

Computer Networks

Network Services (§5.1)



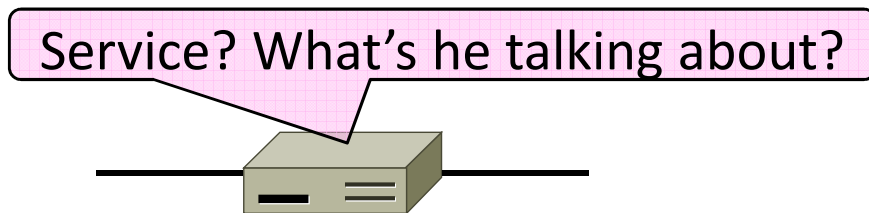
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Topic

- 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, or connection-oriented service

- Like a telephone call

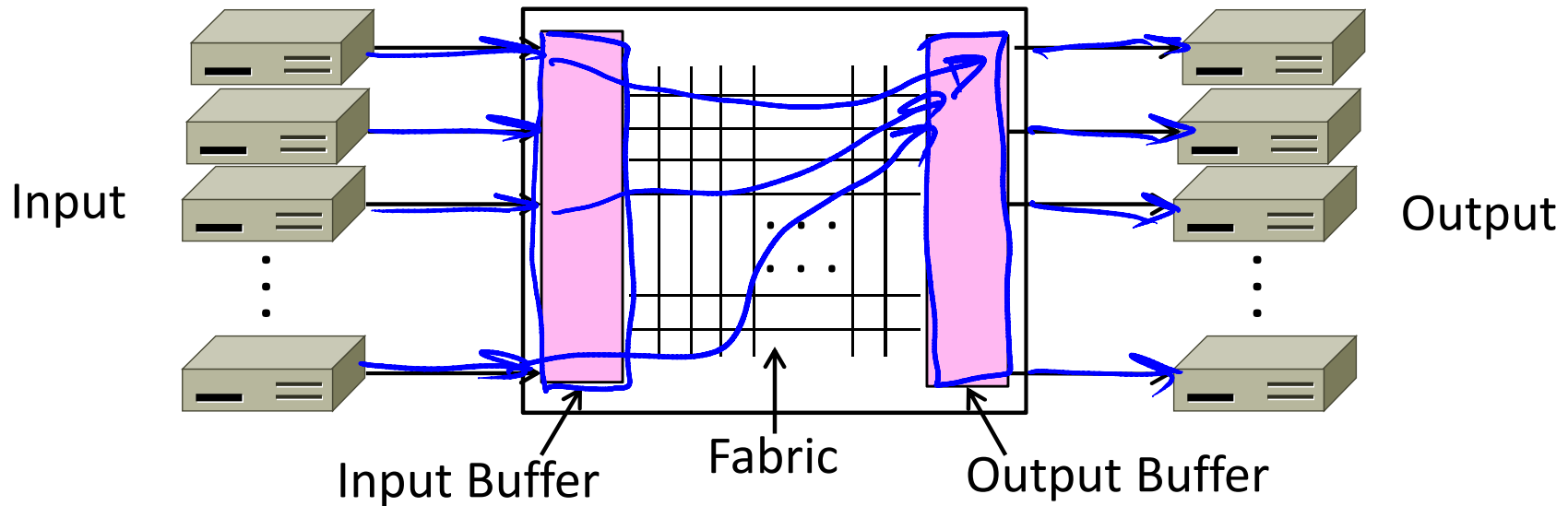


Store-and-Forward Packet Switching

- Both models are implemented with 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

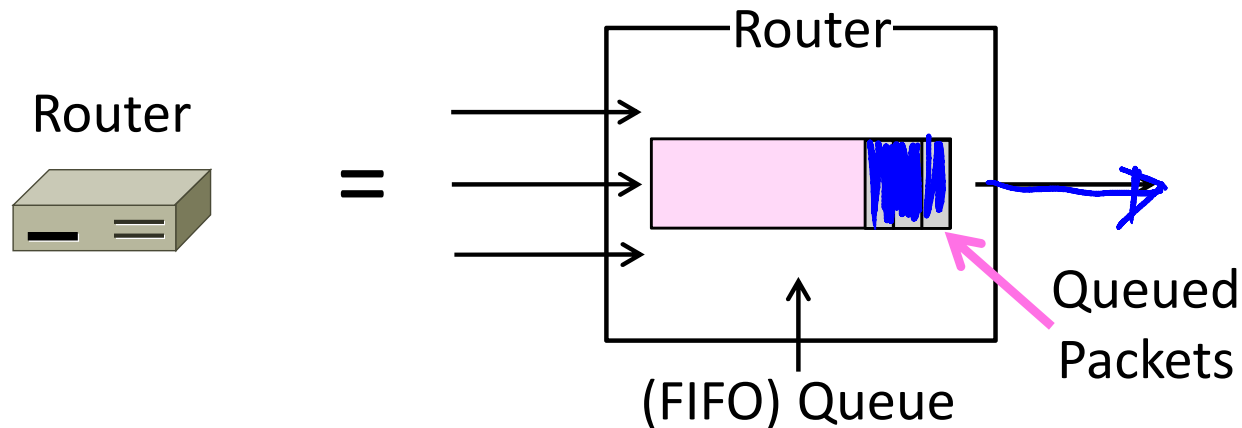
Store-and-Forward (2)

- Switching element has internal buffering for contention



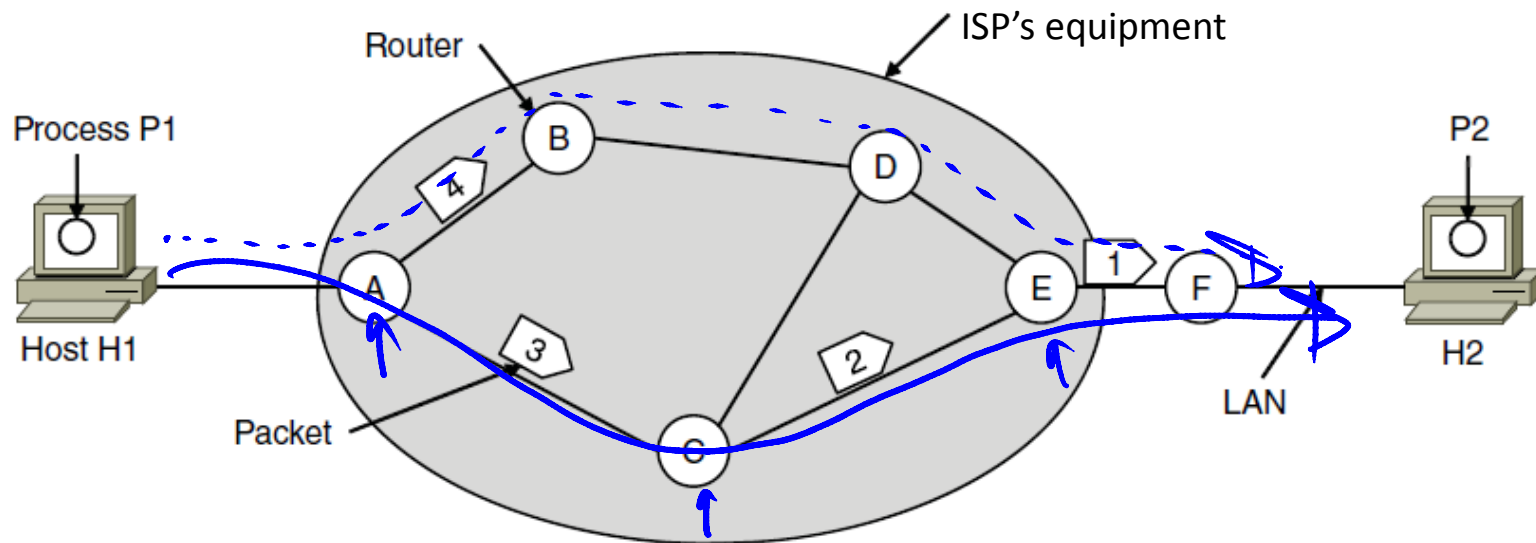
Store-and-Forward (3)

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



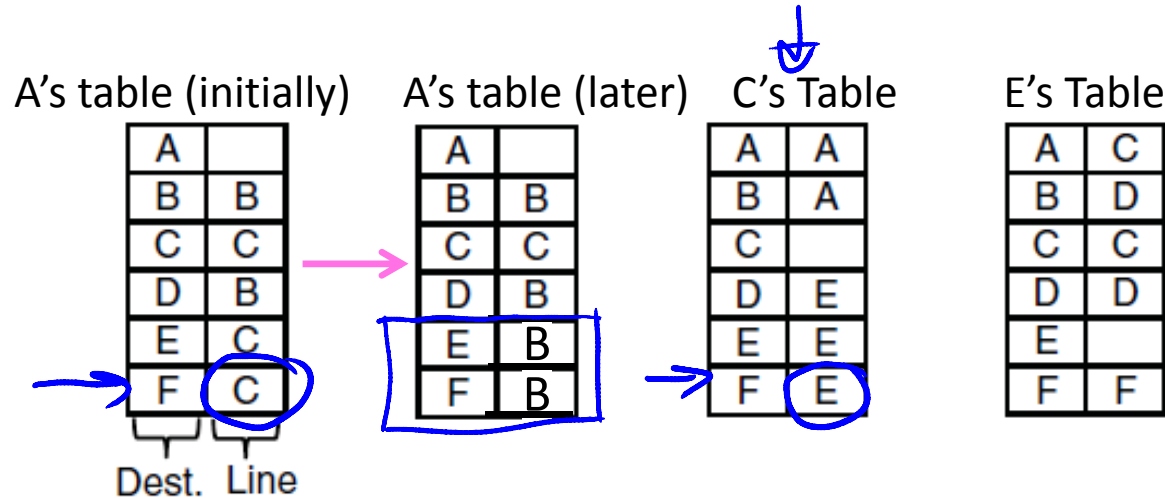
Datagram Model

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



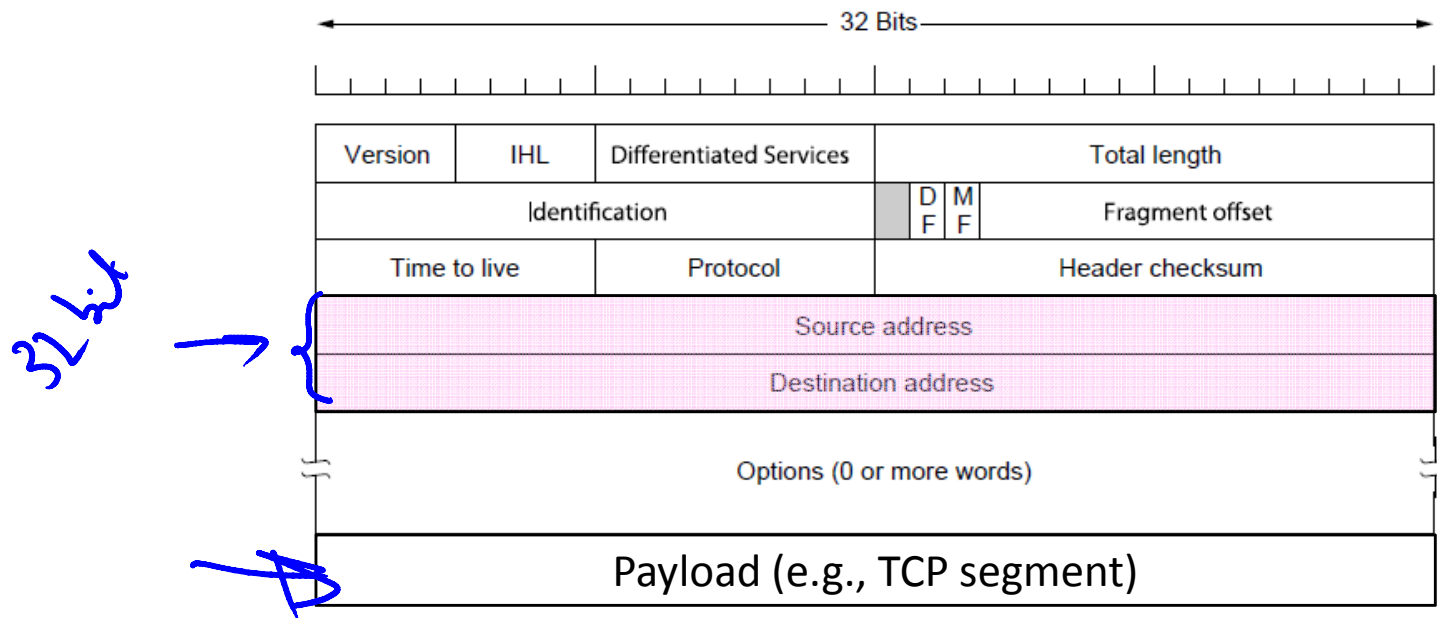
Datagram Model (2)

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



IP (Internet Protocol)

- Network layer of the Internet, uses datagrams (next)
 - IPv4 carries 32 bit addresses on each packet (often 1.5 KB)

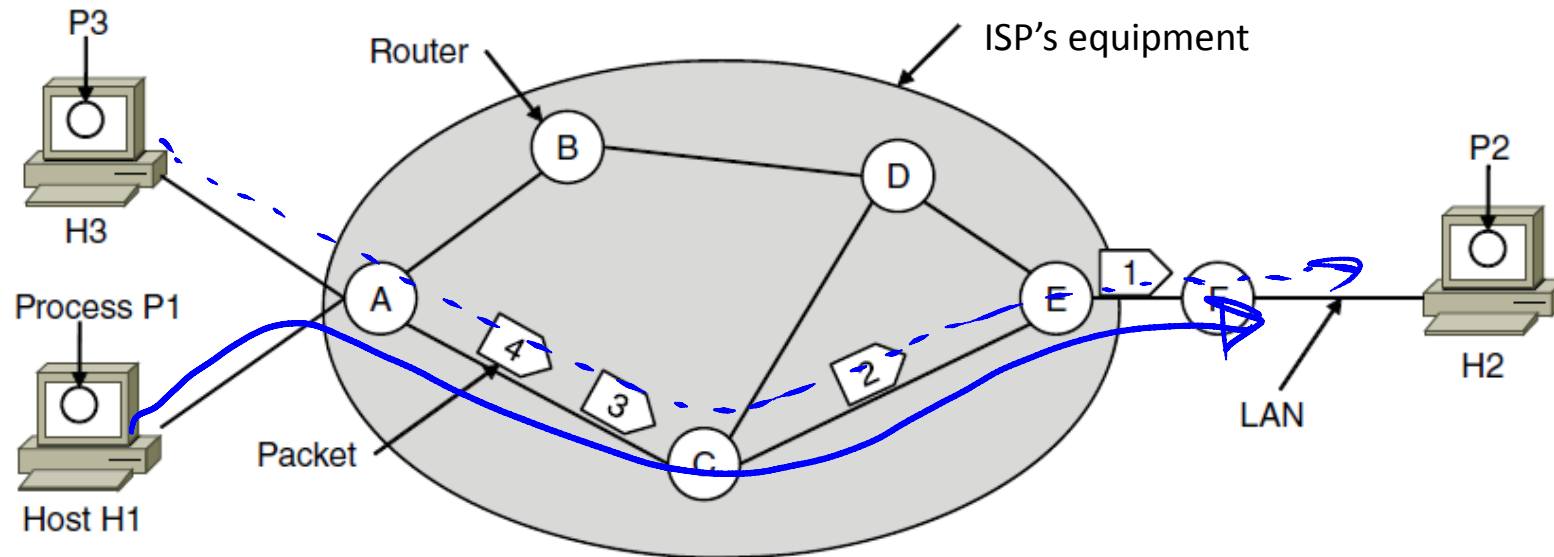


Virtual Circuit Model

- Three phases:
 - ➔ 1. Connection establishment, circuit is set up
 - Path is chosen, circuit information stored 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 be reserved; statistical sharing of links

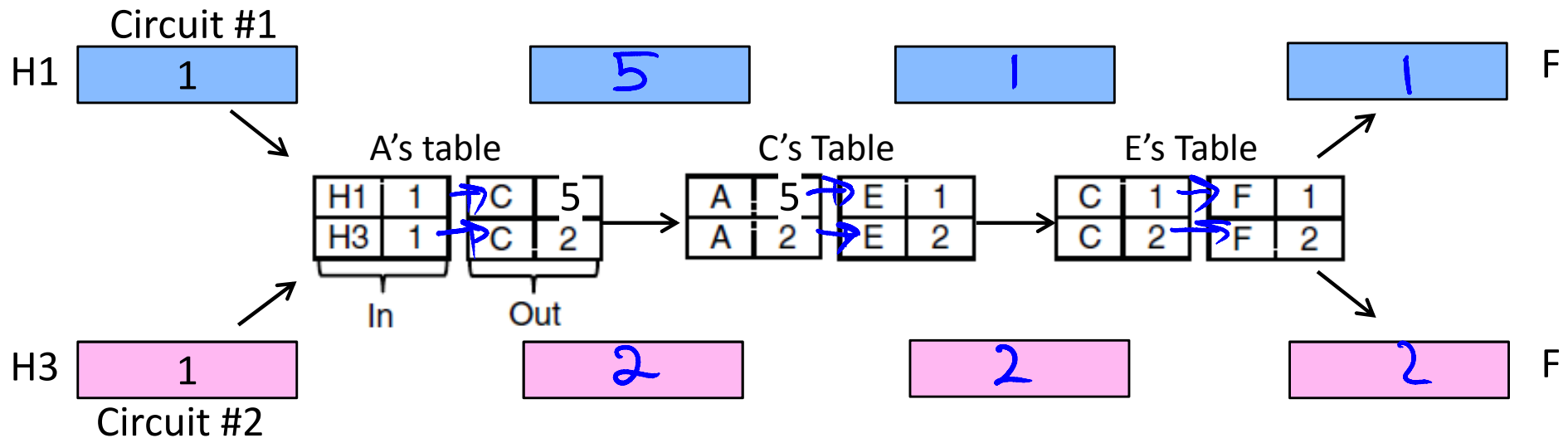
Virtual Circuits (2)

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



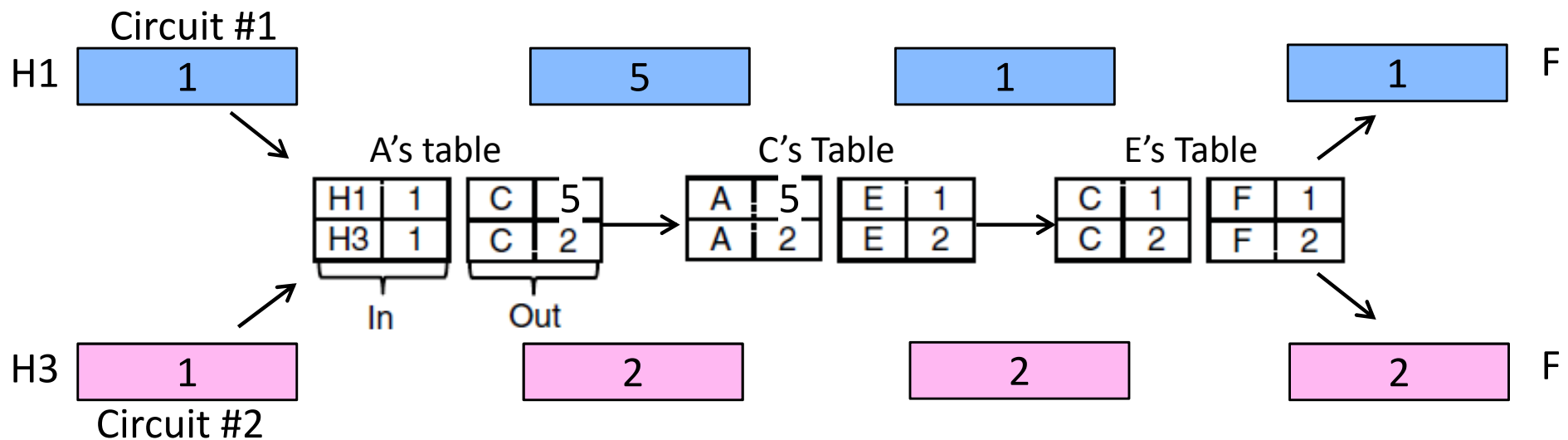
Virtual Circuits (3)

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



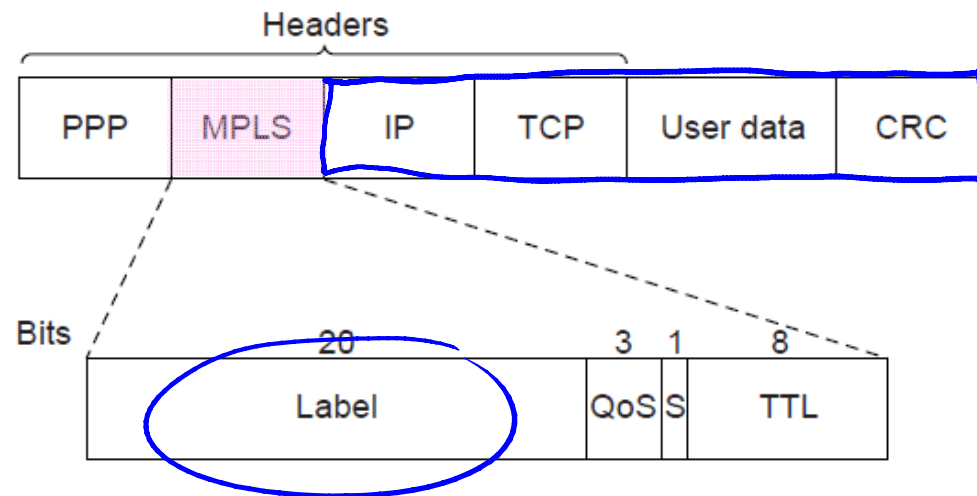
Virtual Circuits (4)

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



MPLS (Multi-Protocol Label Switching, §5.6.5)

- A virtual-circuit like technology widely used by ISPs
 - ISP sets up circuits inside their backbone ahead of time
 - ISP 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

END

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