Considerations for Benchmarking Network Performance in Integrated Space and Terrestrial Networks

draft-lai-bmwg-sic-benchmarking-00

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[IETF#115, BMWG meeting, November 10, 2022]

Background: A New Era of Satellite Internet

- **Broadband Satellite Constellations** in low earth orbit **(LEO)** are gaining tremendous popularity
  - **Operational:** SpaceX's Starlink (as of Nov 2022, launched over **3000** LEO satellites; provide Internet access to over **500,000** subscribers; aim for global mobile phone service after 2023) .
  - **Proposed:** OneWeb (648 satellites), Amazon Kuiper (3276 satellites), Boeing (147 satellites) in plan.

- Promising future direction: Integrated Space and Terrestrial Network **(ISTN)**
  - Emerging satellites can be equipped with high-speed ground-satellite (Ku/Ka-band) and inter-satellite links (laser).
  - Integrating broadband LEO satellites with terrestrial networks for **pervasive and performant Internet services.**


Remote Service


Rural Education

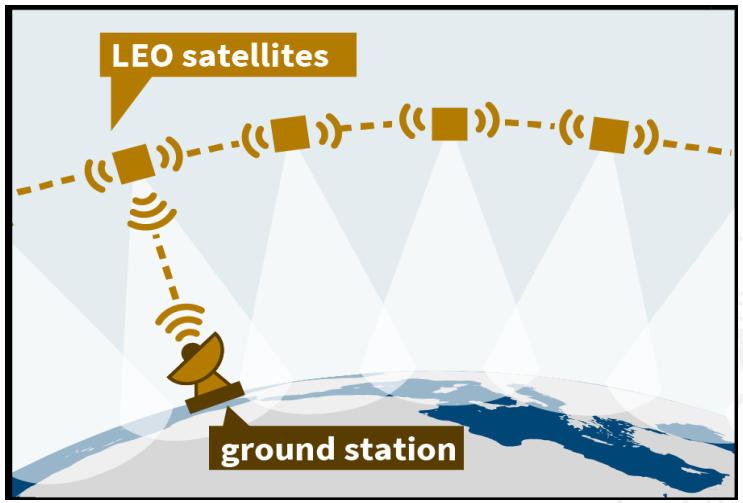

Airplane

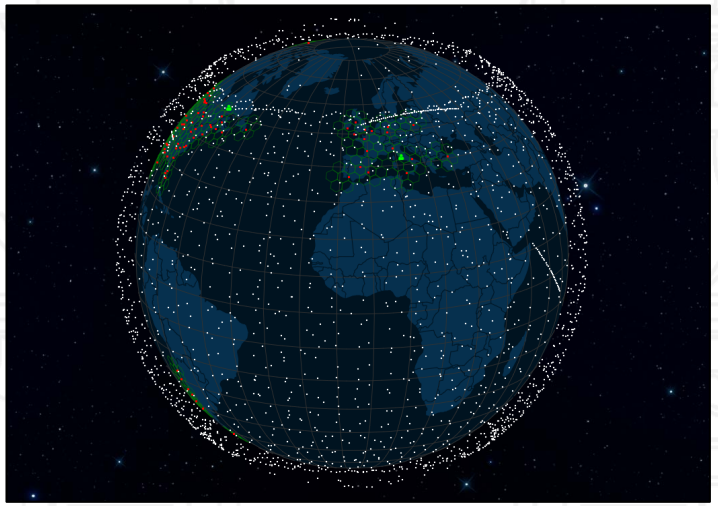

Global IoT


Maritime

Why Benchmarking in ISTN is Important?

- **Motivation**
  - Like in other kinds of conventional networks, network techniques (e.g. new network topology, protocol, functionality) are expected to be carefully evaluated in an **Isolated Test Environment (ITE)**, before they are deployed in a live production environment.
  - Unlike in traditional situations, for ISTN core infrastructures (i.e. satellite router/switch), post-launch upgrades (especially onboard hardware) are difficult and thus require a **more systematic and comprehensive assessment** prior to launch.
- **Recap:** Problems and Requirements of Evaluation Methodology for ISTN
  - **Draft (presented in IETF-112):** https://datatracker.ietf.org/doc/draft-lai-bmwg-istn-methodology/02/.
  - Unique characteristics (e.g. **LEO dynamics**, **mega-scale**), limitation of existing benchmarking methodologies.
- **Remaining Questions**
  - What aspect of ISTN-related problem could be pursued for benchmarking network DUT/SUT?
  - Clarify the work scope that fits the BMWG charter.





Stay in Line with the BMWG Charter, We Consider …

BMWG Charter

- **Major goal:** a series of recommendations concerning the **key performance characteristics of internetworking technologies**, or benchmarks for network devices, systems, and services.
- **Controlled lab environment**

① What play an important role in ISTN performance?

- Constellation topology; network protocol; hardware capability …

② Key performance characteristics pertinent to ISTN

- Service quality; service availability; network reliability, scalability…

③ Important metrics describing the above characteristics

- User-perceived latency/throughput/loss; routing convergence …

④ How to specify methodologies to collect these metrics?

- What is the expected **in-lab benchmarking methodology** for ISTN?
- Concrete approach and test cases (details in our draft and next pages)

⑤ Requirements for reporting ISTN benchmarking results

- Using common and unambiguous report format

A Data-Driven, Emulation-based Benchmark Approach

① community-driven data collection

- Public ISTN information, such as constellation topology, user measurements …

② real-data-driven ITE setup

- Build an ITE via VM- or container-based emulation, with mimicked LEO behaviors (dynamics)

③ specify DUT/SUT and run test cases

- Deploy DUT/SUT in ITE
- Run specific test cases
- Collect and report results

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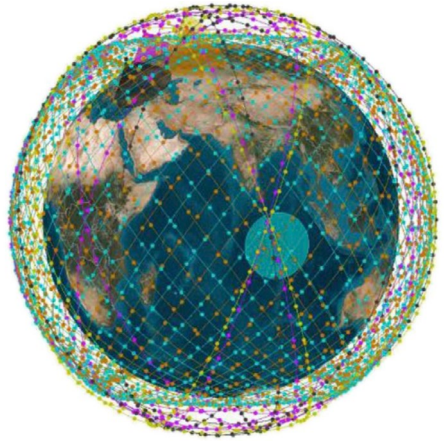

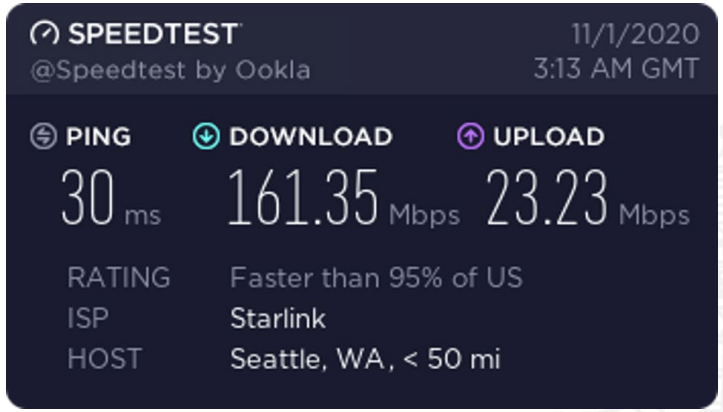

These ISTN-relevant data can guide us to reasonably build and configure an isolated test environment (ITE)

Constellation information from public FCC filings (e.g. # of orbits, # of satellites per orbit, inclination, height …), user measurements …

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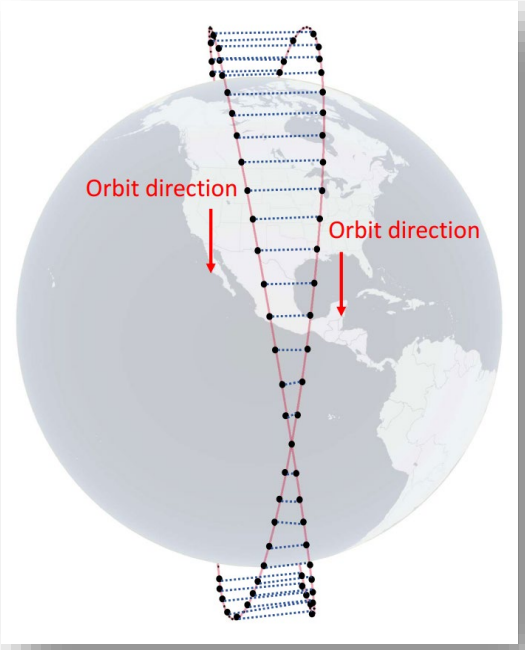
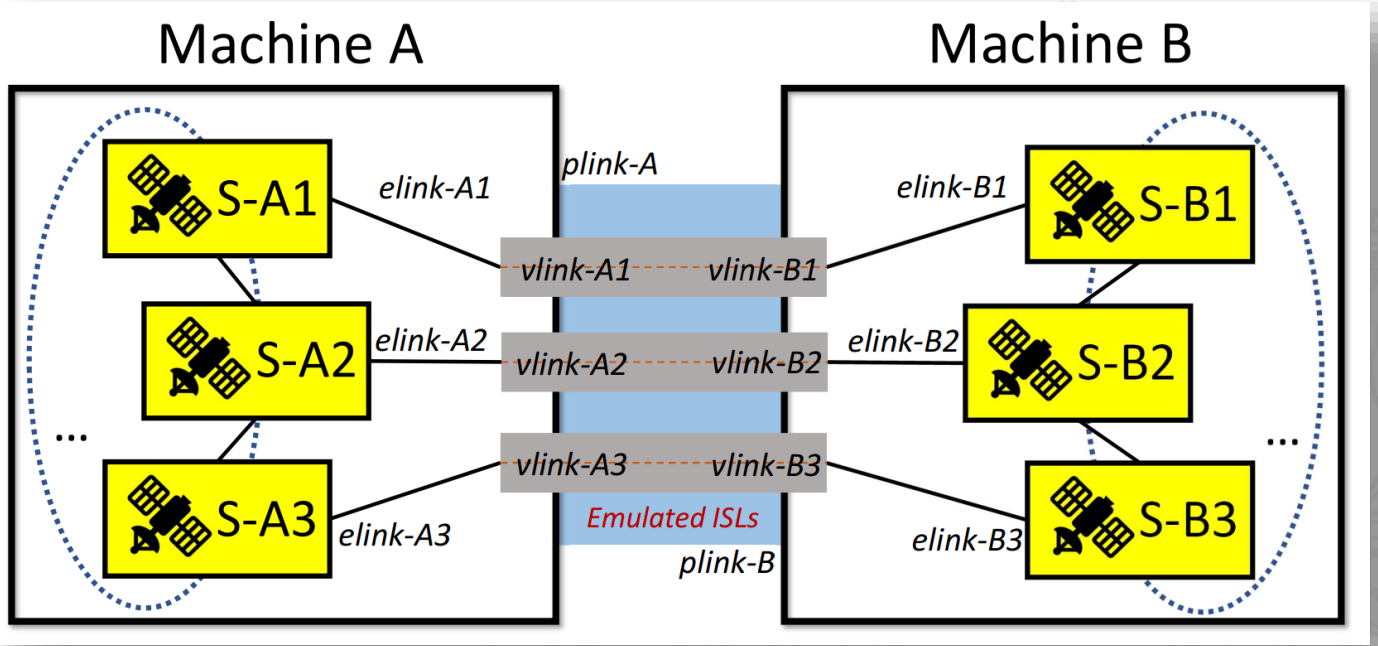


Topology of A Live ISTN

Exploiting data-driven emulation to build the ITE

e.g. using VMs or containers to mimic satellites and their time-varying distance/visibility



A Virtual Representation in A Lab Environment

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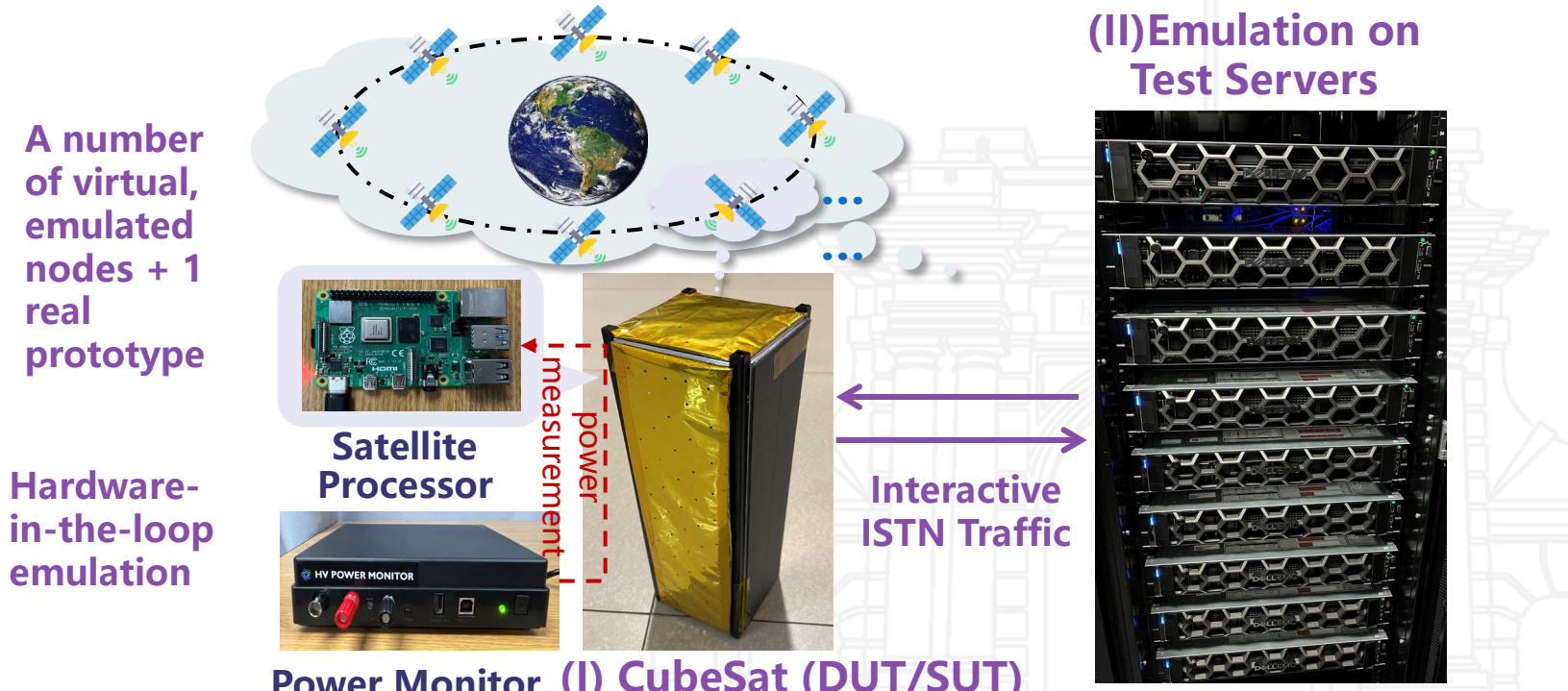
Example:

①In a lab environment, evaluating the power consumption of a new routing protocol implemented on a satellite hardware prototype;

②Evaluating TCP/QUIC throughput in an emulated ISTN experimental environment.



Next Steps

- **Further Discussion & Clarification on:**
  - The class of network functions, systems, or services that are important in emerging LEO satellite Internet constellation and ISTN.
  - Key performance characteristics pertinent to ISTN.
  - A set of important benchmarking metrics.
  - Concrete benchmarking methodology.
  - Proper test cases tailored for ISTN environment.
- **Tools and platforms for building lab-level ISTN test environment**
  - StarPerf [ICNP2020] (codes: https://github.com/SpaceNetLab/StarPerf_Simulator).
  - StarryNet [NSDI2023 (to appear)] (a container-based large-scale ISTN emulator).
  - Facilitating the ITE creation for ISTN benchmarking in a flexible and convenient way.

THANKS

Comments & Questions

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Considerations for Benchmarking Network Performance in Satellite Internet Constellations

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draft-lai-bmwg-istn-methodology-02

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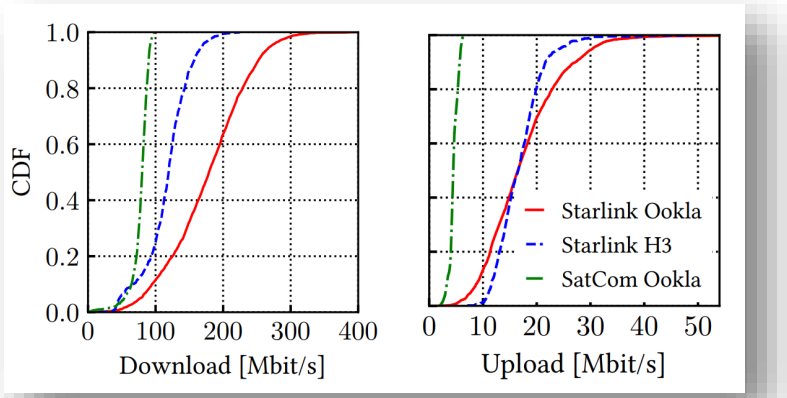
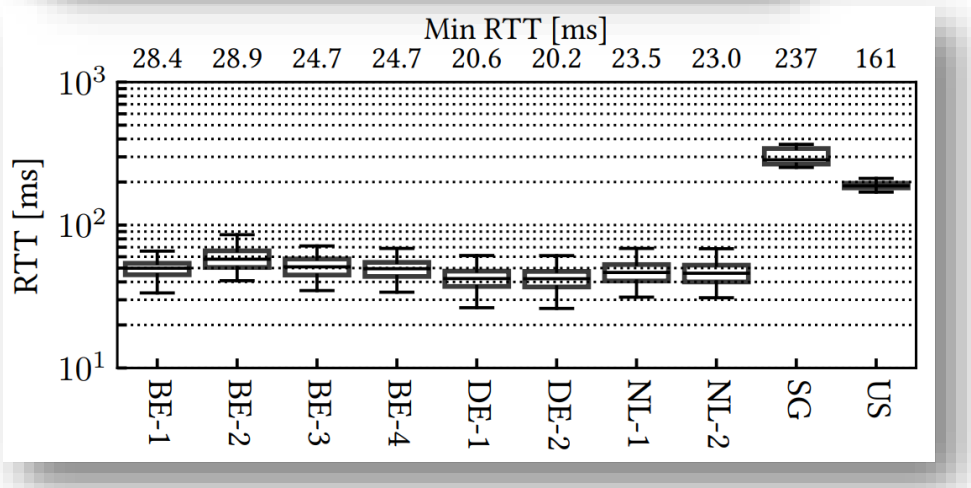
Backup

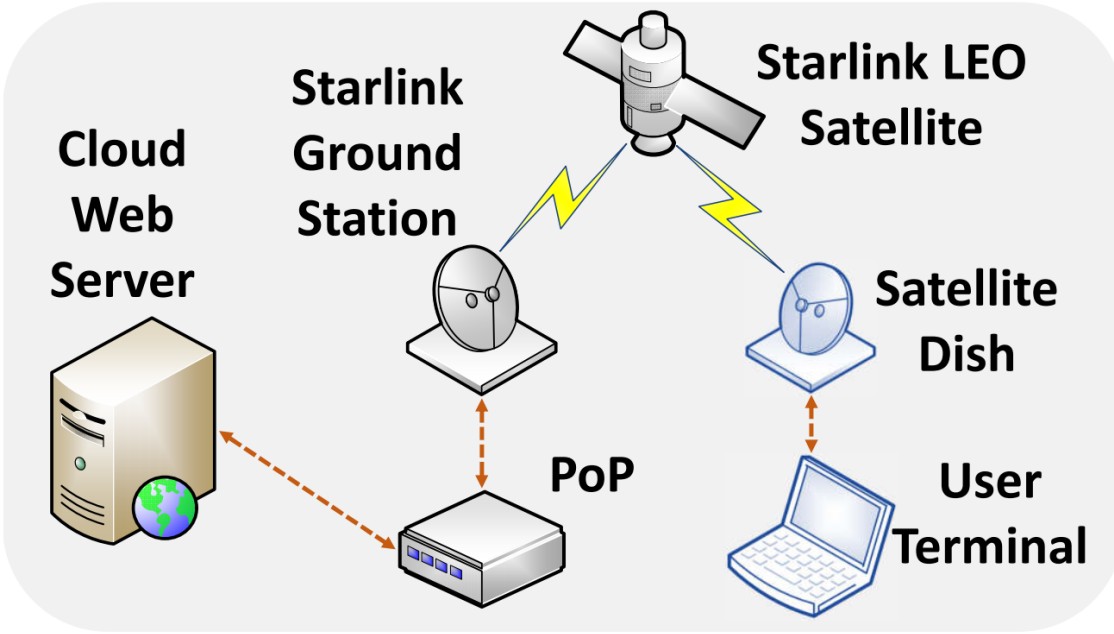
- **How to evaluate the network fidelity of the isolated test environment?**
  - Real-data-driven based configuration





Public LEO satellite performance

Configure link delay and capacity

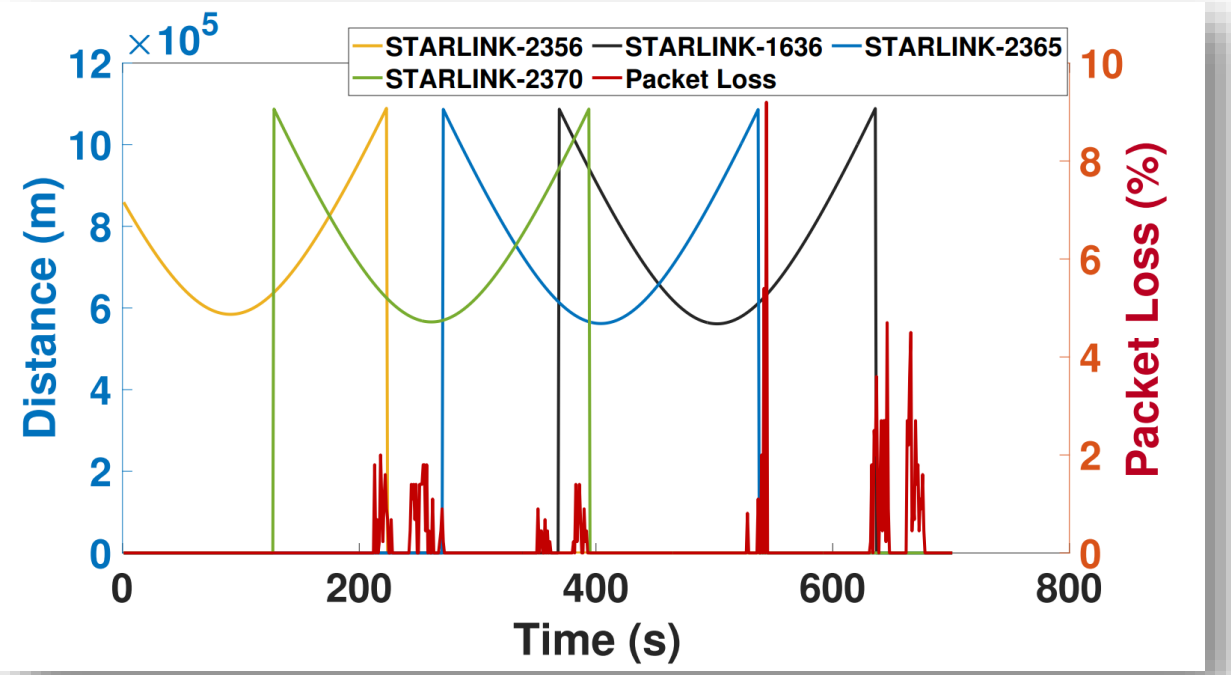


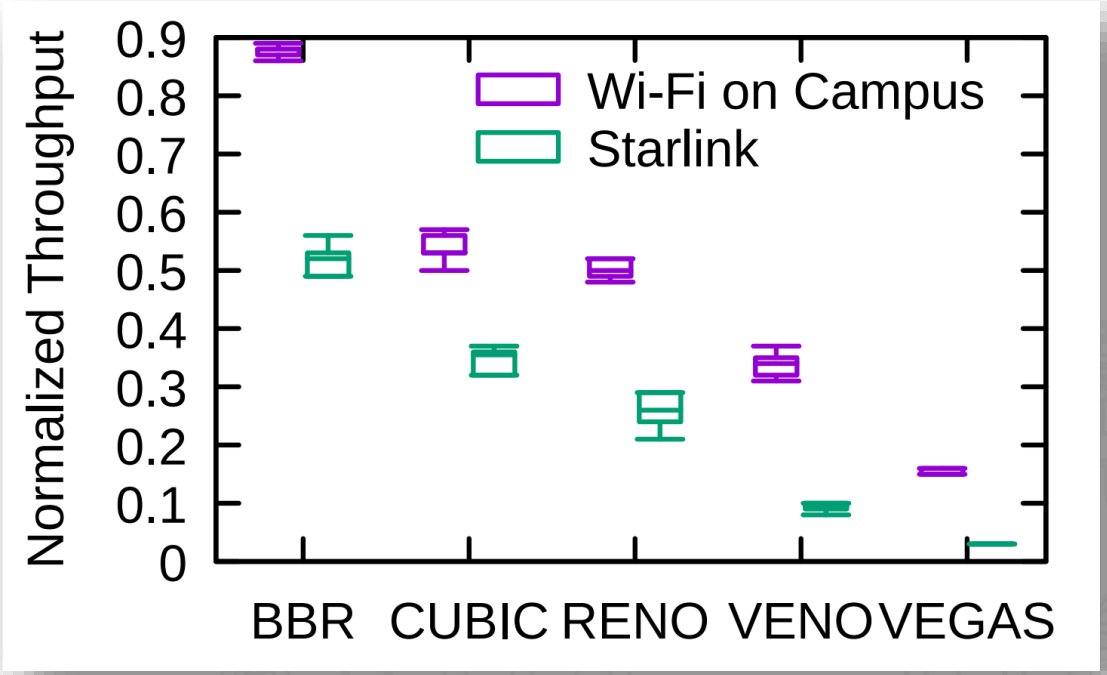
Test Environment: emulated LEO network (e.g. VM/container-based emulation, and use tc to configure link delay and capacity)

Michel, François, et al. "A first look at starlink performance." Proceedings of the 22nd ACM Internet Measurement Conference. 2022.

Backup

- **What is unique in LEO network performance?**
  - Packet loss observed in ISTN due to LEO dynamics
  - Result in different TCP congestion control performance





Kassem, Mohamed M., et al. "A browser-side view of starlink connectivity." *Proceedings of the 22nd ACM Internet Measurement Conference*. 2022.