Computer Networks

Network Services (§5.1)

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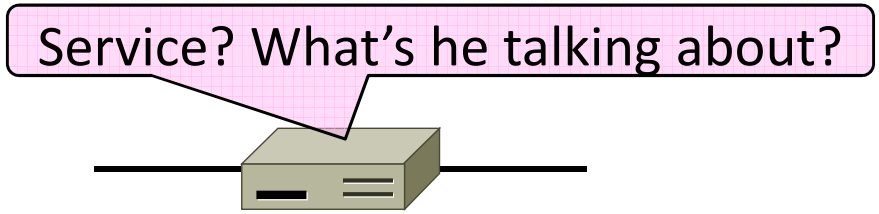
Topic

- 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)

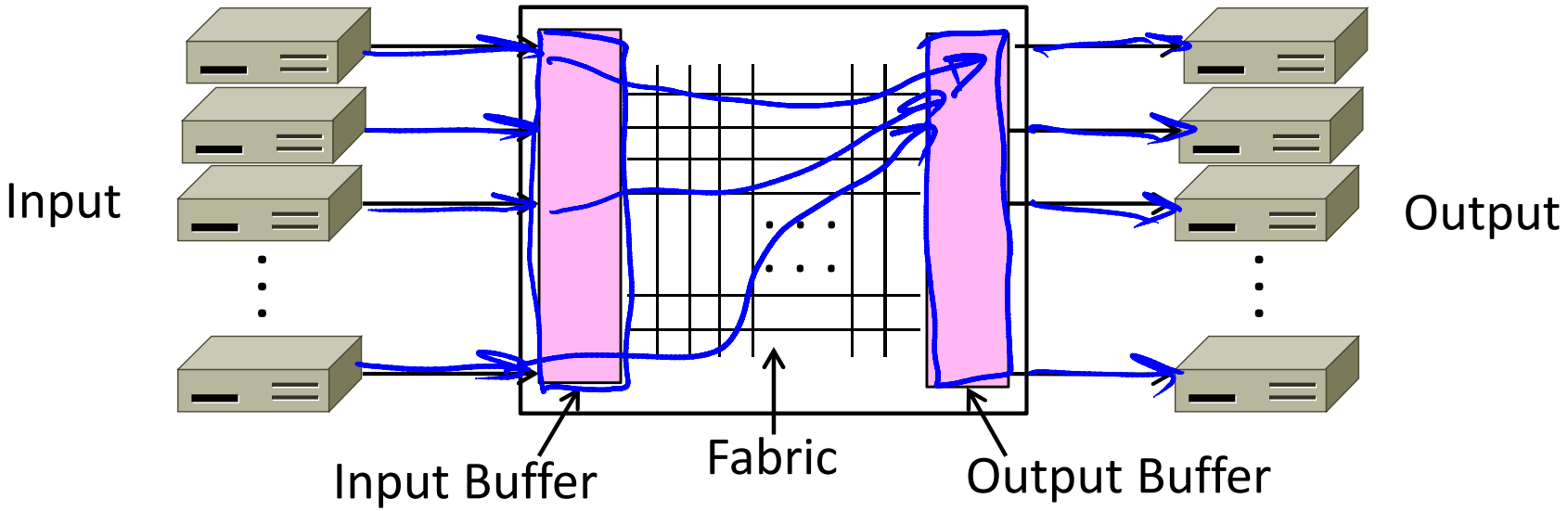
- Virtual circuits, or connection-oriented service
  - Like a telephone call

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

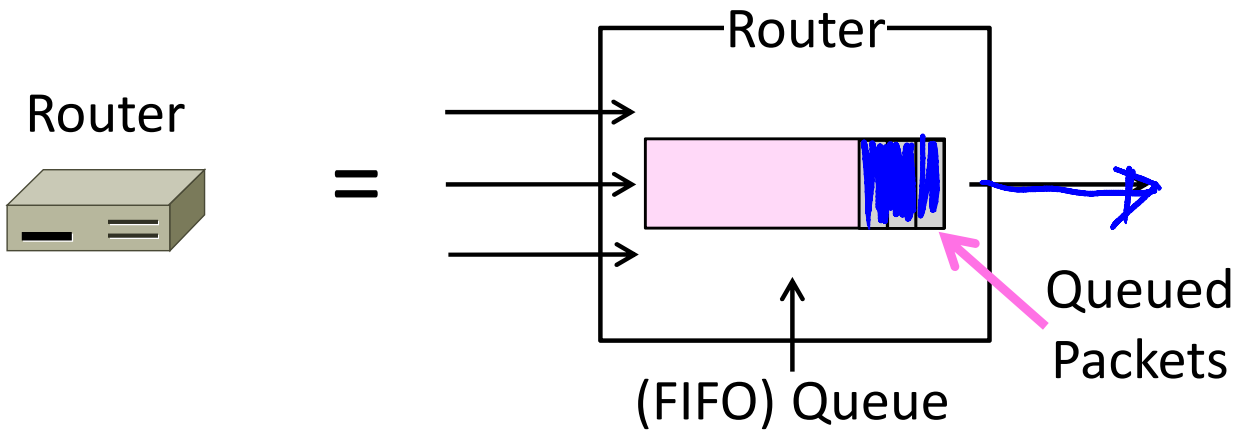
Store-and-Forward (2)

- Switching element has internal buffering for contention



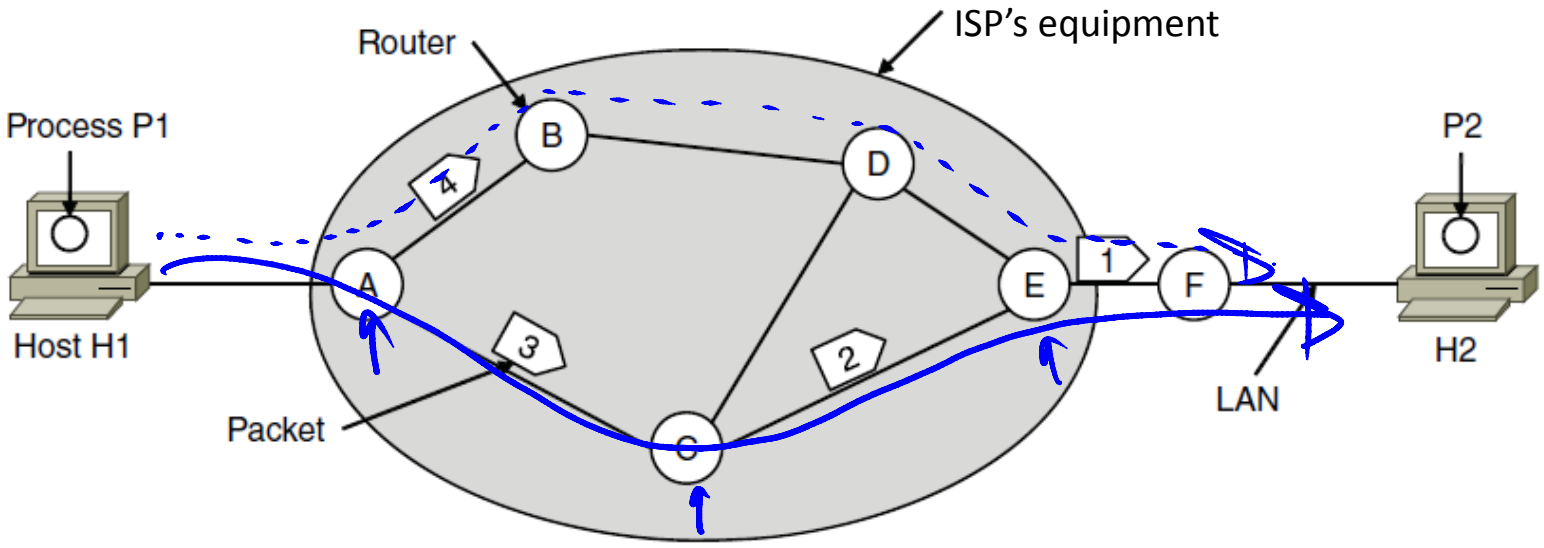
Store-and-Forward (3)

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



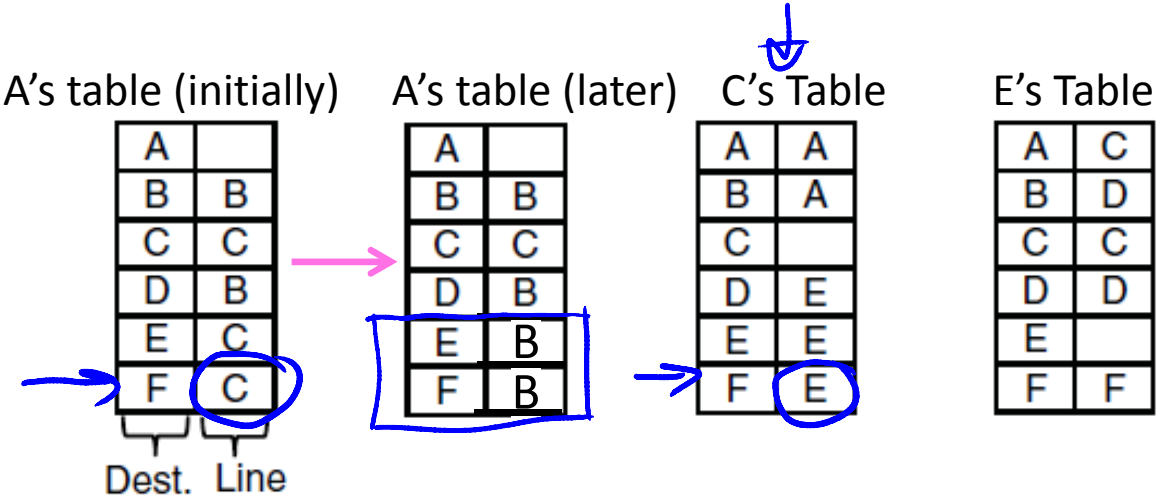
Datagram Model

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



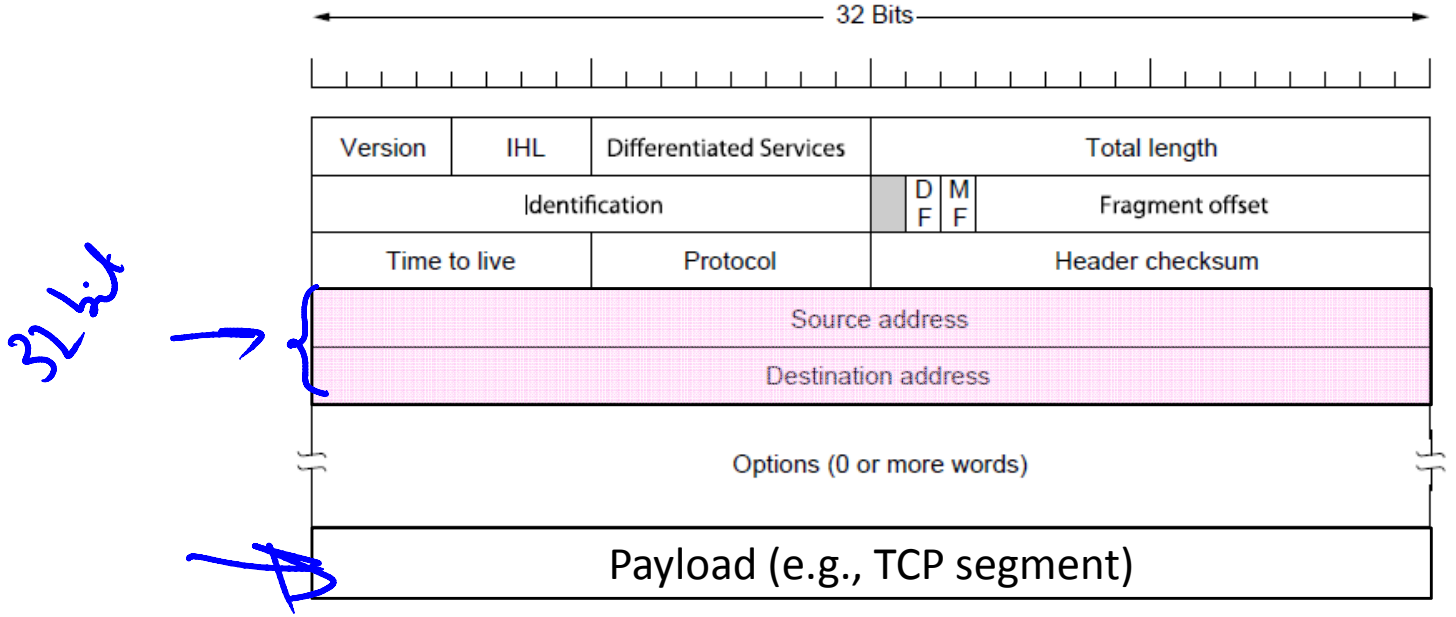
Datagram Model (2)

- 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)

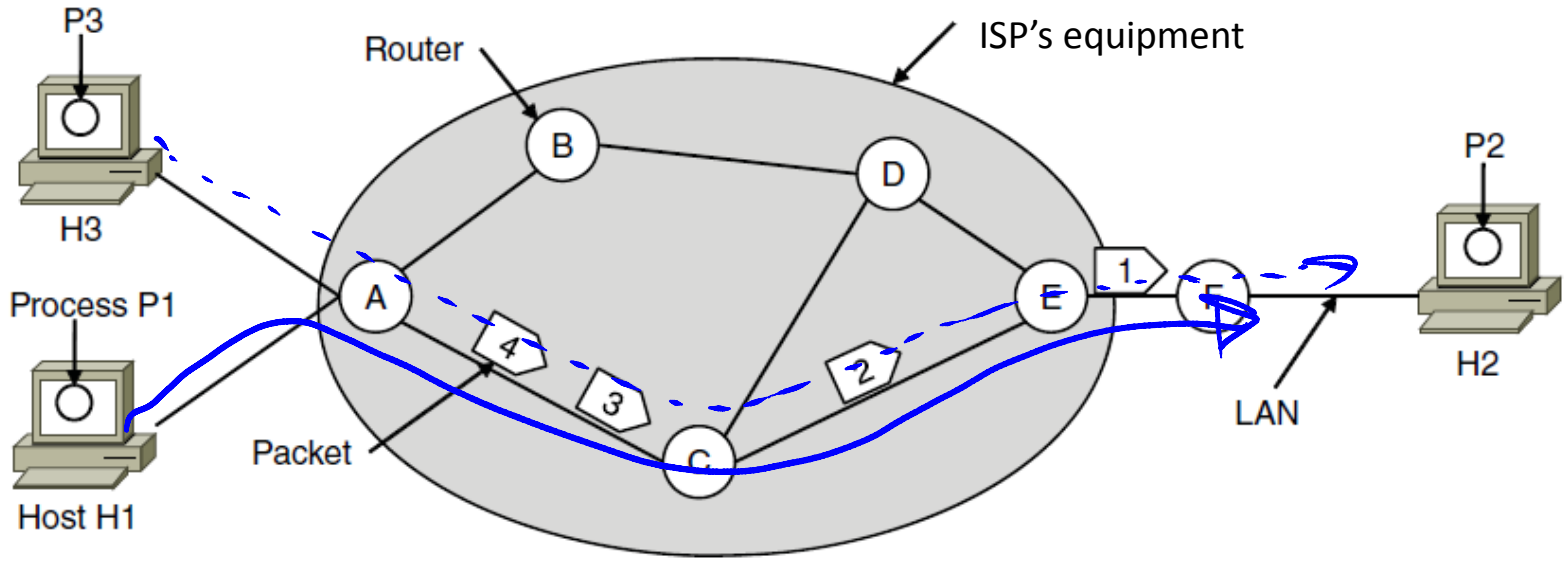


Virtual Circuit Model

- 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

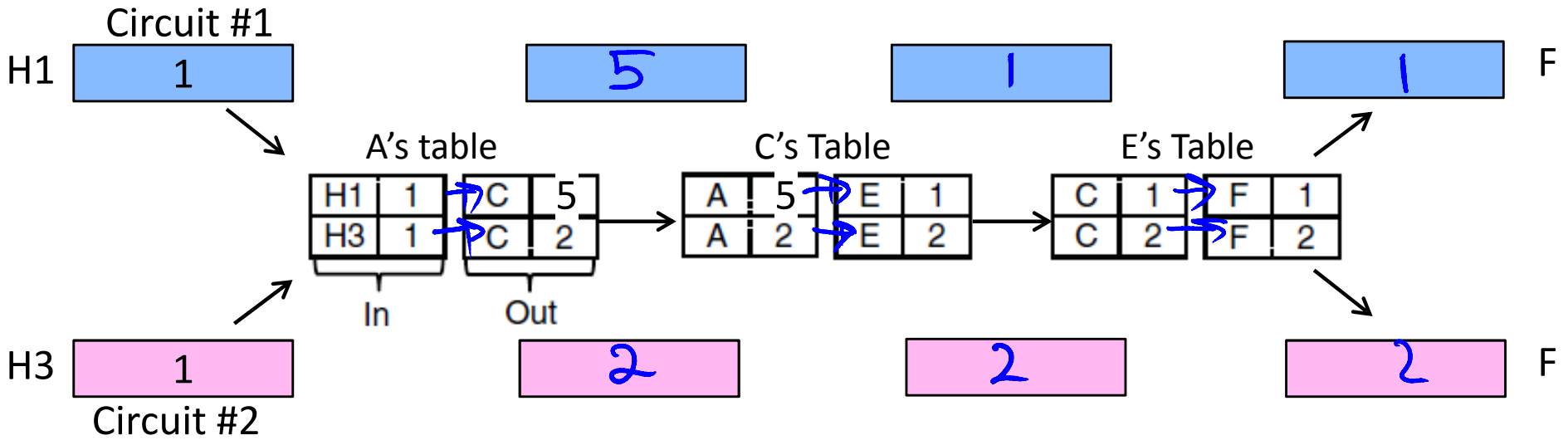
Virtual Circuits (2)

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



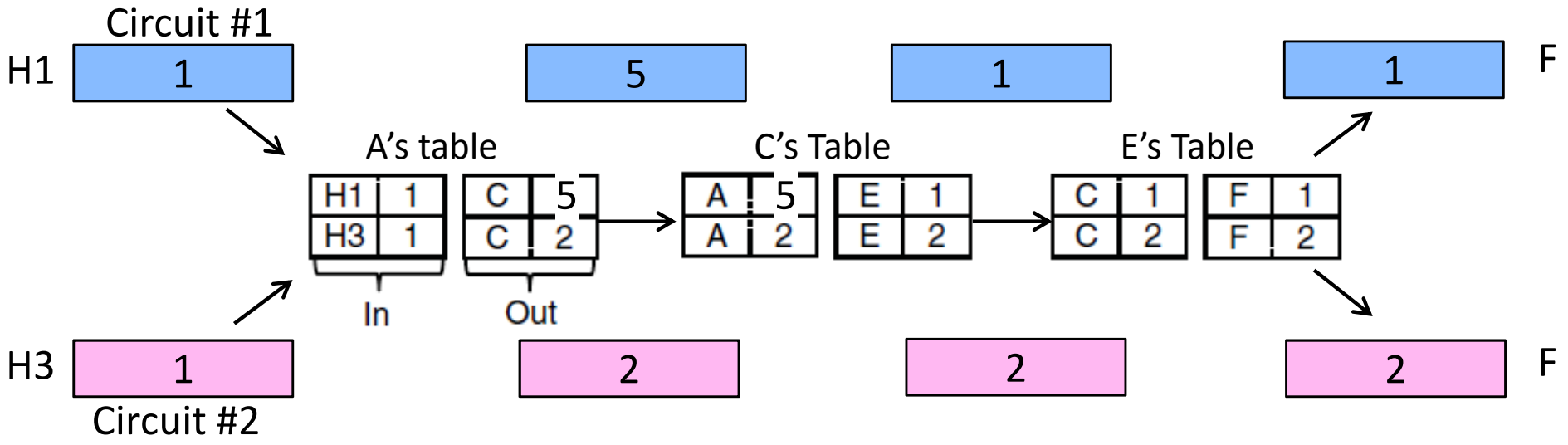
Virtual Circuits (3)

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



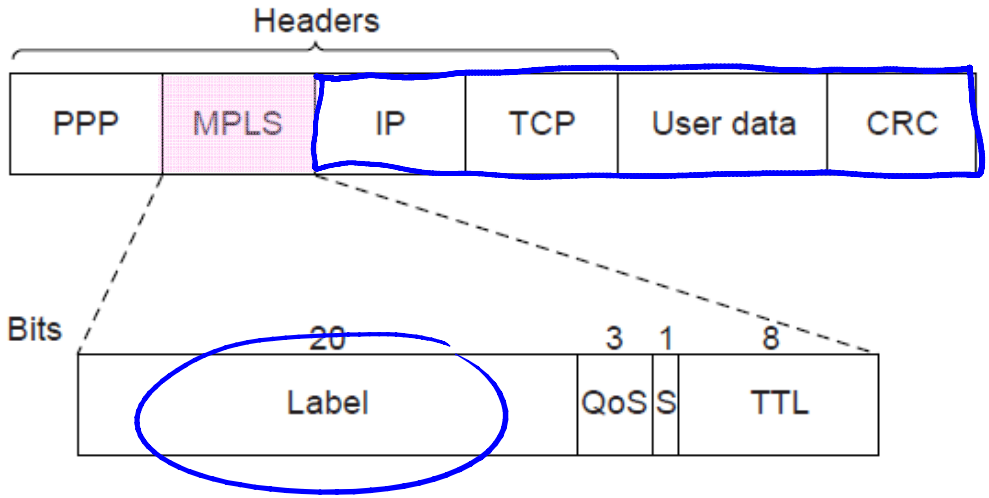
Virtual Circuits (4)

- 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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