Computer Communications

Summary

Important for the exam

When/where:Thursday Dec 15, 14.00-18.00

You may have with you:

- English-X dictionary
- no calculators, PDAs, etc (if/where numbers matter, do rounding)

Grading

- 30,40,48 (out of 60)= 3, 4, 5 (CTH)
- 30-48 (out of 60) = G, VG (GU)

To think during last, summary-study

Overview; critical eye; explain: why is this so? / How does it work?

Flashback

Principles, Organisation

Network Problems (in the order faced in the 1st intro):

- managing communication links (& connections)
- manage access to shared (broadcast) transmission media ,
- transmission errors,
- producer-consumer problems, flow and error control,
- routing,
- congestion,
- connecting transparently different networks,
- performance,
- serving different types of traffic,
- mobility
- security

Layering : principle, why

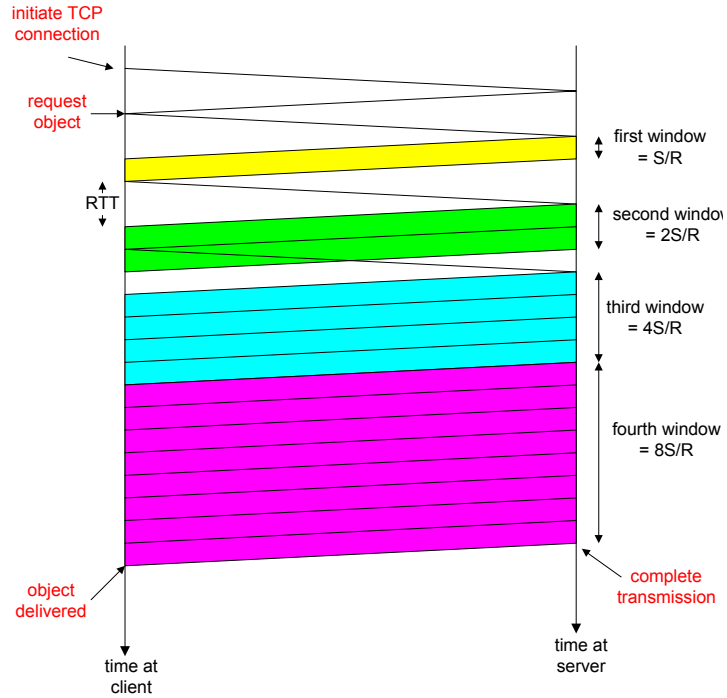
Highlights

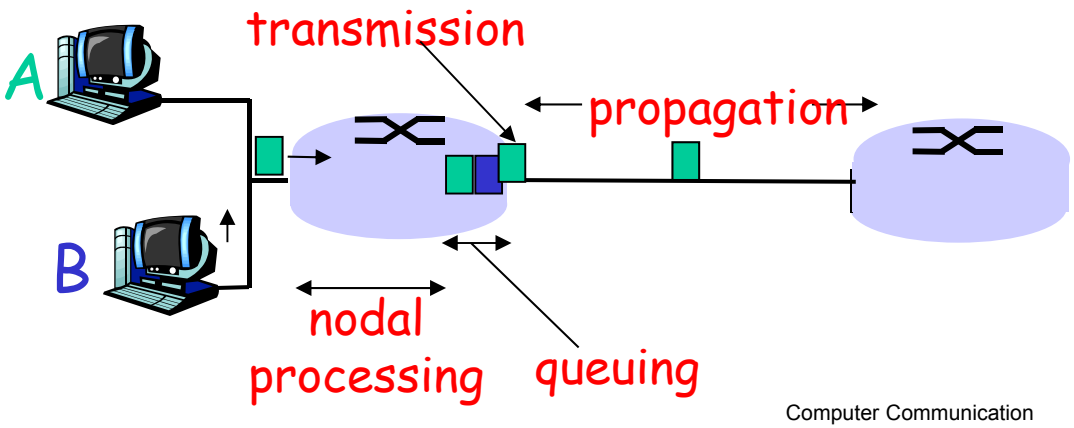
- types of delay; performance
- reliable data transfer (flow, error control)
- datagram vs VC end-to-end communication, congestion control, quality-of-service and RT traffic
- routing, also with mobility
- multiple access protocols (wired, wireless)
- LANs and related technologies
- network security issues covered
- TCP/IP protocol stack (also applications), evolution (p2p applications, overlays, NAT, streaming apps)

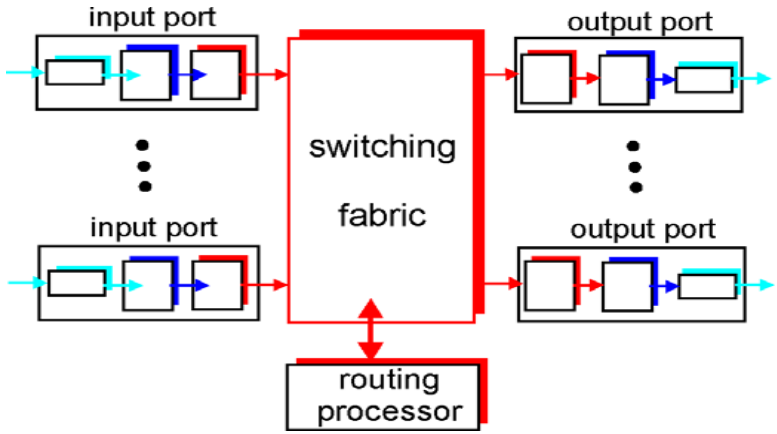
Types of delay; performance

Types of delay: performance

- Propagation, transmission, queueing, processing
- Throughput (effective bandwidth)
- Utilization (efficiency)
- Packet-switching: impact of store&forward
- TCP's slow start
- Sliding windows performance





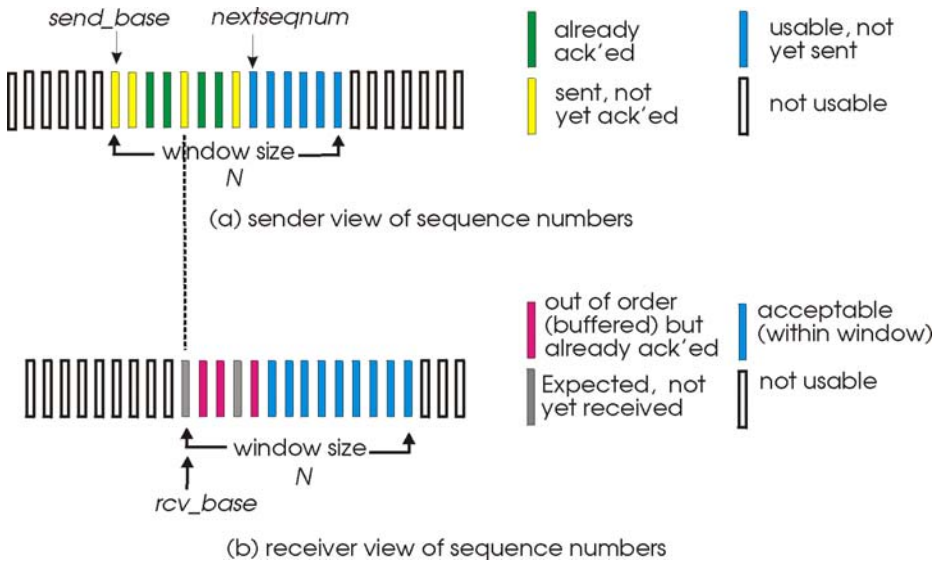


Reliable data transfer

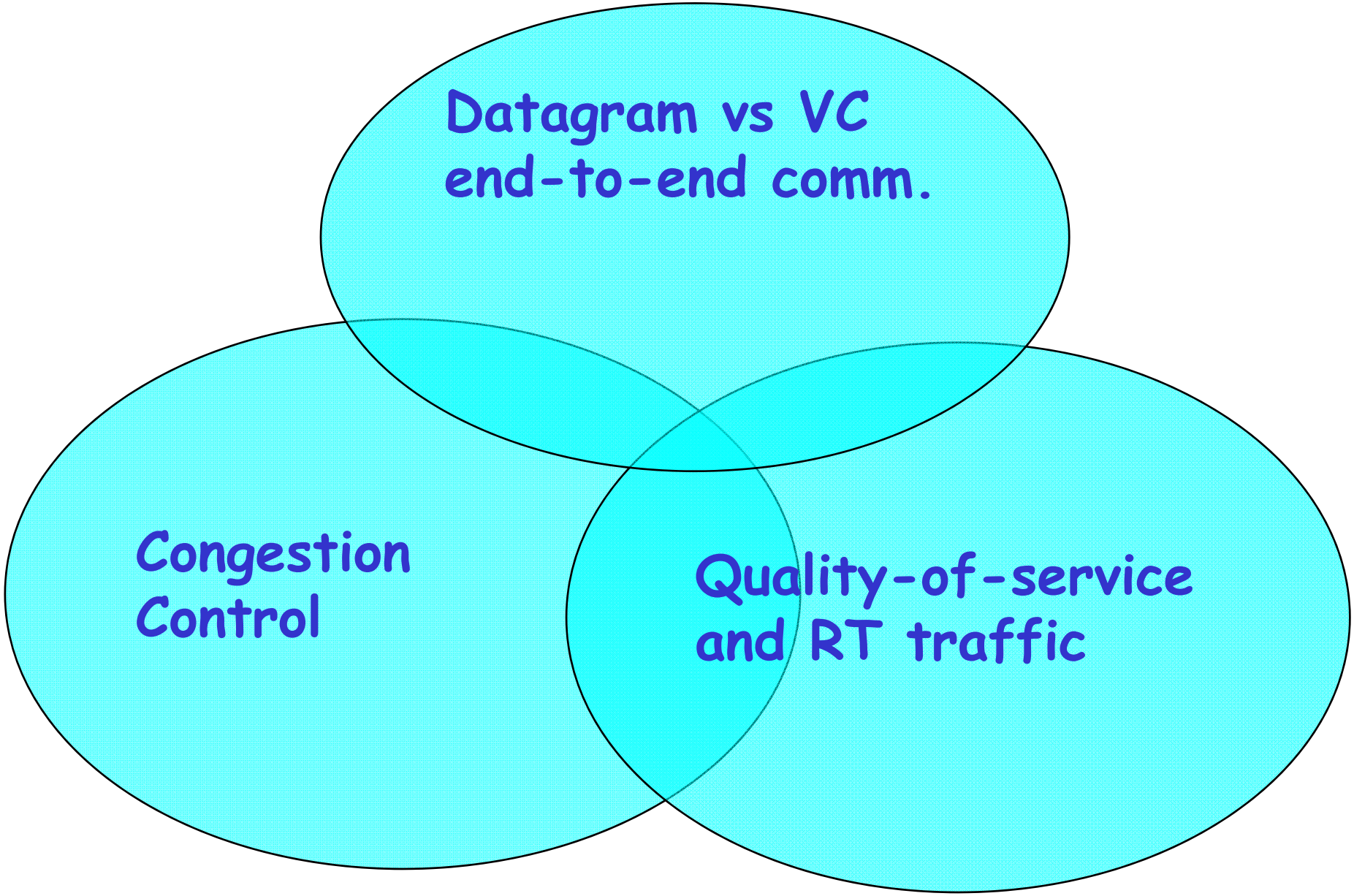
Reliable data transfer

Guaranteed, in-order, correct delivery:

- **Flow control**:
  - stop&wait
  - sliding windows
  - sequence numbers
  - window sizes
  - dynamic windows (TCP)
  - performance

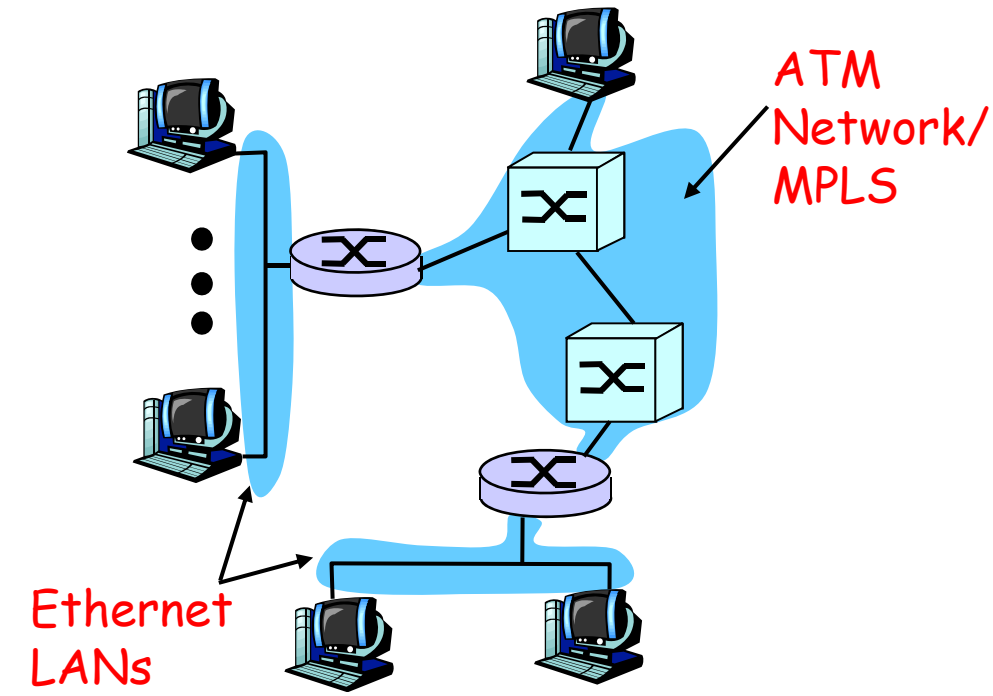


- **Error detection**: checksums, CRC
- **Error control**: go-back-n, selective repeat, FEC methods


Datagram vs VC
end-to-end comm.
Congestion
Control
Quality-of-service
and RT traffic

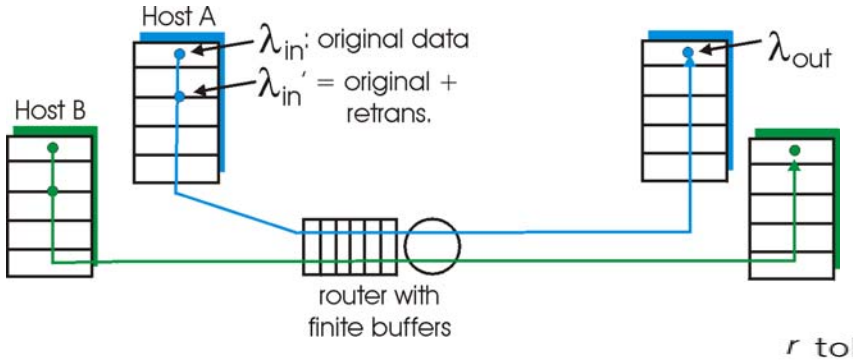
Datagram vs VC end-to-end communication

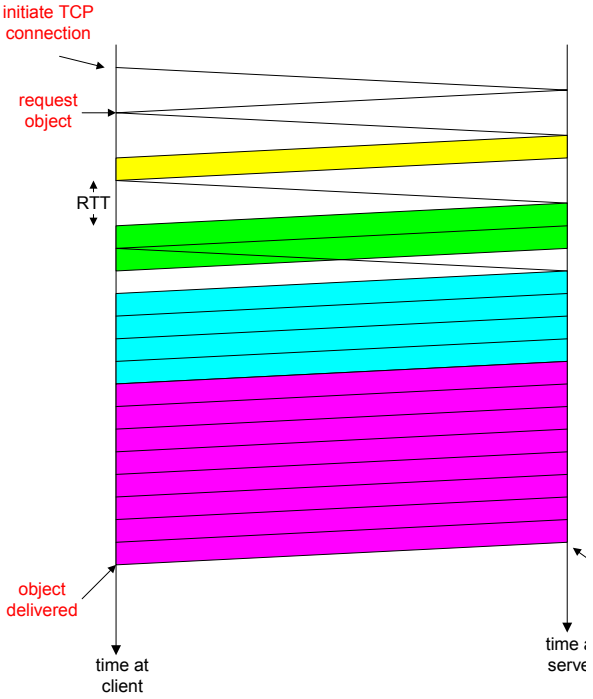
- Conceptual differences
- Example technologies
- Decisions, comparison, why
- Redundancy in current networks (internet; eg IP over ATM, MPLS)

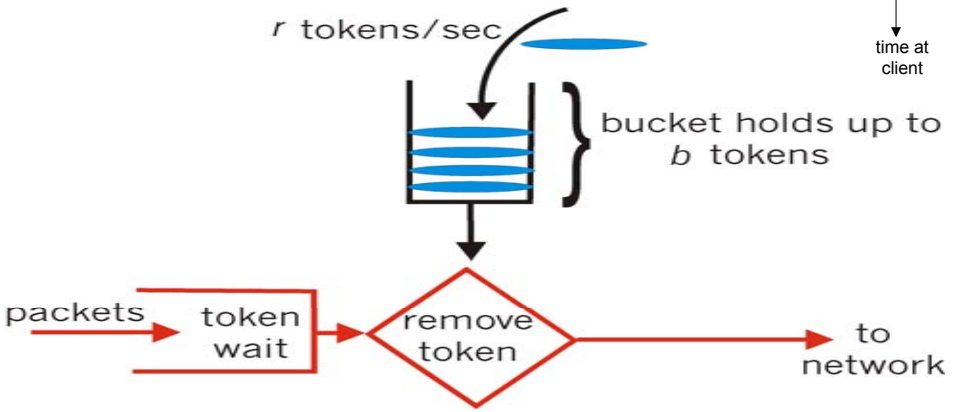


Congestion control (CC)

- why, how congestion occurs
- CC in TCP and performance; implied weaknesses
- CC in other ways, e.g. VC-based networks
  - RT-traffic resource reservation:
    traffic shaping and policing
  - rate-based







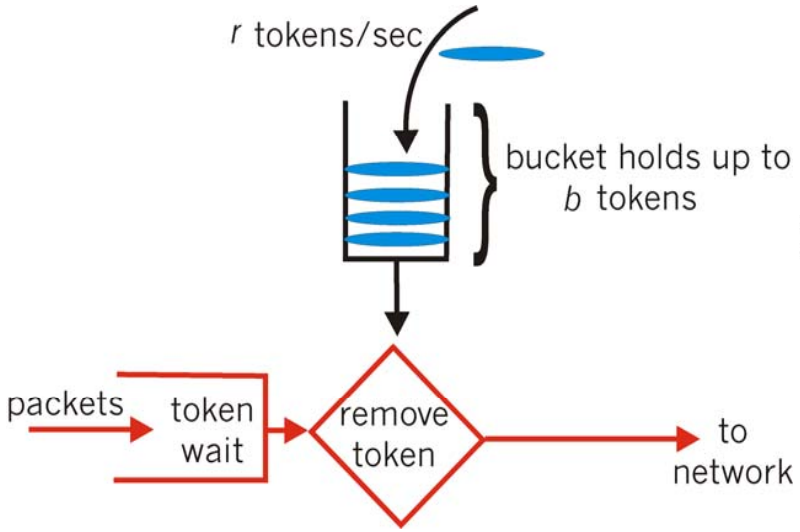
Quality-of-service and RT traffic

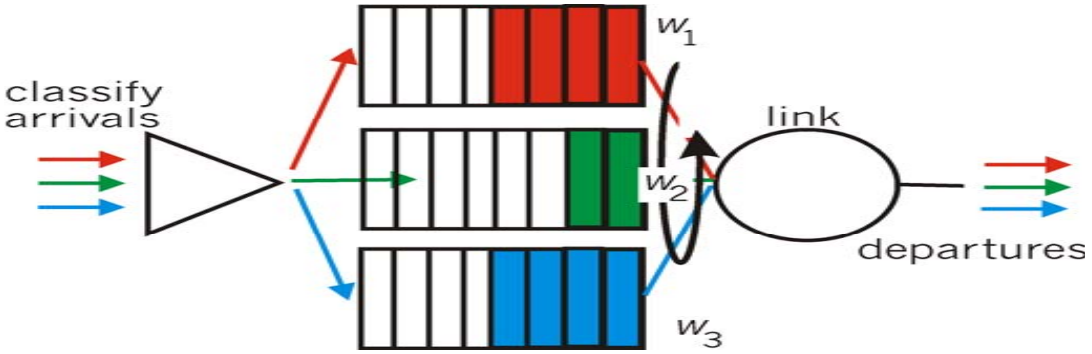
Conceptual needs:

- packet/flow marking
- Admission control
- Traffic shaping & policing
- Packet scheduling (switches)

Internet context

- Application-level solutions (FEC, playout delay, caching-CDN)
- Intserv, Diffserv

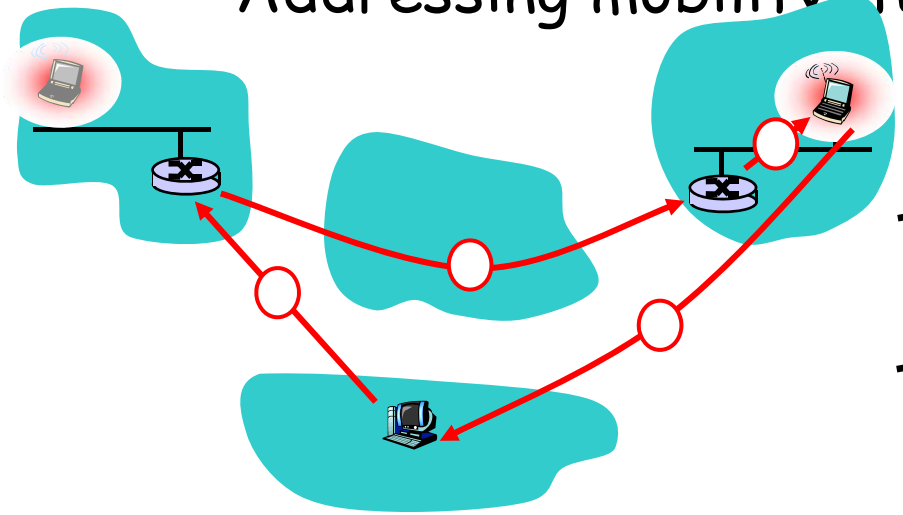


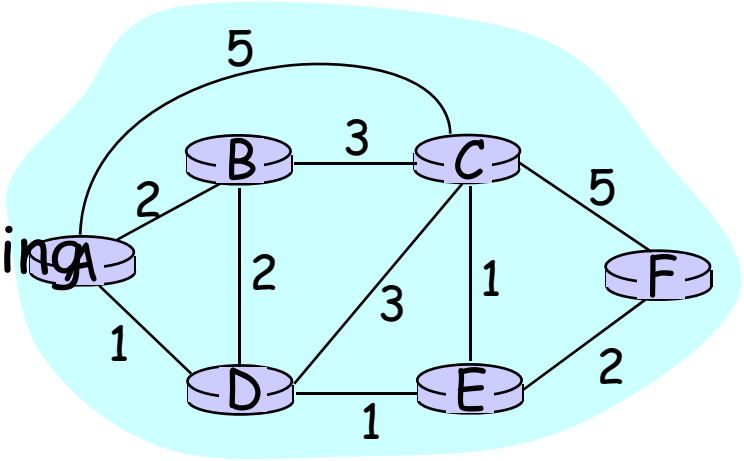


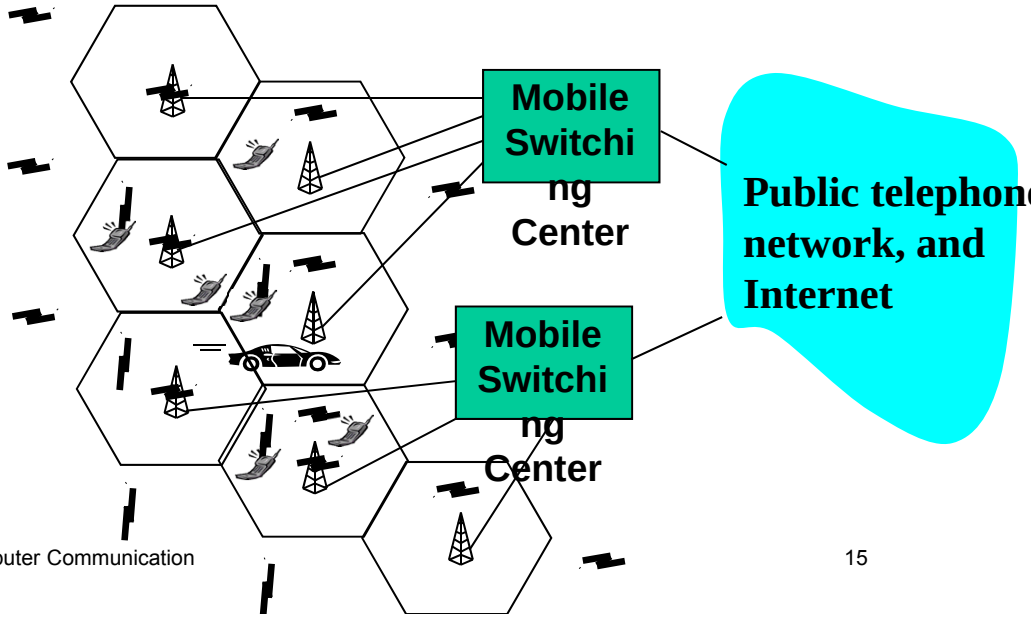
Routing, also with mobility

Routing, also with mobility

- Routing algorithms
- Forwarding
- Resource, policy issues
- Addressing mobility, tunneling





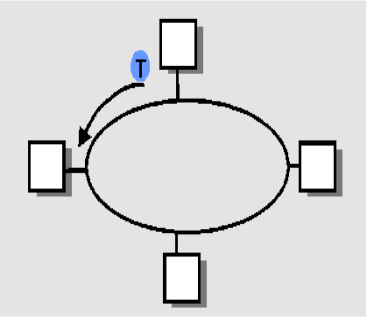


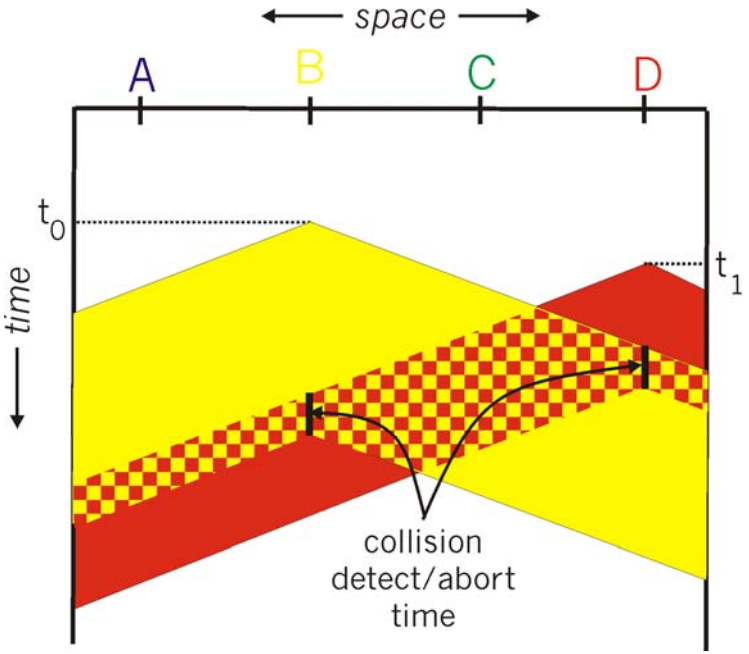
Multiple access algorithms

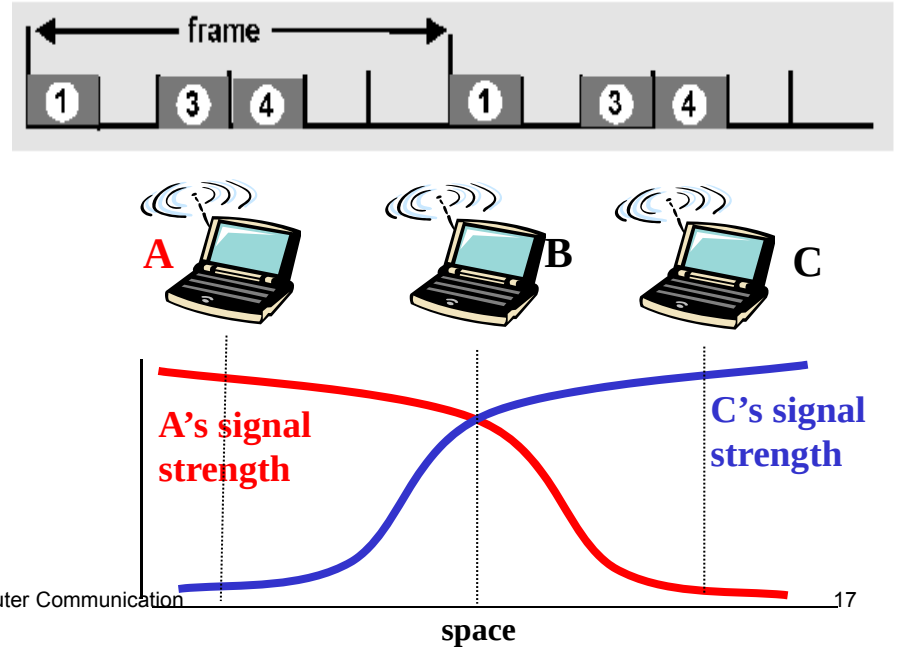
Medium access: multiple access methods

Strategies: (functionality, appropriateness)

- **Contention-based (random access), wired/wireless:**
  - Aloha, CSMA(CD/CA) (collision-delay trade-off)
- **Collision-free:**
  - **Channel partitioning:** TDMA, FDMA, CDMA
  - **Taking turns:** token-passing, reservation-based







LANs & related technologies

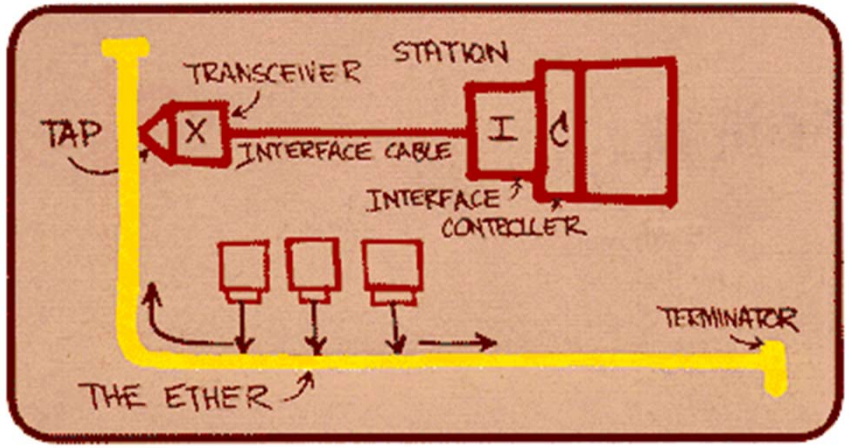
LANs & related link technologies

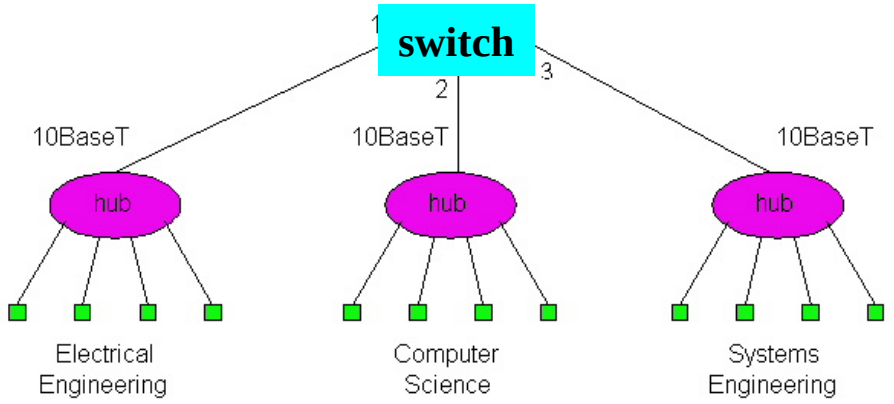
- **Protocol Examples**

  Ethernet, 802.11 (+ 802.16 wimax), GSM:

  Functionality, performance under low/high load

- **Connecting devices**;
  - functionalities and differences (Hubs, switches)
  - Algorithms for switch-"routing": learning& forwarding of packets
- **ARP**



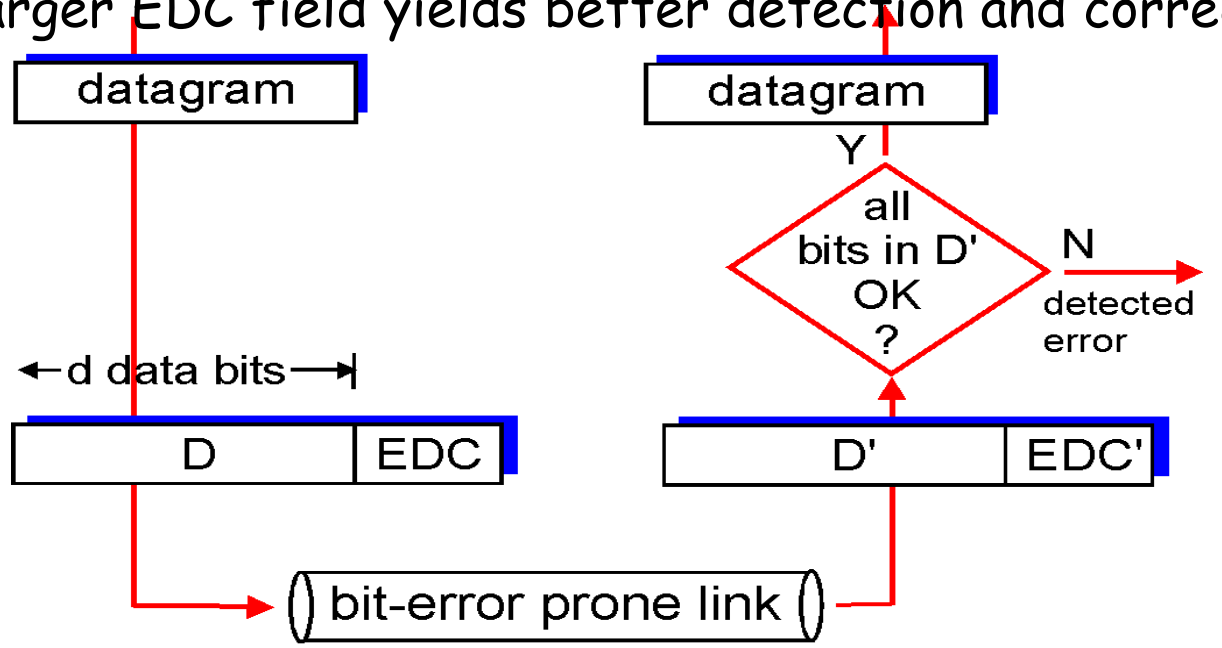


BTW: A little "backpatching"☺

Error Detection

EDC= Error Detection and Correction bits (redundancy)
D = Data protected by error checking, may include header fields

- Error detection not 100% reliable!
  - protocol may miss some errors, but this should happen only rarely
  - larger EDC field yields better detection and correction



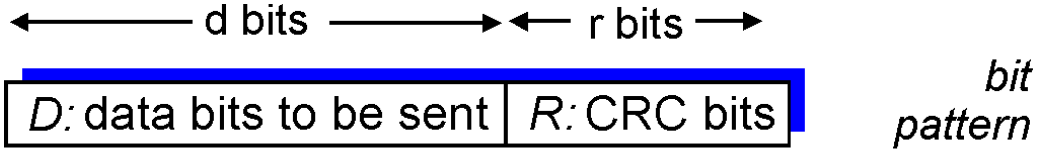
Internet checksums

TCP (UDP)'s checksum:

- segment contents = sequence of 16-bit integers
- checksum: addition (1's complement sum) of segment contents
- sender puts checksum value into UDP (TCP) checksum field

Cyclic redundancy check (CRC)

- data bits, D = binary number
- consider r+1 bit pattern (generator), G
- goal: compute r CRC bits, R, such that
  - <D,R> exactly divisible by G (modulo 2)
  - receiver knows G, divides <D,R> by G. If non-zero remainder: error detected!
  - can detect errors on less than r+1 bits
- International standards for G (CRC polynomials)



$D * 2^r$ XOR R

mathematical formula

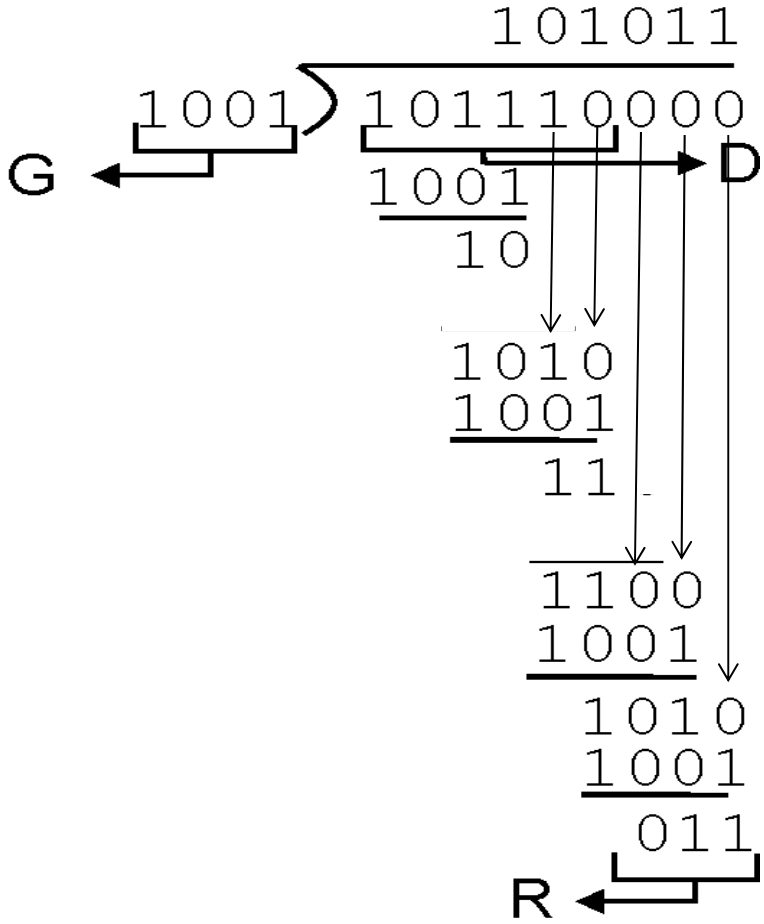
CRC Example

Recall we want:

$D \cdot 2^r$ XOR R = nG

equivalently:

if we divide $D \cdot 2^r$ by G, want remainder R

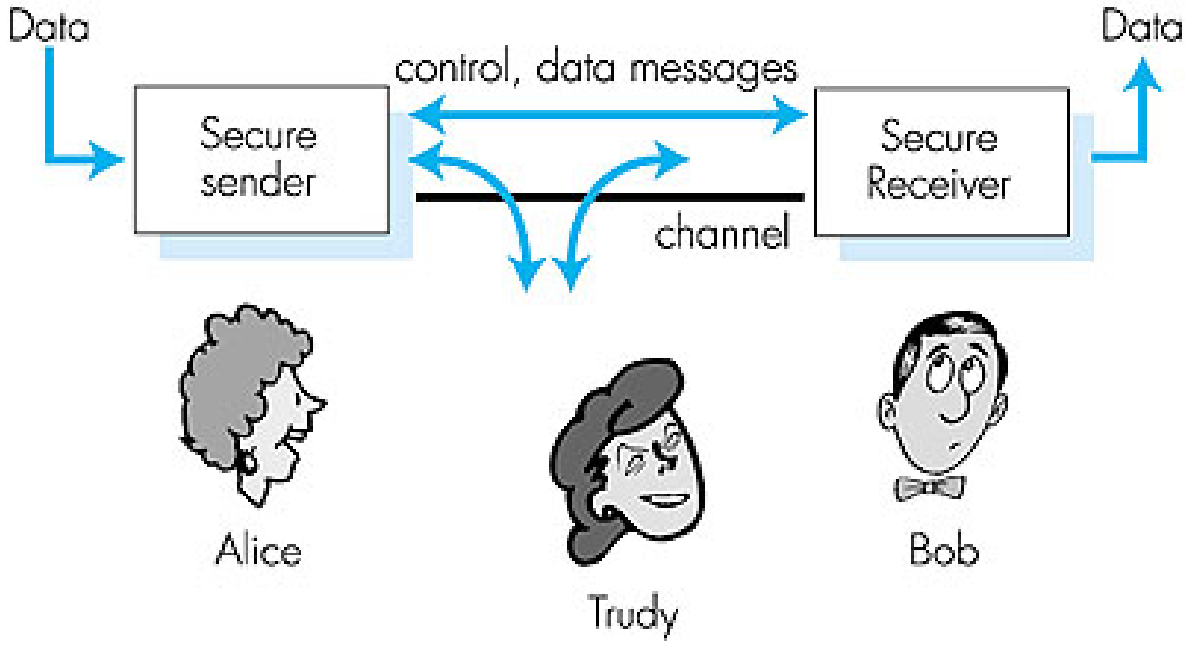


$$R = \text{remainder}\left[\frac{D \cdot 2^r}{G}\right]$$

Security issues

Security issues

- **C, I, A** and methods to achieve them
- Instantiation in Internet: RSA, email PGP, packet authentication
- Firewalls and packet filtering



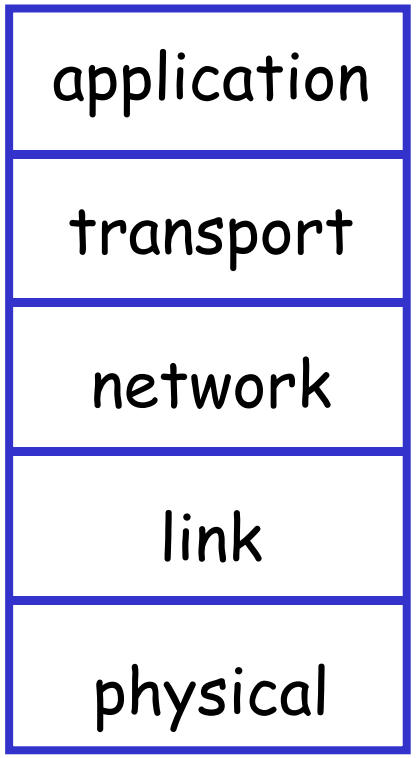
TCP/IP protocol stack (also applications), evolution

TCP/IP protocol stack (also applications), evolution

- Instantiation of network-solutions (Routing, Congestion Control, Flow & error control, applications, link layer technologies)

- Limitations, advantages, updates

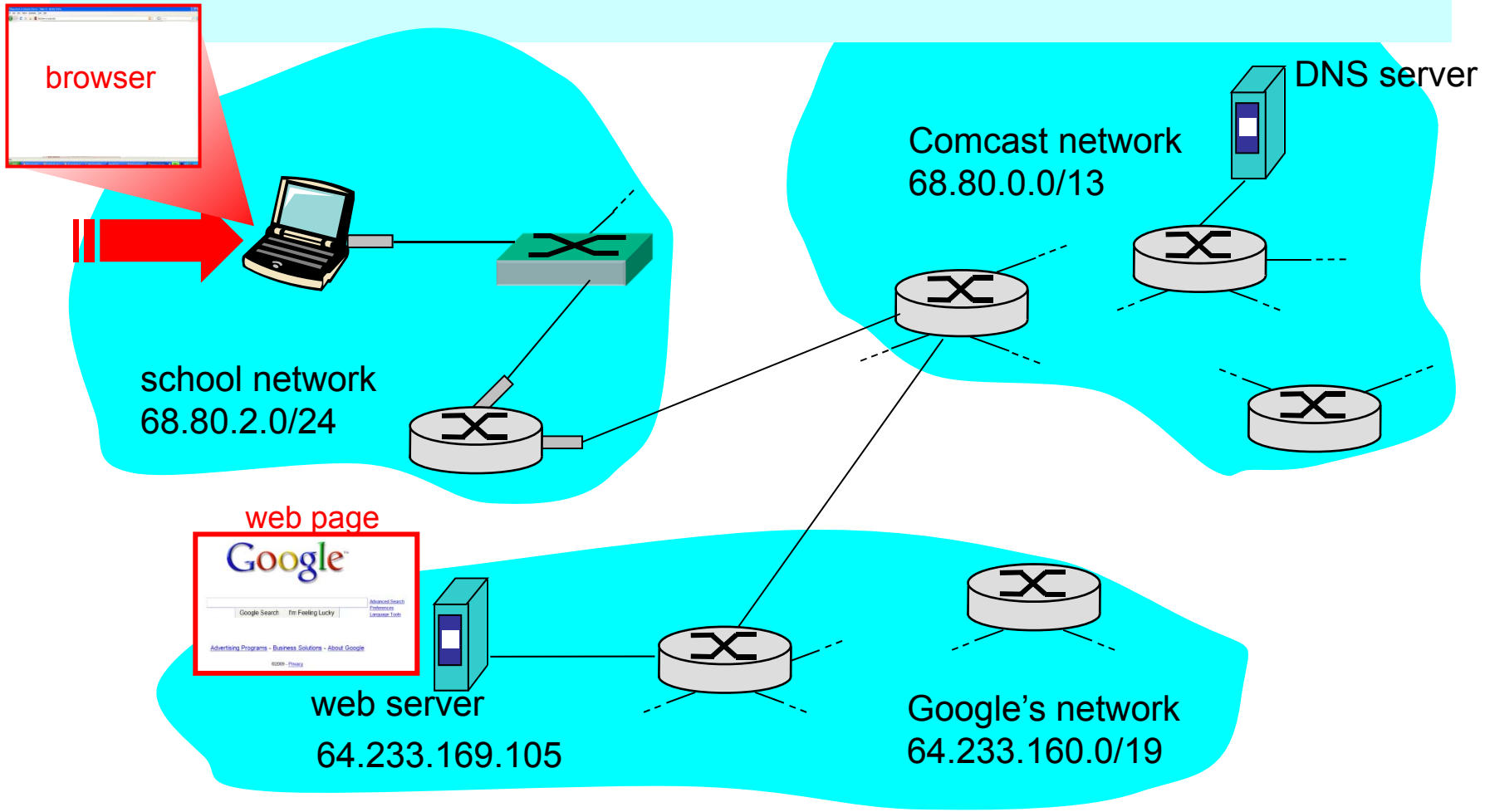
- Application-layer networking (P2P applications, overlays, multimedia-application protocols)



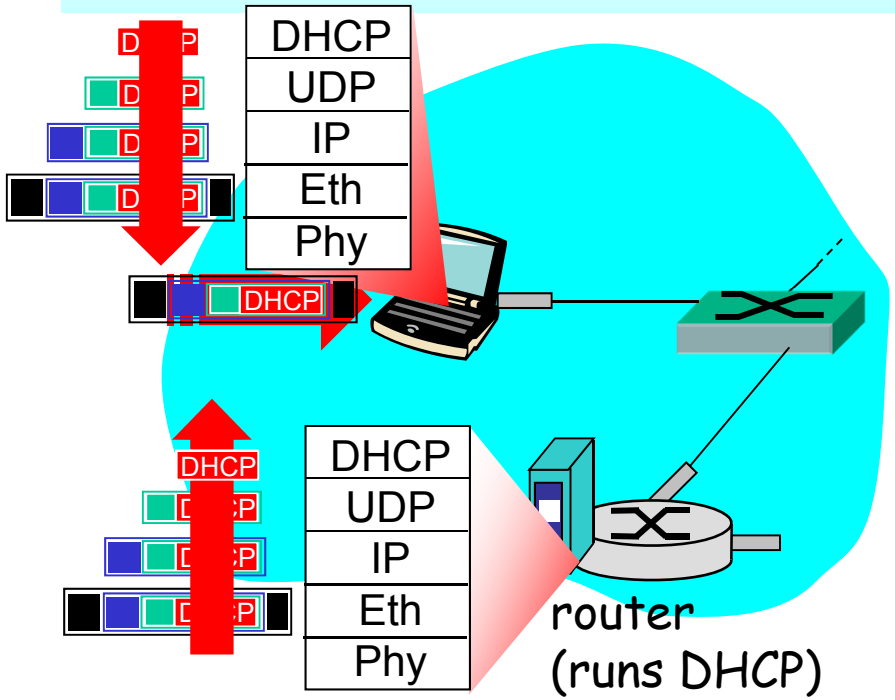
Synthesis: a day in the life of a web request

- 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

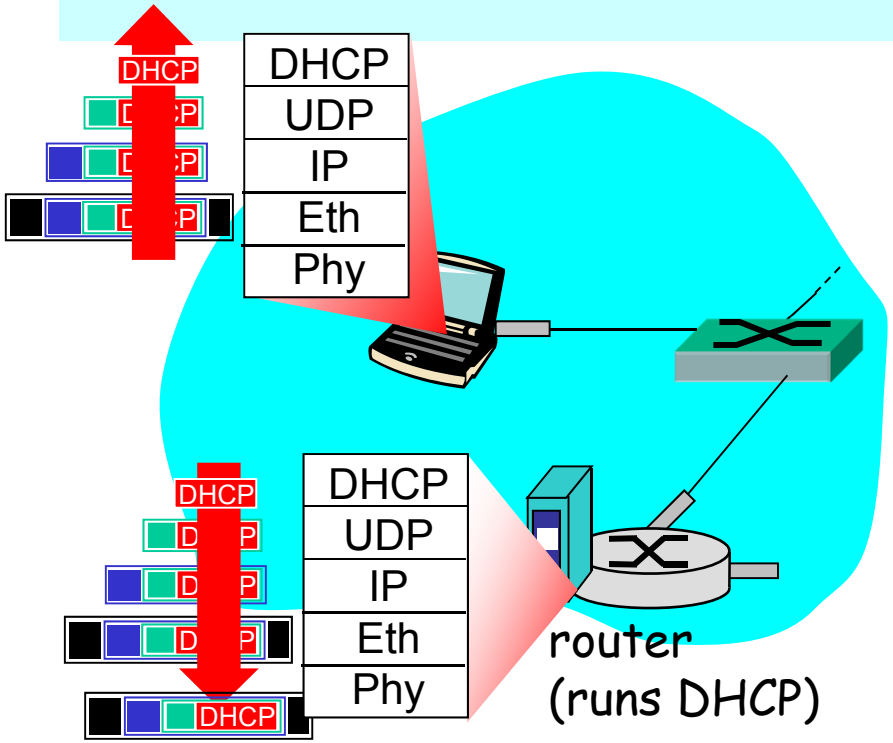


A day in the life… connecting to the Internet



- connecting laptop needs to get its own IP address: use *DHCP*
- DHCP request **encapsulated** in **UDP**, encapsulated in **IP**, encapsulated in **Ethernet**
- Ethernet frame **broadcast** (dest: FFFFFFFFFFFF) on LAN, received at router running **DHCP** server
- Ethernet **demux'ed** to IP **demux'ed** to UDP **demux'ed** to DHCP

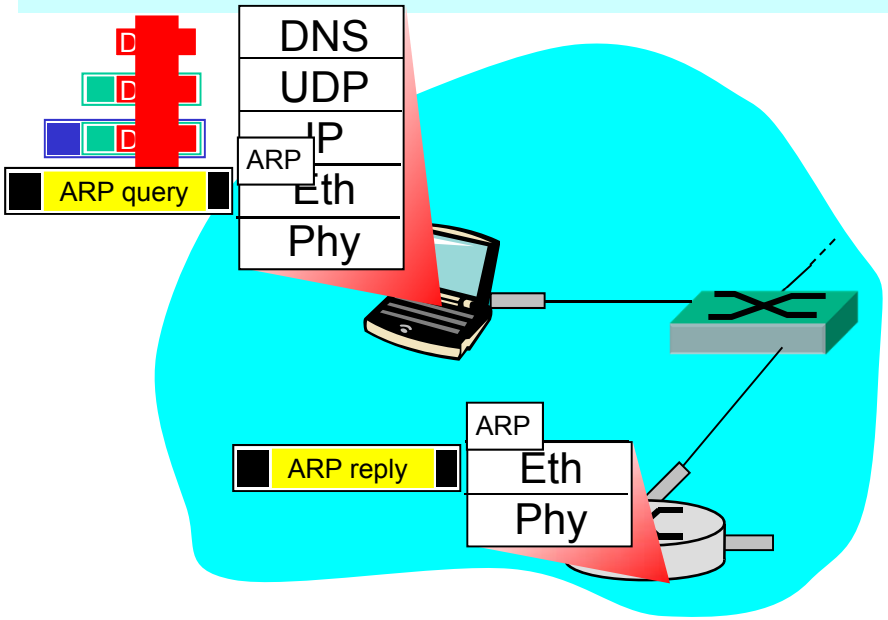
A day in the life… connecting to the Internet



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

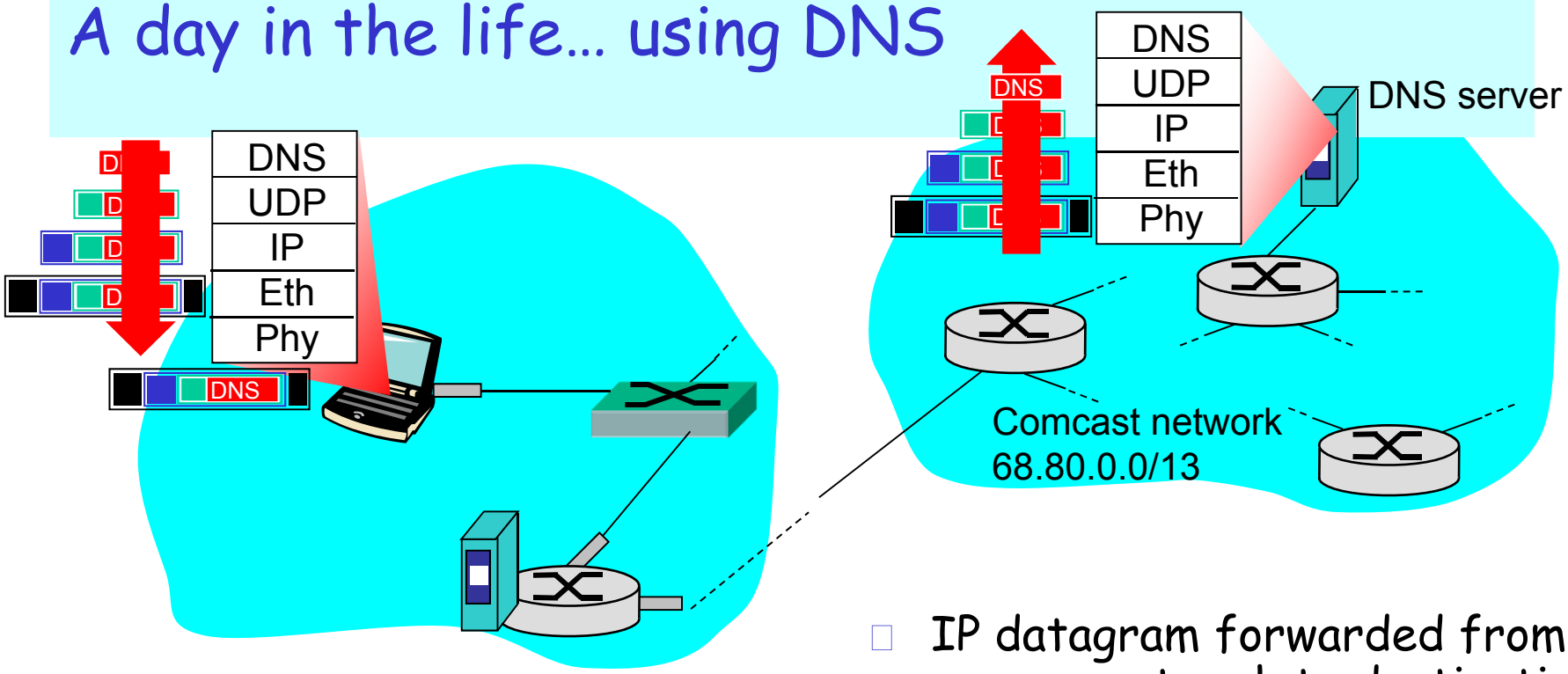
Client now has IP address, knows name & addr of DNS server, IP address of its first-hop router

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



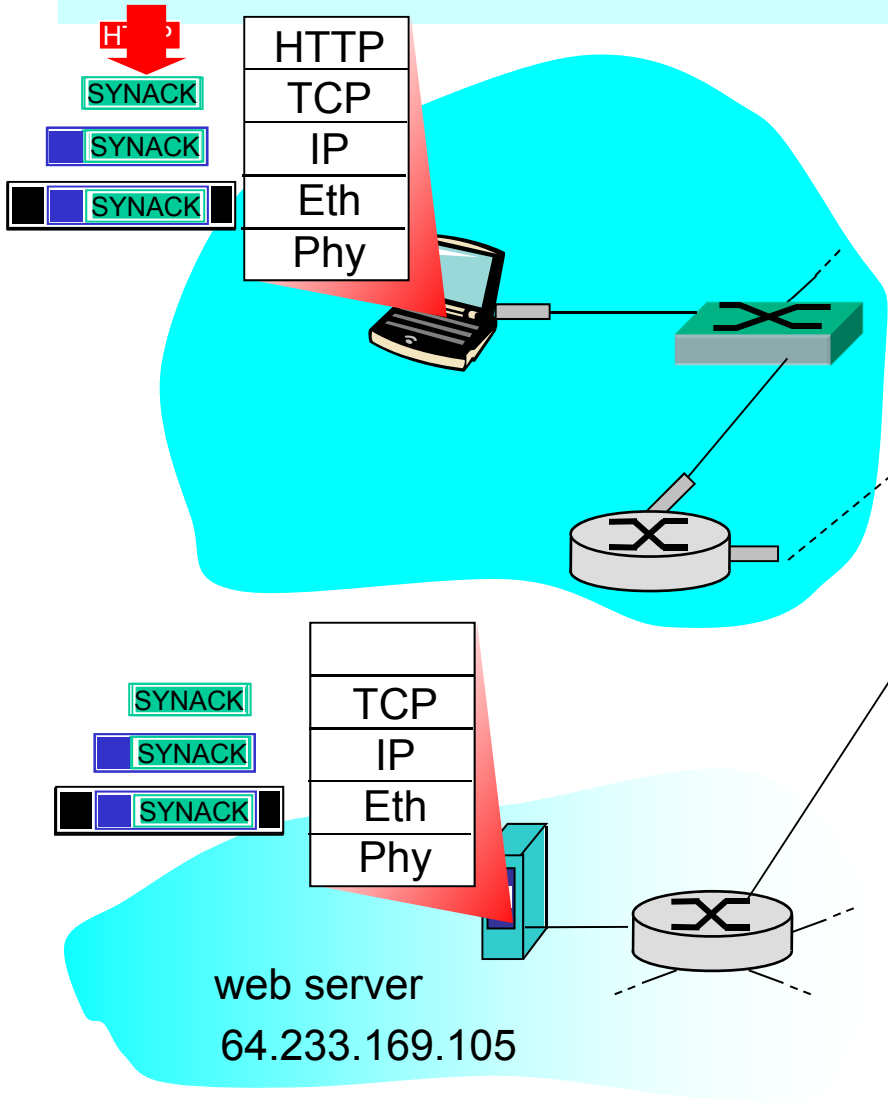
- before sending *HTTP* request, need IP address of www.google.com: *DNS*
- DNS query created, encapsulated in UDP, encapsulated in IP, encasulated in Eth. In order to send frame to router, need MAC address of router interface: *ARP*
- *ARP query* broadcast, received by router, which replies with *ARP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



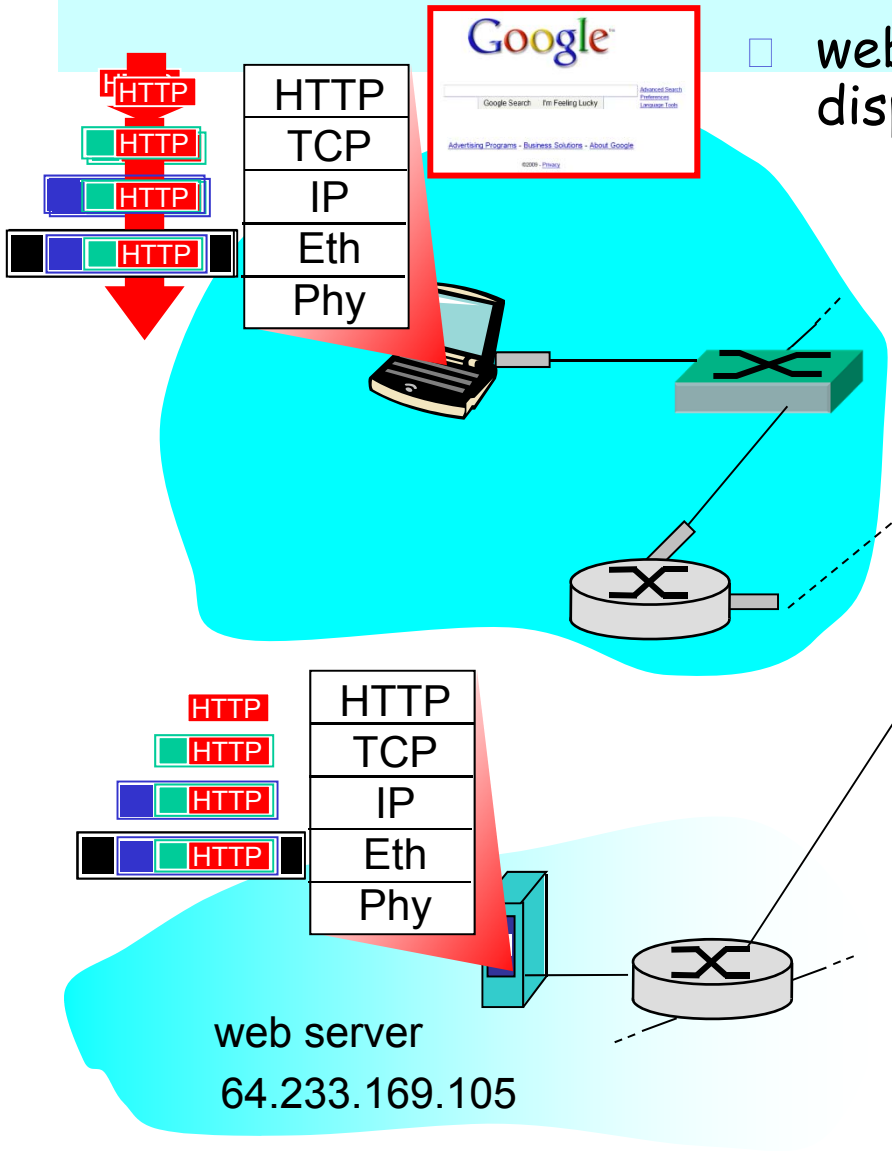
- IP datagram containing DNS query forwarded via LAN switch from client to 1st hop router
- IP datagram forwarded from campus network to destination (DNS-server) network, routed (tables created by **RIP, OSPF** and **BGP** routing protocols) to DNS server
- demux'ed to DNS server
- DNS server replies 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 datgram containing HTTP reply routed back to client

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