Lesson 09: Summary

CS 326E Elements of Networking

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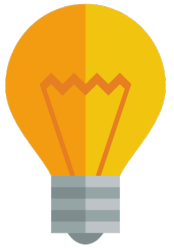
What have we learned so far?

Internet Reference Model



Example Protocols		Responsible for
DNS, HTTP,	Application	application specific needs
TCP, UDP	Transport	process to process data transfer
IP (DHCP, ICMP) Routing, SDN	Network	host to host data transfer across different network
Ethernet, WiFi, ARP, Switch	Link	data transfer between physically adjacent nodes
802.3 PHY	Physical	bit-by-bit or symbol-by-symbol delivery

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Also talked about

- Network security
- Tor

Hands-on Experiences

- DNS Dig
- Traceroute
- Ping
- Wireshark
- Portscan
- Project 1: HTTP Proxy

Let's reflect on the course goals

Course goals

1. Understand HOW Internet works
2. Understand WHY behind its design
3. Know the fundamentals

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First objective:
Understand HOW Internet works

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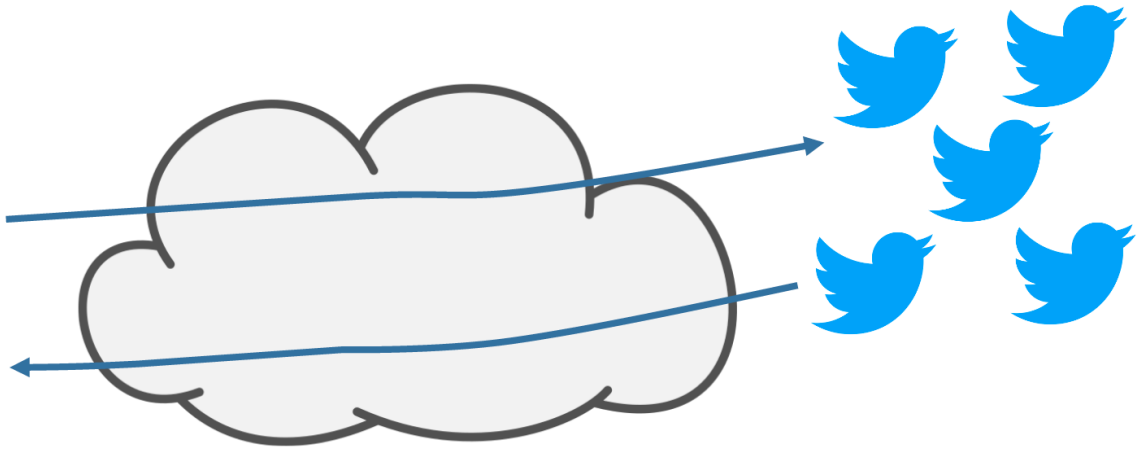
BTS Jungkook's post reached 1M people in just 10 min!

Video of Jeon Jungkook singing Lauv's "Never Not" via Twitter (@BTS_twt)



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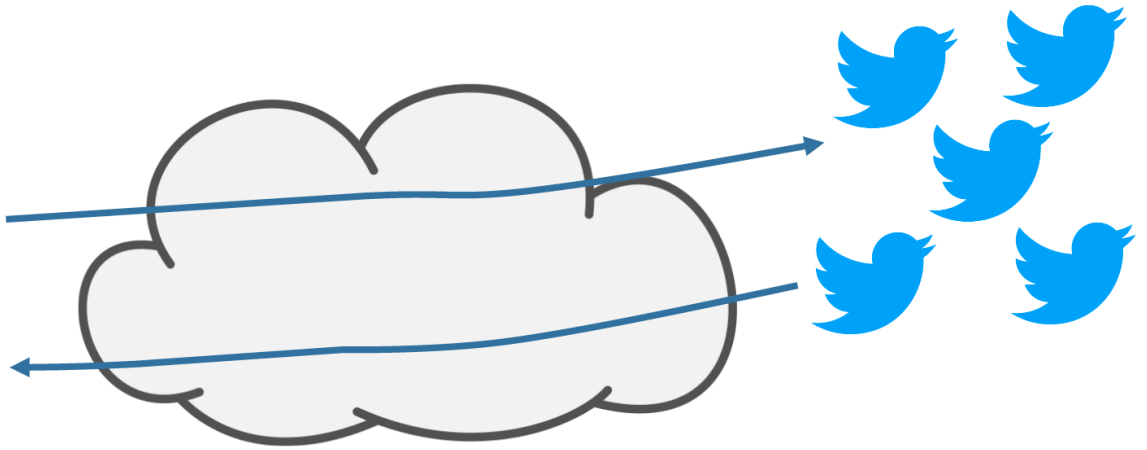
One: Learn HOW Internet works

Video of Jeon Jungkook singing Lauv's "Never Not" via Twitter (@BTS_twt)



What really happened behind the scene?

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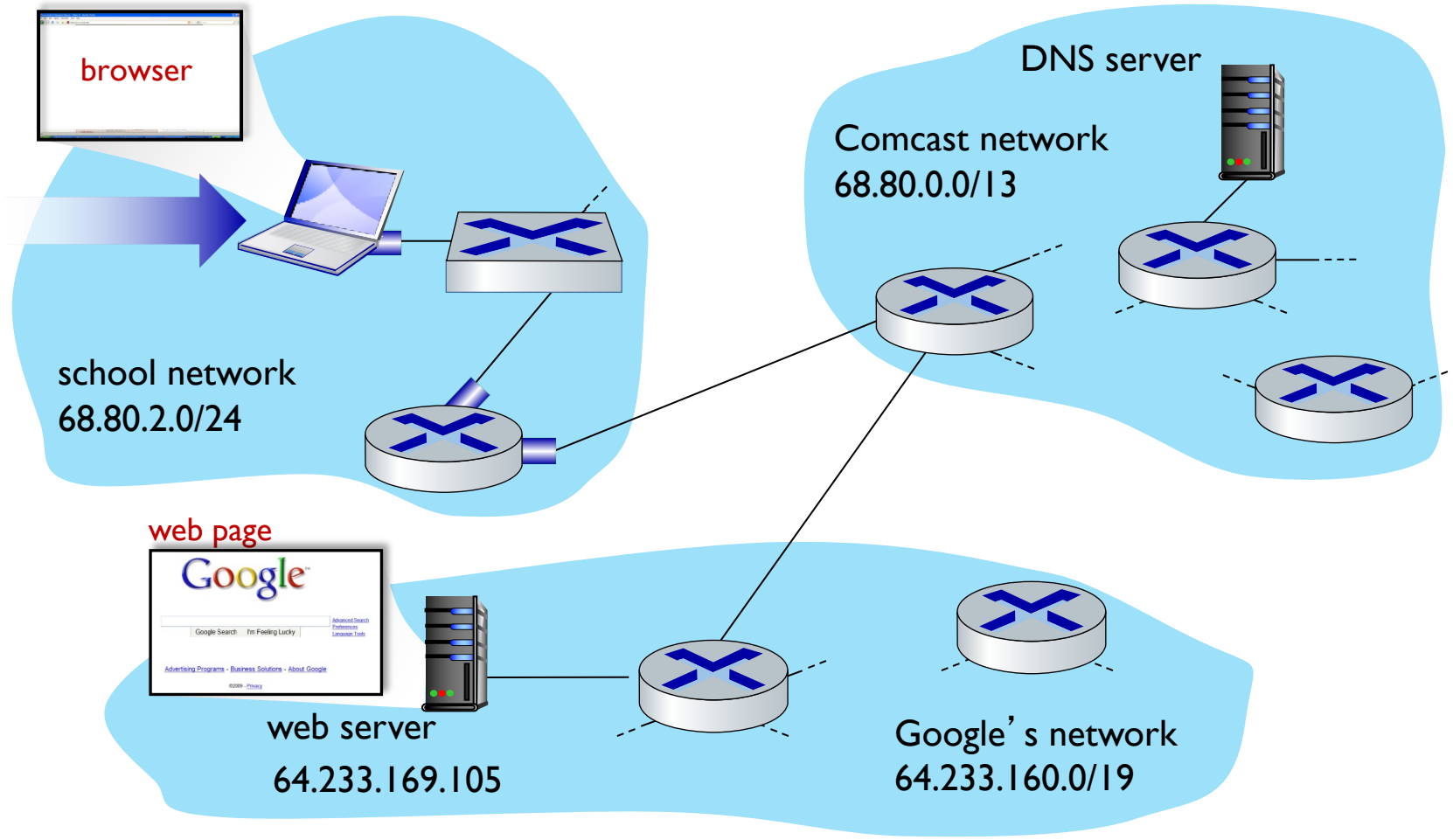
A day in the life: scenario

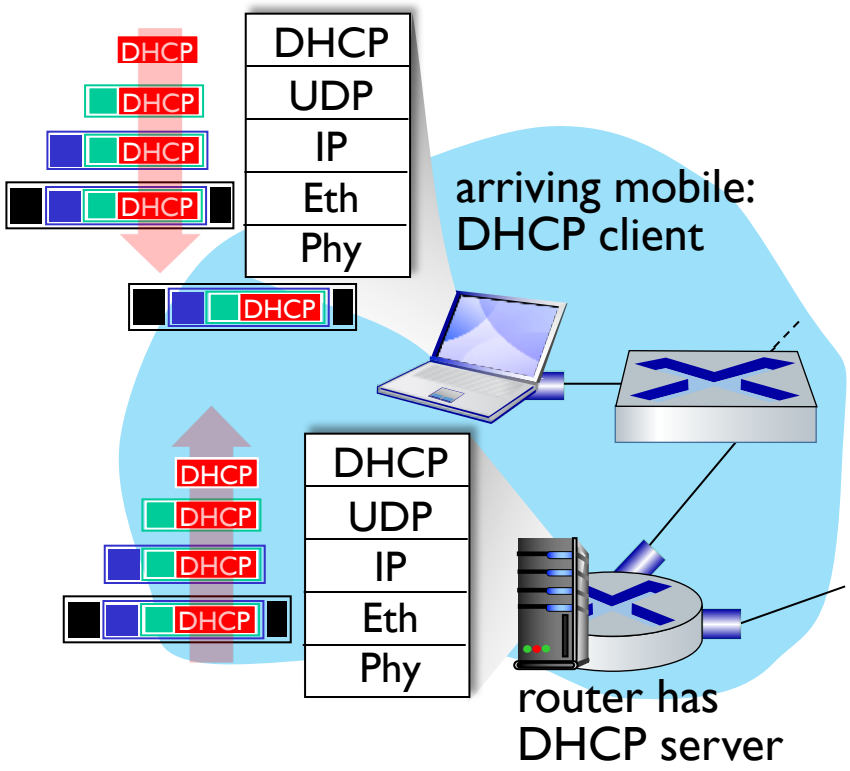


scenario:

- arriving mobile client attaches to network …
- requests web page: www.google.com

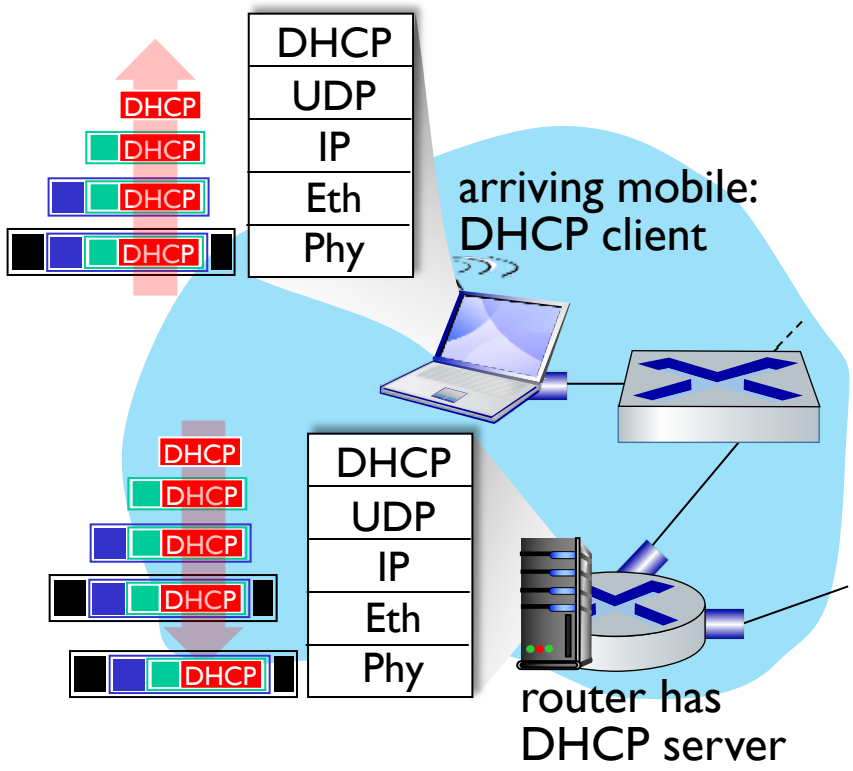
Sounds simple!

A day in the life: connecting to the Internet



- connecting laptop needs to get its own IP address, addr of first-hop router, addr 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

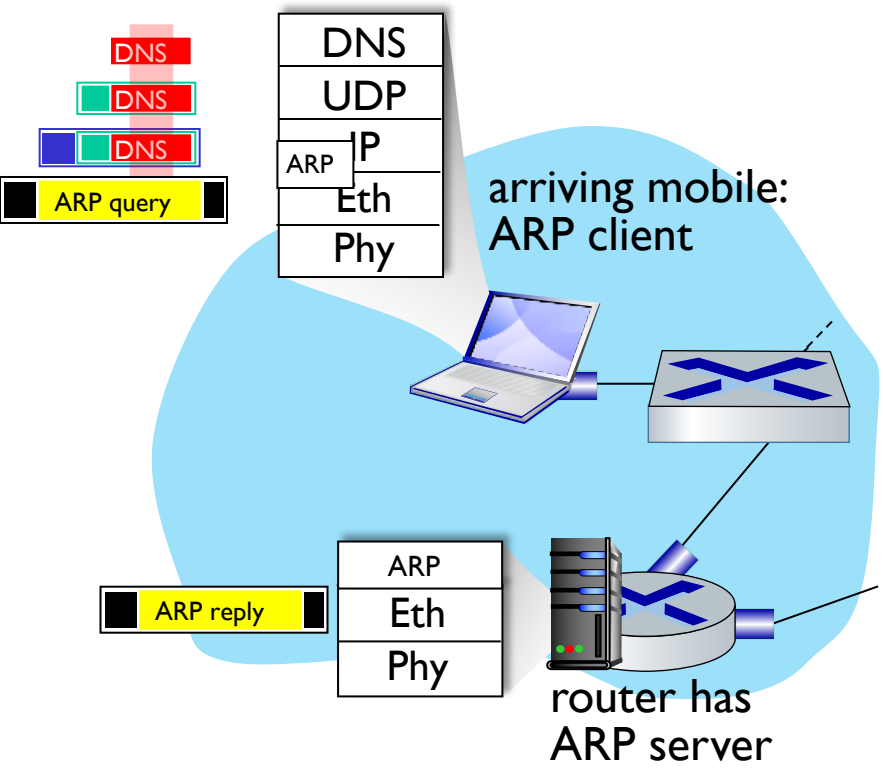
A day in the life: connecting to the Internet



- 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

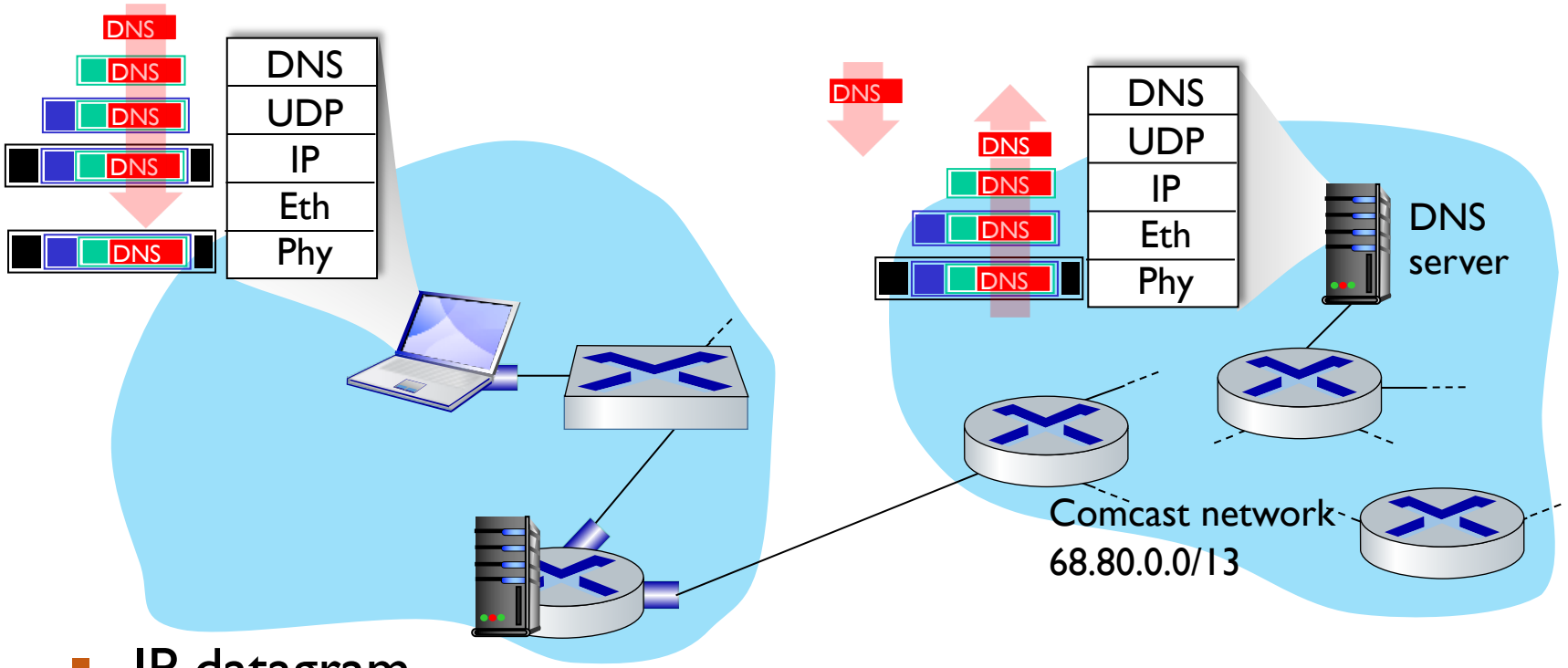
Client now has IP address, knows name & addr of DNS server, IP address of its first-hop router

A day in the life… 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… using DNS

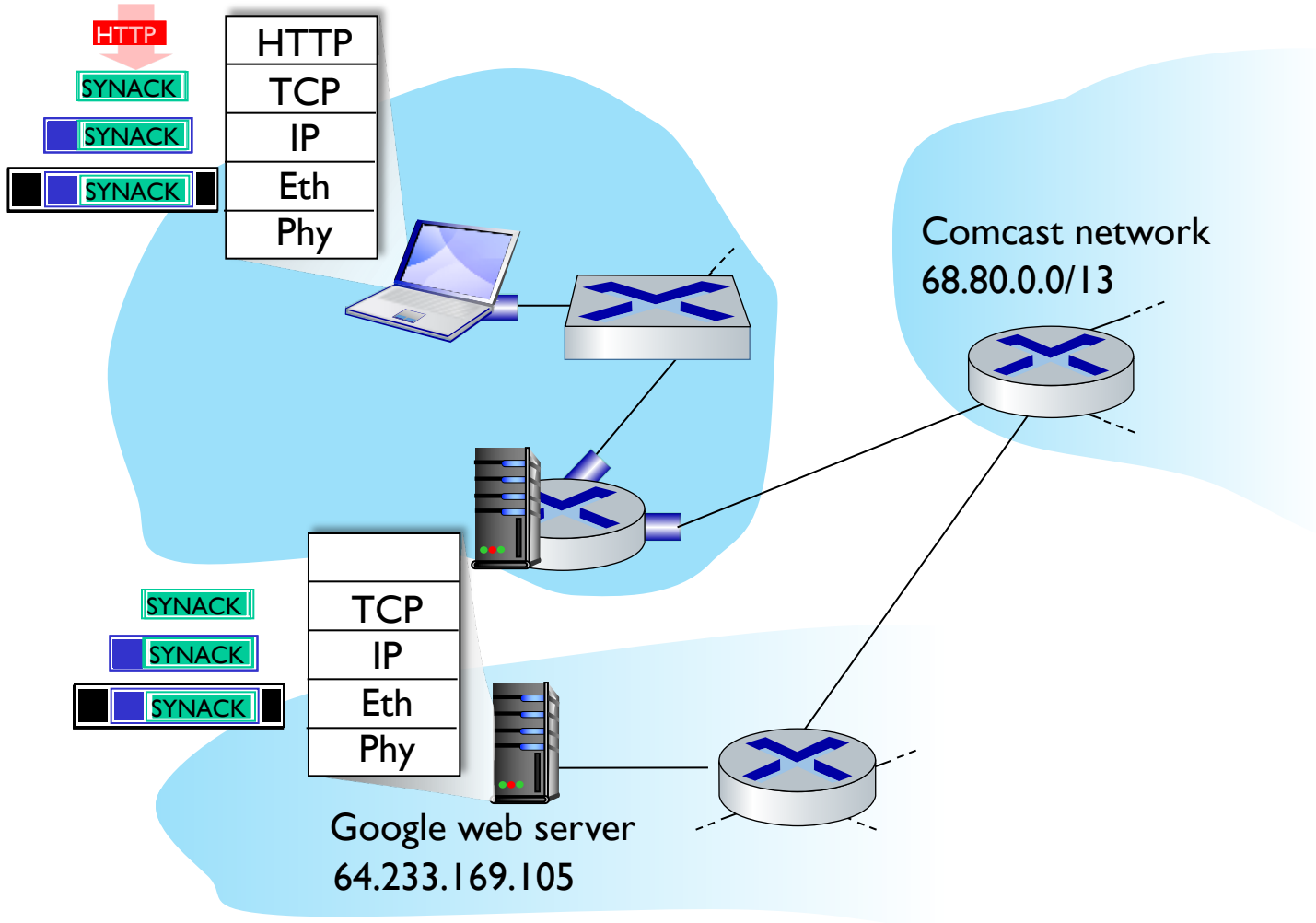


- demuxed to DNS
- DNS replies to client with IP address of www.google.com

- IP datagram containing DNS query forwarded via LAN switch from client to 1st hop router

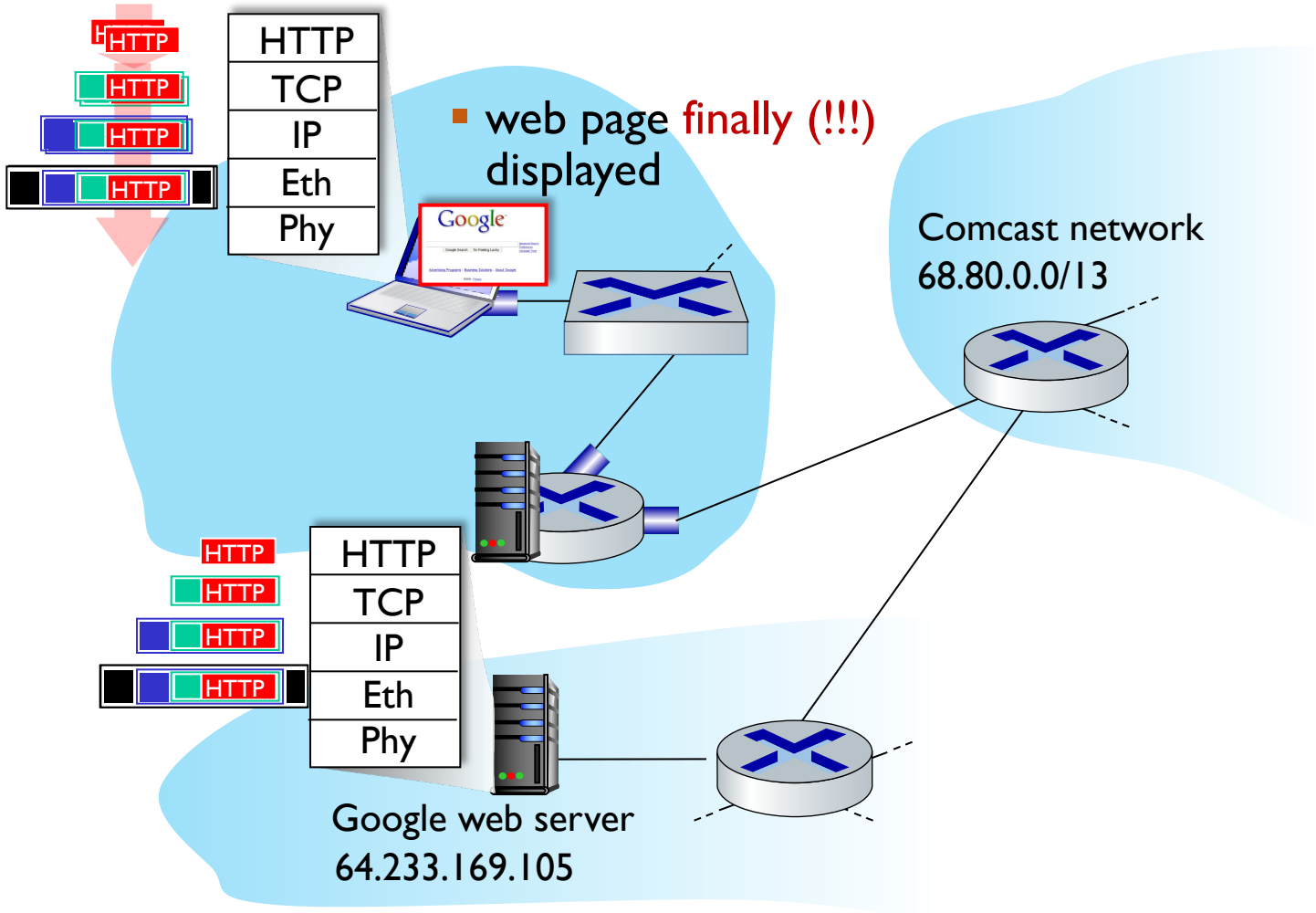
- IP datagram forwarded from campus network into Comcast network, routed (tables created by RIP, OSPF, IS-IS and/or BGP routing protocols) to DNS server

A day in the life…TCP connection carrying HTTP



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

A day in the life… HTTP request/reply



- 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

In addition…

Video of Jeon Jungkook singing Lauv's "Never Not" via Twitter (@BTS_twt)

In addition ….since it's multimedia streaming

- Video encoding
- Web cache
- Dynamic Adaptive Streaming over HTTP (DASH) of Content Distribution Network (CDN)
- Playout buffering
- TLS for security: encryption, message integrity, authentication
- Tor could have been used if users are in a country where Twitter is censored or just proxy
- Bloom filter and distributed hash table could have been used

Second Objective:
Understand WHY behind WHAT

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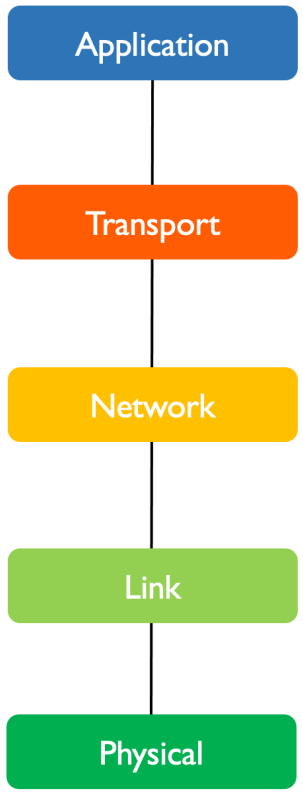
Motivation: Why X?

- Why layers?
- Why root name server?
- Why Subnet?
- Why TCP/UDP?
- Why SDN?
- Why overlay?
- Why Tor?
- …



Responsible for

application specific needs

process to process data transfer

host to host data transfer across different network

data transfer between physically adjacent nodes

bit-by-bit or symbol-by-symbol delivery

Third Objective:
Know the fundamentals of computer networks

- Back of the envelope calculations
- Reliable data transfer
- Stateless vs stateful
- Connectionless vs connection oriented
- Flow control
- Congestion control
- Error detection
- Routing vs switching
- Addressing

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Summary

- Covered 4 layers of Internet stack
- Multi-threaded socket programming projects
  - HTTP Proxy in TCP
- Labs and hands on
  - Network Measurements
  - DNS Dig,
  - Traceroute, ping
  - Wireshark
- Tor and security discussions

Thanks for your hard work! ☺