BPv7 field-tests

(IETF 110 Meeting / DTN WG / 2021-03-11)

D3TN

COMMUNICATE BEYOND FRONTIERS

Agenda

1) Background

2) Overview of µD3TN

3) BPv7 field-test within the COLDSUN project

4) OPS-SAT field-test

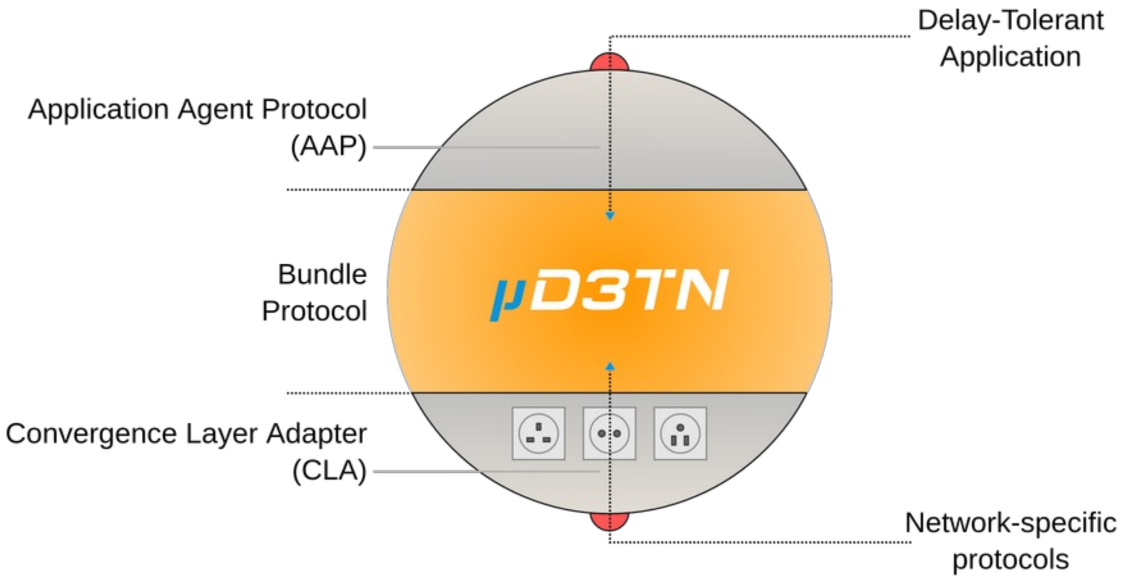
5) Conclusion

The path to the Ring Road

- Ring Road concept was communicated the first time to us by Scott Burleigh during a visit at the JPL in 2013
- Two flight-opportunities emerged in 2013:
  - CubeSat project from TU Dresden (TUD) leveraging an ARM Cortex-M4 microcontroller running FreeRTOS
  - ESA OPS-SAT: Handed in an experiment proposal together with Chris Krupiarz, Ed Birrane and Scott Burleigh
- As a FreeRTOS-based DTN protocol implementation was needed for the TUD flight opportunity, development of µPCN was initiated in the beginning of 2014

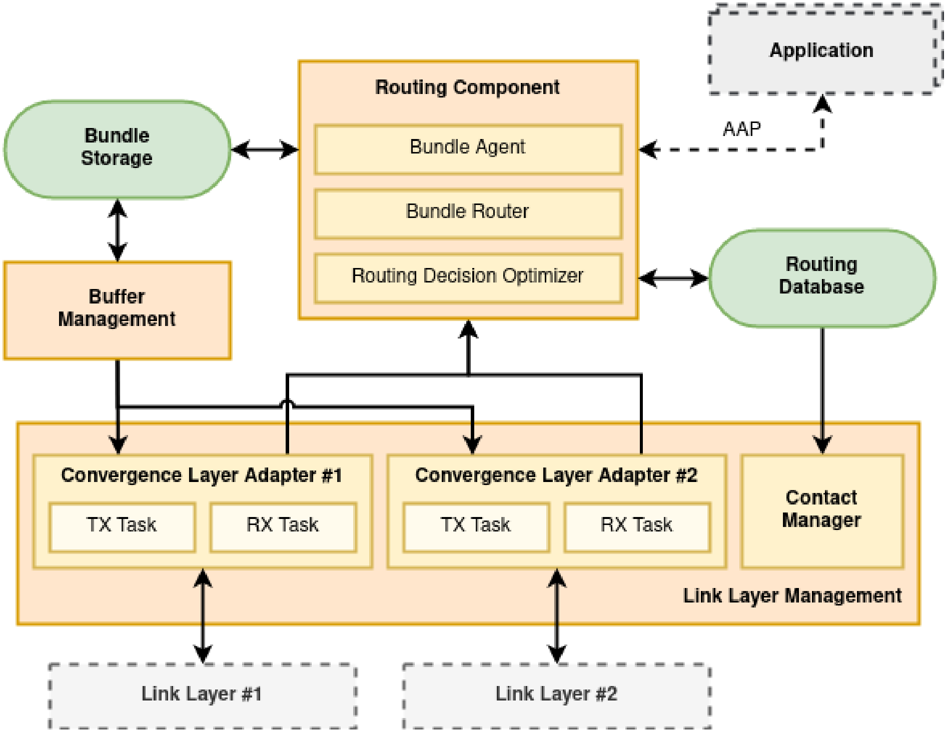
µD3TN - Overview

- µD3TN is an open-source DTN protocol implementation based on µPCN created in 2014
- First BPv7 implementation that has been created (mentioned under the name µPCN in BPv7 draft specification)
- Modular design offering several convergence layer adapters
- Simple integration of delay-tolerant applications due to Application Agent Protocol



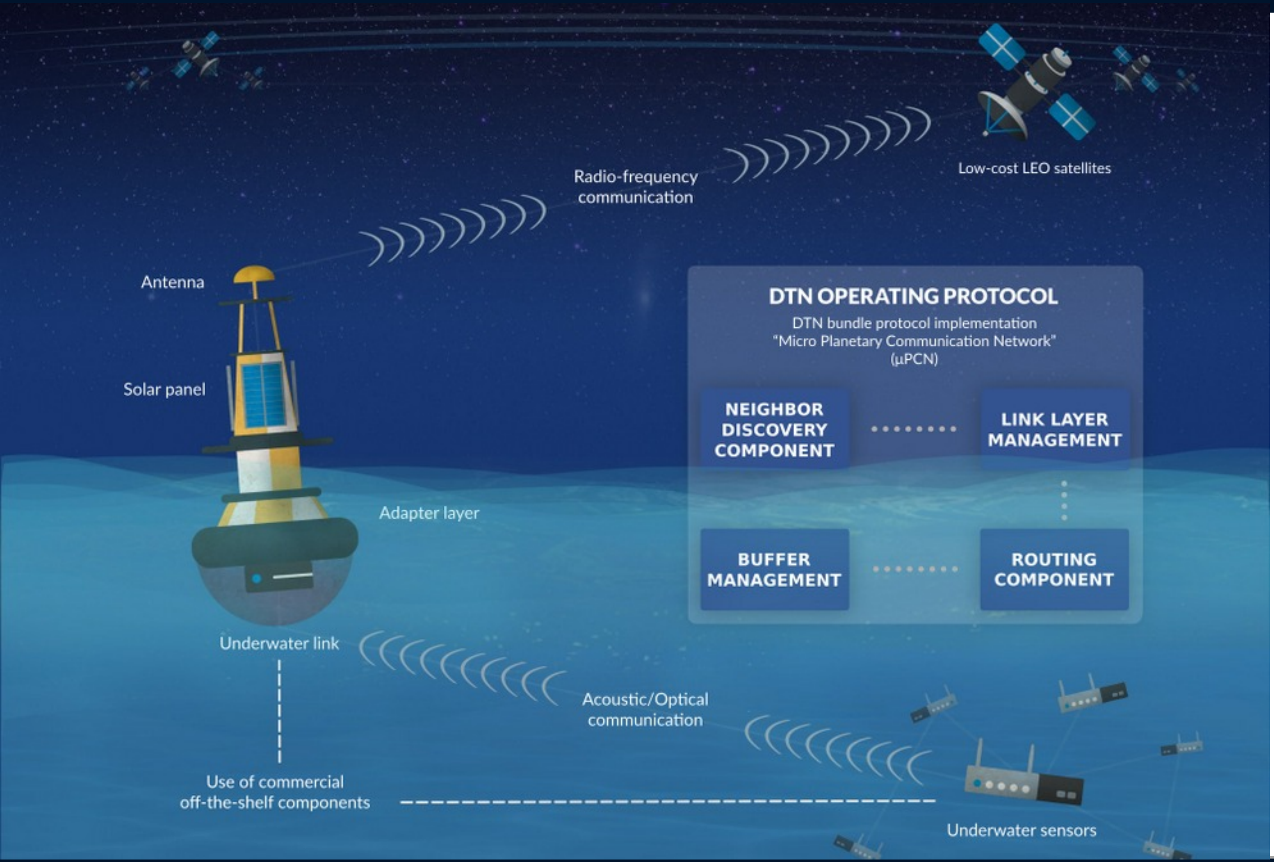
Source code available via:
https://gitlab.com/d3tn/ud3tn

System architecture of µD3TN



- Modular design has been used which renders adaptation to various application scenarios possible
- Convergence Layer Adapters can be easily added to the system
- Routing, Neighbor Discovery and Buffer Management is provided independently from the underlying link

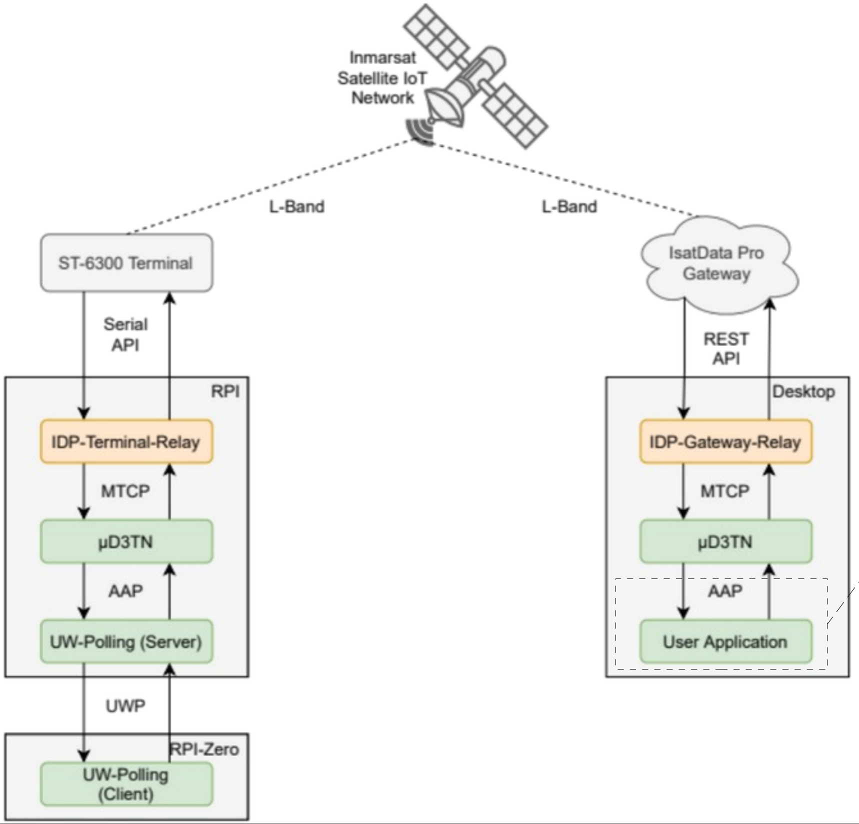
Field-test 1: Project COLDSUN



- Co-funded ESA Business Application project
- Goal: Develop a low-cost communication system for transmitting data from underwater sensor networks to the Internet
- In the project context D3TN conducted the first BPv7 field-test including a satellite link
- Executed from 02/2019-07/2019

See also
https://d3tn.com/projects-coldsun.html

Field-test 1: Project COLDSUN



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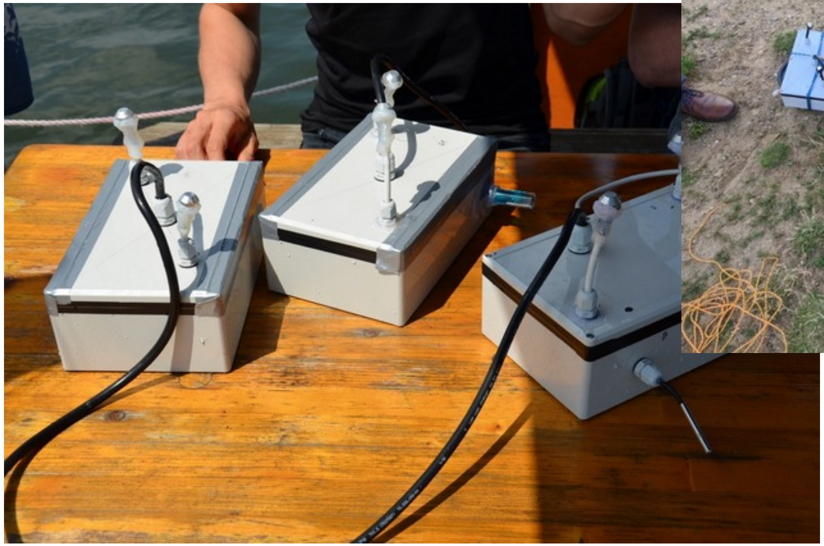

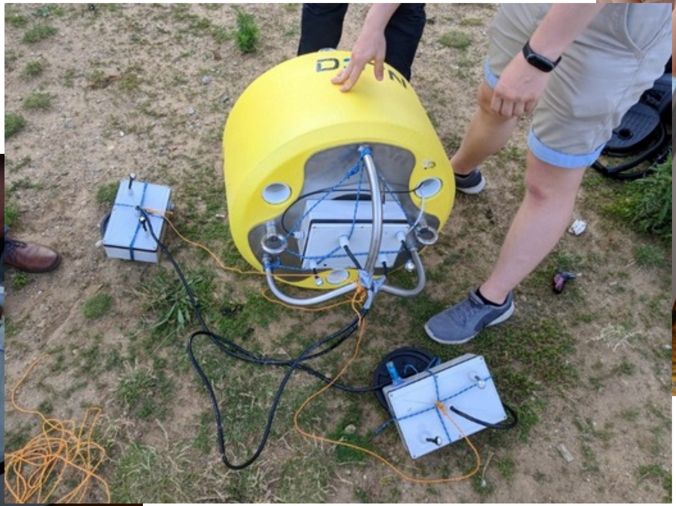

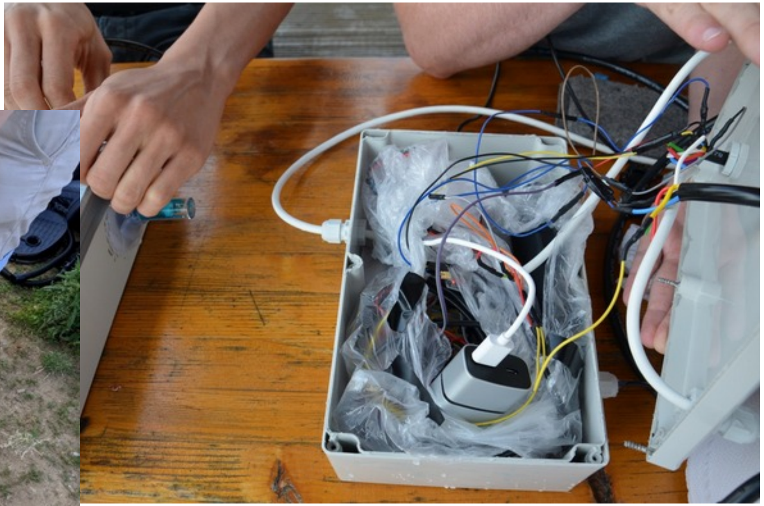

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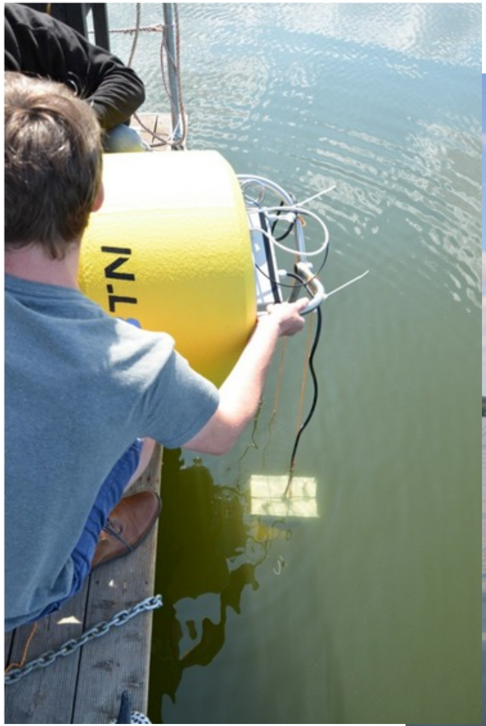
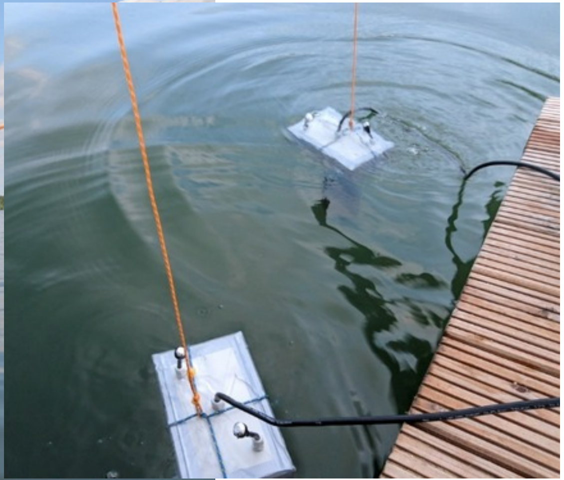
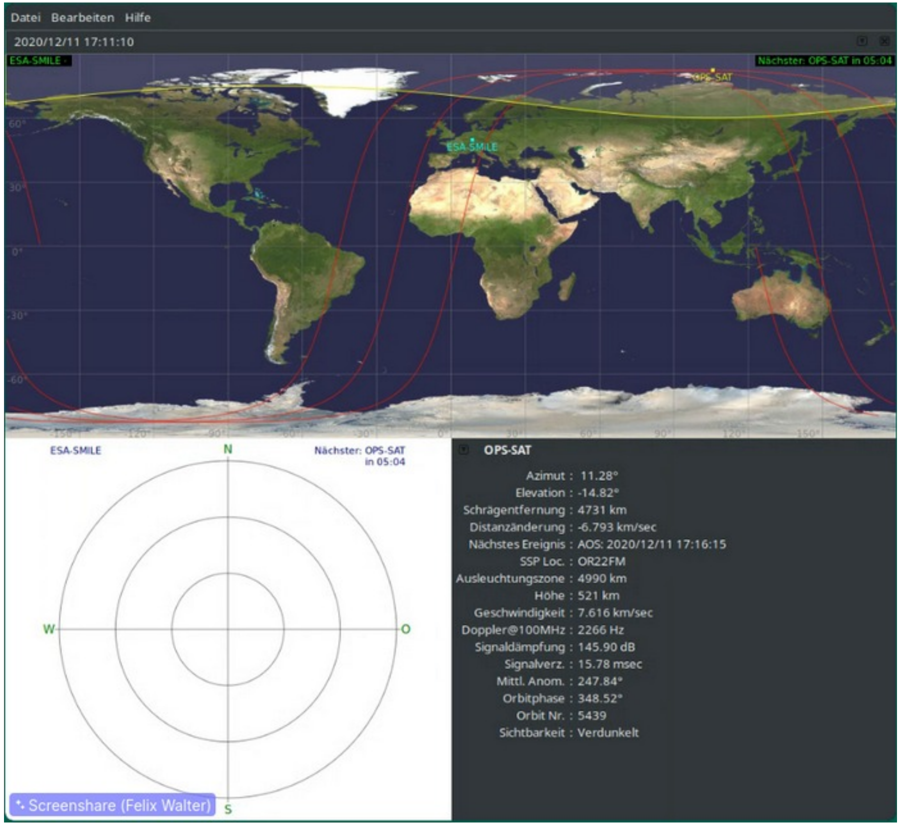


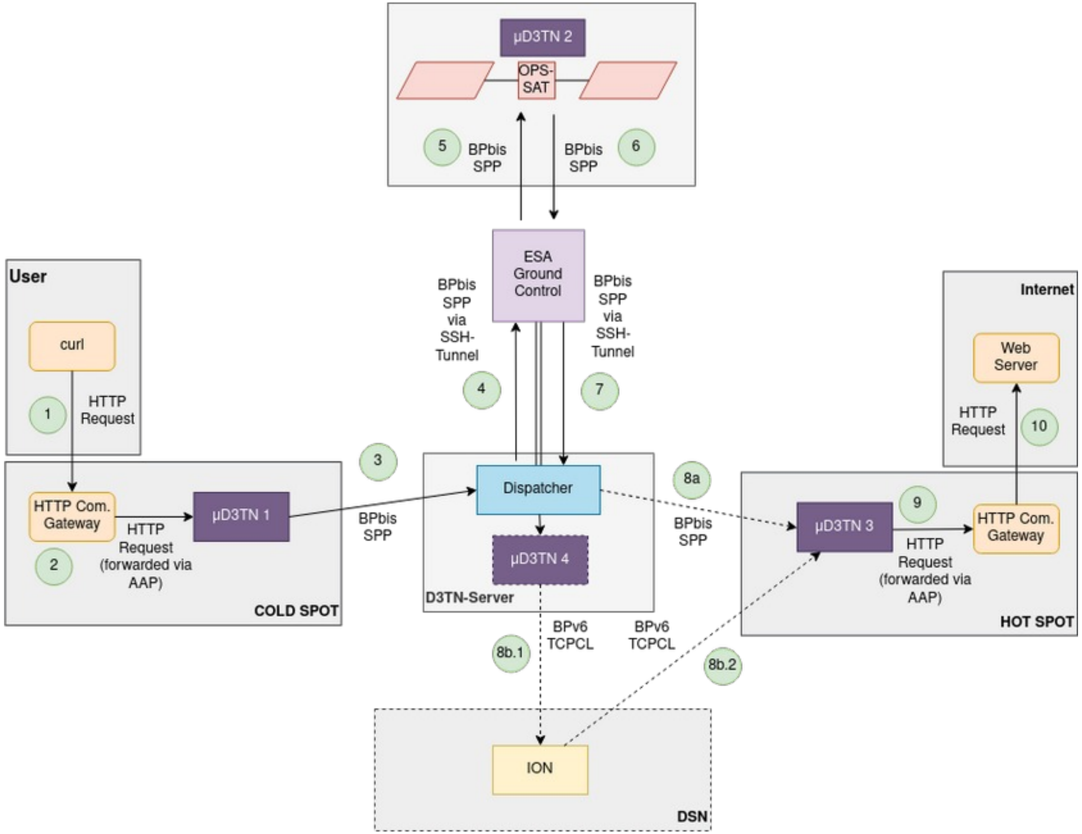


ESA OPS-SAT



- 3U CubeSat launched in December 2019
- Leverages Critical Link MityARM 5CSX with Dual-core 800 MHz ARM Cortex-A9 processors operating Linux
- Offers TCP interface to communication subsystem –> SPP is transferred via TCP by the on-board µD3TN instance
- Access to space segment via ESA SMILE Lab leveraging a reverse SSH port forwarding setup

Field-test 2: OPS-SAT DTN experiment



- D3TN has prepared an experiment for ESA OPS-SAT demonstrating a low-cost world-wide communication system leveraging LEO satellites ("Ring Road Network")
- Experiment was conducted in December 2020
- Experiment leveraged µD3TN on ground as well as on the satellite

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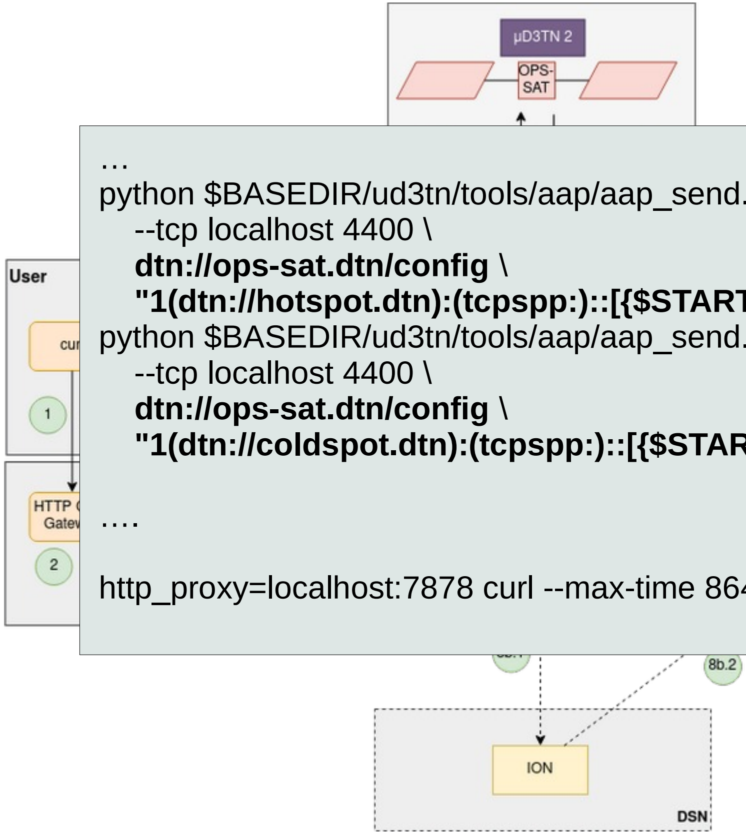


```
…
python $BASEDIR/ud3tn/tools/aap/aap_send.py \
    --tcp localhost 4400 \
    dtn://ops-sat.dtn/config \
    "1(dtn://hotspot.dtn):(tcpspp:)::[{$START_A,$END_A,$BITRATE}];"
python $BASEDIR/ud3tn/tools/aap/aap_send.py \
    --tcp localhost 4400 \
    dtn://ops-sat.dtn/config \
    "1(dtn://coldspot.dtn):(tcpspp:)::[{$START_B,$END_B,$BITRATE}];"

….

http_proxy=localhost:7878 curl --max-time 86400 http://d3tn.com/hi/
```

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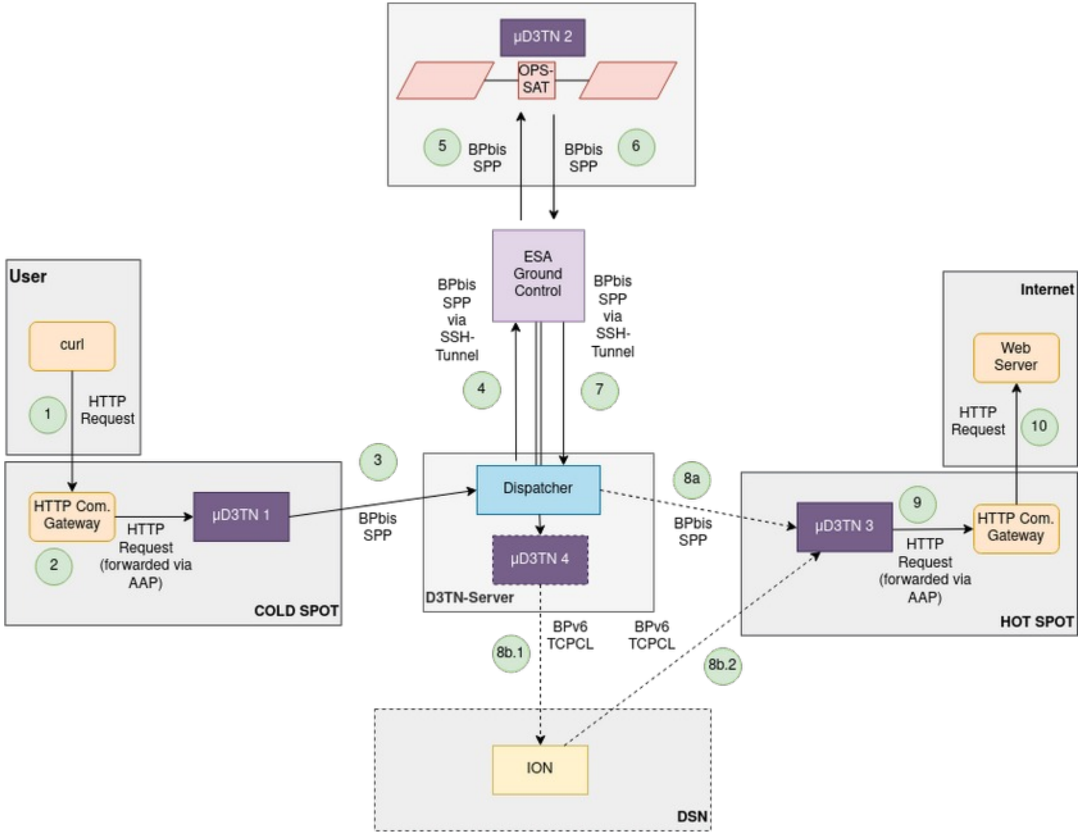

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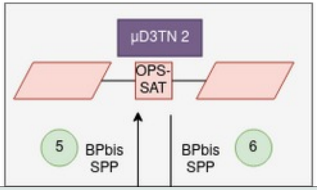
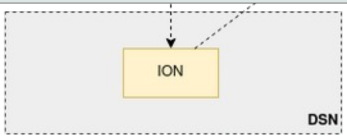


- D3TN has prepared an experiment for ESA OPS-SAT

[Fri Dec 11 18:58:02 2020]: AppAgent: **Received bundle (l = 128) for dtn://hotspot.dtn/dtnweb via AAP**.
[Fri Dec 11 18:58:02 2020]: AppAgent: Injected new bundle (#2).
[Fri Dec 11 18:58:02 2020]: Router: Determined max. frag size of 224 bytes for bundle of size 210 bytes (payload sz. = 128)
[Fri Dec 11 18:58:02 2020]: RouterTask: Bundle #2 [OK] [frag = 1]
[Fri Dec 11 18:58:10 2020]: TCP: Connection accepted from 127.0.0.1:43596 (via CLA tcpspp)!
[Fri Dec 11 18:58:10 2020]: ContactManager: **Scheduled contact with "dtn://ops-sat.dtn" started** (0x7f8dc8000c50).
[Fri Dec 11 18:58:10 2020]: ContactManager: **Queuing bundles for contact with "dtn://ops-sat.dtn"**.
[Fri Dec 11 18:58:10 2020]: TX: **Sending bundle #2 via CLA tcpspp**
[Fri Dec 11 18:58:20 2020]: ContactManager: Scheduled contact with "dtn://ops-sat.dtn" ended (0x7f8dc8000c50).
[Fri Dec 11 18:58:21 2020]: TCP: A peer (via CLA tcpspp) has disconnected gracefully!

ground as well as on the satellite



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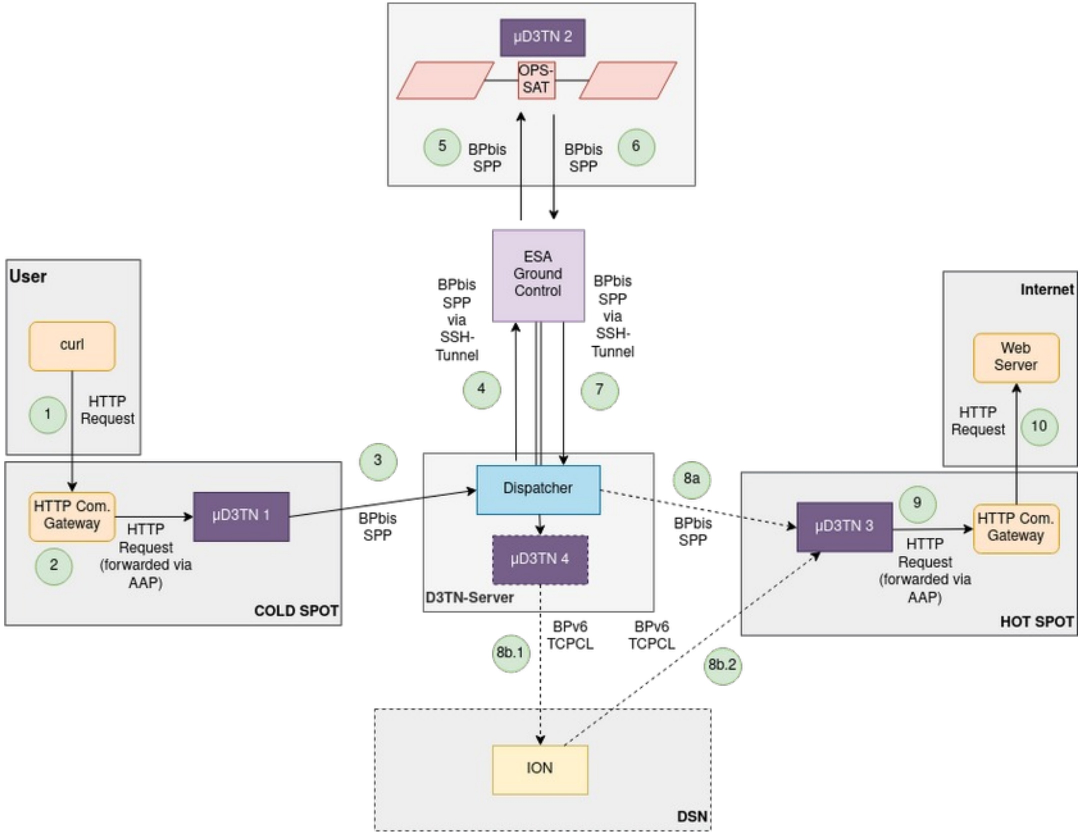

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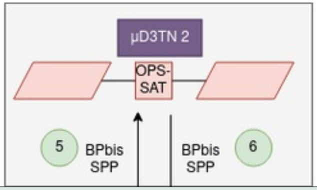

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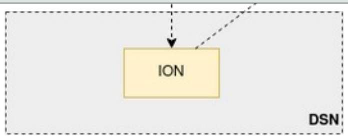
[Fri Dec 11 18:58:22 2020]: TCP: Connection accepted from 127.0.0.1:43732 (via CLA tcpspp)!
[Fri Dec 11 18:58:22 2020]: ContactManager: **Scheduled contact with "dtn://ops-sat.dtn"** started (0x7fb444000ba0).
[Fri Dec 11 18:58:24 2020]: CLA: Received new bundle #5 from "dtn://coldspot.dtn/dtnweb" to "dtn://hotspot.dtn/dtnweb" via CLA tcpspp
[Fri Dec 11 18:58:24 2020]: BundleProcessor: **Received local bundle -> "dtnweb"**; len(PL) = 128 B
[Fri Dec 11 18:58:24 2020]: AppAgent: **Got Bundle for sink "dtnweb" from "dtn://coldspot.dtn/dtnweb", forwarding.**
[Fri Dec 11 18:58:24 2020]: AppAgent: **Received bundle (l = 647) for dtn://coldspot.dtn/dtnweb via AAP**.
[Fri Dec 11 18:58:24 2020]: AppAgent: Injected new bundle (#6).
[Fri Dec 11 18:58:24 2020]: Router: Determined max. frag size of 224 bytes for bundle of size 730 bytes (payload sz. = 647)
[Fri Dec 11 18:58:24 2020]: RouterTask: Bundle #6 [OK] [frag = 5]
[Fri Dec 11 18:58:24 2020]: ContactManager: **Queuing bundles for contact with "dtn://ops-sat.dtn"**.

ground as well as on the satellite



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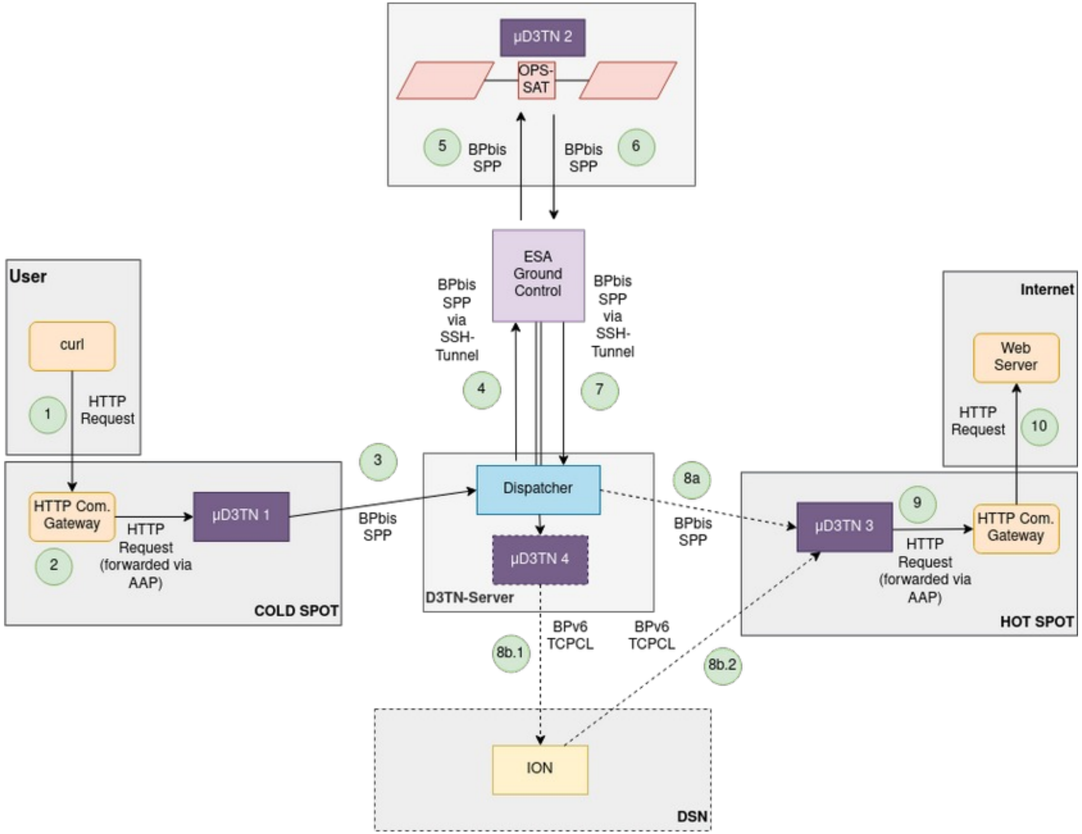

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Conclusion

- BPv7 implementation worked without any issues
- Routing & forwarding based on time is error-prone
- Standardized configuration/management mechanisms are required
- Tools for checking neighbors’ availability and operational states in a DTN are massively useful

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Let’s start with some more extended heterogenous BPv7 deployments and push them jointly forward! ;-)

Thanks for your attention!

contact@d3tn.com