



Analysis for the Adverse Effects of LEO Mobility on Internet Congestion Control

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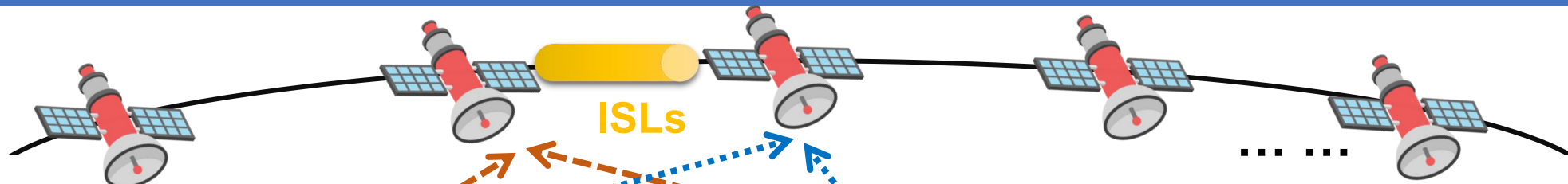
[IETF#125 - CCWG meeting, Shenzhen]

[March 19, 2026]

Outline

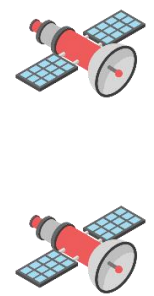
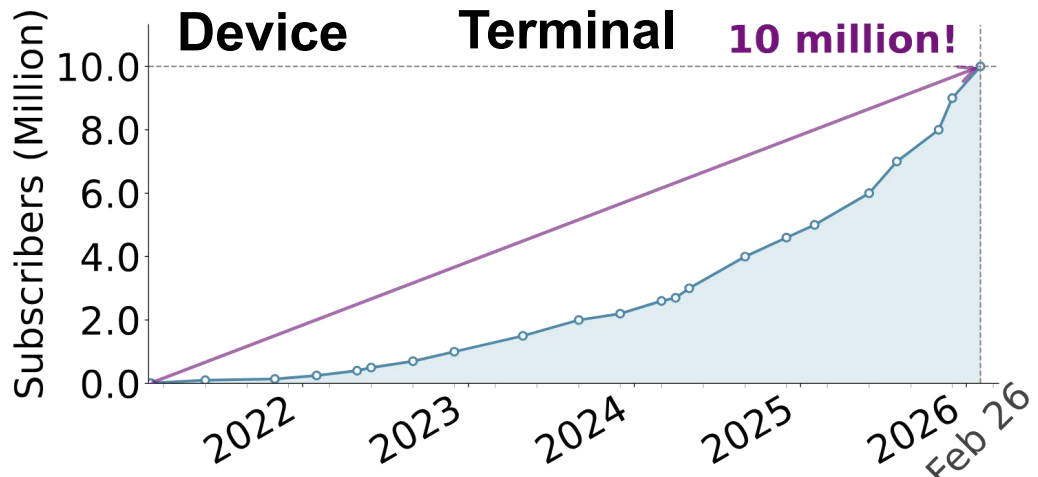
- **Why do LEO Satellite Networks(LSNs) matter today?**
- **What does LEO mobility do to the network path?**
- **Why can these changes mislead existing congestion control?**
- **What design directions should we consider?**

LSN Architecture and Its Importance



Frequent Path Changes due to LEO Dynamics

10 million!

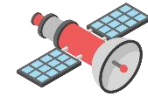
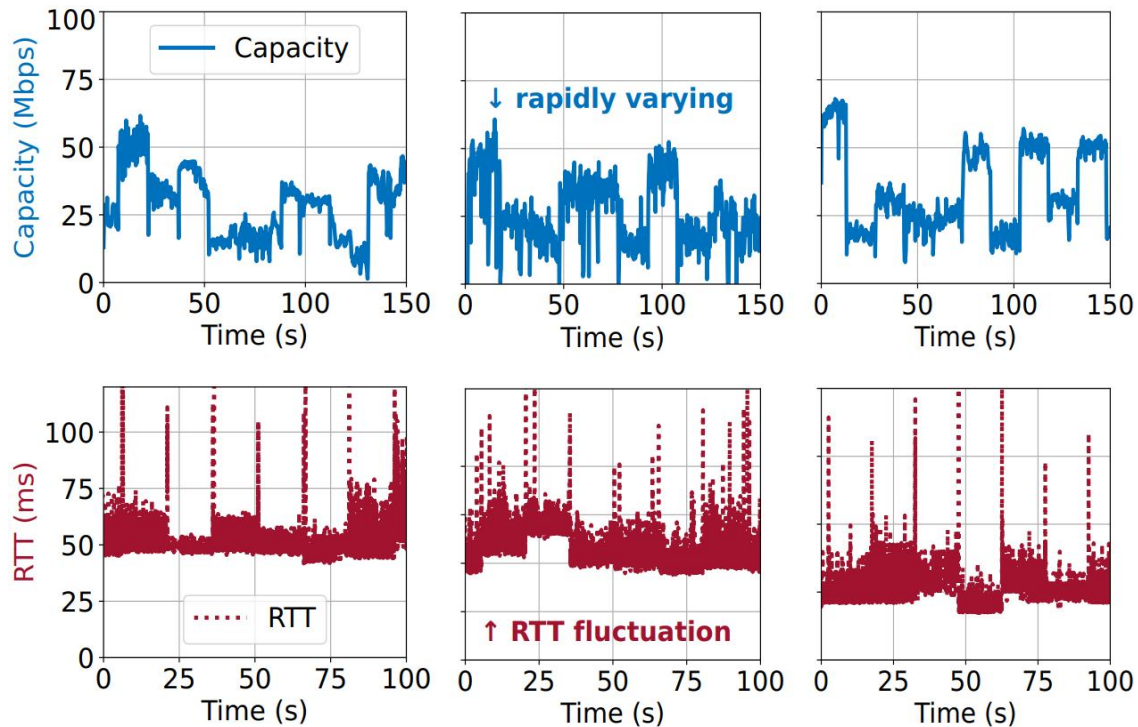


LSNs connect users through a **satellite-terrestrial** end-to-end path. **Rapid growth** is making LSN behavior increasingly relevant to transport

Not only its importance, but also how transport should reason about paths whose behavior are shaped by mobility at scale

What Does LEO mobility Do to Network Paths

LEO mobility can cause **network instabilities** such as:
path changes and radio rescheduling



Sharp shifts in available capacity



Baseline RTT drastically changes



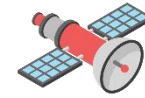
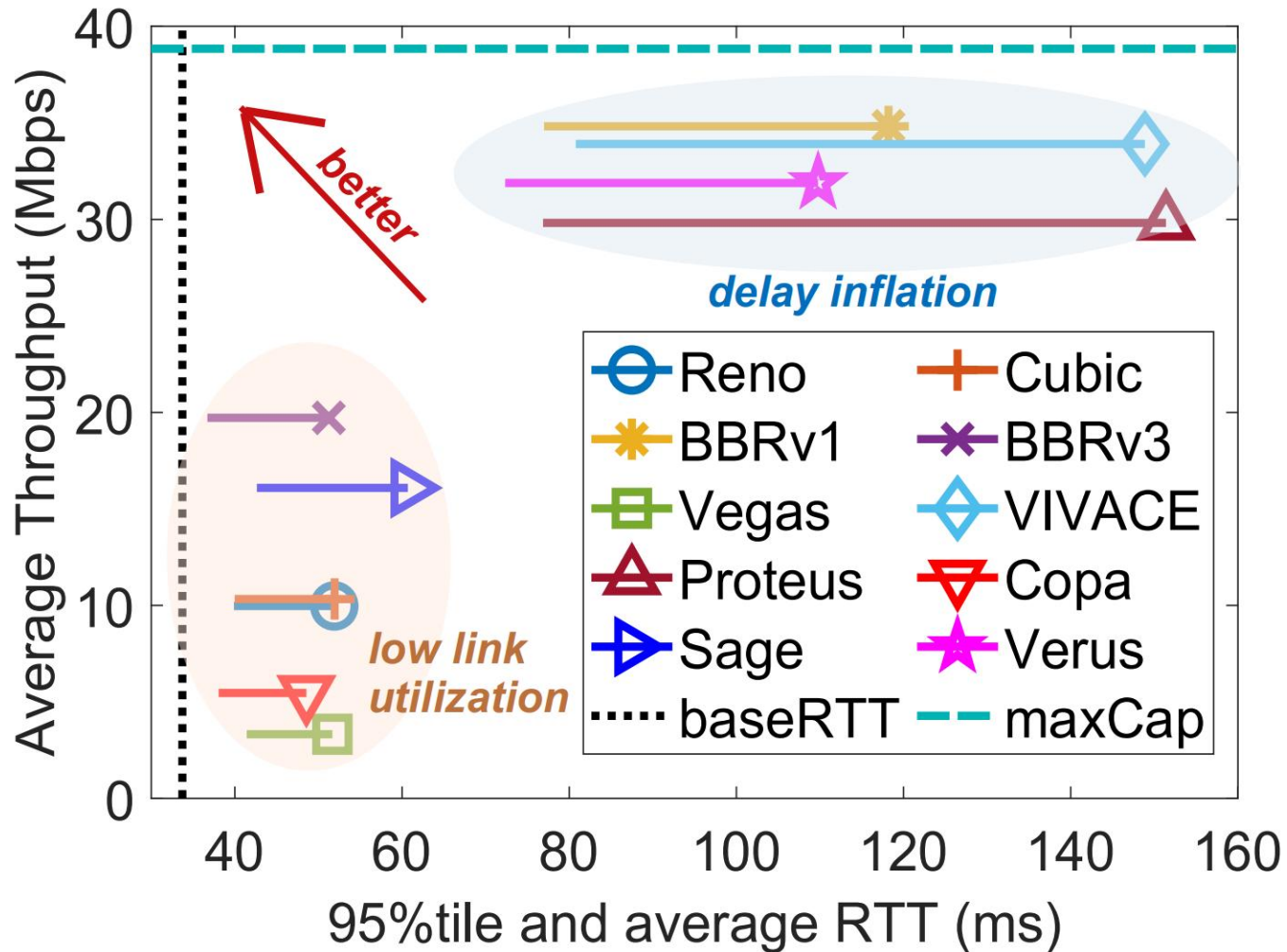
Unpredictable packet loss



the path may move **between**
different operating conditions

Such Distinction matters: it motivates a more structured view
of path behavior than a single continuous time window

Why These Changes Can Mislead CCAs



Most CCAs rely on interpreting signals as indicators of network state. While in LSNs, there are mobility-driven path changes.



Loss-based CC(Reno, Cubic) and **Delay-based CC**(Vegas, Copa)

- **Non-congestive loss and RTT changes** may be mistaken for congestion



Model-based CC(BBRv1, BBRv3)

- **Historical bandwidth and RTT estimates may become stale** across changed conditions

Beyond misreaction: it is that mobility can change the meaning of the very signals these algorithms depend on

The Fundamental Changes and Mitigations

Massive non-congestive network variations break the fundamental models/assumptions of existing CCAs



To mitigate this issue, one potential way is to **identify and filter out LEO-induced non-congestive variations**

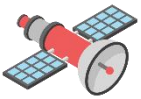


Can we identify a **path-level signal** that indicates when mobility-driven reconfiguration has pushed the connection across a **phase boundary**?

Path Phase Boundary(PPB): reconfiguration

PETITION OF STARLINK SERVICES, LLC FOR DESIGNATION AS AN ELIGIBLE TELECOMMUNICATIONS CARRIER

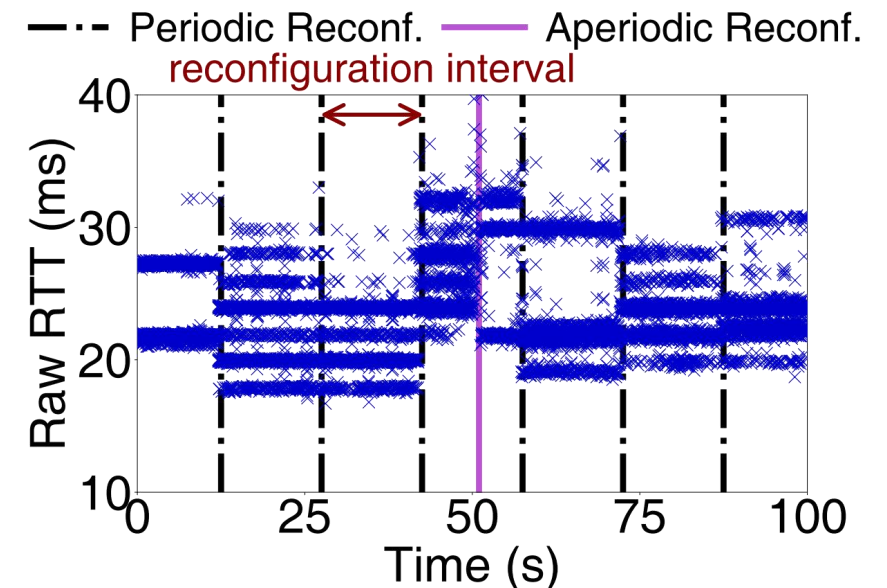
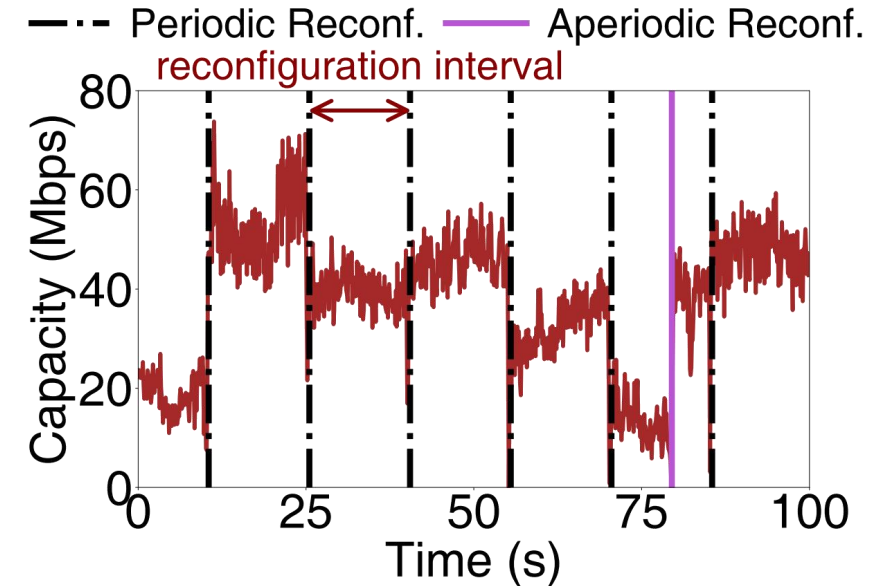
assigned to the user's service area. Because the Starlink satellites are constantly moving, the network plans these connections on 15 second intervals, continuously re-generating and publishing a schedule of connections to the satellite fleet and handing off connections between satellites.



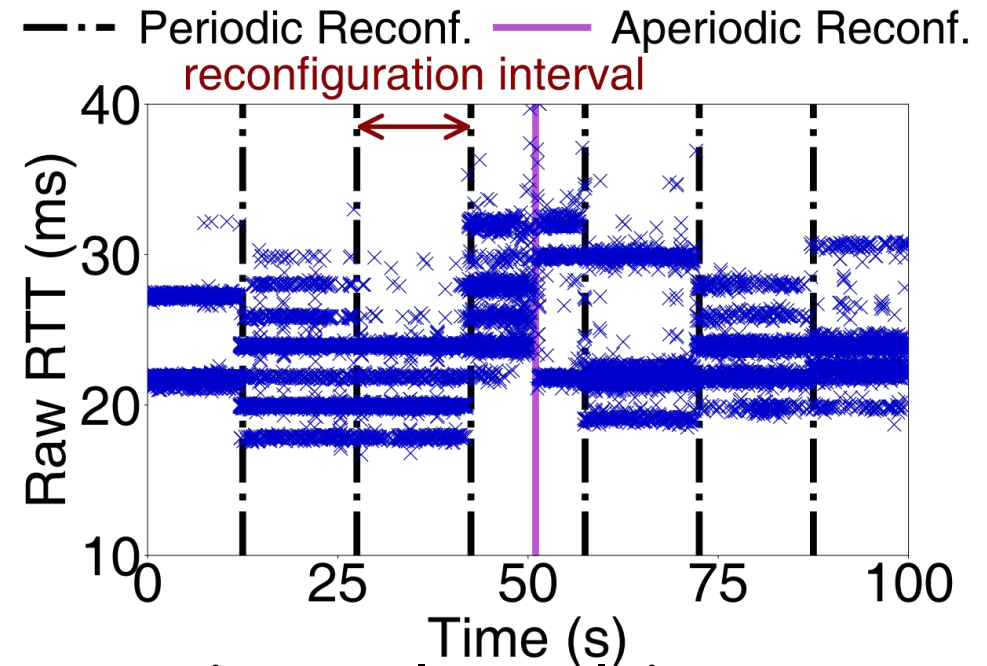
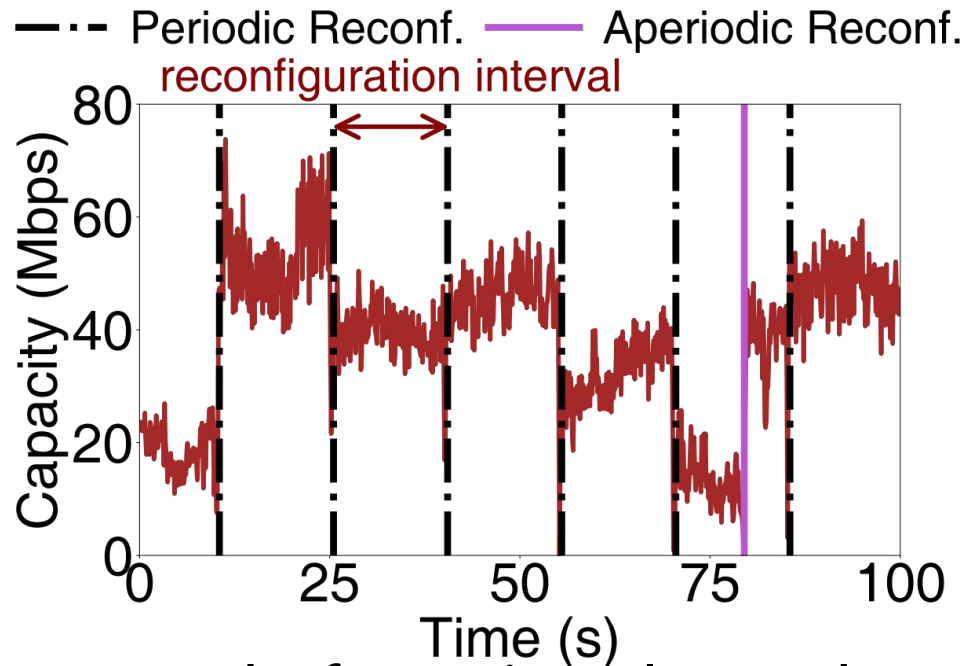
PPB: points where mobility-driven reconfiguration shifts the connection into a new path condition



Capacity/RTT can be fitted as a **step function** if we align the path evolution with a sequence of reconfigurations. Inside a step, Capacity/RTT changes are **relatively mild and smooth**.



Path Phase Boundary(PPB): reconfiguration



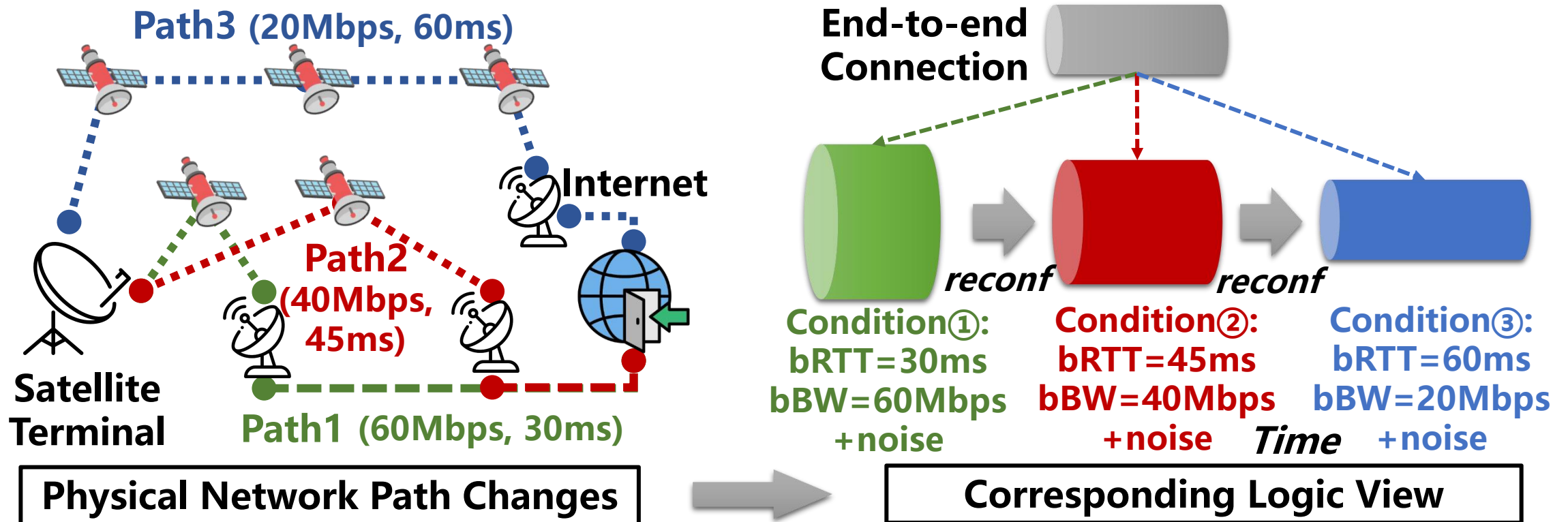
Instead of treating the path as one continuously evolving process, view it as a **sequence of phases separated by reconfiguration-driven boundaries**



PPBs give senders a cleaner way to decide which measurements still belong to the current phase and which ones should no longer be mixed into congestion control decisions

What Path models in LSNs should look like

Intuition: The physical LEO path can be complicated. Senders view each phase through a simpler logical view (**a single bottleneck**)



LEO path is better understood as a sequence of bottleneck regimes, rather than one continuously evolving path process

PPB as a Signal Abstraction for Transport: Points for Community Discussion

Semantic

PPBs indicate **non-congestive path-level** transition, after which old measurements may no longer be safely mixed with new ones.

Exposure

PPBs might be exposed through **explicit signaling** (network-assisted approach), **endpoint inference**, or **cross-layer hints**.

CC Adaptation

Senders may use PPBs to bound estimator history, discount stale state, and re-adapt within the new phase.

Beyond congestion signaling, transport layer may also need **signaling for path-phase changes**

Conclusion and Future Work

- **LEO mobility** creates structured, non-congestive path transitions
- These transitions can **break the assumptions of existing CCAs**
- PPB is a candidate abstraction for representing **path-phase changes** to transport
- We hope this perspective can help frame future discussion on transport design for LEO networks

THANKS

Comments & Questions

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I E T F[®]
CCWG - IETF 125
Shenzhen, 2026.3