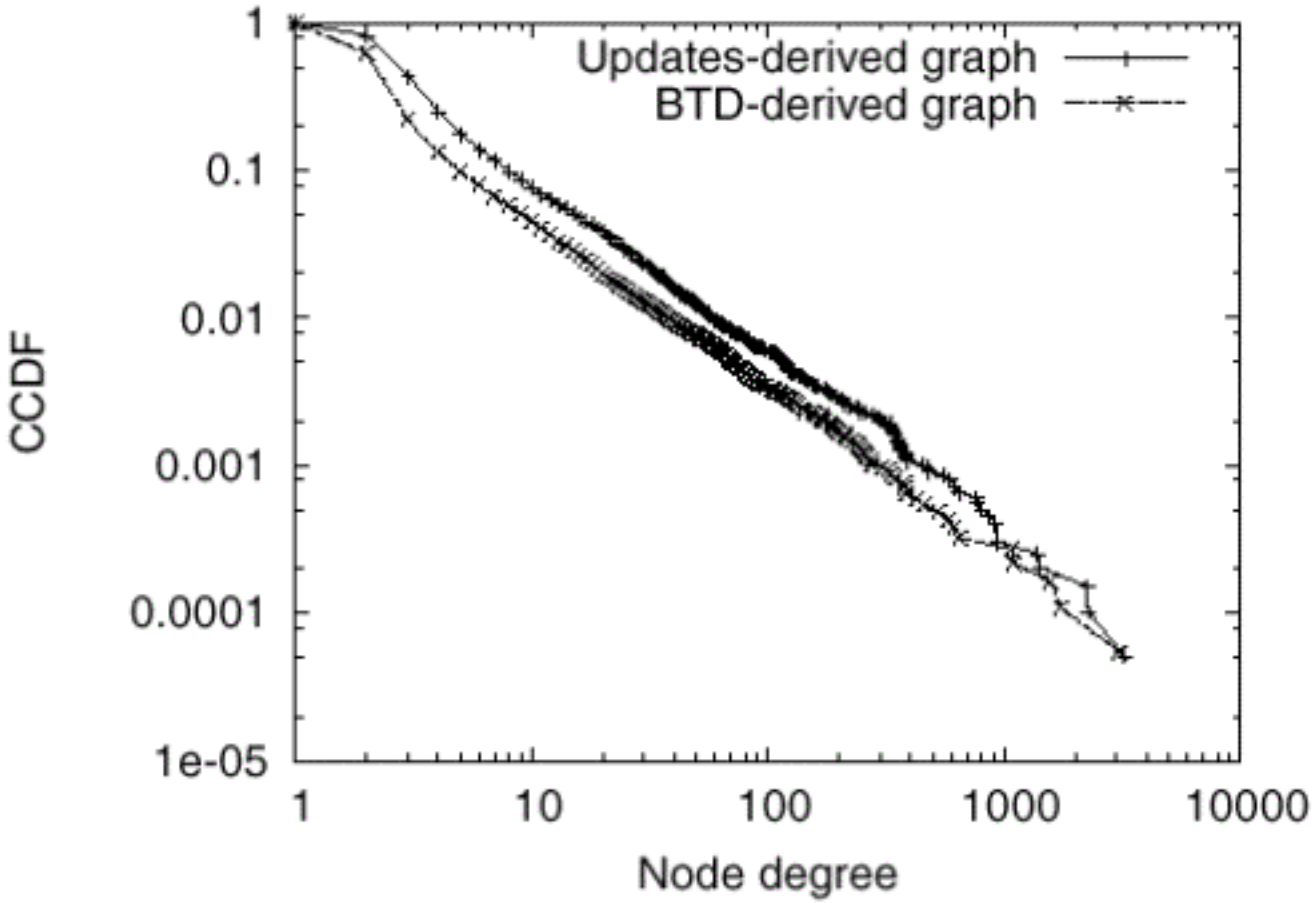


61.5% more AS links than the largest BTD-derived graph

Analysis of data

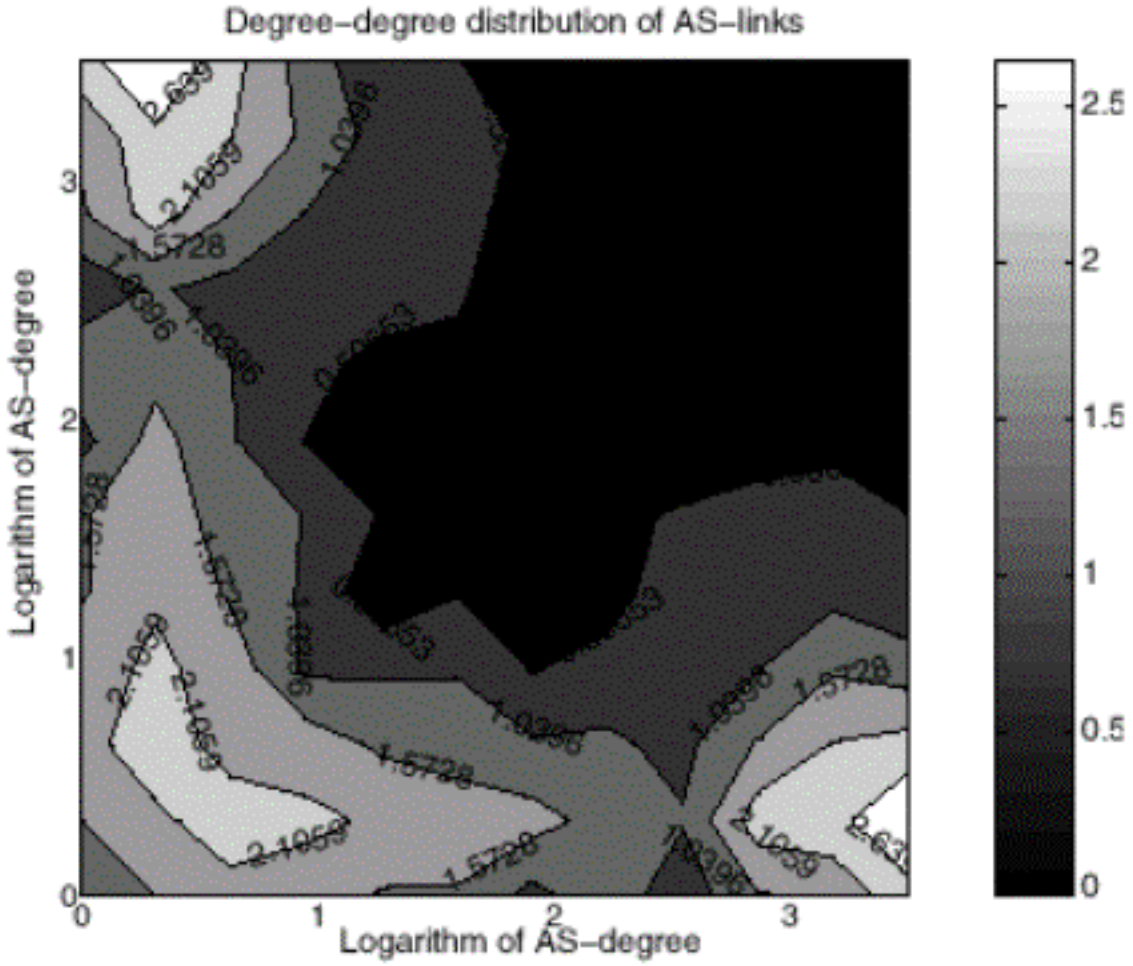
- Temporal properties.
  - A lot of AS links appear only during BGP turbulence and these links are not captured by BTDs.
- Topological properties.
  - Degree distribution of ASs.
  - Degree-degree distribution of AS links.
  - Betweenness distribution of AS links.

AS degree distribution



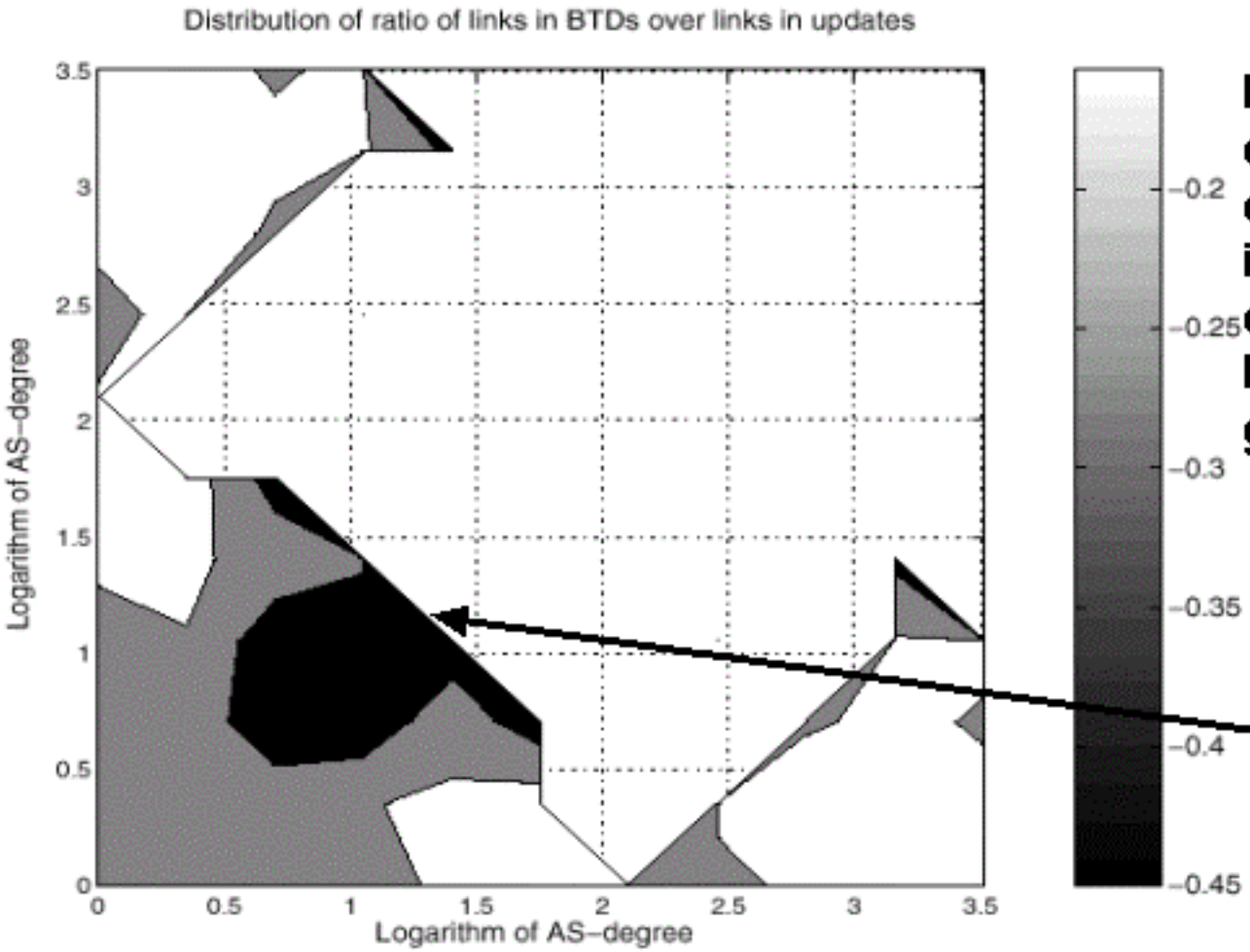
The correlation coefficient of the linear fit for the updates-derived slightly drops to 0.972 from 0.984 for the BTD-derived graph.

Degree-degree distribution of BTD-derived graph



The degree–degree distribution M(k1,k2) is the number of links connecting ASs of degrees k1 and k2.

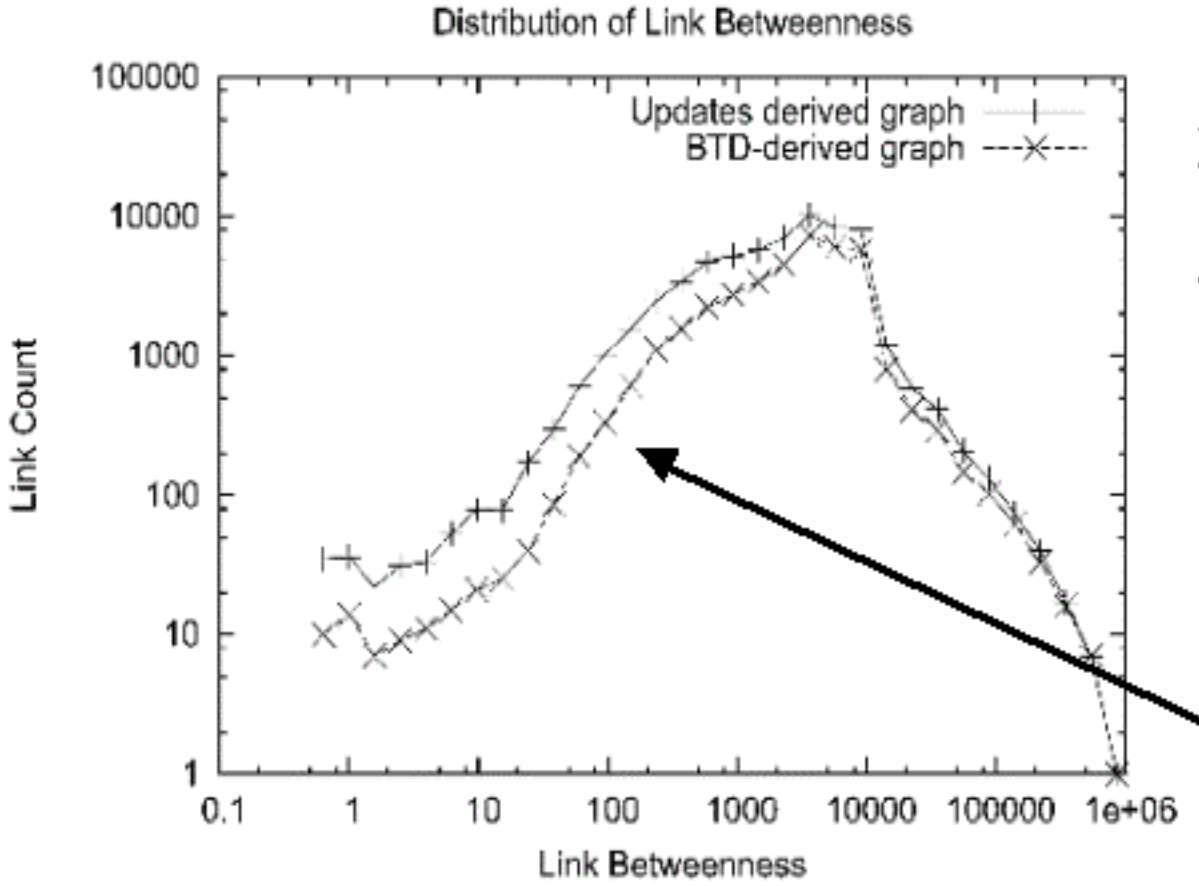
Degree-degree distribution of BTD-versus updates-derived graph



Ratio of links connecting ASs of degrees k1 and k2 in BTD-derived graph over corresponding links in updates-derived graph.

Most of the discovered links are between small and medium size ASs.

Betweenness distribution



Betweenness of an AS-link is a graph theoretic metric that expresses how many times a link appears in shortest paths.

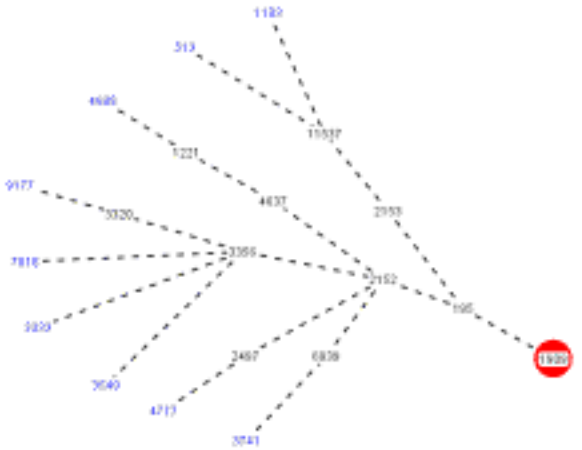
Most of the discovered links have small betweenness.

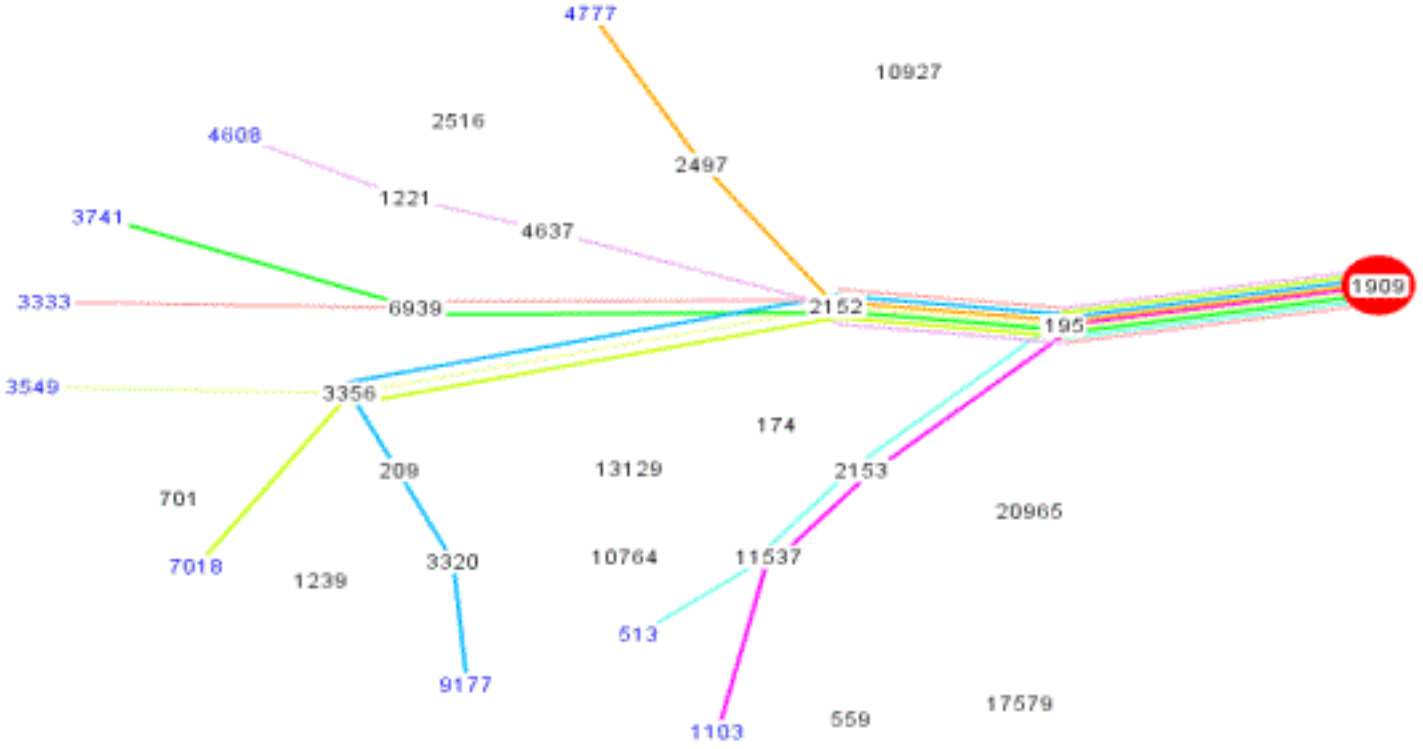
Summary

- BGP updates reveal substantial AS-level topological information that are not seen from BTDs.
- New links lie between small and medium size ASs and have small communication importance (betweenness) pointing to backup AS links.
- Degree distribution remains a power-law function of degree.

Demo (BGPlay)

	Links	Nodes
BTD	19	19
Updates	56	30





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