UMASS AMHERST

ECE 671
Introduction to Computer Networks

Lesson 8
Software-Defined Networks

Rationale

- The lesson introduces software-defined networking (SDN)
  - Emerging technology
  - Used in IP networks, but operates quite differently
- Complete example of protocol interactions across network protocol stack to bring things together

Objectives

- Demonstrate the relationship between data centers and networking
- Compare traffic control between software-defined networks (SDNs) and traditional IP networks
- Explain the protocols used in the process of downloading a webpage from a remote server

Prior Knowledge

- Complete protocol stack and related protocols
- Routing and forwarding in network layer

Orchestrated Discussion (Hand Raise): Lesson Reflection Feedback

- Discuss questions and comments on Lesson Reflection from prior lesson

Student Presentation: Data Center Networking

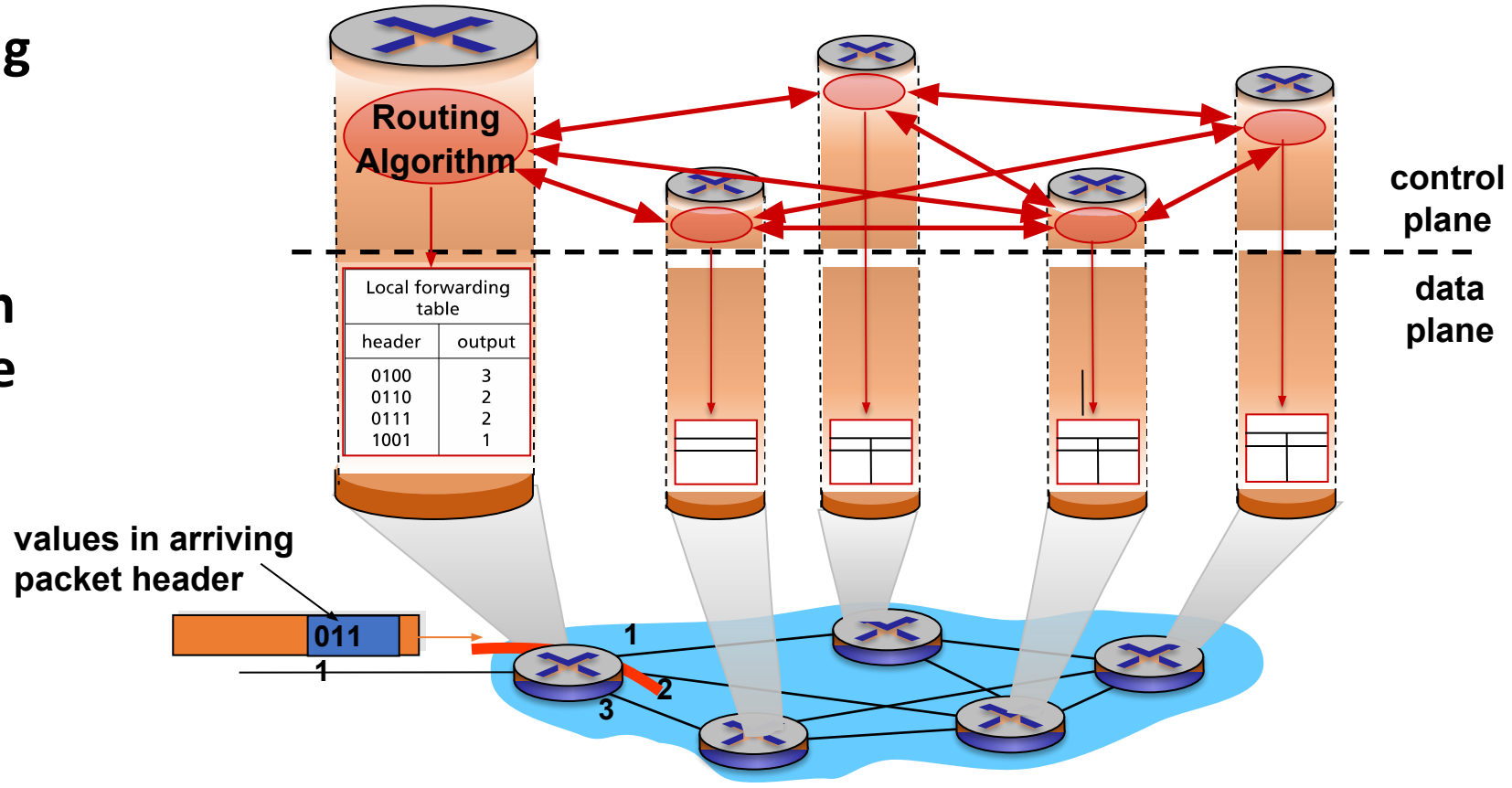
- Student team presentation: data center networking
  - What is a data center? How are networks in data centers used/structured/implemented? What interesting point have you learned about data center networking?
  - 10-minute presentation
    - 2 teams will get to present
  - Suggested source:
    - Kurose & Ross pages 495–500
    - Videos:
      - https://www.youtube.com/watch?v=XZmGGAbHqa0
      - https://www.youtube.com/watch?v=0uRR72b_qvc
    - Any other source (please specify in your presentation)

Software-Defined Networks

- Software-defined networking (SDN) is emerging technology
  - Different approach to controlling traffic in network
  - Crosses multiple layers in protocol stack
- Traditional IP networks
  - Distributed routing
- SDN
  - Logically centralized routing
  - Enables more control over network traffic

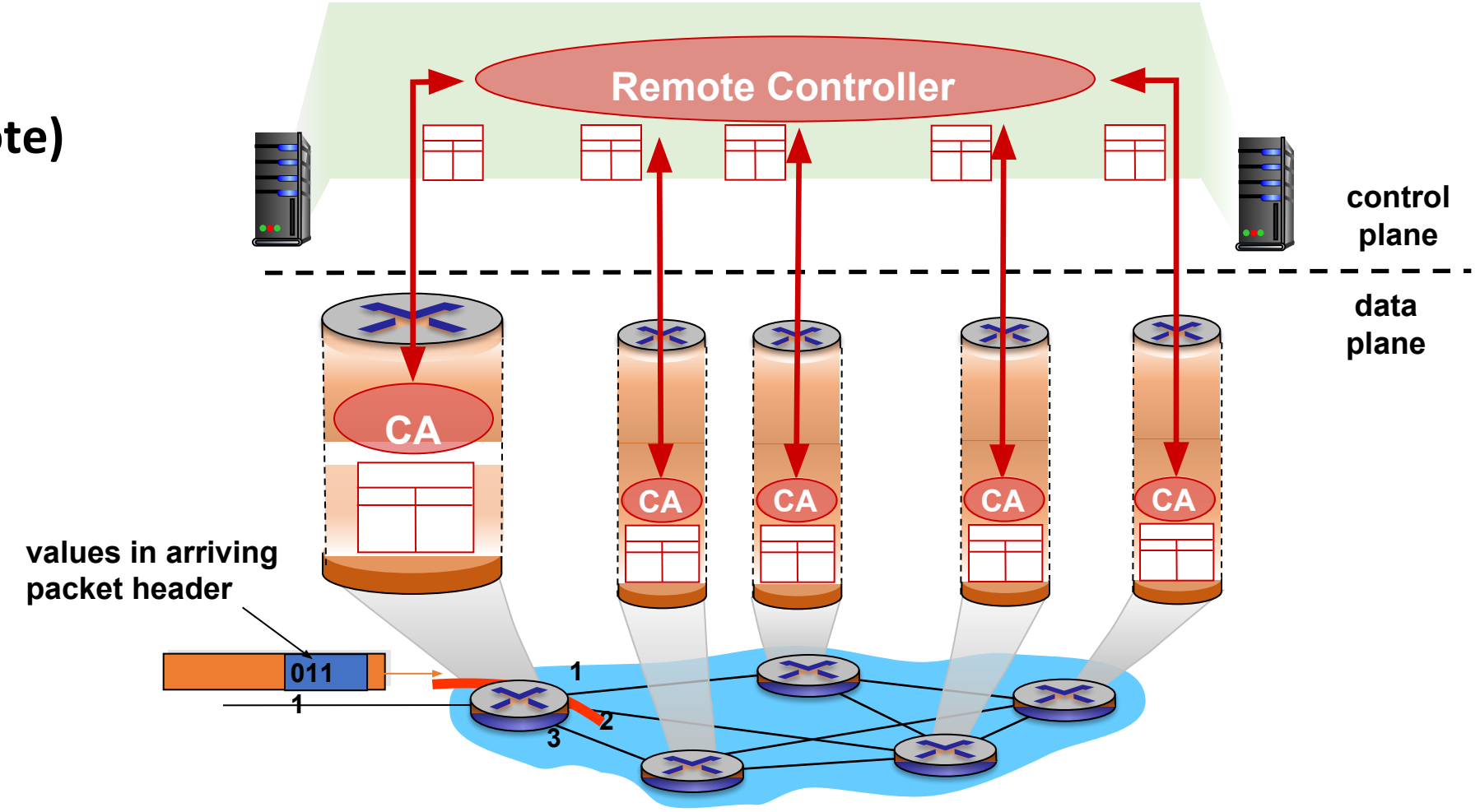
Per-Router Control Plane

- Individual routing algorithm components in each and every router interact in the control plane



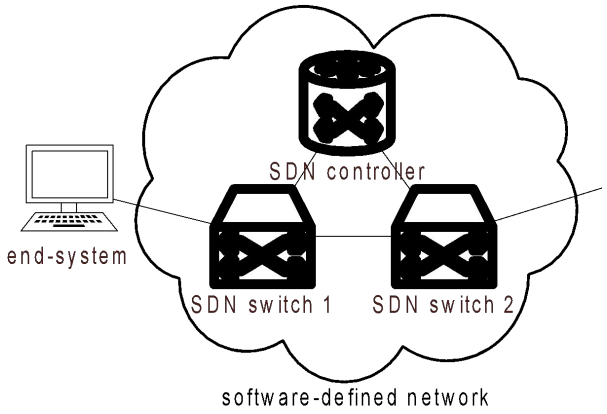
Logically Centralized Control Plane

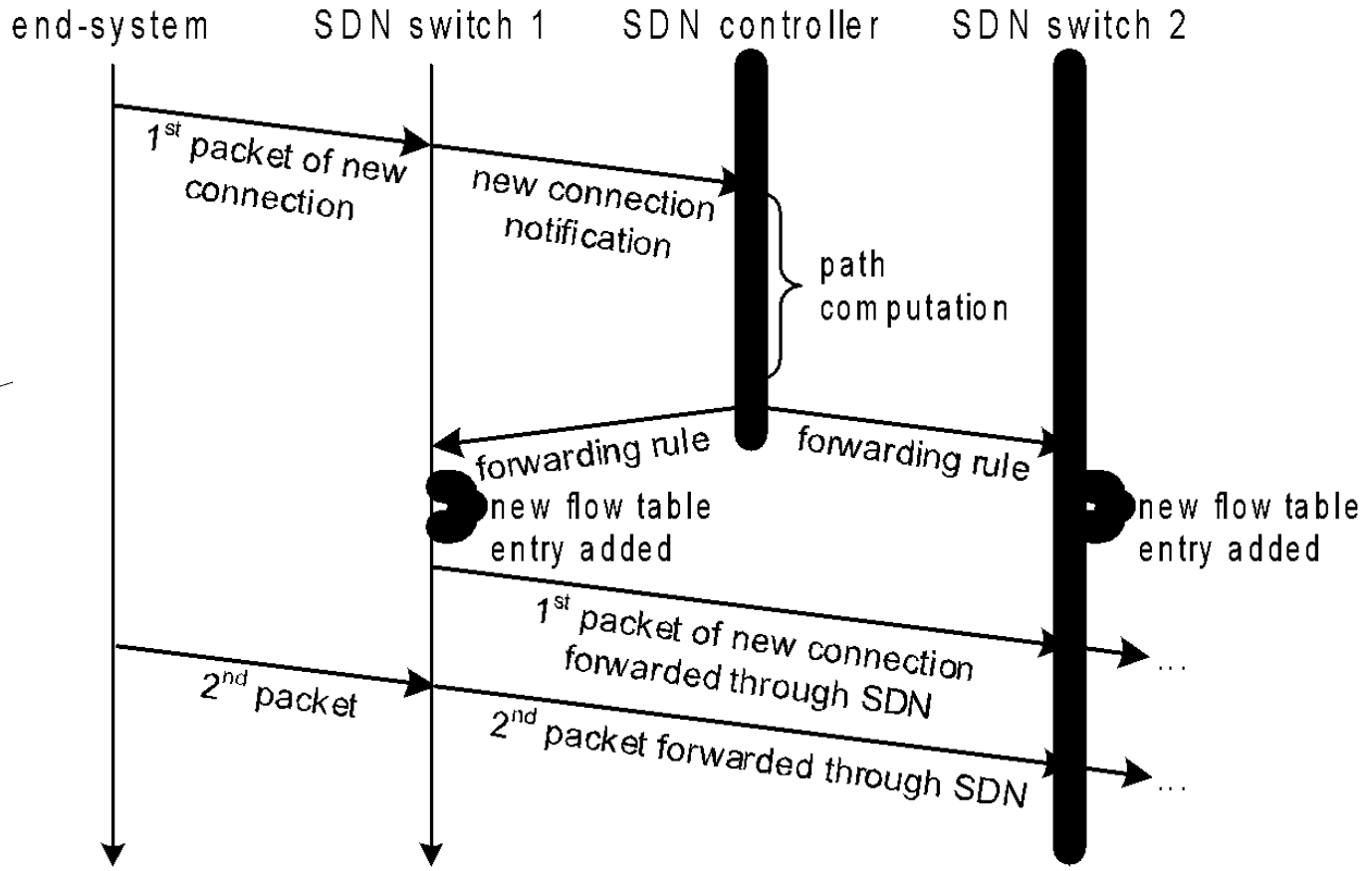
- A distinct (typically remote) controller interacts with local control agents (CAs)



Software-Define Networks

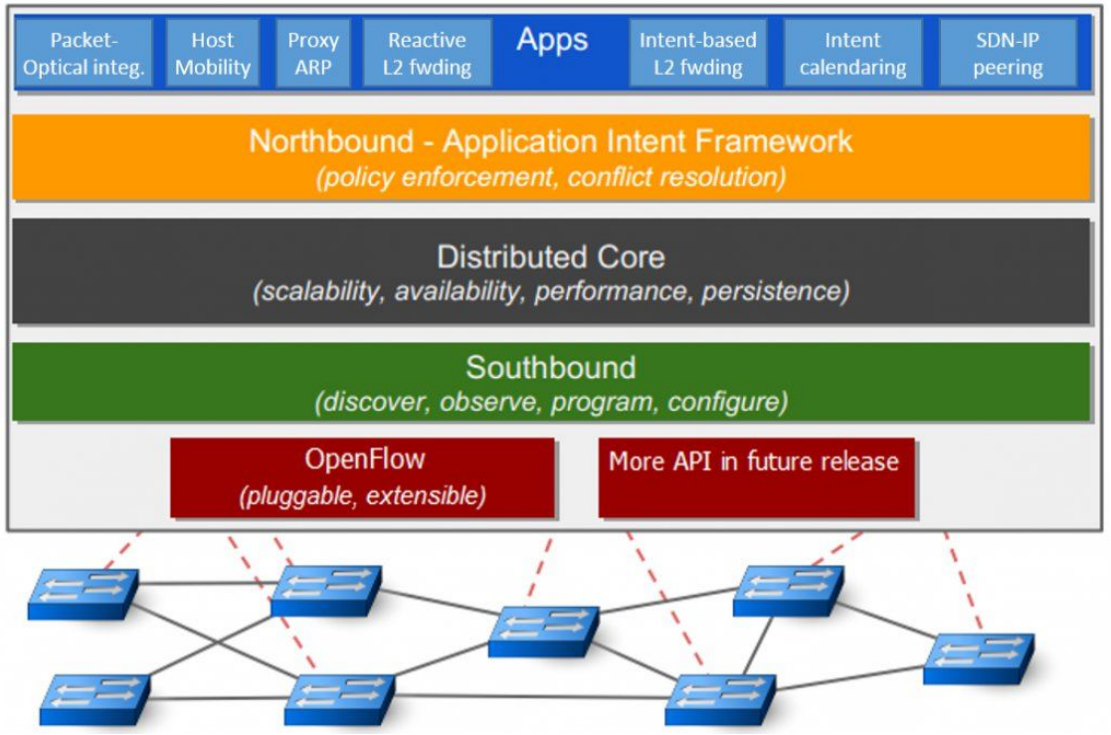
- **Space-time diagram of packet forwarding:**





Programmable Networks

- Network Operating System as extension of control
  - Different “applications” can control network traffic
  - SDN functionality can control individual flows

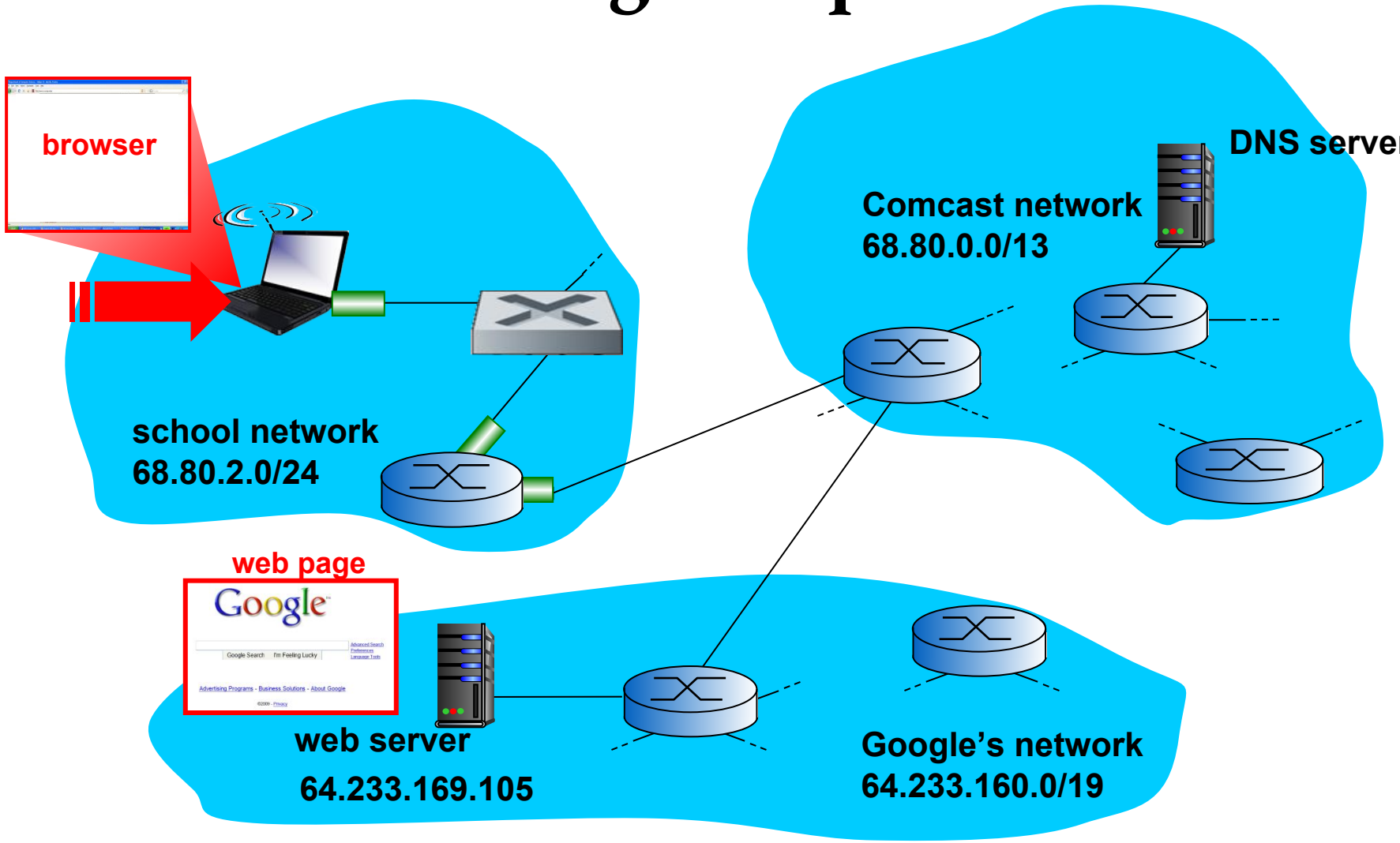


Group Discussion and Report Back (Short Answer): Bringing It All Together

- Determine the interaction of all necessary protocols for downloading a webpage from a remote server
  - Consider protocols in data link layer and above

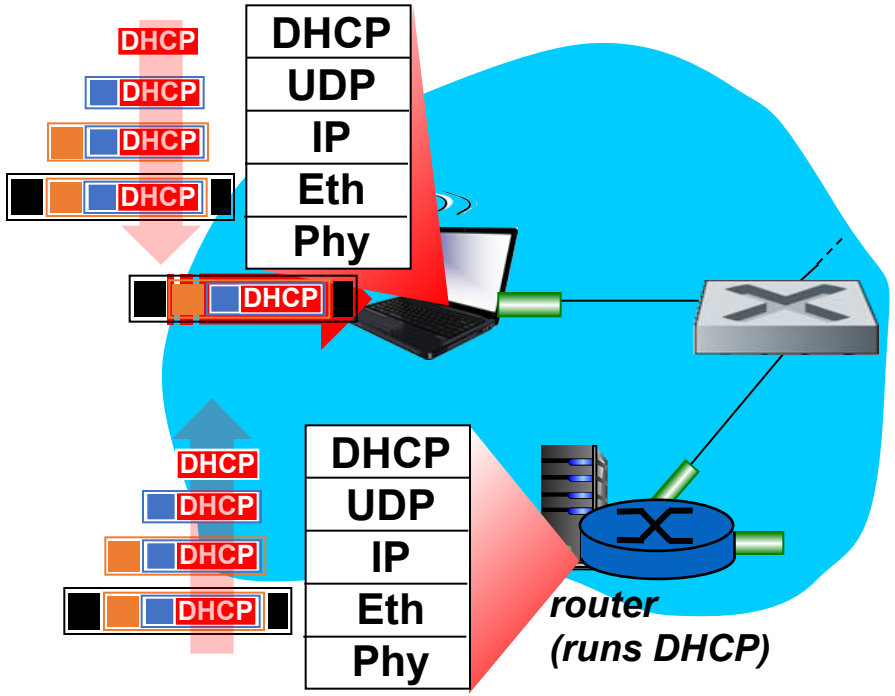
A Day in the Life of a Web Page Request

- Scenario



A Day in the Life of a Web Page Request

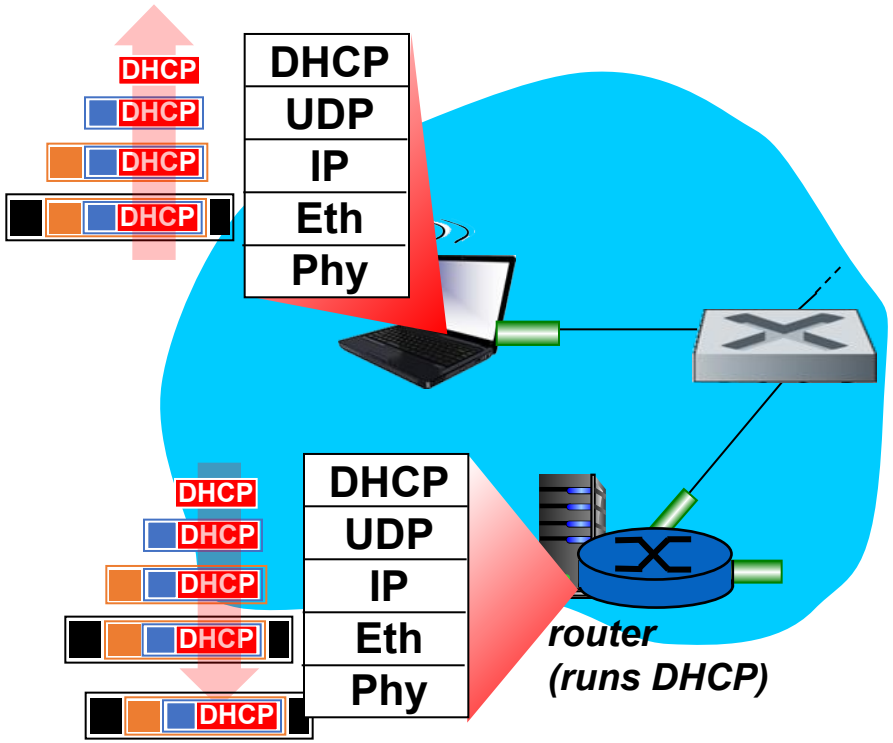
- Connecting to the Internet:



- Connecting laptop needs to get its own IP address, address of first-hop router, address of DNS server: use DHCP
- DHCP request encapsulated in UDP, encapsulated in IP, encapsulated in 802.3 Ethernet
- Ethernet frame broadcast (dest: FFFFFFFFFFFF) on LAN, received at router running DHCP server
- Ethernet demuxed to IP demuxed, UDP demuxed to DHCP

A Day in the Life of a Web Page Request

- Connecting to the Internet

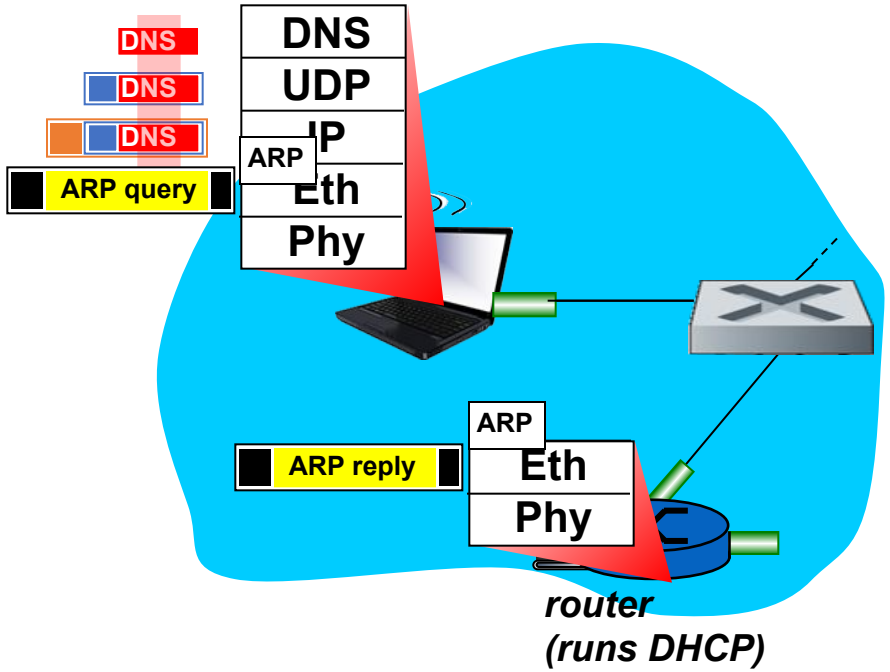


- DHCP server formulates DHCP ACK containing client's IP address, IP address of first-hop router for client, name & IP address of DNS server
- Encapsulation at DHCP server, frame forwarded (switch learning) through LAN, demultiplexing at client
- DHCP client receives DHCP ACK reply

Client now has IP address, knows name and address of DNS server, IP address of its first-hop router

A Day in the Life of a Web Page Request

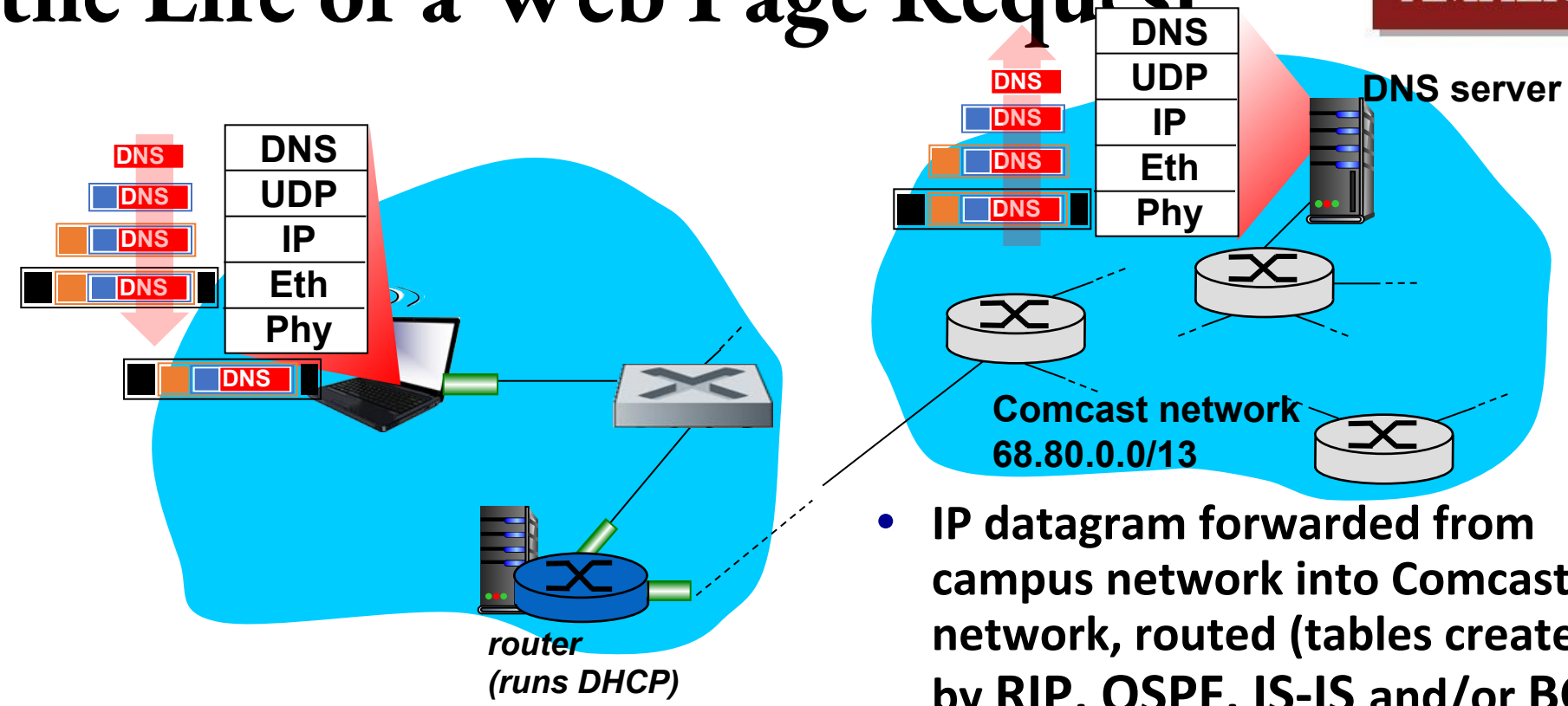
- ARP (before DNS before HTTP):



- Before sending HTTP request, need IP address of www.google.com: DNS
- DNS query created, encapsulated in UDP, encapsulated in IP, encapsulated in Eth. To send frame to router, need MAC address of router interface: ARP
- ARP query broadcast, received by router, which replies with ARP reply giving MAC address of router interface
- Client now knows MAC address of first hop router, so can now send frame containing DNS query

A Day in the Life of a Web Page Request

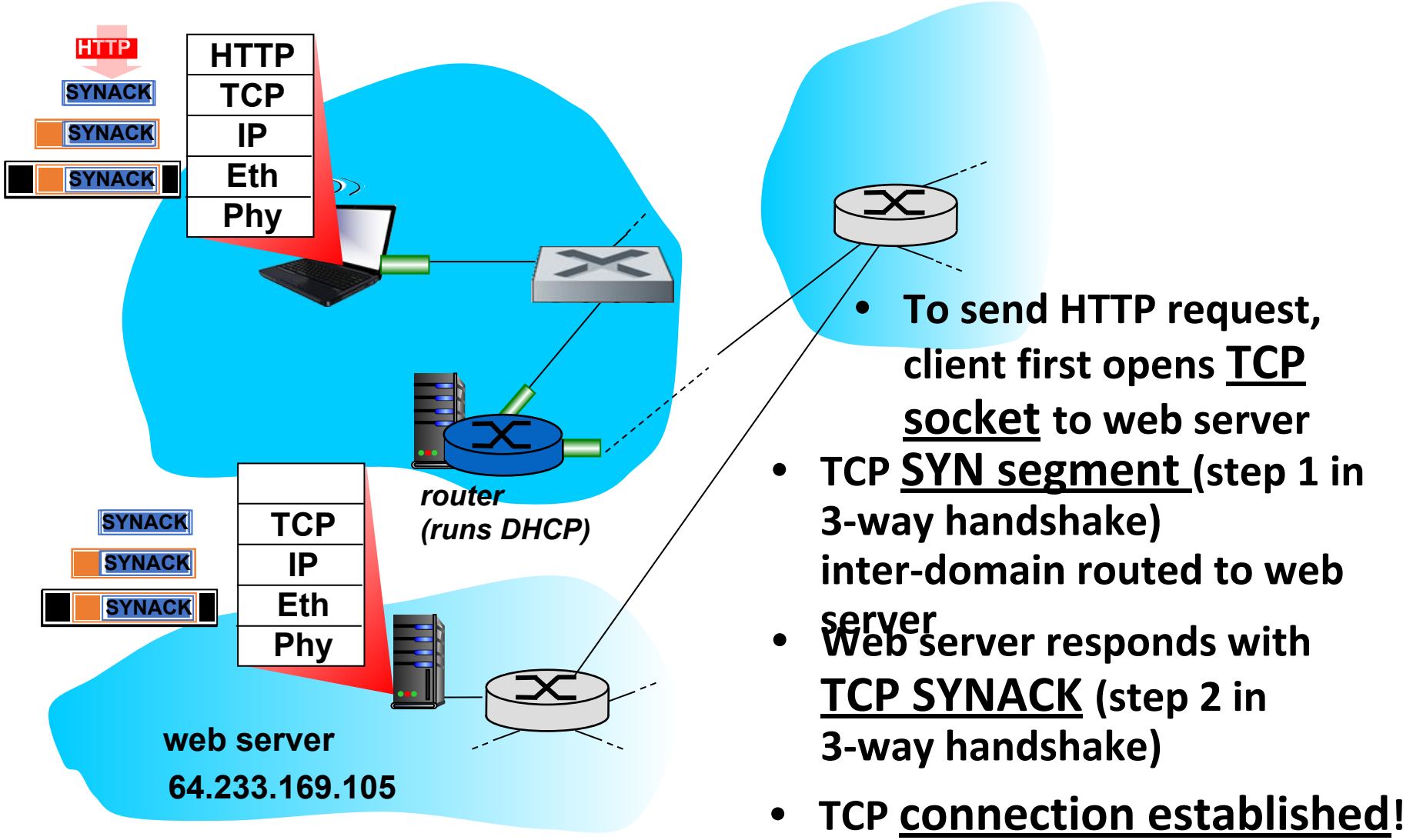
- Using DNS:



- IP datagram containing DNS query forwarded via LAN switch from client to 1st hop router
- IP datagram forwarded from campus network into Comcast network, routed (tables created by RIP, OSPF, IS-IS and/or BGP routing protocols) to DNS server
- Demuxed to DNS server
- DNS server replies to client with IP address of www.google.com

A Day in the Life of a Web Page Request

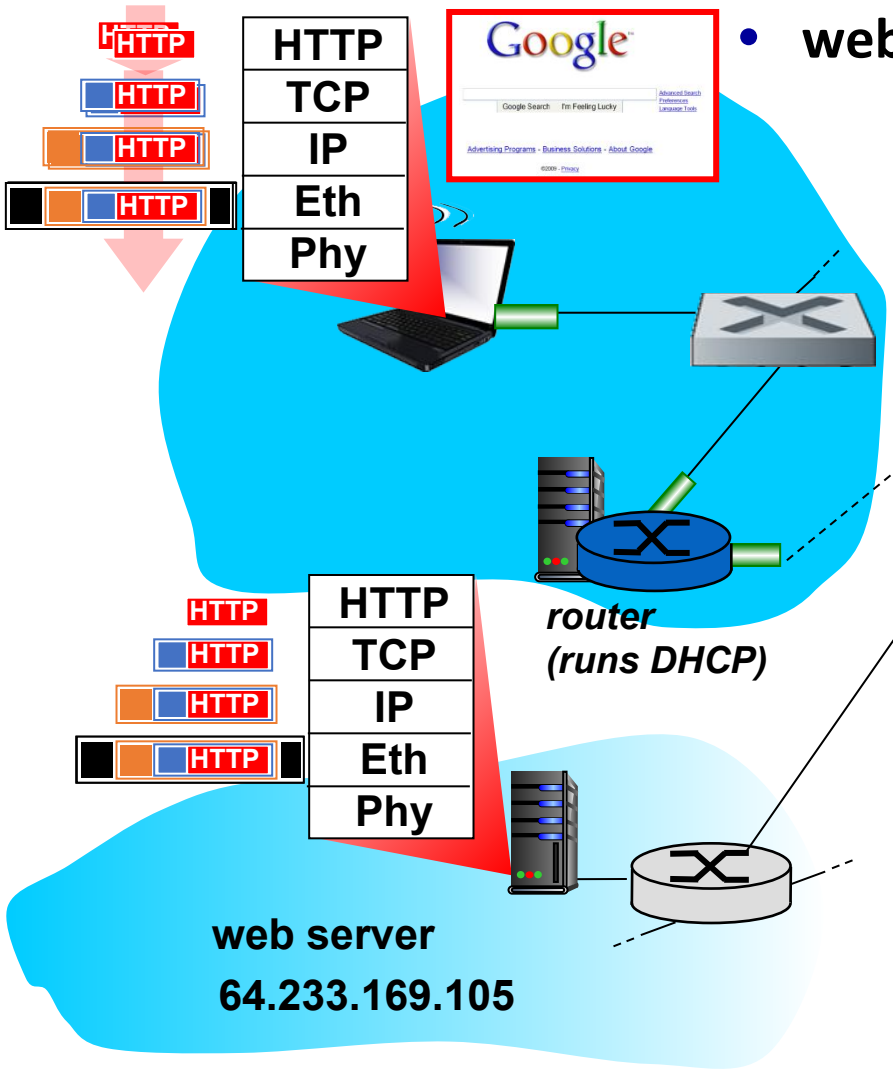
- TCP connection carrying TCP:



- To send HTTP request, client first opens TCP socket to web server
- TCP SYN segment (step 1 in 3-way handshake) inter-domain routed to web server
- Web server responds with TCP SYNACK (step 2 in 3-way handshake)
- TCP connection established!

A Day in the Life of a Web Page Request

- HTTP request/reply:



- web page finally (!!!) displayed

- HTTP request sent into TCP socket
- IP datagram containing HTTP request routed to www.google.com
- web server responds with HTTP reply (containing web page)
- IP datagram containing HTTP reply routed back to client

Orchestrated Discussion (Short Answer): Exam Format and Review

- Format
  - Closed book / closed notes
  - No electronic devices
  - 75 minutes
- Review

Summary of Lesson

- Software-defined networks/logically centralized control
- Protocol example

Post-work for Lesson 8

Homework #5

- **After the Live Lecture, you will complete and submit a homework assignment. Go to the online classroom to view and submit the assignment.**

To Prepare for the Next Lesson

- **Complete and submit the Post-work for Lesson 8.**
- **Study for the Exam.**

Go to the online classroom for details.