Architecture for IP in Deep Space

draft-many-tiptop-ip-architecture

IETF 123 TIPTOP WG Meeting

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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.”

Note: Some topics may migrate between the use-cases draft and this one.

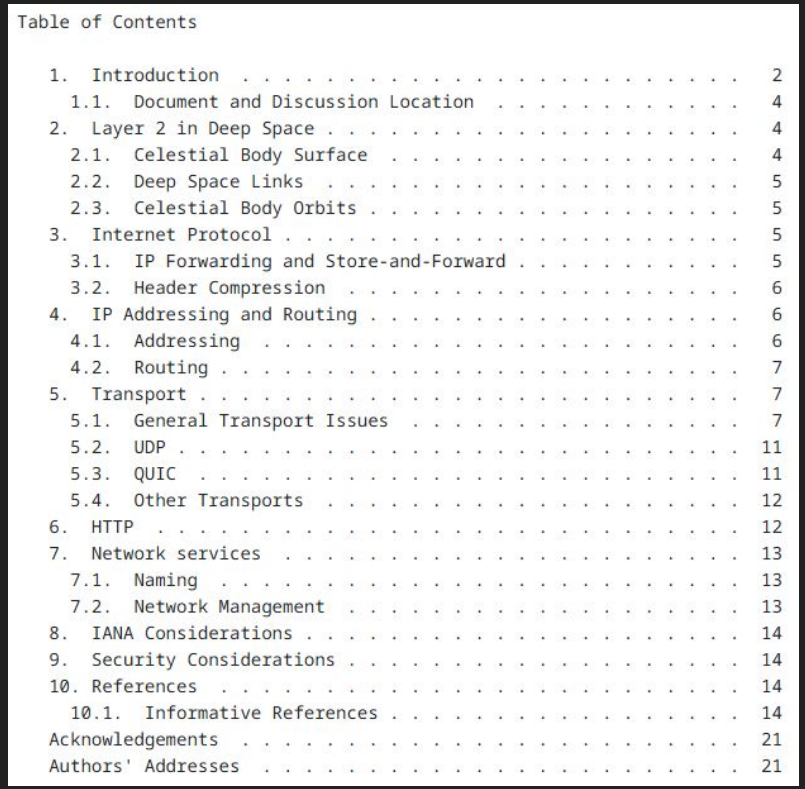
- Use cases: https://datatracker.ietf.org/doc/draft-many-tiptop-usecase/

History

- Concepts in the document grew out of:
  - Years of experience with IP and other protocols in space.
  - Work applying QUIC for deep space usage, and related considerations rippling to other parts of the stack (e.g. L2, IP, DNS, routing, security, management, etc.).
  - Increased commercial and government plans for large-scale Mars & lunar missions that include networking as a basic need.
- Original draft was part of the “deepspace” BoF.
- Tony presented to the WG @ IETF 122.
- Draft updated prior to IETF 123.

Topics Covered

- Deep space L2 differences from common terrestrial link layers.
- IP itself is not inherently constrained to Internet delays and other conditions.
  - Store-and-forward is possible.
- In deep space / interplanetary use:
  - How will IP networks be addressed?
  - How can routing work?
  - How can transport protocol configurations be tailored?
  - What are application needs?
- In total, 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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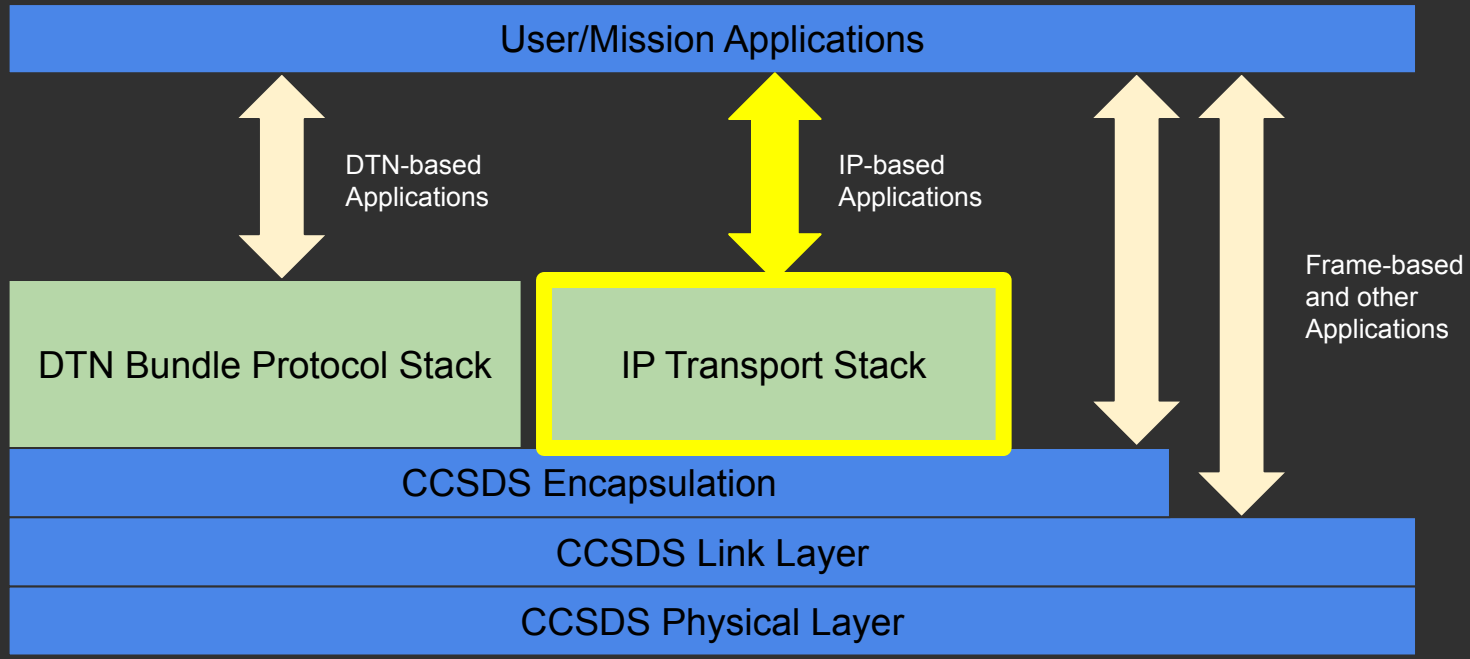
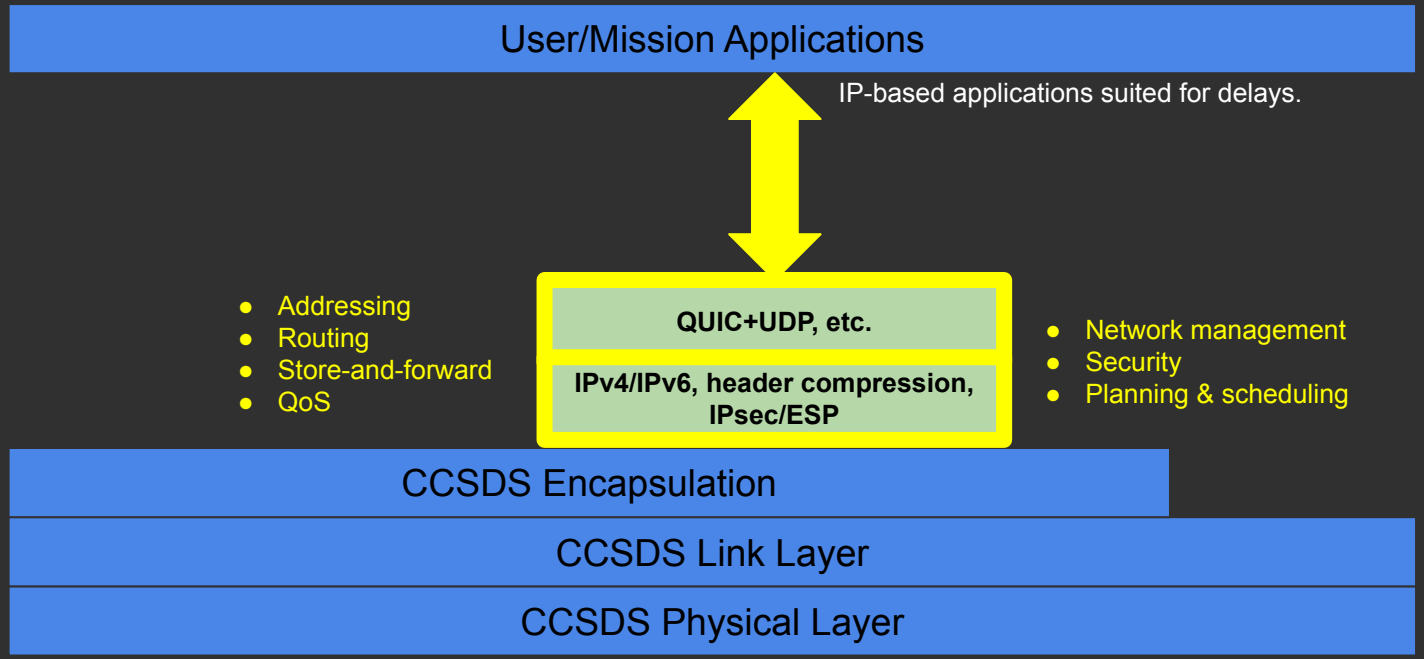
Space Mission Protocol Stacks



Space Mission Protocol Stacks - Based on IP

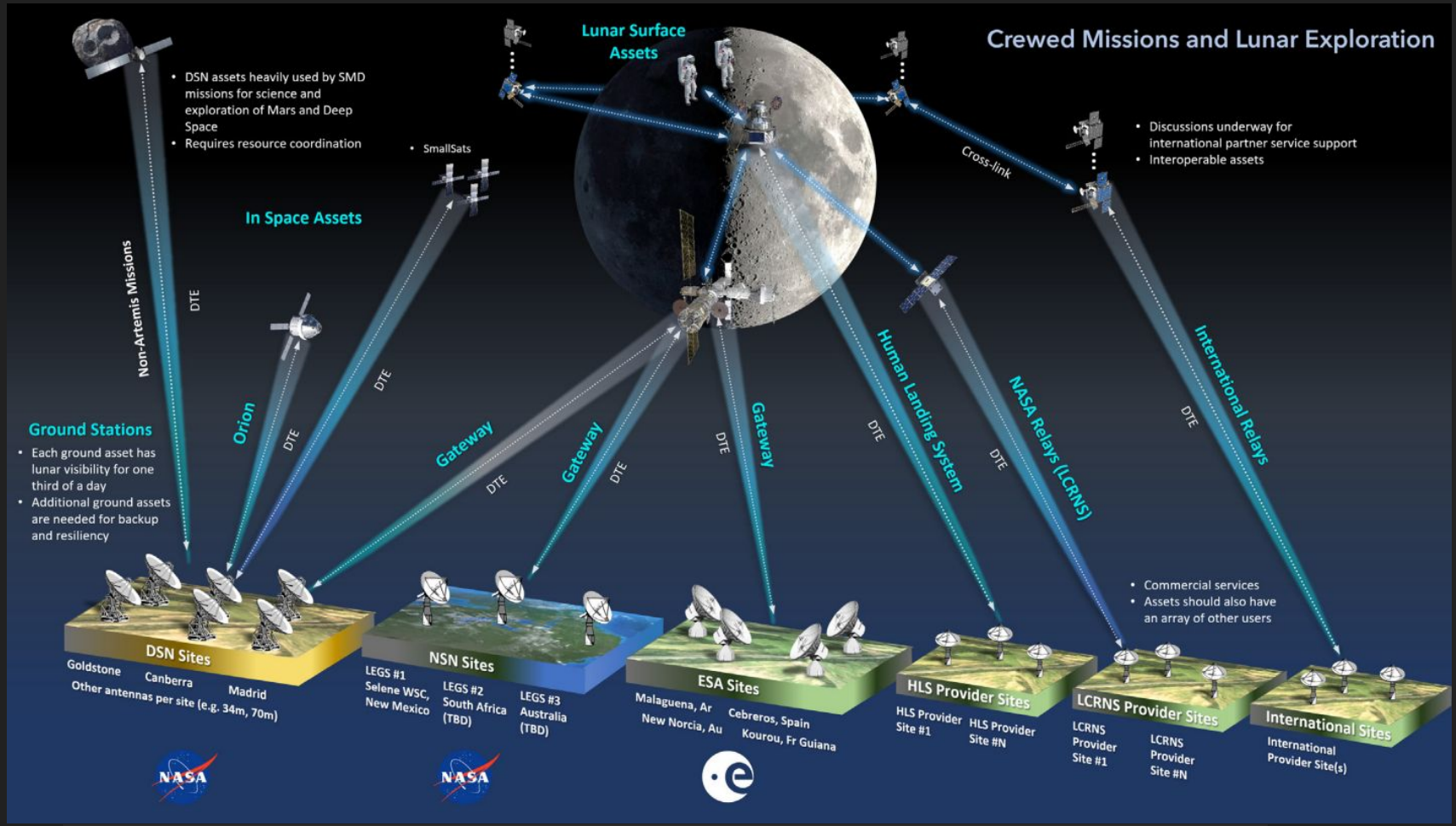


Considerations

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.



https://www.nasa.gov/wp-content/uploads/2024/01/lunar-communications-and-navigation-architecture.pdf?emrc=f1a91a

Updates Since Last Revision

There were some comments and discussion around IETF 122.

The main change is the addition of several pages more specific on transport protocols in general.

- The separate QUIC draft then describes how to configure QUIC related to these considerations.
- This architecture doc covers the considerations for any transport protocol, and how features, properties, and layer interactions need to be handled.

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.

Next Steps

Advance towards working group adoption.

- Any comments?
- Anything missing?
- Anything unclear?

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

Please read and provide feedback to the list or via github issues!