Campus Network Design Workshop

Layer 1, 2 and 3 Refresher

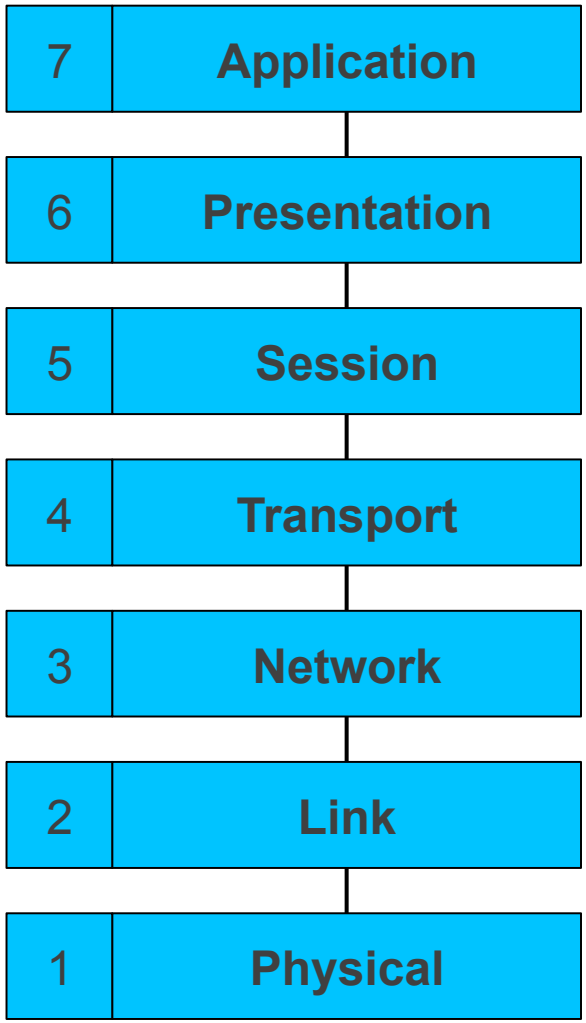
UNIVERSITY OF OREGON

NSRC
Network Startup Resource Center

Objectives

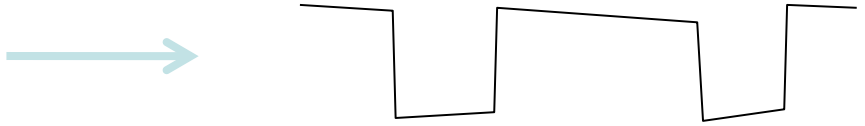
- To revise core networking concepts
- To ensure we are using the same terminology

What is this?


7
Application
6
Presentation
5
Session
4
Transport
3
Network
2
Link
1
Physical

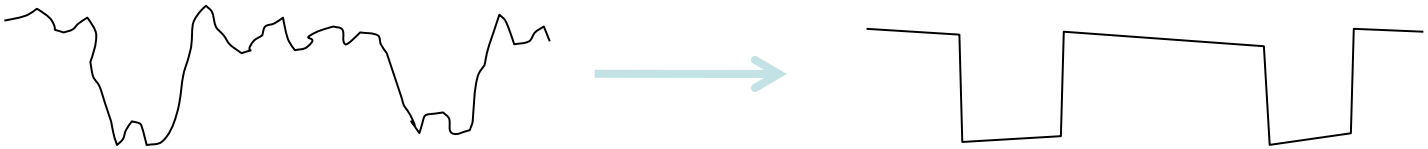
Layer 1: Physical Layer

- 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

101101 

Types of equipment

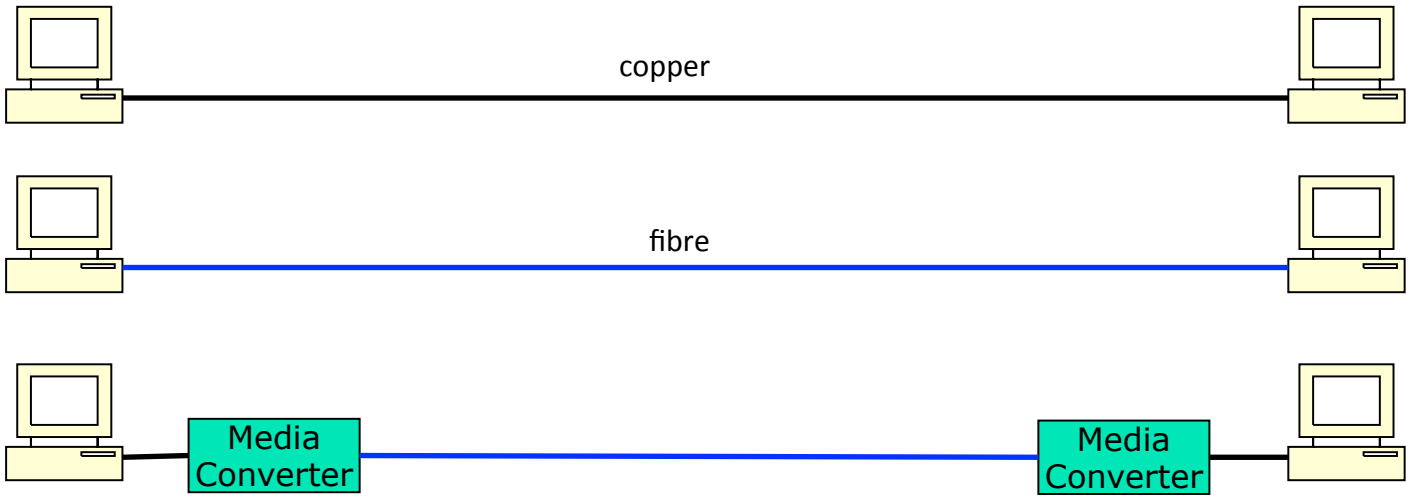
- Layer 1: Hub, Repeater, Media Converter
  - Hubs & Repeaters are not used any more!
- Works at the level of individual bits



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

Building networks at Layer 1

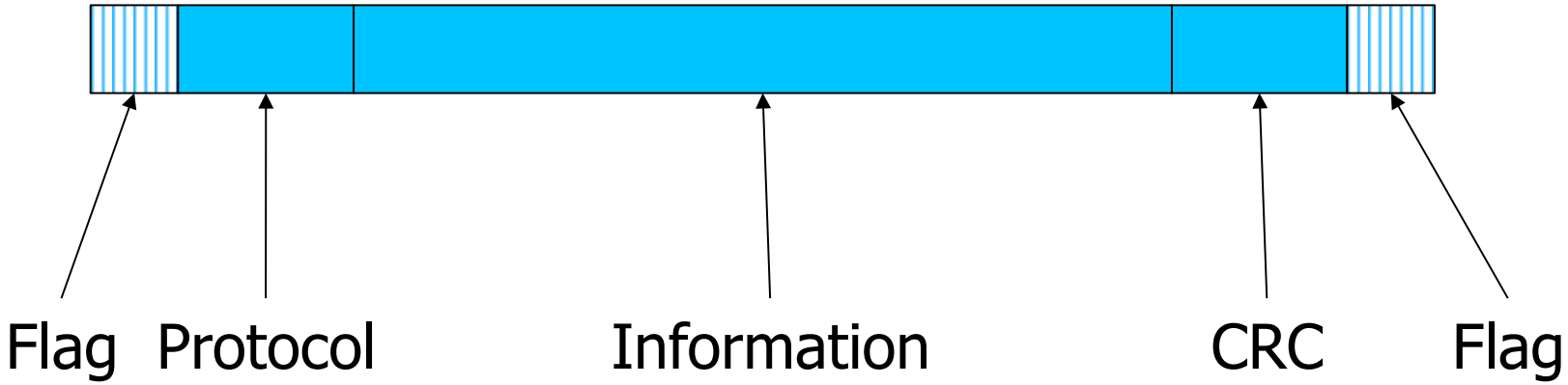
- What limits do we hit?
  - Cat5E/Cat6 cable length?
  - Fibre length?
  - Fibre type?
  - Media converters?



Layer 2: (Data) Link Layer

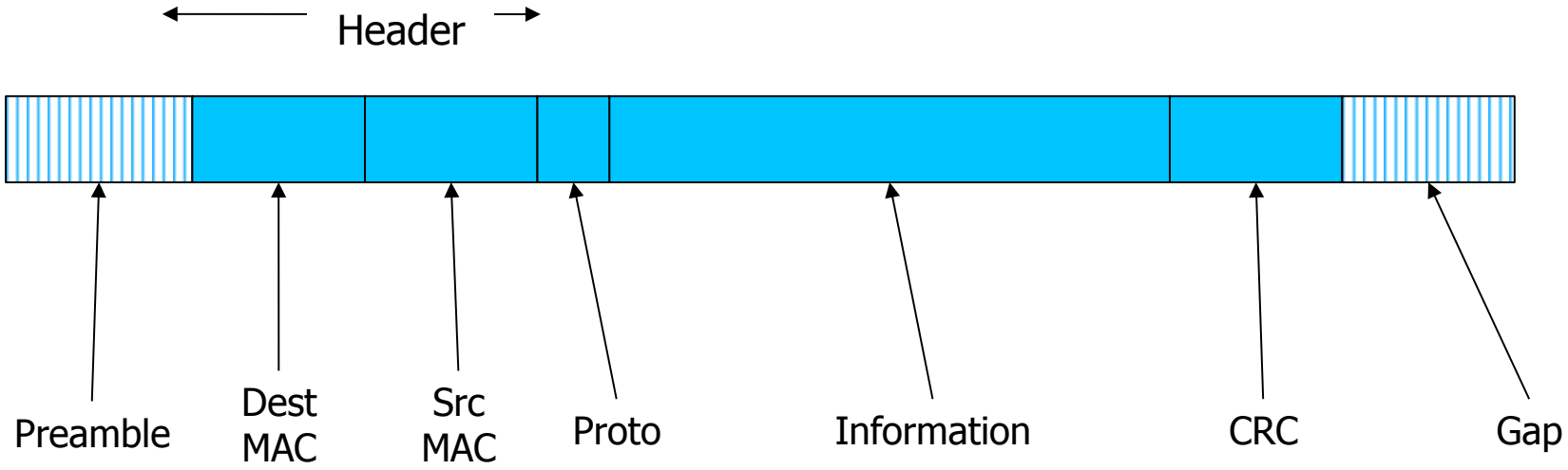
- Organises data into *frames*
- May detect transmission errors (corrupt frames)
- May support shared media
  - Addressing (unicast, multicast) – who should receive this frame
  - Access control, collision detection
- Usually identifies the L3 protocol carried

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



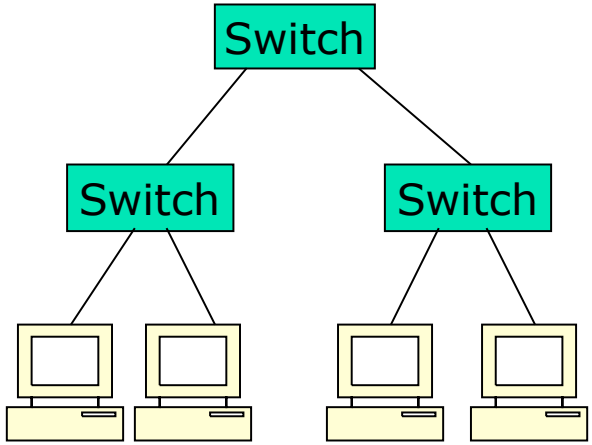
- MAC addresses
- Protocol: 2 bytes
  - e.g. 0800 = IPv4, 0806 = ARP, 86DD = IPv6
- Preamble: carrier sense, collision detection

Types of equipment (contd)

- Layer 2: **Switch, Bridge**
  - Bridges are not used any more
- 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

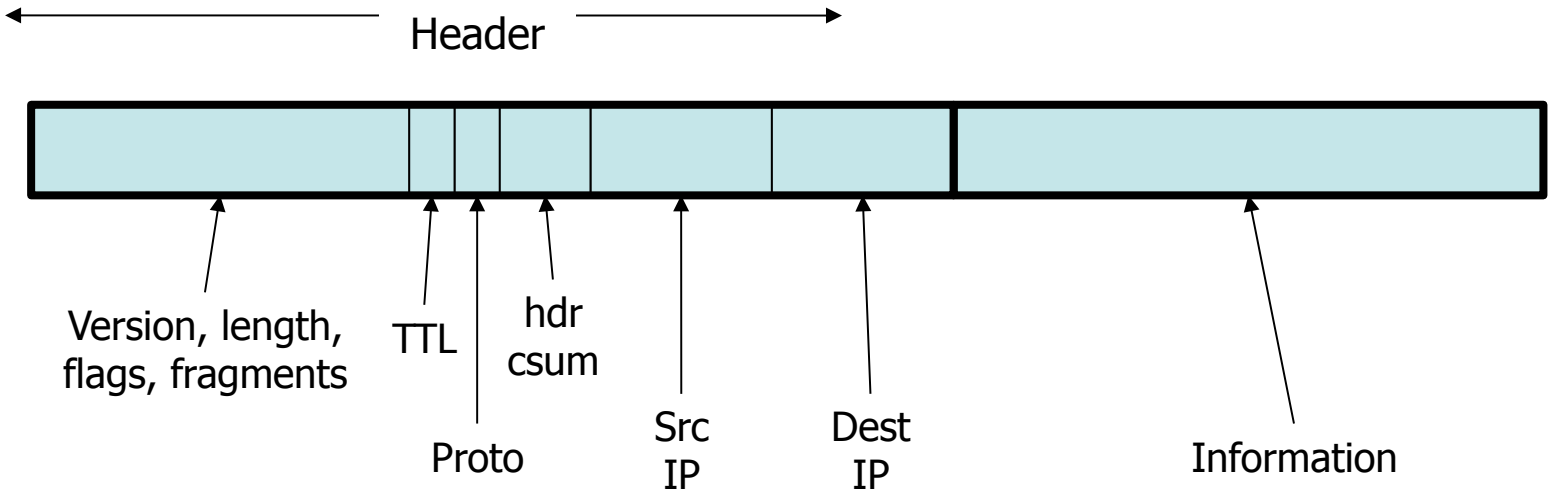
- What limits do we hit?
  - How many switches?
  - How many devices per switch?



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 frame format (datagram)
- 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

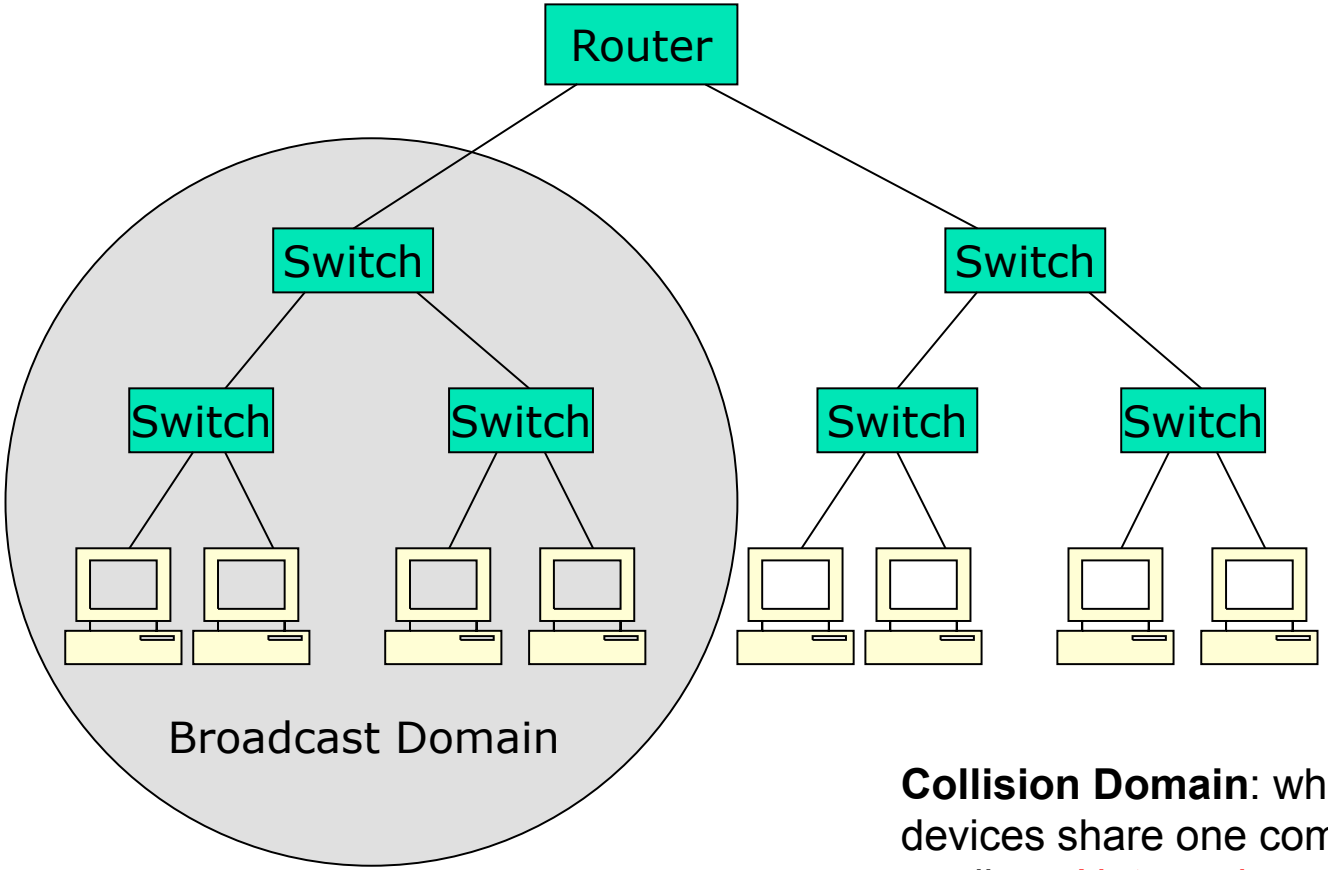


- Src, Dest: IPv4 addresses
- Protocol: 1 byte
  - e.g. 6 = TCP, 17 = UDP (see /etc/protocols)

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. Not used any more because the more devices sharing the one medium, the slower the communication becomes.

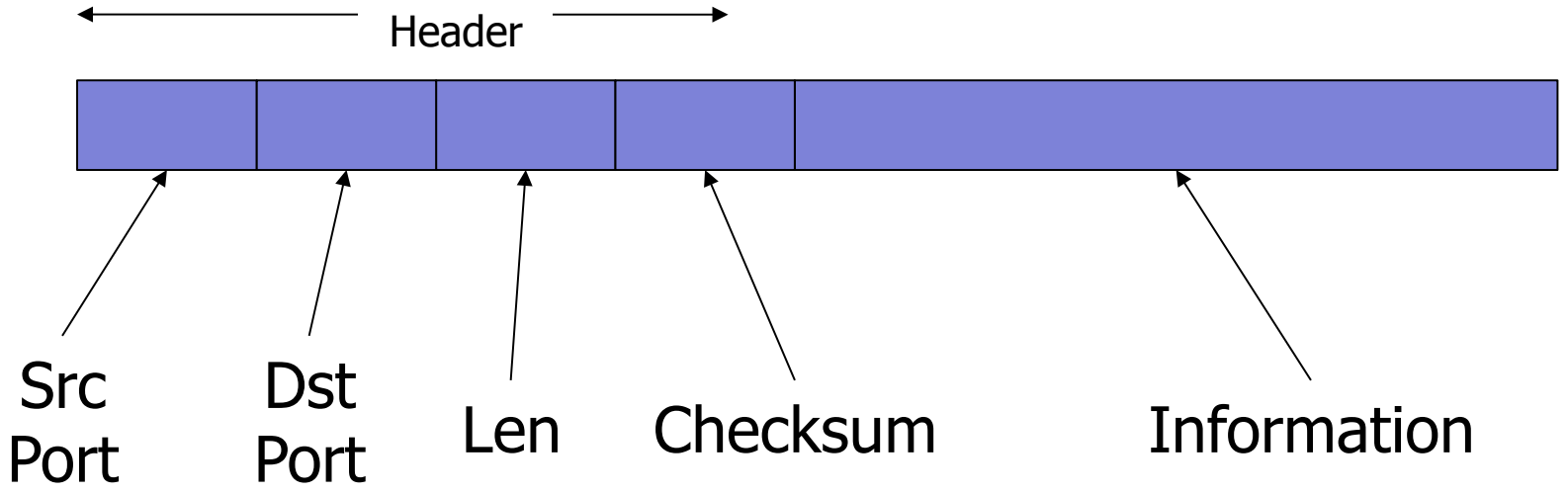
Network design guidelines

- 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

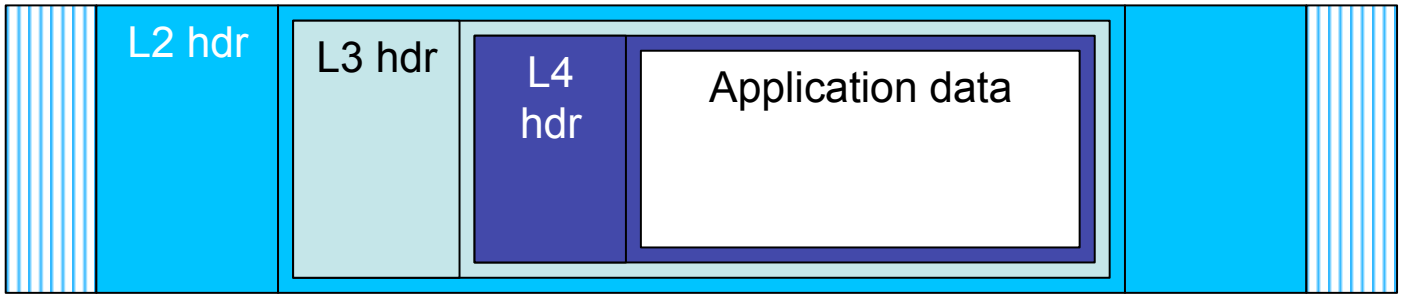
Layer 7: Application layer

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

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?