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Is Explicit Congestion Notification usable with UDP?

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Introduction

- Explicit congestion notification (ECN)

ECN with TCP/IP long established:

- RFC 3168
- Extends IP to mark packets, TCP to return the congestion feedback to sender → widely implemented
- Numerous measurement studies; starting to be enabled by default

Use of ECN with UDP/IP uncommon:

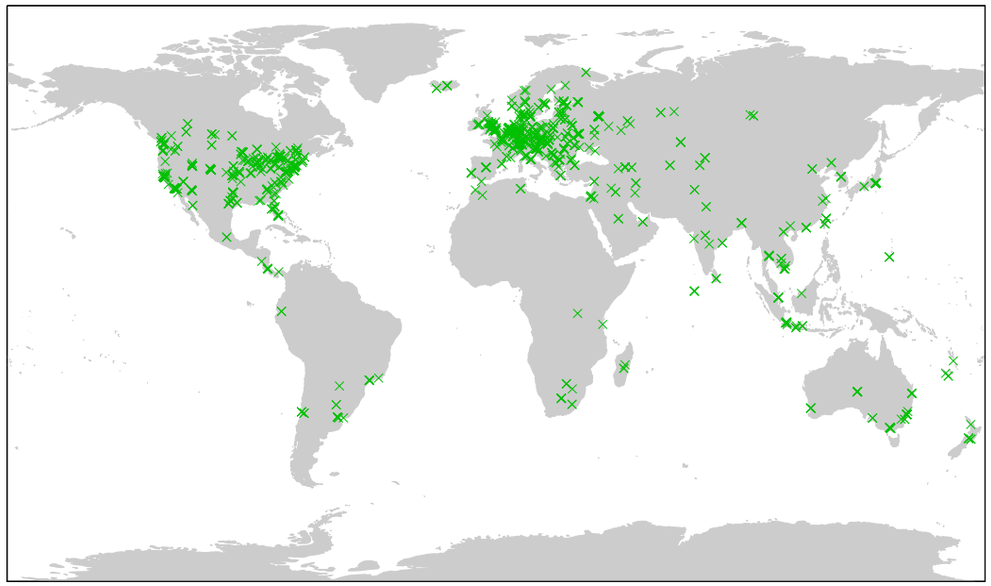
- ECN mark IP packets as usual, but needs an additional protocol above UDP to return congestion feedback
- Use with RTP → RFC 6679
- Use of UDP as a substrate making ECN support increasingly desirable

- Goal: determine if ECN is usable with UDP on the public Internet

Methodology

- Measurement study to determine if ECN is usable with UDP traffic

- Use servers from the NTP pool as measurement targets
  - Global pool of publicly available time servers
  - Round-robin DNS on pool.ntp.org – repeated queries discovered 2500 servers
  - NTP runs over UDP – implemented an NTP probe that makes an ECN-marked query
  - Many pool hosts also run a web server that redirects to www.pool.ntp.org

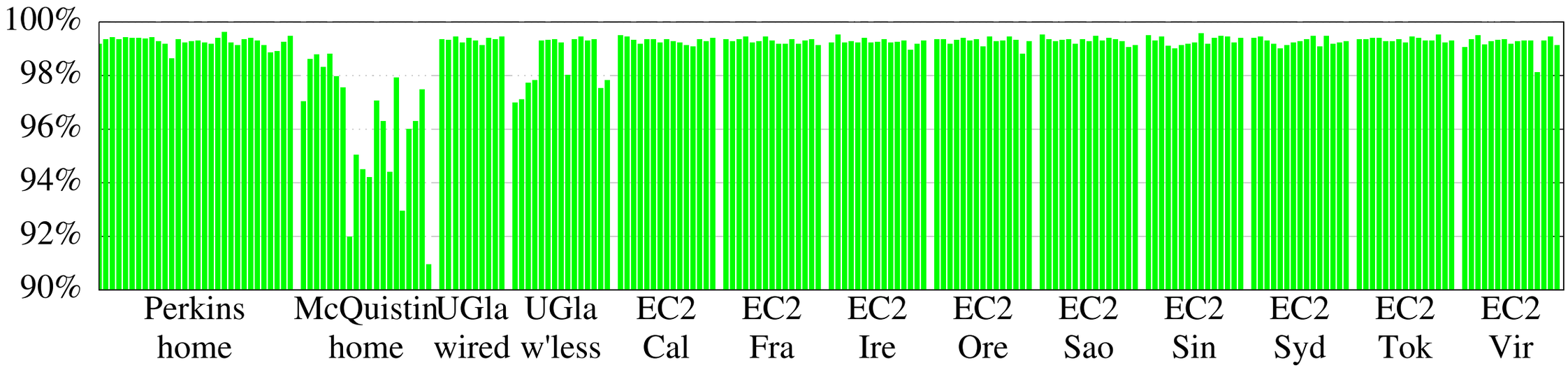


- Probe each pool host in turn with:
  - NTP request in unmarked UDP packet
  - NTP request in ECT(0)-marked UDP packet
  - HTTP request using TCP without ECN
  - HTTP request using TCP with ECN negotiation

from the authors homes, University of Glasgow, and from VMs in each of the nine EC2 regions (N. Virginia, Oregon, N. California, Ireland, Frankfurt, Tokyo, Sydney, Sao Paulo)

Reachability using ECN with UDP (1)

Does use of ECT(0) marks affect reachability of UDP servers?

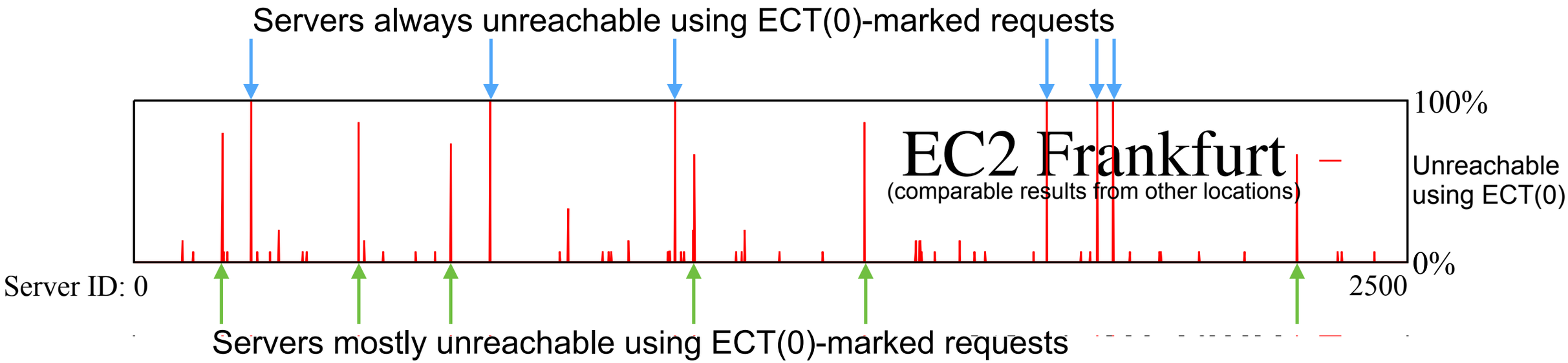


(a) Percentage of servers reachable by not-ECT marked UDP that are also reachable by ECT(0) marked UDP

Not significantly – on average, 98.97% of servers that are reached by regular UDP are also reachable using ECT(0) marked requests

Reachability using ECN with UDP (2)

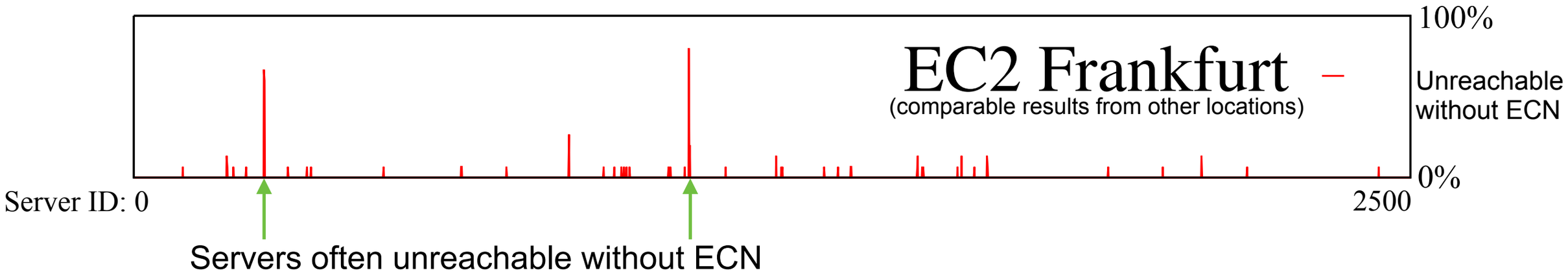
Are servers consistently unreachable using ECT(0) marked requests?



Evidence ECT(0) marked traffic is deterministically dropped near, but not necessarily adjacent to, some servers

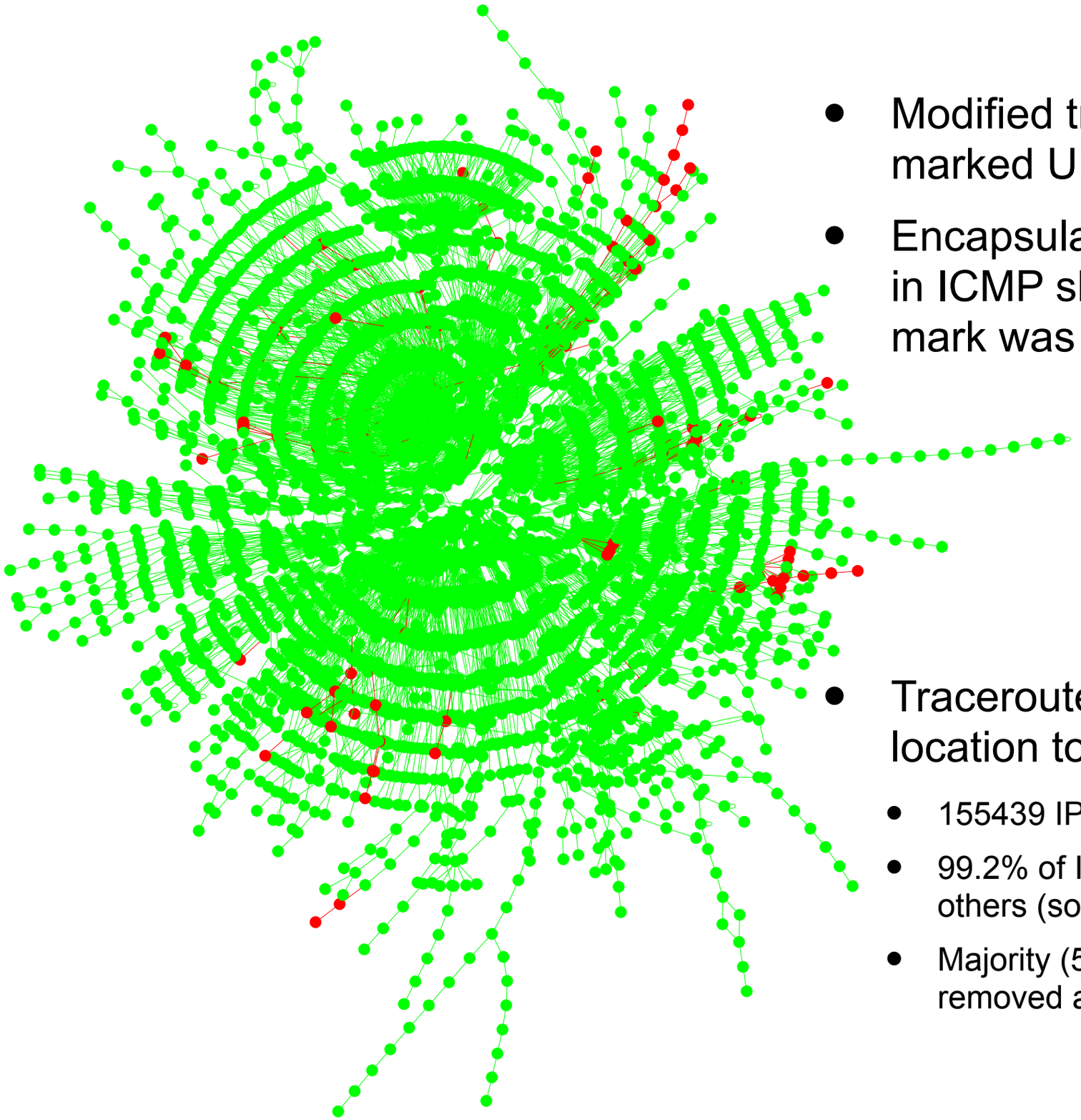
Servers only reachable with ECN

A few servers (0.55%) are often, but not always, unreachable by UDP packets sent without ECN:



Further investigation required to determine cause

Are ECN marks stripped from UDP?

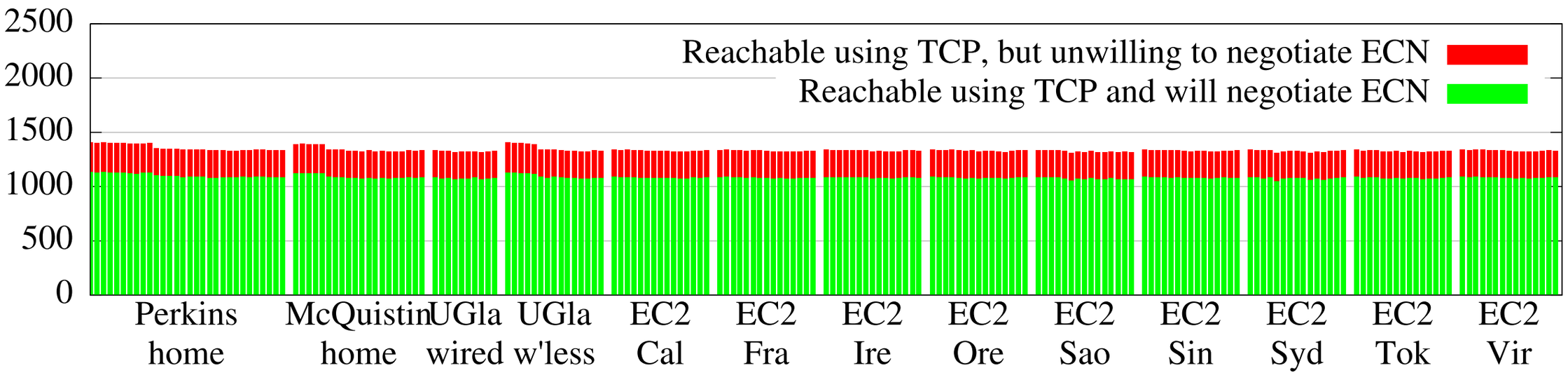


- Modified traceroute to send ECT(0) marked UDP packets
- Encapsulated UDP packet returned in ICMP shows whether the ECT(0) mark was stripped in the network

- Traceroute from each measurement location to all 2500 NTP hosts:
  - 155439 IP level hops, ~1400 ASes
  - 99.2% of IP hops always pass ECT(0) mark, others (sometimes) set it back to not-ECT
  - Majority (59%) of locations where ECT mark removed appear to be at AS boundaries

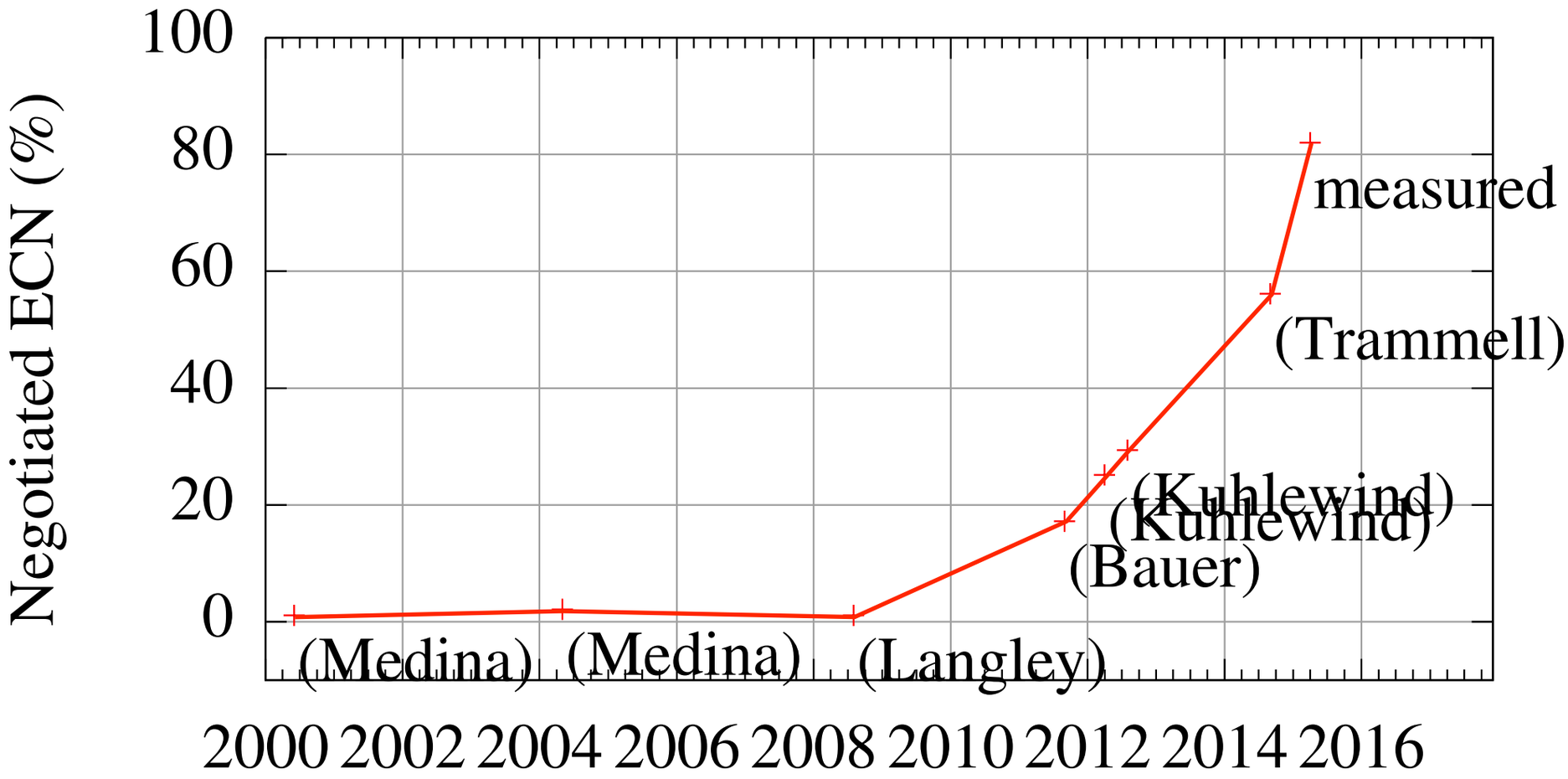
Reachability using ECN with TCP

Proportion of NTP pool hosts running web servers, and those that will negotiate ECN with TCP:



- 53% of the servers tested are reachable with TCP
- 82% of those are willing to negotiate and use ECN

Trends in TCP ECN Capability



Studies used differing methodology, so perhaps not directly comparable

Summary

- For the servers tested, enabling ECN with UDP had a small (~1%) negative impact of reachability
- UDP packets with ECN marks successfully traverse network core in >99% cases
  - In remaining cases, ECN mark generally removed at AS boundary – over zealous attempt to zero ToS bits?
- Fraction of hosts willing to negotiate ECN with TCP increasing, in line with previous studies