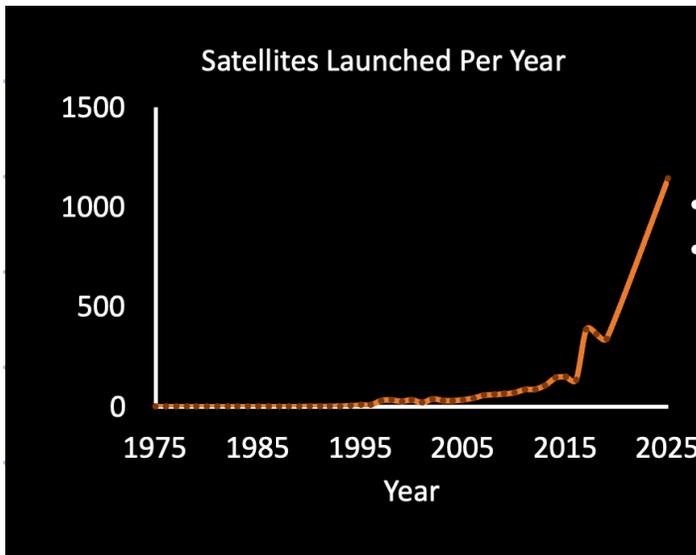


# CS 598, LECTURE 24

- Satellite Networking: Context
- Orbits and implications
- Architectures
- Measurements.

# Satellite Networking: Concepts



→ Reduced cost to build

→ Reduced cost to launch.

# Applications

{ Networking }

IoT

Earth Observation.

# Satellite Internet: Motivation

- Rural connectivity
- Seas, oceans, forests.

How does mobility impact connectivity?  
Are bees a problem?



# Orbits and Tradeoffs

Low Earth Orbit  
(LEO)

500-1000km.

Motion

90 mins.

Intermittent.

Coverage

Latency

Faster

10-20ms.

Signal Strength

Higher signal strength.

Starlink - 5000

Amazon Kuiper - 3000

OneWeb - 1000

Geostationary Orbit  
Satellites  
(GEO)

36000km.

24 hour orbit

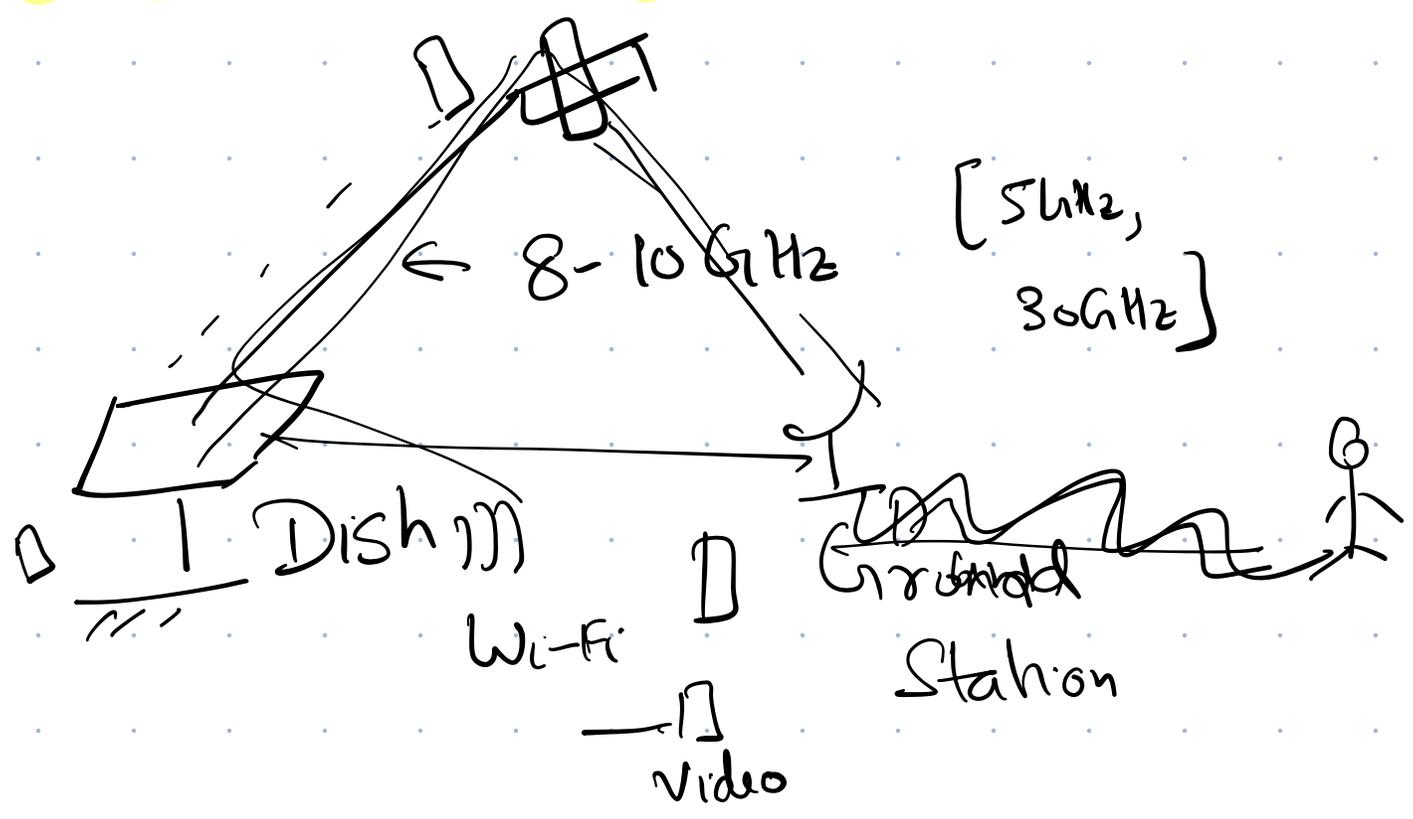
More

240ms.

42000

# Dynamics and Architecture Video

# NETWORK ARCHITECTURE



Bent-pipe architecture

# BENT PIPE TRADEOFFS



## Pros

- Simple
- networking mumbo-jumbo

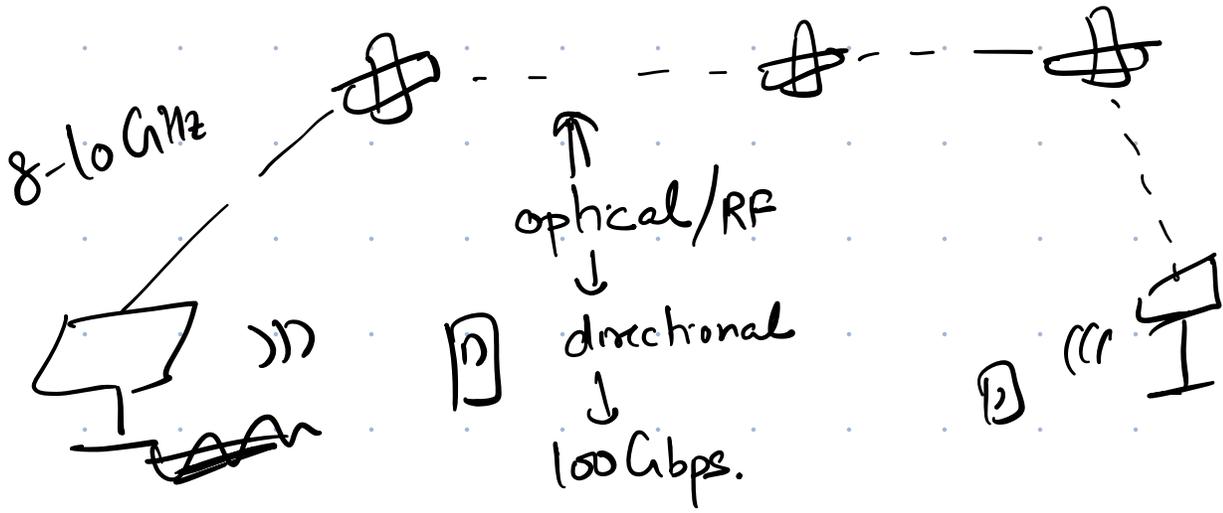
## Cons

- Extensive ground station infrastructure
- How do we get connectivity in oceans.

Is it faster?

- Speed of light over air is <sup>50%</sup>~~33%~~ faster than fiber.

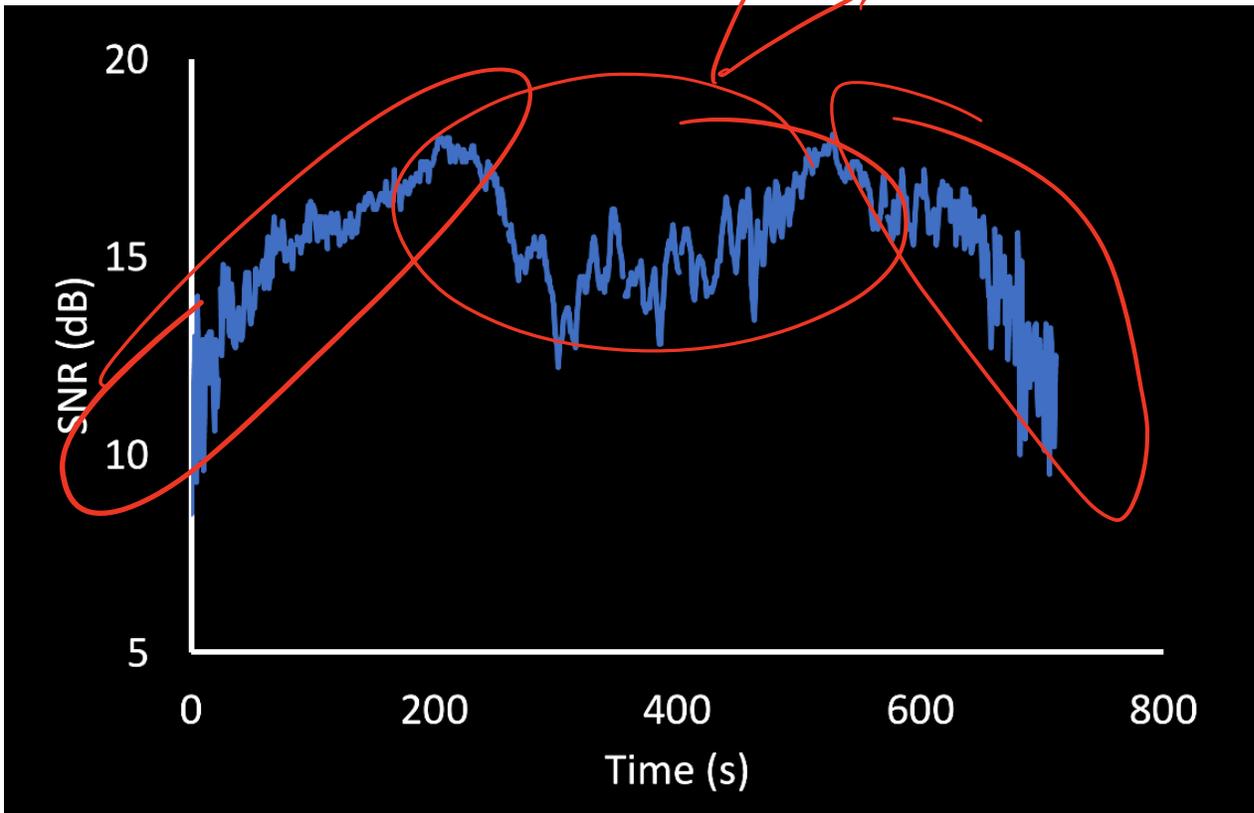
# INTER-SATELLITE LINKS



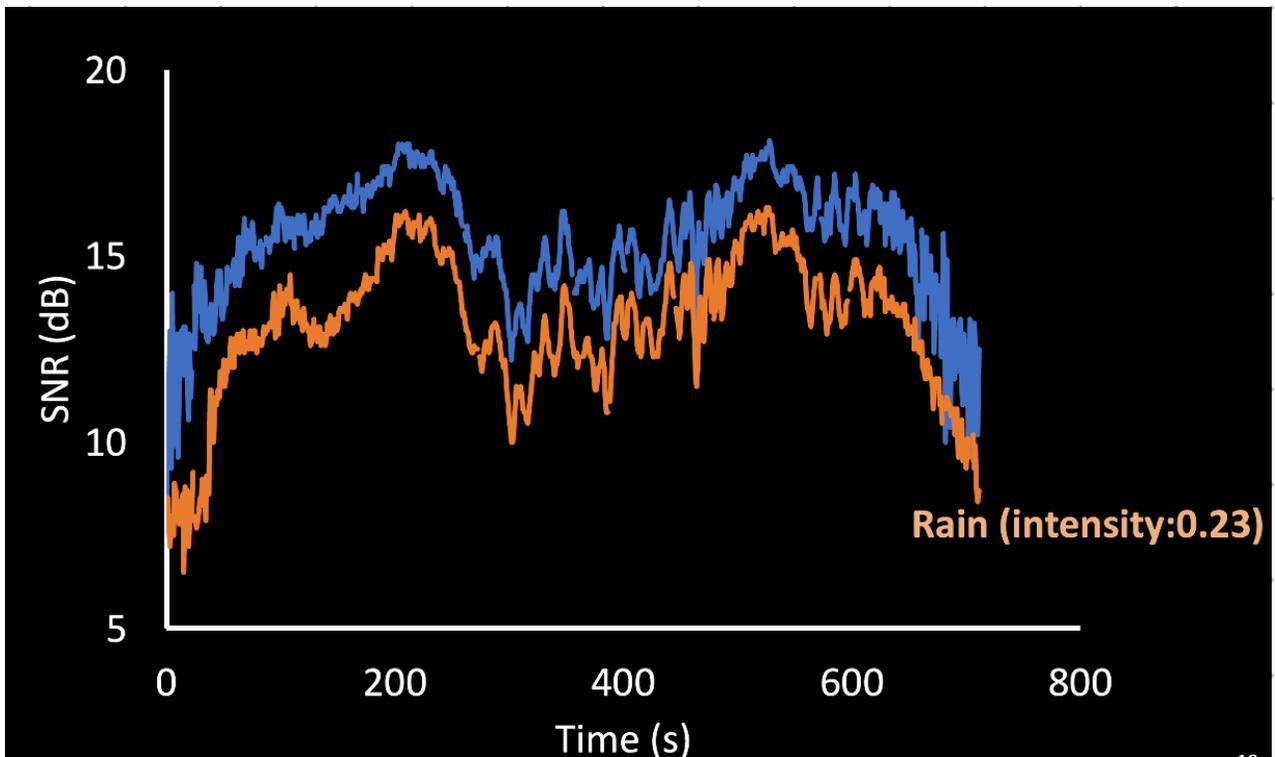
Largely limited to areas with not enough ground infrastructure

# LINK VARIATION

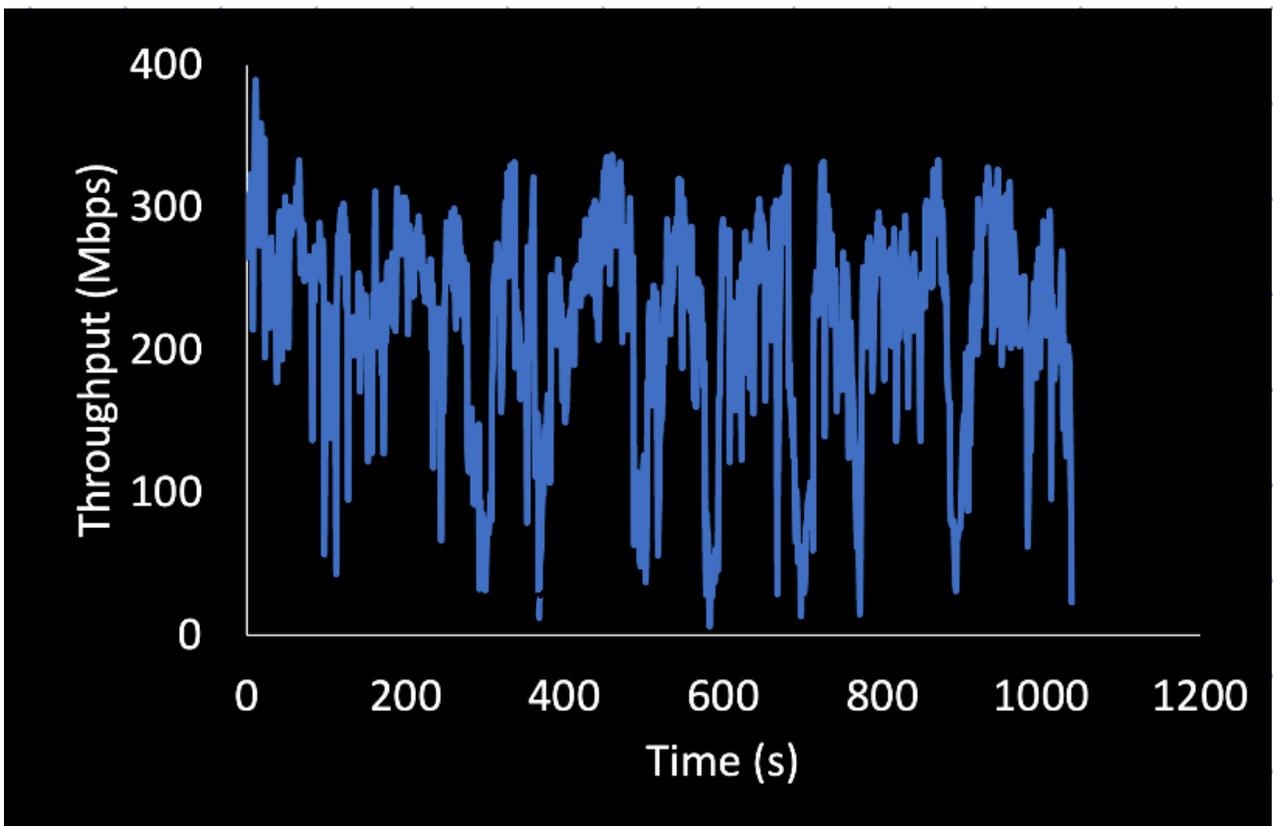
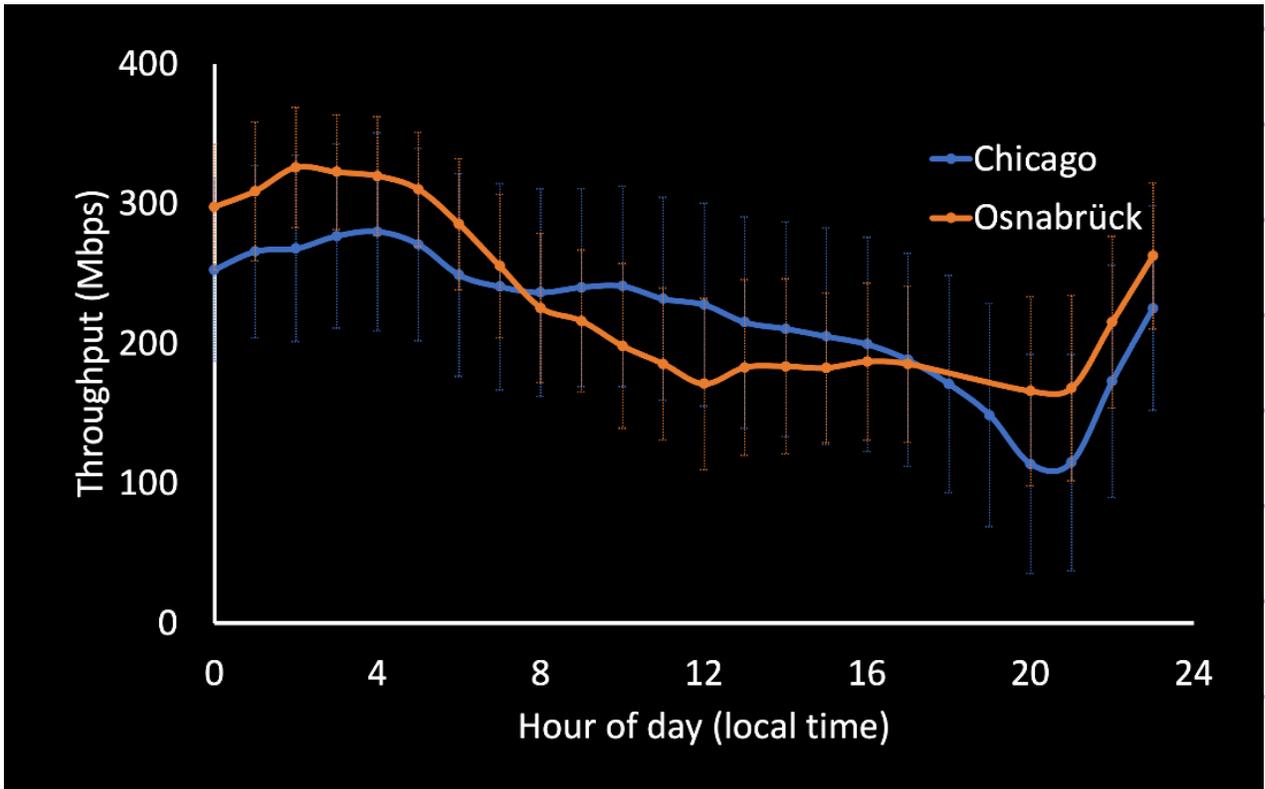
Obstruction  
Multipath.



- ① Distance,
- ② Weather,
- ③ Local factors.



# THROUGHPUT VARIATION



15-second reconfiguration.

# MEDIUM ACCESS



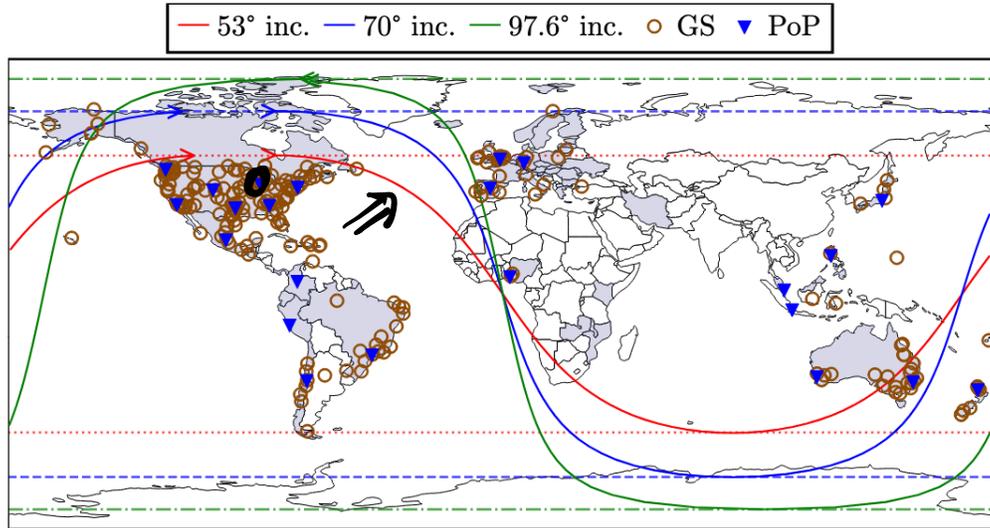
CSMA  
listen-before-talk<sup>x</sup>



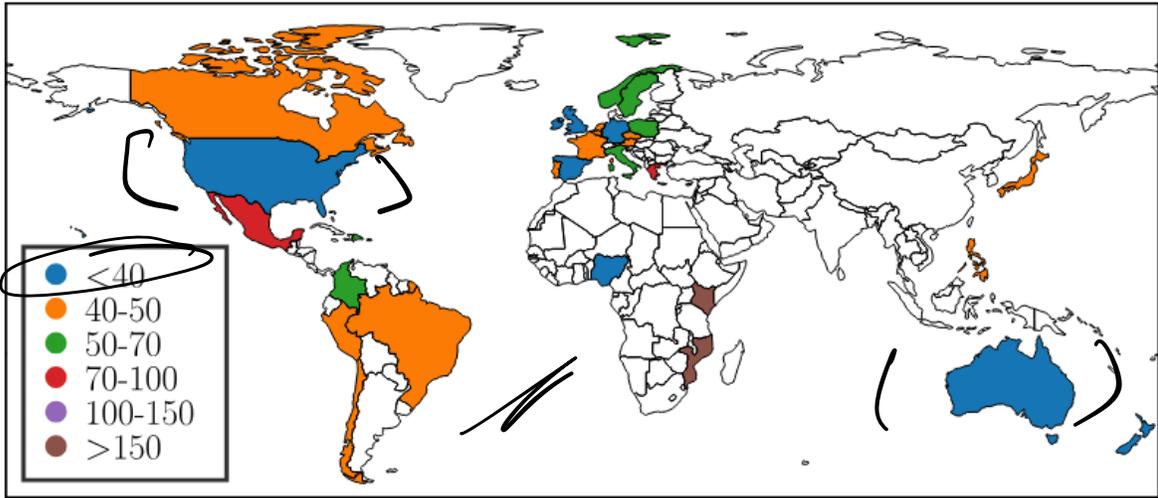
TDMA / FDMA.

Spatial Multiplexing  $\Rightarrow$  beams.

# GLOBAL MEASUREMENTS



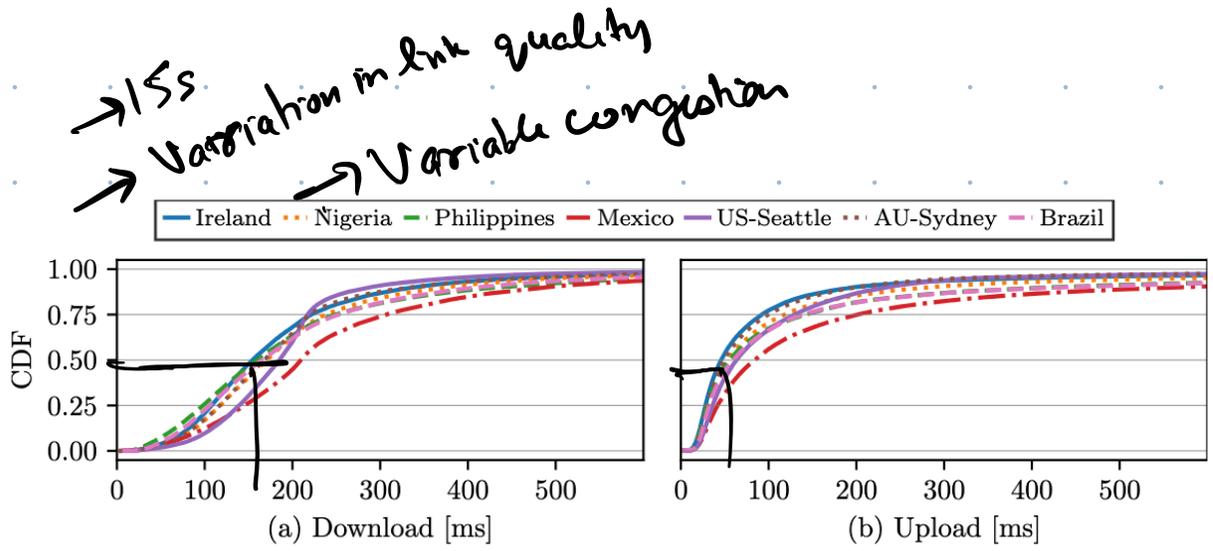
Satellite



Terrestrial  
Top 3 ISPs



CTE



**Figure 8: RTT inflation (maxRTT-minRTT) during M-Lab Starlink speedtests per continent: (a) download, (b) upload traffic.**

	Terrestrial	Cellular	Starlink
Idle RTT (ms)	9	46	40
Throughput (Mbps)	1000	150	220
Frames-per-second	59±1.51	59±1.68	59±1.63
Bitrate (Mbps)	23.08±0.38	22.82±4.24	22.81±2.16
Time at 1080p (%)	100	94.11	99.45
Freezes (ms/min)	0±0	0±220.34	0±119.74
Inter-frame (ms)	17±3.65	18±11.1	16±6.76
Game delay (ms)	133.53±19.79	165.82±23.55	167.13±23.12
RTT (ms)	11±13.41	39±17.06	50±16.28
Jitter buffer (ms)	15±3.27	12±1.33	15±3.35

**Table 1: Luna gaming results over 150 mins playtime. Values denote median±SD and the worst performer is highlighted.**