Internet Path Stability: Exploring the Impact of MPLS

Zakaria Al-Qudah, PhD.

Yarmouk University

April 2, 2015

Outline

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About Myself

- Associate professor of computer engineering at Yarmouk University
- Graduate degrees from Case Western Reserve University, Cleveland OH
- Research Interests: the Internet in general
  - Content delivery networks
  - Internet measurements
  - Security
- Hold a U.S. patent in CDNs area (another is pending)
- Experience working for industrial research labs

Introduction

- Stability (or the lack of) has major consequences
  - Design of systems
  - Design experimental setup
  - Non-stable paths may degrade TCP’s performance

Introduction (cont.)

- Internet paths were found to be stable, but
  - The Internet continues to evolve
  - Internet usage continues to change
  - New technologies have been deployed
    - E.g., MPLS is significantly used today for traffic engineering
- Re-evaluation is always necessary

Related Work

- Paxson et al. (1996) found that Internet paths are very stable
  - Major study that everyone cites until today
- Schwartz et al. (2010) re-evaluated Paxson's results
- The Internet is less stable
  - But major findings of Paxson remain valid

Contribution

- In addition to re-evaluation, we
  - We probe on short time-scale (1 minute interval)
  - We employ broader, more realistic definition of path equality (later)
  - We are investigating the impact of MPLS on path stability

Methodology – Experiment

- Collected ~44K distinct IP from Alexa
- Used PlanetLab nodes to issue traceroutes to these IP addresses
- Each node is randomly assigned a subset of our IP addresses to probe
  - Each IP is probed once every 60 seconds for 24 hours
  - Total of 1440 probe
- Some IPs were probed from more than one PlanetLab nodes
- Used “scamper” with the following major configurations
  - Timeout = 1 second
  - Abort probing when 5 consecutive unresponsive hops are found

Dataset Summary

- Source-destination pairs 47010
- Traceroutes performed: 68M
- Traceroutes that reached the destination: ~34M (~50%)

Methodology - Path Equality

- Some nodes do not respond to ICMP echo requests
  - Traceroute displays “*”
  - Previous studies handled this in various ways
    - Paxson’s study removed paths with “*” from the analysis
    - Schwartz study considered the “*” as a wild- card

Our definitions of Path Equality

For two hops at the same position:

- Strict: unknown != known or unknown
  - E.g., “*” != “*”, “*” != “A”
- Mid: unknown != known, but unknown = unknown
  - E.g., “*” != “A”, but “*” = “*”
- Loose: “*” is a wild card
  - E.g., “*” = “*”, and “*” = A

Methodology – Metrics

- Persistence
  - The amount of time it takes for an observed path between a source- destination pair to change
  - Ratio "No path change" events to the total possible "No path change" events
  - Calculated for all paths whether probes reached their destination or not
- Prevalence
  - Evaluates how often a certain path between two end-points is taken
  - The number of times each distinct path was taken out of the 1440 probes
  - Measured for the path that was taken the most (called the dominant path)
  - Calculated only for paths where the probe reached the destination

Methodology – Metrics

- Persistence and Prevalence are not necessarily coupled
  - R1, R1, R1, R2, R1, R1→ Persistence = 3/5, prevalence of R1 = 5/6
  - R1, R2, R1, R2, R1, R2 → Persistence = 0, prevalence of R1 =3/6

Methodology – MPLS vs. No MPLS

- To assess the impact of MPLS, we need to identify MPLS paths
- The path includes an MPLS tunnel if x% of our probes include an MPLS tunnel
- Examine results' sensitivity to the choice of classification threshold
  - Evaluate results for x = 1/1440, x = 70%, 80%, 90% and 100%
- Result
  - Choice of the parameter x does not seem to affect the classification significantly
  - Choose x = 70% as the classification threshold

Results – Persistence

- 40% of pairs have 0 persistence in strict definition
- 50% of pairs have less than 0.5 persistence in both Mid and loose definitions
- **Paxon's results: About two-thirds of routes last for days or weeks**
- **Caution: Paxon treated high frequency changes as a routing pathology and removed them from his analysis**

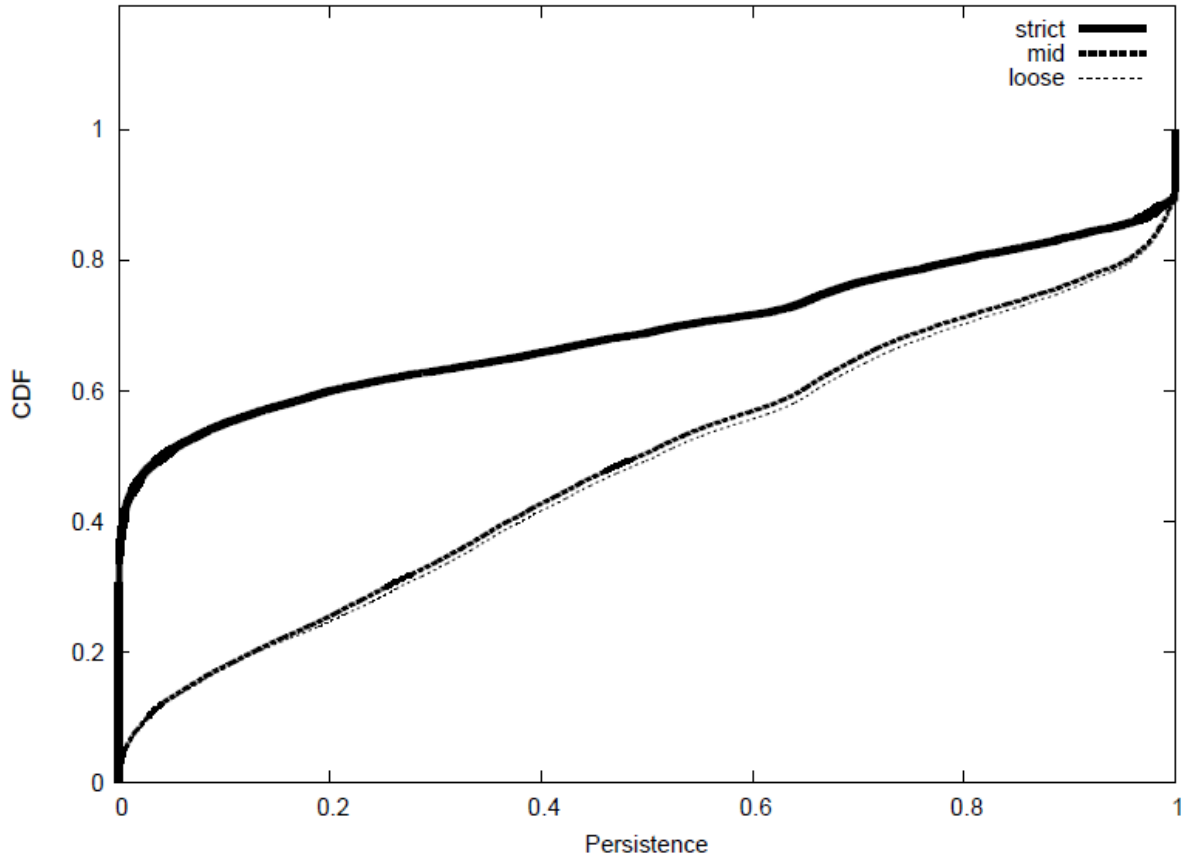

Figure 5.1: Route Persistence.

MPLS Vs. No MPLS – Persistence (mid)

- MPLS
  - 65% of pairs have less than 0.5 persistence
- NO MPLS
  - 35% of pairs have less than 0.5 persistence
- **MPLS significantly decreases the persistence of Internet paths**

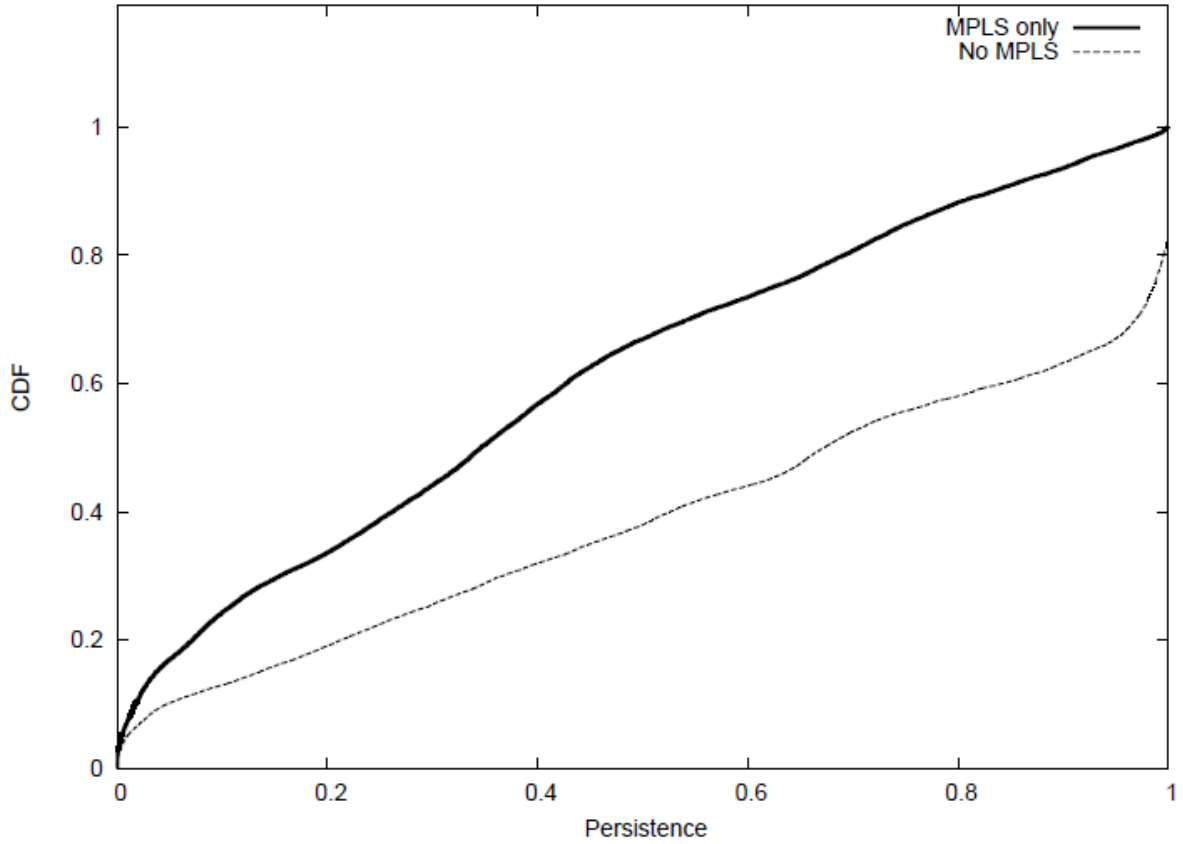

Figure 5.3: Route Persistence. Comparing MPLS paths versus No-MPLS paths with mid definition of path equality.

Dominant Route Prevalence

- 40% of pairs have 0 prevalence in strict definition

- Around 60% of pairs have less than 0.5 prevalence in both Mid and loose definitions

- **Paxon reported only around 20% of pairs have less than 0.5 prevalence**

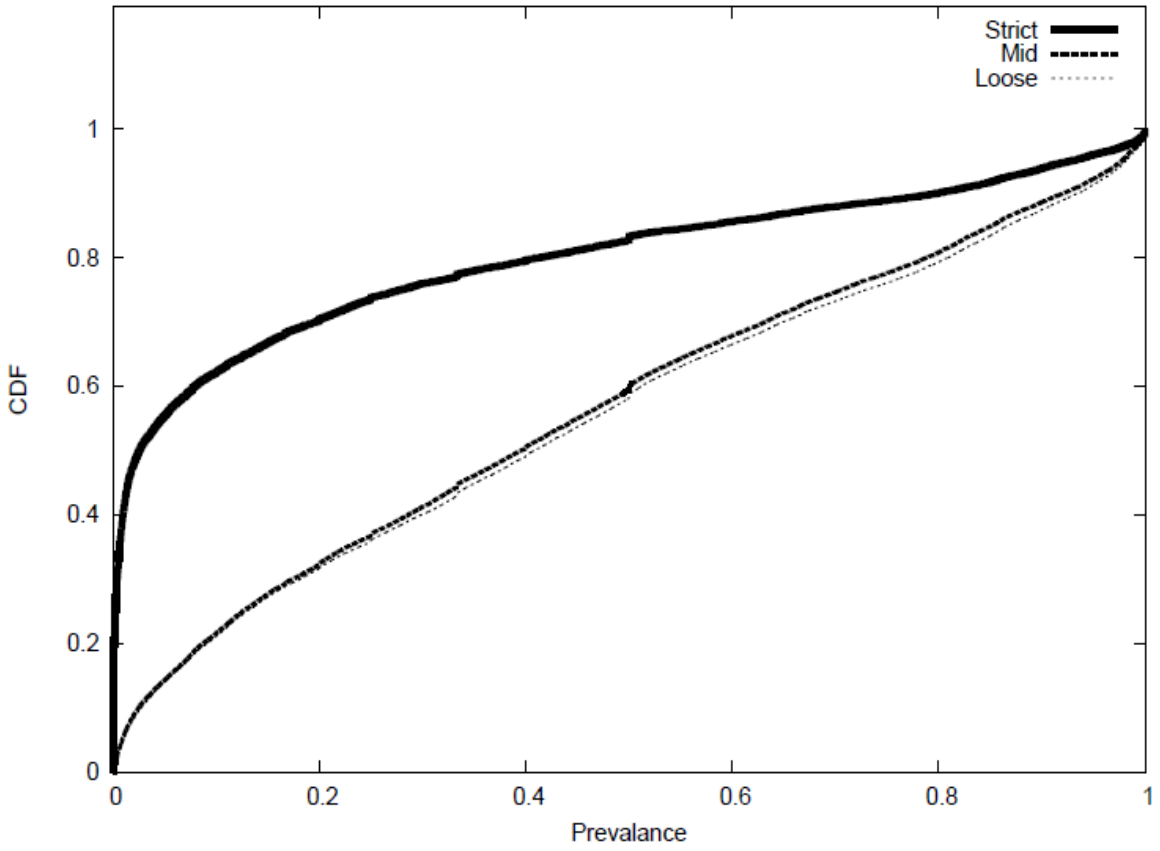

Figure 5.5: Dominant route prevalence.

MPLS Vs. No MPLS – Prevalence (Mid)

- MPLS
  - 60% of pairs have less 0.5 prevalence
- NO MPLS
  - 55% of pairs have less 0.5 prevalence
- MPLS paths have less prevalence

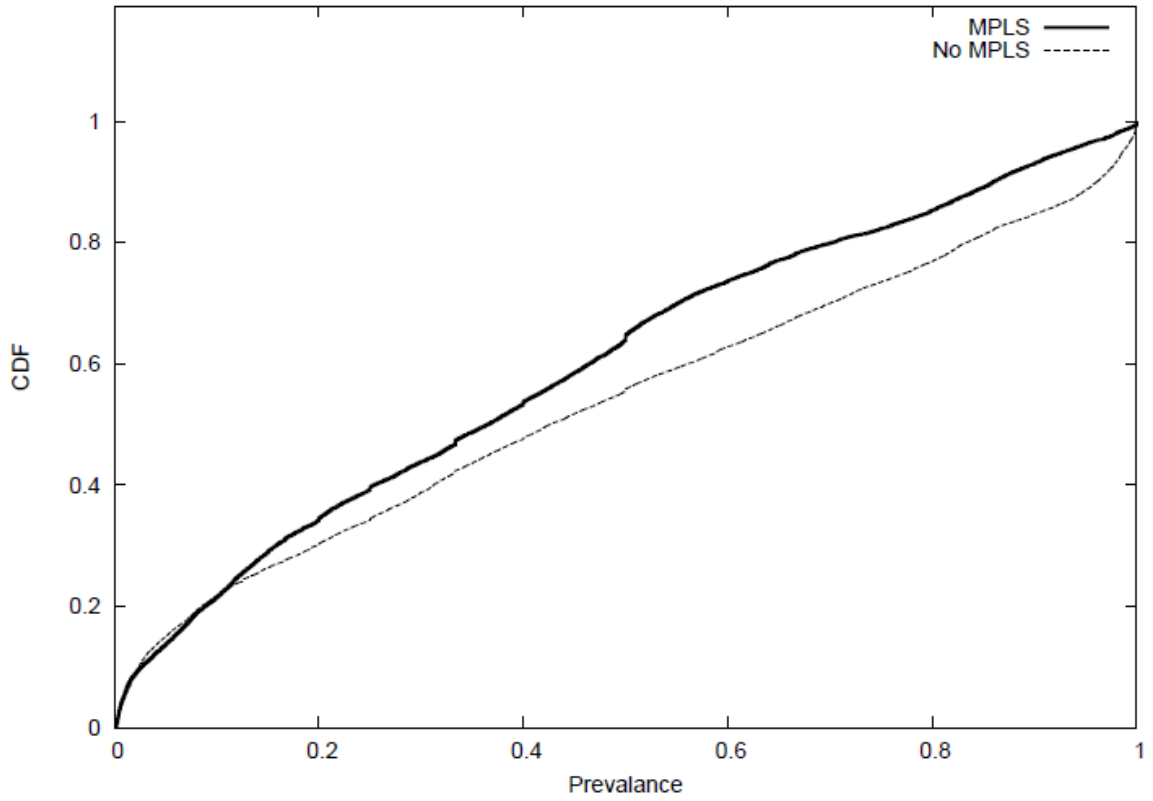

Figure 5.7: Dominant route prevalence. Comparing MPLS paths versus No-MPLS paths with mid definition of path equality.

Conclusions

- Evaluated the stability of Internet paths and the impact of MPLS on this stability
- Stability of Internet paths is significantly less than previously reported
- MPLS contributes significantly to this decrease (from the perspective of persistence)

Thank you!

zakaria.alqudah@gmail.com