Low Orbit, High Impact: What We’ve Learned for Netflix Streaming over LEO

Renata Teixeira
Netflix

IRTF Montreal November 2025

Work From SIGMETRICS’25:

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

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REESE ENGHARDT, Netflix, USA
TE-YUAN HUANG, Netflix, USA
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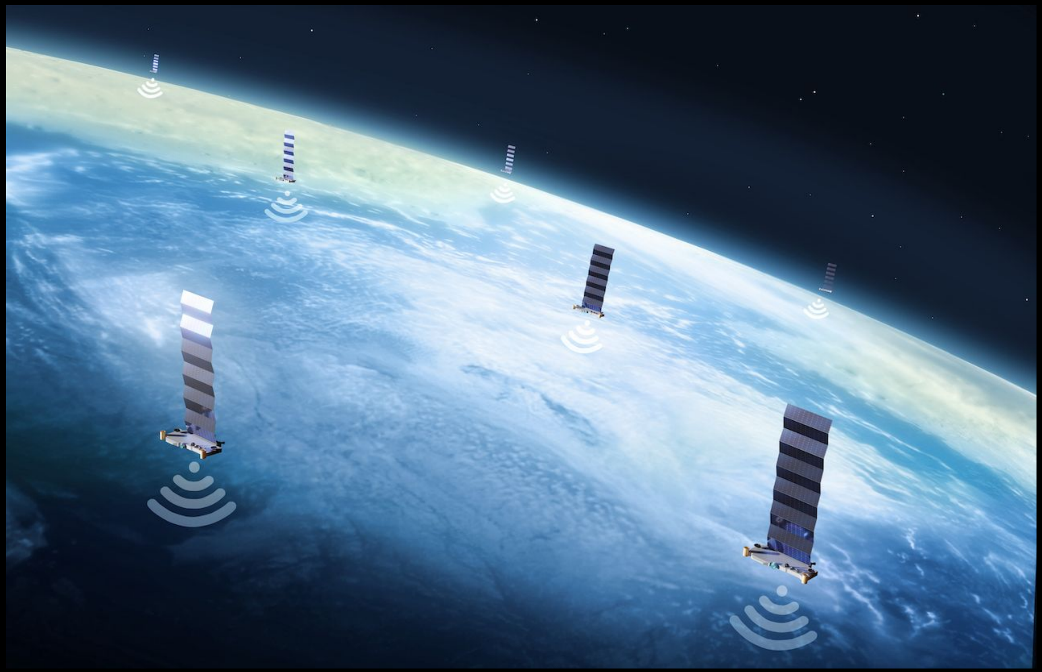
Low Earth Orbit (LEO) Satellite Networks



LEO Satellites work in constellations (e.g., 100s-1000s satellites)

- High global coverage

LEO satellites orbit 300km - 2000km from Earth

- Low Latency: minimum RTT (~10ms), bounded by the speed of light

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

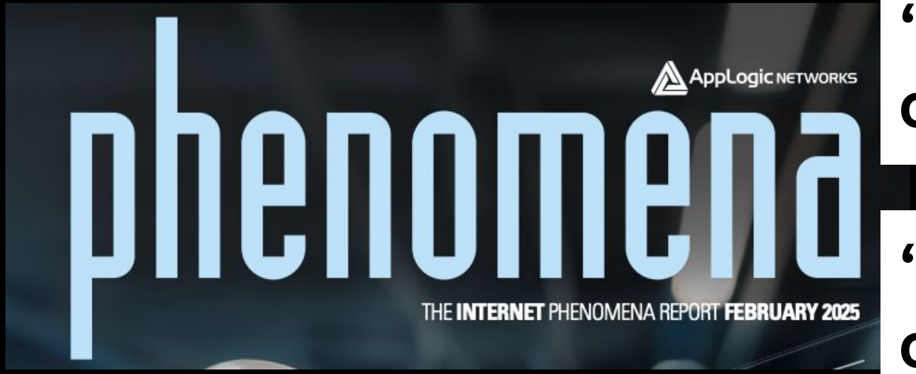
Oct. 13, 2025

amazon

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"

How does LEO affect Netflix streaming?

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

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

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- How good is Netflix on-demand streaming over LEO?

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

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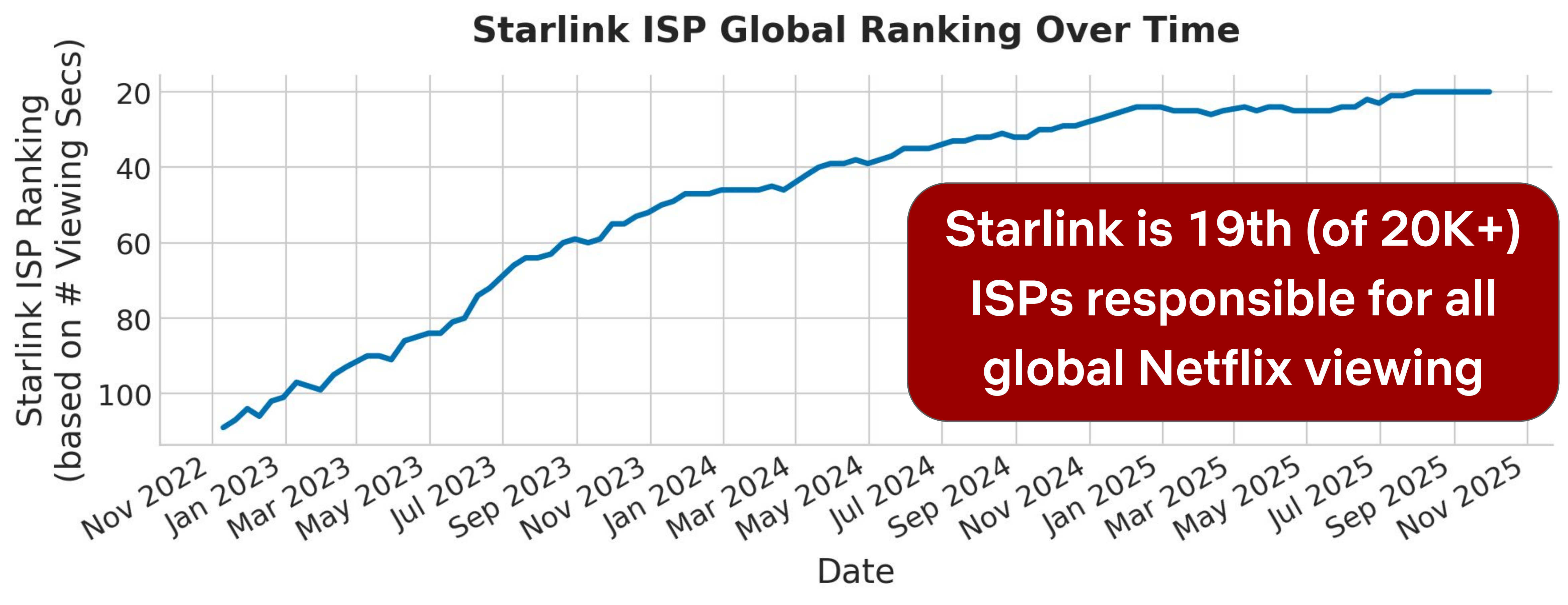
Existing congestion control & adaptive bitrate design principles can partially help, but are not sufficient

- 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 are the research opportunities for LEO streaming?

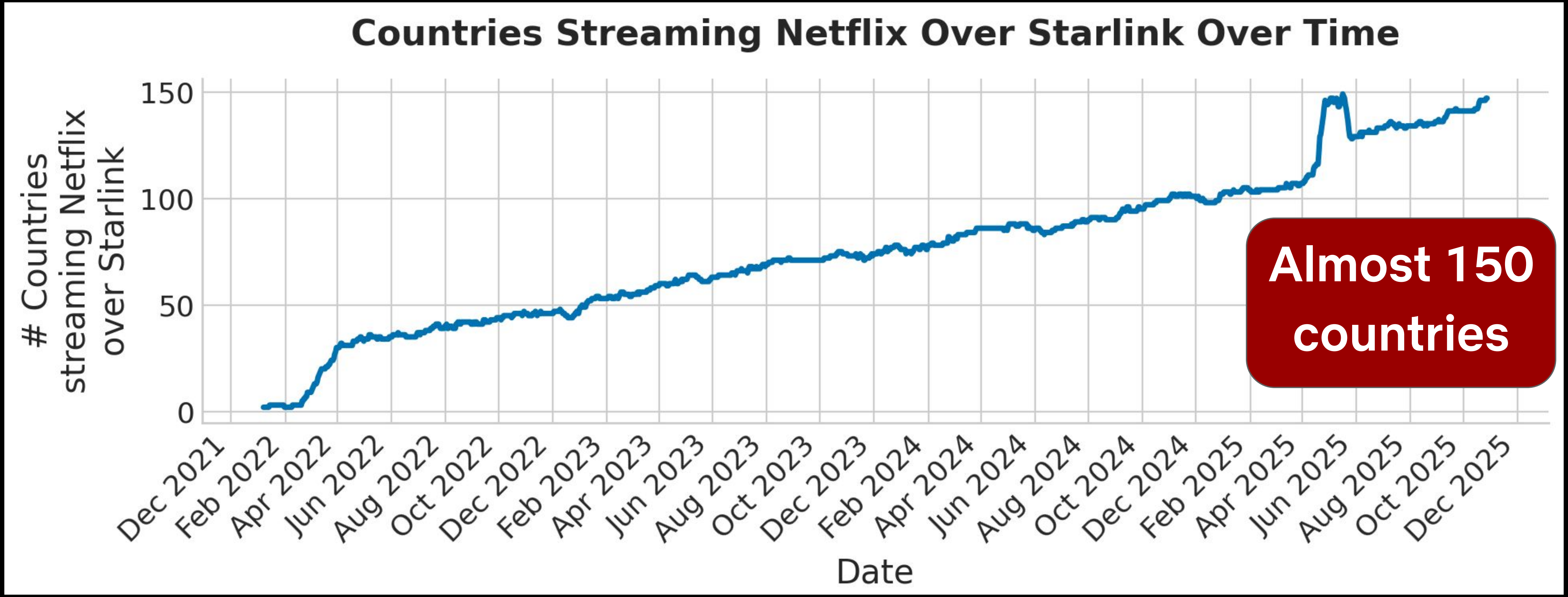
What is LEO’s role in Netflix video delivery?

LEO is growing in popularity

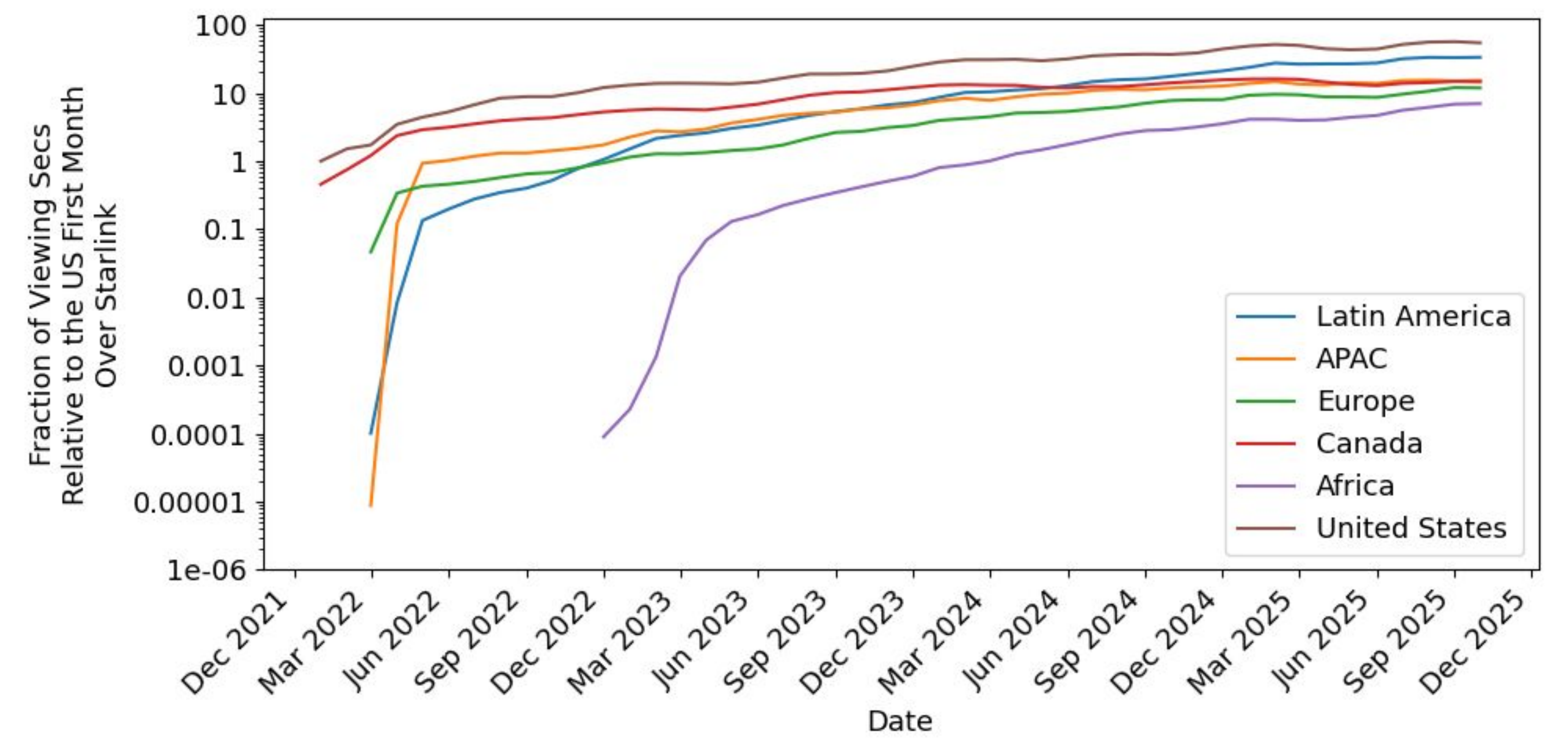


Starlink is 19th (of 20K+) ISPs responsible for all global Netflix viewing

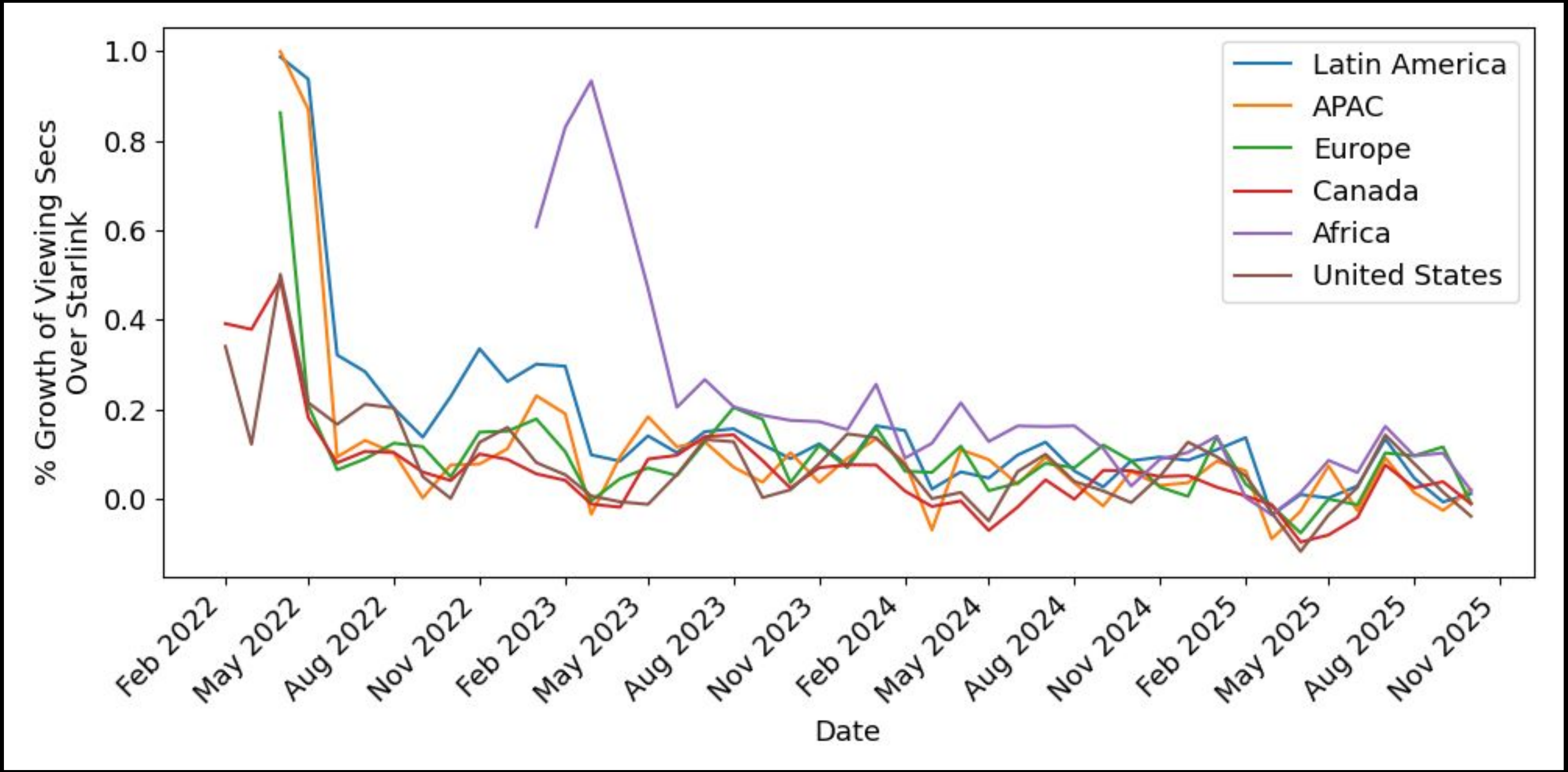
LEO ISPs have global reach



The US streams the most over LEO



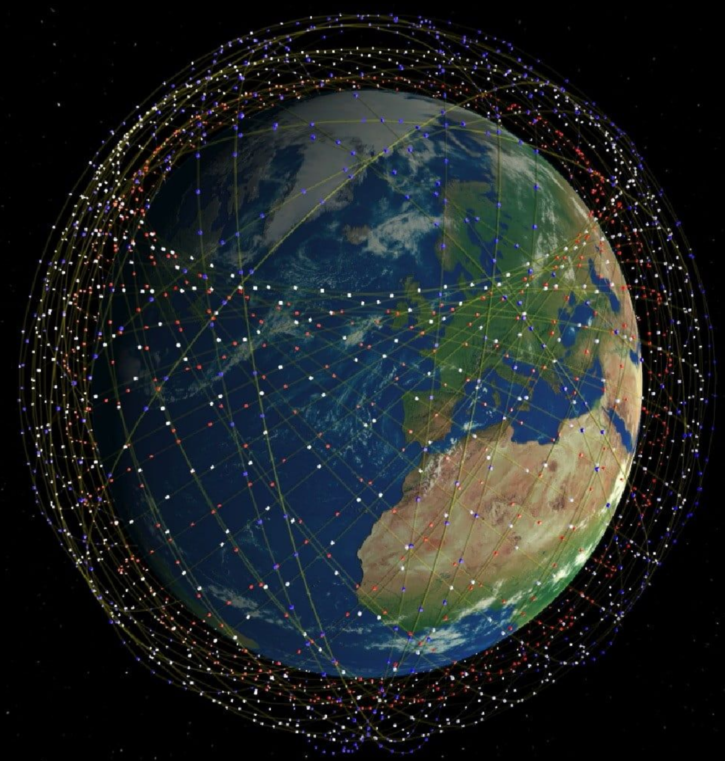
Africa led the growth of streaming over LEO through 2024



LEO’s role in Netflix delivery: What we learned

- Streaming over LEO is rising rapidly
- Expanding Netflix into new and underserved markets (notably in Africa)

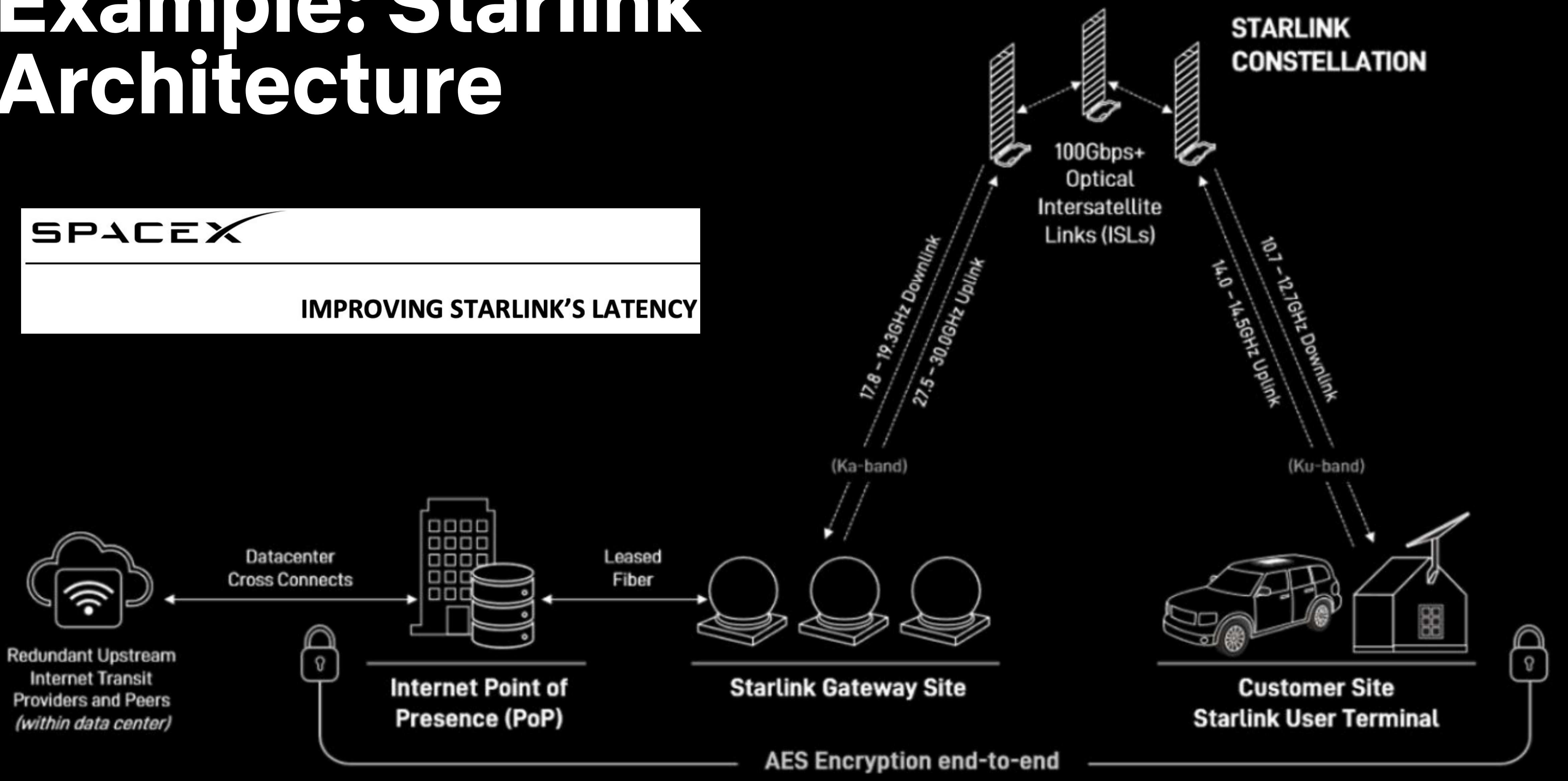
LEO's known challenges: low orbit = high variability



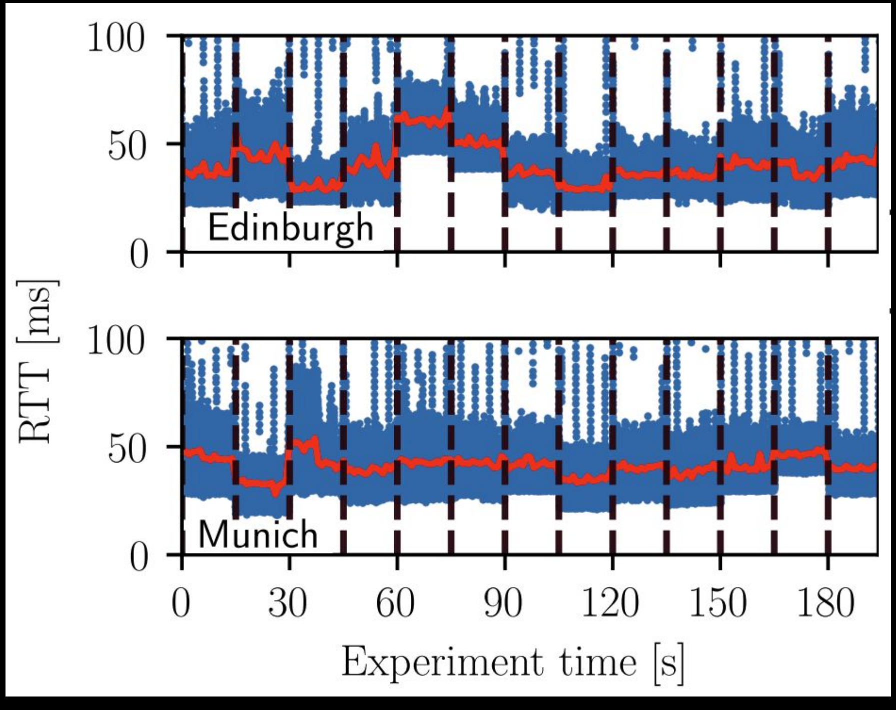
Example: Starlink Architecture

SPACEX

IMPROVING STARLINK'S LATENCY



Periodic RTT level shifts

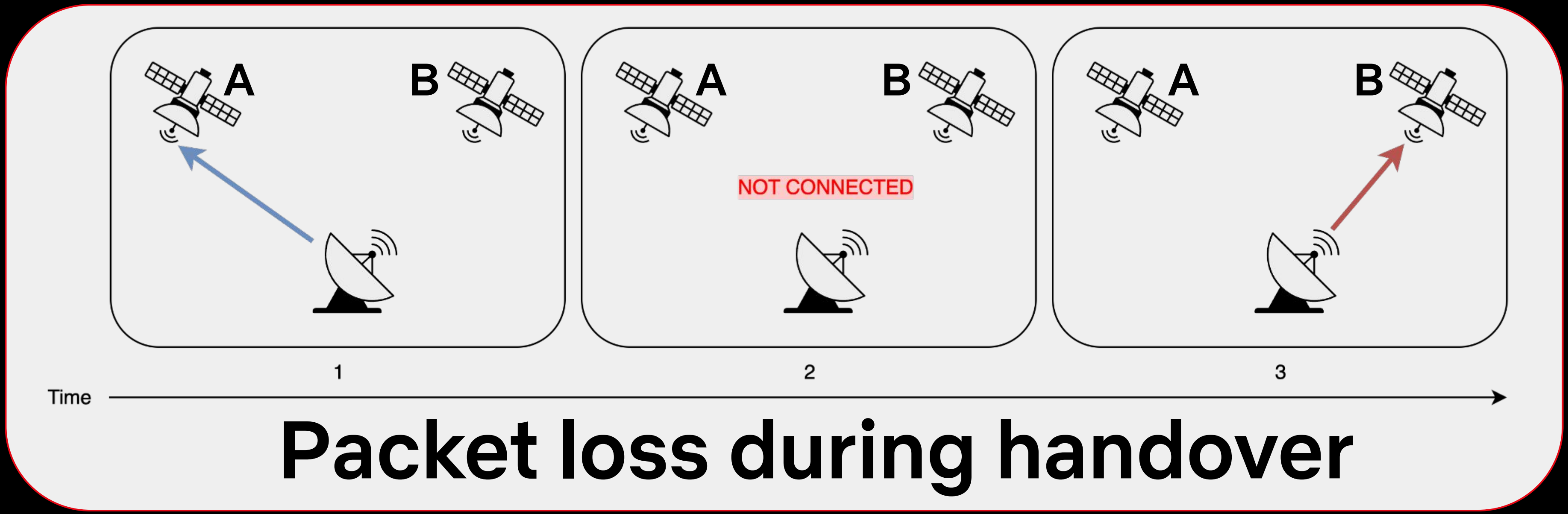


A Multifaceted Look at Starlink Performance

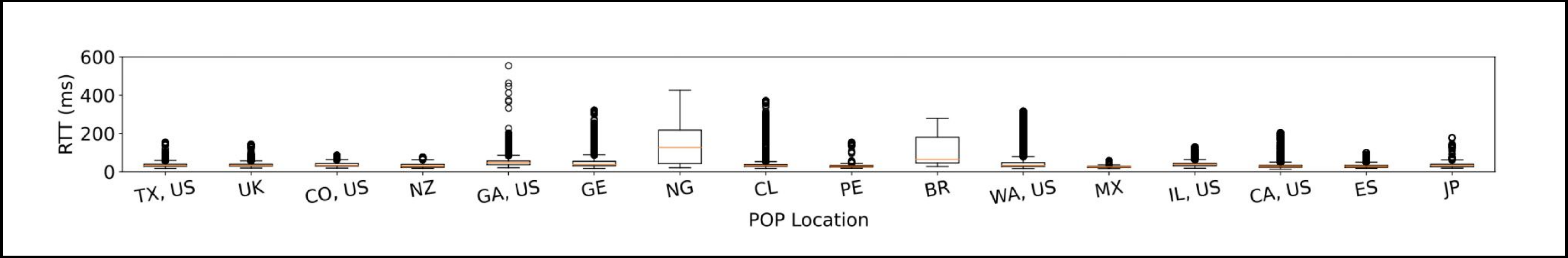
Authors: Nitinder Mohan, Andrew E. Ferguson, Hendrik Cech, Rohan Bose, Prakita Rayyan Renatin, Mahesh K. Marina, Jörg Ott | Authors Info & Claims

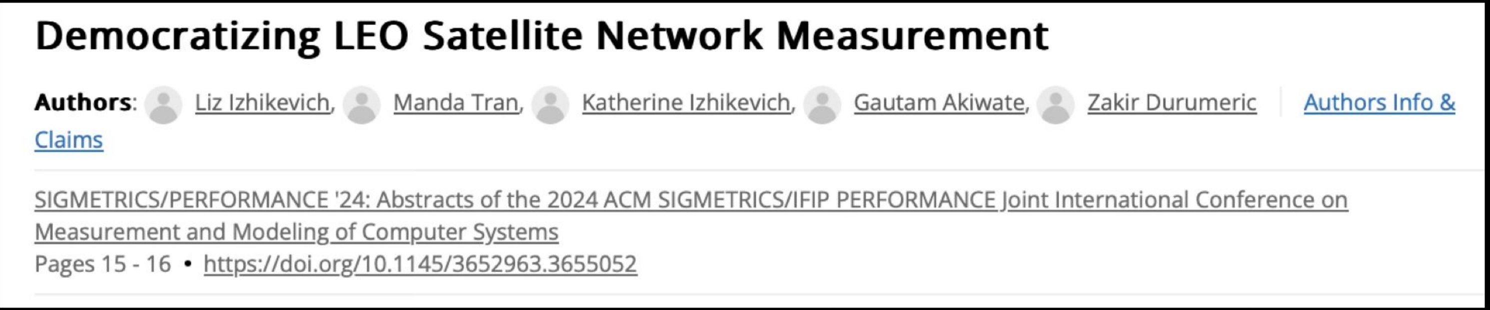
WWW '24: Proceedings of the ACM Web Conference 2024 • Pages 2723 - 2734
https://doi.org/10.1145/3589334.3645328

Periods of high loss



Location matters for RTT variability




Democratizing LEO Satellite Network Measurement

Authors: Liz Izhikevich, Manda Tran, Katherine Izhikevich, Gautam Akiwate, Zakir Durumeric | Authors Info & Claims

SIGMETRICS/PERFORMANCE '24: Abstracts of the 2024 ACM SIGMETRICS/IFIP PERFORMANCE Joint International Conference on Measurement and Modeling of Computer Systems
Pages 15 - 16 • https://doi.org/10.1145/3652963.3655052

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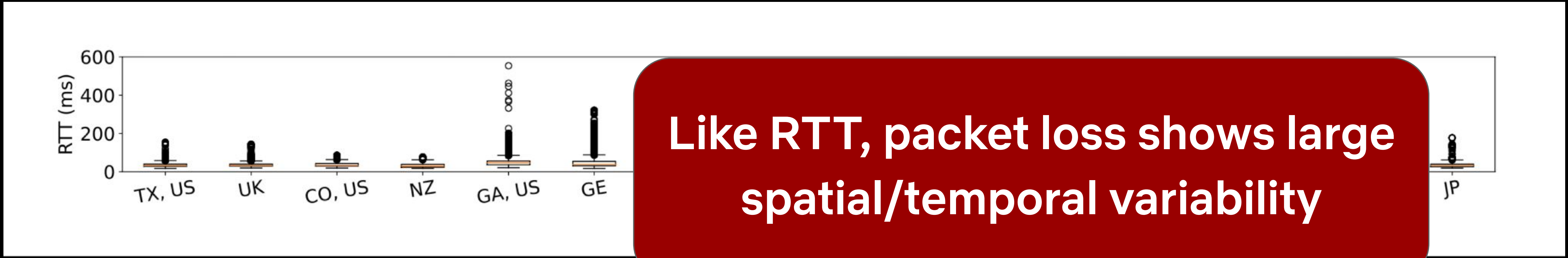

Like RTT, packet loss shows large spatial/temporal variability

Democratizing LEO Satellite Network Measurement

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What prior work tells us about LEO

- Network reconfiguration on ~15-second intervals
- Periodic latency shifts
- Periods of high loss
- Large variations over time and location

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Is this Starlink-specific or general to LEO?

- Specific: ≈15 s reconfig, hard handovers
- General: mobility → handovers/reconfigs in any LEO

How good is Netflix on-demand streaming over LEO?

Quality of Experience (QoE) metrics

- Overall perceptual video quality
- Bitrate switches
- Rebuffers
- Play delay

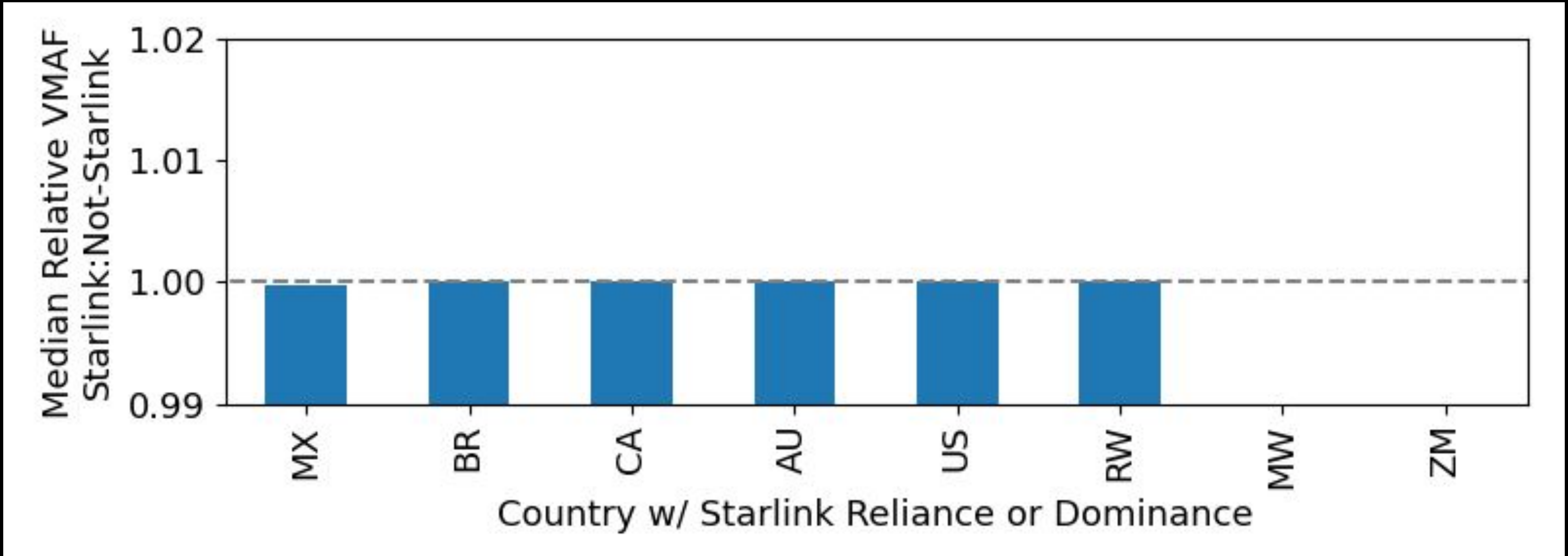
Perceptual Video Quality

- Video Multi-Method Assessment Fusion
  - Predicts human-perceived quality of encoded segments
  - At the same bitrate, simple scenes score higher than complex ones

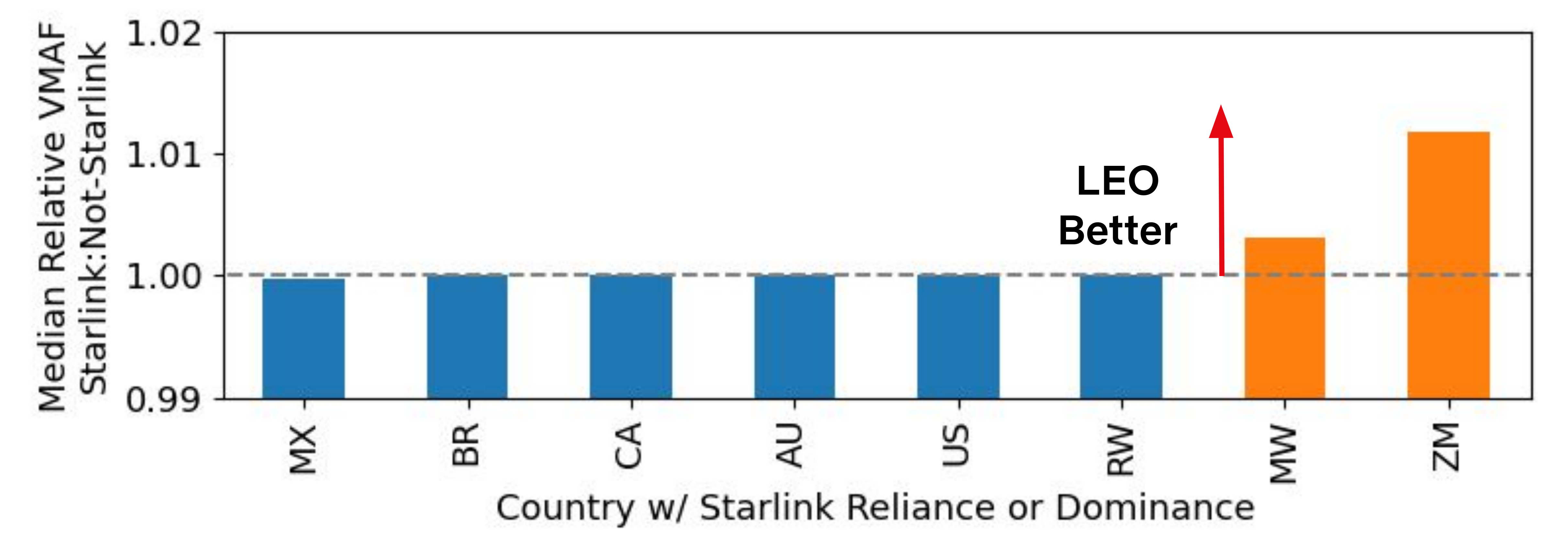
4k @ 23.4Mbps
VMAF 107

216p @ 126.4kbps
VMAF 10

LEO delivers comparable perceptual video quality



Malawi and Zambia experience better quality than local alternatives



Good quality, but more switches

r/Starlink • 2 yr. ago
r00x

Anyone else struggle with poor quality on streaming services (Netflix/Amazon Prime mostly)?

Troubleshooting

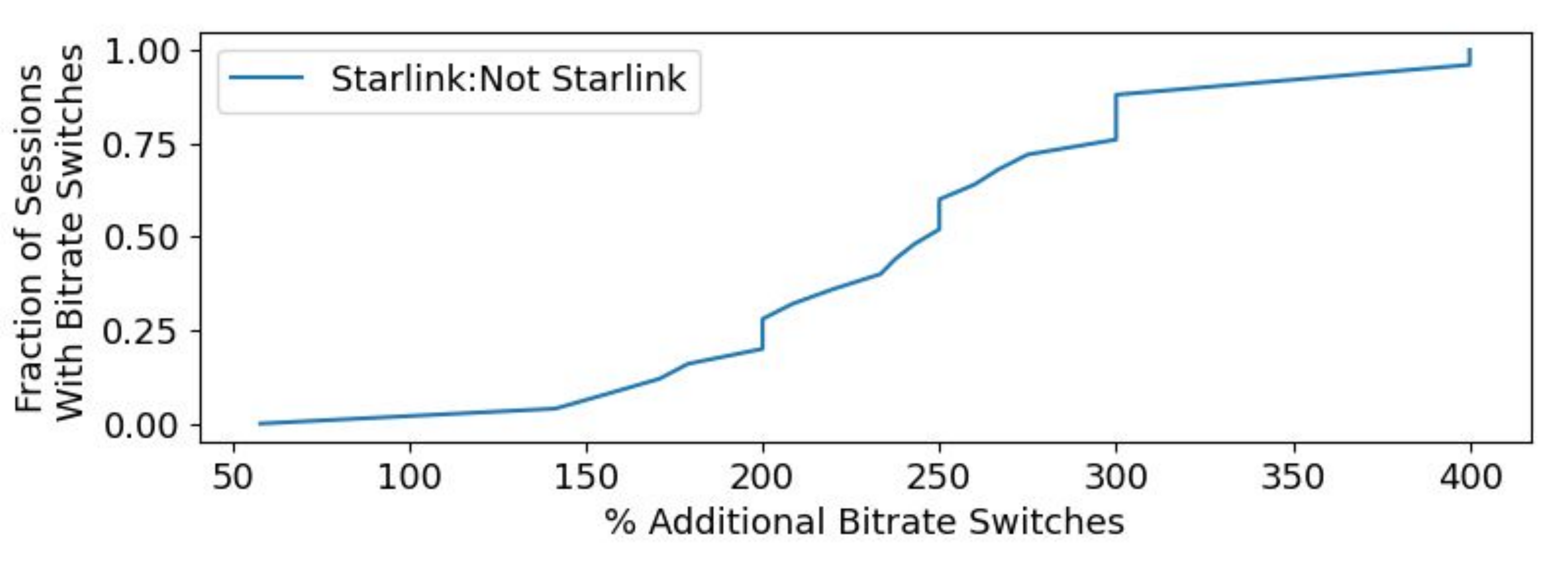
Title. I've found Netflix and Amazon Prime are the worst offenders; regularly dropping stream quality from 4K UHD down to lower resolutions, all the way to unwatchable potato quality sometimes (Prime especially), despite the

r/Starlink • 5 mo. ago
WhereIsMyTequila

Streaming quality going from fine to crap constantly?

Discussion

More bitrate switches on LEO



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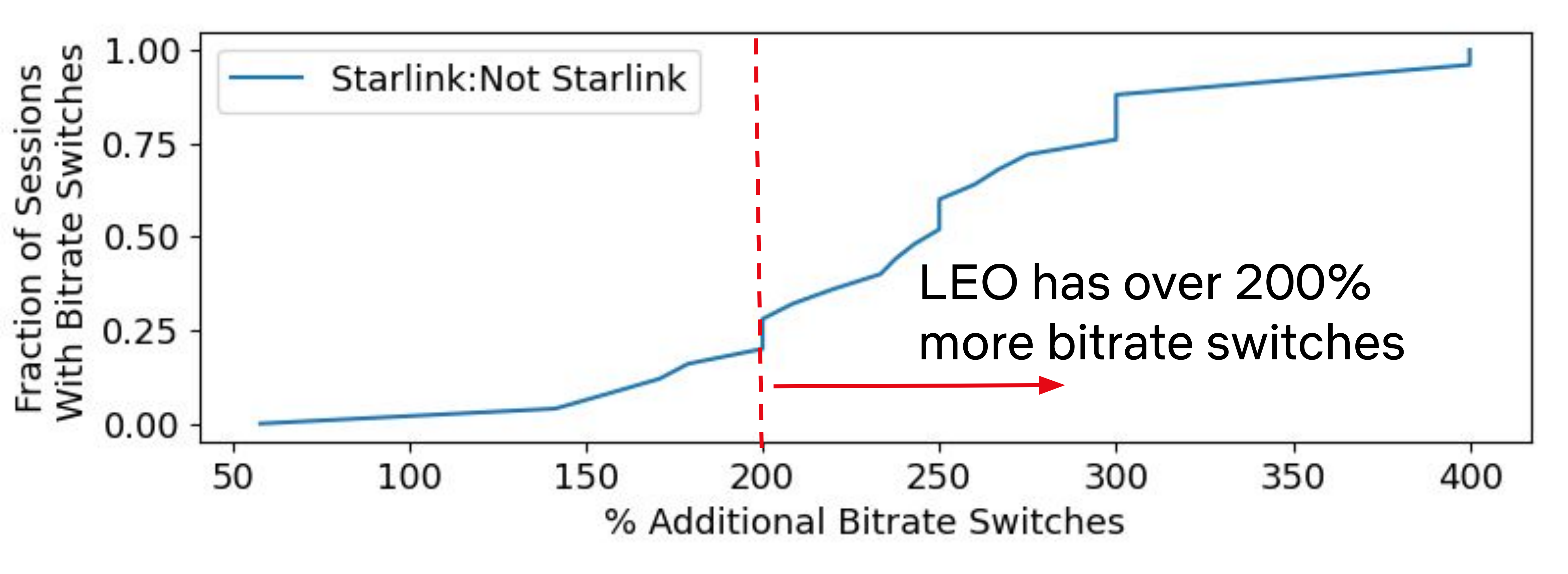
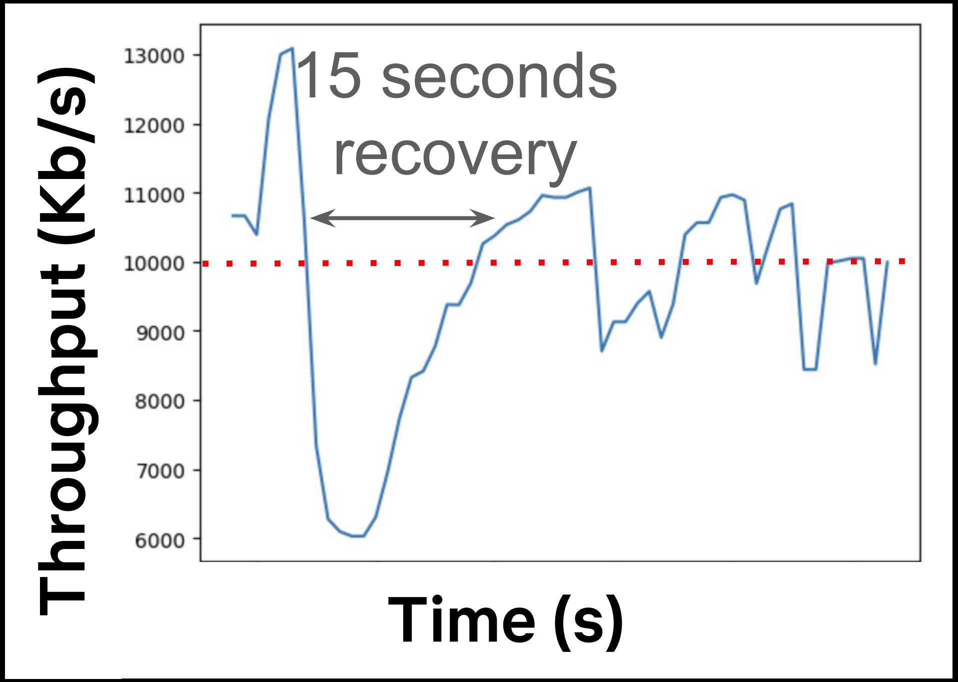
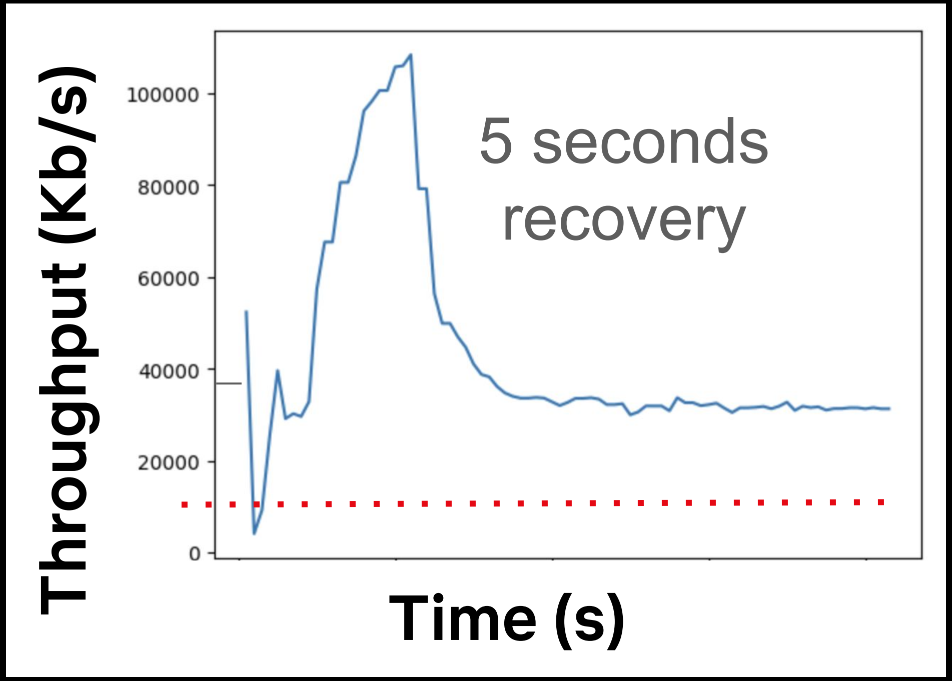


Bitrate switches from throughput fluctuations

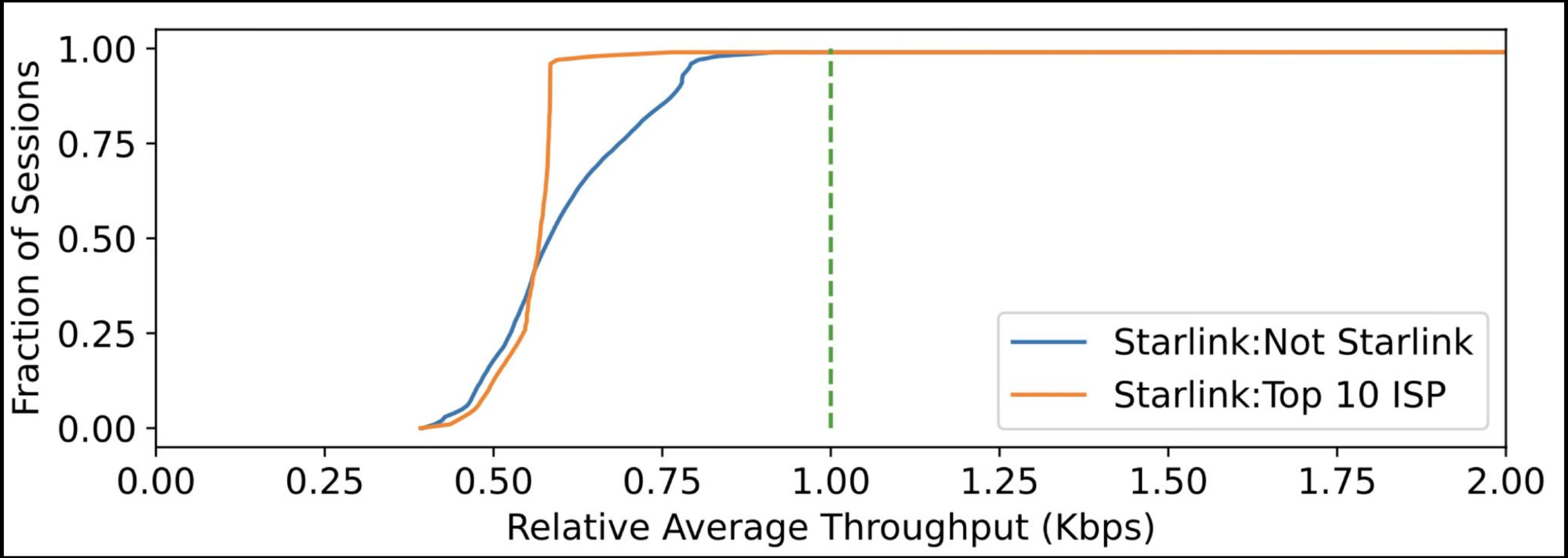
Starlink



Non Starlink



LEO experiences lower throughput



Good quality, but occasional rebuffers

Starlink UK. · Join
Jon Risby · December 12, 2024 ·

Netflix and Buffering 🤦‍♂️

Seem to be struggling with streaming 4K UHD Content, damn thing buffers randomly and will occasionally kick out Netflix. When it buffers I check network stats/throughput and it drops to kb/s even tho I'm attaining the below speeds.

No outages reported. Generally Starlink has been amazing over the last 6months but this buffering is starting to cheese me off 🙈

r/Starlink • 5 mo. ago
FederalSpore593 📡 Owner (Europe)

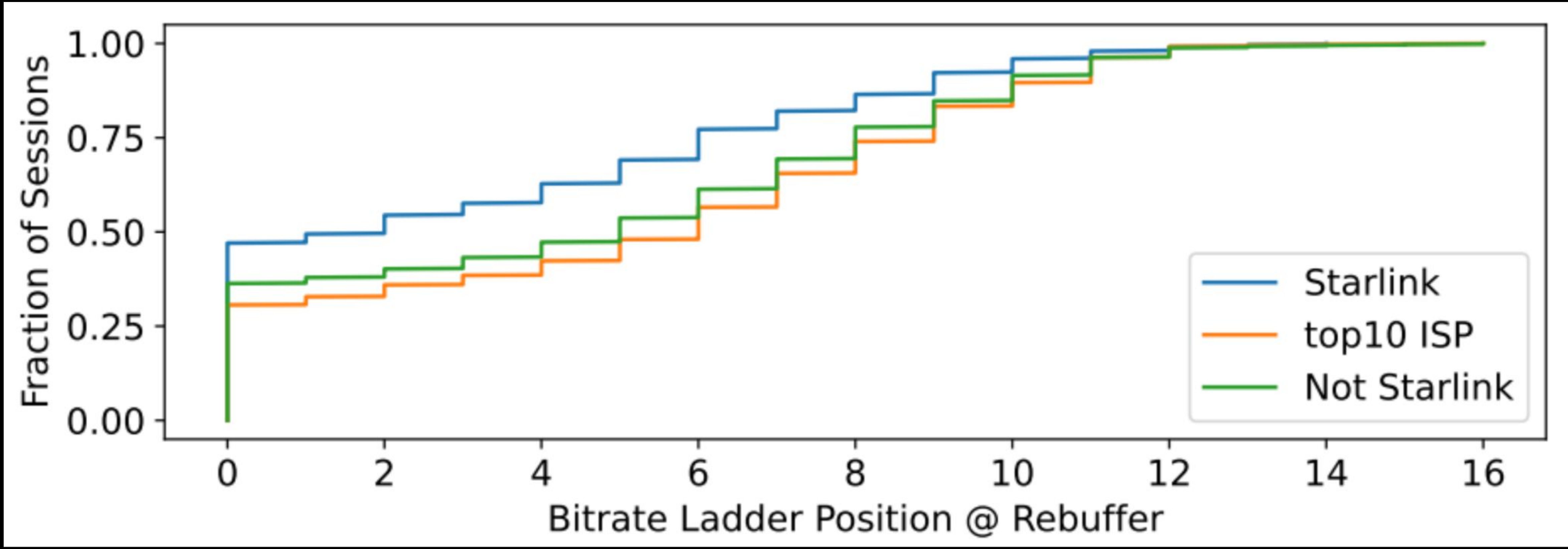
Awesome speeds, but a lot of YouTube buffering.

💻 Troubleshooting

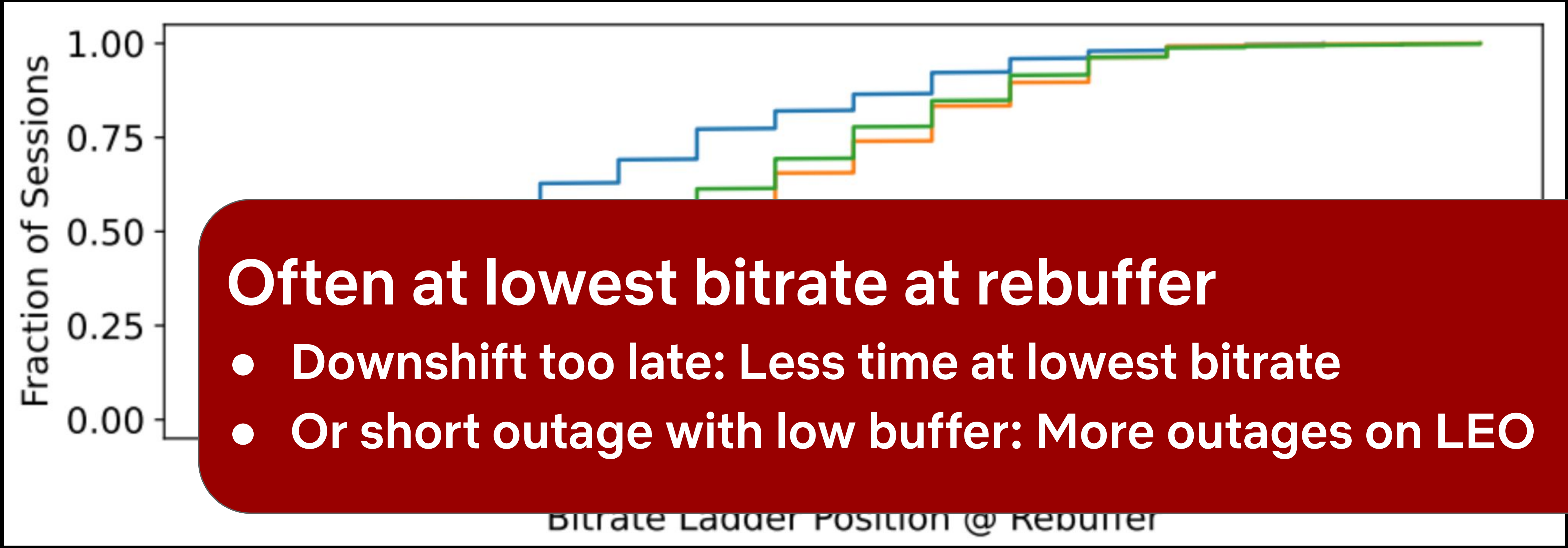
How often do rebuffers occur?

- Extremely rare across all networks
- But, more likely on LEO
  - +216% vs. Top 10 ISPs
  - +40% vs. all non-Starlink

Why rebuffers are more likely on LEO



Why rebuffers are more likely on LEO



Often at lowest bitrate at rebuffer

- Downshift too late: Less time at lowest bitrate
- Or short outage with low buffer: More outages on LEO

Higher rebuffer incidence in Africa and Latin America

Region	Likelihood of >= 1 Rebuffer Relative to US
Canada	0.66x
Asia Pacific	0.9x
United States	1x
Europe	1.07x
Africa	2.7x
Latin America	3.7x

LEO QoE: What we learned

- Comparable quality in well-served regions
- Better quality in small islands, Africa
- Tradeoff: more bitrate switches and rebuffers

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)

Congestion control: What we learned

Tried less reactive congestion control (MulTCP)

✔ Allowed higher throughput and slightly smoother streaming

⚠️ But led to more retransmissions and higher latency

Key insight

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

Adaptive bitrate: What we learned

Tuned standard ABR parameters (e.g., throughput discount)

✔️ Helped somewhat

⚠️ But didn’t close the gap with terrestrial ISPs on switches or rebuffers

Key insight

- Standard ABR relies on point throughput estimates
- On LEO, variance (not just averages) drives the challenge

Curious about the technical details?

🚀 Join us @SPACE RG on Thursday, 9:30am 🚀

Netflix over LEO: Lessons in Adaptive Bitrate and Congestion Control

- Deep dive into our congestion control and ABR experiments
- Results, trade-offs, and open challenges
- Bring your questions!

What are the research opportunities for LEO streaming?

How well does LEO support live, gaming, and conferencing?

Video on-demand is resilient

- Large buffers
- Tolerates short-term variability

Live and gaming should be more challenging

- Sensitive to jitter, loss bursts, and throughput swings
- Little to no buffer

How should adaptive bitrate and congestion control evolve for LEO?

Congestion control

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

Adaptive bitrate: make decisions variance-aware

- Improve throughput prediction under high variability
- Avoid switching on noise

Where should we invest as a community?

Standard set of APIs

- Hints: reconfig/handover soon, stability window

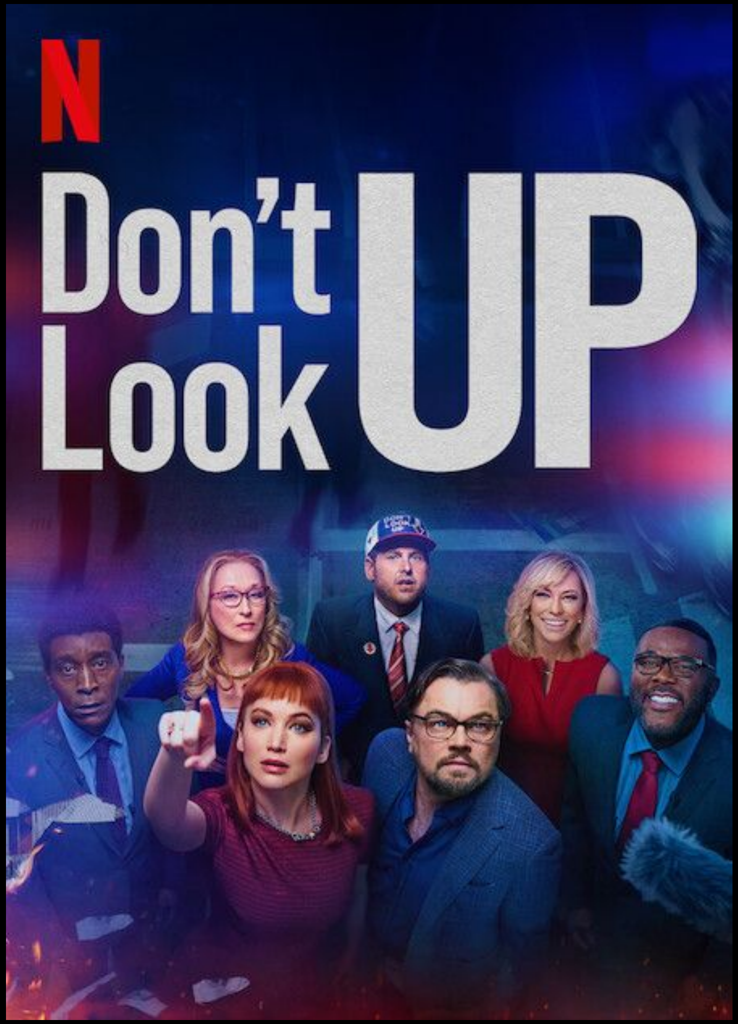
Testing and benchmarks for reproducible evaluation

- Open traces of LEO dynamics
- Realistic simulators/emulators/testbeds

Don’t ignore LEO

- Treat LEO as a first-class target for new protocols and apps

Final Message to Internet Researchers



Thank You

Questions to rteixeira@netflix.com