Reassessing the Use of the IP Protocol Stack in Deep Space

draft-many-deepspace-ip-assessment

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Comms/Networking in Deep Space

- Delays
  - Example: 4-20 minutes one-way to Mars
- Disruptions:
  - Planned: orbital dynamics
  - Un-planned: solar storms/flares/bugs/…
- Working on the harder problem: Mars and beyond. Moon is « simpler », so if we solve the “Mars” problem, then Moon « should be easy ». However, Moon is the nearest (and somewhat urgent) target.
- IOAG/NASA/… stated:
  - to « practice » technologies on Moon first that would be used for Mars,.
- RFC4838: IP not suitable for that environment. A new protocol stack has been designed: Bundle Protocol(RFC9171)

Reassessment

- Instead of reinventing various network services (routing, naming, neighbor discovery, network management, …) AND reinventing applications, frameworks, API, … for the Bundle Protocol, reconsidering the initial assessment (of “rejecting IP protocol stack”), given the advancement of Internet and protocols since then (25 years ago):
  - QUIC transport protocol (over UDP)
  - Adhoc/IoT/energy saving infra/ unconnected networking
  - Change of usage of IP protocol stack applications (HTTP dominant nowadays)
- Reference: draft-many-deepspace-ip-assessment

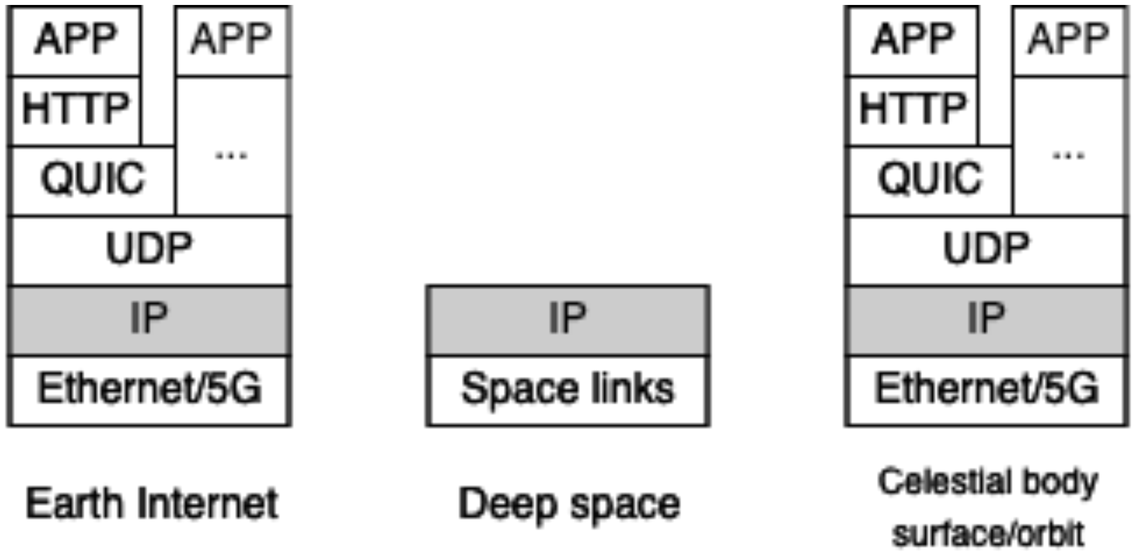
Is this « Internet » in Space?

- Yes and No, mostly No.
- With a 40 minutes RTT and disruptions and limited bandwidth, you can’t:
  - Use SSH as we do, but …
  - Do web browsing as we do, but …
  - Do “real-time” apps as we do, but…
- Internet users can’t “just use” Internet in (deep) space. Air gap between the two networks.
- Reusing the IP protocol stack but tailored for deep space use
  - and it won’t change the laws of physics…

IP Protocol Stack Per Layer

The remaining of this presentation is to discuss each layer and network services needed.

QUIC/UDP is discussed here, but other UDP based applications may work too.



IP Forwarding

- IP has no notion of time. IPv4 TTL or IPv6 Hop Limit is the number of hops.

- Forwarding means a route is available in the forwarding table for the destination (including default route). If none, then ICMP unreachable message sent to the source.

  - If a space link is down, then possibly no route to destination.

  - Cure: Store the IP packet (instead of sending ICMP unreachable) until a window of communication/interface up/route established is restored. (BP also stores Bundles on intermediary nodes)

IP Routing

- IP addressing enables aggregation for routing efficiency.
- Over space links:
  - Static: given the « small » number of devices and networks in deep space, static may be just fine.
  - Simple routing protocol: RIP, for the same reason above.
  - Contact graph routing:
    - Knowledge of contact plans and opportunities are fed into the routing engine for optimized routing.
    - See IETF Time-Variant Routing (TVR) working group
- On celestial body networks: IP routing protocols as usual: OSPF, ISIS, BGP, SDN, …

Transport: QUIC

- Issues for deep space:
  - Timers are made for high speed, bandwidth, full connectivity usage:
    - An initial RTT is used to start the estimation of RTTs. In a typical Internet stack, it is set to 200-300ms. As is, will take a long time to converge/“find” the right RTT (of 40 minutes).
    - Cure: If set appropriately, works fine.
    - Restransmit, ack, cc, … timers need to also be adjusted
  - Congestion Control: CUBIC not good. BBR is better (based on different metrics)
  - Intermittent connectivity: handled at the IP layer. For QUIC, it is “just more delay”.
    - Another possibility can also create an architecture based on QUIC proxies at the edges of the deepspace links, where the proxies will be storing packets.
- See draft-huitema-quic-in-space

HTTP-based Applications

- HTTP: most applications today (and most Internet traffic) uses HTTP and various semantics (REST API, gRPC, …)
  - HTTP has no notion of time, except for some headers (related to expiration of data, caching,…).
  - Cure: Use proper headers with proper values
- HTTP/OS stacks have “short” timers or keepalives
  - Obviously, so that connections on Internet are not hanging around forever.
  - Cure: configure them appropriately (curl -m, nginx http { *_timeout})

Non-HTTP Based Applications

- Do we still have many?
- Email:
  - SMTP can tolerate delays! It is a store and forward protocol. Place appropriate servers at edge of networks.

Naming: DNS

- DNS queries and answers over a interrupted or long delay links do not work as is.
  - Cure: have relevant names cached on celestial bodies IP networks by uploading/syncing the “used” names RR+ related DNSSEC RR to the celestial body DNS local infrastructure, so all name resolution is done locally.
    - Various ways to accomplish that.
    - see: draft-many-dnsop-dns-isolated-networks/

IP over Space Links

- CCSDS (the SDO for space comms) has specified IP (4,6) encapsulation over space links, but it is underspecified.

- There is a need of IPv6 over CCSDS Space Links specification

Next Steps

- Improve specifications:
  - QUIC, DNS, Application BCP, IPv6 over CCSDS, …
- draft-many-deepspace-ip-assessment
  - New version coming based on comments since September
  - Interest in intarea?

Contact

- Marc Blanchet, Viagenie, marc.blanchet@viagenie.ca
- **Join the conversation: mailing list: deepspace@ietf.org**
  - **to subscribe: https://www.ietf.org/mailman/listinfo/deepspace**
- Useful reading:
  - Overall architecture: draft-many-deepspace-ip-assessment
  - QUIC: draft-huitema-quic-in-space/
  - DNS: draft-many-dnsop-dns-isolated-networks
  - TVR Yang model: draft-united-tvr-schedule-yang/