

Impact of Policy on Internet Paths

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Does Policy Skew Paths?

- Observation
 - Can **approximately** overlay AS structure on router-level map
 - With a simplified policy model, can compare shortest router-level path with policy path
- Approximate because
 - ... we don't have all interfaces of router
 - ... of inconsistent interface labeling
 - ... of incompletely populated DNS
 - ... simplistic policy assumptions

AS Overlay Methodology

- Internet map
 - Collected between March 26 – April 10
 - 102,639 nodes, 142,303 links
 - 61,485 traceroute paths
- AS overlay
 - Use BGP routing table and RADB data to determine domain/AS# for each node
 - 3210 private addresses → assigned unused AS#
 - 497 unresolved addresses → assigned unused AS#

AS Overlay Methodology

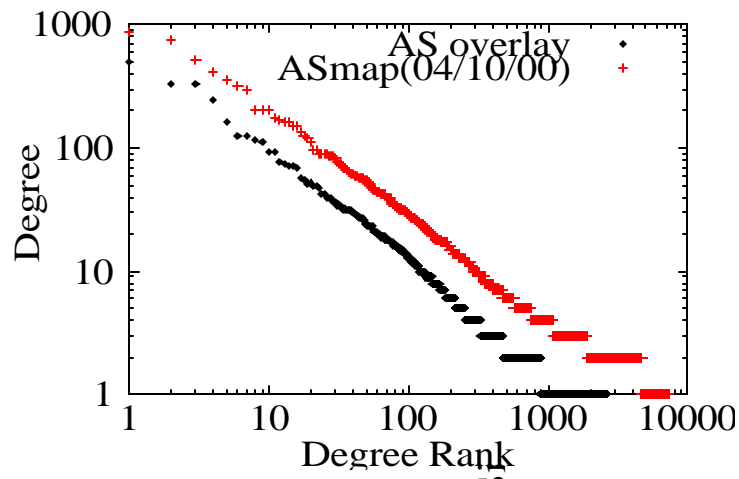
- Collapse nodes into domains
 - Recursively marks neighbors with the same AS# to the same AS domain
 - Due to incomplete Internet map and AS# assignment, there are many disjoint clusters of nodes belonging to the same AS domain
 - Most AS's have one big component and many small clusters
 - Identify the biggest component for each domain
 - Reassign the rest (20,000 nodes) to the nearest AS

AS Overlay Validation

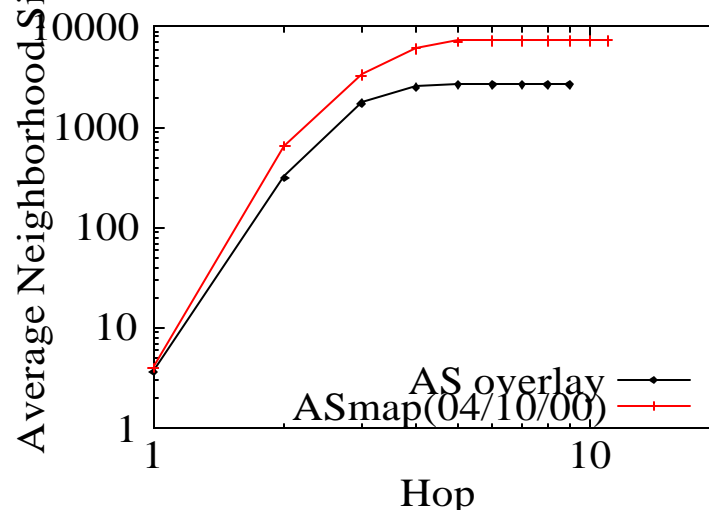
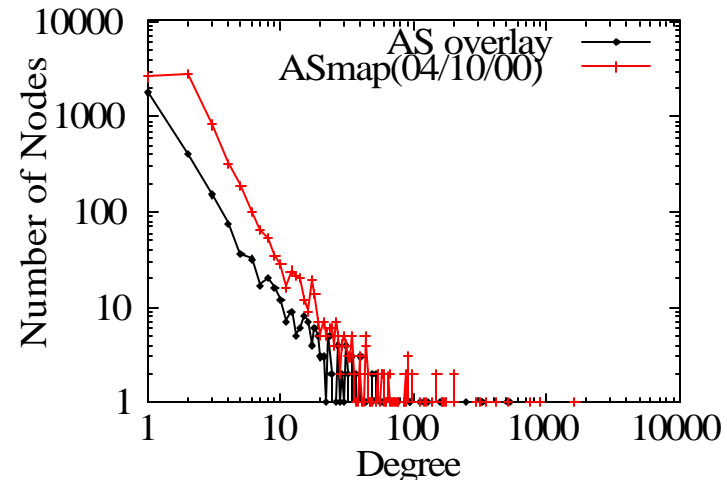
- Comparison of macroscopic properties
 - Degree Rank Distribution
 - Degree Distribution
 - Average Hop-pair Distribution
- ... between AS overlay and actual AS map

Qualitatively Similar Properties

Degree Rank Distribution

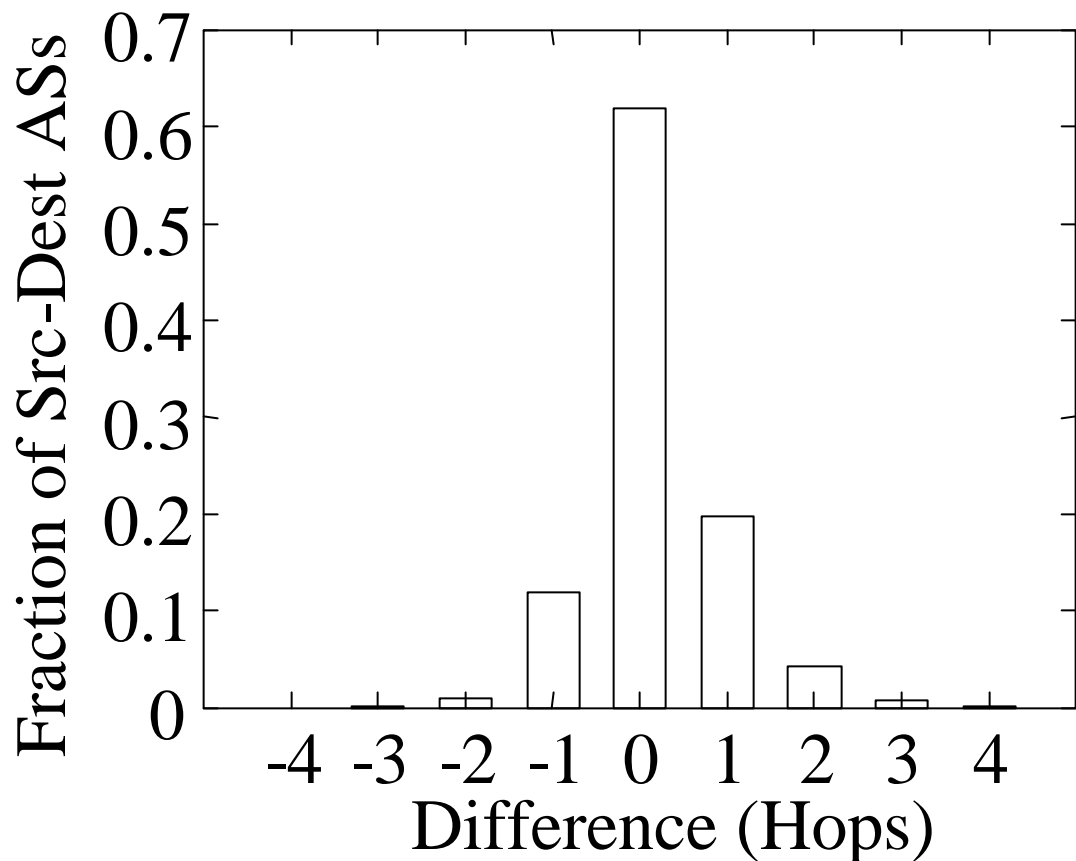


Degree Distribution



Avg Hop-pair Distribution

Validation: Comparing AS Path Lengths



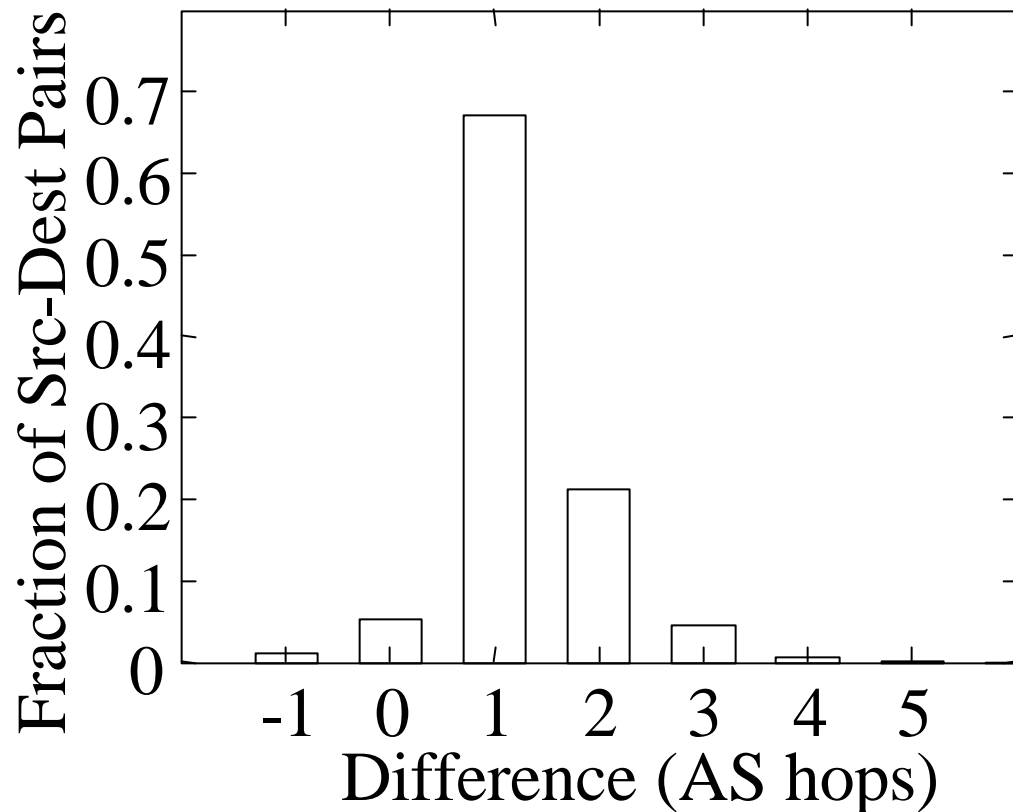
Distribution of path length difference

- Compare AS path length in table with path length in AS overlay
- 60% of node pairs have the same length
- 93% of node pairs are within one AS hop of the corresponding path in the BGP table

Simple Policy Model

- Routing policy model: **Shortest AS Path**
- Actual routing policy
 - Select customer routes only
 - Use shortest AS path otherwise
- Validating the model
 - Use our traceroutes to
 - Compare differences between AS path corresponding to traceroute, and shortest AS path on overlay

Policy Model Validation

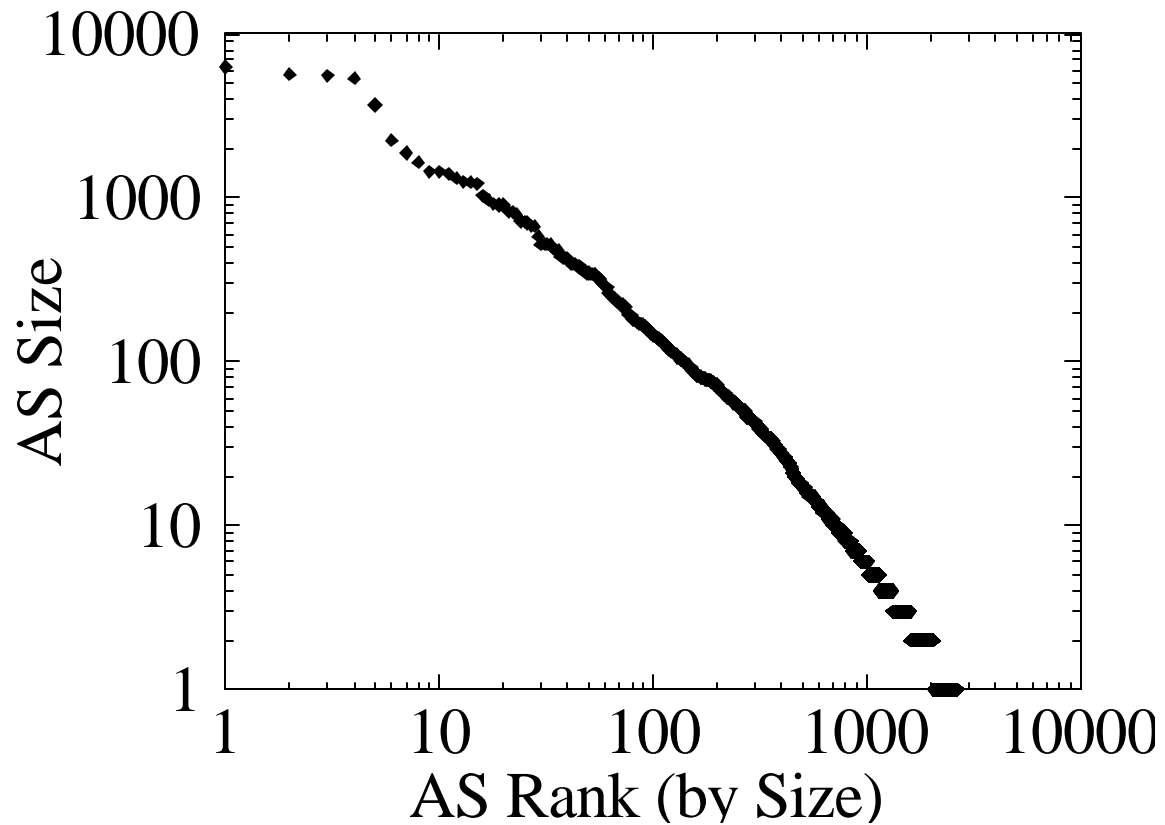


AS path length difference distribution

- Policy model underestimate traceroute AS path by
 - ≤ 1 AS hop for 70%
 - ≤ 2 AS hops for 95%
- Many traceroute AS paths are relatively small

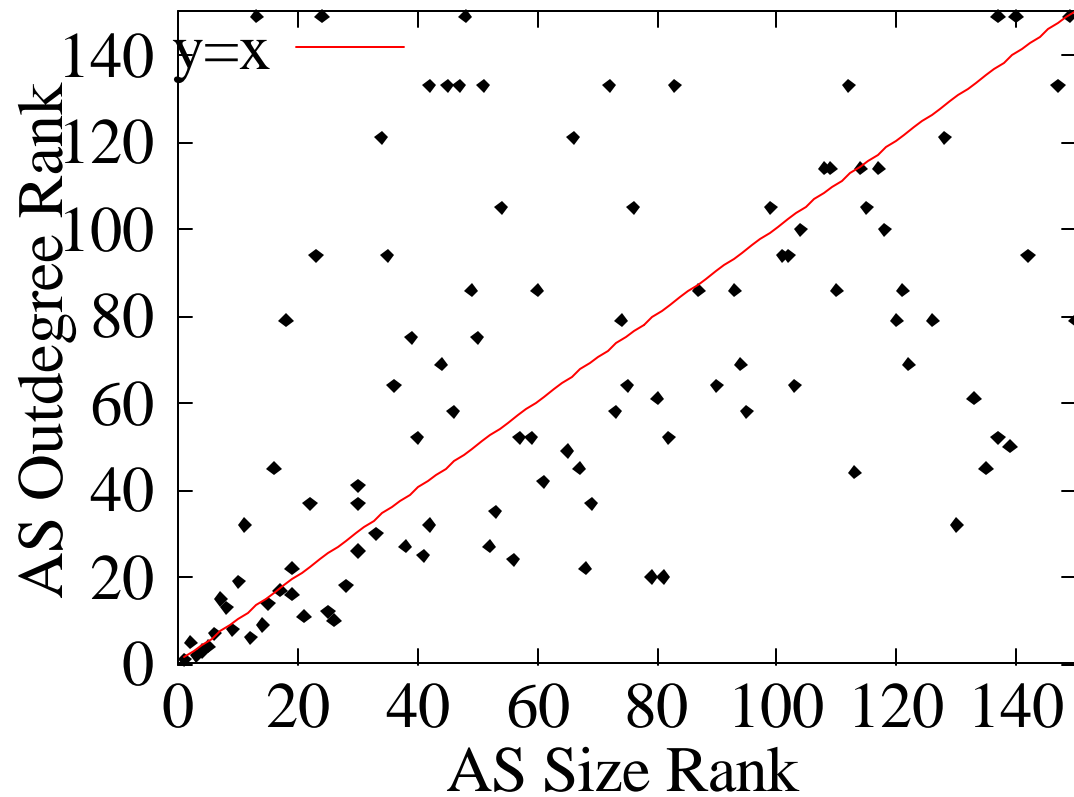
Digression

Power Laws: ISP Size Distribution



Digression

Degree-Size Correlation?



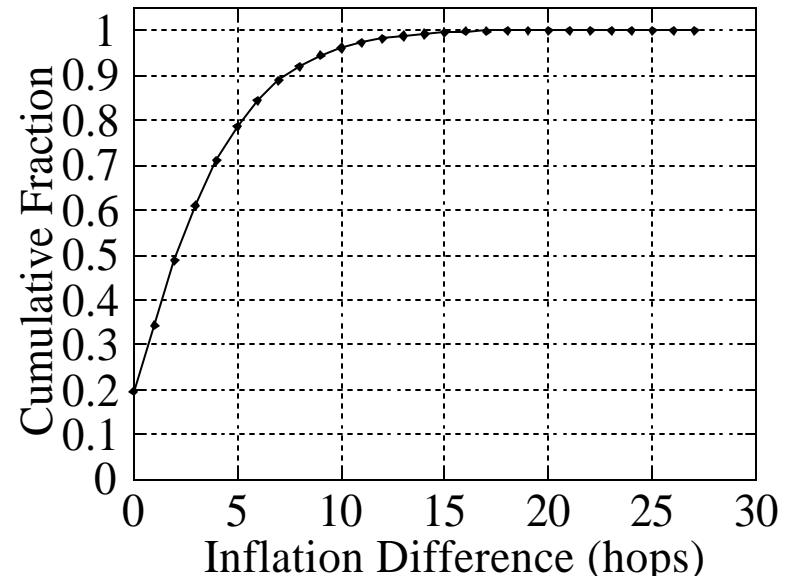
Impact of Policy

- Unicast path inflation
- Detour paths
- Path concentration

Path Length Inflation

- How different are policy paths from shortest paths on the graph?
- Metrics
 - Inflation Ratio
 - Inflation Difference

Path Inflation



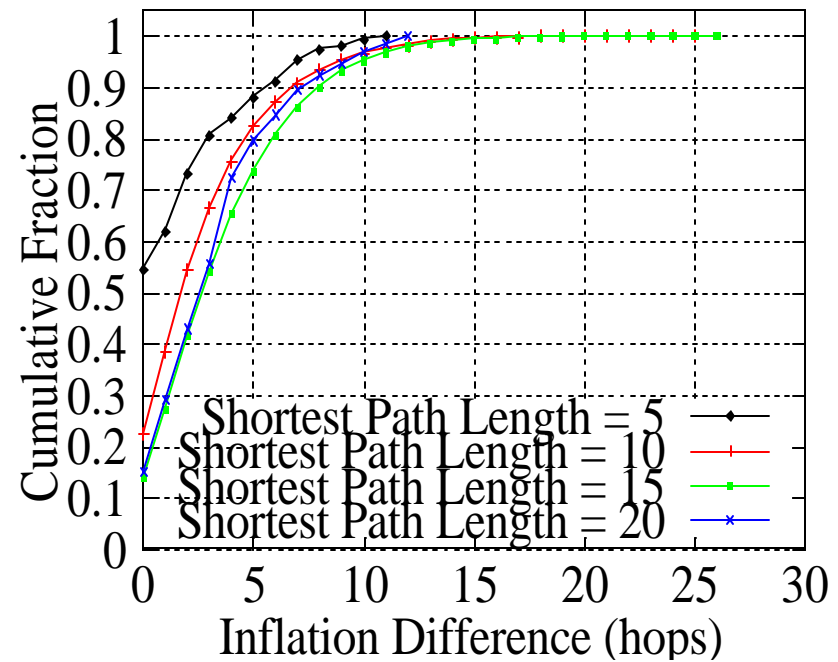
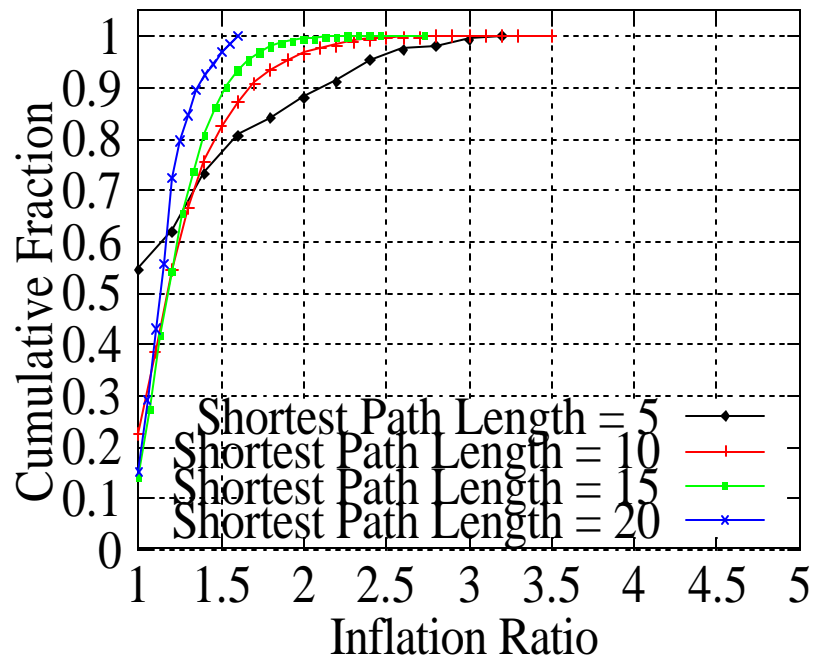
Cumulative distribution of inflation ratio and inflation difference

- 20% of policy paths are inflated by $\geq 50\%$
- 20% of policy paths are inflated by ≥ 5 hops

Inflation by Path Length

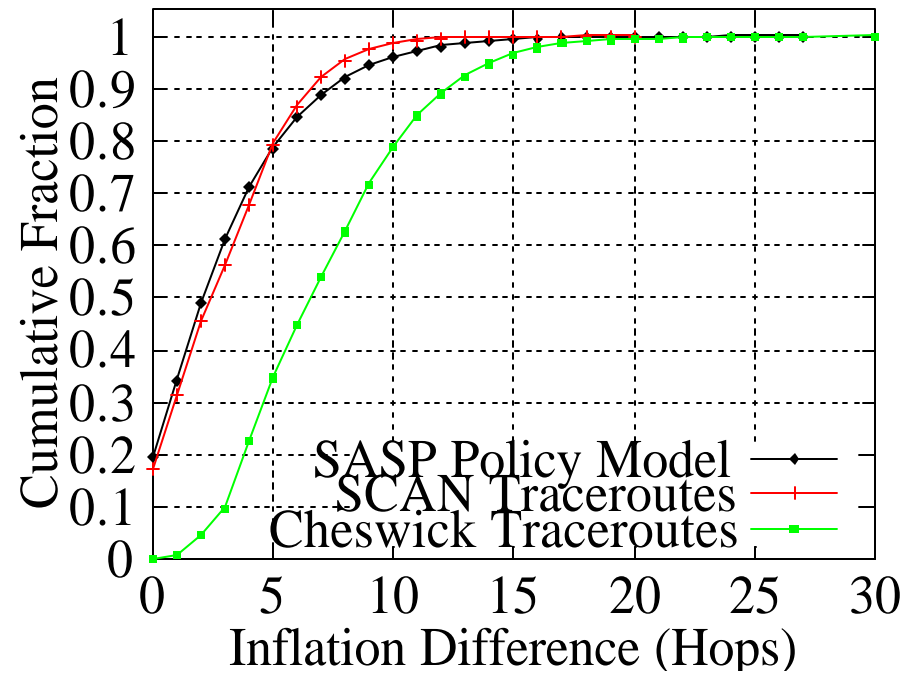
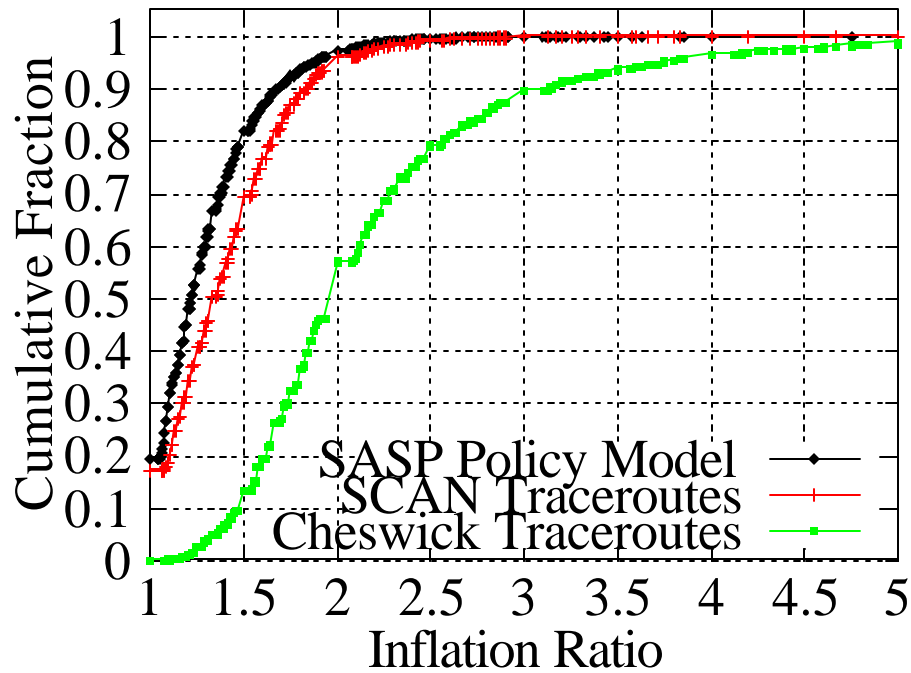
- Widely different path lengths
 - Short: 5 hops
 - Medium : 10 and 15 hops
 - Long: 20 hops
- Compared to shorter paths, longer paths are
 - Less inflated in proportion to their lengths
 - More inflated in the absolute path length

Inflation by Path Length



Cumulative distribution of inflation ratio/difference by path length

Policy Model v.s. Actual Paths

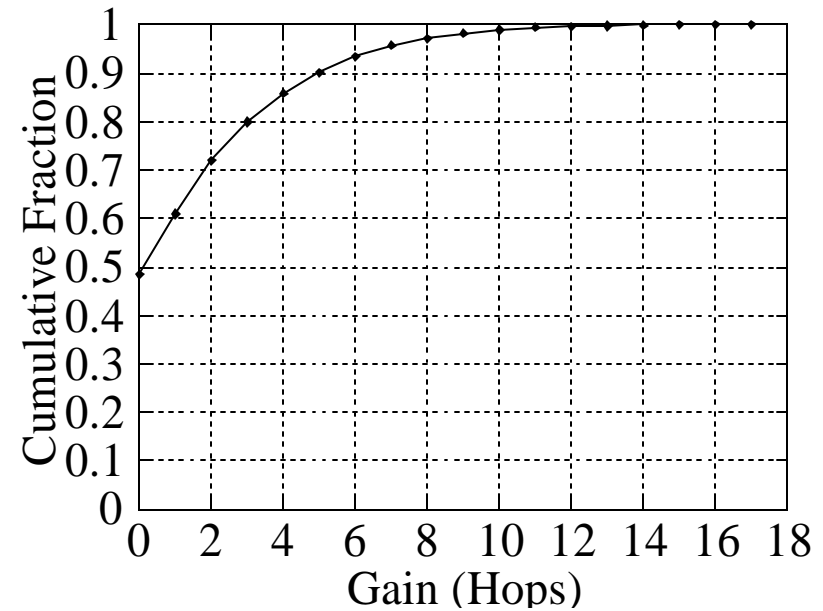
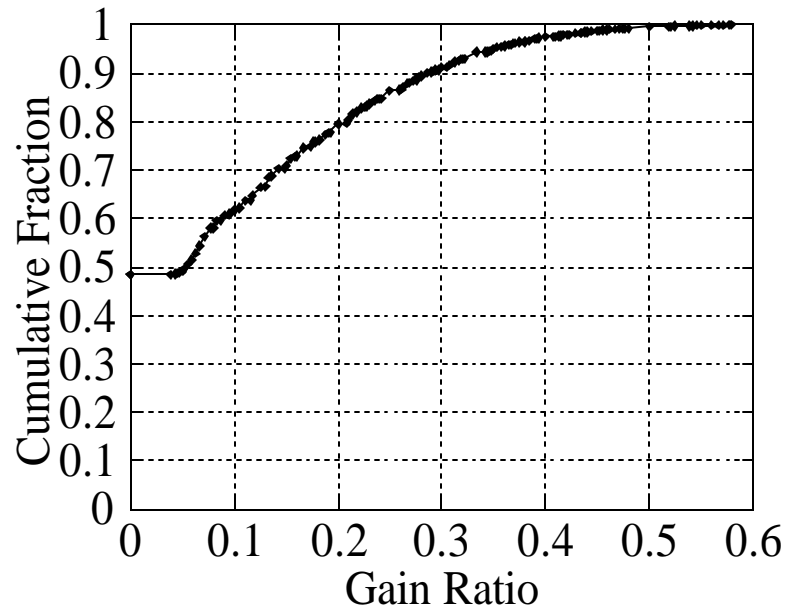


- Our routing policy model is conservative

Detour Paths

- Between nodes A and B, a detour I exists if there is an intermediate node I such that
 - I lies in a different AS than A and B
 - The AS path via I is longer than the AS path between A and B
 - The policy path via I is shorter than the policy path between A and B
- If many detours exist, pick shortest detour
- Metrics:
 - Gain: difference between policy path and path via detour
 - Gain ratio

Detour Gain/Gain Ratio



About 50% of paths have a detour

Path Concentration

- Does routing policy force Internet paths through large AS's?
- More general Question: Is the Internet connectivity rich enough that logical connectivity imposed by policy skews the paths?
- Dominant AS for (A,B): the largest **transit** AS encountered in the path between A and B
 - Ignore all nodes pairs within a single AS, or in adjacent AS's
- Dominance Fraction of AS X: fraction of node pairs for which X is the dominant AS

Path Concentration

