



Problems and Requirements of Addressing in Integrated Space-Terrestrial Network (ISTN)

Yuanjie Li

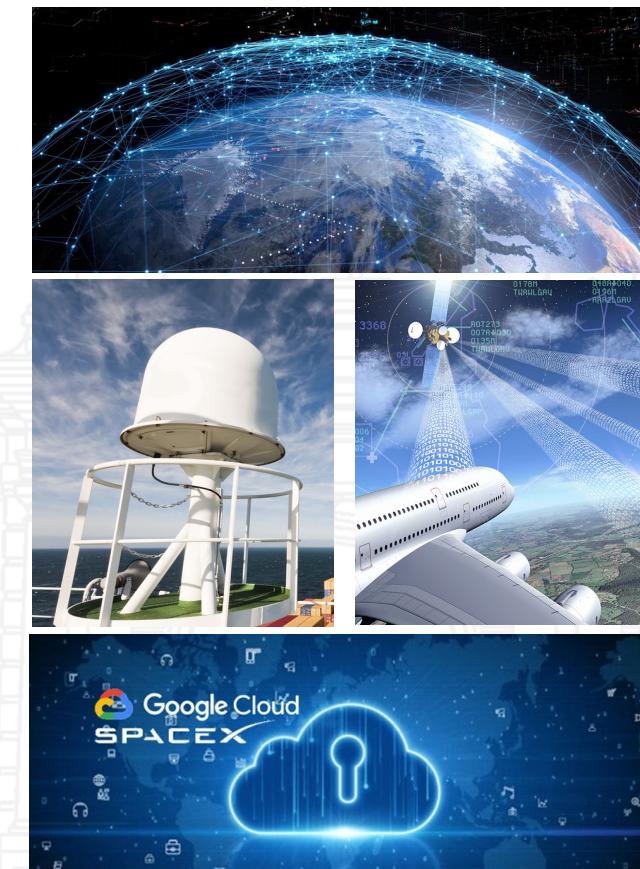
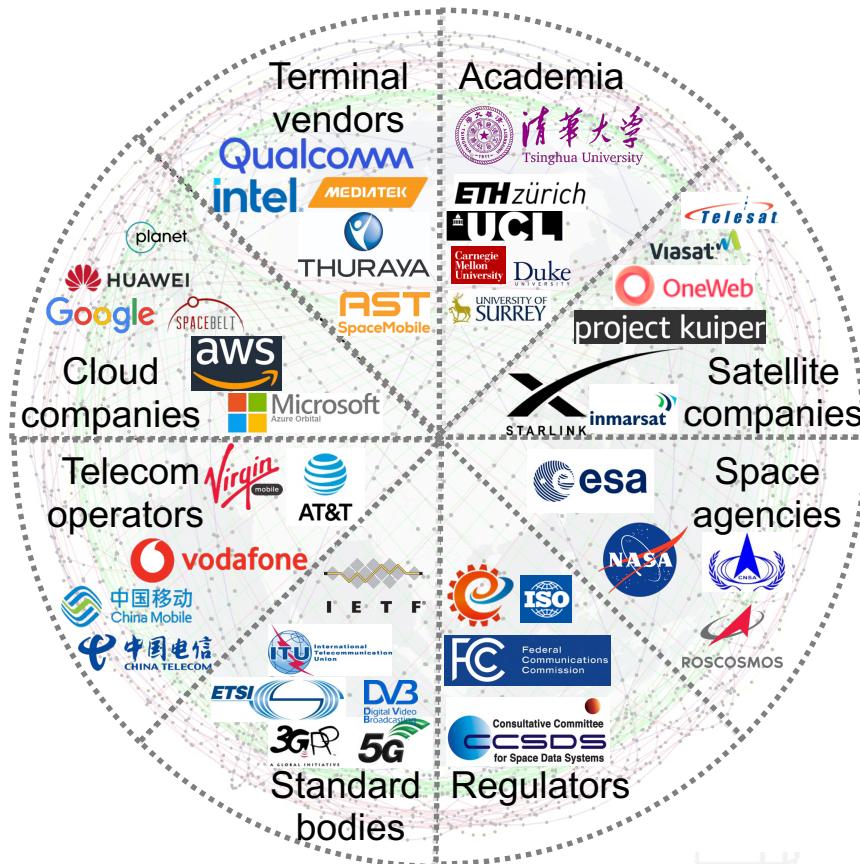
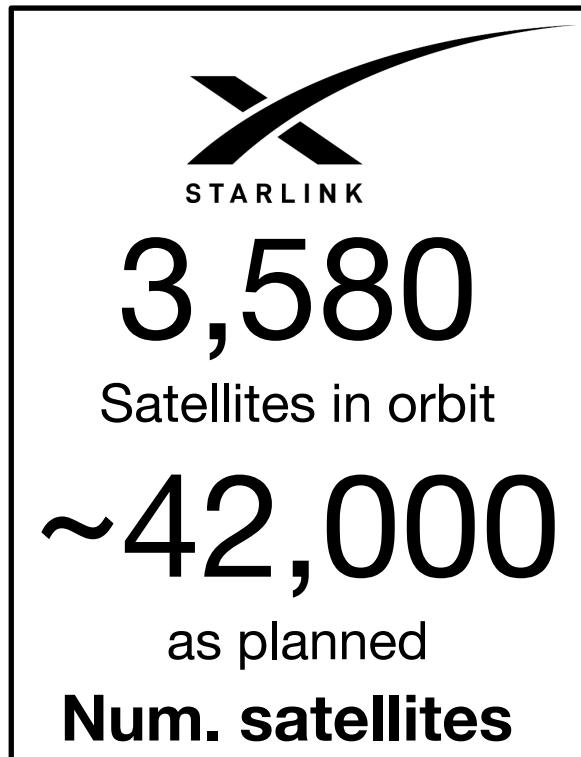
Joint work with Lixin Liu, Hewu Li, Wei Liu, Yimei Chen, Jianping Wu, Qian Wu, Jun Liu, and Zeqi Lai

[draft-li-istn-addressing-requirement-02](#)

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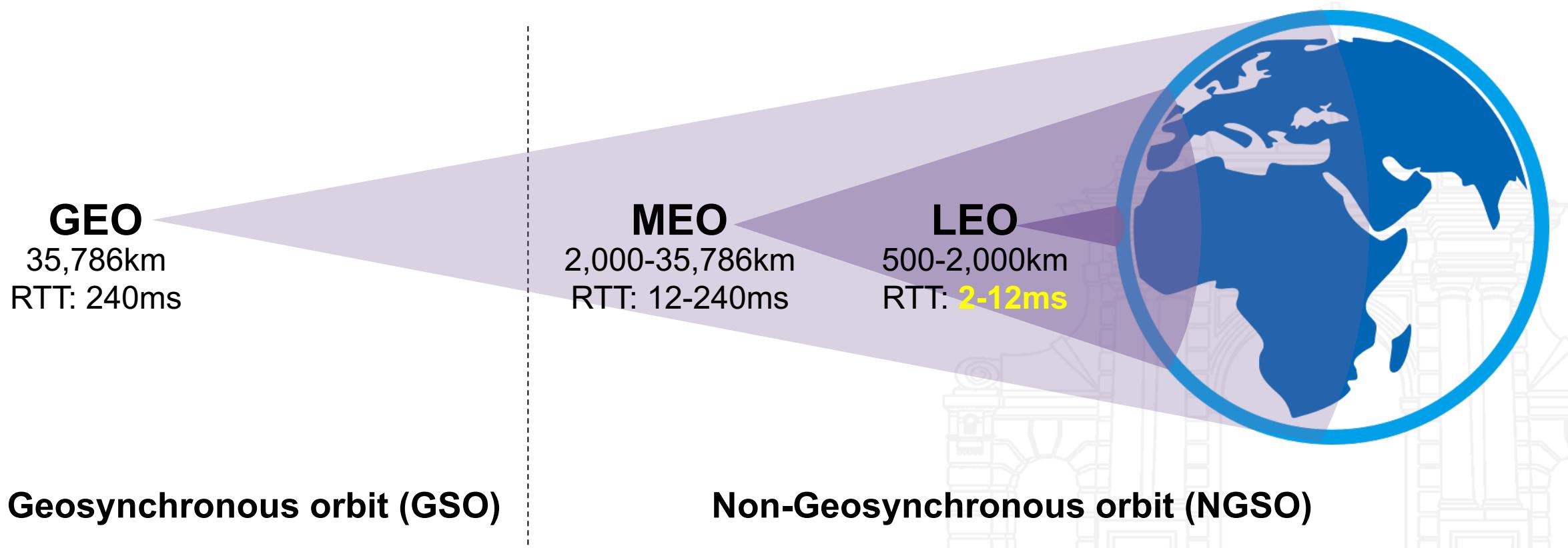
ISTN is on the fast track

- Rocket-fast deployment: From 10s to 10,000s satellites
- Broadband connectivity for the “unconnected” 3.5B global users



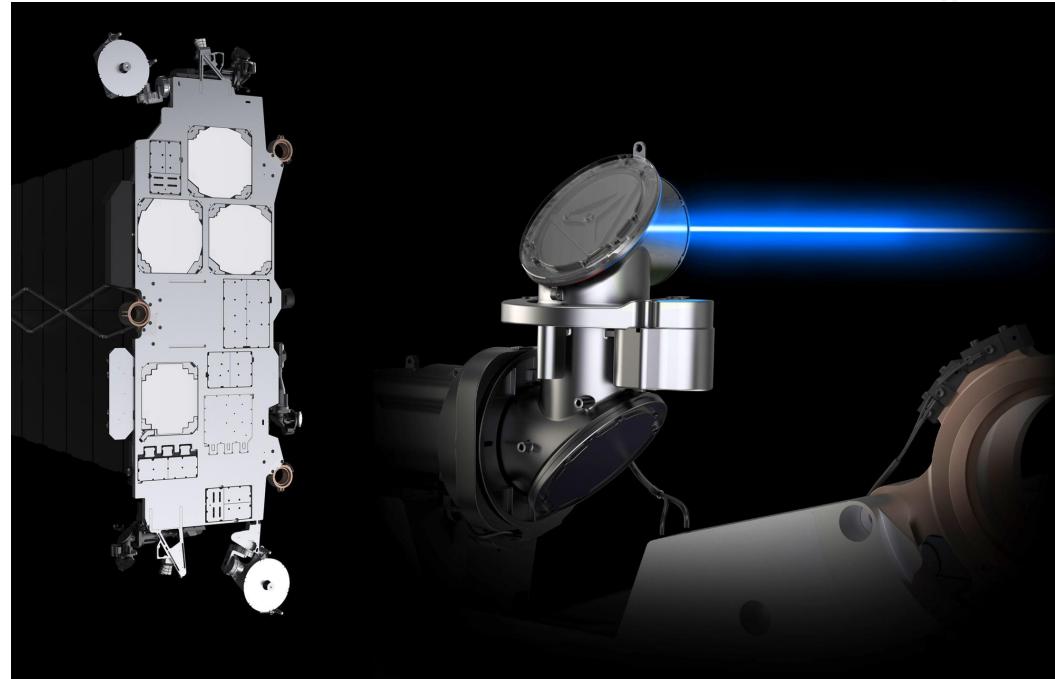
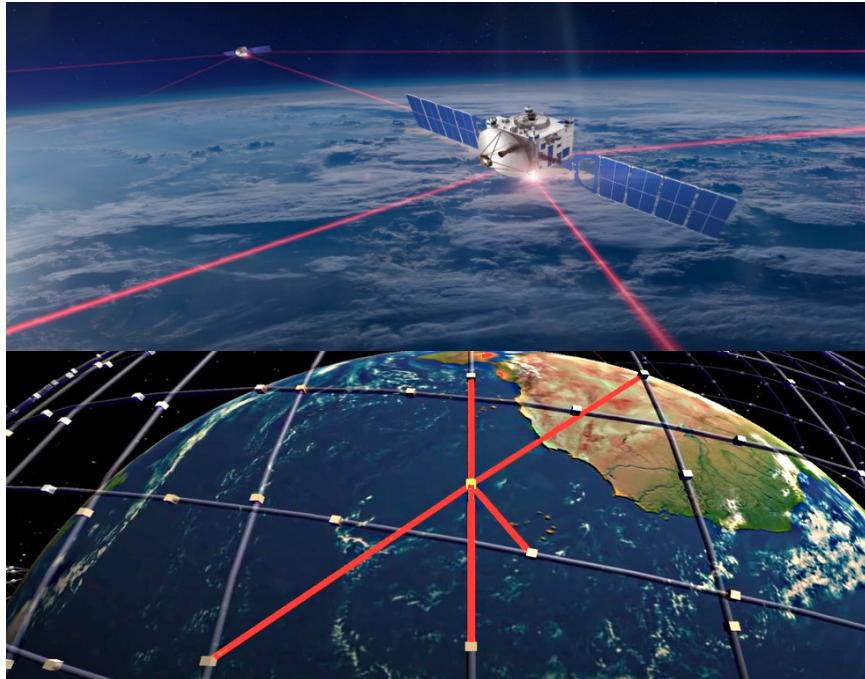
What's new in ISTN?

- **New orbits:** geosynchronous orbit → non-geosynchronous orbits
 - Low-altitude satellites for global broadband Internet, at the cost of coverage



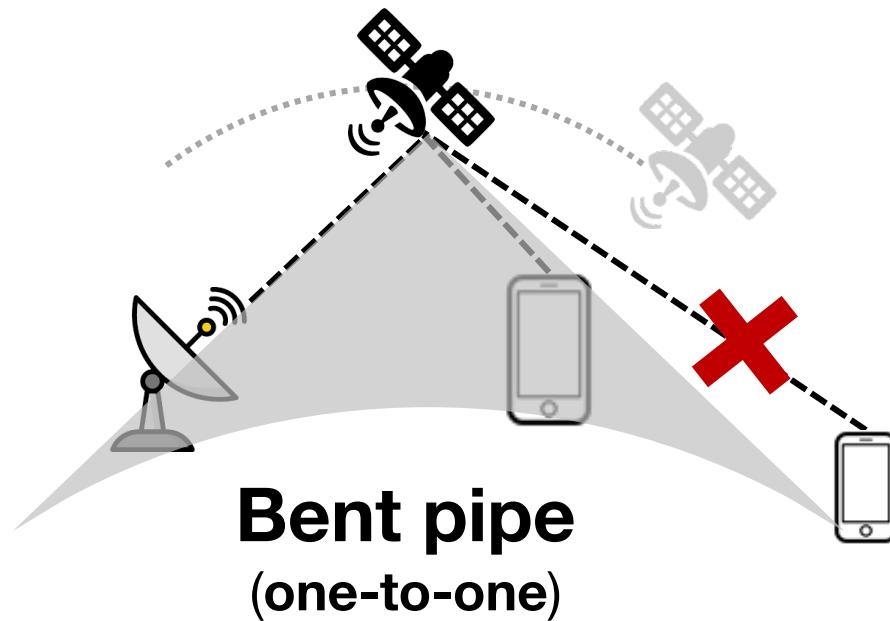
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- **New links:** Ground-to-SAT links (GSLs) → Inter-SAT links (ISLs)



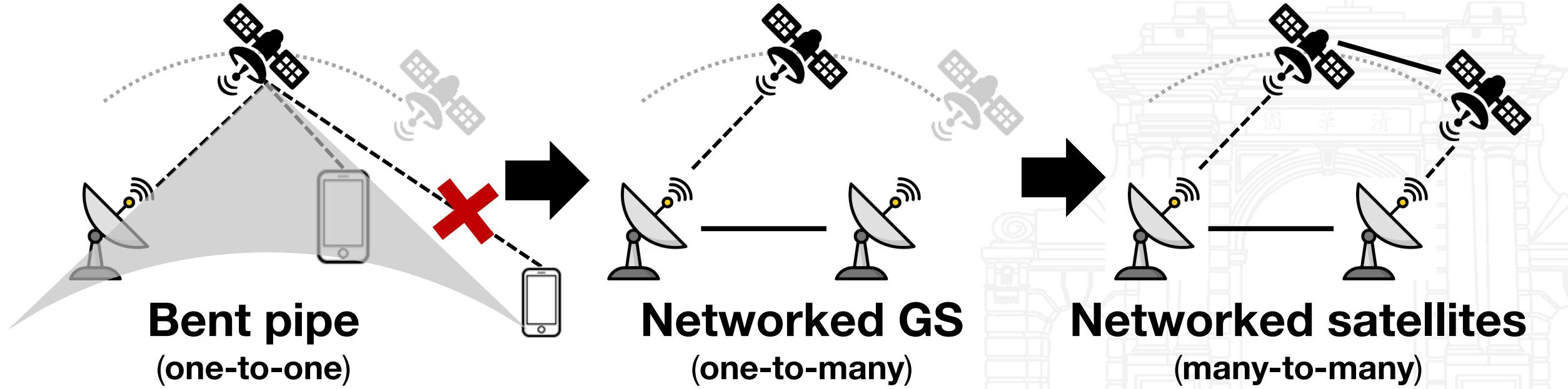
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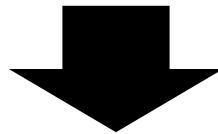
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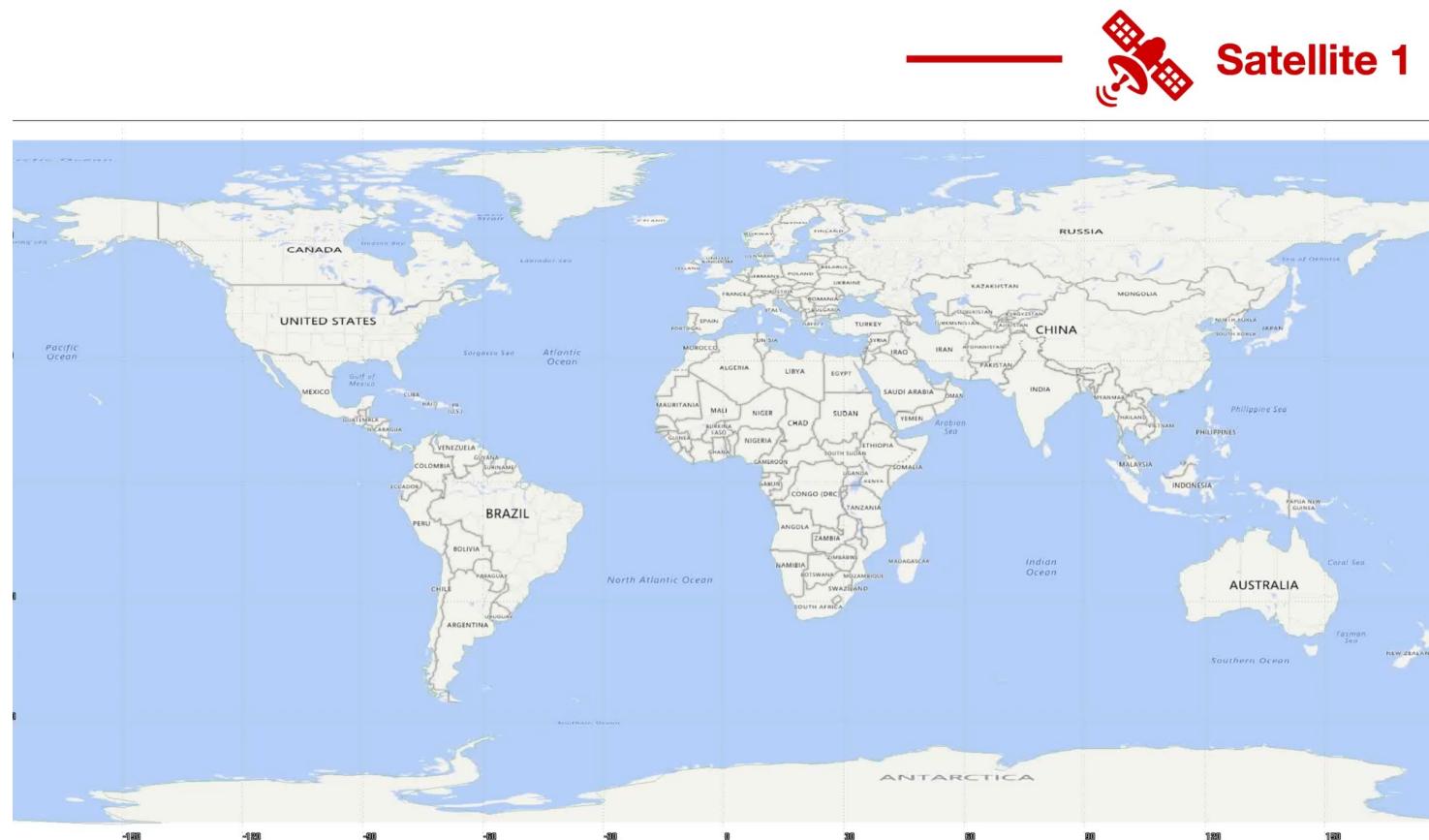
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New challenge:
Exhaustive ISTN topology changes

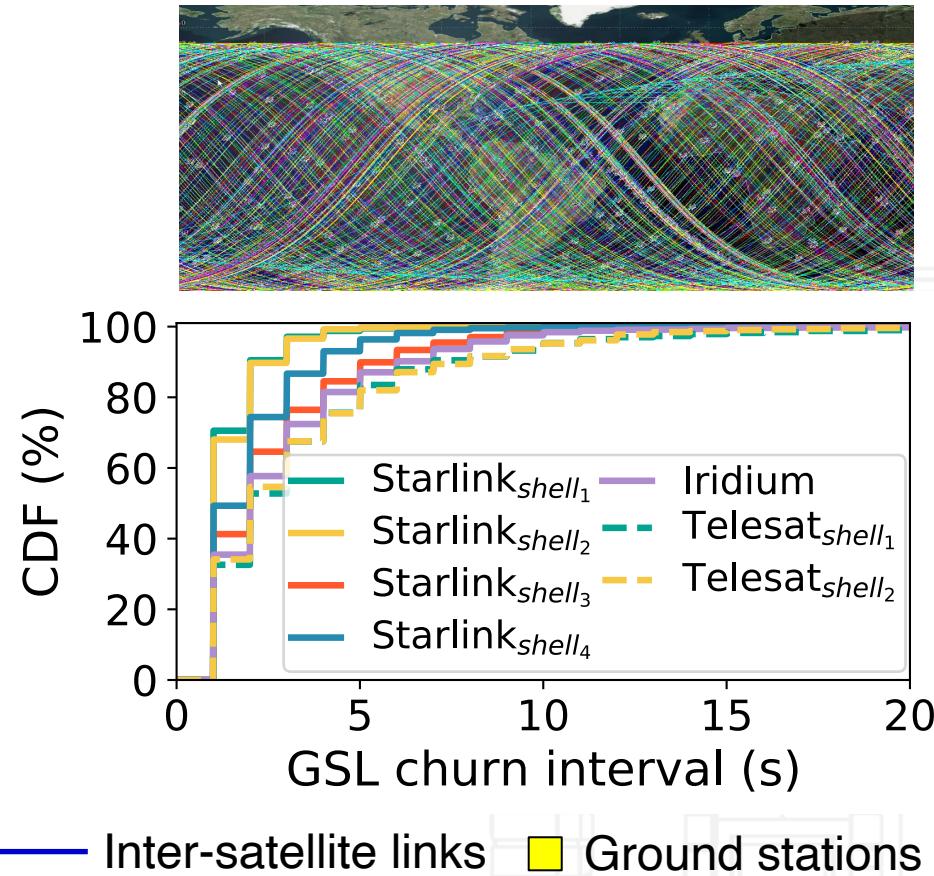
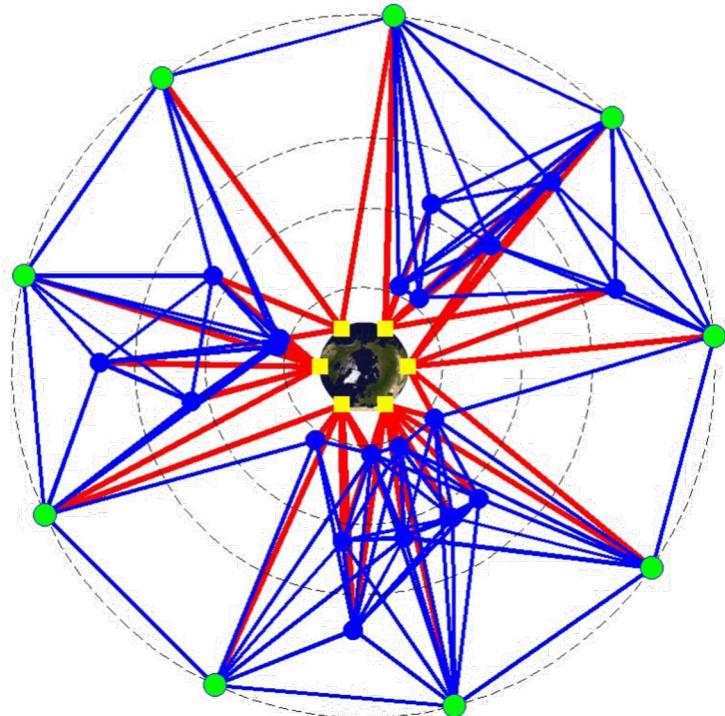
Exhaustive ISTN topology changes

- Asynchronous mobility between every LEO satellite and Earth



Exhaustive ISTN topology changes

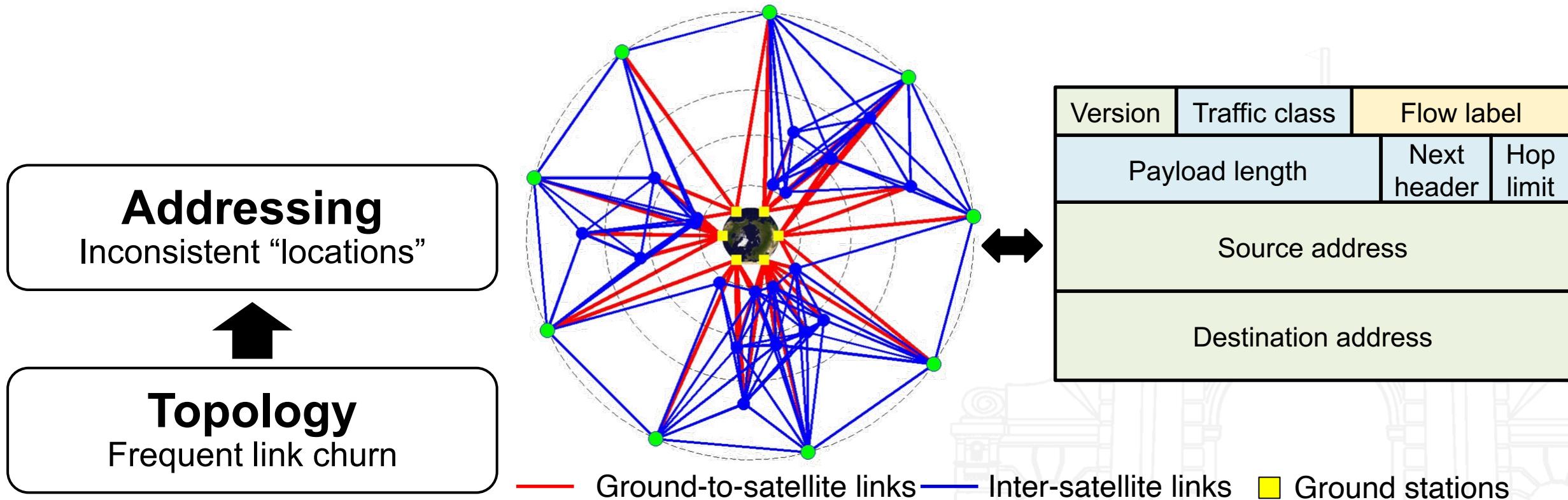
- Asynchronous mobility between every LEO satellite and Earth
 - Ground-to-satellite link (GSL) churn occurs every 1.46–2.61s



— Ground-to-satellite links — Inter-satellite links ■ Ground stations

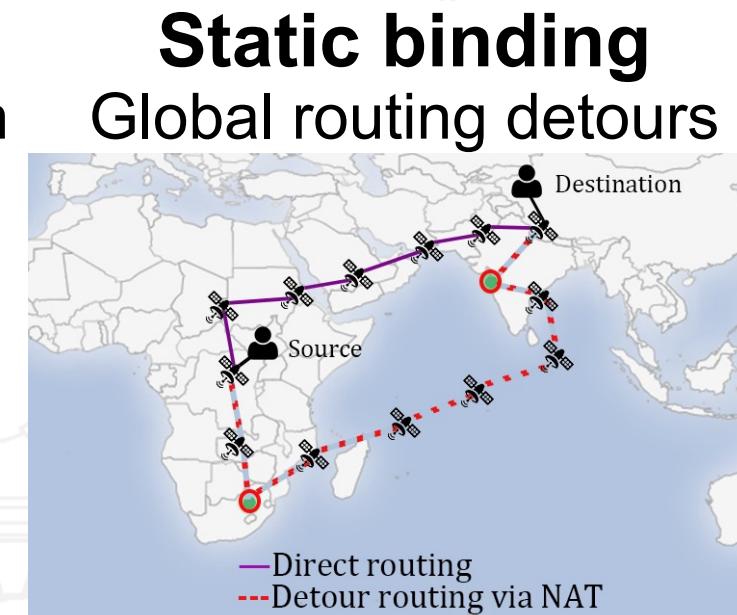
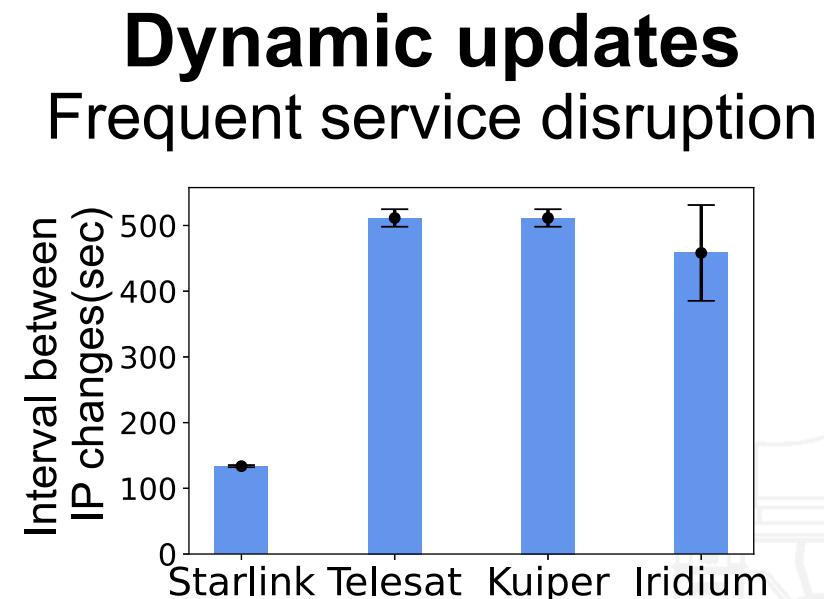
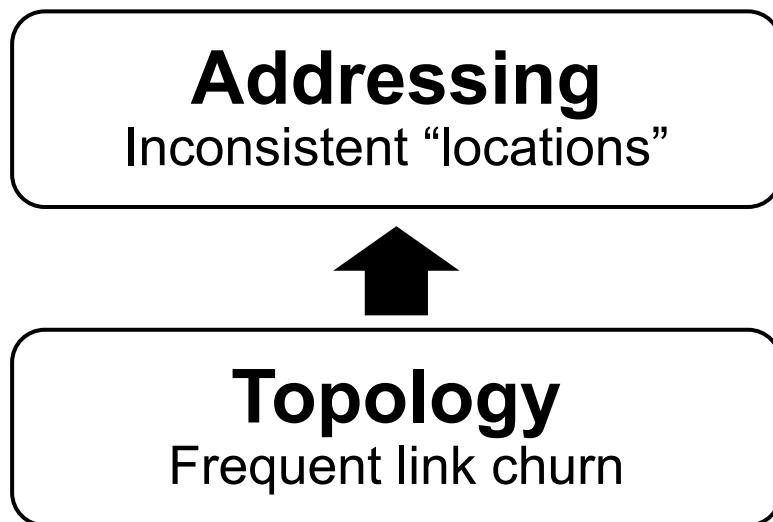
Impacts on ISTN addressing

- Physical node locations ≠ Logical topological locations
 - Logical address is coupled with the fast-changing serving satellites

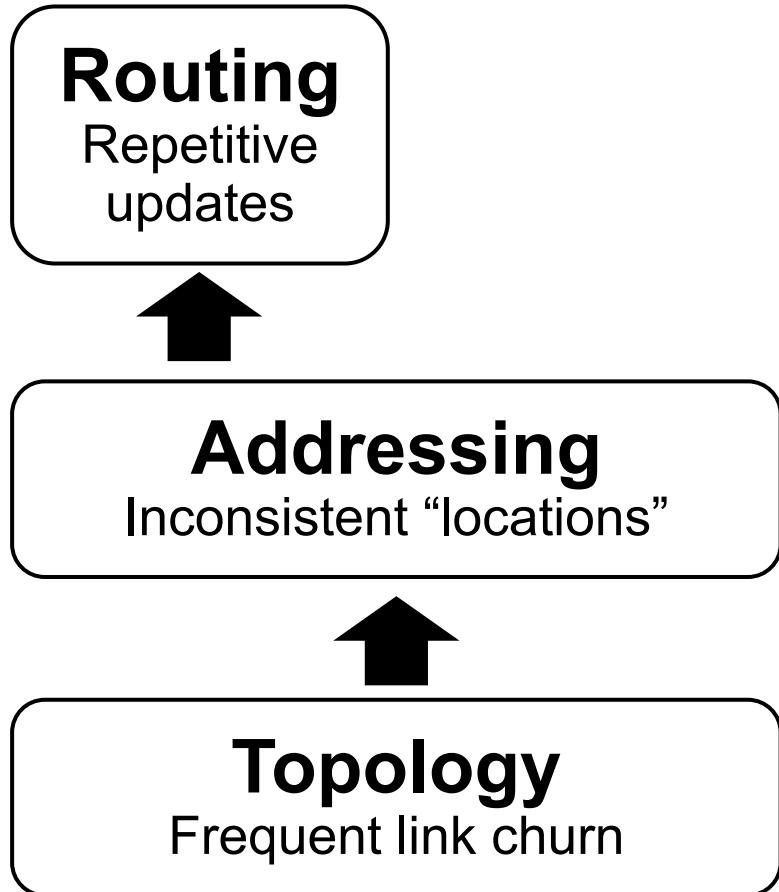


Impacts on ISTN addressing

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 - Logical address is coupled with the fast-changing serving satellites
 - Two addressing options for correct routing under inconsistency

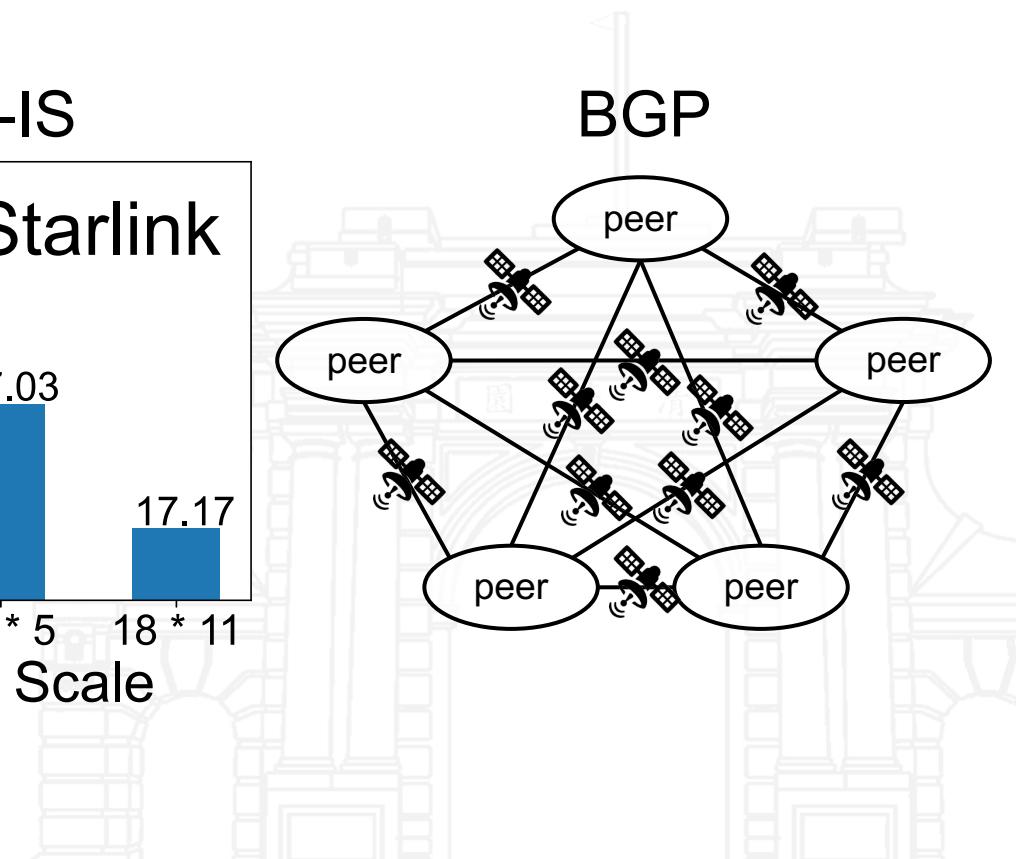
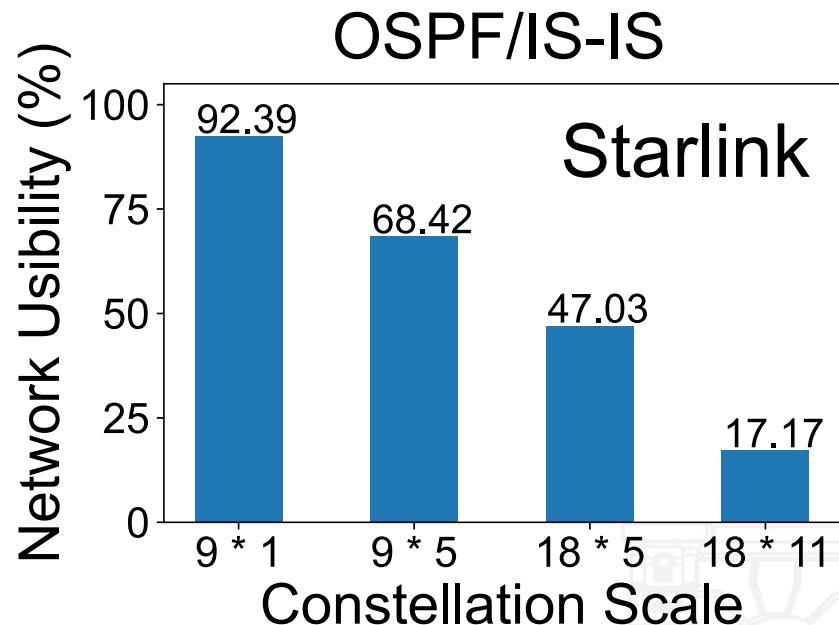


ISTN addressing's impacts

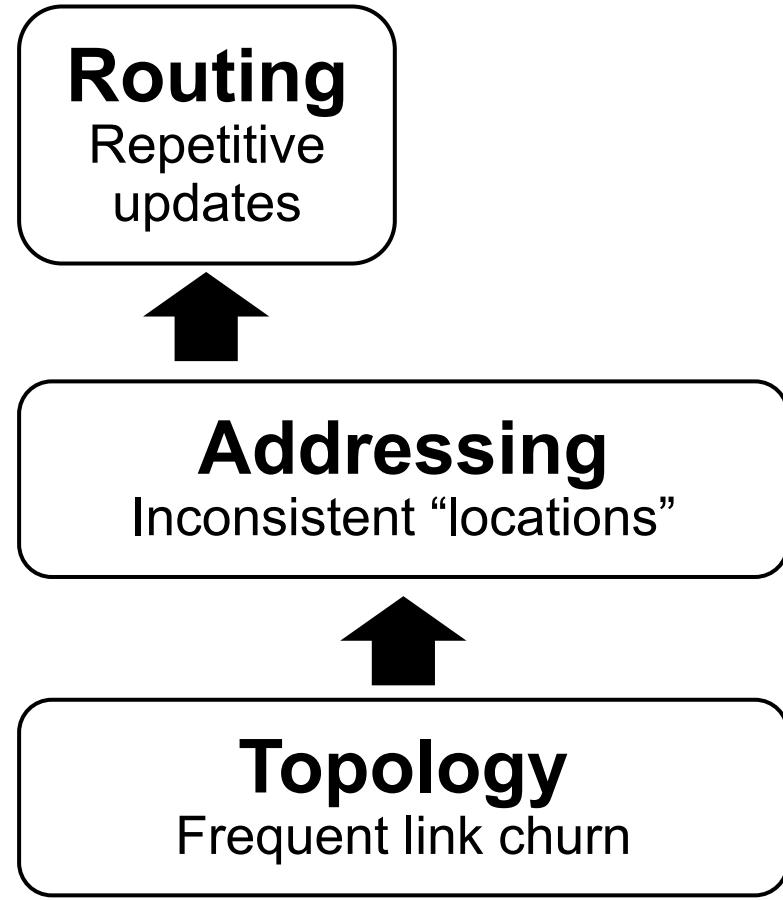


Legacy routing

Proactive routing (OSPF/BGP): repetitive re-convergence
Reactive routing (AODV/DSR): exhaustive route req flooding

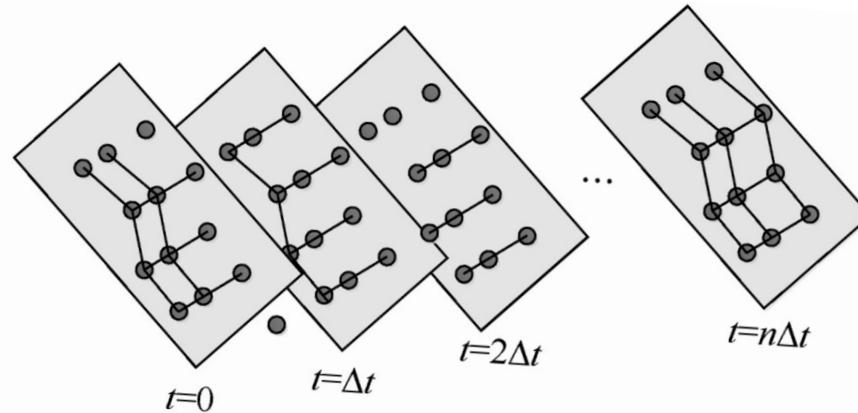


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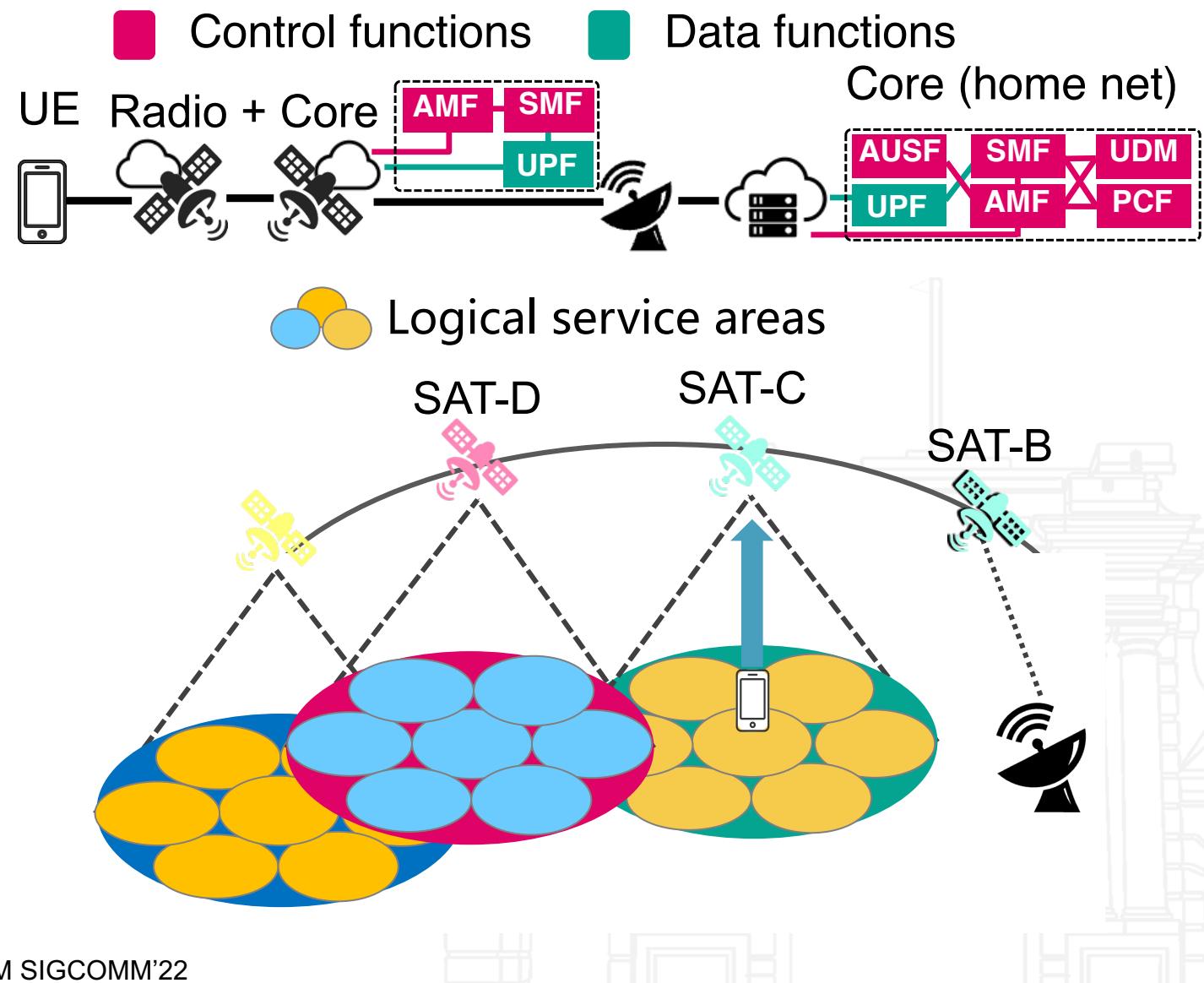
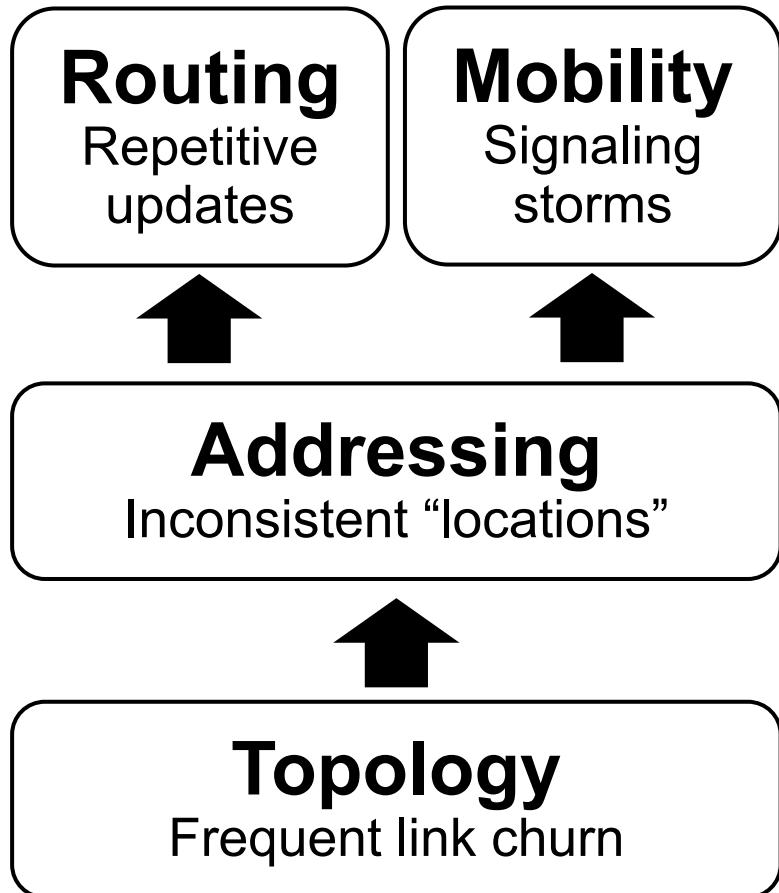
Predictive routing

Repetitive re-computing & inconsistent updates

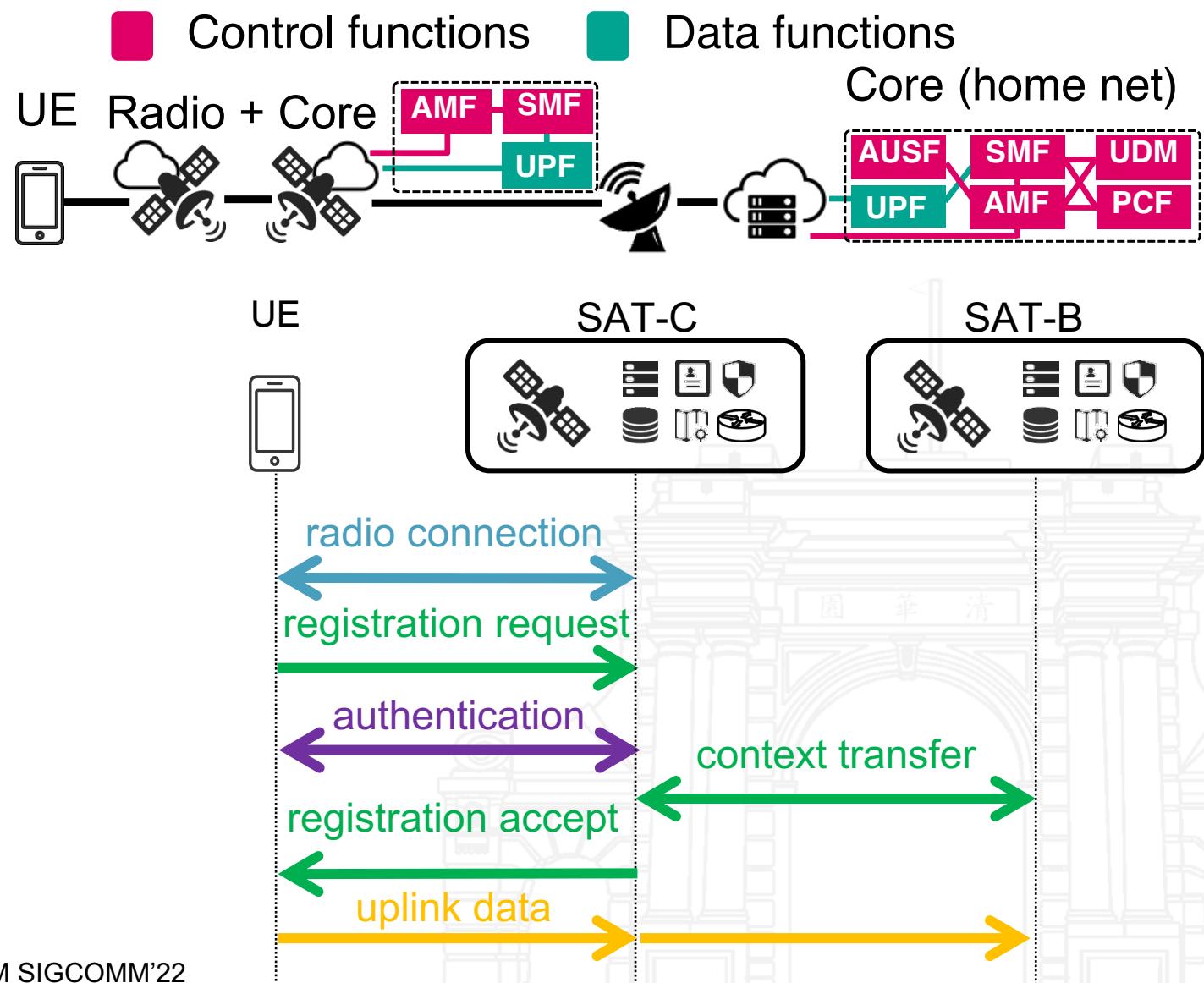
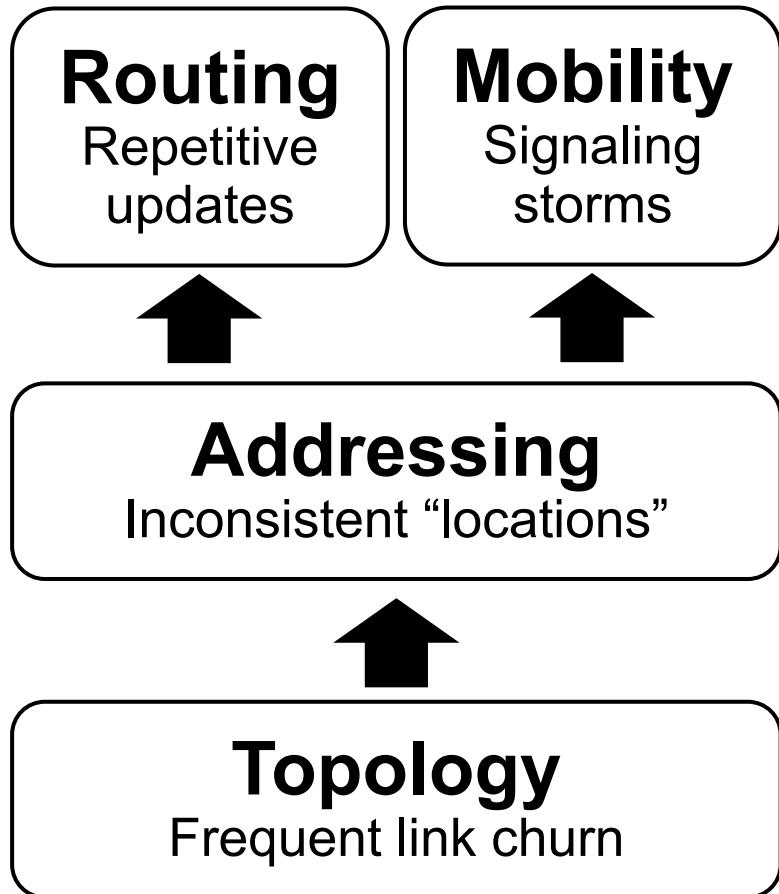


	Num. snapshots in 1 hr		Total FIB entries in 1 hr	
	No sync	Global handoff sync	No sync	Global handoff sync
Starlink	2,647	58	614,104	13,456
Kuiper	1,938	36	449,616	8,352
Telesat	1,588	80	368,416	18,560

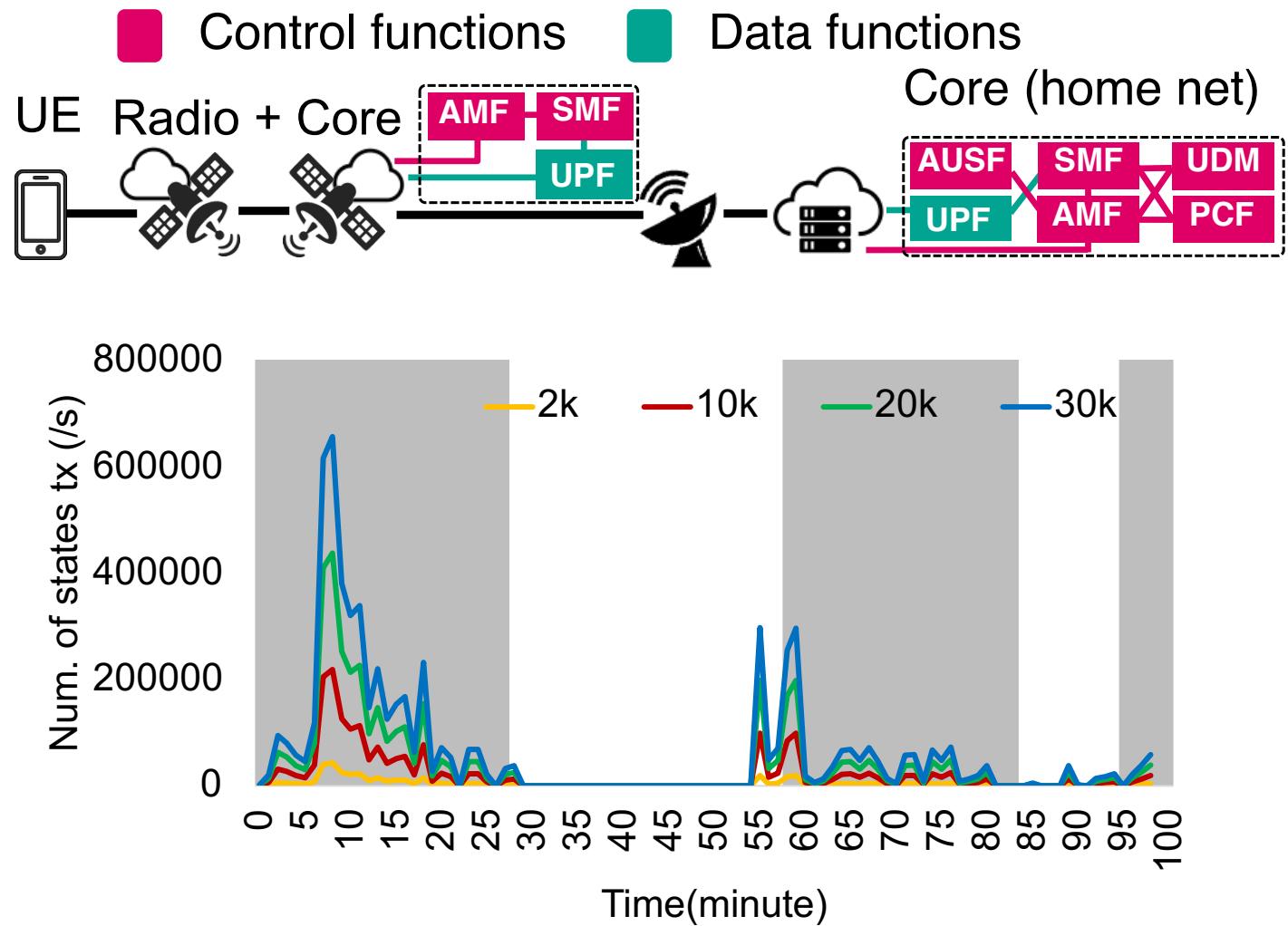
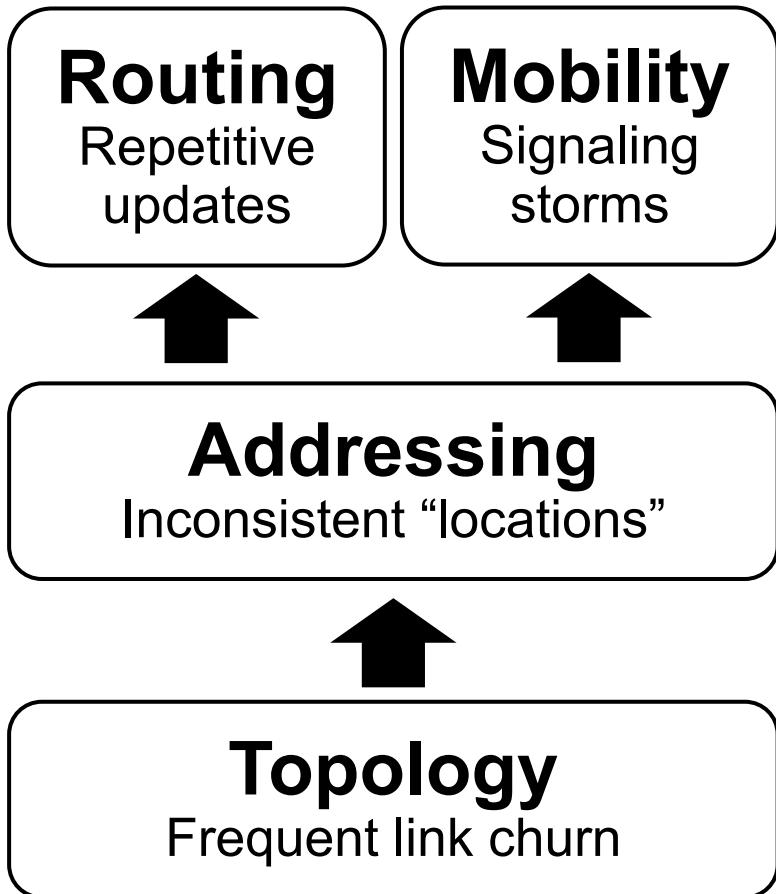
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Preferred properties for ISTN addressing

1. **Uniqueness:** each terrestrial user's L2/L3 address should be globally unique.
2. **Stability:** each terrestrial node's address should stay unchanged despite LEO satellite mobility and Earth's rotations.
3. **Locality:** if two terrestrial nodes' addresses are closer, their physical distances should also be closer.

Preferred properties for ISTN addressing

4. **Scalability:** the address space should scale to numerous terrestrial nodes and LEO satellite mega-constellations
5. **Efficiency:** the ISTN addressing should be spatially compact and computationally lightweight to process
6. **Backward compatibility:** the ISTN addressing should be compatible with state-of-the-art terrestrial network addressing
7. **Any more?**

Preliminary results: geographic ISTN addressing

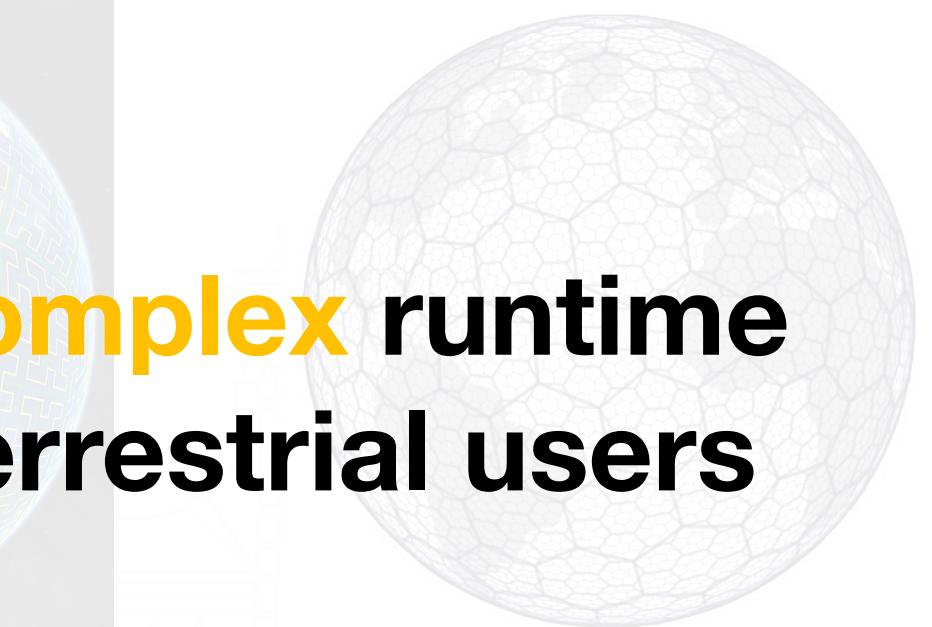
- Decouple a terrestrial node's addressing from its serving satellite
 - ✓ **Stable address** despite LEO satellite mobility and Earth's rotations
 - ✓ **Local address** based on each terrestrial node's geographic location



Latitude-longitude cells



Space-filling curve (Google S2)

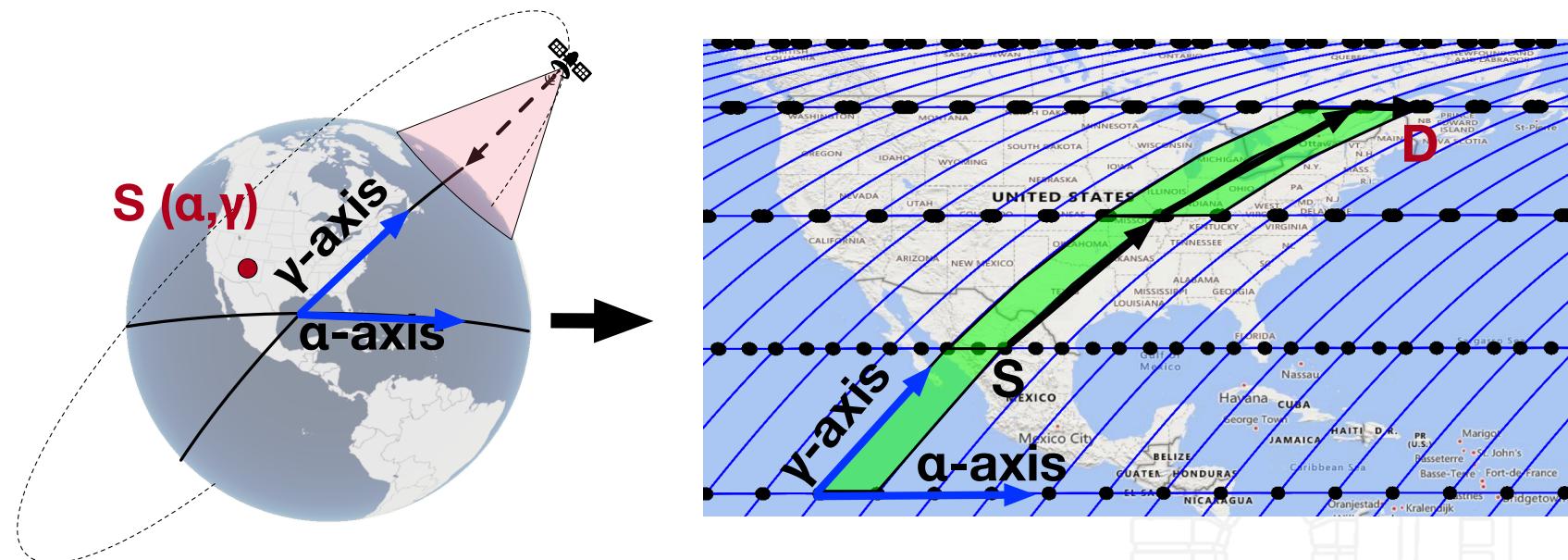


Hexagon cells (Uber H3)



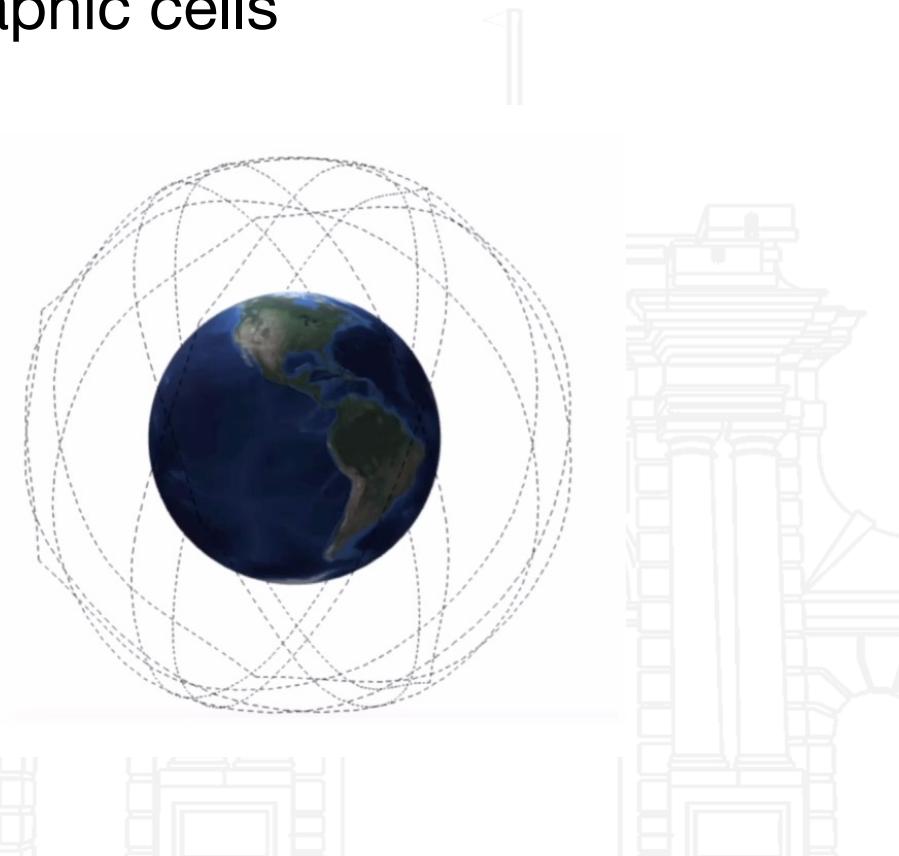
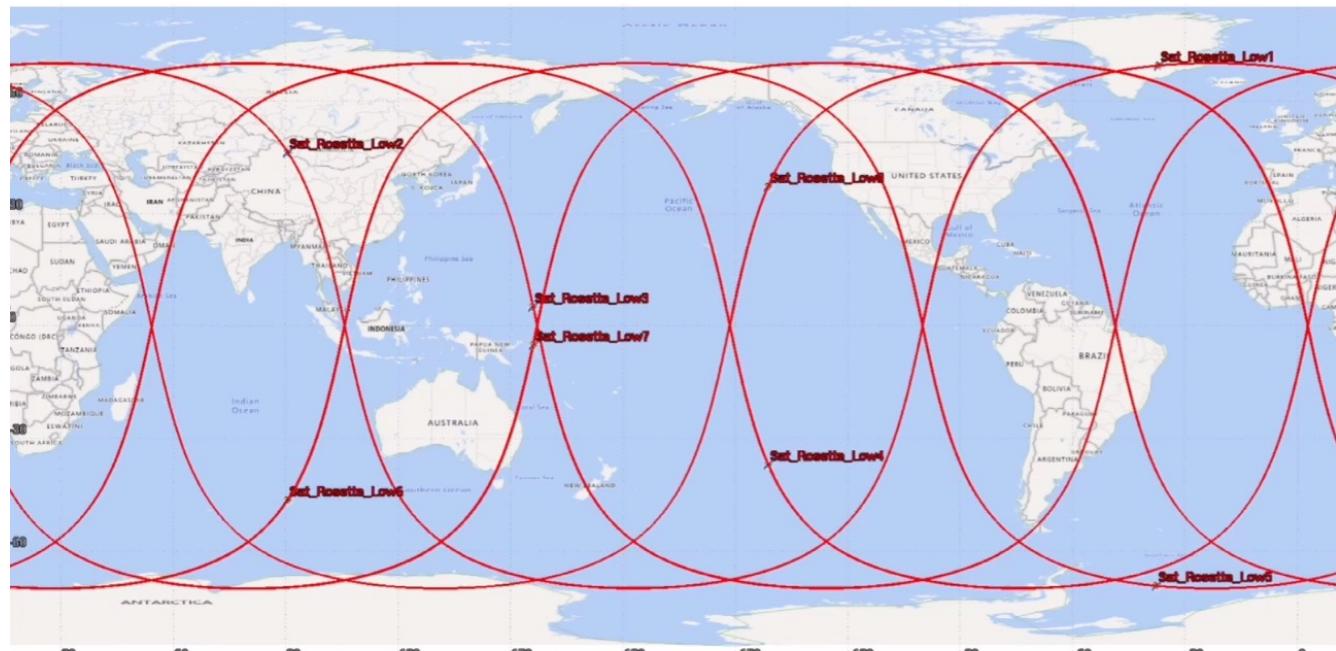
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 - Proposal: align geographic location with orbits to streamline routing



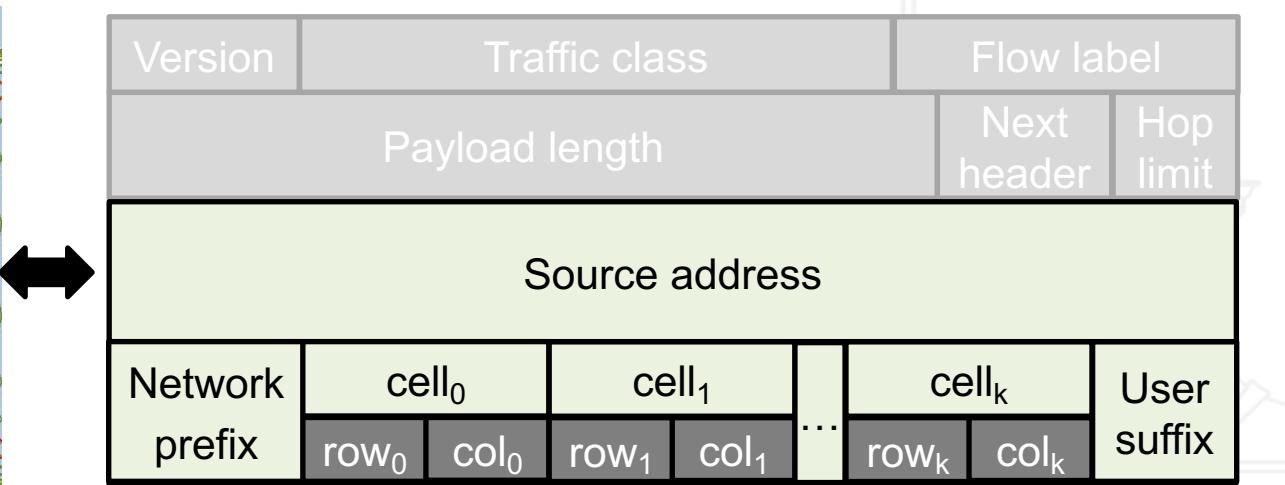
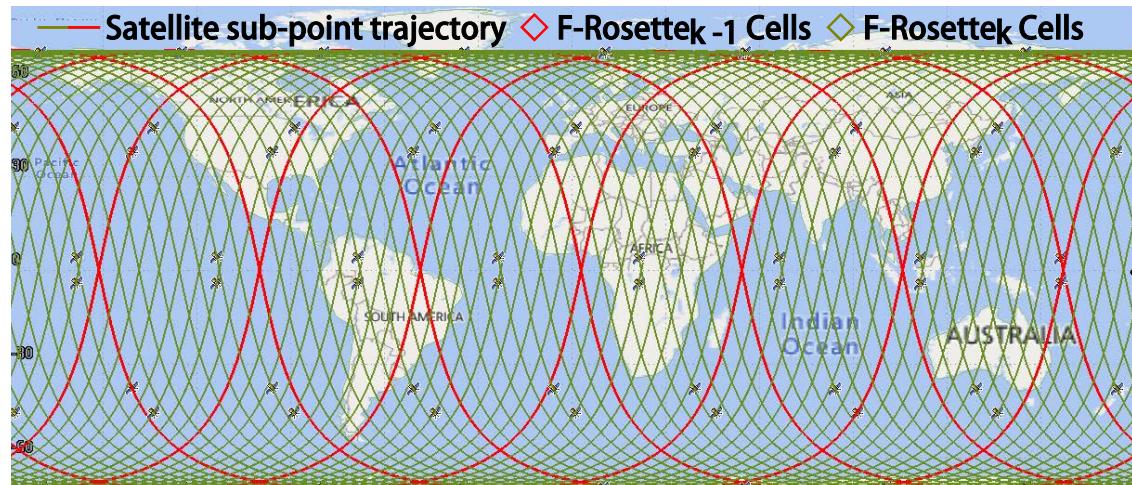
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 - ✓ **Scalable address** based on hierarchical geographic cells



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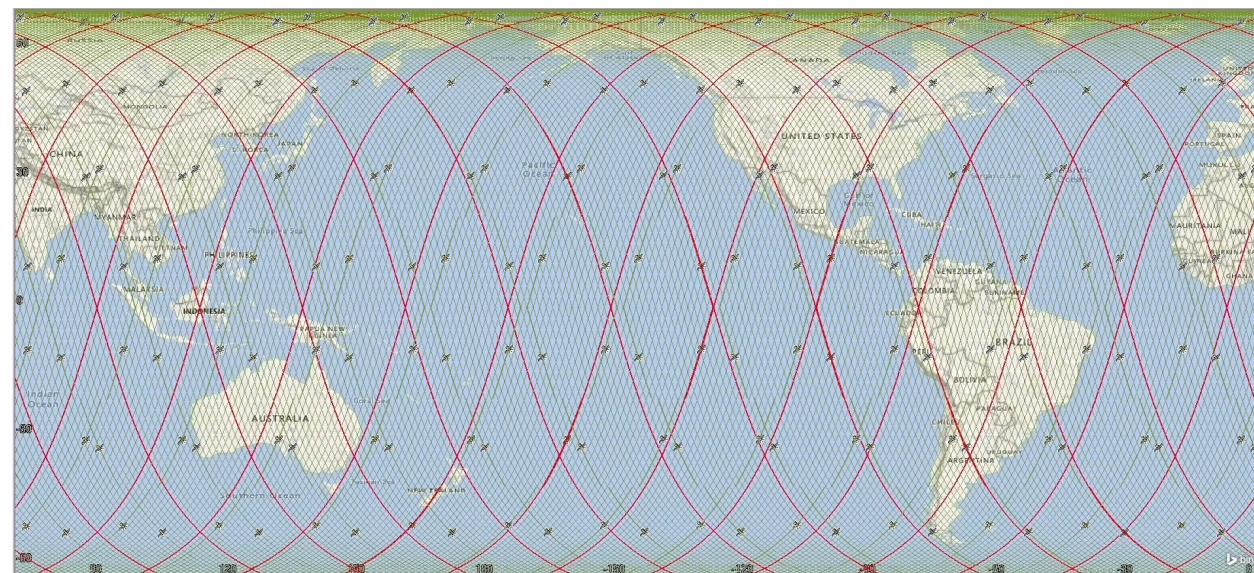
For internetworking
to external network

Hierarchical
geographical cell

Per-user identifier
(unique in each cell)

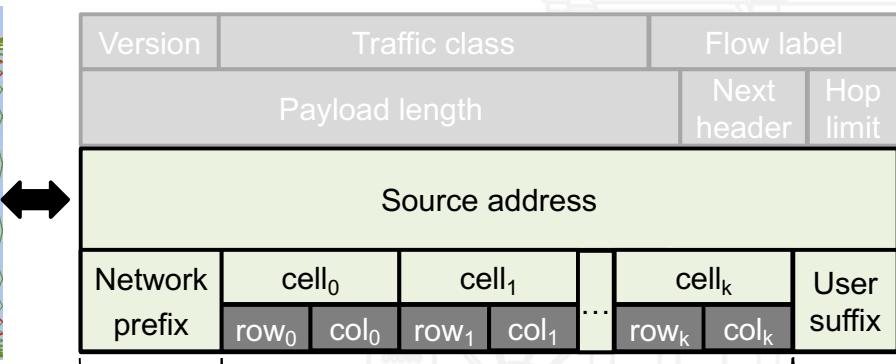
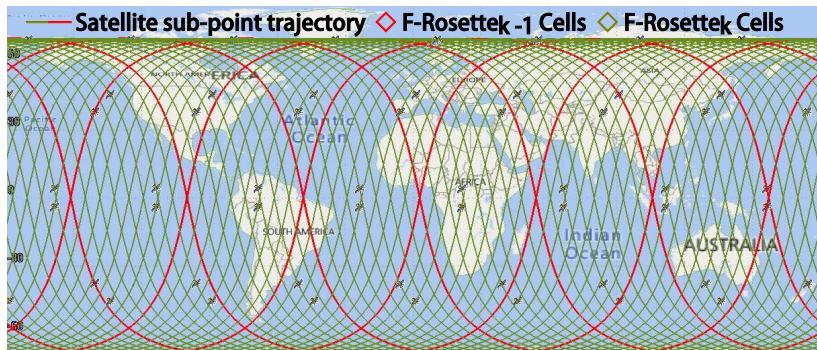
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 - ✓ **Efficient address** to support near-stateless geographic routing



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 - ✓ **Efficient address** to support near-stateless geographic routing
 - ✓ **Unique address** for each terrestrial node
 - ✓ **Backward compatible** with the legacy IP address



For internetworking
to external network

Hierarchical
geographical cell
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Per-user identifier
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Takeaways

- Exhaustive ISTN topology changes threaten addressing and other network functions
- Preferred properties for ISTN addressing
 - Stability, locality, scalability, efficiency, uniqueness, backward compatibility, and more
- Preliminary proposal: geographical addressing for ISTN
 - A standard-compliant addressing refinement for networks from space

Thanks!

