Decentralized integration of non-terrestrial networks into 6G

Internet Research Retreat Raitenhaslach

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Paulo MENDES

Expert in Communication Network Architectures and Design

Airbus

paulo.mendes@airbus.com

This presentation reflects my personal view on the topic and not Airbus position.

Starting point: Flexible satellite technology

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OneSat can be fully reconfigured while in orbit – and it is capable of adjusting its coverage area, capacity and frequency “on the fly” to meet evolving mission scenarios.

Encompasses active antennas enabling several thousand beams.

- Multi-beam RF technology
- Free Space Optical Links
- Flexible payloads

Latest development: Constellations

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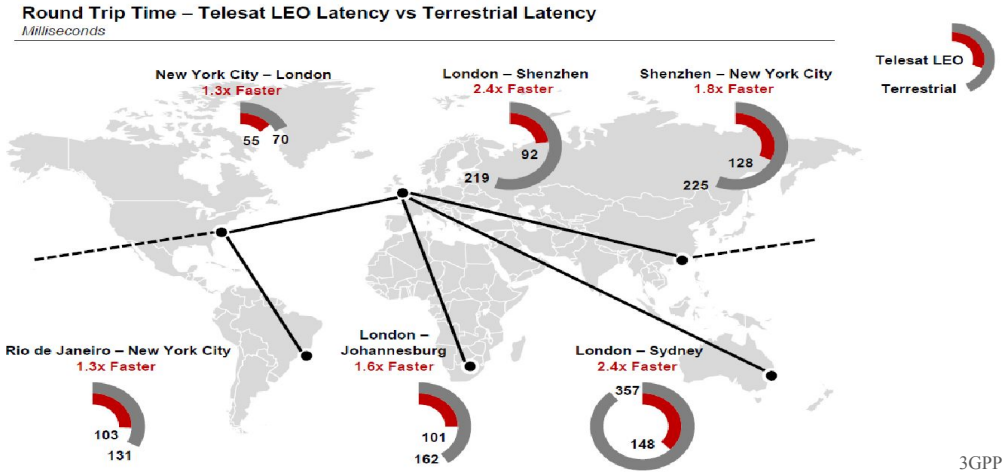

Throughput

Aggregate downlink capacity of the full Starlink deployment is estimated to be 240 Tbps.

Latency

Telesat LEO simulations of traffic moving over only inter-satellite links.

Round-trip time at the network layer including processing latency for system and inter-satellite links.

3GPP TR 38.811 V15.0.0 – Study for New Radio (NR) to support non terrestrial networks (Release 15)

		LEO at 600 km		LEO at 1500 km		MEO at 10000 km	
Elevation angle	Path	Distance D (km)	Delay (ms)	Distance D (km)	Delay (ms)	Distance D (km)	Delay (ms)
UE: 10°	satellite - UE	1932.24	**6,440**	3647.5	12,158	14018.16	46.727
GW: 5°	satellite - gateway	2329.01	7.763	4101.6	13.672	14539.4	48.464
90°	satellite - UE	600	2	1500	5	10000	33.333
Bent pipe satellite							
One way delay	Gateway-satellite_UE	4261.2	14.204	7749.2	25.83	28557.6	95.192
Round Trip Delay	Twice	8522.5	28.408	15498.4	51.661	57115.2	190.38
Regenerative satellite							
One way delay	Satellite -UE	1932.24	**6.44**	3647.5	12.16	14018.16	46.73
Round Trip Delay	Satellite-UE-Satellite	3864.48	**12.88**	7295	24.32	28036.32	93.45

Target development: 3D networks at different altitudes

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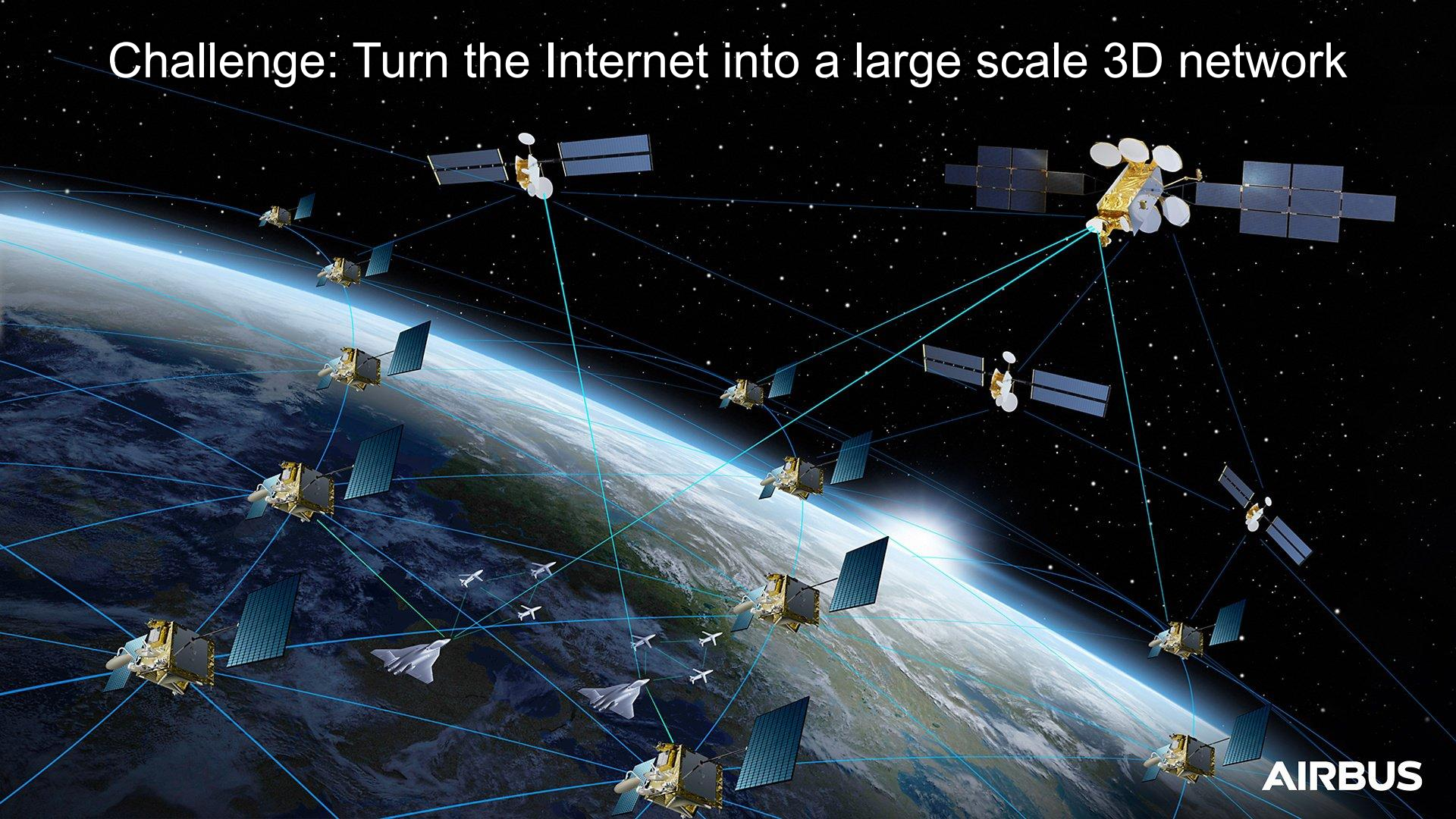
Challenge: Turn the Internet into a large scale 3D network



Turning the Internet into a large scale 3D network

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Vision

Internet able to support a large scale of new services, such as (distributed) in-network computing (for instance for the coordination among autonomous vehicles), while transparently integrating 3D space/airborne networks.

Motivation

Need to devise a more decentralized, scalable and low cost way to operate and manage large scale networks.

Potential Path

Allow dynamic space/airborne networks to deliver services, and not just connectivity, based on different semantics (host, data, service, geolocation), while being self-sustainable by observing and acting autonomously in order to optimise their performance even in scenario with intermittent connectivity and resource availability.

Goal

Make a large number of new services accessible to all 7.3 billion people.

Challenge 1: Self-sustainable networks able to deliver services

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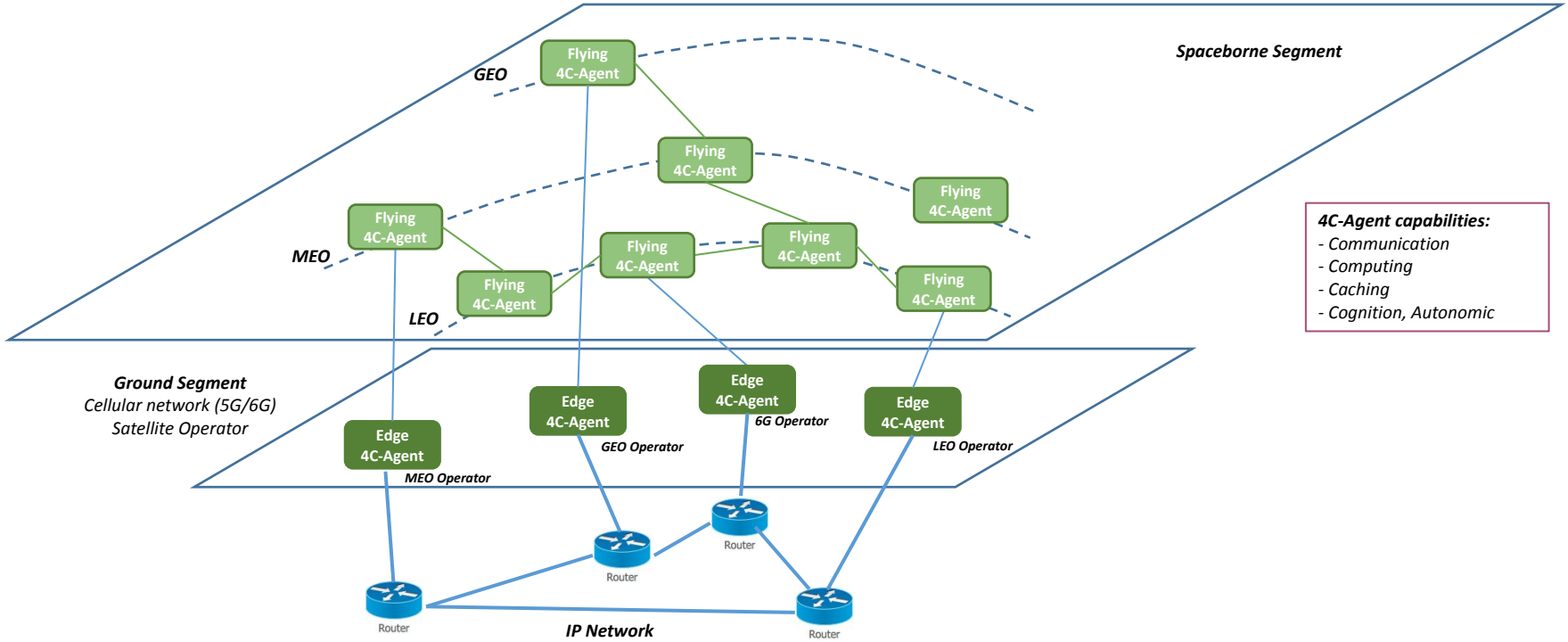

Road to Cognitive service-centric networks

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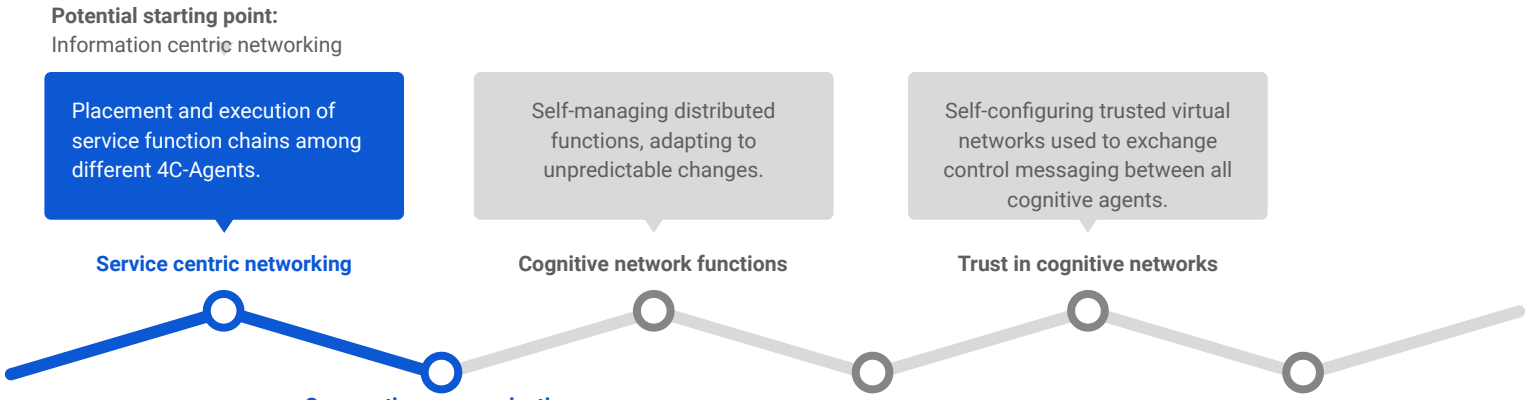

Challenge 2: Global Networking based on different domains

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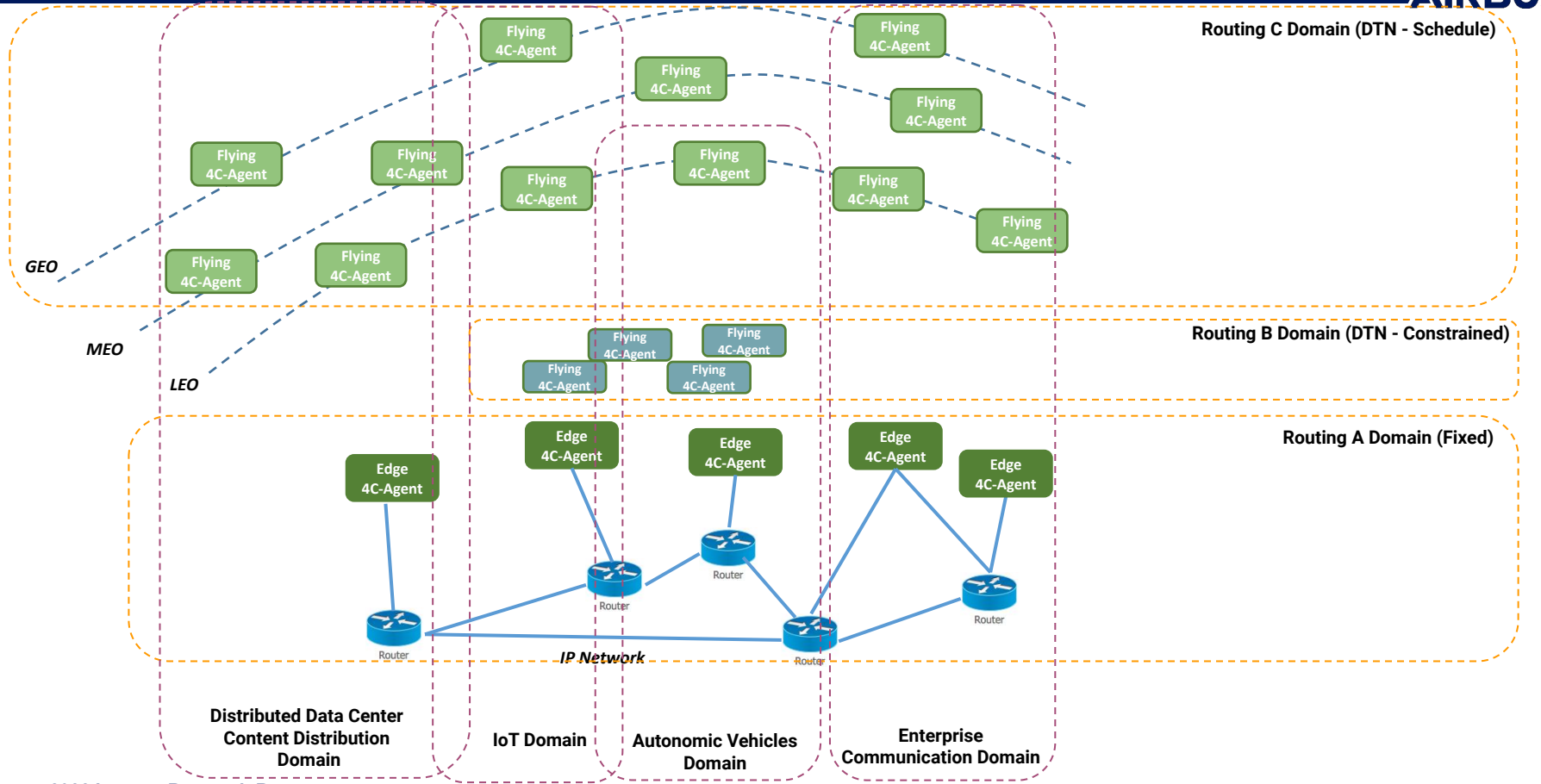

Challenge 2: Global Networking based on different domains

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Future Scenario

In a large scale heterogeneous 3D Internet, with tens of billions of nodes being connected directly and indirectly, there is a trend towards network specific and local requirements, behaviors, and semantics.

Geographic, topology, service, user community, Ad Hoc, etc

Based on RFC 8799

Goal

How to reach global interoperability in a 3D Internet?

- Current limitations:
  - No transparency to IPv6 extension headers.
  - Unreliable path MTU discovery.
  - Problems with TCP maximum segment size.
  - Administrative domain boundaries:
    - Prone to leakage caused by human error.
    - May be difficult to define in dynamic domains.
  - Protocols with semantics limited to specific domain.

- Current management of (routing) domains:
  - Careful configuration of boundary routers and firewalls.
  - Careful management of address assignment to hosts.
  - Configuration errors can lead to unwanted traffic patterns.

- Future perspective on multiple domains:
  - Domains may extent throughout the Internet:
    - Based the notion of network segments.
  - Domains may overlap each other in an arbitrary fashion:
    - Network slices, service function chains.
  - Domains may operate based on different semantics:
    - HostID, DataID, ServiceID, GeoID.
  - Domains may be created and managed automatically:
    - Adaptation of boundaries over time.
    - Perform peer verification (identity and role).

Thank you!

Paulo Mendes
paulo.mendes@airbus.com