LEOScope

Building a Global Testbed for Low-Earth Orbit Satellite Networks

"PlanetLab for Starlink"

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+20,000 Satellites will be in Space by 2027

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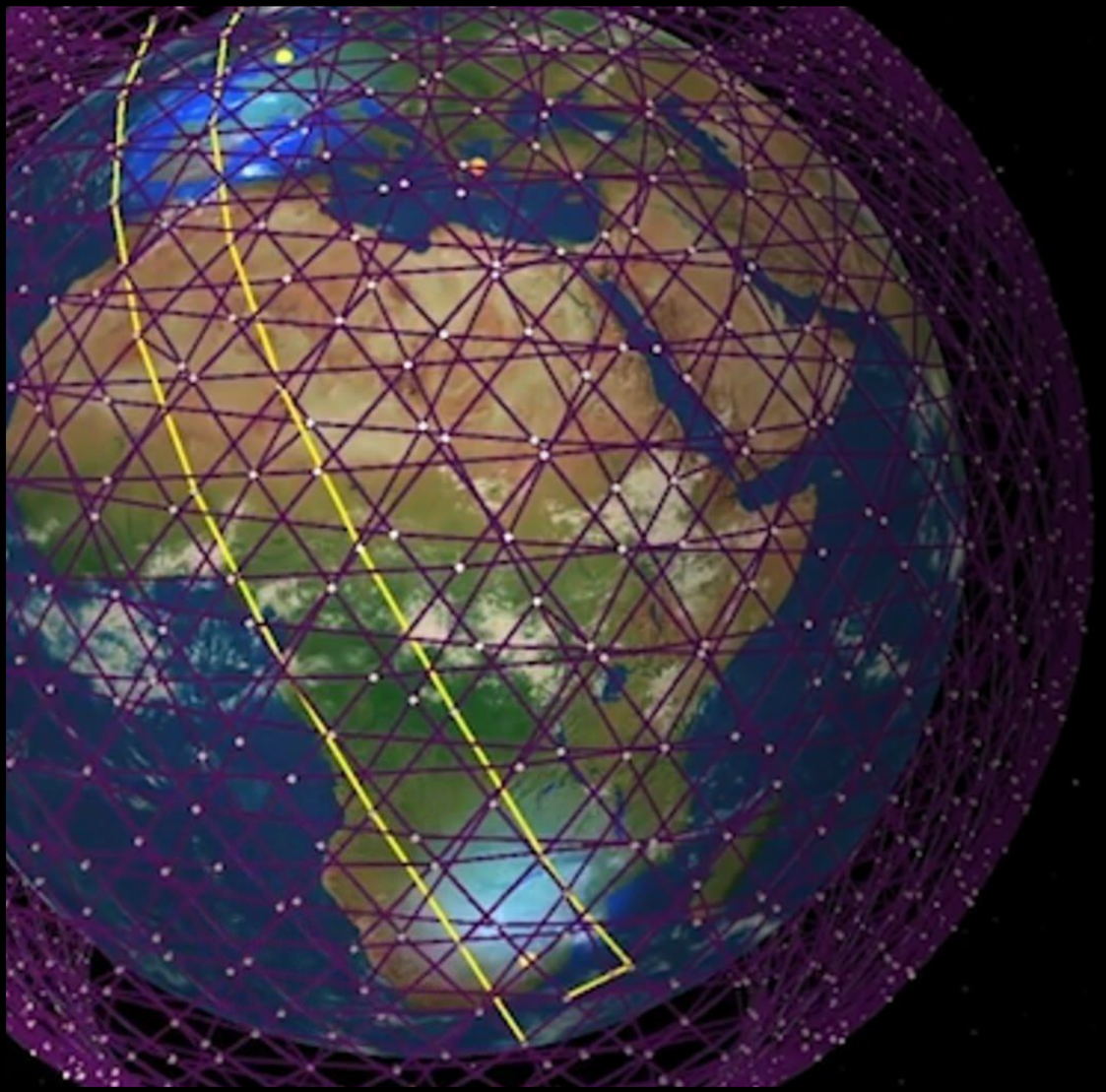


Fast-moving Routers

Traveling at 27,000 KM/h, making the connection with the ground segment ~3-6 mins

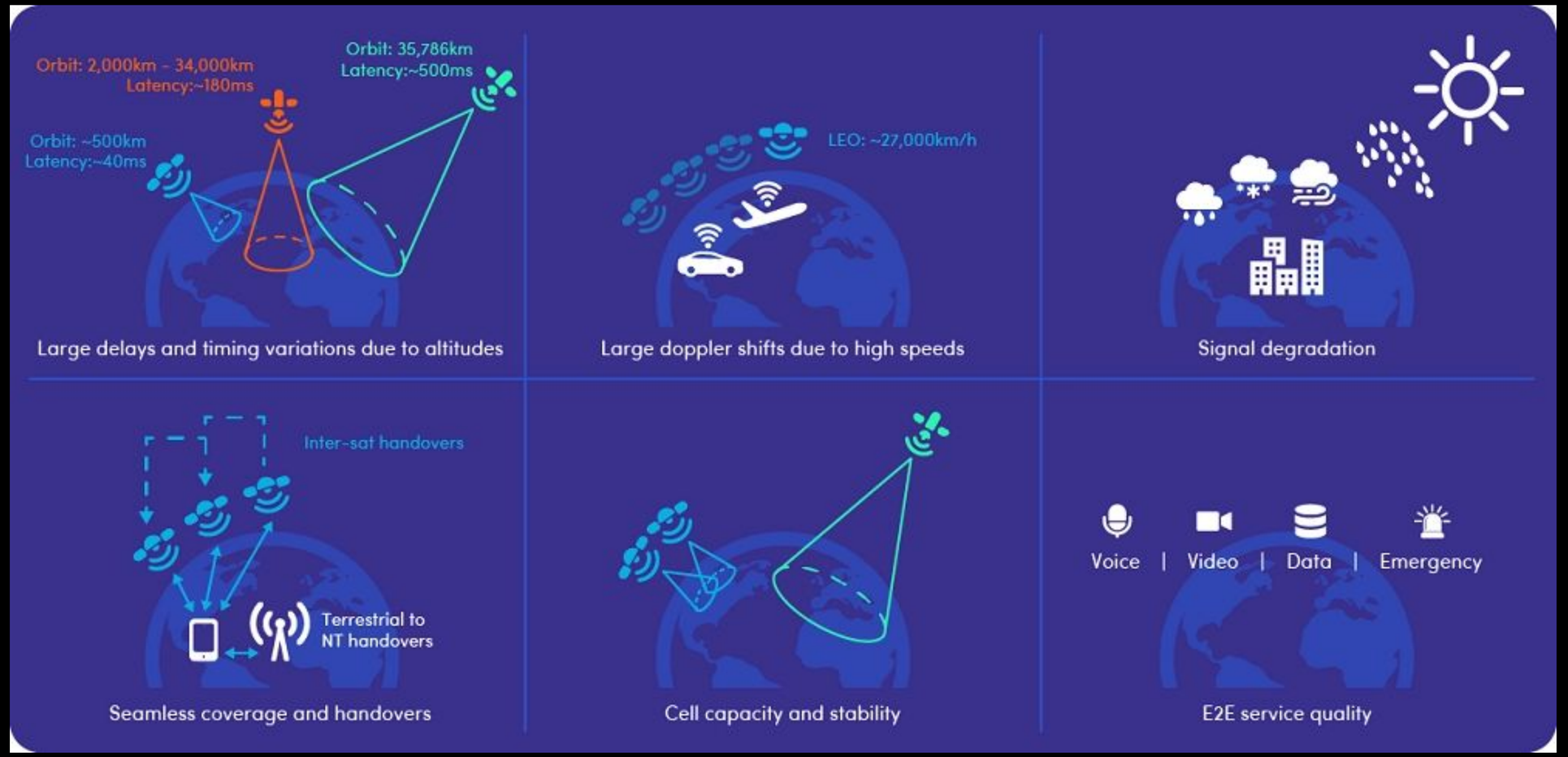
Large Scale, Dynamic Network

High dynamic network and rapid changes to the network topology

Network Protocols

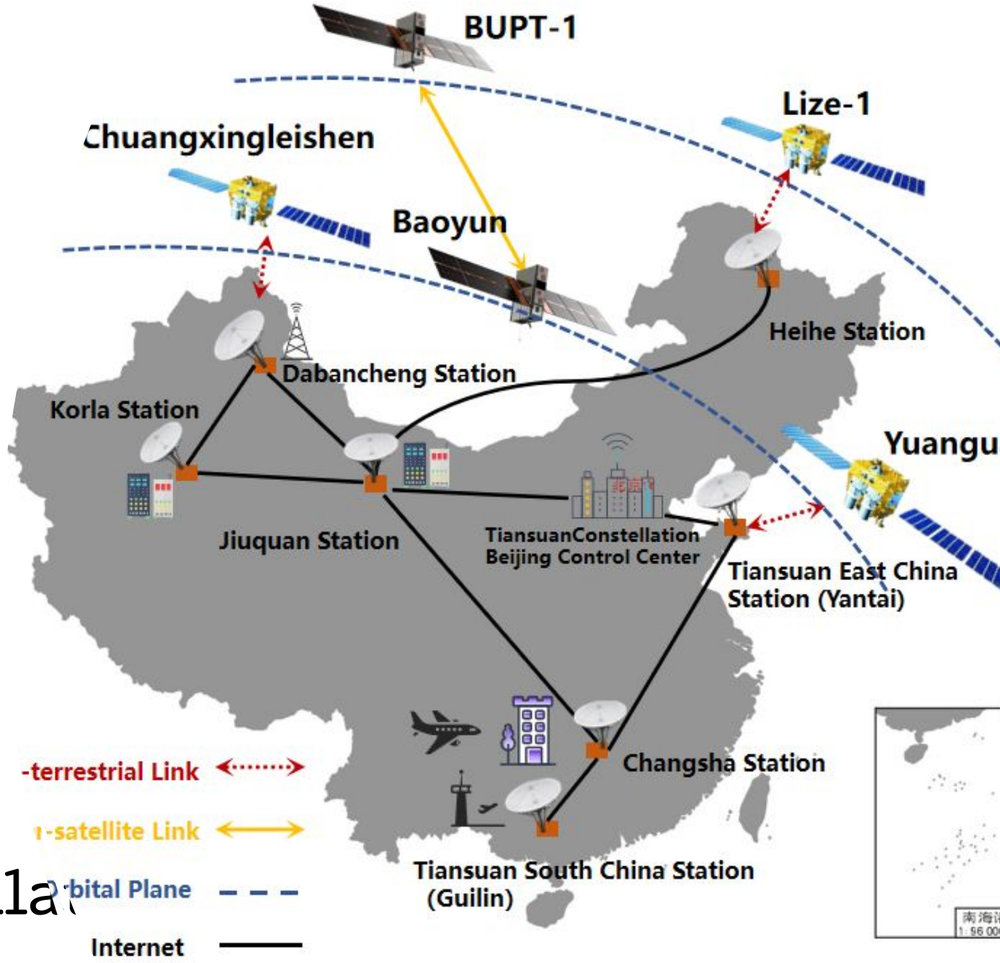
Challenge all our network management, transport and routing protocols

Additional L2 challenges



How to measure & understand?

- BYO Constellation? (BUPT Tianshuan)
- White box visibility which SpaceX won’
- Complex and expensive endeavour!
  - Plan to launch 6 satellites
    - Only two launched so far[1]
  - Does not capture complexity of *mega*constella
    - Starlink has 5K+ satellites **with ISLs**
    - May not replicate emergent behaviours
- Orbits ≠ Starlink (or other constellations)
  - Cannot capture specificities of deployed or planned constellations



[1]http://www.tiansuan.org.cn/morenews.html

Alternative: Earth-based Strategies

1. **Measurement** of *deployed* constellations (LEOScope)

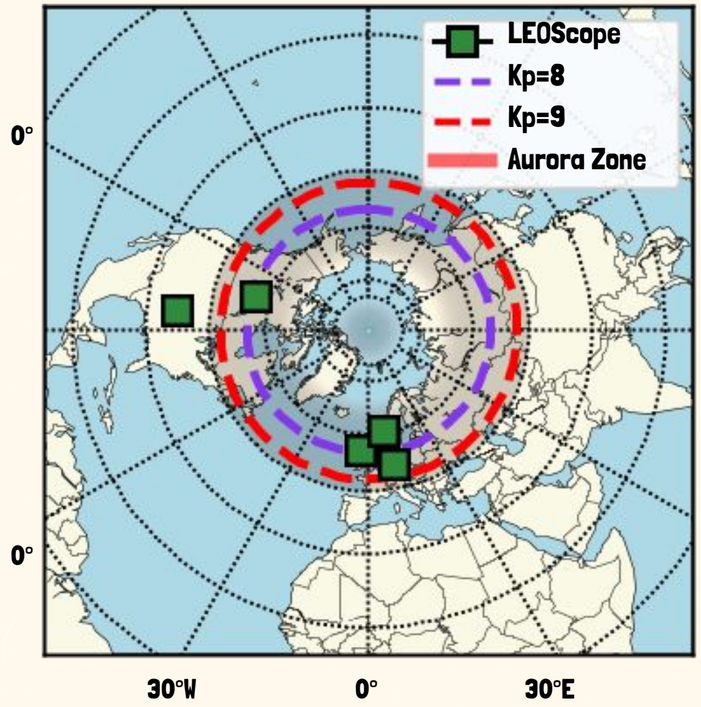
2. **Simulation** of deployed, *planned or imagined* constellations (xEOVerse)

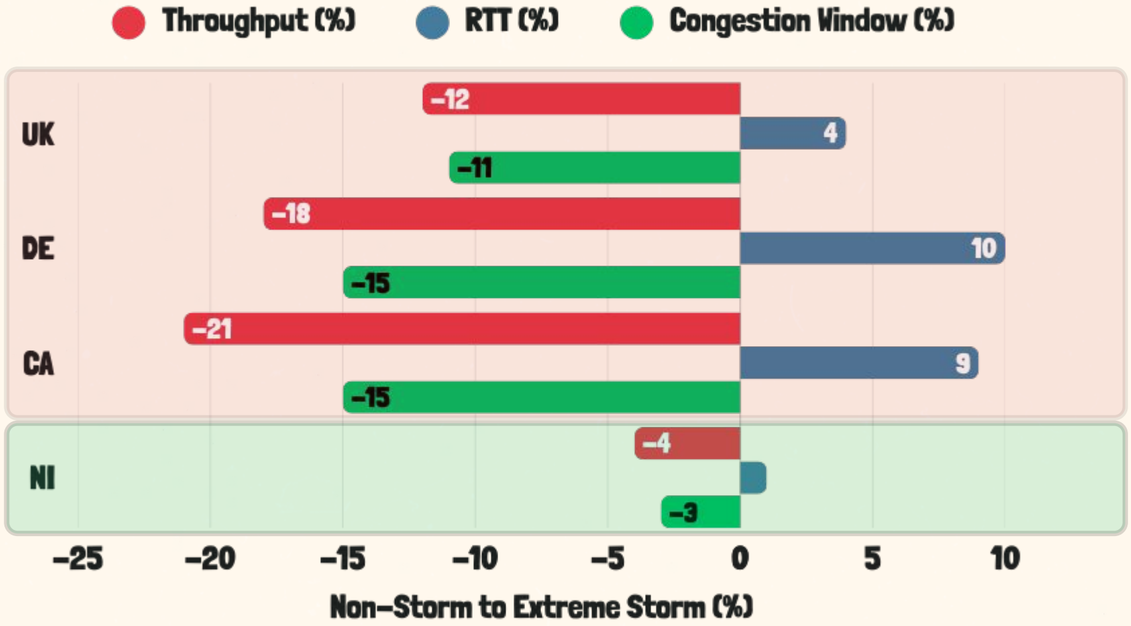
What do we need in an Earth-based LEO Testbed

We still need global coverage

- Performance shifts by latitude
- Different regions = distinct connectivity classes
- Global testbed captures variations → accurate insights

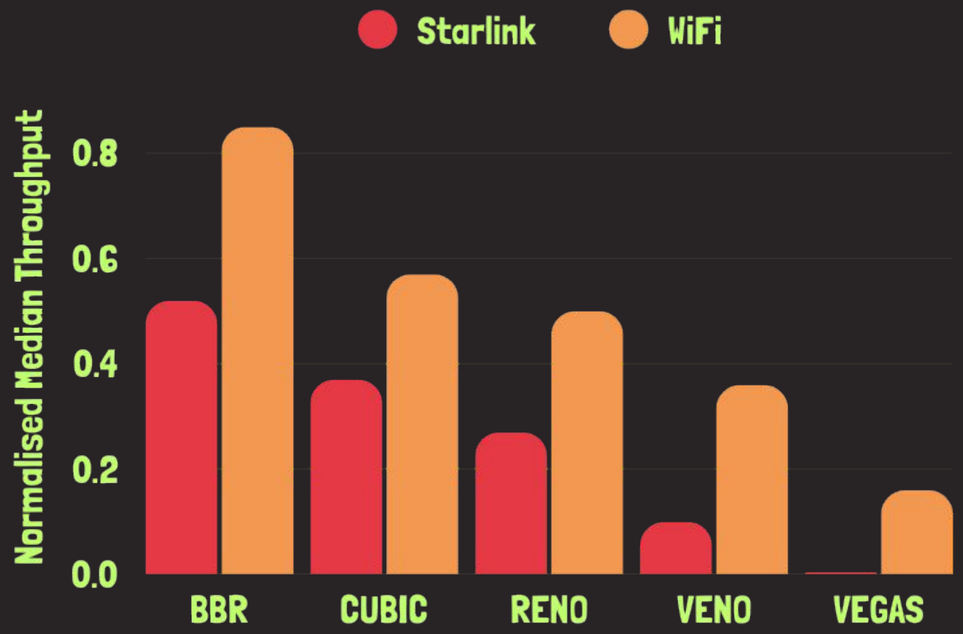
SIGMETRICS'26





Design decision: User-Defined Customizable Experiments

- Beyond basic measurements: flexibility is key
- LEO is new → we need new methods and protocols

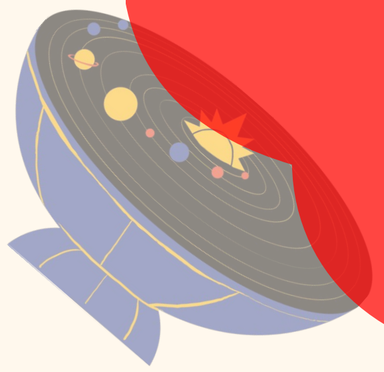


Want to see how different Congestion Control methods perform in LEO networks?

IMC'22

Empowering Researchers, Protecting Volunteers

- Researchers in many regions don’t own a setup.
- Volunteers provide access → but must be protected.



👉 How do we protect and support our volunteers while enabling global, LEO inclusive research?

✨ LEOScope introduces unique features to solve this...

Unique Feature → Scavenger Mode

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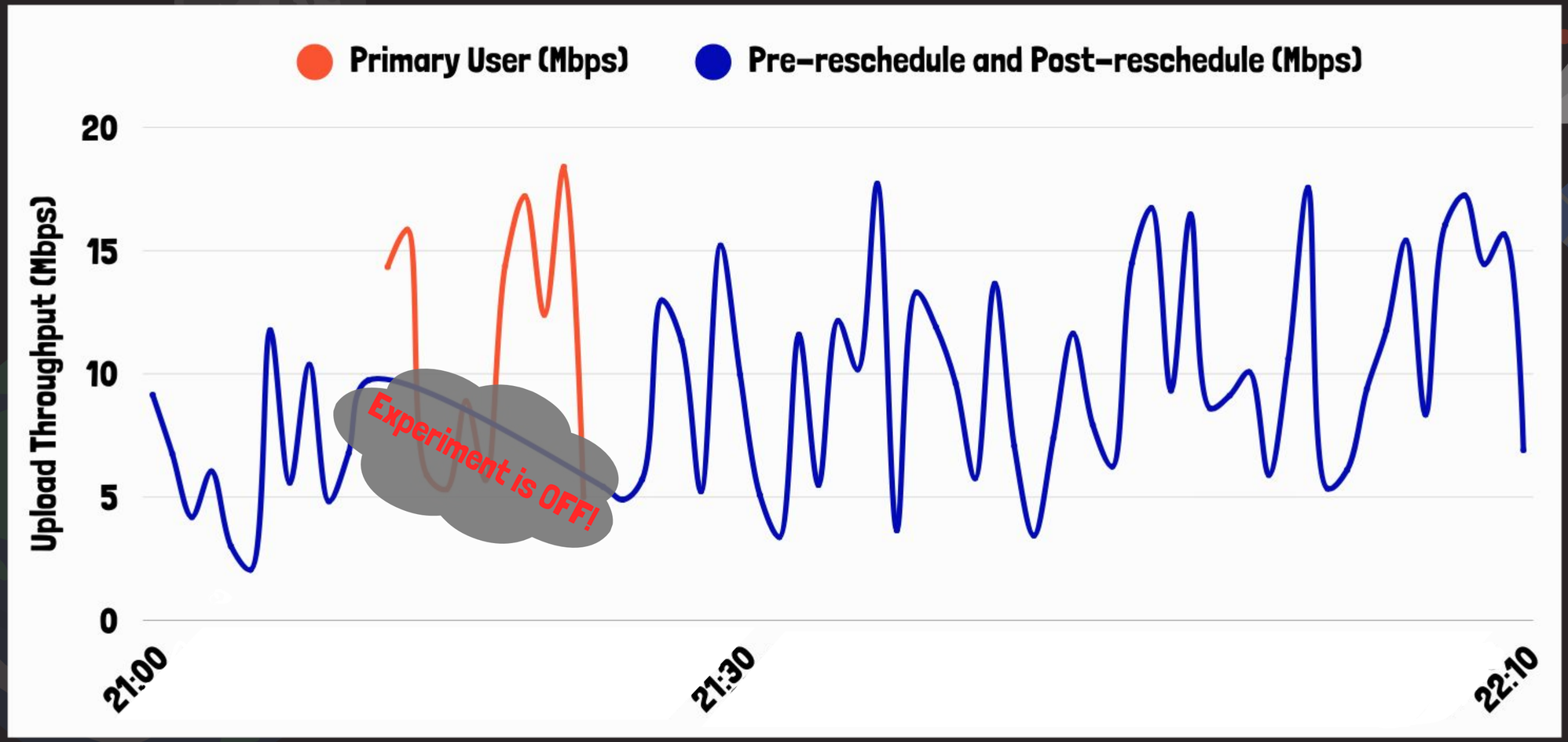
Automatically pauses and reschedules experiments when the primary user starts using bandwidth, ensuring minimal interference and optimal use of network resources.



Unique Feature → Cron Mode

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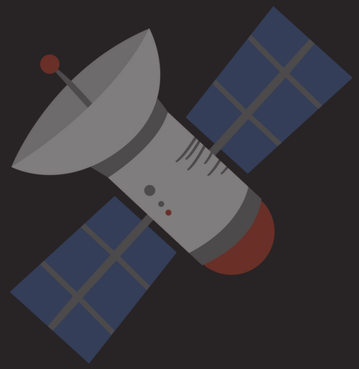
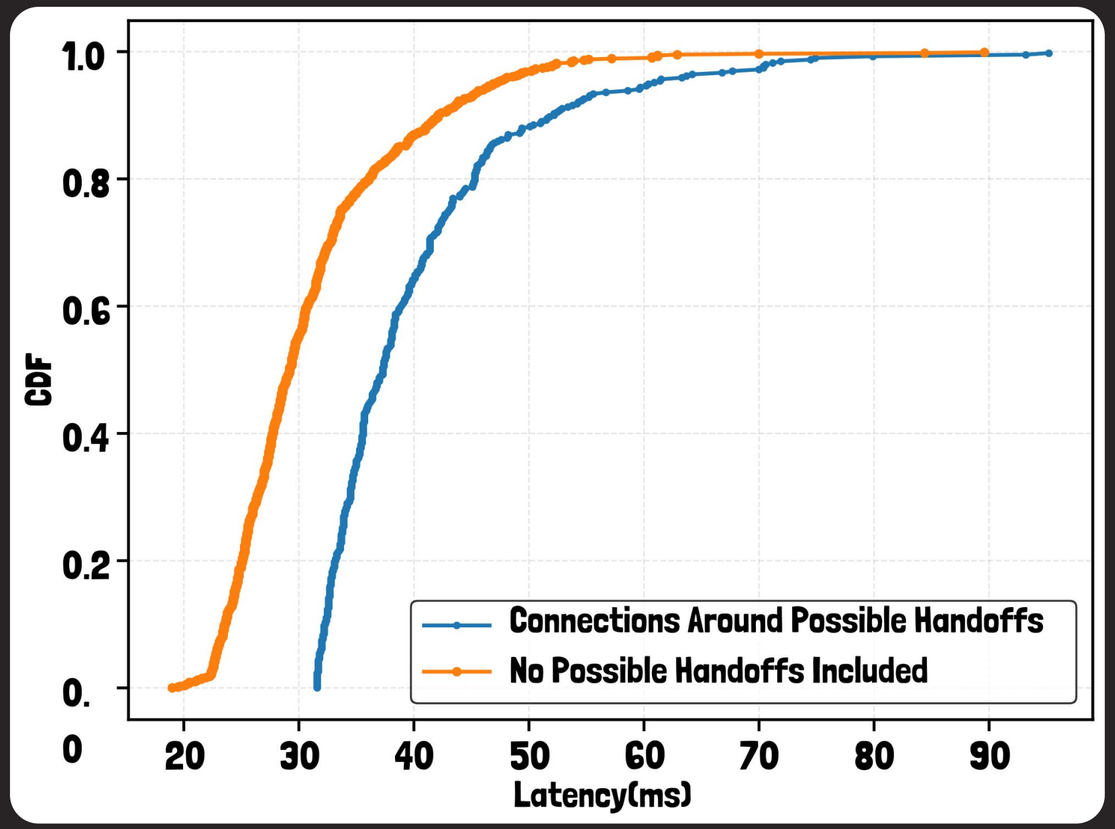
Allows pre-scheduled experiments based on predictable events, such as satellites going out of line-of-sight, enabling targeted performance analysis at specific time points.



Or curious about what effects Starlink's 15-second global scheduler has over latency? Why not running your measurements every 15 seconds then?



Unique Feature → Trigger Mode

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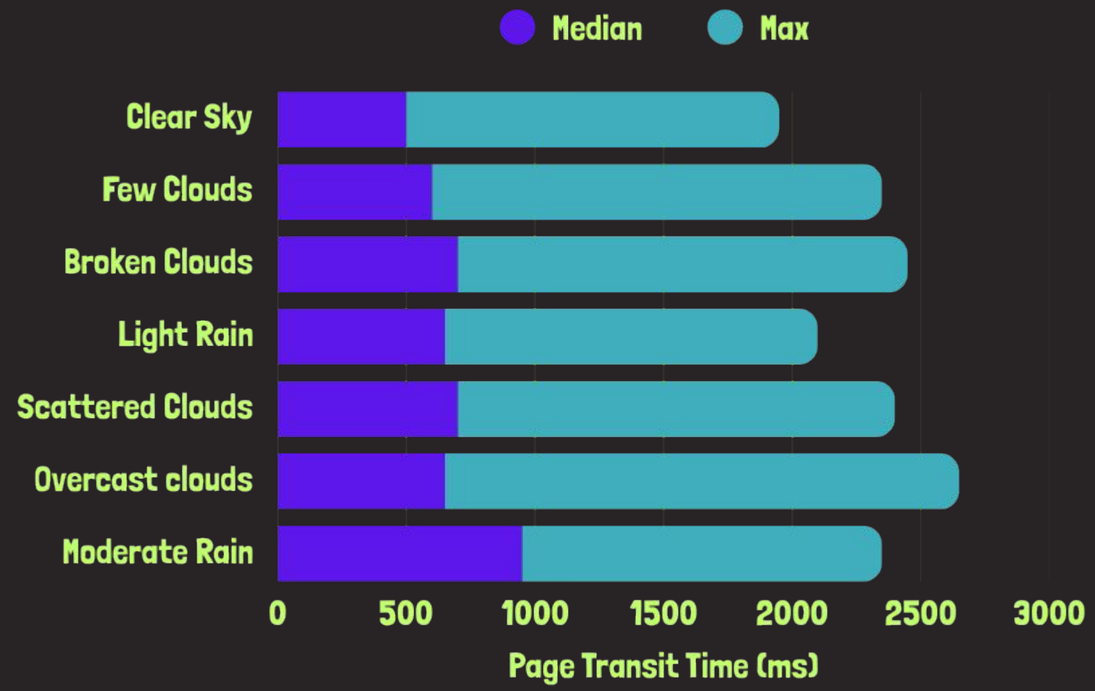
Proactively schedules experiments based on exogenous factors such as weather conditions, and performance metrics allowing real-time data collection and ensuring statistical validity.



Or curious about what is the correlation between weather conditions and web browsing experience?

Realtime Starlink gRPC Telemetry Data

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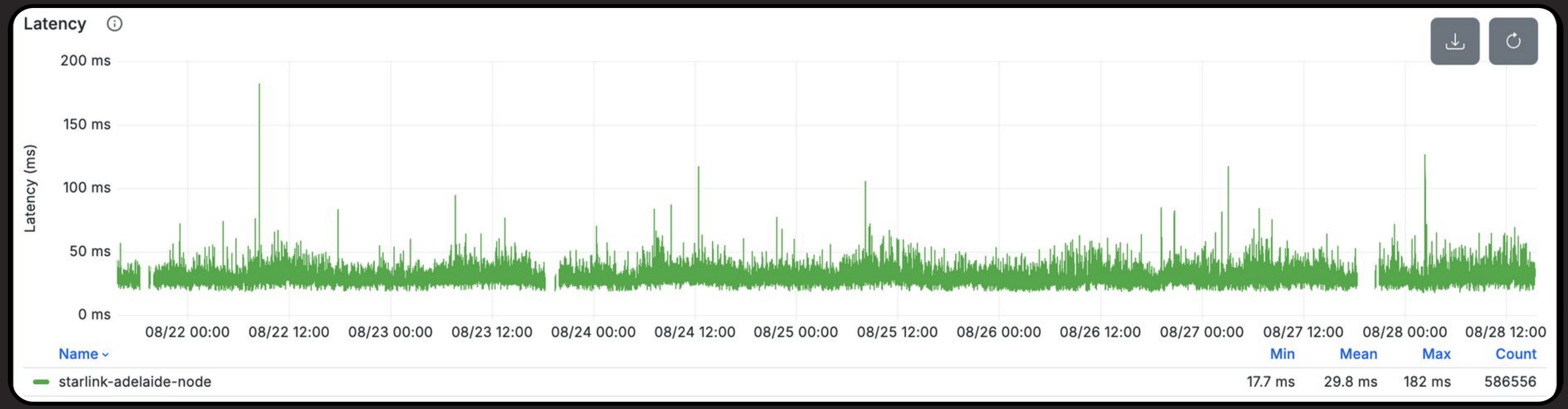
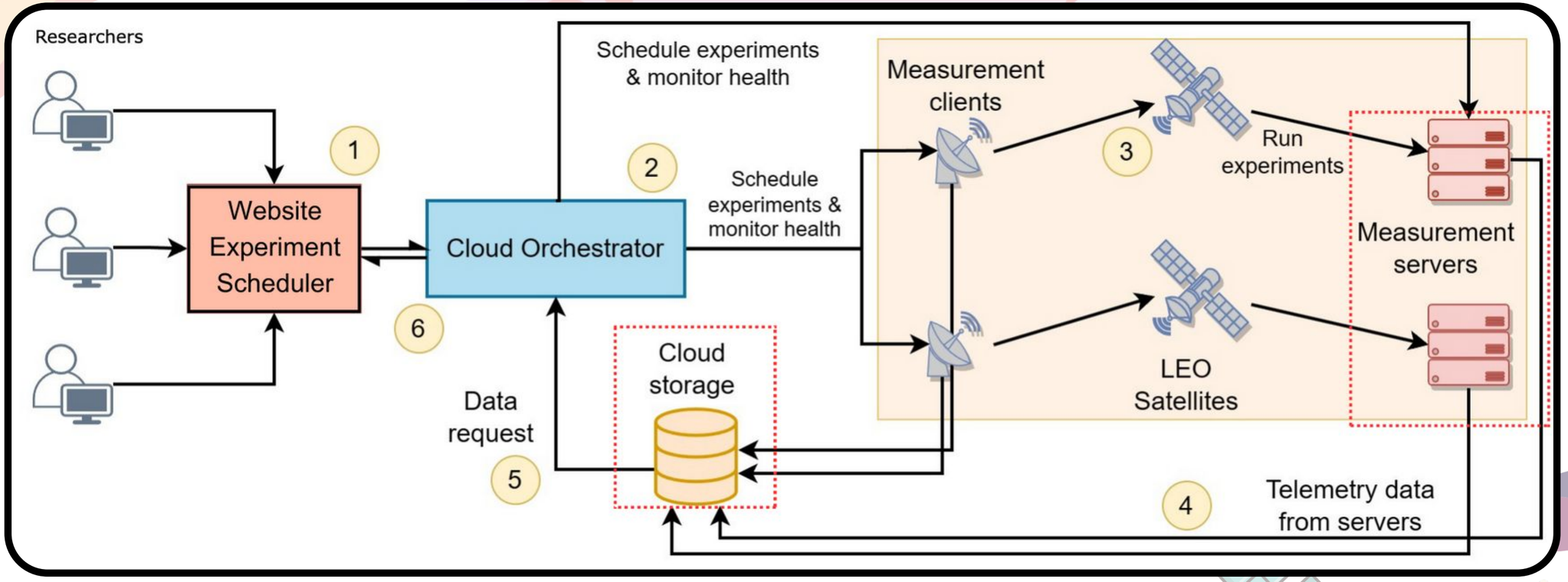
Starlink gRPC Telemetry data includes:

- SNR details
- Dish connection Elevation and Azimuth Angles
- UL + DL Throughput
- PoP Ping Latency + Drop Rate
- Hardware + Software Version details
- Dish Obstruction details



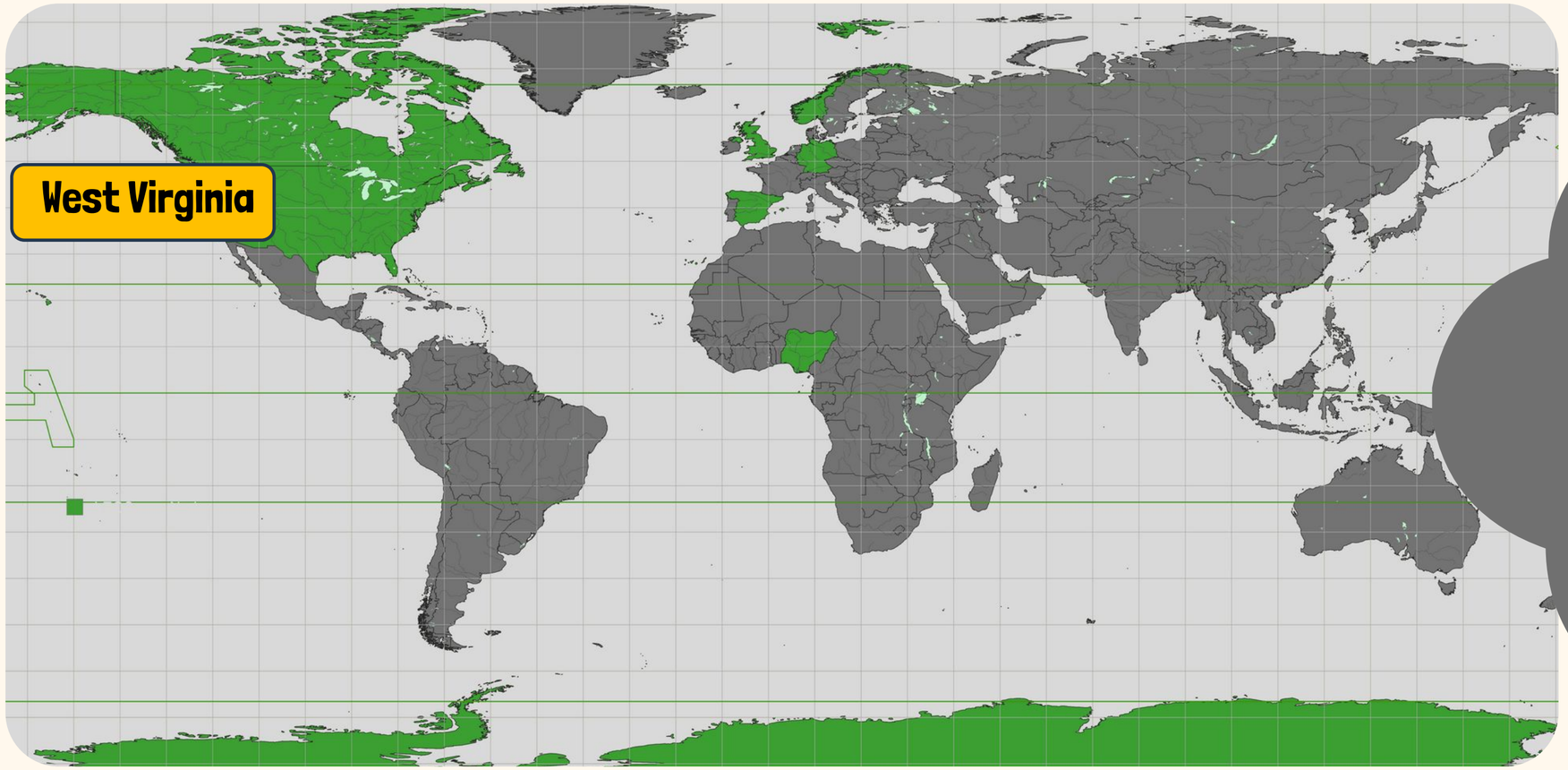
LEOScope Dashboard

LEOScope Architecture



Demotime - I

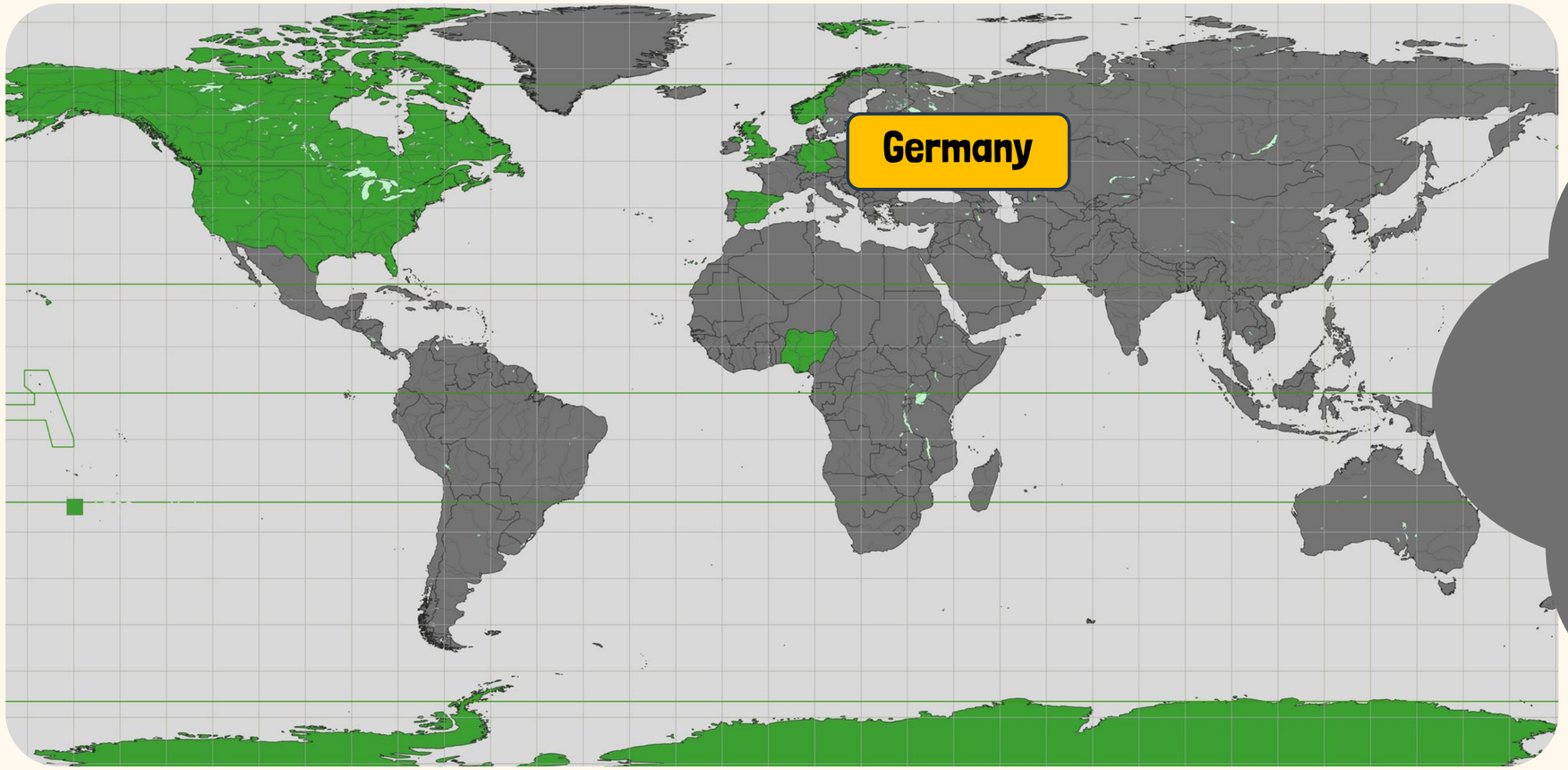
Running a Global Testbed is more Art than Science!



📍 West Virginia Node

"Online only on weekends — during the week the empty house cuts the power, and the node takes a nap. 🏠 zzz"

Running a Global Testbed is more Art than Science!



📍 Germany Node

"Trapped behind university IT firewalls and approval hurdles 🏢"

Running a Global Testbed is more Art than Science!

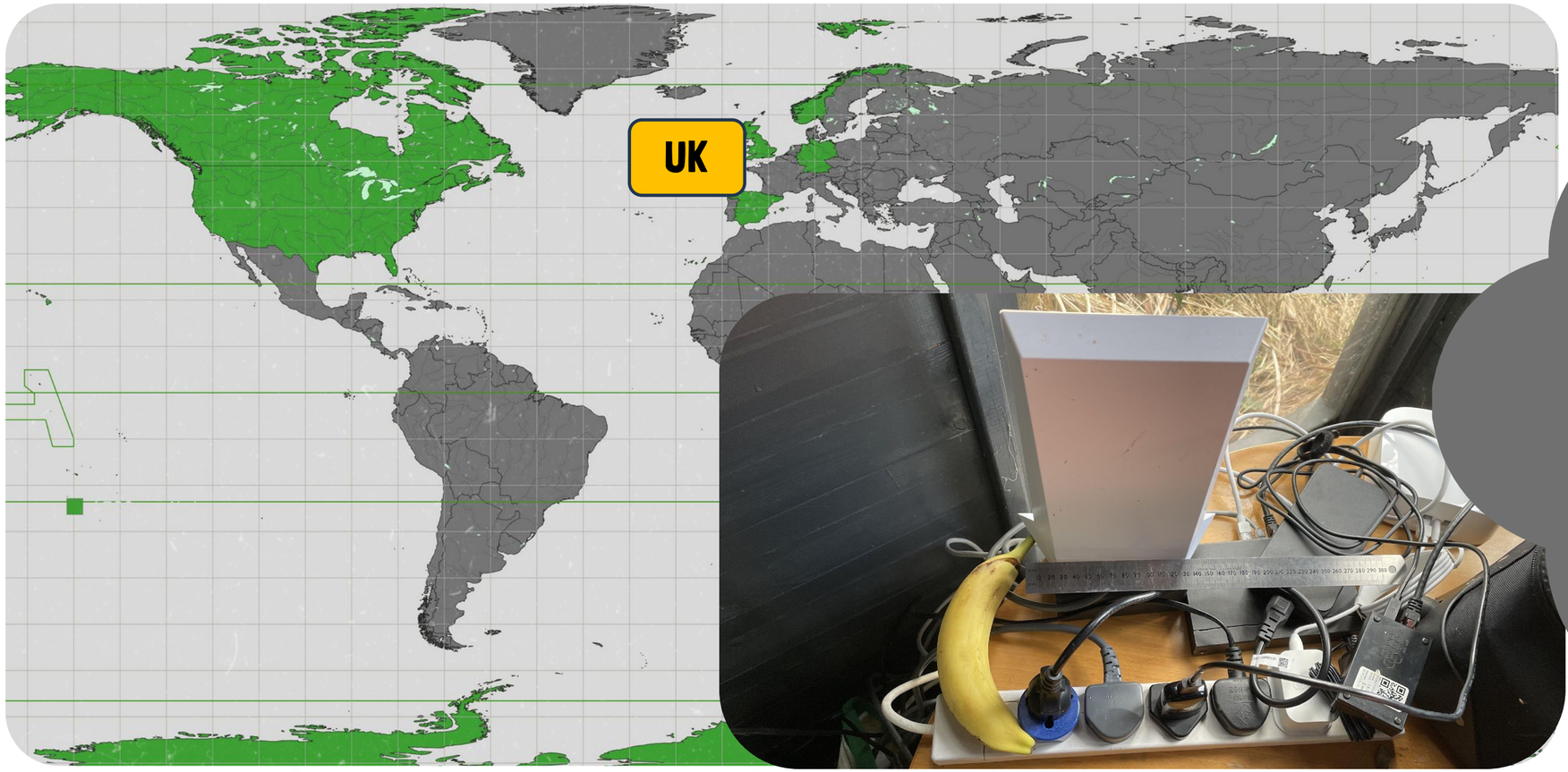
📍 Nigeria Node

Maintained by Abdul's brother (a salesman, not an engineer!)

Constant power cuts ⚡

Needs WhatsApp calls to: "please restart the dish machine"

Running a Global Testbed is more Art than Science!



📍 UK Node

"Hiding in my backyard

Demotime - 2

LEOScope -- Where Are We Now?

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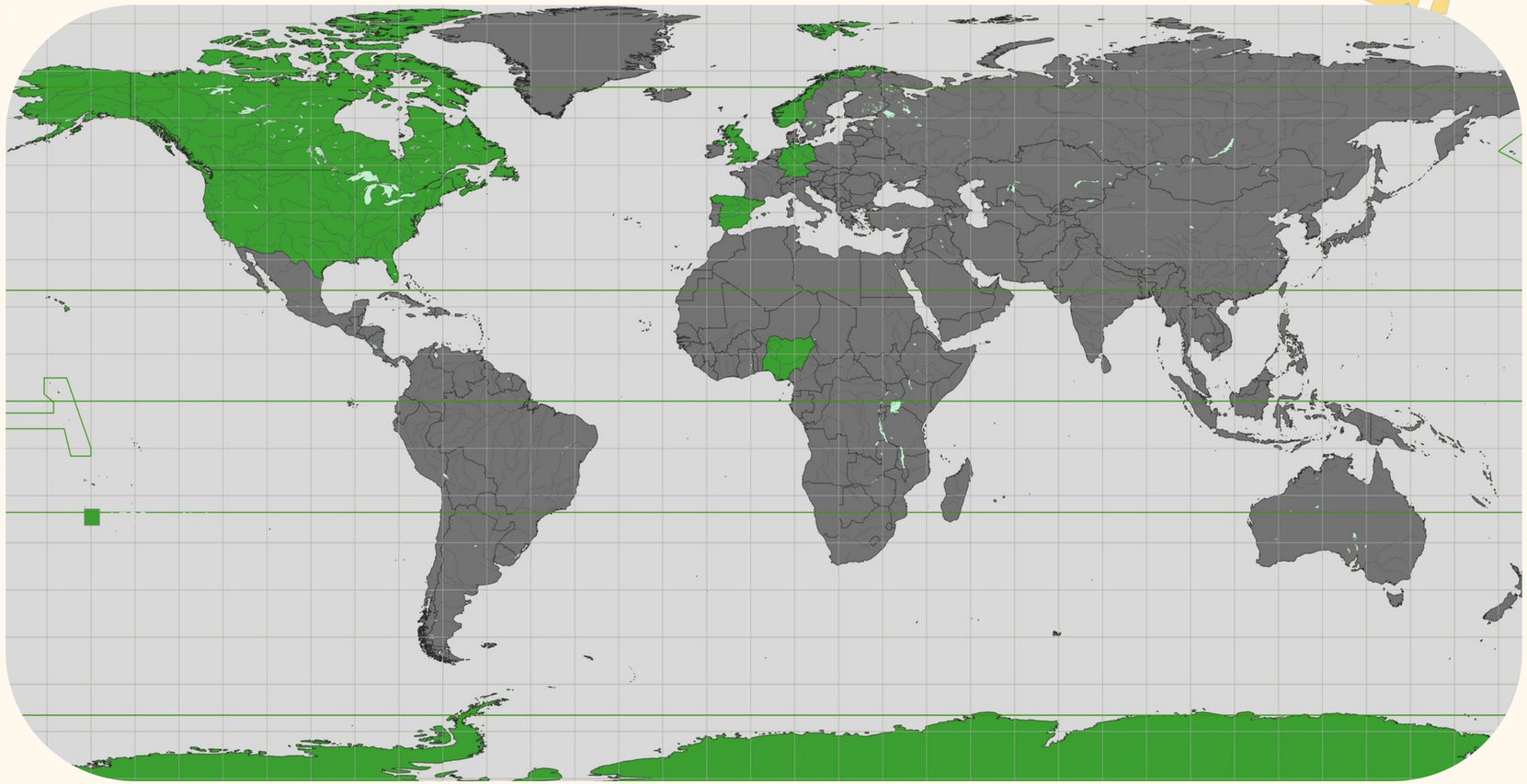
Already active in 5 out of 7 Continents:

- Europe – UK, Germany, Spain, Norway (4 countries)
- North America – US, Canada (2 countries)
- Africa – Nigeria (1 country)
- Australia/Oceania – Australia (1 country)
- Antarctica – Antarctica (1 continent/region)



We are seeking for volunteer nodes in:

- Asia
- South America
- All around the world!

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THANK YOU ALL!

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🌍 Our Volunteers:

- 🇬🇧 Nishanth's place (UK) — still no proper fiber connection!
- 🇳🇬 Abdul's brother (Nigeria)
- 🇨🇦 University of Waterloo (Canada)
- 🇨🇦 University of Victoria (Canada)
- 🇳🇴 Simula Metropolitan Center (Norway)
- 🇩🇪 University of Osnabrück (Germany)
- 🇩🇪 Technical University of München (Germany)
- 🇦🇺 University of Adelaide (Australia)
- 🇺🇸 Virginia Tech (USA)
- 🇦🇶 McMurdo Station (Antarctica)

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VS Other Testbeds?

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	Built-in Telemetry	Trigger (IFTTT)	User Defined Exps	Data Access	Purpose
RIPE Atlas	✓	✗	✗	Public	Broadband Measurements
MLAB	✗	✗	✗	Public	End-user Performance
PlanetLab	✗	✗	✓	Public	Network Service Deployments
EdgeNet	✗	✗	✓	Restricted	Distributed Edge/ Cloud Dev
SamKnows	✓	✗	✗	Restricted	Broadband Measurements
LEOScope	✓	✓	✓	Public	Satellite Network Measurements