# Characteristics of TCP connections at Internet scale

maprg

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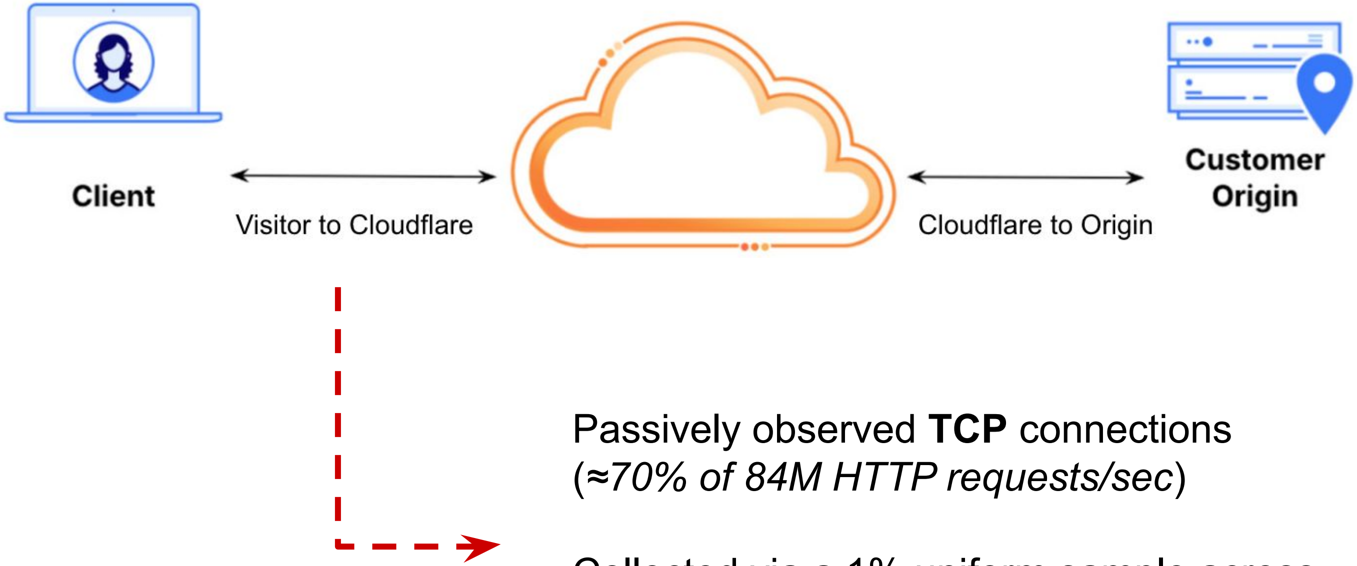
# Capturing Connection Characteristics for the Wider Internet is Challenging

# Capturing Connection Characteristics for the Wider Internet is Challenging — we want to help!




Passively observed **TCP** connections
(*≈70% of 84M HTTP requests/sec*)

Collected via a 1% uniform sample across our data centers from October 7–15, 2025.

# What's in the Dataset

## What we log

- TCP socket metadata via Linux *TCP_INFO* struct (port 80/443)
  - Aligns with RFC 4898 (TCP Extended Statistics MIB)
- Application-layer metadata statistics
  - Number of HTTP requests
  - Duration of connection

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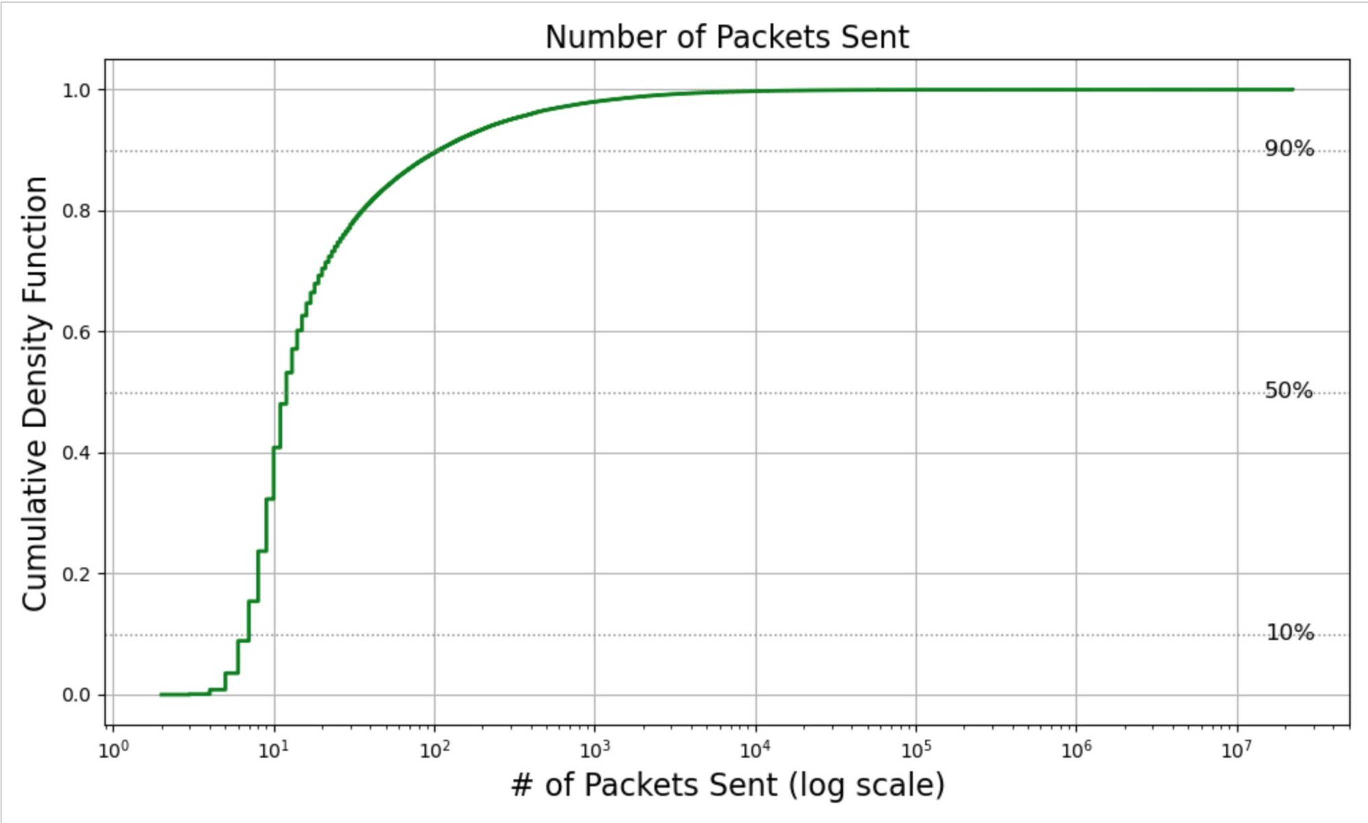
~11% of FIN-closed connections filtered as idle/non-HTTP

# Packet Counts from Cloudflare to Clients



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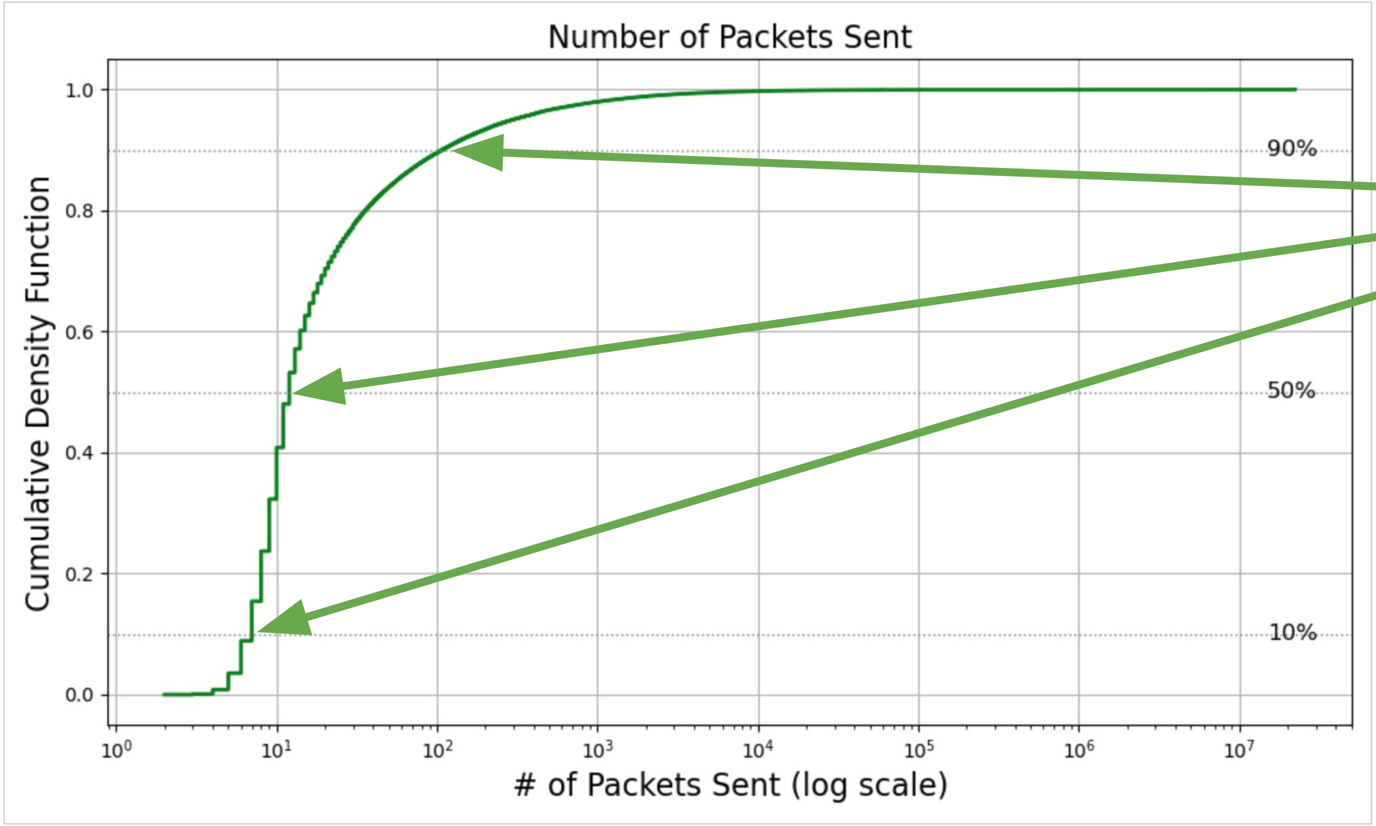


**All connections**

**90th**: 107 packets

**Median**: 12 packets

**10th**: 7 packets

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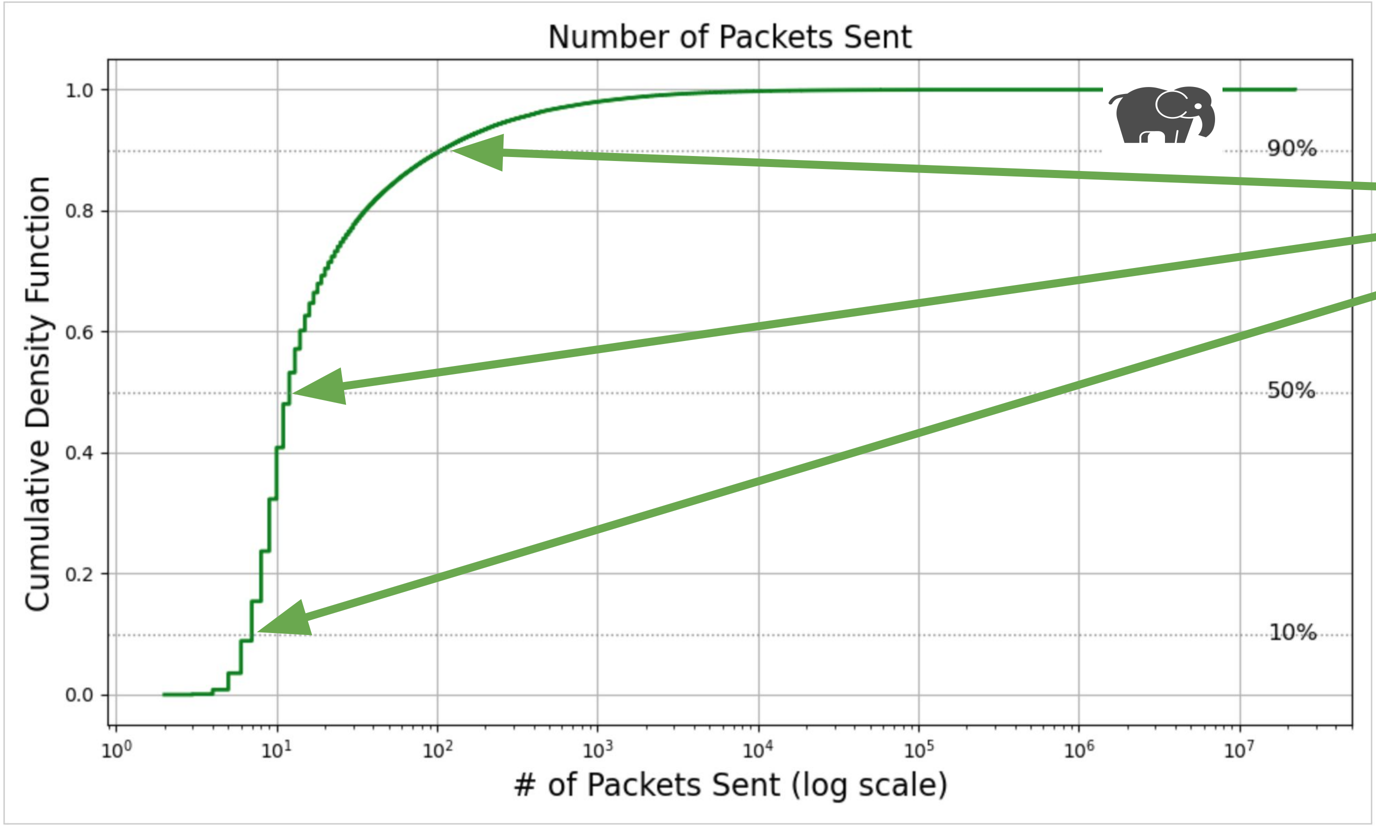


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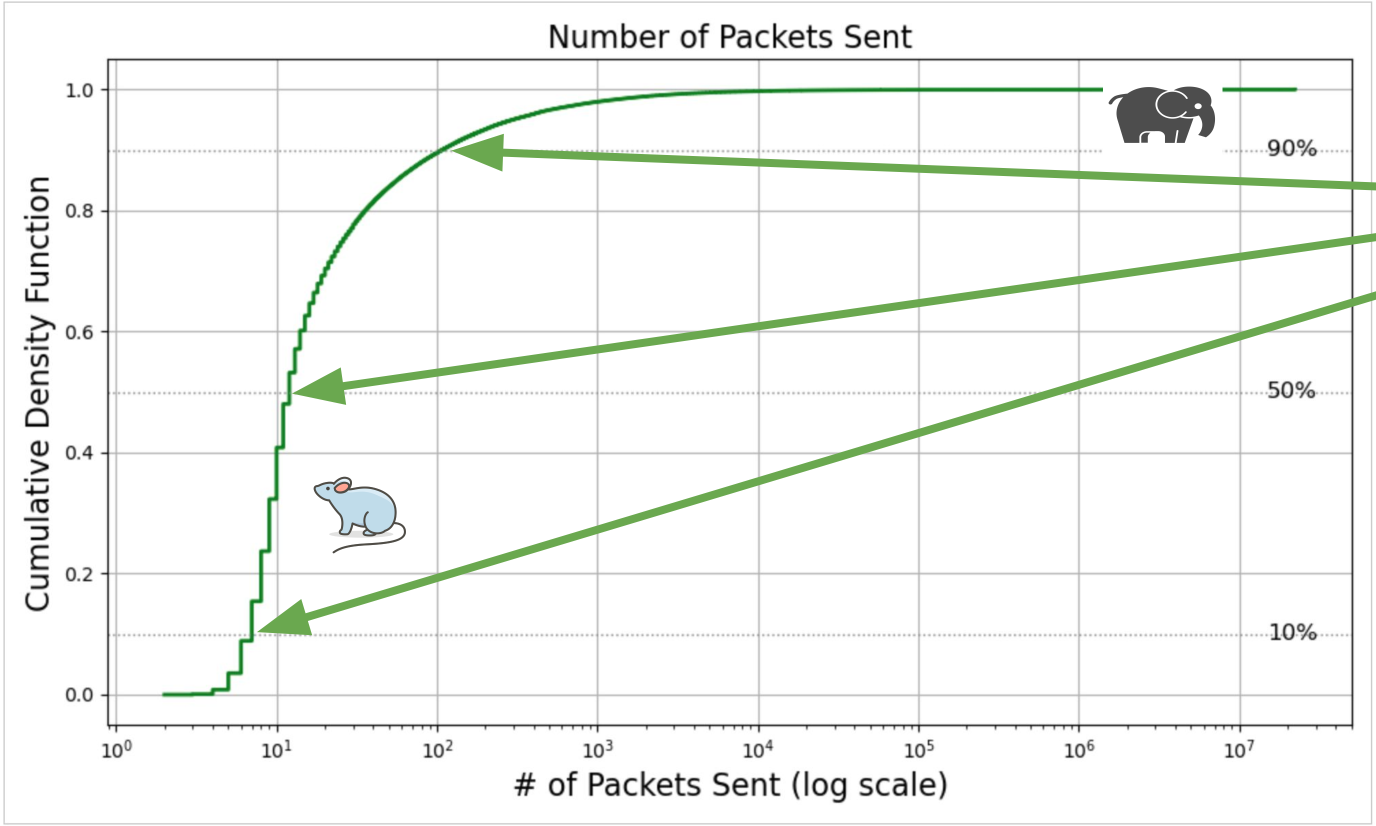


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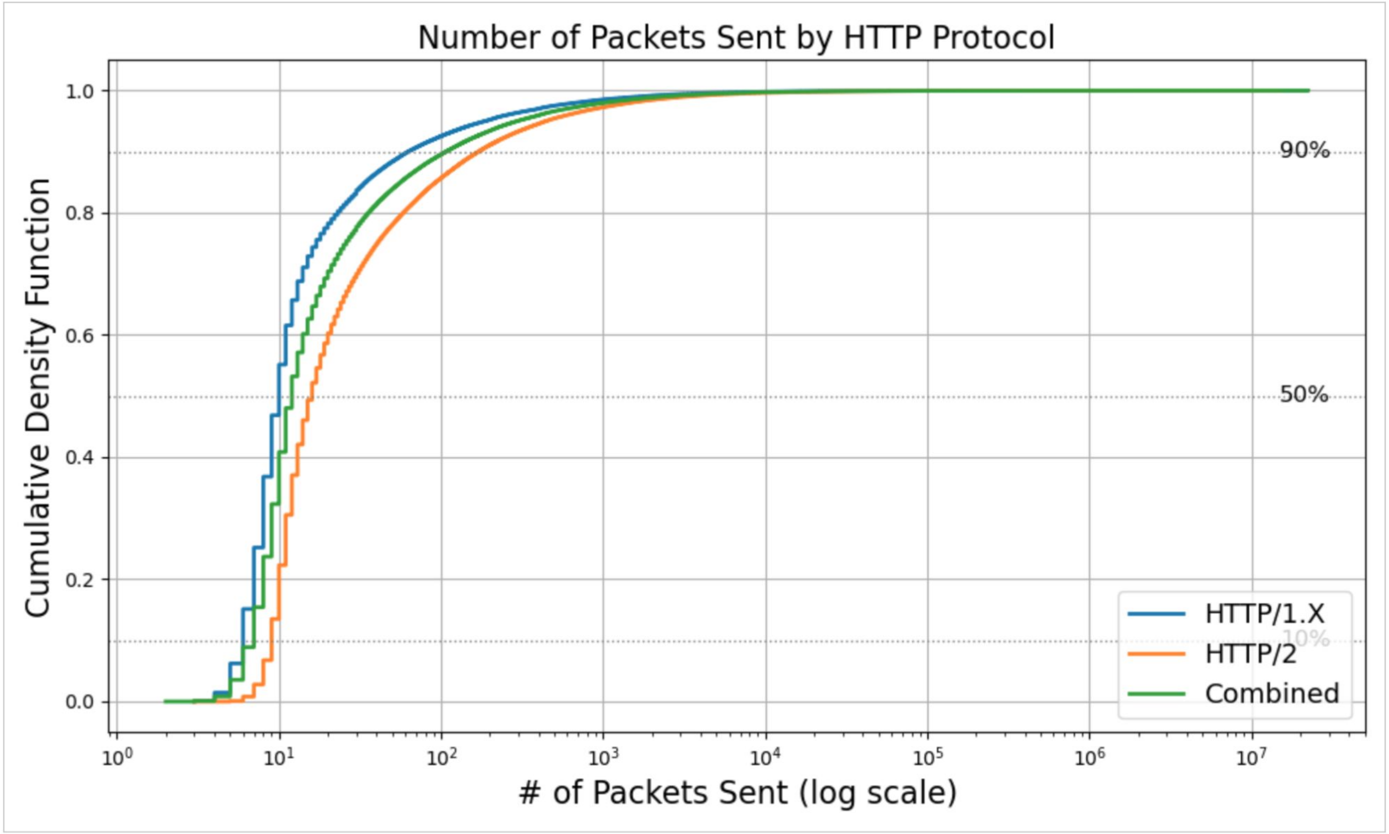
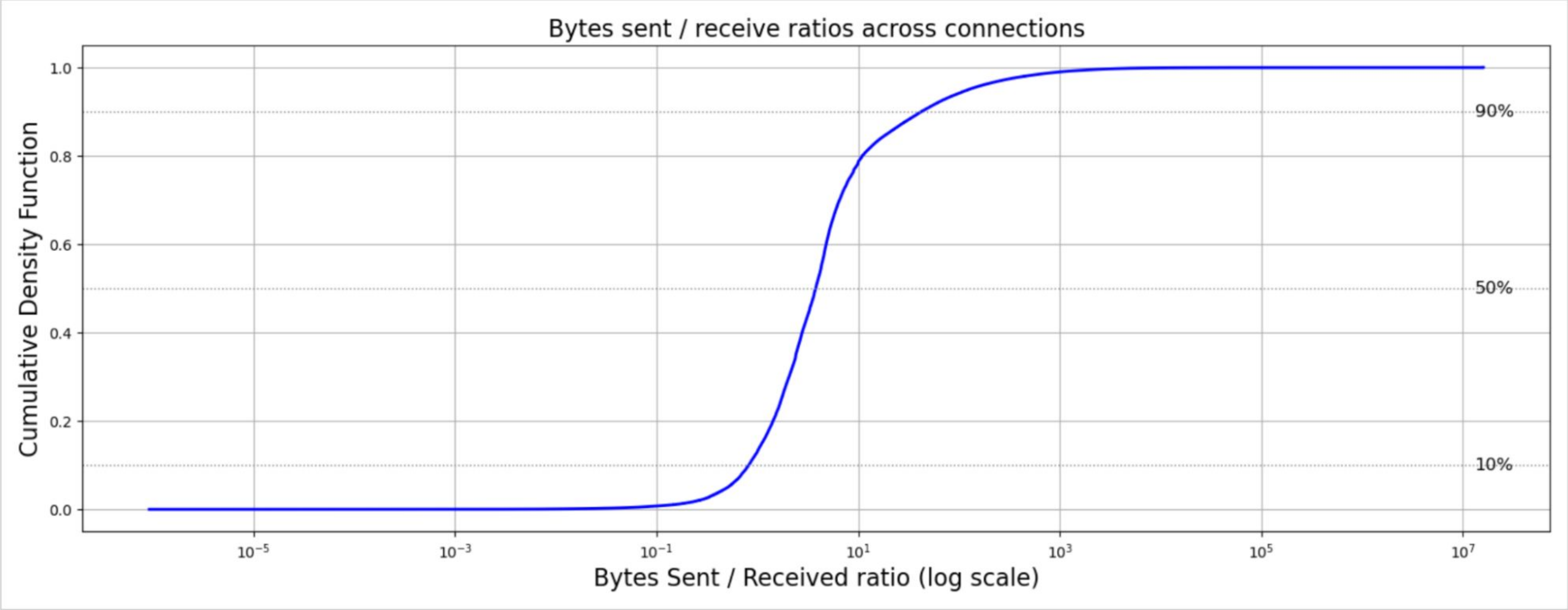



**All connections**
**90th**: 107 packets
**Median**: 12 packets
**10th**: 7 packets

**HTTP 1.0 & 1.1 only**
**90th**: 63 packets
**Median**: 10 packets
**10th**: 6 packets

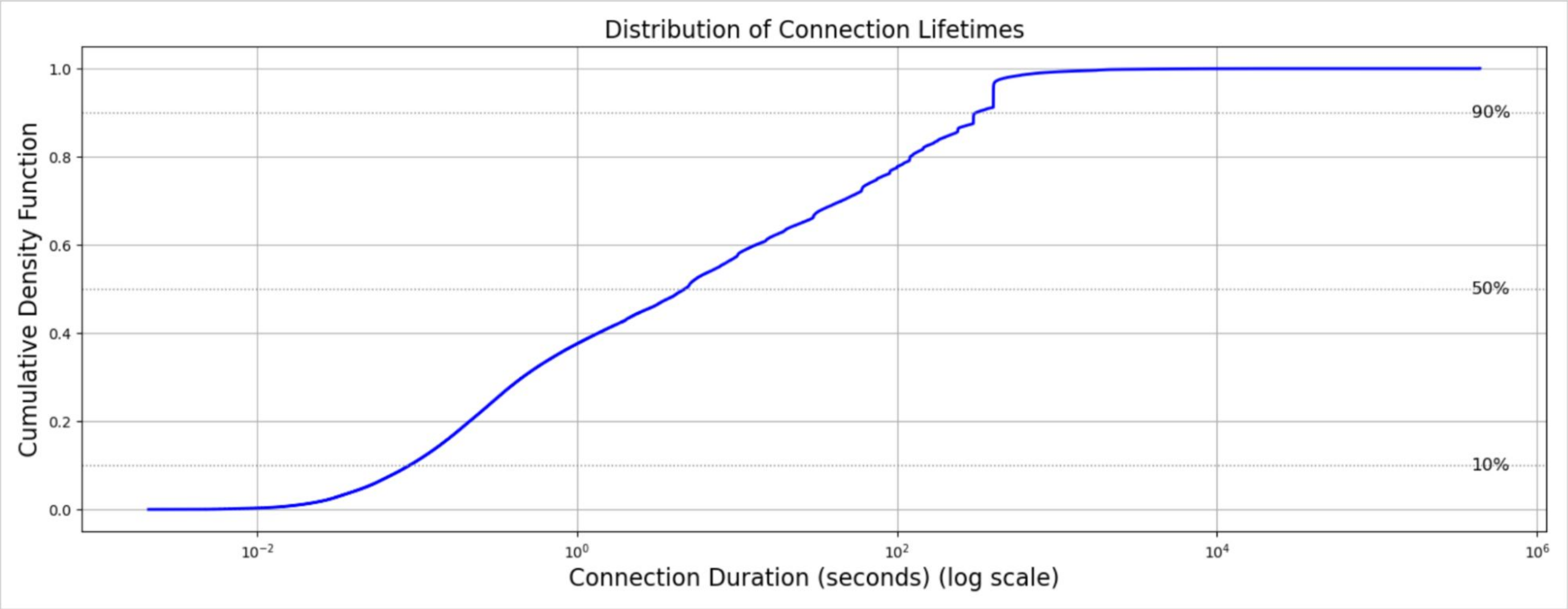
**HTTP/2 only**
**90th**: 170 packets
**Median**: 16 packets
**10th**: 9 packets

# Download-to-Upload Bytes Ratio



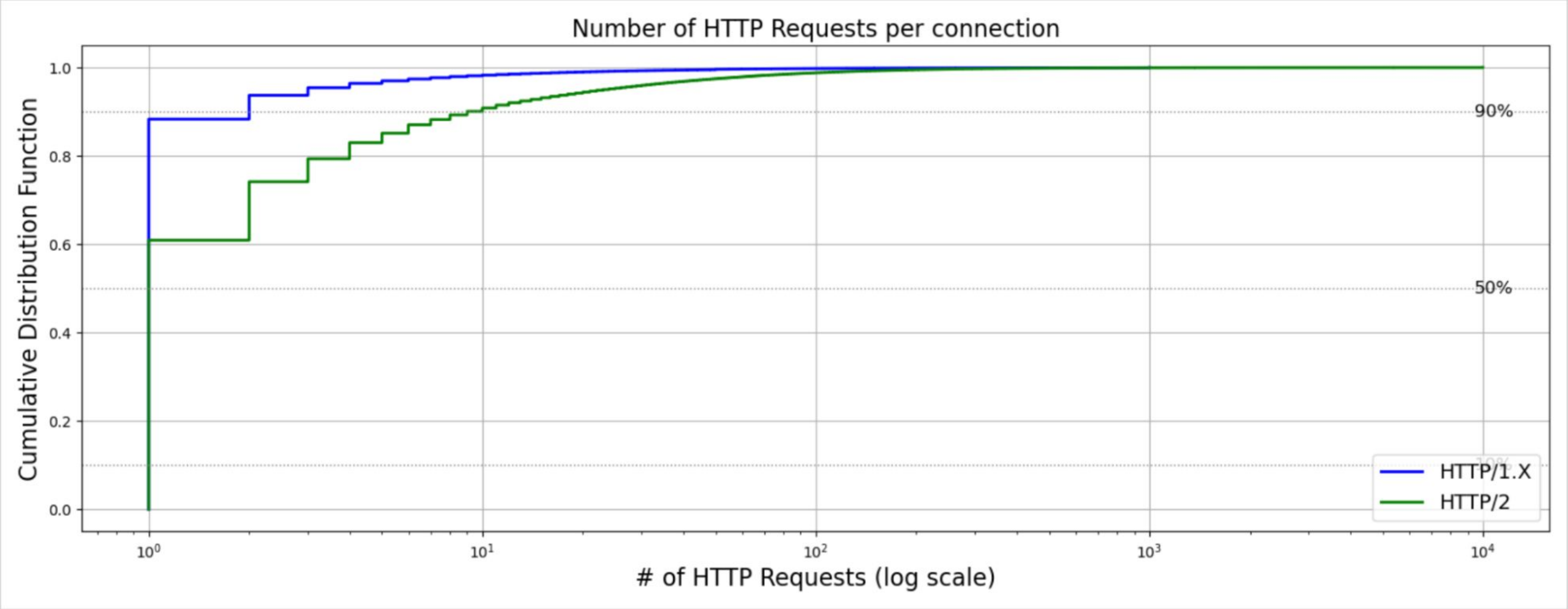

**Median ratio** is 3.8; **Mean** is far higher at 81.1; **Most connections are download-heavy**

# How long do connections last?



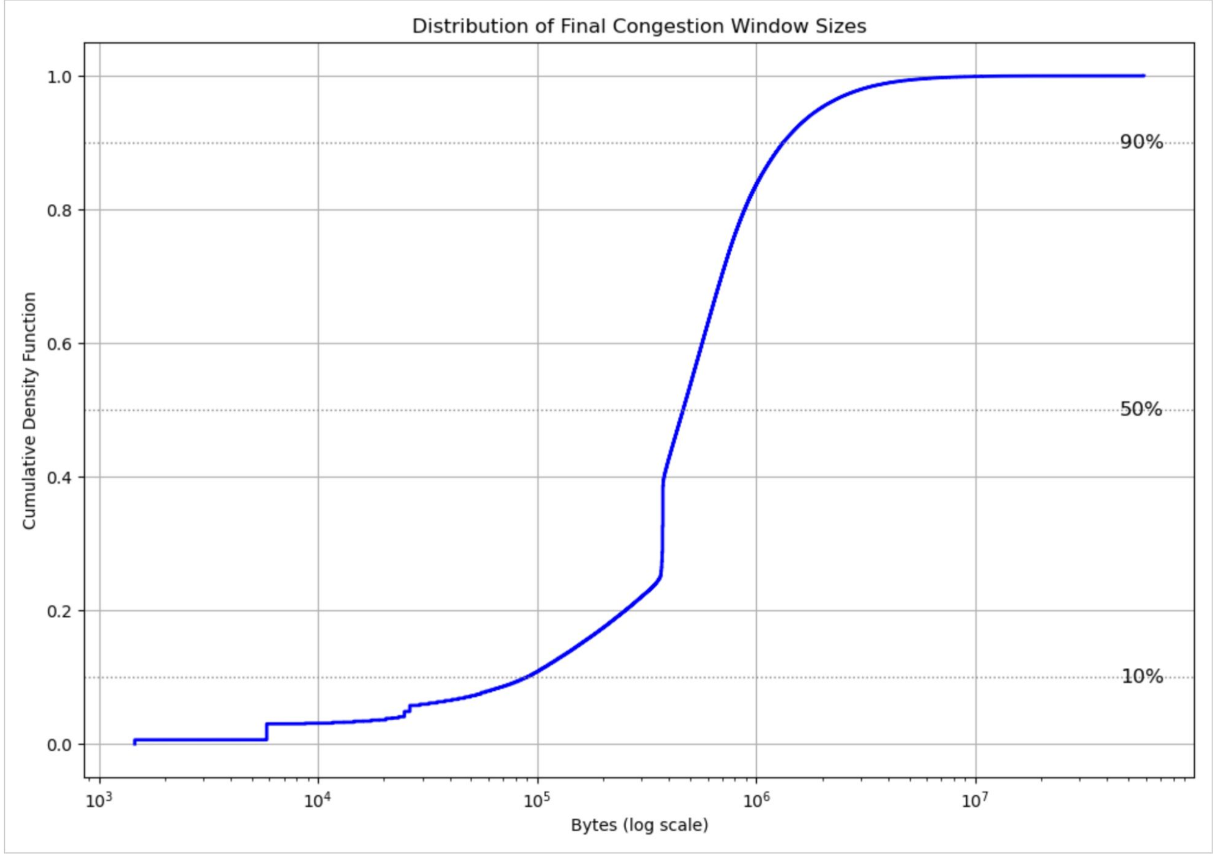

**Median**: 4.7 sec; **Mean**: 96 sec; **10th percentile**: 0.1 sec; **90th percentile**: 300 sec

# Number of HTTP Requests per Connection




**HTTP/1.X: ~90% of connections carry one request**
**HTTP/2: ~60% of connections carry one request**

# Inferring path characteristics: Congestion Window Sizes




- CWND measured at slow-start exit (transition to congestion avoidance) — as calculated by BBR.
- Median 464 KB → with 1500 MTU ~310 packets.
  - Reflects diverse paths; end-user connections and well-provisioned inter-datacenter links.
- High values: BBR inflates CWND by design to cater for network anomalies.

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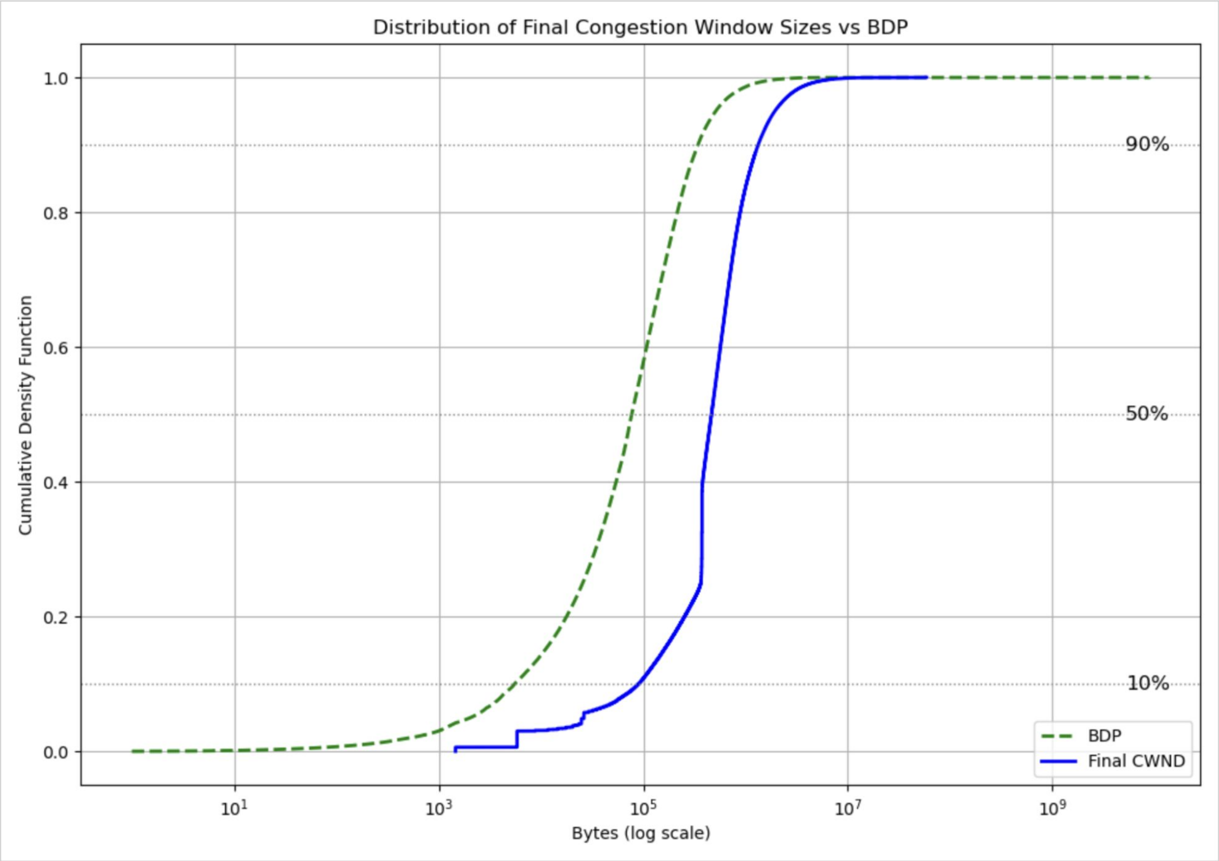


- Median BDP ~77 KB (~50 packets), much lower than median CWND.

- Insights inform reasonable *Initial CWND* sizes; which can impact performance 30–40% for small connections.
  - Revisit long-standing default of 10 packets (RFC 6928)?

# Insights & Takeaways

- **Heterogeneous connections**: Internet traffic shows strong heavy-tail behavior—“elephants and mice” phenomenon.
- **Asymmetric flows**: Download-to-upload byte ratios are high for large flows, but surprisingly small for short flows.
- **Connection Lifetimes**: Majority of web traffic remains short, bursty, and transient.

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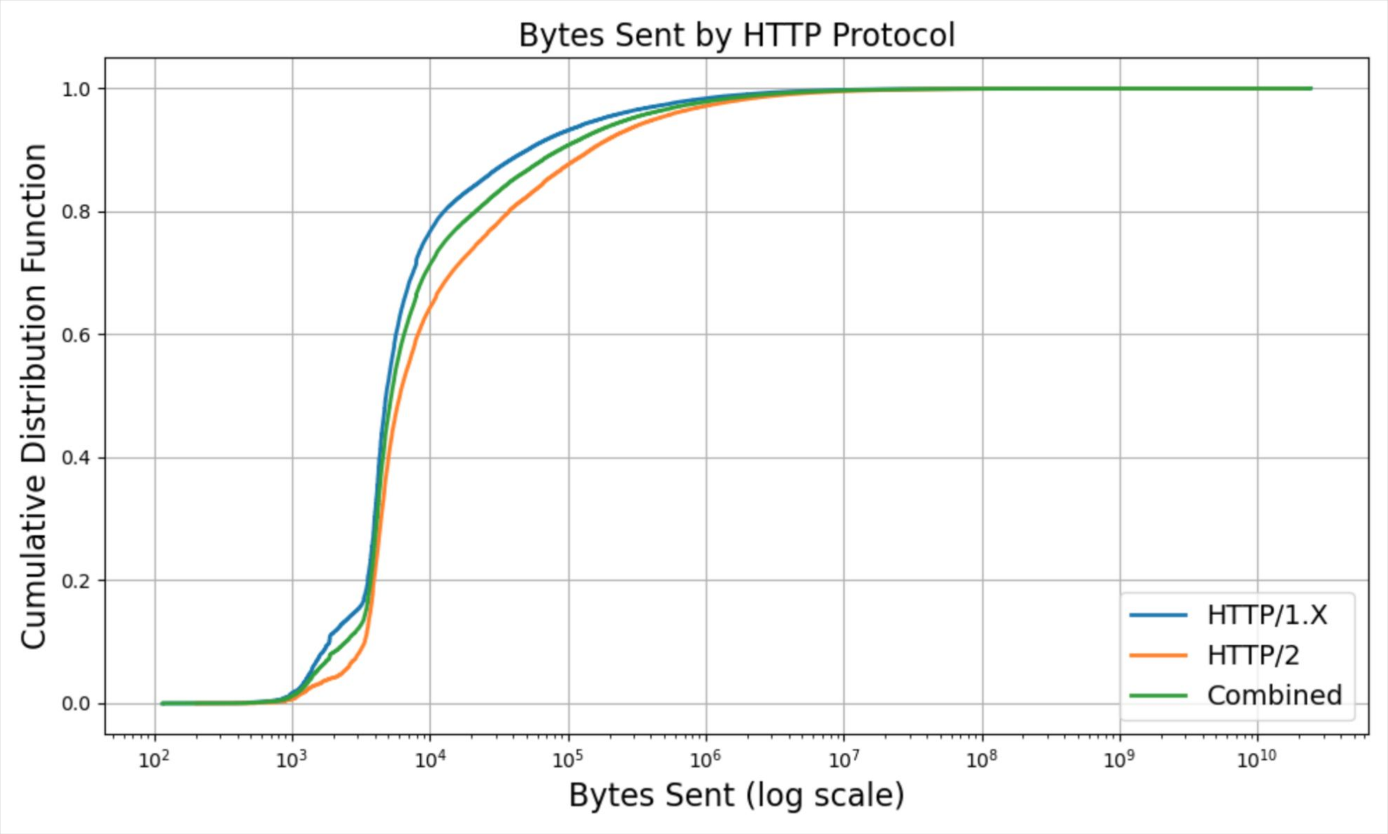
- **Connection Lifetimes**: Majority of web traffic remains short, bursty, and transient.

More details: https://blog.cloudflare.com/measuring-network-connections-at-scale/

Questions, ideas or feedback? Reach out at: ask-research@cloudflare.com

# BACKUP SLIDES

# Bytes Sent from Cloudflare to Clients




**All connections**

**90th**: 86 KB
**Median**: 5.2 KB
**10th:** 1.9 KB

**HTTP 1.0 & 1.1 only**

**90th**: 51 KB
**Median**: 4.8 KB
**10th:** 2.5 KB

**HTTP/2 only**

**90th**: 146 KB
**Median**: 6 KB
**10th:** 3.4 KB