NDN in Large LEO Satellite Constellations: A Case of Consumer Mobility Support
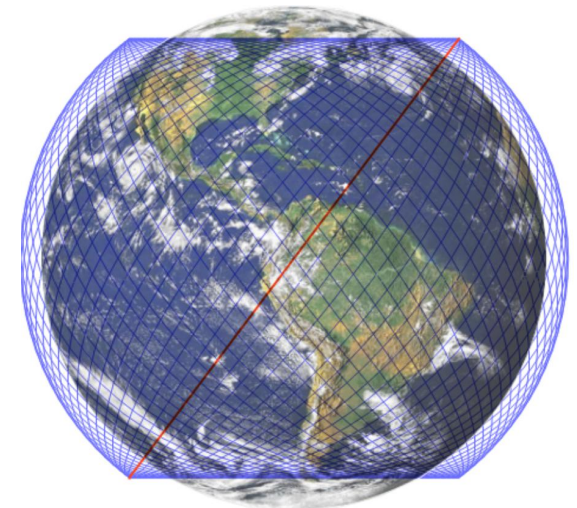
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2021/09/23

Large LEO Satellite Constellations

- They intend to provide low-latency and high-bandwidth connectivity

- Satellites are launched at low altitudes (e.g., 340 miles)
  - they are moving fast, resulting in a handover every 2-5 minutes
  - require a massive number of satellites
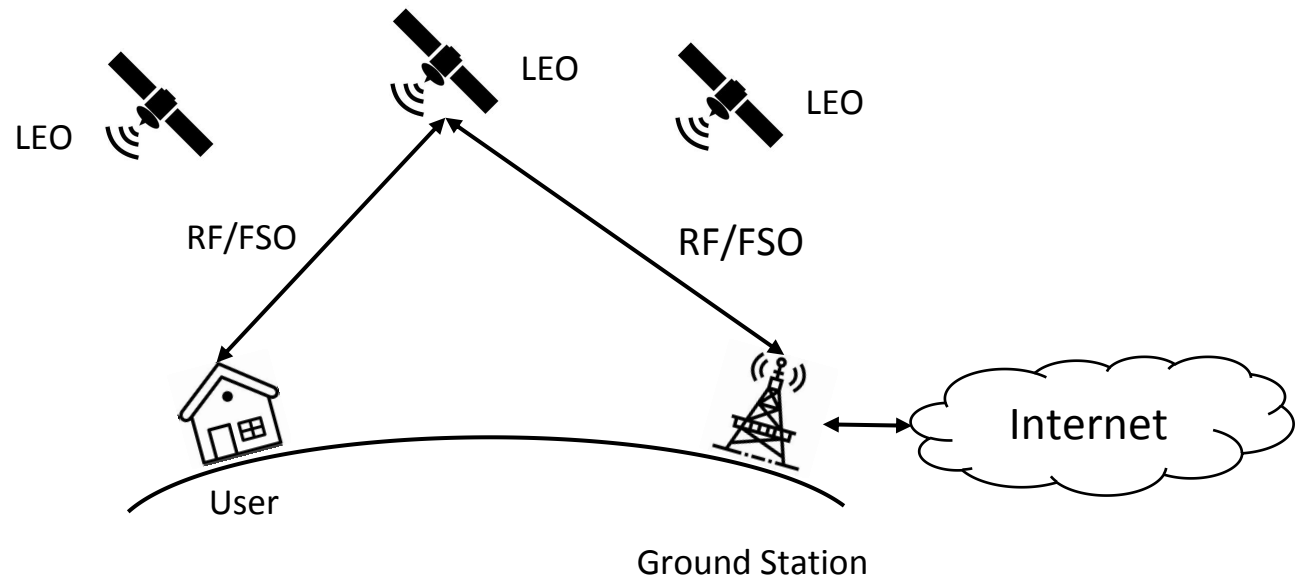
Large LEO Satellite Constellations

- ## Hardware resources
  - ### SpaceX disclosed that each launch carries 60 satellites containing 4000 Linux computers in June 2020.

- ## Connectivity
  - ### Stage one
    - #### No inter-satellite links
    - #### only uplink and downlink

LEO

LEO

LEO

RF/FSO

RF/FSO

Internet
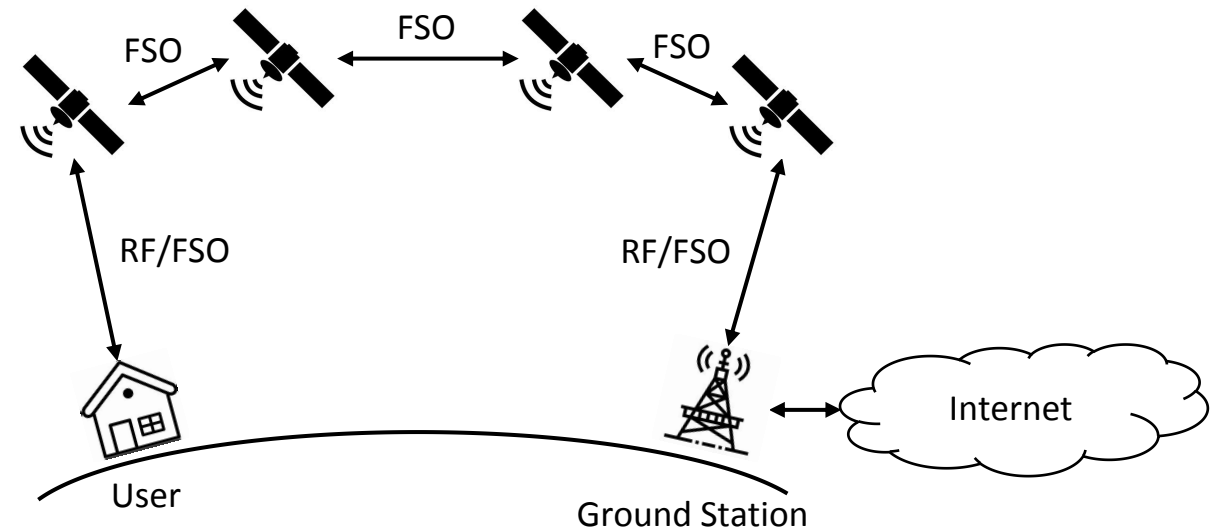
User

Ground Station

Large LEO Satellite Constellations

- Connectivity
  - Stage two
    - Four inter-satellite links (ISL)
    - Uplink and downlink

  - Two ISLs on the same plane
  - Two ISLs on different planes

Why NDN?

- Adaptive forwarding
  - multiple paths
  - the uplink and downlink can use both RF and FSO communication technologies,
  - inter-orbital optical links change over time and take non-trivial time to set up
- In-network Caching
  - built-in multicast reduces network traffic
  - in-network data caching reduces both delay and network traffic
- Off-the-grid Communication
  - NDN provides a unified data retrieval protocol no matter it is on or off the grid

Why NDN?

- Data mule services
  - store-and-forward capability can be easily supported in NDN

- In-network/edge computing
  - NDN can reduce the complexity of such infrastructure

- Consumer Mobility Support

- Data-centric Security
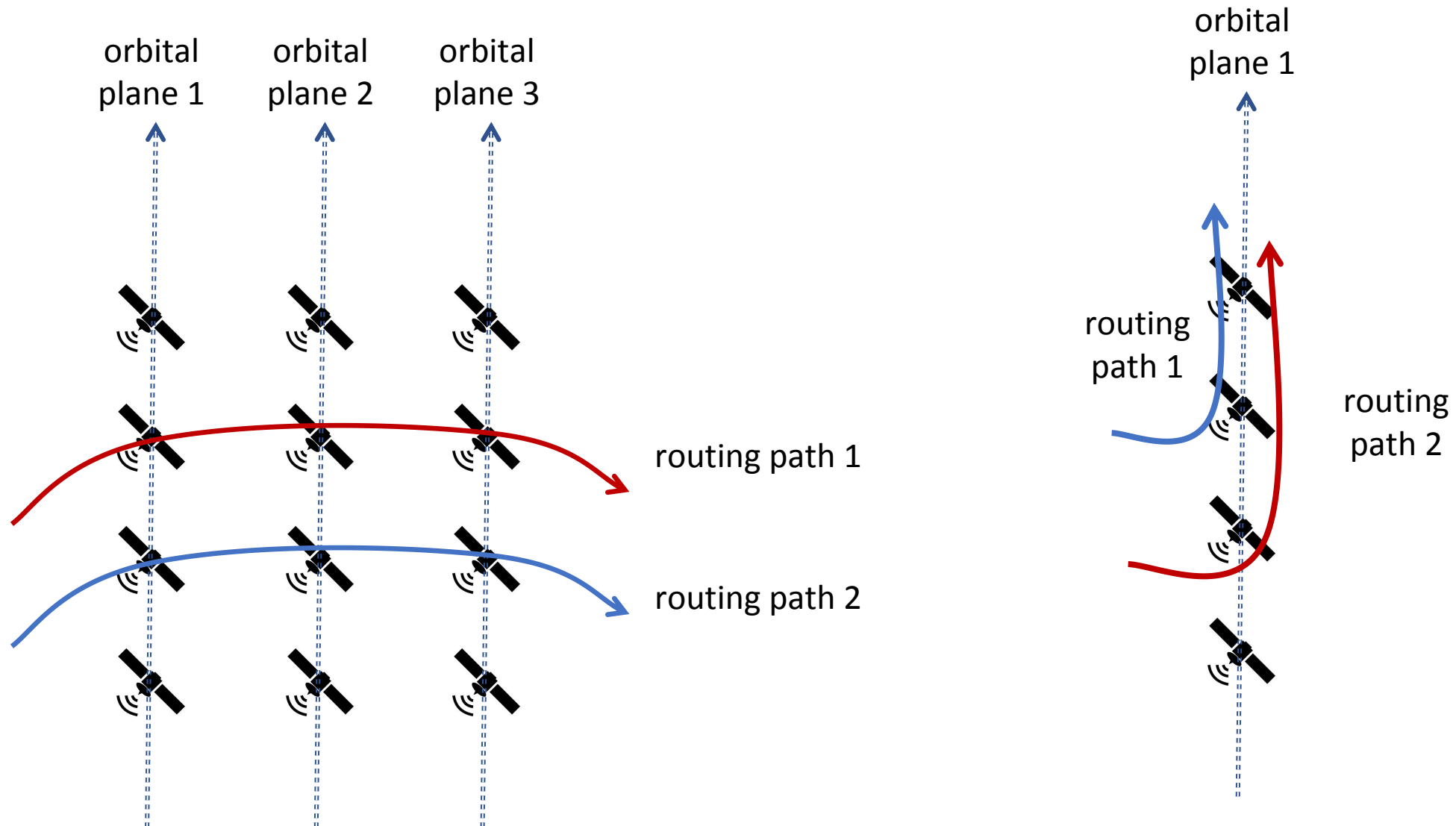
Consumer Mobility Support

- Native Consumer Mobility Support
  - Because of NDN's pull communication model
  - Applications can simply retransmit Interests after timeouts, which deals with handovers naturally
  - Interest timeout in applications can be too long to negtively impact users' quality of experience, and congestion control mechanisms

- A better solution: In-network Interest retransmission
  - When the end node detects a handover, it retransmit pending Interests to the newly connected satellite
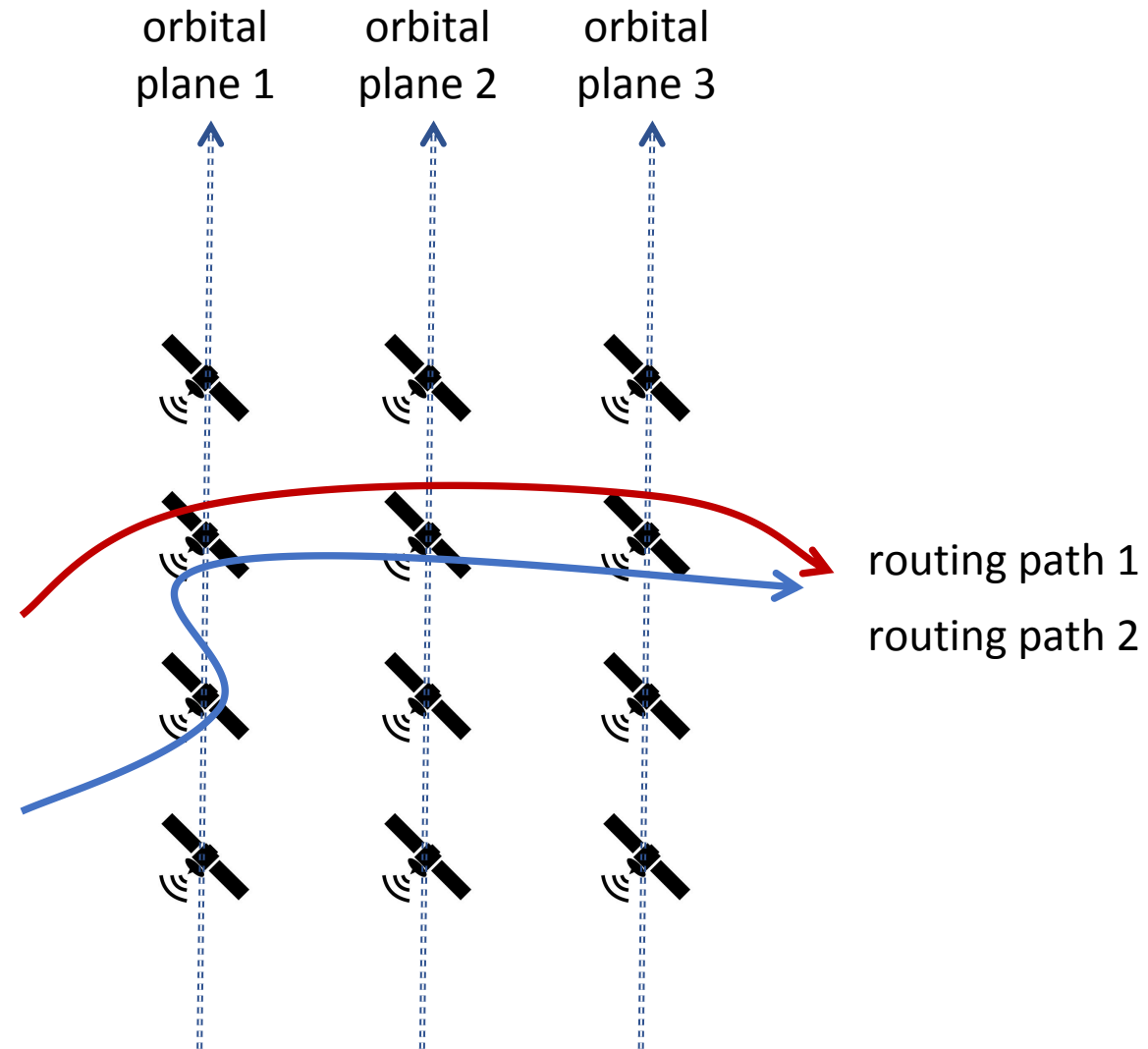 - No need to wait apps to take actions

Consumer Mobility Support

- Can we do better?

- The performance depends on if retransmitted Interests are forwarded to the previously connected satellites
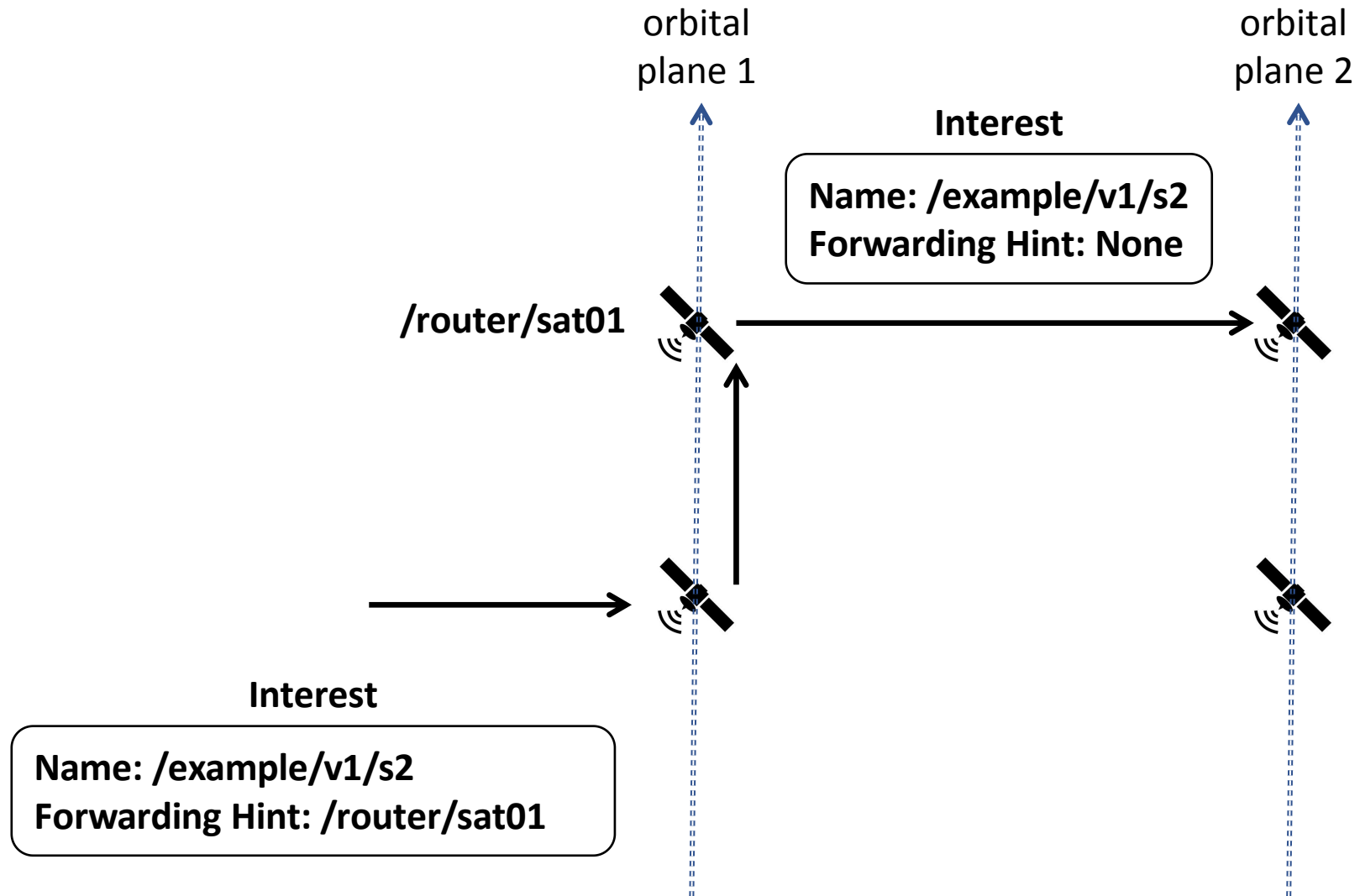
- Does the routing paths overlap?
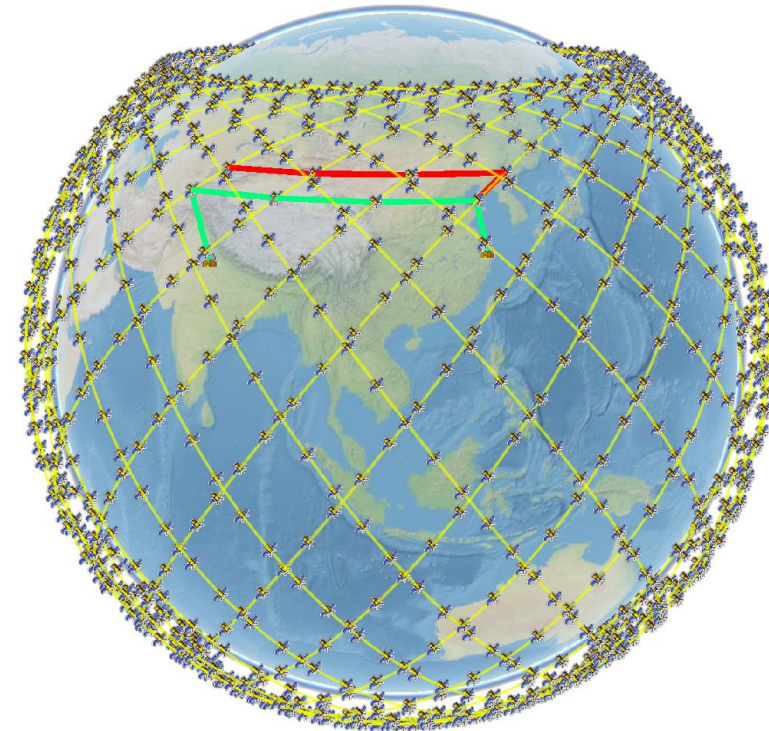
When will two routing paths overlap?

Direct forwarding using hint

In-network Interest Retransmission + forwarding hint

orbital plane 1

orbital plane 2

Interest

Name: /example/v1/s2
Forwarding Hint: None

/router/sat01

Interest

Name: /example/v1/s2
Forwarding Hint: /router/sat01

Evaluation

- Goal: evaluate the performance of the three mechanisms
  - Application Interest retransmission (AIR)
  - In-network Interest retransmission (IIR)
  - In-network Interest retransmission + forwarding hint (IIR+FW)
- Metrics:
  - The average data retrieval delay
  - The number of the retrieved data
  - Effective data retrieval ratio
- Scenario:
  - One consumer downloads a file from a producer at a different geolocation
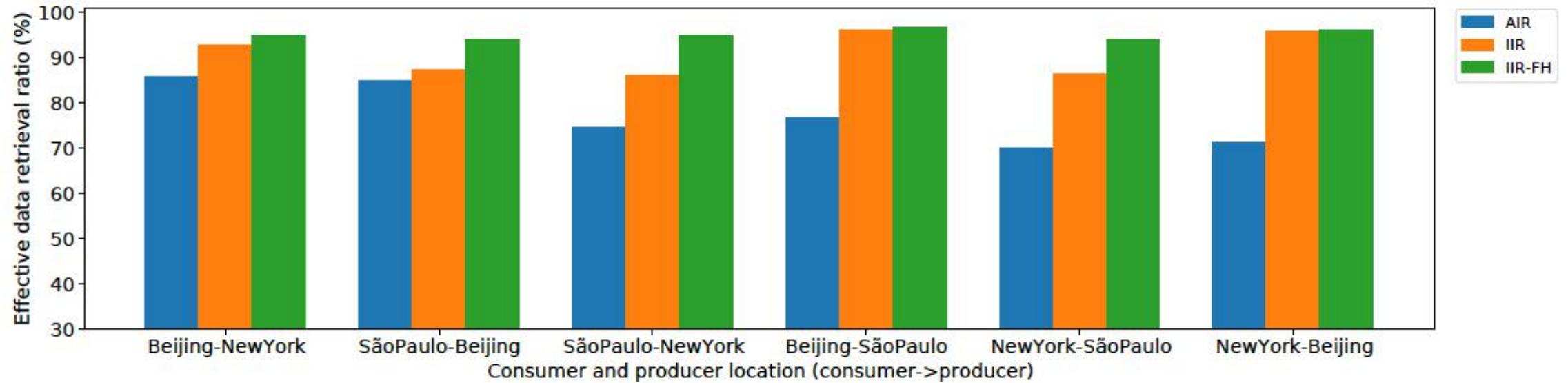 - Collect data in a period of 2 seconds, one before and one after the handover

Evaluation: the avarage data retrieval delay
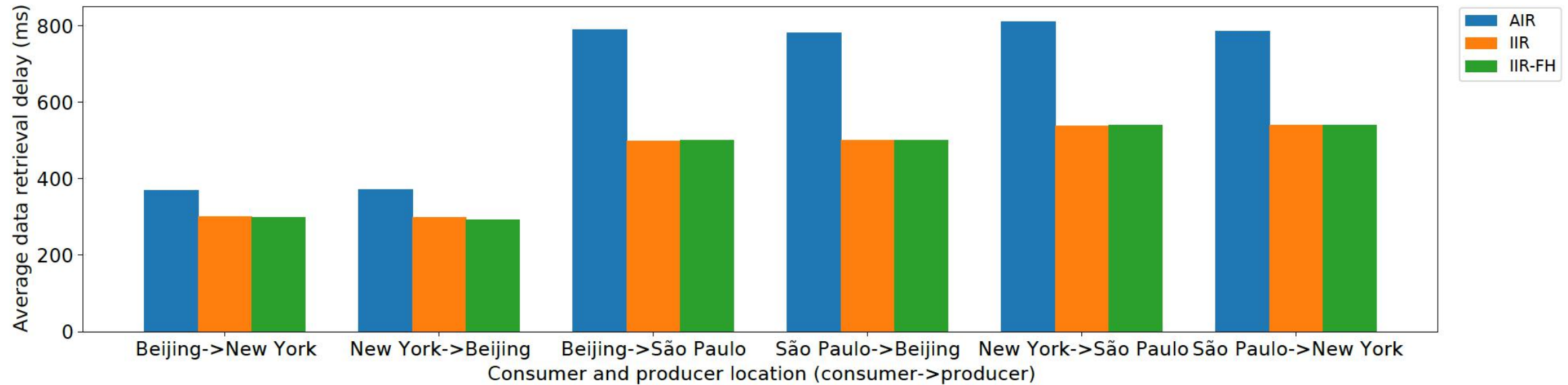
Evaluation: the number of retrieved data
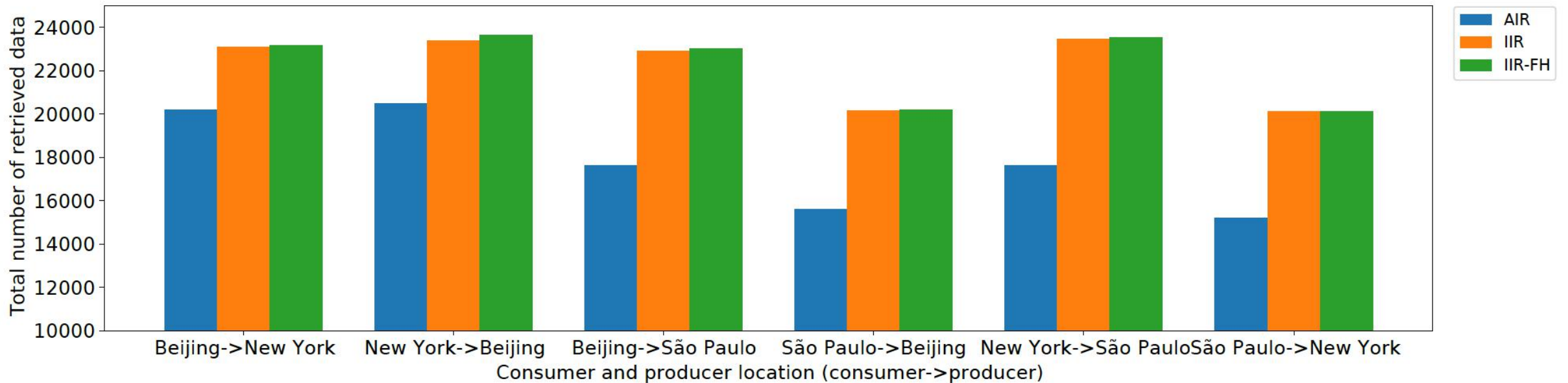
Evaluation: Effective data retrival ratio

Q/A

Thanks!