

# Problems and Requirements of Satellite Constellation for Internet

draft-lhan-problems-requirements-satellite-net-01

# Satellite Semantic Addressing for Satellite Constellation

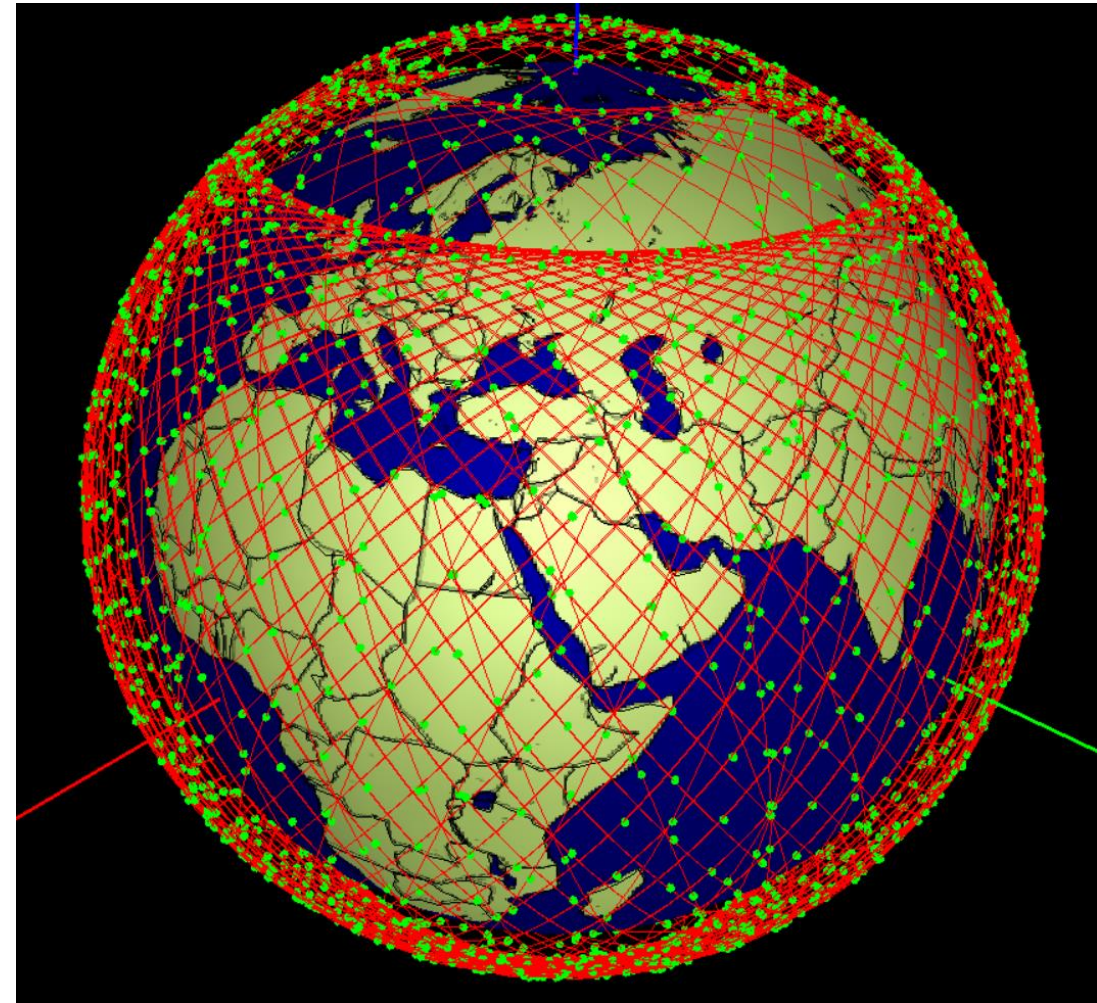
draft-lhan-satellite-semantic-addressing-00

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# Objectives

- Large scale satellite constellation network for Internet access with shorter latency and global coverage
  - LEO/VLEOs, couple of k or over 10K,
  - Inter-satellite-link (ISL) by laser is used to connect satellites
  - Satellite network is integrated with many ground stations by microwave or laser
  - GW ground station can do relay; connected to Internet, over 10K GW on earth
  - Terminal ground station connected to user network; may be able to do relay as well.



StarLink phase 1: <https://en.wikipedia.org/wiki/Starlink>  
5 layers, 4396 satellites, finish by 2027, now: 1584

# Example: StarLink

Phase	Orbital shells		Orbital planes <sup>[190]</sup>			Committed completion date		Deployed satellites	
	Altitude (km or mi)	Satellites	Inclination	Count	Satellites per	Half	Full	working, 19 October 2021	Inactive, deorbited, 19 October 2021
1	550 km (340 mi)	1584 <sup>[191]</sup>	53.0°	72	22	March 2024	March 2027	1584 <sup>[1]</sup>	141 <sup>[1]</sup>
	540 km (340 mi)	1584	53.2°	72	22			0	
	570 km (350 mi)	720	70°	36	20			51 <sup>[1]</sup>	0 <sup>[1]</sup>
	560 km (350 mi)	336	97.6°	6	58			13 <sup>[1]</sup>	0 <sup>[1]</sup>
		172		4	43			0	
2 <sup>[192]</sup>	335.9 km (208.7 mi)	2493	42.0°			November 2024	November 2027	0	
	340.8 km (211.8 mi)	2478	48.0°					0	
	345.6 km (214.7 mi)	2547	53.0°					0	

4 shells  
4396 satellites

<https://en.wikipedia.org/wiki/Starlink>

# Problems

- Satellite constellation is very dynamic but well ordered
  - Every satellite position is keep changing (at the speed of 7.x km/s).
  - Satellite's orbit parameters are constant
- Fast topo changes
  - Link state, cost change too frequently
    - All link cost (distance) keep changing
    - Sat-to-ground-station links: (interruption/per 2~3 min for 450km altitude)
    - Links on Latitude direction: steady
    - Links on Longitude direction, unsteady at polar area (2 interruption/per T ~ 1.6h for 550km Altitude)
    - Links with satellites moving in opposite direction, (interruption/per 3~4 min)
    - Vertical links, depends on the difference of altitude, inclination, etc.
- Satellite position predicable, but not the links
  - Ground-station to Satellite link (quality) impacted by weather, obstacles, etc.
  - Links between satellites impacted by tracking, distance, position, etc.
- Distributed IGP/BGP/MPLS model hard to use
  - Convergency issue for too frequently changed topology
  - Constant Control Data flooding issues
  - Overhead of control protocol msg for precious ISL bandwidth.
- Centralized SDN model hard to use
  - Where is the controller?
  - Basic connectivity between controller to ALL satellites?
  - How to guarantee the forwarding table on ALL satellites are synced?
  - How often the controller needs to update the forwarding table?

# Updated:

## Problems and Requirements of Satellite Constellation for Internet

- Section 5.2.1

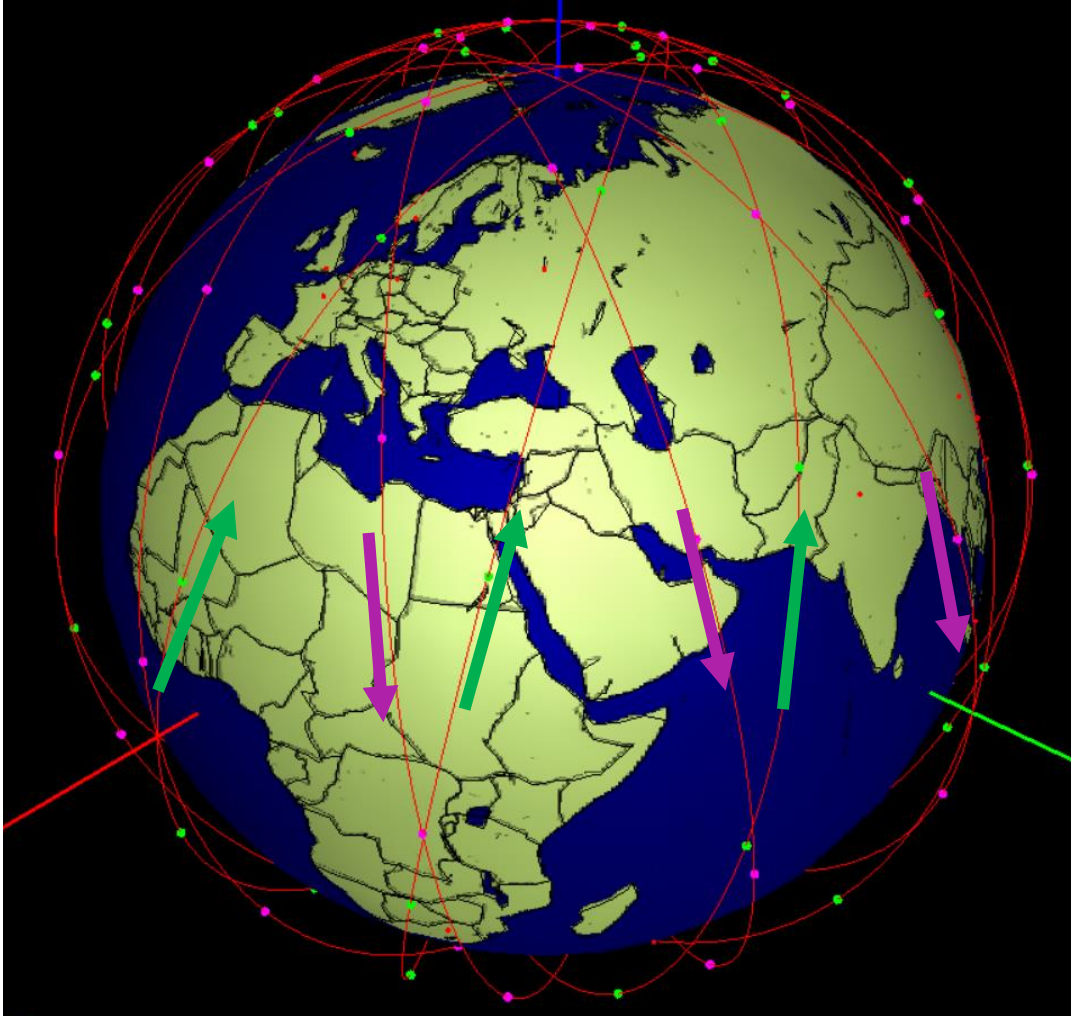
- Satellites on adjacent orbits within the same altitude.
  - Non-polar area:
    - Same moving direction; different moving direction
  - Polar area
    - ISL facing will be swapped.

- Section 5.2.2

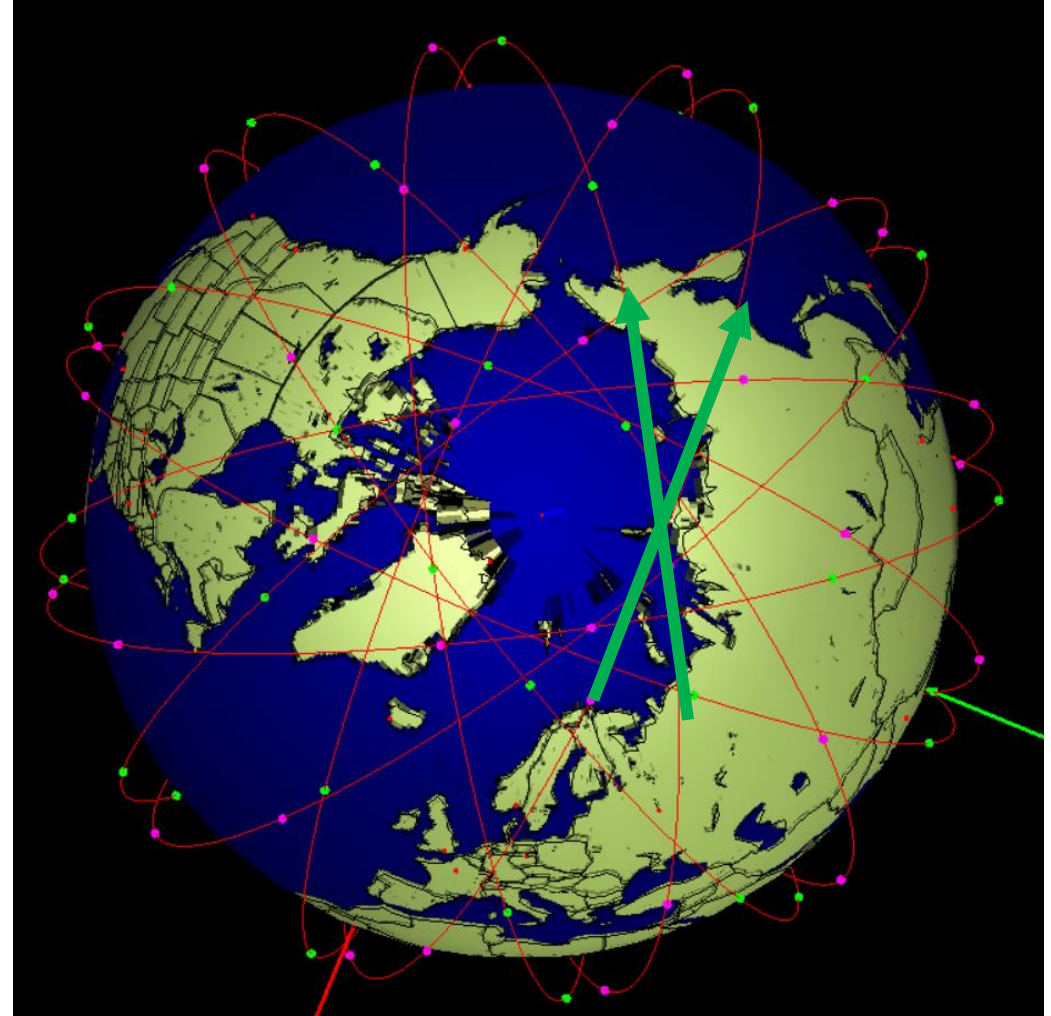
- Estimation of communication lifetime for satellites on adjacent orbits within the same altitude, moving on different direction.



Satellites on adjacent orbits  
moving in opposite direction

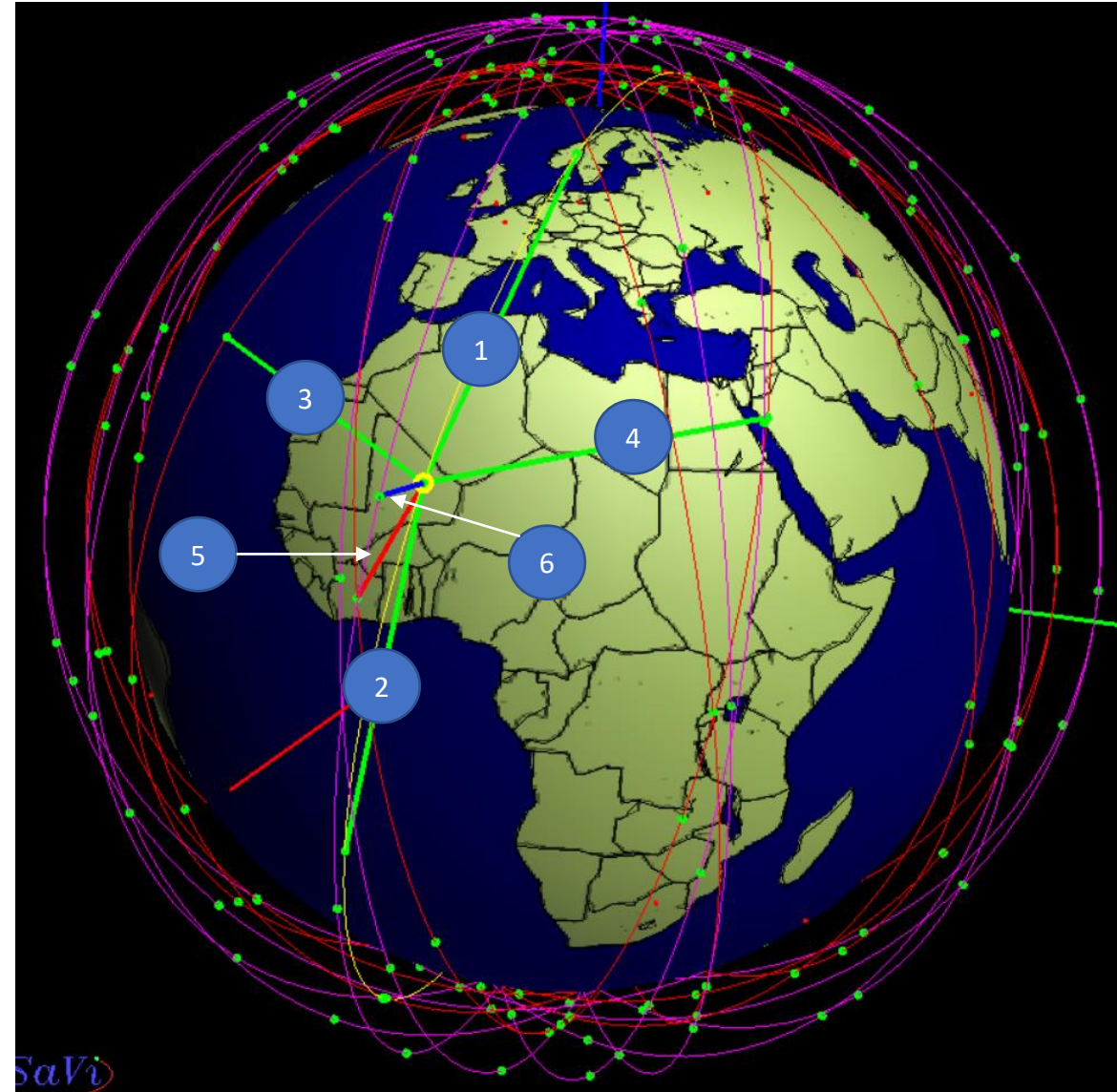


Satellites on adjacent orbits  
moving in same direction at  
Polar area



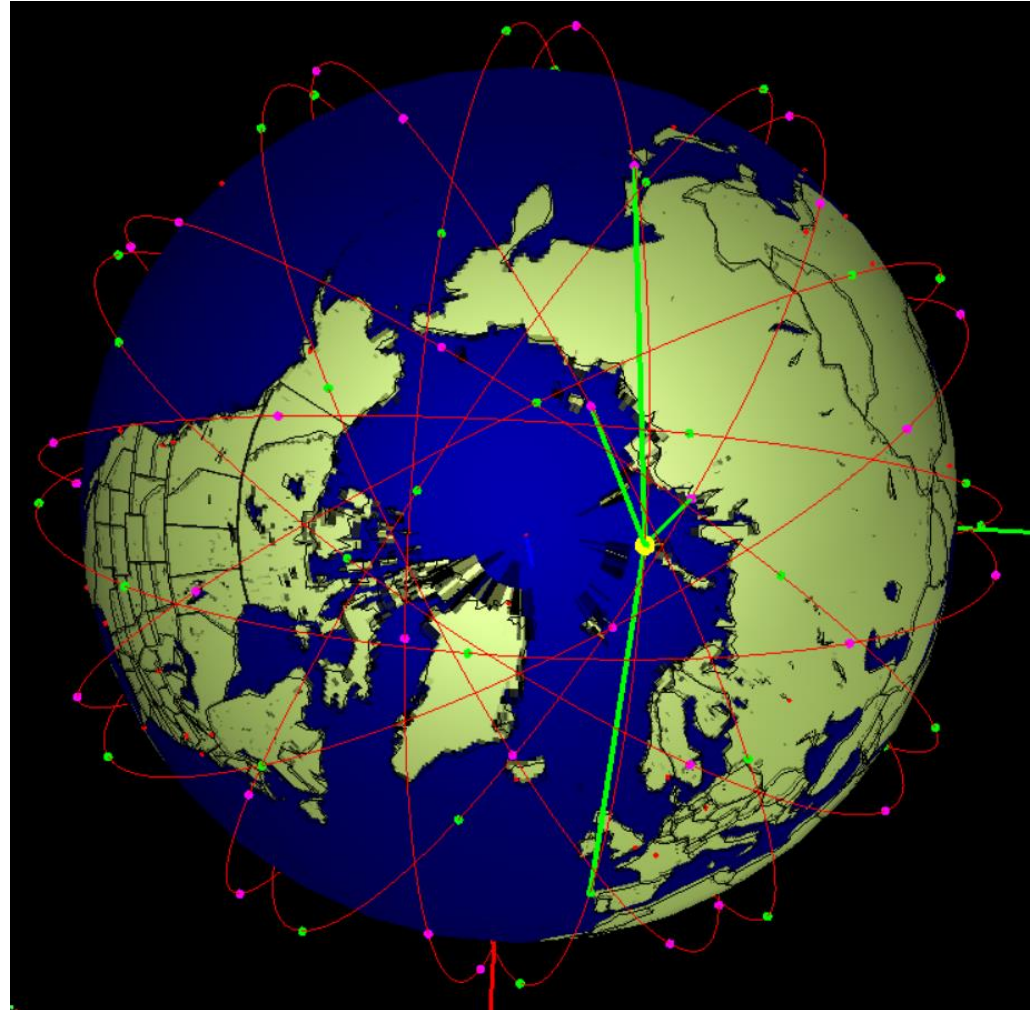
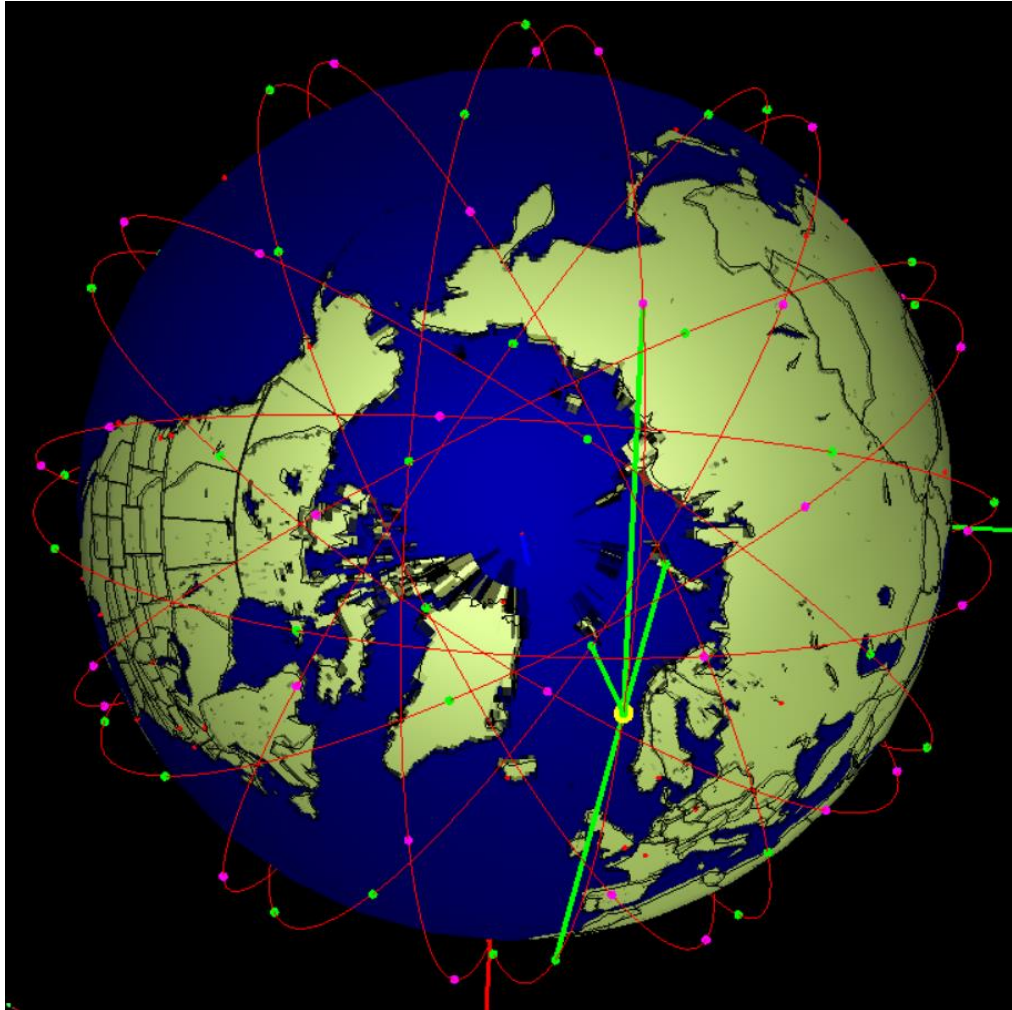
# Satellite links by ISL

- Links on Latitude direction (1,2)
  - Between satellites on the same orbit
  - Constant distance
  - Steady links
- Links on Longitude direction (3,4)
  - Between satellites on adjacent orbit with same moving direction
  - Distance changing
  - Steady at non-polar area
  - Not steady on polar area
- Unsteady links (5)
  - Between satellites on adjacent orbit with different moving direction
  - Distance changing faster
- Vertical links (6)
  - Between satellites on adjacent orbit with different altitude
  - State depends on the difference of altitude, inclination angle and other orbit parameters





Links on Longitude direction on polar areas  
(Interface Facing will change after the orbit crossing)





# New draft

## draft-lhan-satellite-semantic-addressing-00

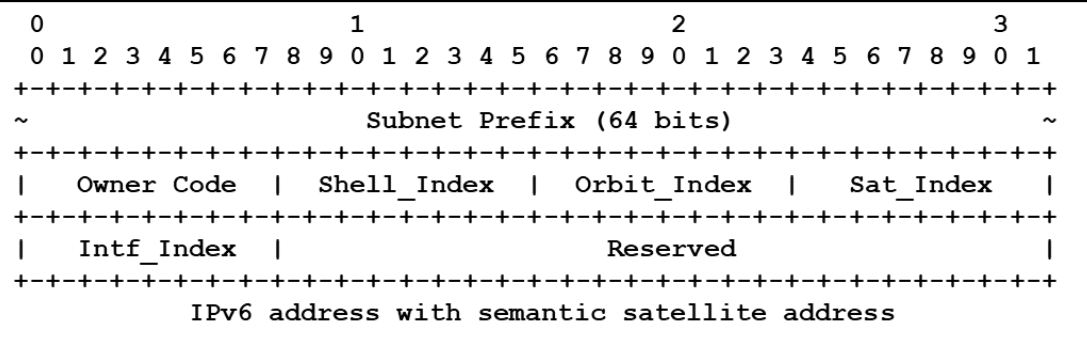
- Objective:
  - Semantic Satellite IP address
  - Embed the orbit and other information into the IP address.
- What to embed
  - Owner Index – indicating the owner of the satellite constellation
  - Shell Index – indicating the orbit altitude in the constellation
  - Orbit Plane Index – indicating the orbit plane in the orbit shell
  - Satellite Index – indicating the satellite position in the orbit plane
  - Interface Index – indicating the interface in a satellite.
- Why
  - Make the identifying steady/unsteady links/neighbors faster and easier
  - Make the semantic routing and switching possible (described in another draft)

# How to use it

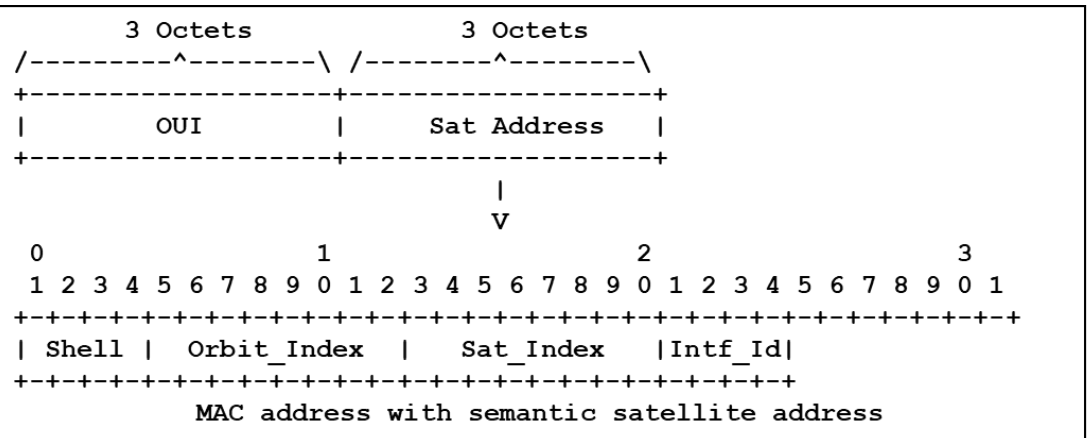
- IPv6 address
  - Embed into the 64-bit interface identifier
- MAC address
  - Embed into the 24-bit NIC field
- Directly use it as variable length IP address (shorter than 128-bit)
  - 48-bit to 64-bit

# How to use it

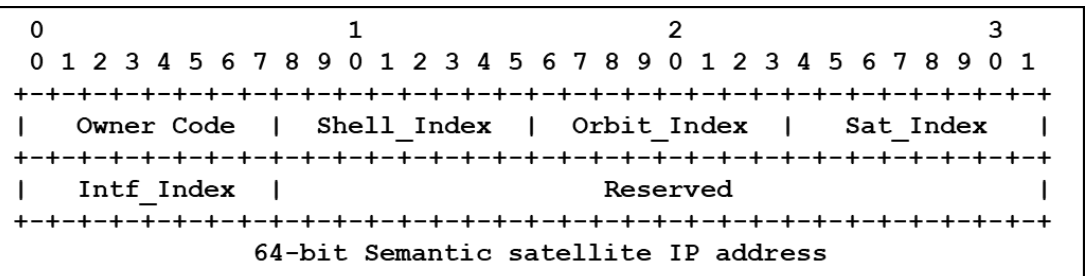
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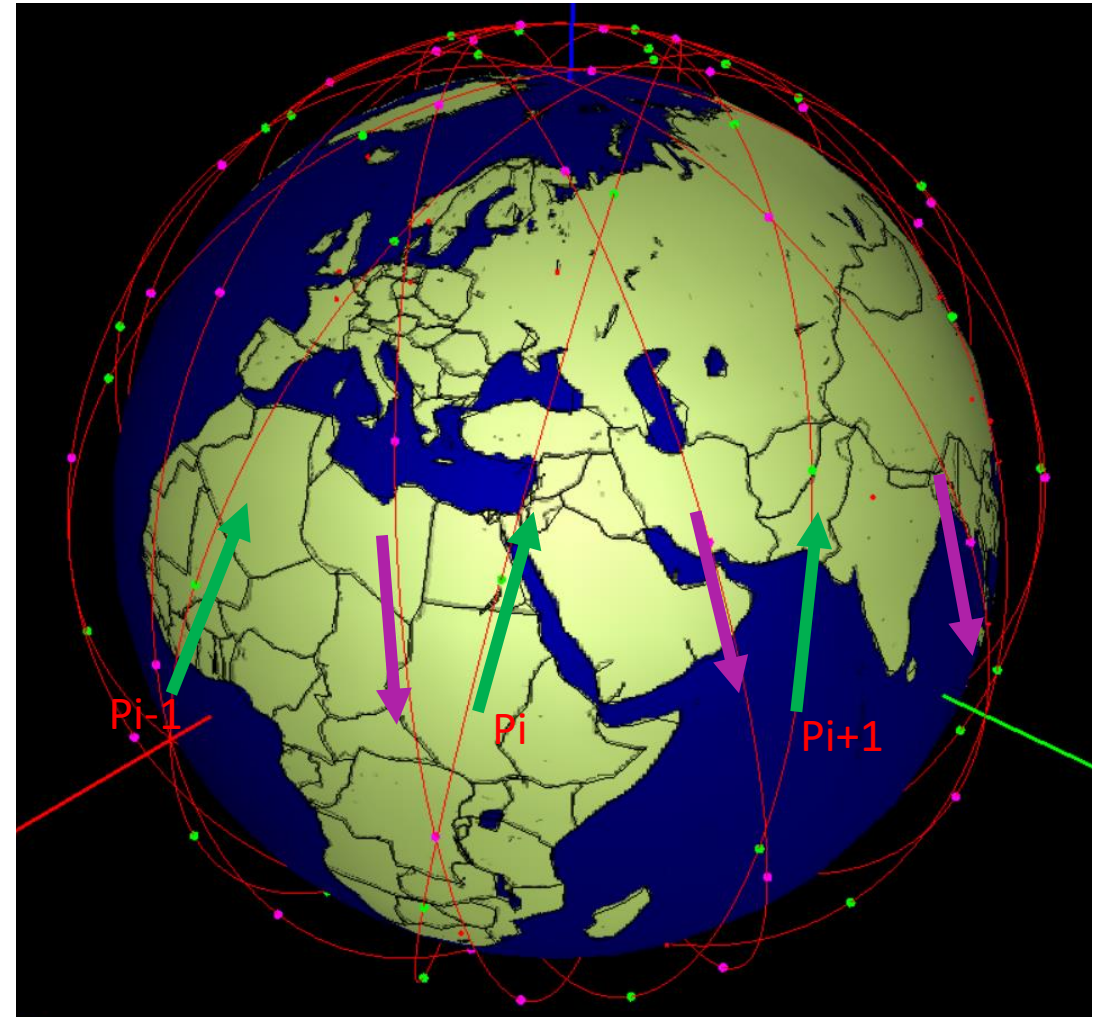
- Variable length IP address:
  - 48-bit to 64-bit





# Example to identify links

- Links on Latitude direction:
  - Satellite index difference is one
- Links on Longitude direction:
  - Plane index difference is one, steady
  - Plane index difference is more than one, unsteady
- Links on Vertical direction:
  - Shell index difference is one.



- <https://youtu.be/M49yyJ0o5YU>

Q&A

Comments? Like to collaborate?

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