BOLT
Sub-RTT Congestion Control for Ultra-Low Latency

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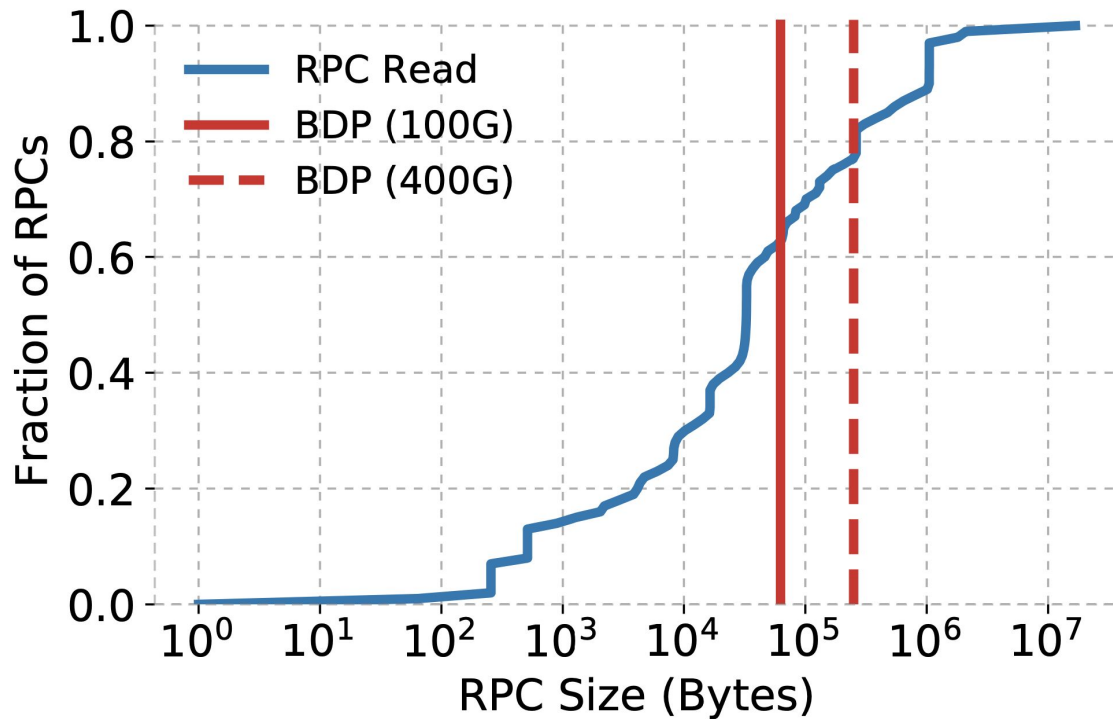
Bandwidth-Delay-Product is increasing!

RPC Sizes in Our Data Centers

How Would a CC Oracle Behave?

Detect **precise amount and location** of congestion,

act **instantaneously**.

Challenges:

Fine-Grained Feedback	Minimal Feedback Delay

Minimizing the Feedback Delay

Two Components:

1. Congestion Notification Delay

2. Under-Utilization Feedback Delay

Challenges:

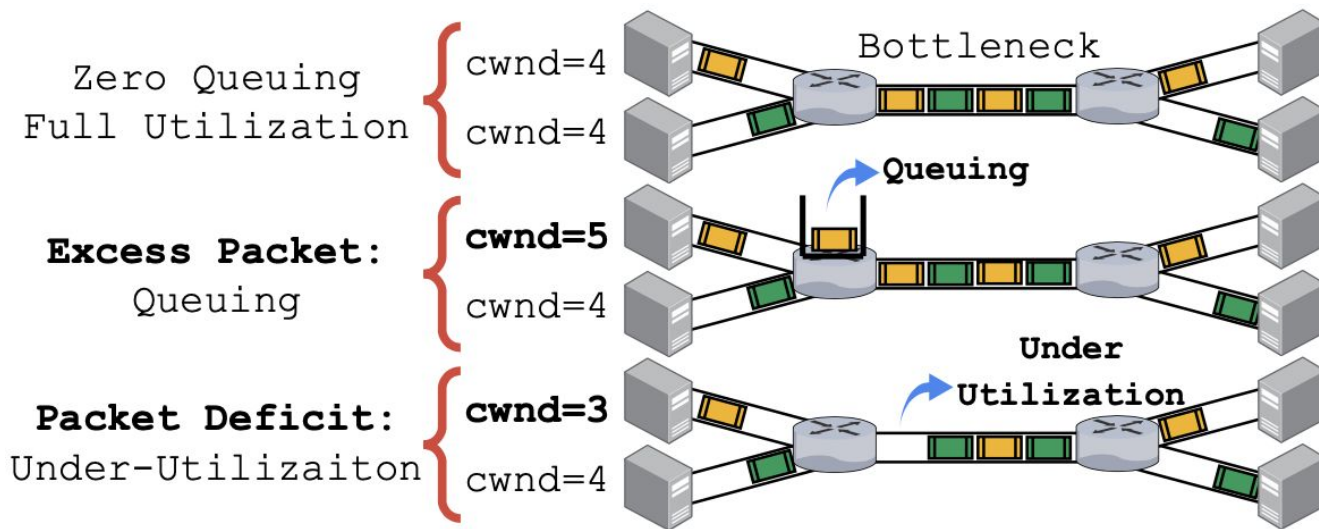| Fine-Grained Feedback	Minimal Congestion Notification Delay	Latent Under-Utilization Feedback Delay

"Bolt Addresses All of These"

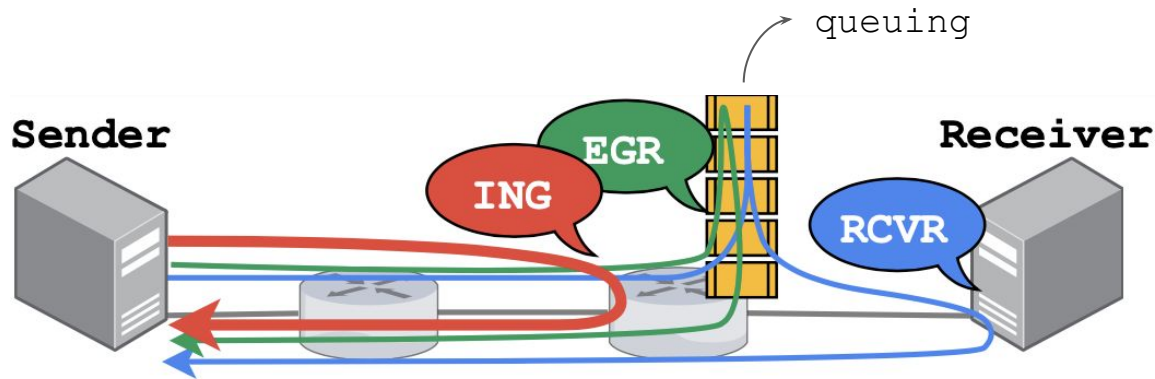| Fine-Grained Feedback	Minimal Congestion Notification Delay	Latent Under-Utilization Feedback Delay

Underlying Model

Packet Conservation Principle

| Fine-Grained Feedback | Minimal Congestion Notification Delay | Latent Under-Utilization Feedback Delay |

Sub-RTT Control (SRC)

queuing

Sender

ING EGR RCVR

Receiver

Decrease **congestion notification delay** to its absolute minimum
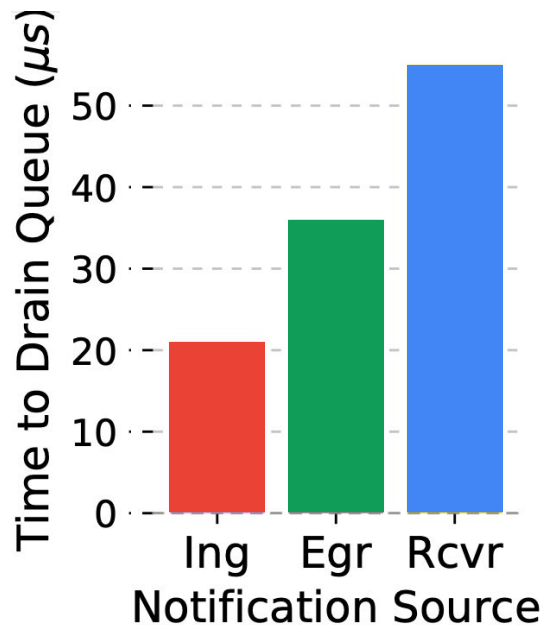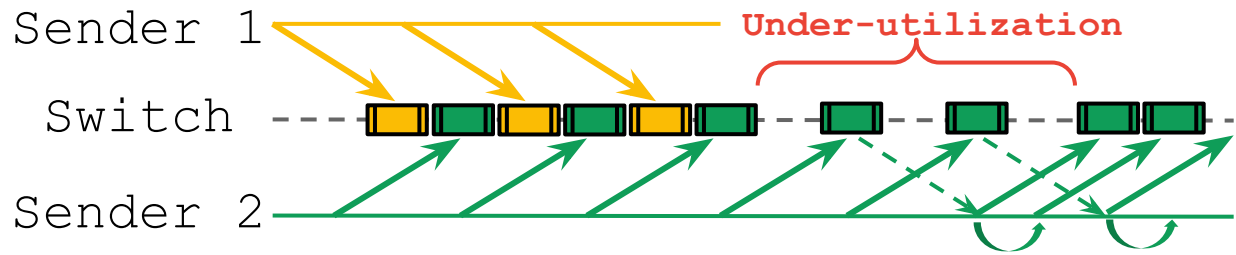
Time to Drain Queue (µs)

Ing Egr Rcvr
Notification Source

Fine-Grained Feedback	Minimal Congestion Notification Delay	Latent Under-Utilization Feedback Delay

Sender 1

Under-utilization
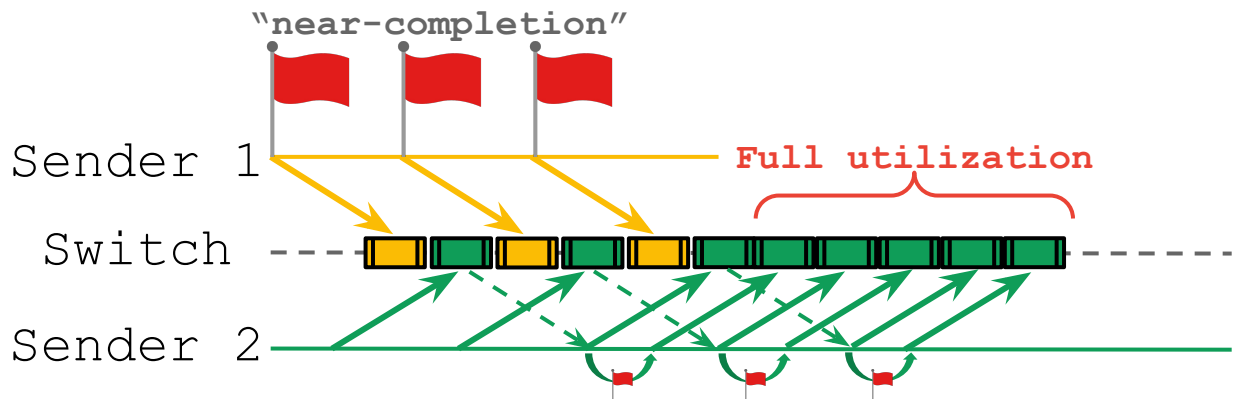
Switch

Sender 2

Fine-Grained Feedback	Minimal Congestion Notification Delay	Latent Under-Utilization Feedback Delay

Proactive Ramp-Up (PRU)

Hides **under-utilization feedback delay**

Fine-Grained Feedback	Minimal Congestion Notification Delay	Latent Under-Utilization Feedback Delay

Evaluations

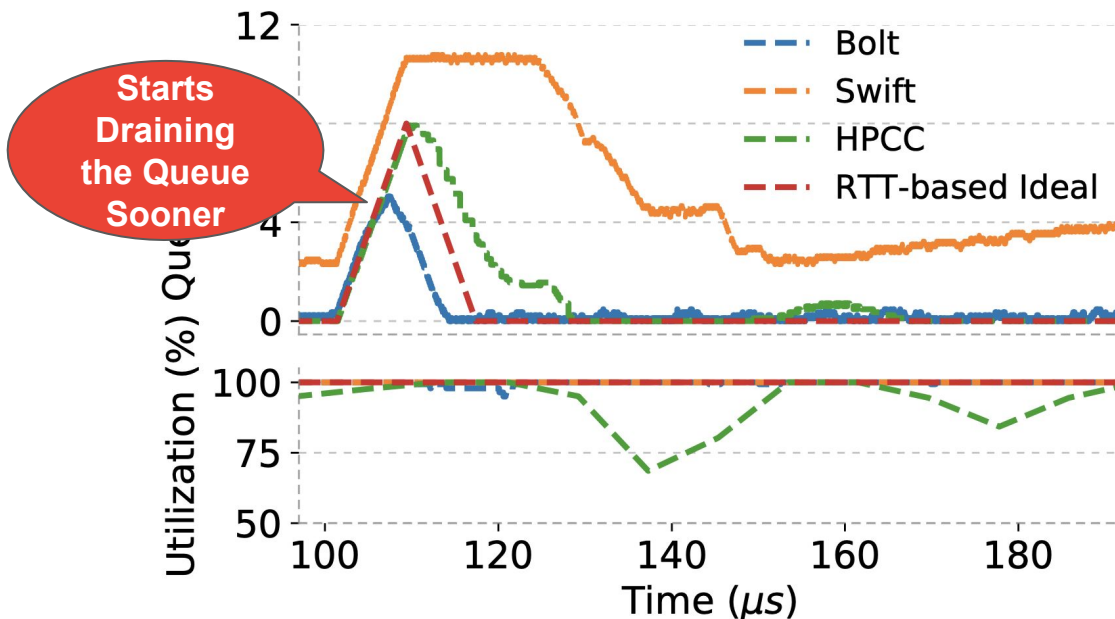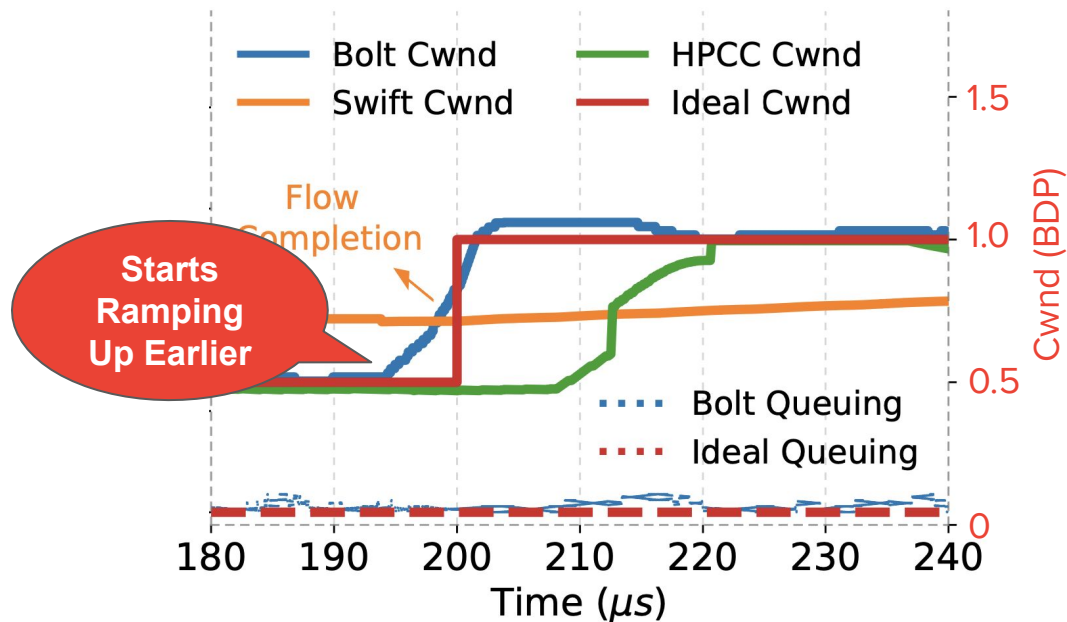Bolt's reaction to **flow arrival** versus the ideal behavior

| Fine-Grained Feedback | Minimal Congestion Notification Delay | Latent Under-Utilization Feedback Delay |

Evaluations

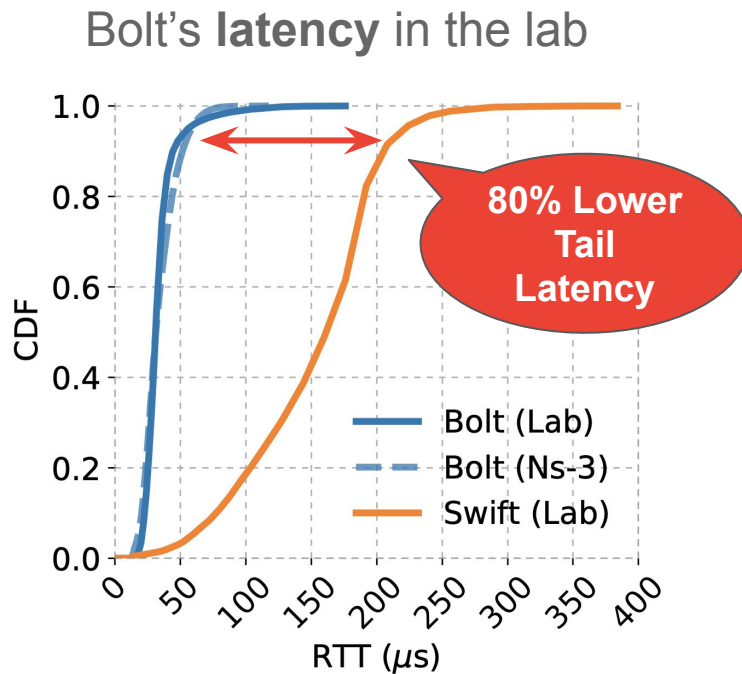Bolt's reaction to **flow completion** versus the "ideal" behavior

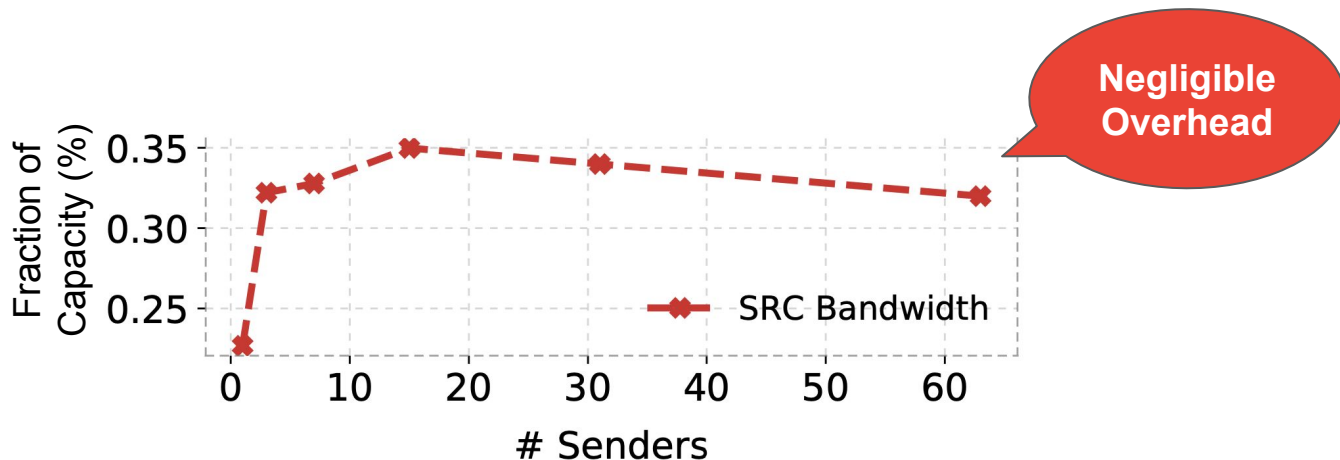| Fine-Grained Feedback | Minimal Congestion Notification Delay | Latent Under-Utilization Feedback Delay |

Evaluations

Bolt's **latency** in the lab

80% Lower Tail Latency

Bolt (Lab)
Bolt (Ns-3)
Swift (Lab)

Fine-Grained Feedback	Minimal Congestion Notification Delay	Latent Under-Utilization Feedback Delay

Evaluations

SRC **Overhead** for different levels of burstiness

Negligible Overhead

Fine-Grained Feedback	Minimal Congestion Notification Delay	Latent Under-Utilization Feedback Delay

Evaluations

Bolt's overall performance on a **cluster**
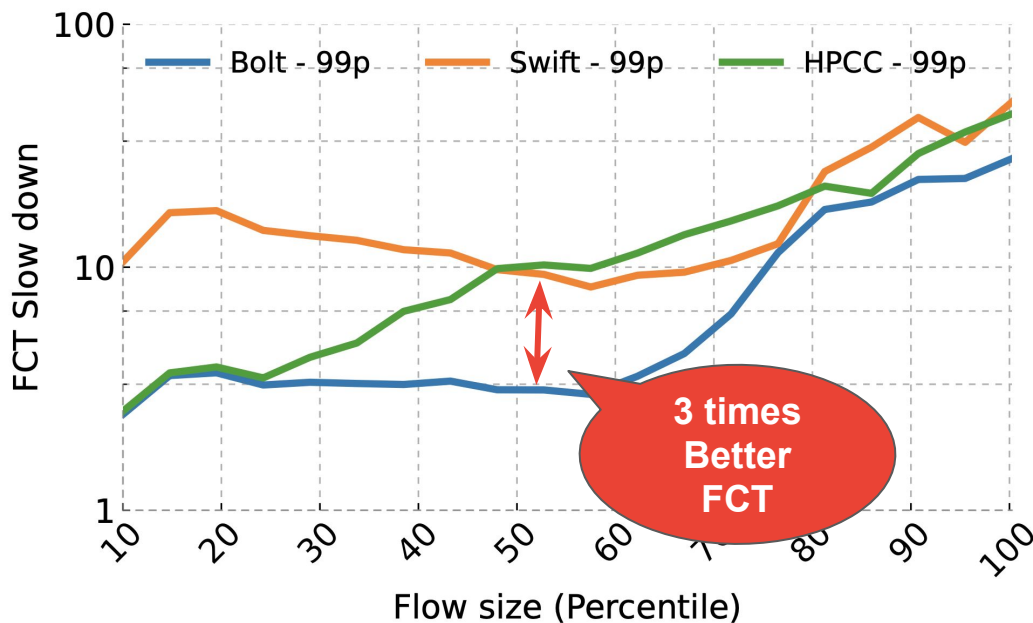
| Fine-Grained Feedback | Minimal Congestion Notification Delay | Latent Under-Utilization Feedback Delay |

Key Takeaways

- **Bolt** pushes CC towards its limits via:

  - The most **fine-grained feedback**

  - The absolute **minimum congestion notification delay** (SRC)

  - **Latent under-utilization feedback delay** (PRU)

- Results:

  - **80%** reduction in tail queuing

  - **3X** improvement in tail FCT

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