IPNSIG ACADEMY
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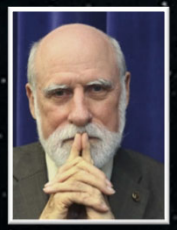
Space Policy, Perspective on IPN Governance



Moderator: Vint Cerf
Board Member, IPNSIG

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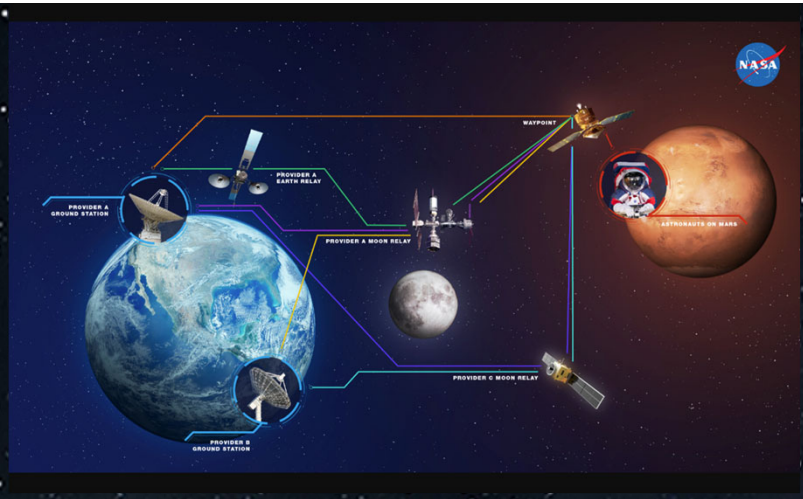
Director of the Space Policy Institute and a Professor of the Practice of International Affairs at George Washington University's Elliott School of International Affairs

The Interplanetary Internet will be Familiar but Different



Terrestrial Internet

- Traveling from LA to San Diego
- A government program that transitioned to a multi-stakeholder enterprise
- Technology first, governance later

Interplanetary Internet

- Traveling from LA to Jakarta
- Space communications are point-to-point with governance by national space agencies and cooperative agreements among them
- Barriers to entry are higher, but opportunities to take “lessons learned”

Internet Protocol Issues

IP Addresses on other planets and in space

- Continued use of IP as a near term issue. A transition strategy is needed for implementing delay tolerant networking – bundle protocols (DTN BP) that can cope with delays and communication breakups. It is entirely possible that independent internets will arise on the other planets, moons and spacecraft navigating the Solar System.
- Recommendations needed on how to disjunct Earth uses of the IP address space from uses off Earth.
- The same should be done for the Autonomous System Number (ASN) numbering space.

Recommendations are needed for node numbers and names

- A numbering and domain name structure that enables future expansion and scale of the interplanetary internet
- How Authorities and sub-Authorities for numbering are managed (e.g., national, agency, program, project levels).
- Whether or not there needs to be a defined relationship between IP addresses – Node numbers – Domain names. Domain names are critical components of Internet electronic mail and the World Wide Web. It is an open question whether domain names should be created for use with the Bundle Protocol and how such references between the Internet, internets and an interplanetary internet should work.

U.S. Proposal for Lunar Space Allocations

ADD USA/10 (LUNAR/CISLUNAR)/3

DRAFT NEW RESOLUTION [A10-LUNAR] (WRC-23)

Spectrum allocations and associated regulatory provisions to support lunar and cislunar communications in specific frequency bands

The World Radiocommunication Conference (Dubai, 2023),

considering

a) that scientific and commercial operations on the moon and between the moon and Earth are increasing, and will be robust by later in this decade and into the 2030s;

b) that operations on the moon are considered to be lunar operations, and operations in the vast void between the moon and where Earth-orbiting satellites operate (and the Earth itself) are considered to be cislunar operations;

c) that the operations referred to in *considering a)* above will need a reliable, understandable, usable, and available communications and data architecture in place to handle the substantial communication and data transmissions services that support such scientific and commercial operations;

d) that the ITU-R has begun preliminary studies on the technical issues associated with lunar and cislunar communications,

considering further

a) that the architecture envisioned for the operations referred to in *considering a)* include the following components:

Lunar operations need "space-to-space" service allocations in addition to Earth-Space and Space-Earth.
No "Moon" service allocations exist (yet).

International Standards Organizations

After naming and numbering protocols, and spectrum allocations, decisions are needed on key standards:

- Definition of domain name boundaries (between Earth-domain and non-Earth domains. These could be based on physical characteristics, such as gravitational sphere of influence, or transmission times (e.g., light-seconds). Alternatively, topological connectivity (e.g. sharing of a common contact graph) may be more pragmatic.
- Adoption of coordinate systems for operations across physical domains (e.g., barycentric celestial reference system or BCRS).
- Requirements for time standards and the distribution of precision time for the efficient functioning of the network.

Time transfer is largely a solved problem for Earth-based networks. For the interplanetary internet, the problem of determining what time it is at each node is complicated due to large distances and time-varying relativistic effects. The next level problem is correcting for computer and spacecraft clock drifts. Time synchronization from Earth may be sufficient or local time references on the Moon and Mars could be used (e.g., local atomic clocks).

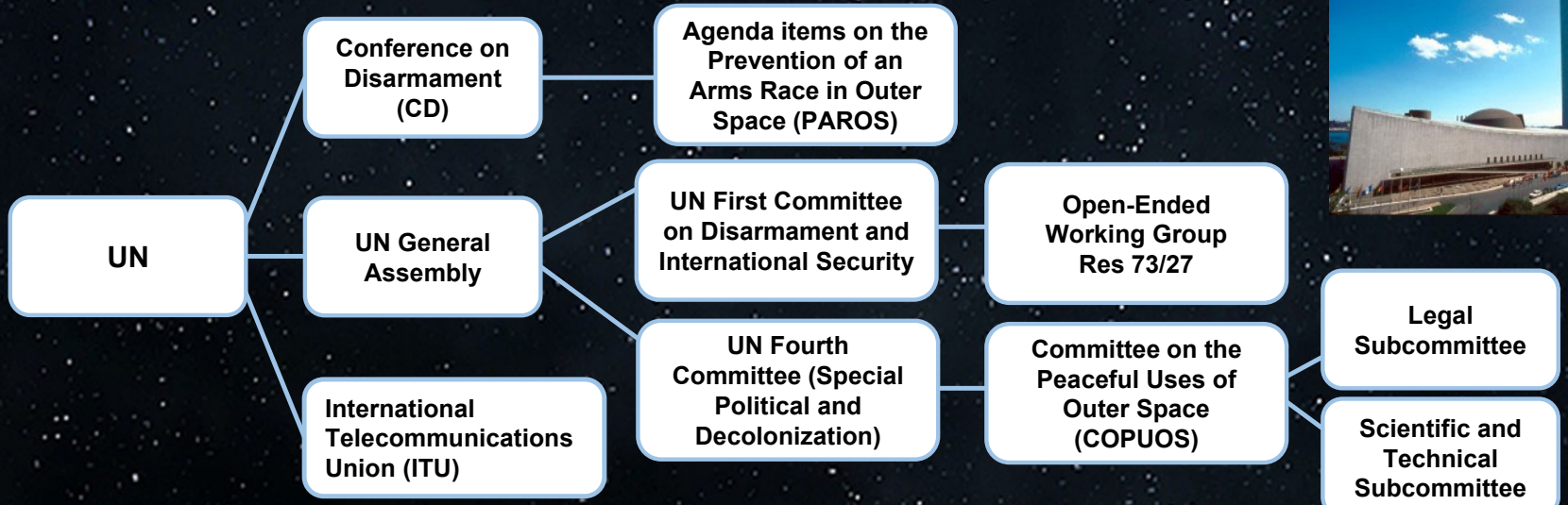
For the Internet, there is a network time protocol (NTP) for clock synchronization to Coordinated Universal Time (UTC). Should there be a Space NTP? A potential cost/risk trade for implementing a Space NTP is whether a single clock on the Moon or Mars would suffer local gravitational effects and create a single, systemic bias. On Earth, multiple atomic clocks around the world are used to develop UTC.

This raises a potential policy issue in that all official UTC sites are defined as terrestrial laboratories. Using a terrestrial UTC may be acceptable out to GEO, but for beyond GEO, it may be desirable to create a UTC (Moon) or UTC (Mars) that would be recognized by the global timing community.

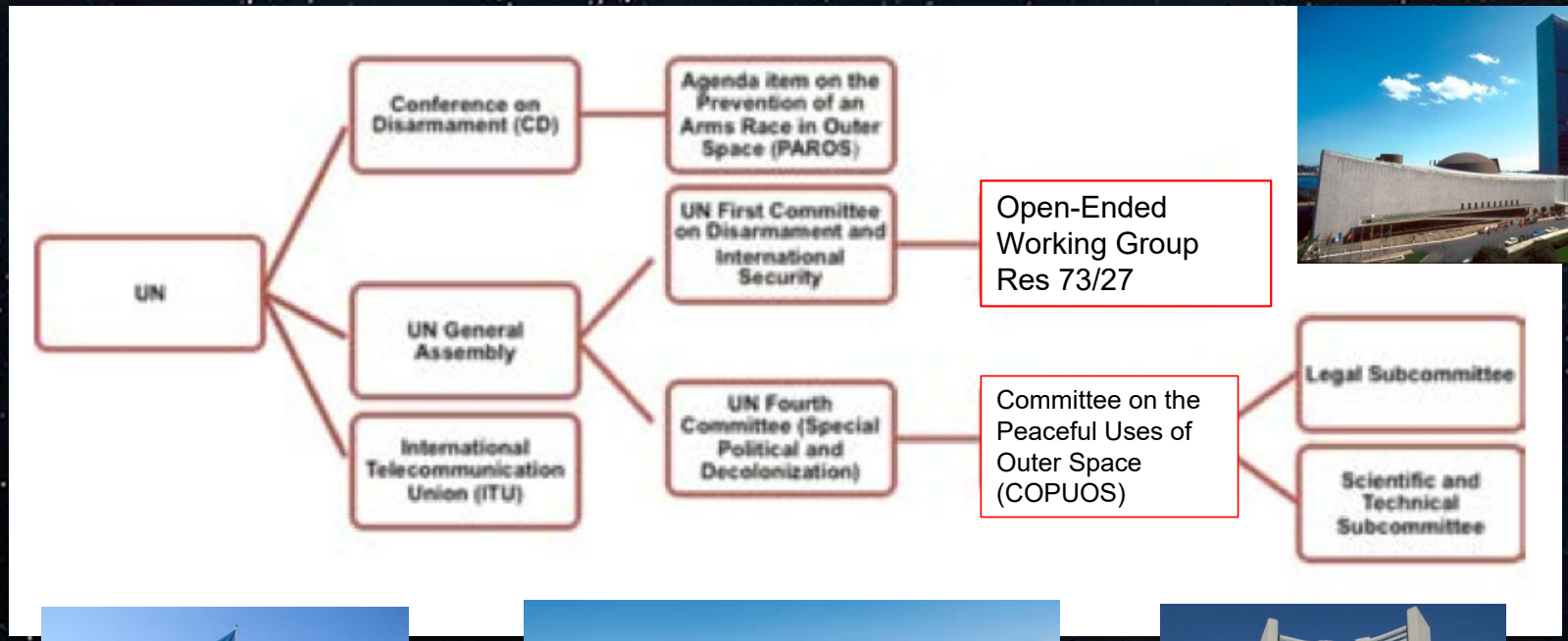
Artemis Accords

- As of March 1, 2023, there are 23 signatories.
  - Germany, India, Russia, and China are among the notable spacefaring nations that have not signed or expressed an intention to sign.
- Section 5 of the Artemis Accords is perhaps most relevant as it calls for interoperability across all partners. "The Signatories recognize that the development of interoperable and common exploration infrastructure and standards, including but not limited to fuel storage and delivery systems, landing structures, **communications systems**, and power systems, will enhance space-based exploration, scientific discovery, and commercial utilization. The Signatories commit to use reasonable efforts to **utilize current interoperability standards** for space-based infrastructure, to **establish such standards when current standards do not exist or are inadequate**, and to follow such standards."
- NASA currently does not have one set of definitions for what constitutes "cislunar" space. Additionally, the defined GNSS space service volume is not tied to the cislunar term. The relationship of interplanetary internet domains to physical domains is a likely topic for discussion among Accord signatories, starting with decisions by LunaNet.
  - Platforms in near Earth orbit may be part of the Earth domain while Lunar Gateway and lunar surface operations are part of the Moon domain. Sub-regions of the Moon domain could include shadowed craters and underground tunnels not directly accessible to communications from Earth.

UN-related Institutions Relevant to Space



UN-related Institutions Relevant to Space



UN Committee on the Peaceful Uses of Outer Space (UNCOPUOS)

Like the UN Internet Governance Forum, UNCOPUOS is not an effective forum for technical development or operations, but it is a forum for information exchange.

- Technical expertise is provided in a “bottom up” manner, guidelines are developed with multilateral consensus, and implemented by sovereign states – not a transnational authority. UNCOPUOS is unlikely to have a direct governance role.

Some COPUOS-developed guidelines may affect operations, such as end of life disposal of orbital assets. There are two potential areas which should be monitored for future impacts:

- The creation of a radiofrequency quiet zone on the lunar far side. A quiet zone on the Moon could be implemented in a number of ways, such as through the ITU or via CCSDS.
- Provision of space safety services. The 1968 Agreement on the Rescue and Return of Astronauts imposes positive obligations on member States to treat astronauts as “envoys of mankind” and provide aid to those in distress. SSI support for emergency communications, regardless of nationality, could be an example of the United States fulfilling its obligations under this treaty.

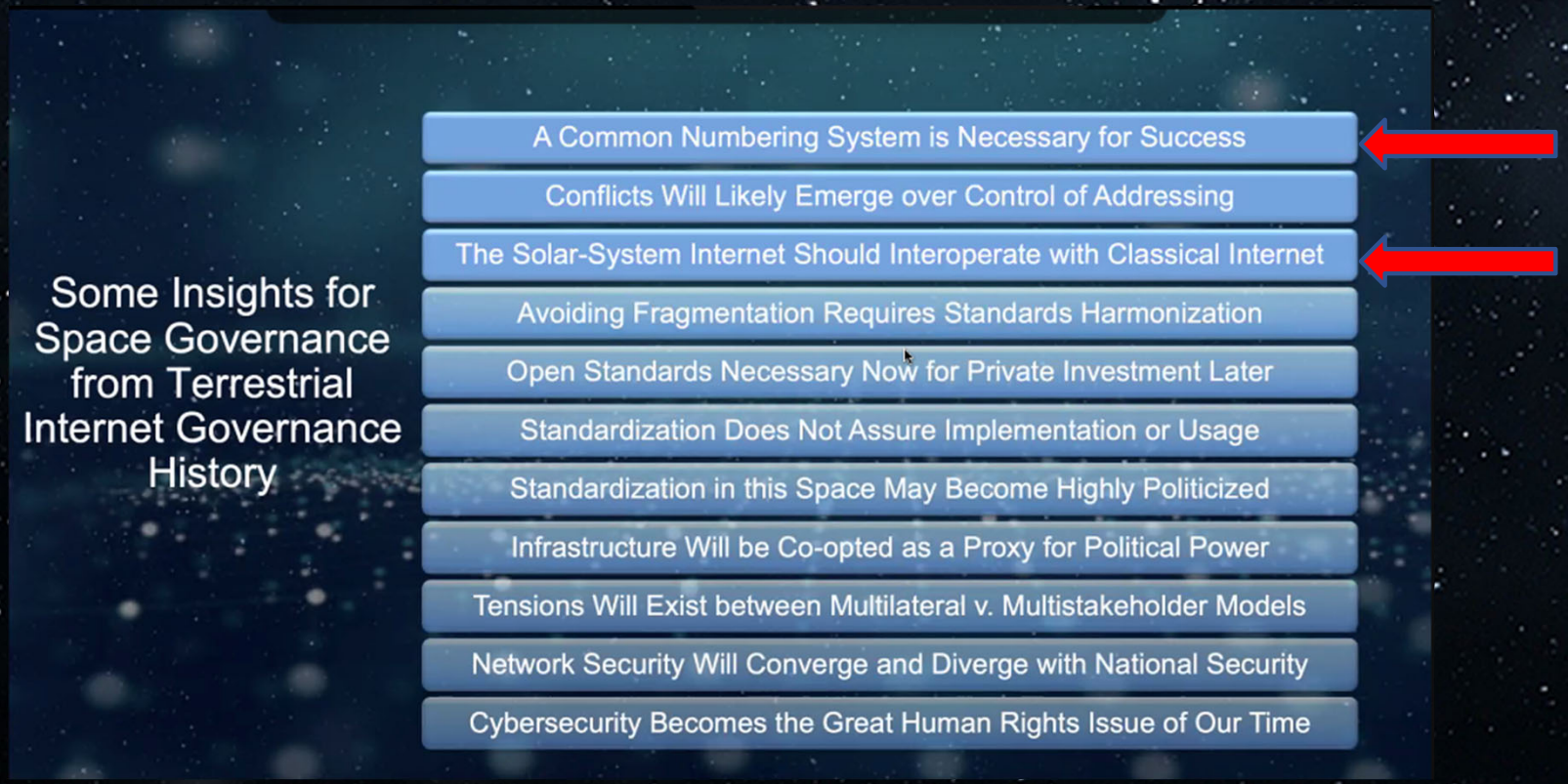
Observations

- No fundamental governance barriers to the creation of an Interplanetary Internet
  - Multiple international forums exist to explain and promote the concept, ranging from the ISECG and Artemis Accord signatories to UN COPUOS. No centralized authority but rather a set of technical standards, interfaces and protocols that must be tended and implemented.
  - The CCSDS is working on several standards relative to the interplanetary internet. Work may overlap with other standards bodies such as the IETF, the IOAG, and ITU-T.
- The Interplanetary Internet cannot be based on IP but must use DTN-BP. IP may continue to be used in very localized system. Determining time, to include relativistic corrections, is a pacing challenge.
- Spectrum for lunar communications and navigation systems needs to be recognized internationally.
  - The United States has proposed a specific agenda item for the next World Radiocommunications Conference on lunar RF spectrum allocations.

Way Ahead

- No single international governance mechanism to make or enforce a particular transition – multiple forums exist
  - A UN ICG for space operations could be created to facilitate transparency among all spacefaring states.
- International support needed for ITU recognition of lunar spectrum needs
- How should the interplanetary internet access and use time?
- An immediate question is how to reach an agreement on a naming and numbering scheme.
  - The lack of a path for implementing DTN-BP will result in the use of legacy standards that may not meet the goals of LunaNet, much less those of the interplanetary internet.

From Laura DeNardis



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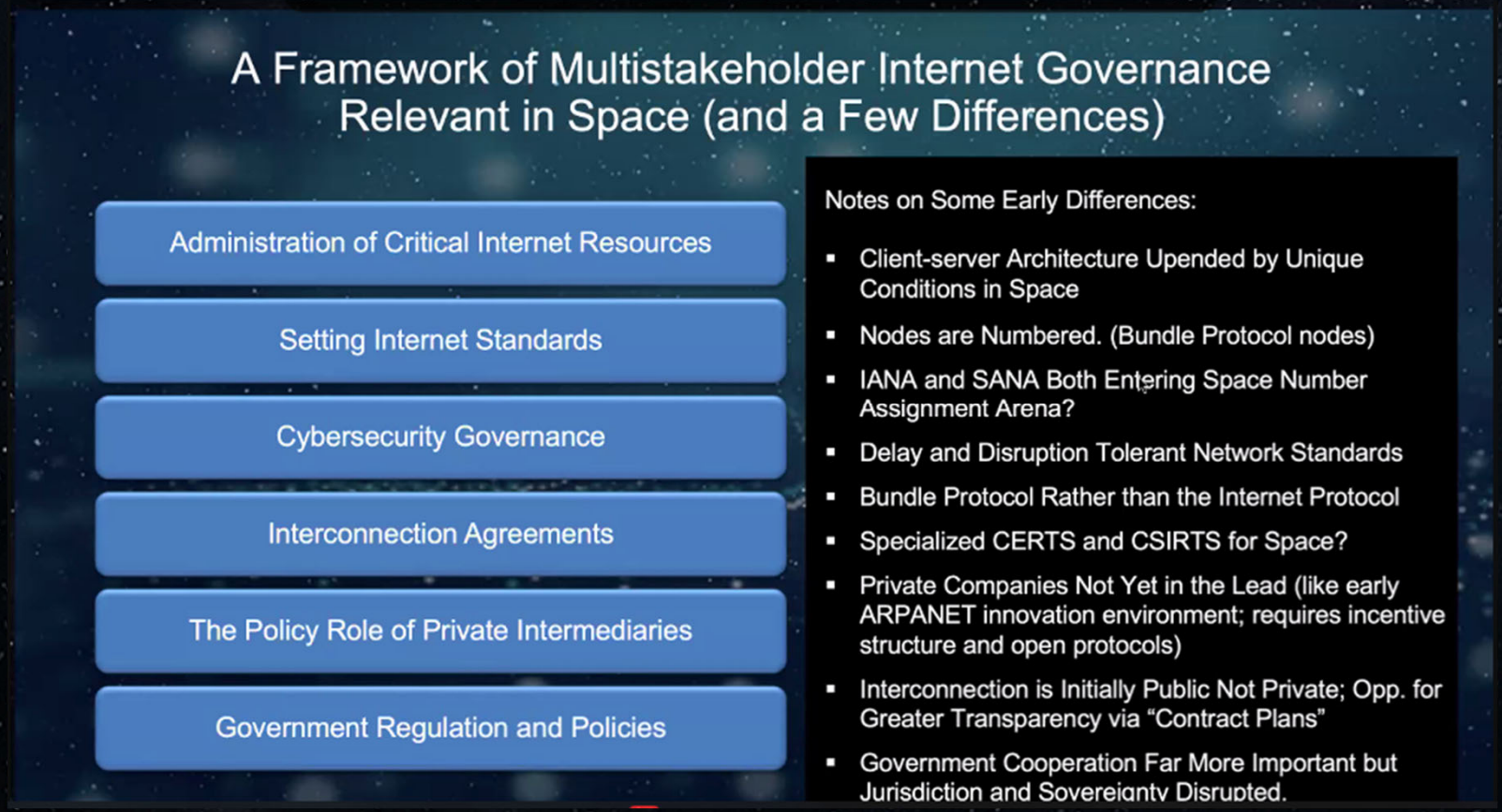

Academy materials at:

➡ *https://ipnsig.org/ipnsig-academy-events/*

Any questions to:

➡ *secretariat@ipnsig.org*

IPNSIG Academy – Program for 2022-2023

Links to recordings - https://ipnsig.org/ipnsig-academy-events

1. Yosuke Kaneko	**100+ Years Vision [May 18]**
2. Vinton G. Cerf	**DTN Overview [June 1]**
3. Oscar Garcia	**DTN Projects Work [July 13]**
4. Scott Burleigh	**SSI Architecture Study [Aug 3]**
5. Lara Suzuki	**DTN Live Demonstration [Sep 7]**
6. Dave Israel	**NASA Luna Net Overview [Oct 12]**
7. David Gomez Otero	**ESA Moonlight Overview [Nov 2]**
8. Ed Birrane	**IETF Standardization Efforts [Dec 7]**
9. Keith Scott	**CCSDS Standardization Efforts [Jan 4]**
10. Laura DeNardis	**Interplanetary Internet Governance [Feb 1]**
11. Scott Pace	**Space Policy, Perspective on IPN Governance [Mar 1]**
12. “IPNSIG Workshop”	**Architecture and Governance of IPN [April 5]**

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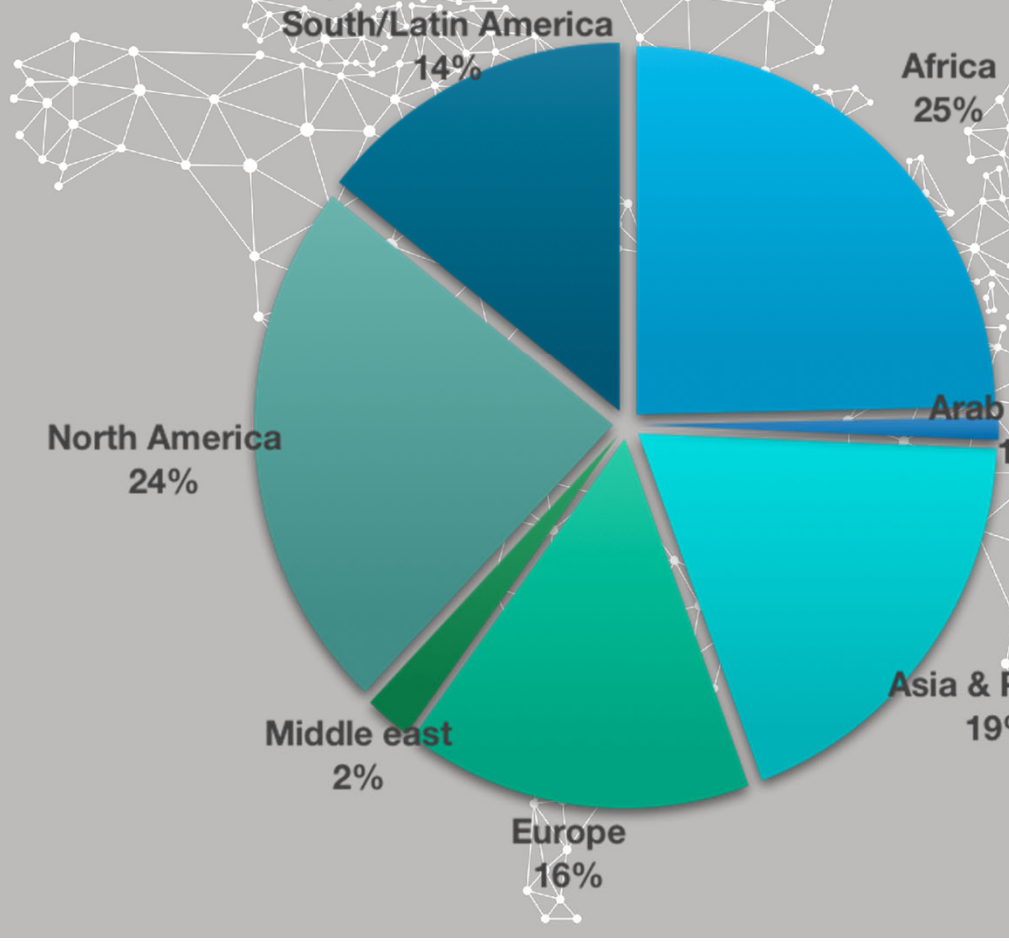

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