Satellite Ground Routing Architecture Based on Access Satellite Prediction

draft-hou-rtgwg-satellite-ground-routing-00

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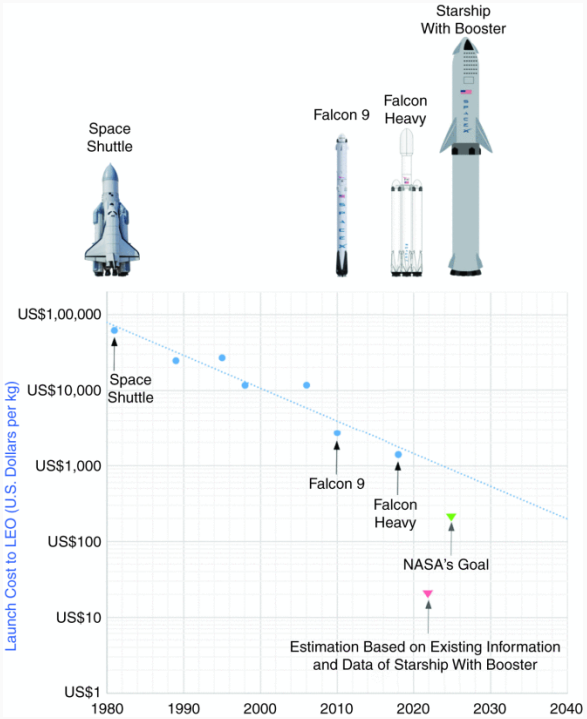
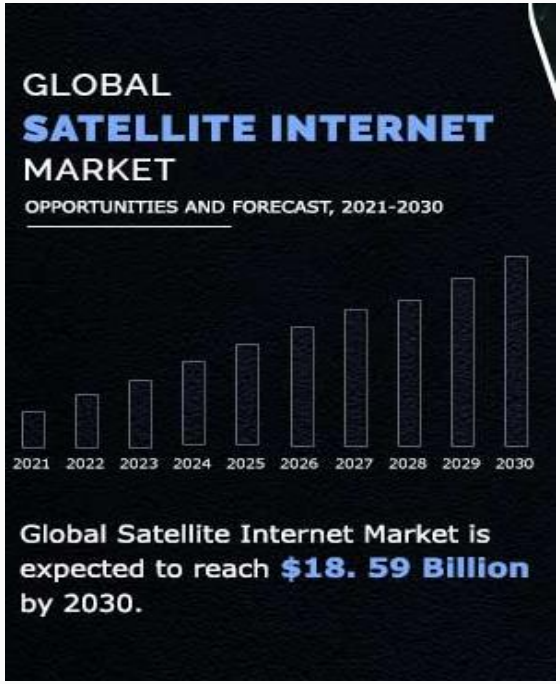
Background

- Rapid development of satellite technology



- Widespread attention of satellite network

- Broad market of satellite Internet

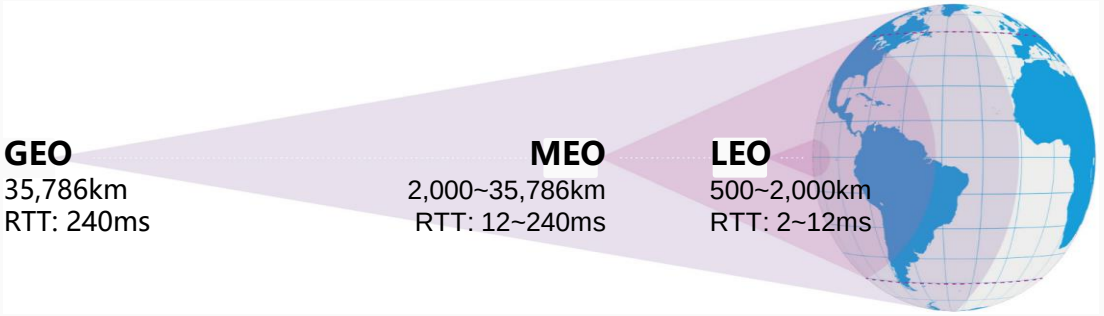


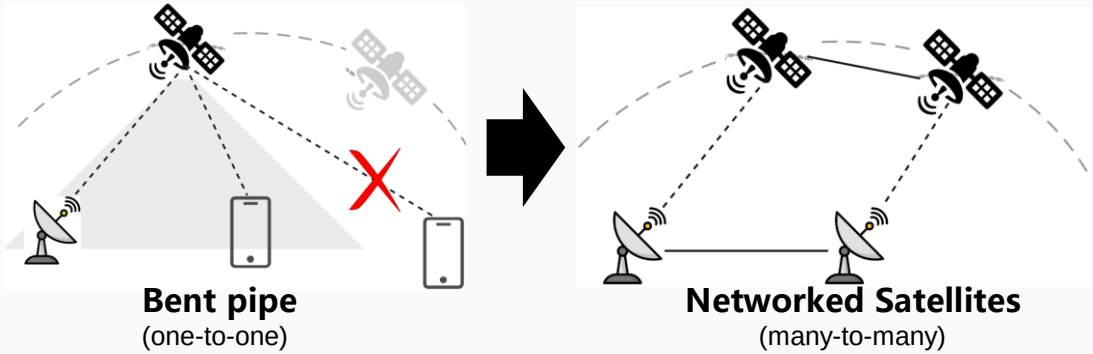
The satellite network is on the fast track.

Trends

NEW orbit: Evolving from GEO to LEO/VLEO.

Trends: Larger network scale, e.g. 42,000 satellites as planned in Starlink.



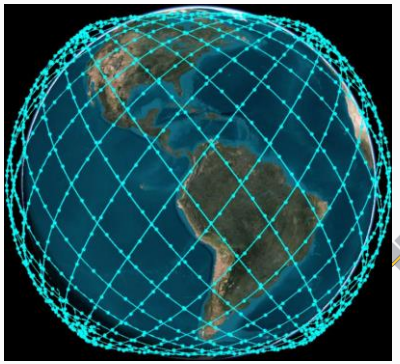


NEW infrastructure: Evolving from bent pipe to networked satellites.

Trends: More frequent link changes, e.g. satellite peering relationship changes roughly every 6~7 min.

NEW link: Evolving from Ground-to-Sat links to Inter-Sat links.

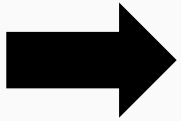
Trends: More complex route selection.



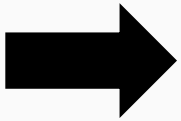
Problem Analysis

Issues:

- The connection between terrestrial nodes and satellites switch frequently which causes continuous routing information update.
- Sudden connection interruption can't be avoided for the complex communication environment in the space.
- The continuous routing information update further influences the stability of the terrestrial network.

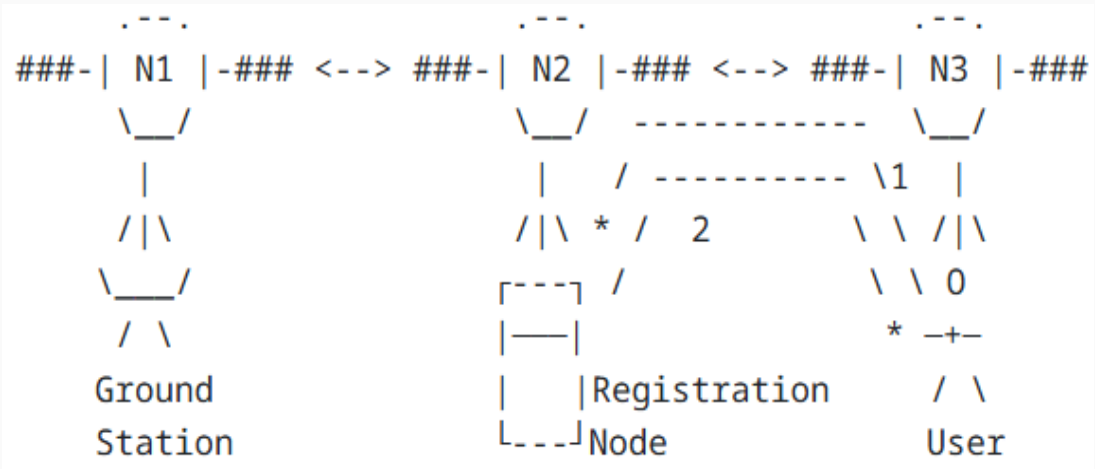


The tunnel-based integration architecture which isolates the impact between different networks is a viable approach.



The maintenance and acquisition of packet encapsulation information is the key issue. A satellite ground routing architecture based on access satellite prediction is proposed.

Satellite Ground Routing Architecture



- Access satellite: the satellite which communicates with ground nodes at a designated time.

Satellite Number	Satellite Identifier	Network Prefix
sat1	sat1_iden	prefixA
sat2	sat2_iden	prefixB
sat3	sat3_iden	prefixC
.....	.....	.....

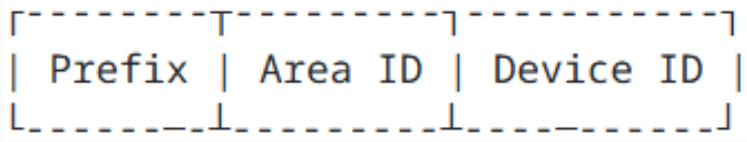
- Registration node: the node which records the network information of all the terrestrial nodes accessing the satellite network.

Network Node	Node Identifier	Geographical Location
User	prefix1.area_id1.device_id1	(lon1,lat1)
GS	prefix2.area_id2.device_id2	(lon2,lat2)
.....	.....	.....

- Terrestrial node: the node includes ground stations, terminal users, and etc.

Terrestrial Node Addressing

When accessing the satellite network, the terrestrial node establishes connection with the registration node, and informs its address information as well as location informaiton to the registration node.
The address registered by the terrestrial node should meet two requirements:
(1) The address information is a unique identifier of the terrestrial node.
(2) Based on the address information and the satellite orbit prediction, the address which is served to connect the remote terrestrial node at a specific time can be determined.



- **Prefix:** The prefix part of an address, which can be used to distinguish node types such as ground station, end user, and etc.
- **Area ID:** The geographic identifier marks different regions of the Earth, to achieve the mapping relationship between the location of the terrestrial node and the Earth's surface regions.
- **Device ID:** The identification information of the terrestrial node, which is used to distinguish different nodes in the same area.

Encapsulation Address Generation

(1) The satellite orbit information is used to determine the satellite ephemeris, that is, to determine which satellite is providing service to the designated Earth area at a specific time.
(2) The access satellite of the remote terrestrial node can be determined at a certain time.
(3) Then, according to the access network of the access satellite and the address information of the terrestrial node, the access address of the remote terrestrial node can be calculated at a certain time.

Network Node	Node Identifier	Geographical Location
User	prefix1.area_id1.device_id1	(lon1,lat1)
GS	prefix2.area_id2.device_id2	(lon2,lat2)
.....	.....	.....

Time Slot	Access Address
t0-t1	prefixA.area_id1.device_id1
t1-t2	prefixB.area_id1.device_id1
t2-t3	prefixC.area_id1.device_id1

Note: “area_id1 or (lon1, lat1)” + “t0-t1” → “prefixA”

Step1: The GS finds the destination user’s access satellite's access network and the address information of the destination user, which are prefixA and prefix1.area_id1.device_id1 at time slot t0-t1.
Step2: The GS calculates and uses the access address of the destination user for data packet transmission.
Step3: After receiving data packet from GS, the GS’s access satellite checks the destination address.
Step4: The GS’s access satellite encapsulates the data packet and forwards the encapsulated data packet.

Our Works

- What we have done in IETF:

(1) Routing Framework for LEO Mega-constellation Based on Region Division
https://datatracker.ietf.org/doc/draft-hou-satellite-routing-framework/

(2) Satellite Network Routing Use Cases
https://datatracker.ietf.org/doc/draft-hou-tvr-satellite-network-usecases/

(3) Lightweight Route Information Advertisement for LEO Mega-constellation
https://datatracker.ietf.org/doc/draft-hou-satellite-route-advertisement/

(4) An Emulation System Architecture for Space Network
https://datatracker.ietf.org/doc/draft-zh-sn-emulation-arch/

- Considerations for the future:

(1) Extension of routing protocols to support the architecture described in this document.
(2) Improvement of the routing algorithm presented in this document to consider more network metrics and obtain the optimal path.

Thanks