Using the Spin Bit and ECN with QUIC
Adoption and Challenges in the Wild

Ike Kunze\textsuperscript{12*}, Constantin Sander\textsuperscript{12*}, Leo Blöcher\textsuperscript{2*}, Mike Kosek\textsuperscript{2†}, and Klaus Wehrle\textsuperscript{12*}

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\textsuperscript{†} TU Munich

1 Does It Spin? On the Adoption and Use of QUIC’s Spin Bit
2 ECN with QUIC: Challenges in the Wild

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

- Large scale longitudinal QUIC web measurements (Apr. 2022 – May 2023)
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com/net/org

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DNS resolver

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Methodology:
- `zgrab2 + quic-go`
- DNS resolver
- DNS
- "Resolved" "QUIC"
- "Total"
- "ECN Use" 1 "Spin" 0
- Alexa, Umbrella, Majestic, Tranco
- ICANN CZDS, com/net/org, > 1000 other TLDs

Webhosting and DNS resolver performance:

- Webhosting DNS resolution success
- QUIC protocol usage
- ECN Use
- Spin
The QUIC Spin Bit in the Wild

- Single-bit, explicit RTT measurement signal

![Diagram of client-server interaction with spin bits]
The QUIC Spin Bit in the Wild

- Single-bit, explicit RTT measurement signal

- Optional and few public stacks support it
The QUIC Spin Bit in the Wild

- Single-bit, explicit RTT measurement signal

- **Optional** and few public stacks support it

Q1: Who uses the spin bit?
The QUIC Spin Bit in the Wild

- Single-bit, explicit RTT measurement signal
  
- Optional and few public stacks support it
  
- End-points must disable it sometimes
  
  ▶ RFC 9000 vs RFC 9312 and different ways for disabling

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Q1: Who uses the spin bit?
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The QUIC Spin Bit in the Wild

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![Diagram showing the spin bit in use](image)

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- **End-points must disable it sometimes**
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- **Its practical usefulness unknown**
  - Mainly studied in test settings [1,2]
  - Includes app. delay & vulnerable to reordering

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Q3: How accurate are the measurements?

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**Q1:** Is the spin bit used and by whom?

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<td>1</td>
<td>11.48 M</td>
<td>Cloudflare</td>
<td>0</td>
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RTT Measurement Accuracy

- Use all connections with spin bit activity
- Compare resulting RTT measurement with QUIC groundtruth
  - Received packet order / Sorted by packet numbers

Q3: How accurate are the measurements?

- Received
- Sorted

Real RTT larger by
Spin RTT larger by

Share

Absolute difference up to .. [ms]
RTT Measurement Accuracy

• Use all connections with spin bit activity
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![Graph showing percentage of absolute RTT differences.][1]

Q3: How accurate are the measurements?

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[1]: # RTT Measurement Accuracy — Use all connections with spin bit activity — Compare resulting RTT measurement with QUIC groundtruth

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Q3: How accurate are the measurements?
RTT Measurement Accuracy

- Use all connections with spin bit activity
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Q3: How accurate are the measurements?

![Graph showing RTT ratio and absolute difference](image)
Spin Bit – Takeaways

• The spin bit indeed sees use in the wild
  ▶ ~10 % of domains with QUIC support use it
  ▶ 50 – 60 % of underlying hosts

• RTT measurements draw an ambiguous picture
  ▶ Often quite accurate
  ▶ More often large overestimation
  ▶ Some underestimation
Visible QUIC ECN Support

- ECN mirroring: MUST* in QUIC RFC – but can it be used?
- Visit websites via HTTP/3 / QUIC and log ECN counters (from Germany in CW15)

* if accessible, RFC Erratum exists
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Alexa / Tranco / Umbrella / Majestic

- Supports QUIC
- Mirrors ECN

Domains

Supports QUIC
Mirrors ECN

525.58k
3.3%
Domains
2.72M

17.30M
5.6%
Domains
183.28M

- Given that mirroring should be mandatory: Low support

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- Given that mirroring should be mandatory: Low support
- Mainly LiteSpeed HTTP/3 server, Amazon Cloudfront and tests by Google mirror ECN
  - Again low support by hyperscalers and content providers

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Clarifying Missing Support

- Stacks could ignore ECN or networks clear codepoints
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  - Tracebox tracing for missing ECN (similar to related work)

- No visible ECN clearing for 97.5% of 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
**ECN Validation Challenges**

- **QUIC requires ECN validation to use ECN**
  - Checks for the first packets whether
    - Timeouts occur with ECN
    - Wrong codepoints
    - Missing / undercounted codepoints
ECN Validation Challenges

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- **0.2% of com/net/org pass validation ⇔ 96% of mirroring domains fail due to**
  - **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
ECN with QUIC – Takeaways

- **Multiple challenges for ECN with QUIC**
  1. Several QUIC stacks do not mirror ECN
  2. Some network elements clear signals
  3. Often ECN validation fails (stack + network impairments)
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- **Trend is probable to be increasing, changes over time visible**
  - QUIC RFC Erratum on ECN may trigger rework of stacks
  - Open ticket with stack vendor and in touch with ISP for debugging ECN issues
Conclusion

- Large scale longitudinal QUIC web measurements

- Spin bit
  - Optional, yet sees use in the wild
  - How useful is the provided measurement accuracy?

- ECN
  - Mandatory, yet significantly limited on a global scale
  - Many challenges (stack support to faulty network devices)

- Check out papers for more details