CSC4200/5200 – COMPUTER NETWORKING

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INTERNET PROTOCOL (IP)

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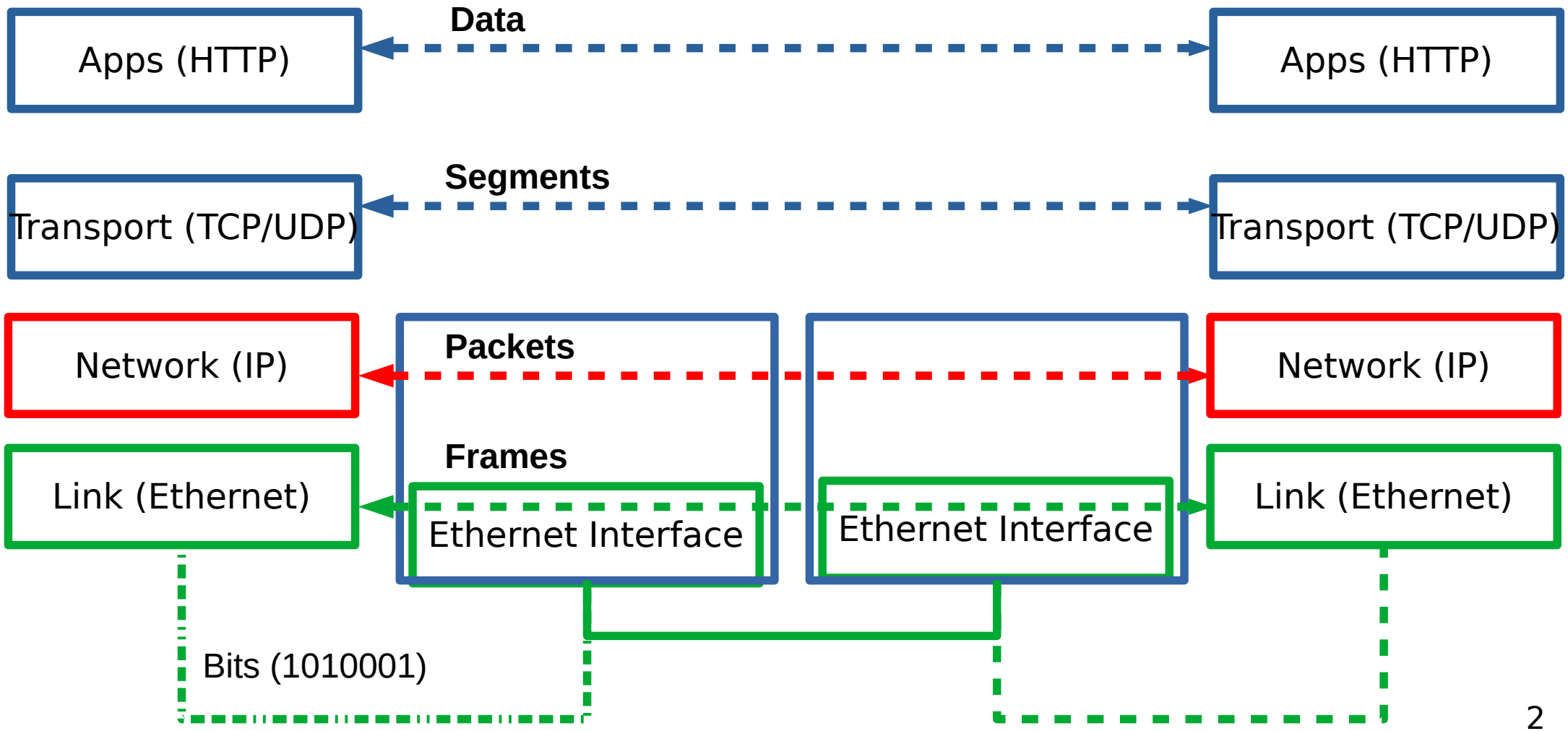
Tennessee TECH

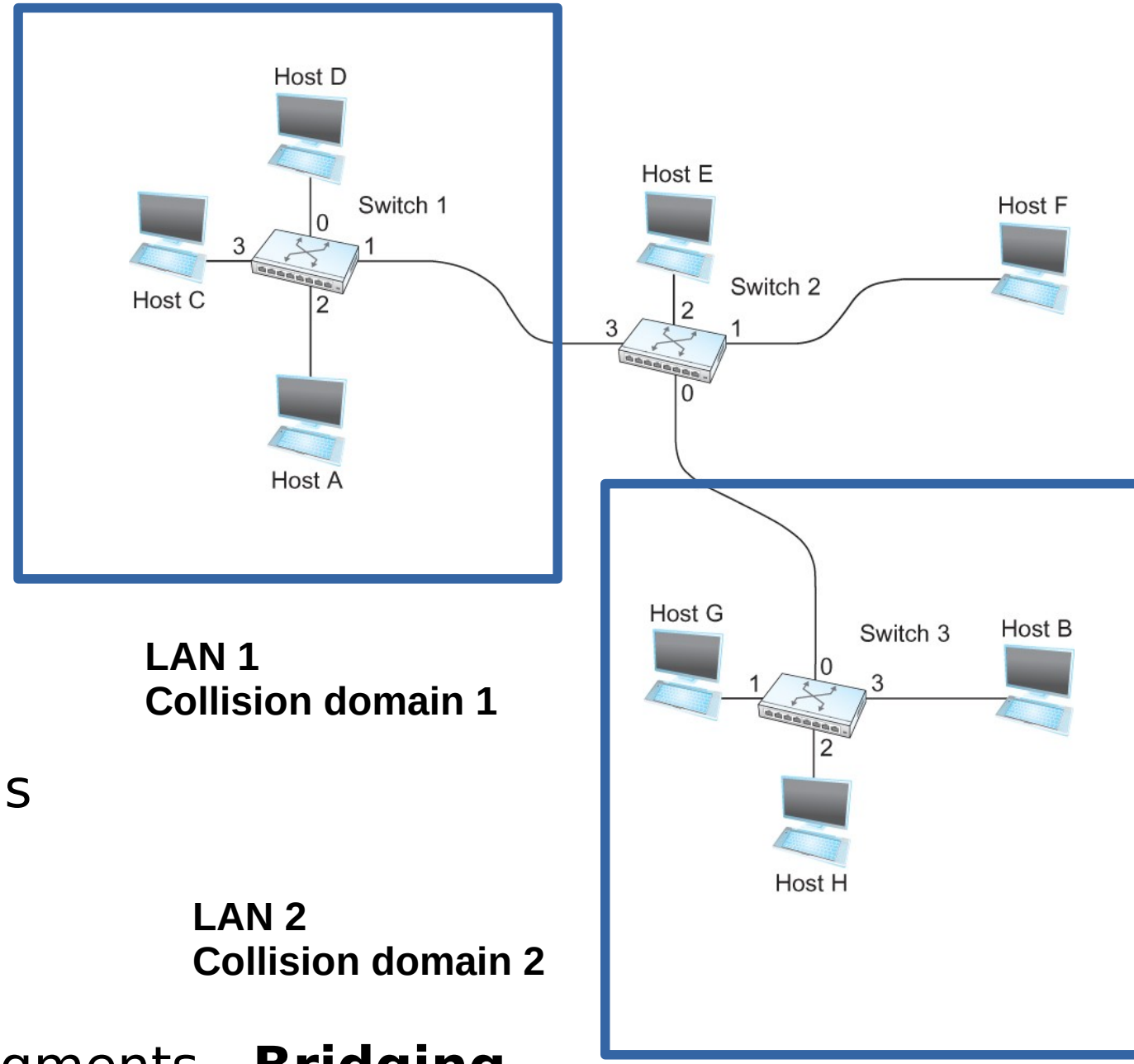

Apps (HTTP)
Data
Apps (HTTP)
Transport (TCP/UDP)
Segments
Transport (TCP/UDP)
Network (IP)
Packets
Network (IP)
Link (Ethernet)
Frames
Ethernet Interface
Ethernet Interface
Link (Ethernet)
Bits (1010001)

So far...

- We are forwarding packets between different LANs
- Spanning tree algorithm for preventing loops

Switching

- Switch
  - A mechanism to interconnect links to form a large network
  - Forward **frames**
  - Separate the collision domains
  - Filter packets between LANs
  - Connects two or more LAN segments - **Bridging**



How do we create a spanning tree?

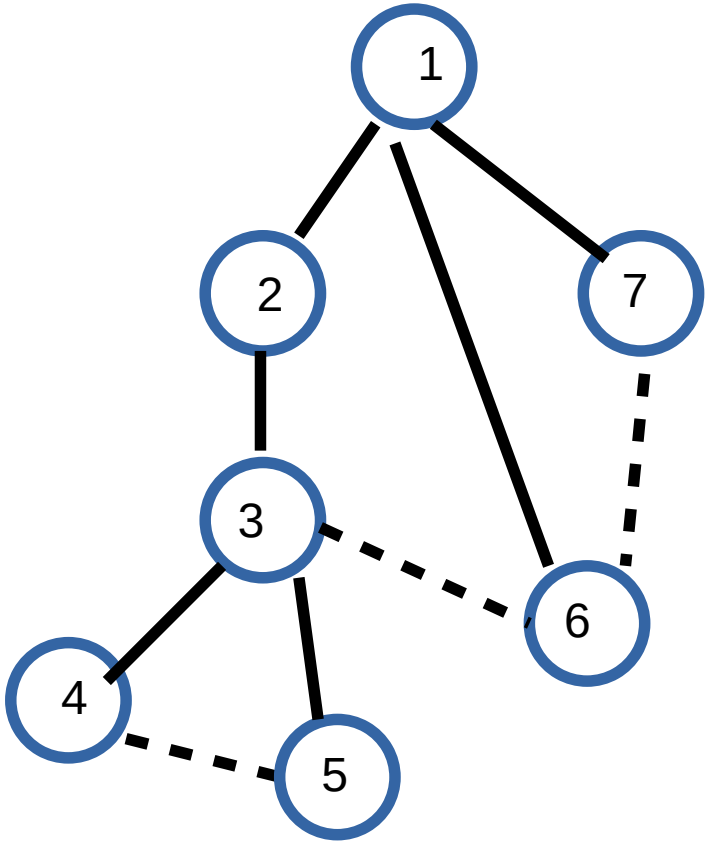
- **Message (Y, d, X) - (to, distance, from)**

- 4 thinks it’s the root

- Sends (4, 0, 4) to 3 and 5
- Receives (3,0,3) from 3
  - Sets it to as the root since 3 < 4

- Receives (3,1,5) from 5
  - Sees that this is a longer path to 3
  - 2 hops vs direct path (1 hop)
  - Removes 4-5 link from the tree

- **Does not scale!**

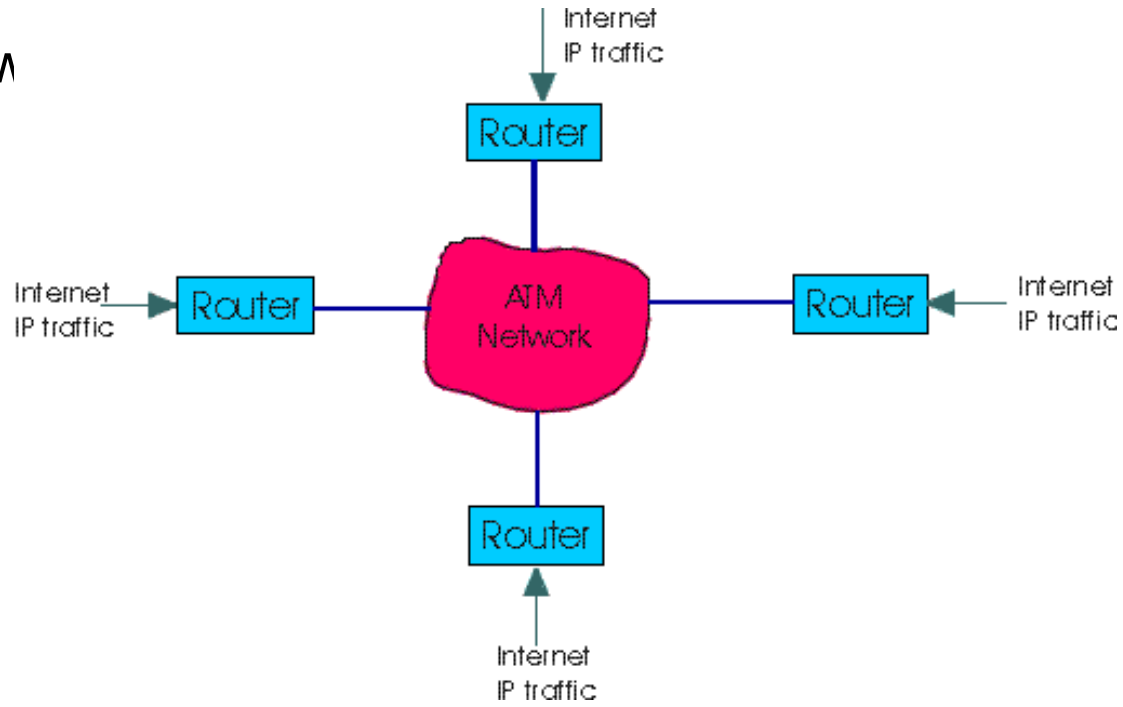


ATM (Carries Cells, not Money)

- ATM (Asynchronous Transfer Mode)
  - Connection-oriented packet-switched network
- Packets are called cells
- 5 byte header + 48 byte payload
- Fixed length packets are easier to switch in hardware
- **Why?**

ATM (Carries Cells, not Money)

- ATM (Asynchronous Transfer Mode)
  - Connection-oriented packet-switched netw
  - Packets are called cells
  - 5 byte header + 48 byte payload
- Fixed length packets are easier to switch in hardware
  - Simpler to design
  - Enables parallelism
- Still used in long distance private links



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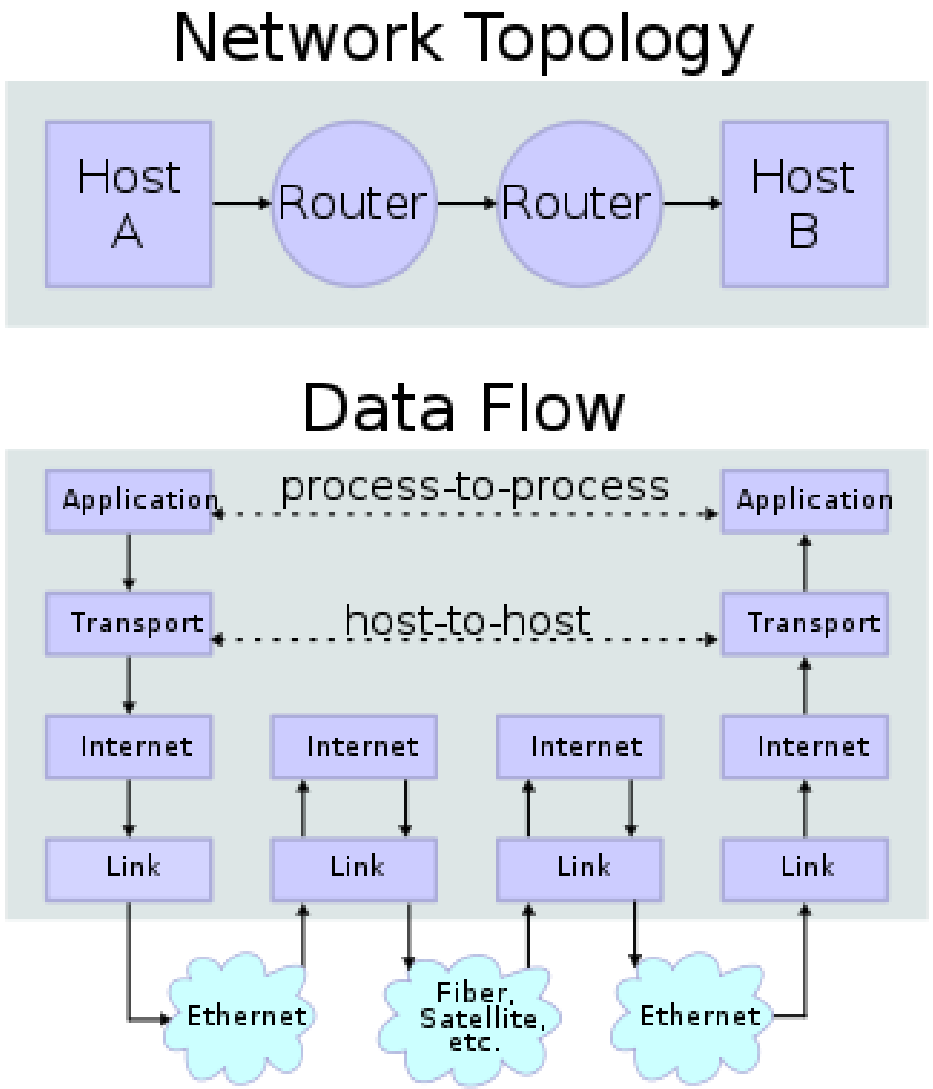
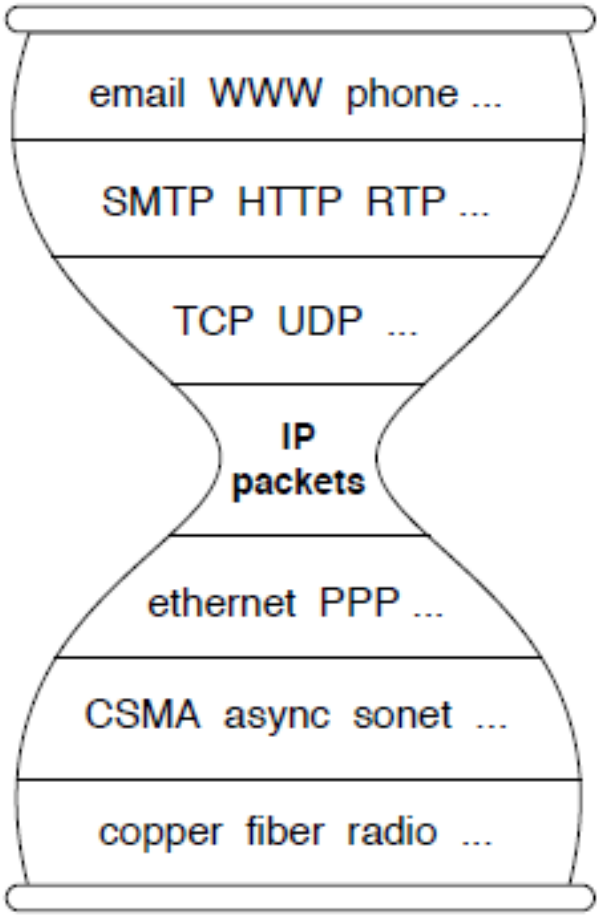
IP Suite – From the First Lecture





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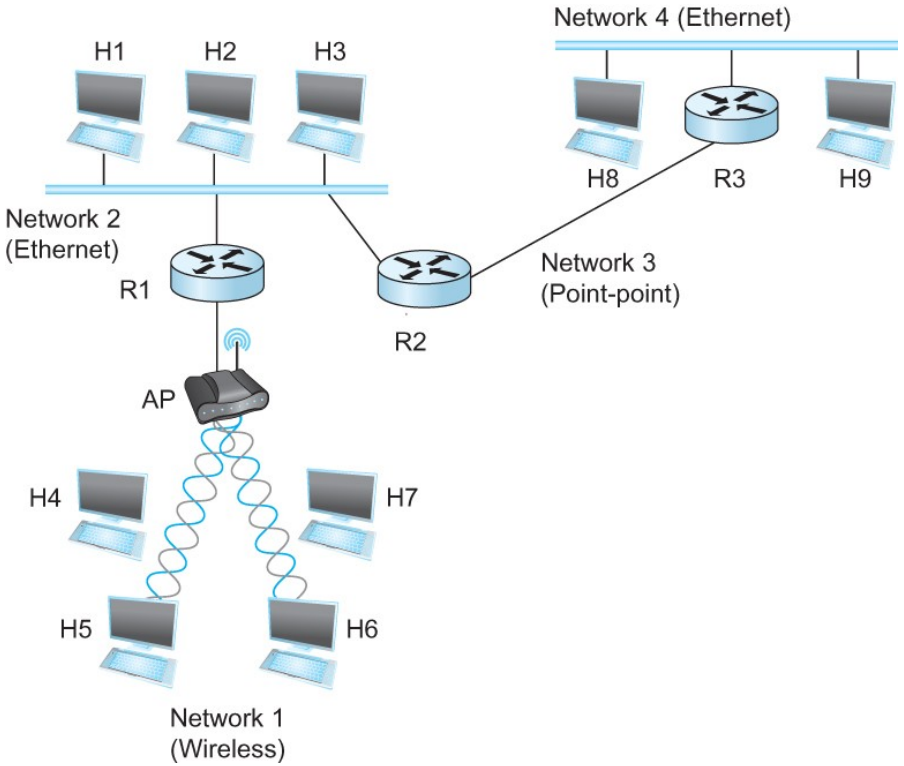
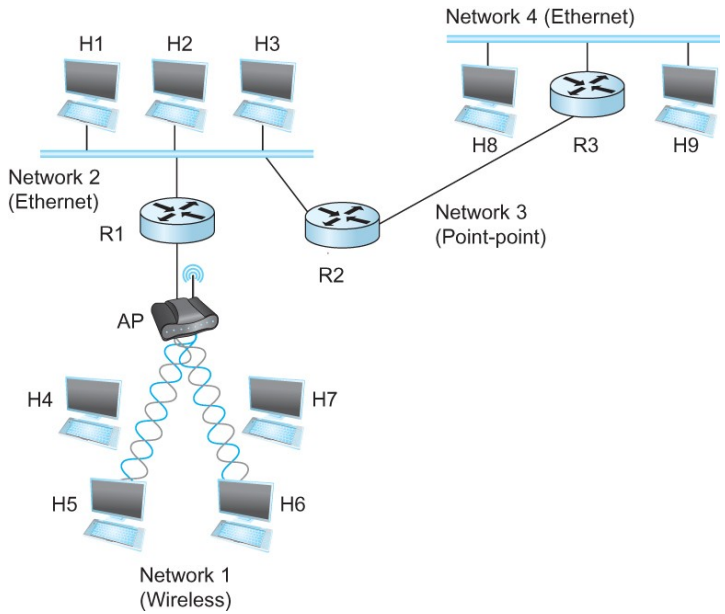
Internet Protocol (IP)

- What is an internetwork?
  - An arbitrary collection of networks interconnected to provide some sort of host-host to packet delivery service



But that’s what switches are for – No?

- Switches create networks, Routers connect different networks.
- Typically switches are at **Layer 2**, Routers are at **Layer 3**
- Switches forward **FRAMES,** Routers forward **PACKETS**

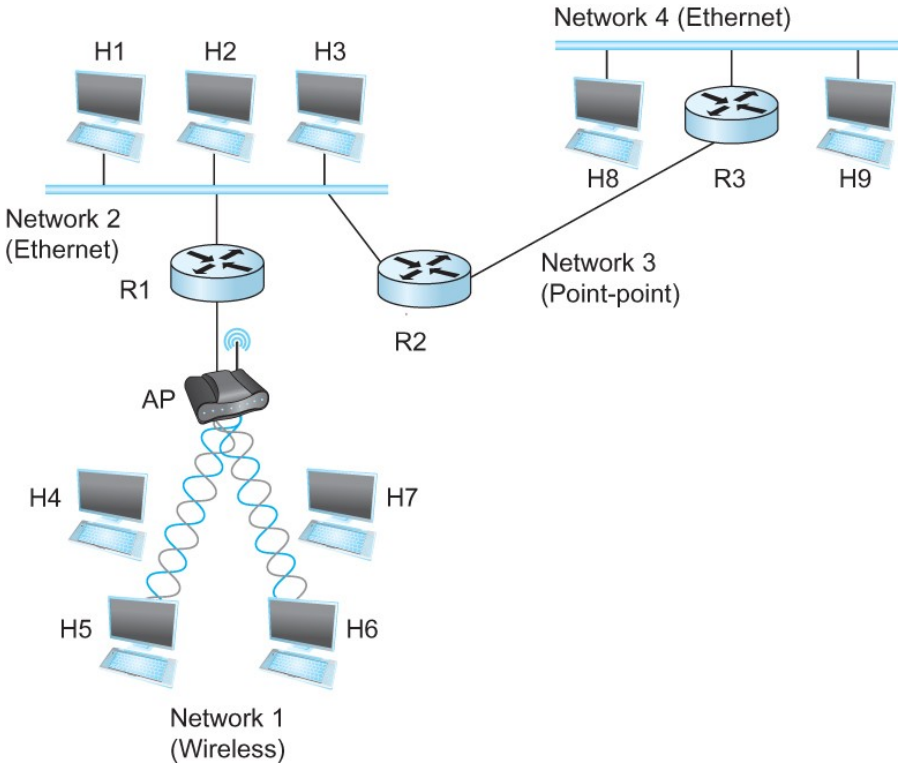


But that’s what switches are for – No?

- This room → Point-to-point link
- This room + next room → Switch
- This room + next room + foundation hall → Switches with VLAN
- This university + Internet → Router
- **Good for conceptualization - not always as simple**

Internetworking Protocol (IP)

- What is an internetwork?
  - An arbitrary collection of networks
  - provide some sort of host-host to packet delivery service



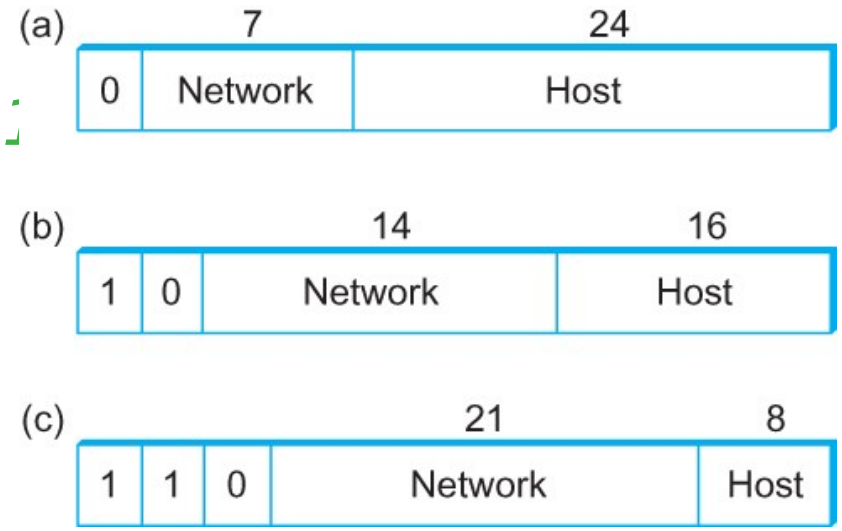
Every device has a MAC – Why do we need another address?

- Ethernet (MAC) addresses are flat
- Not the only link layer
- Not related to network topology
  - Remember – we are still connecting to hosts!
  - How do we go from: 52:54:00:86:38:14 to tntech?
  - **Other reasons?**

Global Address in IP – Each node has an unique address

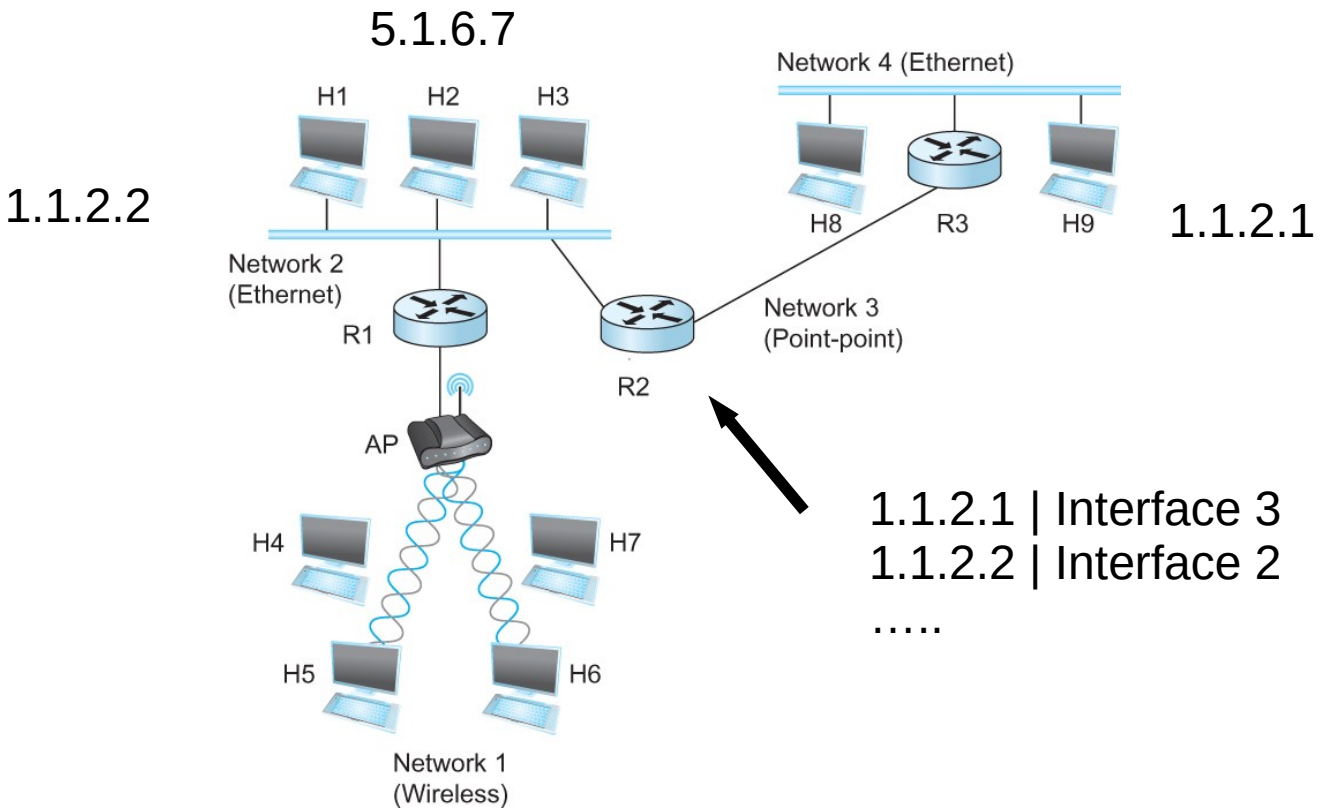
- A 32 bit number in quad-dot notation
- Identifies an ***Interface***
  - ***A host might have several interfaces!!!***
- *129.82.138.254*

  10000001.01010010.10001010.11



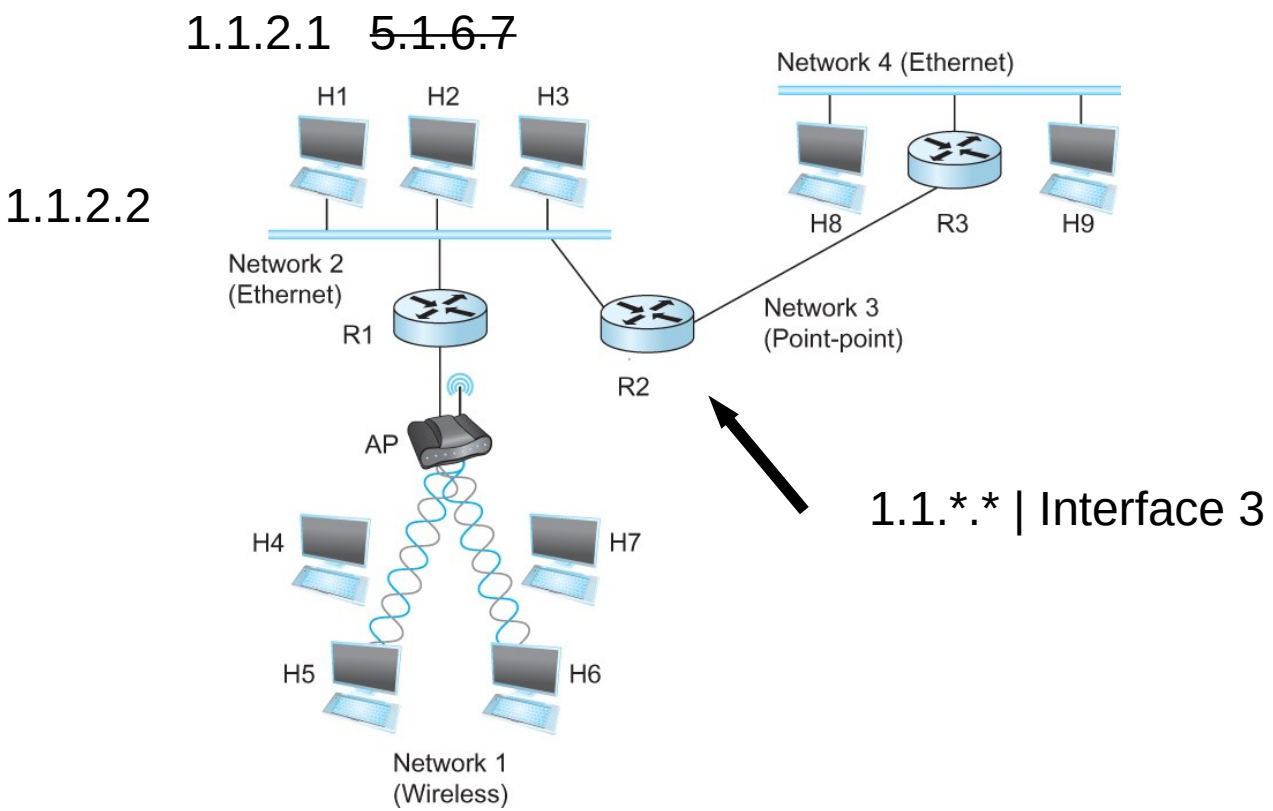
IP allows the network to scale!

- What if addresses were arbitrary?



Solution - Group hosts

- What if addresses were arbitrary?



IP addresses are in Network + Host

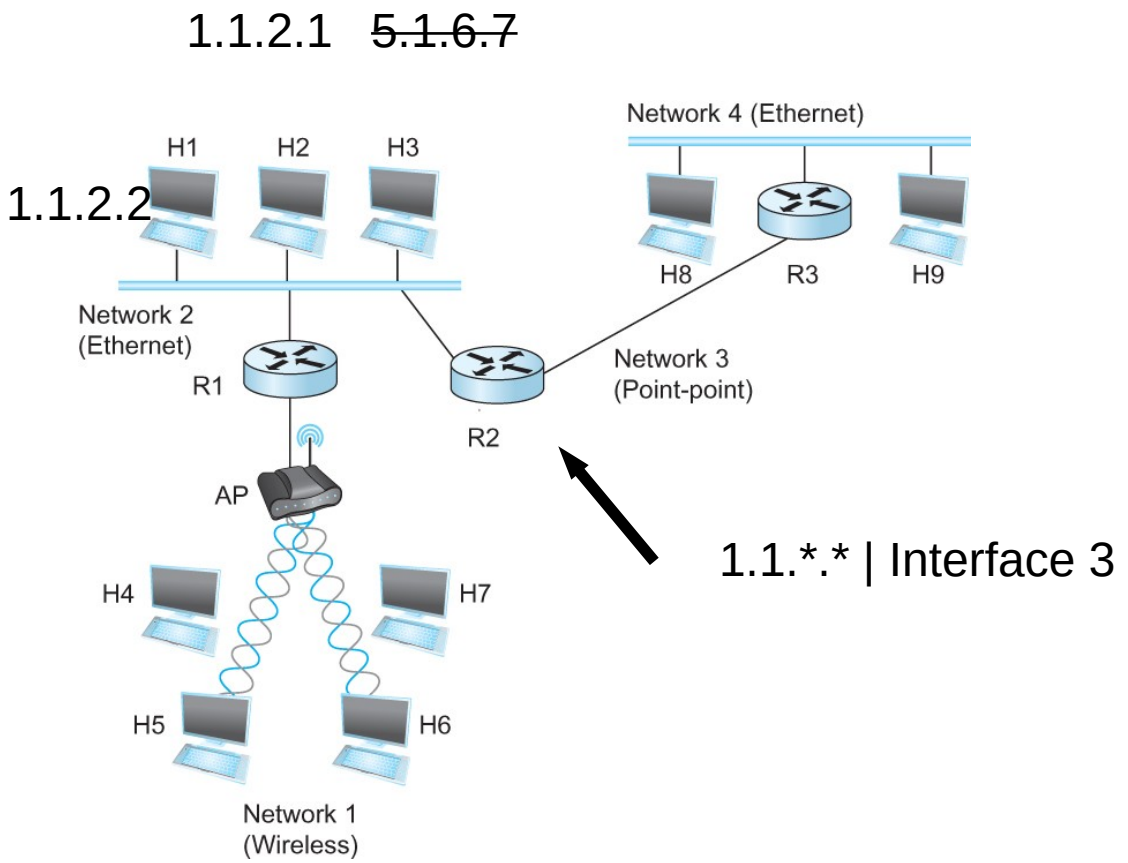
- 1.1.2.1 →
  - 1.1 → Network part
  - 2.1 → host part
- Each octet can range from 1- 255

- Hierarchical address

129.82.138.254

10000001.01010010.10001010.11111110

Network part (24 bits). Host part(8 bits)

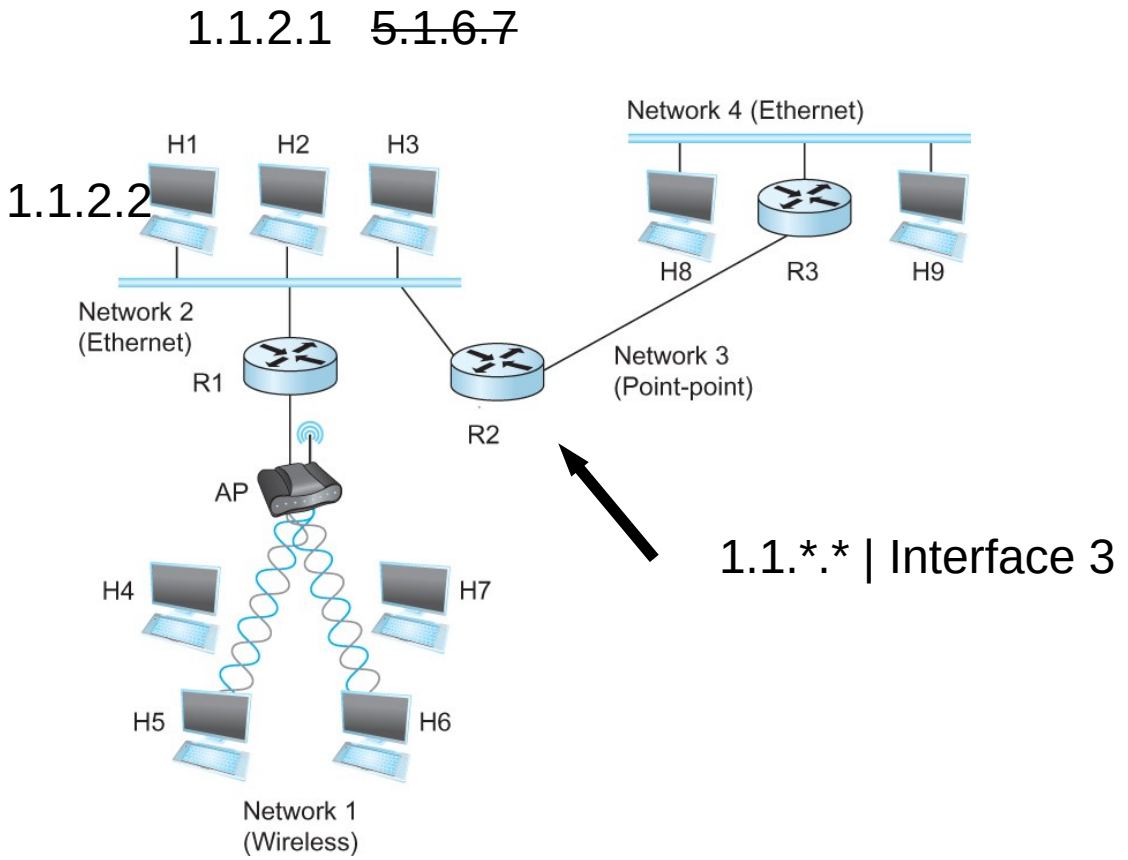


How do we know host vs network → Subnetting

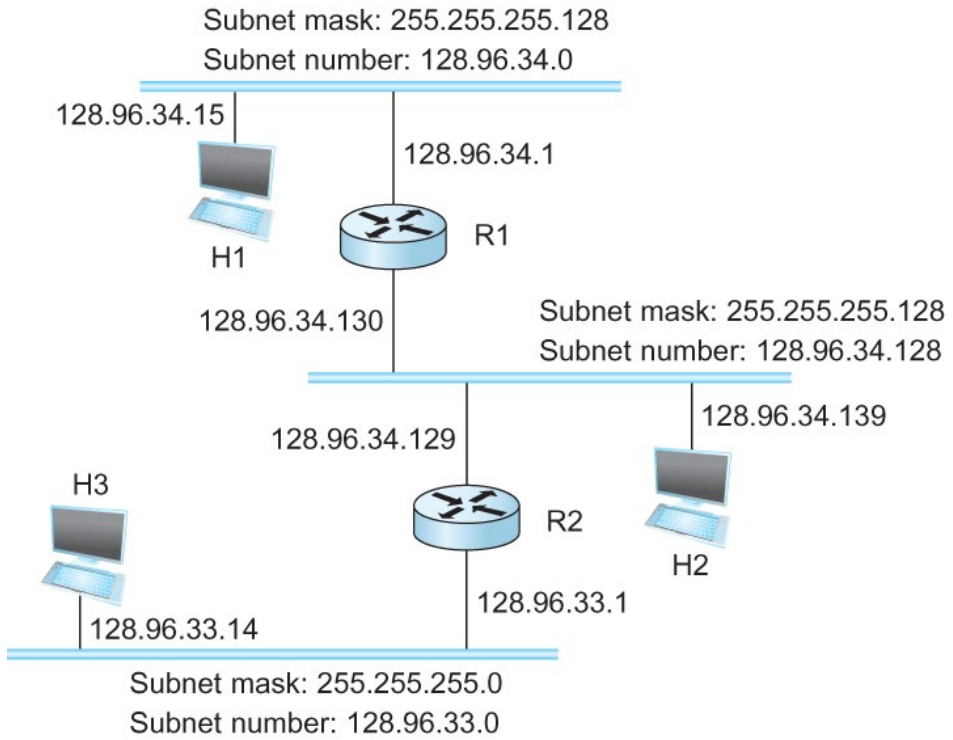
129.82.138.254 (Address)

10000001.01010010.10001010.11111110
11111111.11111111. 11111111.00000000

255.255.255.0 (Subnet mask)



Subnetting



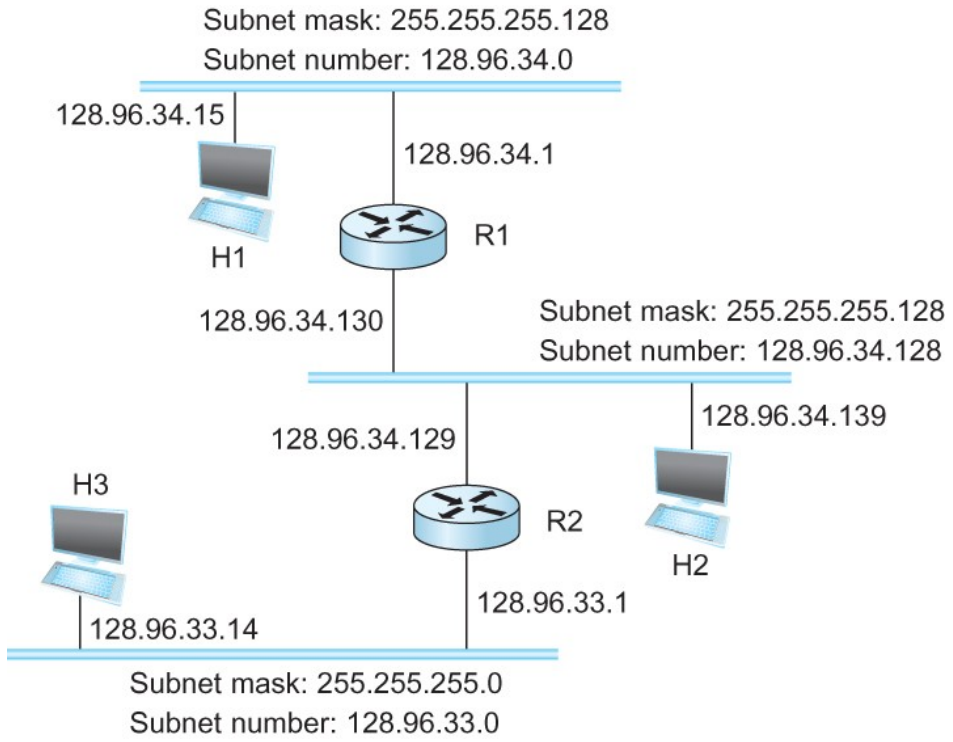
Forwarding Table at Router R1

SubnetNumber	SubnetMask	NextHop
128.96.34.0	255.255.255.128	Interface 0
128.96.34.128	255.255.255.128	Interface 1
128.96.33.0	255.255.255.0	R2

Subnetting

Three classes:

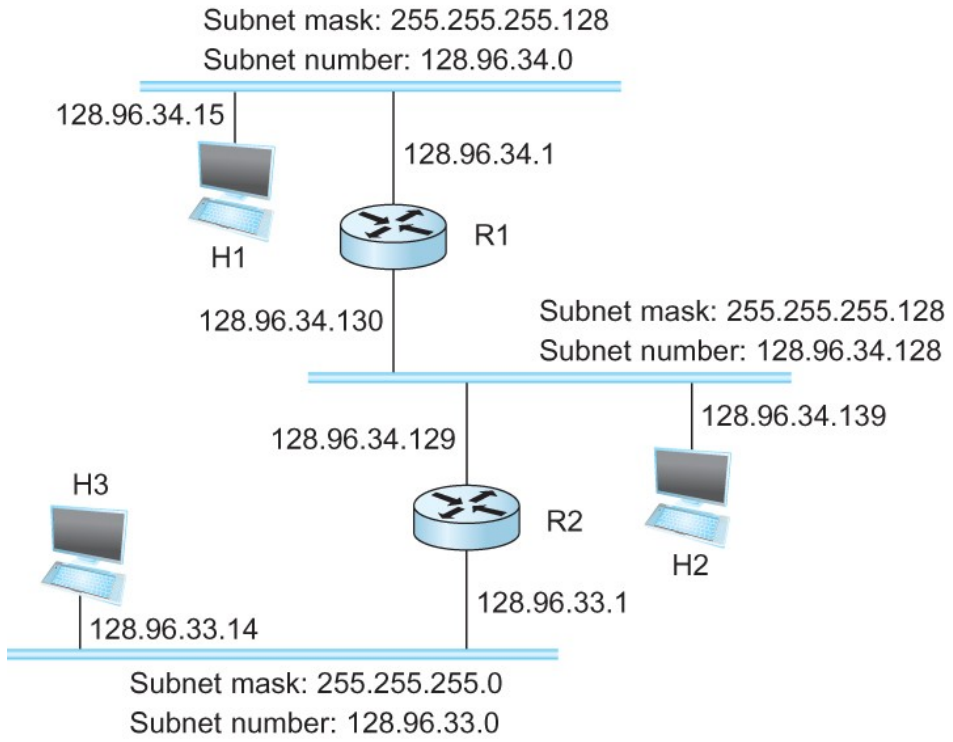
- Class A: 129.0.0.0/8
- Class B: 129.82.0.0/16
- Class C: 129.82.2.0/14



SubnetNumber	SubnetMask	NextHop
128.96.34.0	255.255.255.128	Interface 0
128.96.34.128	255.255.255.128	Interface 1
128.96.33.0	255.255.255.0	R2

Well, not really!

- CIDR: Classless Interdomain routing
- subnet portion of address of arbitrary length
- address format: a.b.c.d/x, where x is # bits in subnet portion of address
  - 129.82.13.0/23
  - More flexible



SubnetNumber	SubnetMask	NextHop
128.96.34.0	255.255.255.128	Interface 0
128.96.34.128	255.255.255.128	Interface 1
128.96.33.0	255.255.255.0	R2

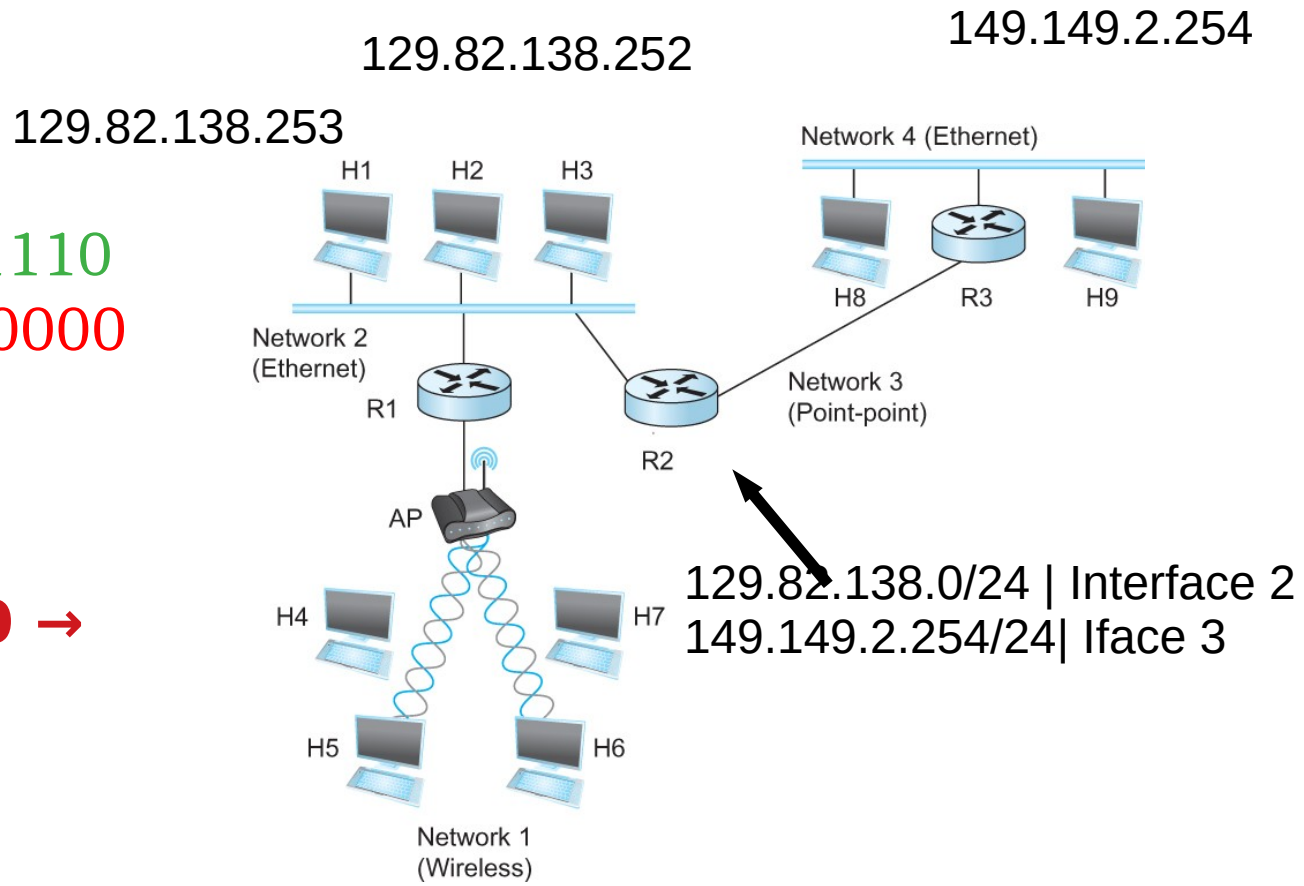
Now routers can operate on Network address!!!!

129.82.138.254 (Address)

10000001.01010010.10001010.11111110
11111111.11111111. 11111111.00000000

255.255.255.0 (Subnet mask)

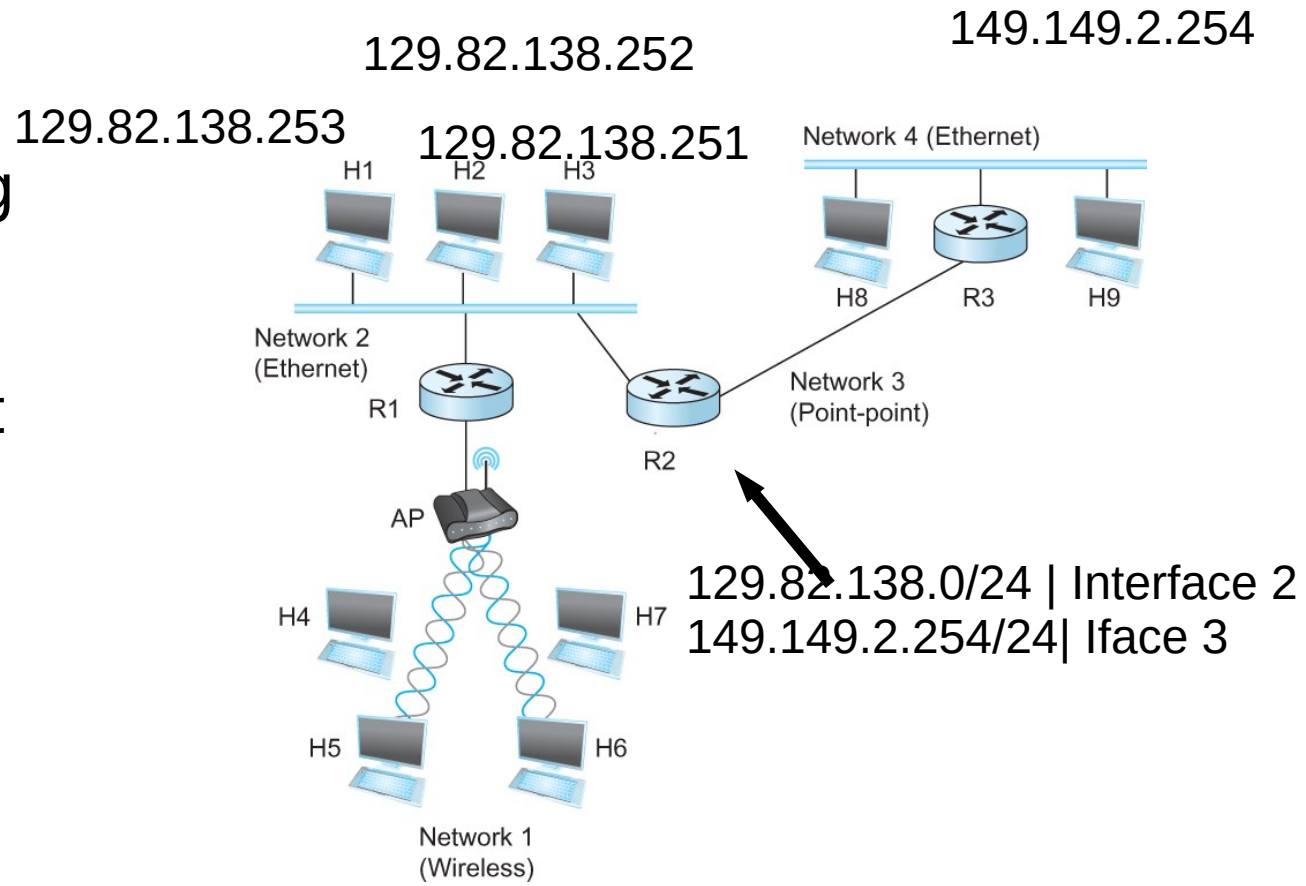
129.82.138.254 + 255.255.255.0 → 129.82.138.0/24



Address management is localized

No coordination needed for adding 129.82.138.251

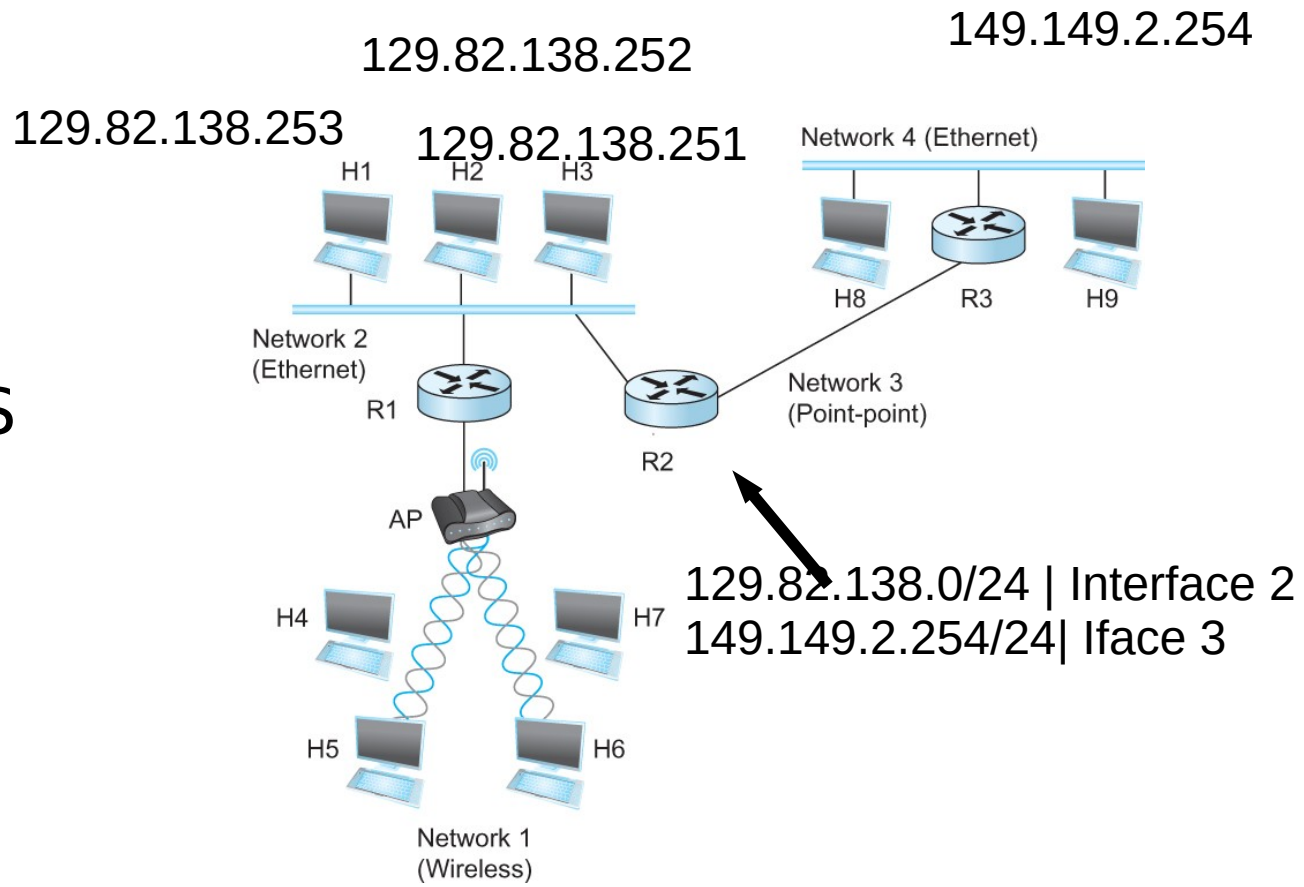
No routing update needs to go out



Address management can be automated

ARP:
    Map IP address to MAC address
DHCP:
    Learn IP address, gateway, DNS

More on these later.



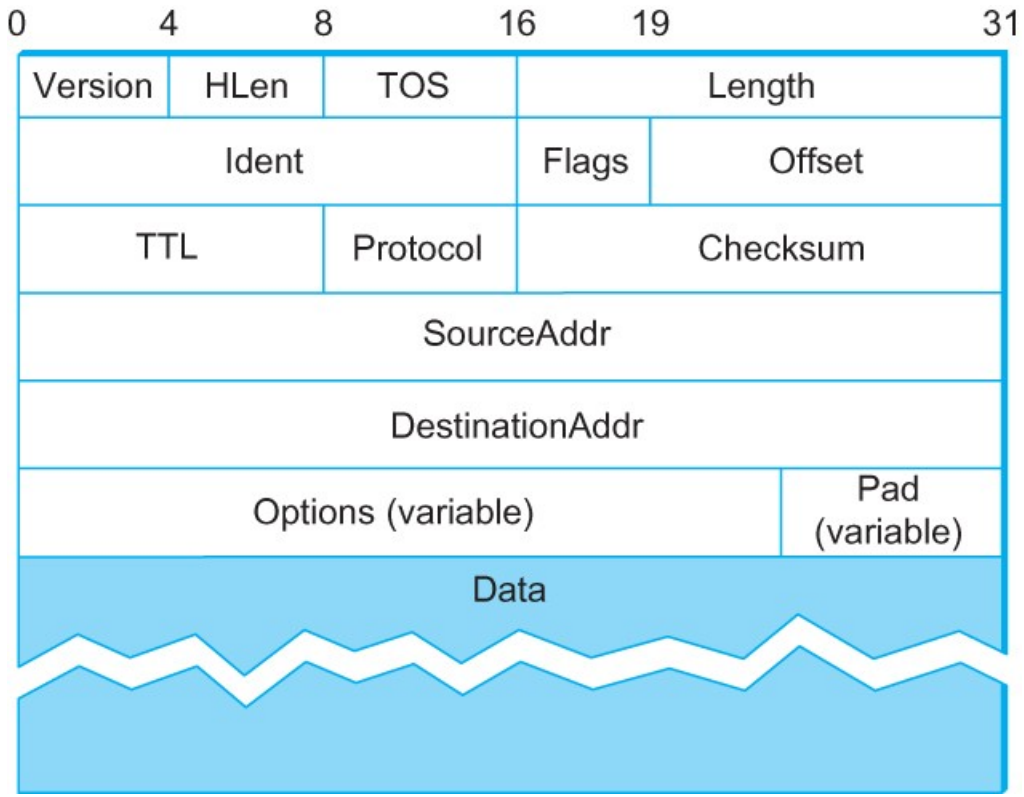
You have an address – Send data now. IP service model

- Packet Delivery Model
  - Connectionless model for data delivery

- Best-effort delivery (unreliable service)
  - packets are lost
  - packets are delivered out of order
  - duplicate copies of a packet are delivered
  - packets can be delayed for a long time

- Global Addressing Scheme
  - Provides a way to identify all hosts in the network

IP Packet



Version (4): 4

Hlen (4): number of 32-bit words in header

TOS (8): type of service (not widely used)

Length (16): number of bytes in this datagram

Ident (16): used by fragmentation

Flags/Offset (16): used by fragmentation

TTL (8): number of hops this datagram has traveled

Protocol (8): demux key (TCP=6, UDP=17)

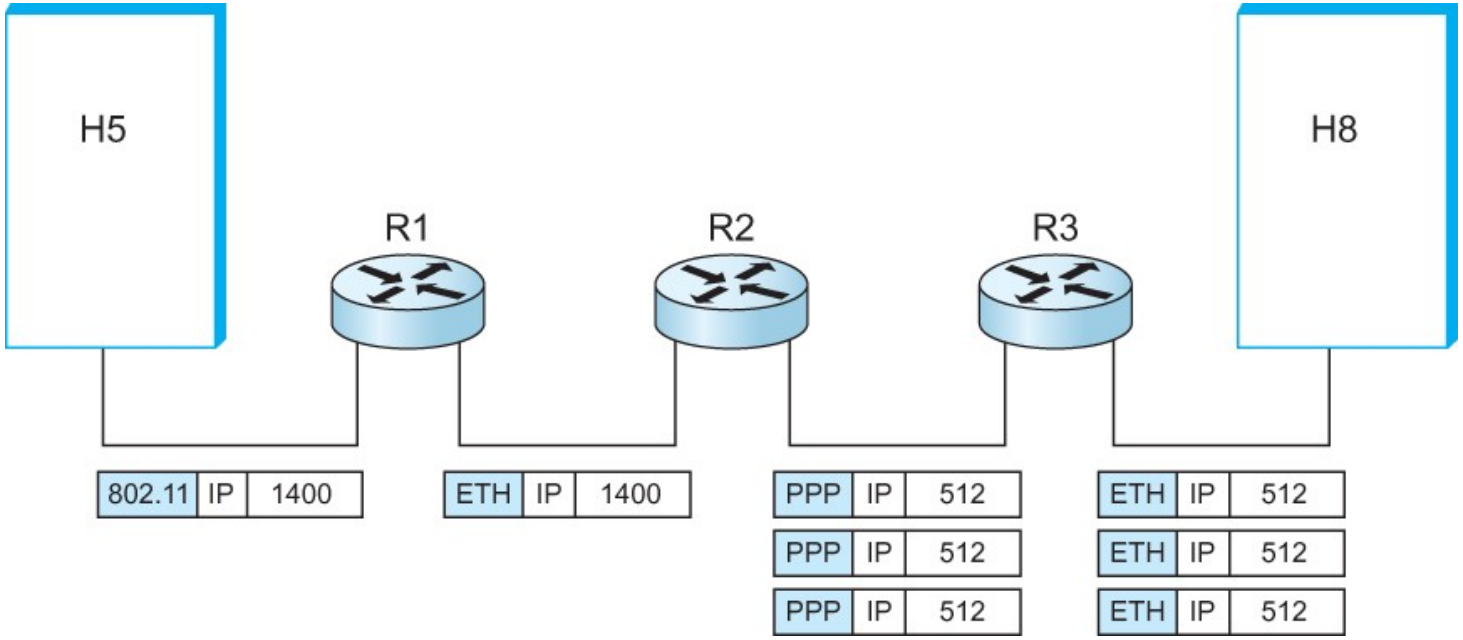
Checksum (16): of the header only

DestAddr & SrcAddr (32)

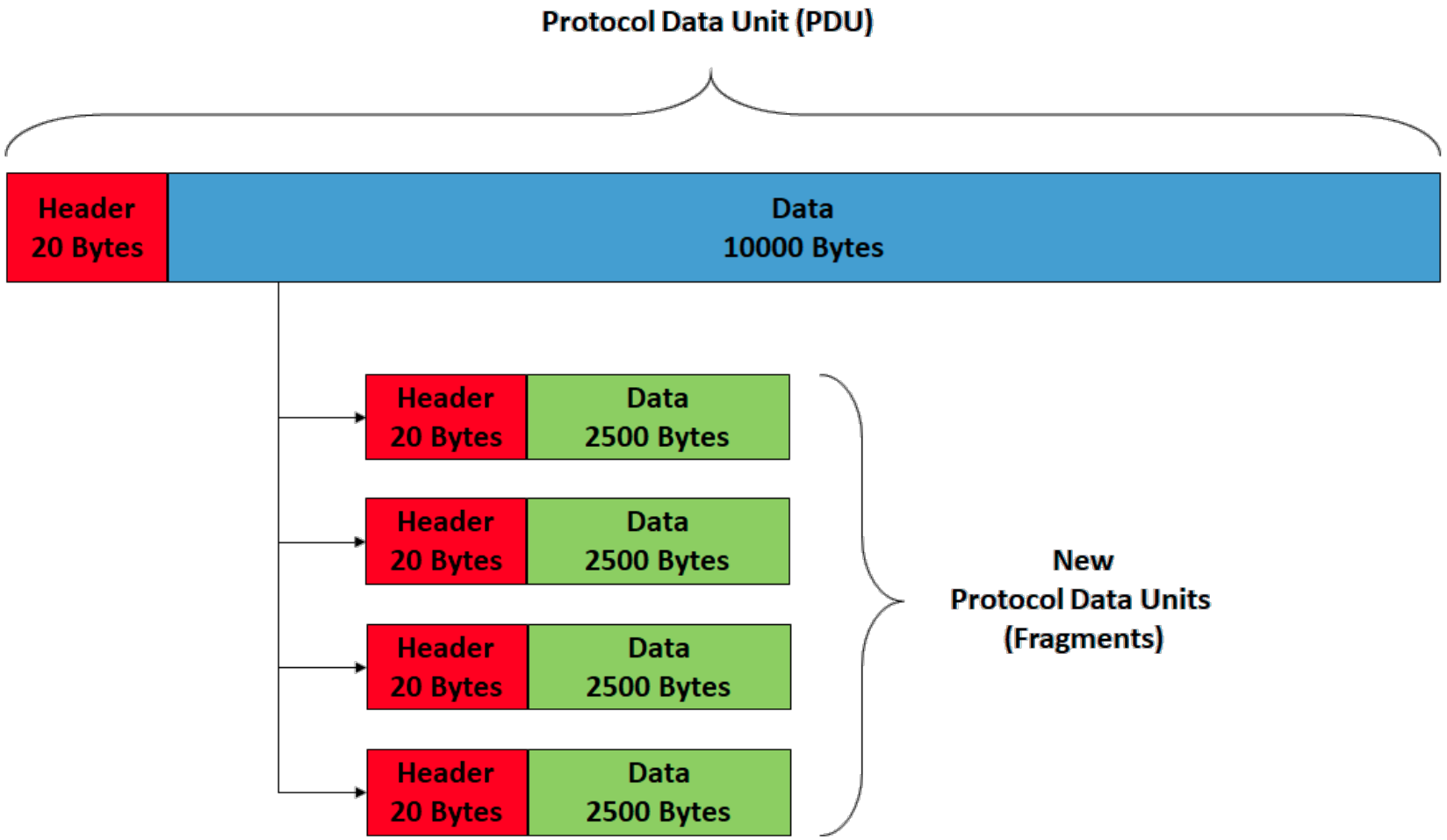
IP Fragmentation and Reassembly

Underlying Layer 2 limitations
- Ethernet 1500
- PPP 512

- Break packets into smaller chunk and reassemble later



IP Fragmentation and Reassembly



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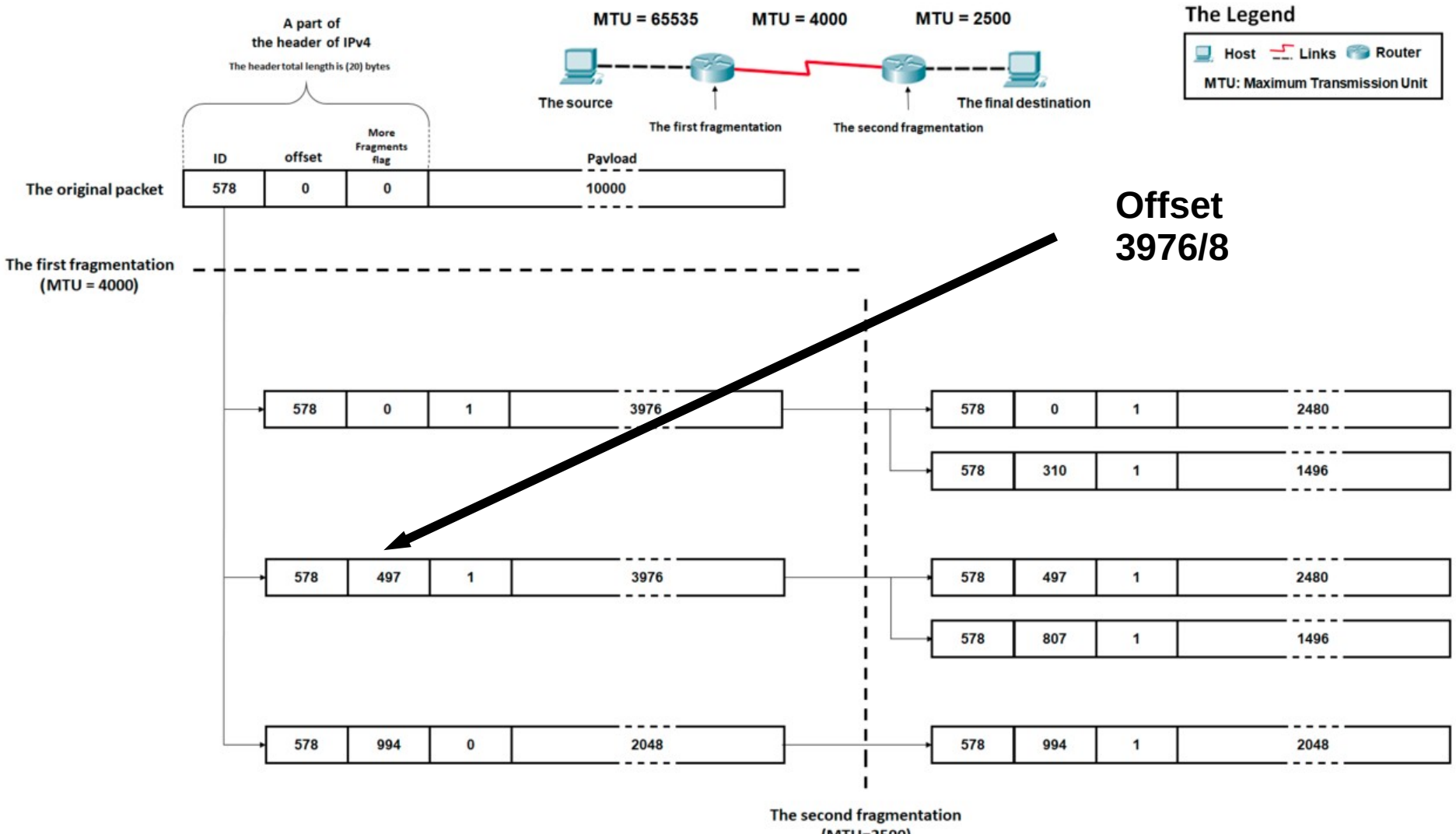
IP Fragmentation and Reassembly



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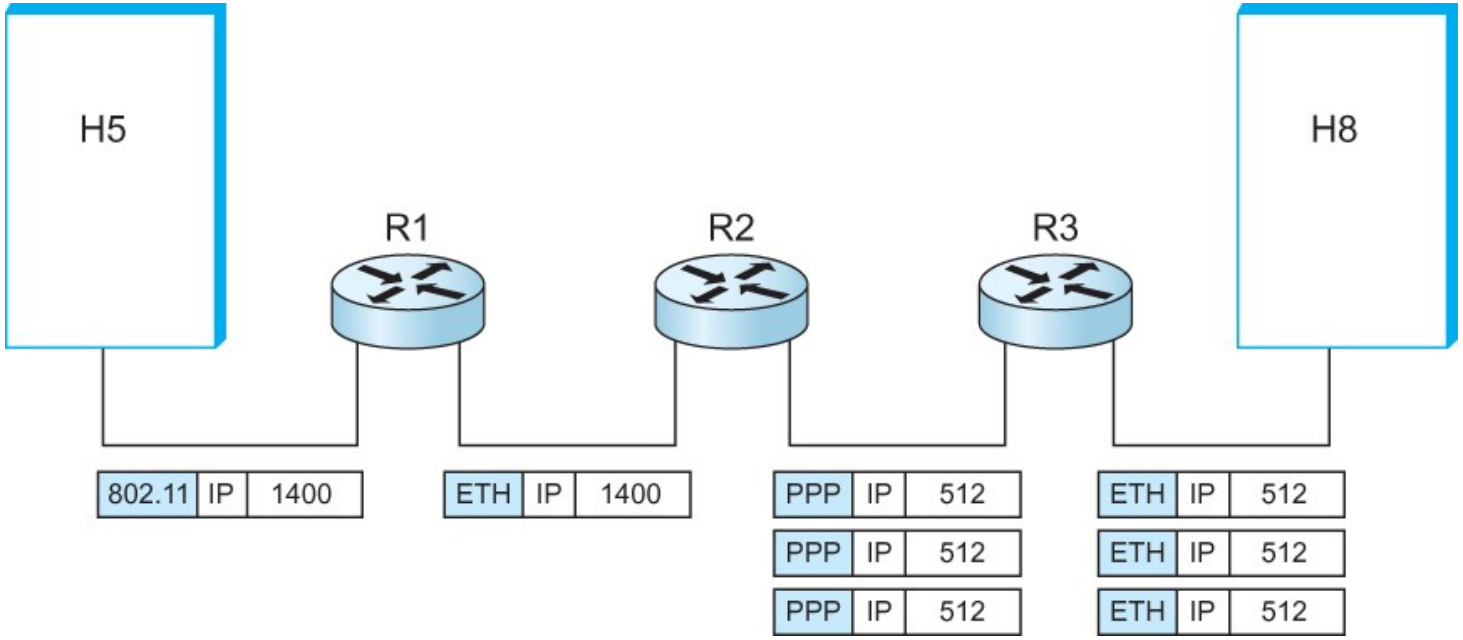

Next Steps

Routing