CSC4200/5200 – COMPUTER NETWORKING

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INTERNET PROTOCOL (IP)
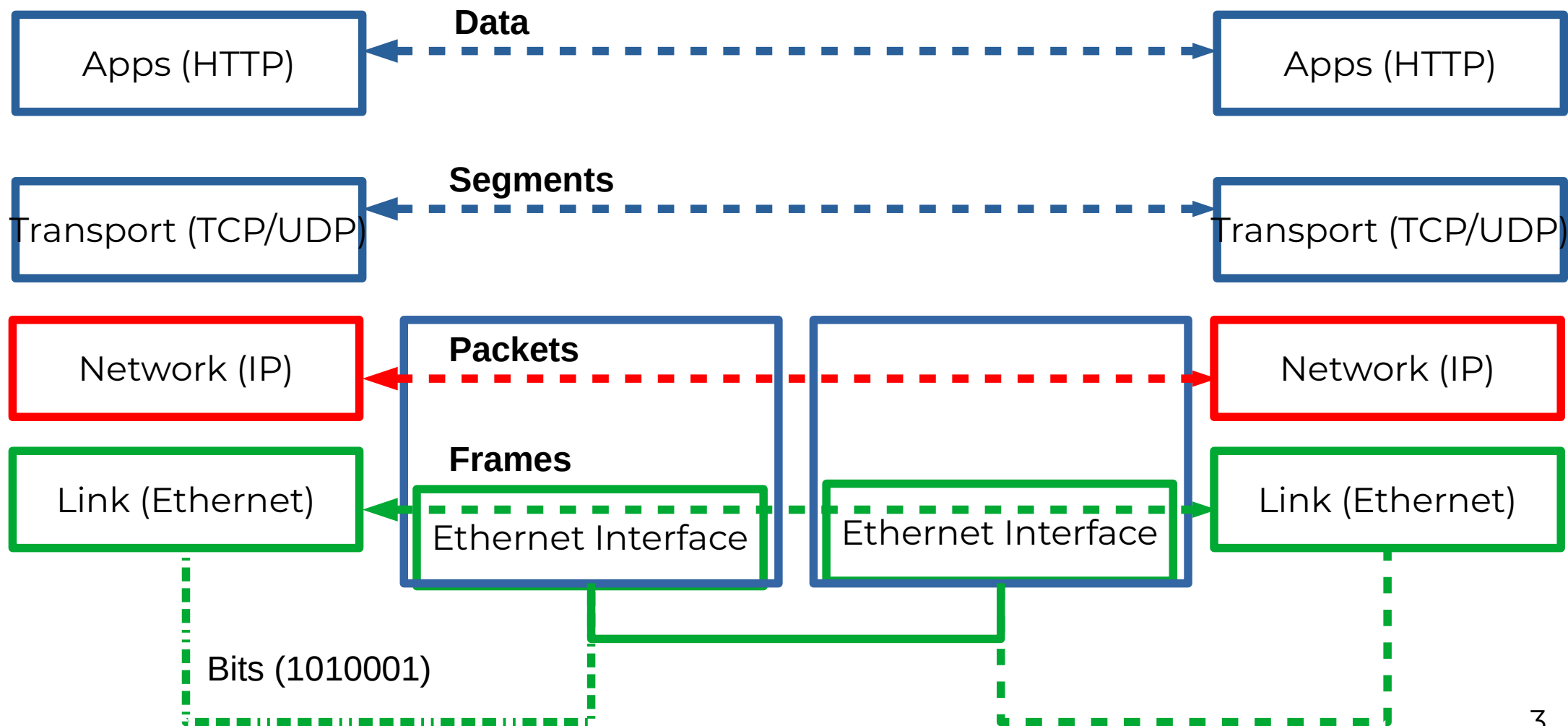
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Tennessee
TECH

The mystery that is iLearn...

- No special characters in filename! ← Probably this was your problem

- Up to 40MB

Apps (HTTP) **Data** Apps (HTTP)

Transport (TCP/UDP) **Segments** Transport (TCP/UDP)

Network (IP) **Packets** Network (IP)

Link (Ethernet) **Frames** Link (Ethernet)

Ethernet Interface Ethernet Interface

Bits (1010001)

3

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**

LAN 1
Collision domain 1

LAN 2
Collision domain 2

5
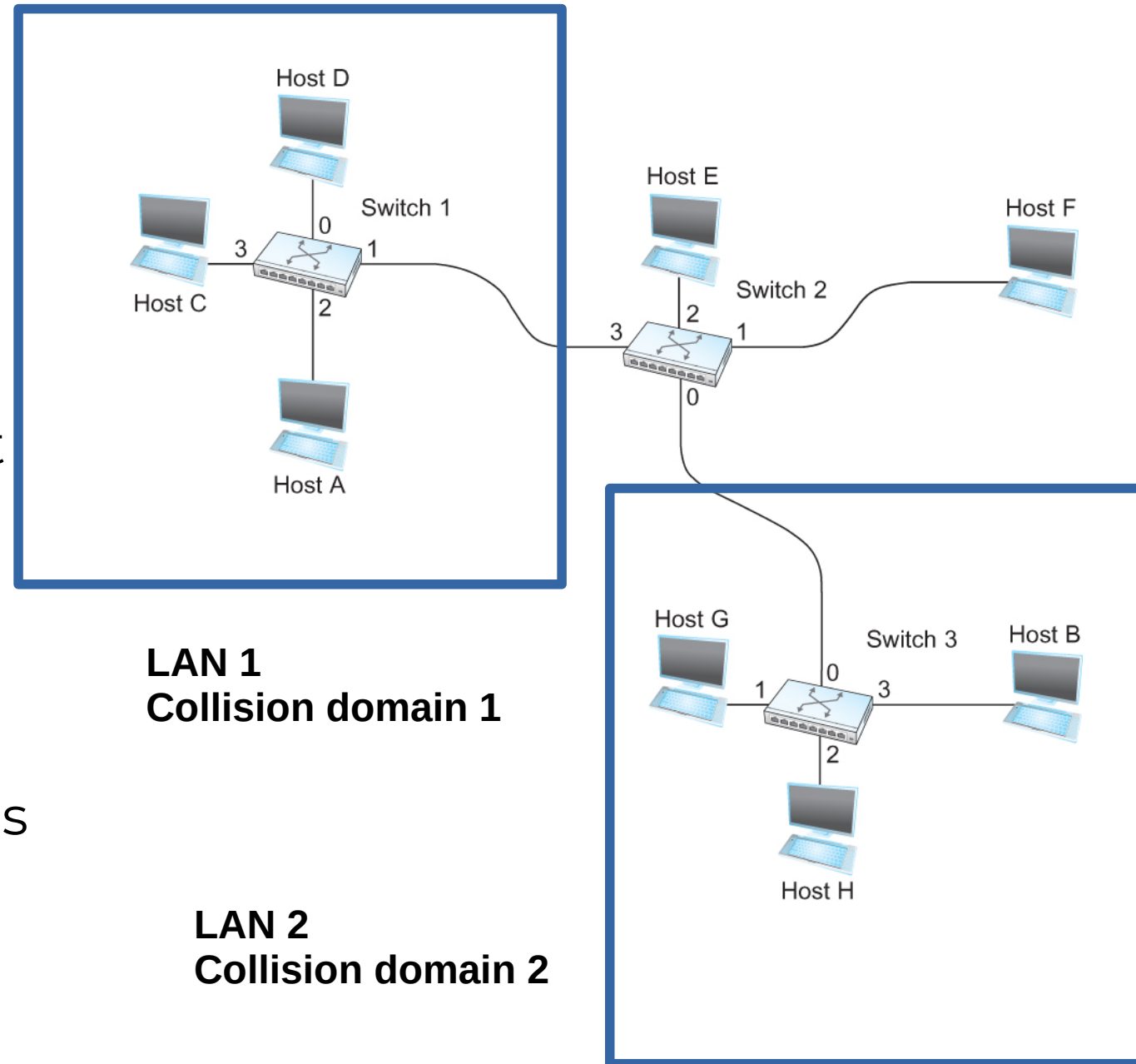
How do we create a spanning tree?

- **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)
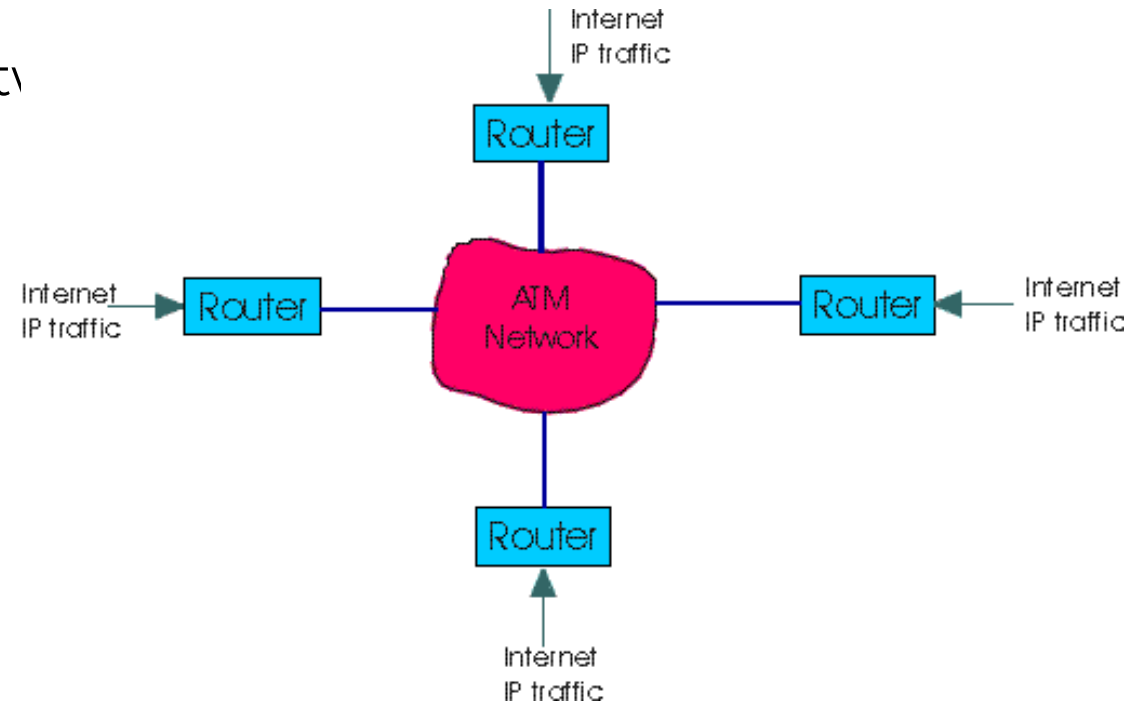 - Removes 4-5 link from the tree

- **Does not scale!**
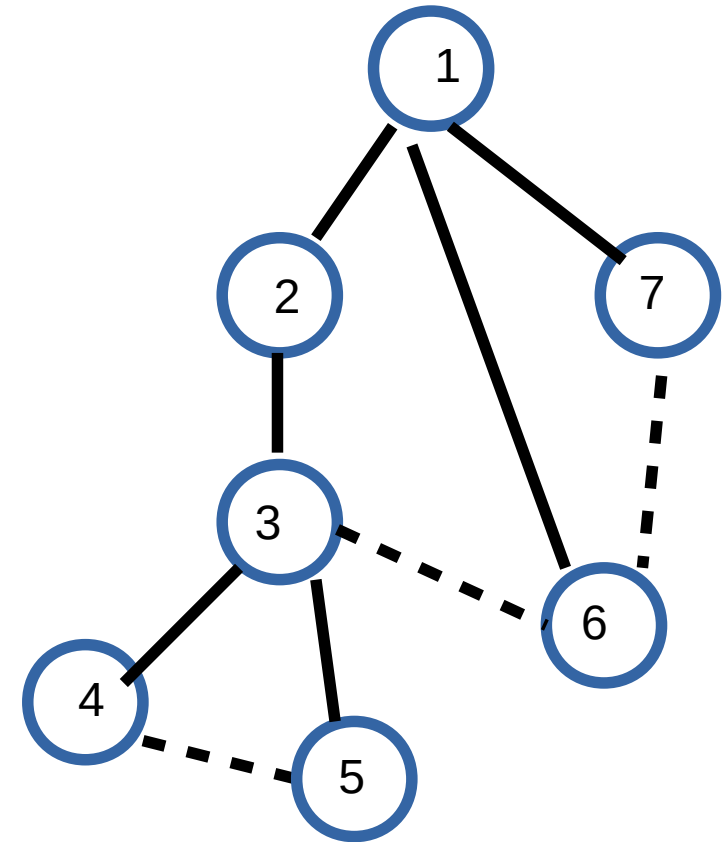
ATM (Carries Cells, not Money)

- 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
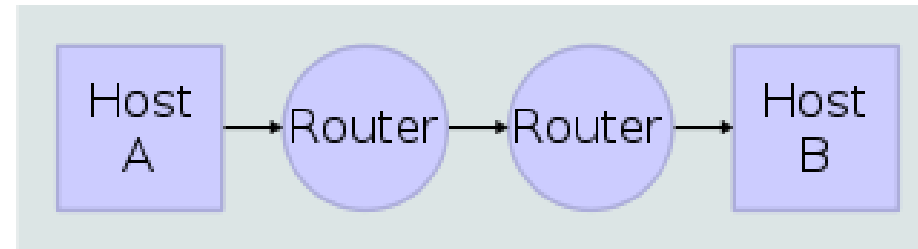- **Why?**

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

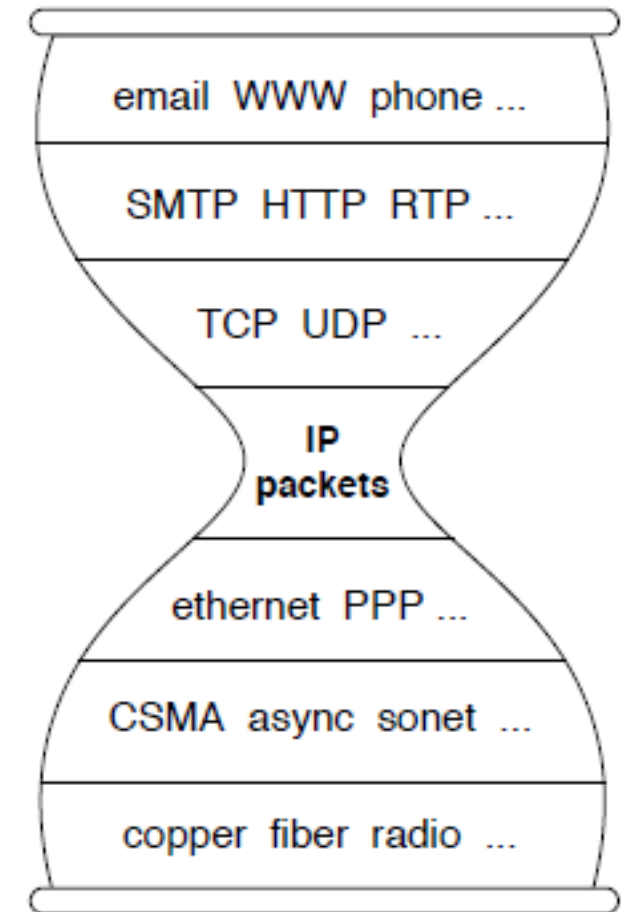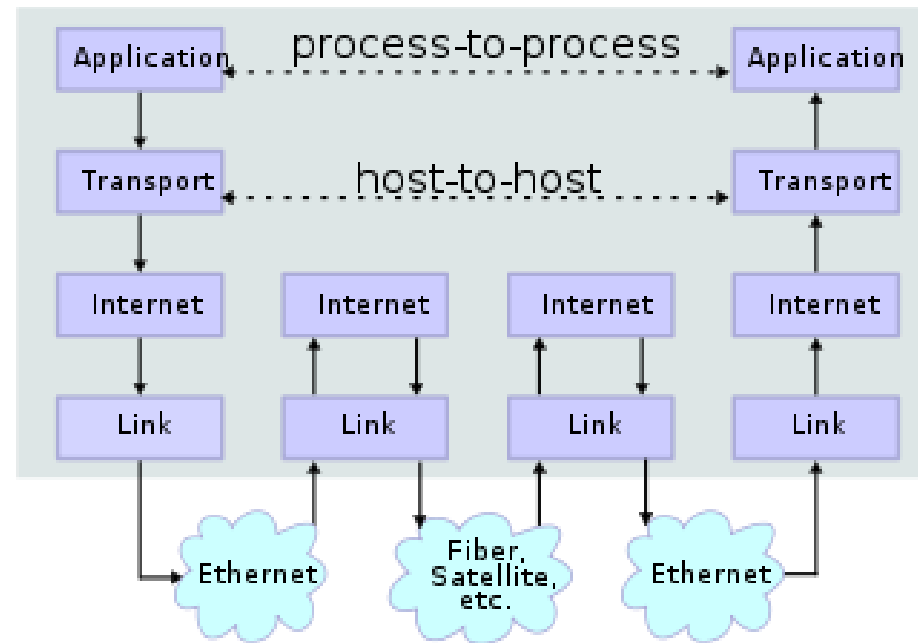- Still used in long distance private links

Internet
IP traffic

Router

Internet
IP traffic → Router — ATM Network — Router ← Internet
IP traffic

Router

Internet
IP traffic

kurose/ross

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IP Suite – From the First Lecture

Network Topology

Host A → Router → Router → Host B

Data Flow

Application	process-to-process		Application
Transport	host-to-host		Transport
Internet	Internet	Internet	Internet
Link	Link	Link	Link

Ethernet | Fiber, Satellite, etc. | Ethernet

email WWW phone ...

SMTP HTTP RTP ...

TCP UDP ...

IP packets

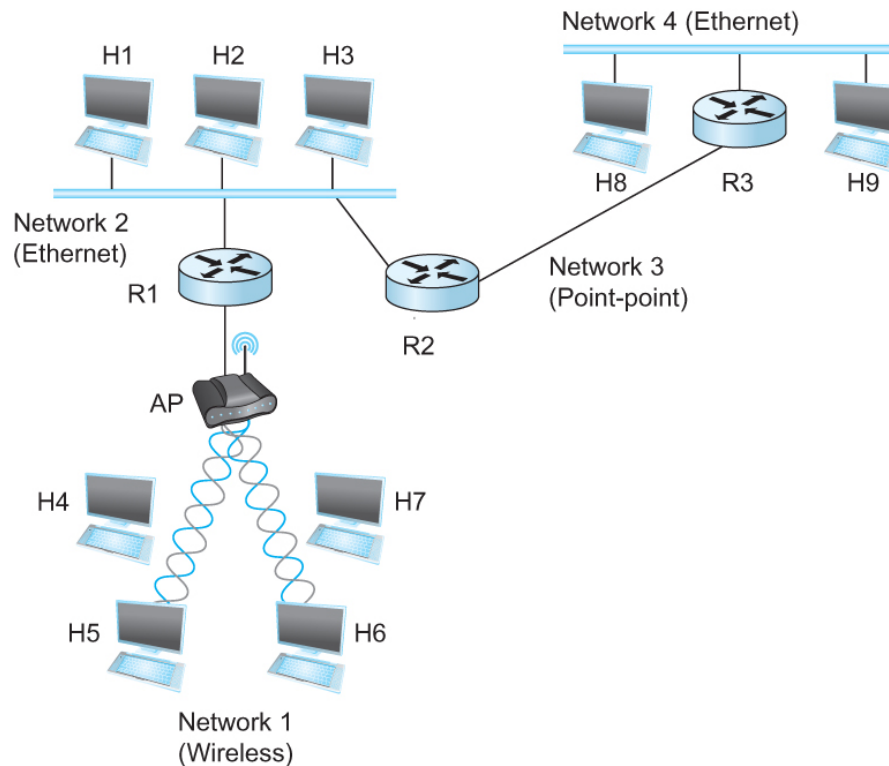ethernet PPP ...

CSMA async sonet ...
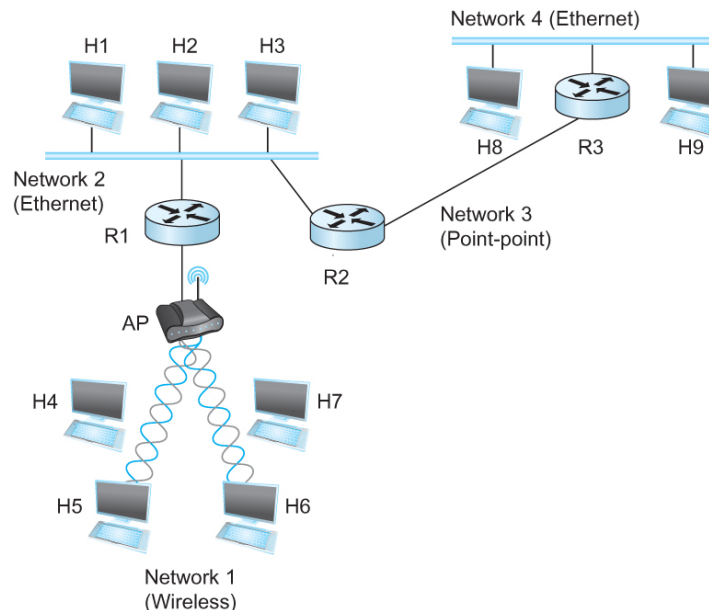
copper fiber radio ...

wikipedia

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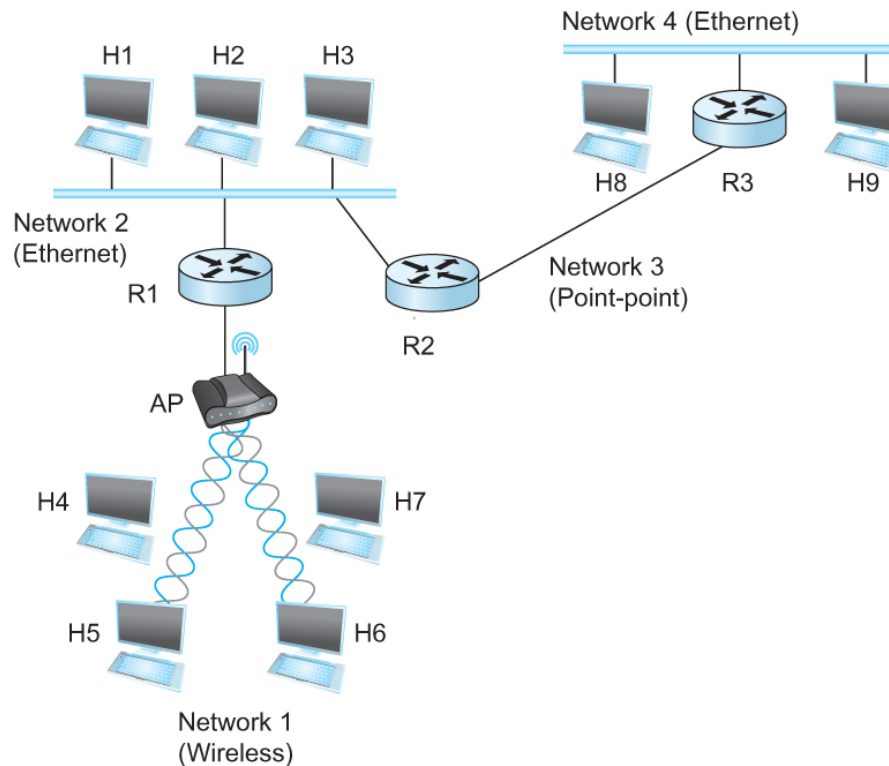
Every device has a MAC – Why do we need another address?

- 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

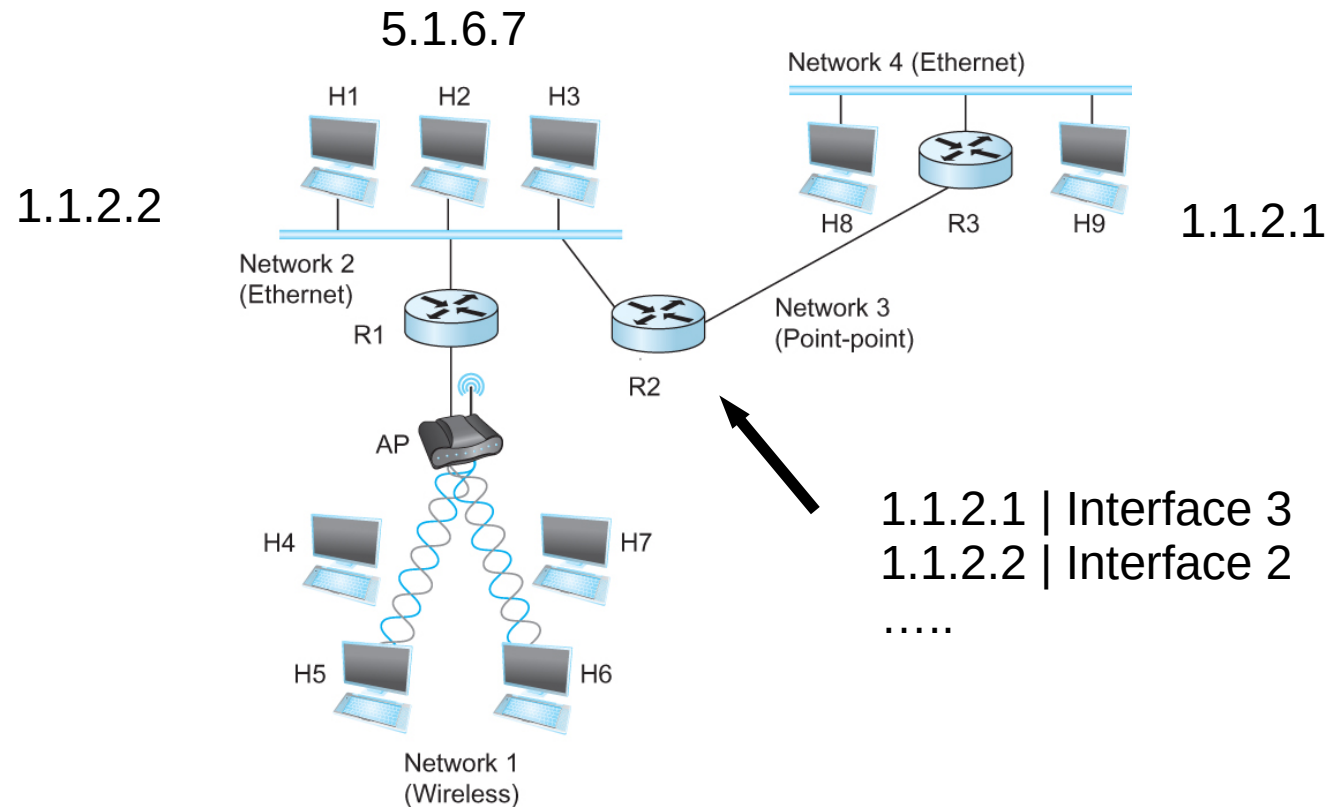- Identifies an *Interface*
  - *A host might have several interfaces!!!*

- *129.82.138.254*

  10000001.01010010.10001010.11111110

IP allows the network to scale!
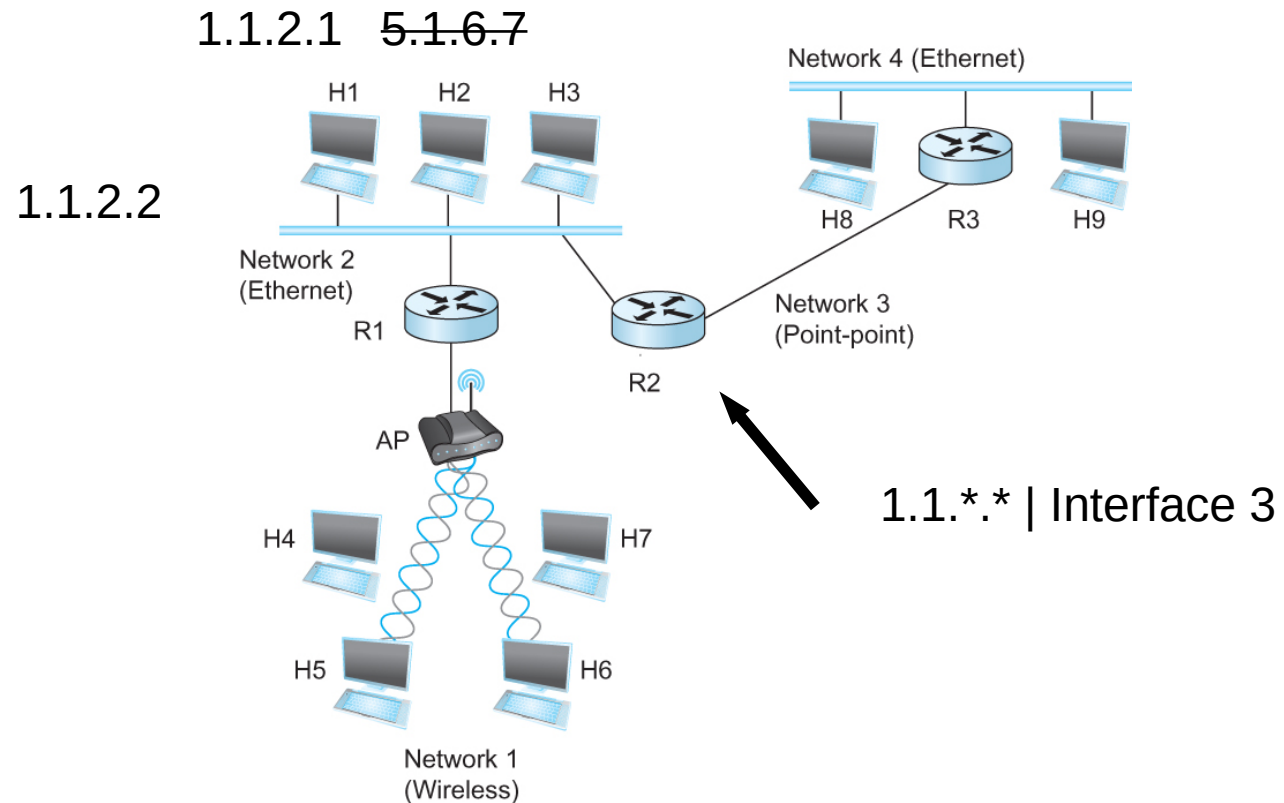
- What if addresses were arbitrary?

5.1.6.7

1.1.2.2

1.1.2.1

1.1.2.1 | Interface 3
1.1.2.2 | Interface 2
.....

Solution - Group hosts

- What if addresses were arbitrary?

1.1.2.1   ~~5.1.6.7~~

1.1.2.2

1.1.*.* | Interface 3

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)

1.1.2.1   ~~5.1.6.7~~

Network 4 (Ethernet)

1.1.2.2

H1   H2   H3

H8   R3   H9

Network 2
(Ethernet)

R1

AP

Network 3
(Point-point)

R2

1.1.*.* | Interface 3

H4   H7

H5   H6
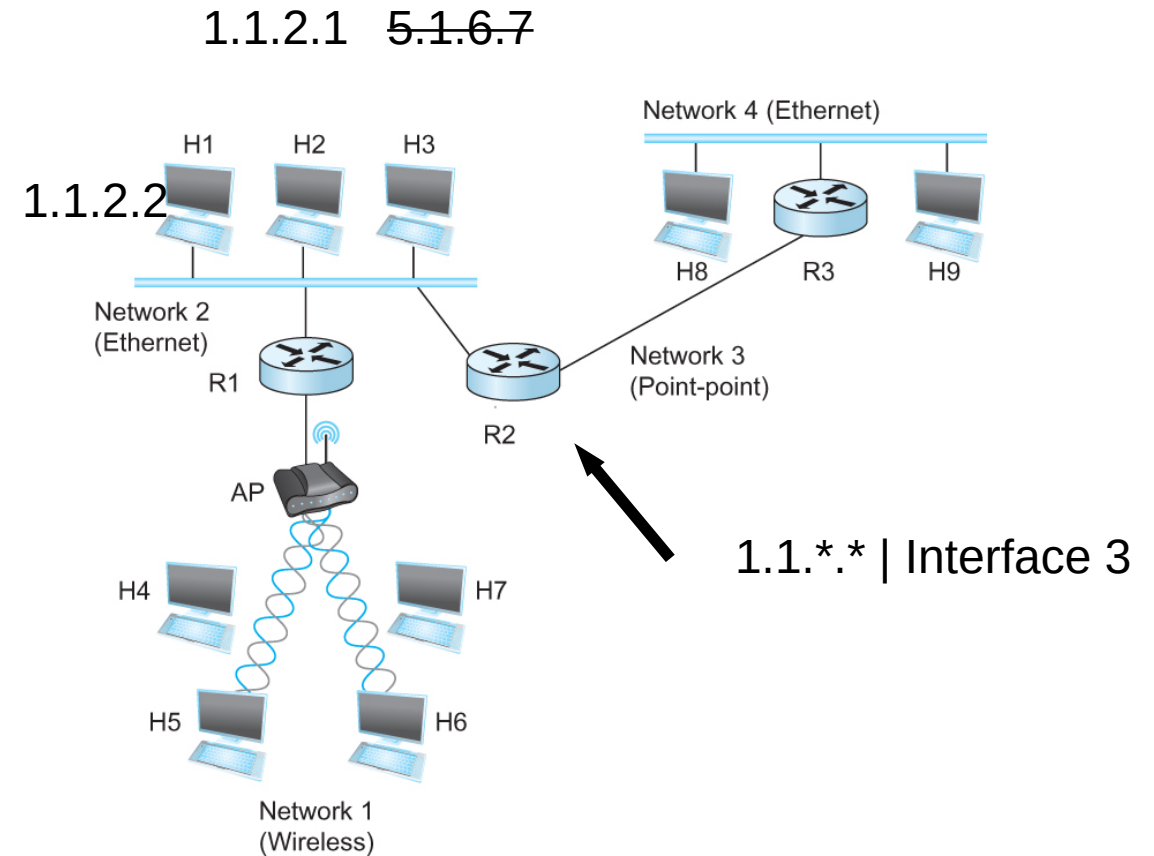
Network 1
(Wireless)

How do we know host vs network → Subnetting
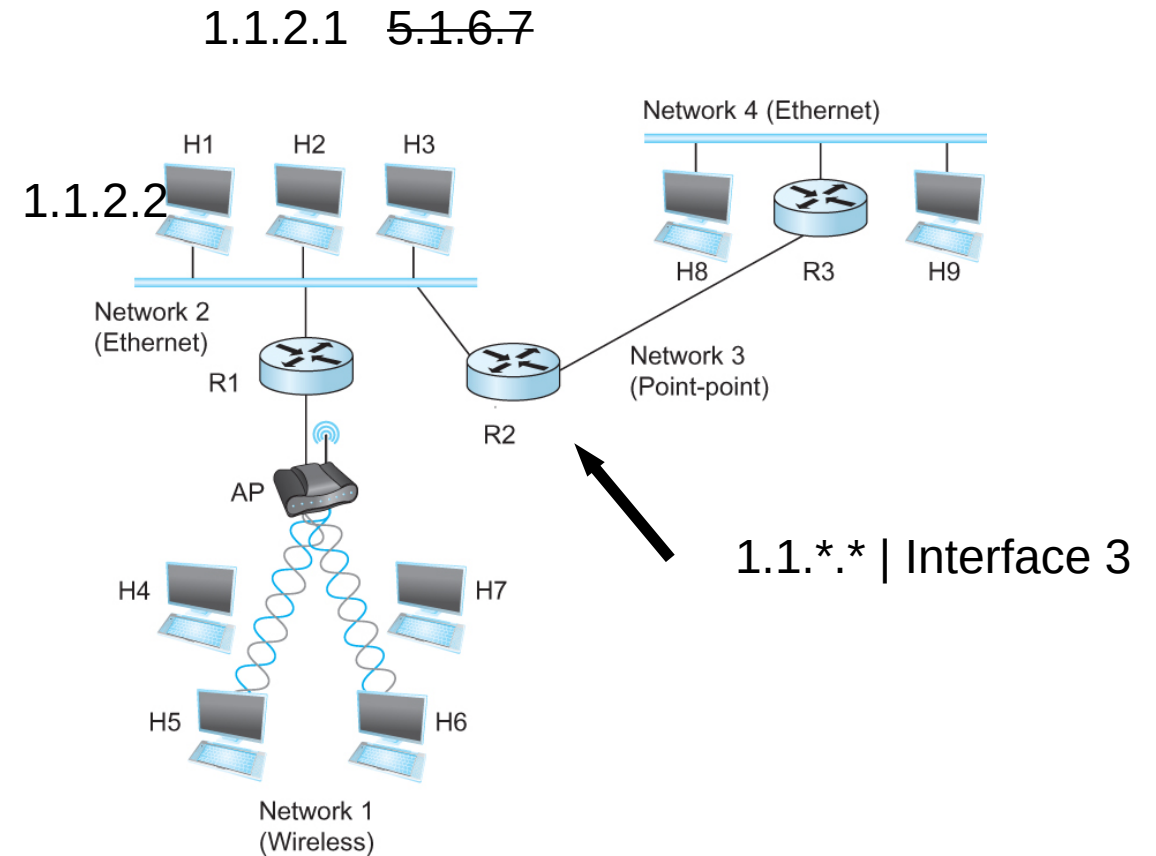
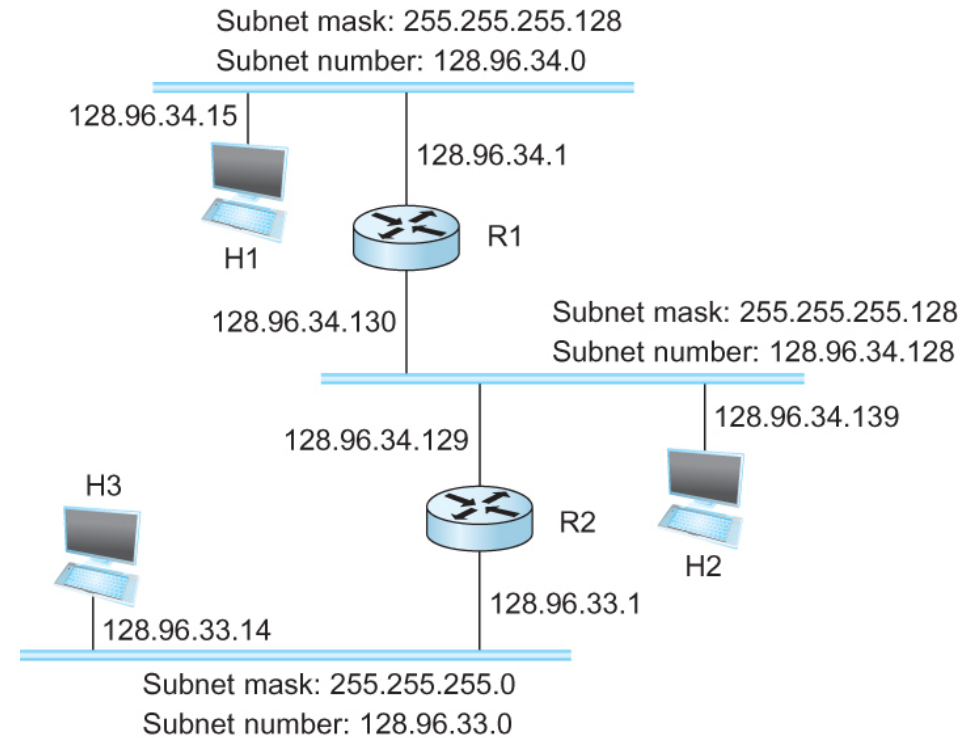**129.82.138**.254 (Address)

10000001.01010010.10001010.11111110
11111111.11111111. 11111111.00000000

255.255.255.0 (Subnet mask)

1.1.2.1   ~~5.1.6.7~~

1.1.2.2

Network 4 (Ethernet)

H1   H2   H3

H8   R3   H9

Network 2
(Ethernet)

R1

Network 3
(Point-point)

R2

AP

1.1.*.* | Interface 3

H4   H7

H5   H6

Network 1
(Wireless)

Subnetting

Subnet mask: 255.255.255.128
Subnet number: 128.96.34.0

128.96.34.15

128.96.34.1

H1 R1

128.96.34.130

Subnet mask: 255.255.255.128
Subnet number: 128.96.34.128

128.96.34.139

128.96.34.129

H3

R2

H2

128.96.33.1

128.96.33.14

Subnet mask: 255.255.255.0
Subnet number: 128.96.33.0

Forwarding Table at Router R1

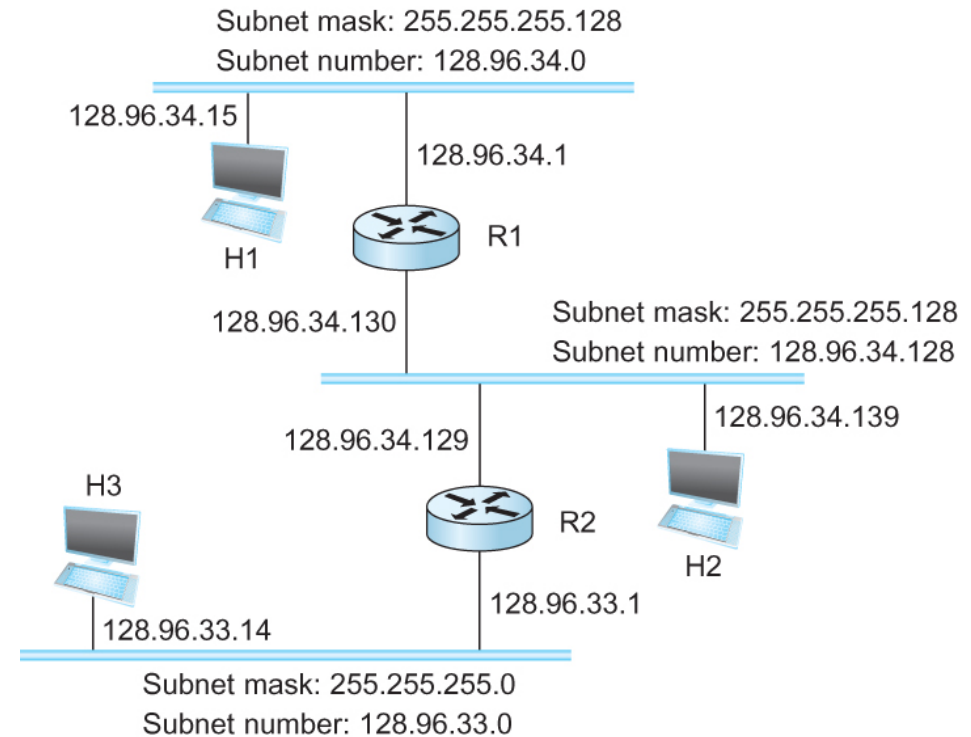| SubnetNumber	SubnetMask	NextHop
128.96.34.0	255.255.255.128	Interface 0
128.96.34.128	255.255.255.128	Interface 1
128.96.33.0	255.255.255.0	R2

Subnetting

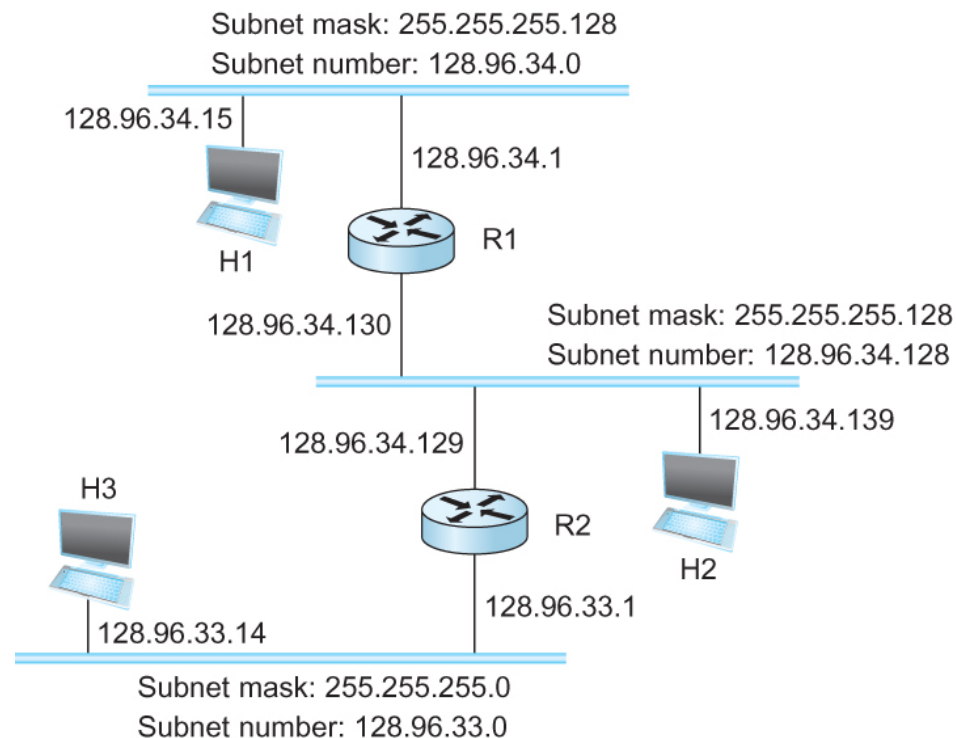Three classes:
    Class A: 129.0.0.0/8
    Class B: 129.82.0.0/16
    Class C: 129.82.2.0/14

Subnet mask: 255.255.255.128
Subnet number: 128.96.34.0

128.96.34.15

128.96.34.1

R1

H1

128.96.34.130

Subnet mask: 255.255.255.128
Subnet number: 128.96.34.128

128.96.34.139

128.96.34.129

H3

R2

H2

128.96.33.1

128.96.33.14

Subnet mask: 255.255.255.0
Subnet number: 128.96.33.0

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

Subnet mask: 255.255.255.128
Subnet number: 128.96.34.0

128.96.34.15

128.96.34.1

R1
H1

128.96.34.130

Subnet mask: 255.255.255.128
Subnet number: 128.96.34.128

128.96.34.139

128.96.34.129

H3

R2

H2

128.96.33.1

128.96.33.14

Subnet mask: 255.255.255.0
Subnet number: 128.96.33.0

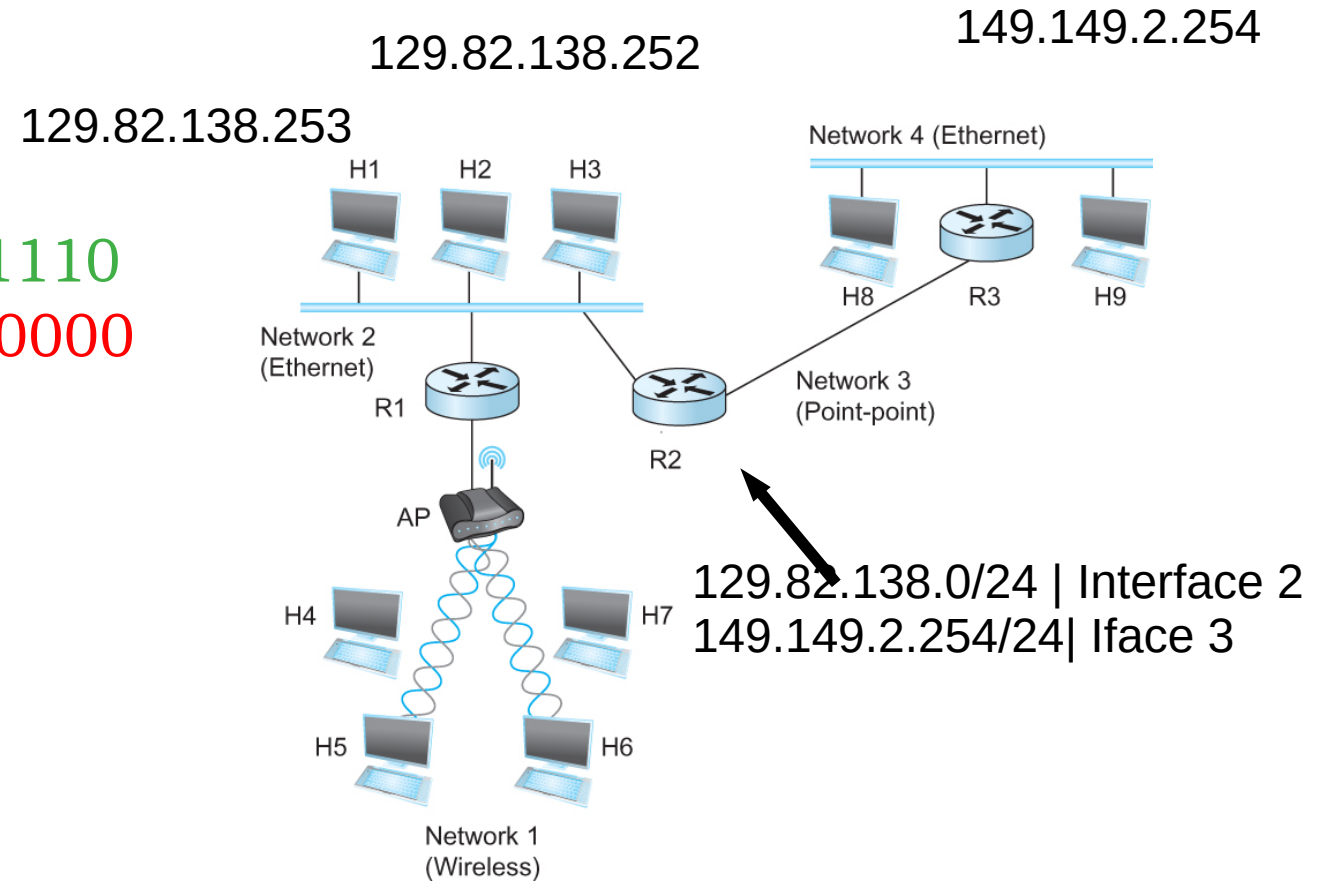| SubnetNumber	SubnetMask	NextHop
128.96.34.0	255.255.255.128	Interface 0
128.96.34.128	255.255.255.128	Interface 1
128.96.33.0	255.255.255.0	R2

Now routers can operate on Network address!!!!

129.82.138.254 (Address)

10000001.01010010.10001010.11111110
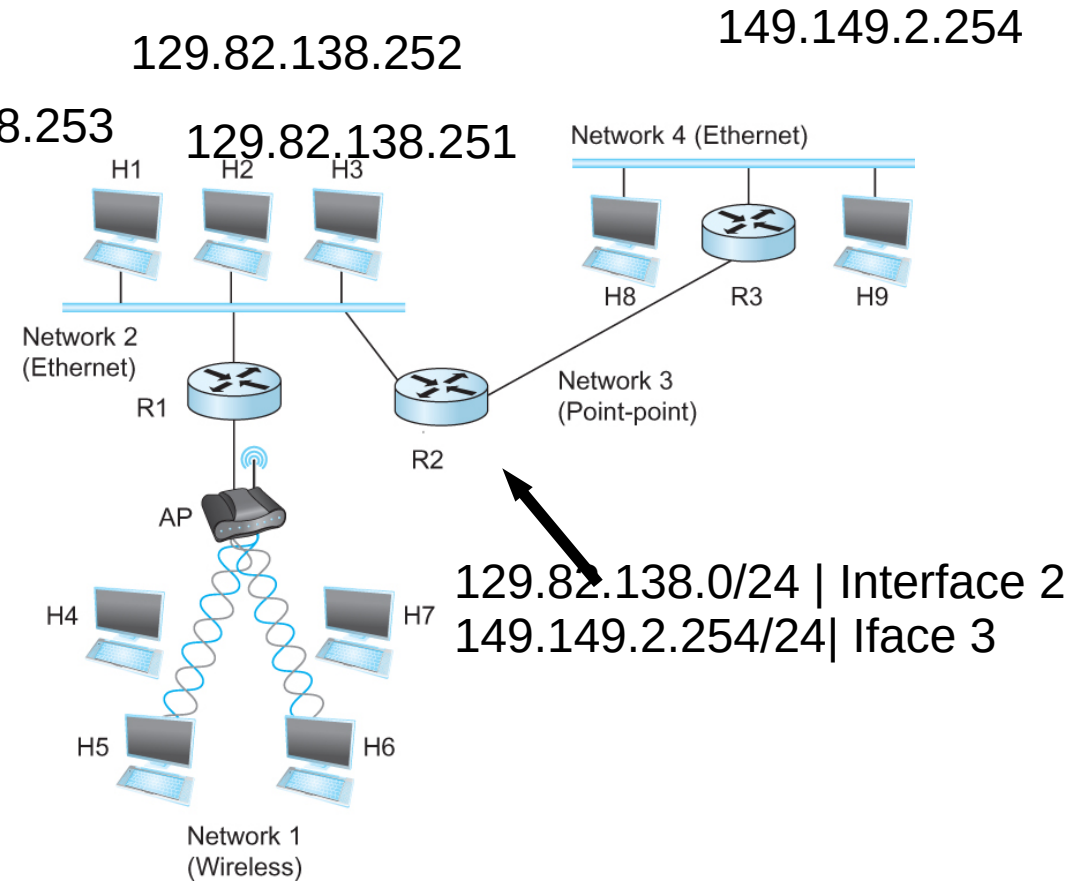11111111.11111111. 11111111.00000000

255.255.255.0 (Subnet mask)

**129.82.138.254 + 255.255.255.0 →
129.82.138.0/24**

129.82.138.253

129.82.138.252

149.149.2.254

Network 4 (Ethernet)

H1   H2   H3

Network 2
(Ethernet)

R1

AP

H4   H7

H5   H6

Network 1
(Wireless)

H8   R3   H9

Network 3
(Point-point)

R2

129.82.138.0/24 | Interface 2
149.149.2.254/24| Iface 3

Address management is localized

No coordination needed for adding
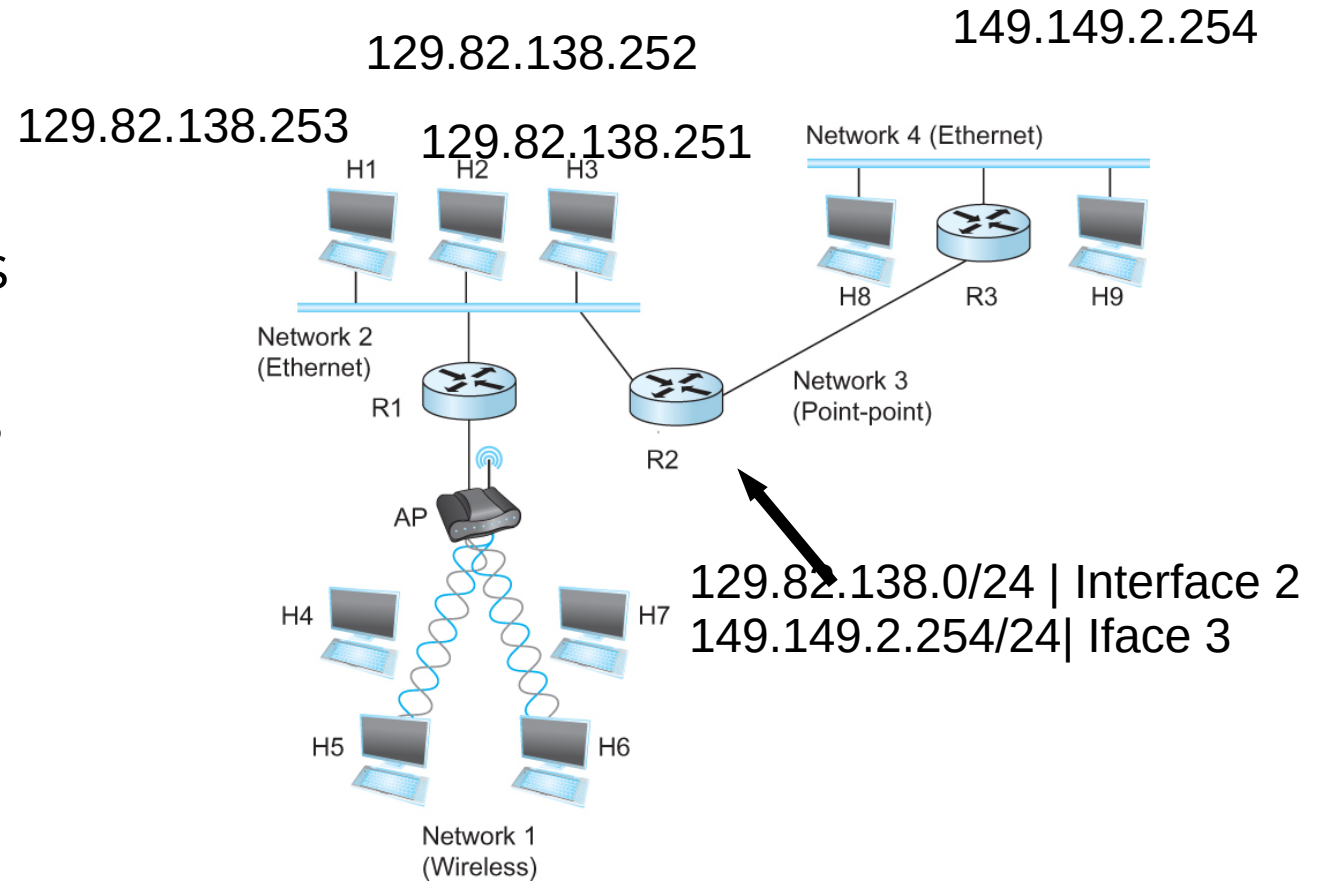129.82.138.251

No routing update needs to go out

149.149.2.254

129.82.138.252

129.82.138.253

129.82.138.251

Network 4 (Ethernet)

H1 H2 H3

H8 R3 H9

Network 2
(Ethernet)

R1

Network 3
(Point-point)

R2

AP

129.82.138.0/24 | Interface 2
149.149.2.254/24| Iface 3

H4 H7

H5 H6

Network 1
(Wireless)

Address management can be automated

ARP:
    Map IP address to MAC address

DHCP:
    Learn IP address, gateway, DNS

More on these later.

149.149.2.254

129.82.138.252

129.82.138.253

129.82.138.251

129.82.138.0/24 | Interface 2
149.149.2.254/24| Iface 3

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
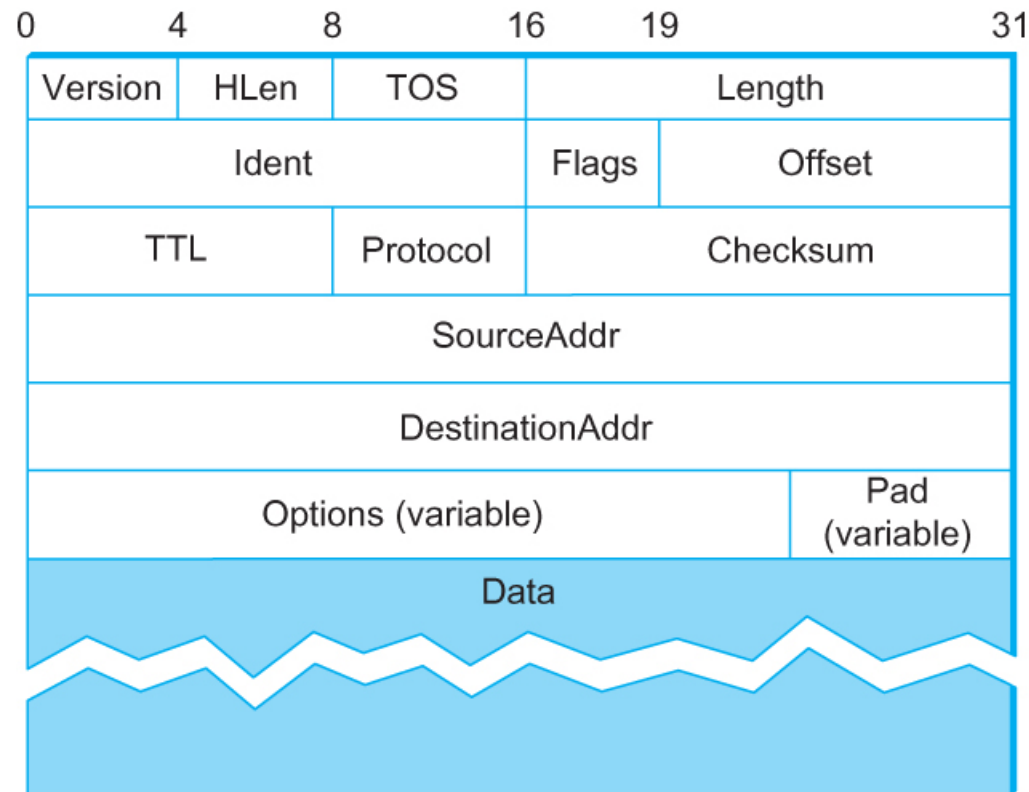
Version (4): 4

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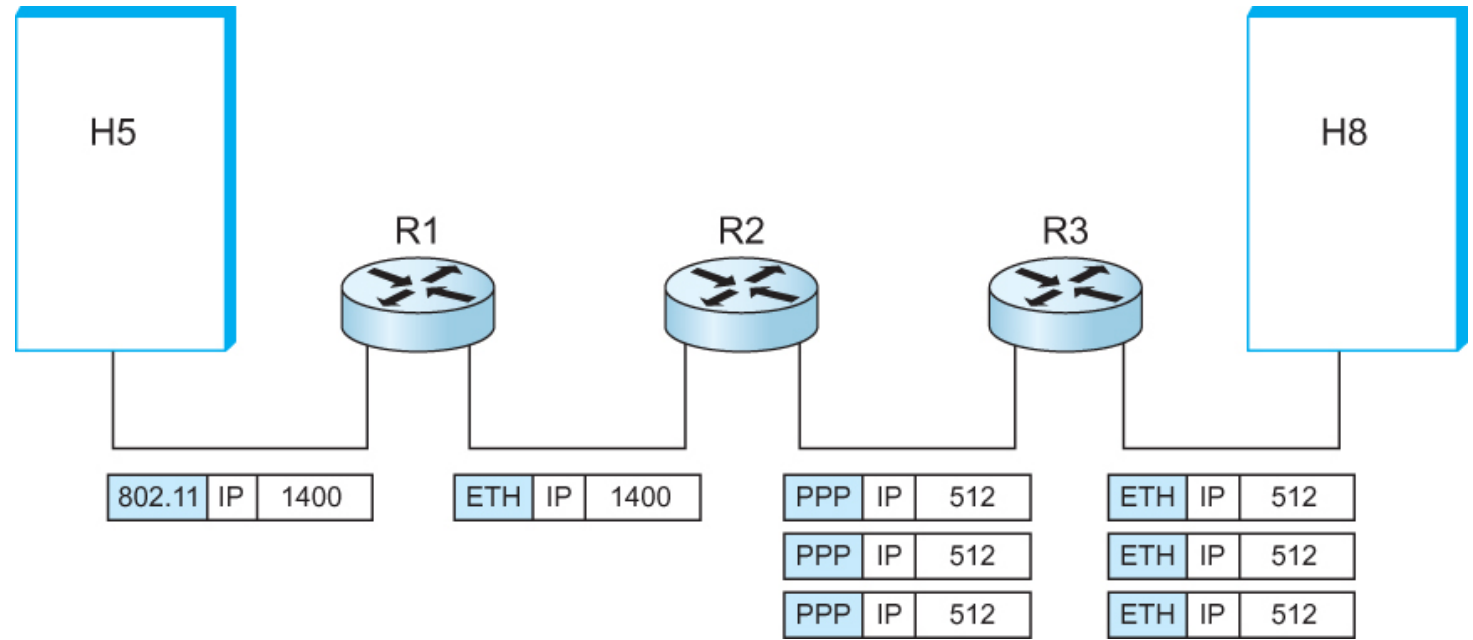
Protocol (8): demux key (TCP=6, UDP=17)

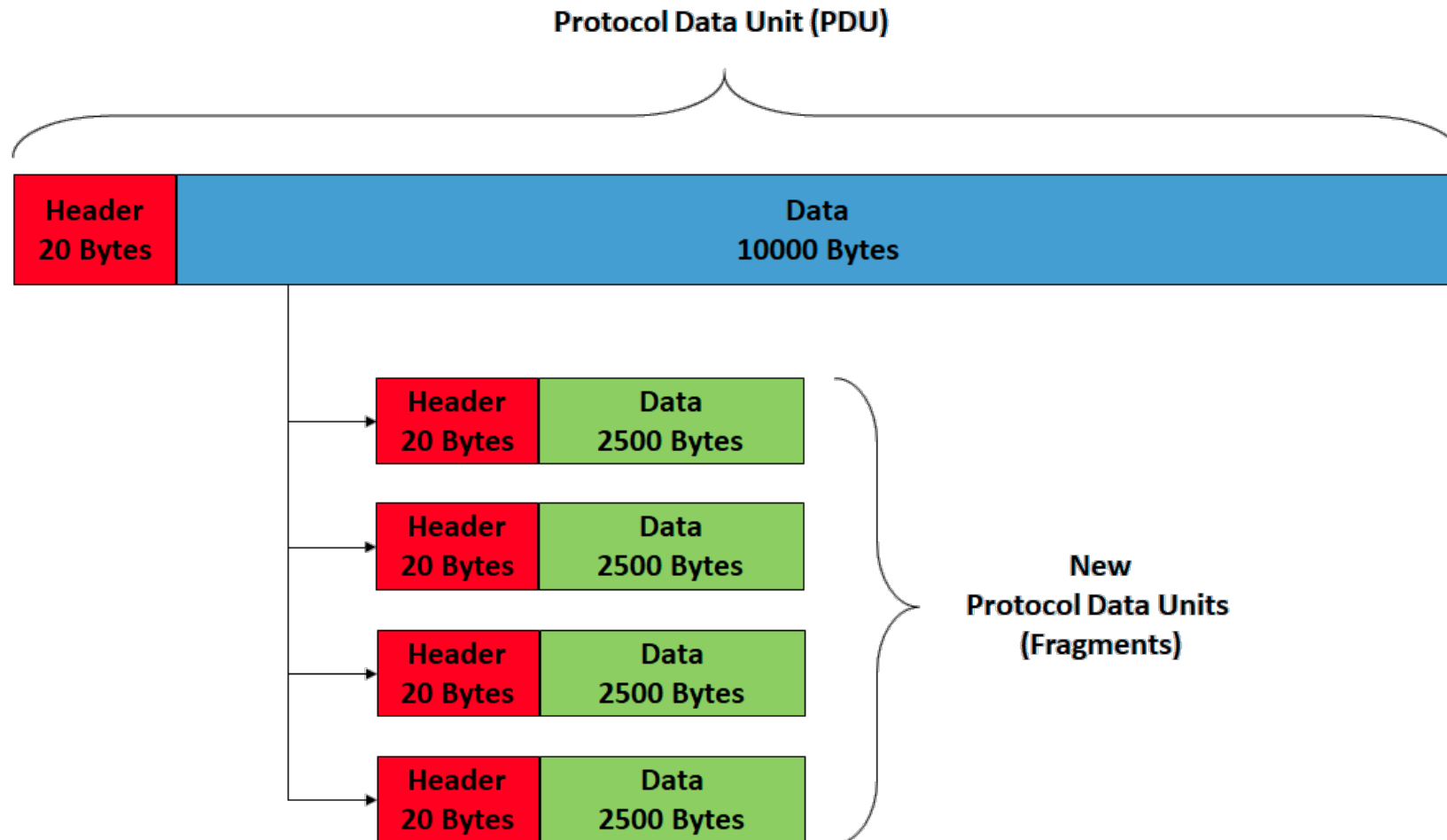Checksum (16): of the header only

DestAddr & SrcAddr (32)

IP Fragmentation and Reassembly

Underlying Layer 2 limitations
- Ethernet 1500
- PPP 512

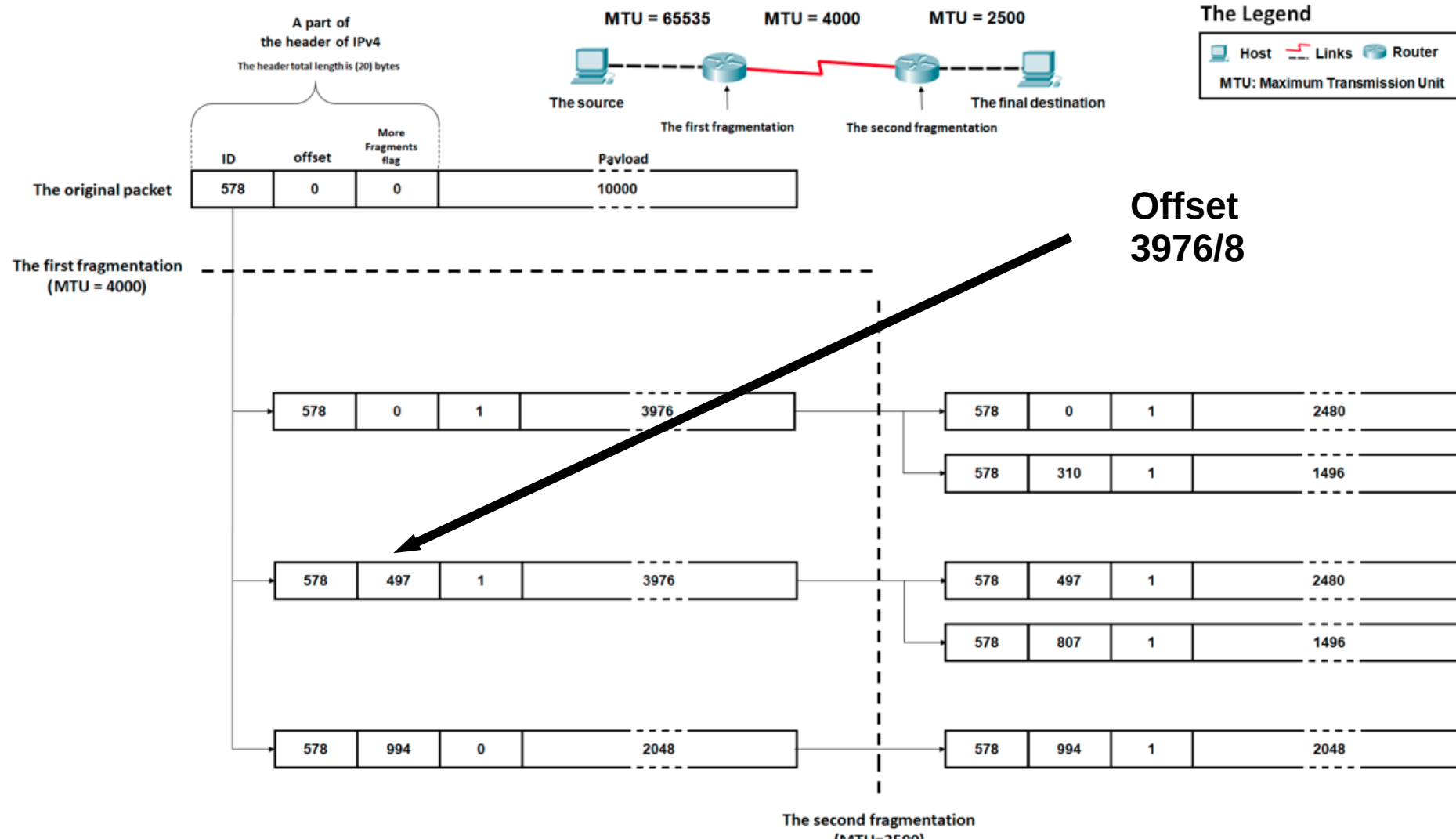- Break packets into smaller chunk and reassemble later

IP Fragmentation and Reassembly

wikipedia

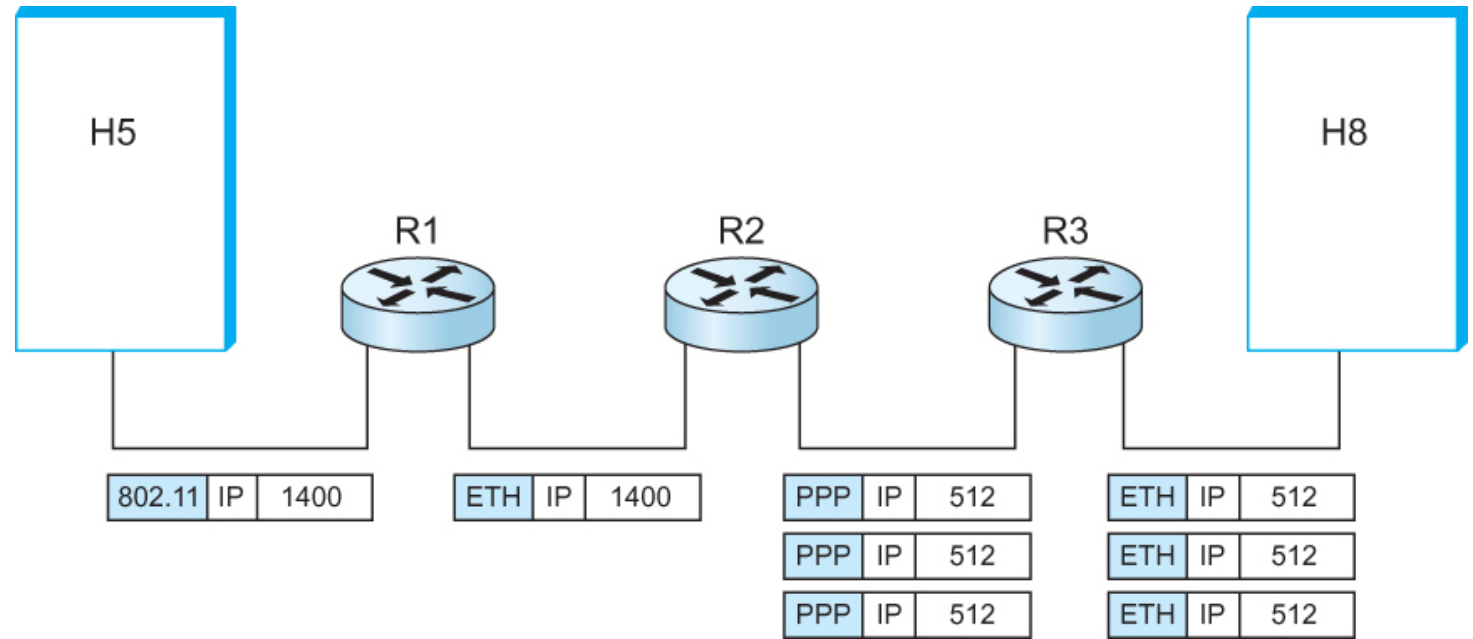# IP Fragmentation and Reassembly

wikipedia

IP Fragmentation and Reassembly

Underlying Layer 2 limitations
- Ethernet 1500
- PPP 512

- Break packets into smaller chunk and reassemble later

Next Steps

Routing