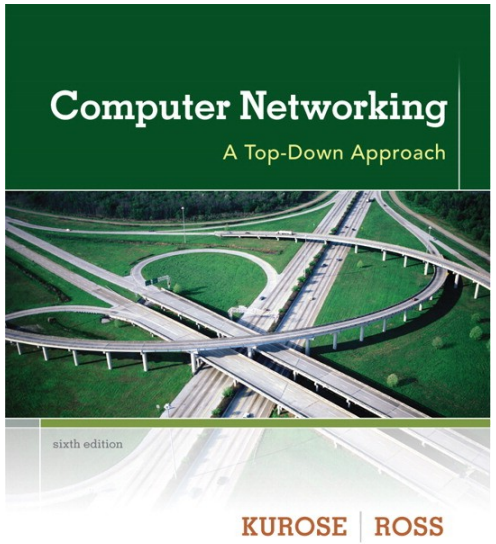
Chapter 1 Introduction



Computer Networking: A Top Down Approach

6th edition

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Addison-Wesley

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Thanks and enjoy! JFK/KWR

Chapter 1: introduction

our goal:

- *get "feel" and terminology*
- *more depth, detail later in course*
- *approach:*
  - use Internet as example

overview:

- *what's the Internet?*
- *what's a protocol?*
- *network edge; hosts, access net, physical media*
- *network core: packet/circuit switching, Internet structure*
- *performance: loss, delay, throughput*
- *security*
- *protocol layers, service models*
- *history*

Chapter 1: roadmap

1.1 what *is* the Internet?

1.2 network edge

- end systems, access networks, links

1.3 network core

- packet switching, circuit switching, network structure

1.4 delay, loss, throughput in networks

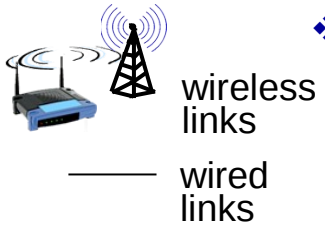
1.5 protocol layers, service models

1.6 networks under attack: security

1.7 history

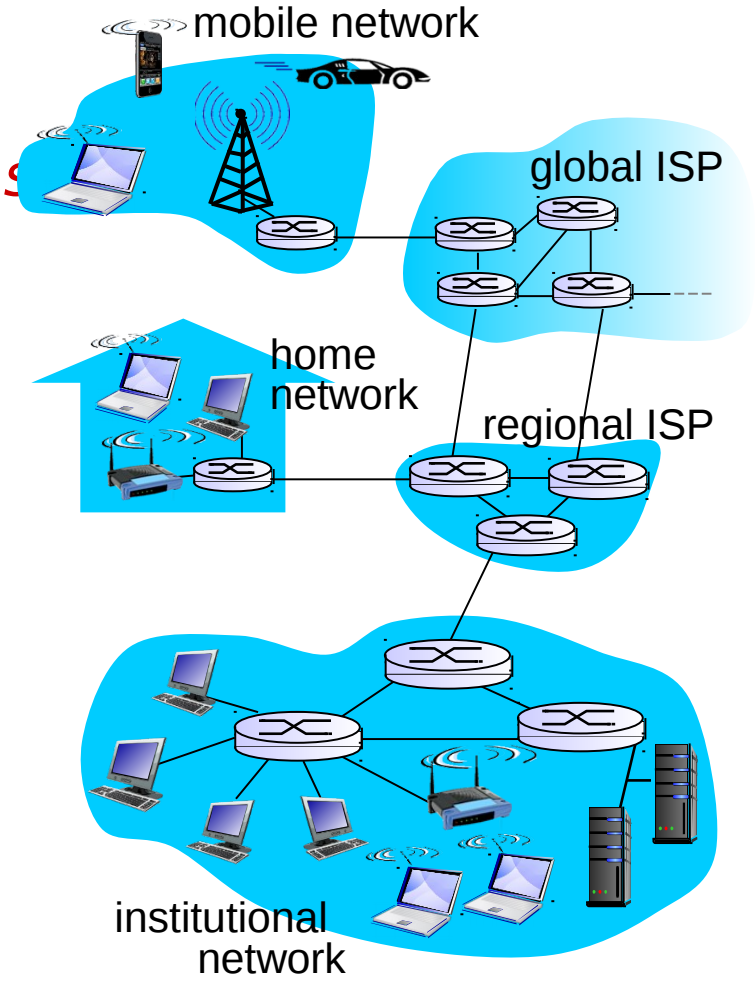
What's the Internet: "nuts and bolts" view

- *millions of connected computing devices:*
  - *hosts = end systems*
  - running *network apps*



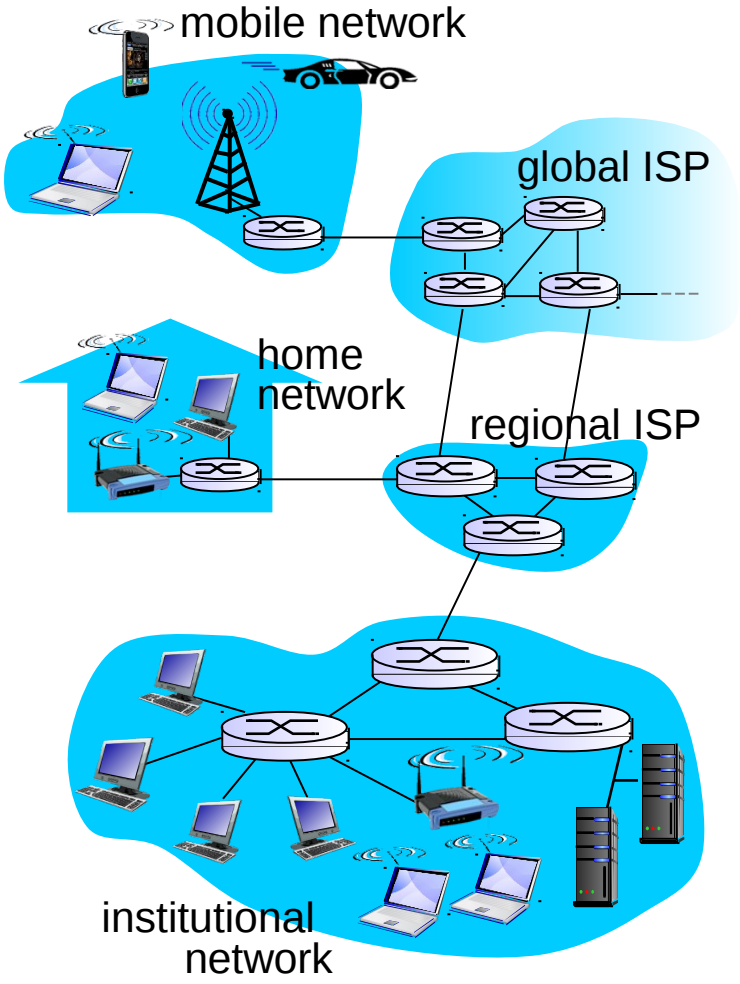
- *communication links*
  - fiber, copper, radio, satellite
  - transmission rate: *bandwidth*

- *Packet switches:* forward packets (chunks of data)
  - *routers* and *switches*



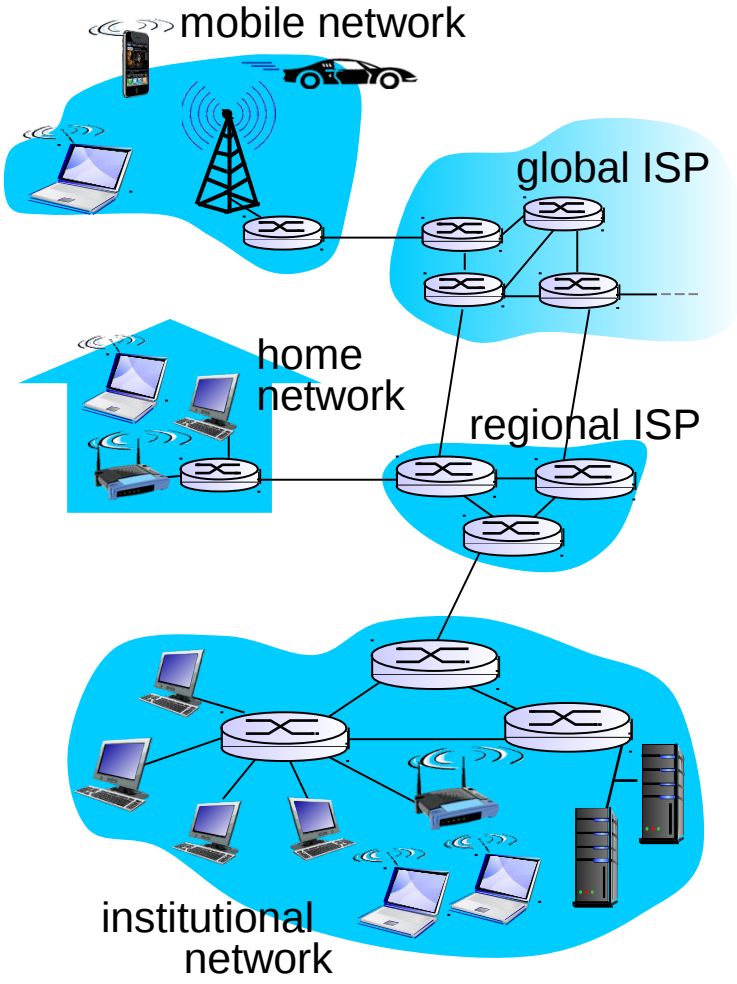
What's the Internet: "nuts and bolts" view

- *Internet: "network of networks"*
  - Interconnected ISPs
- *protocols control sending, receiving of msgs*
  - e.g., TCP, IP, HTTP, Skype, 802.11
- *Internet standards*
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force



What's the Internet: a service view

- *Infrastructure that provides services to applications:*
  - Web, VoIP, email, games, e-commerce, social nets, …
- *provides programming interface to apps*
  - hooks that allow sending and receiving app programs to "connect" to Internet
  - provides service options, analogous to postal service



What's a protocol?

human protocols:

- *"what's the time?"*
- *"I have a question"*
- *introductions*

... specific msgs sent

... specific actions taken when msgs received, or other events

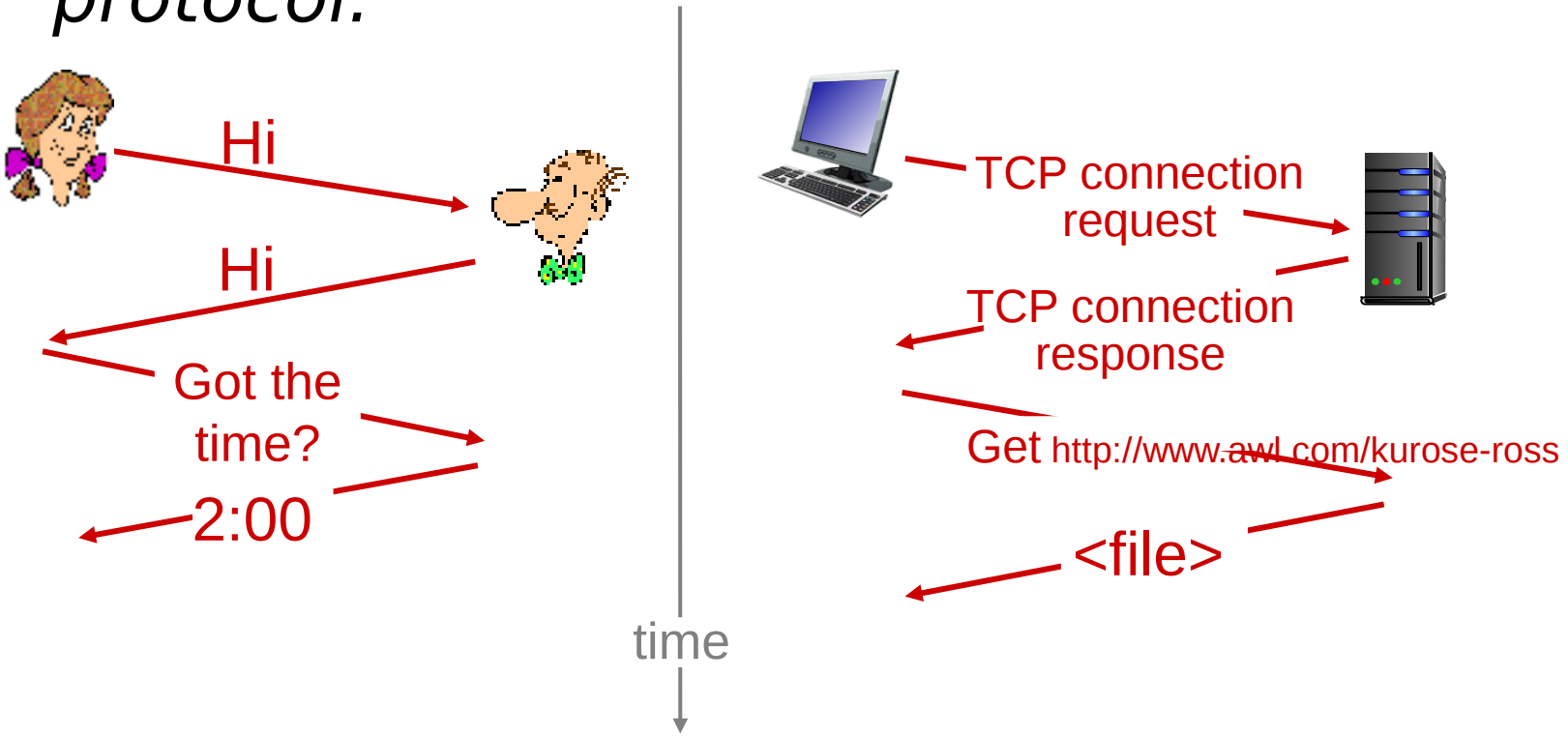
network protocols:

- *machines rather than humans*
- *all communication activity in Internet governed by protocols*

protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt

What's a protocol?

a human protocol and a computer network protocol:



Q: other human protocols?

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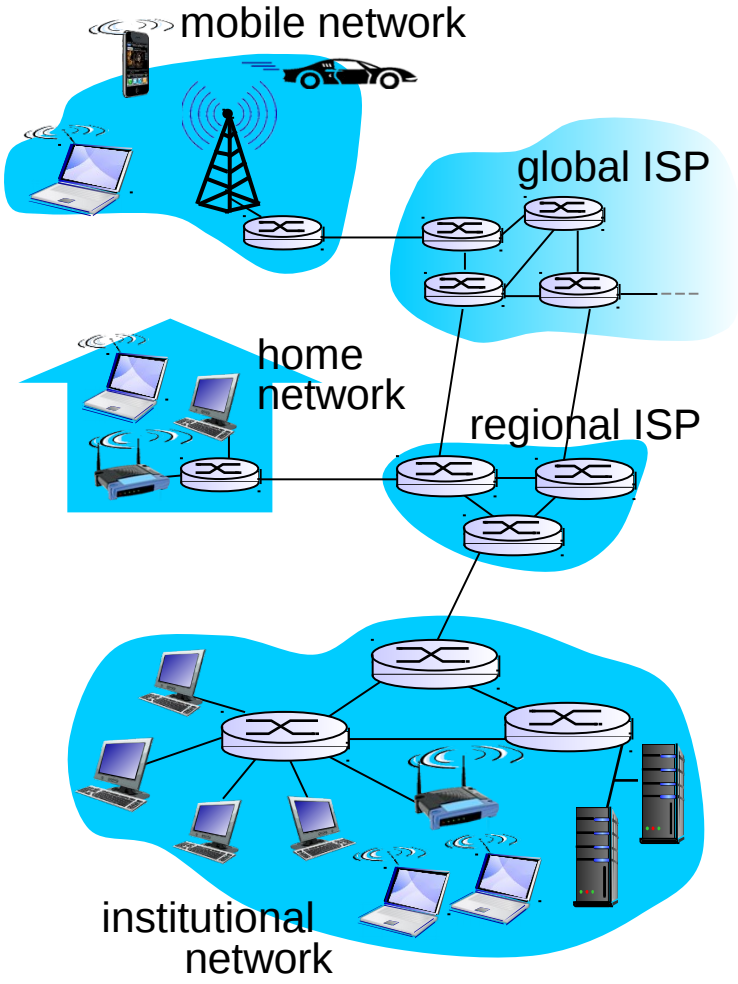
A closer look at network structure:

- *network edge:*
  - hosts: clients and servers
  - servers often in data centers
- *access networks, physical media:* wired, wireless communication links
- *network core:*
  - interconnected routers
  - network of networks



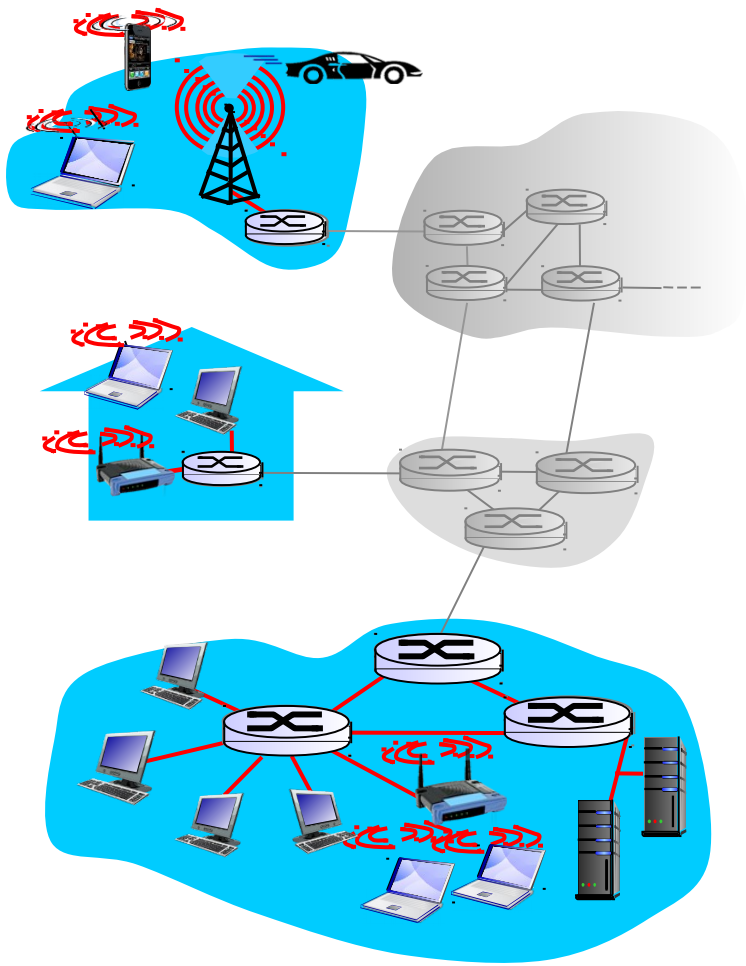
Access networks and physical media

Q: How to connect end systems to edge router?

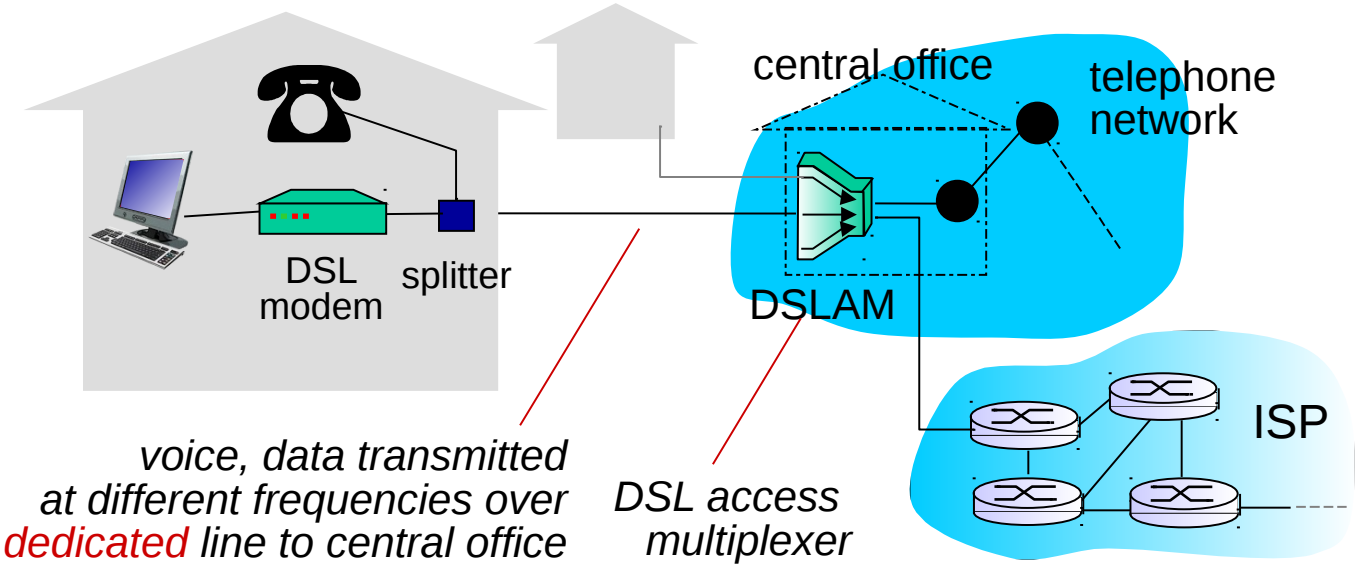
- *residential access nets*
- *institutional access networks (school, company)*
- *mobile access networks*

keep in mind:

- *bandwidth (bits per second) of access network?*
- *shared or dedicated?*

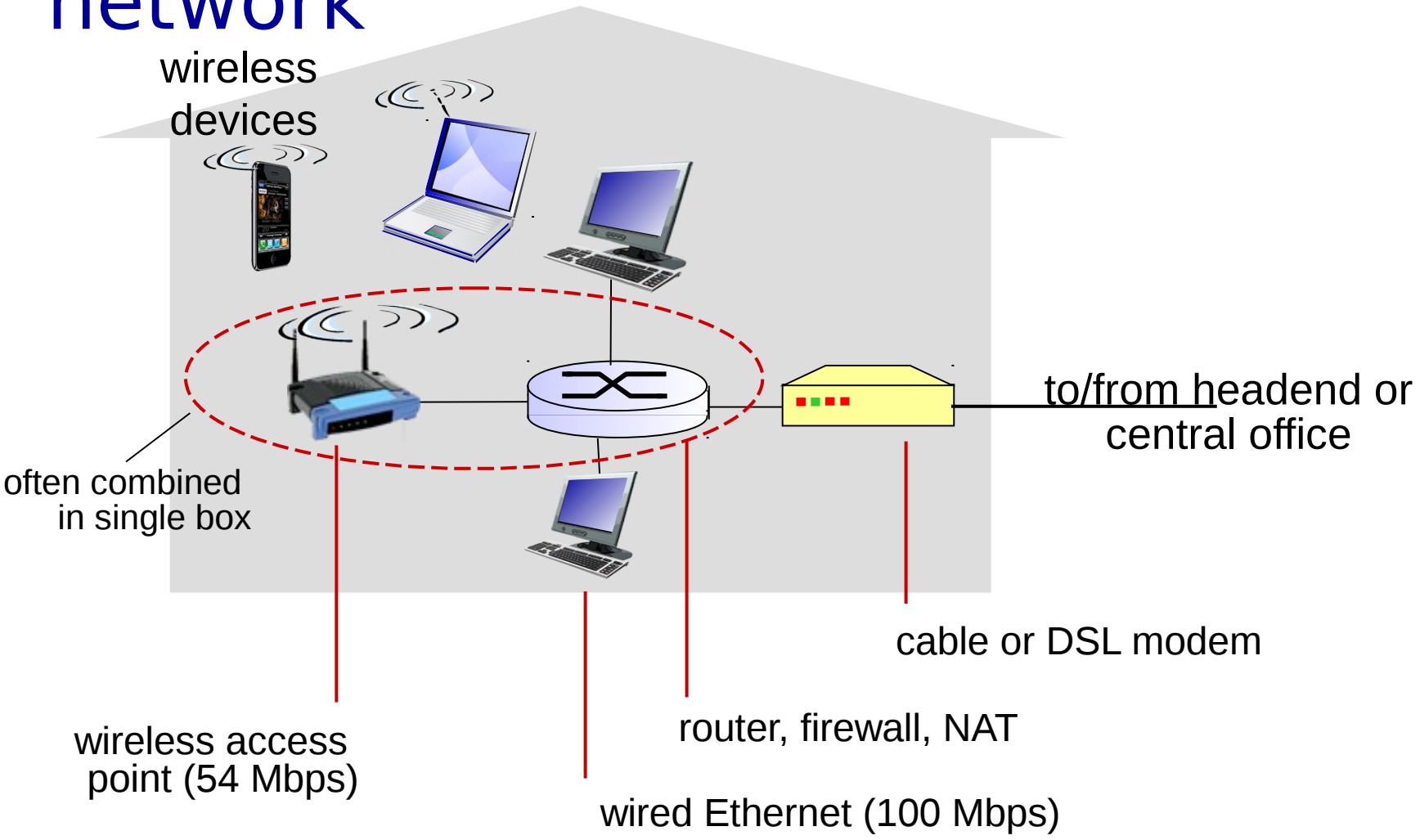


Access net: digital subscriber line (DSL)

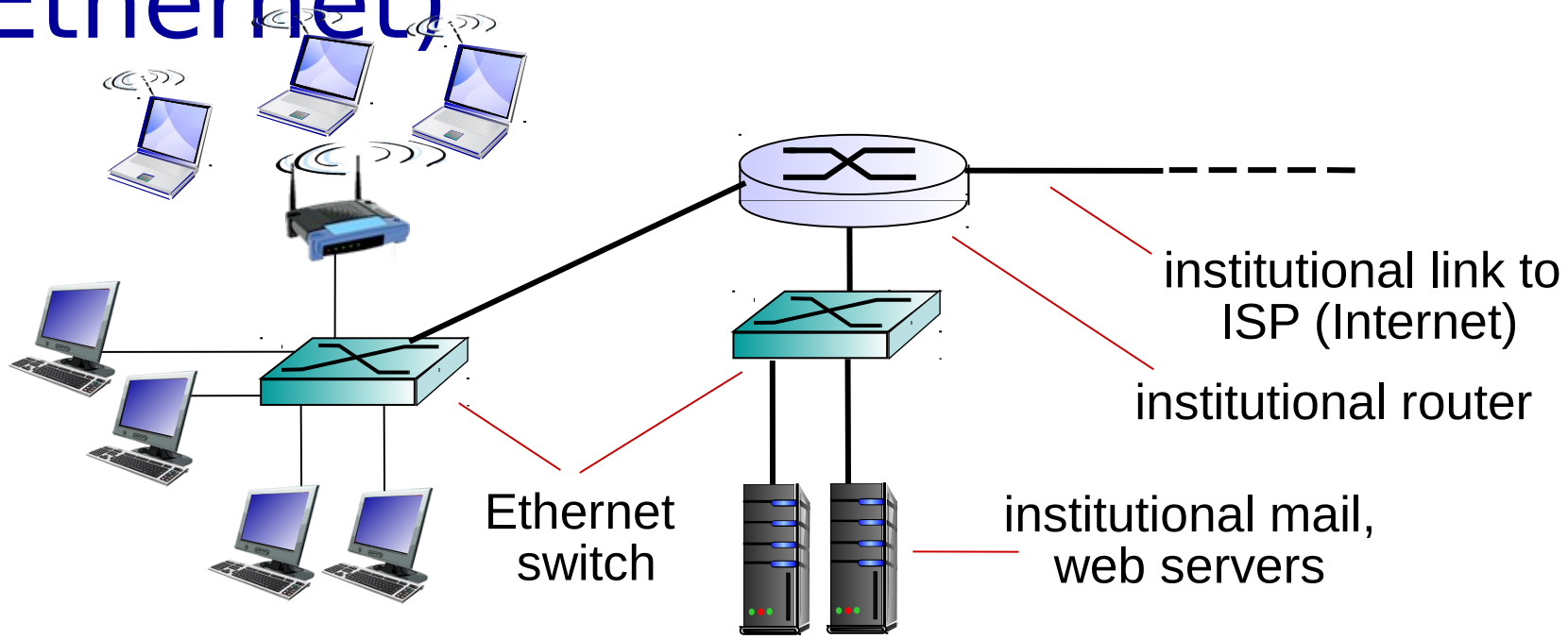


- use *existing* telephone line to central office DSLAM
  - data over DSL phone line goes to Internet
  - voice over DSL phone line goes to telephone net
- < 2.5 Mbps upstream transmission rate (typically < 1 Mbps)
- < 24 Mbps downstream transmission rate (typically < 10 Mbps)

Access net: home network



Enterprise access networks (Ethernet)



- *typically used in companies, universities, etc*
- 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
- today, end systems typically connect into Ethernet switch

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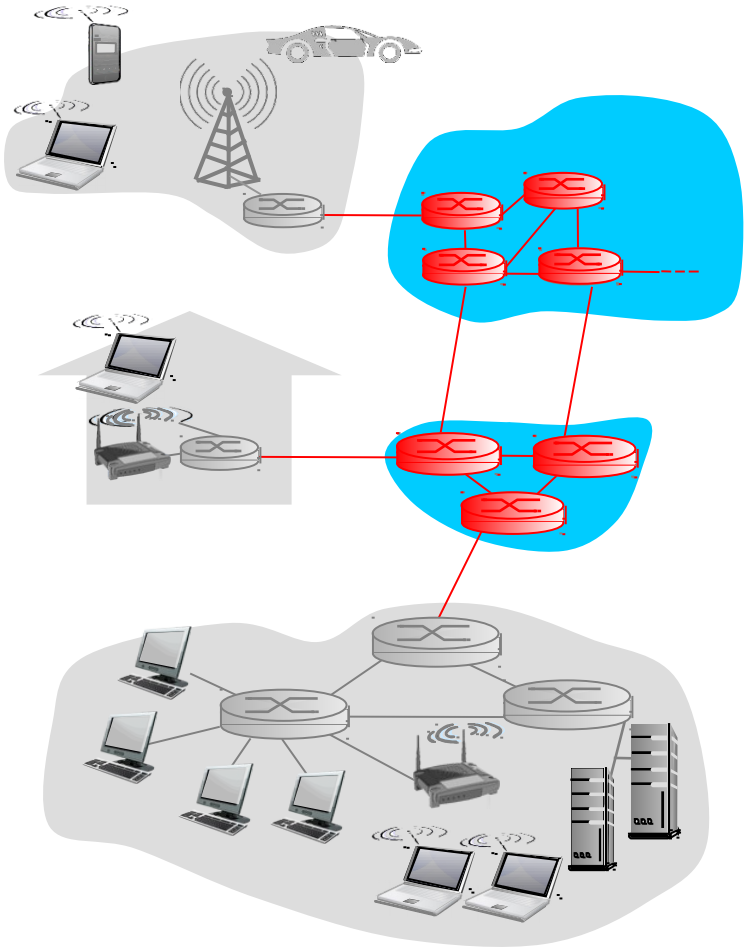
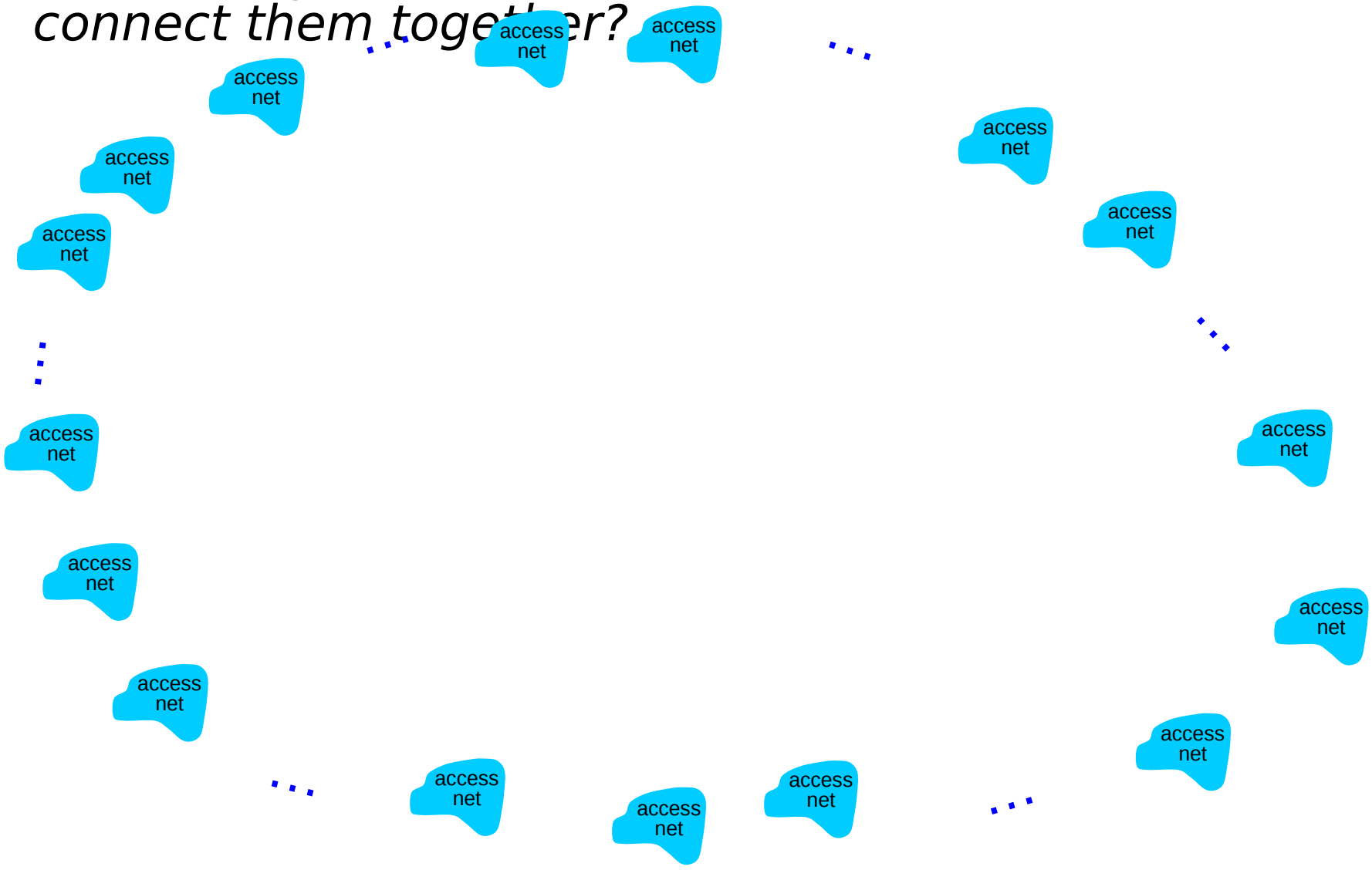
The network core

- *mesh of interconnected routers*
- *packet-switching: hosts break application-layer messages into packets*
  - forward packets from one router to the next, across links on path from source to destination
  - each packet transmitted at full link capacity



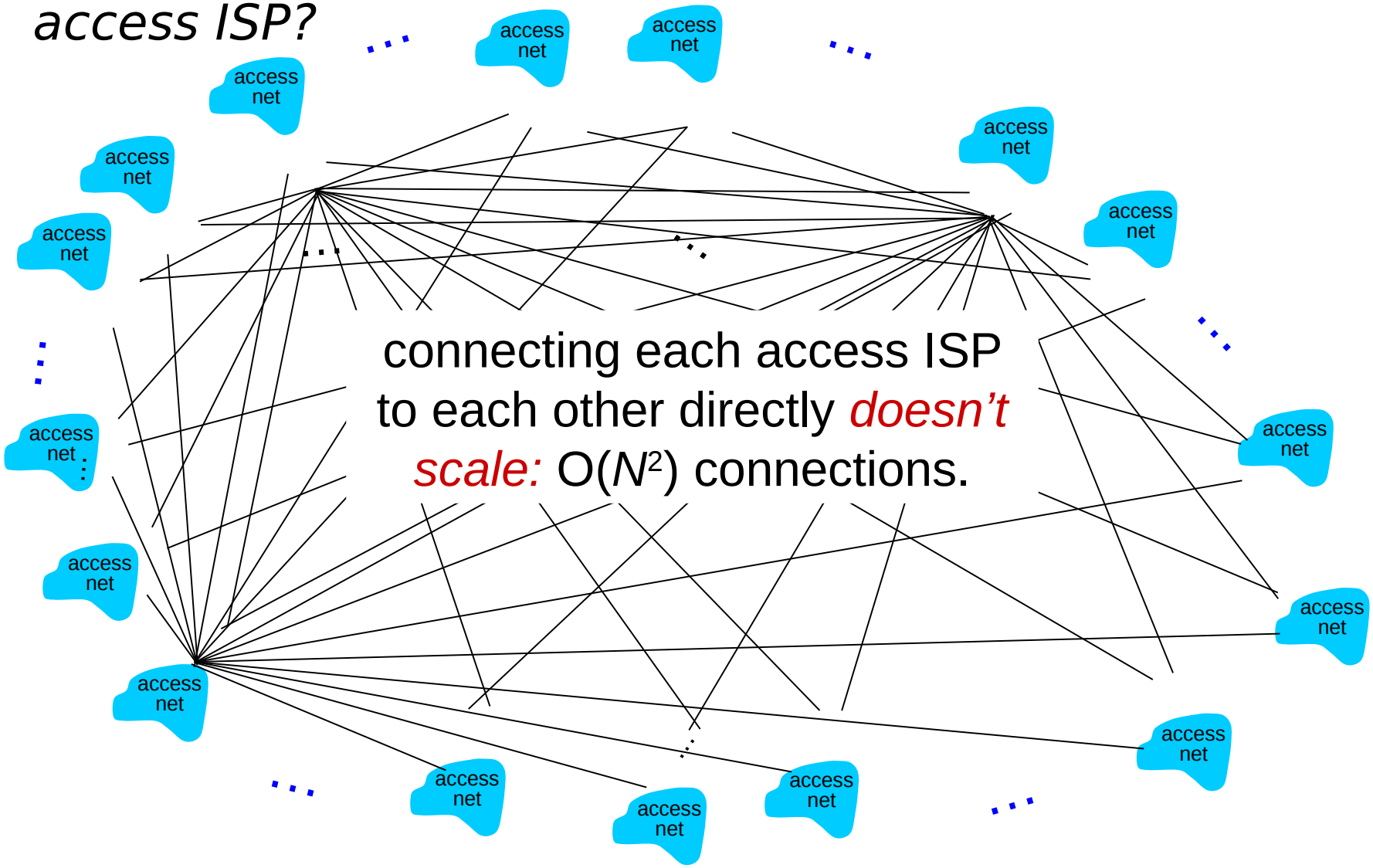
Internet structure: network of networks

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



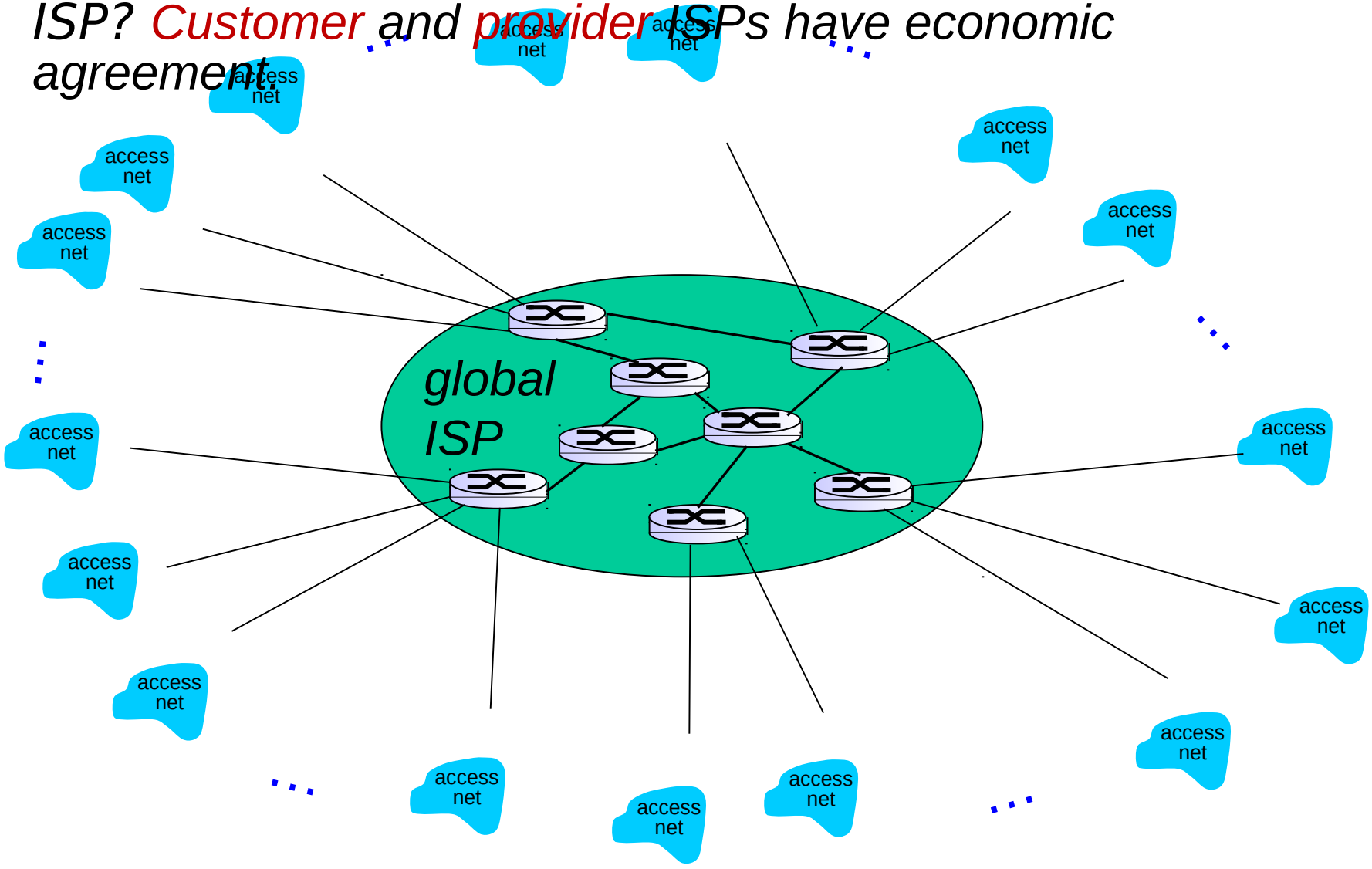
Internet structure: network of networks

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



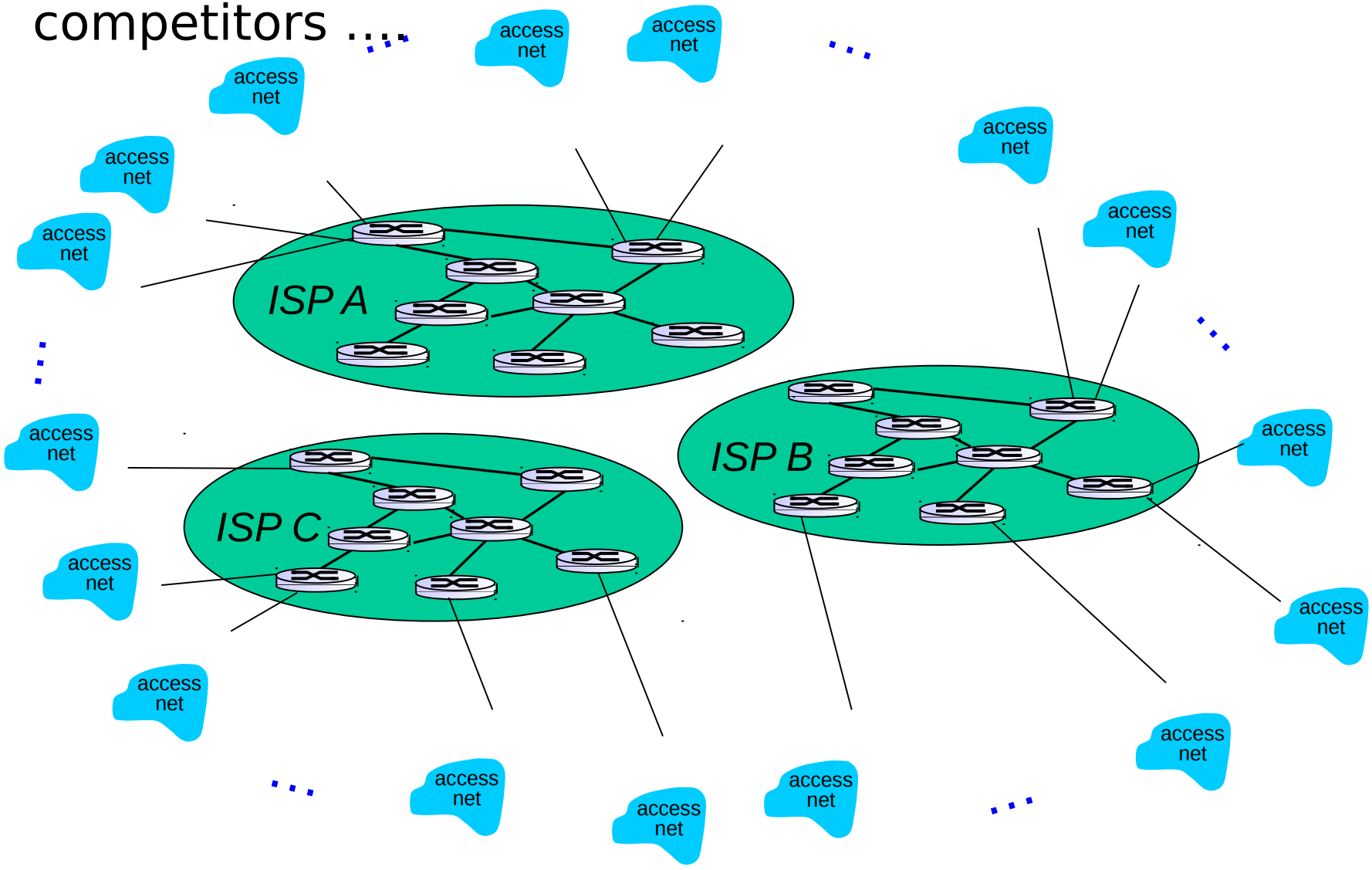
Internet structure: network of networks

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



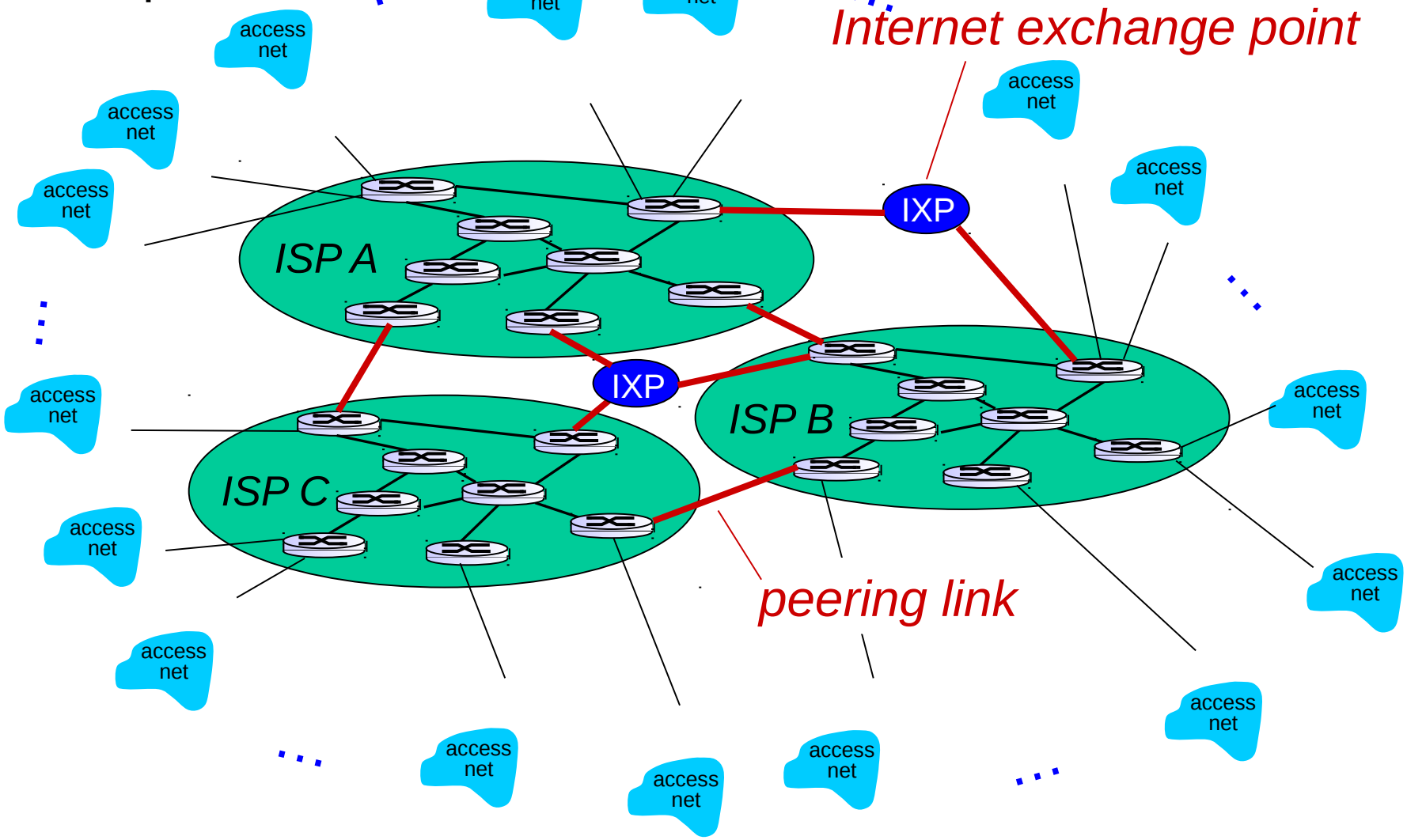
Internet structure: network of networks

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



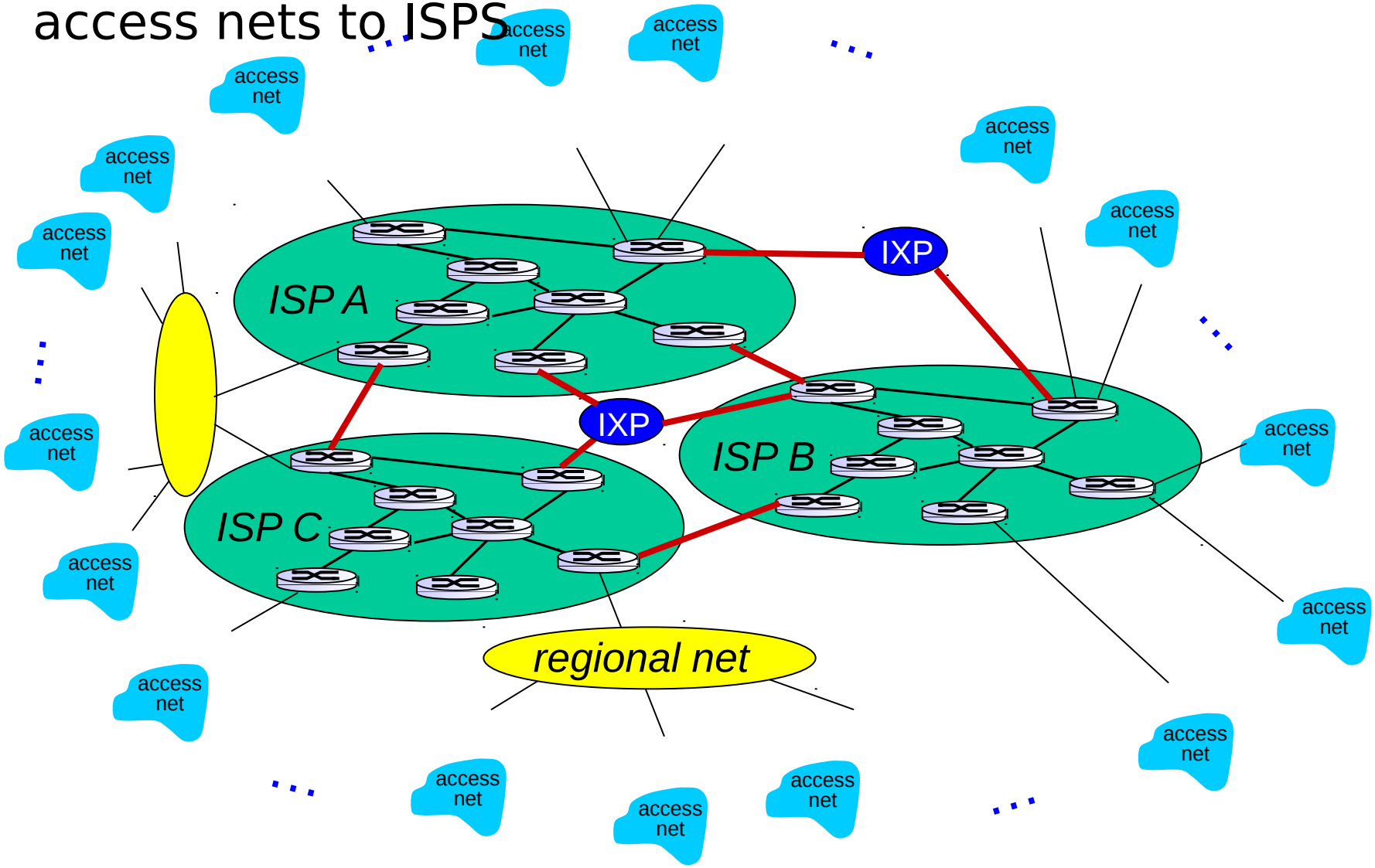
Internet structure: network of networks

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



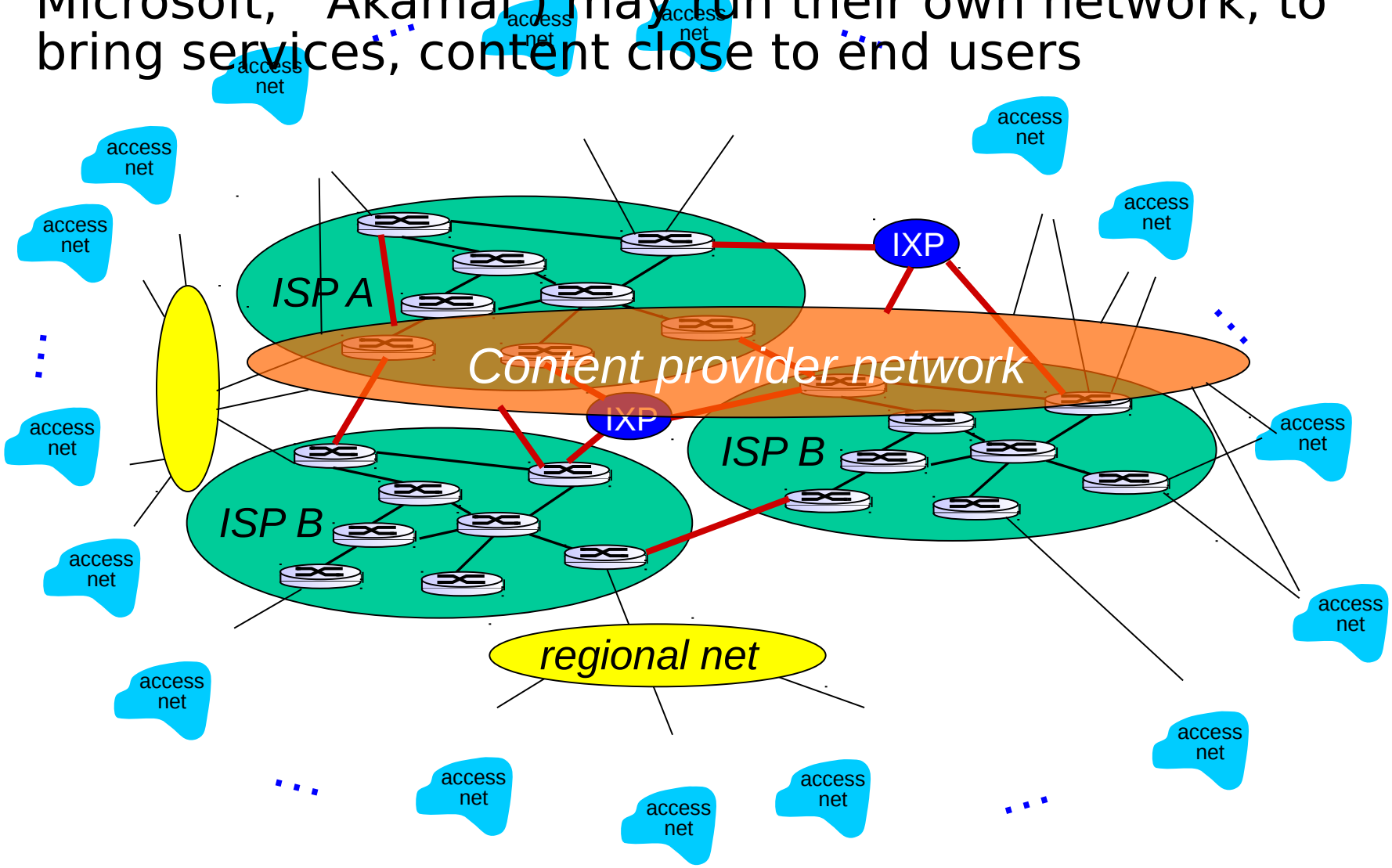
Internet structure: network of networks

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

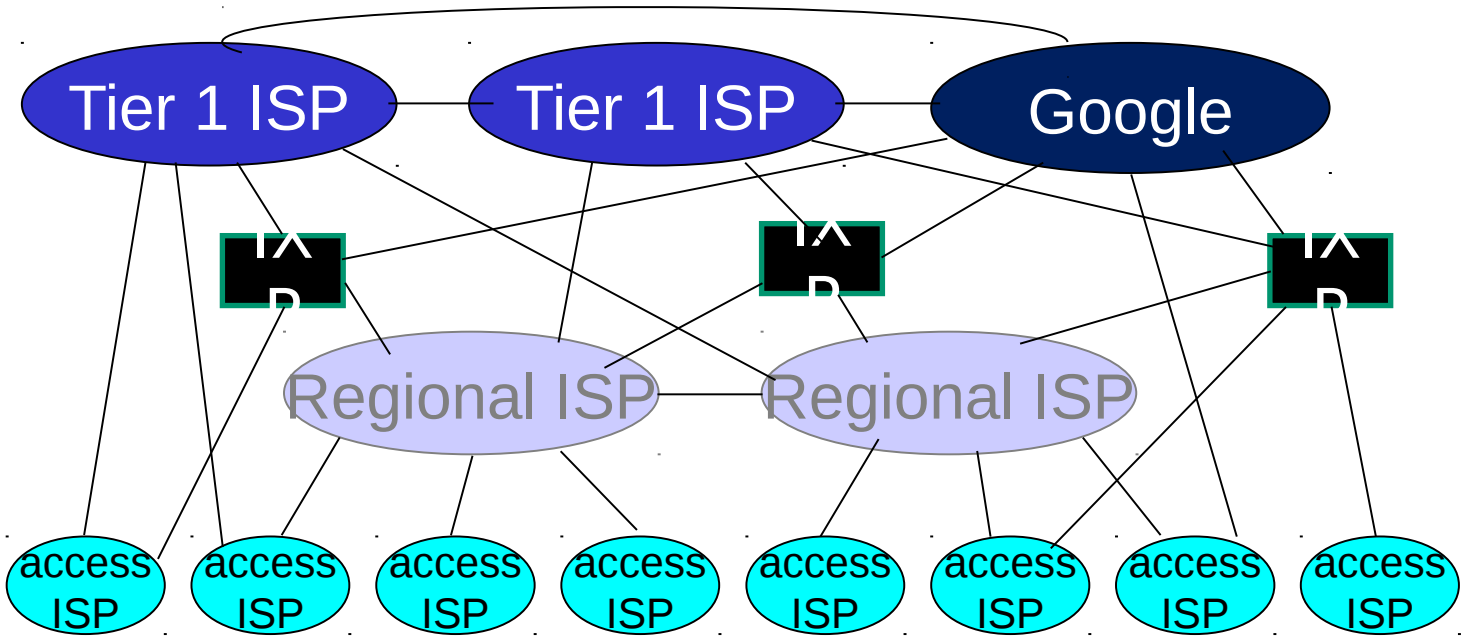


Internet structure: network of networks

… 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
  - content provider network (e.g, Google): private network that connects it data centers to Internet, often bypassing tier-1, regional ISPs

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Protocol “layers”

Networks are complex, with many “pieces”:

- hosts
- routers
- links of various media
- applications
- protocols
- hardware, software

Question:

is there any hope of organizing structure of network?

…. or at least our discussion of networks?

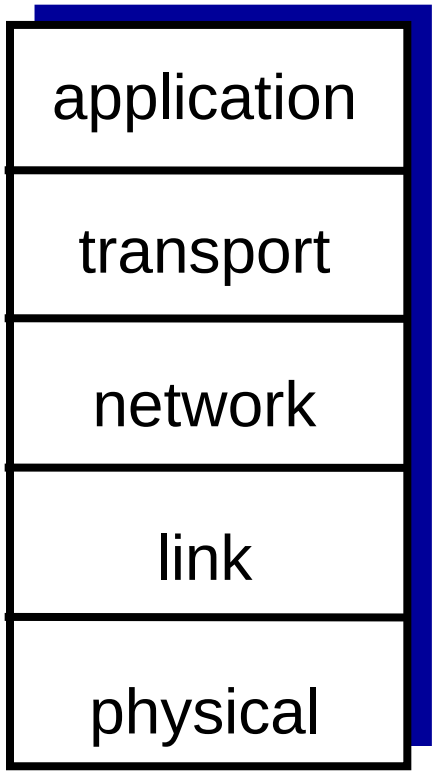
Why layering?

dealing with complex systems:

- *explicit structure allows identification, relationship of complex system's pieces*
  - layered *reference model* for discussion
- *modularization eases maintenance, updating of system*
  - change of implementation of layer's service transparent to rest of system
  - e.g., change in gate procedure doesn't affect rest of system

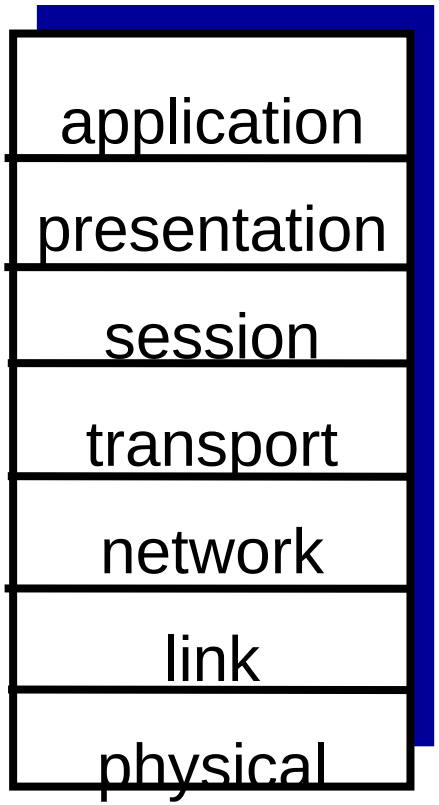
Internet protocol stack

- *application: supporting network applications*
  - FTP, SMTP, HTTP
- *transport: process-process data transfer*
  - TCP, UDP
- *network: routing of datagrams from source to destination*
  - IP, routing protocols
- *link: data transfer between neighboring network elements*
  - Ethernet, 802.111 (WiFi), PPP
- *physical: bits "on the wire"*



ISO/OSI reference model

- *presentation: allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions*
- *session: synchronization, checkpointing, recovery of data exchange*
- *Internet stack "missing" these layers!*
  - these services, *if needed,* must be implemented in application
  - needed?



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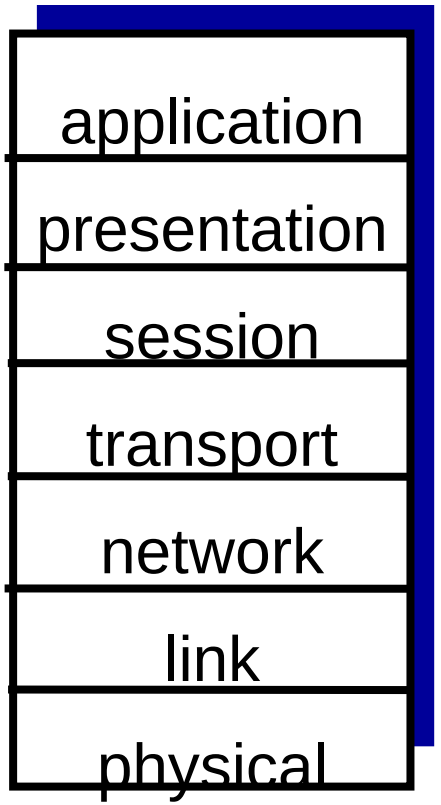
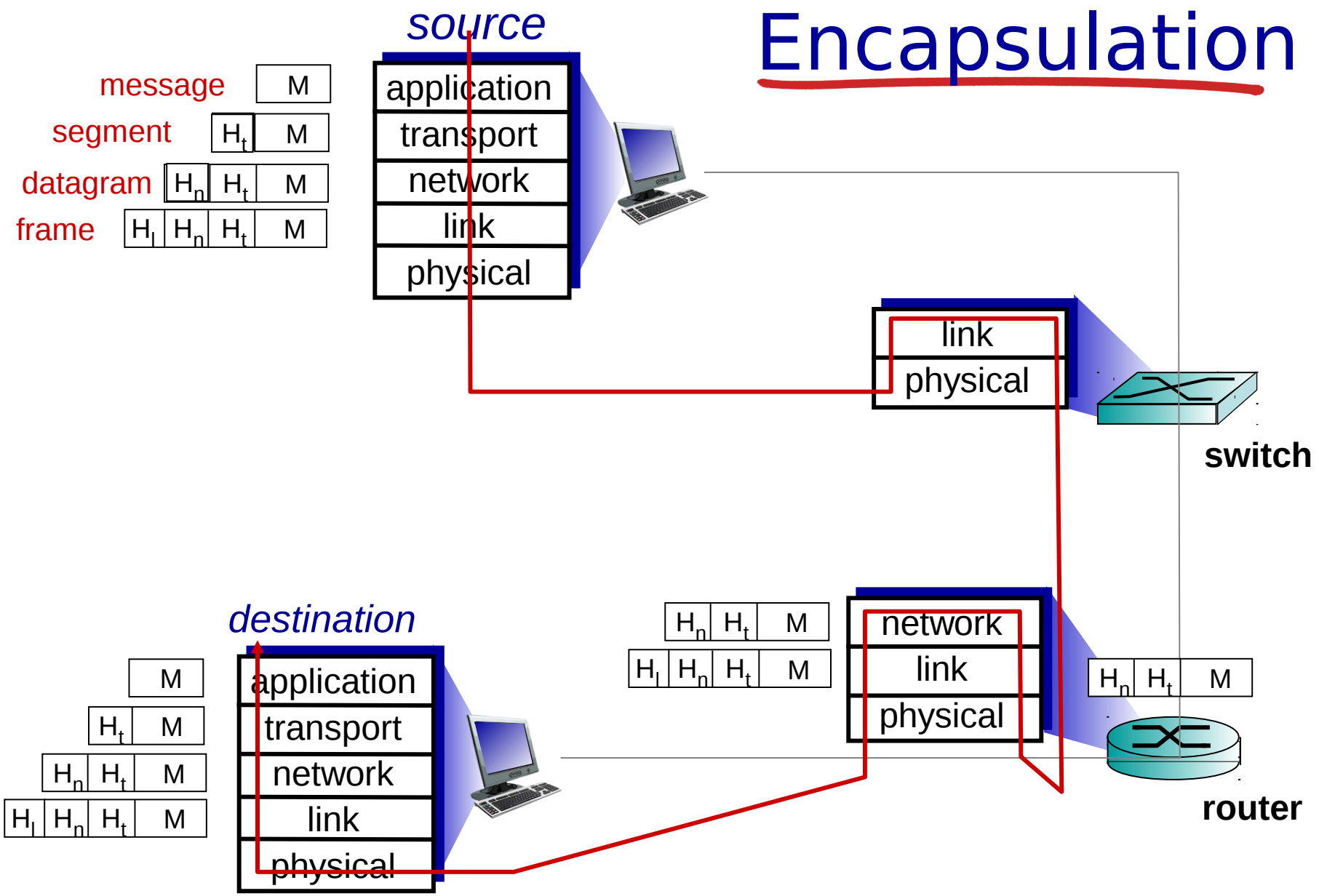


Encapsulation



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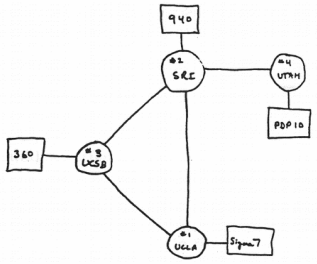
Internet history

http://www.internetsociety.org/internet/what-internet/history-internet/brief-history-internet

1961-1972: Early packet-switching principles

- *1961: Kleinrock - queueing theory shows effectiveness of packet-switching*
- *1964: Baran - packet-switching in military nets*
- *1967: ARPAnet conceived by Advanced Research Projects Agency*
- *1969: first ARPAnet node operational*

- *1972:*
  - ARPAnet public demo
  - NCP (Network Control Protocol) first host-host protocol
  - first e-mail program
  - ARPAnet has 15 nodes



THE ARPA NETWORK

Internet history

1972-1980: Internetworking, new and proprietary nets

- *1970: ALOHAnet satellite network in Hawaii*
- *1974: Cerf and Kahn - architecture for interconnecting networks*
- *1976: Ethernet at Xerox PARC*
- *late70's: proprietary architectures: DECnet, SNA, XNA*
- *late 70's: switching fixed length packets (ATM precursor)*
- *1979: ARPAnet has 200 nodes*

Cerf and Kahn's internetworking principles:

- minimalism, autonomy - no internal changes required to interconnect networks
- best effort service model
- stateless routers
- decentralized control

define today's Internet architecture

Internet history

1980-1990: new protocols, a proliferation of networks

- *1983: deployment of TCP/IP*
- *1982: smtp e-mail protocol defined*
- *1983: DNS defined for name-to-IP-address translation*
- *1985: ftp protocol defined*
- *1988: TCP congestion control*
- *new national networks: Csnet, BITnet, NSFnet, Minitel*
- *100,000 hosts connected to confederation of networks*

Internet history

1990, 2000's: commercialization, the Web, new apps

- *early 1990s: Web*
  - HTML, HTTP: Berners-Lee
  - 1994: Mosaic, later Netscape
  - late 1990's: commercialization of the Web

late 1990's – 2000's:

- *more killer apps: instant messaging, P2P file sharing*
- *network security to forefront*
- *est. 50 million host, 100 million+ users*
- *backbone links running at Gbps*

Internet history

2005-present

- *~750 million hosts*
  - Smartphones and tablets
- *Aggressive deployment of broadband access*
- *Increasing ubiquity of high-speed wireless access*
- *Emergence of online social networks:*
  - Facebook: soon one billion users
- *Service providers (Google, Microsoft) create their own networks*
  - Bypass Internet, providing "instantaneous" access to search, email, etc.
- *E-commerce, universities, enterprises running their services in "cloud" (eg, Amazon EC2)*

Introduction: summary

covered a "ton" of material!

- *Internet overview*
- *what's a protocol?*
- *network edge, core, access network*
  - packet-switching versus circuit-switching
  - Internet structure
- *performance: loss, delay, throughput*
- *layering, service models*
- *security*
- *history*

you now have:

- *context, overview, "feel" of networking*
- *more depth, detail to follow!*