University of Victoria
British Columbia • Canada

ECE363 Communication Networks

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About the instructor

- Dr. Wenjun Yang
  - Engineering LAB Wing A334
  - Email: wenjunyang@uvic.ca
- Course web:

https://web.uvic.ca/~wenjunyang/ece363

  - Office hours: MTh10:30-11:30 am, or by appointment

About the labs

- Four labs
  - Check UVic timetable for your lab time/location
  - Our lab website will be ready soon

Assessment

- Assignments: 10%
- Labs: 20%
- Mid-term: 30% (Mar. 3)
- Final exam: 40% (TBD)

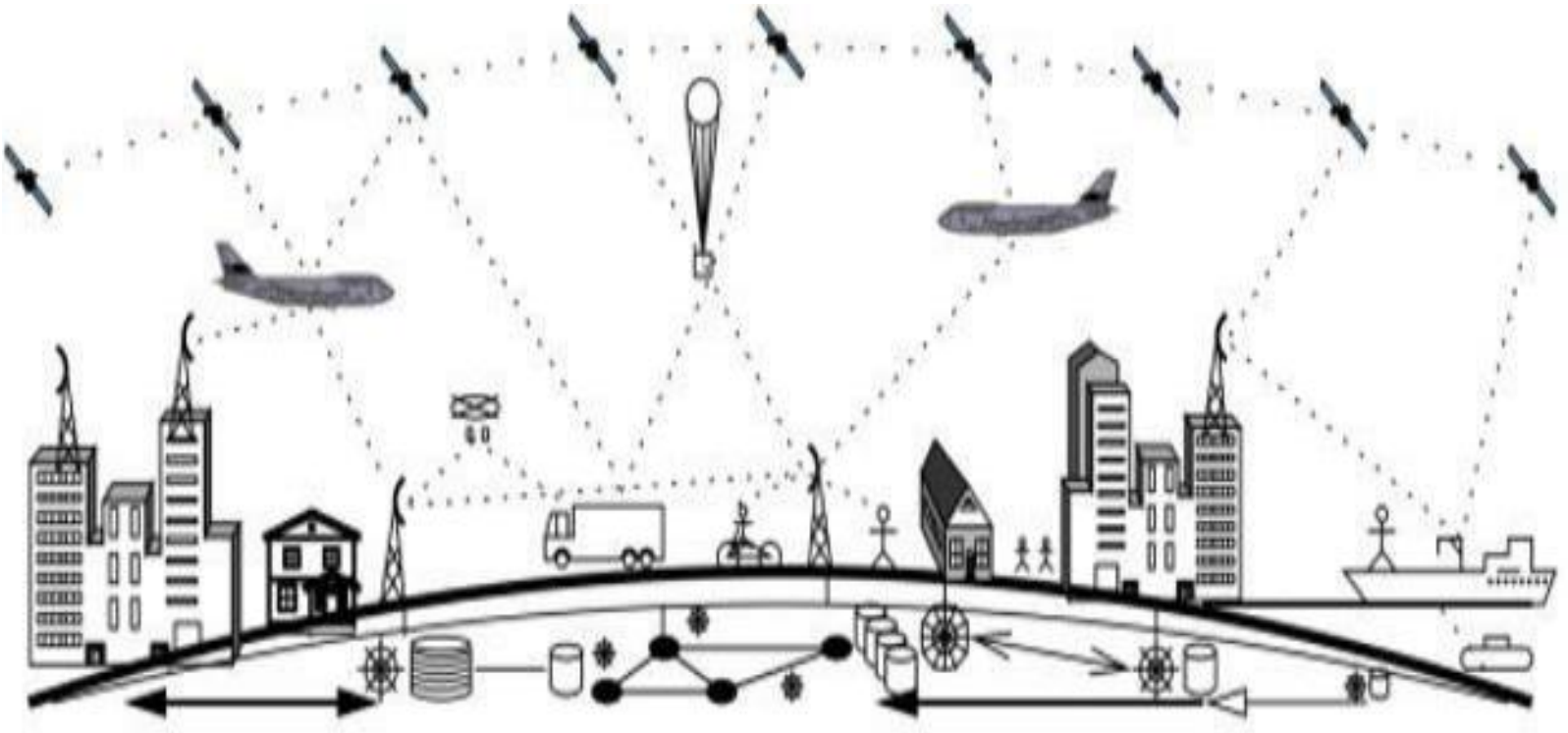
Why take this course?

- How to use networks
  - Not as a network user
  - But as a network engineer/programmer/researcher!
- How to design/engineer network
  - or design any large-scale, distributed systems
- How to implement network protocols and algorithms

Next generation communication networks?

- Infinite possibilities
- Limited collections and view of each individual

Ubiquitous network: Space/air/ground/water



- Ubiquitous: anywhere, anytime, any devices
- Future growth driven by new ***communication technologies, paradigms,*** and ***applications***

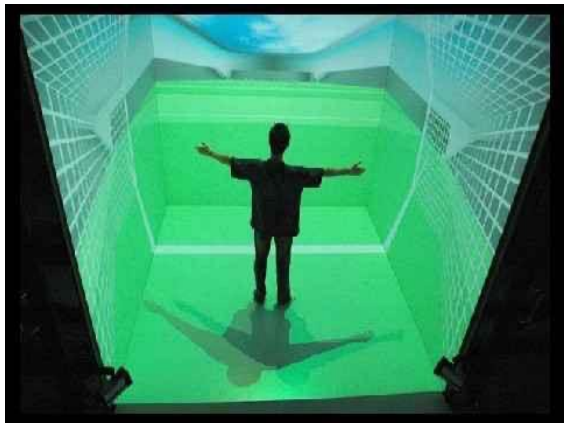
Driven forces

New Applications – Multimedia

IPTV/VoD

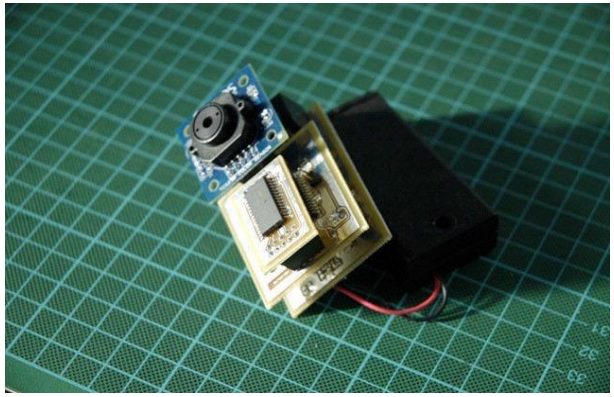
http://www.academyconfidential.co.uk/images/3D_01.jpg

3D-TV



http://youreyeonthefuture.files.wordpress.com/2009/09/virtual-reality-3.jpg

Virtual Reality



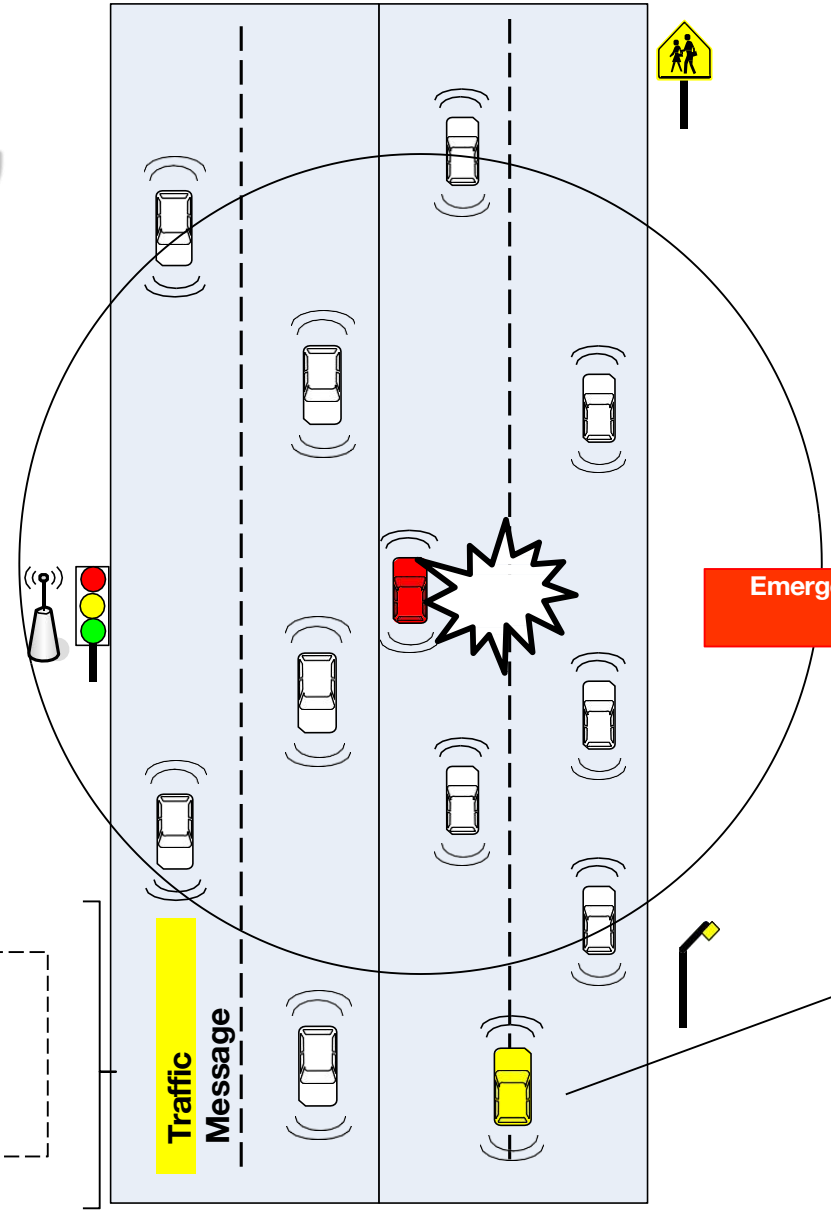
http://www.bash-design.com/pic/one_pixel_camera_1.png

One-pixel camera using compressive sensing

New Applications – VANET

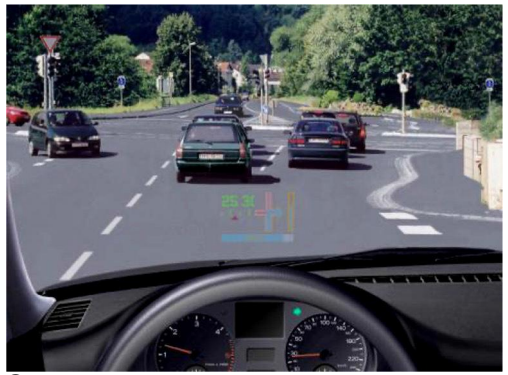
RSU

Hazard warning etc



Emergency Message

Position, current time, direction, velocity, accelerator, etc.



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New Applications – Human-cyber-physical interactions

New applications for real-time interactions between human, cyber systems, physical systems

AI for Network and Network for AI

- **From data**
- **➔ information**
- **➔ knowledge**

Driven forces

Networking challenges?

Challenges

- Support heterogenous applications with
  - Different traffic characteristics
  - Various QoS requirements: delay, jitter, loss, throughput requirements
- Bandwidth burden from new service paradigms
  - Peer-to-peer: relieve the bottleneck at the cost of potentially waste bandwidth
  - Cloud computing: scalability, fault-tolerance, capacity, privacy and security
    - TCP incast problem

Challenges (cont'd)

- Broadband wireless communication channels
  - Time-varying, location-dependent, and frequency-selective fading, shadowing, interference
- Underwater acoustic communication channels
  - Low bandwidth, high propagation delay
- Nano-scale communication channels?
- ...

Challenges (cont'd)

- Advanced PHY layer control mechanisms
  - adaptive modulation/coding
  - diversity
    - space, time, frequency
    - user cooperation
  - ...
- Impact of network topologies and mobility
- Constraints: energy, cost, environment, safety, security, ...

Challenges = Opportunities

Driven forces

Networking challenges?

Key to opportunities

Course materials

- Textbook
  - Computer networks, 4th edition (CN)
- Lecture notes

https://web.uvic.ca/~wenjunyang/ece363/363-schedule.html

- Explore further
  - Internet
- Google

Questions?

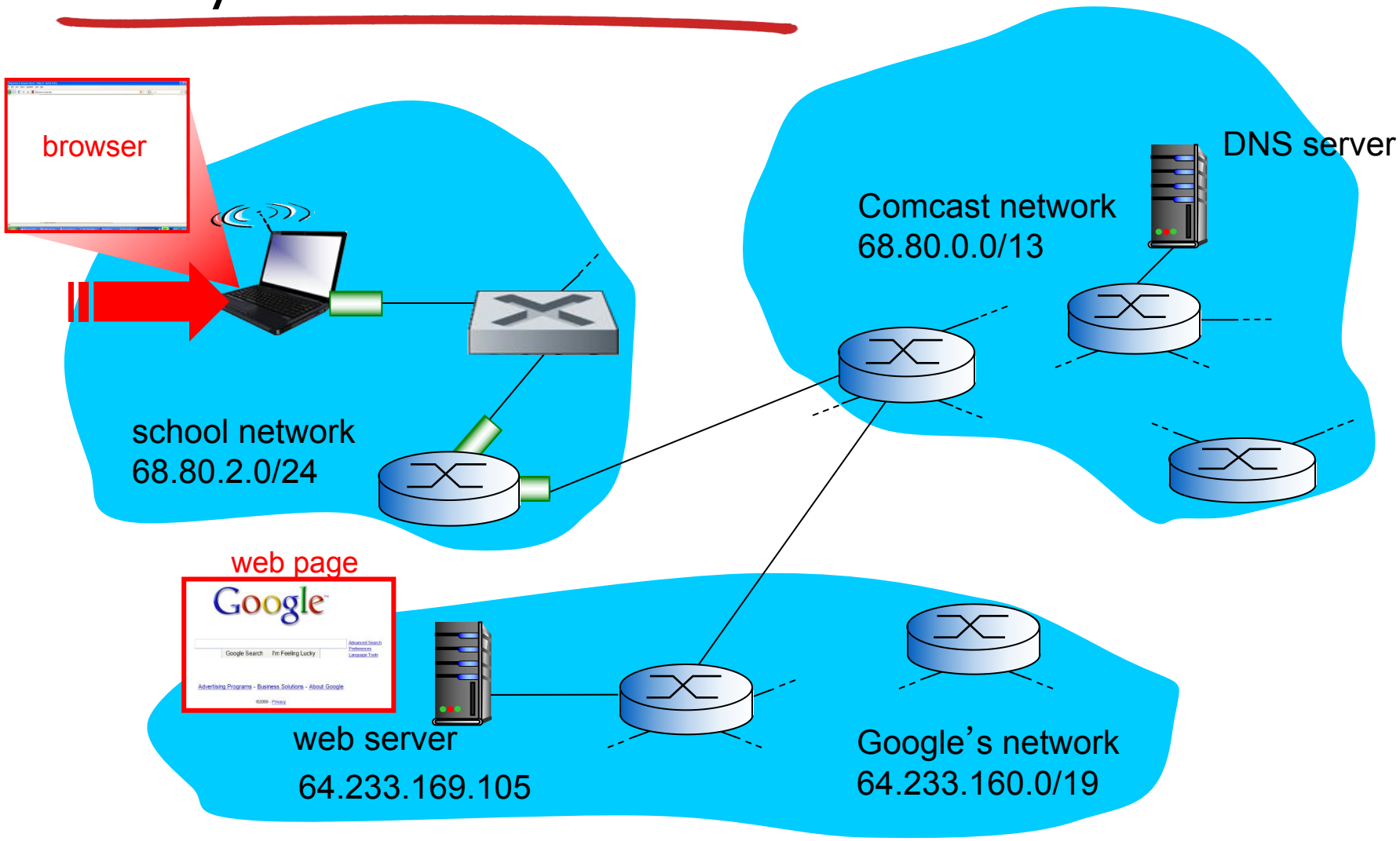
http://koolmornings.files.wordpress.com/2009/09/uvic-rabbit.jpg

Thank you for your attention!

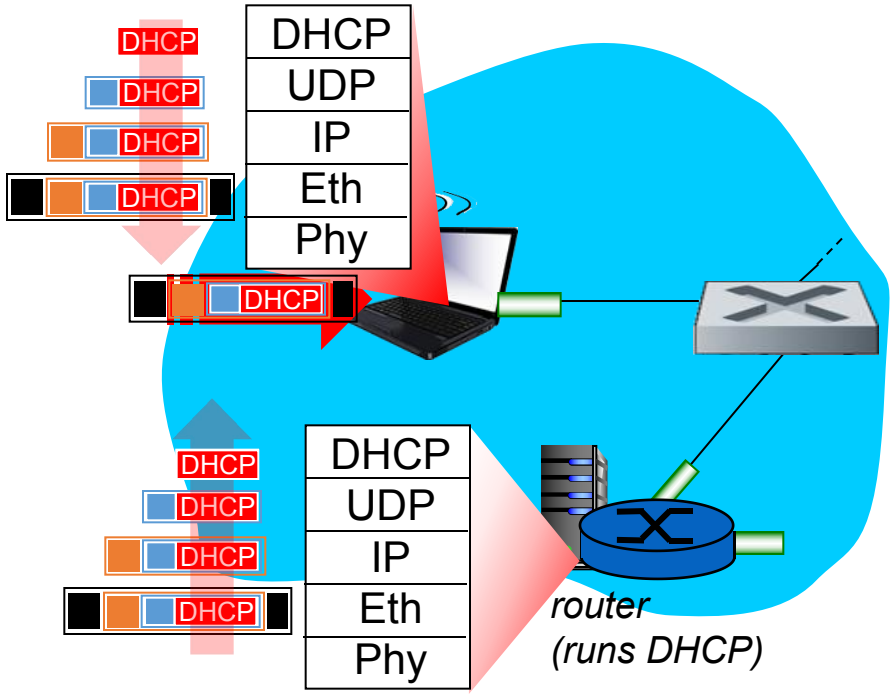
Synthesis: a day in the life of a web request

- journey down protocol stack complete!
  - application, transport, network, link
- putting–it–all–together: synthesis!
  - *goal:* identify, review, understand protocols (at all layers) involved in seemingly simple scenario: requesting www page
  - *scenario:* student attaches laptop to campus network, requests/receives www.google.com

A day in the life: scenario

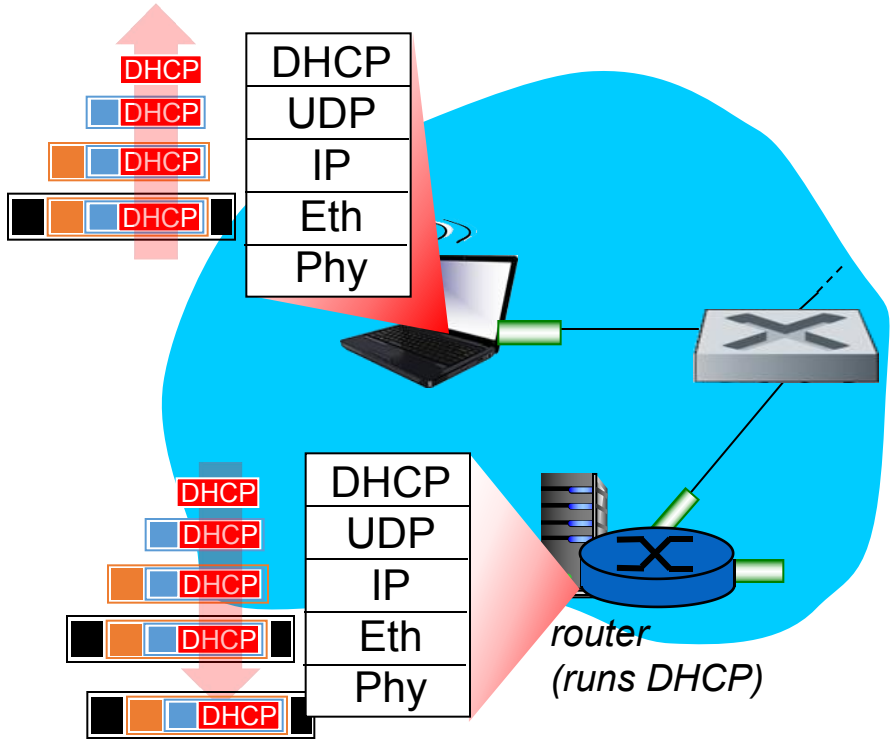


A day in the life… connecting to the Internet



- 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

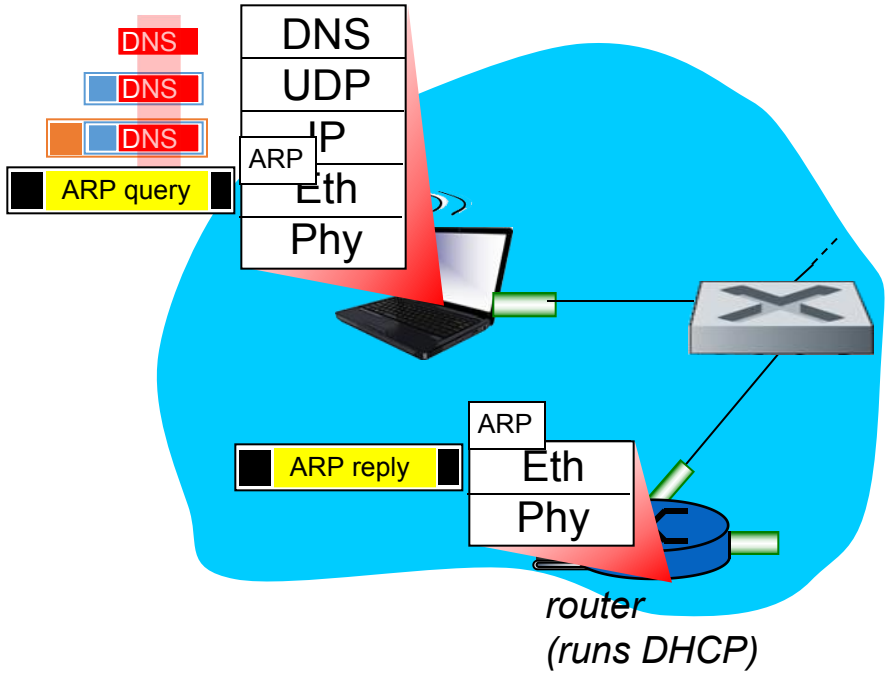
A day in the life… connecting to the Internet



- 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

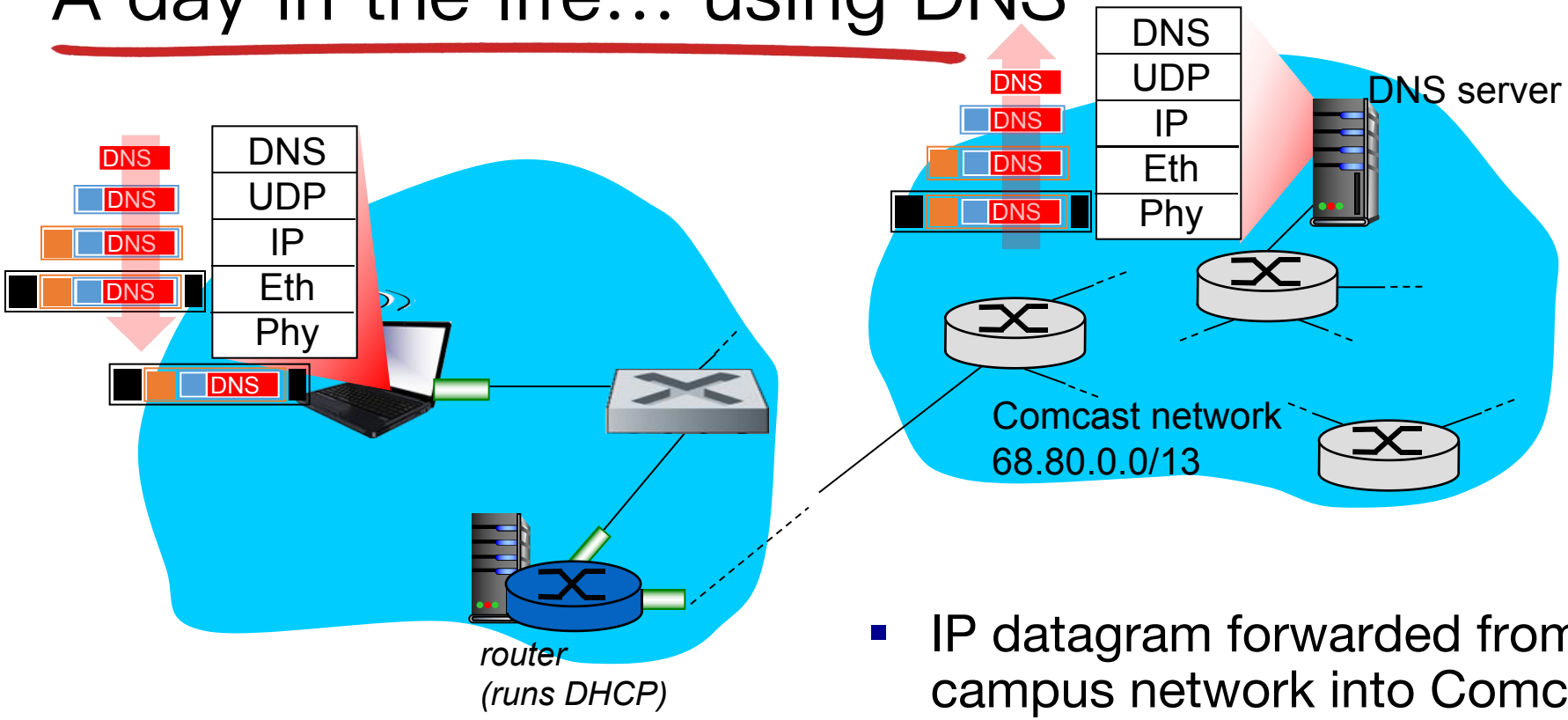
Client now has IP address, knows name & addr of DNS server, IP address of its first–hop router

A day in the life… ARP (before DNS, before HTTP)



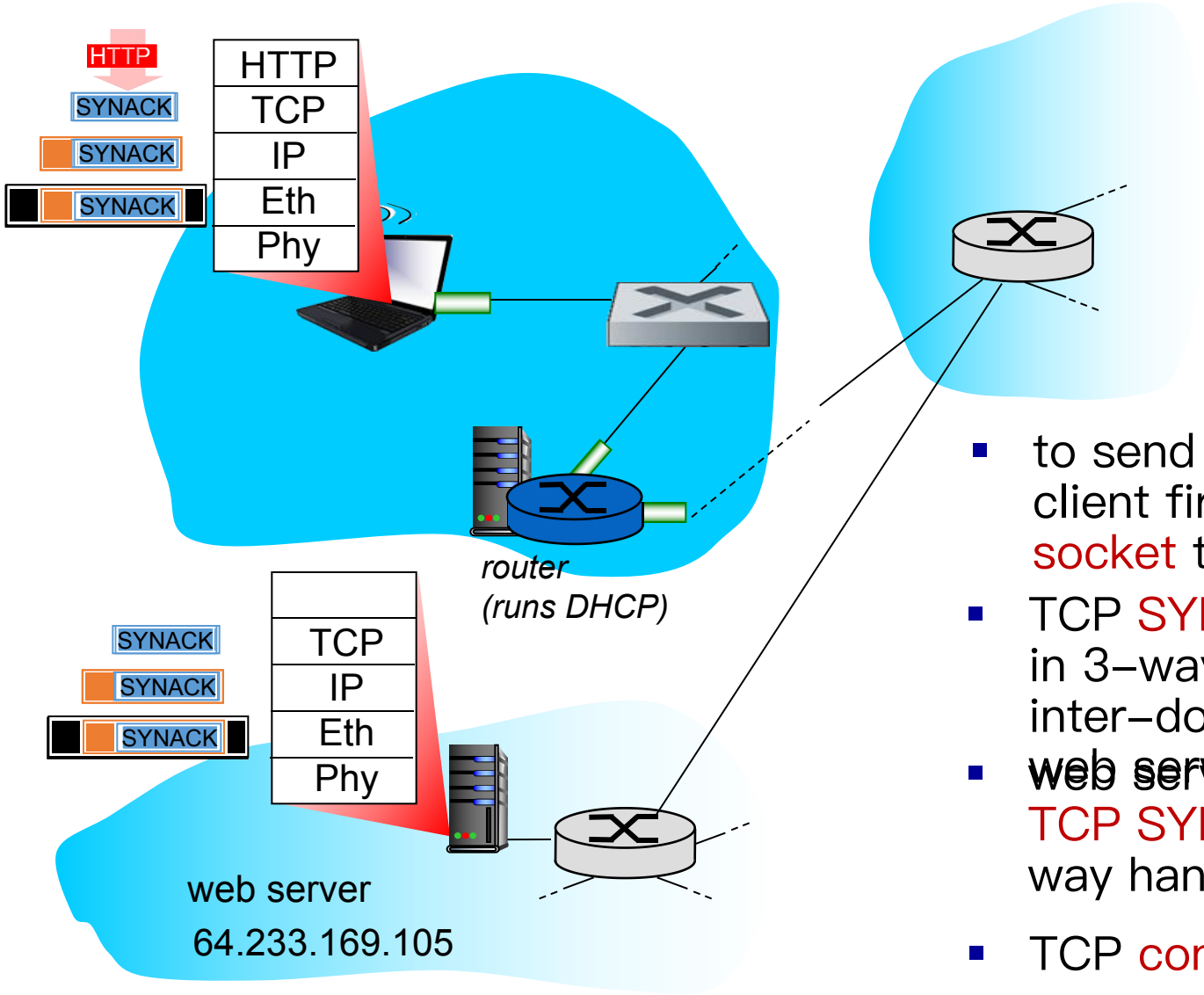
- before sending *HTTP* request, need IP address of www.google.com: *DNS*
  - DNS query created, encapsulated in UDP, encapsulated in IP, encapsulated in Eth. To send frame to router, need MAC address of router interface: ARP
  - ARP query broadcast, received by router, which replies with ARP reply giving 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



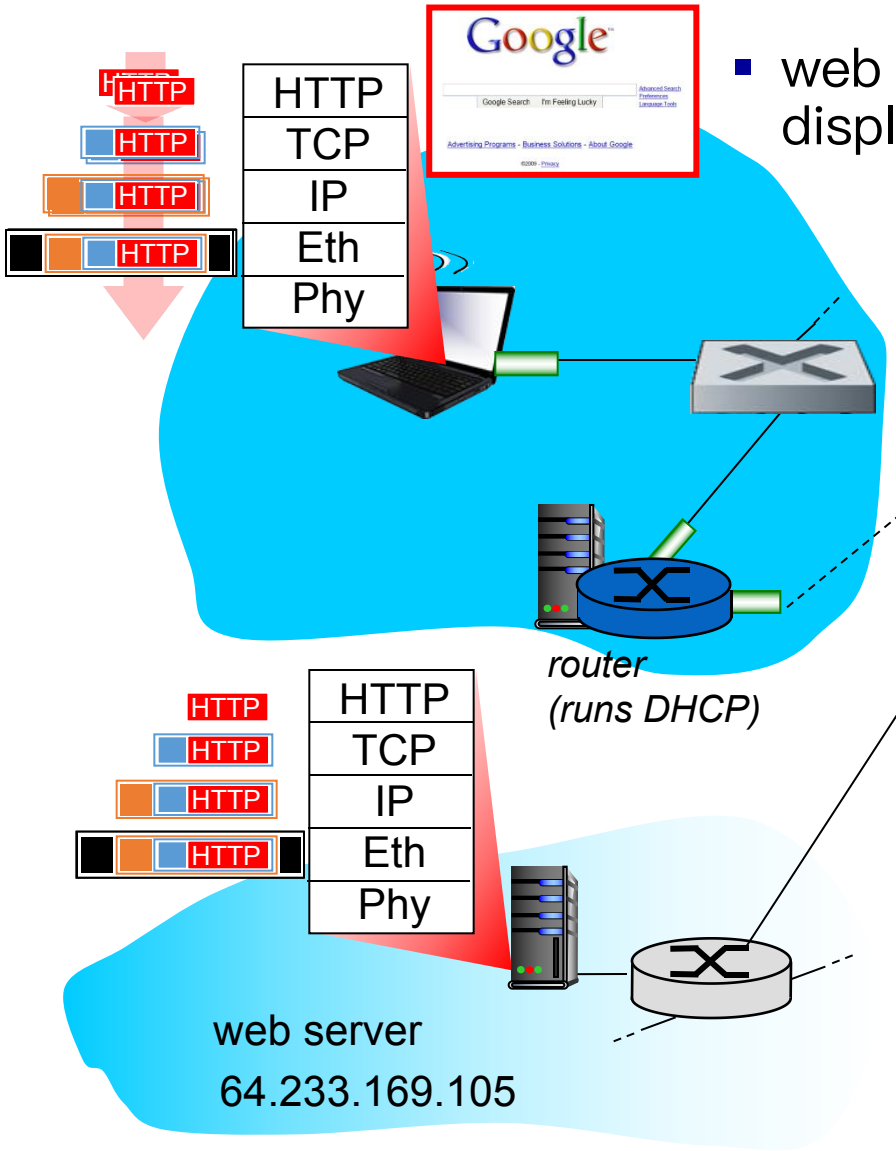
- IP datagram containing DNS query forwarded via LAN switch from client to 1st hop router
- IP datagram forwarded from campus network into Comcast network, routed (tables created by RIP, OSPF, IS-IS and/or BGP routing protocols) to DNS server
- demuxed to DNS server
- DNS server replies to client with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

A day in the life...TCP connection carrying HTTP



- 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... 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