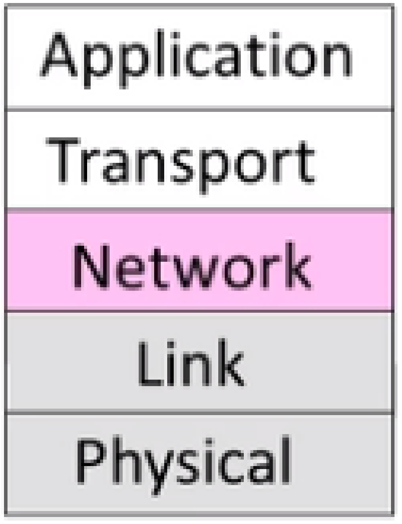
Network Layer

Where we are in the course

- Starting the Network Layer!
  - Builds on the link layer. Router sends packet over multiple networks



Network Layer

- The Network Layer is the third layer of the OSI model.
- It handles the service requests from the transport layer and further forwards the service request to the data link layer.
- The network layer translates the logical addresses into physical addresses
- It determines the route from the source to the destination and also manages the traffic problems such as switching, routing and controls the congestion of data packets.
- The main role of the network layer is to move the packets from sending host to the receiving host.

Main Functions

- **Routing**: When a packet reaches the router's input link, the router will move the packets to the router's output link. For example, a packet from S1 to R1 must be forwarded to the next router on the path to S2.
- **Logical Addressing**: The data link layer implements the physical addressing and network layer implements the logical addressing. Logical addressing is also used to distinguish between source and destination system. The network layer adds a header to the packet which includes the logical addresses of both the sender and the receiver.

Main Functions

- **Internetworking**: This is the main role of the network layer that it provides the logical connection between different types of networks.
- **Fragmentation**: The fragmentation is a process of breaking the packets into the smallest individual data units that travel through different networks.

Network layer design issues

1. Store and Forward packet switching:
   - The host sends the packet to the nearest router. This packet is stored there until it has fully arrived once the link is fully processed by verifying the checksum then it is forwarded to the next router till it reaches the destination. This mechanism is called “Store and Forward packet switching.”

Network layer design issues

2. Services provided to Transport Layer:
   - Through the network/transport layer interface, the network layer transfers it’s services to the transport layer.
   - Offering services must not depend on router technology.
   - The transport layer needs to be protected from the type, number and topology of the available router.
   - The network addresses for the transport layer should use uniform numbering pattern also at LAN and WAN connections.

Network layer design issues

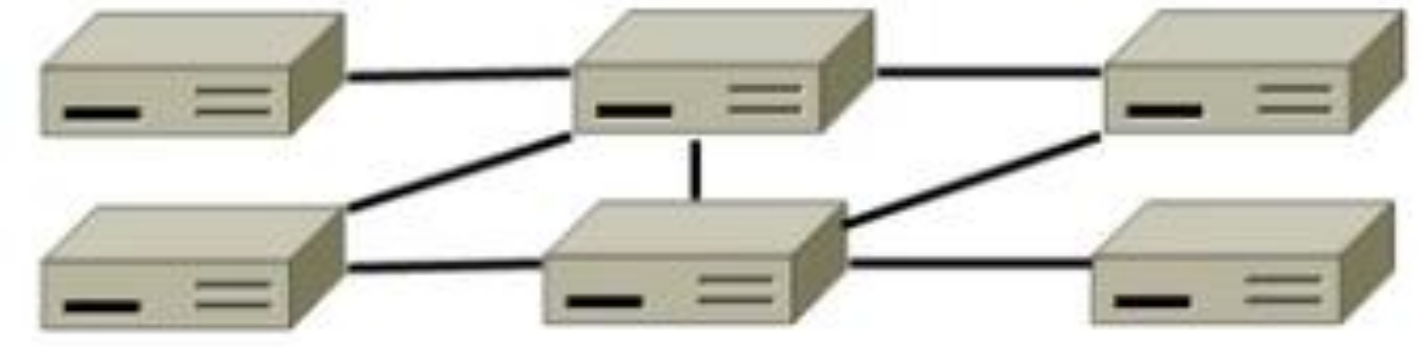
3. Implementation of Connectionless Service:
   - Packet are termed as "datagrams" and corresponding subnet as "datagram subnets". When the message size that has to be transmitted is 4 times the size of the packet, then the network layer divides into 4 packets and transmits each packet to router via. a few protocol. Each data packet has destination address and is routed independently irrespective of the packets.

Network layer design issues

4. Implementation of Connection Oriented service:
   - To use a connection-oriented service, first we establishes a connection, use it and then release it. In connection-oriented services, the data packets are delivered to the receiver in the same order in which they have been sent by the sender.
   - It can be done in either two ways :
     - Circuit Switched Connection
     - Virtual Circuit Switched Connection

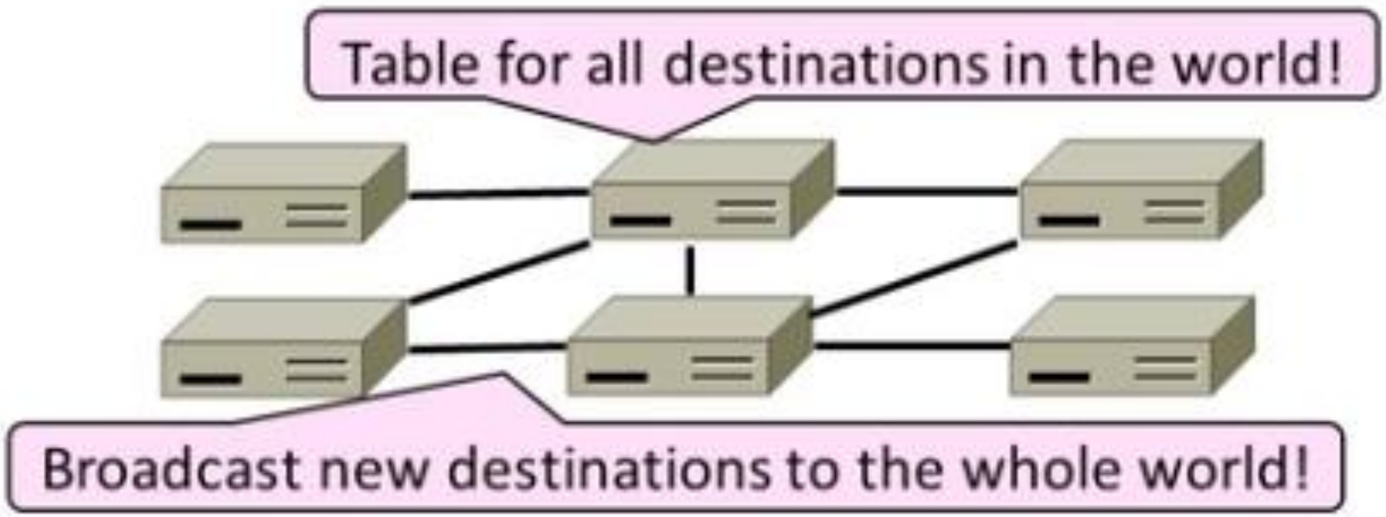
Why do we need a Network Layer?

- We can already build networks with links and switches and send frame between hosts….



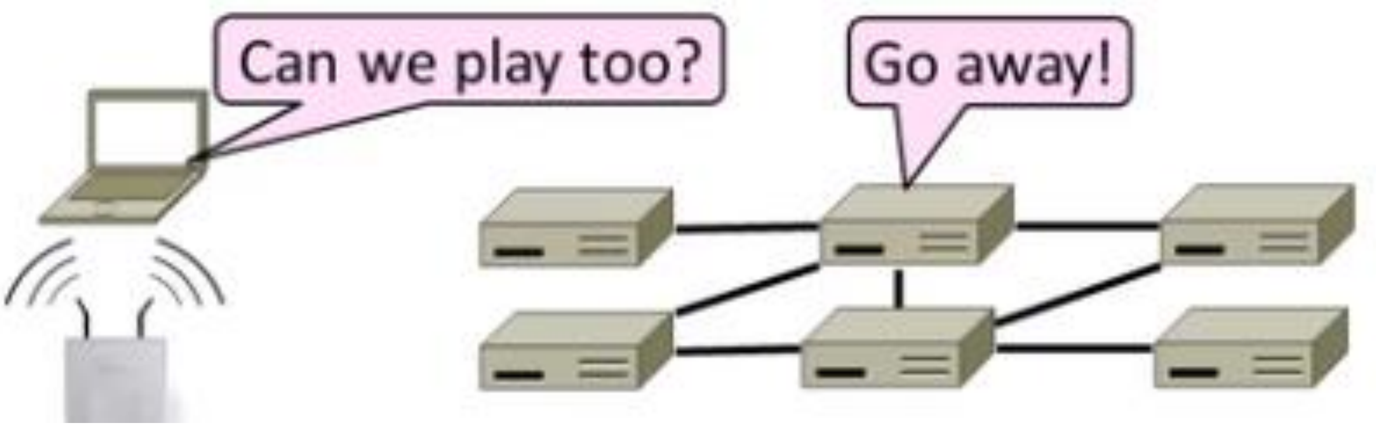
Shortcomings of Switches

- Don’t scale to large networks
  - Blow up of routing table, broadcast



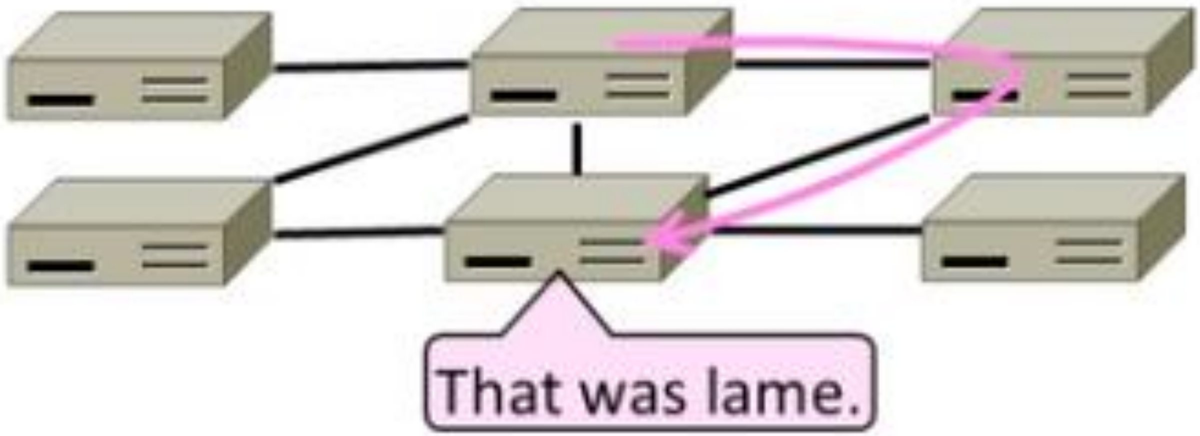
Shortcomings of Switches

- Don’t work across more than one link layer technology
  - Hosts on Ethernet + 3G + 802.11…



Shortcomings of Switches

- Don’t give much traffic control
  - Want to plan routes / bandwidth

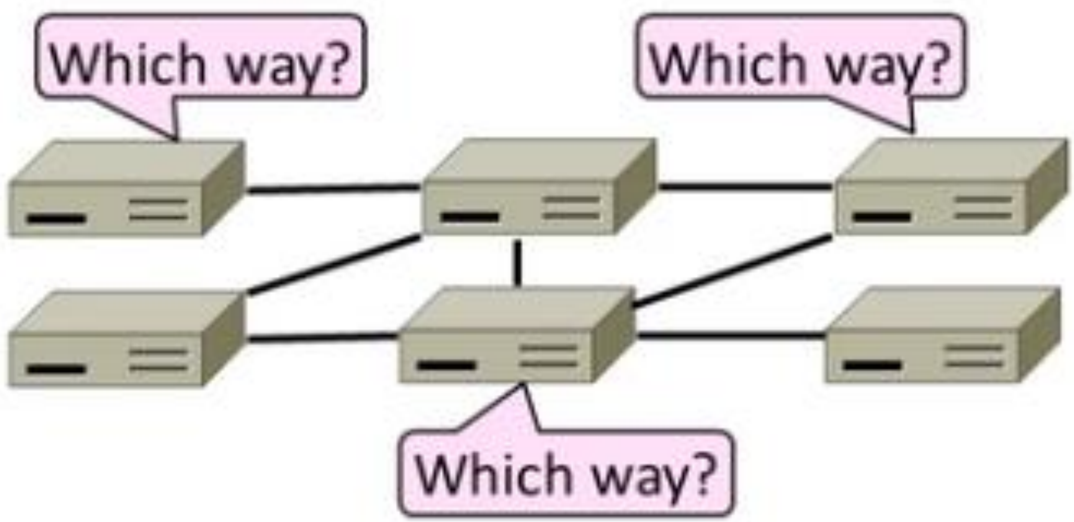


Network Layer Approach

- Scaling
  - Hierarchy, in the form of prefixes
- Heterogeneity
  - IP for internetworking
- Bandwidth Control:
  - Lowest-cost routing
  - Later QOS (Quality of Service)

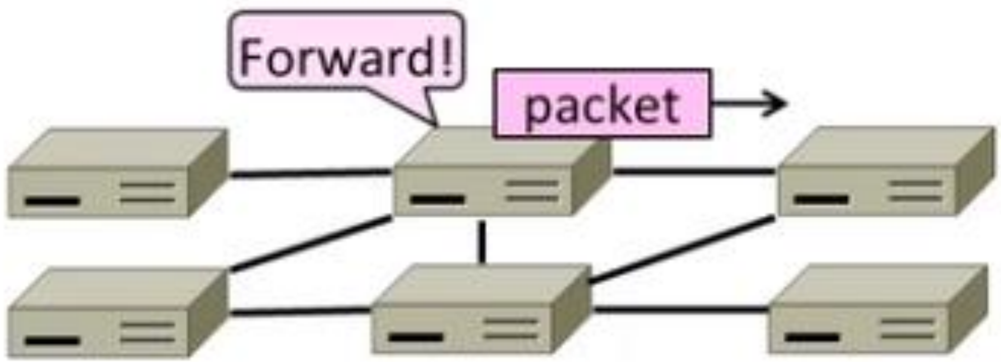
Routing Vs Forwarding

- Routing is the process of deciding in which direction to send traffic
  - Network wide (global) and expensive



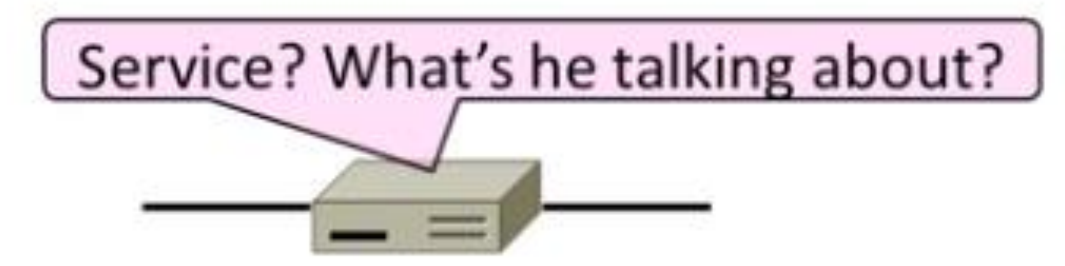
Routing Vs Forwarding

- Forwarding is the process of sending a packet on its way
  - Node process (local) and fast



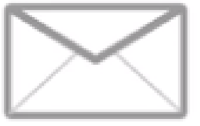
Network Services

- What kind of service does the Network layer provide to the Transport layer?
  - How is it implemented at routers?



Two Network Service Models

- Datagrams, or connectionless service
  - Like postal letters
  - (This one is IP)



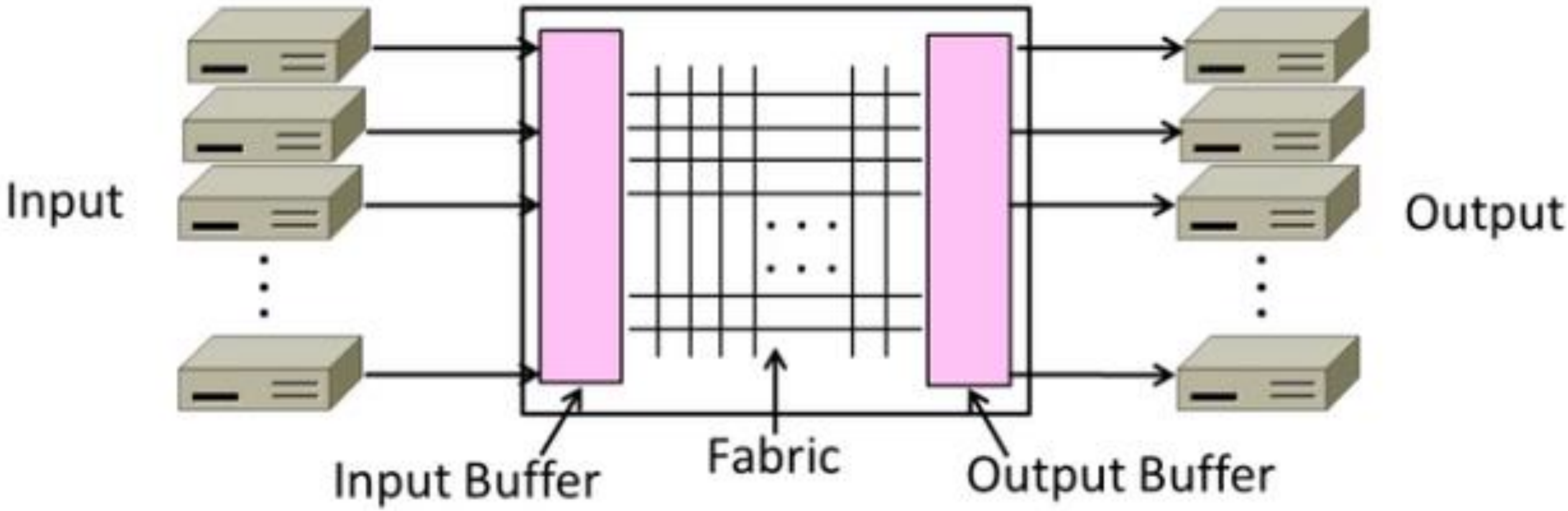
- Virtual Circuits, connection-oriented service
  - Like a telephone call

Store-and-Forward Packet Switching

- Both models are implemented store-and-forward packet switching
  - Routers receive a complete packet, storing it temporarily if necessary before forwarding it onwards
  - We use statistical multiplexing to share link bandwidth over time

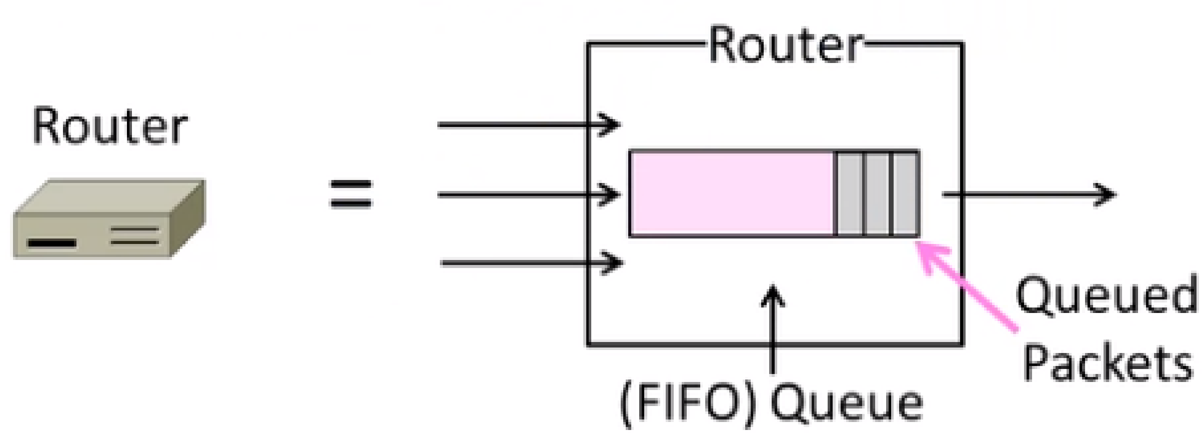
Store-and-Packet

- Switching element has internal buffering for contention



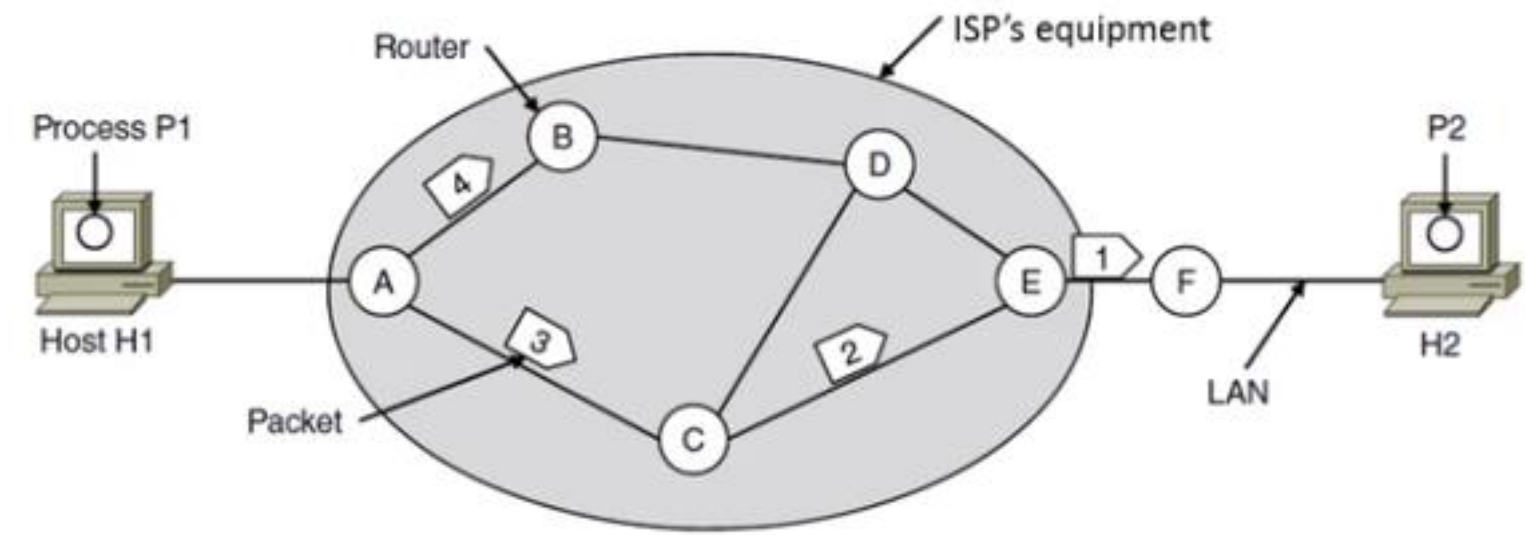
Store-and-Packet

- Simplified view with per port outport buffering
  - Buffer is typically a FIFO (First In First Out) queue
  - If full, packets are discarded (congestion, later)



Datagram Model

- Packets contain a destination address; each router uses it to forward each packet, possibly on different paths



Datagram Model

- Each router has a forwarding table keyed by address
  - —Gives next hop for each destination address; may change

A's table (initially)

Dest.	Line
A	
B	B
C	C
D	B
E	C
F	C

A's table (later)

A	
B	B
C	C
D	B
E	B
F	B

C's Table

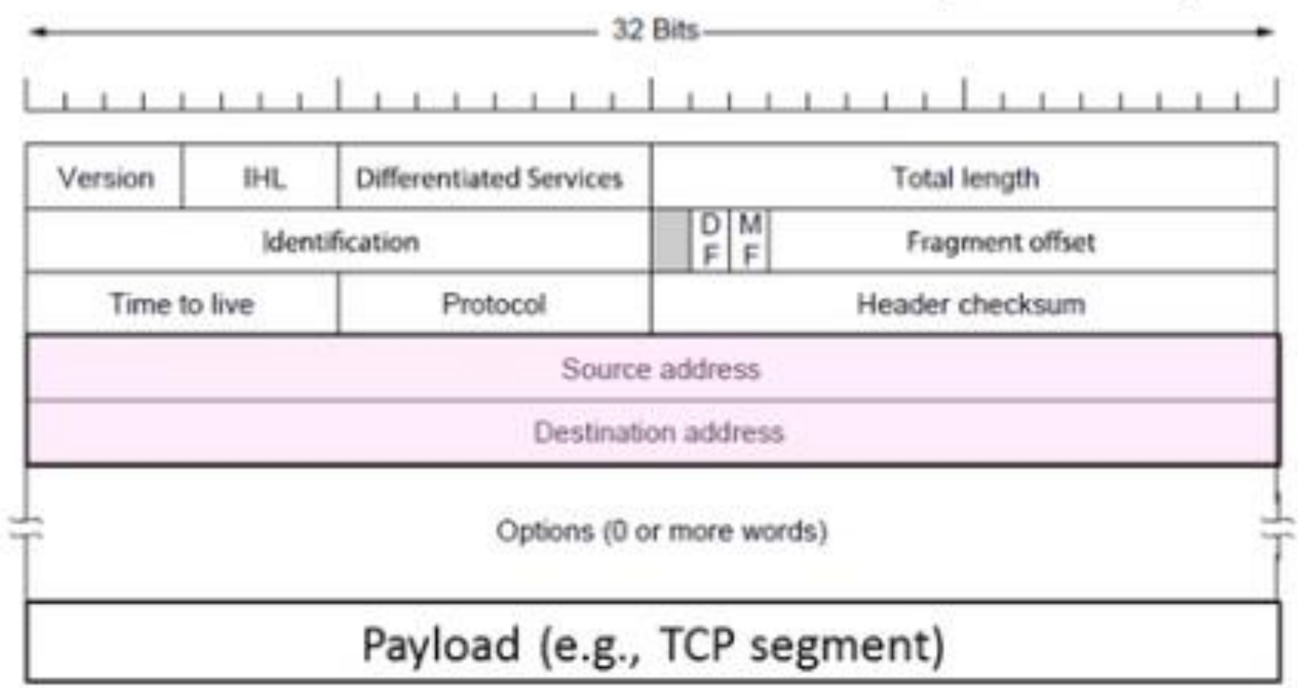
A	A
B	A
C	
D	E
E	E
F	E

E's Table

A	C
B	D
C	C
D	D
E	
F	F

IP (Internet Protocol)

- Network layer of the internet, uses datagram (next)
- IP carries 32 bit addresses on each packet (often 1.5 KB)

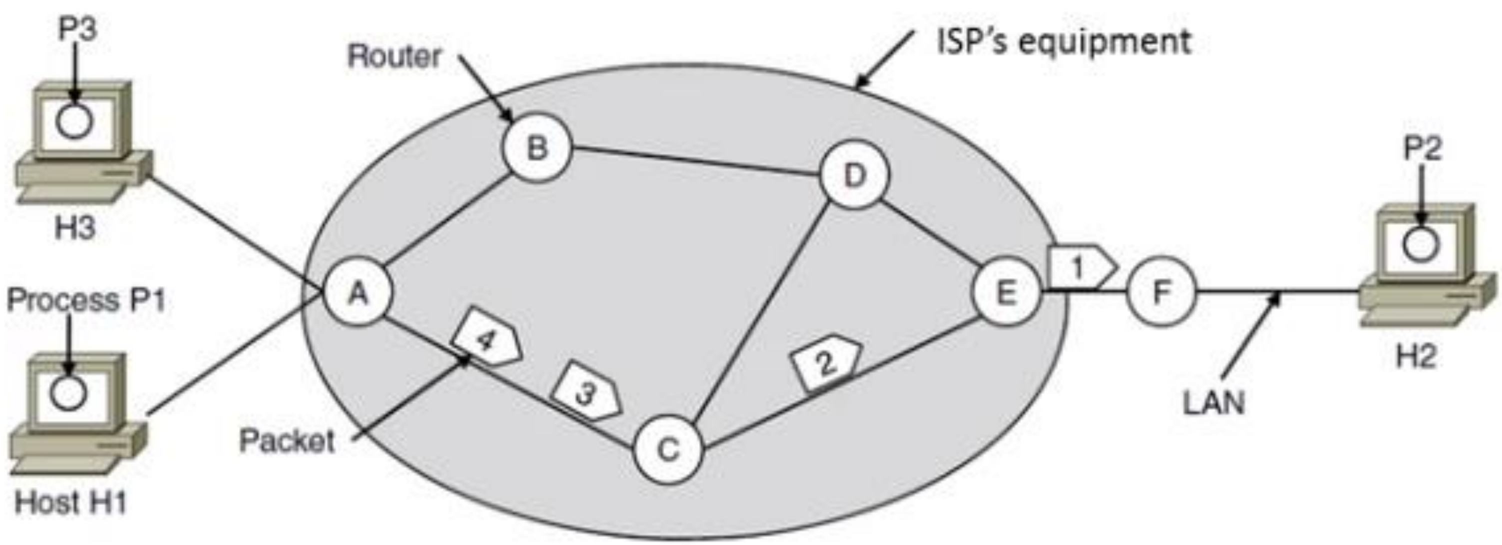


Virtual Circuit Model

- Three phases:
  1. Connection establishment, circuit is set up
     - Path is chosen, circuit information store in routers
  2. Data transfer, circuit is used
     - Packets are forwarded along the path
  3. Connection teardown, circuit is deleted
     - Circuit information is removed from routers
- Just like a telephone circuit, but virtual in the sense that no bandwidth need to be reserved; statistical sharing for the links

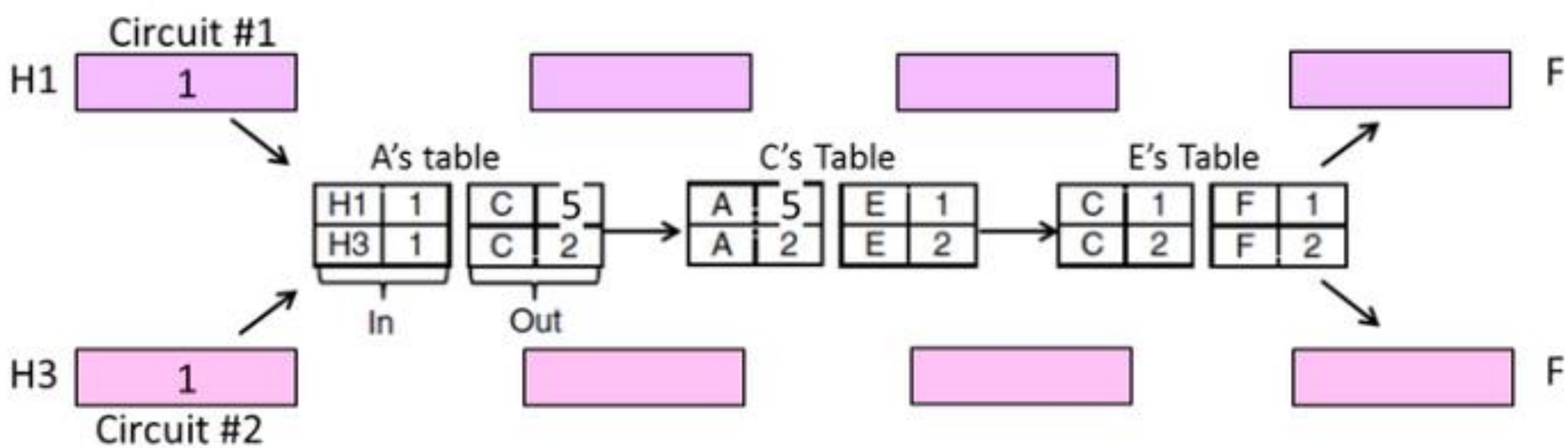
Virtual Circuit

- Packets only contain a short label to identify the circuit
  - Labels don't have any global meaning, only unique for a link



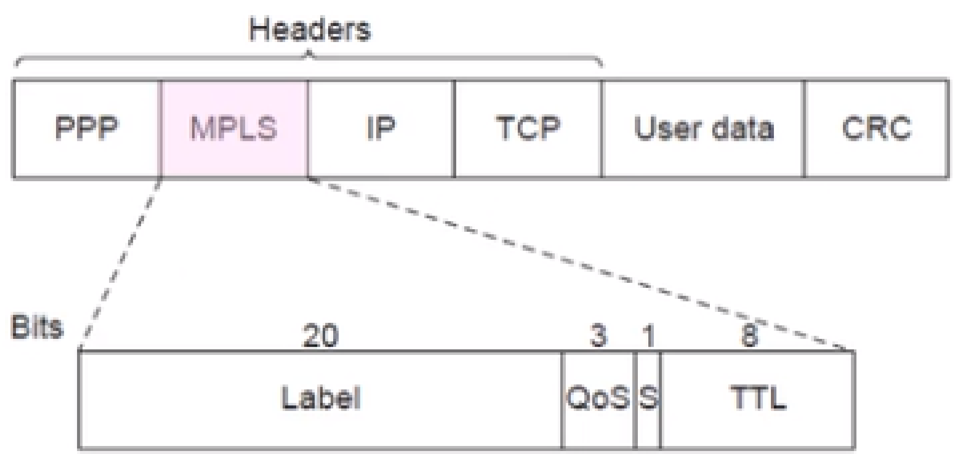
Virtual Circuit

- Each router has a forwarding table keyed by circuit
  - Gives output line and next label to place on packet



MPLS (Multi- Protocol Label Switching)

- A virtual-circuit like technology widely used by ISPs
  - ISPs setup circuits inside their backbone ahead of time
  - ISPs adds MPLS label to IP packet at ingress, undoes at egress



Datagrams Vs Virtual Circuits

- Complementary strengths

Issue	Datagrams	Virtual Circuits
Setup phase	Not needed	Required
Router state	Per destination	Per connection
Addresses	Packet carries full address	Packet carries short label
Routing	Per packet	Per circuit
Failures	Easier to mask	Difficult to mask
Quality of service	Difficult to add	Easier to add