

شبکه های کامپیوتری ۲

جلسه ۱ فصل ۱

مرور و یادآوری مباحث شبکه ۱

دانشگاه صنعتی اصفهان

دانشکده مهندسی برق و کامپیوتر

Chapter I

Introduction

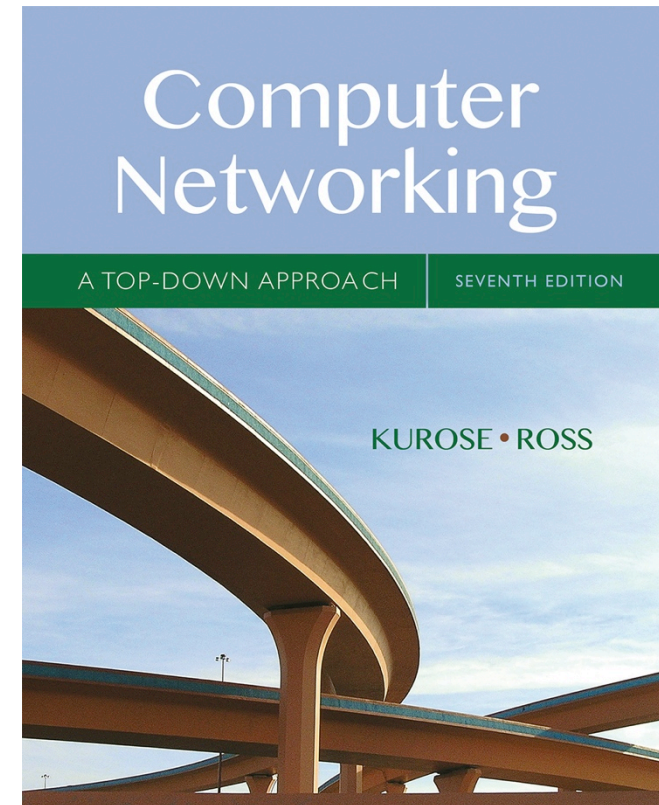
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Computer Networking: A Top Down Approach

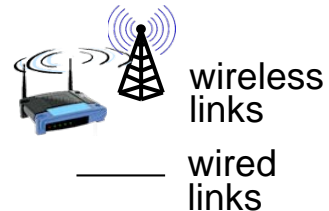
7th edition

Jim Kurose, Keith Ross

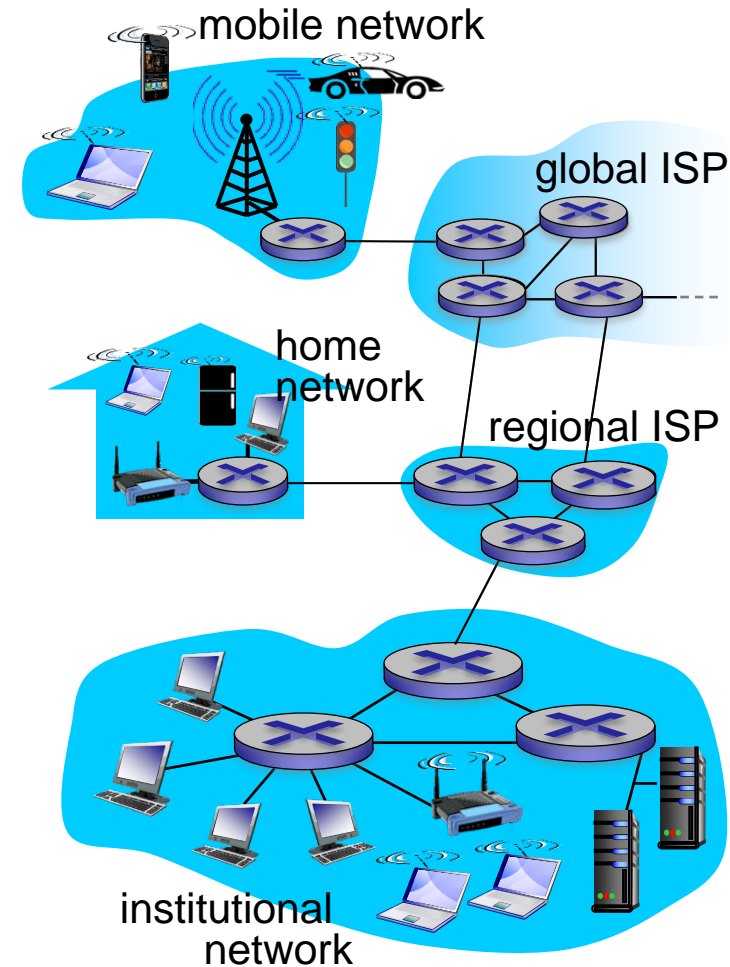
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April 2016

What's the Internet: “nuts and bolts” view

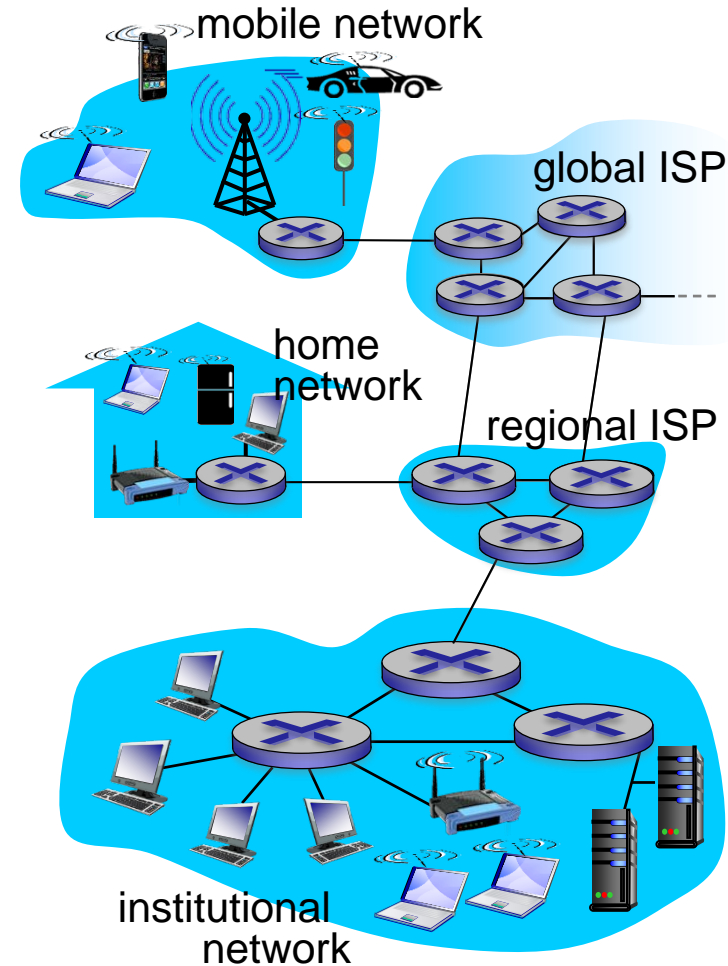


- billions of connected computing devices:
 - *hosts* = *end systems*
 - running *network apps*
- *communication links*
 - fiber, copper, radio, satellite
 - transmission rate: *bandwidth*
- *packet switches*: forward packets (chunks of data)
 - *routers* and *switches*



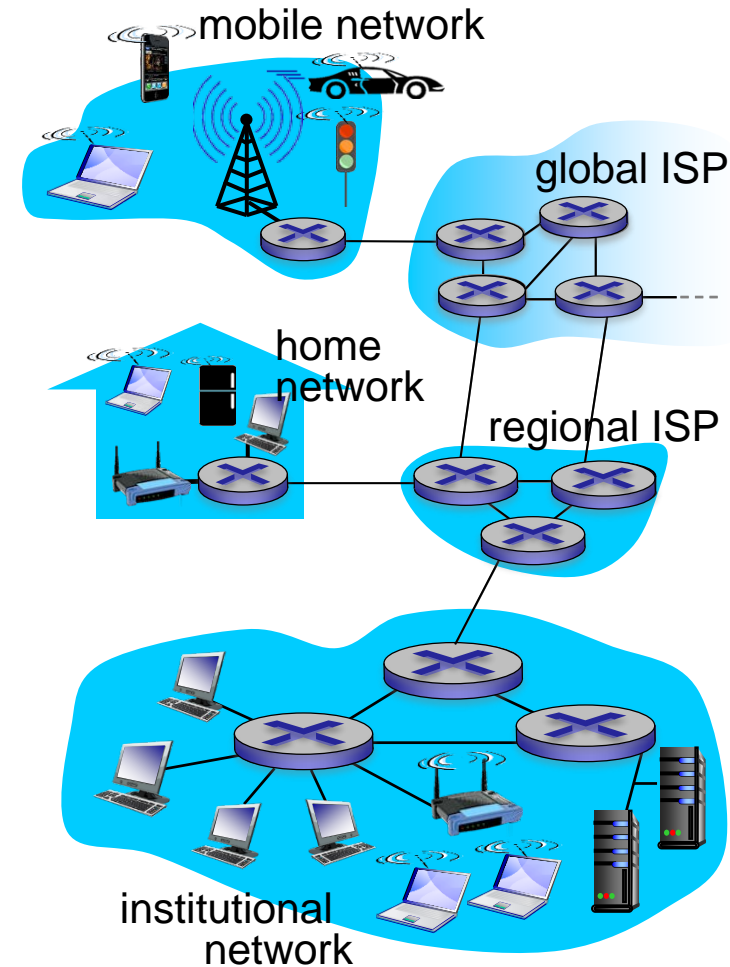
What's the Internet: "nuts and bolts" view

- *Internet: "network of networks"*
 - Interconnected ISPs
- *protocols* control sending, receiving of messages
 - 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 messages sent

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

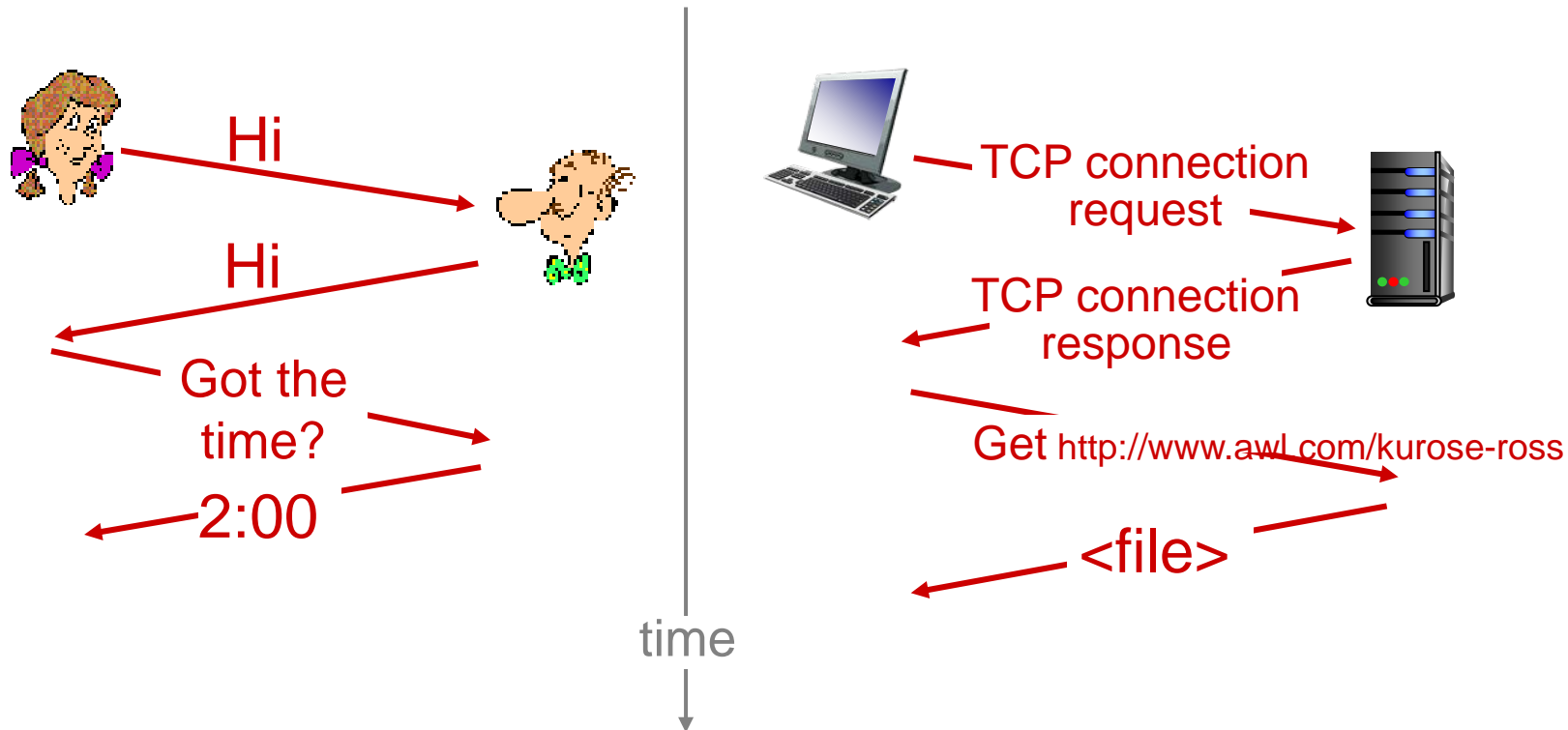
network protocols:

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

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

What's a protocol?

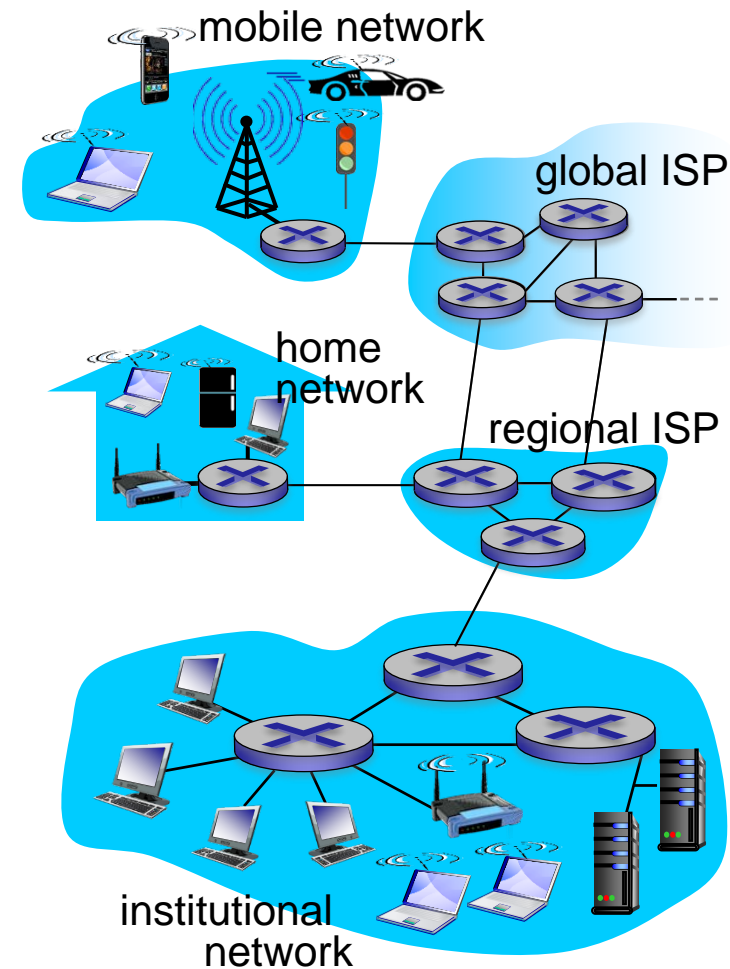
a human protocol and a computer network protocol:



Q: other human protocols?

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



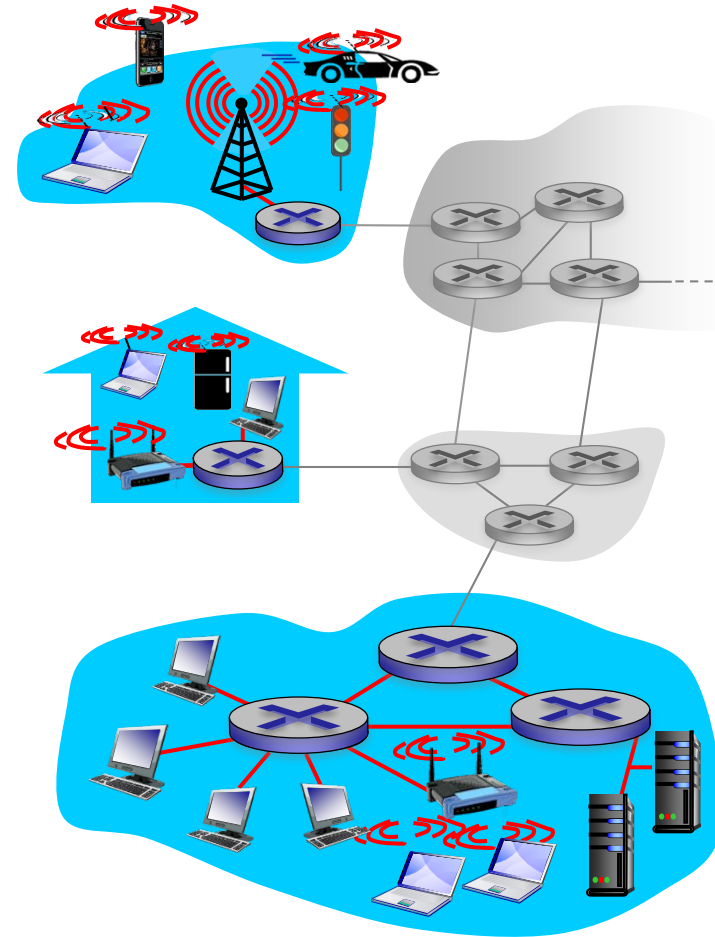
Access networks and physical media

Q: How to connect end systems to edge router?

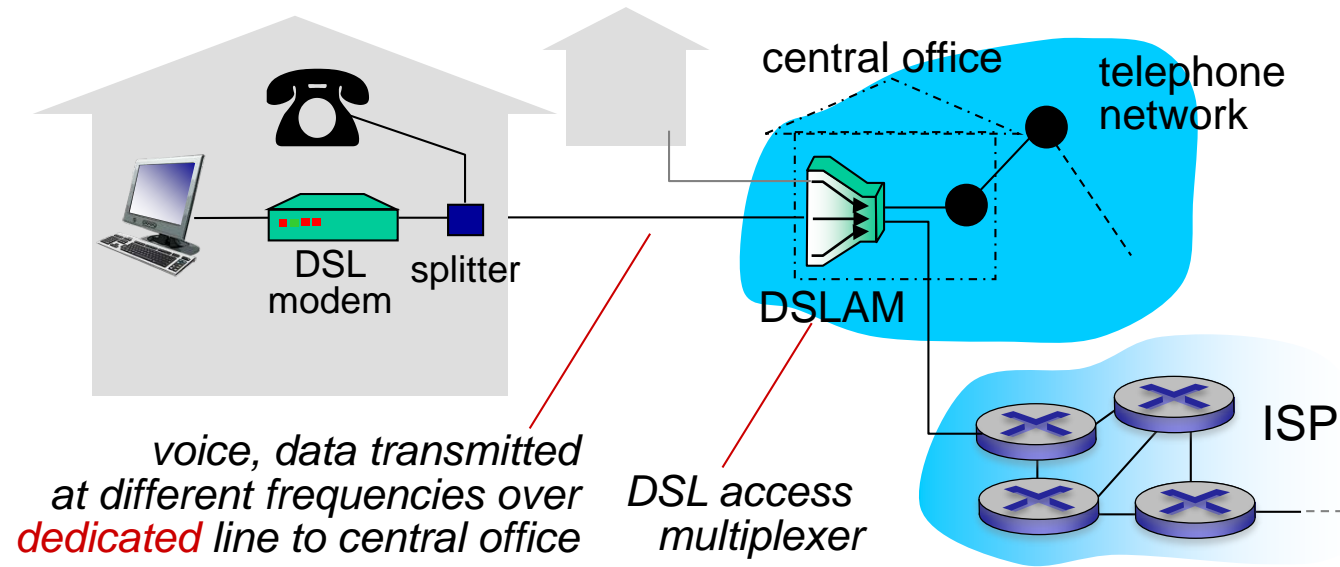
- residential access nets
- institutional access networks (school, company)
- mobile access networks

keep in mind:

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

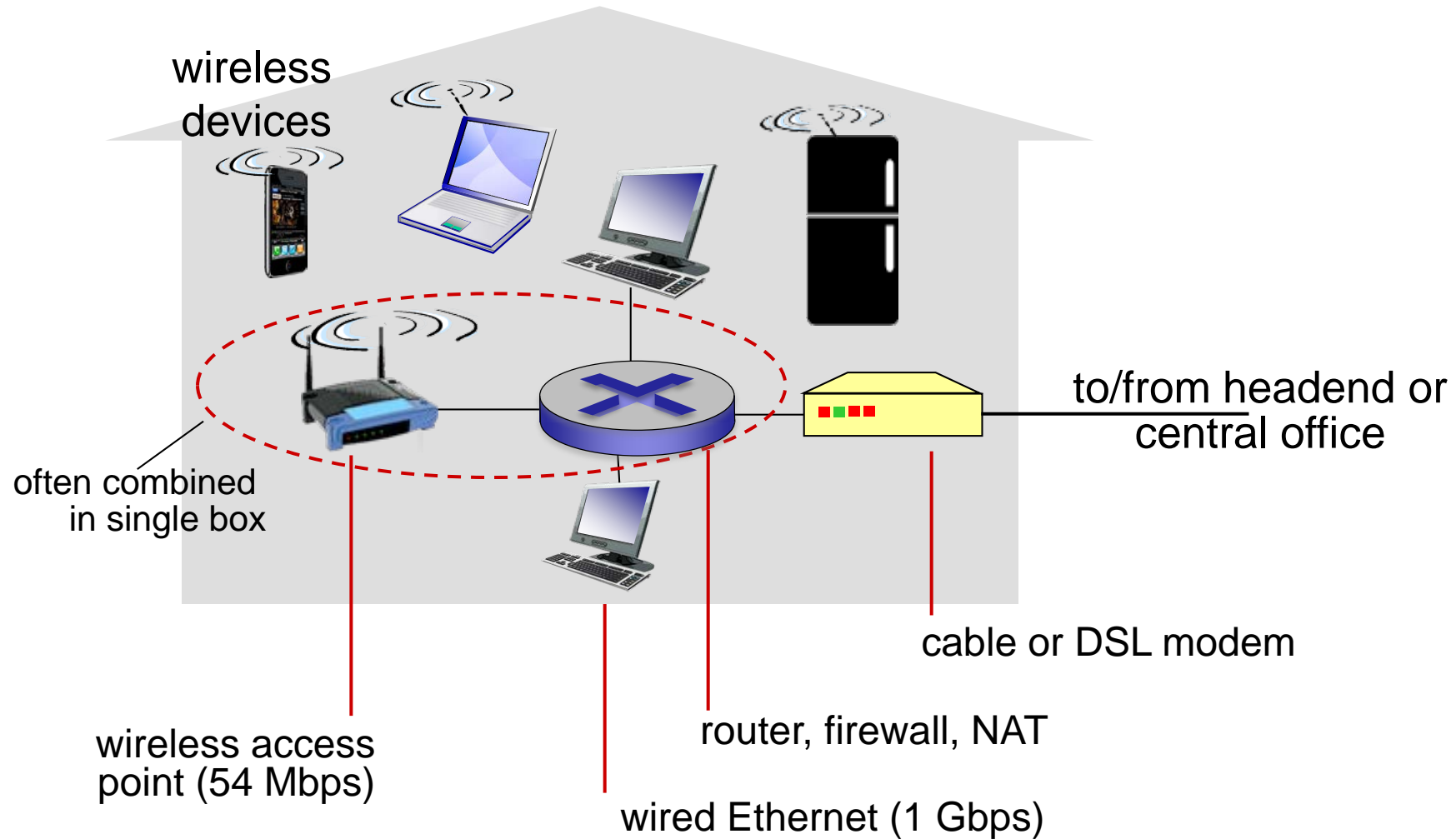


Access network: digital subscriber line (DSL)

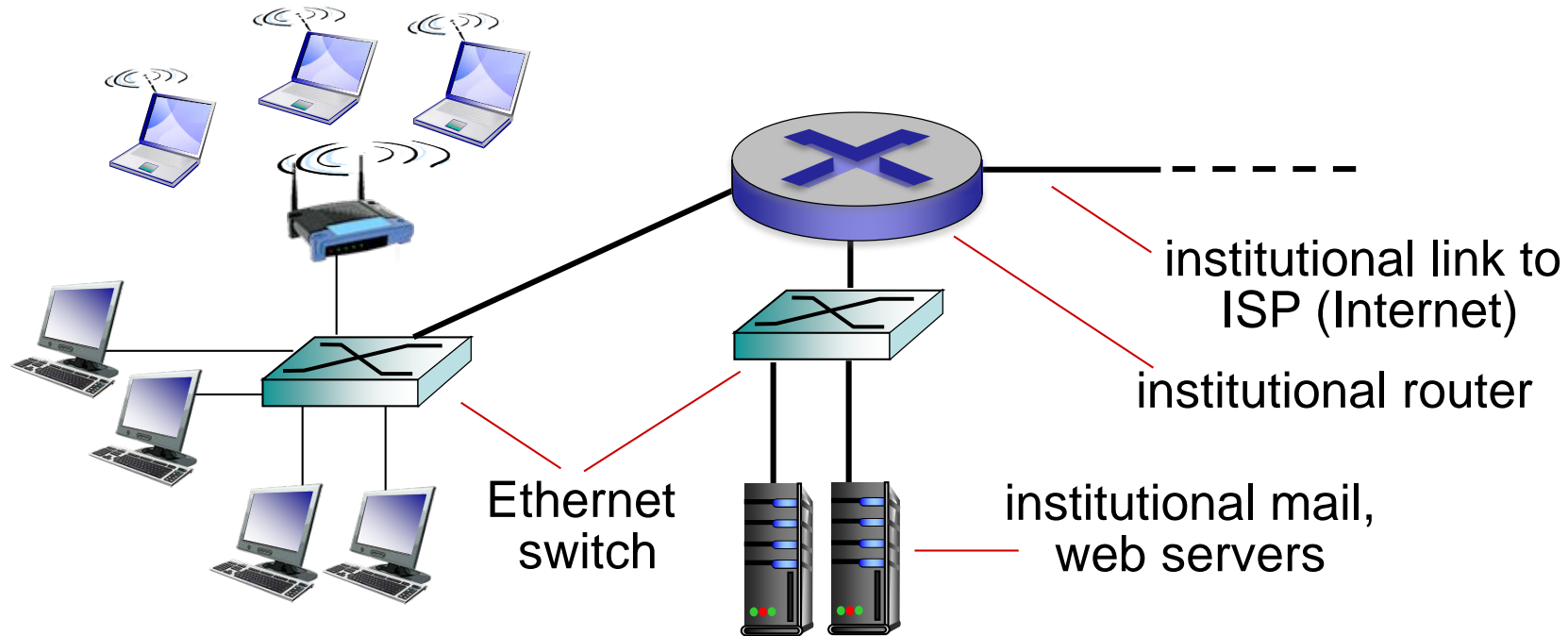


- use *existing* telephone line to central office DSLAM
 - data over DSL phone line goes to Internet
 - voice over DSL phone line goes to telephone net
- < 2.5 Mbps upstream transmission rate (typically < 1 Mbps)
- < 24 Mbps downstream transmission rate (typically < 10 Mbps)

Access network: home network



Enterprise access networks (Ethernet)



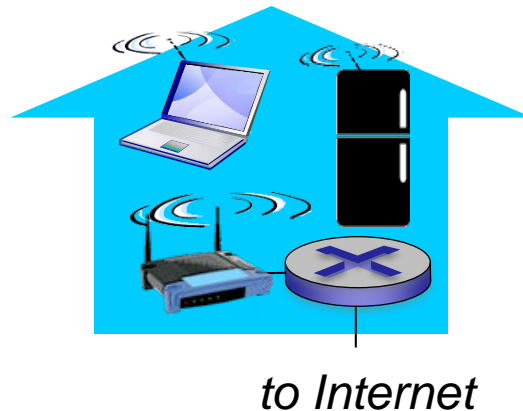
- typically used in companies, universities, etc.
- 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
- today, end systems typically connect into Ethernet switch

Wireless access networks

- shared *wireless* access network connects end system to router
 - via base station aka “access point”

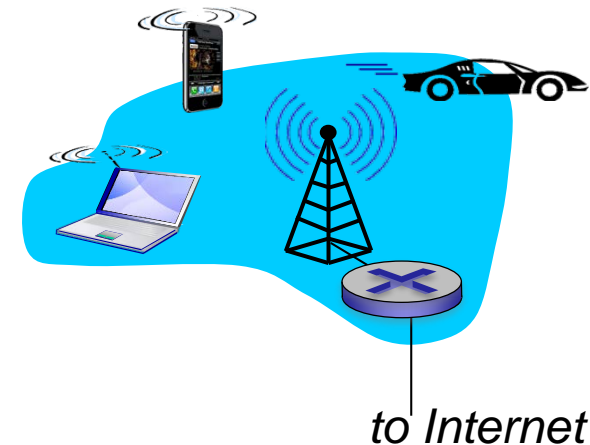
wireless LANs:

- within building (100 ft.)
- 802.11b/g/n (WiFi): 11, 54, 450 Mbps transmission rate



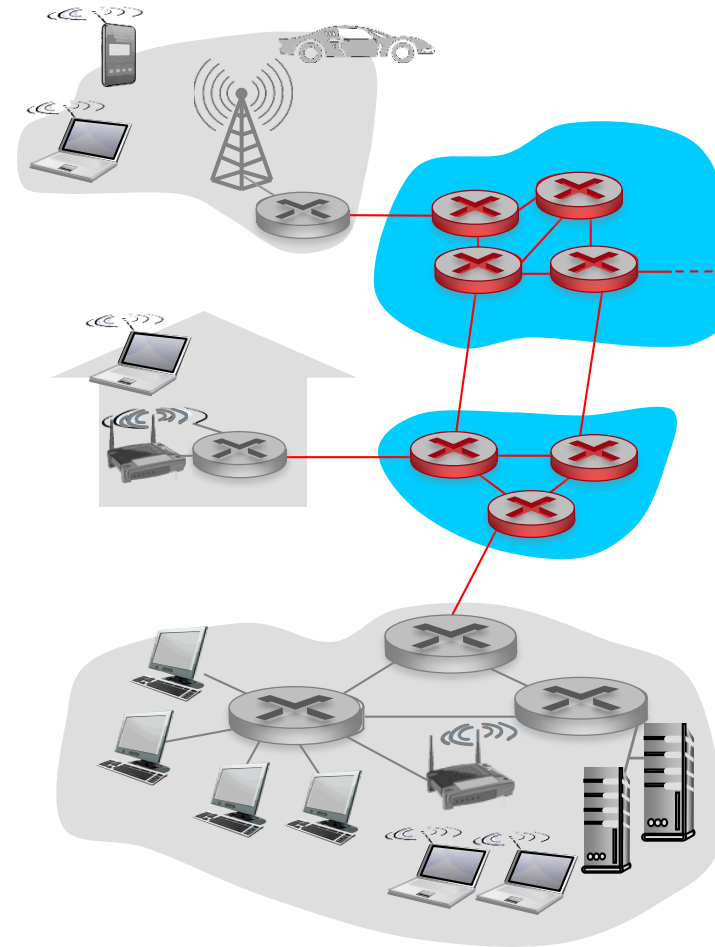
wide-area wireless access

- provided by telco (cellular) operator, 10's km
- between 1 and 10 Mbps
- 3G, 4G: LTE



The network core

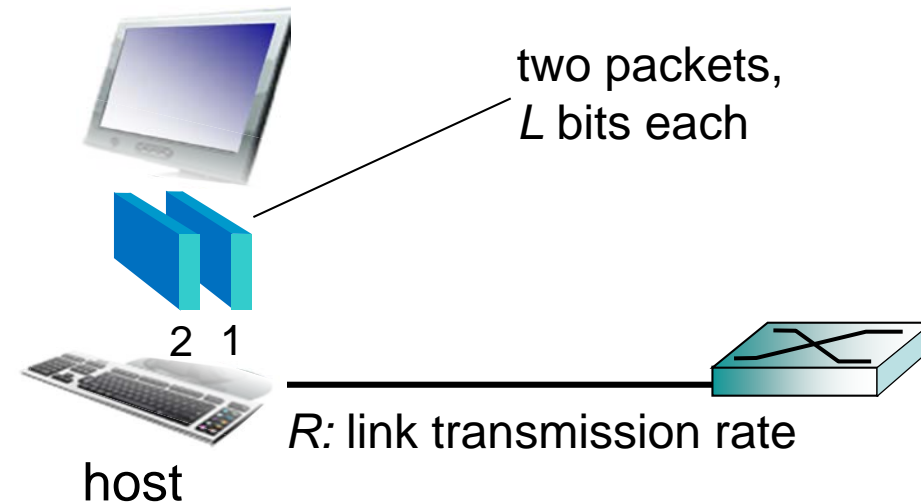
- mesh of interconnected routers
- packet-switching: hosts break application-layer messages into *packets*
 - forward packets from one router to the next, across links on path from source to destination
 - each packet transmitted at full link capacity



Host: sends *packets* of data

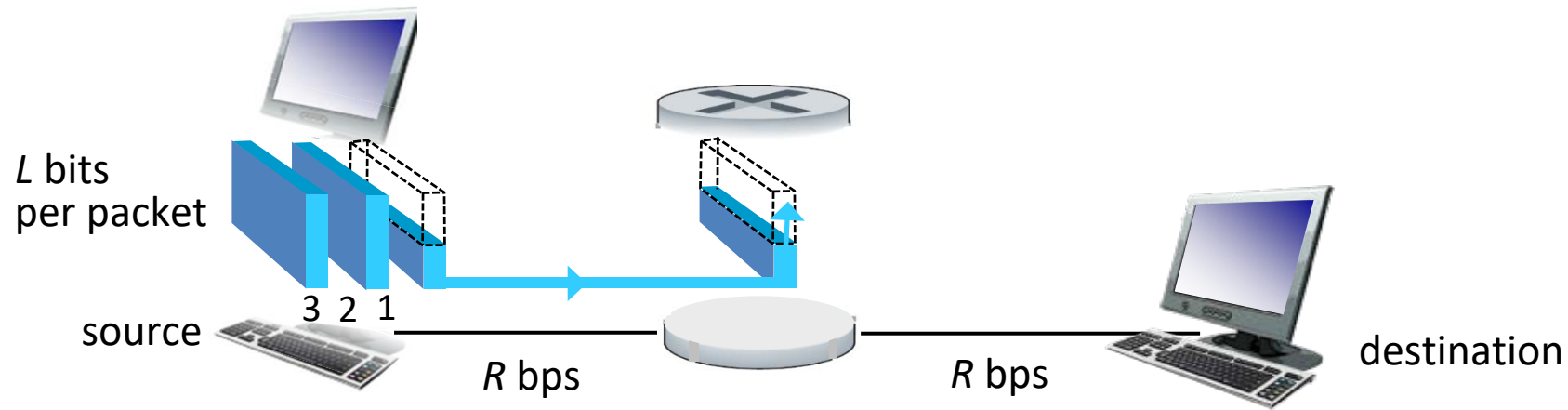
host sending function:

- takes application message
- breaks into smaller chunks, known as *packets*, of length L bits
- transmits packet into access network at *transmission rate R*
 - link transmission rate, aka link *capacity*, aka *link bandwidth*



$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

Packet-switching: store-and-forward



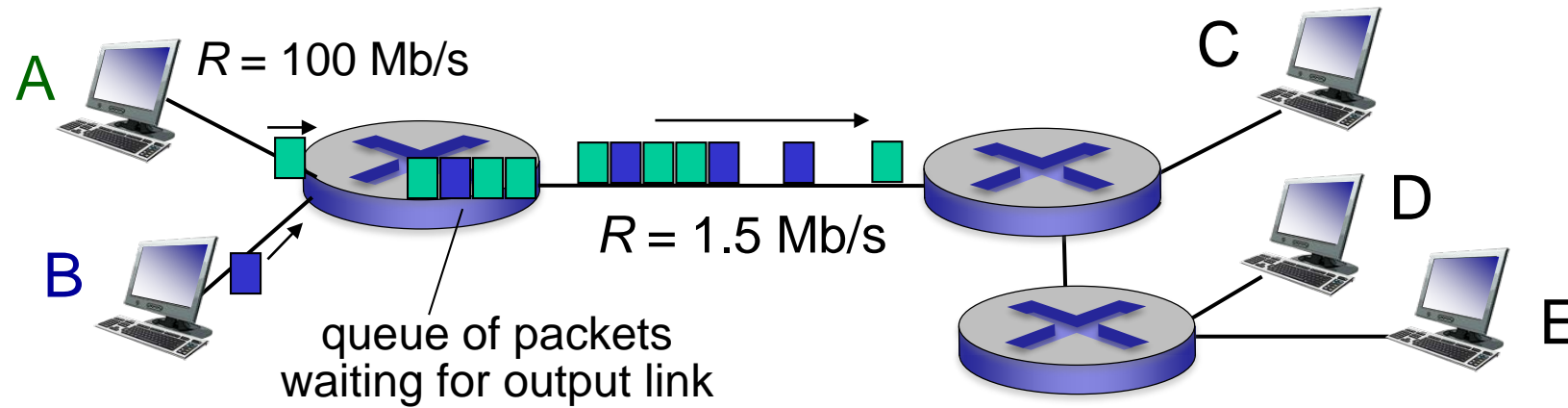
- takes L/R seconds to transmit (push out) L -bit packet into link at R bps
- *store and forward*: entire packet must arrive at router before it can be transmitted on next link
- end-end delay = $2L/R$ (assuming zero propagation delay)

one-hop numerical example:

- $L = 7.5$ Mbits
- $R = 1.5$ Mbps
- one-hop transmission delay = 5 sec

} more on delay shortly ...

Packet Switching: queueing delay, loss



queueing and loss:

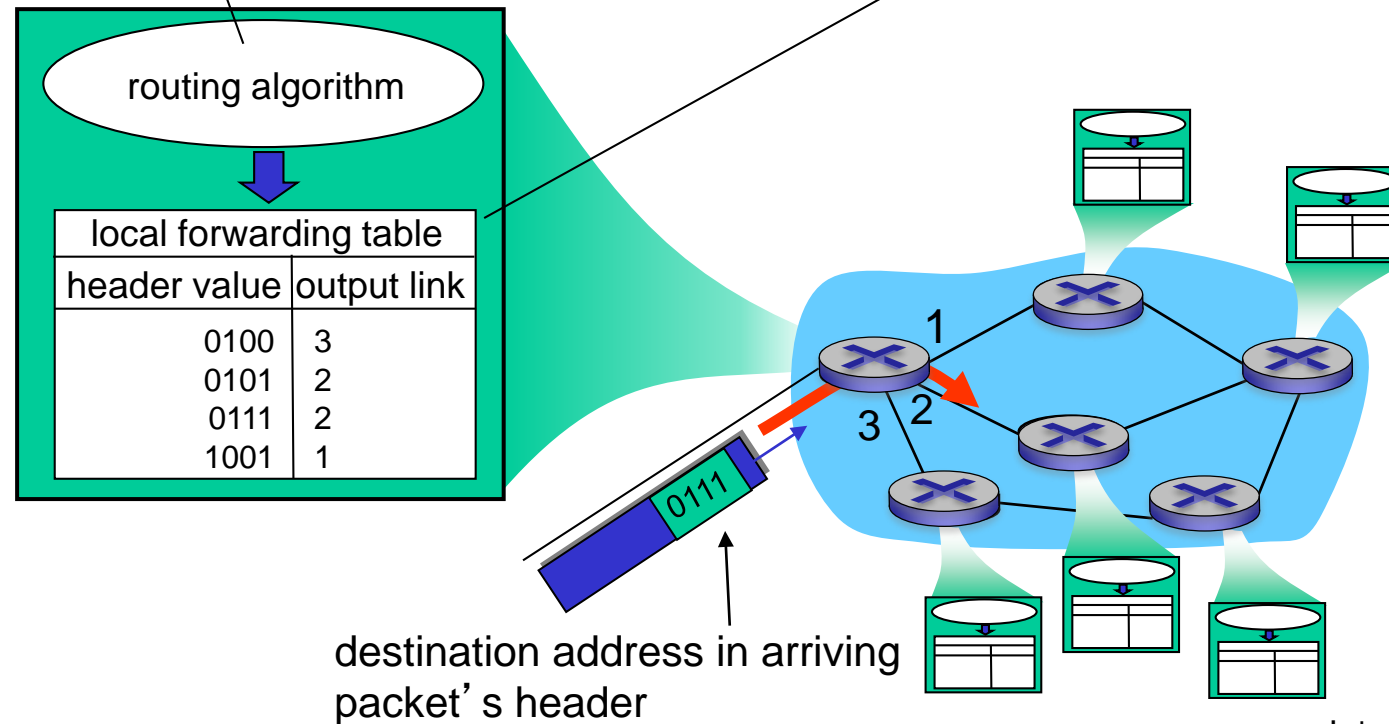
- if arrival rate (in bits) to link exceeds transmission rate of link for a period of time:
 - packets will queue, wait to be transmitted on link
 - packets can be dropped (lost) if memory (buffer) fills up

Two key network-core functions

routing: determines source-destination route taken by packets

- *routing algorithms*

forwarding: move packets from router's input to appropriate router output

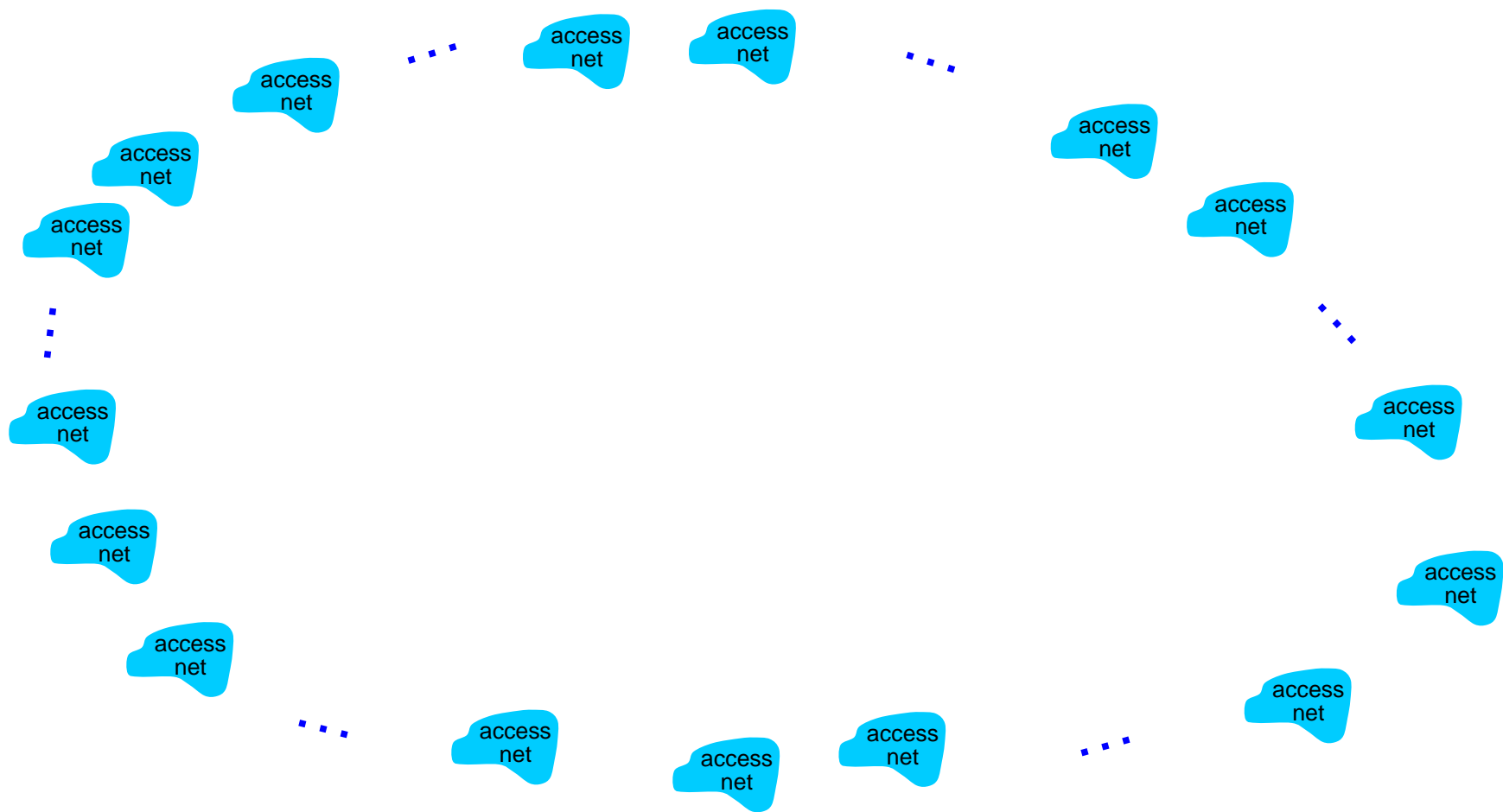


Internet structure: network of networks

- End systems connect to Internet via **access ISPs** (Internet Service Providers)
 - residential, company and university ISPs
- Access ISPs in turn must be interconnected.
 - so that any two hosts can send packets to each other
- Resulting network of networks is very complex
 - evolution was driven by **economics** and **national policies**
- Let's take a stepwise approach to describe current Internet structure

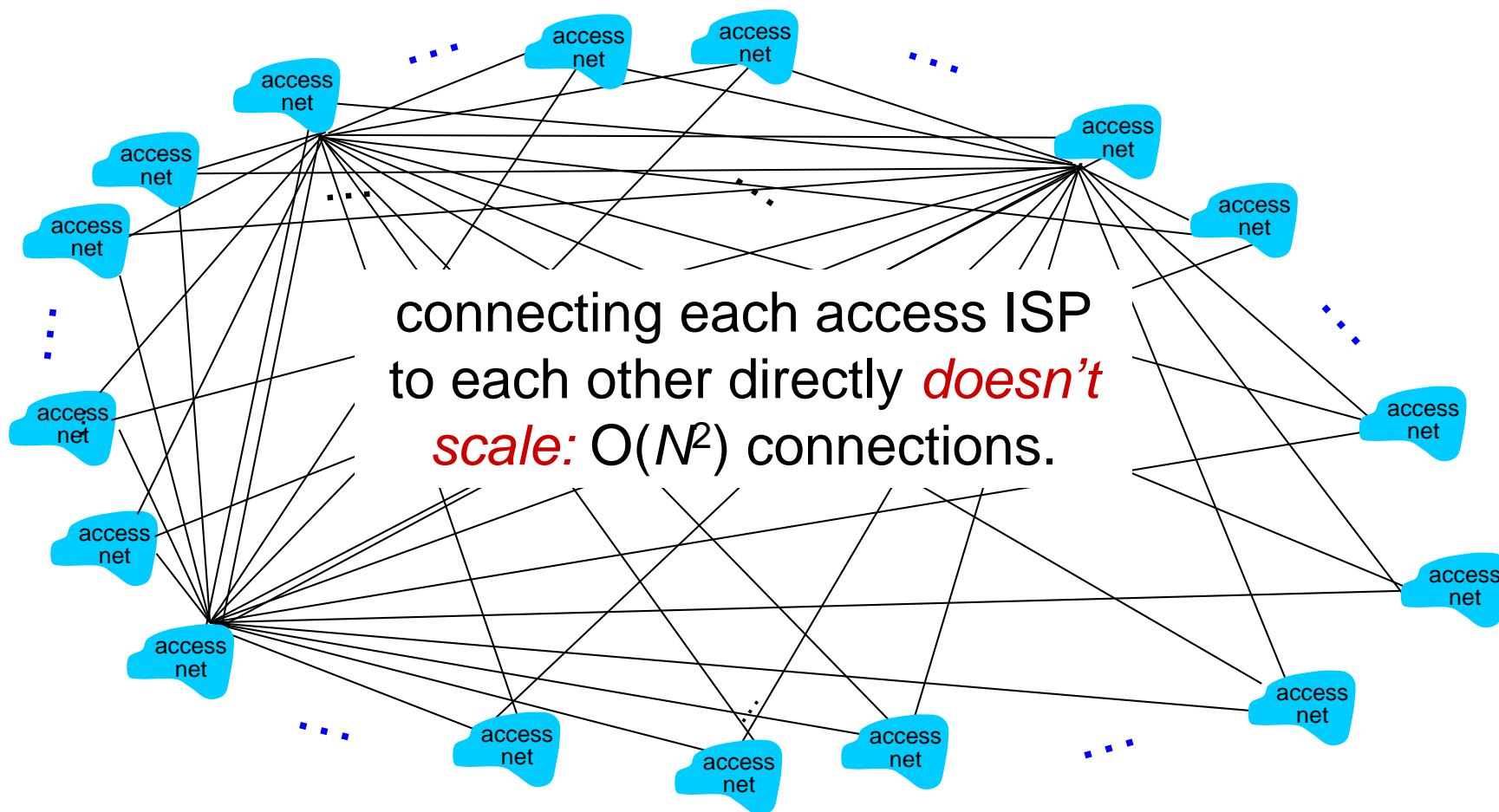
Internet structure: network of networks

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



Internet structure: network of networks

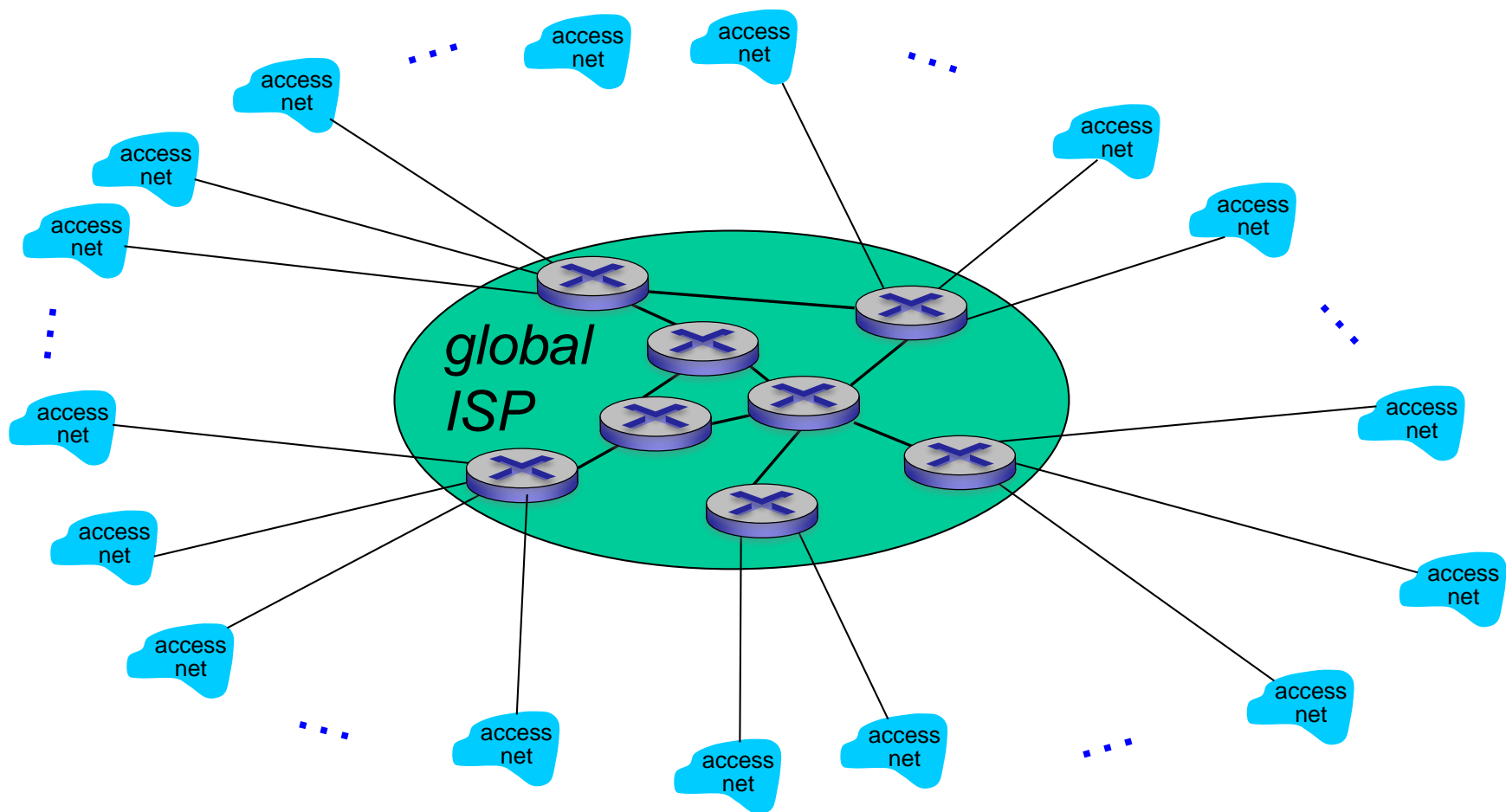
Option: connect each access ISP to every other access ISP?



Internet structure: network of networks

Option: connect each access ISP to one global transit ISP?

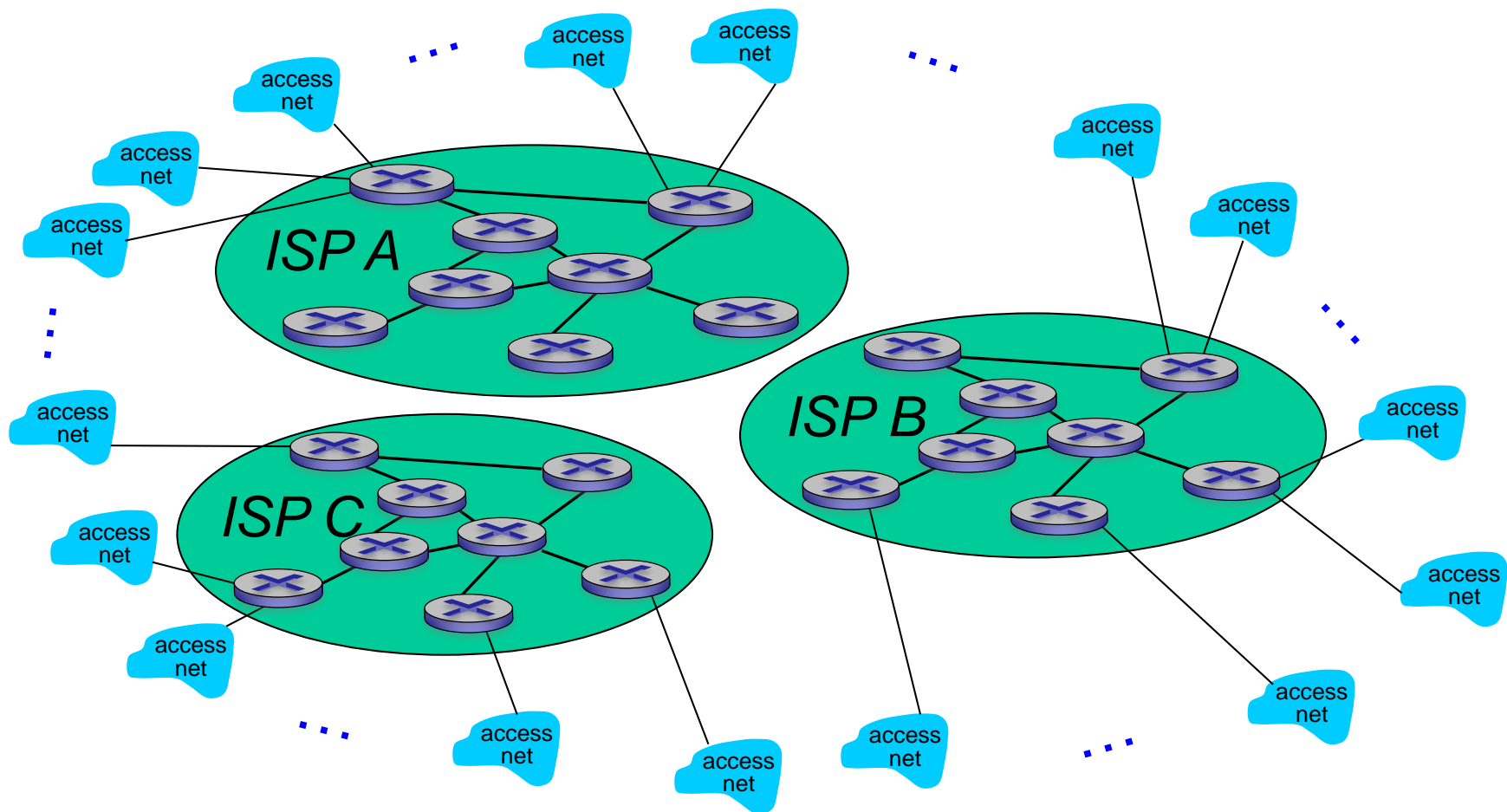
Customer and *provider* ISPs have economic agreement.



Internet structure: network of networks

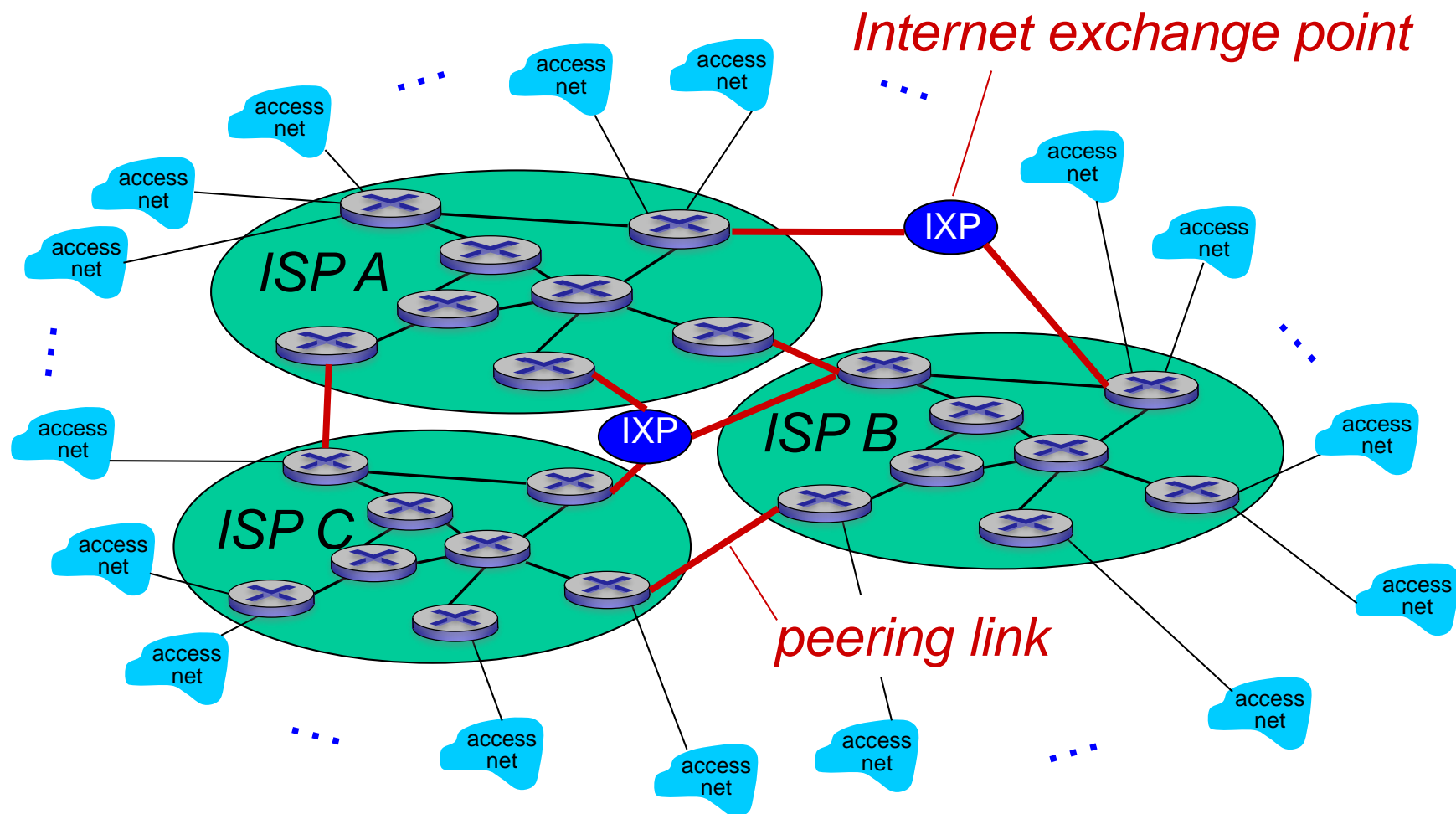
But if one global ISP is viable business, there will be competitors

....



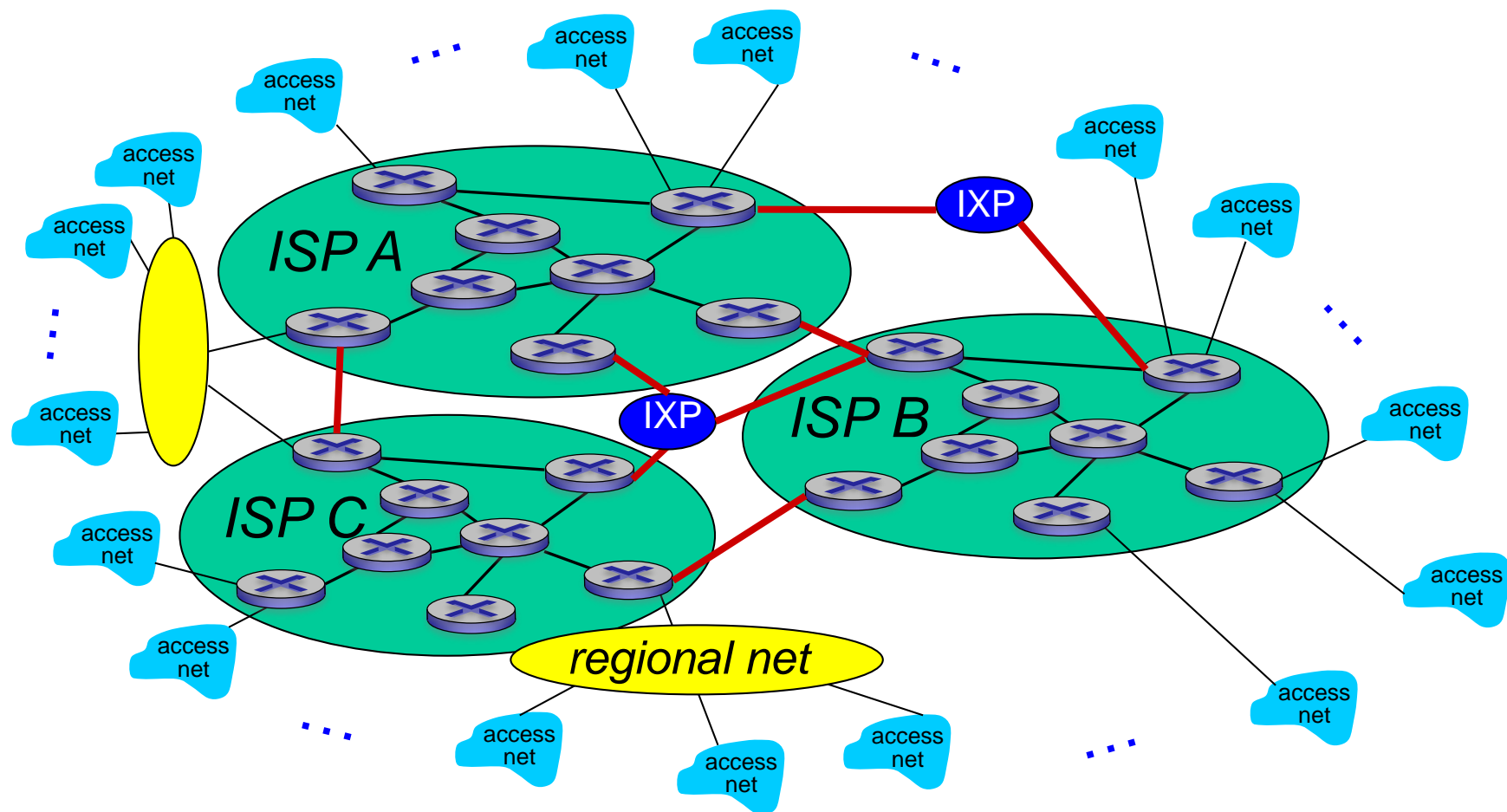
Internet structure: network of networks

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



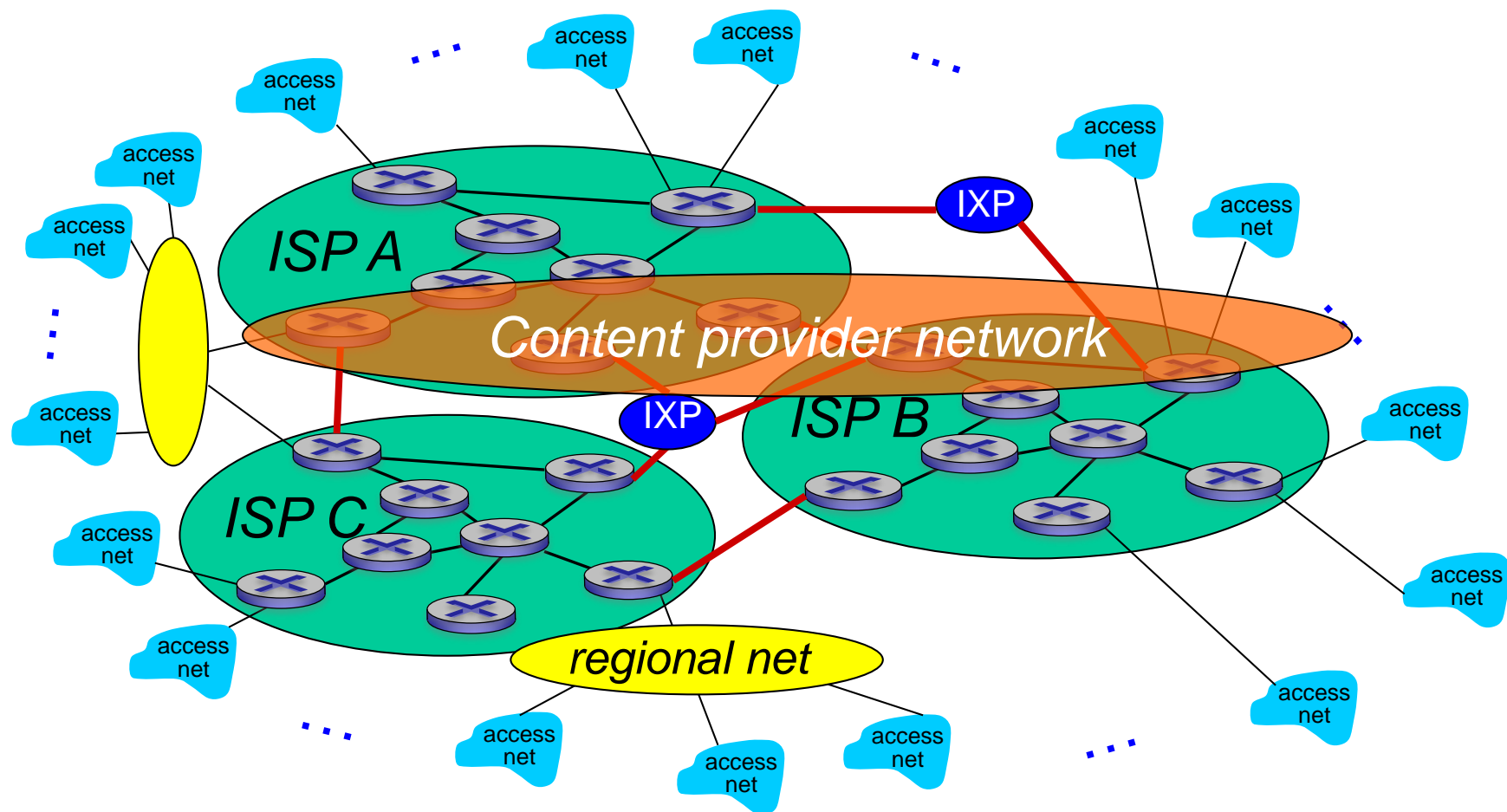
Internet structure: network of networks

... and regional networks may arise to connect access nets to ISPs

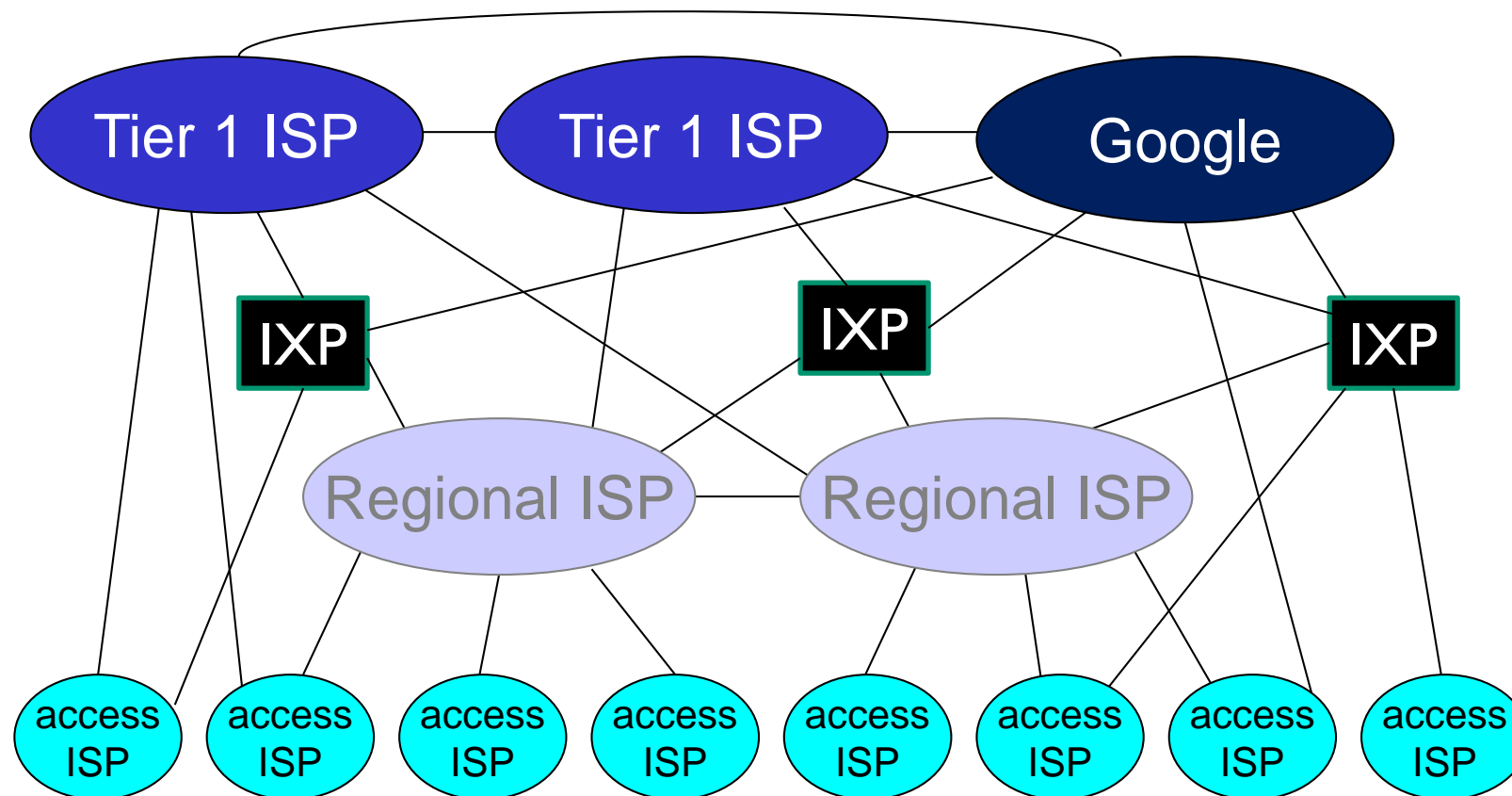


Internet structure: network of networks

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

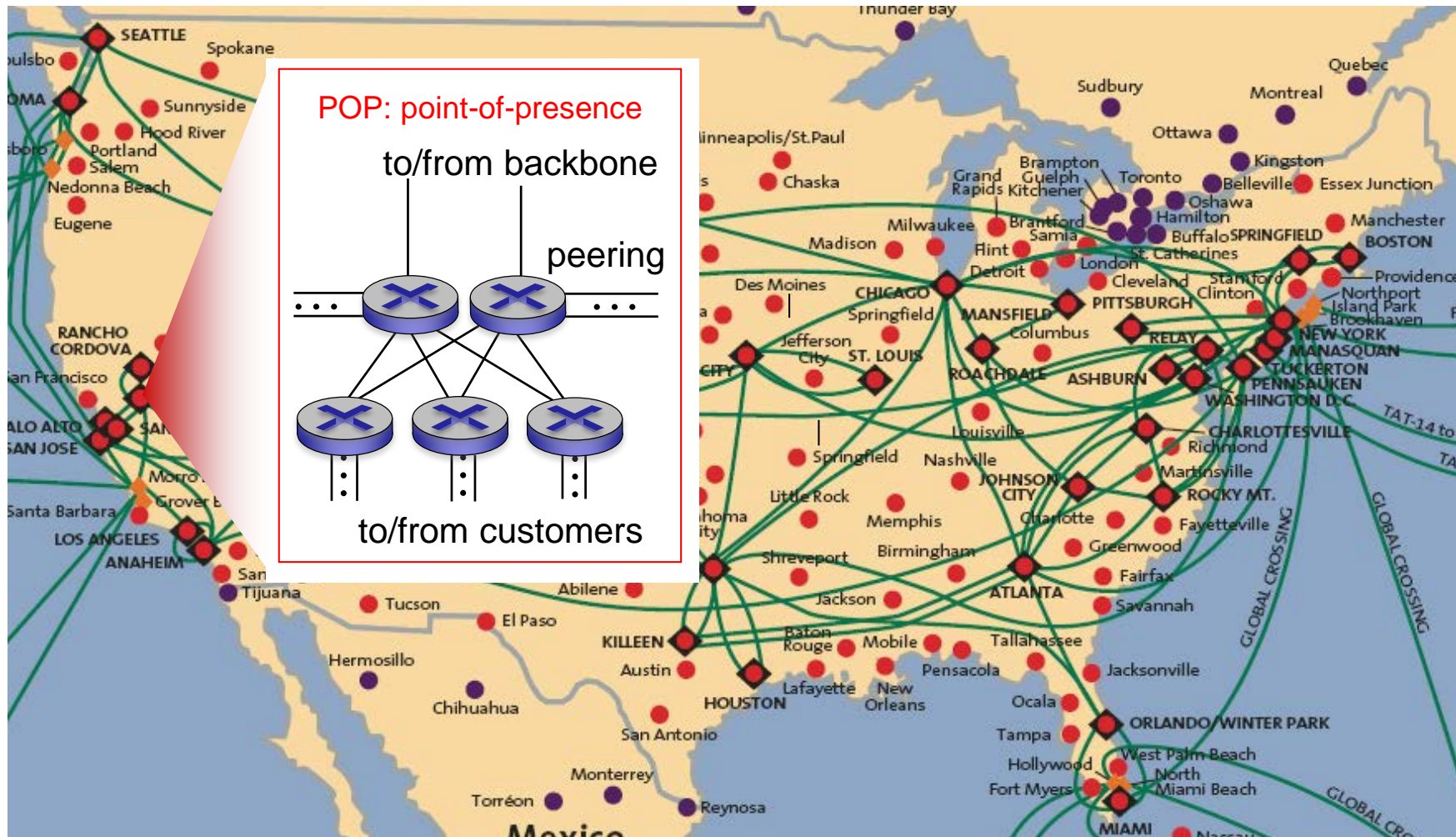


Internet structure: network of networks



- 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 its data centers to Internet, often bypassing tier-1, regional ISPs

Tier-I ISP: e.g., Sprint



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?

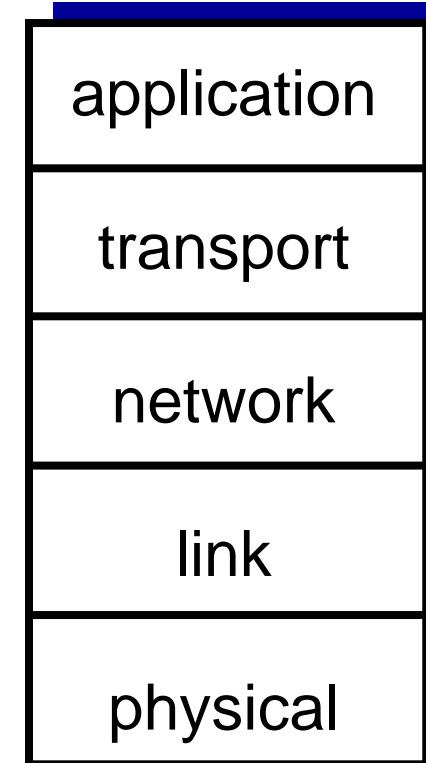
Why layering?

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
- layering considered harmful?

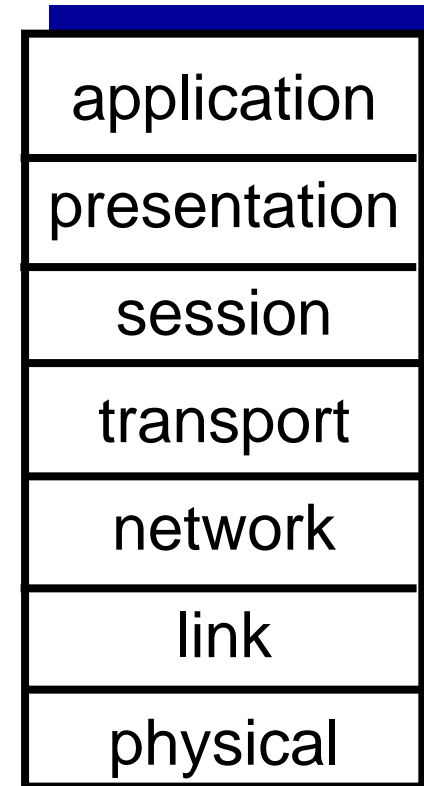
Internet protocol stack

- *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?



Encapsulation

