Deep Space IP

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Agenda

- Administrativia
- What is Deep Space IP?
- Update on testbed
- COAP for deep space IP
- Congestion control discussion

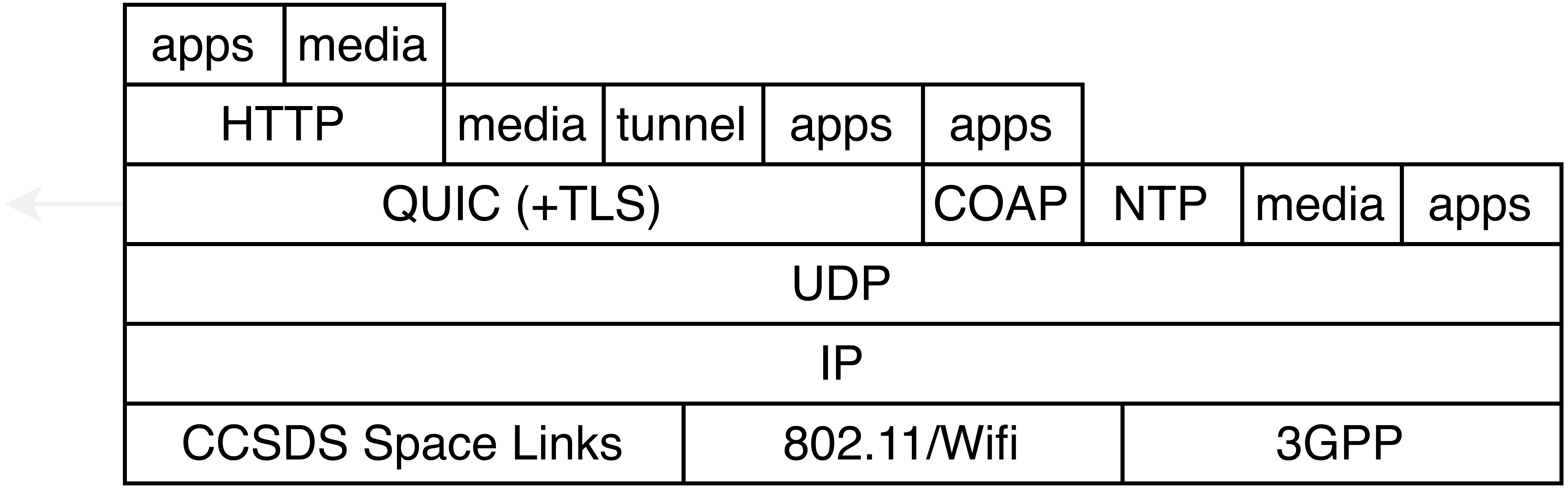
Administrativia

- Meeting under IETF Note Well
- Group Mailing list: deepspace@ietf.org
  - Subscribe at: https://www.ietf.org/mailman/listinfo/deepspace
- Group web site (using GitHub Pages):
  - https://deepspaceip.github.io/
  - Repo for slides, meeting notes, drafts, projects, issues, …
  - If interested in contributing, send me a note.
- QUIC in space Slack sub-channel under quicdev.slack.com main channel (send me a note if you want to join)
- This meeting remote access: https://ietf.webex.com/meet/sidemeetingietf1

What is Deep Space IP?

- Context: Deep space communications has specific characteristics, such as long delays and disruptions
- Goal: Using the Internet Protocol suite in deep space, as an alternative to the Bundle Protocol
- Work: Investigating how to profile the IP protocols and apps to make them work in deep space
- Key considerations:
  - IP forwarding: on an intermediate node, do not drop but instead store IP packets when there is no entry to destination in the forwarding table (same requirement as bundle storage in forwarders)
    - To handle intermittent connectivity
  - Transport profile (how to run QUIC in this context, but others too)
  - Routing
  - Applications and Applications protocols profiling (set larger timers…)

Deep Space IP Protocol Stack



- While initial focus has been on QUIC, COAP or native UDP protocols/apps are being investigated and profiled.

Update on Deep Space IP Testbed

Netem Update

- Netem
  - Linux TC Netem enables simulating various network conditions such as delay, packet loss, duplication, reordering, queueing, …
  - The delay maximum value has been limited to 274s. Ok for basic tests, but was limiting factor. Had to induce delays by other means who were more complicated.
  - After some email exchanges with iproute2/tc/netem author and maintainer, he provided a patch and I tested since the last 2 weeks, works great! and the fix has very recently been committed to iproute2 repo. Commit. (Send me email if you need help to use it)
  - New maximum value is 2^64 seconds!

QUIC Stack

- The Quinn QUIC stack has been used recently for the testbed.
  - Written in Rust
  - Has an extensive API to set almost all possible transport parameters. Easier for prototyping.
  - Has an HTTP client and server implementation
  - Big thanks to Benjamin Saunders (co-author) for helping.

Updates to Quinn HTTP client and server

- Default transport parameters have been changed in the HTTP client and server:
  - Implements a base line « comparison » with Bundle Protocol (which has no congestion control)
  - Path MTU discovery almost disabled.
    - PMTUD is probably not that useful in deep space since all links are well known and managed and the number is small
    - It could be kept as optional depending on the needs, just creates a few additional packets
  - Set various parameters to large values: initial_rtt, max_idle_timeout, ack_frequency, window sizes
  - Implemented a simple congestion controller: only sets the window size
    - This enables pacing the data sent by the client, based on the mission needs
    - Still, QUIC manages reordering, loss, duplicates, …
  - Not yet implemented: NCID pool. May or may not be needed. Or a small one.
  - All these are settings passed as arguments on the cli at the moment of the request.
    - They can be adapted and used depending on the mission/application/use case

Early Results

- Done very recently (thanks to netem update)
- Work in Progress

An HTTP Request to Voyager!

- 18 hours (64800 seconds) delay each way; 36 hours RTT

	Time	Source	Destination	Protocol	Lengtł	Info
1	0.000000	192.168.65.33	192.168.65.25	QUIC	1242	Initial, DCID=d61b8e047f
2	64800.438656	192.168.65.25	192.168.65.33	QUIC	1380	Handshake, DCID=2f26ef8a
3	129600.8077…	192.168.65.33	192.168.65.25	QUIC	1242	Handshake, DCID=bf92a7a2
4	129600.8086…	192.168.65.33	192.168.65.25	QUIC	200	Protected Payload (KP0),
5	194401.1215…	192.168.65.25	192.168.65.33	QUIC	691	Protected Payload (KP0)
6	259201.4231…	192.168.65.33	192.168.65.25	QUIC	79	Protected Payload (KP0),
7	259201.4236…	192.168.65.33	192.168.65.25	QUIC	96	Protected Payload (KP0),
8	259201.4245…	192.168.65.33	192.168.65.25	QUIC	86	Protected Payload (KP0),

  - 1-2: client-server initial connection handshake. Crypto set.
  - 3. NCIDs. Haven't yet worked on it.
  - 4. GET HTTP REQUEST
  - 5. HTTP RESPONSE
  - 6. NCIDs. Haven't yet worked on it.
  - 7-8. Client connection close

An HTTP Request to Voyager!

- Since QUIC have streams, a connection between two peers can be set for loooong time and all HTTP requests/responses and other apps can use it.
- So the connection establishment (first 2) and the connection close (last 2) are done « once » maybe per hour/day/week/month/year to/from a spacecraft.
- The HTTP Request and response then takes only 1 packet sent and 1 packet received and 1 RTT
  - Or more if they cannot fit in a packet.
  - Forgetting NCIDs (that may or may not be « fixed »)

Other Tests Done

- Repeat X times the same HTTP request within the same connection.
  - Demonstrate the use of an established QUIC connection (lower total time).
  - (Same request just because it is simpler to test, verify and automate).
- Reorder:
  - early test of 30% reorder with HTTP request 10x repeat succeeded (all 10 responses received) and show a few more packets added. More analysis to do.
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One more thing…

Network Management

- SNMP uses UDP. No timeout defined in the SNMP protocol, nor UDP.
  - Timeout is set by the client.
- Test:
  - net-snmp on client and server
  - Delay of 2h each way = 4h RTT
  - snmpget -t 14500 $oid   (14400 = 4 hours)
  - Just worked!
- Network Management: ✅

Time Distribution

- NTP uses SNMP.
- NTP is a complex time machinery to compensate network conditions to accurately set time based on remote reference servers.
- NTP experts were consulted, and they are pretty sure that NTP would work with looong delays, except that the notorious precision (< 10ms) will not be as good. Ok!
- Let’s put it to test!
  - ntpd on server, serving its own time
  - ntpdate on client
  - Delay of 2h each way = 4h RTT
  - Set artificially the client system date to a very bad value outside of the RTT. Aka 10 hours behind. (pretty bad clock drift!)
  - sudo ntpdate -t 14500 $serverIPaddress
  - Worked. Accuracy was ~30 seconds
  - Do it second time: sudo ntpdate …
  - Worked. Accuracy was ~2 seconds
- Time Distribution: ✅

Testbed Future Work

- QUIC related:
  - Need to investigate the NCID additional packet (recipe known, need to be implemented)
  - Use the key log file to decrypt and analyze
  - Packet loss, duplicate, reorder, …
  - Migration
  - More analysis and tuning of parameters
- More automation
  - Automate everything based on scenarios described in a JSON file
  - Automate graphics and tabular results (like QLOG flows)
- Time warp: QUIC or Linux level.
- Additional protocols and applications
- Complex network with disruptive events
- Publish results