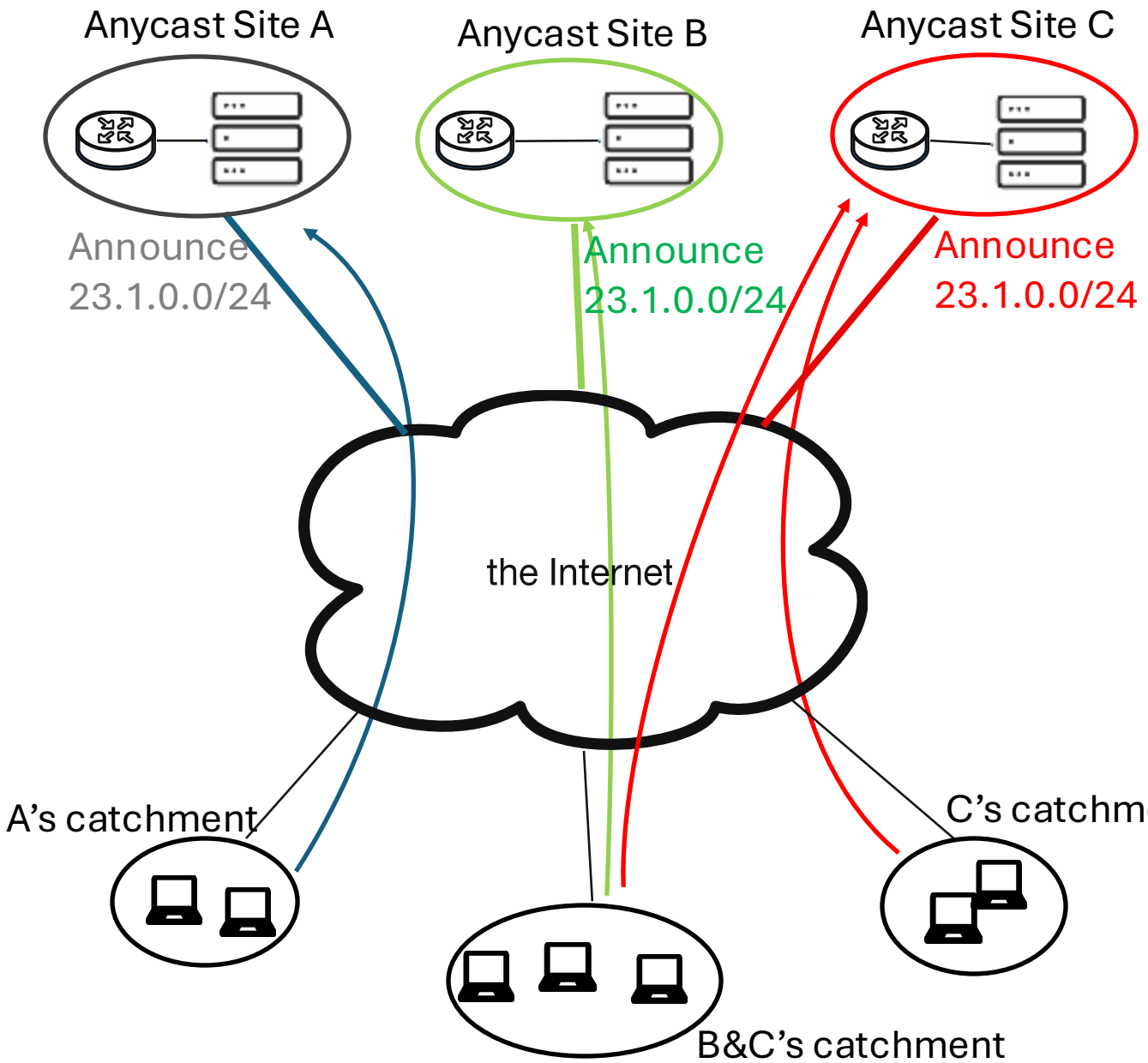
Characterizing Anycast Flipping: Prevalence and Impact

Xiao Zhang, Shihan Lin, Tingshan Huang,
Bruce M. Maggs, Kyle Schomp, Xiaowei Yang

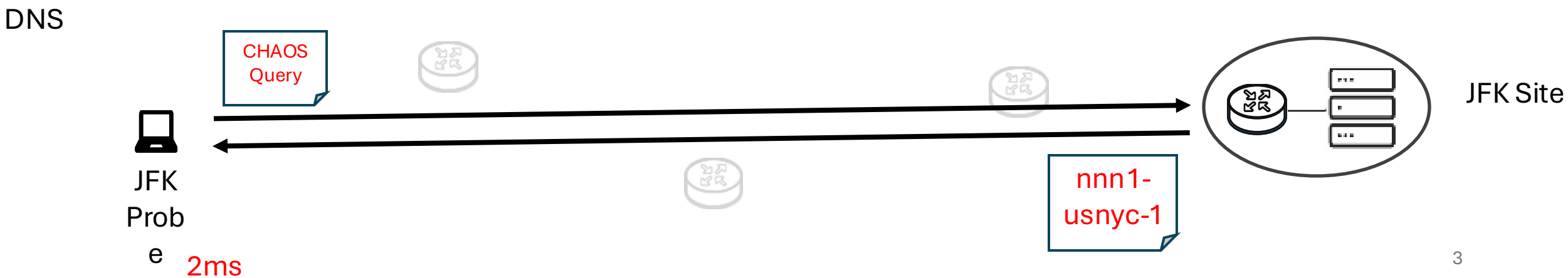
IP Anycast



- IP anycast: the same IP prefix is announced from multiple locations
- Many services use IP anycast for performance and resilience
  - DNS
  - CDN
  - DDoS mitigation systems
- Anycast Flipping
  - Constantly flip between sites

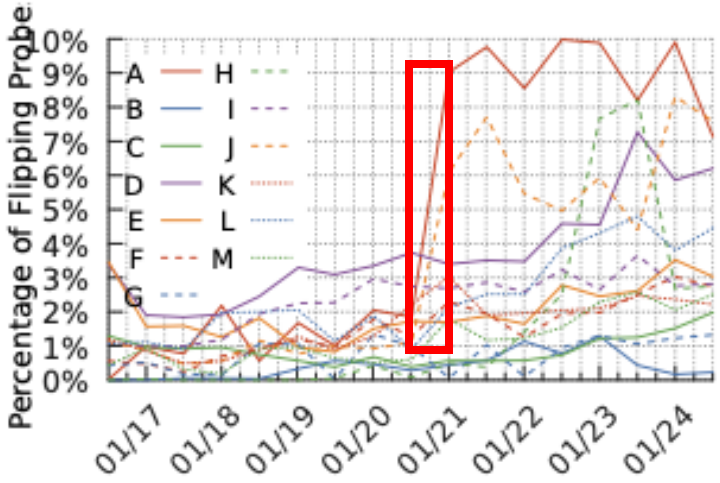
DNS Root Server Ontology

- Only 1% of RIPE Atlas VPs flip constantly in 2016 (Wei and Heidemann)
- Compile a site ontology of 1,014 different replies
  - IATA
  - UN/LOCODE
  - …

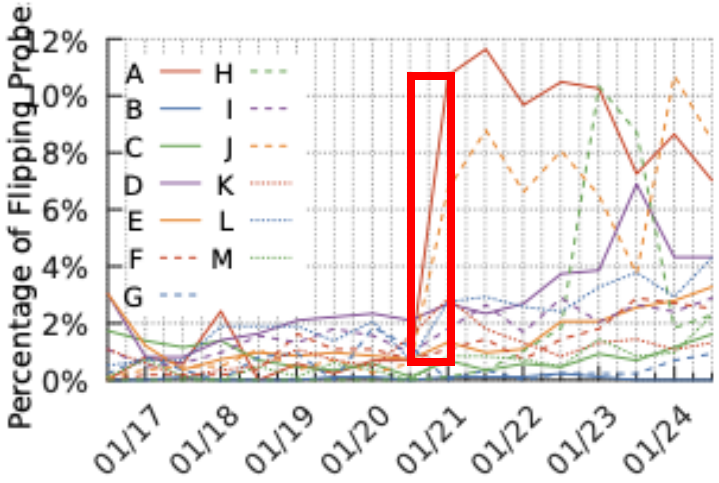


DNS Root Server Flipping - Occurrence

- Extend measurement from Jan-2017 to Jan-2024
  - “mean time between flips is 10 minutes or less”
  - For all available VPs: 1.1% -> 3.5%
  - For active VPs for 8 years: 0.8% -> 3.2%



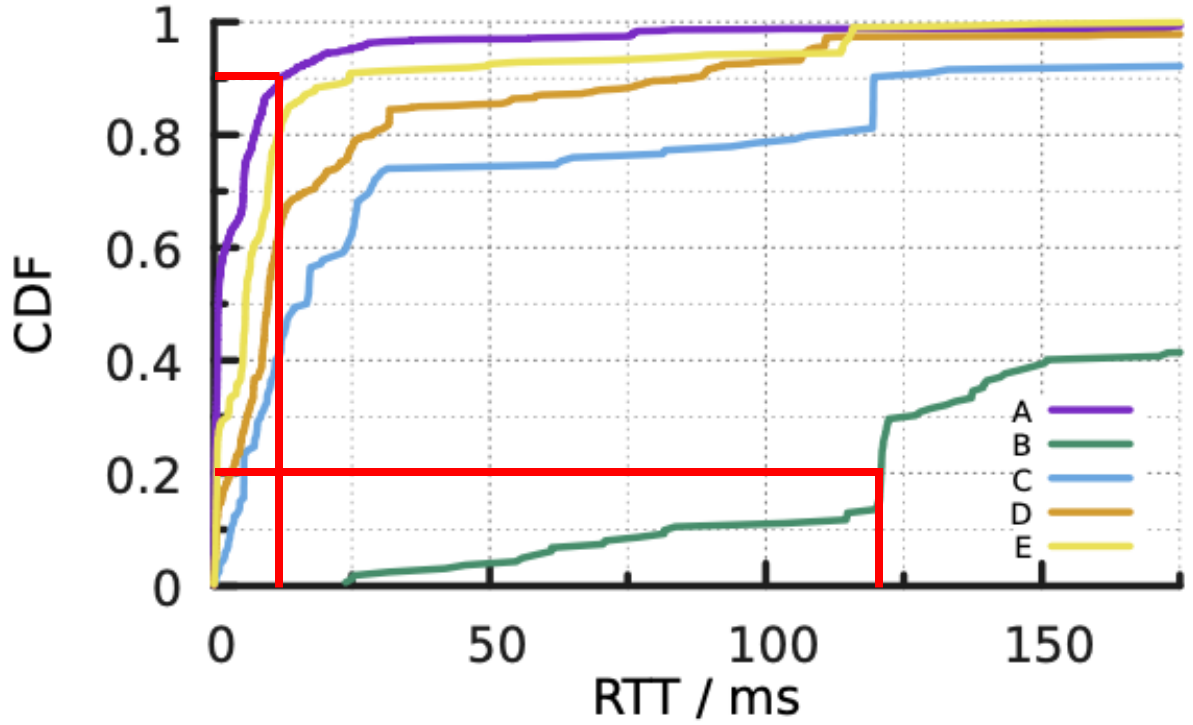
(a) *All RIPE Atlas probes*



(b) *RIPE Atlas probes that are active throughout the past eight years*

DNS Root Server Flipping - Performance

- Extra time incurred for flipping probes
  - A-root: 90% < 12 ms
  - B-root: 80% > 120 ms
- RIPE Atlas Probe #6505 in SG
  - Flip between C-root SG site and C-root LA, US site



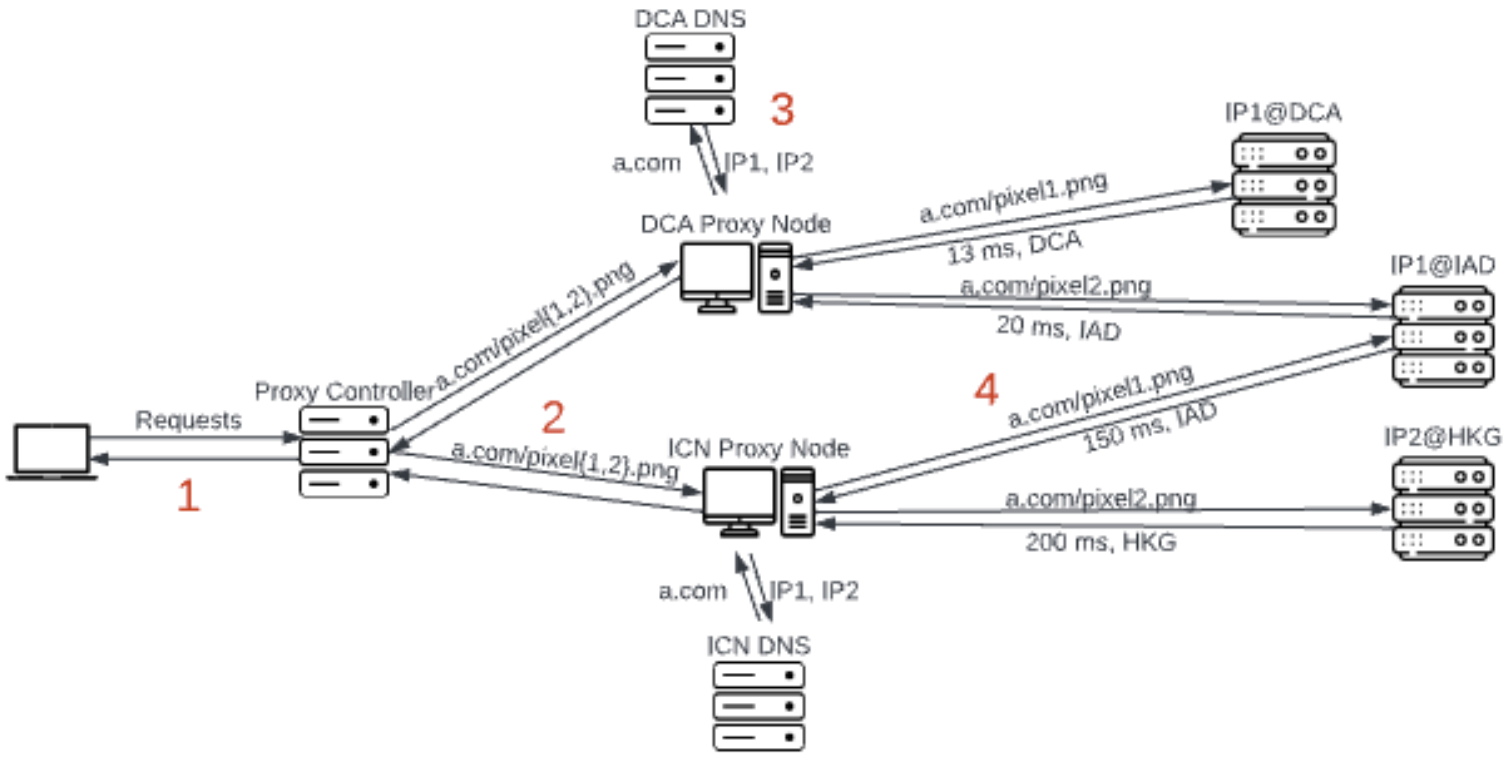
How about CDN?

- The deployment could be different (A tale of two systems)
- TCP session multiplex
  - HTTP 1.1 use 6
  - HTTP 2 use 1

- Challenge - Locating Site without CHAOS
  - A website/80 pixels hosted on the Anycast CDN
  - Use Bright Data Resident Proxy to download the webpage/pixels

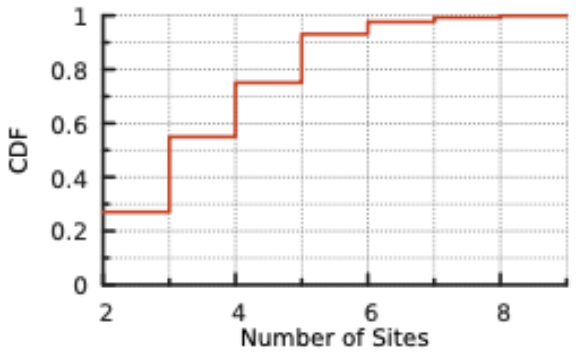
BrightData Workflow

- Consistent Session
- Performance Info
  - VP loc/AS connect time
  - CDN site
  - *CDN Server IP
- 17,600 total session
  - Proxy error/ inconsistent session …
  - 91% intact measures

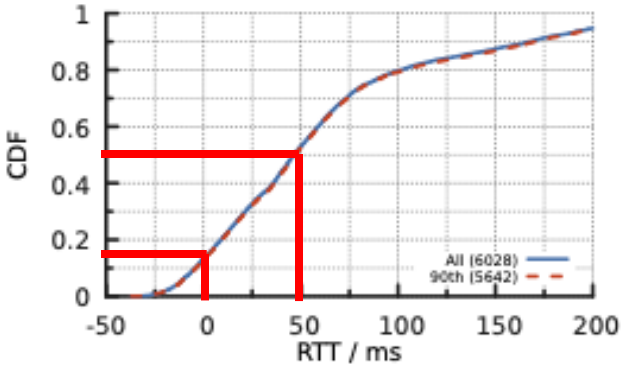


CDN measure

- Prevalence
  - 18,294 unique <proxy, anycast IP> pairs
  - 6,028 (33.0%) reach to multiple sites
  - 2 – 9 different sites for 50 TCP sessions
- Extra Delay
  - Compare to the Mode site
  - Reduce latency for 13%* <proxy, anycast IP> pairs
  - > 50 ms for 47.5% <proxy, anycast IP> pairs



(b) *# sites reached per proxy node*



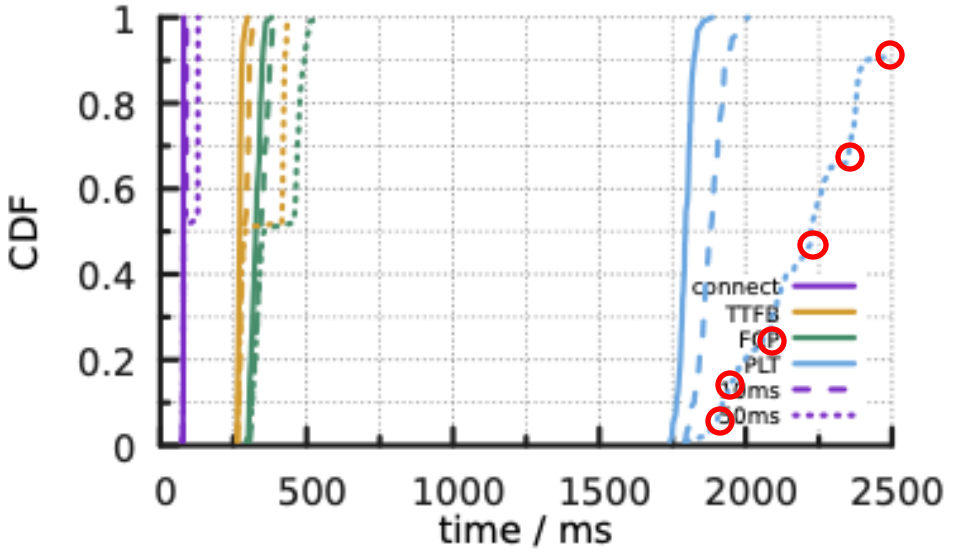
(c) *ΔRTT of proxy nodes that flip between sites*

Simulation – Mock Page

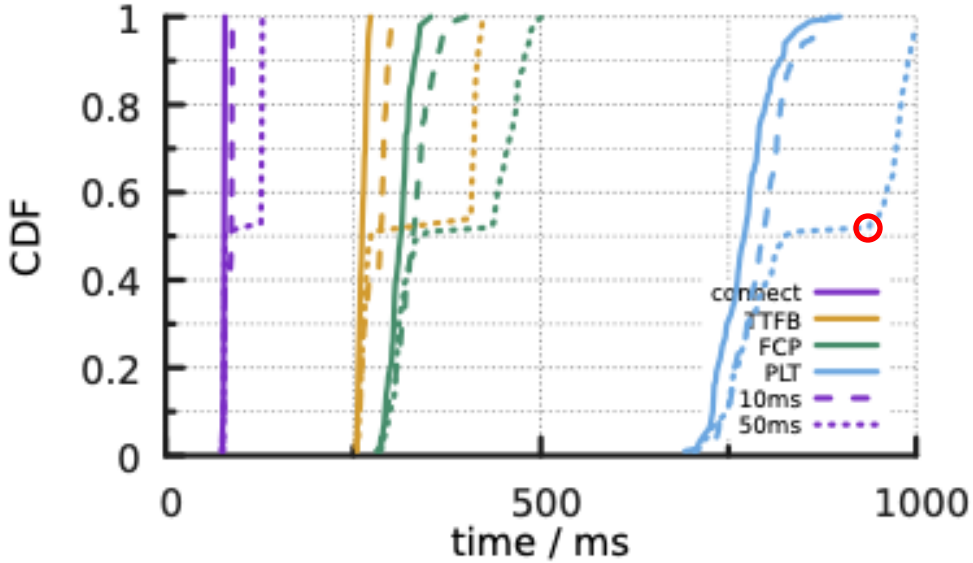
- Mock page in MAHIMAHI
  - 50% flip chance
  - 10/50 ms additional RTT
  - 100 runs for each config

- HTTP /1.1 six segments in PLT indicate the number of flipped/delayed TCP session

- HTTP /2 one-off impact due to only one TCP session is used



(a) *HTTP/1.1*

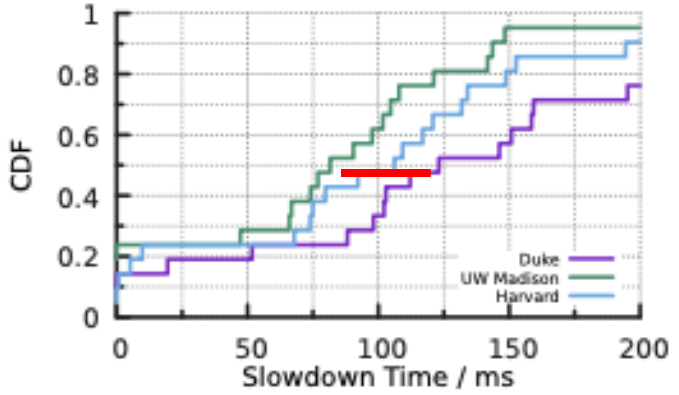


(b) *HTTP/2*

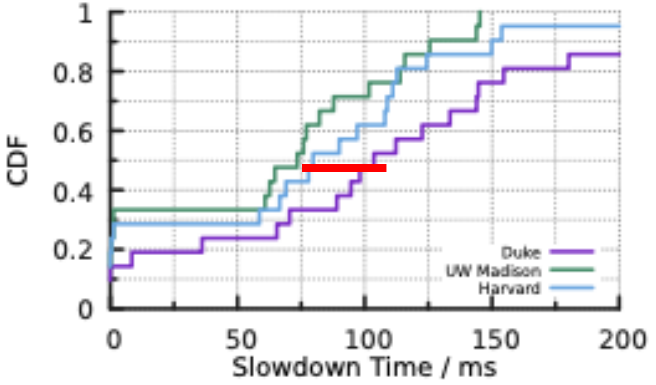
Simulation – Popular Websites

- 20 popular websites on Tranco recorded at three VPs by CloudLab
- 50% chance 50 ms delay
- 100 runs W flip and 100 runs W/O

- FCP slow down for median
  - 81-111 ms for HTTP/1.1
  - 77-109 ms for HTTP/2



(a) *HTTP/1.1 Slowdown Time*



(b) *HTTP/2 Slowdown Time*

Contributions

- Anycast flipping, first observed in 2016, is still present in 2024 and has grown more prevalent;
- Anycast flipping also impacts a small but significant number of CDN’s vantage points, can incur more than 50 ms extra delay;
- Simulation shows the impact of anycast flipping on web performance can be significant.

Possible Causes of Anycast Flipping

Inter AS flipping
- BGP multipath

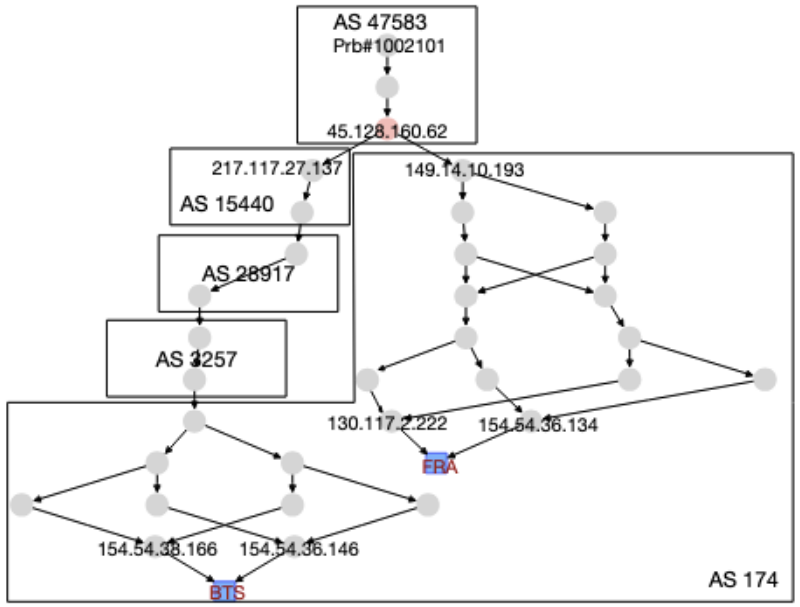


Fig. 2: Flipping at the border between two ASes

Intra AS flipping
- ECMP

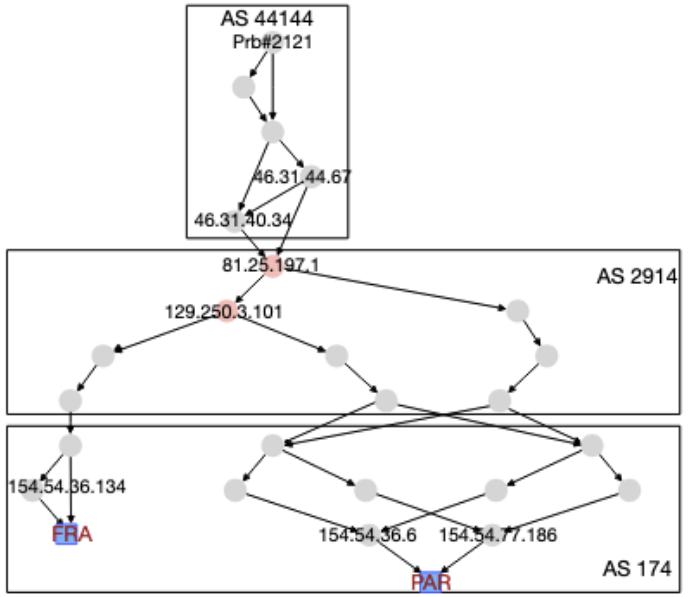


Fig. 3: Flipping internal to an AS