# Serviços Telemáticos

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# The Internet: a “nuts and bolts” view

Billions of connected computing *devices*:

- *hosts = end systems*
- running *network apps* at Internet’s “edge”a

*Packet switches*: forward packets (chunks of data)

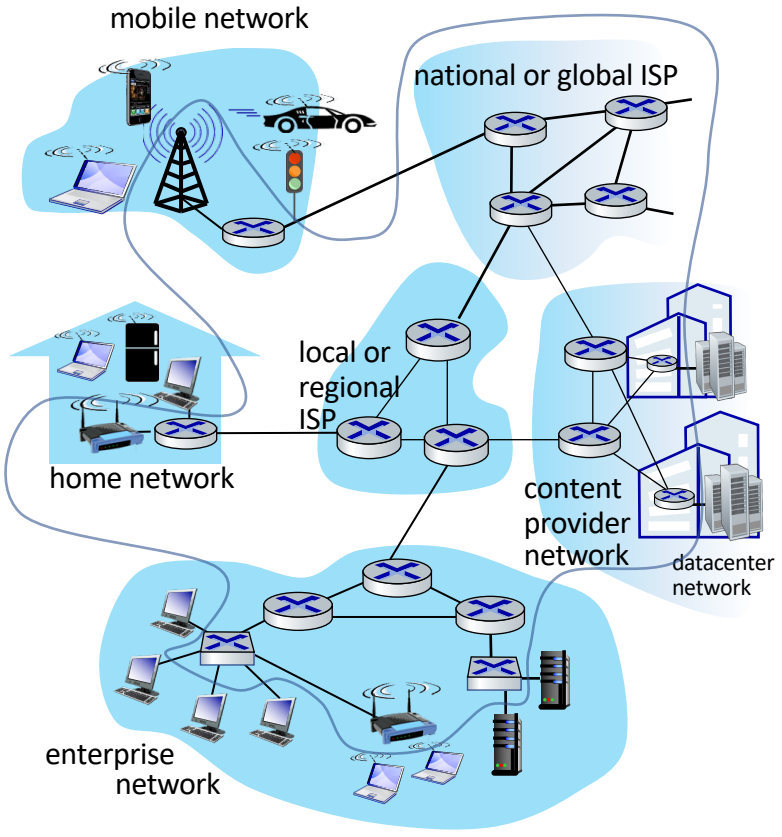
- *routers, switches*

*Communication links*

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

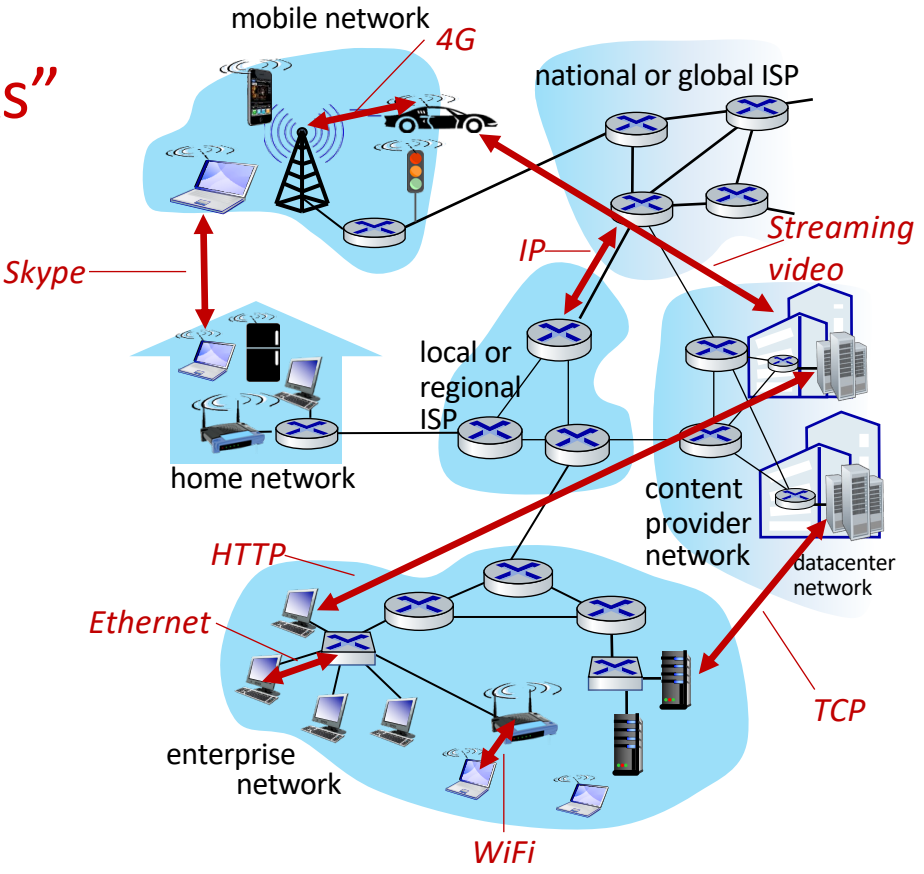
*Networks*

- collection of devices, routers, links: managed by an organization



# The Internet: a "nuts and bolts" view

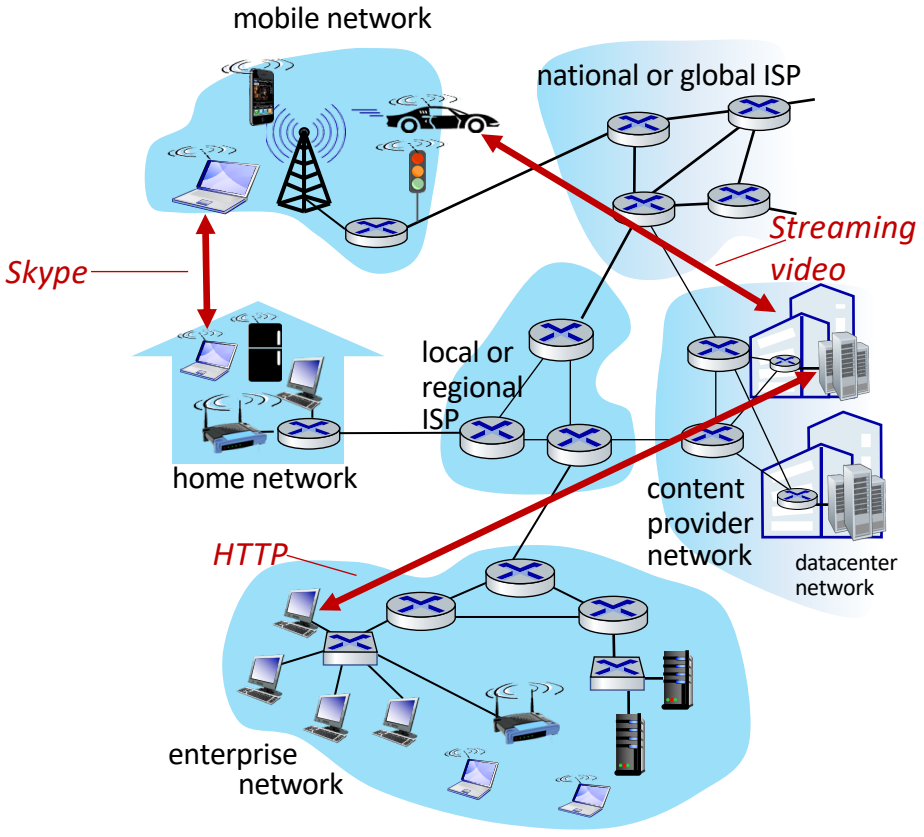
- *Internet:* "network of networks"
  - Interconnected ISPs
- *protocols* are *everywhere*
  - control sending, receiving of messages
  - e.g., HTTP (Web), streaming video, Skype, TCP, IP, WiFi, 4/5G, Ethernet
- *Internet standards*
  - RFC: Request for Comments
  - IETF: Internet Engineering Task Force



# The Internet: a "services" view

- *Infrastructure* that provides services to applications:
  - Web, streaming video, multimedia teleconferencing, email, games, e-commerce, social media, inter-connected appliances, …

- provides *programming interface* to distributed applications:
  - "hooks" allowing sending/receiving apps to "connect" to, use Internet transport service
  - provides service options, analogous to postal service



# What's a protocol?

*Human protocols:*

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

Rules for:

… specific messages sent

… specific actions taken when message received, or other events

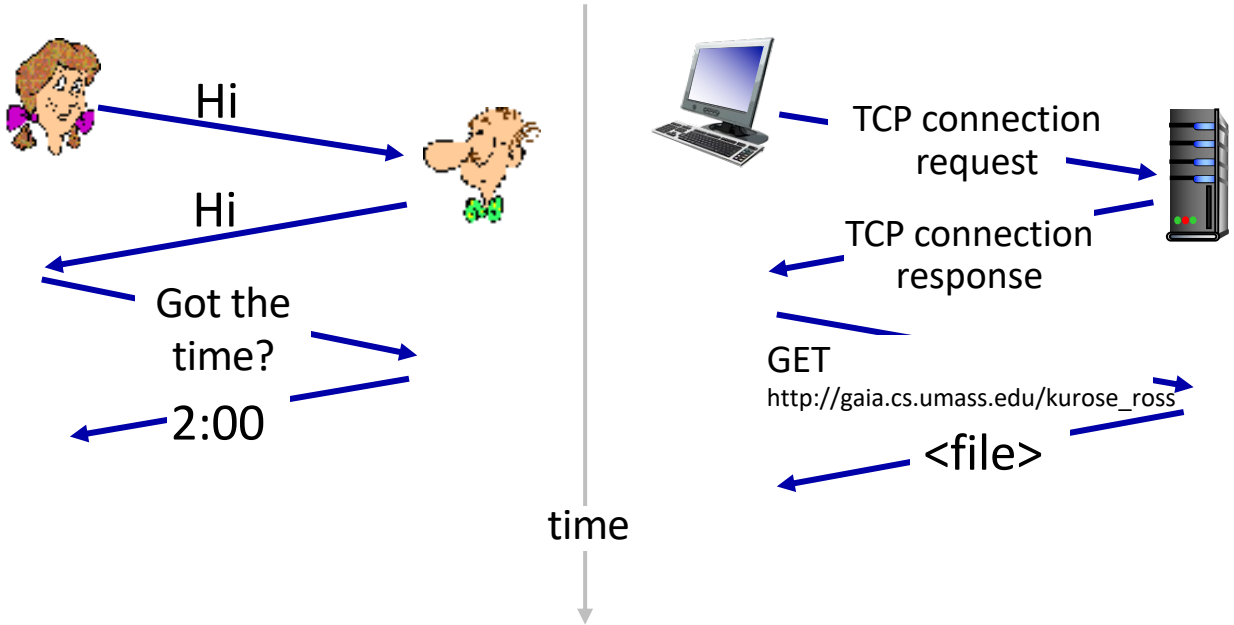
*Network protocols:*

- computers (devices) rather than humans
- all communication activity in Internet governed by protocols

*Protocols define the 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:

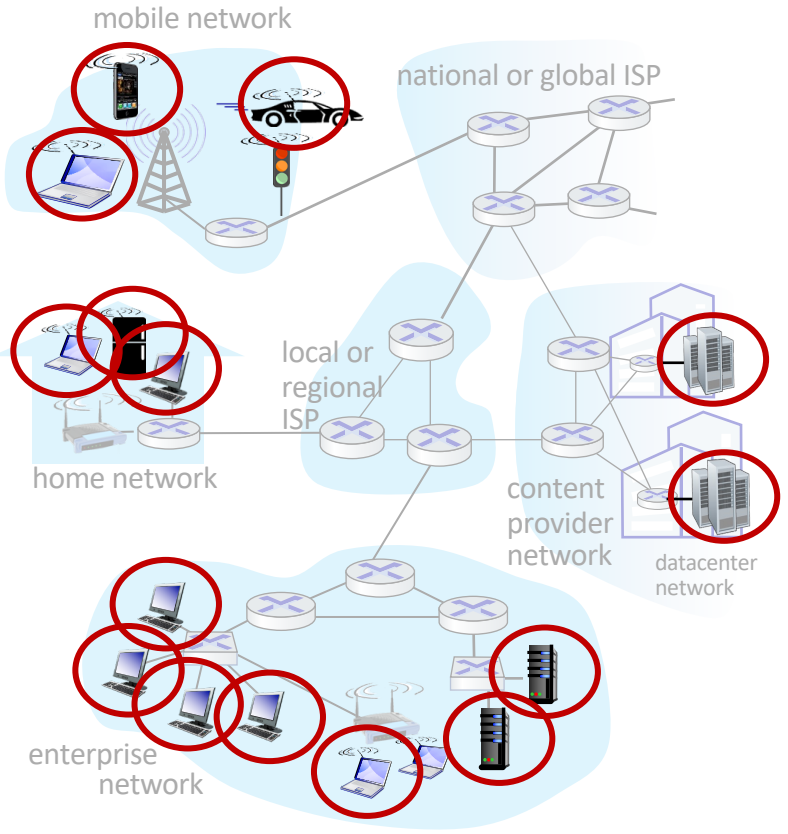



*Q:* other human protocols?

# A closer look at Internet structure

Network edge:

- hosts: clients and servers
- servers often in data centers



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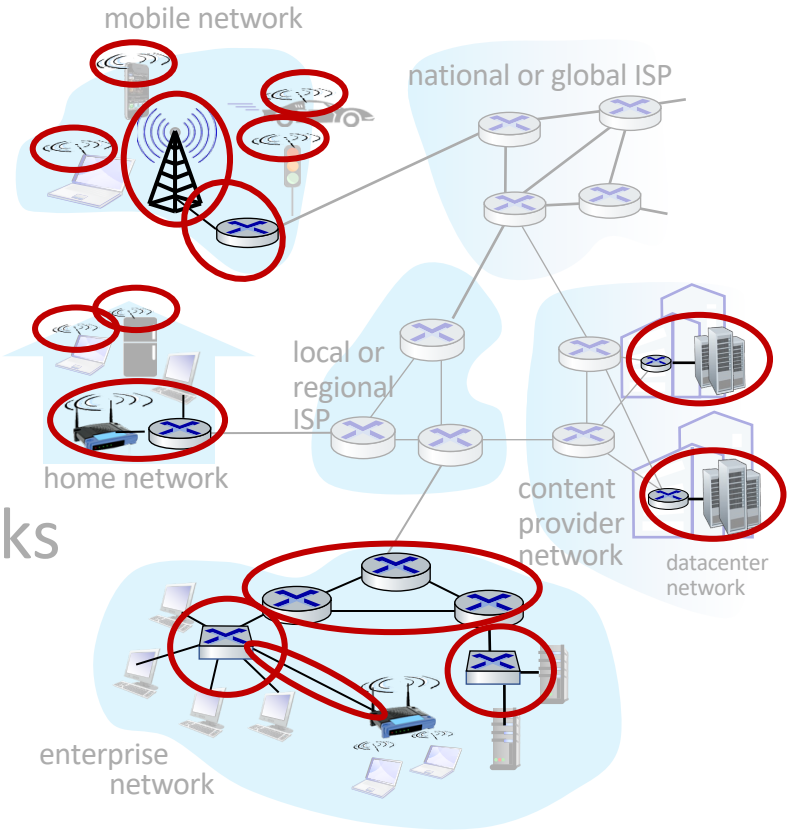
Access networks, physical media:

- wired, wireless communication links



# A closer look at Internet structure

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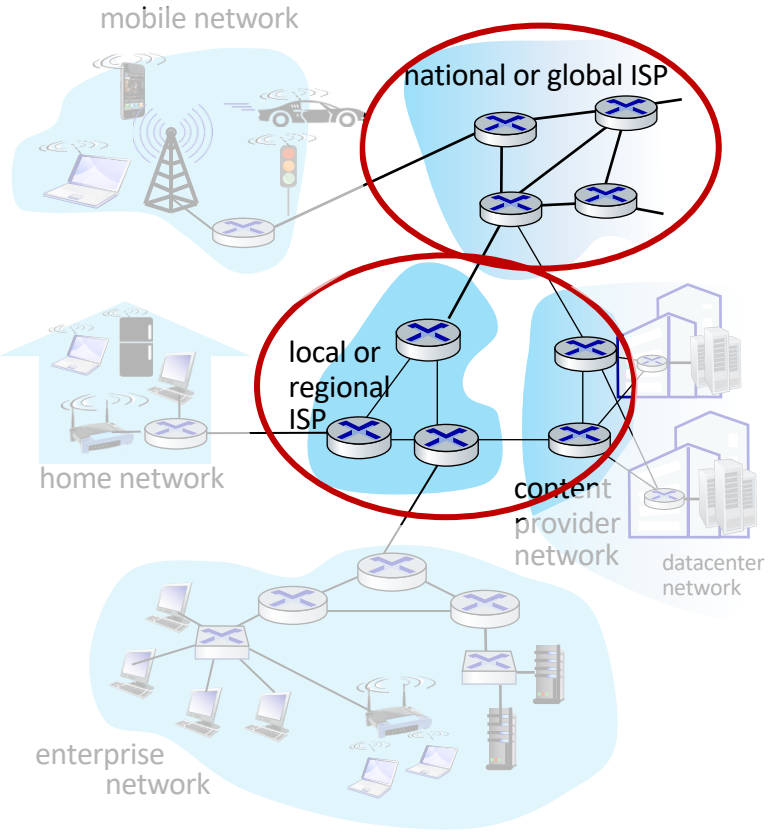
Network core:

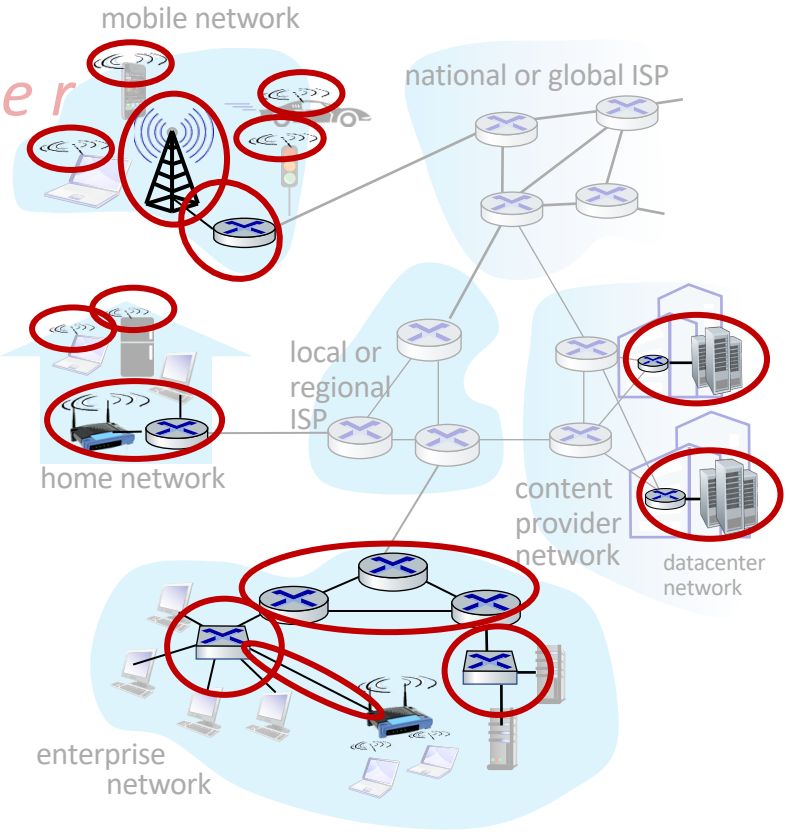
- interconnected routers
- network of networks



# Access networks and physical media

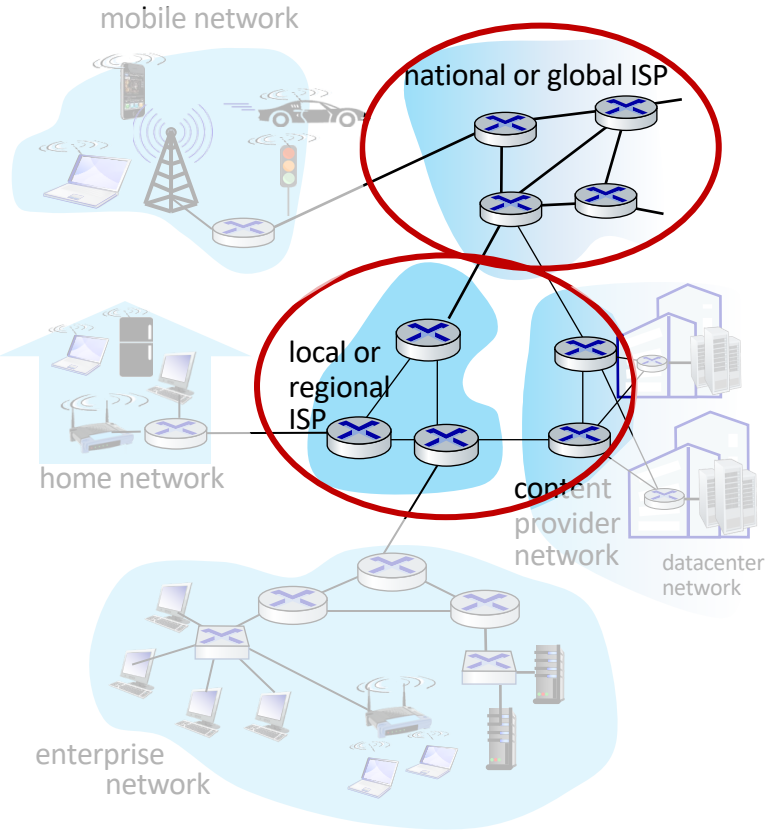
*Q: How to connect end systems to edge r*

- residential access nets
- institutional access networks (school, company)
- mobile access networks (WiFi, 4G/5G)



# The network core

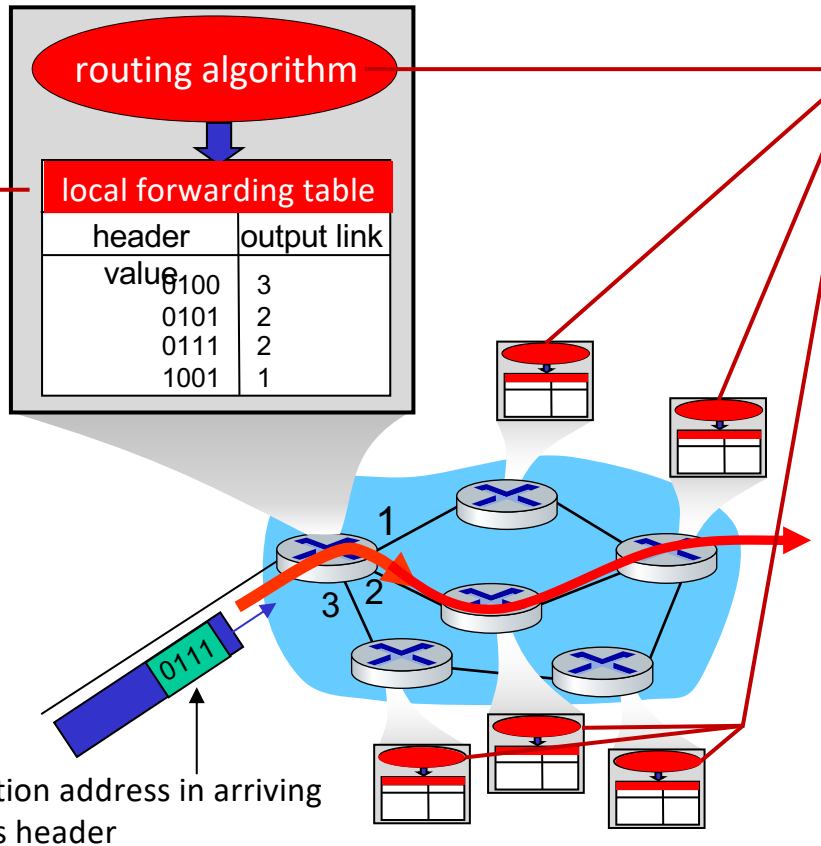
- mesh of interconnected routers
- packet-switching: hosts break application-layer messages into *packets*
  - network forwards packets from one router to the next, across links on path from source to destination



# Two key network-core functions

*Forwarding:*

- aka "switching"
- *local* action: move arriving packets from router's input link to appropriate router output link




*Routing:*

- *global* action: determine source-destination paths taken by packets
- routing algorithms


routing
45 h
3,053 miles
48 h
3,309 miles
United States
San Jose
Northampton
Victoria
Seattle
Portland
San Francisco
Sacramento
Las Vegas
Los Angeles
San Diego
Phoenix
Tucson
El Paso
Dallas
Austin
Houston
San Antonio
New Orleans
Kansas City
Minneapolis
Chicago
Detroit
Toronto
Ottawa
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Quebec City
New York
Philadelphia
Indianapolis
Nashville
Charlotte
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Jacksonville
Orlando
Tampa
WASHINGTON
OREGON
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NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
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NORTH DAKOTA
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MARYLAND
WEST VIRGINIA
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WISCONSIN
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NEW HAMPSHIRE
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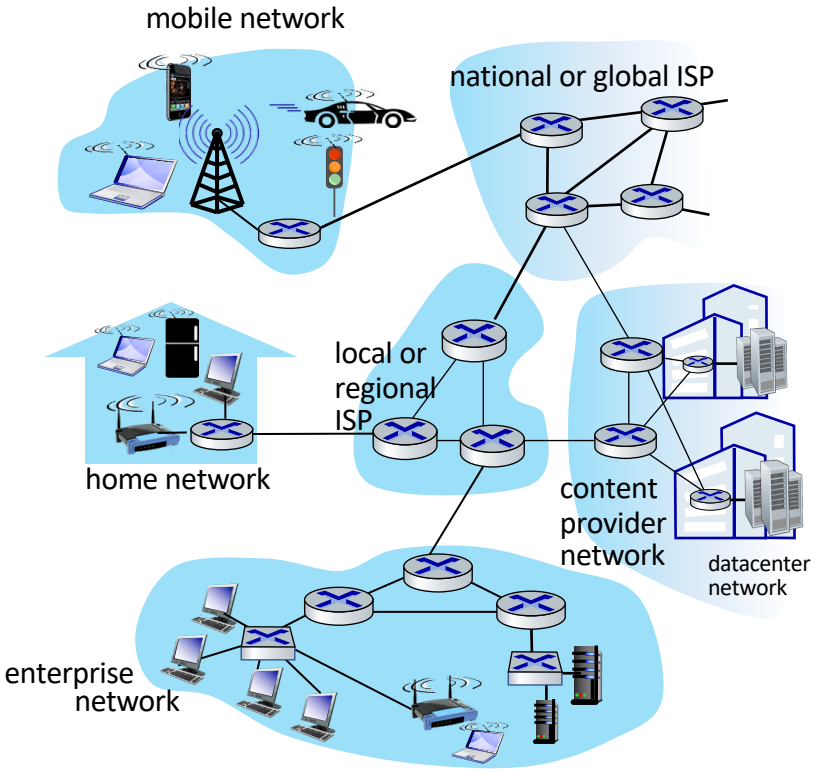
SONORA
CHIHUAHUA
COAHUILA

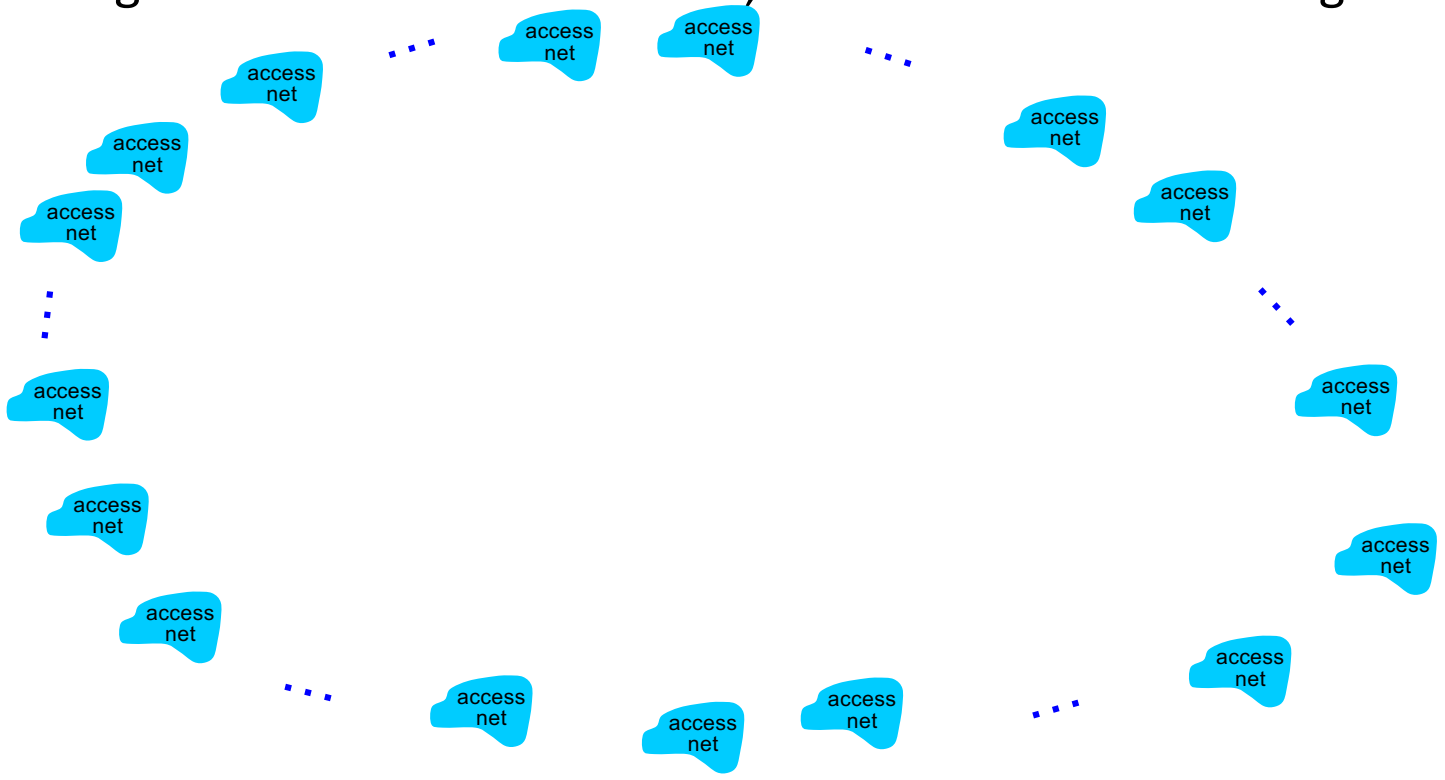
# Internet structure: a “network of networks”

- hosts connect to Internet via access Internet Service Providers (ISPs)
- access ISPs in turn must be interconnected
  - so that *any* two hosts *(anywhere!)* can send packets to each other
- resulting network of networks is very complex
  - evolution driven by economics, national policies



# Internet structure: a “network of networks”

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



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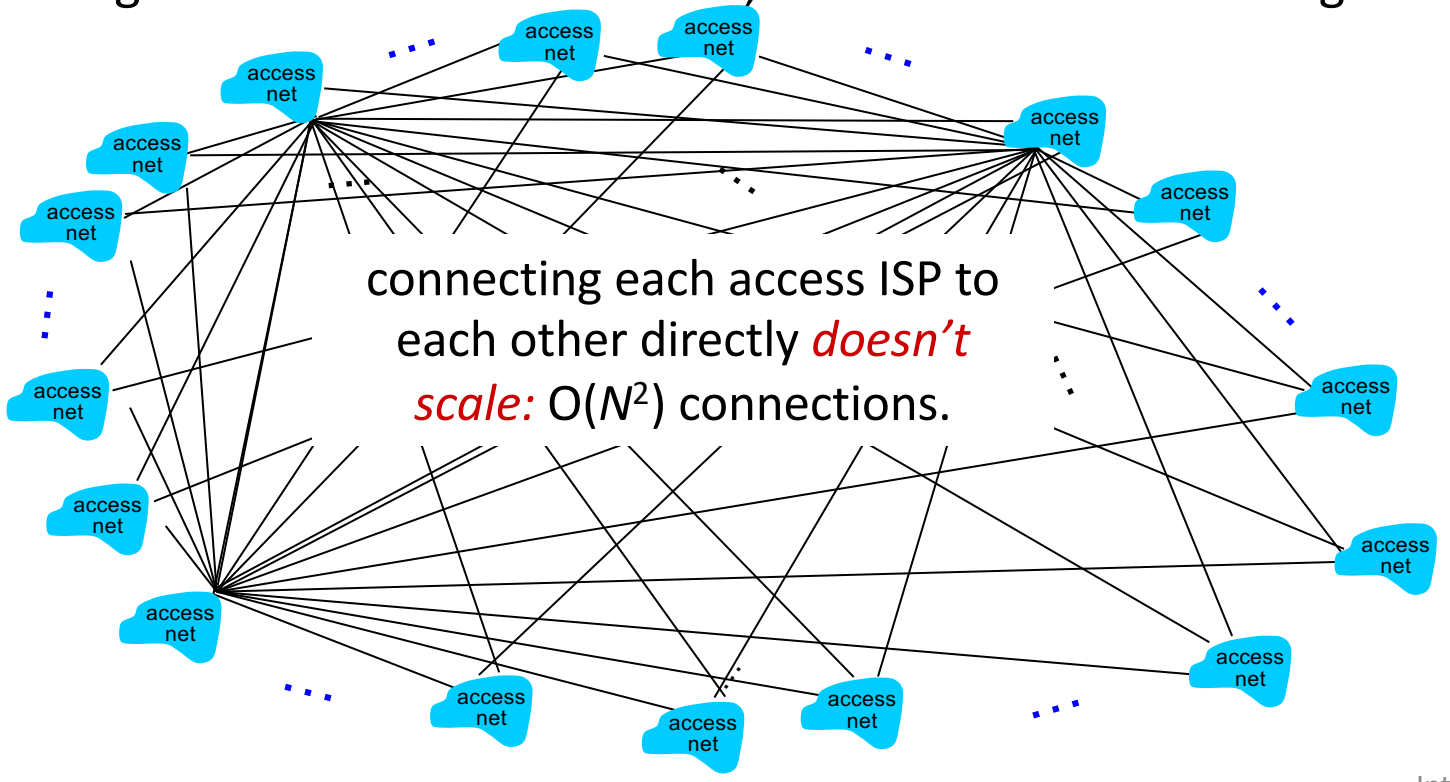
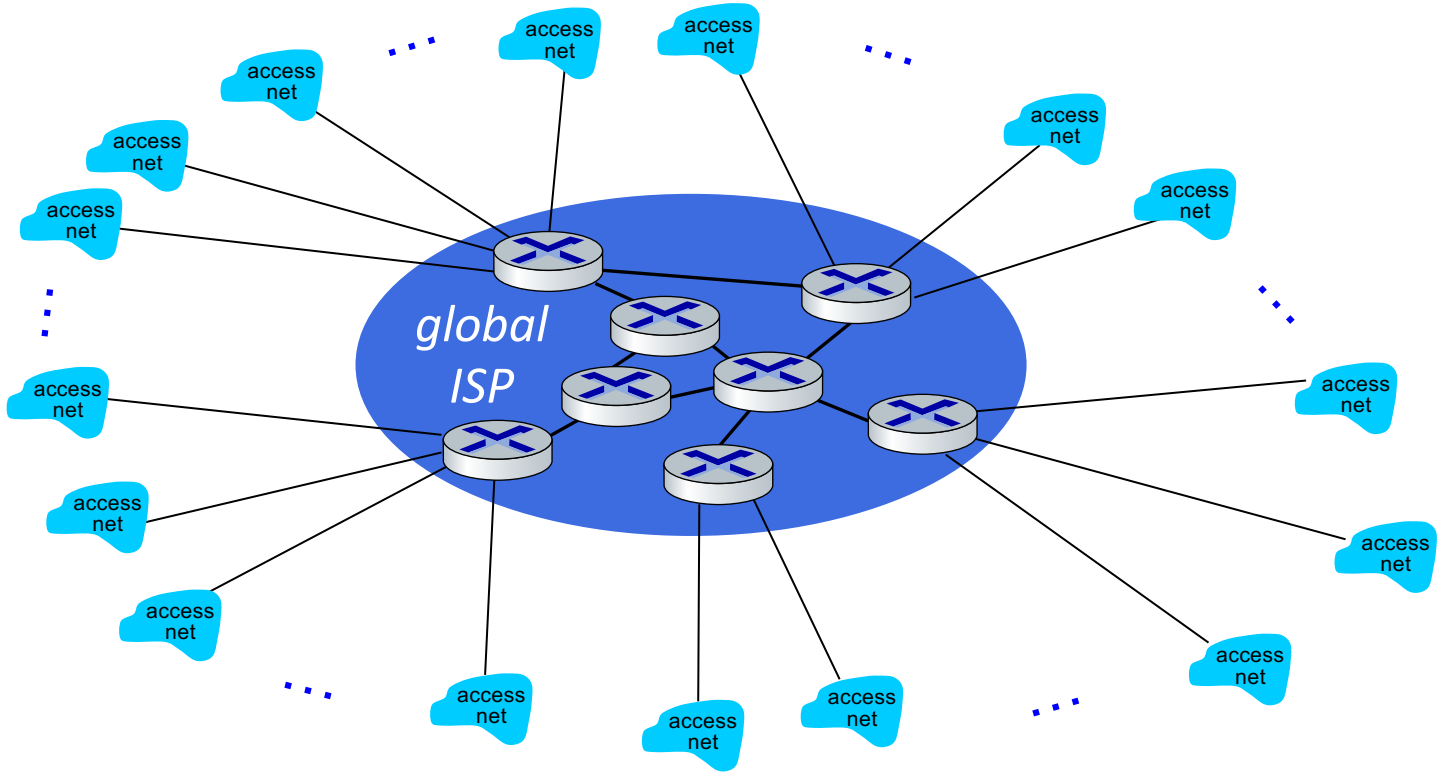


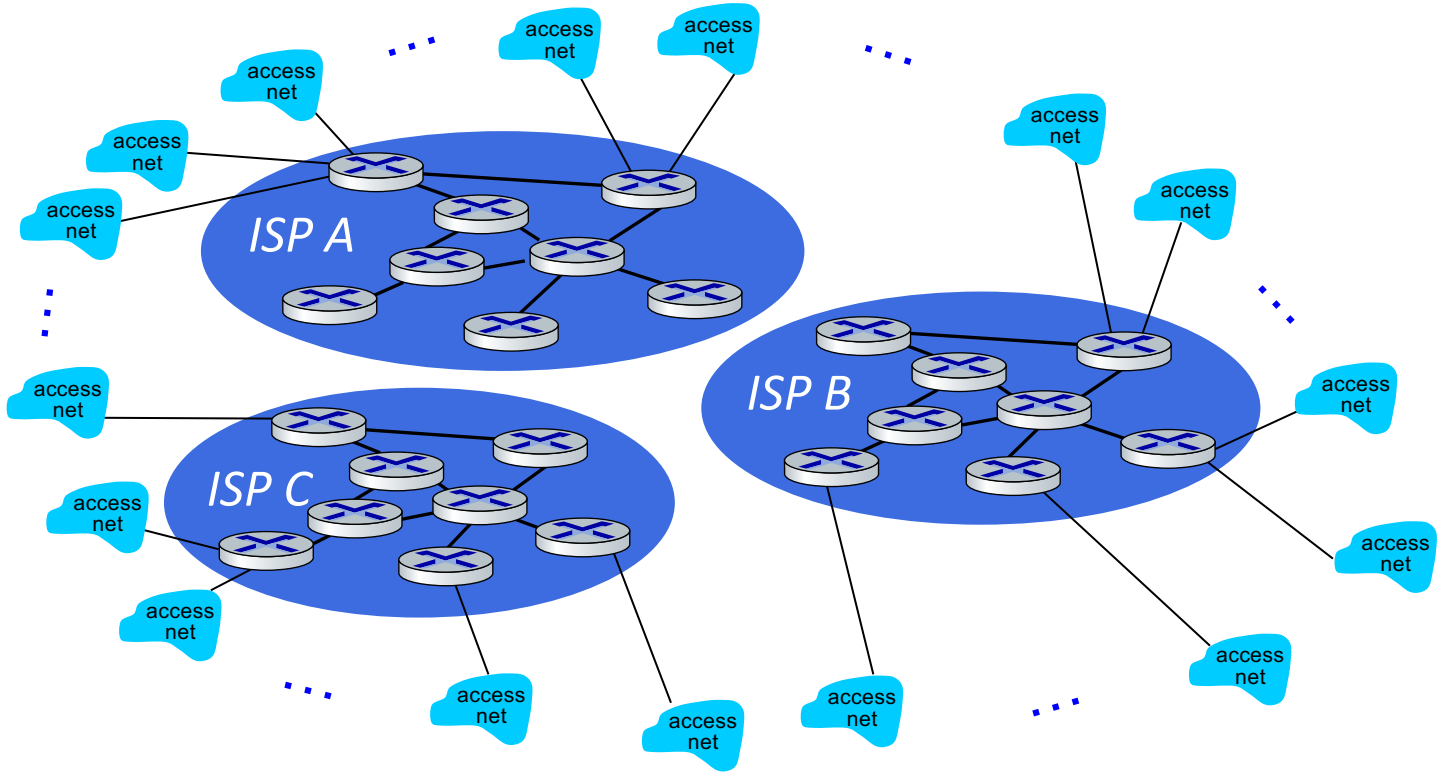
# Internet structure: a “network of networks”

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



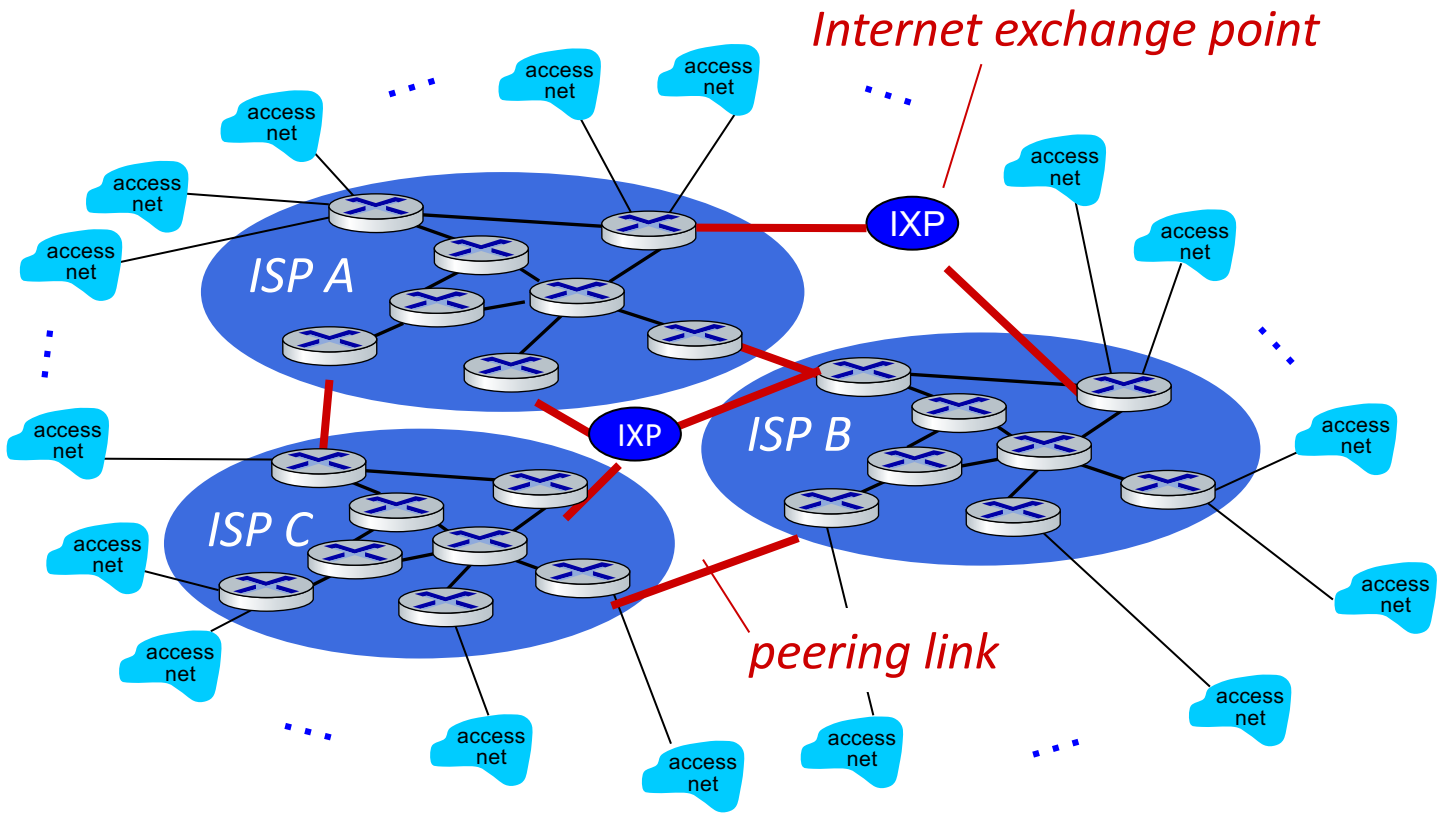
# Internet structure: a “network of networks”

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



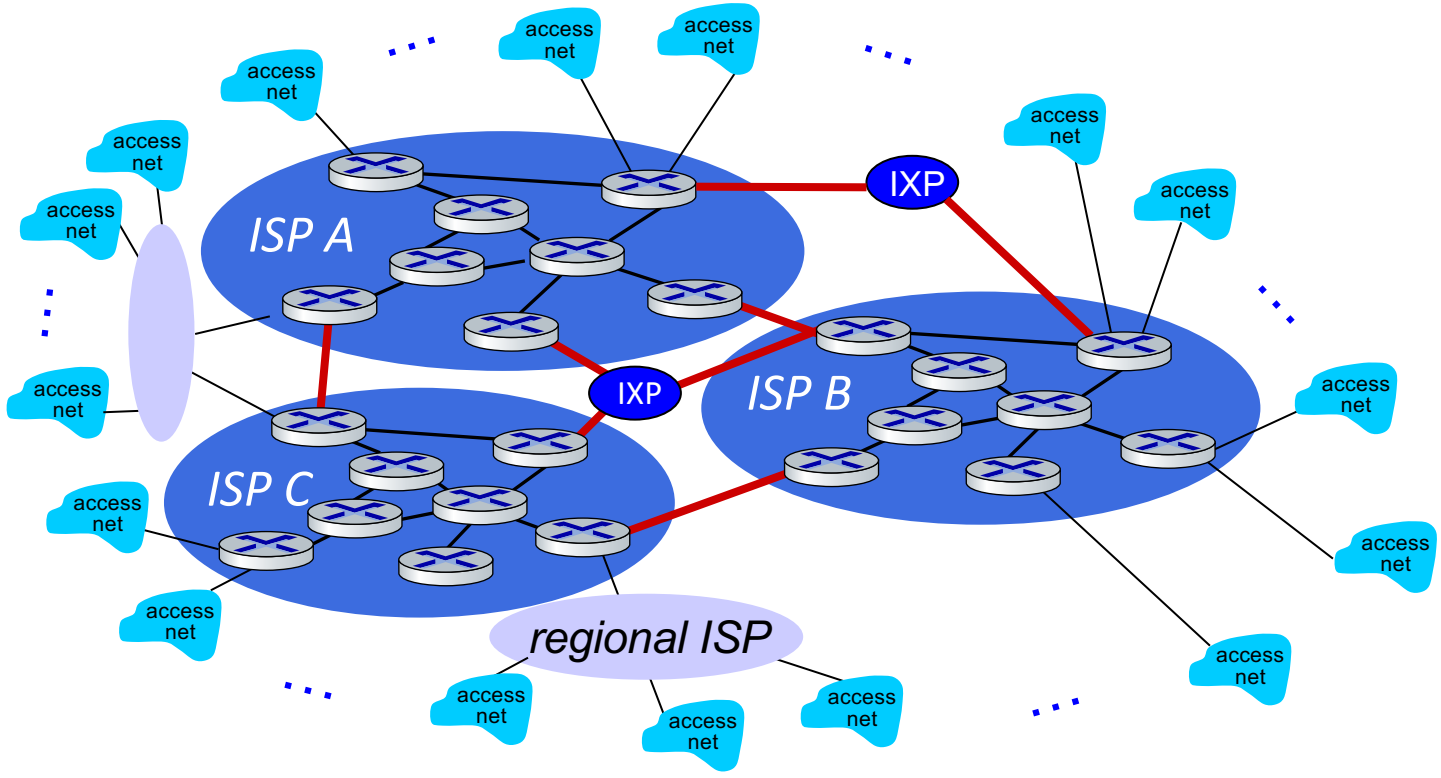
# Internet structure: a “network of networks”

But if one global ISP is viable business, there will be competitors …. who will want to be connected



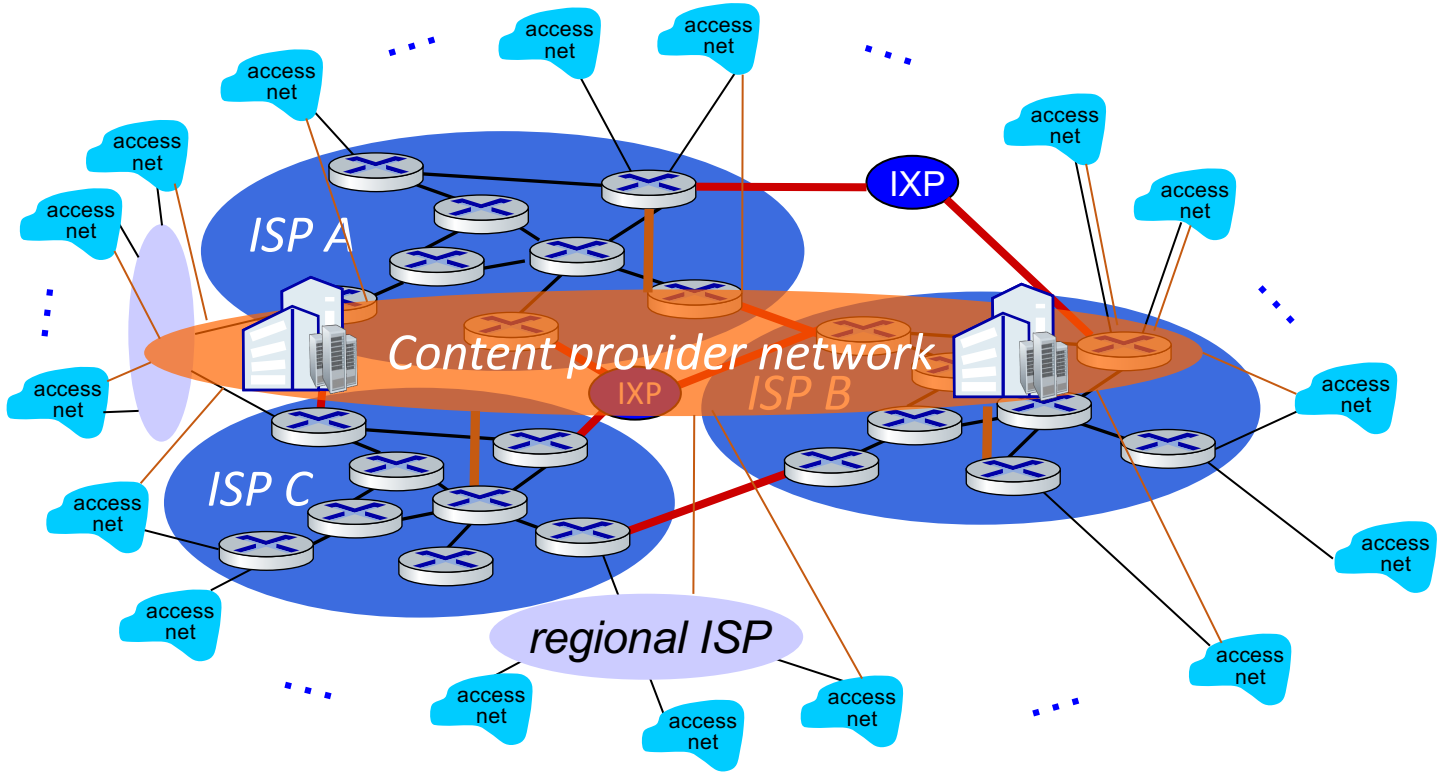
# Internet structure: a “network of networks”

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

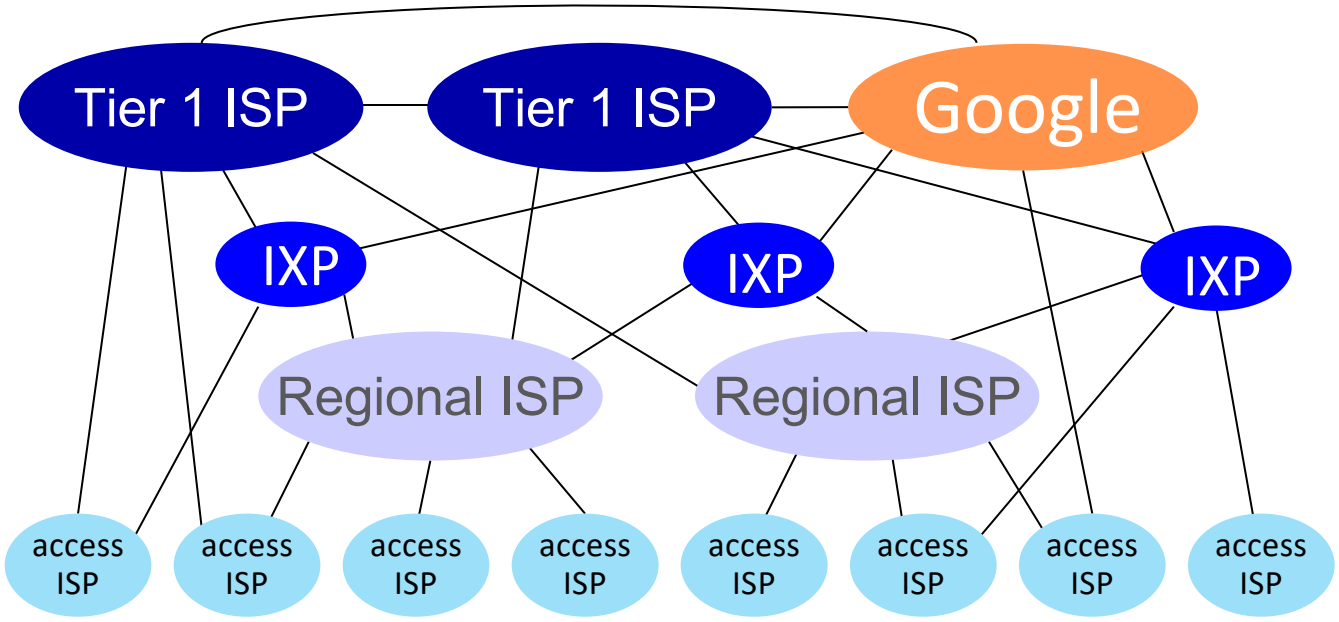


# Internet structure: a “network of networks”

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



# Internet structure: a “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 networks (e.g., Google, Facebook): private network that connects its data centers to Internet, often bypassing tier-1, regional ISPs