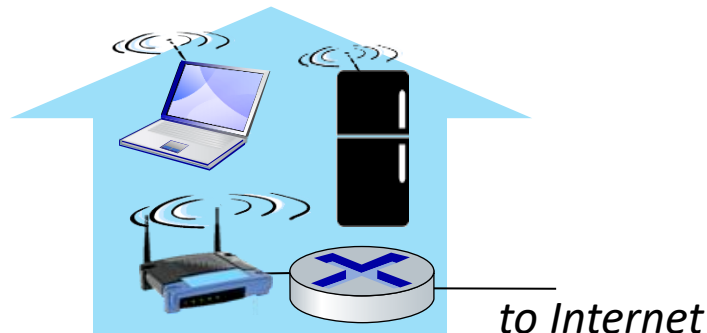# Wireless access networks

Shared *wireless* access network connects end system to router

- via base station aka "access point"
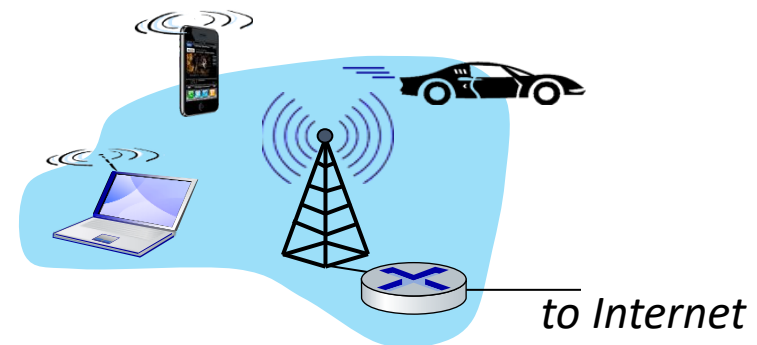
Wireless local area networks (WLANs)

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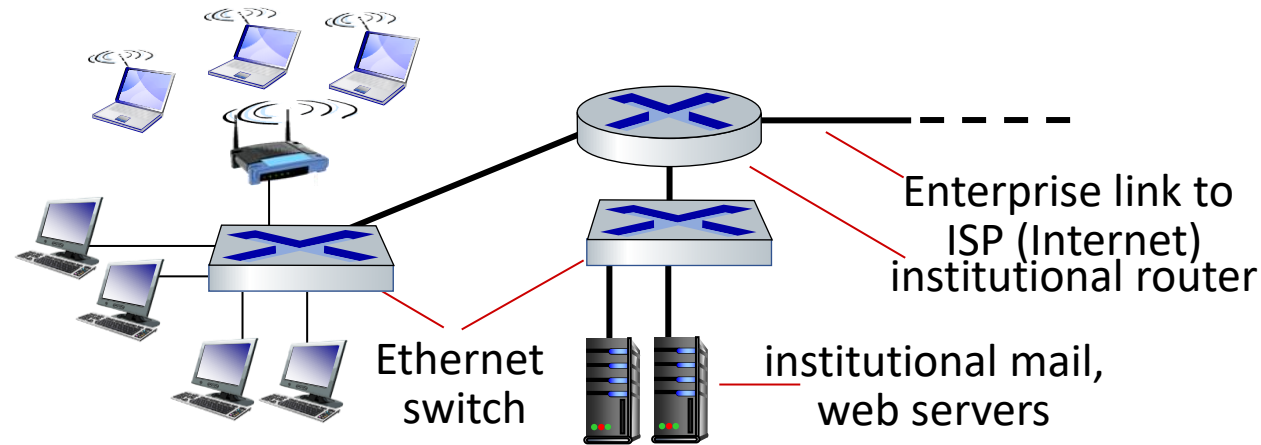- 802.11b/g/n (WiFi): 11, 54, 450 Mbps transmission rate

to Internet

Wide-area cellular access networks

- provided by mobile, cellular network operator (10's km)
- 10's Mbps
- 4G/5G cellular networks

to Internet

Access networks: enterprise networks

Enterprise link to
ISP (Internet)
institutional router

Ethernet
switch

institutional mail,
web servers

- companies, universities, etc.
- mix of wired, wireless link technologies, connecting a mix of switches and routers (we'll cover differences shortly)
  - Ethernet: wired access at 100Mbps, 1Gbps, 10Gbps
  - WiFi: wireless access points at 11, 54, 450 Mbps

Links: physical media

- **bit:** propagates between transmitter/receiver pairs

- **physical link:** what lies between transmitter & receiver

- **guided** media:
  - signals propagate in solid media: copper, fiber, coax

- **unguided media:**
  - signals propagate freely, e.g., radio

Twisted pair (TP)

- two insulated copper wires
  - Category 5: 100 Mbps,
  - Category 5e: 1 Gbps Ethernet
  - Category 6: 10Gbps Ethernet
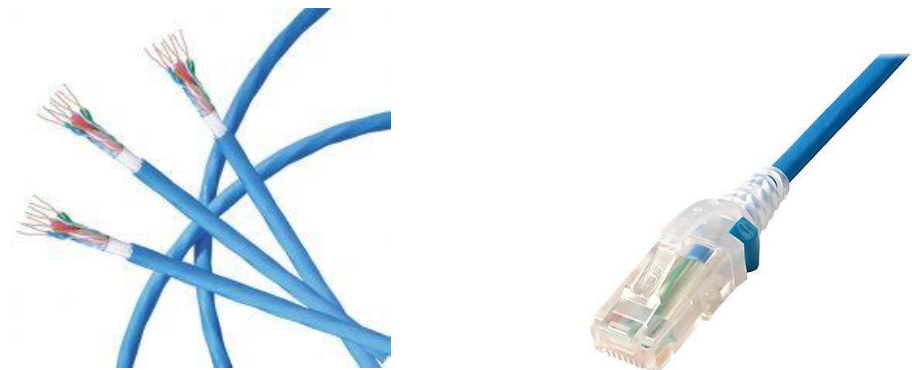
Links: physical media

Coaxial cable:

- Copper conductor
- broadband:
  - multiple frequency channels on cable
  - 100's Mbps per channel

Fiber optic cable:

- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - high-speed point-to-point transmission (10's-100's Gbps)
- low error rate:
  - repeaters spaced far apart
  - immune to electromagnetic noise
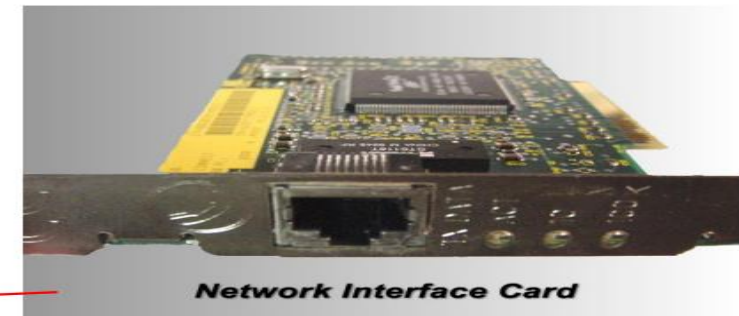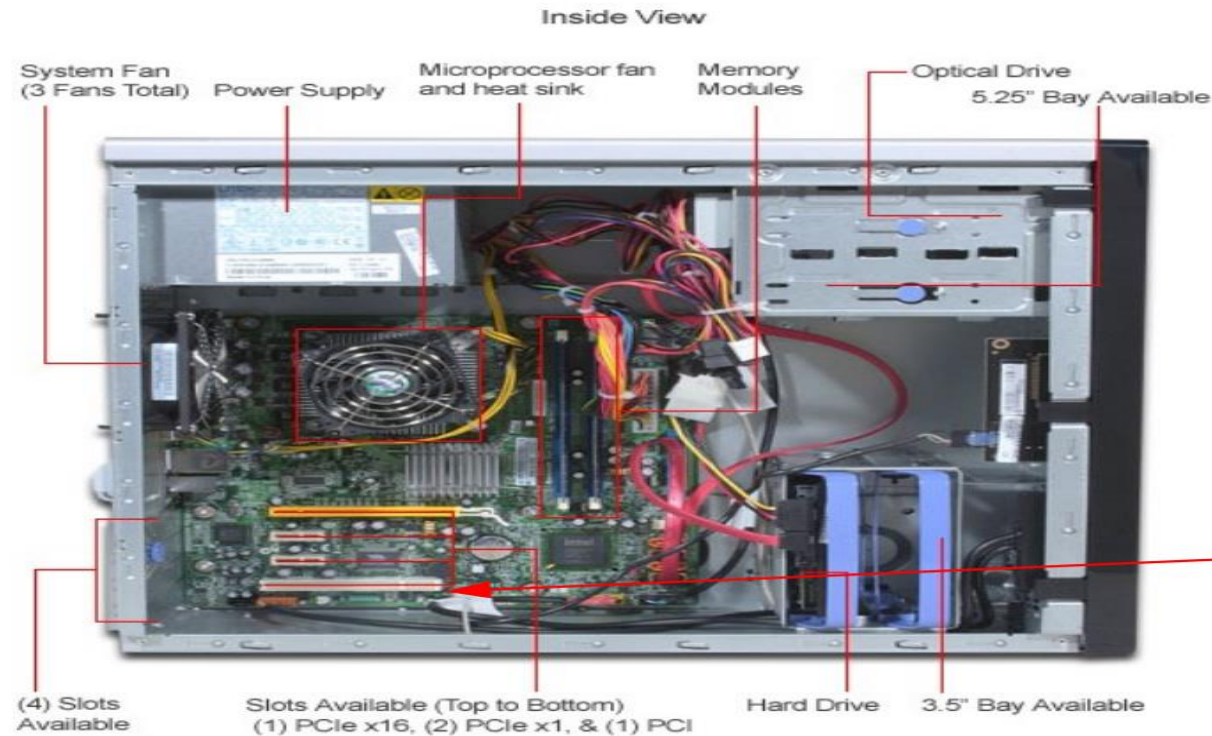
Links: physical media

Wireless radio

- signal carried in ==electromagnetic spectrum==
- no physical "wire"
- broadcast and "==half-duplex==" (==sender to receiver==)
- propagation environment effects:
  - ==reflection==
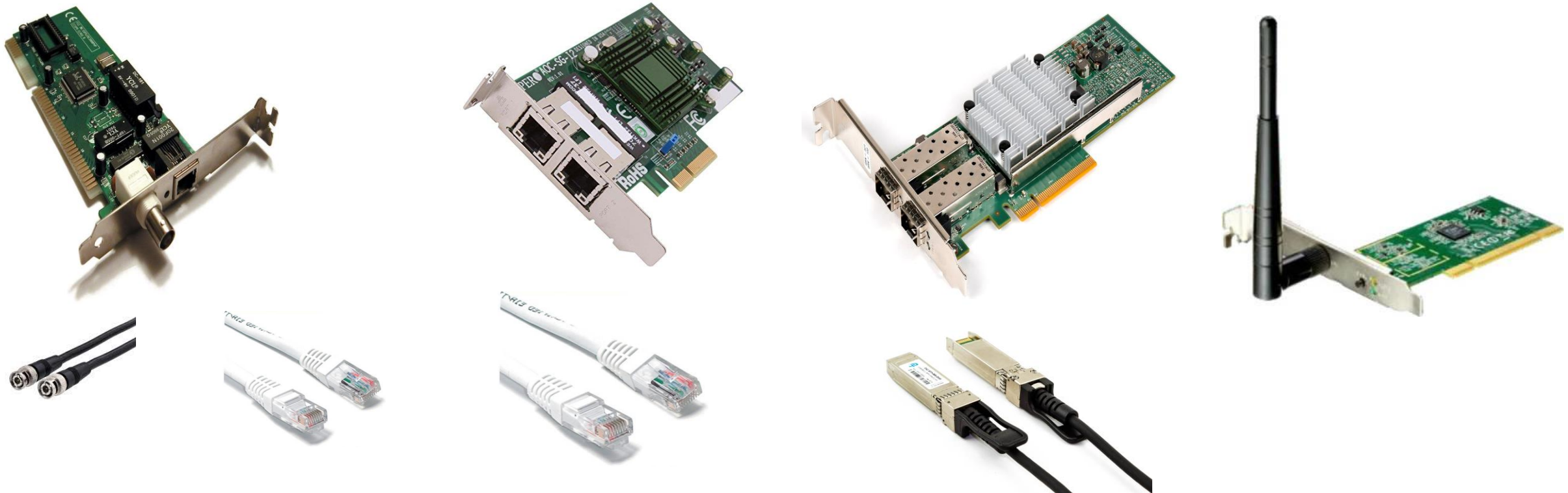 - ==obstruction== by objects
  - ==interference==

Radio link types:

- Wireless LAN (==WiFi==)
  - Up to ==100's Mbps==
- ==wide-area== (e.g., cellular)
  - 4G cellular: ~ ==10's Mbps==
- ==satellite==
  - up to ==45 Mbps== ==per channel==
  - ==270== msec end-end ==delay==
  - ==geosynchronous== versus low-earth-orbit

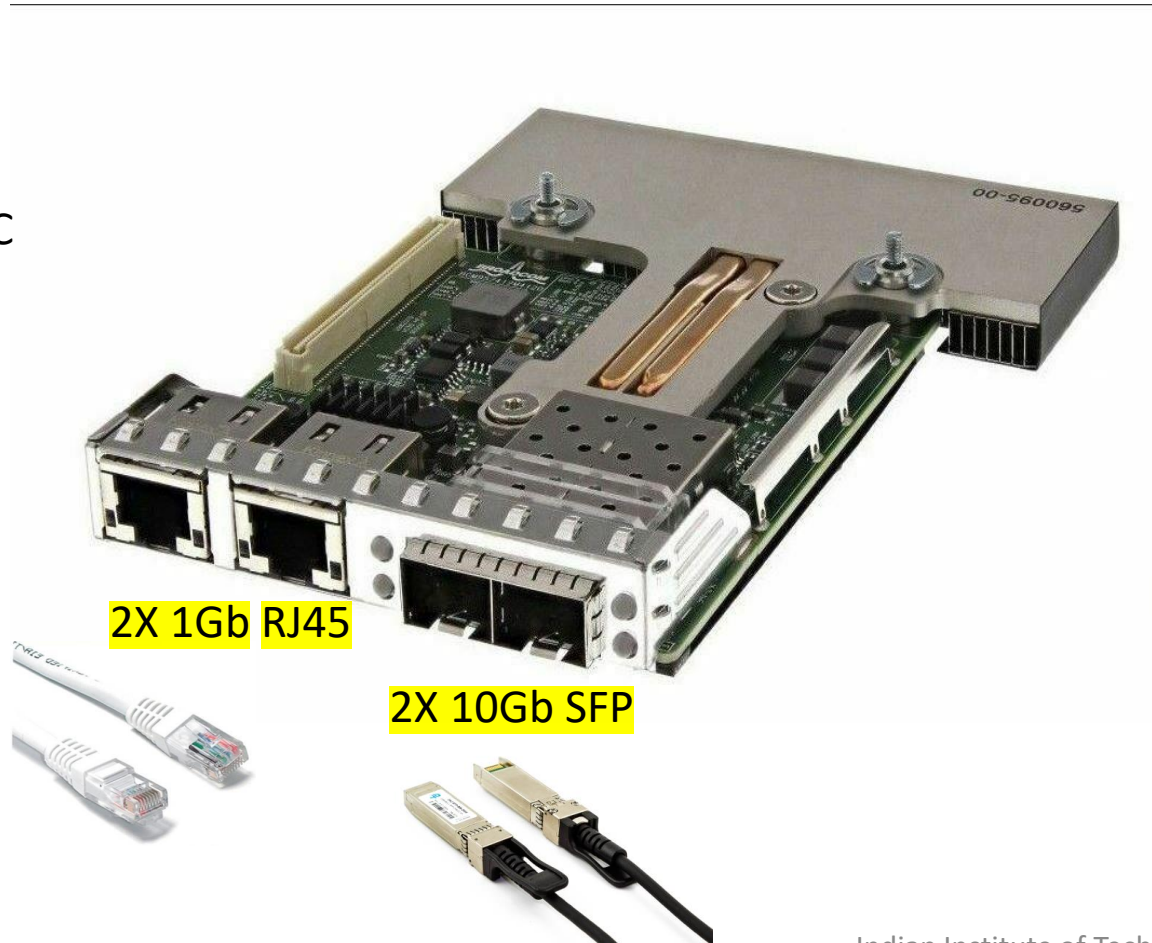# Network Interface Card (NIC) inside computer

Inside View

System Fan
(3 Fans Total)
Power Supply
Microprocessor fan
and heat sink
Memory
Modules
Optical Drive
5.25" Bay Available

(4) Slots
Available
Slots Available (Top to Bottom)
(1) PCIe x16, (2) PCIe x1, & (1) PCI
Hard Drive
3.5" Bay Available

Network Interface Card

NIC and connector

NIC Cont..

Quad Port NIC

2X 1Gb RJ45

2X 10Gb SFP

Indian Institute of Technology Bhilai
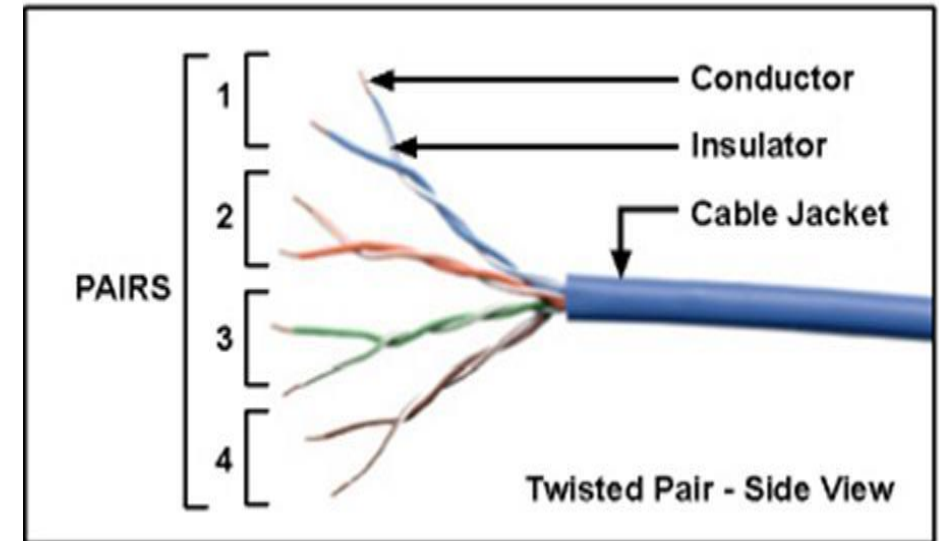
Crimping LAN/Ethernet cables

Cable/Network Crimping tool

Network cable

RJ45 Pinout
T-568B

1. White Orange   5. White Blue
2. Orange   6. Green
3. White Green   7. White Brown
4. Blue   8. Brown
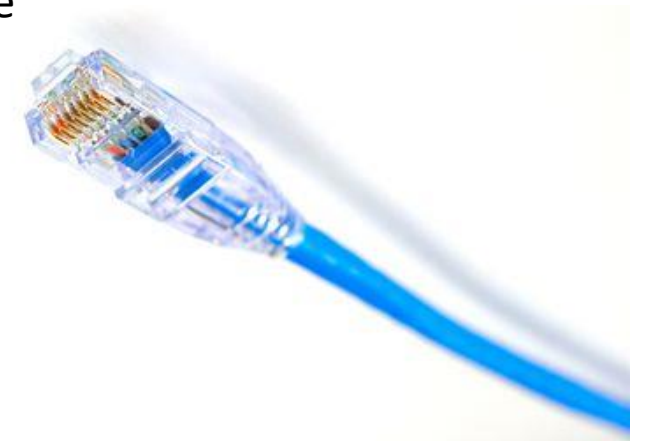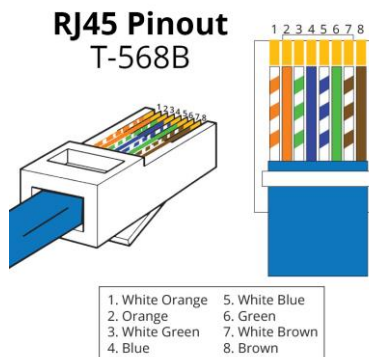
Internet structure: a "network of networks"

- Hosts connect to Internet via access Internet Service Providers (ISPs)
  - residential, enterprise (company, university, commercial) 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
- Let's take a stepwise approach to describe current Internet structure

Internet structure: a "network of networks"
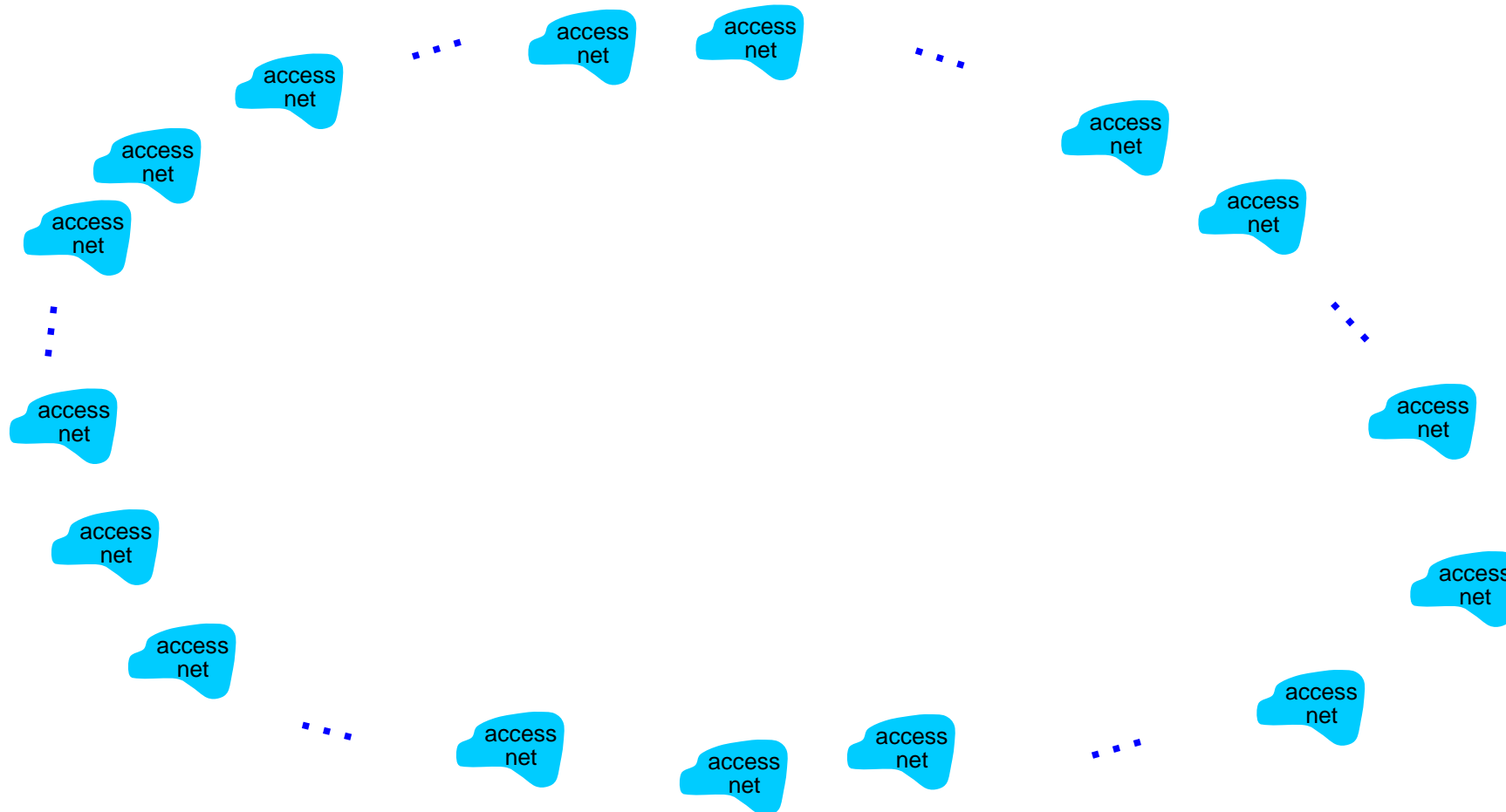
Question: given *millions* of access ISPs, how to connect them together?
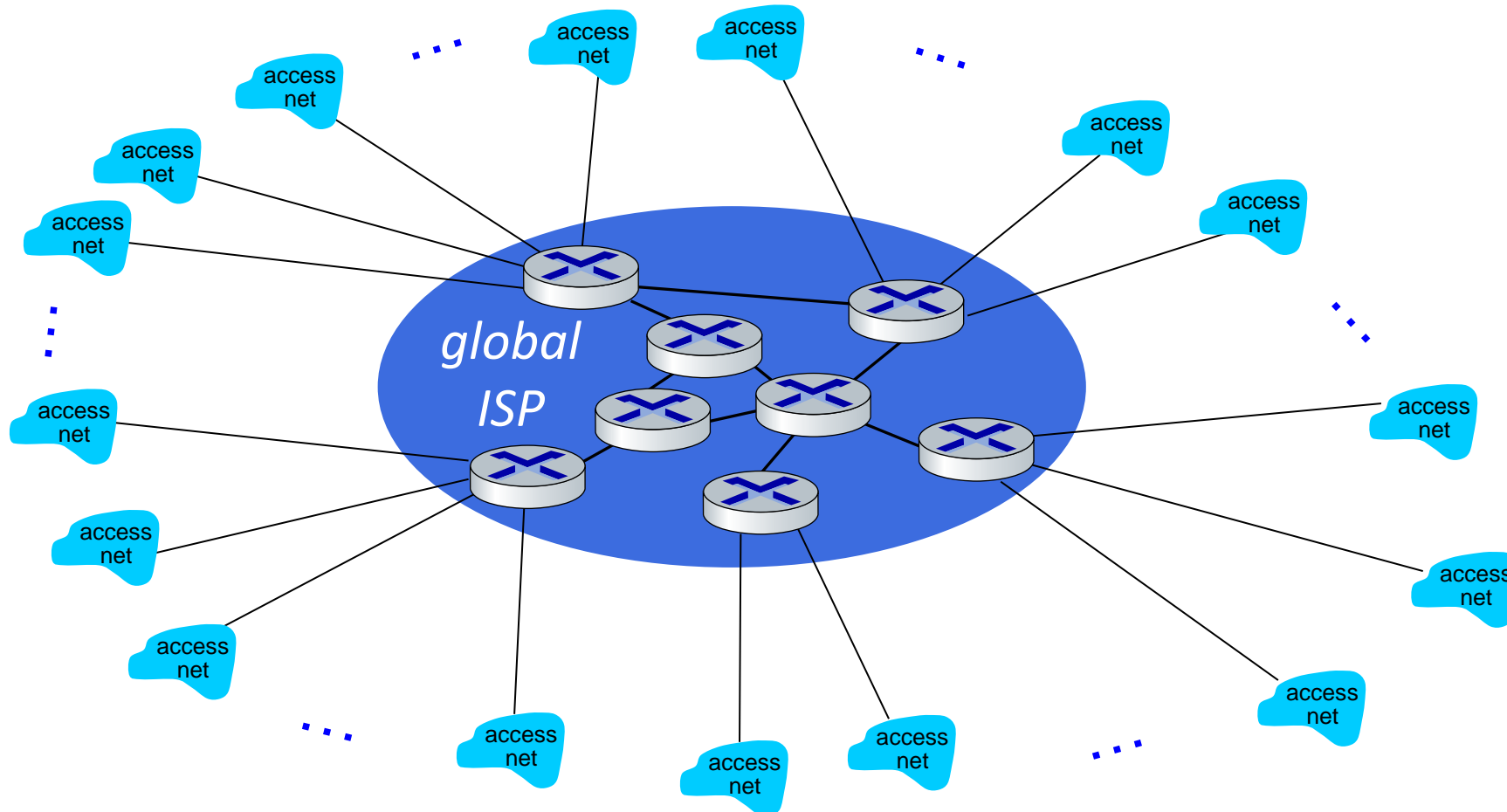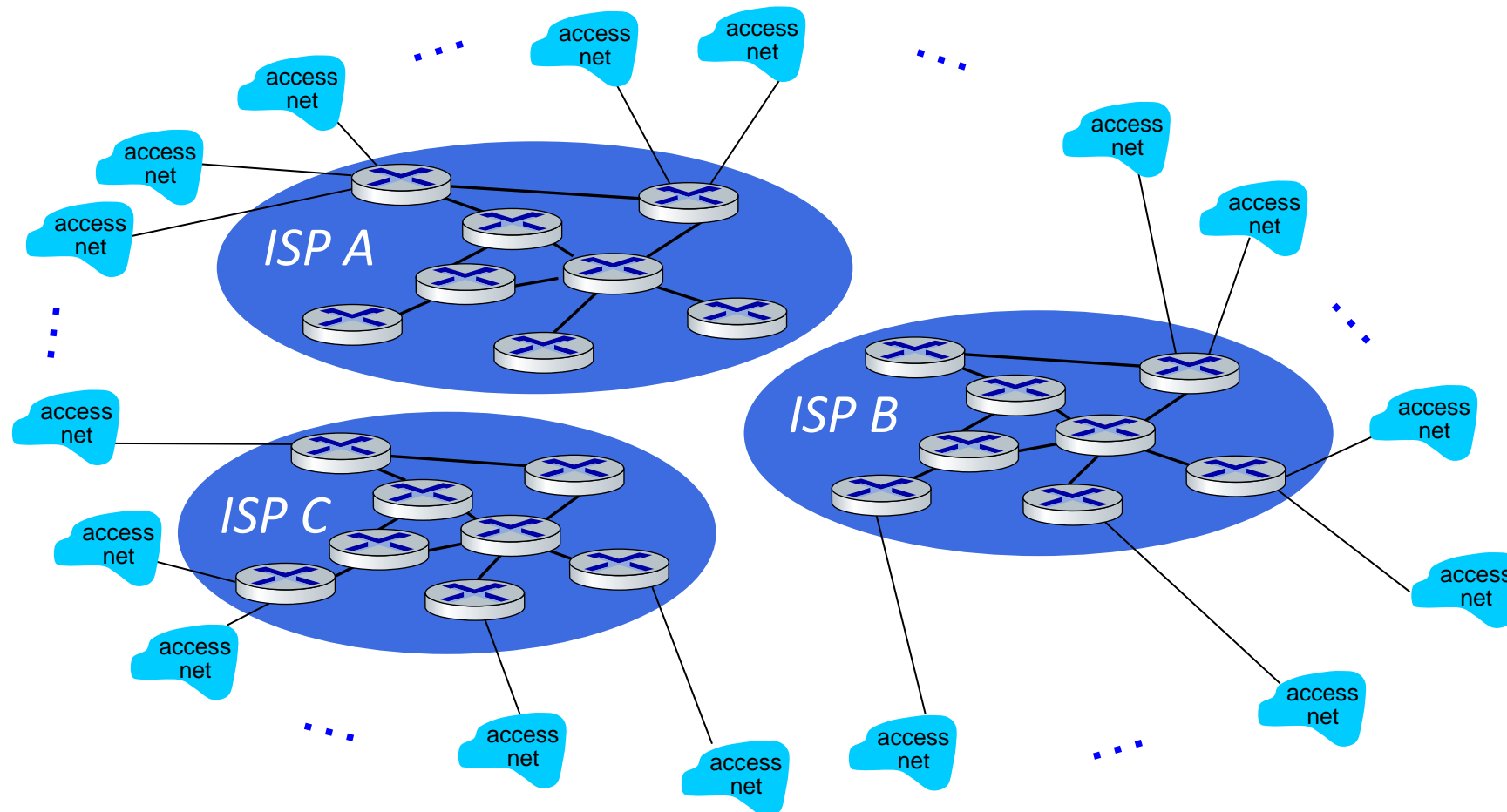
Internet structure: a "network of networks"

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

connecting each access ISP to each other directly *doesn't scale:* O(N^2) connections.
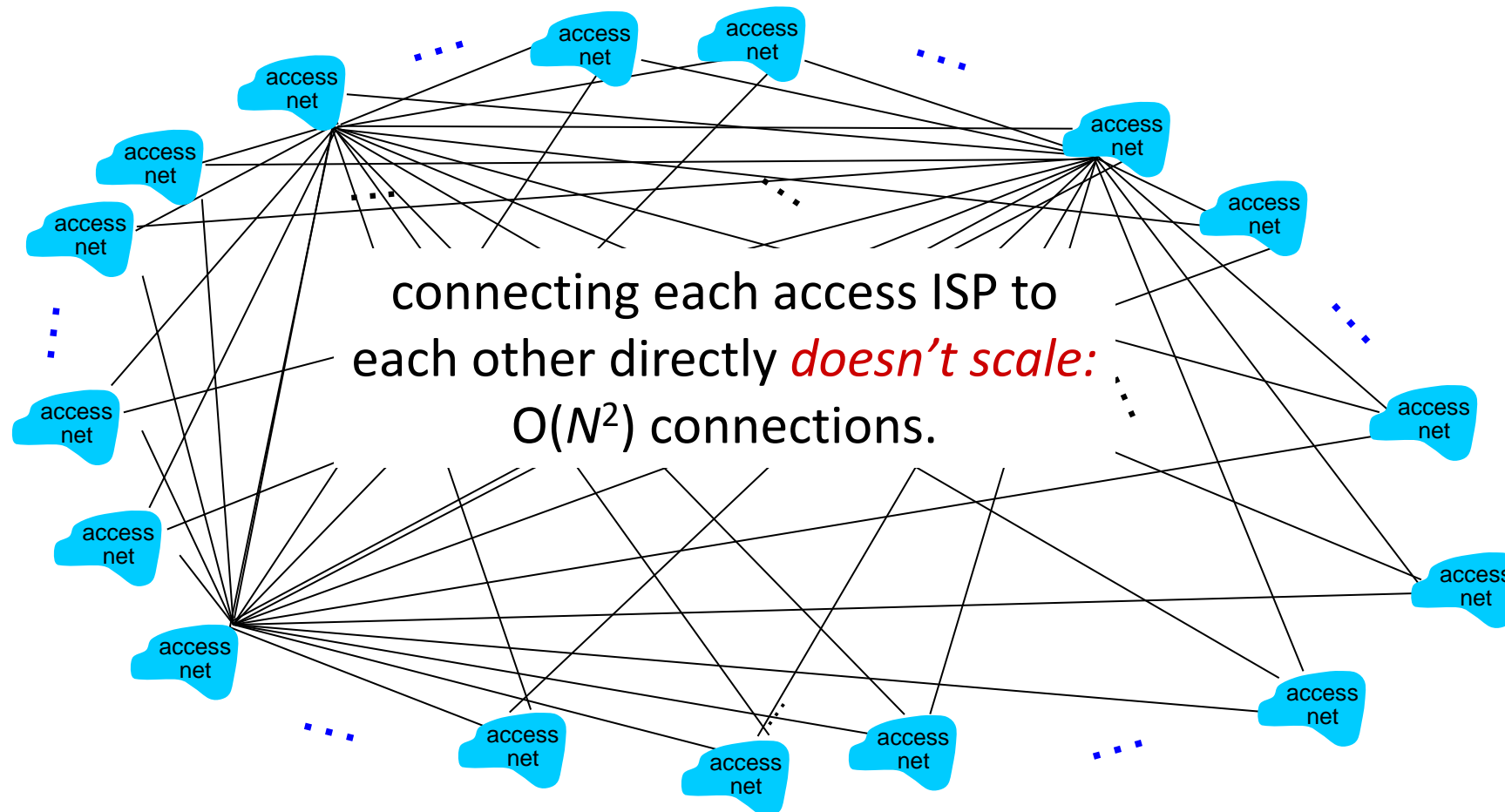
Internet structure: a "network of networks"

Option: connect each access ISP to <mark>one global transit ISP</mark>?
*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 exchange point

peering link

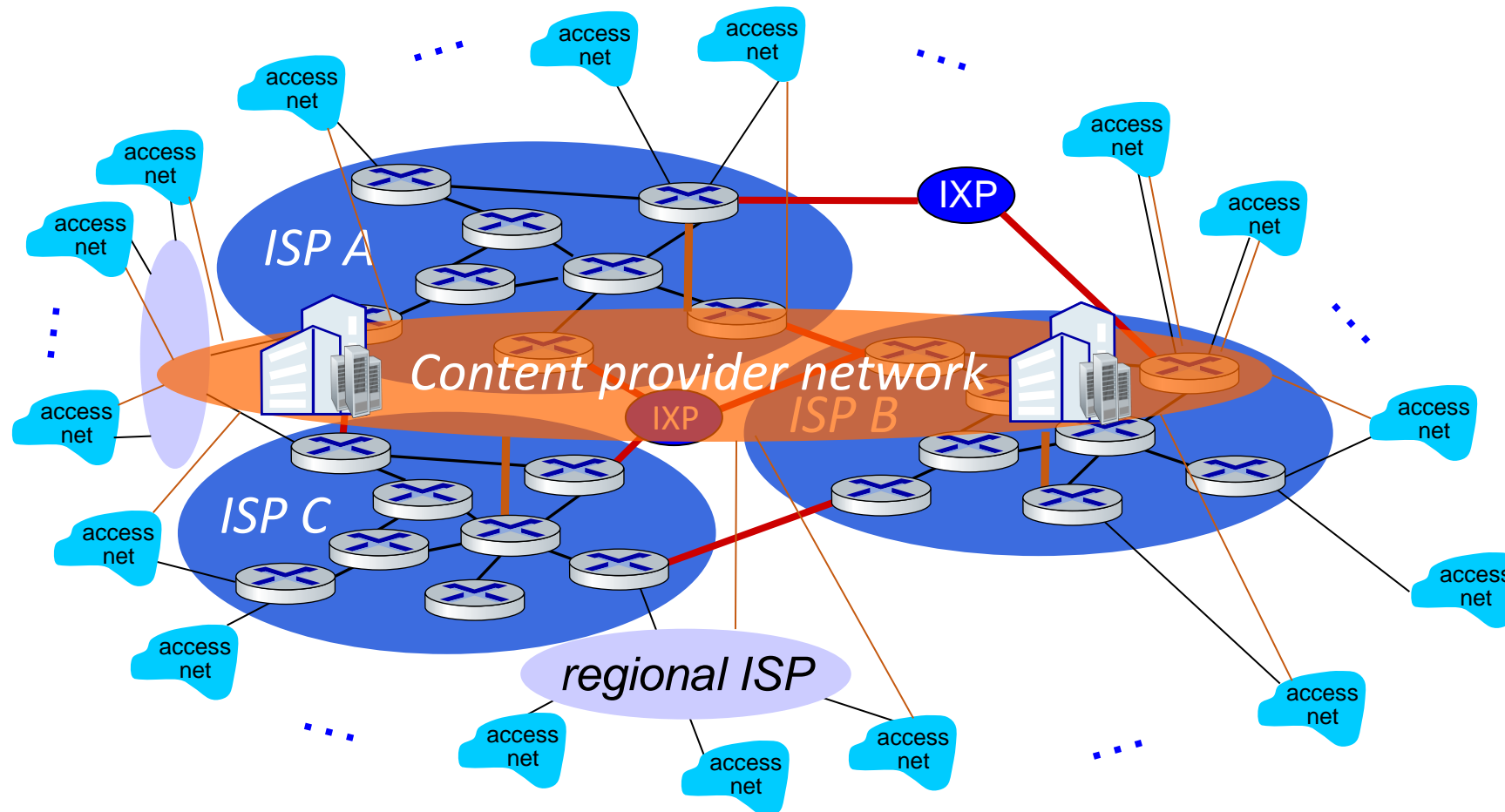https://www.internetexchangemap.com/
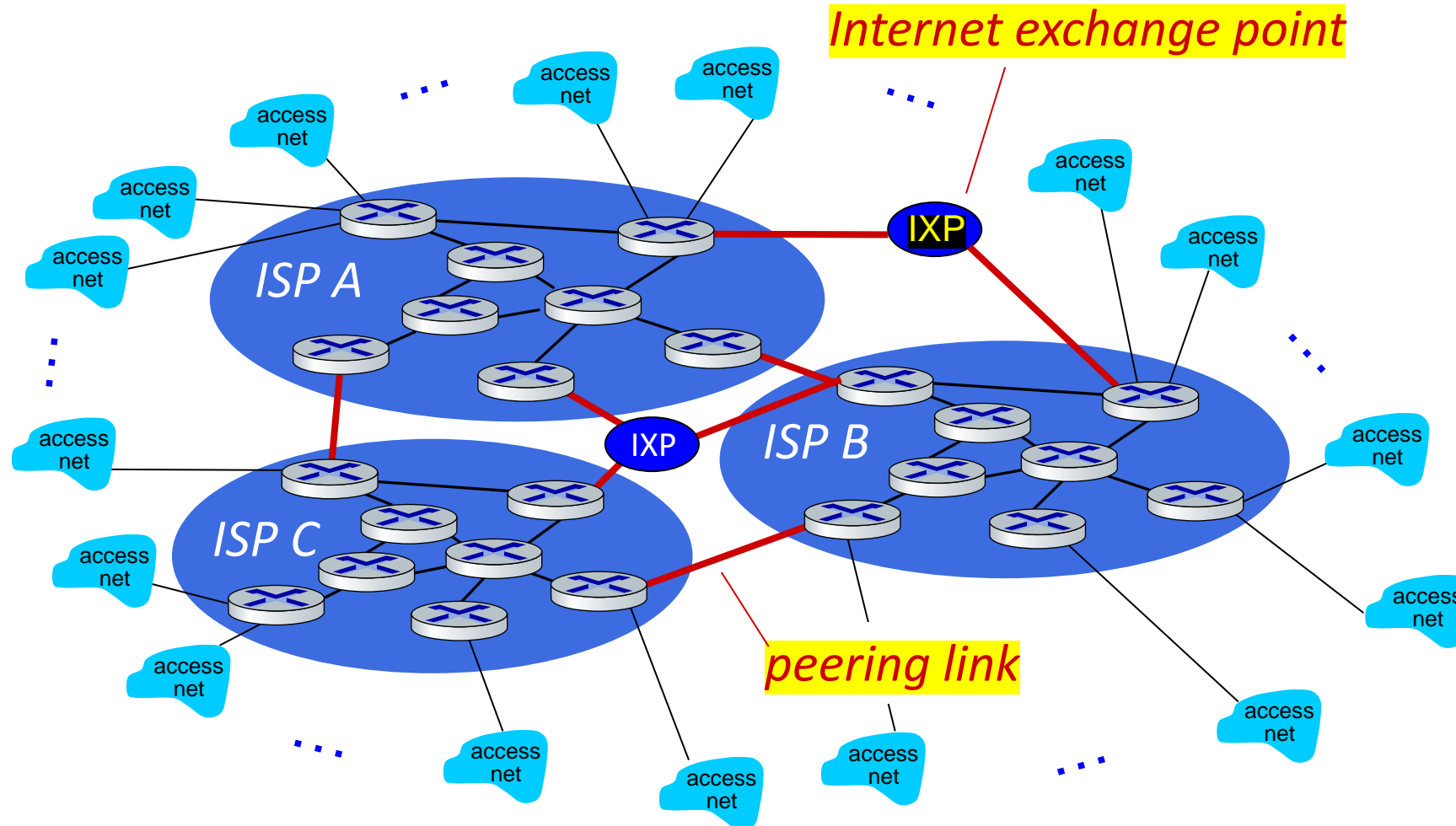
Internet structure: a "network of networks"

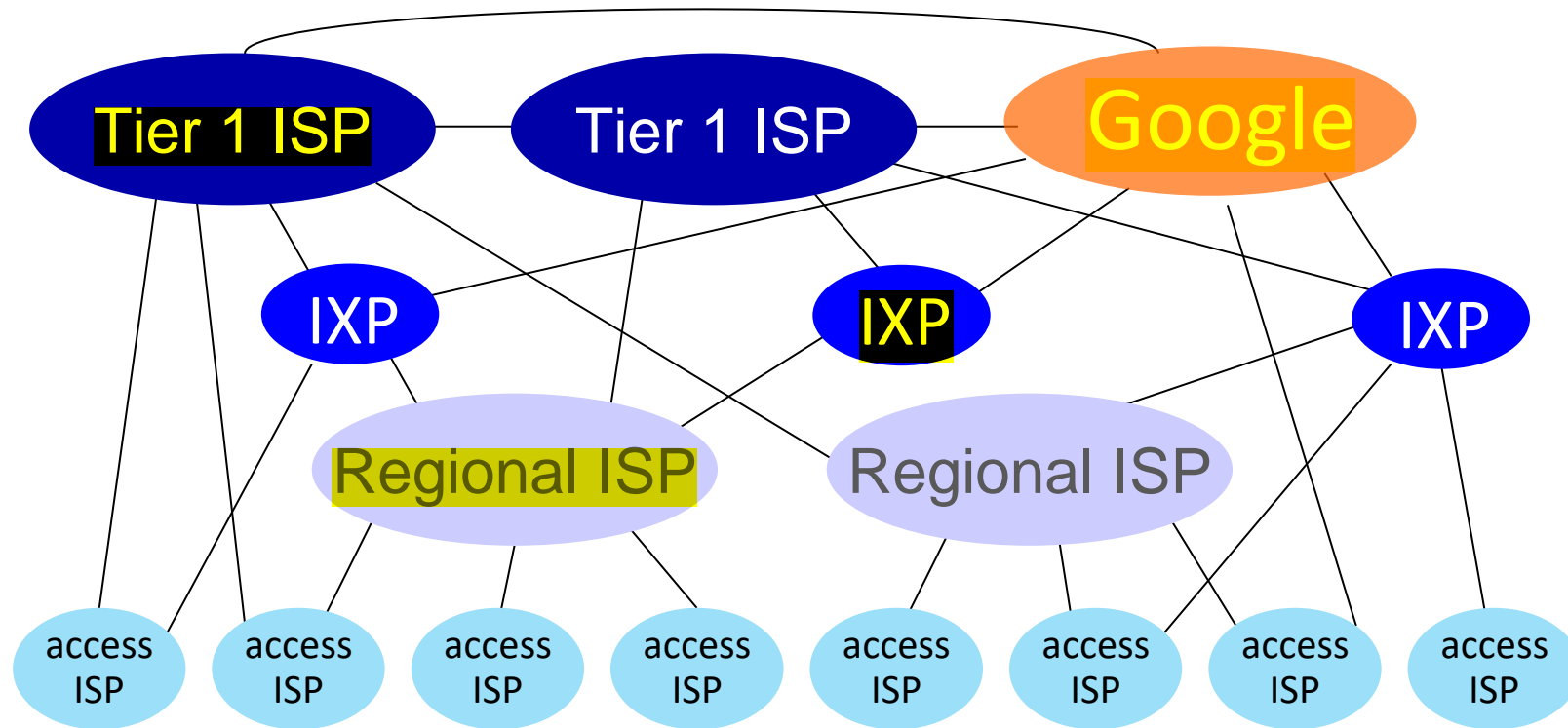... and regional networks may arise to connect access nets to ISPs
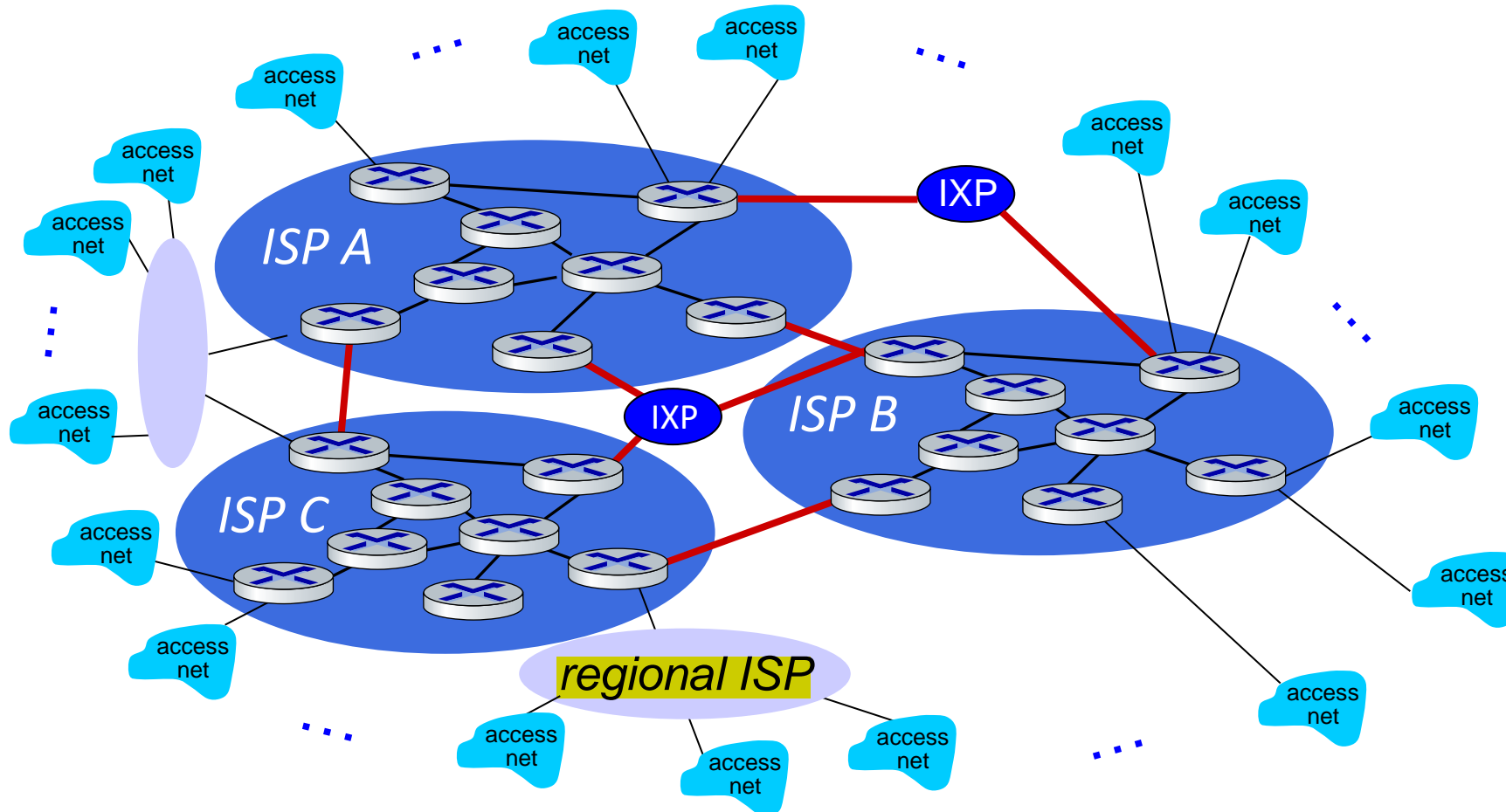
Internet structure: a "network of networks"

… 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