

DTN Architecture

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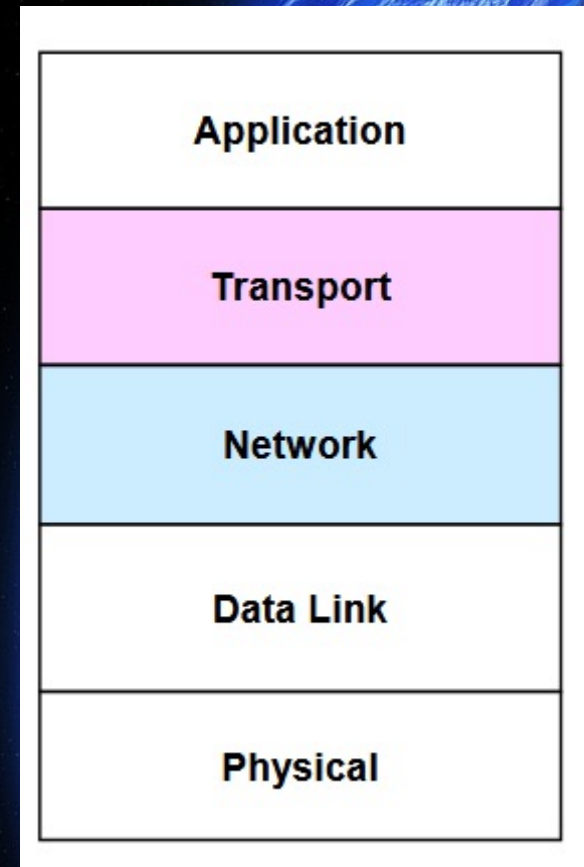
Interplanetary Networking Special Interest Group

Link to the NASA's Interplanetary Overlay Network course

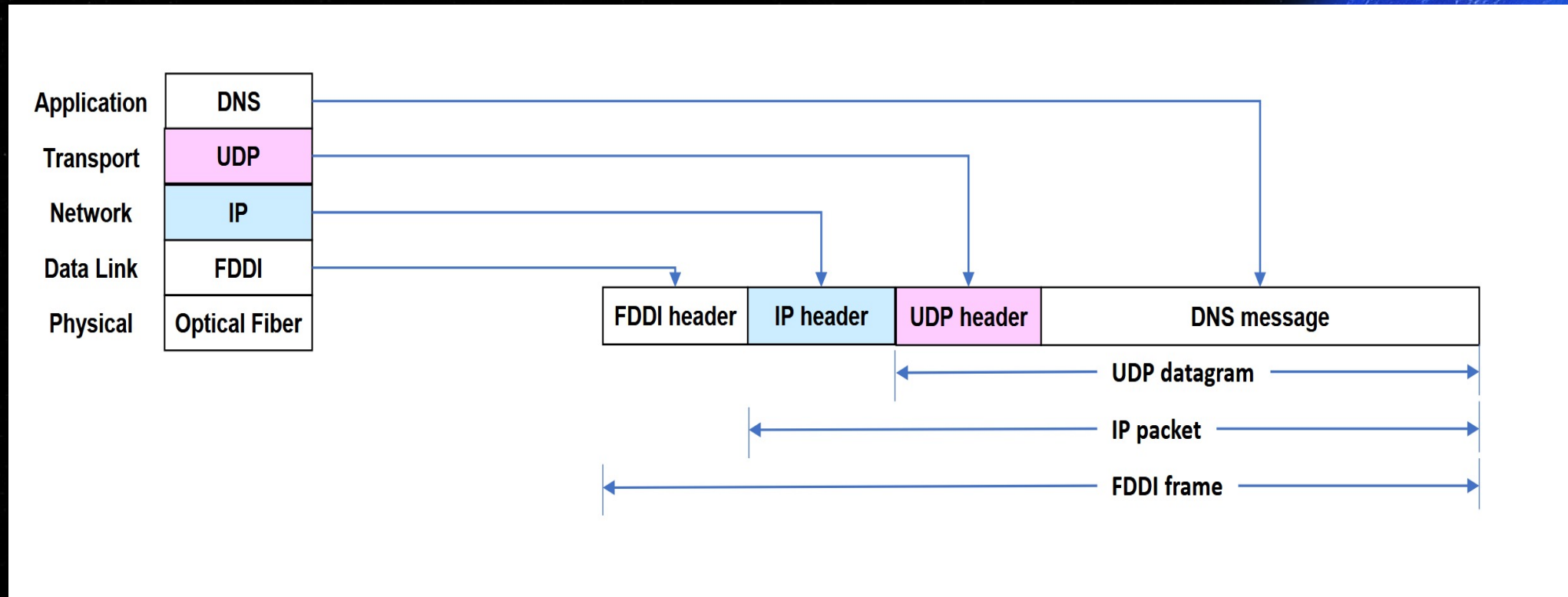


Internet Network Protocol Stack

- Layered
- Every layer performs the function at that layer
- Relying on services of the layer below
- Providing services to the layer above

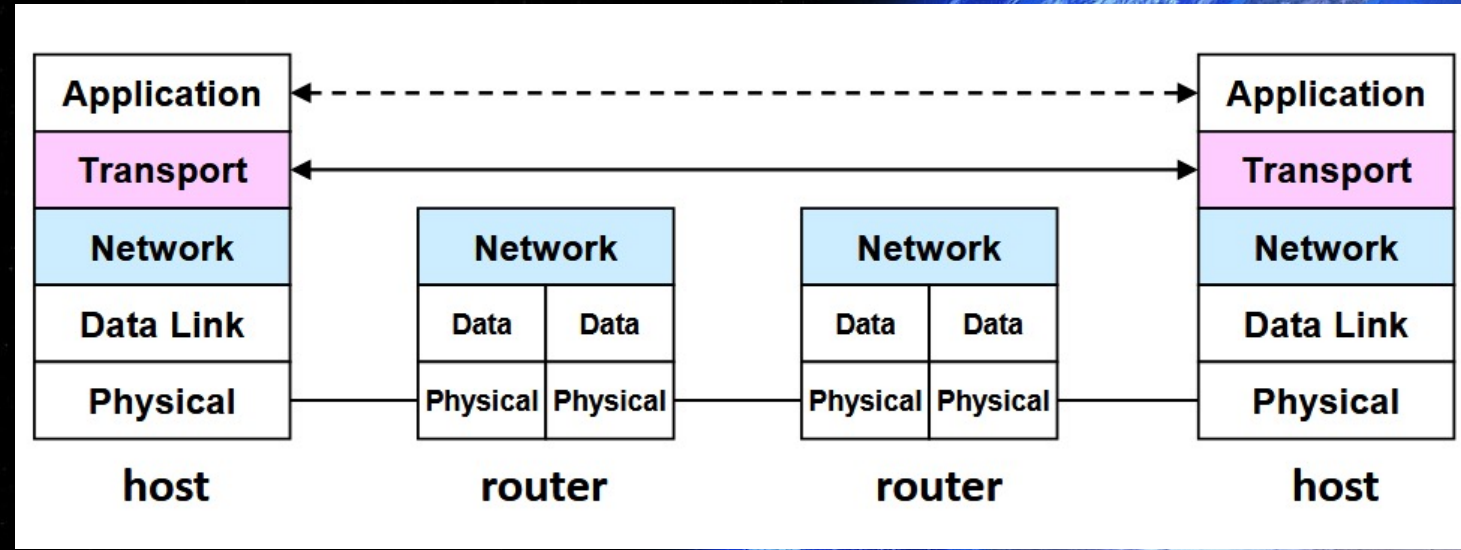


Data encapsulation



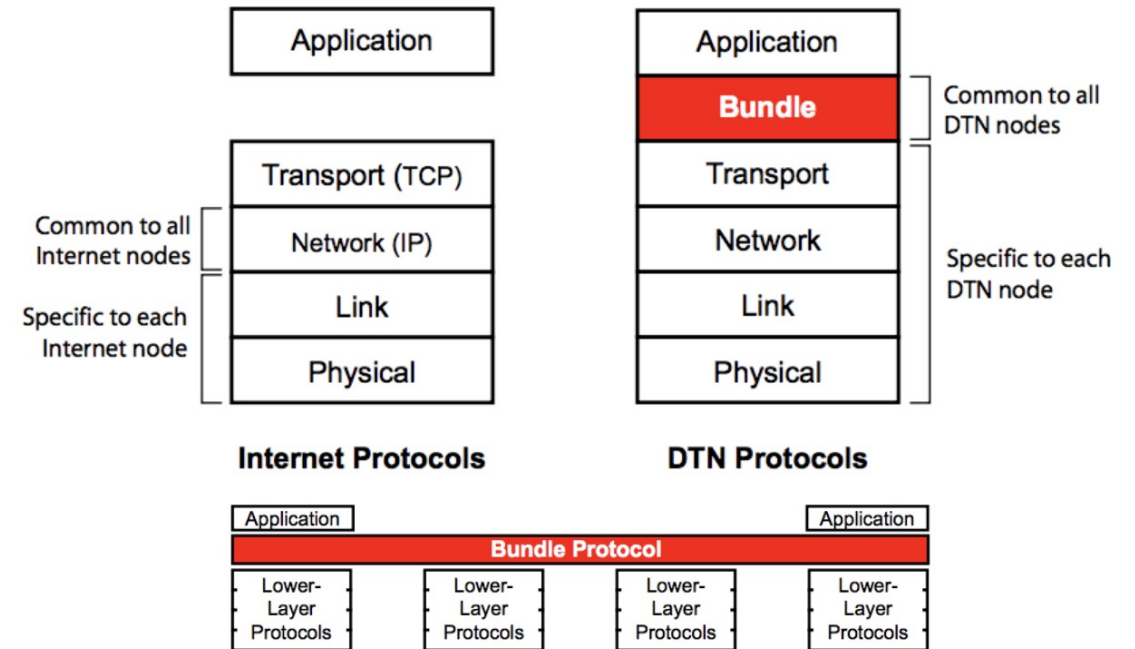
Internet Routing

- Individual networks connected into internetwork (AS)
- Data Can get from a source to a destination
- Network topology changes slowly
- Round trips cheap, low packet loss
- IP Addresses organized into tree structure
- Provides scalability, Issues with mobility



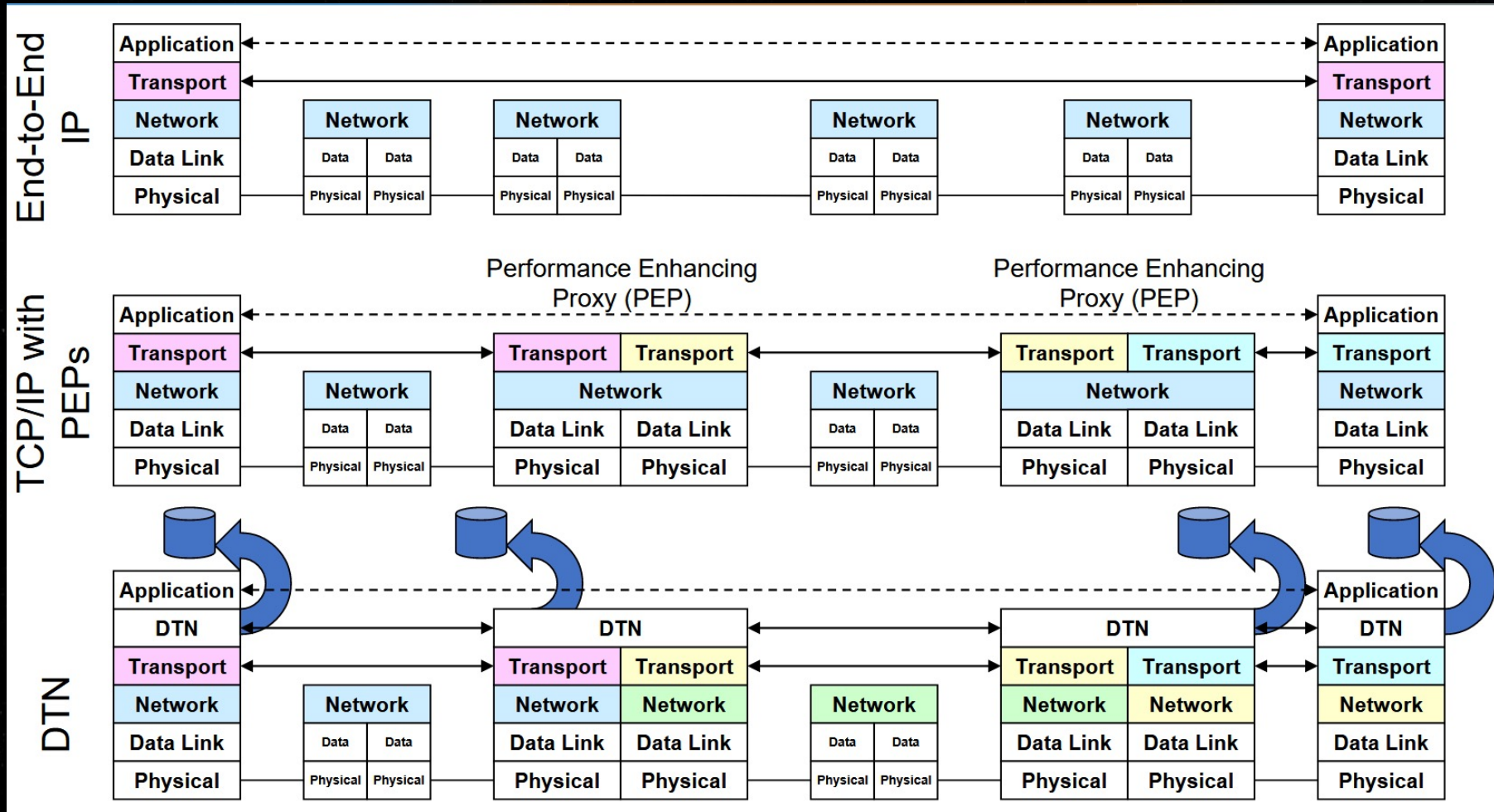
The DTN Model

- One layer higher in the protocol stack
- Bundle Protocol analogue to the IP
- Convergence Layer (underlying stack)



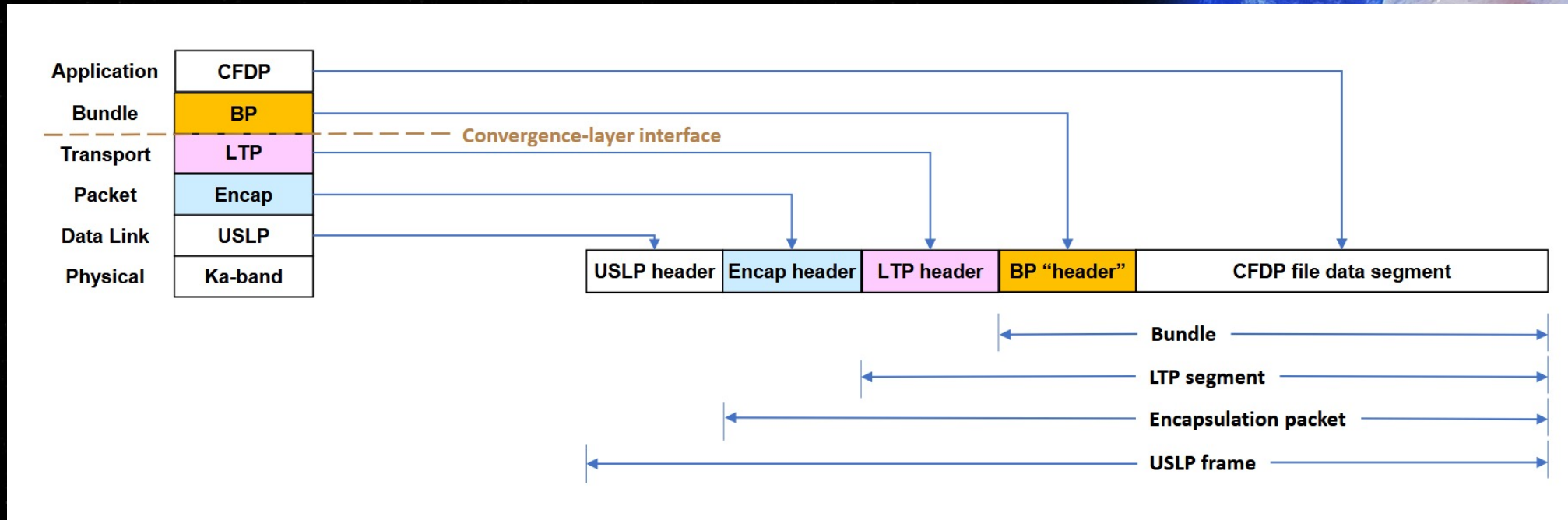
Refer to *Delay and Disruption-Tolerant Networks (DTNs)*
A Tutorial - Version 3.2

End-to-End IP, PEPs, and DTN



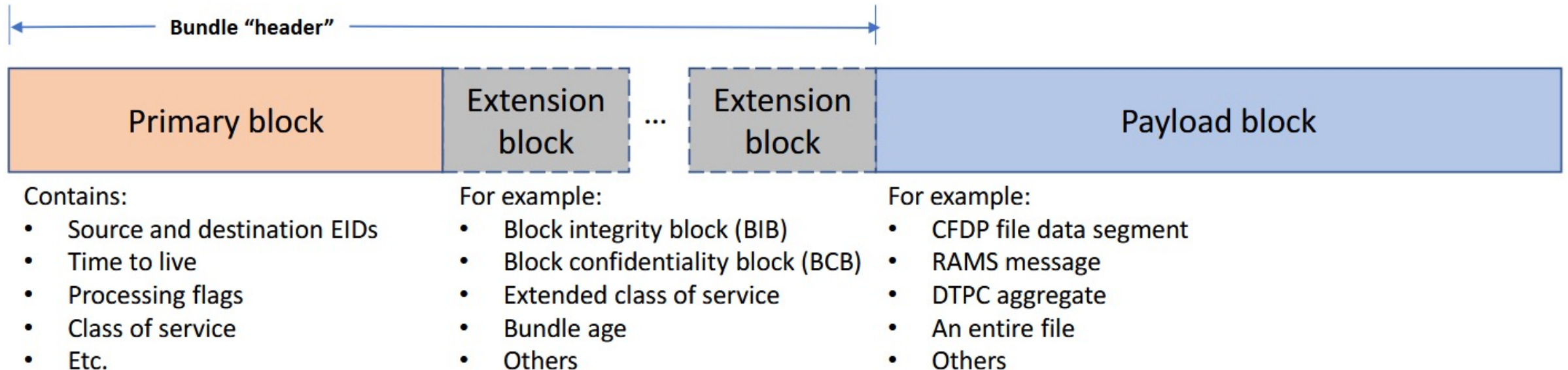
Convergence layers

- Stacking of protocols, encapsulation
- Any form of communication (WiFi, Ethernet, IPv6, RS-232, USB Sticks, smoke signals, etc.)



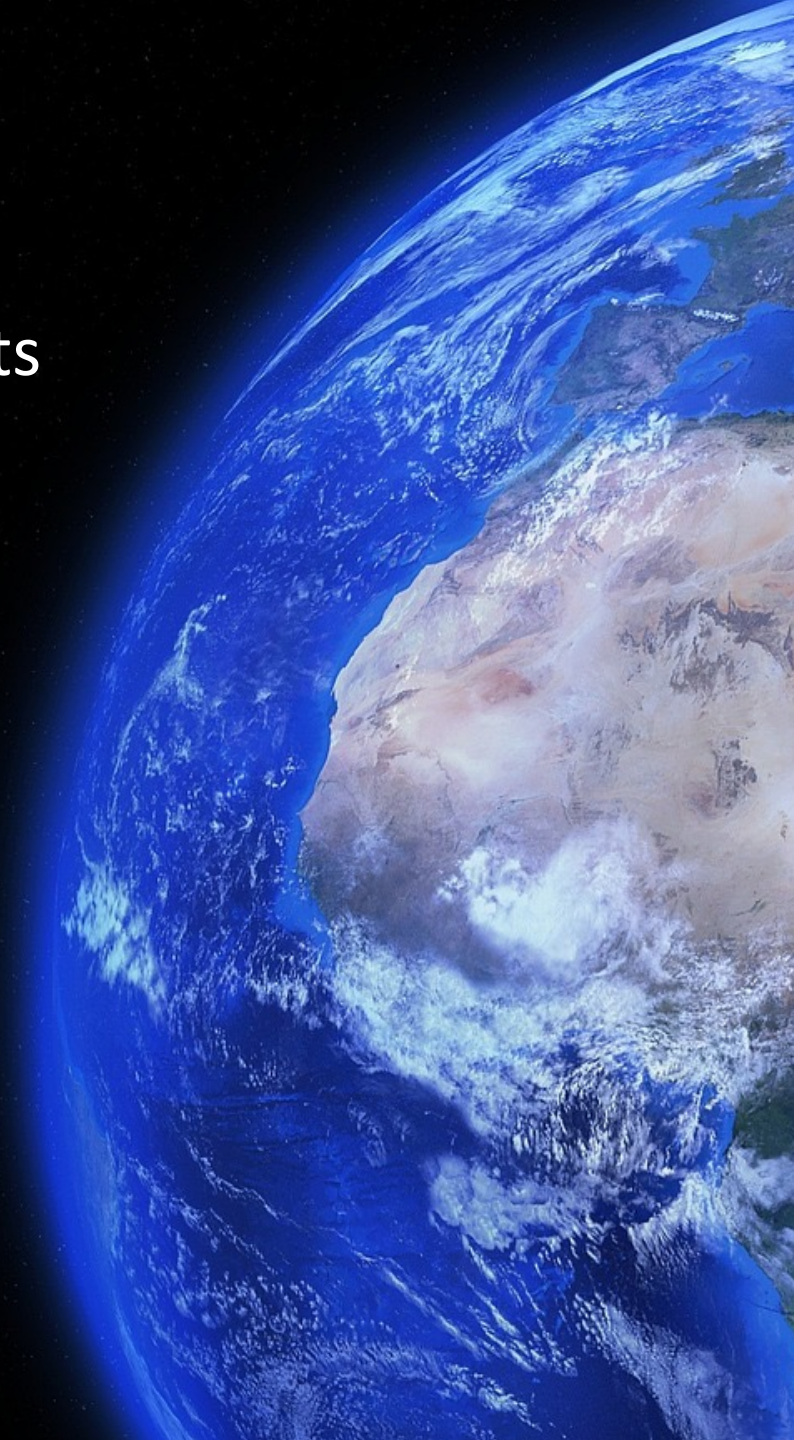
Structure of a Bundle

- Sequence of blocks:
 - Primary block
 - Zero or more extension blocks
 - Payload block
- Variable-length fields (SDNV, CBOR)



Endpoint IDs

- The source and destination of bundle are endpoints
- BP endpoint IDs are names , not addresses (no topological significances),
- No hints about the route, flat namespace
- Two name schemes defined:
 - DTN: dtn://namenode.organization/service
 - IPN: ipn://nodenumber.servicenumber
- IPN defined to reduce transmission overhead



Security

- Built into the Bundle Protocol (but not every implementation)
- Every block of a bundle can be signed by a Bundle Integrity Block (BIB) enabling detection of tampering with block data. When there a BIB for the Primary block, which identifies the source node, the authenticity of the bundle can be verified.
- Bundle in Bundle Encapsulation can be used as defense against traffic analysis



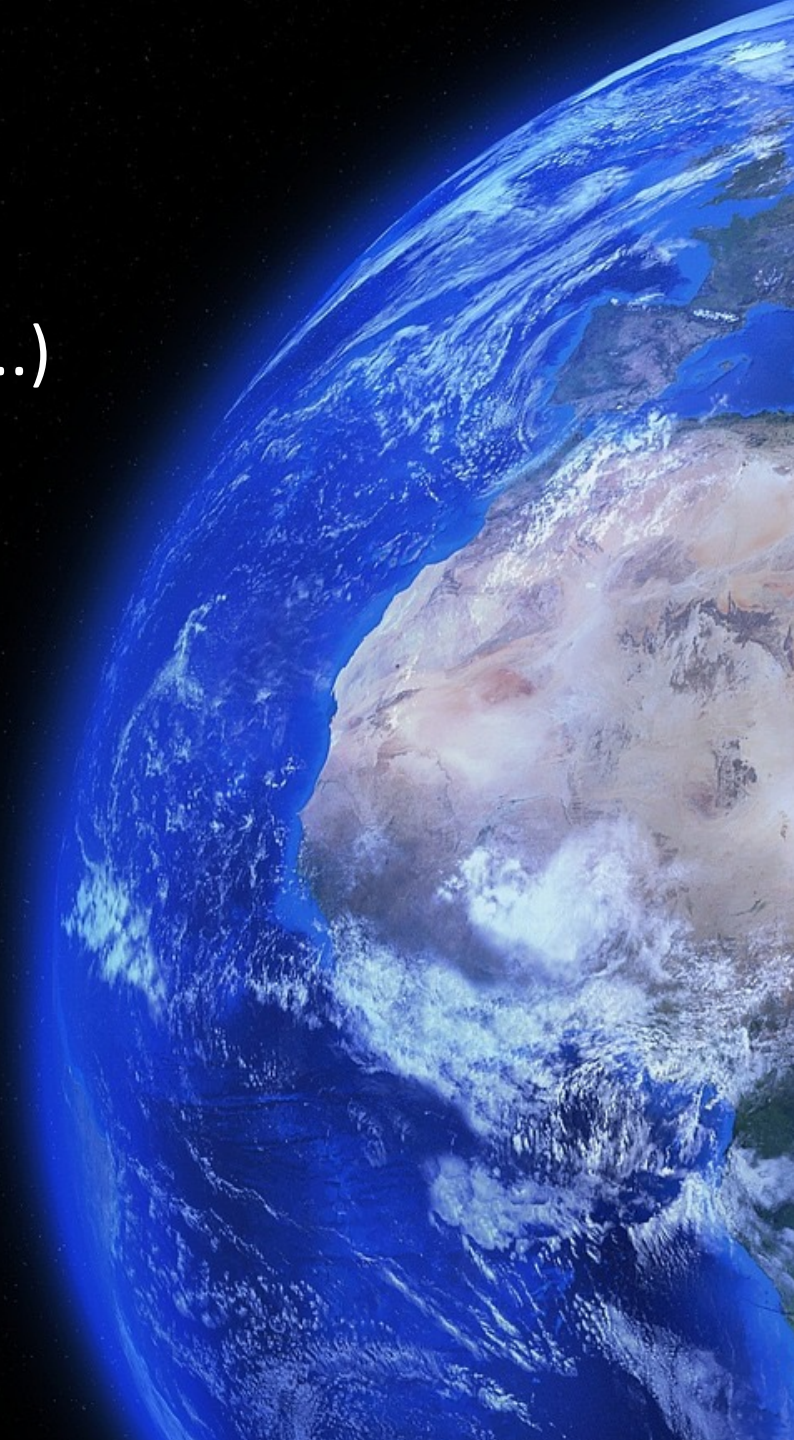
Routing/Forwarding in DTN

- Replication-based routing (congestion, wasteful, scalability)
 - Epidemic
 - PROPHET
 - MaxProp
 - RAPID
 - SprayAndWait
 - Bubble Rap (social based)
- Forwarding-based routing
 - DTLSR (link state)
 - Contact Graph Routing (scheduled)



DTN and time

- What time to use in space (earth time, lunar time,..)
- Important for TTL of bundles
- Every bundle gets a timestamp
- If time is not available?
 - Primary block is immutable
 - BP uses time extension block to keep track of time
 - Important to use sequence nr.



Open challenges in DTN

- BPv7 vs BPv6
- Governance (IPN naming)
- API
 - ION – Inter-process comm.
 - D3DTN – IP socket
 - Files
- Flat name space, hard to aggregate IPNs
- Scalability?
- Inter-Regional-Routing (BGP) missing
- Standardization of bundle payloads
- Missing features in implementations



Structure of a typical DTN node

- Application/Service
- Bundle agent (storage, forwarding alg.)
- Convergence layer adapters
 - Ingress (incoming links)
 - Egress (exit links)
 - Support for asymmetrical links



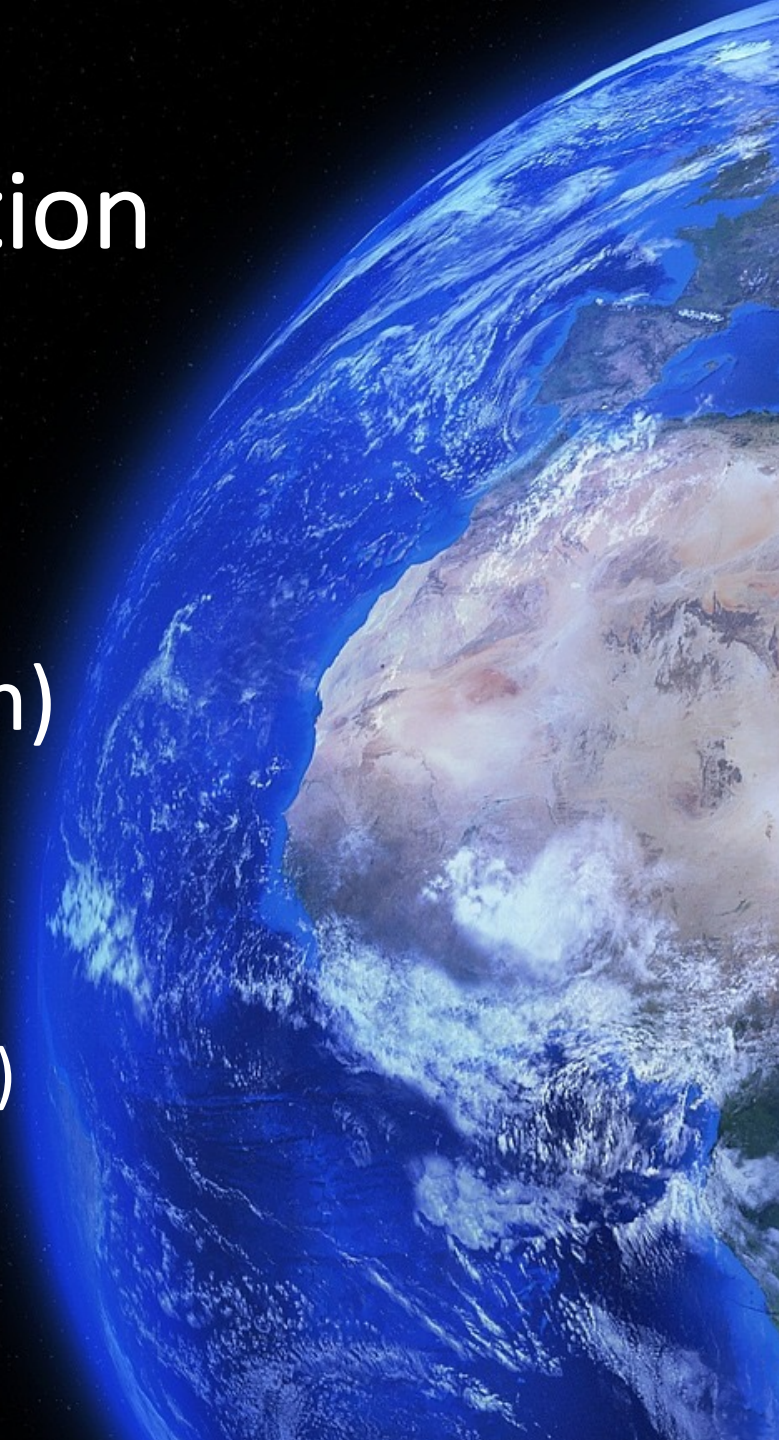
Bundle Protocol Implementations

Feature/Stack	Subfeature	ION ION-Core	IONE	HDTN	uD3TN	DTNME	BPLib/CFS	Unibo	IBR
BPv6		Y	Y	Y	Y	Y	Y	N	Y
	TCPClv3	Y	Y	Y	Y	Y		N	Y
	UDPCL	Y	Y	Y	N	Y		N	Y
	LTPv1	Y	Y	Y	N	Y		N	N
	BPSEC	Y	Y	N	N	N		N	Y
	Custody BPv6	Y	Y	Y	N	Y		N	
BPv7		Y	Y	Y	Y	Y	Y	Y	N
	TCPClv3	Y	Y	Y	Y	Y		Y	N
	TCPClv4	Y	Y	Y	N	Y		N	N
	UDPCL	Y	Y	Y	N	Y		N	N
	LTPv1	Y	Y	Y	N	Y		Y	N
	BPSEC	Y	Y	Y	N	N		N	N
	Custody (with BIBE)	Y	Y	N		Y		N	N
	RTP	N	N	Y	N			N	N
CGR, SABR		Y	Y	Y	N	N		Y	Y
CCSDS SPP		N	N	N	Y	N		N	N
Bundle Streaming Service Protocol		Y	Y	N	N	N		N	N
Asynchronous Message Service		Y	Y	N	N	N		N	N
IPv6 (for CLAs)		N	Y	N	Y	N		Y	Y
IPND		Y	Y	N	N	N		N	Y
CFDP		Y	Y	N	N	Y		N	N
Primary Language		C	C	C++	C	C++	C	C++	C++

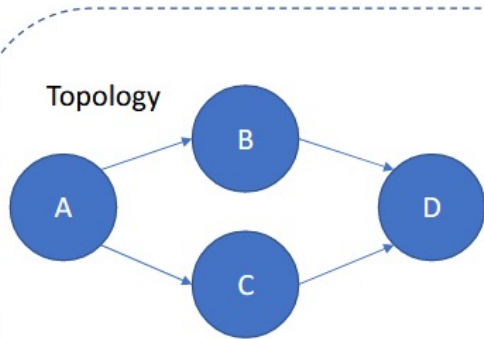


ION Bundle Protocol Implementation

- Closest to the “reference” implementation
- Developed for actual space flight environments (runs on int. space station)
 - Link constrains
 - Processor constrains (economical use of resources)
 - Operation constrains (reliability, static mem allc)

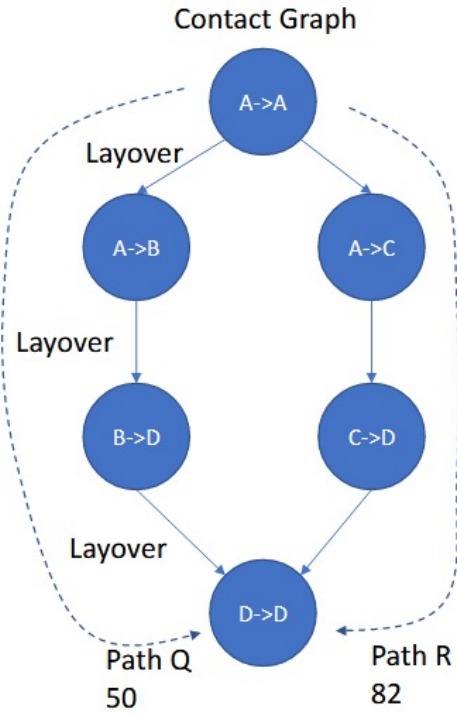


Contact Graph Routing (CGR)



Contact Plan

Link	Start	End	Capacity	Link	OWLT
A->B	10	20	1000	A->B	1
B->A	10	20	1000	B->D	10
B->D	40	50	1000	A->C	30
D->B	40	50	1000	C->D	2
A->C	60	70	1000		
C->A	60	70	1000		
C->D	80	90	1000		
D->C	80	90	1000		



Size	TTL	Send ON	Amt Queued for Q
100	30	---	
100	60	Q	100
100	150	Q	200
200	60	Q	400
100	70	Q	500
300	150	Q	800
300	150	R	

*OWLT-
OneWayLightTime

*Contact Volume