

Layer 1, 2 and 3 Refresher

Campus Network Design & Operations Workshop



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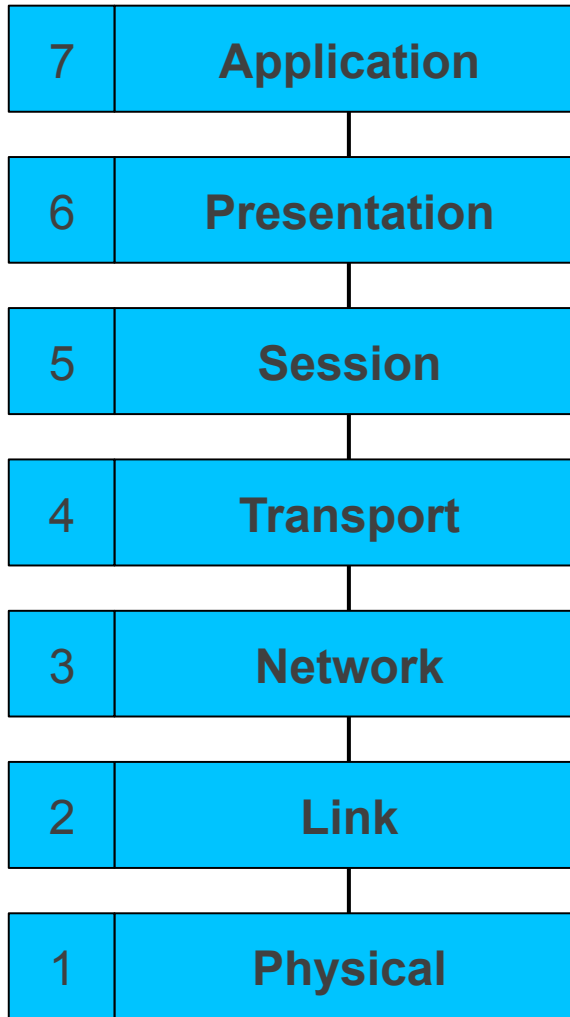
Last updated 20th April 2017



Objectives

- To revise core networking concepts
- To ensure we are using the same terminology

What is this?



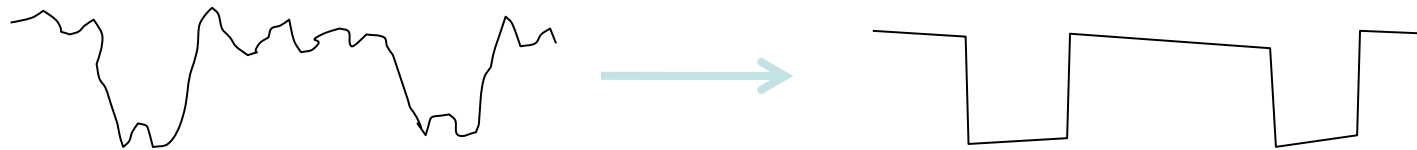
Layer 1: Physical Layer

- Transfers a stream of bits
- Defines physical characteristics
 - Connectors, pinouts
 - Cable types, voltages, modulation
 - Fibre types, lambdas
 - Transmission rate (bps)
- No knowledge of bytes or frames



Types of equipment

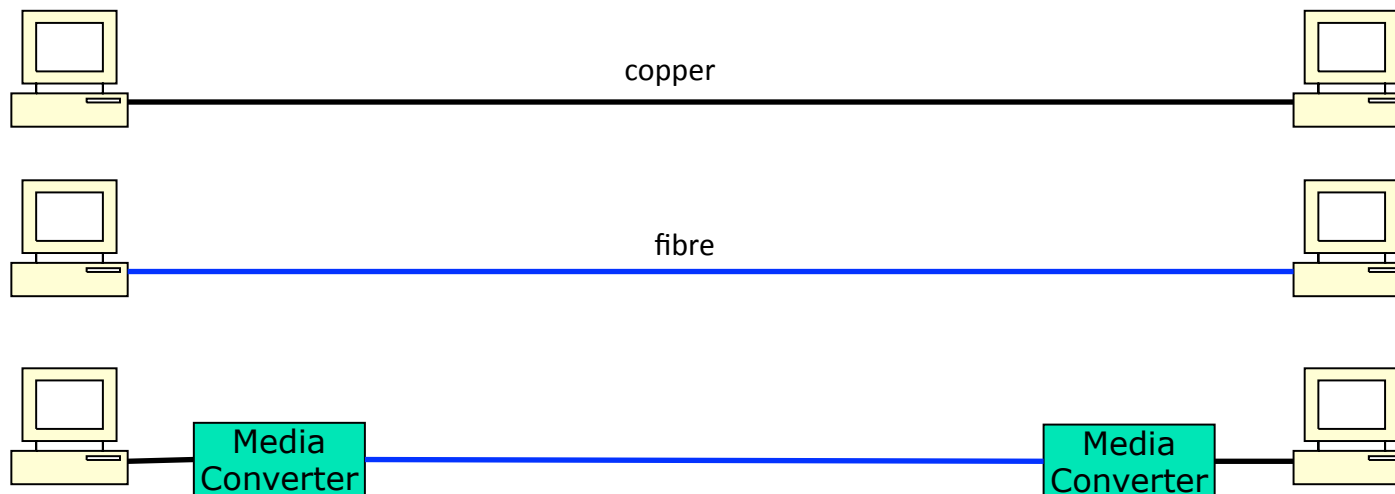
- Layer 1: Hub, Repeater, Media Converter
 - Hubs & Repeaters are not used any more!
- Works at the level of individual bits



- All data sent out of all ports
- Hence data may end up where it is not needed

Building networks at Layer 1

- What limits do we hit?
 - Cat5E/Cat6 cable length?
 - Fibre length?
 - Fibre type?
 - Media converters?

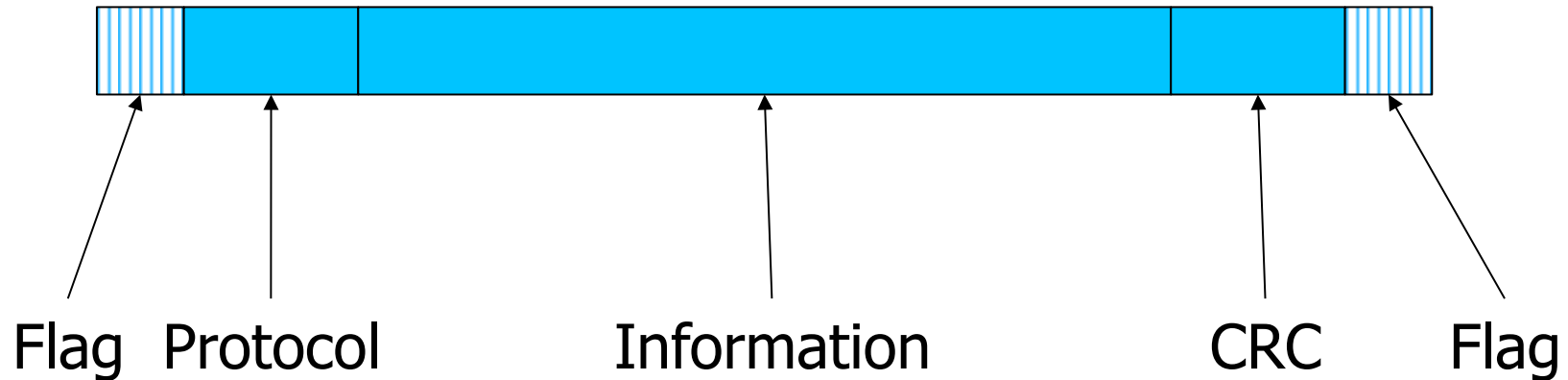


Layer 2: (Data) Link Layer

- Organises data into *frames*
- May detect transmission errors (corrupt frames)
- May support shared media
 - Addressing (unicast, multicast) – who should receive this frame
 - Access control, collision detection
- Usually identifies the L3 protocol carried

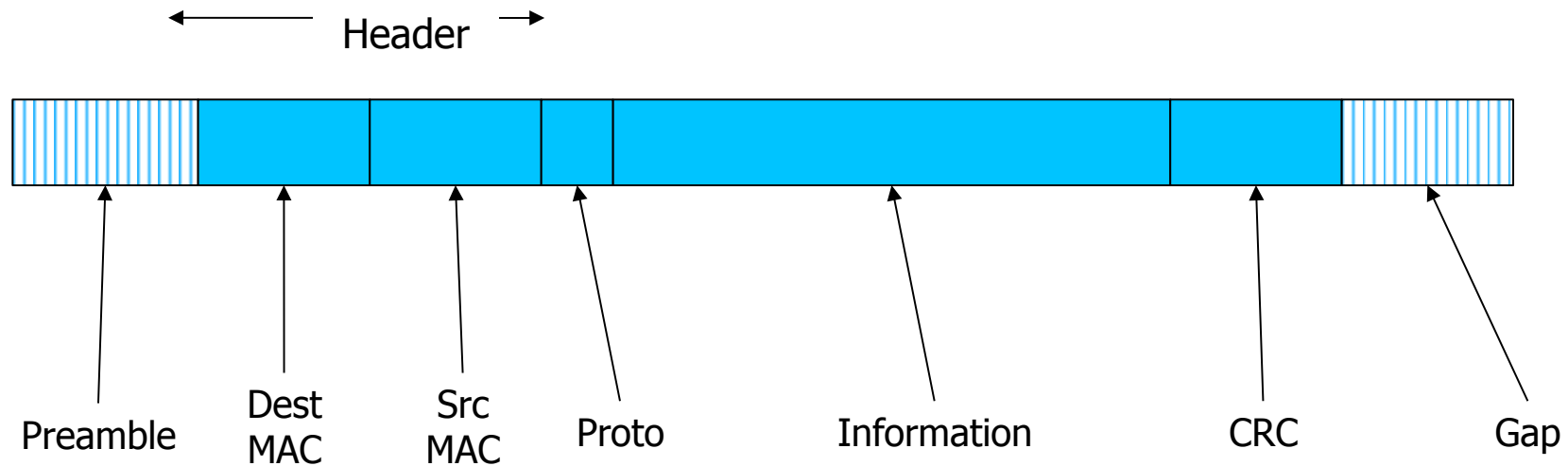


Example Layer 2: PPP



- Also includes link setup and negotiation
 - Agree link parameters (LCP)
 - Authentication (PAP/CHAP)
 - Layer 3 settings (IPCP)

Example Layer 2: Ethernet



- MAC addresses
- Protocol: 2 bytes
 - e.g. 0800 = IPv4, 0806 = ARP, 86DD = IPv6
- Preamble: carrier sense, collision detection

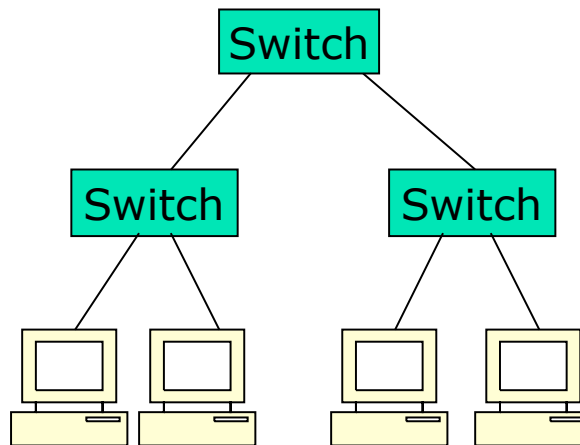
Types of equipment (contd)

- Layer 2: **Switch, Bridge**
- Receives whole layer 2 frames and selectively retransmits them
- Learns which MAC addr is on which port
- If it knows the destination MAC address, will send it out only on that port
- Broadcast frames must be sent out of all ports, just like a hub
- Doesn't look any further than L2 header



Building networks at Layer 2

- What limits do we hit?
 - How many switches?
 - How many devices per switch?

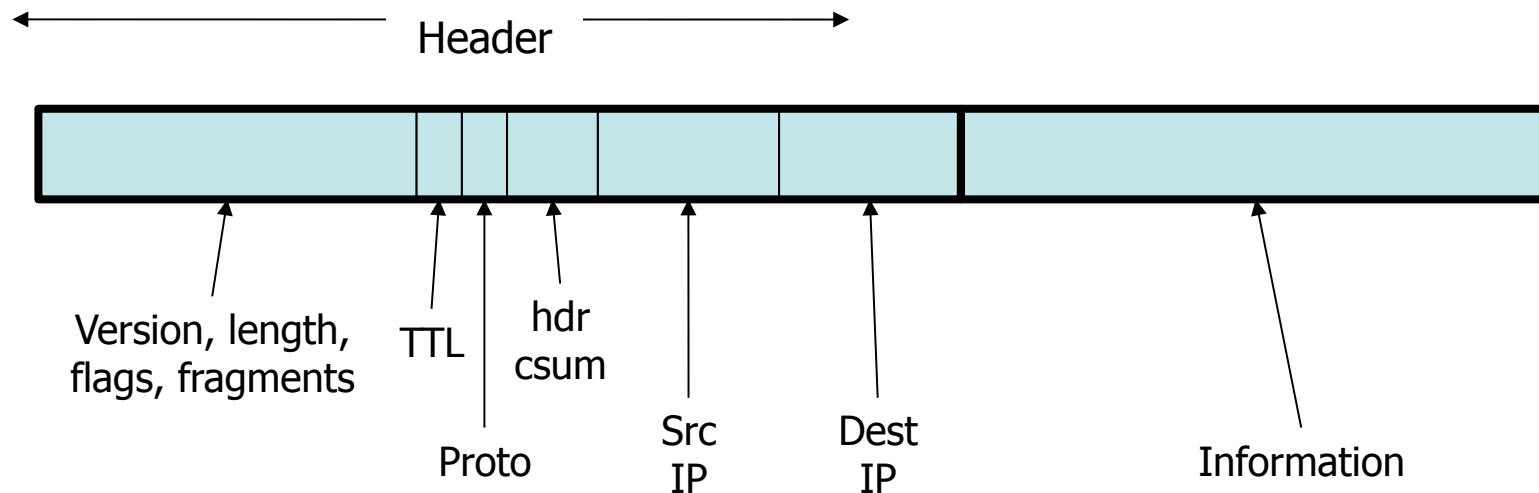


Layer 3: (Inter)Network Layer

- Connects Layer 2 networks together
 - Forwarding data from one network to another
 - These different networks are called subnets (short for sub-network)
- **Universal datagram (Layer 3 data unit) format**
- Unified addressing scheme
 - Independent of the underlying L2 network(s)
 - Addresses organised so that it can scale globally (aggregation)
- Identifies the layer 4 protocol being carried
- Fragmentation and reassembly



Example Layer 3: IPv4 Datagram



- Src, Dest: IPv4 addresses
- Protocol: 1 byte
 - e.g. 6 = TCP, 17 = UDP (see /etc/protocols)

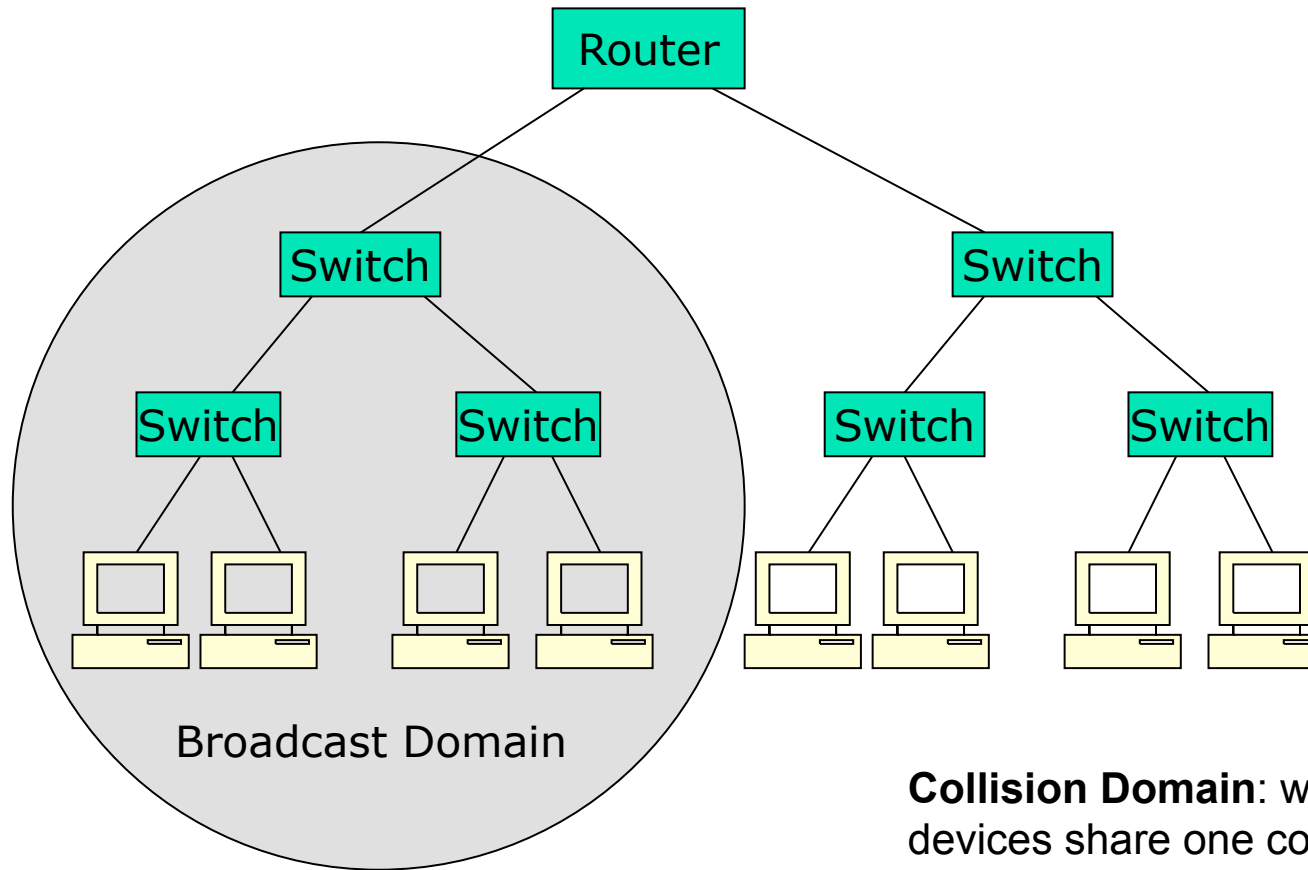


Types of equipment (contd)

- Layer 3: **Router**
- Looks at the destination IP in its Forwarding Table to decide where to send next
- Collection of routers managed together is called an “Autonomous System”
- The forwarding table can be built by hand (static routes) or dynamically
 - Within an AS: IGP (e.g. OSPF, IS-IS)
 - Between ASes: EGP (e.g. BGP)



Traffic Domains



Broadcast Domain: all devices on the same sub-network

Collision Domain: where several devices share one communication medium (for example, on wireless networks)



Network design guidelines

- No more than ~250 hosts on one subnet
 - Implies: subnets no larger than an IPv4 /24
 - Maybe bigger if a lot of address churn (e.g. roaming wireless devices)
- Campus guideline
 - At least one subnet per building
 - More than one subnet will usually be required for larger buildings

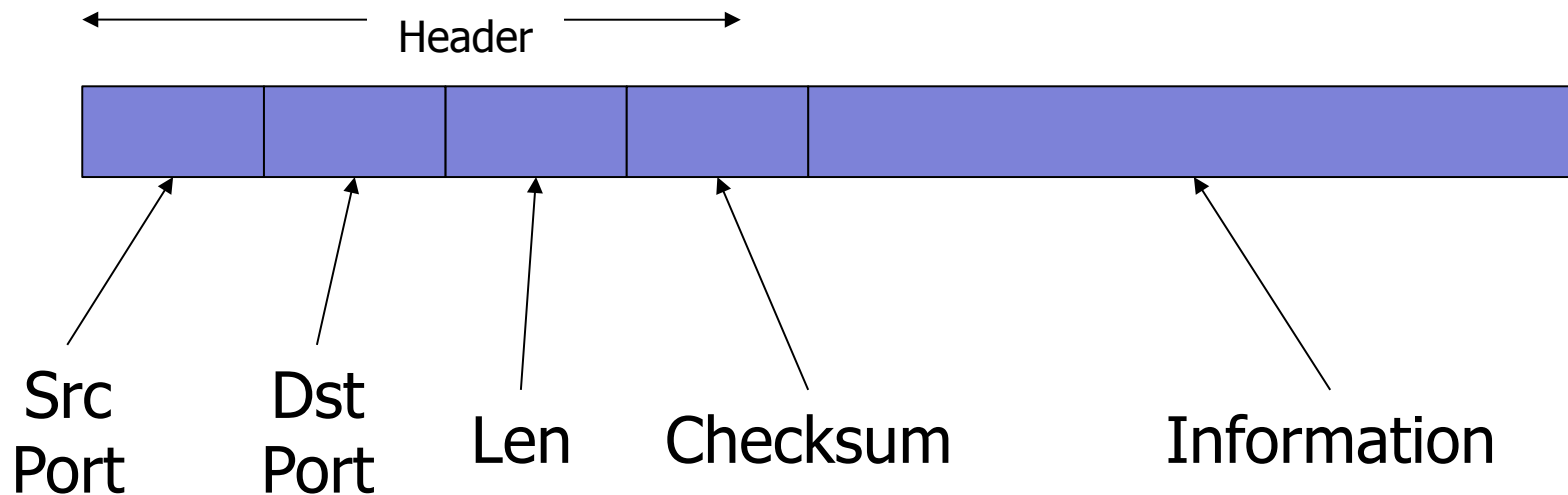


Layer 4: Transport Layer

- Identifies the *endpoint* process
 - Another level of addressing (port number)
- May provide reliable delivery
 - Streams of unlimited size
 - Error correction and retransmission
 - In-sequence delivery
 - Flow control
- Might just be unreliable datagram transport



Example Layer 4: UDP



- Port numbers: 2 bytes
 - Well-known ports: e.g. 53 = DNS
 - Ephemeral ports: ≥ 1024 , chosen dynamically by client



Layers 5 and 6

- Session Layer: long-lived sessions
 - Re-establish transport connection if it fails
 - Multiplex data across multiple transport connections
- Presentation Layer: data reformatting
 - Character set translation
- Neither exist in the TCP/IP suite: the application is responsible for these functions



Layer 7: Application layer

- The actual work you want to do
- Protocols specific to each application
- *Give some examples*



OSI vs TCP/IP

OSI	TCP/IP
Application	Application
Presentation	
Session	
Transport	Transport (host-to-host)
Network	Internet
Data Link	Network Access
Physical	Physical

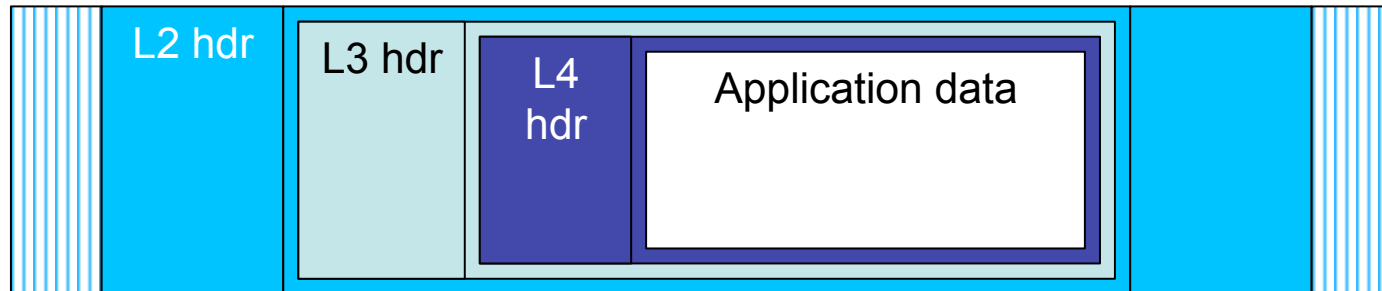
Source: William Stallings
*"Data and Computer
Communications"*



Encapsulation

- Each layer provides services to the layer above
- Each layer makes use of the layer below
- Data from one layer is *encapsulated* in frames of the layer below

Encapsulation in action



- L4 segment contains part of stream of application protocol
- L3 datagram contains L4 segment
- L2 frame has L3 datagram in data portion



For discussion

- Can you give examples of equipment which interconnects two networks and operates at layer 4? At layer 7?
- At what layer does a wireless access point work?
- What is a “Layer 3 switch”?
- How does traceroute find out the routers which a packet traverses?

Debugging Tools

- What tools can you use to debug your network
 - At layer 1?
 - At layer 2?
 - At layer 3?
 - Higher layers?



Questions?



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