

Architecture for IP in Deep Space

[draft-many-tiptop-ip-architecture](#)

IETF 124 TIPTOP WG Meeting

Marc Blanchet (marc.blanchet@viagenie.ca)

Wesley Eddy (wes@aalyria.com)

Tony Li (tony.li@tony.li)

<https://datatracker.ietf.org/doc/draft-many-tiptop-ip-architecture/>

This draft targets the WG charter item for "Documentation of the necessary differences that apply to the IP architecture when considering space networking compared to terrestrial IP use."

At chairs' request, this is a presentation of the whole architecture draft before proceeding to a WG adoption call.

Outline

Brief background.

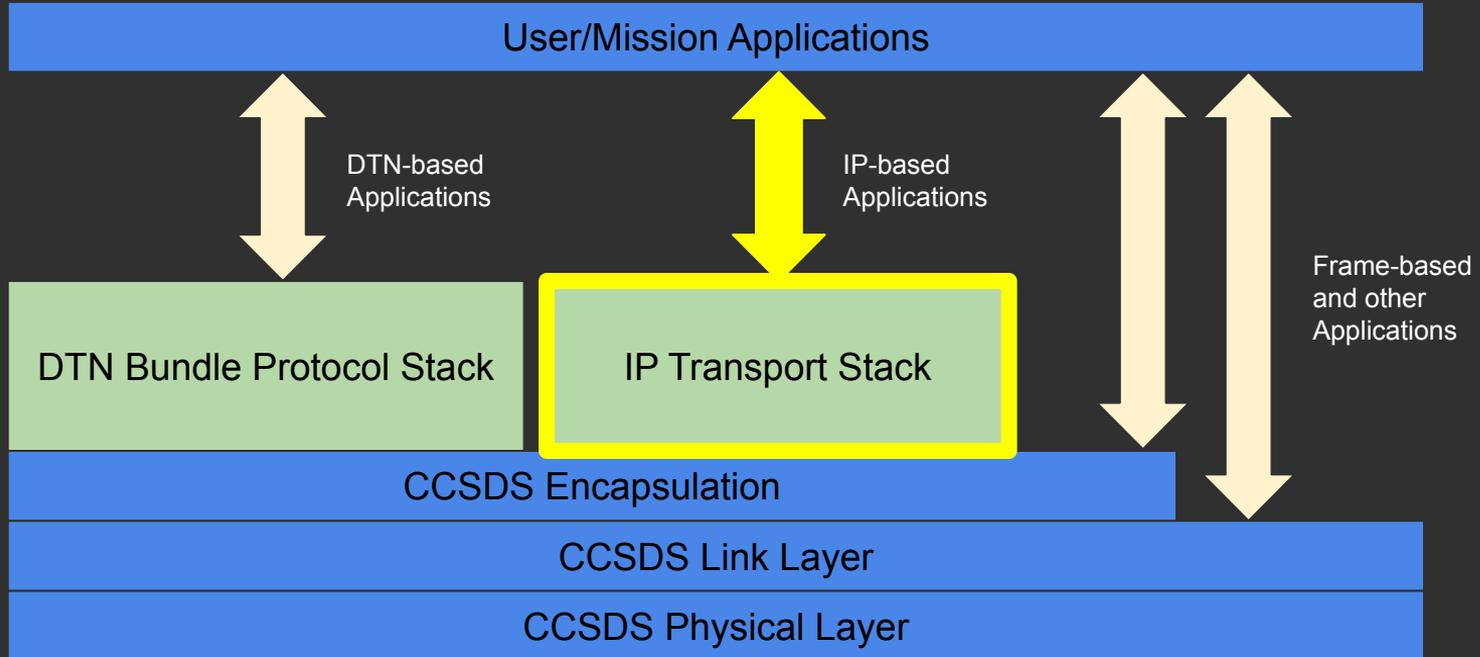
What's in the draft?

- Review document status and content.
- Explain the “architecture” and key aspects.
- Explain key “open questions”.

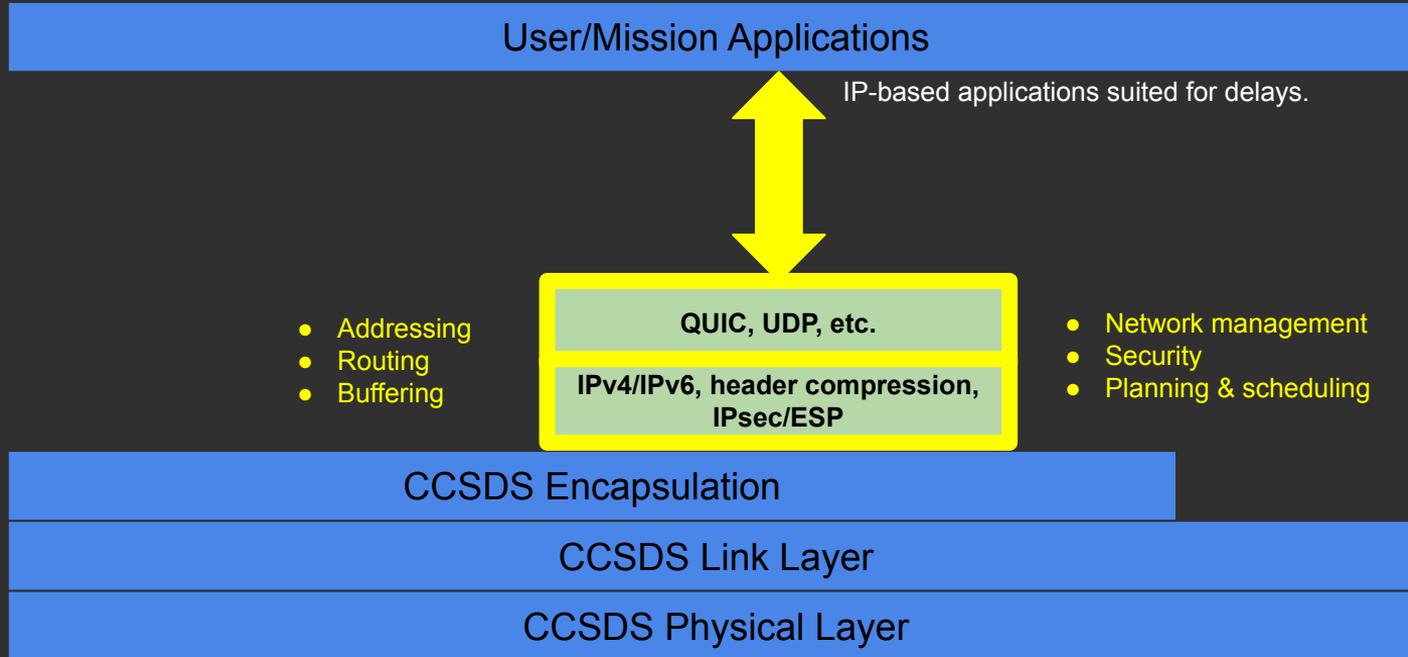
Next steps towards WG adoption.

Backup/reference material from prior presentations.

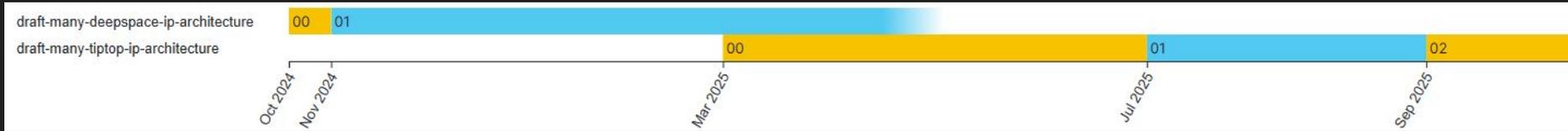
Space Mission Protocol Stacks



Space Mission Protocol Stacks - Based on IP



History



- Original draft was part of the “deepspace” BoF.
- Tony presented to the WG @ IETF 122, and Wes @ IETF 123.
- Latest draft includes clarifications and improvements from discussions following the prior meeting.
 - There was good engagement and expressions of support, but also still higher-level questions that needed to be addressed.
 - **We think this is ready to be a product of the working group.**

Topics Covered

- For IP in deep space / interplanetary networks:
 - What layer-2 protocols and encapsulations are used?
 - How will IP addressing work?
 - How can routing work?
 - How do transport protocols need to be configured?
 - What are application layer and other service needs?
- Overall: What do IP-based protocol stacks for deep space look like, and what aspects of their operation differ from normal Internet use?

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Updates Since Last Revision

Clarified goals.

Clarified discussion on buffering/queueing of outbound packets. The suggested behavior is not a general storage service; it is not related to DTN; it is just holding onto outgoing IP packets rather than immediately dropping. Service is still “best effort”; packets can be dropped (there is no concept of “custody”).

Mentions CoAP.

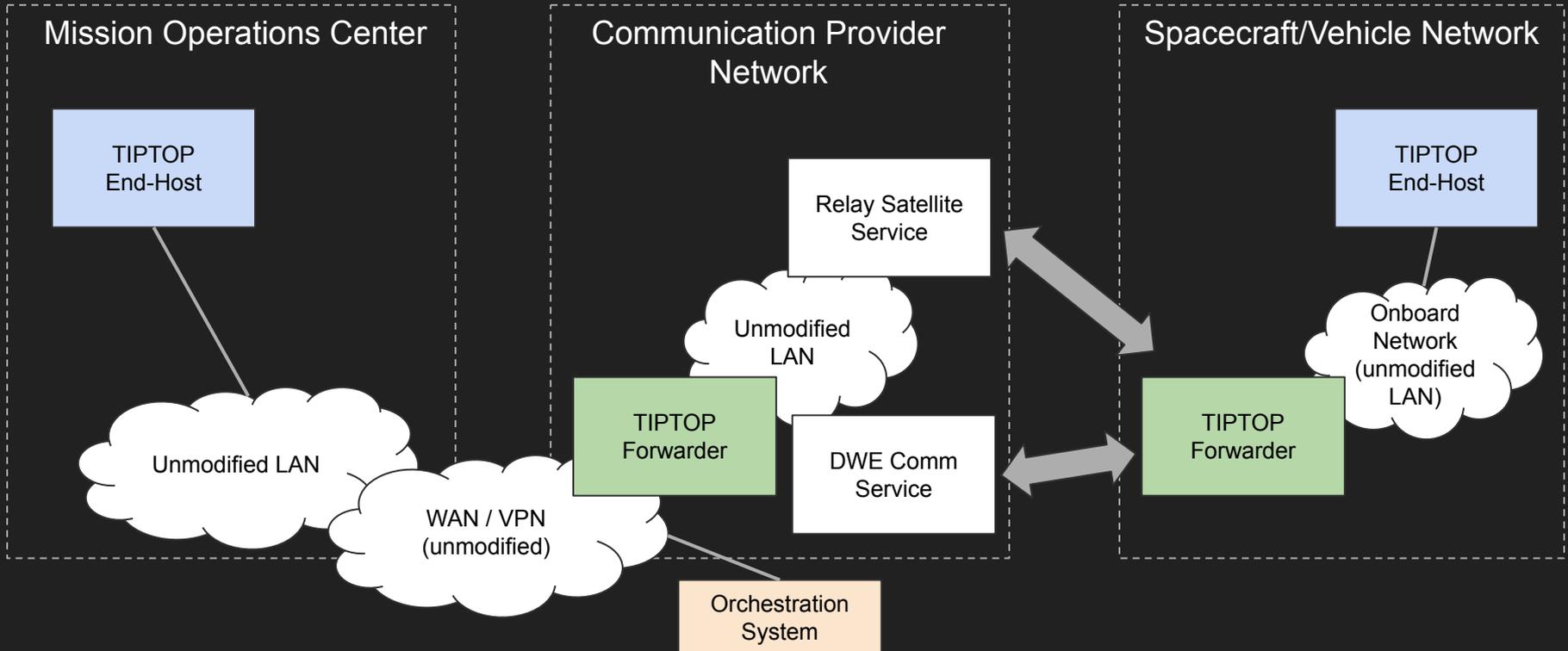
Slight expansion on network management.

Architecture - Types of Nodes

Node Type	Key Aspects	Where Present? (examples)
Unmodified / Internet	Existing typical un-tuned IP stack.	In the “middle” of planetary surface networks and spacecraft onboard networks.
TIPTOP end-host	Tuned transport/application parameters.	Application endpoints or proxies.
TIPTOP forwarder	Queueing of outbound IP packet data	At transition points, connecting to scheduled deep space comm systems.
TIPTOP-full	End-host + forwarder	Small spacecraft (single-node), small rovers, etc.
Scheduling/orchestration	Create and distribute coordinated network plans based on application needs	Earth or planetary “core” networks.

These definitions are not in the draft yet, but we would plan to include them in an update.

Architecture - Example end-to-end flow



One example only! This is not in the current draft, but we would plan to include a version in an update.

Layer-2 Protocols

- Examples only - does not need to be standardized in the architecture.
- RF and optical options for deep space links
 - E.g. CCSDS AOS/USLP
- RF “proximity” links (surface-to/from-orbit)
 - E.g. CCSDS AOS/USLP/Prox-1
- Surface wireless networks
 - WiFi
 - 3GPP radio technologies
 - Prox-1
- Ethernet onboard networks

All of the data links support IP, with existing standard encapsulations.

IP Addressing

The draft says:

Space networks provide a unique opportunity to provide extremely efficient routing by assigning a unique prefix or block of addresses per celestial body and its proximal orbits. Management of the IP address space is currently documented in [RFC7020], but this only covers continental regions and does not provide for addressing for space.

Address space for outer space should be managed by a Regional Internet Registry (RIR) and blocks of address space should be allocated for each celestial body of interest. Space service providers should use prefixes assigned by this RIR.

Separate draft: <https://datatracker.ietf.org/doc/draft-li-tiptop-address-space/>

Routing

- Typical routing protocols can be used in surface and proximity networks.
- Proof-of-liveness is not viable for neighbors over deep space links.
- **A PCE-like approach is recommended.**
 - This is consistent with the planning/scheduling functionality assumed.

Transport

The document provides general discussions of algorithms within transport protocols (and applications) that assume closed-loop feedback for probing paths, etc.

This provides a framework for tuning specific transport protocols.

QUIC is the focus of a separate draft:

<https://datatracker.ietf.org/doc/draft-many-tiptop-quick-profile/>

Applications

- HTTP configuration is discussed in detail.
- CoAP is referenced, and discussed in detail separately:
<https://datatracker.ietf.org/doc/draft-gomez-tiptop-coap/>

Services

The document has only a high-level discussion of tuning specific services.

- DNS is mentioned, but is focused on in a separate document:
<https://datatracker.ietf.org/doc/draft-many-tiptop-dns/>
- Network management protocols are mentioned, and can be worked on separately.
- NTP/timing and other topics can be addressed in updates & separately.

Open Questions

1. How / where to do buffering of packet data.
 - a. IP-layer and L2 buffers have been discussed.
 - b. Juan Fraire has more thoughts.
 - c. **The architecture does not require a final/definitive answer.**
2. MPLS could be used in parts of the network.
 - a. **Should this be further discussed; e.g. for layer-2 encapsulations, etc.?**
3. Security - MLS/TLS discussion moved to QUIC WG.
 - a. We think this can be considered later.

Next Steps

Github: <https://github.com/marcblanchet/draft-deepspace-ip-architecture>

No open/blocking github issues.

Expected changes:

- Editorial improvements.
- Better define elements of architecture, and which nodes are tuned for TIPTOP versus normal IP forwarding.
- Should mention possible MPLS use.
- Might expand/reorganize application layer content.
- Might expand services & network management content.

WG adoption?

BACKUP

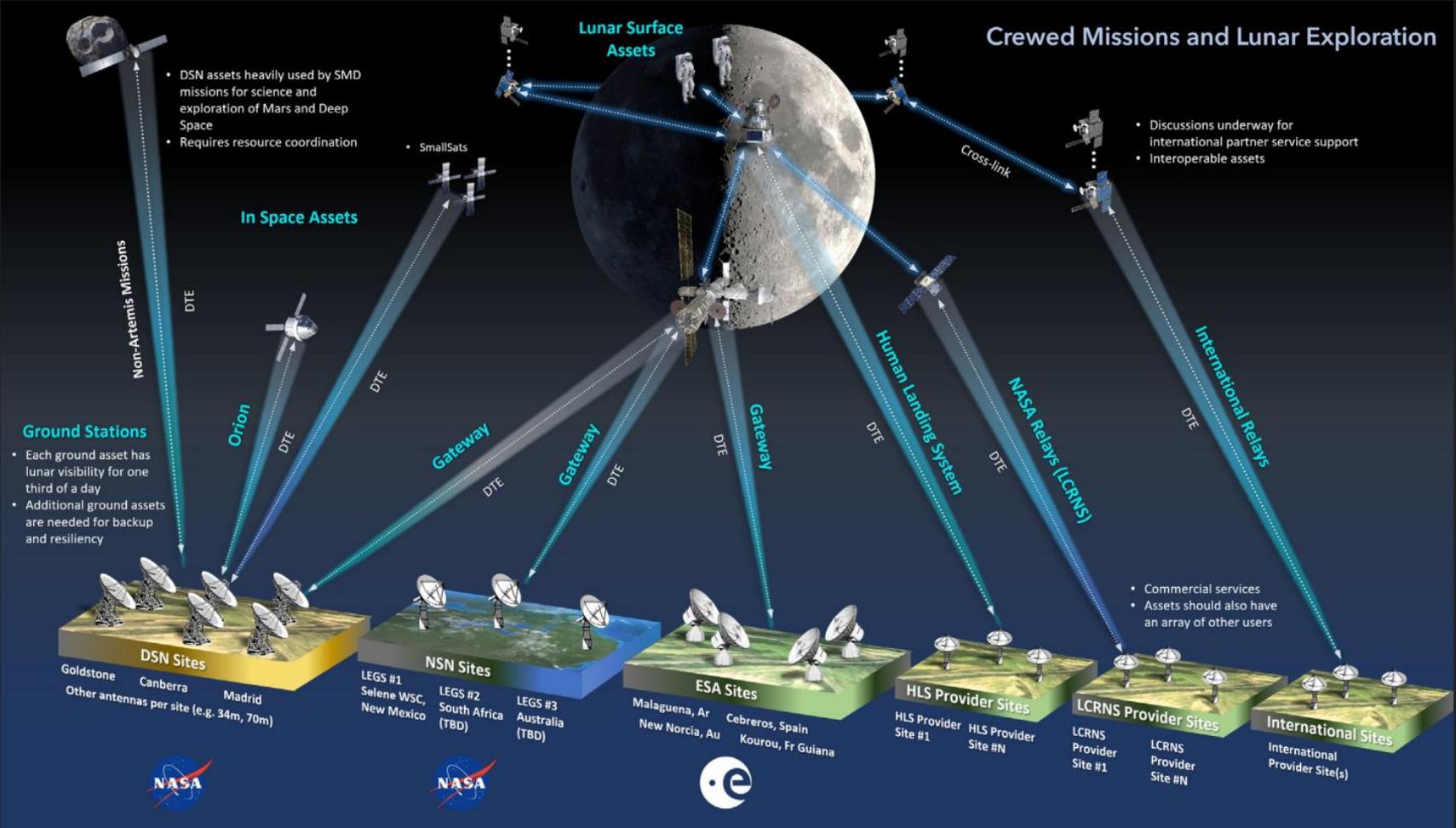
Background Considerations

The architecture should be compatible / able to accommodate user and network provider systems built based on current and upcoming standards and frameworks from the international space systems community, e.g.:

- CCSDS link layer standards
- Surface use IEEE WLAN and 3GPP stacks
- LunaNet / LNIS
- ICSIS requirements
- IOAG architectures for lunar & Mars
- (others ...)

These define context that the architecture exists within.

Crewed Missions and Lunar Exploration



- DSN assets heavily used by SMD missions for science and exploration of Mars and Deep Space
- Requires resource coordination

In Space Assets

- SmallSats

- Discussions underway for international partner service support
- Interoperable assets

Ground Stations

- Each ground asset has lunar visibility for one third of a day
- Additional ground assets are needed for backup and resiliency

DSN Sites
 Goldstone Canberra Madrid
 Other antennas per site (e.g. 34m, 70m)

NSN Sites
 LEGS #1 Selene WSC, New Mexico
 LEGS #2 South Africa (TBD)
 LEGS #3 Australia (TBD)

ESA Sites
 Malaguena, Ar
 New Norcia, Au
 Cebreros, Spain
 Kourou, Fr Guiana

HLS Provider Sites
 HLS Provider Site #1
 HLS Provider Site #N

LCRNS Provider Sites
 LCRNS Provider Site #1
 LCRNS Provider Site #N

International Sites
 International Provider Site(s)



Transport Protocol Considerations

- Protocol negotiation / “happy eyeballs”
- Connection initiation / handshaking
- Capability / feature negotiation
- Retransmission
- Handling failures
- Congestion control
- Path MTU discovery
- Multiple streams
- Multipath transport
- Transport FEC

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In early usage, the goals of these functionalities can be met in deepspace IP networks through the use of:

- Planning/scheduling and orchestration
- Pre-establishment of information in structures such as the destination cache.
- Long-lived transport connection state.

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Leveraging scheduling and orchestration of the network, these functionalities can be adjusted from normal Internet use for early deepspace IP networks via:

- Time-based parameter tuning, rather than closed-loop algorithms.
- Resource planning to largely avoid congestion and corruption losses.

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Some transport stack functions are available for deepspace IP applications to make intelligent use of, but are not critical to the architecture, and algorithms for using them could vary from typical Internet cases without needing new protocols or standards.