IP in space: QUIC Profile ~~and Simulations~~

draft-many-tiptop-quic-profile
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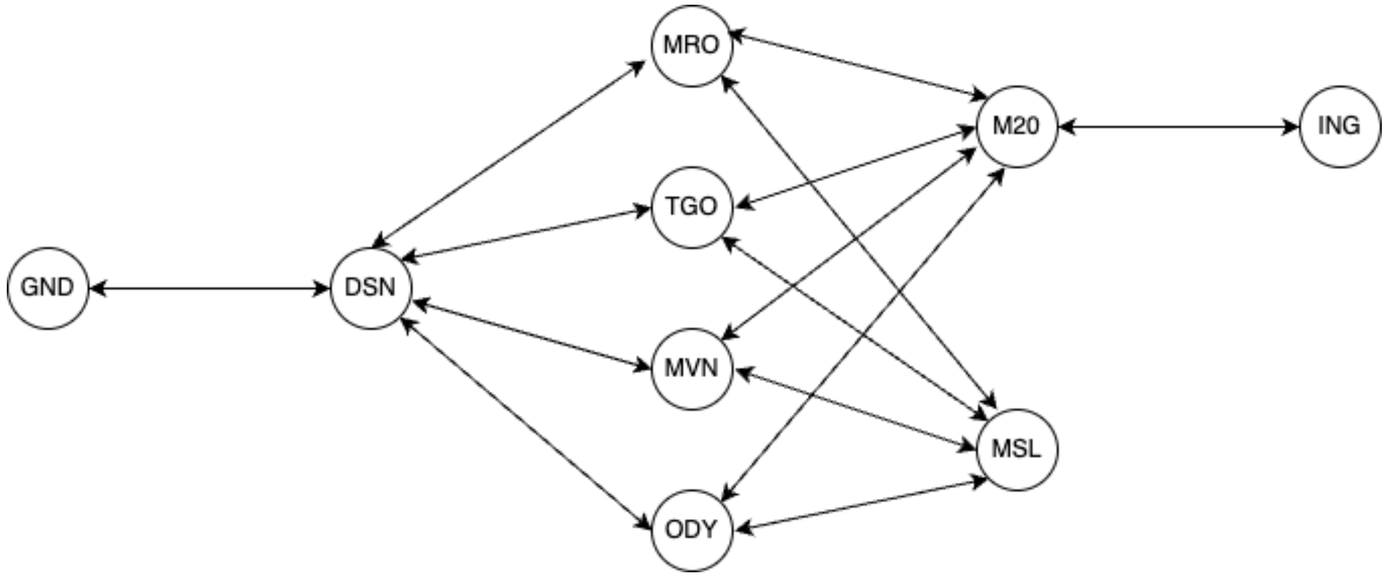
IETF 122 Bangkok, March 2025

IP in Space: Transport Considerations

- From draft-many-tiptop-usecase and draft-many-tiptop-ip-architecture:
  - Minimize handshake
  - Long delays
  - Provide e2e reliable delivery of data
  - Provide e2e security (confidentiality, integrity, authentication)
  - Transport does not see intermittence. Instead, it sees large variations of delays because of intermittence.
- QUIC was studied. May or may not apply to other transports.

IP in Space: Intermittence Example

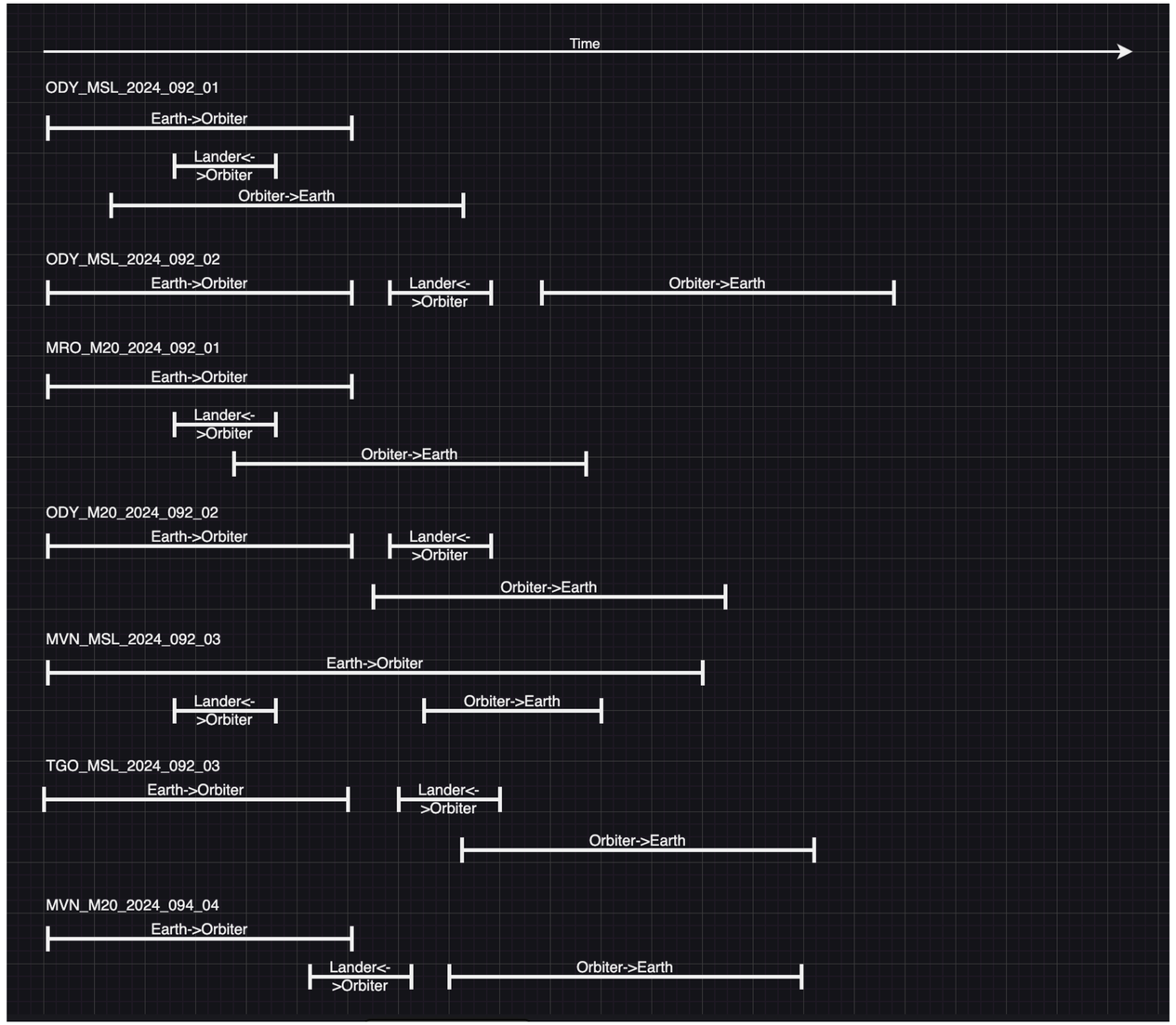
- Earth-Mars communication windows study[1]
- In collaboration with NASA/JPL
- 3 months dataset
- 4 orbiters, 2 rovers



- [1] Deepspace Informal group meeting, IETF 121, https://deepspaceip.github.io/meetings/ietf121/

IP in Space: Intermittence Patterns

- Not all types shown
- Not at scale
- Some provide direct e2e
- Some use storage in both directions
- "Best" RTT approximated by knitting segments and optimizing comms timing
  - Min: 37 min
  - Average: 16h
  - Max 7 days



QUIC: One Slide (Incomplete) Summary

- Reliable transport (handles loss, reorder, duplicates)
- 1 RTT handshake, including TLS
- Connection migration: if client changes IP address, connection continues (no restart, no context loss), 1RTT handshake, optionally 0RTT (data can be sent right away)
- Stream based: Multiple applications/contexts within a single connection
  - A single QUIC connection can be used over long time(minutes, days, hours, days,...) for "unlimited" number of queries/responses.
- User-space: easier to upgrade, migrate, adapt, ...
- More configurable

QUIC in Space: Considerations

Congestion and Flow Control

- Given deep buffers(store-and-forward) in the forwarding plane, congestion is "different".
- Without knowing intermittence events timing, difficult to have any proactive control, and reactive can be pretty bad in many cases.
- Example:
  - Orbiter is currently storing packets because next hop unreachable.
  - Source concludes congestion (say for some CC, by seeing loonger delays), so pacing down.
  - The next second, the orbiter, at one-way delay time from source, has link up and next hop becomes reachable, so it forwards its stored packets and incoming packets.
  - Source is not using the available bandwidth as it should.
  - The intermittence window may be small, given delay, so no time for the source to find the new state and increase pacing. And if it does, it may be too late, as the orbiter maybe now again storing.
  - Somewhat similar to what can happen on Internet, but the RTT and BDP and their variations may be large.
  - Bandwidth usage is pretty precious in space

QUIC in Space: Considerations

Congestion and Flow Control

- A proposal:
  - A) "Simple" profile:
    - congestion control is essentially off
    - flow control is used under certain conditions (e.g. surface asset to orbital relay, in Moon case)
    - Transport configuration based on calculation of worst conditions: longest plausible overall delay (including intermittence)
      - Transport is unaware of intermittence. It sees variations of delays
  - B) "Advanced" profile:
    - By some means (network controller or else), intermittence periods and delays are known to the endpoints
    - Optimization based on that knowledge (example: decrease pacing just in time of an intermittence event)
    - Must be made safe even when something unexpected happens (next planned window did not happen as planned)
- draft-many-tiptop-quic-profile describes the "Simple" profile.
- Simulations are also based on the "Simple" profile.

QUIC in Space: "Simple" Profile

Strategy

- For the application/mission/...
  - Calculate longest plausible delay, including intermittence
  - Calculate bandwidth-delay product (BDP)
  - Configure timers and sizes based on those calculations at connection establishment
- Could be "changed dynamically", for example using careful-resume
- For spacecraft launching from Earth, connection could be established while on Earth and kept during the whole mission. (Pros and cons)
- Proxies could be put at space edge, for example using MASQUE

QUIC in Space: "Simple" Profile

Considerations on Timers and Values

- **initial_rtt**: used to start estimation of RTT. Default in X00 ms. Should be set in relation to the longest delay
- **max_idle_timeout**: used to terminate connection if no activity from other peer. Should be set in relation to the longest delay
- **initial_max_data/initial_stream_max_data**: Should be set in relation to the BDP
- **window size**: Should be set in relation to the BDP, but given deep buffers...
- **Path MTU Discovery (within QUIC)**: might underuse bandwidth at the beginning. Since path MTU well known in space and links do not change much, might want to turn PMTUD off.
- **Acknowledgement Frequency**: tradeoffs between endpoint memory and bandwidth usage
- Send ASAP or "wait a bit"
- For each value, discussion in the draft about if the value set is too low or too high.

QUIC Deep Space Simulations

Quinn Workbench

- Used for simulating QUIC in space networks: asymmetric and uni-directional links, bandwidth, delays, topology
- Open-source
- Based on Quinn[1] QUIC stack
- Presented before at deepspace informal group meetings[1,3,4]
- Implements HTTP client and server over QUIC.
- Does one or many, simultaneous or parallel, HTTP request/response, with configurable response size
- Creates a whole network topology of "any" size with characteristics of nodes (storage) and links (bandwidth, delay, loss,...), described in a JSON file
- Creates link up/down events at specified times, described in a JSON file
- QUIC Transport parameters (initial_rtt, maximum_idle_timeout, ...), described in a JSON file
- Time warping: A many day simulation using delays of minutes/hours/days will take seconds to execute
- Generates: PCAP files and replay events file
- Simulation config files and results posted (regularly)[5]

- [1] https://github.com/quinn-rs/quinn
- [2] https://github.com/aochagavia/quinn-workbench
- [3] https://deepspaceip.github.io/meetings/ietf121/ Workbench Update presentation
- [4] https://deepspaceip.github.io/meetings/ietf120/ Workbench presentation
- [5] https://deepspaceip.github.io/testbed

Questions?

- Ask for WG adoption
- Time later for presenting/discussing in details QUIC simulations?

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- draft-many-tiptop-quic-profile
- Quinn Workbench: https://github.com/aochagavia/quinn-workbench