Netflix over LEO: Lessons in Adaptive Bitrate and Congestion Control

Renata Teixeira
Netflix

SPACE RG
IRTF Montreal November 2025

Work From SIGMETRICS'25:

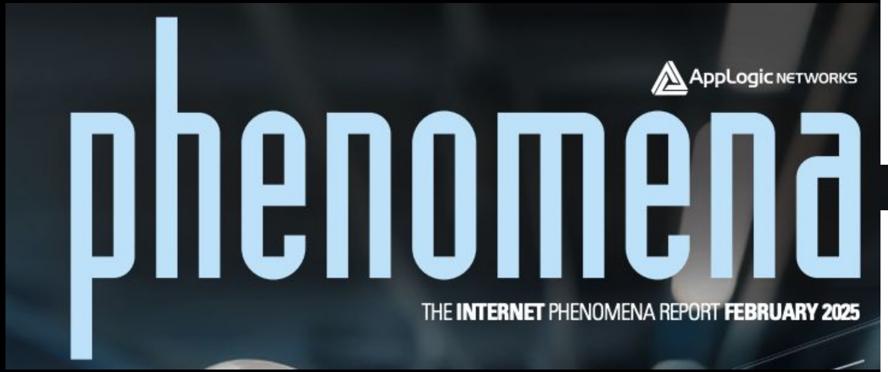
A Global Perspective on the Past, Present, and Future of Video Streaming over Starlink

LIZ IZHIKEVICH, University of California, Los Angeles, USA
REESE ENGHARDT, Netflix, USA
TE-YUAN HUANG, Netflix, USA
RENATA TEIXEIRA, Netflix, USA

Streaming Keeps Growing

Streaming Cranks Up the Heat in July, Accounts For Nearly Half of All TV Viewing in Nielsen's The Gauge™

Nielsen



"video remains the largest application category by volume"

"The top ten traffic days in 2024 all coincided with a live streaming sporting event"

Millions rely on LEO… with more to come

/ NEWS / INSIGHTS STARLINK SPACEX

Starlink Crosses 7 Million Subscribers Globally

What does it mean for the global internet?

by Ogbonda Chivumnovu Updated September 16, 2025

Project Kuiper mission updates: 150+ satellites in orbit following sixth successful launch

Oct. 13, 2025

amazon

How does LEO affect Netflix streaming?

- What is LEO’s role in Netflix video delivery?

- What is LEO’s role in Netflix video delivery?

Streaming over LEO is rapidly rising in popularity, especially in Africa

- What is LEO’s role in Netflix video delivery?
- How good is Netflix on-demand streaming over LEO?

- What is LEO’s role in Netflix video delivery?
- How good is Netflix on-demand streaming over LEO?

Often similar to terrestrial connections… but increased bitrate switches and rebuffers

- What is LEO’s role in Netflix video delivery?
- How good is Netflix on-demand streaming over LEO?
- How can we reduce bitrate switches and rebuffers on LEO?

- What is LEO's role in Netflix video delivery?
- How good is Netflix on-demand streaming over LEO?
- How can we reduce bitrate switches and rebuffers on LEO?

Existing congestion control & adaptive bitrate design principles can partially help, but are not sufficient

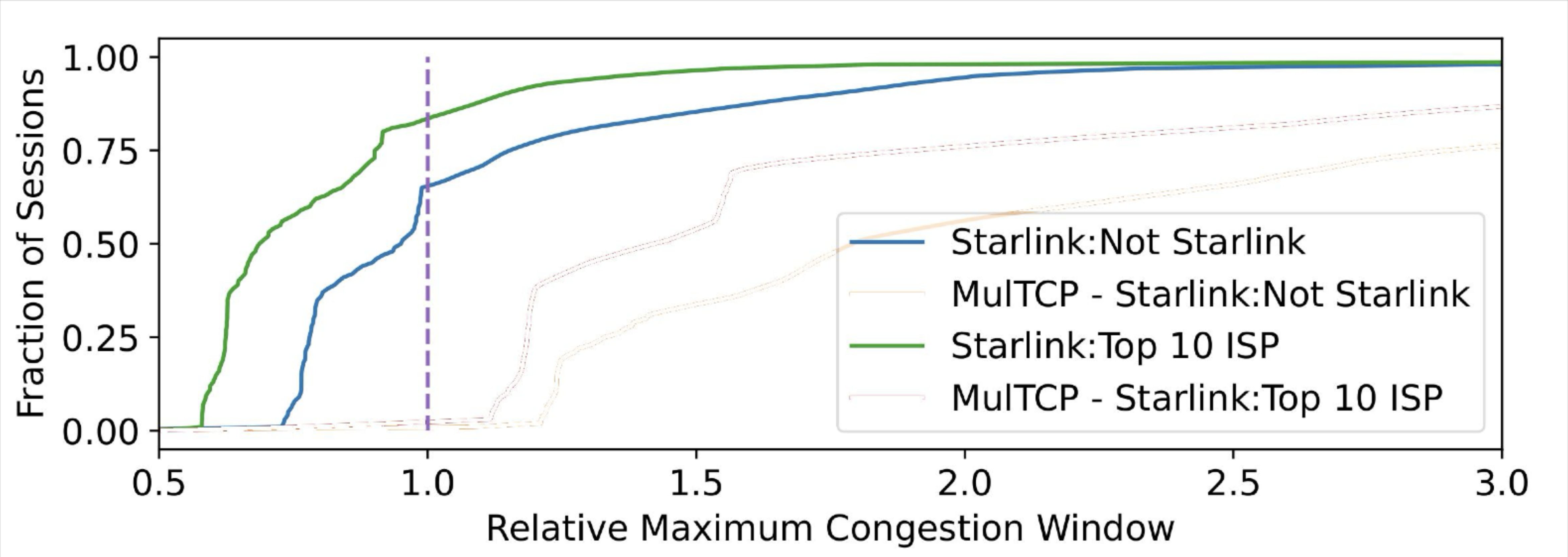
How can we reduce bitrate switches and rebuffers on LEO?

Two levers to adapt to LEO dynamics

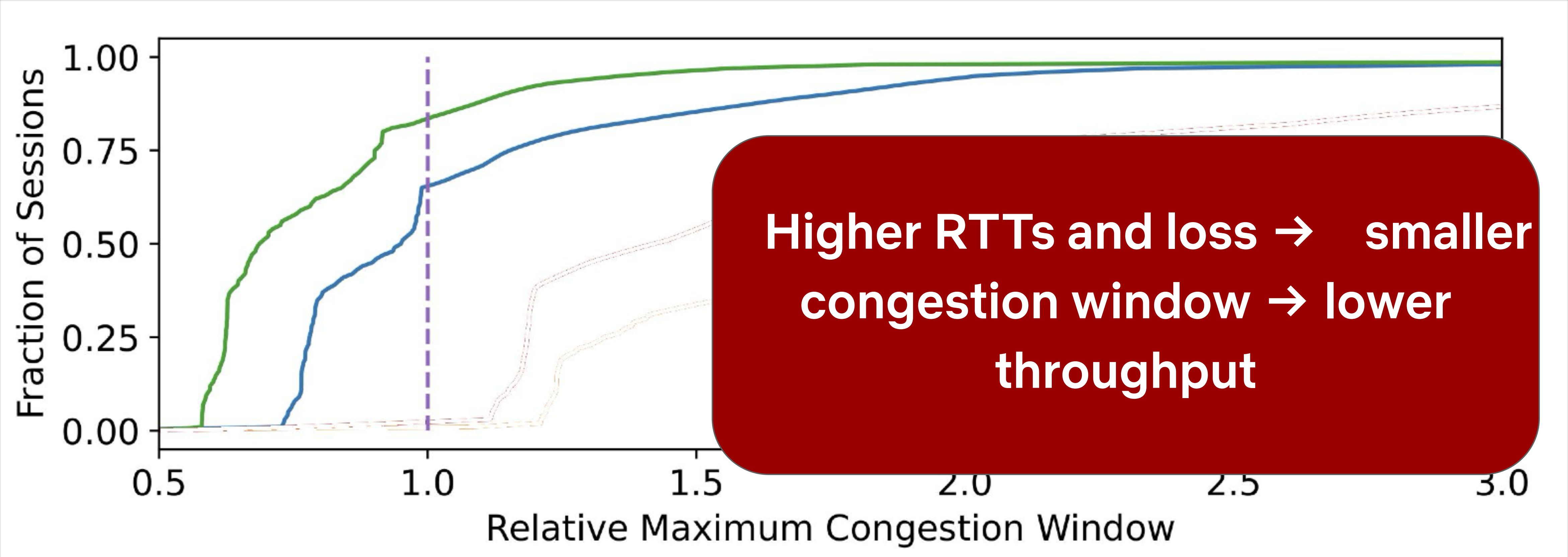
- Congestion control (CC)
  - Controls send rate on the network path
- Adaptive bitrate (ABR)
  - Chooses the video representation (resolution/bitrate)

Improving congestion control for LEO?

TCP NewReno sees smaller congestion windows on LEO



TCP NewReno sees smaller congestion windows on LEO



Can we grow the congestion window to improve throughput?

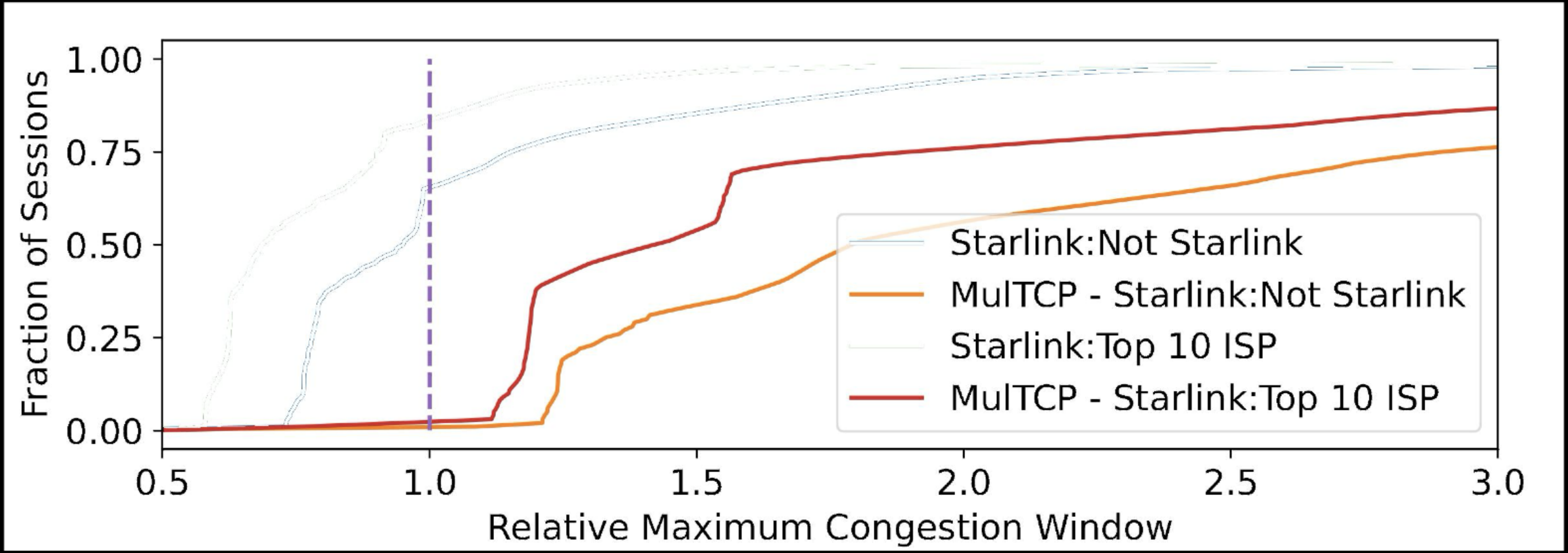
Less reactive congestion control: MulTCP (3 connections)

- Congestion window grows by three bytes for every ACKed byte
- Upon packet loss, window is reduced by one byte

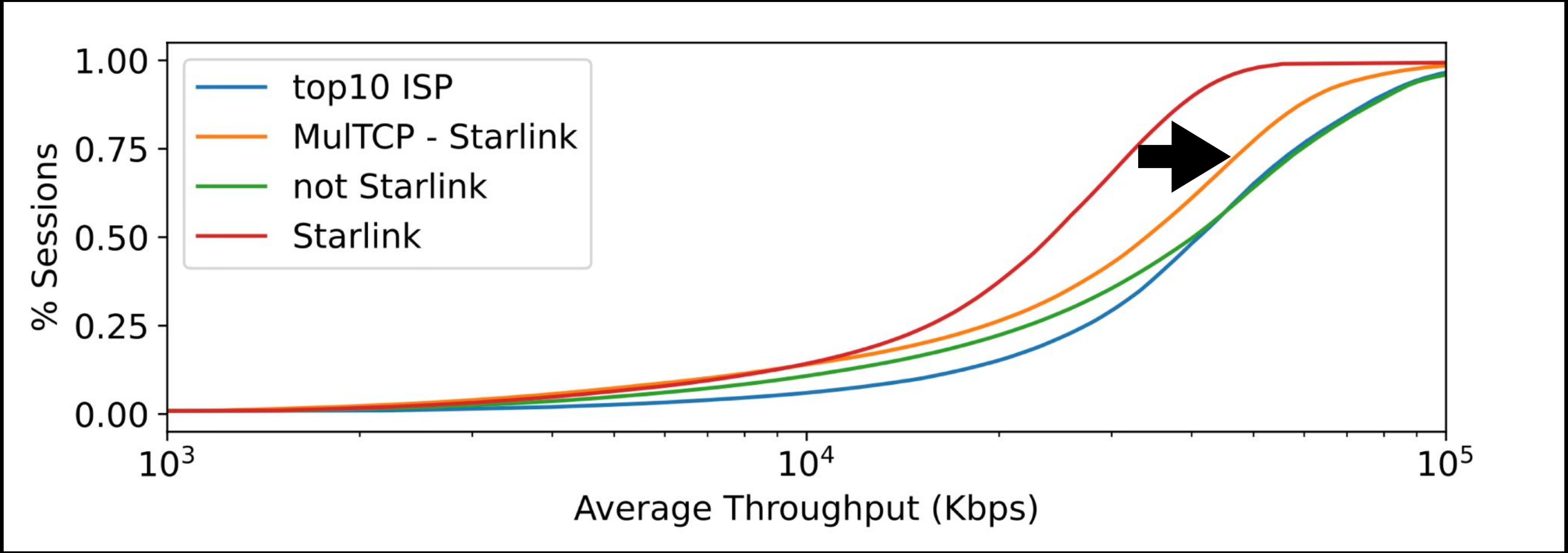
A/B test in April 2024 across 1M+ Starlink households

- 50%: default TCP NewReno
- 50%: MulTCP (3x)

Less reactive CC increases the congestion window on LEO



Less reactive CC increases average throughput on LEO



Less reactive CC has pros and cons

Quality of Experience benefits

- +0.08% to +1% in lower-quantile VMAF
- −7% network rebuffers per hour
- −2% play delay
- −5% bitrate switches

Network performance drawbacks

- Retransmission rates ↑ ~300% on average
- 95th-percentile latency ↑ ~77% on average

Congestion control: What we learned

🔎 Key findings

- Tweaking CC helps, but can’t fully overcome LEO’s high variability
- Tradeoff: more throughput often means more queueing and loss

💡 Implications

- Expect moving bottlenecks and non-congestive losses
- Use rate-based control (e.g., BBR) and pacing
- Explore simple LEO-aware hints

Improving adaptive bitrate for LEO?

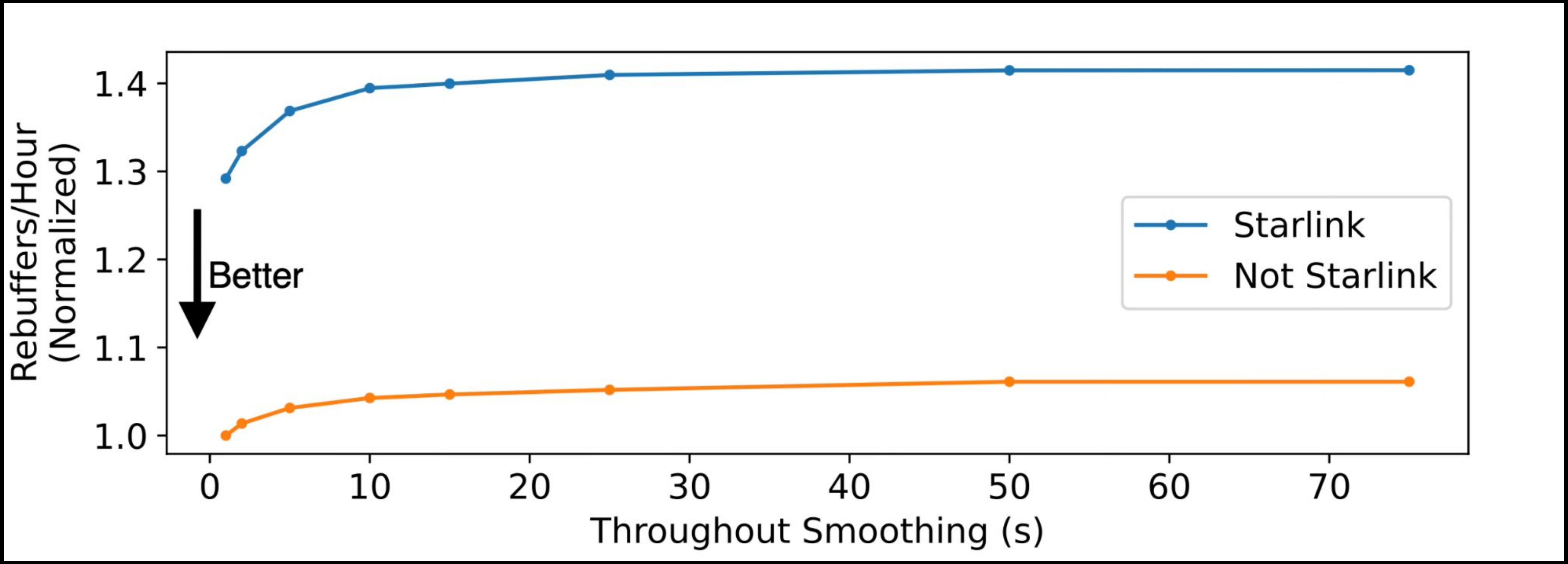
Adaptive Bitrate (ABR) parameters

- Throughput discount: pick a bitrate below measured throughput
- Low-buffer threshold: when buffer < threshold, apply extra discount
- Throughput smoothing: summarize past throughput with an EWMA

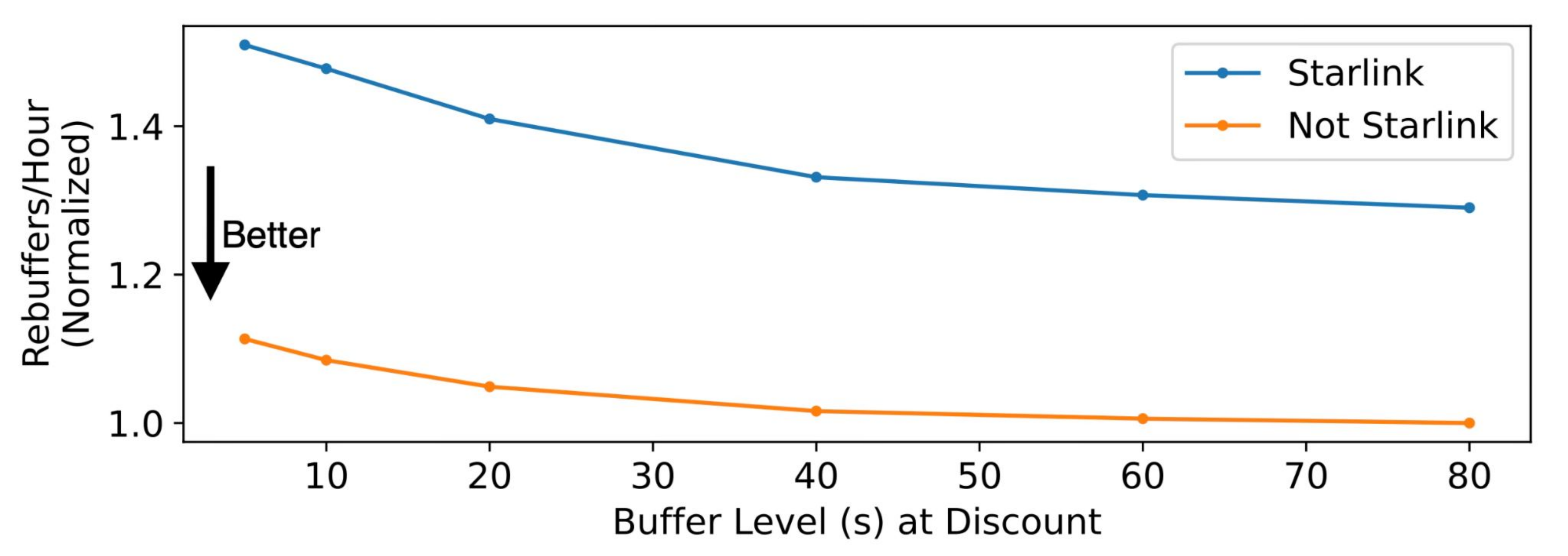
Can we tune these for LEO to reduce switches and rebuffers?

- Simulations with 500K Starlink and 500K non-Starlink sessions across parameter sweeps
- A/B tests with 300K Starlink households confirm the trends

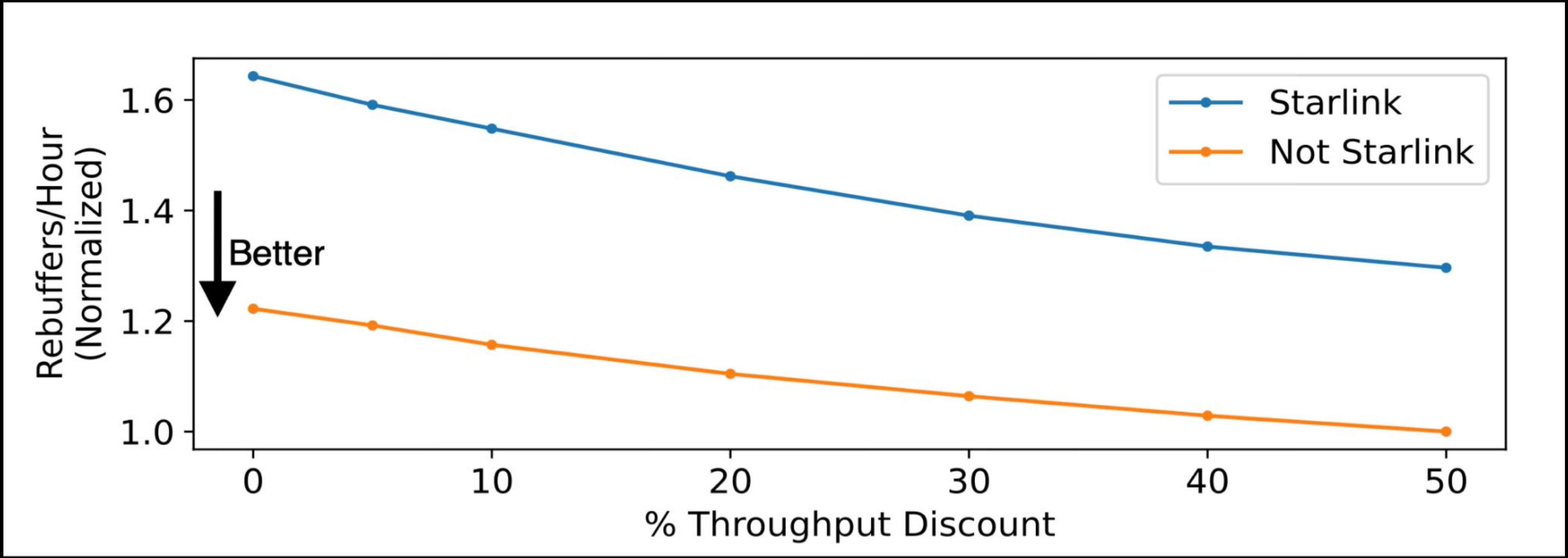
Smoothing helps, but LEO's rebuffer rate remains higher



Higher low-buffer threshold helps, but LEO’s rebuffer rate remains higher



Higher throughput discount helps, but LEO's rebuffer rate remains higher



Adaptive bitrate: What we learned

🔎 Key findings

- ABR tuning reduced rebuffers, but increased switches
- Variance (not averages) limits streaming stability on LEO

💡 Implications

- Make ABR variance-aware and improve throughput prediction
- Avoid switching on short-term noise

Conclusion & Next Steps

LEO means high variability

We need systems that expect change and thrive on it

Where should we invest?

- Realistic testing and open benchmarks
- Protocols and apps designed for LEO from day one

Thank You

Questions to rteixeira@netflix.com