CS144
An Introduction to Computer Networks

Ethernet and CSMA/CD

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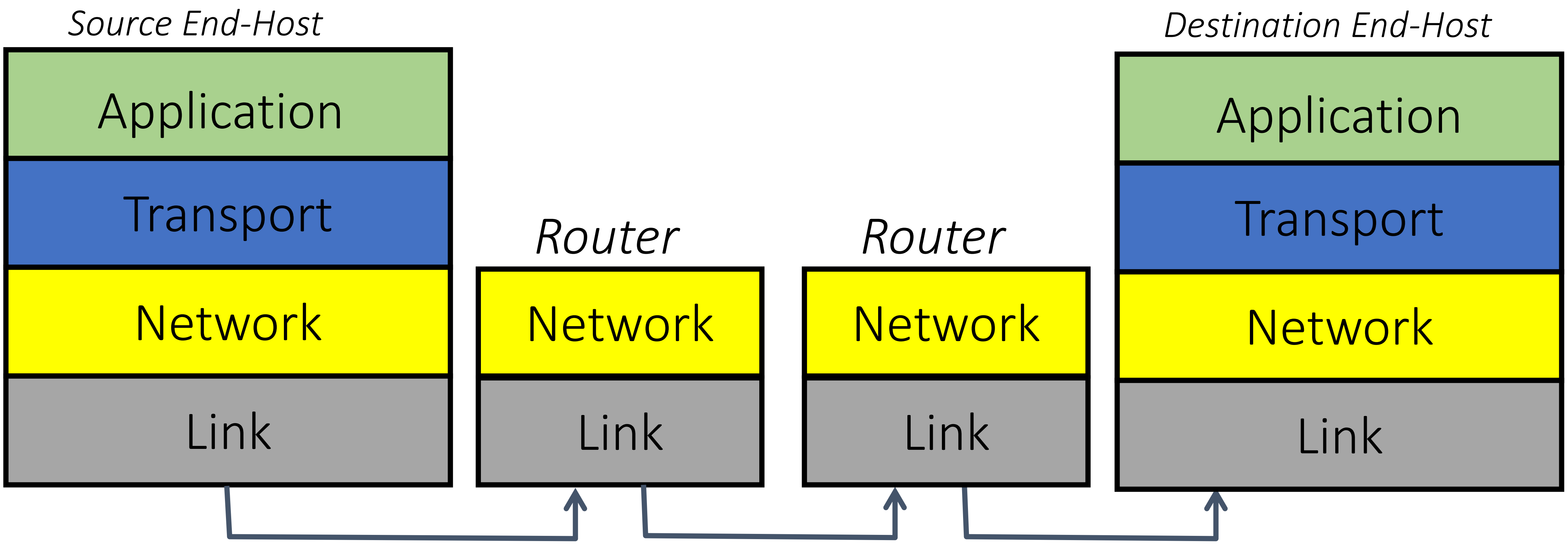
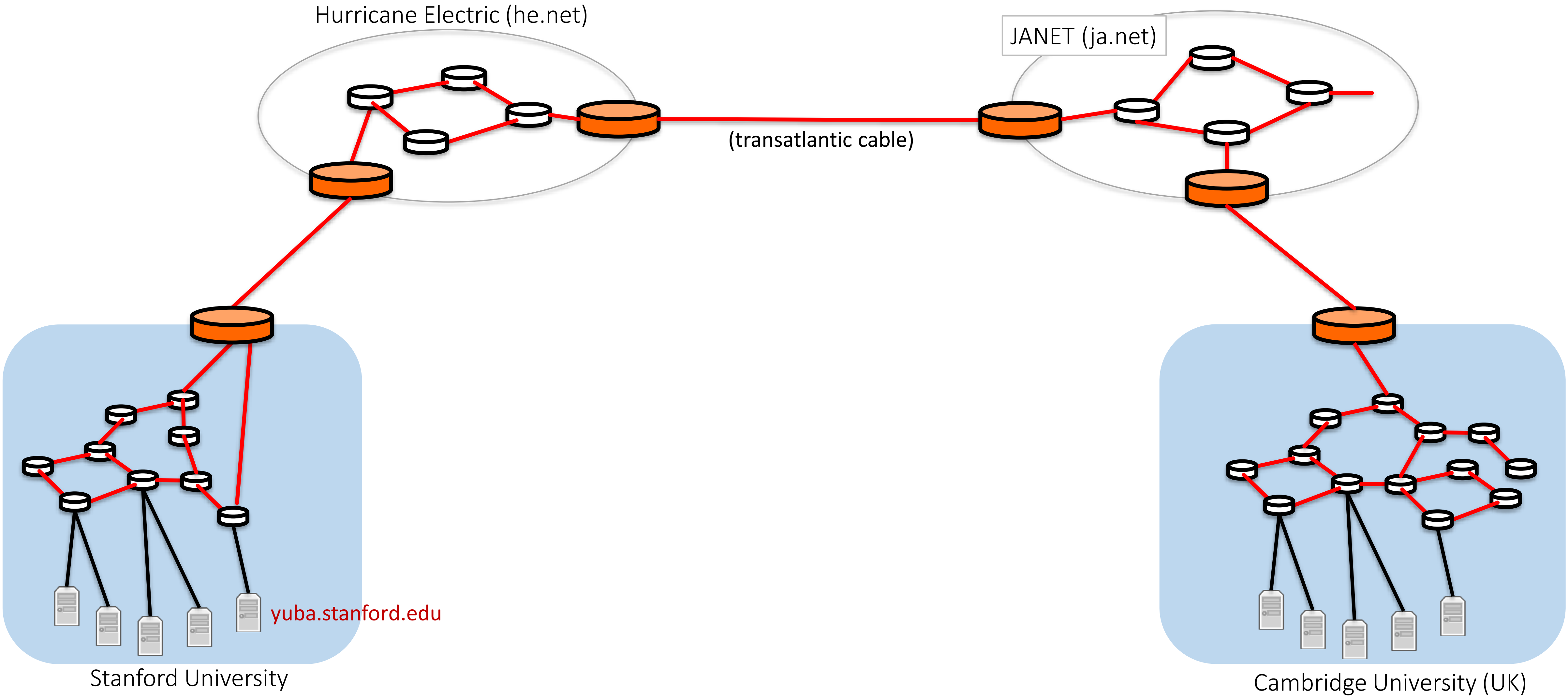
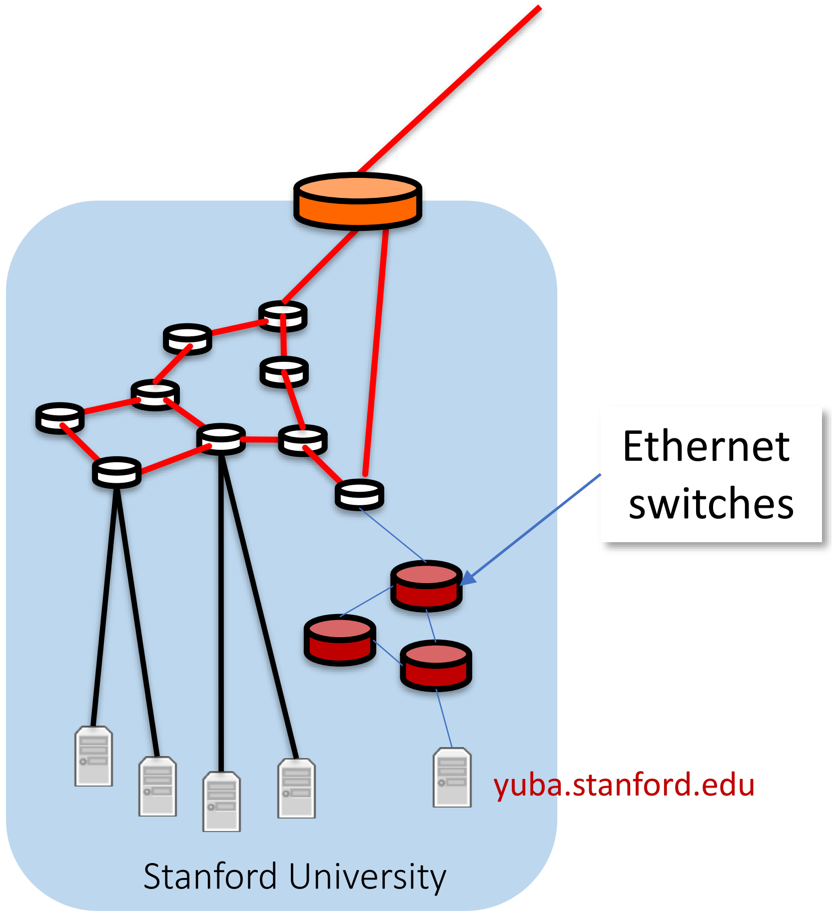
The 4 Layer Internet Model




Hurricane Electric (he.net)
JANET (ja.net)
(transatlantic cable)
yuba.stanford.edu
Stanford University
Cambridge University (UK)


Ethernet switches
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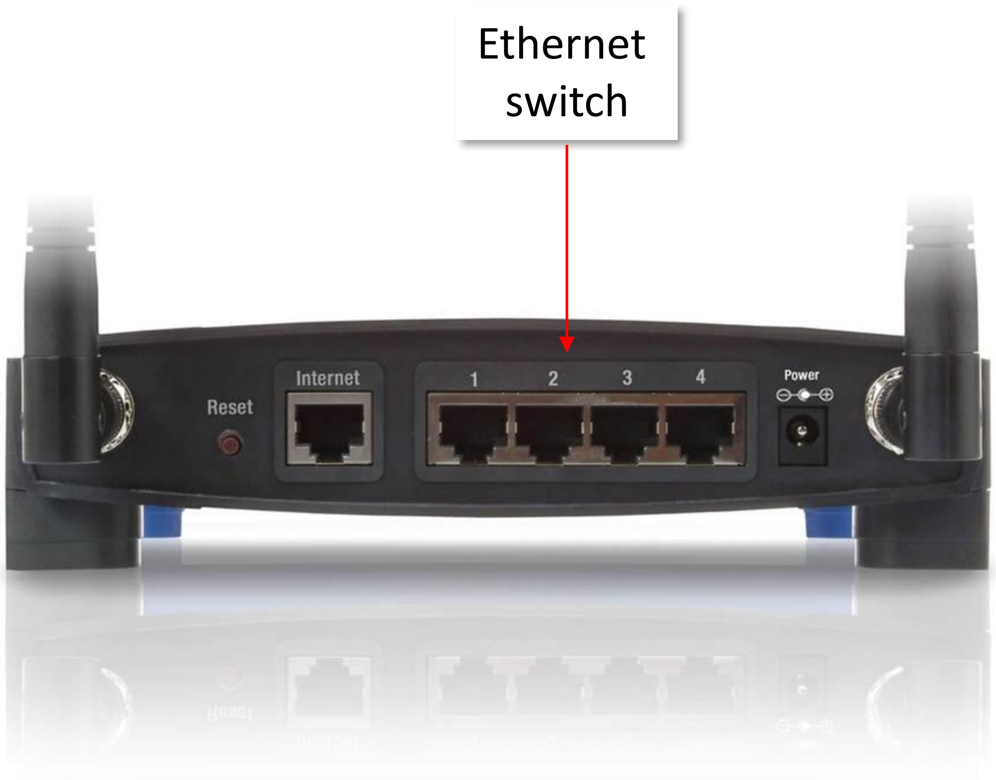
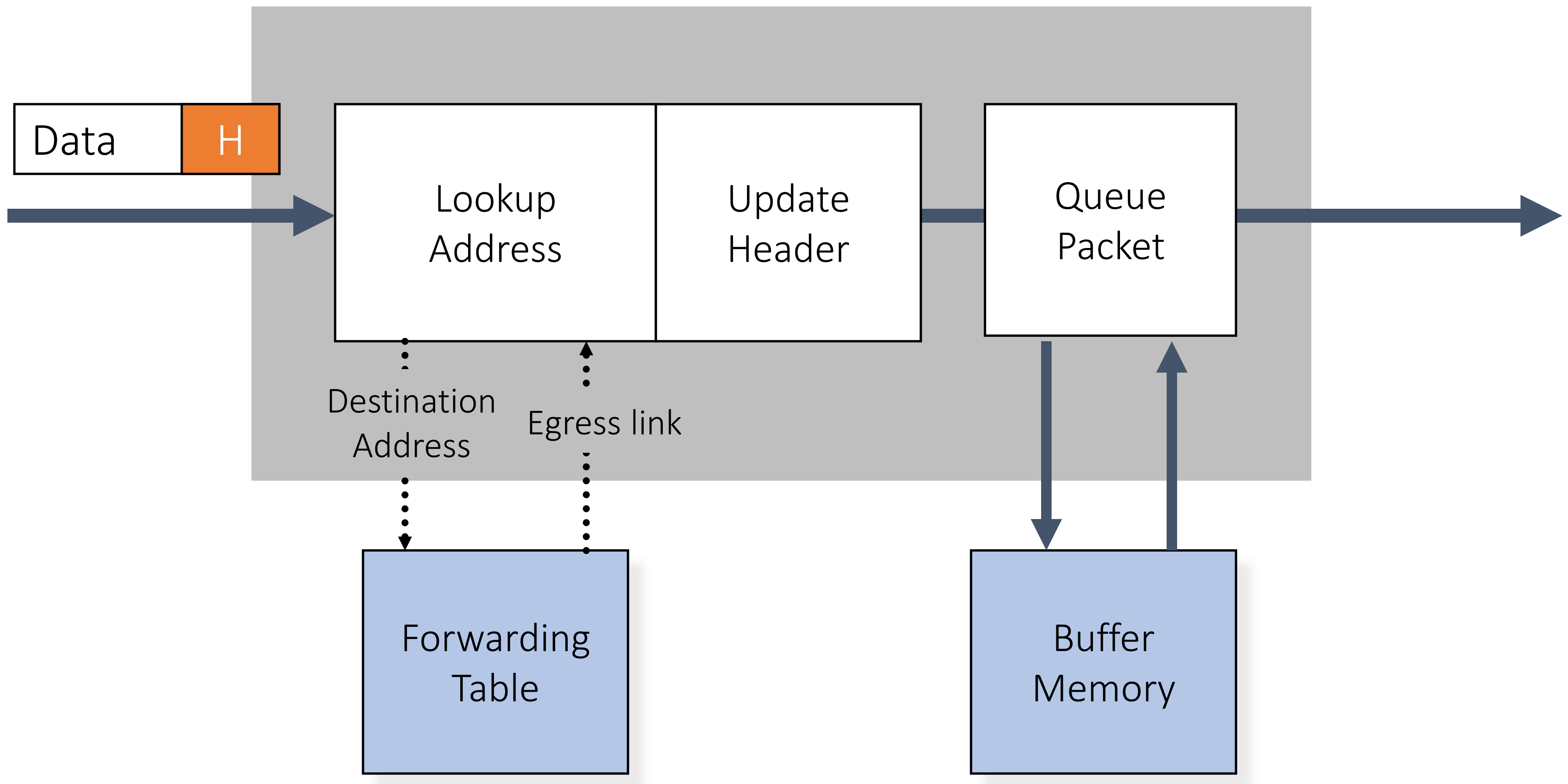
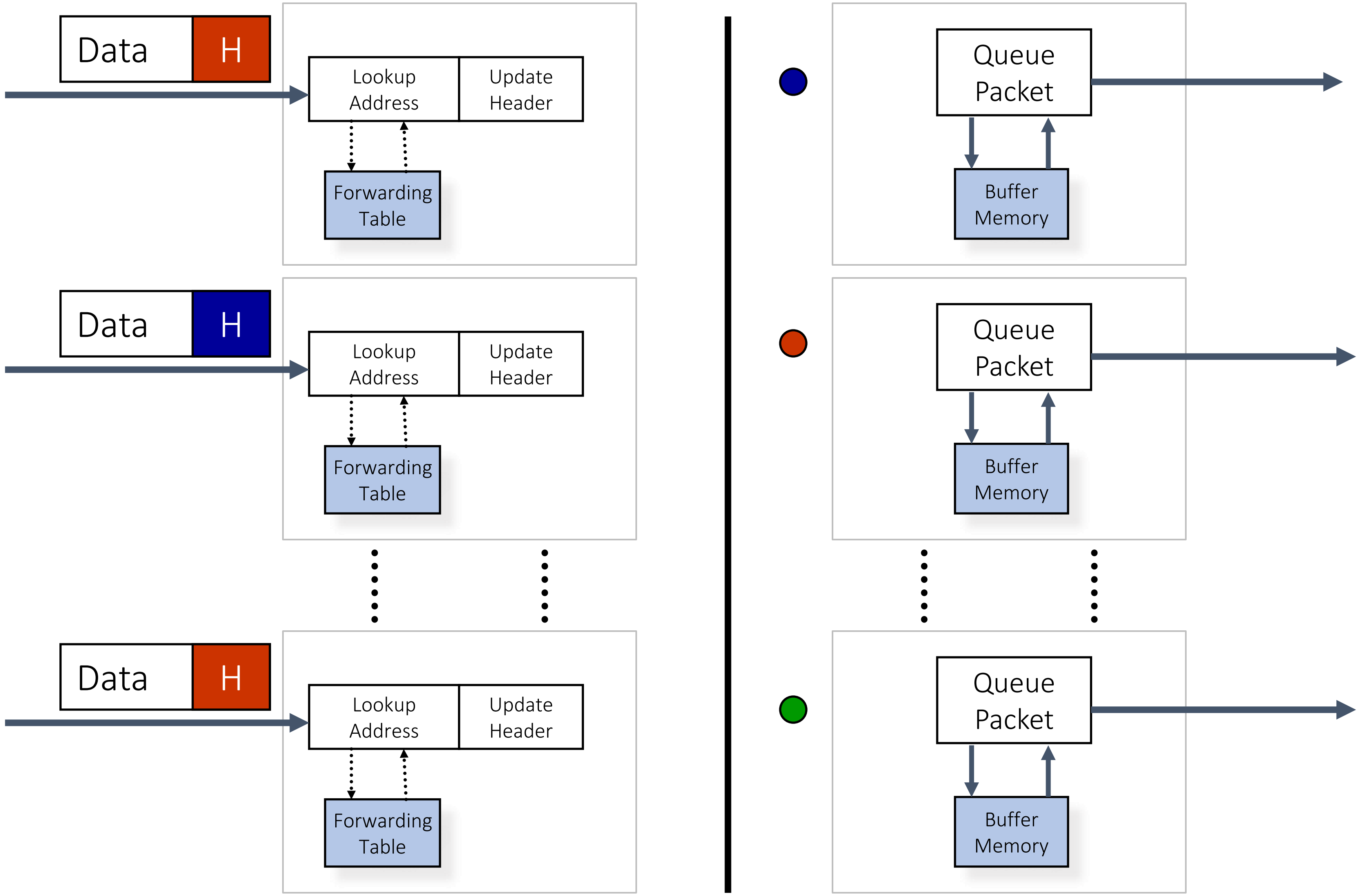
LINKSYS
Secure Easy Setup
Wireless-G
Ethernet
Power
DMZ
USB
WLAN
1 2 3 4
Internet
Wireless-G
Broadband Router
With 4-Port Switch
Model WRT54GL


Ethernet switch
Internet
Reset
1 2 3 4
Power

Generic Packet Switch



Generic Packet Switch



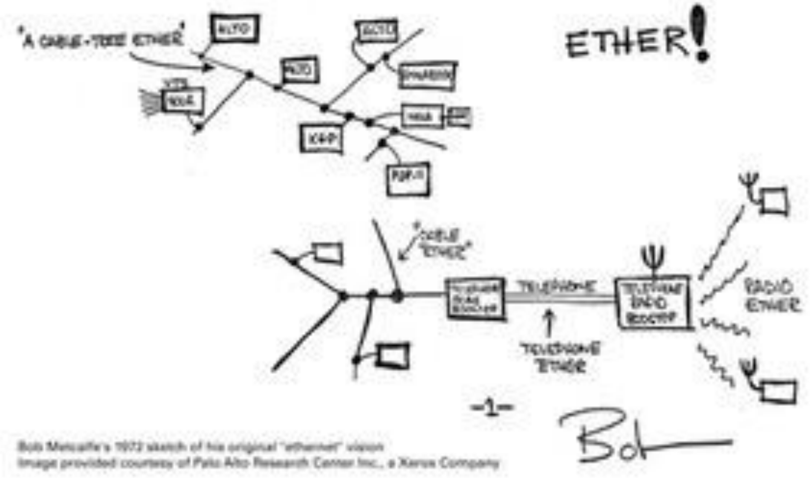
Ethernet Switch

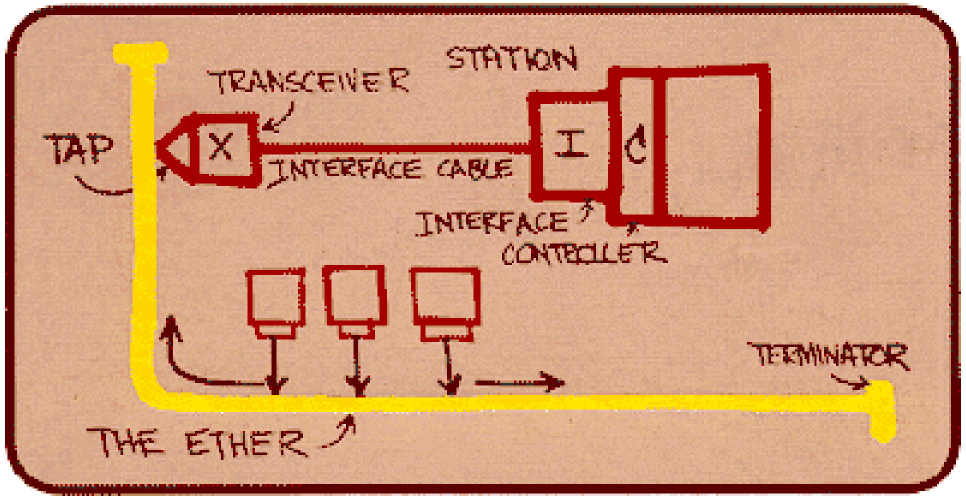
1. Examine the header of each arriving frame.
2. If the Ethernet DA (aka "MAC Address") is in the forwarding table, forward the frame to the correct output port(s).
3. If the Ethernet DA is not in the table, broadcast the frame to all ports (except the one through which the frame arrived). i.e. flooding.
4. Entries in the table are learned by checking to see if the Ethernet SA of arriving packets are already in the table. If not, then add them.

Internet Router

1. If the Ethernet DA of the arriving frame belongs to the router, accept the frame. Else drop it.
2. Examine the IP version number and length of the datagram.
3. Decrement the TTL, update the IP header checksum.
4. Check to see if TTL == 0.
5. If the IP DA is in the forwarding table, forward to the next hop.
6. If IP DA doesn’t match a table entry
   a) If there is a Default Route entry, then forward to it (often a BGP router).
   b) Else, drop the packet and send an ICMP message back to the source.
7. Find the Ethernet DA for the next hop router.
8. Create a new Ethernet frame and send it.

The Original Ethernet





Original pictures drawn by Bob Metcalfe,
co-inventor of Ethernet (1972 – Xerox PARC)

Ethernet Frame Format

1st bit on wire

Bytes:	7	1	6	6	2	0-1500	0-46	4
	Preamble	SFD	DA	SA	Type	Data	Pad	CRC

1. **Preamble**: trains clock-recovery circuits
2. **Start of Frame Delimiter**: indicates start of frame
3. **Destination Address**: 48-bit globally unique Ethernet address assigned by manufacturer.
   - 1b: unicast/multicast
   - 1b: local/global address
4. **Type**: Indicates protocol of encapsulated data (e.g. IP = 0x0800)
5. **Pad**: Zeroes used to ensure ***minimum frame length***
6. **Cyclic Redundancy Check**: check sequence to detect bit errors.

The origins of Ethernet

Sharing a “medium”

- Ethernet is, or at least was originally, an example of multiple hosts sharing a common cable (“medium”).
- To share the medium, we need to decide who gets to send, and when.
- There is a general class of “Medium Access Control Protocols”, or MAC Protocols. Hence the name “MAC address”.
- Ethernet uses a MAC protocol called “CSMA/CD”.

CSMA/CD Protocol

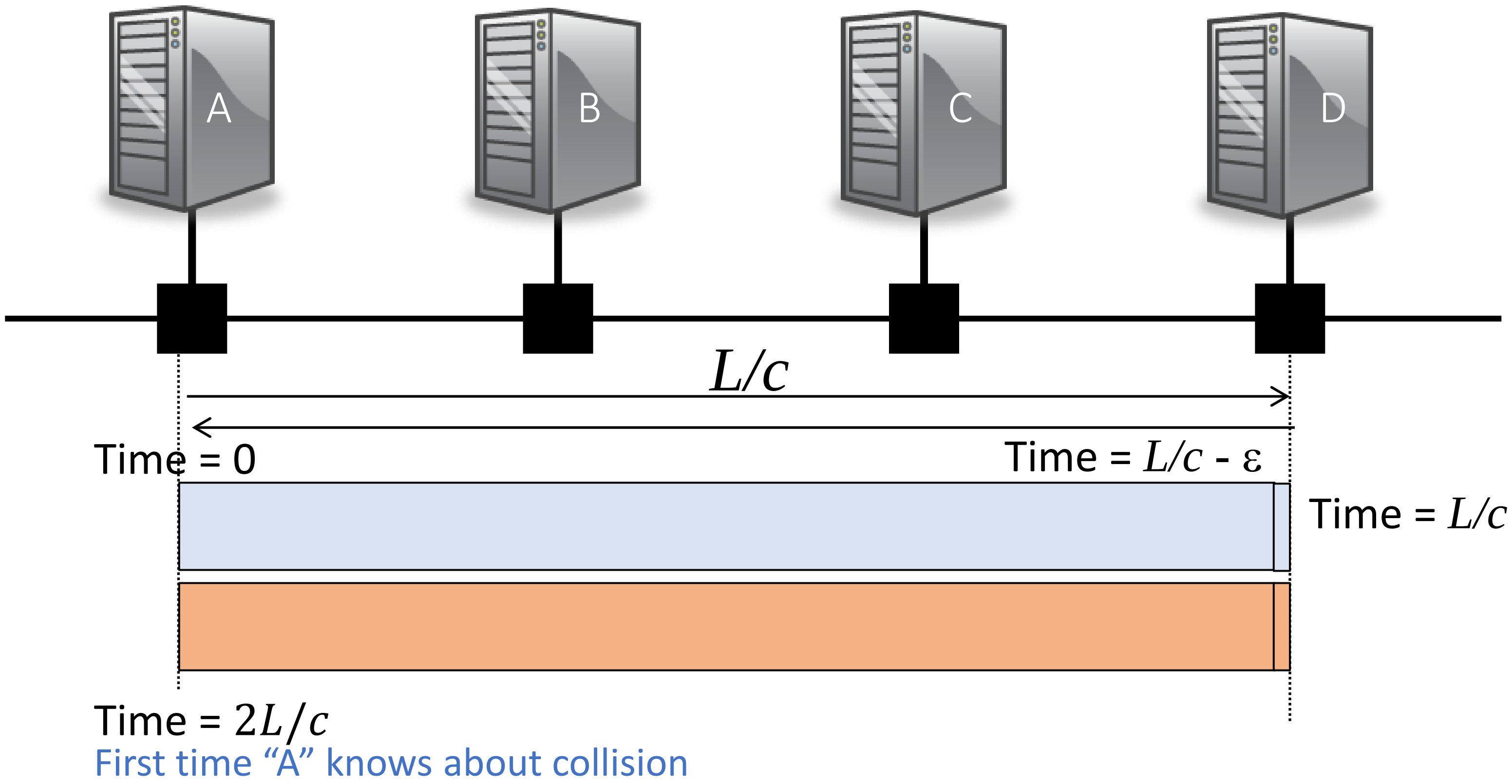
All hosts transmit & receive on one channel
Packets are of variable size.

When a host has a packet to transmit:

1. Carrier Sense: Check if the line is quiet before transmitting.
2. Collision Detection: Detect collision as soon as possible.
   If a collision is detected, stop transmitting; wait a random time, then return to step 1.

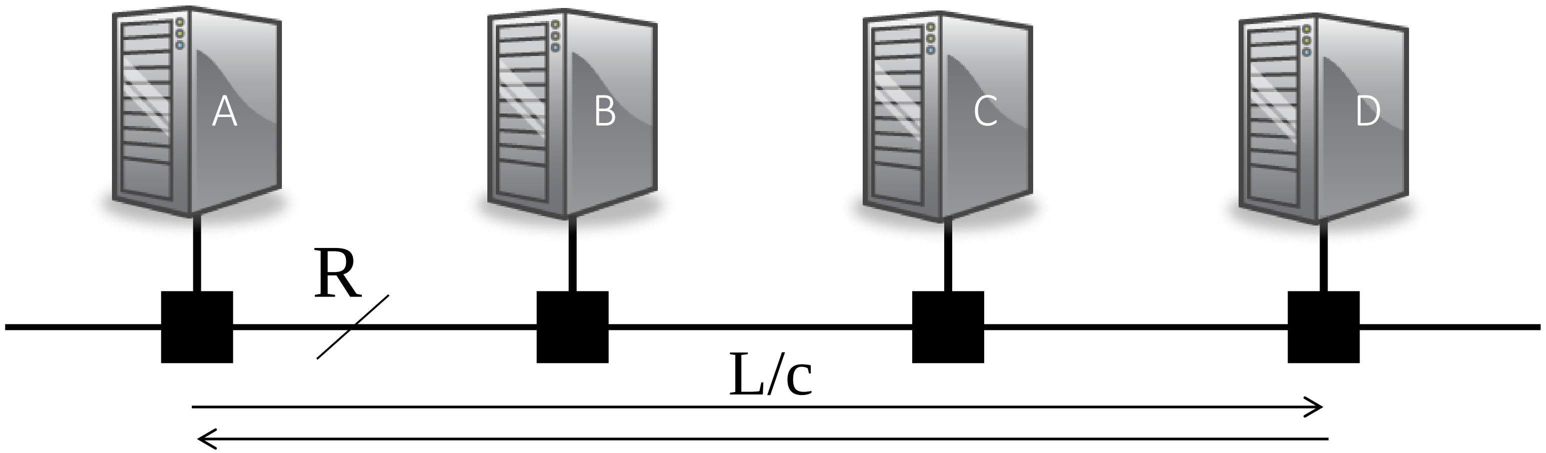
binary exponential backoff

CSMA/CD Packet size requirement



Therefore, Host A is guaranteed to know about the collision while it is still transmitting if: $\frac{P}{R} > \frac{2L}{c}$

CSMA/CD Packet size requirement



For an end host to detect a collision before it finishes transmitting a packet, we require:

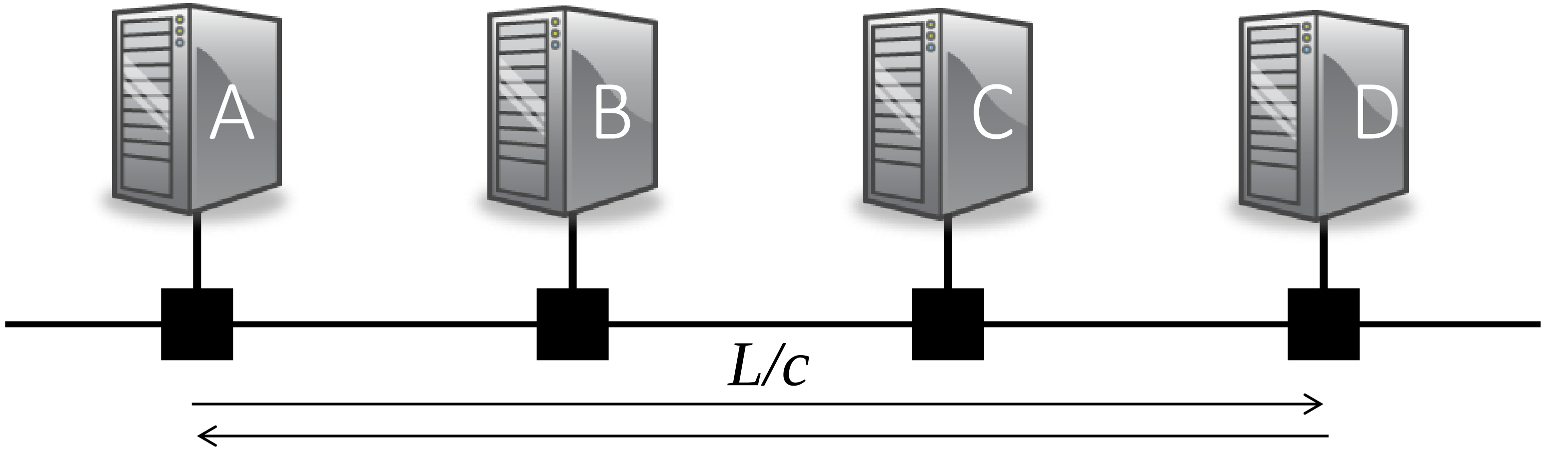
$$\frac{P}{R} > \frac{2L}{c}$$

where P is the size of a packet.

CSMA/CD Packet size requirement

Example:

R = 10Mb/s, L = 10,000m, c = 2 x 10^8 m/s.

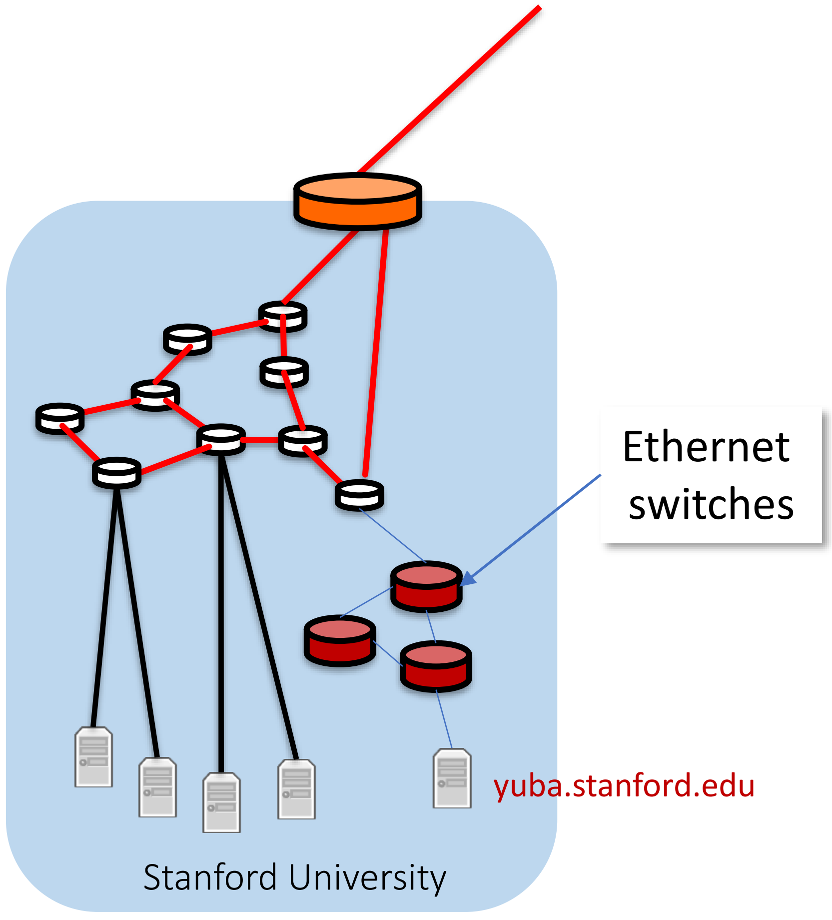


$$\frac{P}{R} > \frac{2L}{c}$$

$$\therefore P_{min} = \frac{2LR}{c} = \frac{2 \times 10^{11}}{2 \times 10^{8}} = 1{,}000\ bits$$

Ethernet evolution

- **Early 1980s**: Ethernet was a 10Mb/s shared medium. Literally a thick coaxial cable that snaked around the floor into which every computer was plugged.
- **Late 1980s**: Ethernet "10baseT" used the twisted-pair phone cables already installed in buildings. Used a star topology. Ethernet hubs connected end hosts together with one big collision domain.
- **Early 1990s**: Ethernet Switches were invented. Dedicated cable between the switch and the end host carrying packets in both directions simultaneously. No collisions any more!
- **Since then**: 100Mb/s Ethernet, 1GE, 10GE, 100GE, 400GE, …


Ethernet switches
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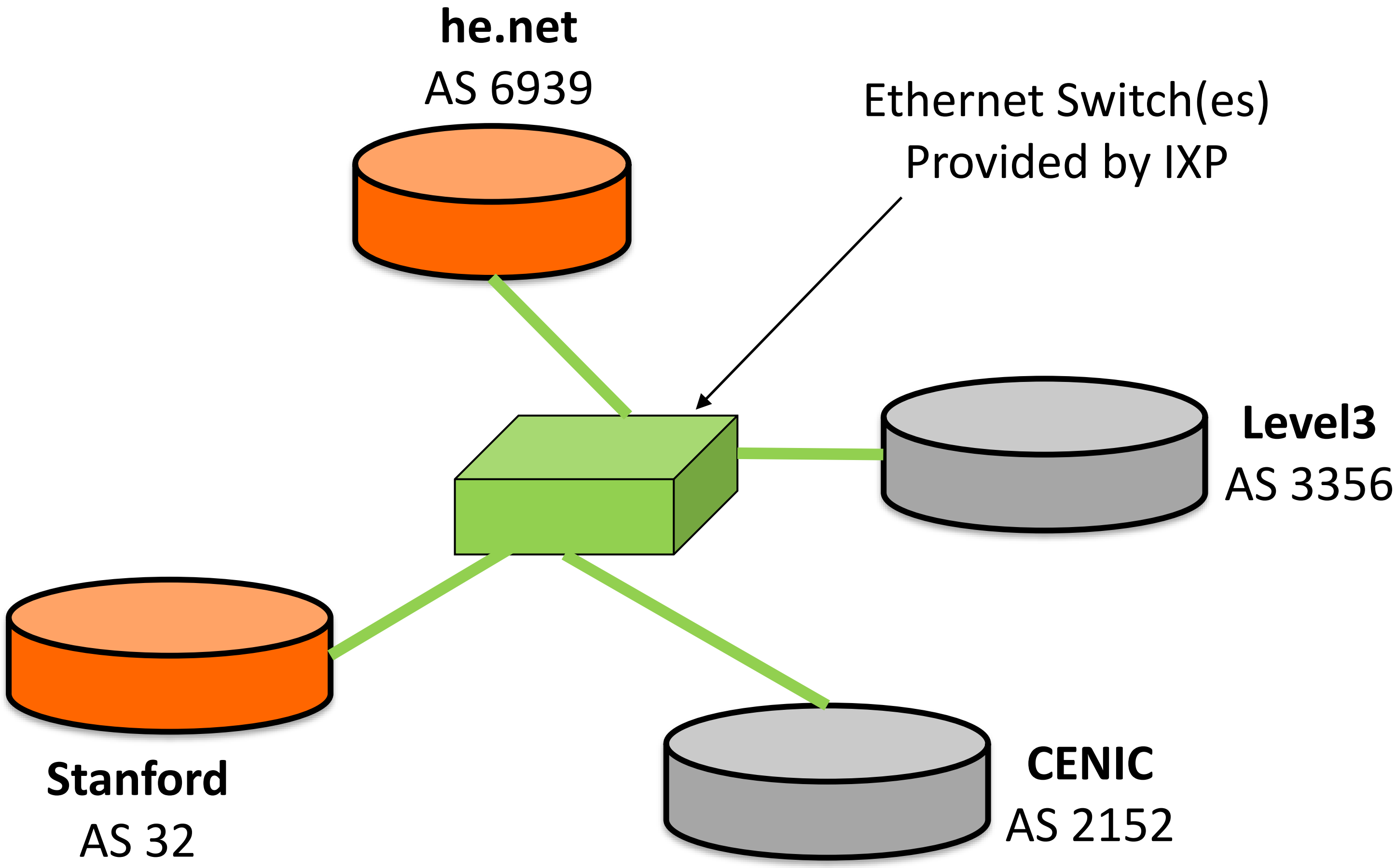
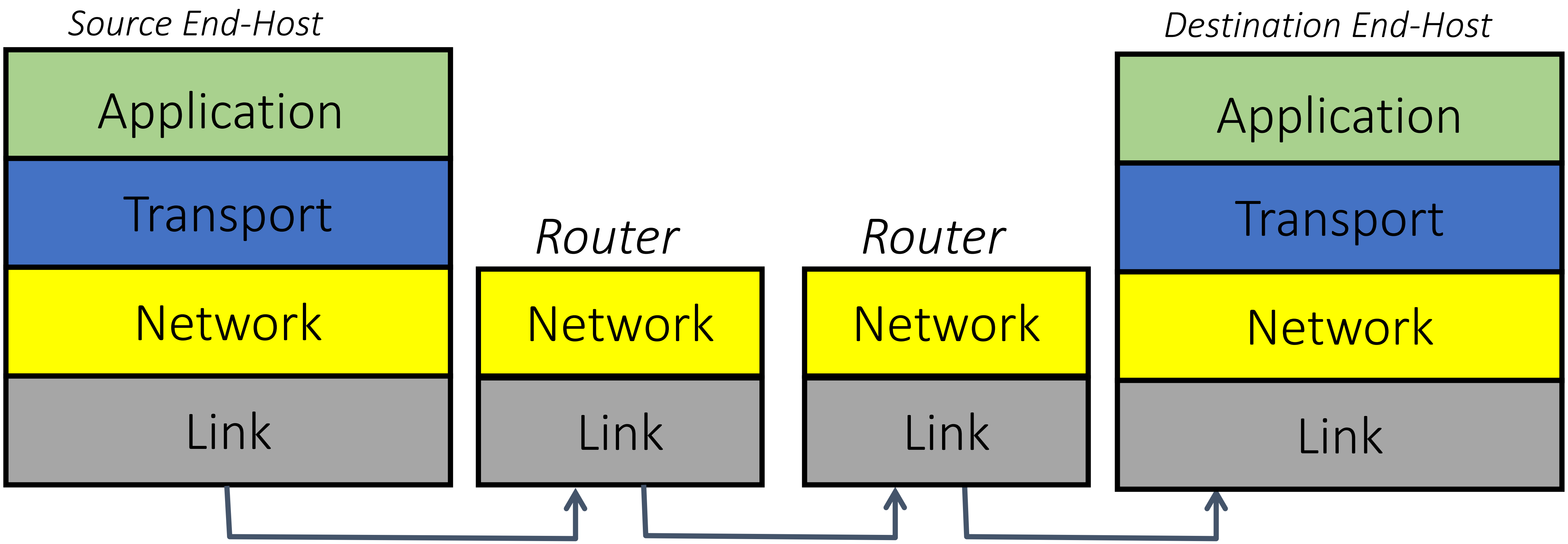
Autonomous Systems (AS's) usually connect to each other in an Internet eXchange Point (IXP)

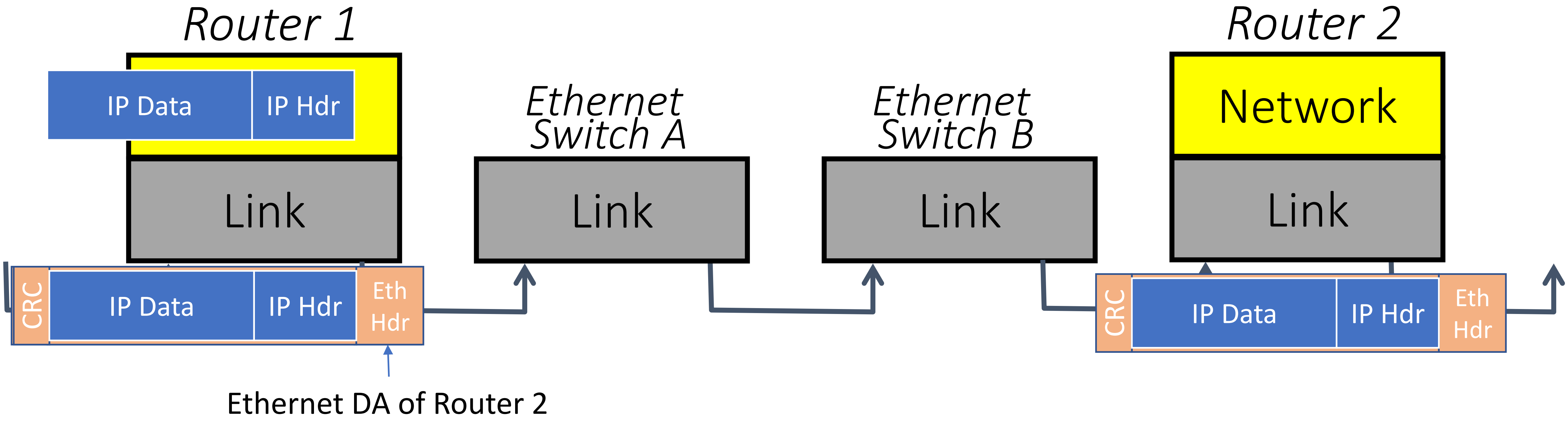


Other ISPs at local IXP

The 4 Layer Internet Model



Ethernet switches operate at the link layer



Why an IXP uses Ethernet switches…

- The IXP doesn’t need to maintain routing tables
- The IXP doesn’t need to exchange routing entries with its customers
- The IXP doesn’t need to decide how packets are routed
- It merely provides “Link Layer” connectivity among its customers.

Ethernet in use today

- Almost all enterprises and campuses use Ethernet as a simple, quick, cheap, easy-to-manage way to interconnect hosts and WiFi APs inside a building. Routers are typically use to connect buildings together.
- Data-centers typically use an Ethernet switch to connect 48-64 servers together in each rack. Called “Top of Rack” or ToR switches. Routing is typically used to connect racks together.