CSCE 463/612
Networks and Distributed Processing
Spring 2024

Transport Layer

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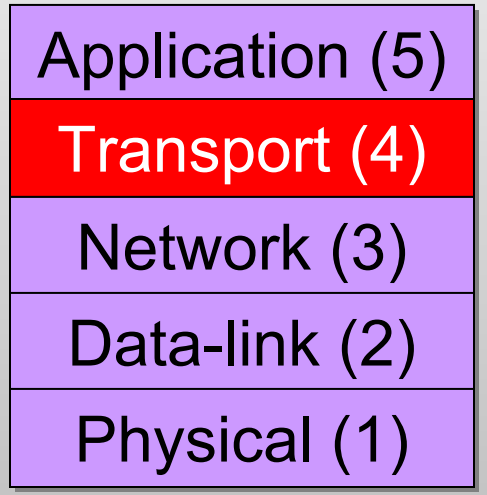
Chapter 3: Transport Layer

Our goals:

- Understand principles behind transport layer services:
  - Multiplexing/demultiplexing
  - Reliable data transfer
  - Flow control
  - Congestion control
- Learn about transport layer protocols in the Internet:
  - UDP: connectionless transport
  - TCP: connection-oriented transport



Chapter 3: Roadmap

3.1 Transport-layer services

3.2 Multiplexing and demultiplexing

3.3 Connectionless transport: UDP

3.4 Principles of reliable data transfer

3.5 Connection-oriented transport: TCP

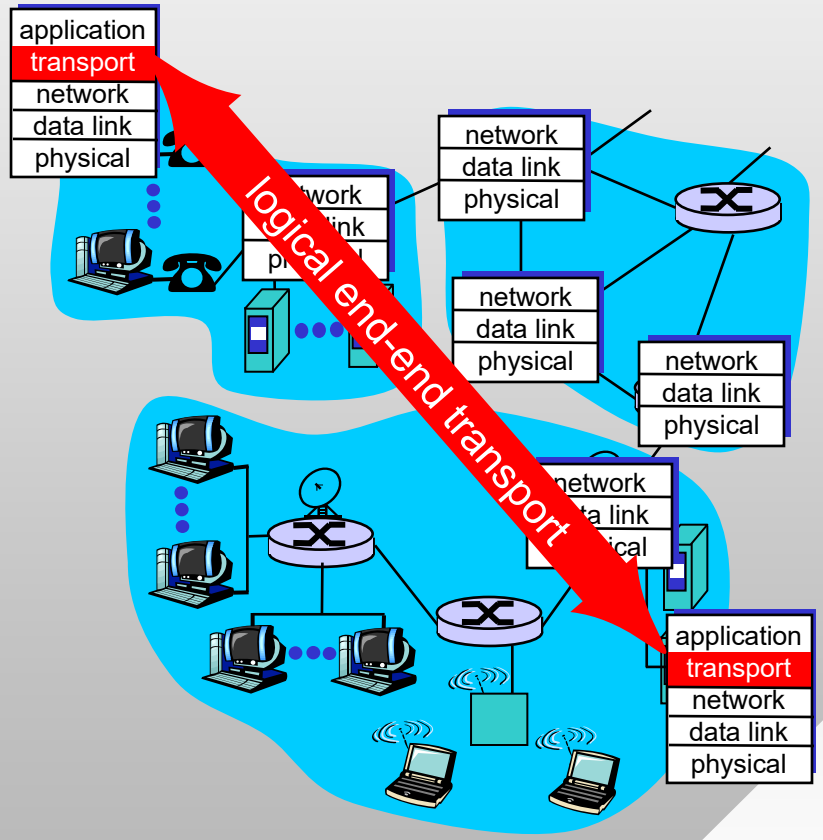
- Segment structure
- Reliable data transfer
- Flow control
- Connection management

3.6 Principles of congestion control

3.7 TCP congestion control

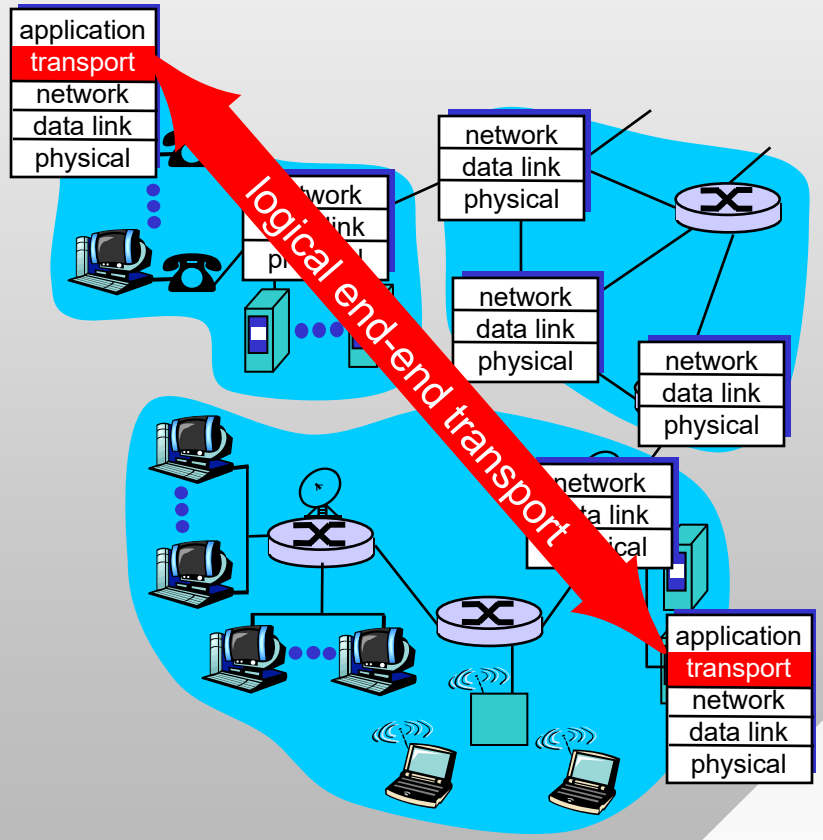
Transport Services and Protocols

- *Transport layer:* logical communication between processes on different hosts
  - Relies on and enhances network-layer services
- *Network layer:* logical communication between hosts



Internet Transport-layer Protocols

- Reliable, in-order delivery: TCP
  - Congestion control
  - Flow control
  - Connection setup
- Unreliable, unordered delivery: UDP
  - No-frills extension of “best-effort” IP
- Services not available:
  - Delay or loss guarantees
  - Bandwidth guarantees



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Multiplexing/Demultiplexing

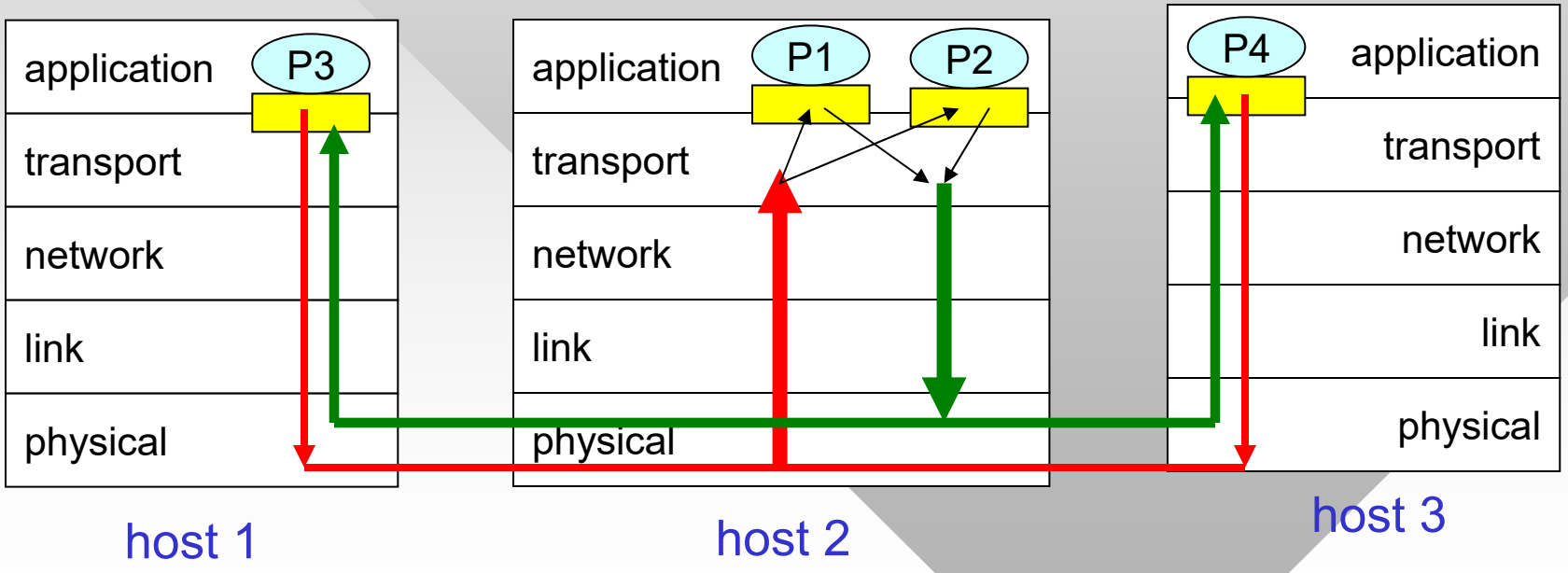
Demultiplexing at receiver host:

Delivering received segments to correct socket

Multiplexing at sender host:

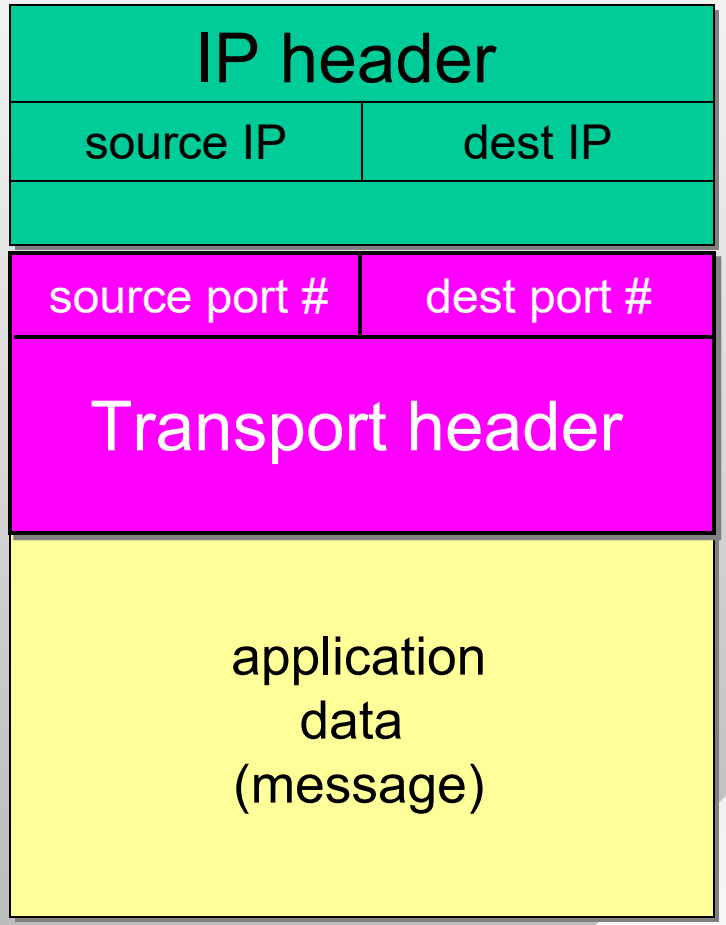
Gathering data from multiple sockets, enveloping data with header (later used for demultiplexing)

= socket = process



How Demultiplexing Works

- Host receives IP datagrams
  - Each datagram has source IP address and destination IP address
- Each datagram carries one transport-layer header
  - Transport header starts with source and destination port numbers
- Kernel uses port numbers to direct packets to appropriate socket or reject the message
  - Each port # is a 16-bit unsigned integer (1-65535)



TCP/UDP segment format

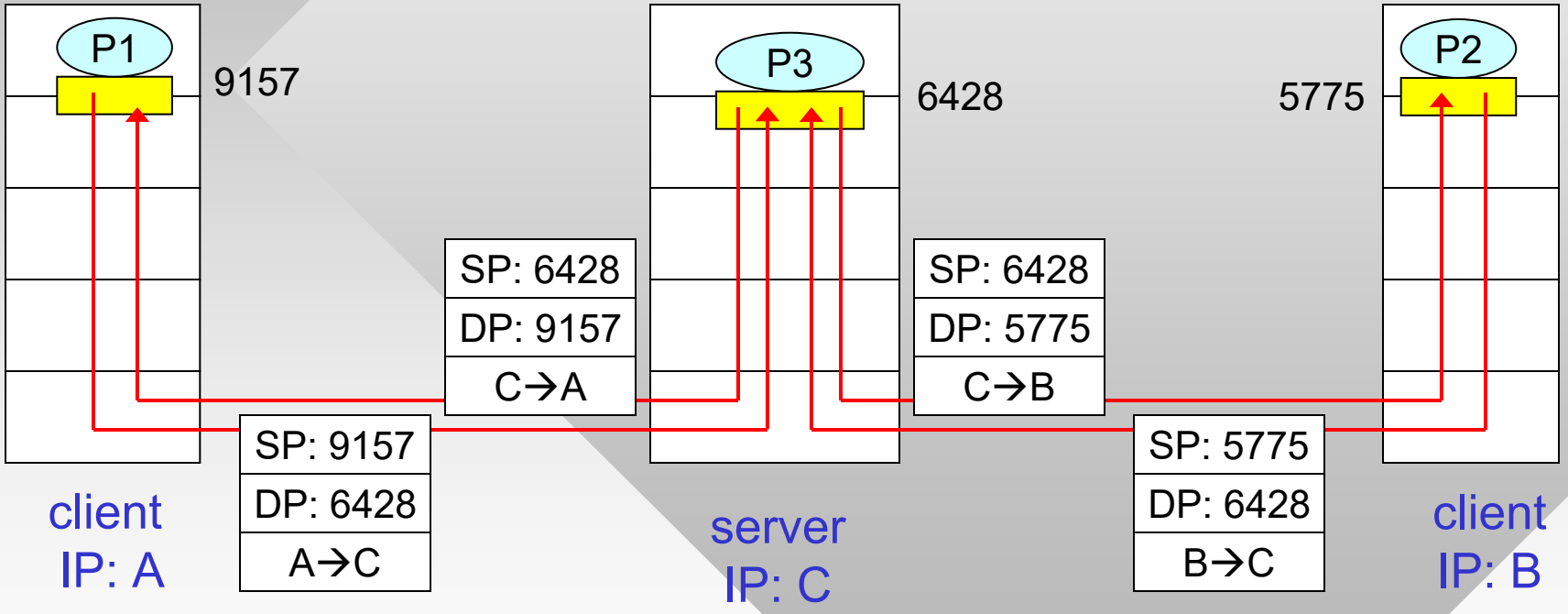
Connectionless Demultiplexing

- Create a SOCK_DGRAM socket
- Bind the socket
  - Server: specify a well-known port (e.g., 53 for DNS)
  - Client: bind to port 0 (OS assigns next available #)
- Use sendto(), recvfrom()
- Target UDP socket is identified by a 2-tuple: (dest IP address, dest port number)

- When host receives UDP segment:
  - OS checks destination port/IP in segment
  - Directs segment to the socket with a matching combination if socket is open; rejects otherwise
- IP datagrams with different source IP addresses and/or source port numbers may be directed to the same socket!

Connectionless Demultiplexing (Cont)

SP = source port, DP = destination port



SP provides “return address”

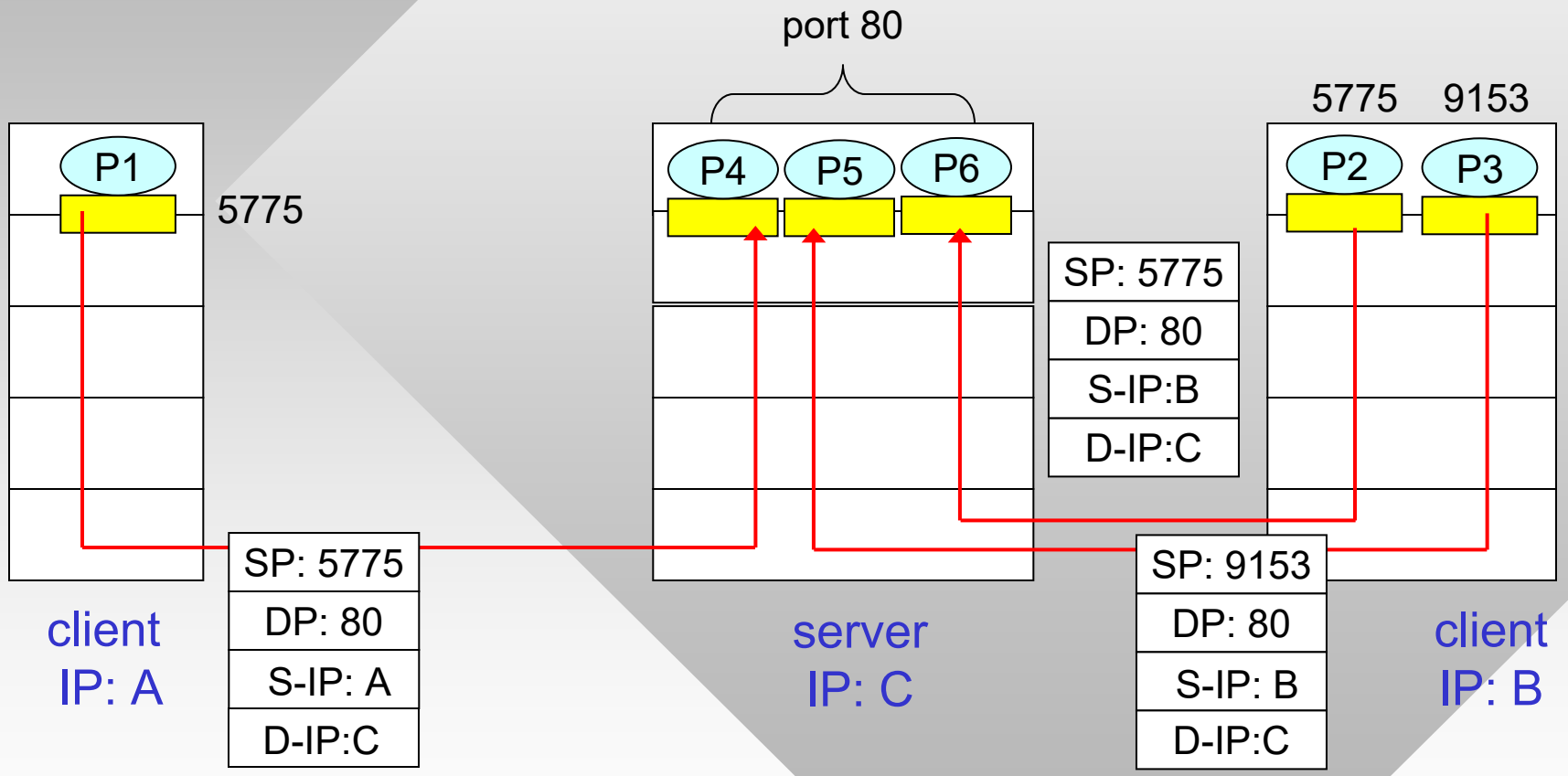
Connection-Oriented Demultiplexing

- TCP socket identified by a 4-tuple:
  - Source IP address
  - Source port number
  - Destination IP address
  - Destination port number
- Receiver host uses all four values to find appropriate socket
- Clients: each socket must have unique port

- Servers: possible to have multiple TCP sockets with same port number:
  - Each socket identified by its own 4-tuple
- Web servers have different sockets for each connecting client
  - All are on port 80
  - Non-persistent HTTP may have different socket for each request

Connection-Oriented Demultiplexing (Cont)

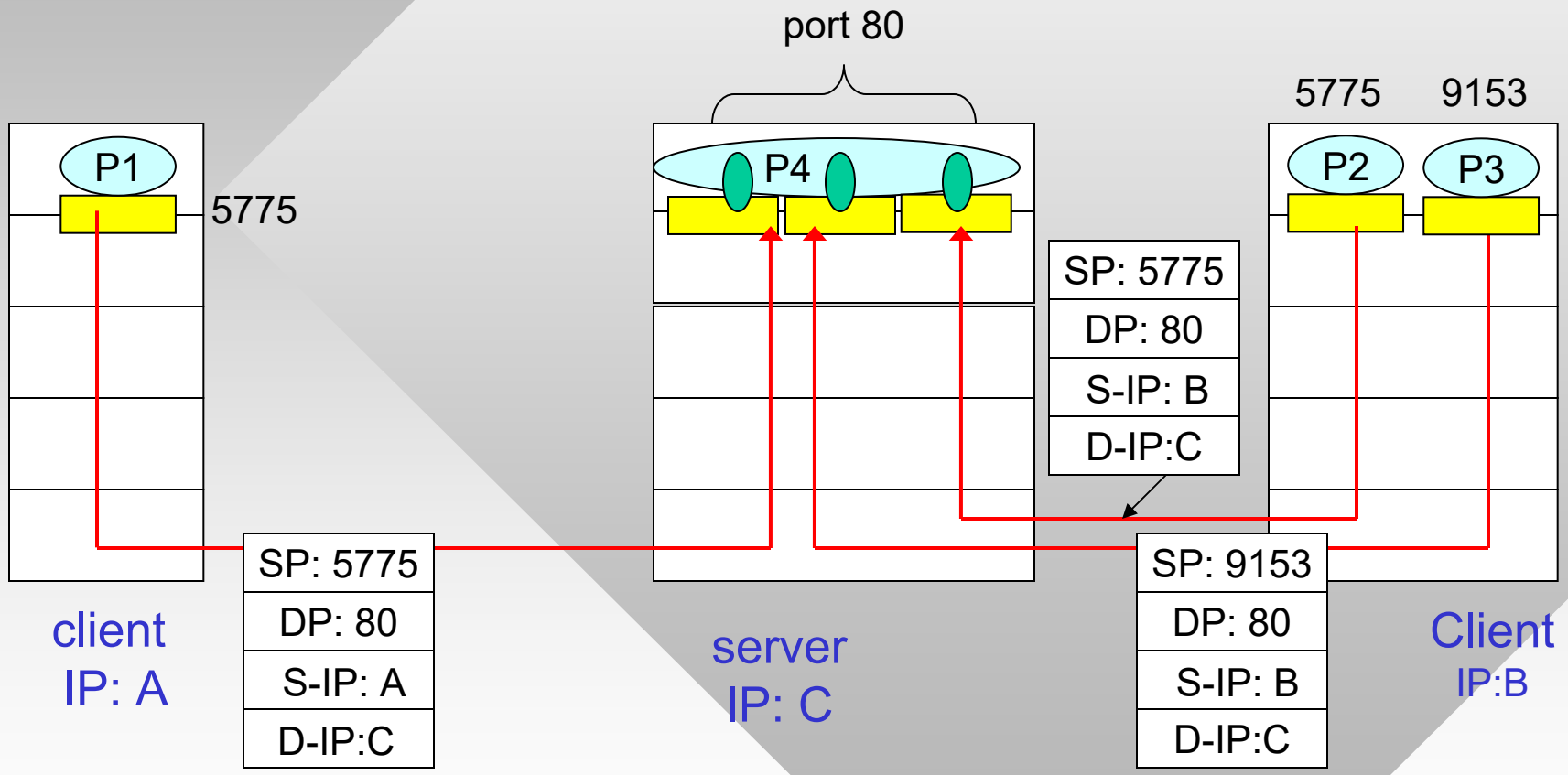
Web server spawns a new process per connection



SP = source port, DP = destination port;
S-IP = source IP, D-IP = destination IP

Connection-Oriented Demultiplexing (Cont)

Web server spawns a new thread per connection



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