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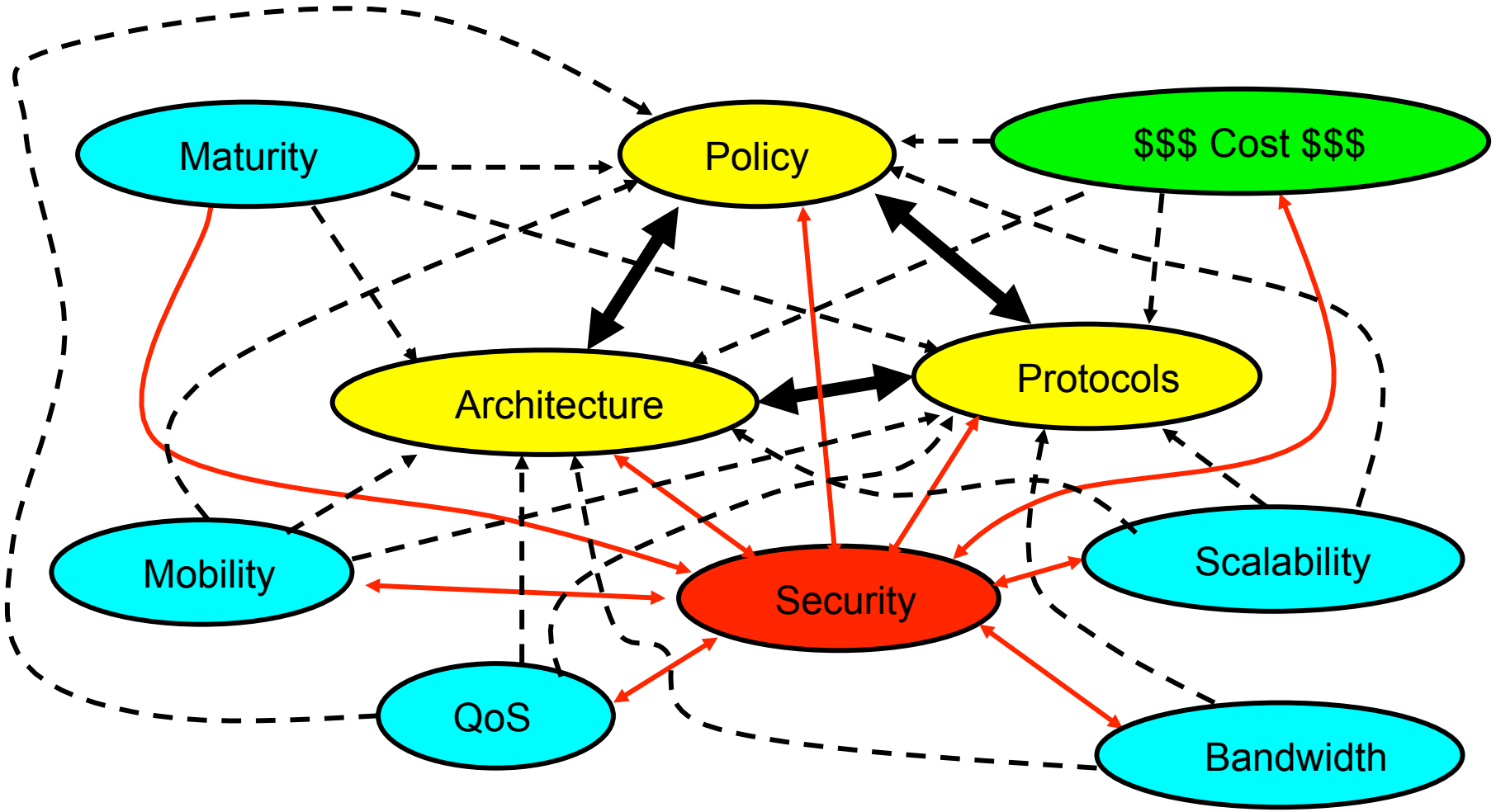
Networking 1

A crash course in networking

(Because Networking 101 requires more time)

Network Design Triangle



Protocol Stack

	OSI Model	TCP/IP Model	
	Application	Application	E-Mail, FTP, Web Browsing, etc…
	Presentation		
	Session		
Layer 4	Transport	Transport	TCP, UDP, SCTP, LTP. etc…
Layer 3	Network	Network	IPv4, IPv6
Layer 2	Data Link	Data Link	IEEE 802, SONET Frame Relay (HDLC), etc…
Layer 1	Physical	Physical	Wire, Fiber, RF, etc…

Basic Packet Characteristic

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Source	Originator
Destination	Where
QOS	Quality of Service
Hop Count	Prevents packets from circulating forever due to Routing loops.
CRC	Cyclical Redundancy Check for reliability
Data	Payload Data

Network Layers

- Why Layering?
  - Flexibility
  - Extensibility
  - Divide and conquer
- Transport Layer
  - Protocols to move data between end systems
- Network Layer
  - End-to-End addressing
  - Routing and Forwarding
- Data Link Layer
  - Point-to-Point addressing
  - Maps Network to physical layers
  - Provides media access (CDMA, TDMA, FDMA, Collision Sense Multiple Access, Aloha)

CCSDS relationship with the OSI Layers

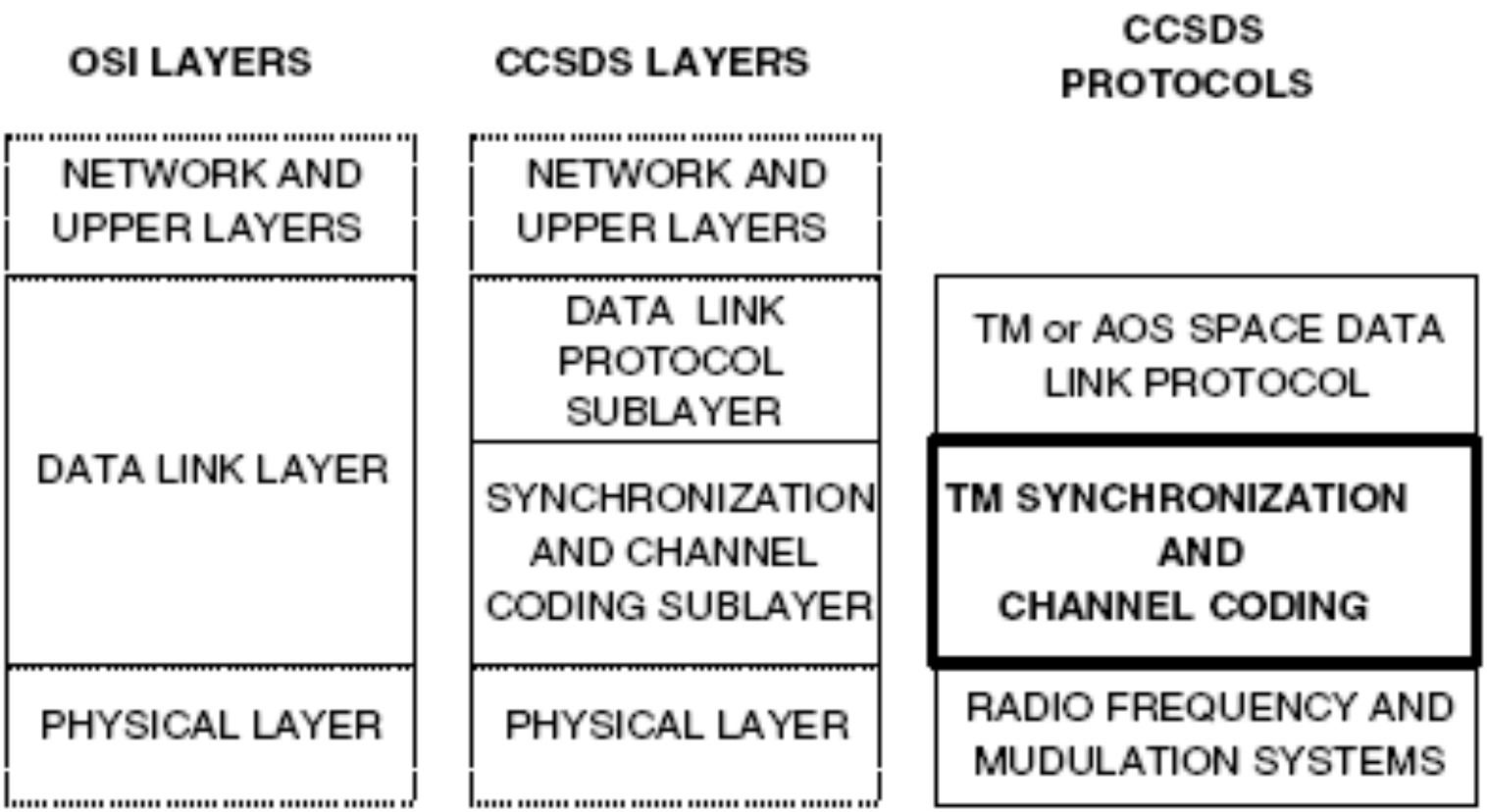

Figure 2-1: Relationship with OSI Layers

CCSDS Really Doesn't have a Network layer.

The Space Packet Protocol is designed to meet the requirements of space missions to efficiently transfer space application data of various types and characteristics over a network that involves a ground-to-space or space-to-space communications link (hereafter called space link).

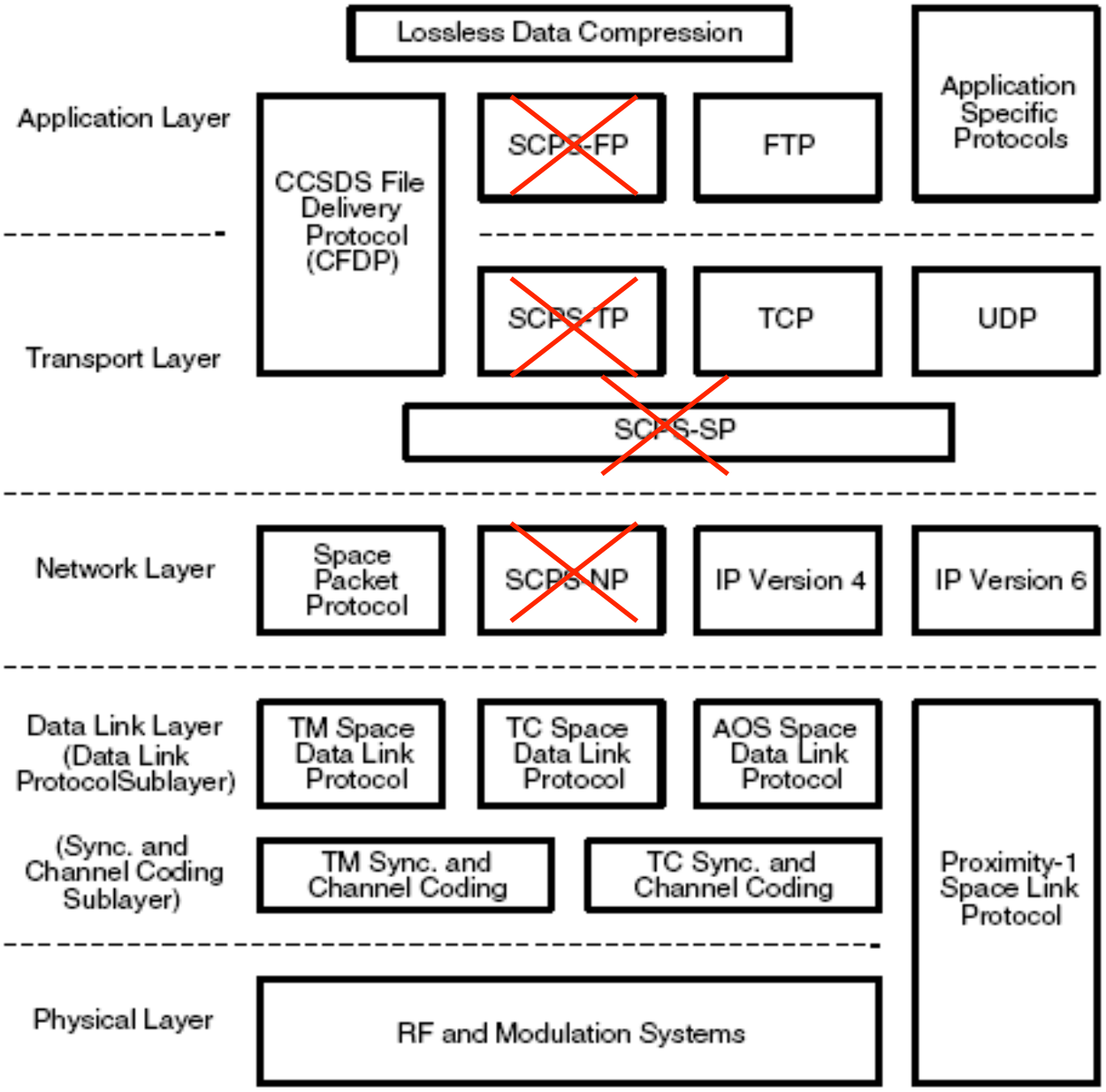

Figure 2-1: Space Link Protocols

Naming and Address Resolution

- Applications like Web has Name (www.nasa.gov)
  - Domain Name Server maps name to IP address
- Layer 3 had source, destination addresses
  - Layer 3 has ultimate source, destination
  - Address Resolution Protocol (ARP – IPv4) or Network Discovery (ND –ipv6) map network address to datalink address (i.e. Ethernet)
- Layer 2 was just point-to-point links (mostly)
  - Layer 2 has next hop source, destination

CCSDS Protocols and DTN have no automated naming and address resolution. Everything is manually configured.

Space Packet Protocol Addressing

- Each Logical Data Path (LDP) is uniquely identified by a Path ID. A Path ID consists of an Application Process Identifier (APID) and an optional APID Qualifier.
- An APID Qualifier identifies a naming domain for APIDs and APIDs are unique only in a single naming domain. *An APID naming domain usually corresponds to a spacecraft (or an element of a constellation of cooperating space vehicles).* Each space project shall establish APID naming domains to be used in their project. The assignment of APIDs to LDPs within a naming domain is controlled by the space project that owns the naming domain.

There is not global addressing scheme.
Everything is manually configured and mission unique.

Why all the confusion with TCP?

- TCP/IP (Transmission Control Protocol/Internet Protocol Suite)
  - A suite of protocols
  - Over 4000 Request for Comments (RFCs)
  - NOTE! Often times the term TCP is used as short hand for the TCP/IP protocol Suite. Lately, an attempt has been made to use IP for identify the TCP/IP protocols suite to alleviate the confusion between the TCP/IP suite and TCP the transport protocol.
- TCP (Transmission Control Protocol)
  - A Reliable Transport Protocol
  - Designed for fairness
    - Optimized for shared links
    - Congestion Control (Multiplicative Decrease / Additive Increase)
    - Self-Probing to discover link capacity
  - Delay and bandwidth sensitive (bandwidth/delay product)
- UDP (User Datagram Protocol)
  - An Unreliable Transport Protocol
  - No Congestion Control
  - Insensitive to delay
- IPv4 and IPv6 (Internet Protocol version 4 and Internet Protocol version 6)
  - Internet Protocols used to identify and route packets
  - Source and Destination Addresses
  - Quality of Service Bits
  - Hop Count (Used to keep packets from propagating continuously)
  - IP is insensitive to delay

IPv4 & IPv6 Header Comparison

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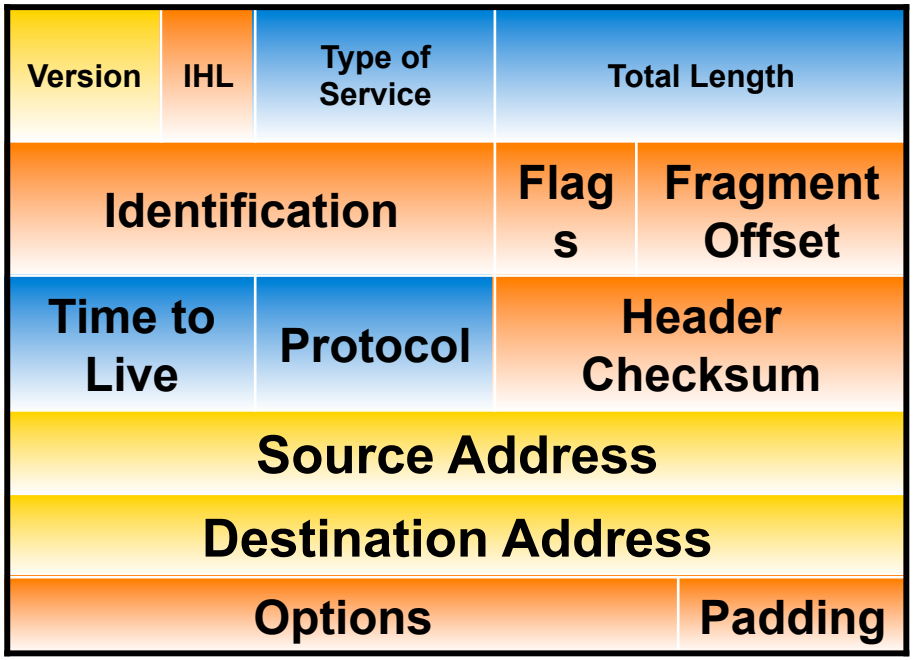
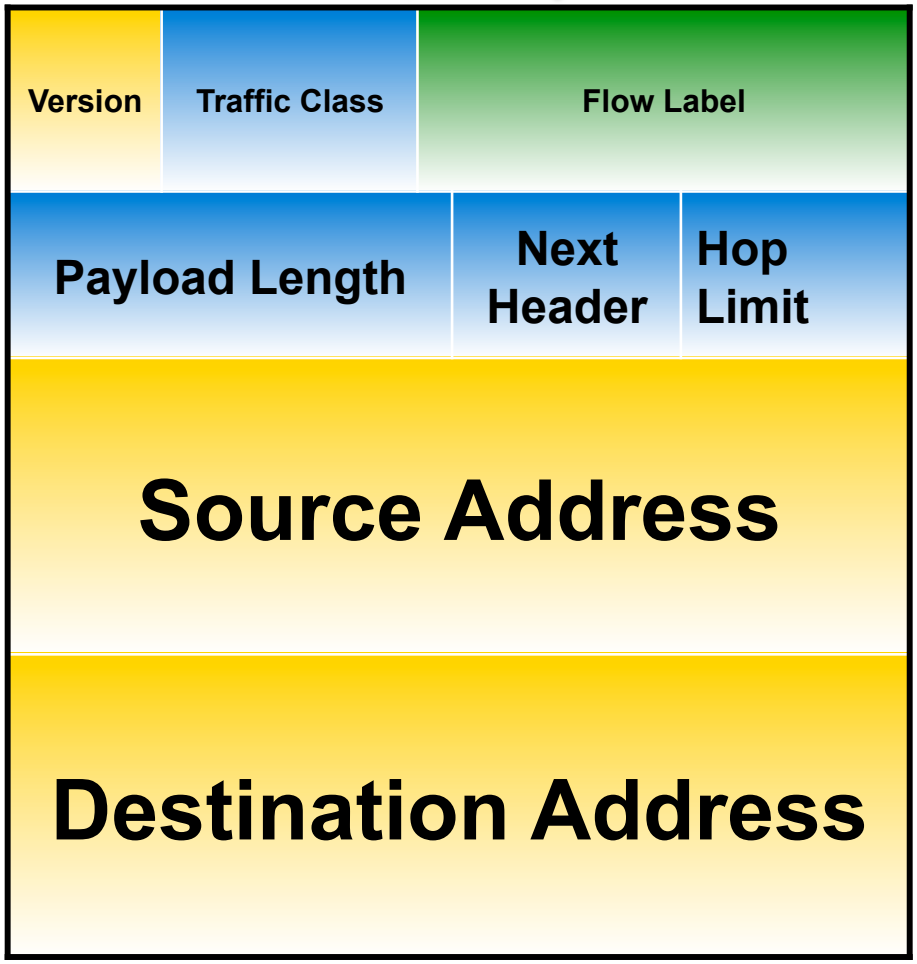
IPv4 Header 20 bytes



IPv6 Header, 40 bytes fixed



Legend

field's name kept from IPv4 to IPv6

fields not kept in IPv6

Name & position changed in IPv6

New field in IPv6

Important IPV6 Header Changes

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Fragmentation fields moved out of base header:

- Devices should do PATH MTU Discovery (Min MTU=1280 bytes vs. 68)
- IPv6 frag. & reasm. is an end-to-end function; routers do not fragment packets en-route if too big—they send ICMP "packet too big" instead.
- Though discouraged, can use the IPv6 Fragment Header to support upper layers that do not (yet) do path MTU discovery.

Header Checksum eliminated:

- There are already two layers of checksum at the transport and datalink layer, only exception is SLIP.
- UDP checksum required w/V6

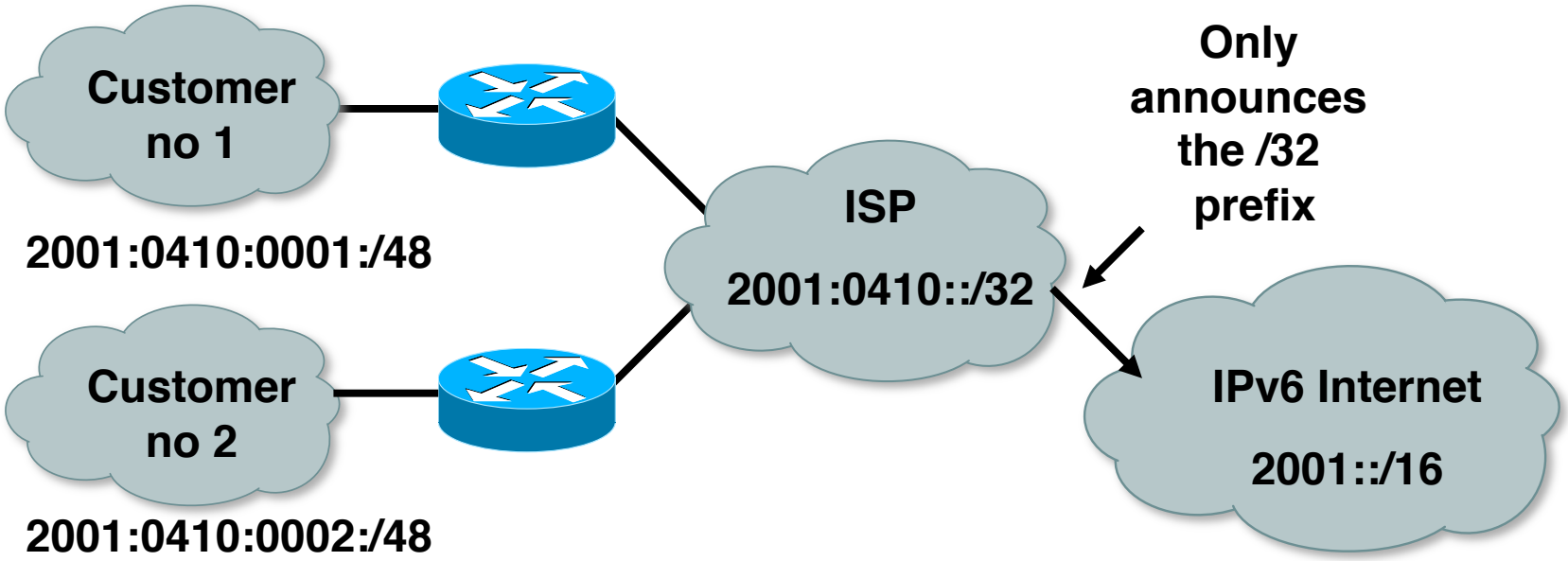
All fields in header are 64 bit aligned, however:

- 128 bit addresses are larger than the atomic word of most current processors so doing a lookup has a clear impact on performance.
- Packet filtering at L4 (TCP/UDP) results in parsing optional headers which equates to more CPU time
- In the long term, hardware will be optimized to take advantage of the 64 bit alignment to improve routing efficiency.

IP Routing

- Dynamic Routing is a service (application)
- Types/Terms
  - Default (Route of last resort)
  - Static (Predetermined)
  - Dynamic
    - Interior Gateway Protocols
      - RIP (Routing Information Protocol)
        - » Small Networks
      - Open Shortest Path First (OSPF)
        - » Many additional metrics available
        - » Widely used in large networks (e.g. DoD, Businesses, Universities)
    - Exterior Gateway Protocols
      - BGP (Boarder Gateway Protocol)
        - » Used in the Big Internet such as between ISPs (Internet Service Providers)
  - MANETs (Mobile Ad hoc NETworks)
    - Self-configuring and self-organizing network of mobile nodes usually connected via wireless links
    - Proactive routing protocols Optimized Link State Routing (OLSR), Open Shortest Path First (OSPF) extension
      - Applicable for relatively stable networks
      - Suitable for large and dense networks
    - Reactive routing protocol Ad Hoc On-Demand Distance Vector (AODV), Dynamic Source Routing protocol (DSR), Dynamic MANET On-demand (DYMO)
      - Applicable to highly dynamic networks

Hierarchical Addressing & Aggregation

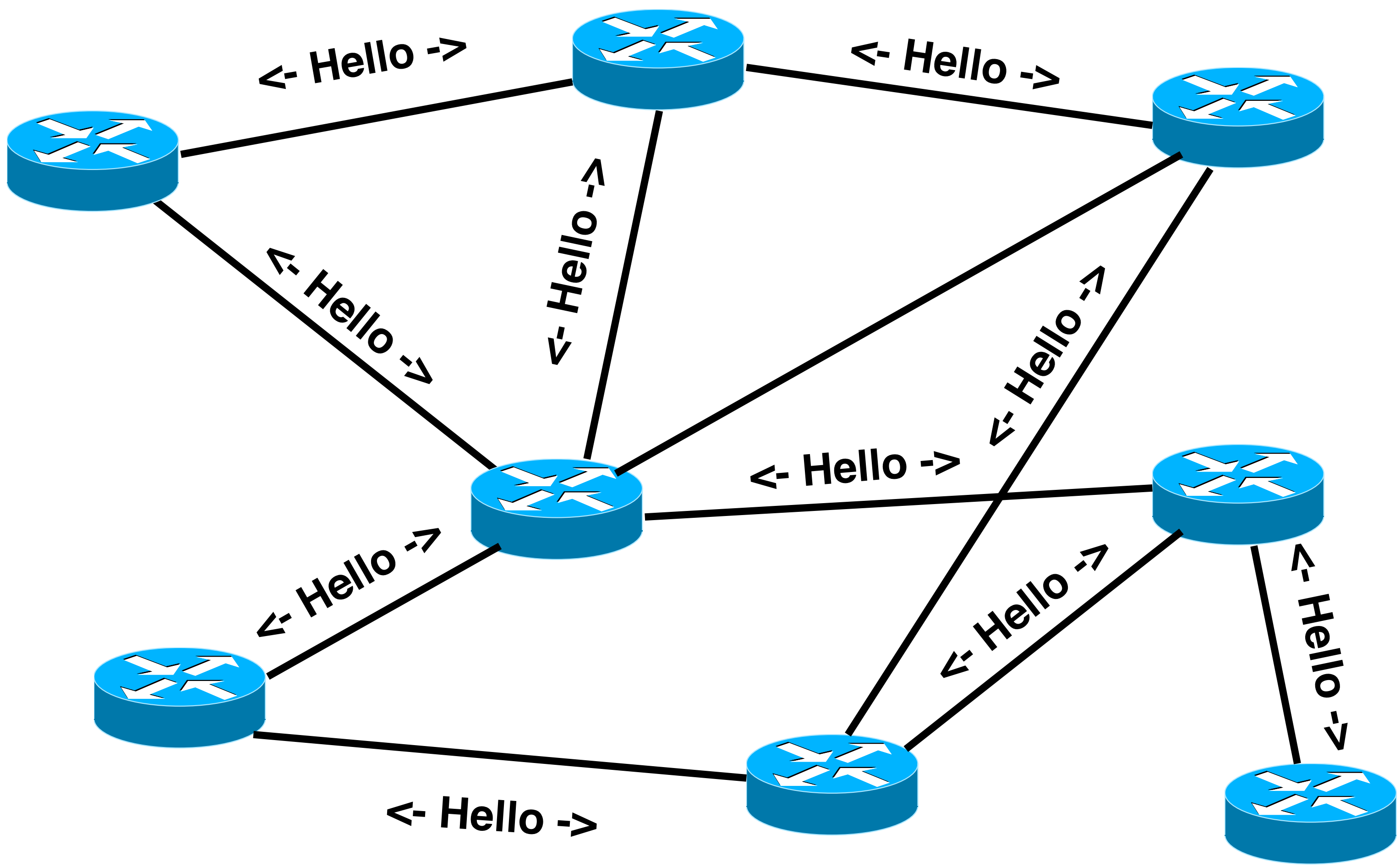


–Larger address space enables:

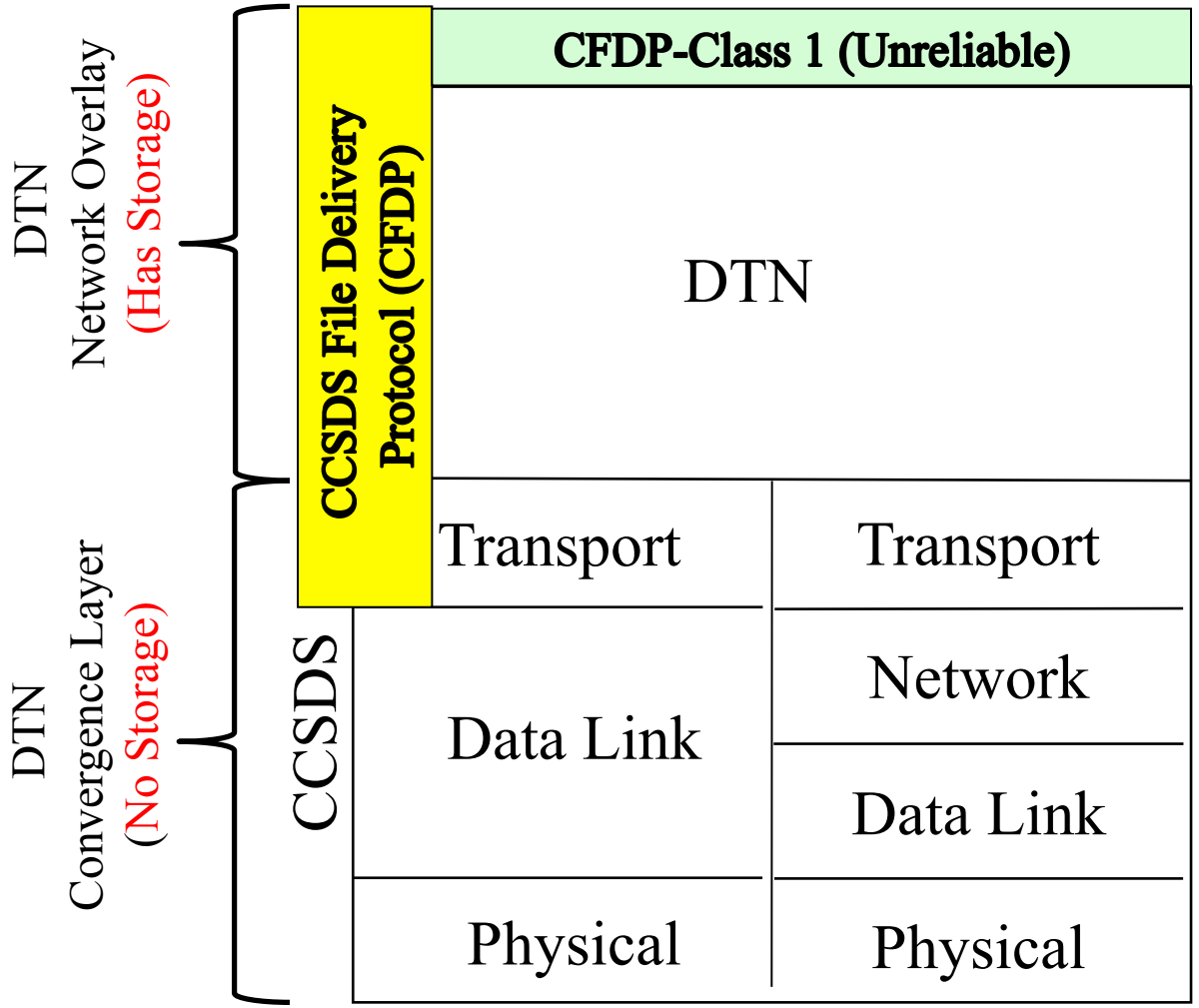
Aggregation of prefixes announced in the global routing table.

- Helps improve routing speed.
- Efficient and scalable routing.

IP Router Discovery



DTN



DTN is a network overlay that resides on top of other networks. DTN has many characteristics of an Application Layer Gateway
Note Well: DTN has no Addressing just naming (End Point Identifier –EID)! It is a flat network with no current mechanism for aggregation.

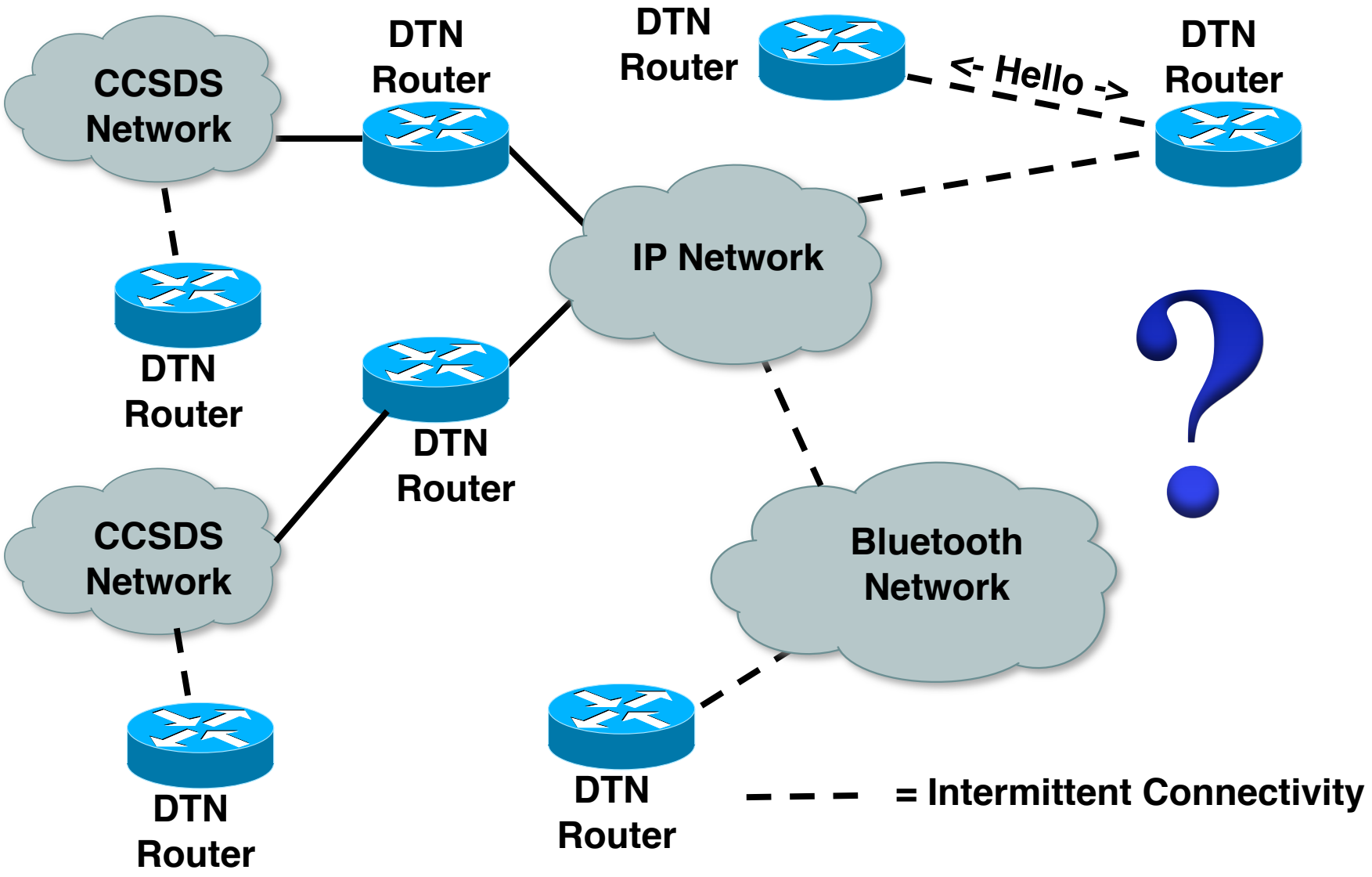
TCP, UDP, SCTP, LTP, etc…

IPv4, IPv6

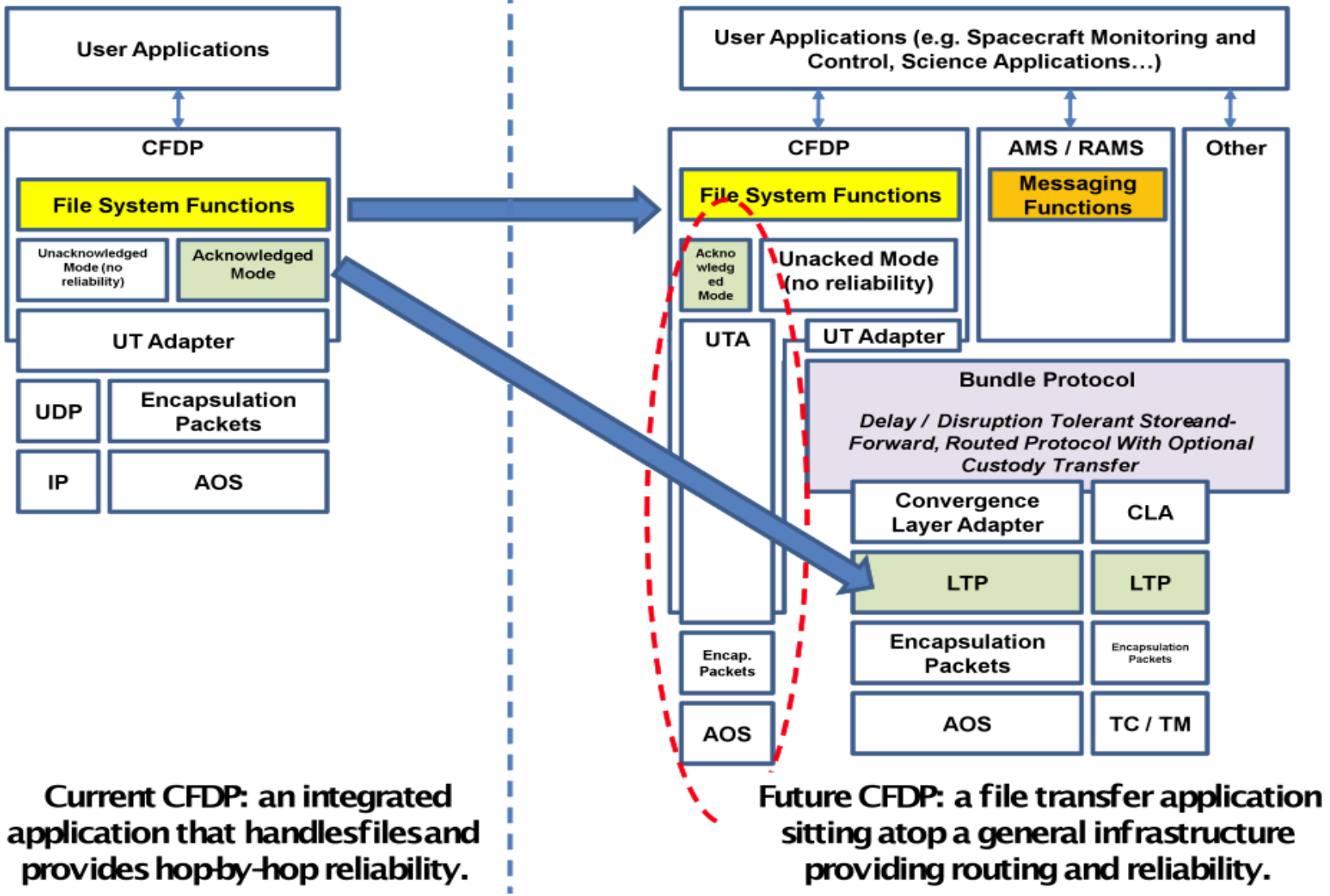
IEEE 802, SONET
Frame Relay (HDLC), etc…

Wire, Fiber, RF, etc…

DTN Router Agent Discovery ?



DTN for Space

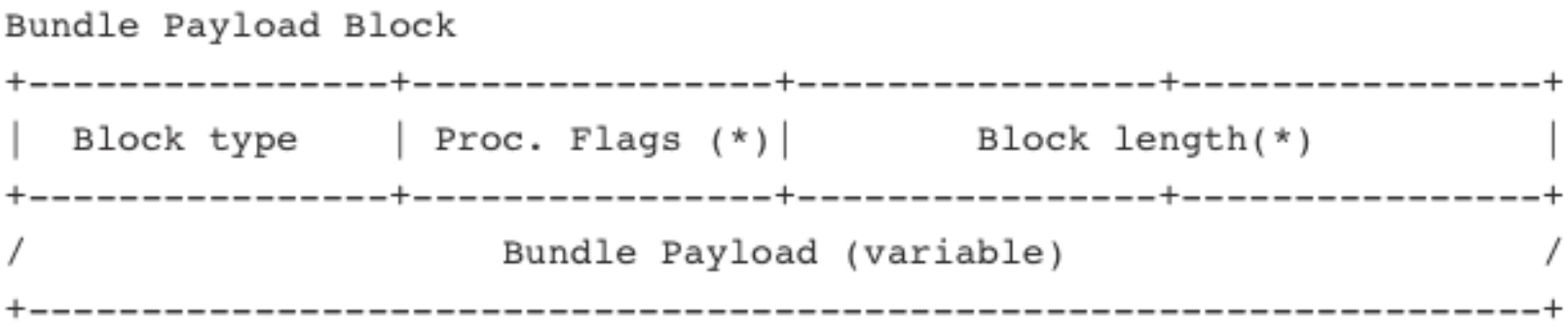


Bundle Format – Primary block

Version (1 byte)	Bundle Processing Control Flags (SDNV)
Block Length (SDNV)	
Destination Scheme Offset (SDNV)	Destination SSP Offset (SDNV)
Source Scheme Offset (SDNV)	Source SSP Offset (SDNV)
Report-To Scheme Offset (SDNV)	Report-To SSP Offset (SDNV)
Custodian Scheme Offset (SDNV)	Custodian SSP Offset (SDNV)
Creation Timestamp (SDNV)	
Creation Timestamp Sequence Number (SDNV)	
Lifetime (SDNV)	
Dictionary Length (SDNV)	
Dictionary (byte array)	
Fragment Offset (SDNV, optional)	
Application data unit length (SDNV, optional)	

Source: "DTN: An Architectural Retrospective," Fall, K. Farrell, S., IEEE Journal on Selected Areas in Communications, Volume: 26, Issue: 5, pp: 828-836, June 2008.

Bundle Payload/Extension Block



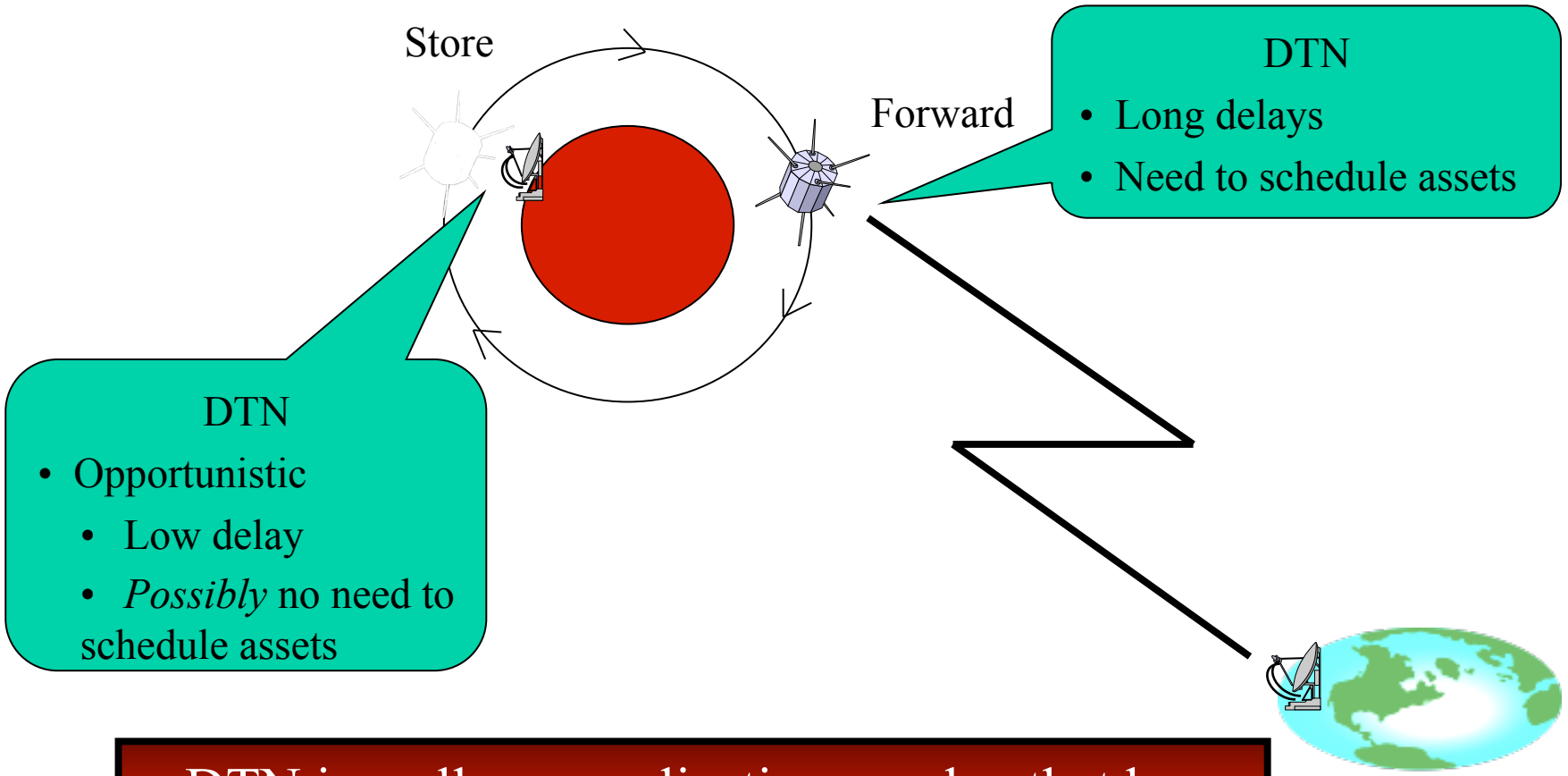
Bundle Extension Blocks

"Extension blocks" are all blocks other than the primary and payload blocks. ***Because extension blocks are not defined in the Bundle Protocol specification (the present document), not all nodes conforming to this specification will necessarily instantiate Bundle Protocol implementations that include procedures for processing (that is, recognizing, parsing, acting on, and/or producing) all extension blocks***. It is therefore possible for a node to receive a bundle that includes extension blocks that the node cannot process.

Whenever a bundle is forwarded that contains one or more extension blocks that could not be processed, the "Block was forwarded without being processed" flag must be set to 1 within the block processing flags of each such block. For each block flagged in this way, the flag may optionally be cleared (i.e., set to zero) by another node that subsequently receives the bundle and is able to process that block…

Extension Blocks are great for research, but critical items MUST be in the main header (i.e. hop count).

Delay/Disruption Tolerant Networking (DTN)



DTN is really an application overlay that has aspects of scheduling, data transport and routing.

Contract Graph Routing (CGR)

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- Bandwidth
- Contact Time
- Link Quality ??? (probably not)
- Bundle Size
  - Assume a Max of 64KBytes ??? (Probably, but this assumes de-aggregation.)
- Bundle Lifetime
- Quality of Service

DTN Routing is far harder than IP routing and even Mobile Ad Hoc Networking (manet) routing. DTN routing is very much a research area.

Amazon Protocol Example (Aggregation … or Not!)

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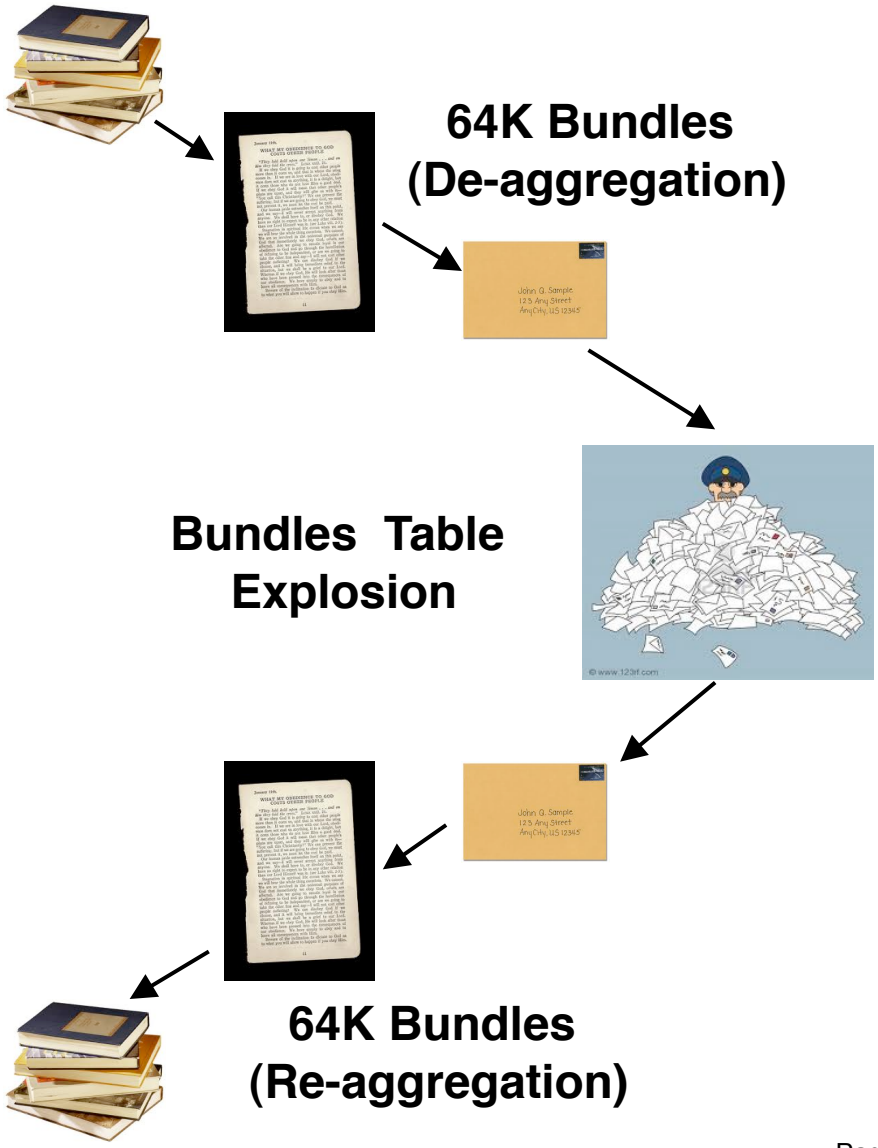
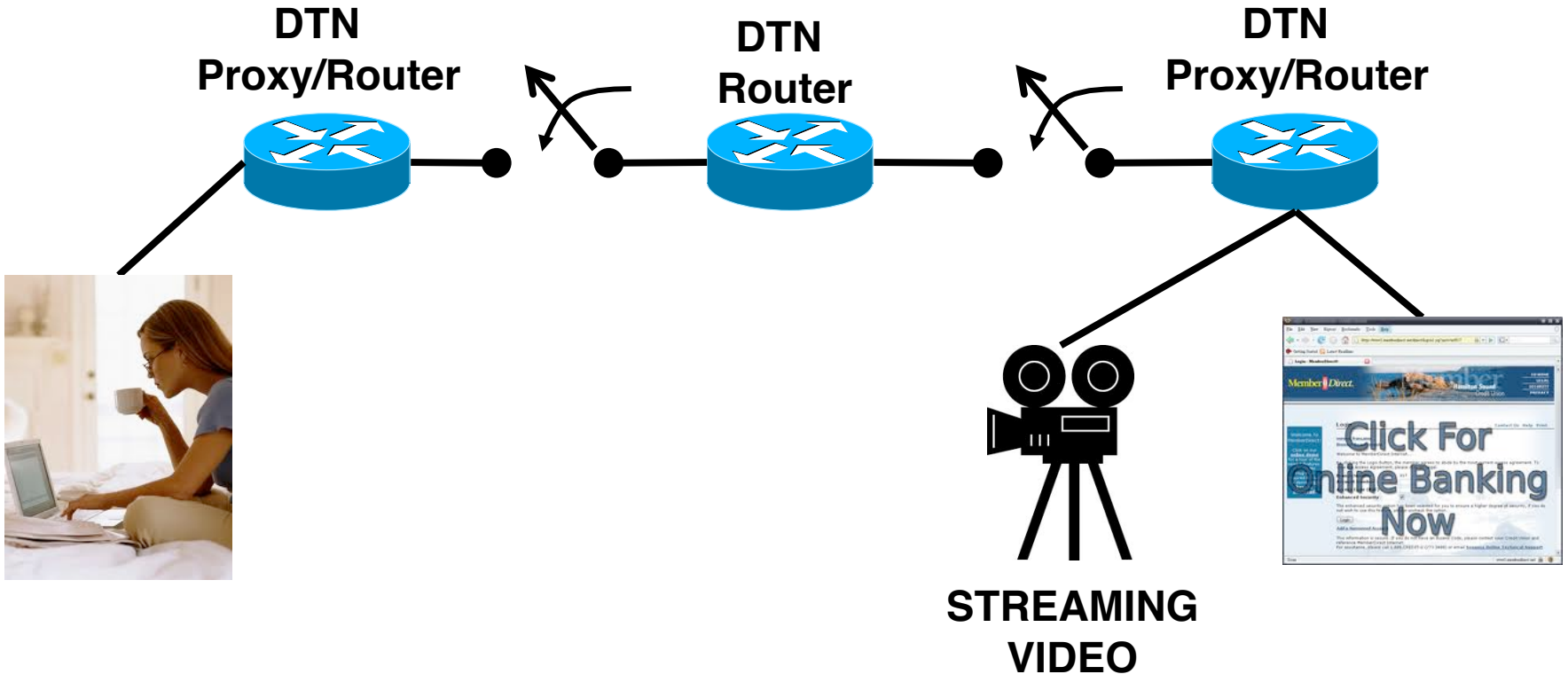


DTN Applications



Applications must be DTN Aware!

Network Security

- Where
  - Data/Application
    - End-to-End
  - Transport
    - Transport Layer Security (TLS)
    - End-to-End
  - Network
    - IPsec (IP Security)
    - End-to-End
    - DTN (Bundle Security Protocol)
  - Data-Link Layer (Bulk Encryption)
    - Point-to-Point
- Key Types
  - Symmetric
    - Pre-placed Keys
    - Insensitive to delay
  - Asymmetric
    - Public Key Infrastructure (PKI)
    - Generally sensitive to delay
- Issues
  - Key Management (Distribution)
  - Policy Management (Distribution)
  - ITAR

- Security is hard.
- Security breaks (changes) everything.
- Security cannot be done as an afterthought.

Summary and Important Information

- Network design entails Policy, Protocols and Architecture
- Protocols are tools
  - Be sure to apply the proper tool relative to the environment being used.
  - One size does not fit all!
- TCP/IP is a suite of international commercial-off-the-shelf protocols
  - Protocols that require handshaking or a response/replay do not work over long delays and intermittently connected networks
  - Protocols that require infrastructure may not necessarily be applicable to space unless caching of information is used.
  - Many TCP/IP protocols are delay insensitive and can be utilized in a variety of environments.
- Default routes and Static routes can get one in trouble – be careful
- One of the great powers of COTS products is the debugging tools
- In a Delay/Disruption Tolerant Network, the Applications MUST be designed to handle that environment!