Deepspace IP Use Case

IETF 121 Dublin, SCHC wg meeting

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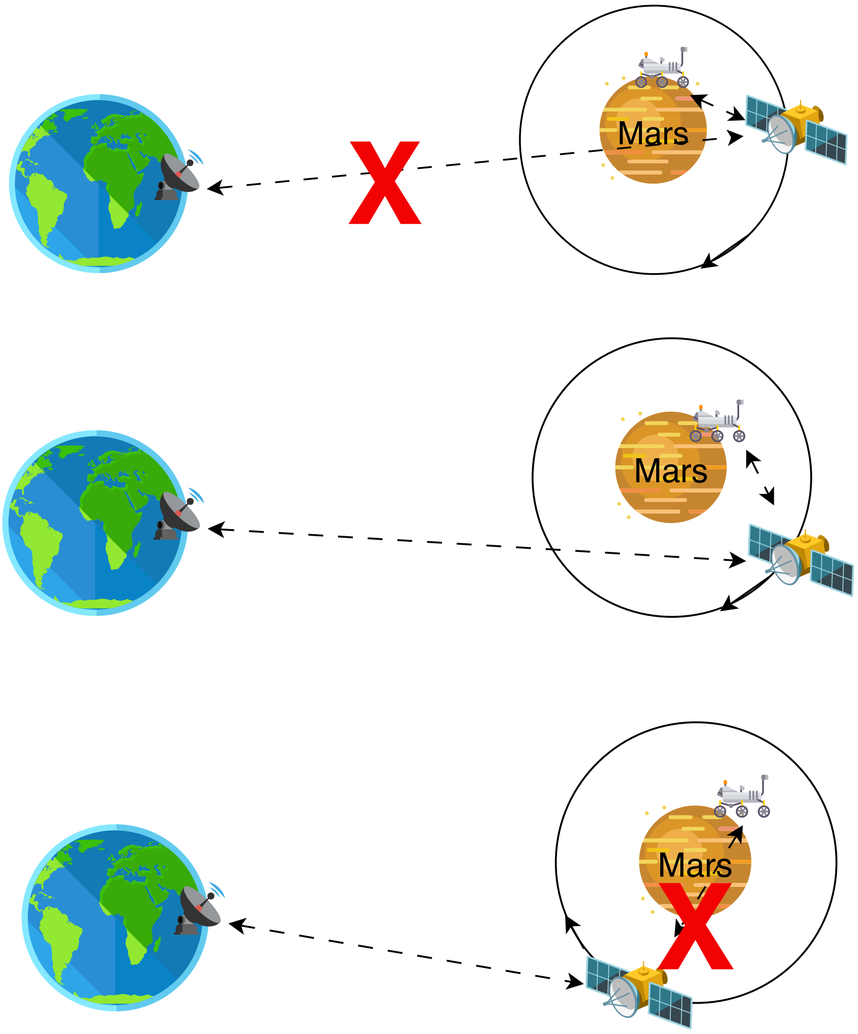
Deep Space Communications

- Delays:
  - Earth-Mars:
    - one-way delay: 5-20 minutes
    - Round trip time(RTT): 10-45 minutes
  - Earth-Moon:
    - One-way delay < 2s
- Links:
  - Interrupted

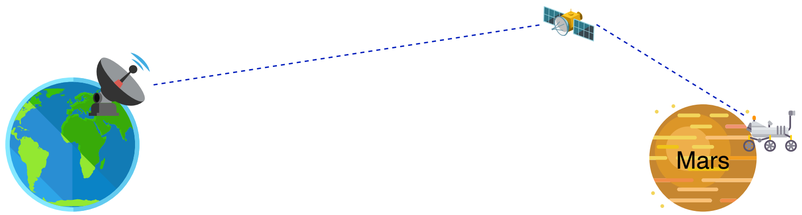
Deep Space Communications Are Interrupted

- Planets, Moons are orbiting
- Orbiters are orbiting ;-)
- Consequence:
  - No continuous communications: planned windows of communication between peers for each link
    - Earth-Mars relay
    - Mars relay - Mars rover/habitat/…
  - Relays/forwarders/routers need to store frames/ packets until next hop becomes reachable.
    - Can be done at L2 (example: MRO for Mars) or L3 or ..



Mars Communications Windows Study

- Study done with NASA/JPL
- Dataset of 3 months(2024Q2) of communication windows plans from the MAROS database, between:
  - Earth->Mars orbiters
  - Mars orbiters<->rovers
  - Mars orbiters->Earth



- Currently, each mission (DSN, orbiter1, orbiter2, rover1, rover2, …) inputs data in the database, and then comm windows are manually chosen and dedicated to a single mission

Results (Preliminary)

- “Knitted” 2534 round trip paths: Earth-MarsOrbiter-rover-sameMarsOrbiter-Earth.
  - of those only 532 (~20%) were actually used by the missions
- Uplink (Earth->Mars) comm window duration:
  - Average: 2.5h
  - Minimum: 10 min
  - Maximum: 10h
- Downlink (Mars->Earth) comm window duration
  - Average: 1.5h
  - Minimum: 1 min
  - Maximum: 10h
- N.B. with a lot of variations

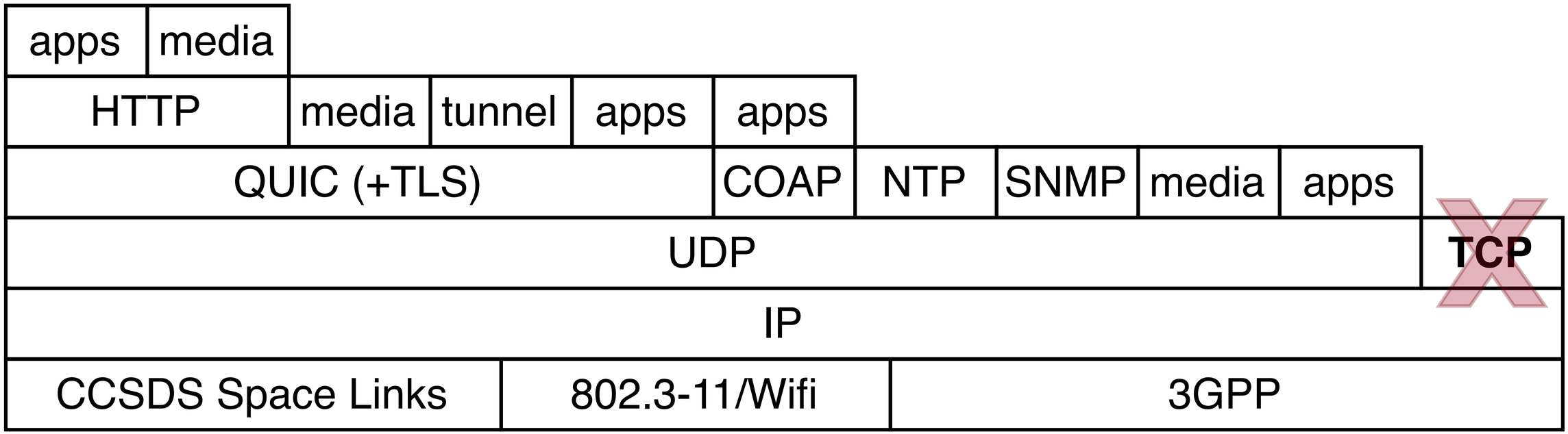
Results (cont.)

- “Best” RTT:
  - Approximated, using some heuristics: packet sent the latest time to reach the orbiter, returned the earliest time to reach Earth. (Typically, RTT will be greater than that)
  - Average: 15h 55m
  - Minimum: 37m
    - when both uplink and downlink windows are overlapping orbiter-rover window. Therefore RTT =~ 2 way light time
  - Maximum: 171 h =~ 7 days.
    - Maven had a 7 day off between two passes

Results (cont.)

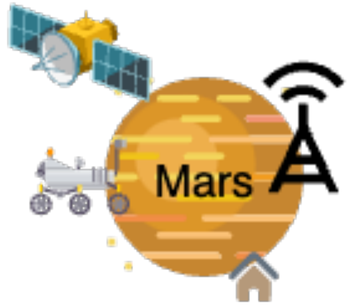
- Orbiter holding time (duration of data storage):
  - Average: 14h 56m
  - Minimum: 0
    - when both uplink and downlink windows are overlapping orbiter-rover window
  - Maximum: 170 h =~ 7 days

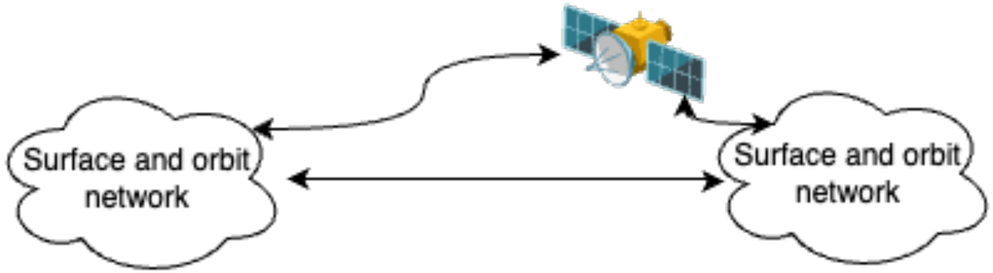
Deep Space IP Stack



* The Interagency Operations Advisory Group(IOAG) identifies that 3GPP and IEEE 802.11 Link layers will be used on and around celestial body surface and orbits, while CCSDS Space Links will be used in deep space (and to/from surface).

Network Architecture

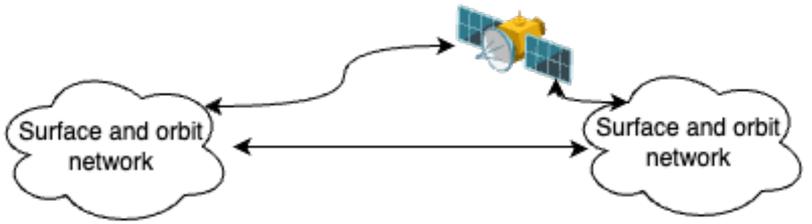




Functional representation

Functional Network Representation

- Network - P2P links - Network
- Header compression makes complete sense for point to point links



Functional representation

Link Characteristics

- IP encapsulated in CCSDS Frames
  - multiple L2 protocols, but a generic encapsulation protocol for all
- Point to Point in deep space
- Bandwidth?
  - Precious
  - « It depends ». Really
  - Currently:
    - Mars: uplink: Earth->Mars: kbit/sec, Mars->Earth: ~1Mbit/sec
  - Optical (Lasers): 100M -> Gbit/sec
- Loss:
  - BER vs FER.
  - CCSDS link uses pipeline of codecs, which makes FER very low
  - BER happens more at the start and tail of a communication window (radio locking, elevation degrees,…)

IP Stack Layers

- IP
- Transport:
  - UDP and QUIC
  - TCP: not for Mars, maybe for Moon
- Application:
  - Current applications in space are limited to command, file transfer, and video « streaming » (not really…)
  - For Moon, people will be creative…

Deepspace IP Working Group?

- BOF thrusday 2024-11-07
- Questions asked during the meeting (numbers from my memory):
  - Only Moon (1/3) or includes Mars (2/3)
  - Want to work on it (95%, 50+)
- Large support
- Charter to be ironed out
- Might change the wg name… :(

More Information

- Deepspace mailing list: https://mailman3.ietf.org/mailman3/lists/deepspace@ietf.org/
- Group web site (includes archives of all side meetings, presentations, links to documents, recordings, …):
  - https://deepspaceip.github.io
- BOF (presentations, minutes,…)
  - https://datatracker.ietf.org/wg/deepspace/meetings/
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