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# Geosynchronous Network Grid Addressing for Integrated Space-Terrestrial Networks

**Gao Zheng, Ning Wang, Rahim Tafazolli**

*5GIC, University of Surrey, Guildford, Surrey, UK*

{g.zheng, n.wang, r.tafazolli}@Surrey.ac.uk

**Xinpeng Wei**

*Huawei Technologies Co.,Ltd. Beijing, China*

weixinpeng@huawei.com

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## Outline

### Background

### The Geosynchronous Network Grid Addressing scheme

- The basic idea.
- Design details.
- Networking with the GNGA scheme.

### Performance evaluation

### Conclusion

# Background

## Space-Terrestrial network integration

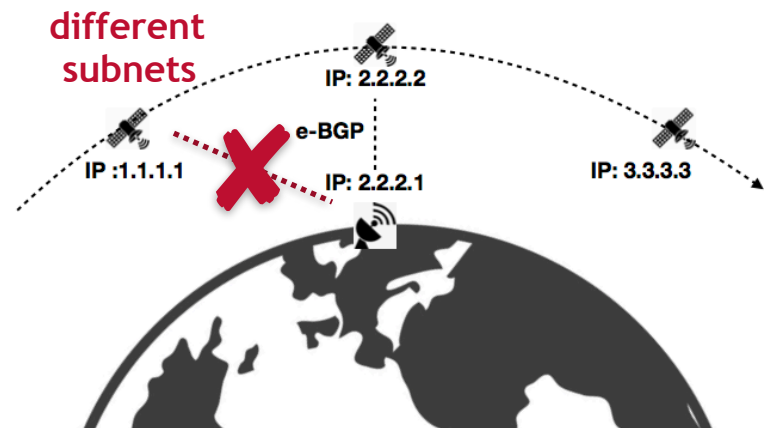
- Networking with Low Earth Orbit (LEO) satellites has received increasing attentions in recent years.

## The Key challenge

- Satellite-terrestrial routing stability problem.

## Recent attempts

- Satellite as an independent network.
- Satellite as the access network.
- Satellite as the transit network.



# The Geosynchronous Network Grid Addressing scheme

## The Goal

- Seamlessly integrate the space and terrestrial networks based on a unified common IP infrastructure.
- Without introducing severe routing stabilises caused by the LEO satellite constellation behaviours.
- Especially considering the legacy routing infrastructure on the terrestrial network side.
- Implementation friendly.

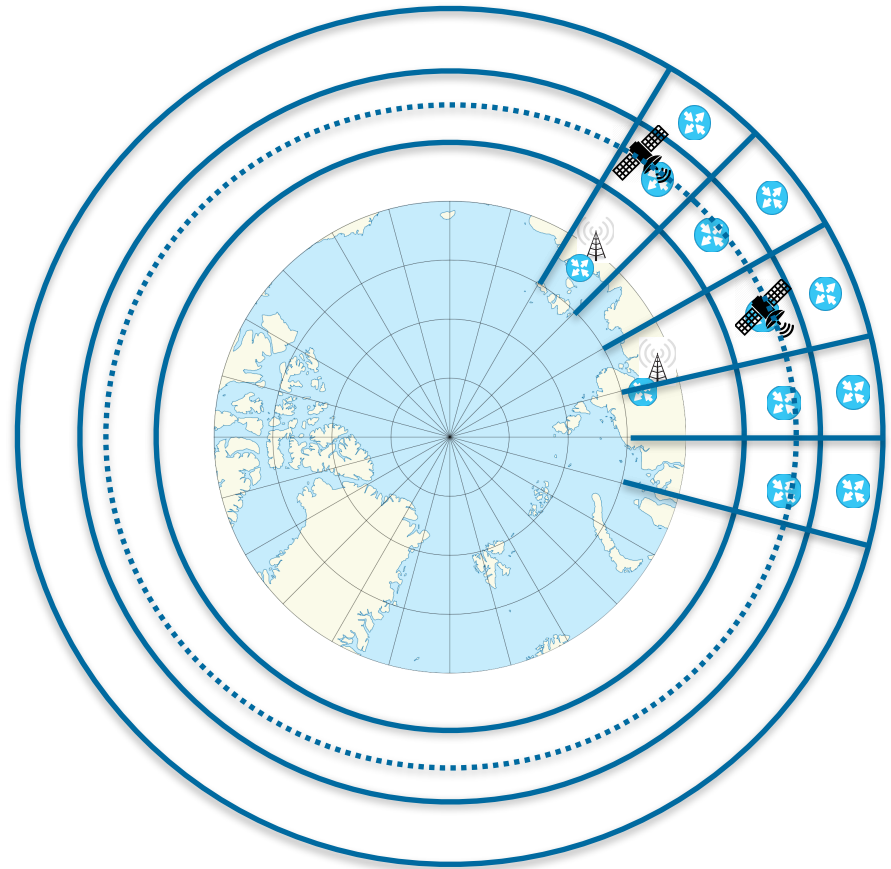
# The Geosynchronous Network Grid Addressing scheme

## The basic idea

- Divide the space into grids.
- The grids are designed to be geosynchronous.
- Each grid is by logic a virtual router.
- The virtual routers are consecutively instantiated by the passing-by satellites.

## The advantages

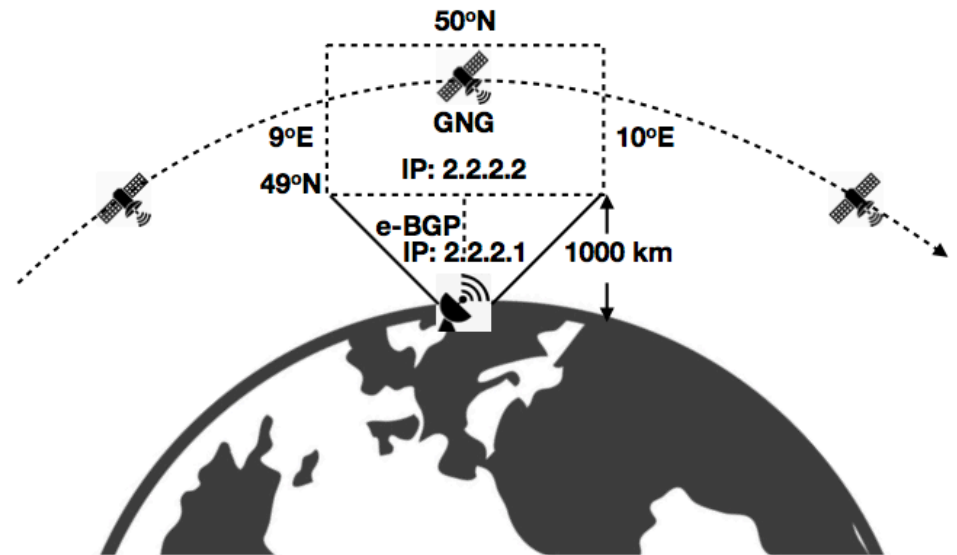
- The virtual routers (i.e., the grids) are static to the ground stations.
- Topology dynamic is hidden from layer 3.



# The Geosynchronous Network Grid Addressing scheme

## Design details

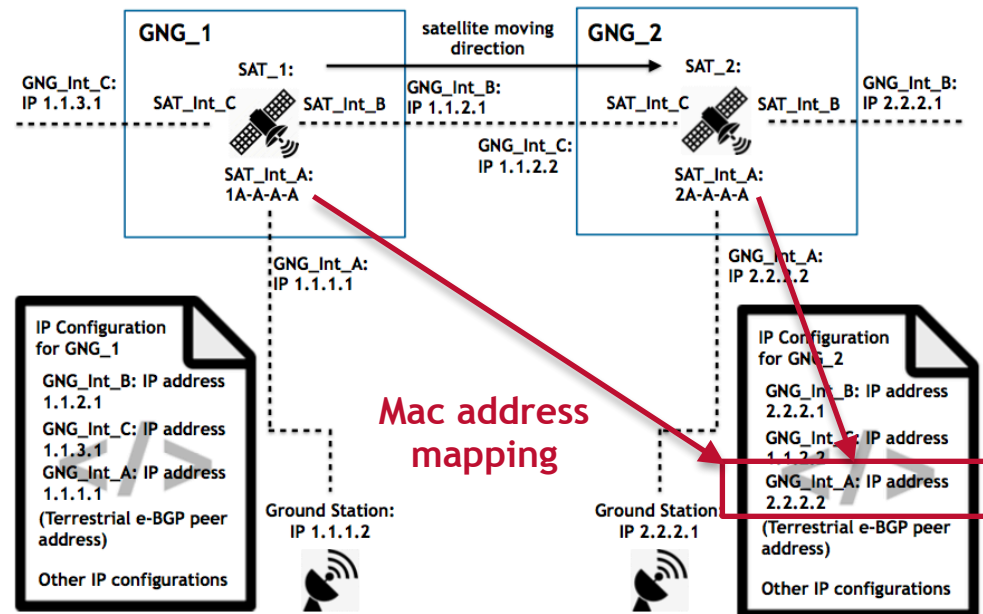
- Use geographic coordinates to divide the grids.
- IP addresses are bound to the grids instead of the satellites.
- Each ground stations talks to a fixed piece of sky above it.
- The IP function of a GNG is consecutively instantiated by the passing-by satellites.



# The Geosynchronous Network Grid Addressing scheme

## Instantiating the GNGs with satellites

- The configuration is GNG-based.
- The configuration includes e.g., IP addresses, BGP settings.
- A satellite would need to activate the right configuration before it enters a grid.

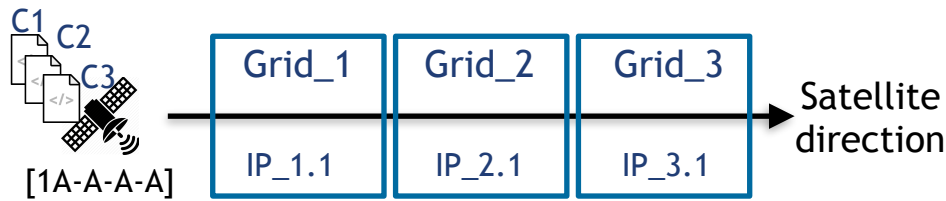


# The Geosynchronous Network Grid Addressing scheme

## Setting coordination

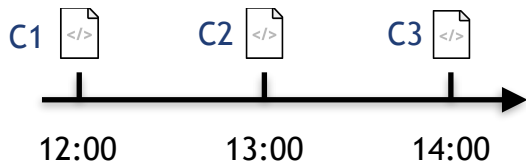
- A satellite will need to periodically shift its setting during a mission.
- The two configuration shifting options.

### 1. Active shifting



Advertise the ARP mapping:

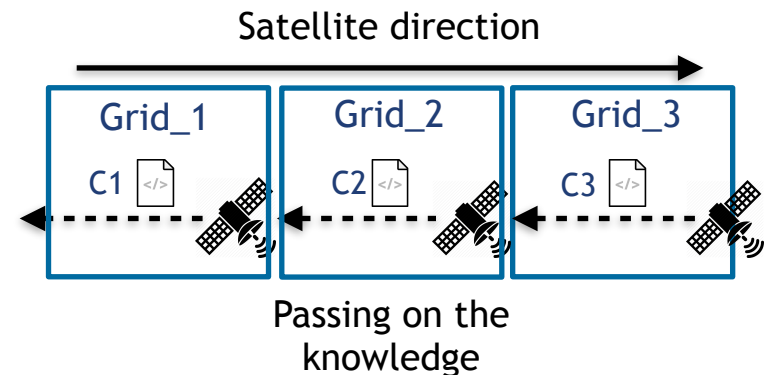
IP\_1.1 <--> IP\_2.1 <--> IP\_3.1 <-->  
[1A-A-A-A] [1A-A-A-A] [1A-A-A-A]



Time line

Using GTS information is also an option

### 2. Passive shifting





# The Geosynchronous Network Grid Addressing scheme

## Networking with GNGs

An example of the packets:

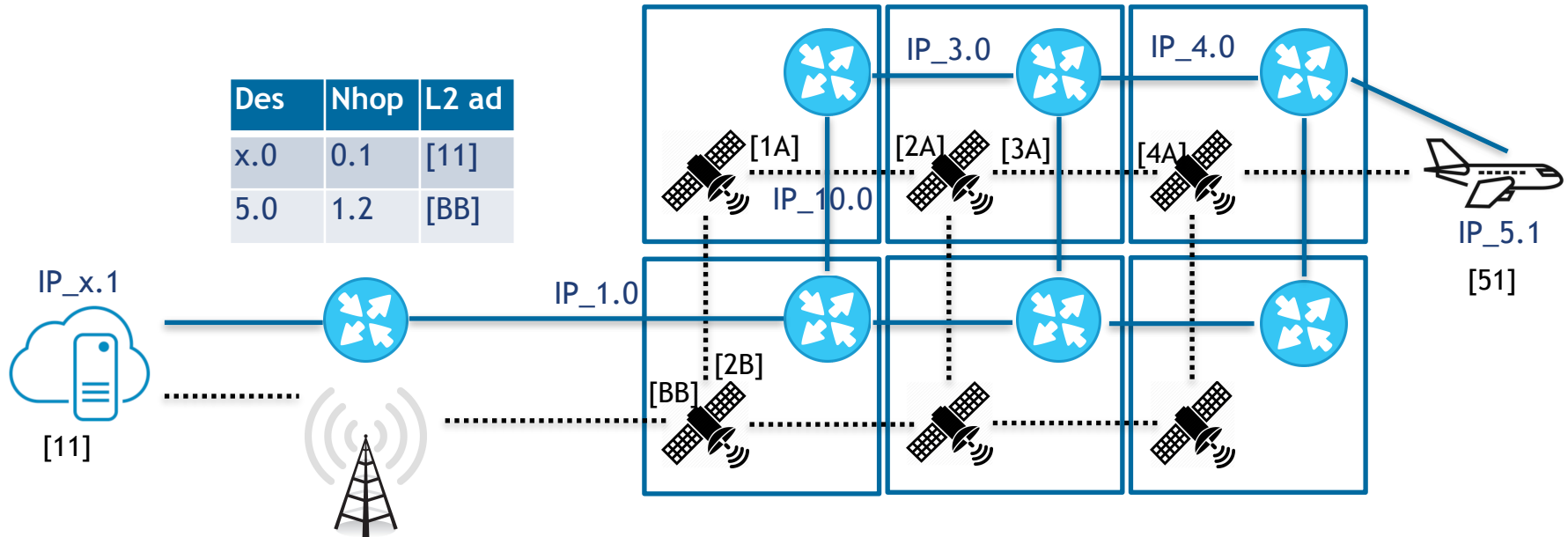
Destination_L2	Source_L2	Destination_IP	Source_IP	Data
[3A]	[4A]	x.1	5.1	Data

- Use IP for routing.
- Use satellite address for switching.

Des	Nhop	L2 ad
x.0	10.2	[2B]
5.0	3.2	[2A]

Des	Nhop	L2 ad
x.0	3.1	[1A]
5.0	4.2	[4A]

Des	Nhop	L2 ad
x.0	4.1	[3A]
5.0	5.1	[51]



# Performance evaluation

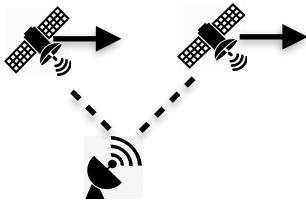
## Basic setups

- IGPs are redistributed into BGP.
- configuration shifting option: active shifting.

The address/protocol configurations are made proactively.

- Two handover Types

Smooth: make before break



Hard: break before make

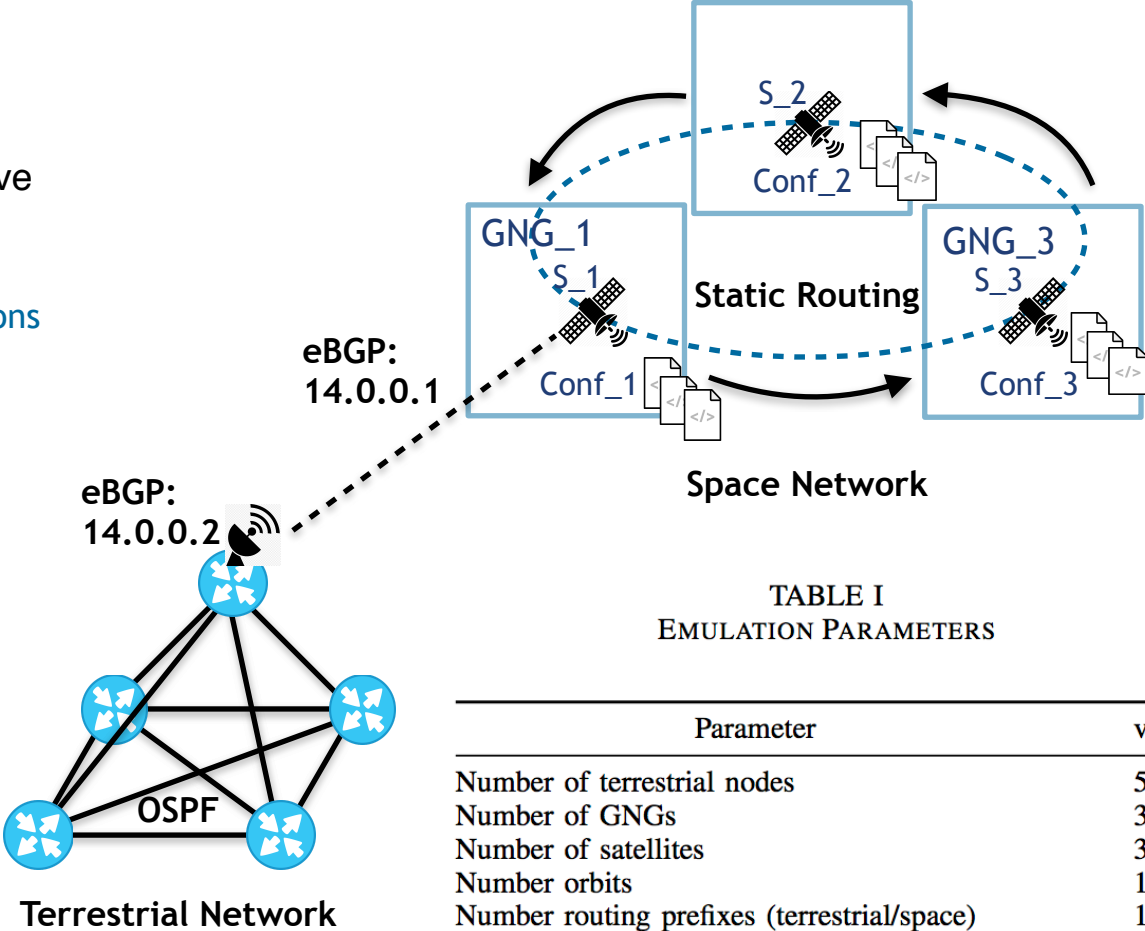
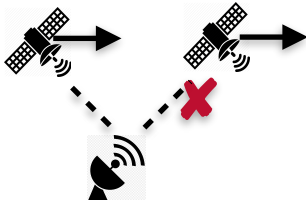
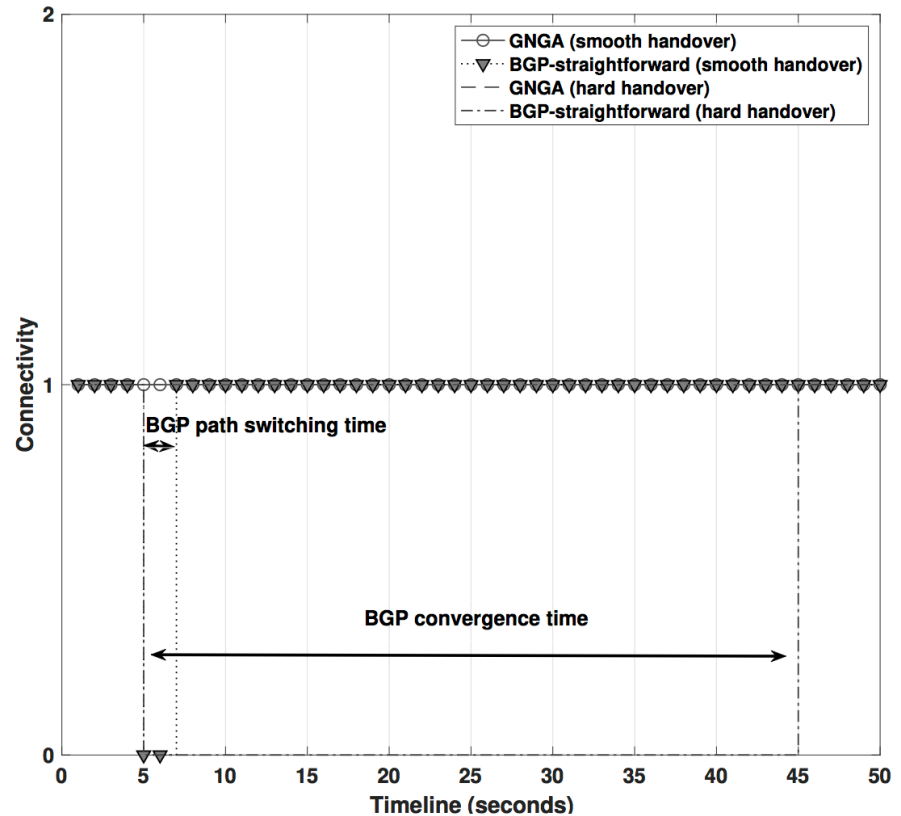


TABLE I  
EMULATION PARAMETERS

Parameter	value
Number of terrestrial nodes	5
Number of GNGs	3
Number of satellites	3
Number orbits	1
Number routing prefixes (terrestrial/space)	10/3

## Network connectivity performance

- Connectivity being 1 means the space/terrestrial network can perform normal communication with each other.
- Hard handover:
  - BGP-straightforward approach would require approximate 30 seconds to converge.
  - GNGA can recover instantly after the handover event.
- Smooth handover:
  - GNGA is seamless.
  - BGP-straightforward approach would have a 10-seconds path switching time.



## Impact to the space/terrestrial system

- For GNGA, handovers will not trigger prefix updates propagating into both the space and terrestrial infrastructure.
- For BGP straightforward scheme:

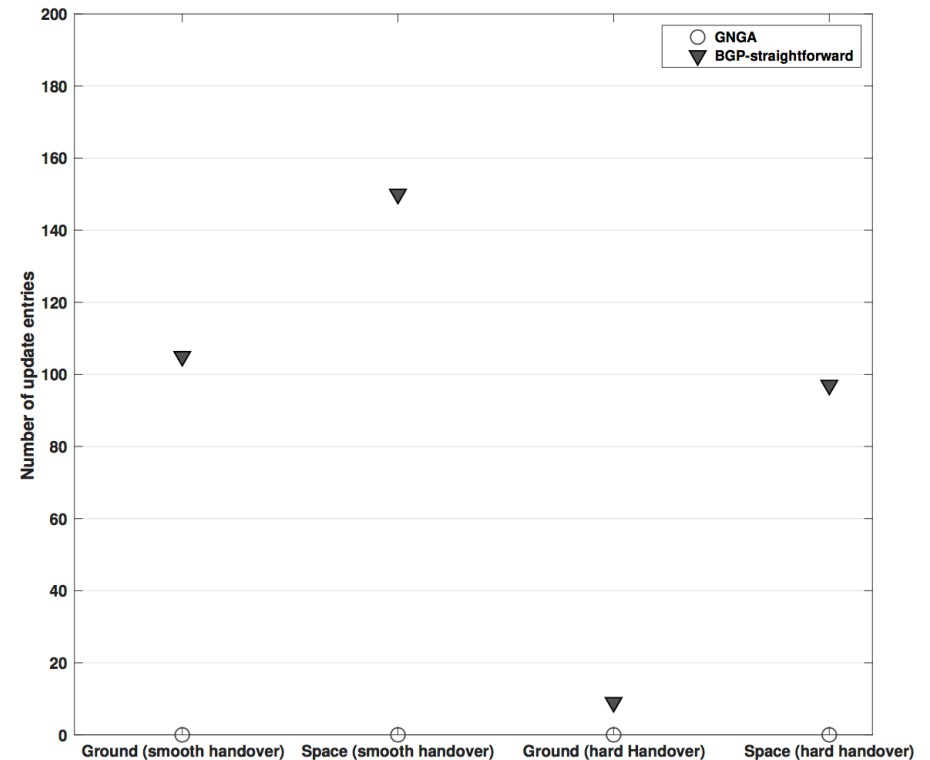
With hard handovers:

The numbers of update entries propagated into ground/space are 9 and 97.

With smooth handover:

The numbers of update entries propagated into ground/space are 105 and 150.

- For the BGP-straightforward approach, smooth handover can circumvent the convergence issue but will cause more impact to both sides.



# Conclusion

## **GNG is a competitive solution for Space-Terrestrial network integration.**

1. Topology dynamic is hided from the IP layer.
2. The network connectivity performance is significantly improved.
3. The integration impact is small to the existing terrestrial system.
4. All the incremental changes are made from the space segment, thus it is considered as implementation friendly.

# NIPAA Program

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## Thank you

**Gao Zheng**

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