



Interplanetary Overlay Network

Networking in
Space

Disruption-Tolerant Networking

Communication between base stations, near-space and deep-space satellites and spacefaring devices

Traditional networking priorities don't really work

- Intermittent connectivity

- Delayed transmission

- Take advantage of predicted or opportunistic connectivity

Interplanetary Overlay Network

The most common implementation of a DTN stack

Organisations:

NASA

CCSDS (Consultative Committee for Space Data Systems)

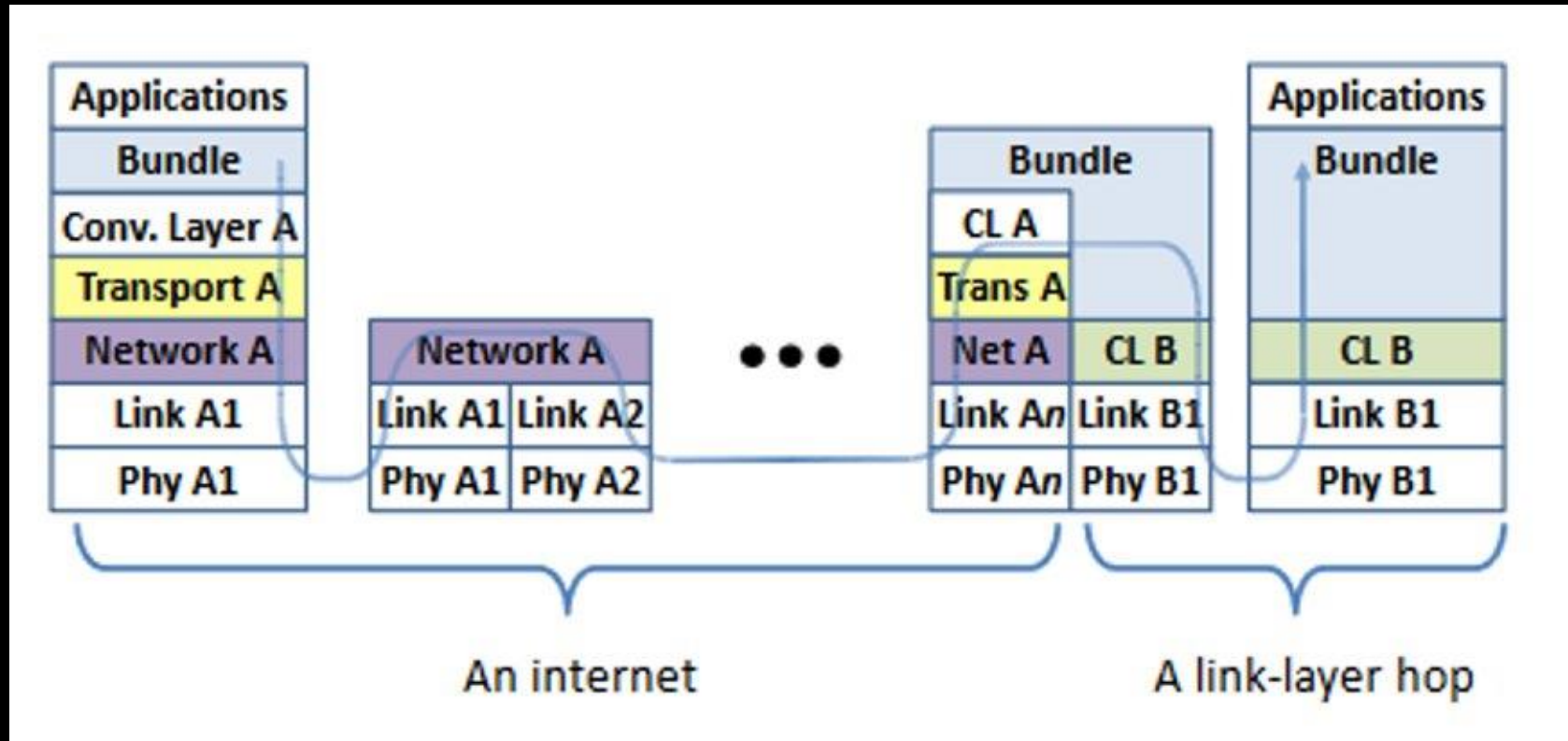
IETF (RFCs)

Network Stacks

OSI	
Application	HTTP, FTP
Presentation	TLS
Session	
Transport	TCP, UDP
Network	IP
Data Link	Ethernet, WiFi
Physical	Ethernet, WiFi

DTN	
Application	CFDP
Bundle	Bundle Protocol
Convergence/ transport	Licklider Transmission Protocol
Data Link	Various, often proprietary
Physical	Cool space radios?

Bundle Protocol Communication



Testing Stack

Leave lower layers as normal

Builds DTN layers on top

DTN – Testing Stack	
Application	CFDP
Bundle	Bundle Protocol
Convergence	Licklider Transmisison Protocol
Transport	UDP
Network	IP
Data Link	Ethernet
Physical	Ethernet, virtual cable connections within CORE

CFDP

CCSDS File Delivery Protocol

For sending and receiving files

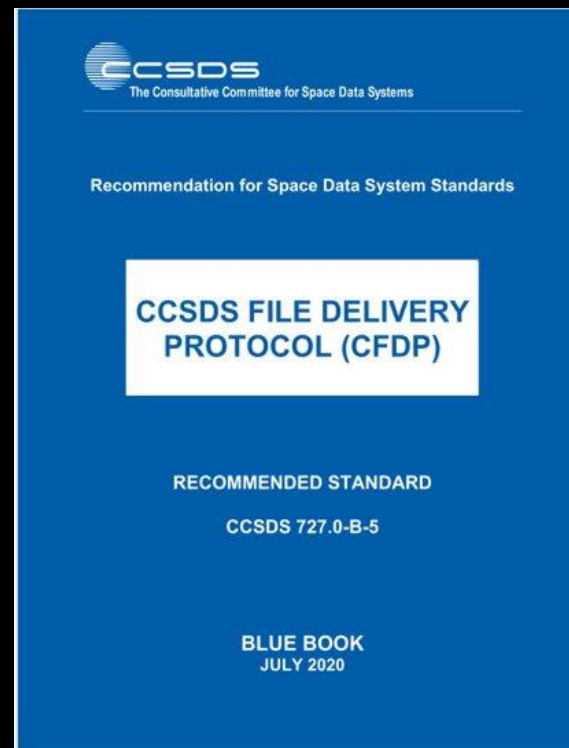
Doesn't care what's underneath it

Doesn't care about how the data is stored

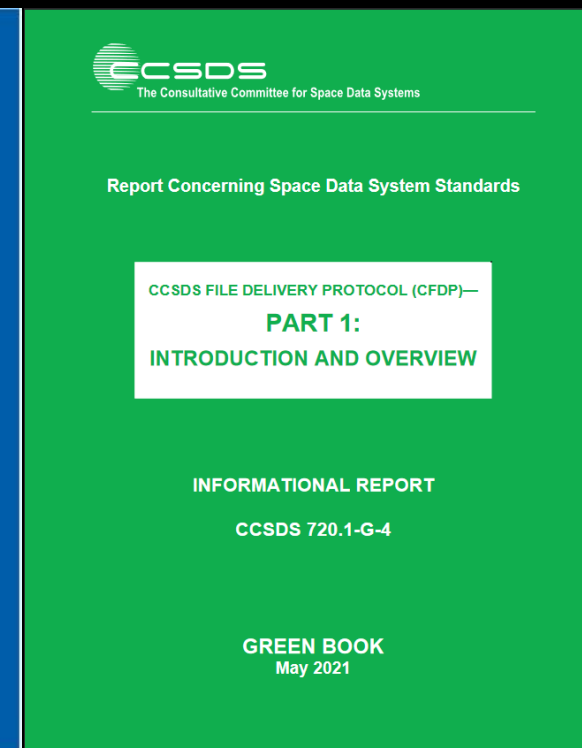
'Acknowledged' or 'unacknowledged' modes,
for reliable and unreliable transport

'Core' and 'Extended' interactions, for
situations where there are intermediary
entities ('waypoints')

Forward error correction helps with
transmission errors



<https://public.ccsds.org/Pubs/727x0b5.pdf>



<https://public.ccsds.org/Pubs/720x1g4.pdf>

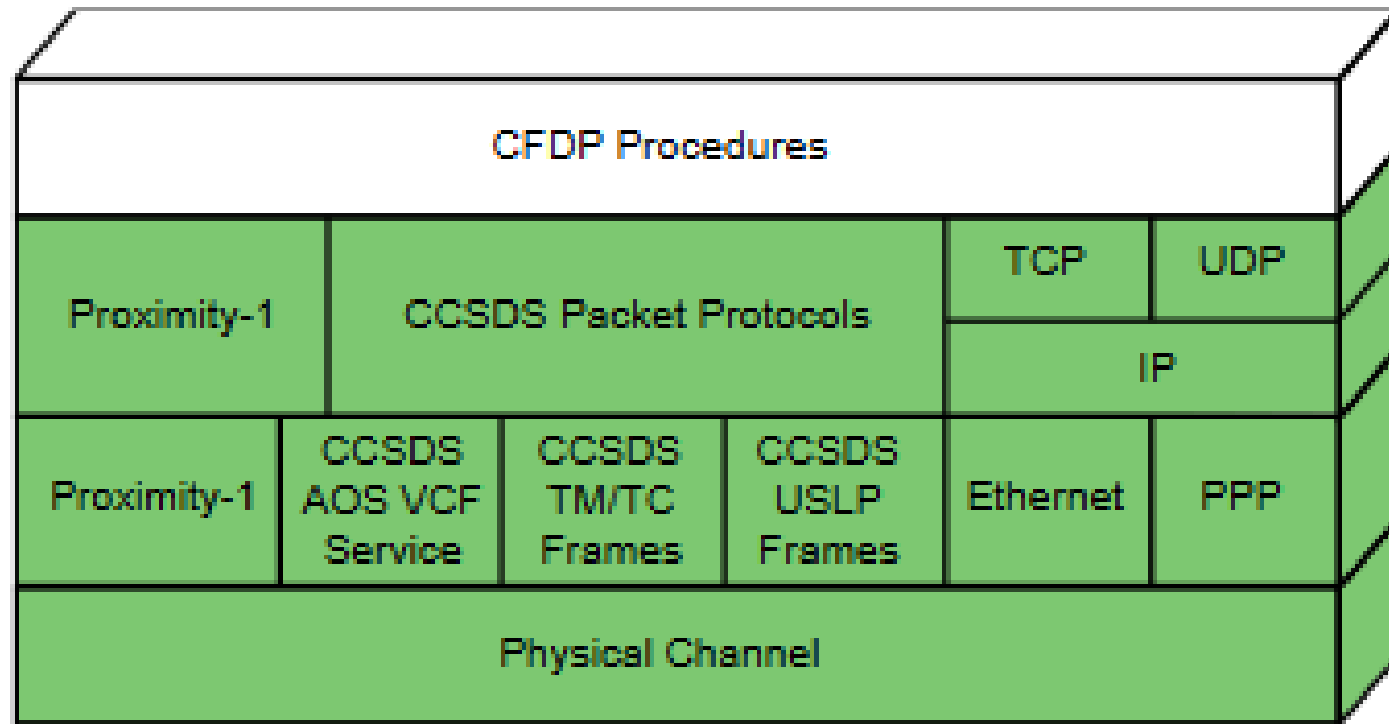


Figure 2-1: The CFDP Operates over a Wide Range of Underlying Protocols

Bundle Protocol

Disruption-Tolerant Network protocol, used in space communications

Bundle Protocol sits between LTP (or sometimes UDP) and the Application Layer

Some parallels to IP, some to TCP/UDP

Addressing (instead of 10.0.1.1:80 you have **ipn:2.1**)

Routing

Bundle Protocol Extensions

Additional headers to the Bundle which indicate other features:

Confidentiality (Encryption)

Integrity (signing)

Sequencing

Administrative records (status reports, logs)



<https://public.ccsds.org/Pubs/734x2b1.pdf>

Licklider Transmission Protocol

Sits between BP and Link Layer

Stateful – keeps track of what's at the other end

First part 'red blocks' always reliable

Contains details about rest of block

First part 'green blocks' unreliable

Contains details about rest of block

Extensions

Cookies (to avoid DOS)

Authentication (signing)



<https://public.ccsds.org/Pubs/734x1b1.pdf>

NASA DTN-ION Dev Kit

NASA publishes a set of C programs for communicating in CFDP, BP and LTP

Downloadable <https://sourceforge.net/projects/ion-dtn/>

NASA released an Ubuntu based system for testing and development

Uses CORE (Common Open Research Emulator) <https://github.com/coreemu/core>

Comes with premade

Has C apps compiled ready to go

We added PyION - Python interface to these apps

(Sometimes) available at <https://www.mitre.org/download-nasas-dtn-development-kit>

Contact me if you want it - site is generally broken

Capturing from veth4.0.27

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

ip.dst == 10.3.3.2

No.	Time	Source	Destination	Protocol	Length	Info
2366	713.856871121	10.3.3.1	10.3.3.2	LTP Se...	133	Red data
2368	713.904541509	10.3.3.1	10.3.3.2	LTP Se...	49	Report ack segmen

▶ Frame 2366: 133 bytes on wire (1064 bits), 133 bytes captured (1064 bits) on interface 0
 ▶ Ethernet II, Src: 00:00:00_aa:00:04 (00:00:00:aa:00:04), Dst: 00:00:00_aa:00:05 (00:00:00:aa:00:05)
 ▶ Internet Protocol Version 4, Src: 10.3.3.1, Dst: 10.3.3.2
 ▶ User Datagram Protocol, Src Port: 42065, Dst Port: 1113
 ▼ Licklider Transmission Protocol

- ▼ LTP Header
 - LTP Version: 0
 - LTP Type: 3 (Red data, Checkpoint, EORP, EOB)
- ▼ Session ID
 - Session originator: 4
 - Session number: 326
 - Header Extension Count: 0
 - Trailer Extension Count: 0
- ▼ Data Segment
 - Client service ID: 1 (Bundle Protocol)
 - Offset: 0
 - Length: 80
 - Checkpoint serial number: 14361
 - Report serial number: 0
- ▼ Data[1]
 - ▼ Data (80 bytes)
 - Data: 9f89071844018202820304820100820100821b000000a442...
 - [Length: 80]

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