Campus Networking Workshop

Networking Fundamentals Refresher

Objectives

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

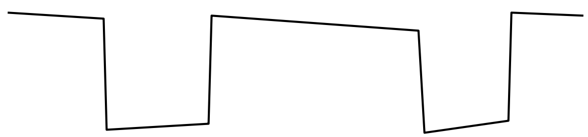
What is this?

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 →



Can you think of some examples of Layer 1?

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
- Identifies the layer 3 protocol being carried

Layer 3: (Inter)Network Layer

- Connects Layer 2 networks together
  - Forwarding data from one network to another
- 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

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
- Or might just be unreliable datagram transport

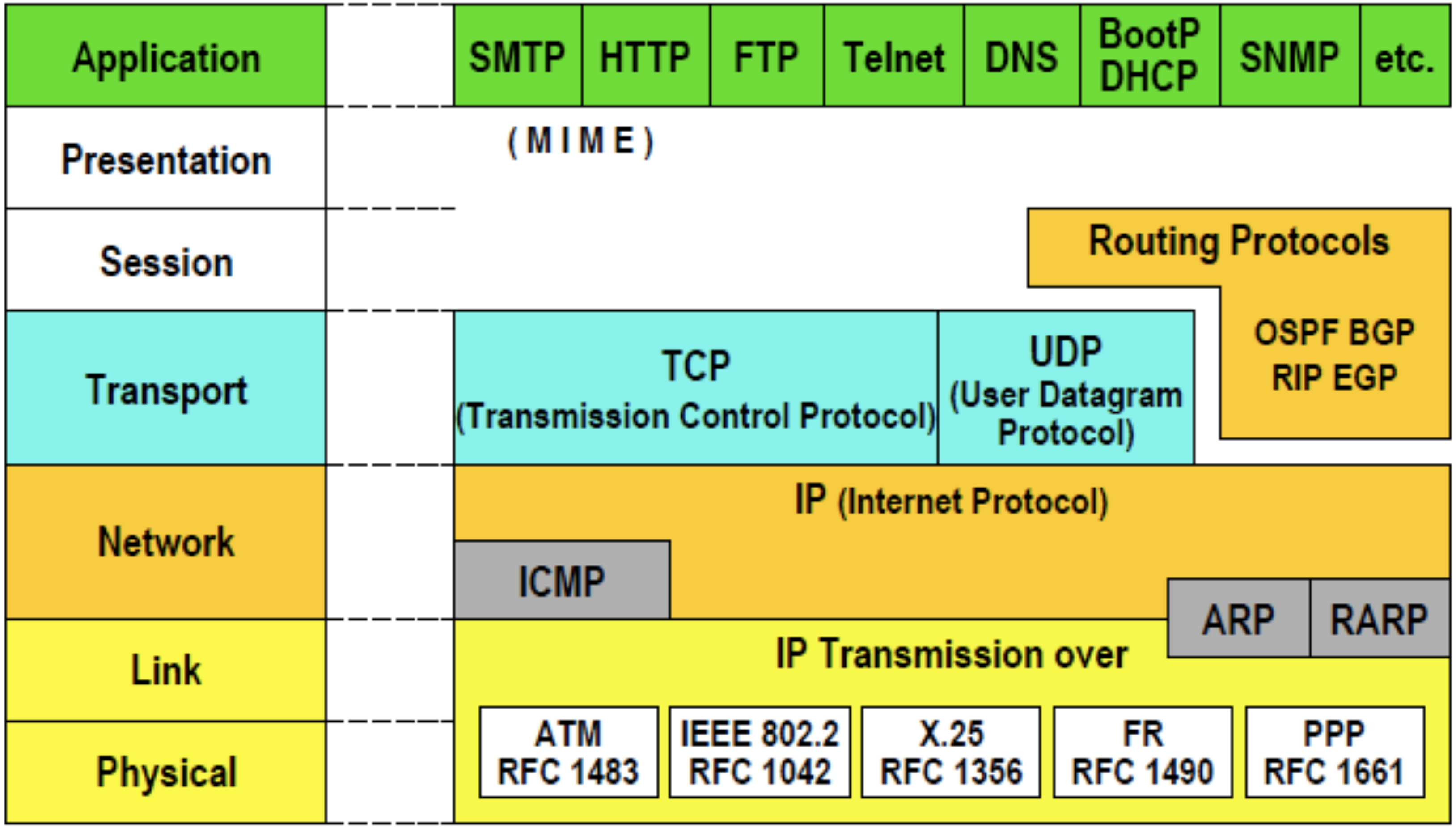
Layers 5 and 6

- 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
- *Examples?*

IP Layers

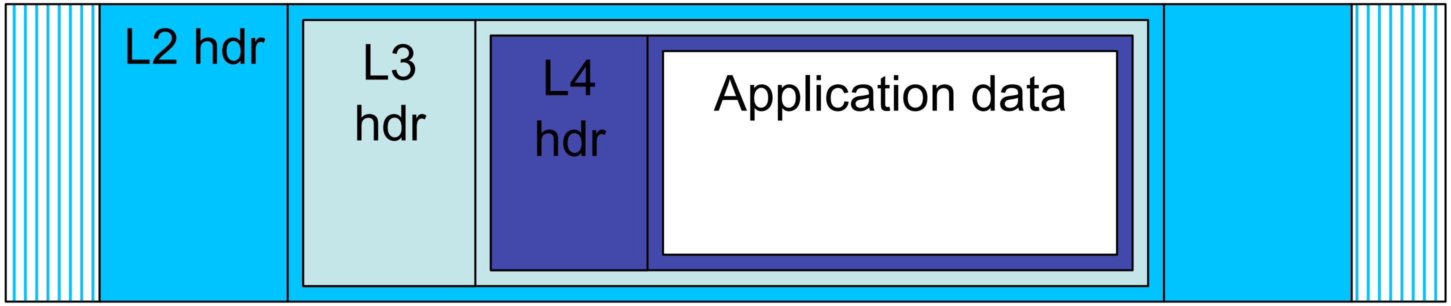


Application
Presentation
Session
Transport
Network
Link
Physical
SMTP
HTTP
FTP
Telnet
DNS
BootP DHCP
SNMP
etc.
(M I M E)
Routing Protocols
OSPF BGP RIP EGP
TCP (Transmission Control Protocol)
UDP (User Datagram Protocol)
IP (Internet Protocol)
ICMP
ARP
RARP
IP Transmission over
ATM RFC 1483
IEEE 802.2 RFC 1042
X.25 RFC 1356
FR RFC 1490
PPP RFC 1661

Encapsulation

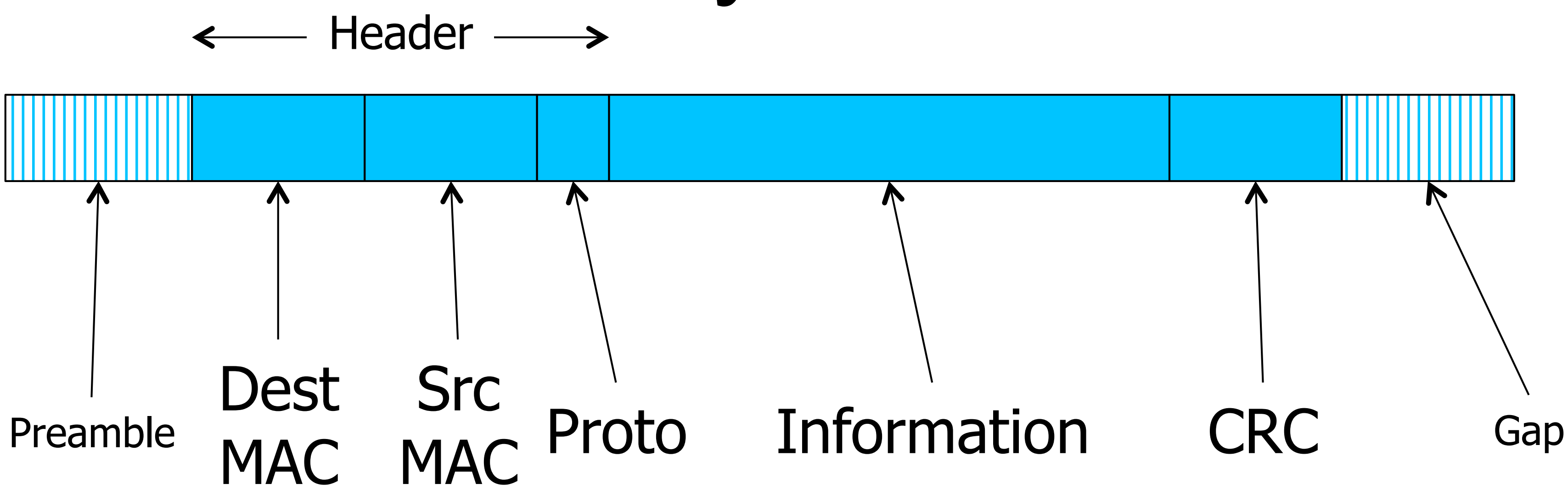
- Each layer provides services to the layer above
- Each layer makes use of the layer below
- Data from one layer is *encapsulated* in frames of the layer below

Encapsulation in action



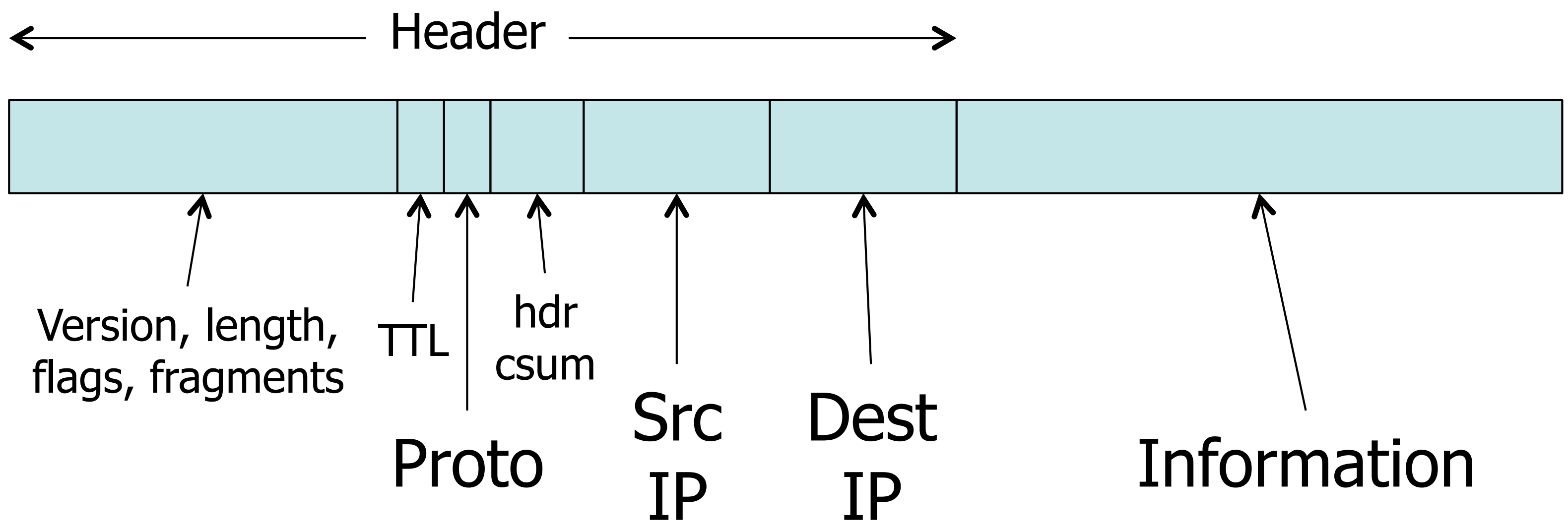
- L4 segment contains part of stream of application protocol
- L3 datagram contains L4 segment
- L2 frame contains L3 datagram in its data portion

Example Layer 2: Ethernet



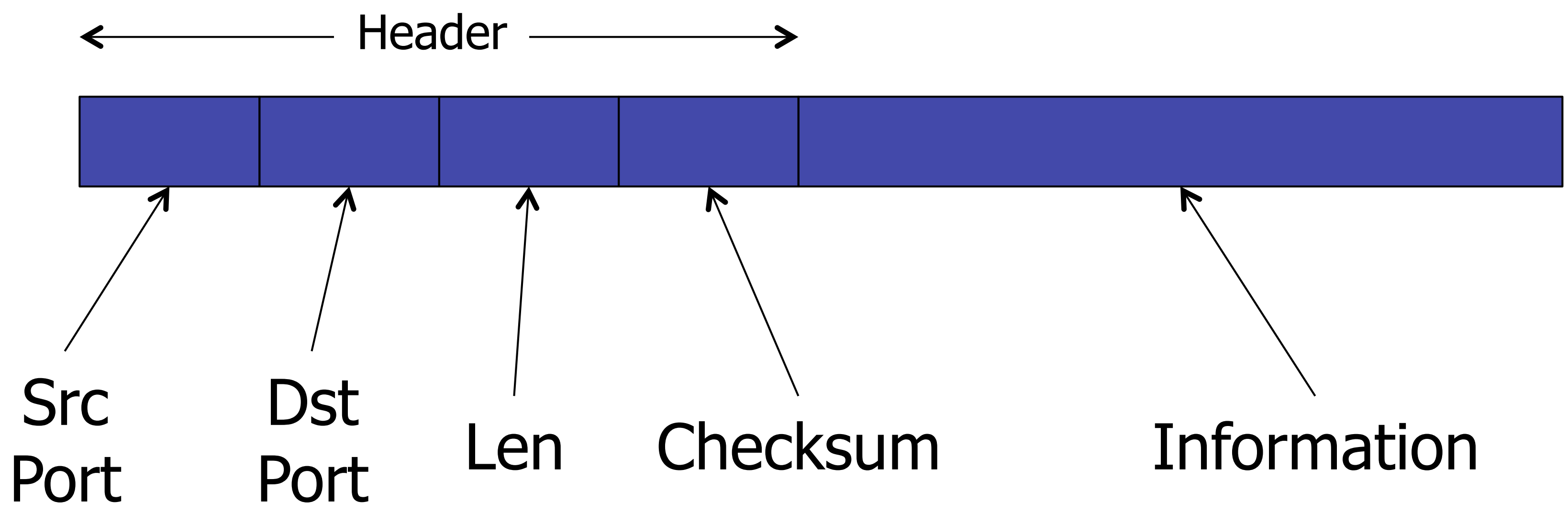
- MAC addresses
- Protocol: 2 bytes
  - e.g. 0800 = IPv4, 86DD = IPv6
- Preamble: carrier sense, collision detection

Example Layer 3: IPv4 Datagram



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

Example Layer 4: UDP

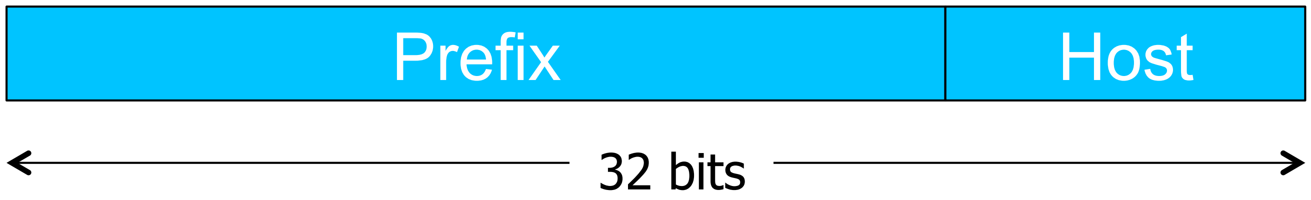


- Port numbers: 2 bytes
  - Well-known ports: e.g. 53 = DNS
  - Ephemeral ports: ≥1024, chosen dynamically by client

Addressing at each layer

- What do the addresses look like?
- Where do they come from?
- Examples to consider:
  - L2: Ethernet MAC addresses
  - L3: IPv4, IPv6 addresses
  - L4: TCP and UDP port numbers

IPv4 “Golden Rules”



1. All hosts on the same L2 network must share the *same* prefix
2. All hosts on the same subnet have *different* host part
3. Host part of all-zeros and all-ones are reserved

Subnetting Example

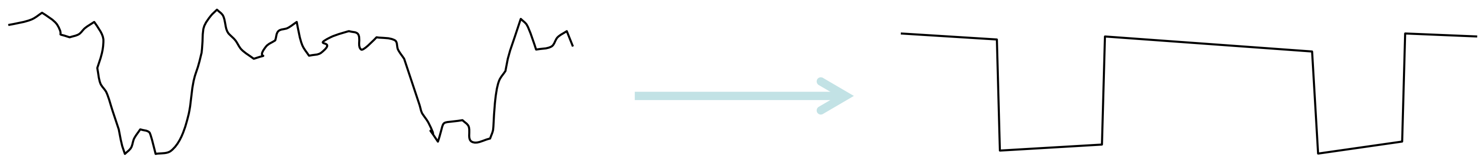
- You have been given 192.0.2.128/27
- How many addresses are available?
- You want to build two Layer 2 networks
- Can you split this address space into two equal-sized pieces?
  - What are they?

IPv6 rules

- 128-bits of address
- As with IPv4, each Layer 2 network needs its own prefix
- But with IPv6, every network prefix is /64
  - (OK, some people use /126 for P2P links)
- The remaining 64 bits can be assigned by hand, or picked automatically
  - e.g. derived from NIC MAC address
- There are special prefixes, e.g. link local

Types of equipment

- Layer 1: **Hub, Repeater**
- Works at the level of individual bits



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

Types of equipment (contd)

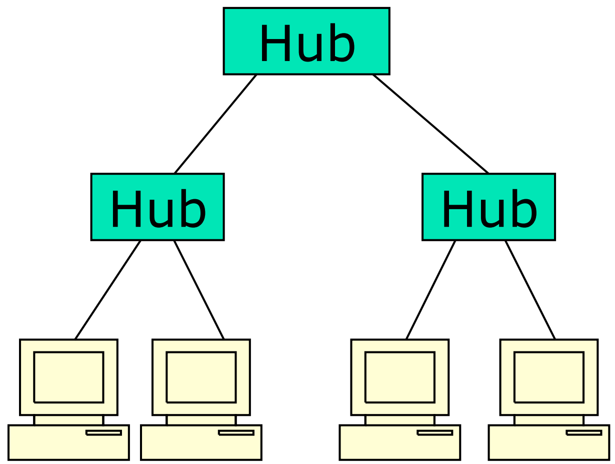
- Layer 2: **Switch, Bridge**
- Receives whole layer 2 frames and selectively retransmits them
- Learns which MAC addr is on which port
- If it knows the destination MAC address, will send it out only on that port
- Broadcast frames must be sent out of all ports, just like a hub
- Doesn’t look any further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

Types of equipment (contd)

- Layer 3: **Router**
- Looks at the dest 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)

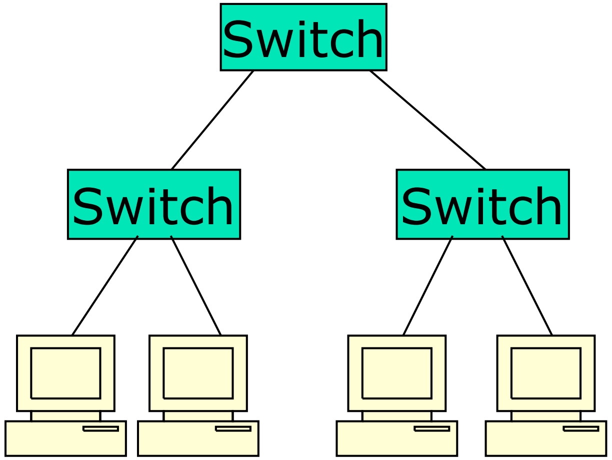
Building networks at Layer 1

- What limits do we hit?

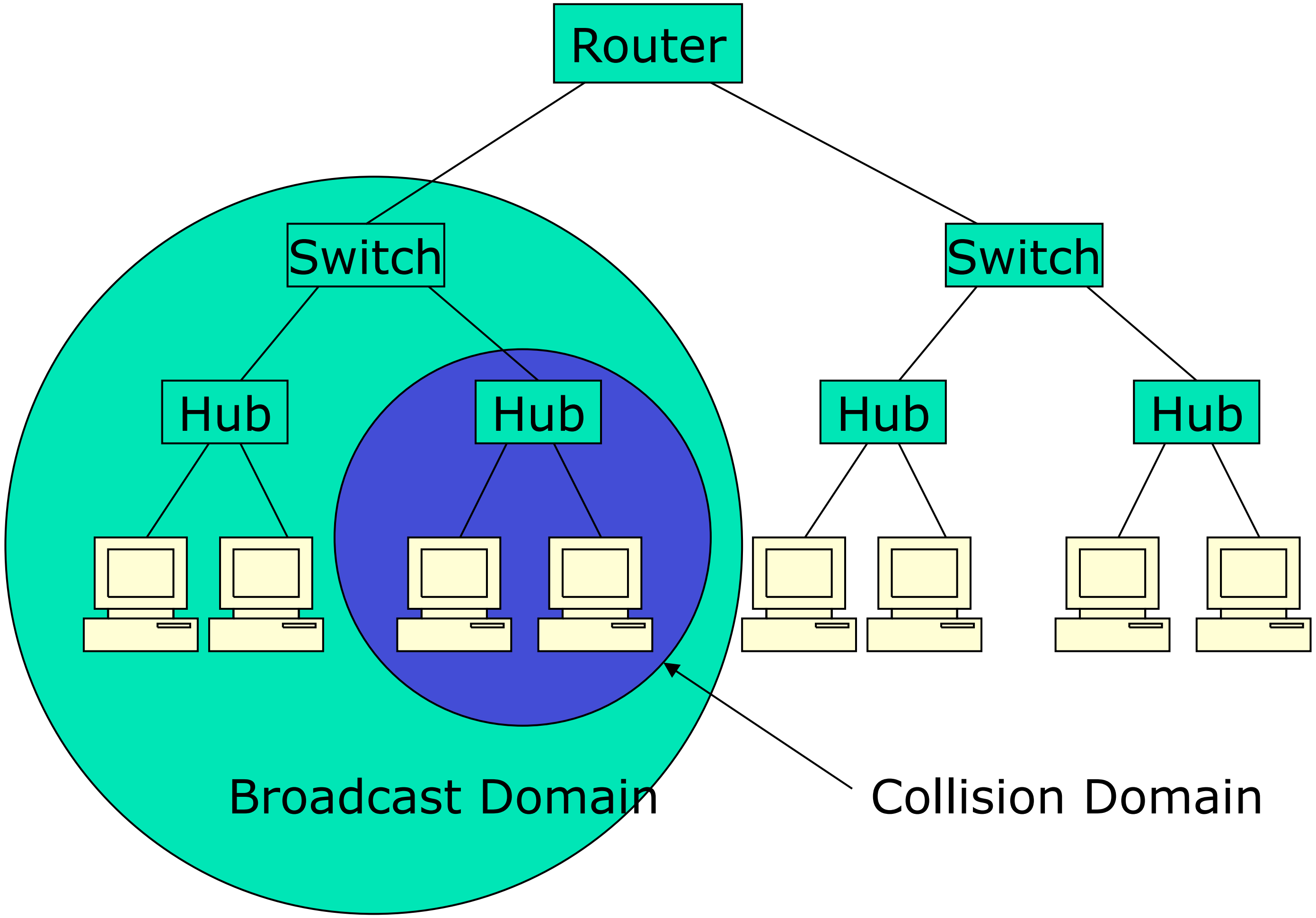


Building networks at Layer 2

- What limits do we hit?



Traffic Domains



For discussion

- Can you give examples of equipment which operates at layer 4? At layer 7?
- At what layer does a wireless access point work?
- What is a “Layer 3 switch”?

Debugging Tools

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

Other pieces

- What is MTU? What limits it?
- What is ARP?
  - Where does it fit in the model?
- What is ICMP?
  - Where does it fit in the model?
- What is NAT? PAT?
  - Where do they fit in the model?
- What is DNS?
  - Where does it fit in the model?