Computer Communications
DIT 420 EDA343

Summary

Important for the exam

When/where:Friday Dec 21, 14.00-18.00 , H

You may have with you:

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

Grading

- 30-40, 41-50, 51-60 (out of 60)= 3, 4, 5 (CTH)
- 30-50, 51-60 (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):

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

Layering : principle, why

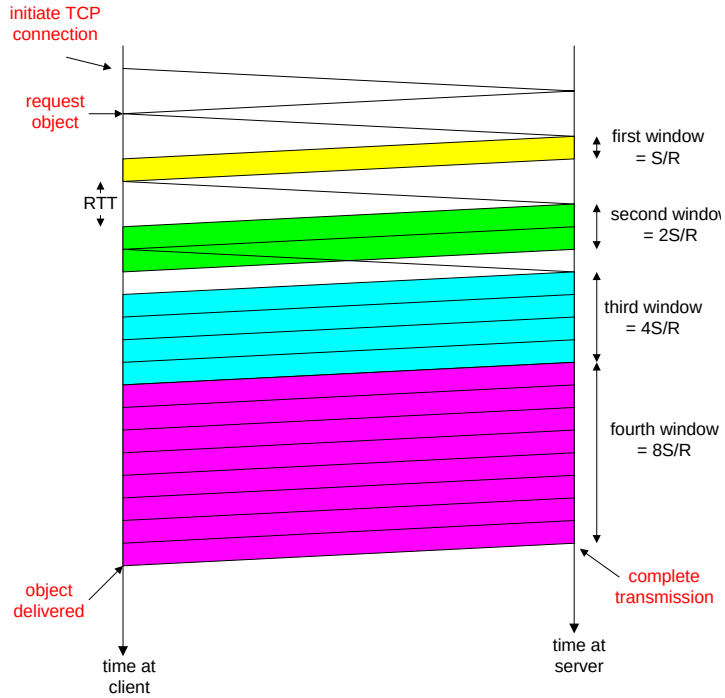
Highlights

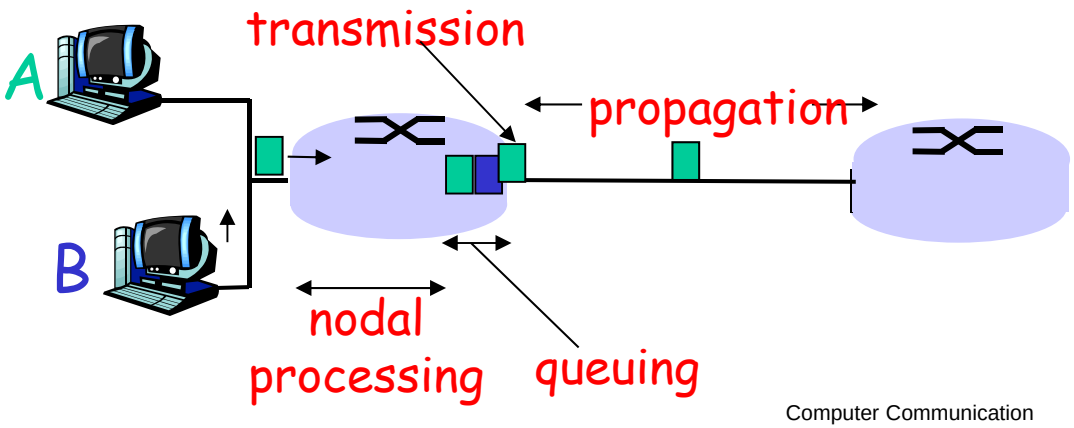
- types of delay; performance
- reliable data transfer (flow, error control)
- datagram vs VC end-to-end communication, congestion control
- routing, also with mobility
- multiple access protocols (wired, wireless)
- LANs and related technologies
- network security issues
- TCP/IP protocol stack (also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

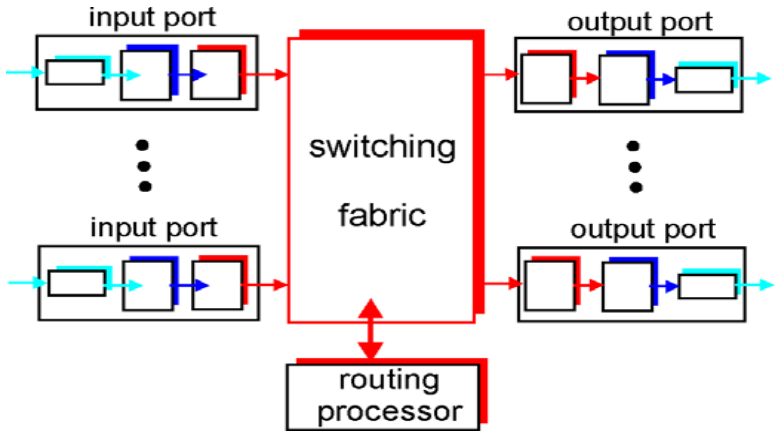
Types of delay; performance

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





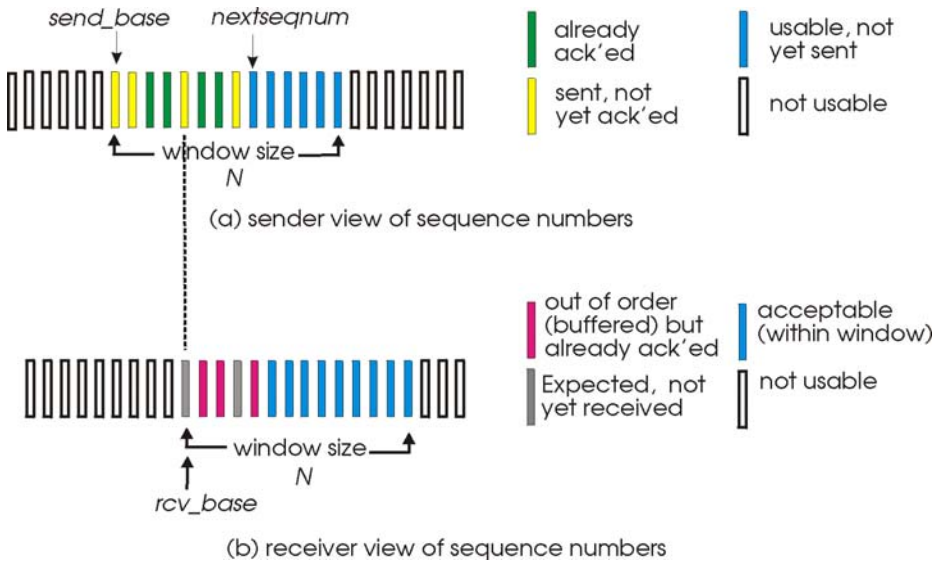


Reliable data transfer

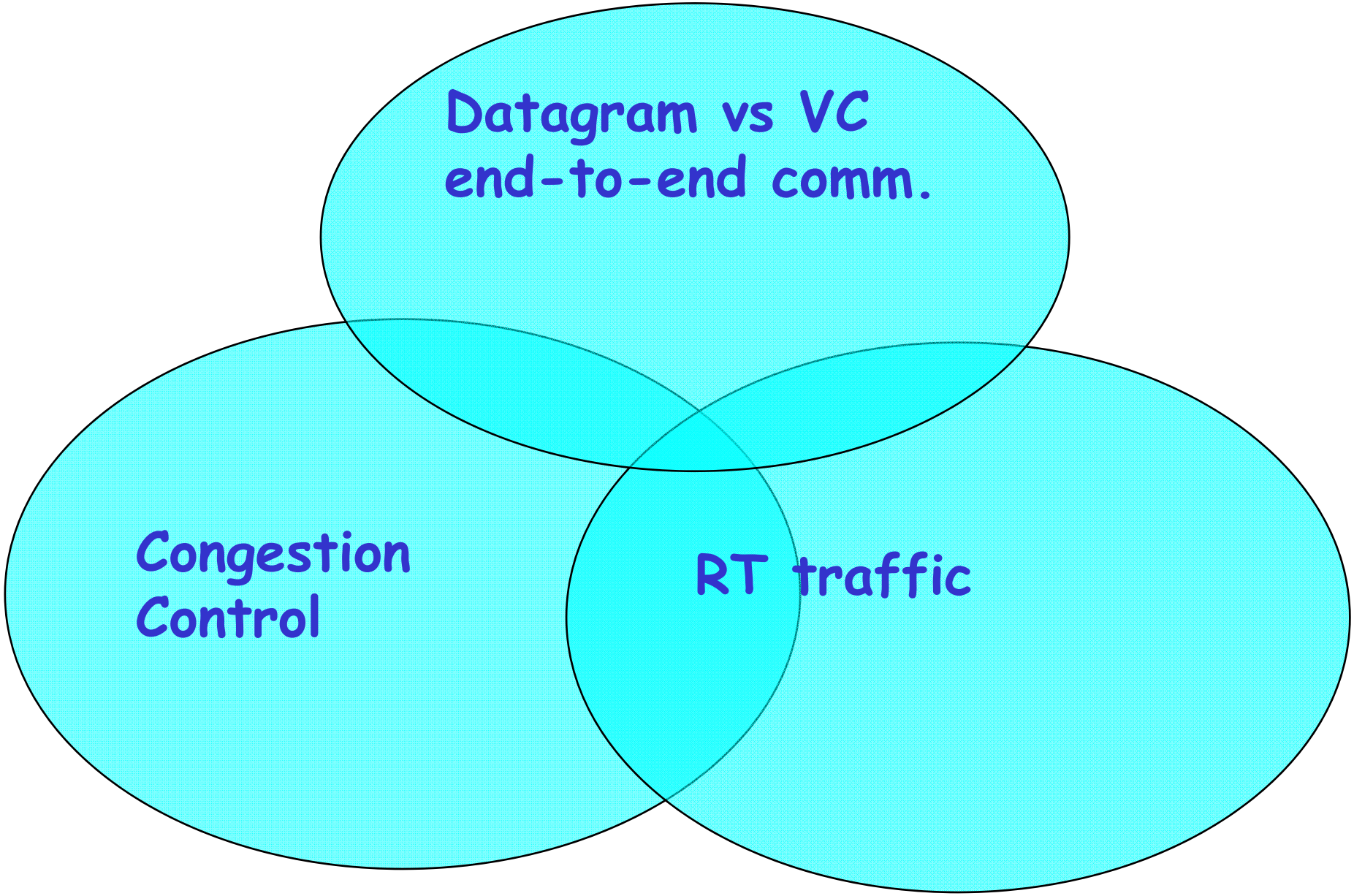
Reliable data transfer

Guaranteed, in-order, correct delivery:

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

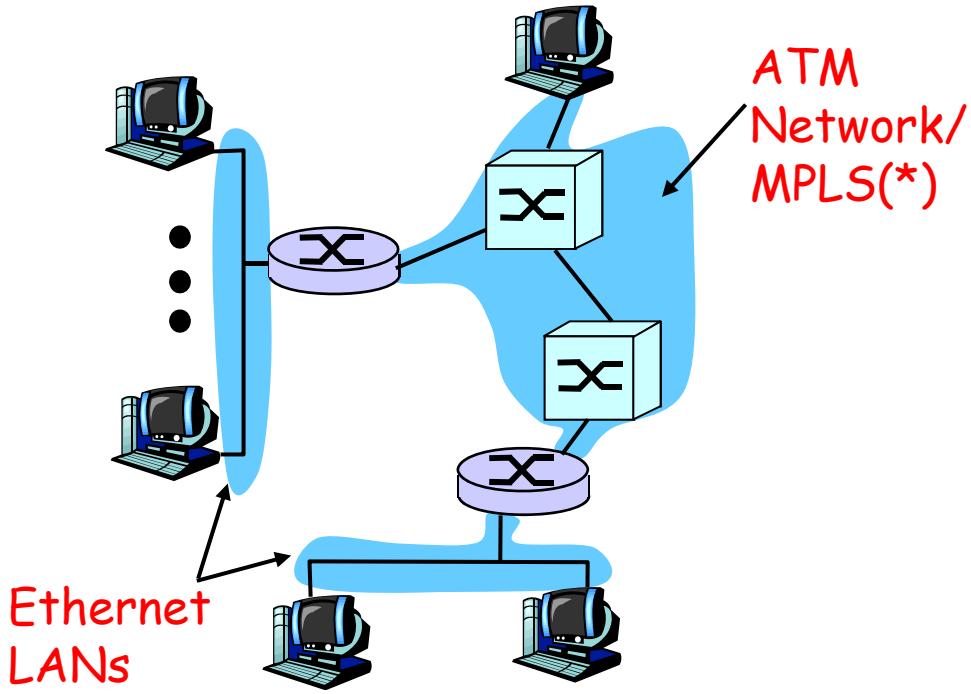


- **Error detection**: checksums, CRC (*)
- **Error control**: go-back-n, selective repeat, FEC methods


Datagram vs VC
end-to-end comm.
Congestion
Control
RT traffic

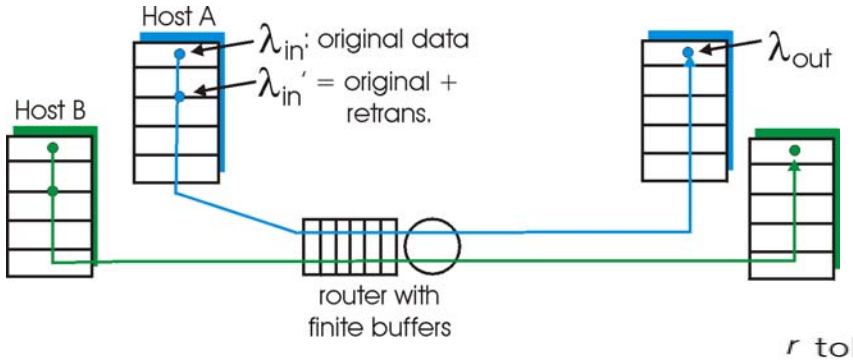
Datagram vs VC
end-to-end communication

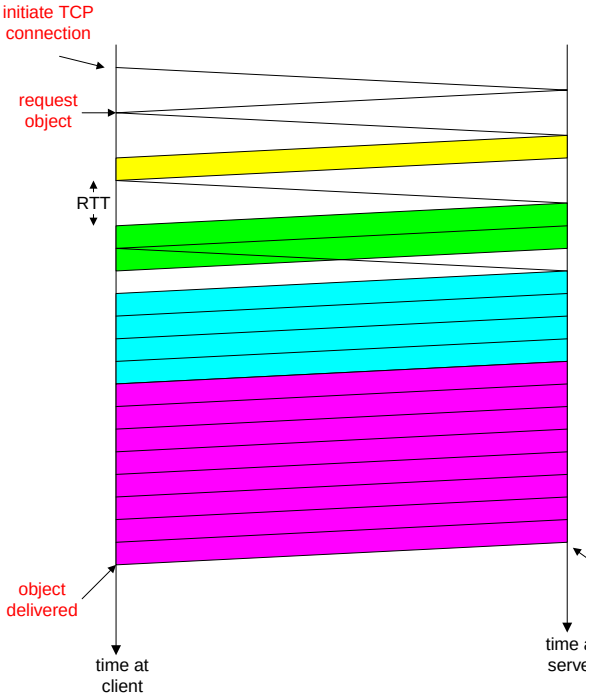
- Conceptual differences
- Decisions, comparison, why

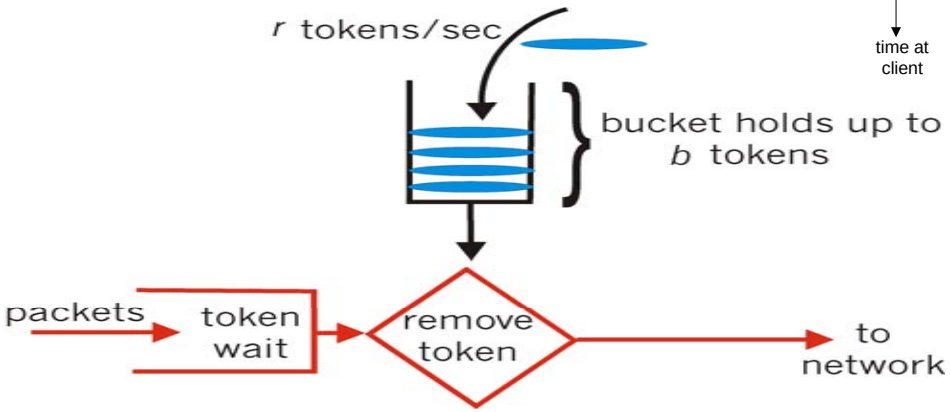


Congestion control (CC)

- 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







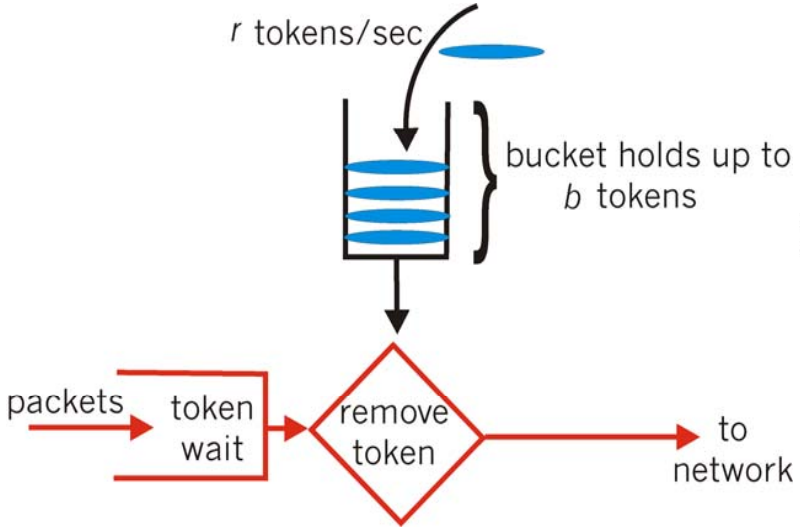
RT/streaming traffic

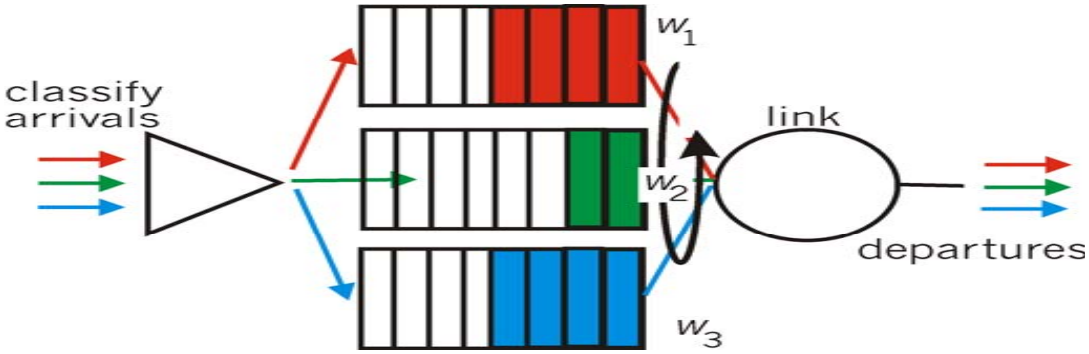
Conceptual needs:

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

Internet context

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

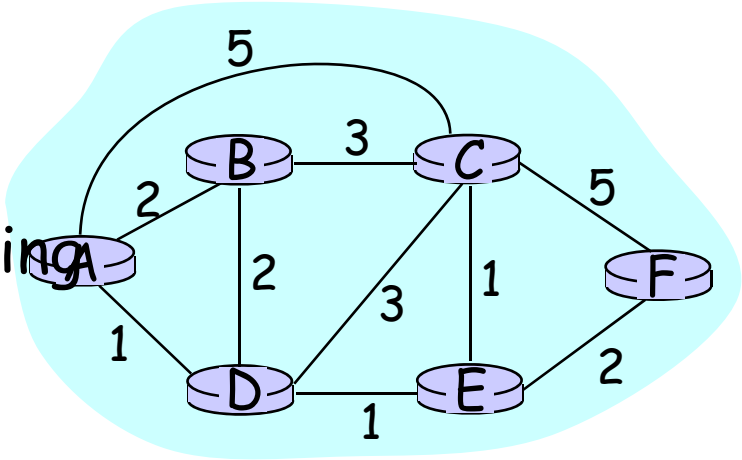


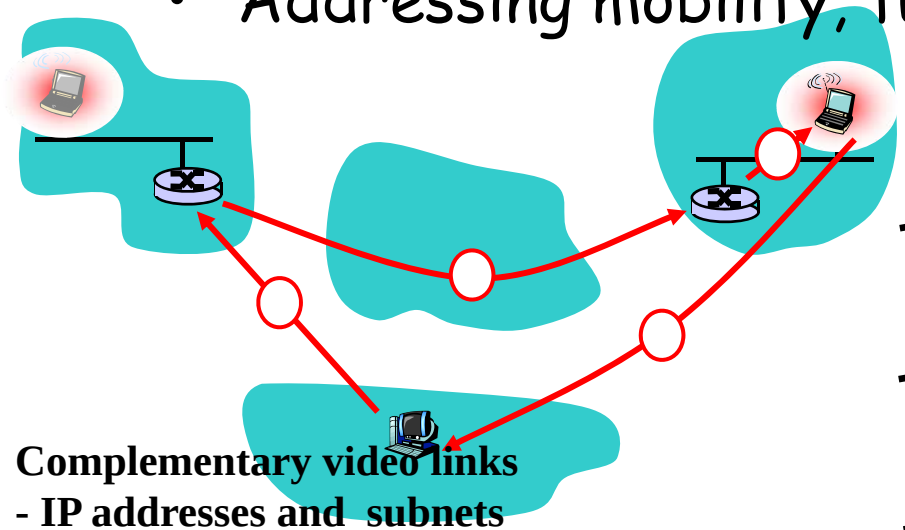


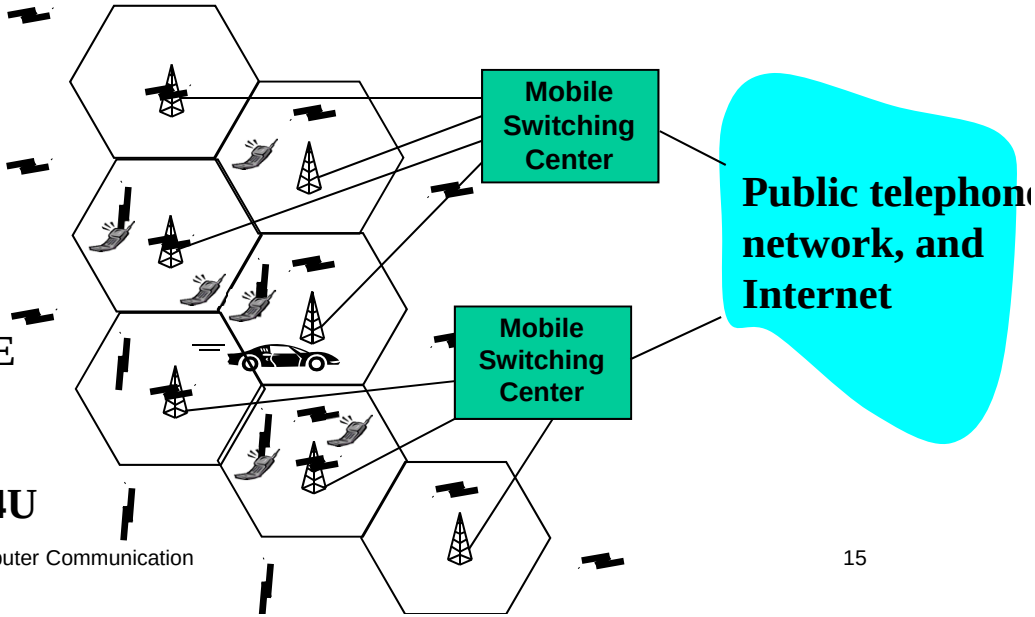
Routing, also with mobility

Routing, also with mobility

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







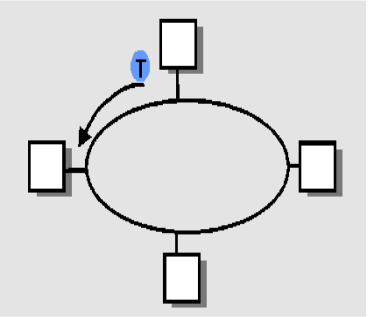
Complementary video links
- IP addresses and subnets
http://www.youtube.com/watch?v=ZTJIkjgyuZE&list=PLE9F3F05C381ED8E8&feature=plcp
- How does BGP choose its routes
http://www.youtube.com/watch?v=RGe0qt9Wz4U&feature=plcp

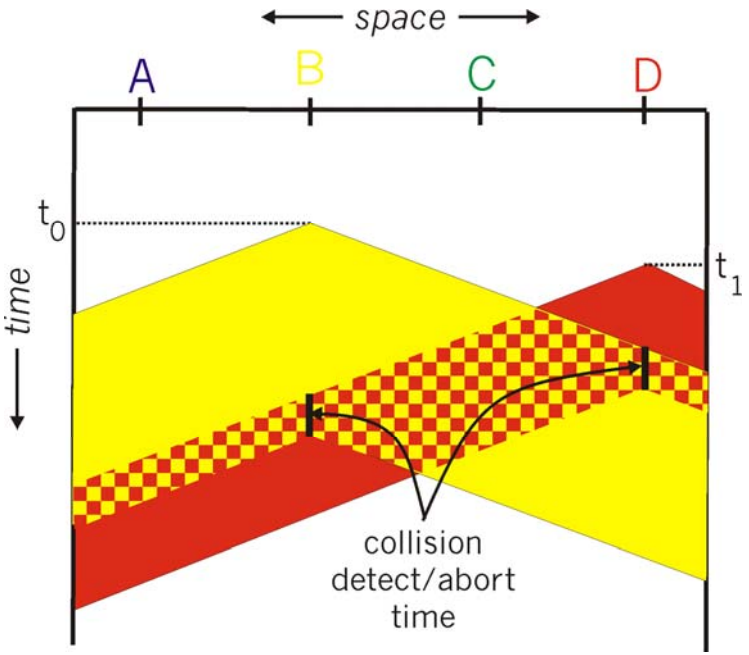
Multiple access algorithms

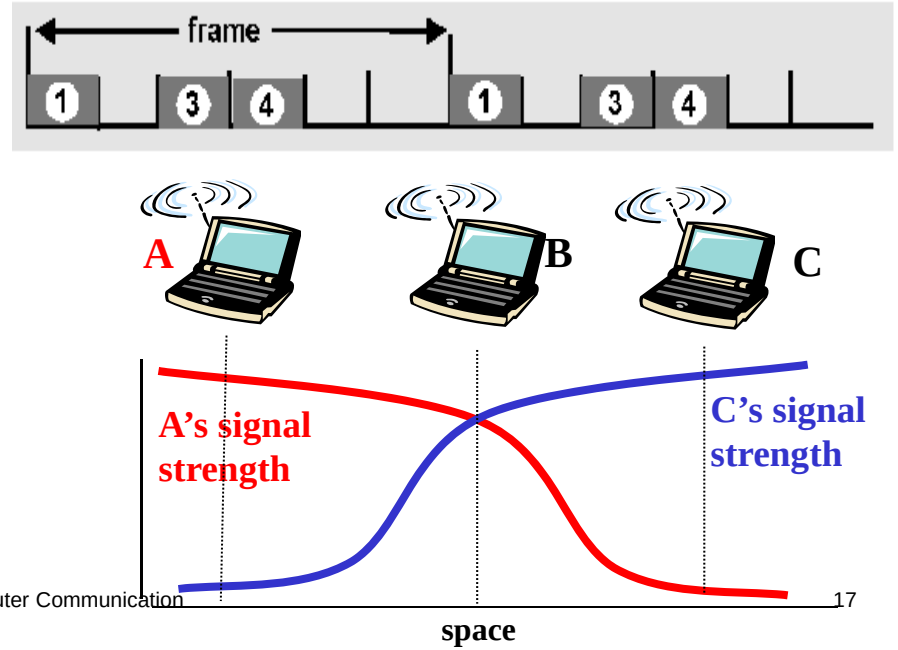
Medium access: multiple access methods

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

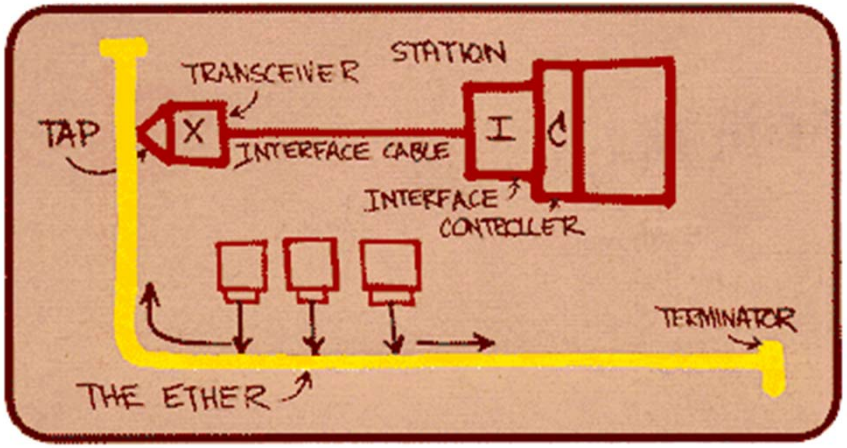
LANs & related link technologies

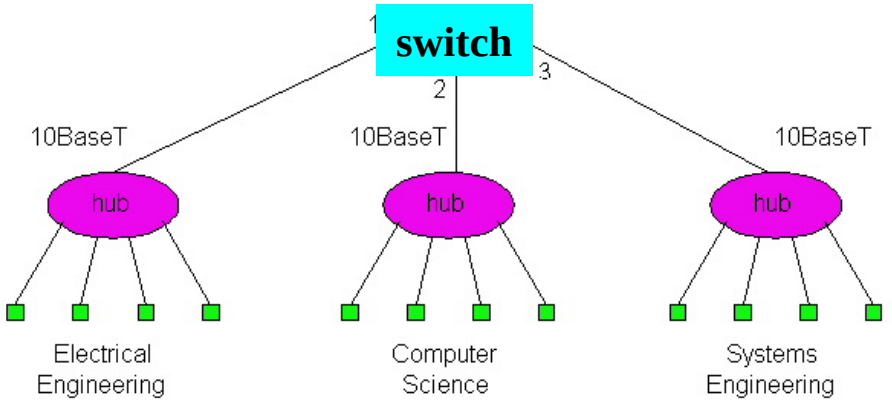
- **Protocol Examples: wired, wireless**

  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**



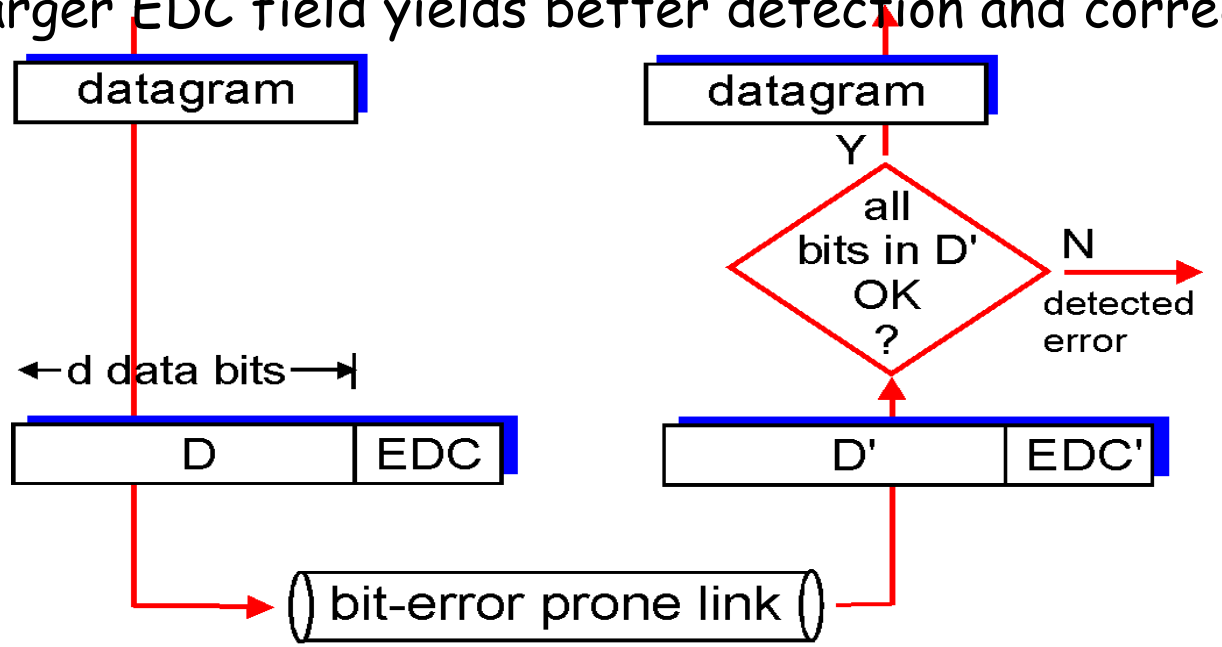


BTW: A little "backpatching"☺

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

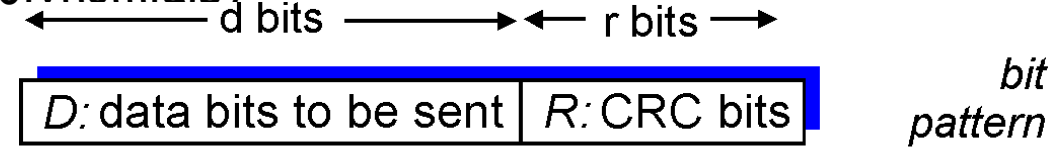
TCP (UDP)'s checksum:

- 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)

- more powerful error-detection coding
- 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

r = 3

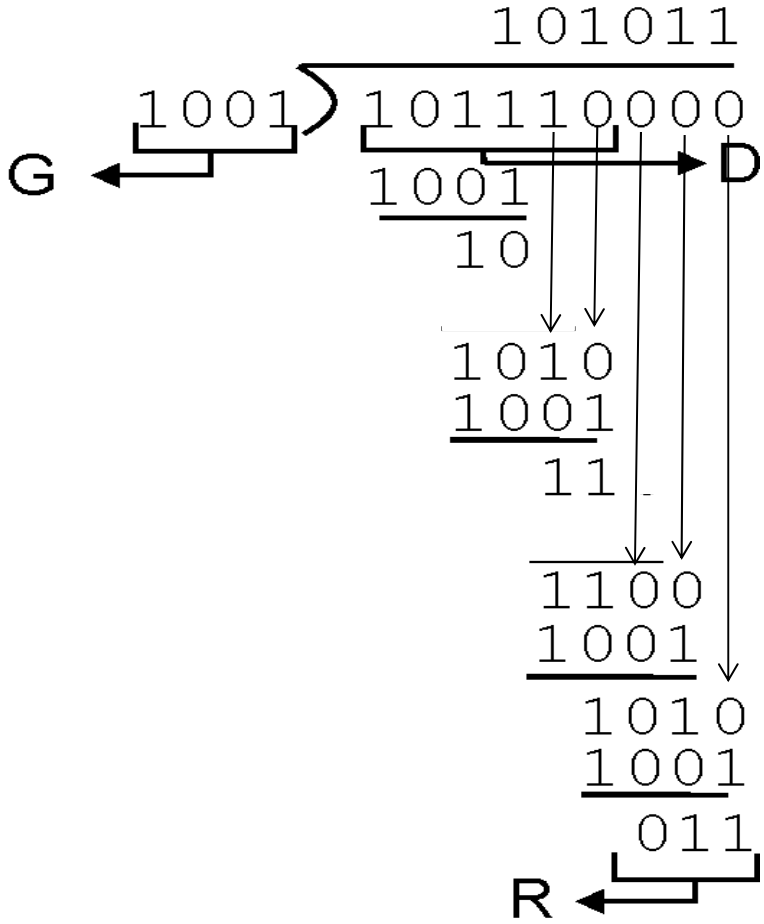
Recall we want:

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

equivalently:

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

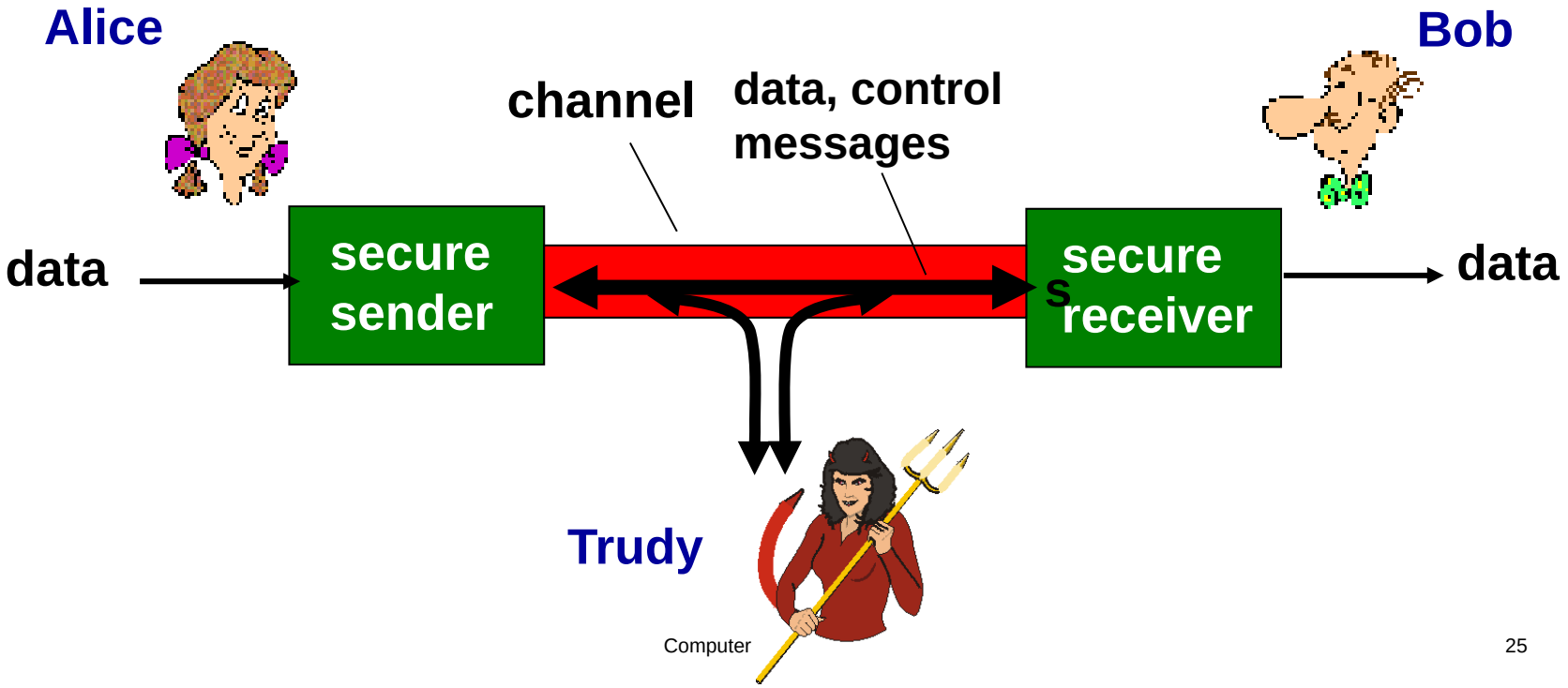
$$R = \text{remainder}\left[\frac{D \cdot 2^r}{G}\right]$$



Security issues

Security issues

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



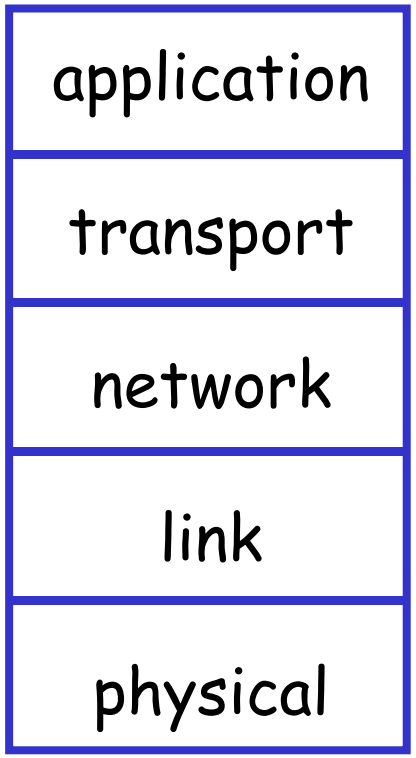
TCP/IP protocol stack (also applications), evolution

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, CDNs, multimedia/streaming application protocols)



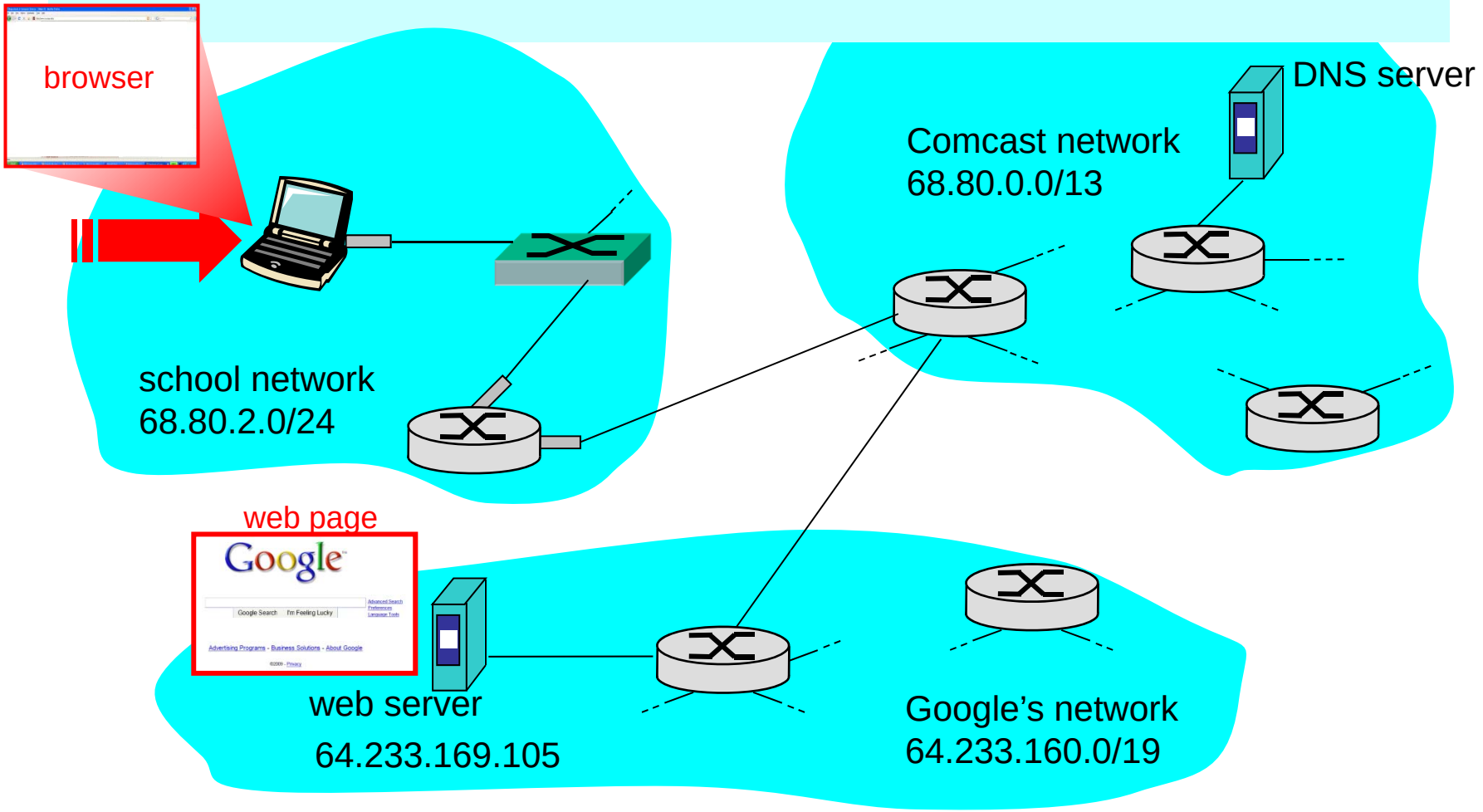
Items we discussed in less detail

- But exist in the slides you received
- Good to read (remember: reading is from the book! The slides cannot replavce the book reading) for own benefit; but need not consider for the exam next week
  - CRC's
  - Intserv, Diffserv, RSVP
  - MPLS

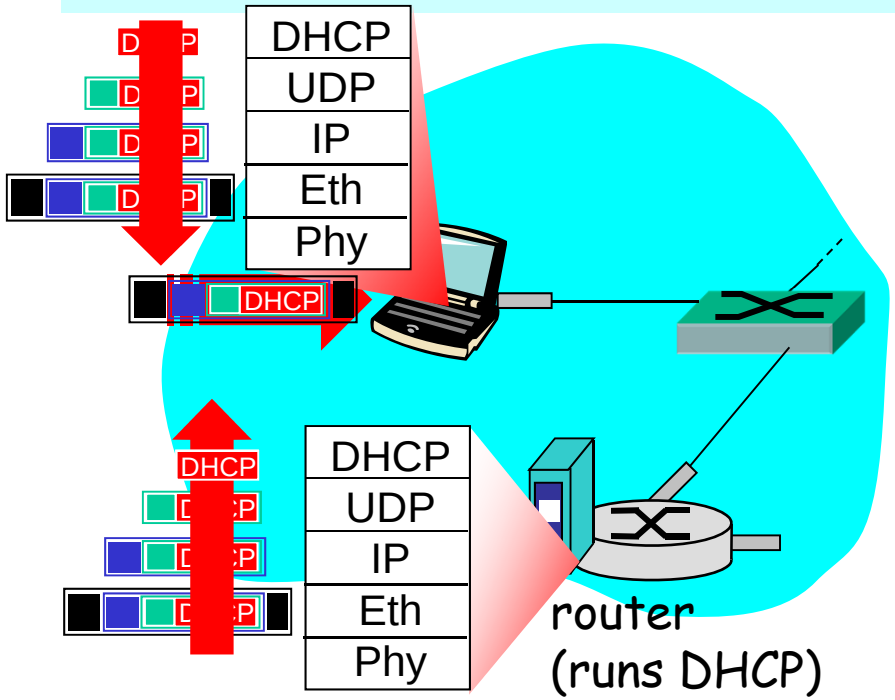
Synthesis: a day in the life of a web request

- putting-it-all-together: synthesis!
  - *goal:* identify, review 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

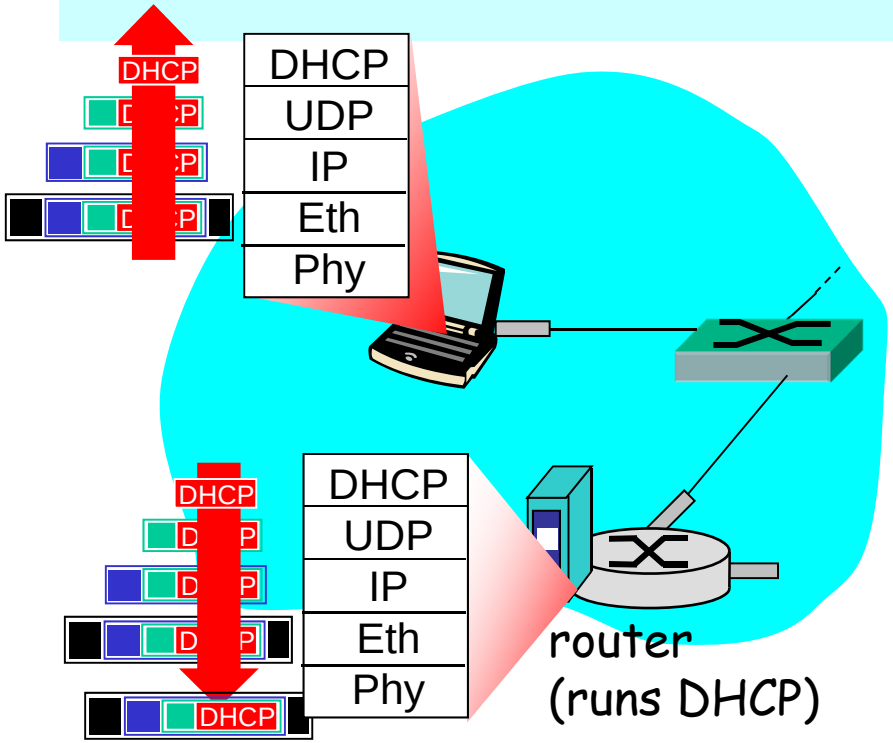


A day in the life… connecting to the Internet



- 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

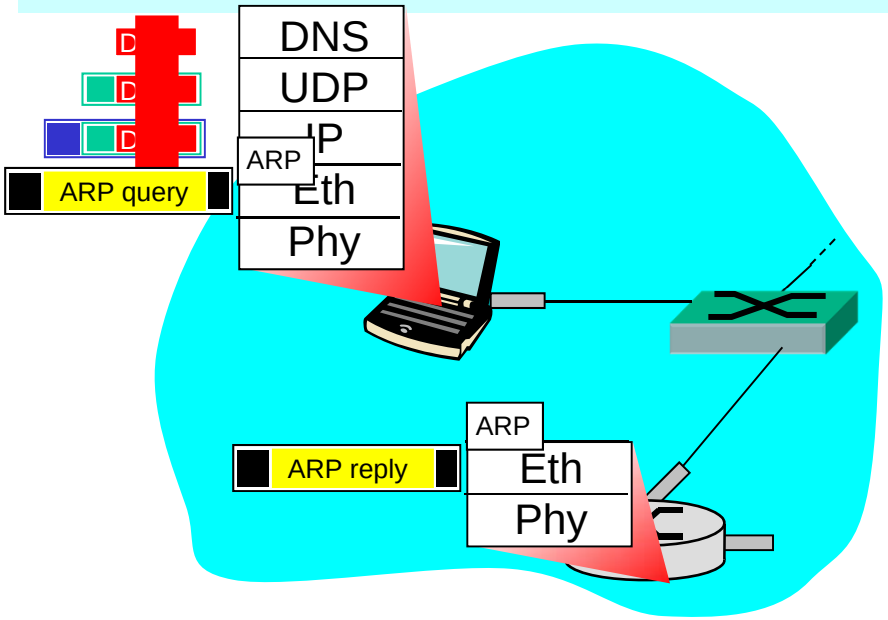
A day in the life… connecting to the Internet



- 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

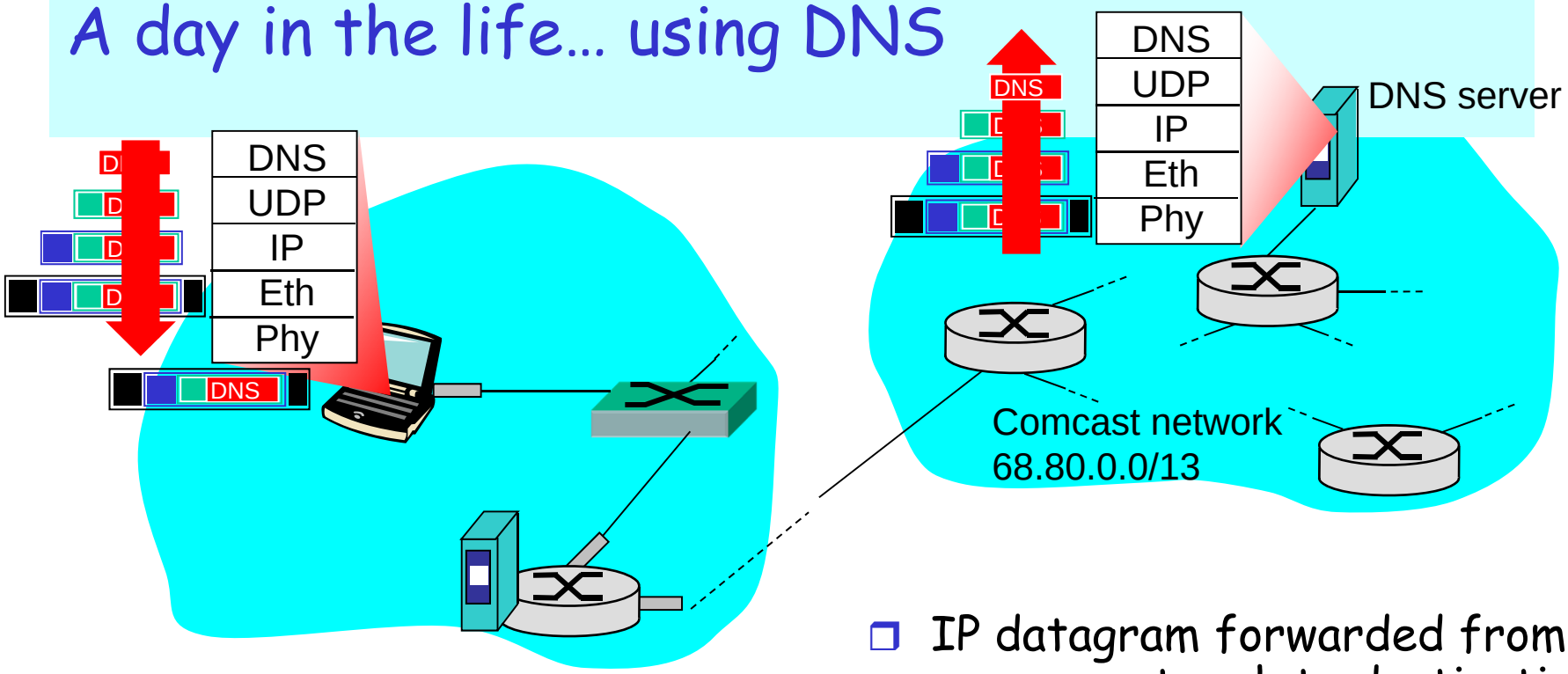
Client now has IP address, knows name & addr of DNS server, IP address of its first-hop router

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



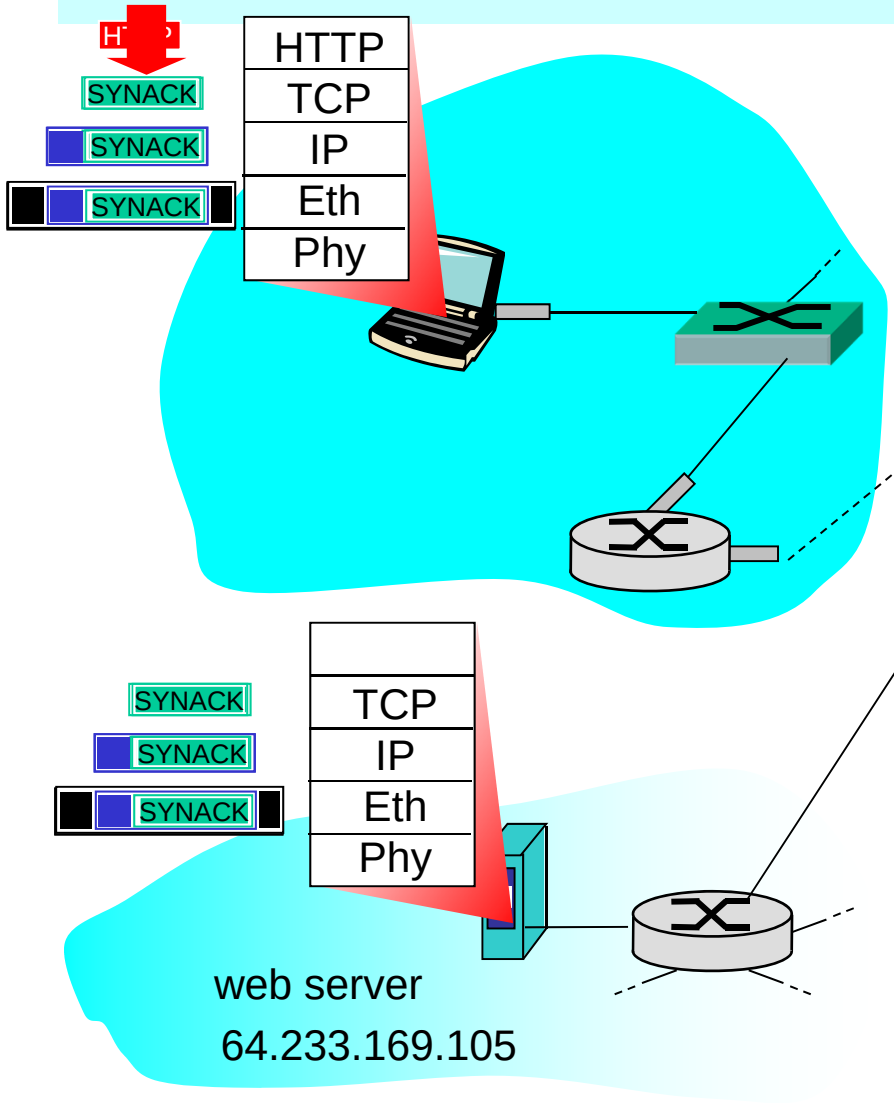
- before sending *HTTP* request, need IP address of www.google.com: *DNS*
- DNS query created, encapsulated in UDP, encapsulated in IP, encasulated in Eth. In order to send frame to router, need MAC address of router interface: *ARP*
- *ARP query* broadcast, received by router, which replies with *ARP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

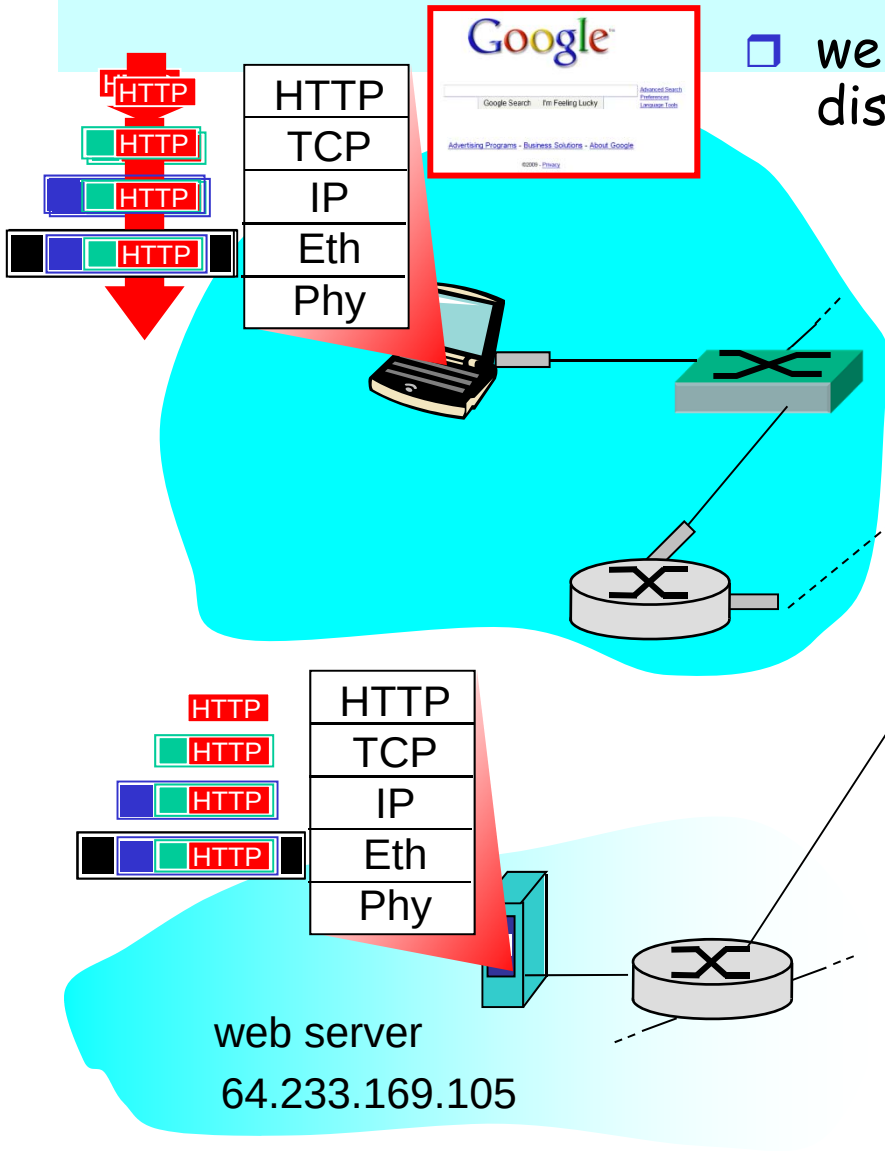
A day in the life… TCP connection carrying HTTP



- 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**

- TCP **connection established!**

A day in the life… HTTP request/reply



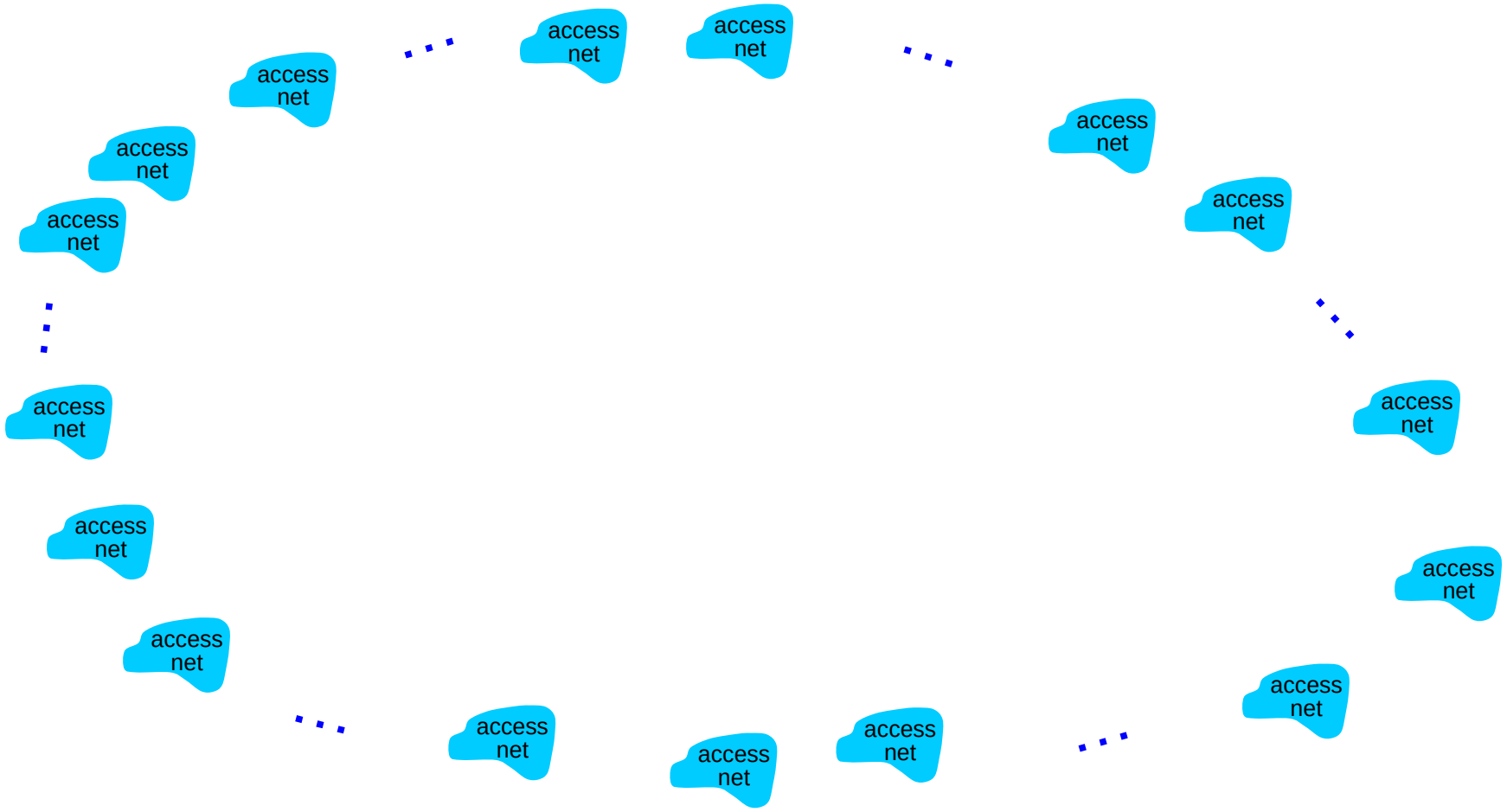
- web page **finally (!!!)** displayed

- **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

Synthesis cont.

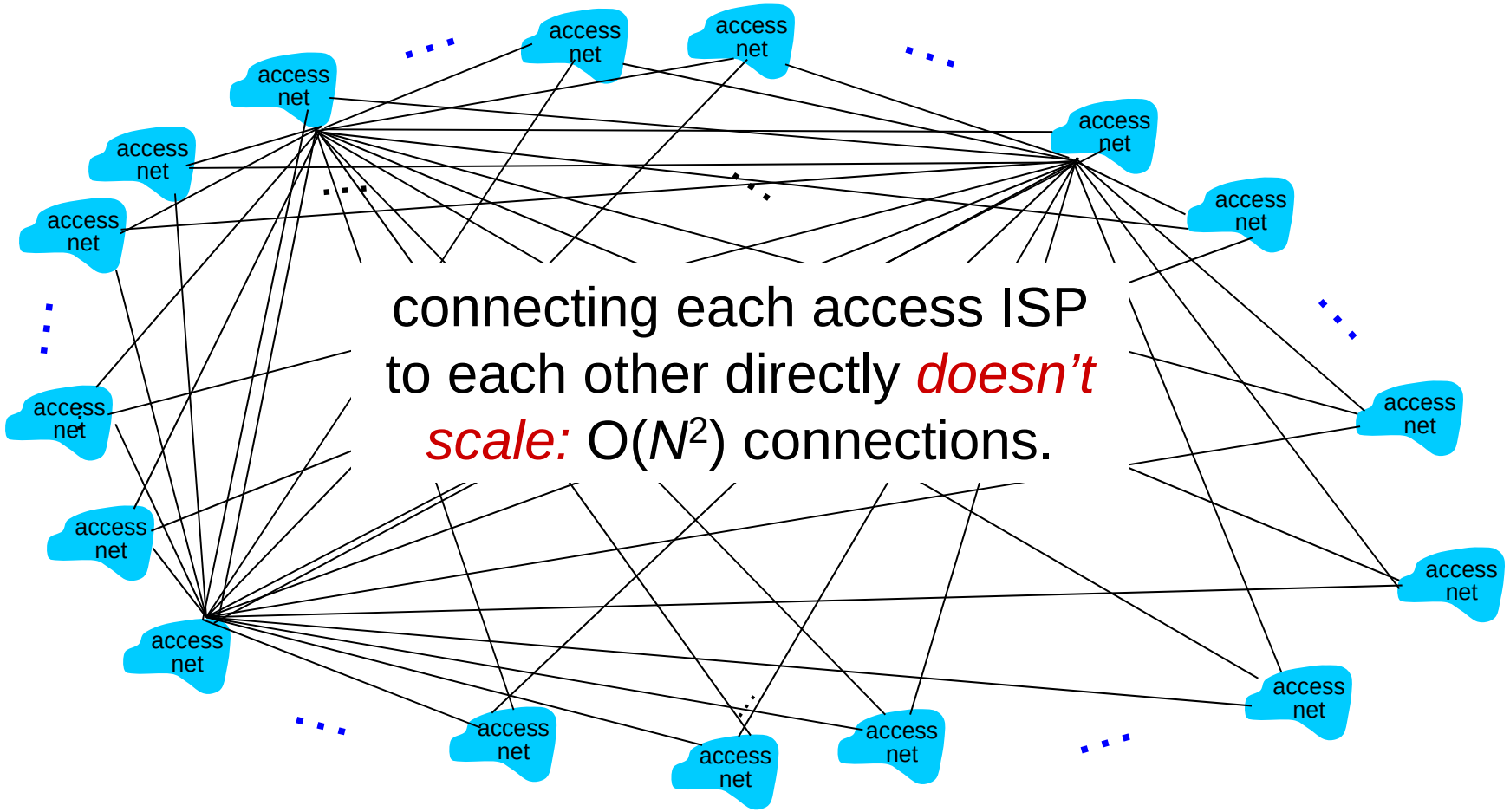
Internet structure: network of networks

Question: given *millions* of access ISPs, how to connect them together?



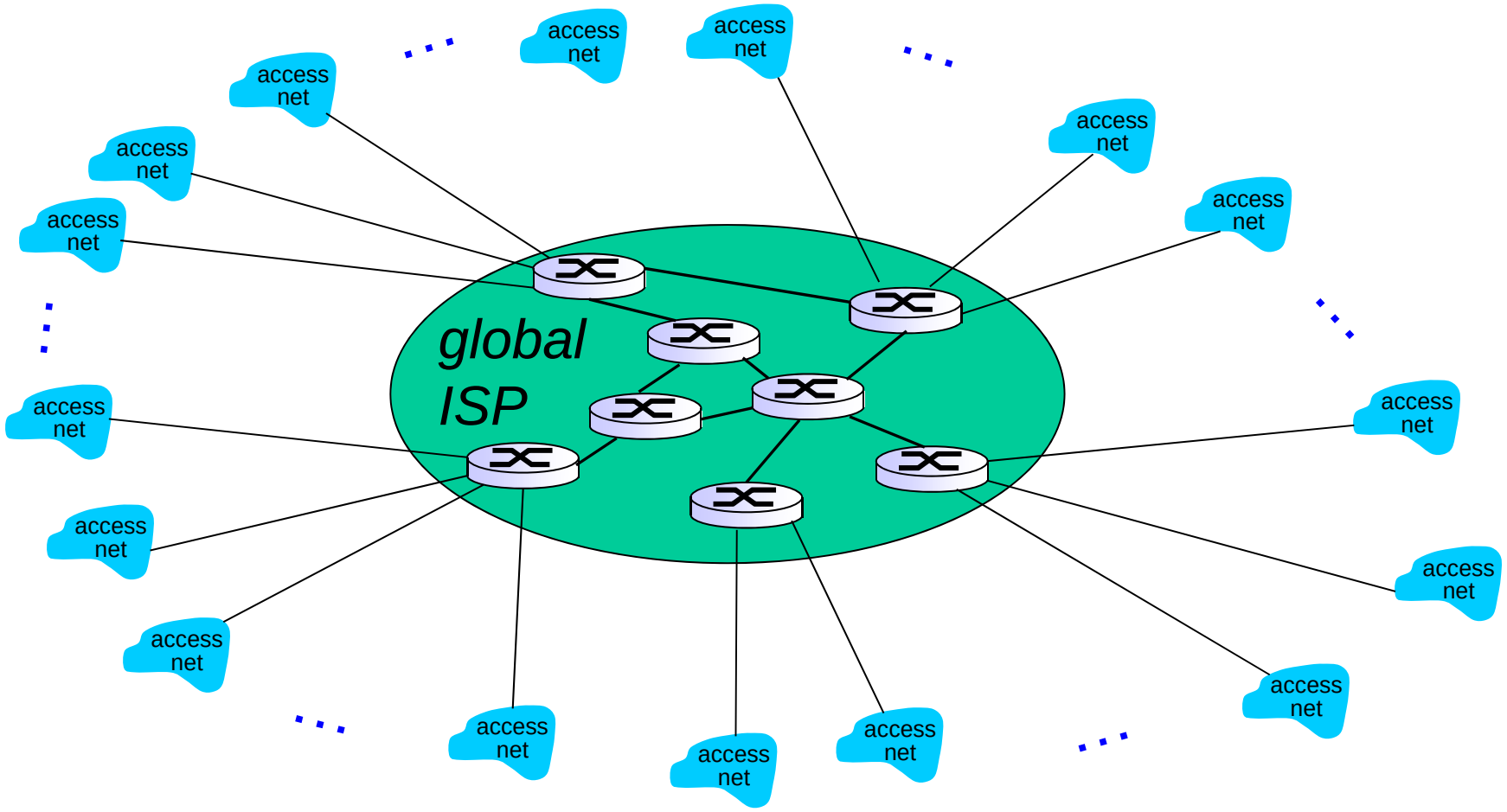
Internet structure: network of networks

Option: connect each access ISP to every other access ISP?



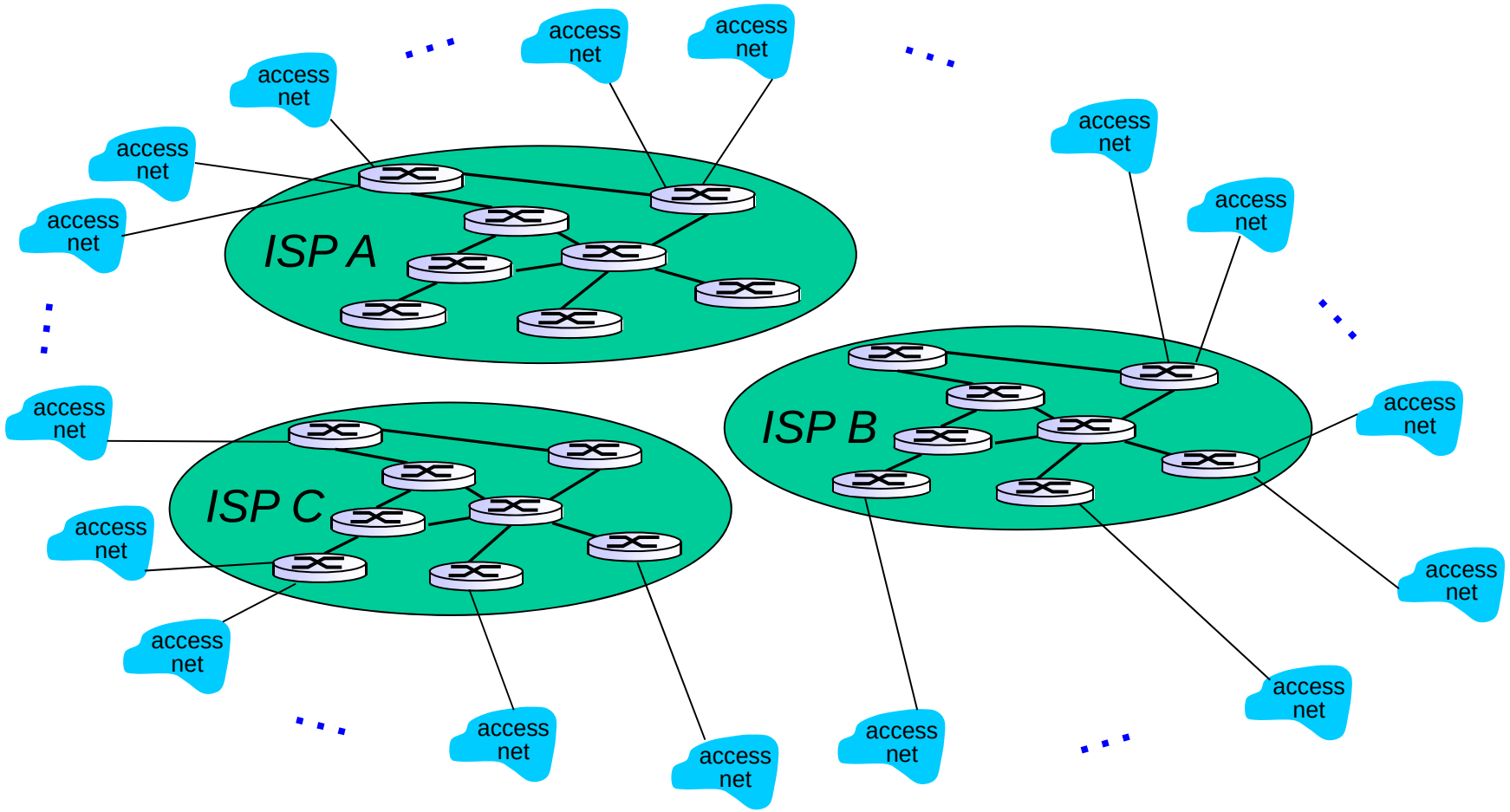
Internet structure: network of networks

Option: connect each access ISP to a global transit ISP? Customer and provider ISPs have economic agreement.



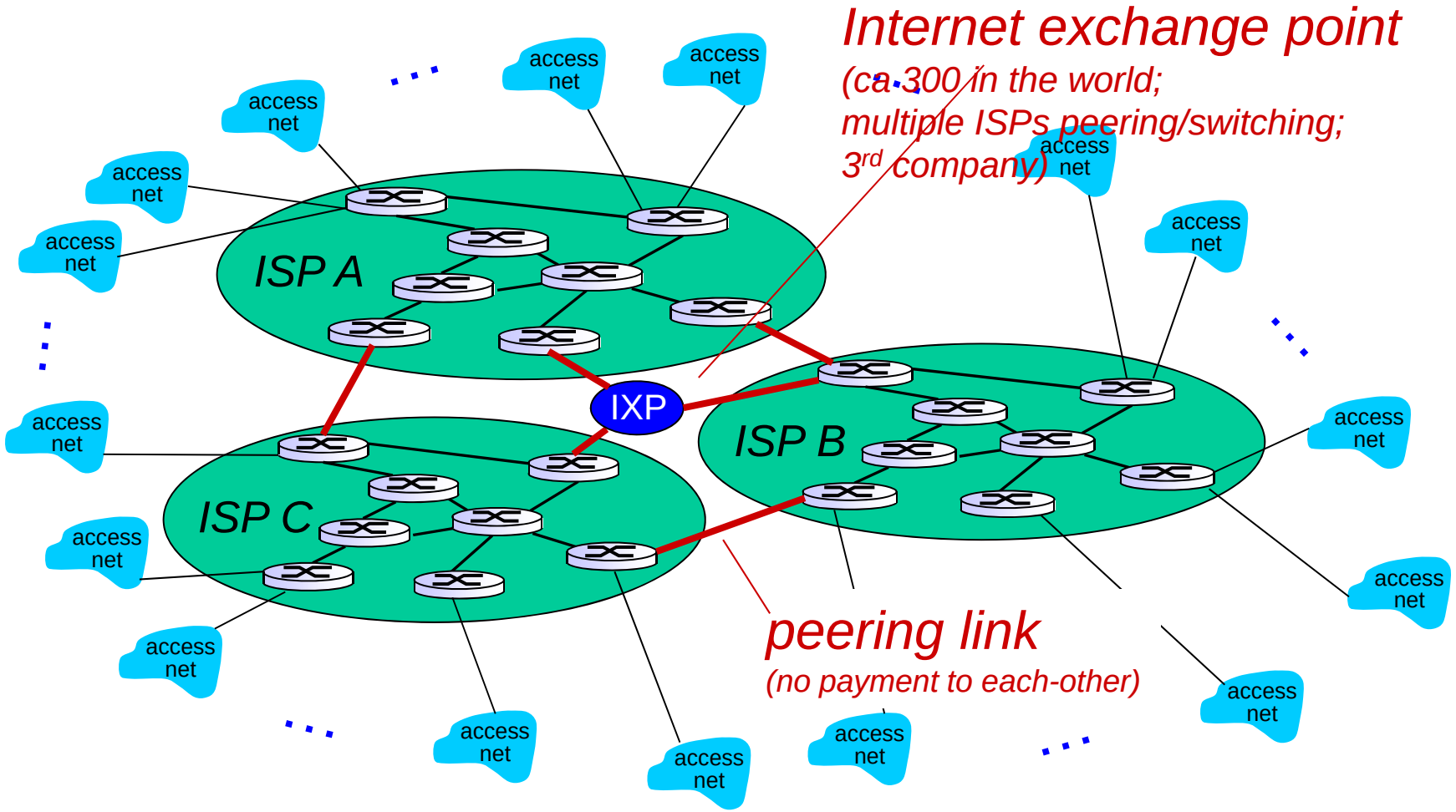
Internet structure: network of networks

But if one global ISP is viable business, there will be competitors ….



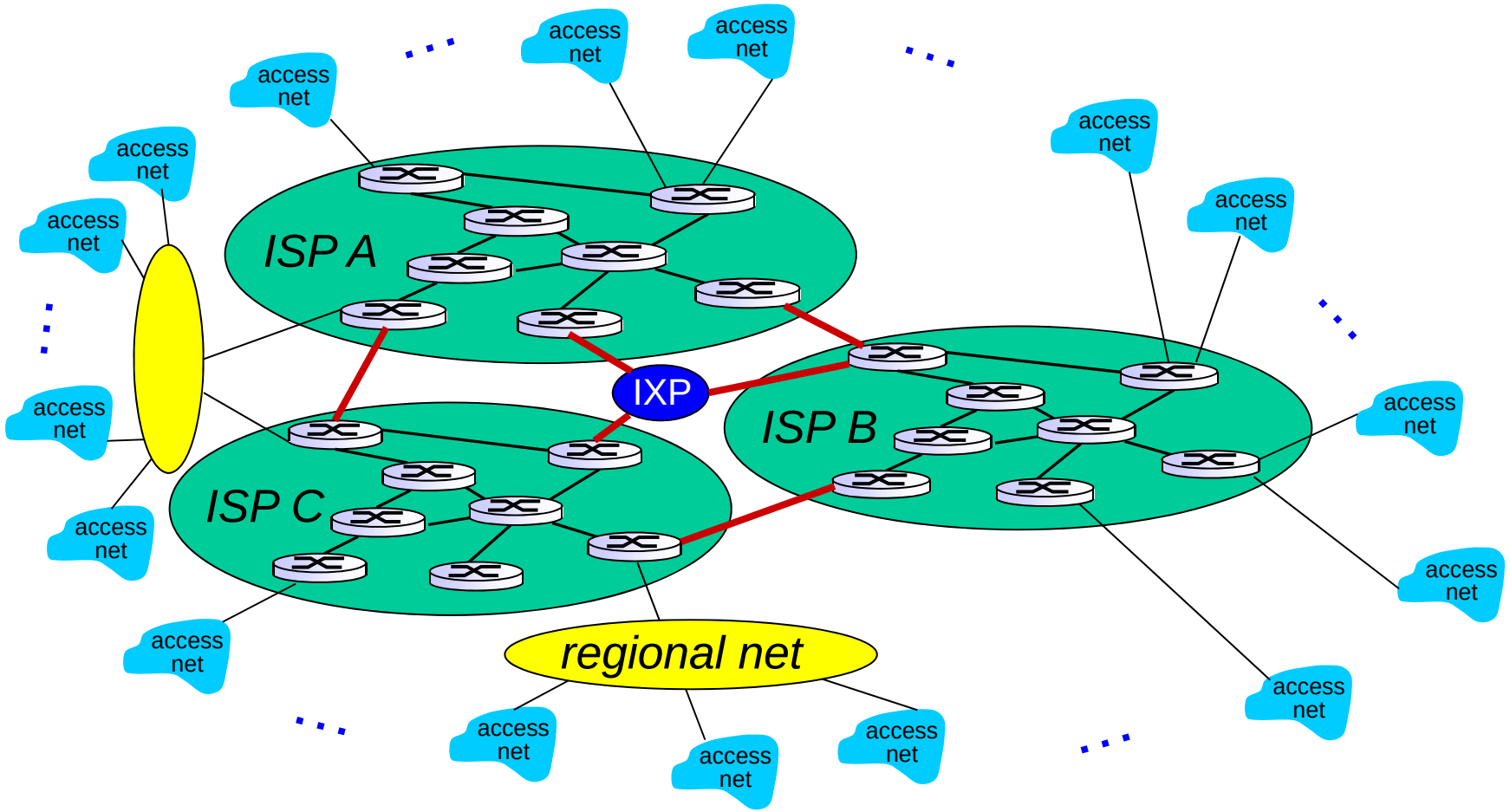
Internet structure: network of networks

But if one global ISP is viable business, there will be competitors …. which must be interconnected



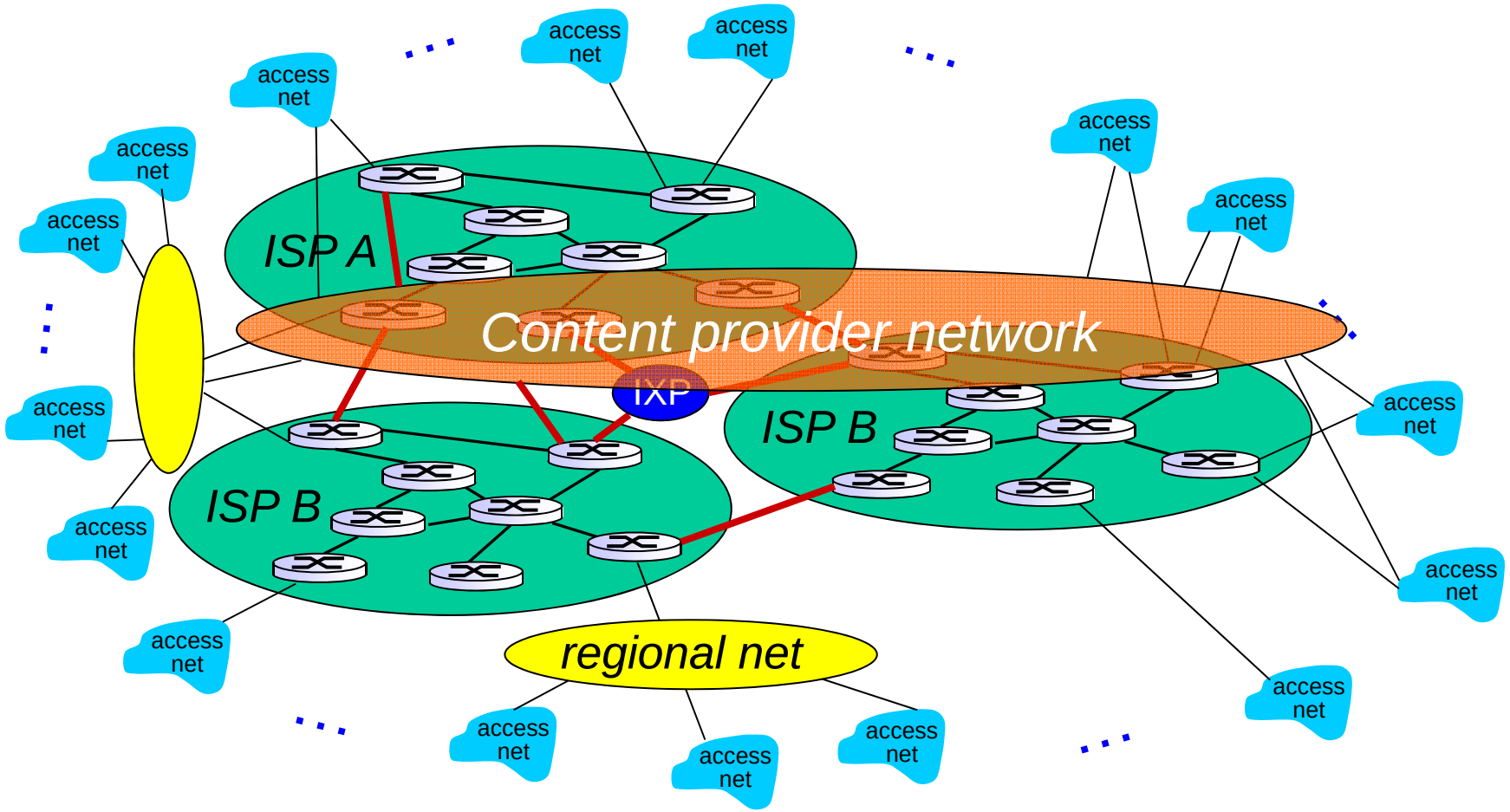
Internet structure: network of networks

… and regional networks may arise to connect access nets to ISPS

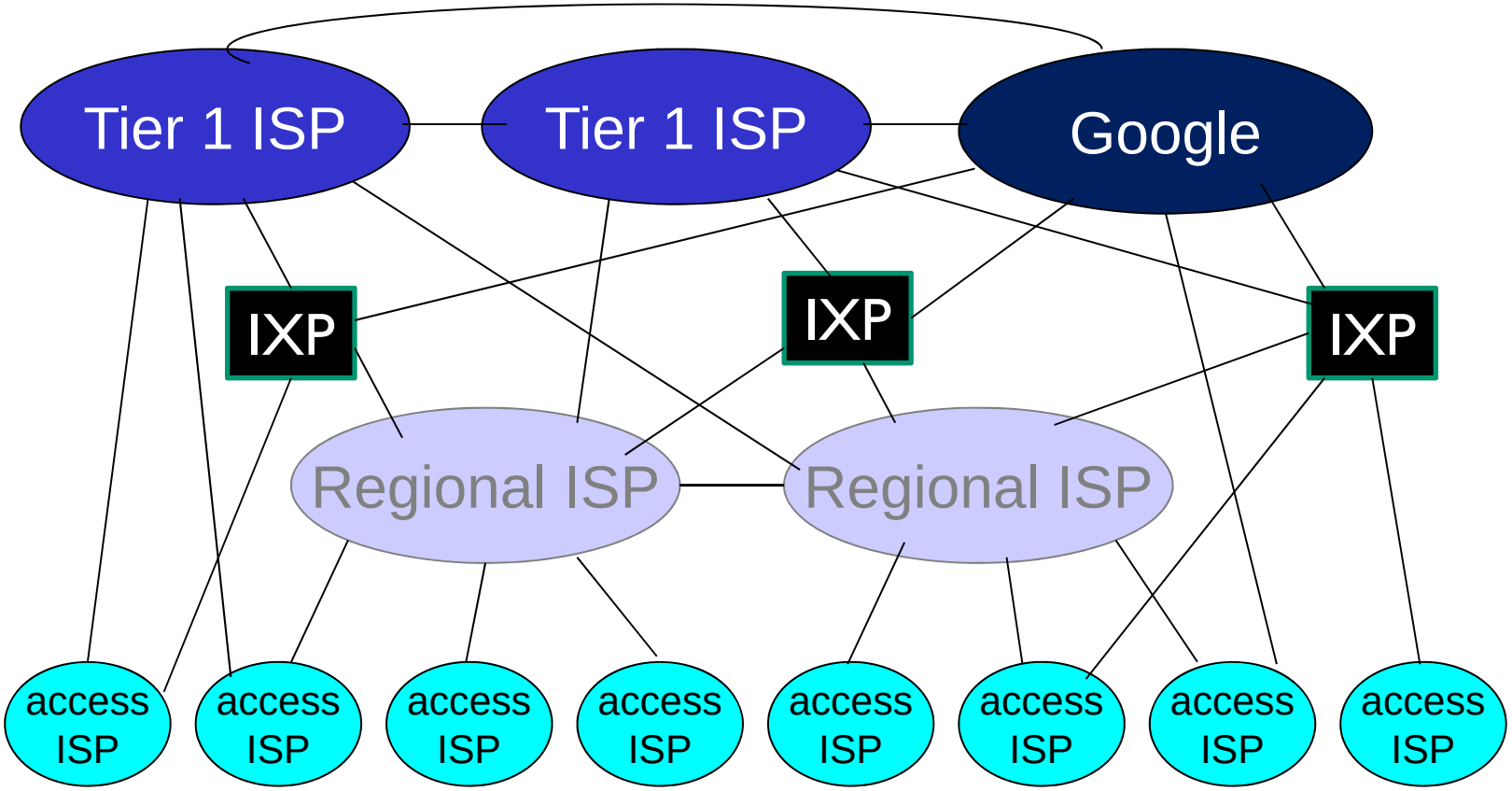


Internet structure: network of networks

… and content provider networks (e.g., Google, Microsoft, Akamai) may run their own network, to bring services, content close to end users



Internet structure: network of networks



- at center: small # of well-connected large networks
  - "tier-1" commercial ISPs (e.g., Level 3, Sprint, AT&T, NTT), national & international coverage
  - A new form of content provider network (e.g, Google): private network that connects it data centers to Internet, often bypassing tier-1, regional ISPs

Thank you & good luck in the exam!!

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