ECN with QUIC: Challenges in the Wild

Constantin Sander[*], Ike Kunze[*], Leo Blöcher[*], Mike Kosek[†], Klaus Wehrle[*]

[*]RWTH Aachen University
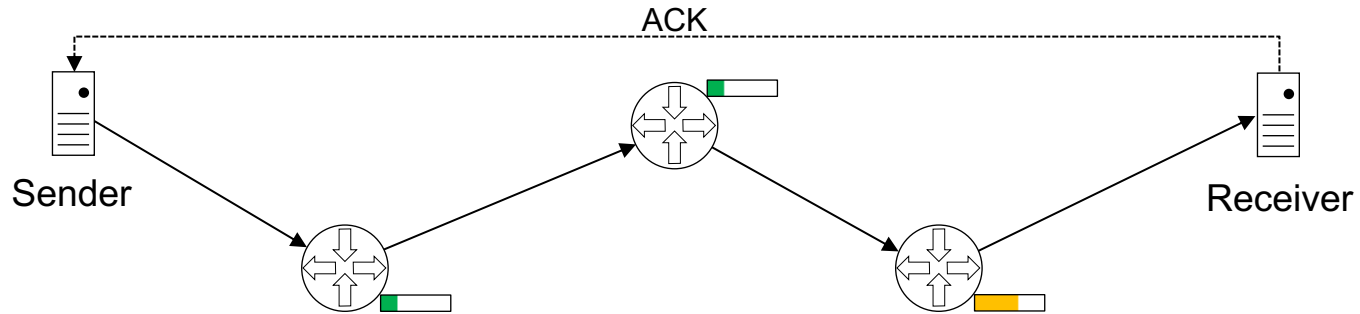
[†]Technical University of Munich
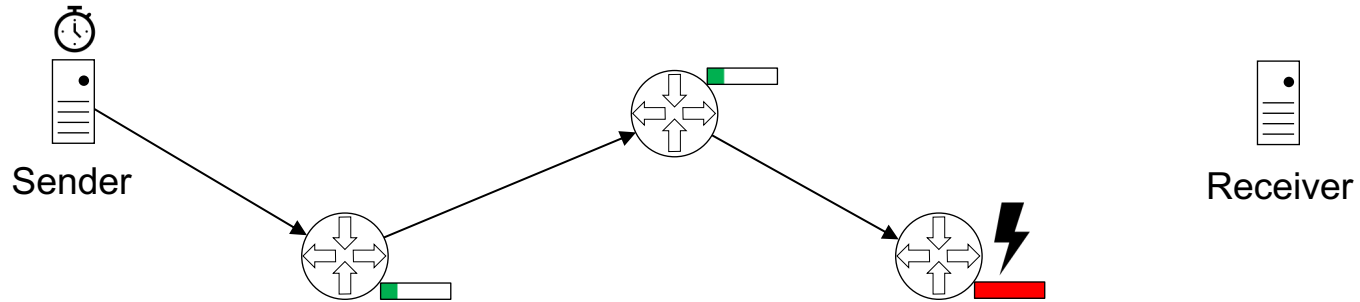
RIPE 87 MAT WG Meeting,
November 28th 2023

ACM Internet Measurement Conference,
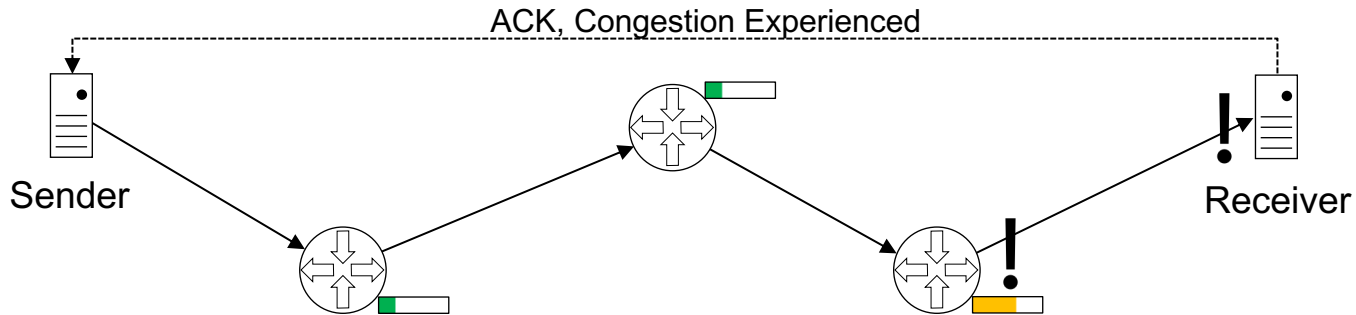Montréal, CA, October 26th 2023

https://www.comsys.rwth-aachen.de/

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Constantin Sander, Ike Kunze, Leo Blöcher, Mike Kosek, Klaus Wehrle

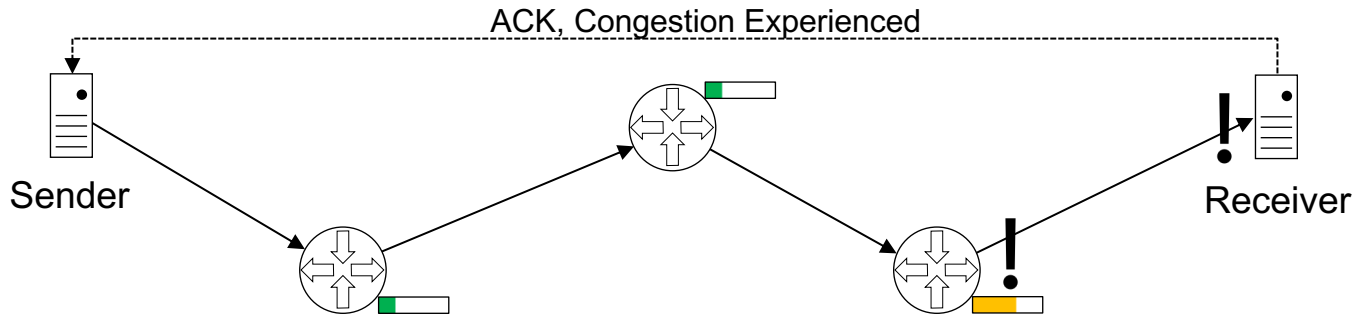Constantin Sander, Ike Kunze, Leo Blöcher, Mike Kosek, Klaus Wehrle

Background: Congestion Loss and ECN

- **ECN: Mark packets instead of dropping them during congestion**
  - ▶ Requires interaction on Network Layer (Routers) and Transport Layer (End Hosts)

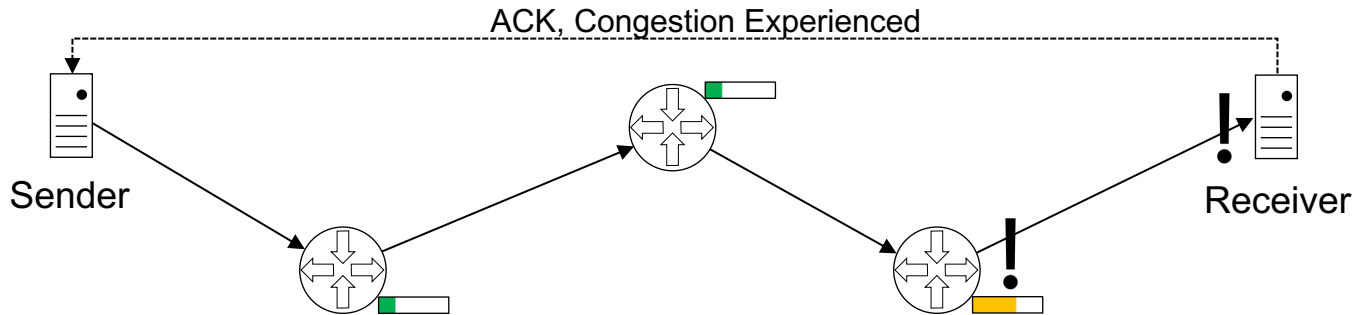Constantin Sander, Ike Kunze, Leo Blöcher, Mike Kosek, Klaus Wehrle

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  - ▶ 00: not-ECT, 10: **ECT(0)**, 01: **ECT(1)**, 11: Congestion Experienced / **CE**

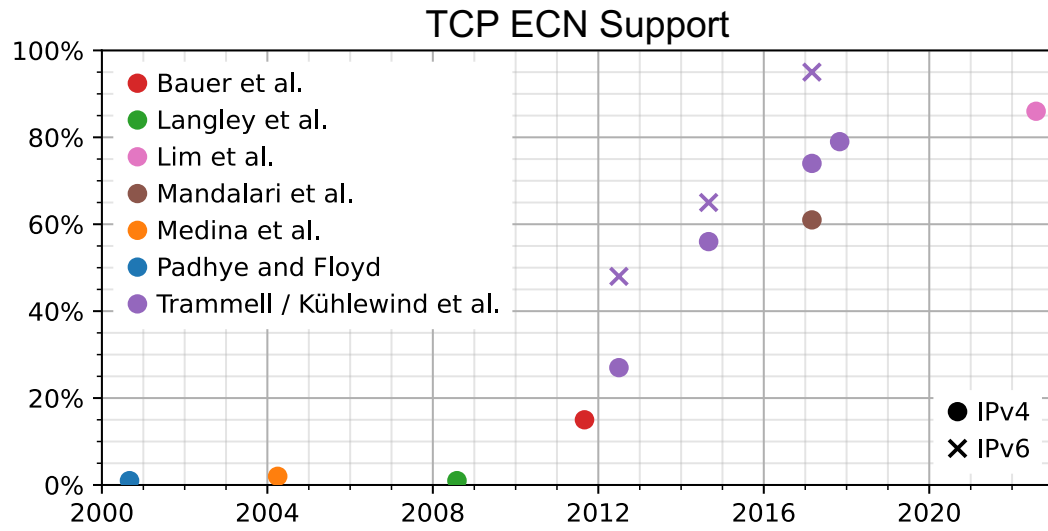Constantin Sander, Ike Kunze, Leo Blöcher, Mike Kosek, Klaus Wehrle

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- **Transport Layer: mirror CE to sender to adjust sending rate**

- **TCP negotiates ECN support**

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  - ▶ Rising support since introduction
  - ▶ Path impairments can hinder ECN

TCP ECN Support

Legend:
- Bauer et al.
- Langley et al.
- Lim et al.
- Mandalari et al.
- Medina et al.
- Padhye and Floyd
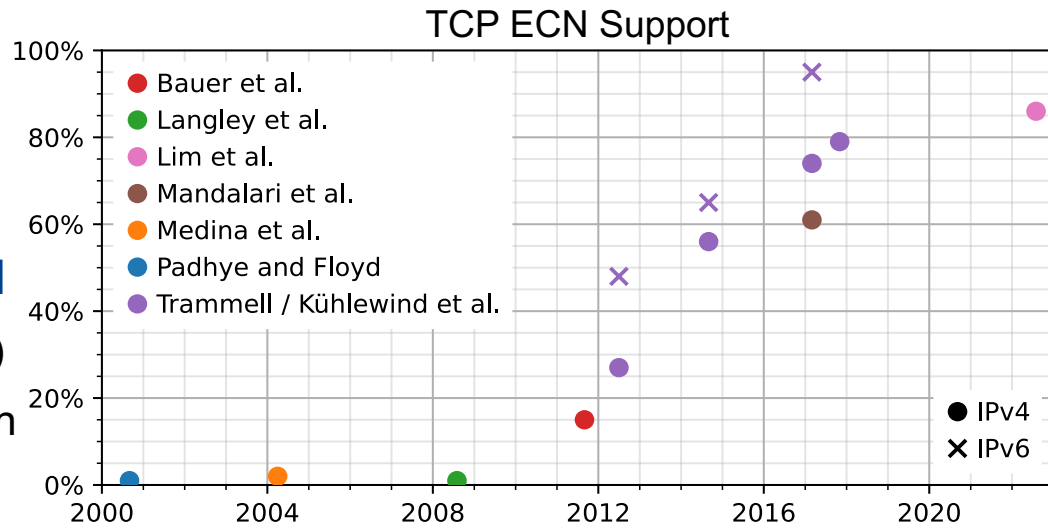- Trammell / Kühlewind et al.

● IPv4
✕ IPv6

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  - ▶ Codepoint counters + ECN Validation
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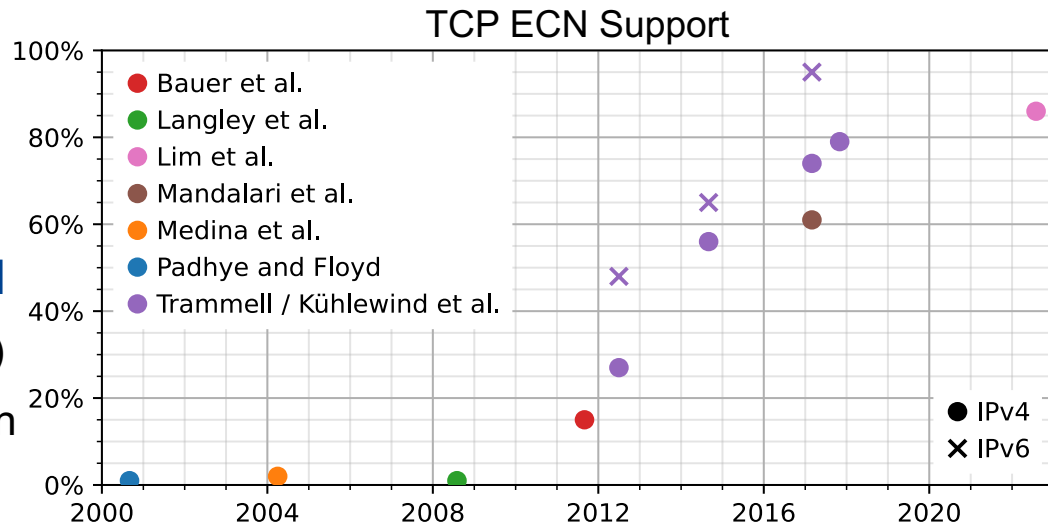- Trammell / Kühlewind et al.

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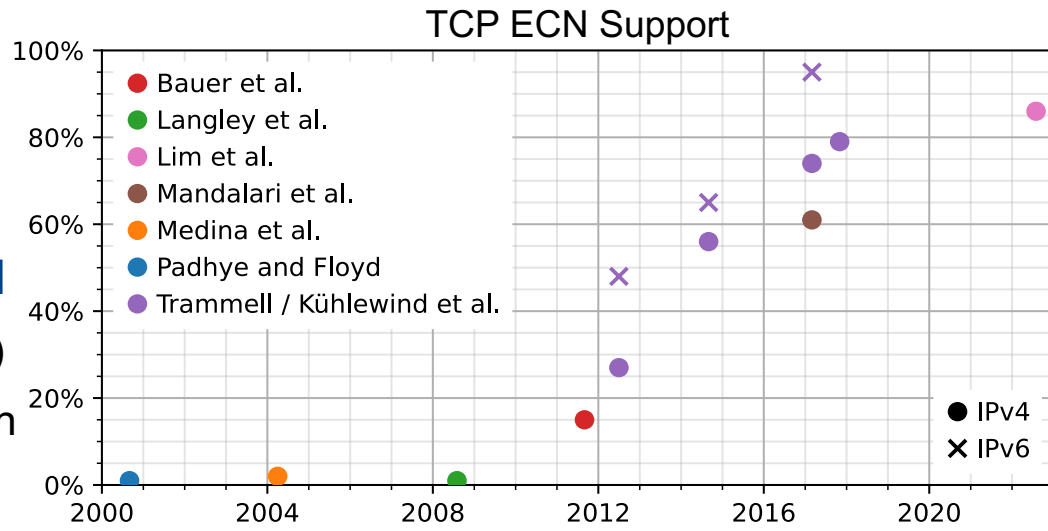Constantin Sander, Ike Kunze, Leo Blöcher, Mike Kosek, Klaus Wehrle

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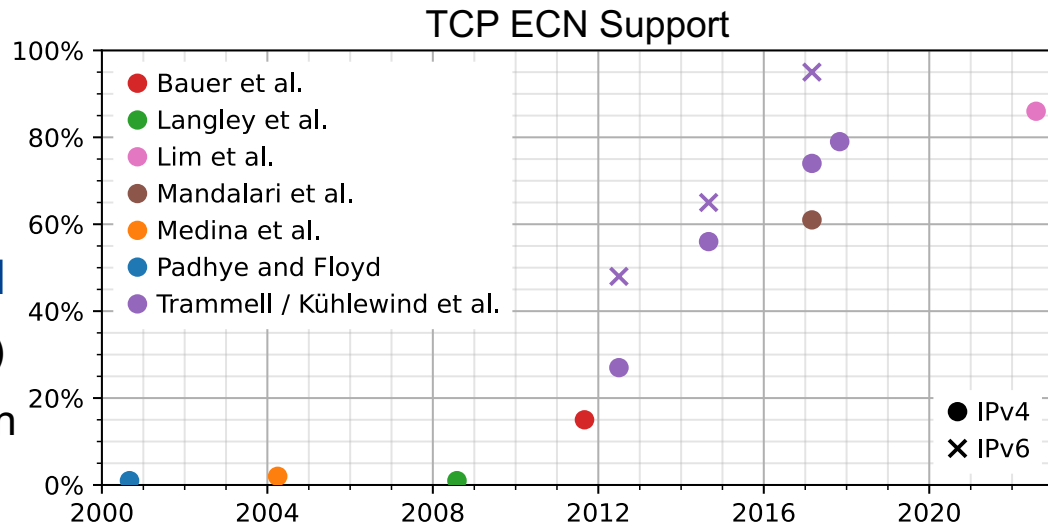 - ▶ Lim et al.: low ECN on UDP port 443

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→ **New stacks + validation + hints for low use: Can ECN be used with QUIC?**

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→ **New stacks + validation + hints for low use: Can ECN be used with QUIC?**

→ Are stacks mirroring ECN?   → Why not?   → Does ECN Validation always pass?

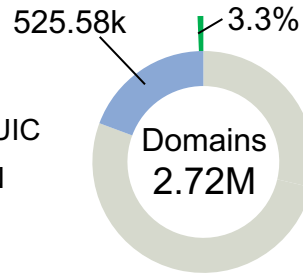- **Visit websites via HTTP/3 / QUIC and log ECN counters (from Germany in CW15)**

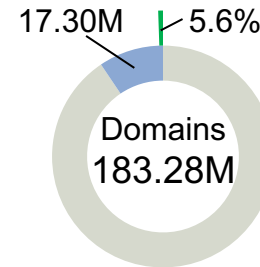 Alexa / Tranco / Umbrella / Majestic   .com / .net / .org

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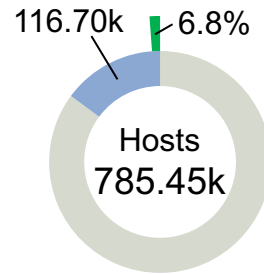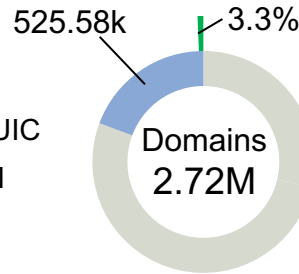
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.com / .net / .org

525.58k ⌐3.3%

Domains
2.72M

■ Supports QUIC
■ Mirrors ECN

17.30M ⌐5.6%

Domains
183.28M

▶ Given that mirroring should be mandatory: Low support

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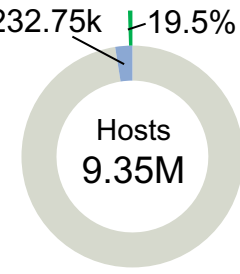
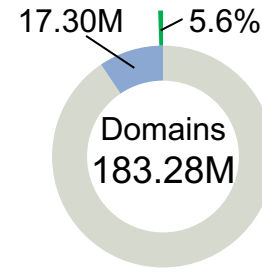Alexa / Tranco / Umbrella / Majestic

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525.58k — 3.3%

Domains
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116.70k — 6.8%

Hosts
785.45k

17.30M — 5.6%

Domains
183.28M

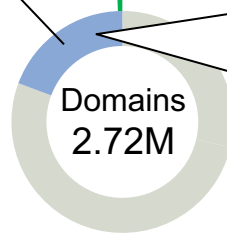232.75k — 19.5%

Hosts
9.35M

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▶ Higher support among hosts than among domains on relative scale

  ■ Potential hint at content centralization and content provider stacks not supporting ECN

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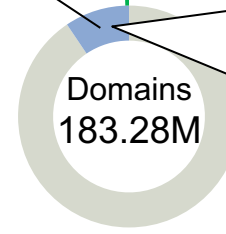
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Total	AS Org	Mirroring
67.1%	Cloudflare	0.0%
12.5%	Google	0.1%
0.6%	Amazon	96.6%
0.3%	SingleHop	82.2%

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.com / .net / .org

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Domains 183.28M

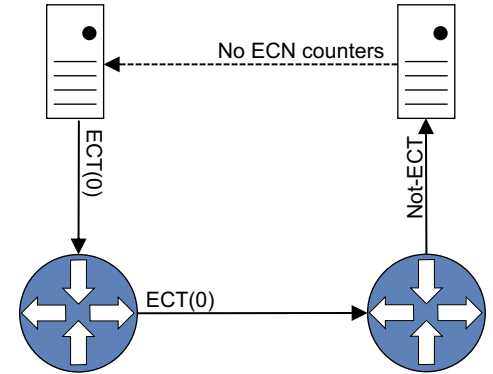| Total	AS Org	Mirroring
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0.8%	A2 Hosting	35.7%

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▶ Mainly LiteSpeed HTTP/3 server, Amazon Cloudfront and tests by Google mirror ECN
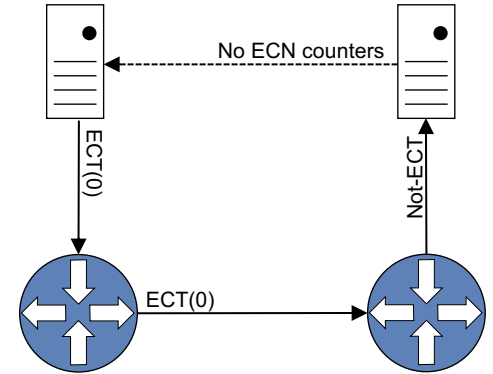
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- **No visible ECN clearing for 97.5% of domains**
  - ▶ 2% visible clearing, 0.5% not traced due to sampling

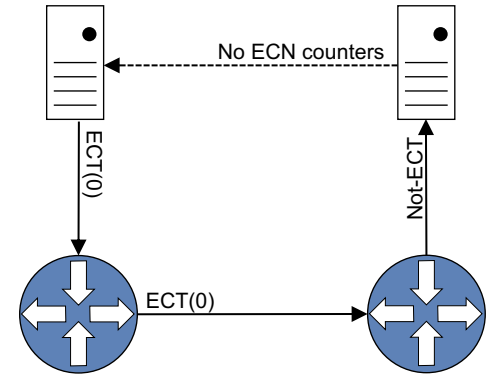- **Stacks could ignore ECN or networks clear codepoints**
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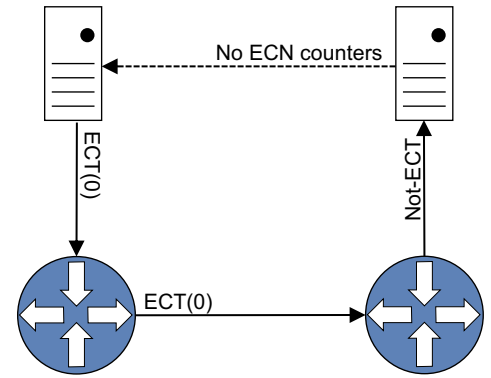- **No visible ECN clearing for 97.5% of domains**
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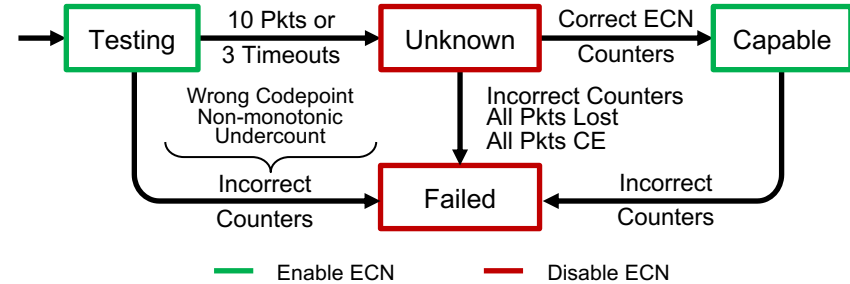- **Single Tier 1 ISP impacts 98.6% of affected domains**
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- **Missing support by content providers not due to clearing**
  - ▶ Support ECN via TCP, QUIC stacks or undiscovered middleboxes ignore ECN
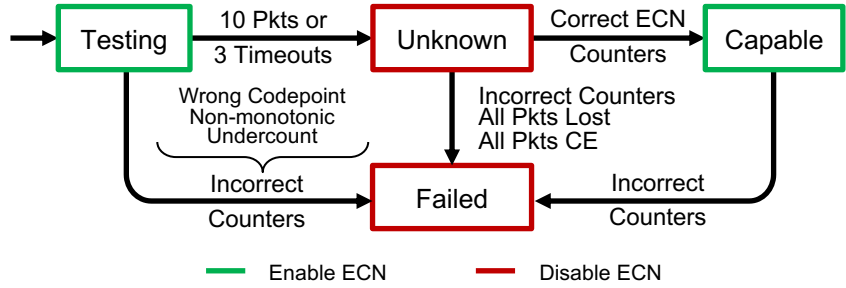
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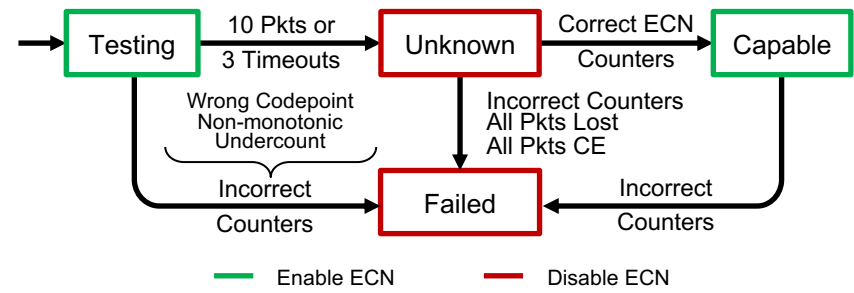
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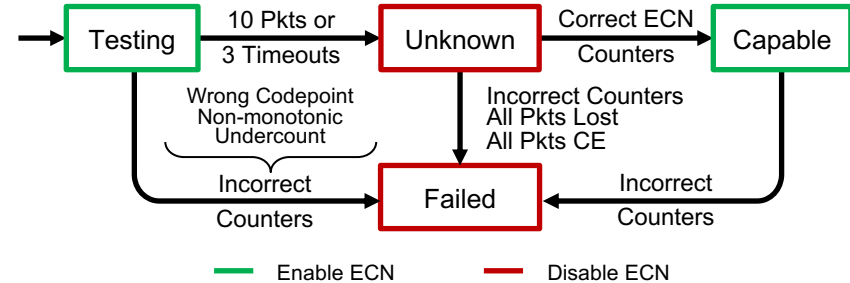 ▶ Checks for the first packets whether

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  ▶ Undercounting

  - Google AS

    - Related work suspects DCTCP

  - LiteSpeed Server

    - Packetno. switch can disable ECN
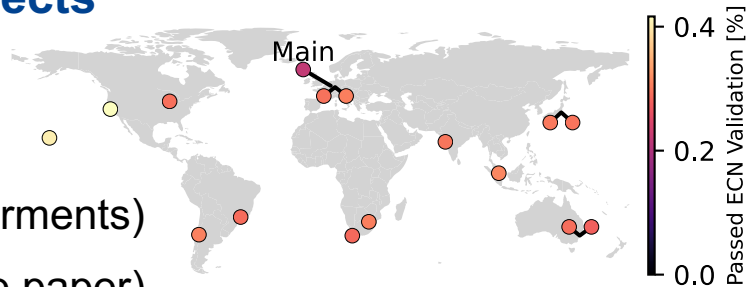
  ▶ Re-marking

  - Again network elements of Tier 1 ISP

    - Also rewriting of codepoints

  - Again Google's AS

    - Potentially again DCTCP usage

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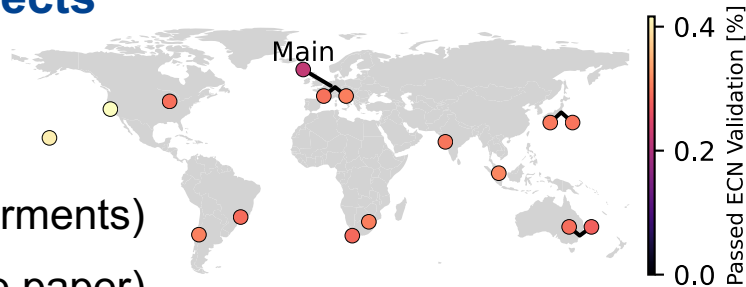
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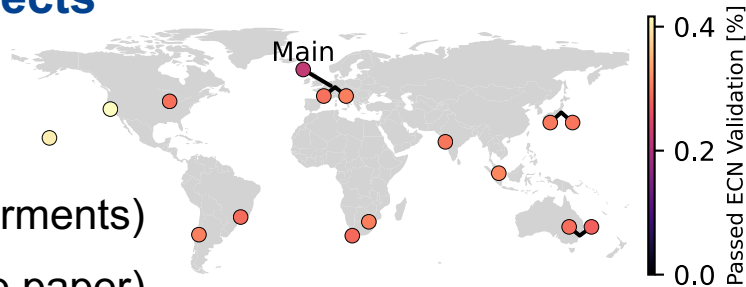 - ▶ Usage also limited on global scale and for IPv6 (see paper)

- **Findings also present challenges for novel ECN mechanisms such as L4S**

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- **Trend is probable to be increasing, changes over time visible** (see paper)

  ▶ RFC Erratum may trigger rework of stacks, will probably not trigger 100% support

  ▶ Open ticket with stack vendor and ISP debugs router ECN issues