National University of Computer & Emerging Sciences

CS 3001 - COMPUTER NETWORKS

Lecture 02

Chapter 1

25th August, 2022

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nauman.moazzam@lhr.nu.edu.pk

Office Hours: 02:30 pm till 06:00 pm (Every Tuesday & Thursday)

Course Administration

Course Information

Program: BS

Credit Hours: 3+1 (Theory + LAB (Separate Instructor))

Type: Core

Class Meeting Time: Sec 5A , Tuesday & Thursday 01:00 pm till 02:30 pm

Course Website: Google Classroom

Class Venue: CS-8

Prerequisites: CS 218 , CL 218

Instructor Email: nauman.moazzam@lhr.nu.edu.pk

TA Name: Mr. Ali Idrees

TA Email: l191141@lhr.nu.edu.pk

Course Information (Subject to Change)

Assignments: 5	**(10%)**
Quizzes: 5	**(15%)**
Midterm / Sessional: 2	**(15% + 15% = 30%)**
Final Exam: 1	**(45%)**
Total:	**(100%)**

Grading Policy

Absolute Grading as per Department policy for Core Courses

What is a "Computer"Network?

- It is a set of nodes such as routers, switches, hosts etc. interconnected via transmission facilities like copper, cable, fibre, satellite, radio, micorwave etc. for the purpose of providing services to the end systems / users

- Why the " "? Non traditional end sytems / fun internet appliances like smart phones, home appliances, gaming consoles, sensors, medical and health equipment etc. are being connectec to the internet

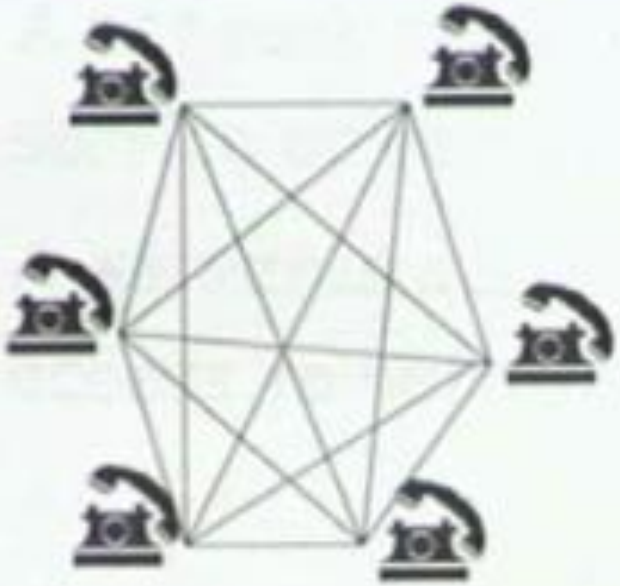
- Point to Point communications is not practical!
  - Devices are too far apart
  - Large set of devices would need impractical number of connections (A simple example on the next slide)

Web-enabled toaster + weather forecaster

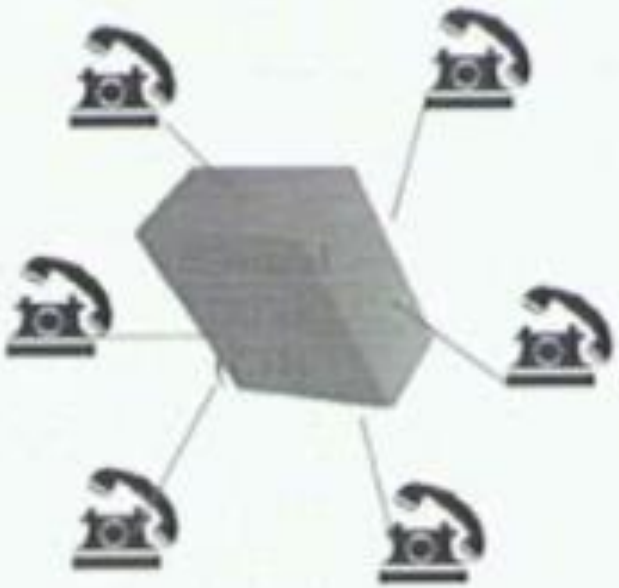
IP picture frame

Internet refrigerator

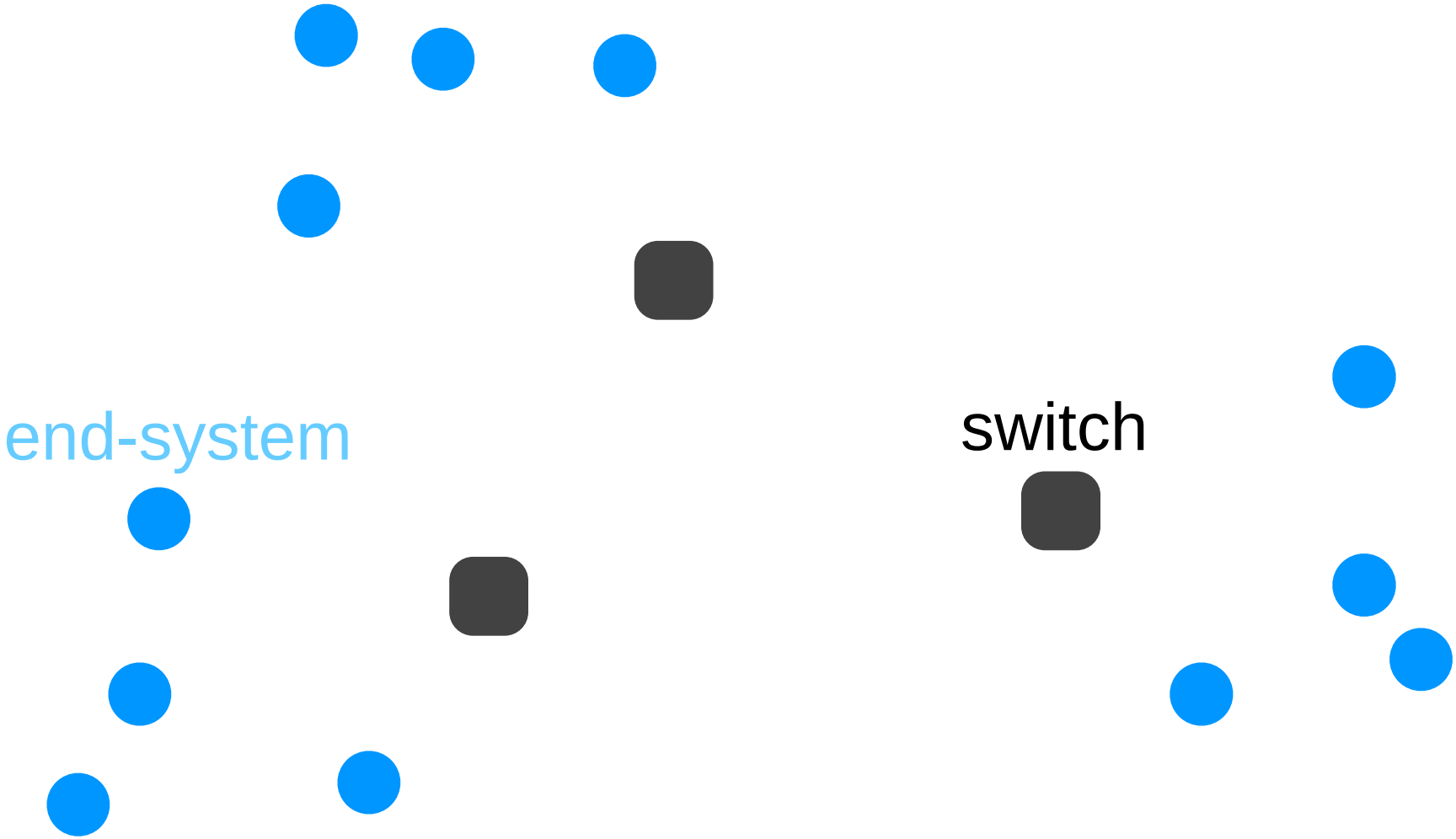
Example: Telephone Network

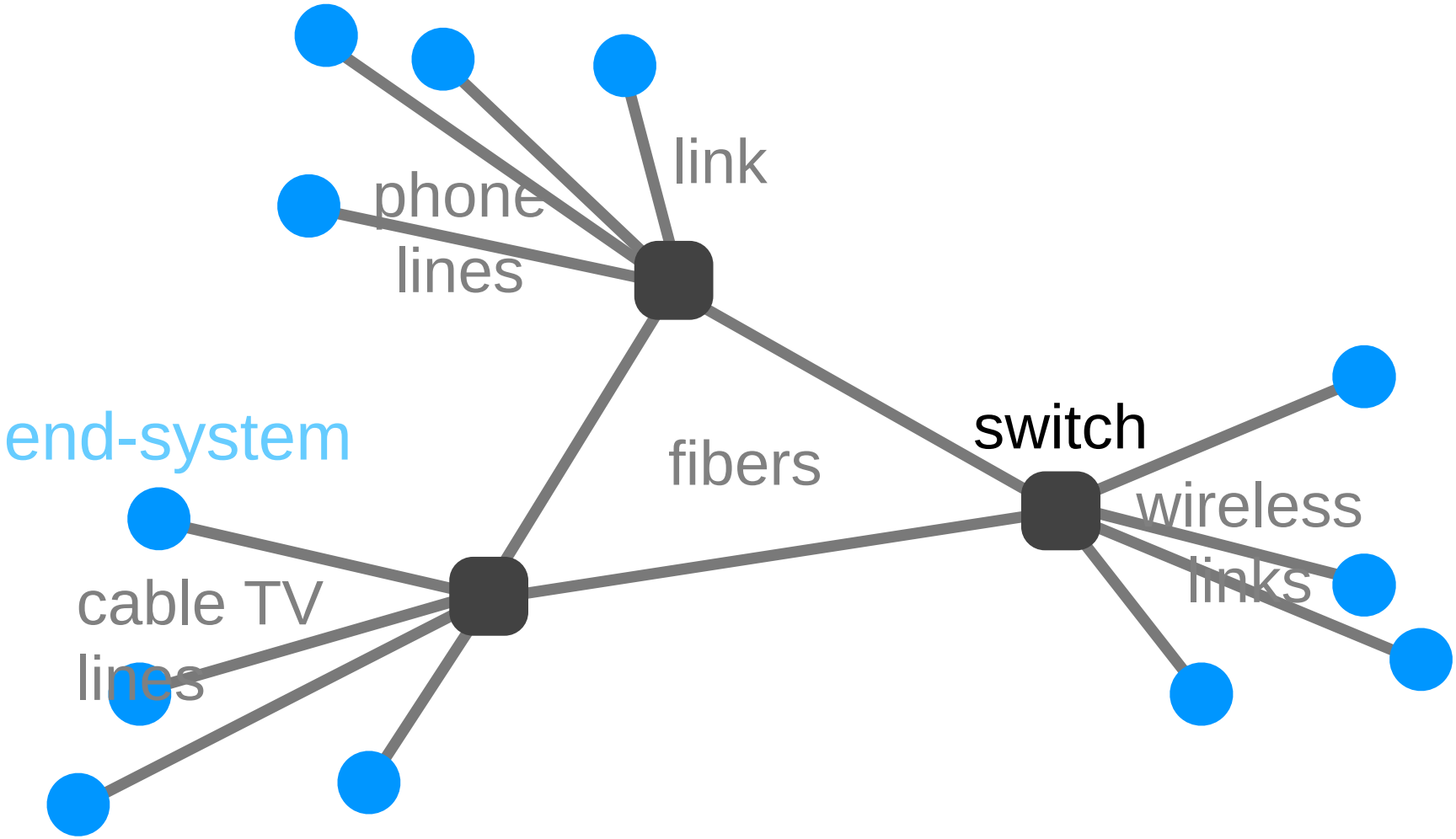


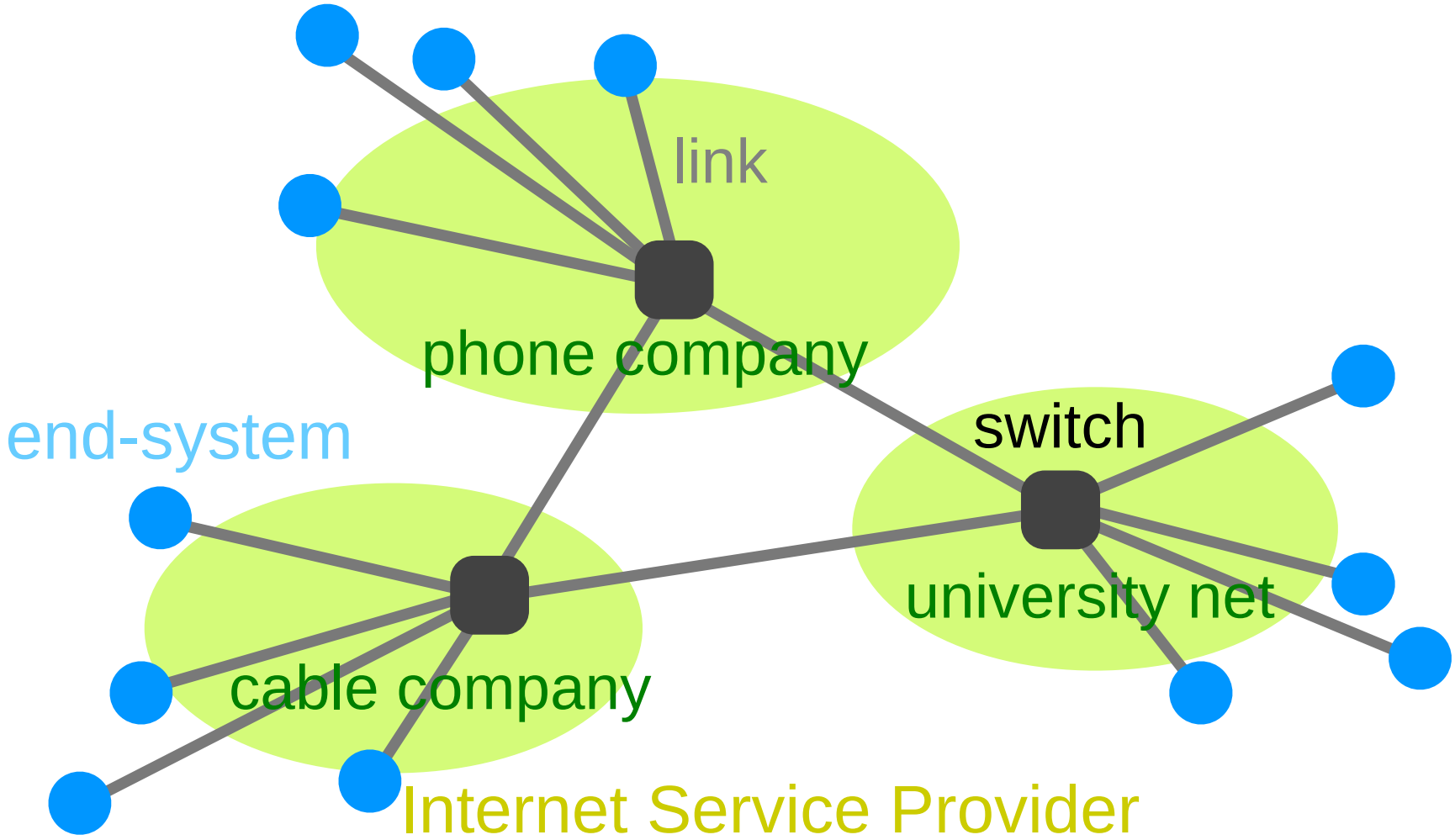
Fully-Connected Mesh
# of FDX links = N(N-1)/2
e.g., N=6; 6(5)/2=15 links
Total # ports = N(N-1)
e.g., N=6; 6(5)=30 ports

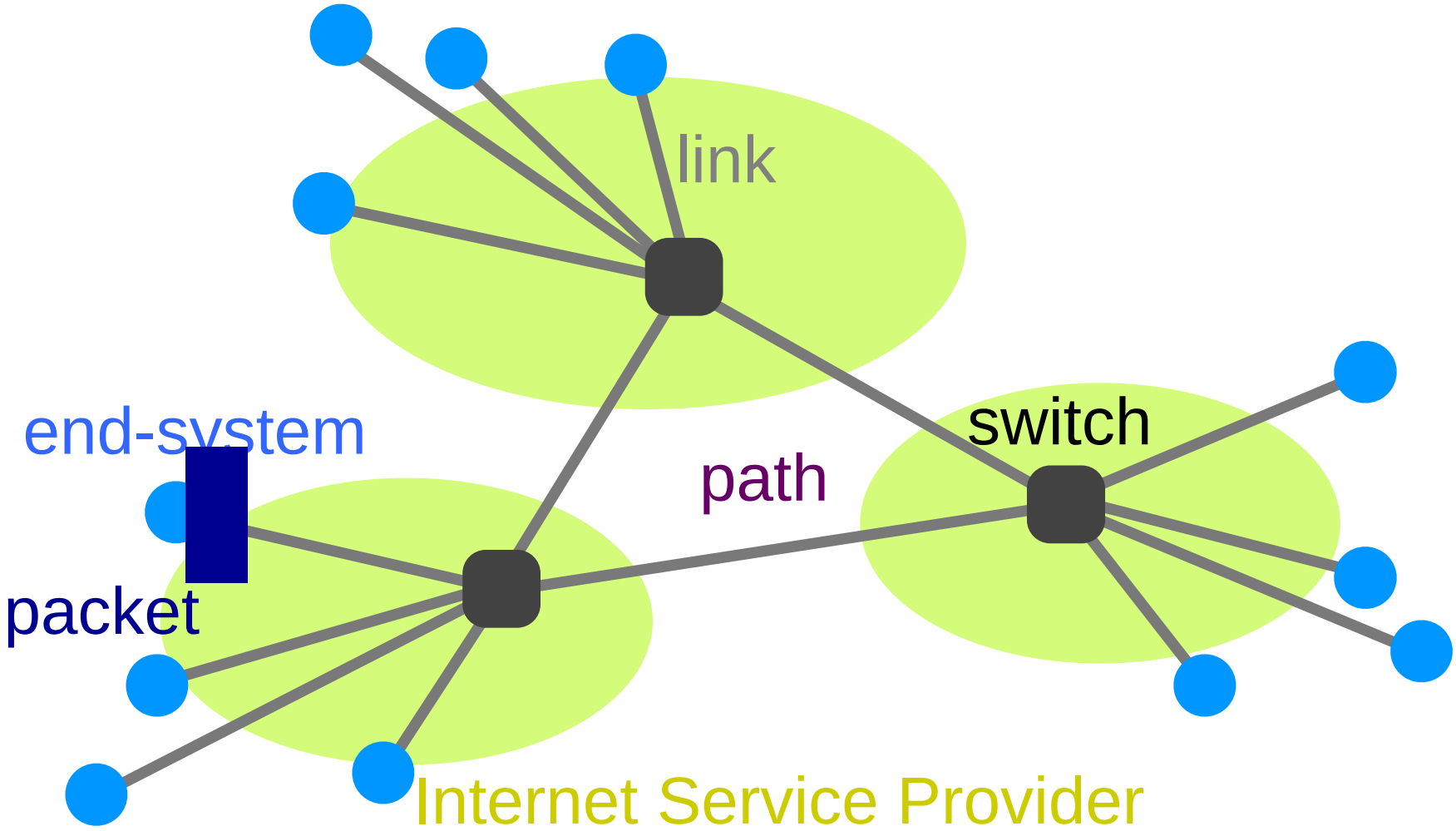


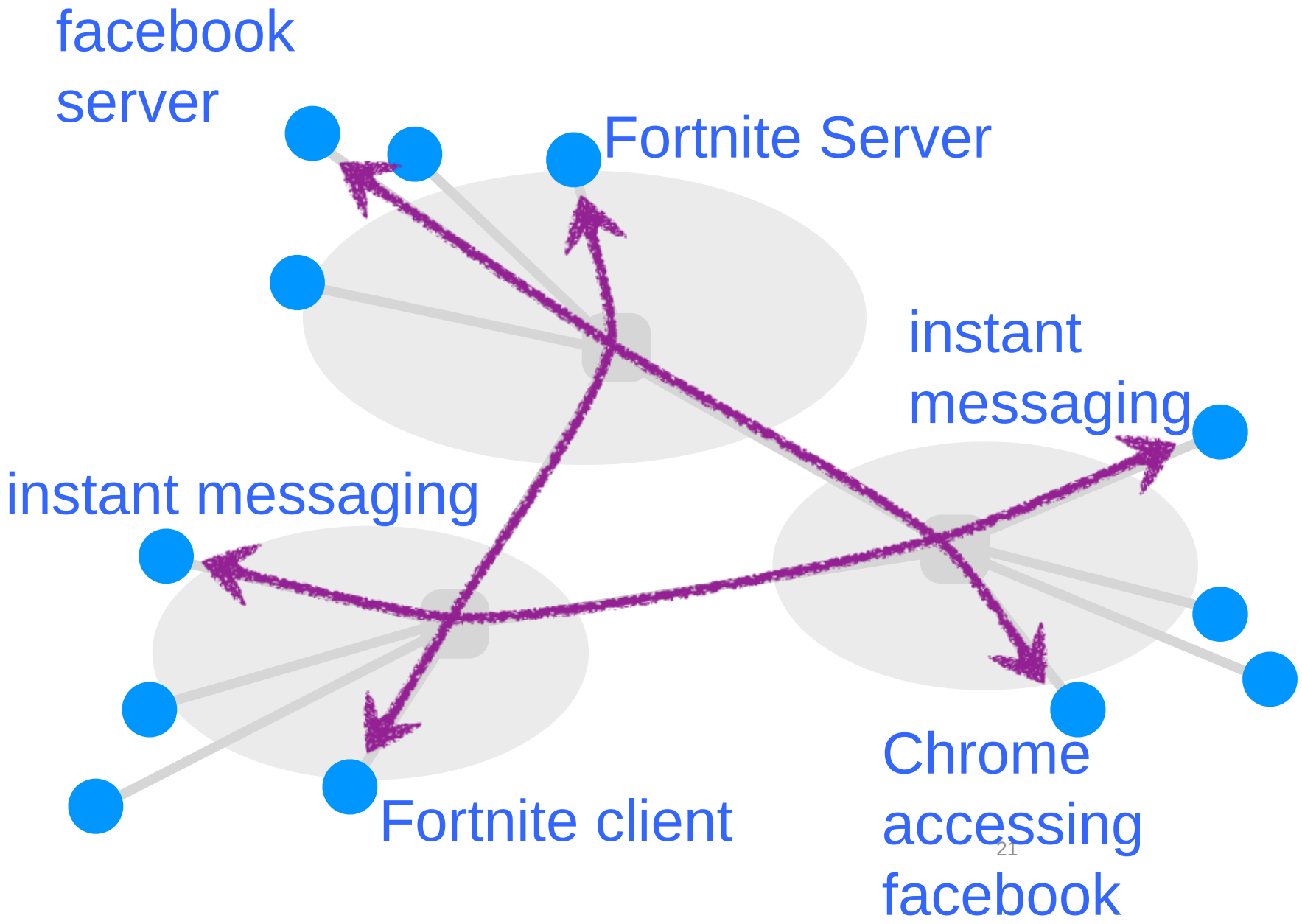
With Central Office
# of FDX links = N
e.g., N=6; 6 links
Total # of ports = N
e.g. N=6, 6 ports


end-system
switch


link
phone
lines
end-system
fibers
switch
wireless
links
cable TV
lines


link
phone company
end-system
switch
university net
cable company
Internet Service Provider


link
end-system
switch
path
packet
Internet Service Provider


facebook
server
Fortnite Server
instant
messaging
instant messaging
Chrome
accessing
facebook
Fortnite client

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We're making these slides freely available to all (faculty, students, readers). They're in PowerPoint form so you can add, modify, and delete slides (including this one) and slide content to suit your needs. They obviously represent a *lot* of work on our part. In return for use, we only ask the following:

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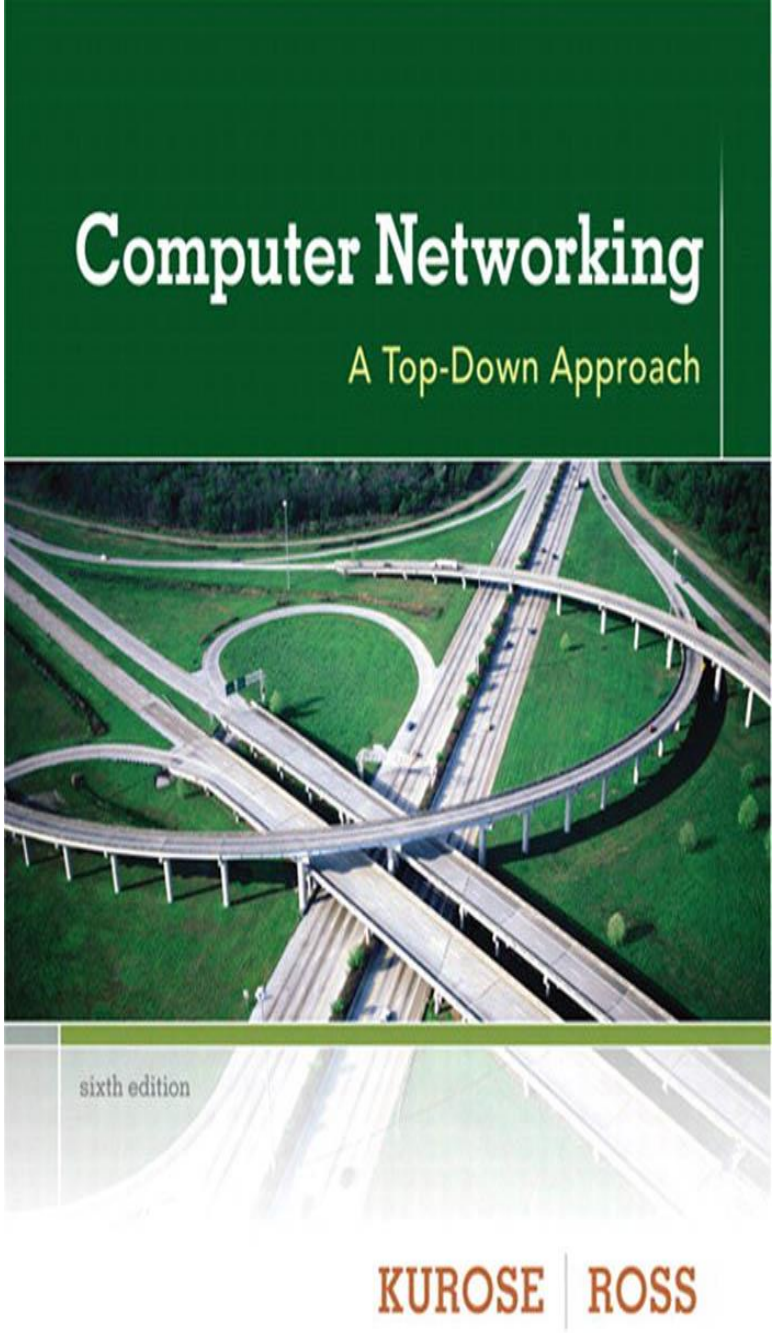
- If you post any slides in substantially unaltered form on a www site, that you note that they are adapted from (or perhaps identical to) our slides, and note our copyright of this material.

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

- circuit switching, packet switching, network structure

1.4 Delay, loss and throughput in packet-switched networks

1.5 Protocol layers, service models

1.6 Networks under attack: security

1.7 History

What is The Internet? (Wikipedia)

The Internet is the global system of interconnected computer networks that uses the Internet protocol suite (TCP/IP) to link devices worldwide. It is a network of networks that consists of private, public, academic, business, and government networks of local to global scope, linked by a broad array of electronic, wireless, and optical networking technologies. The Internet carries a vast range of information resources and services, such as the inter-linked hypertext documents and applications of the World Wide Web (WWW), electronic mail, telephony, and file sharing.

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

PC

server

wireless laptop

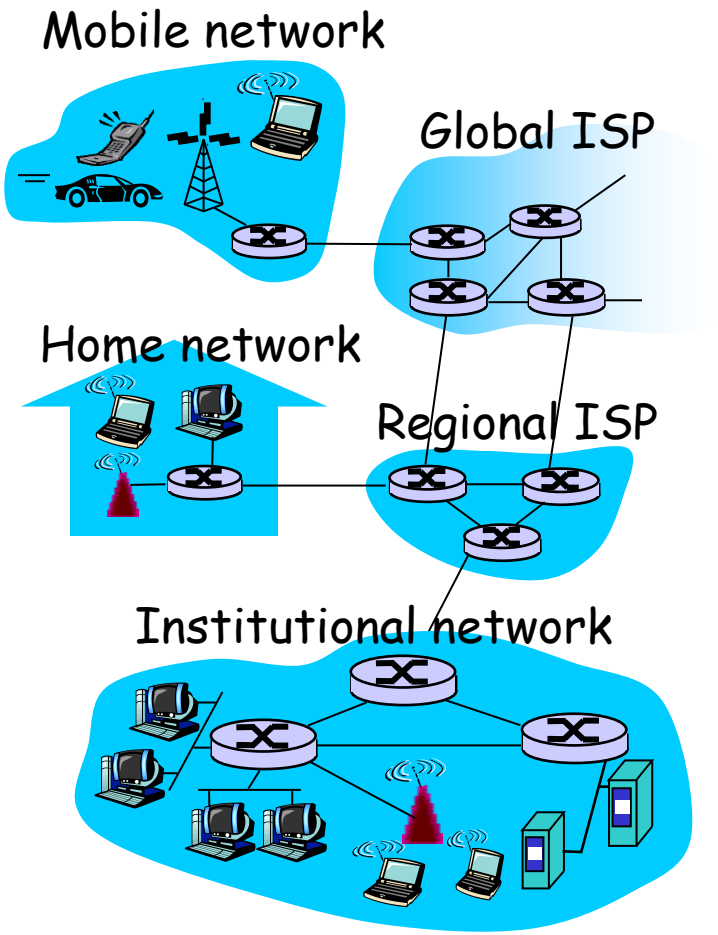
cellular handheld

access points

wired links

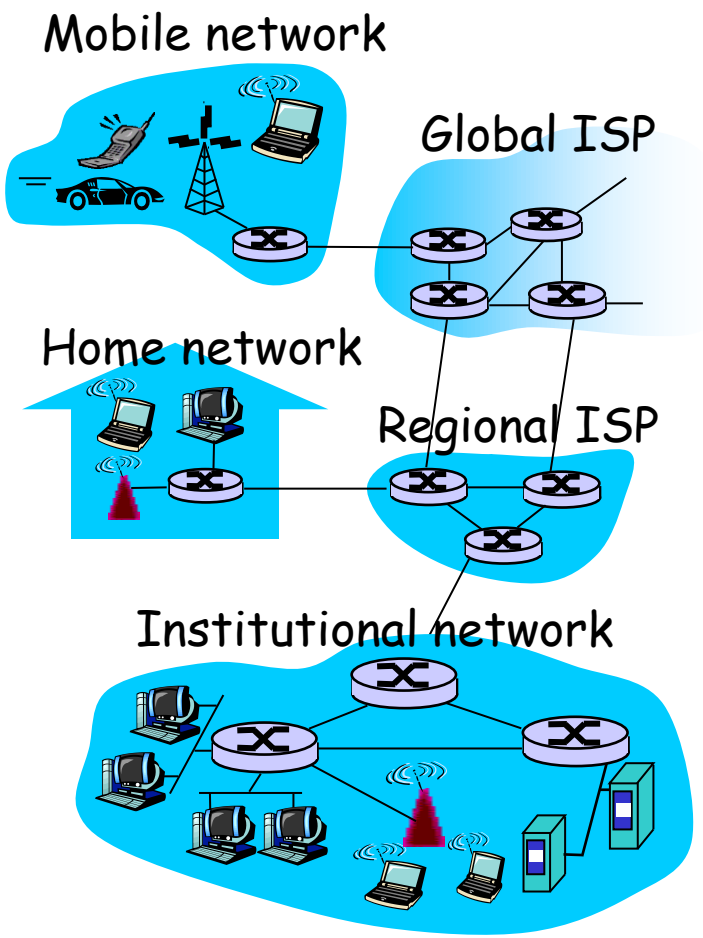
router

- billions of connected computing devices: *hosts = end systems*
  - running *network apps*
- *communication links*
  - fiber, copper, radio, cable, satellite
  - Provides transmission rate = *bandwidth*
- *routers:* forward packets (chunks of data) from source to destination



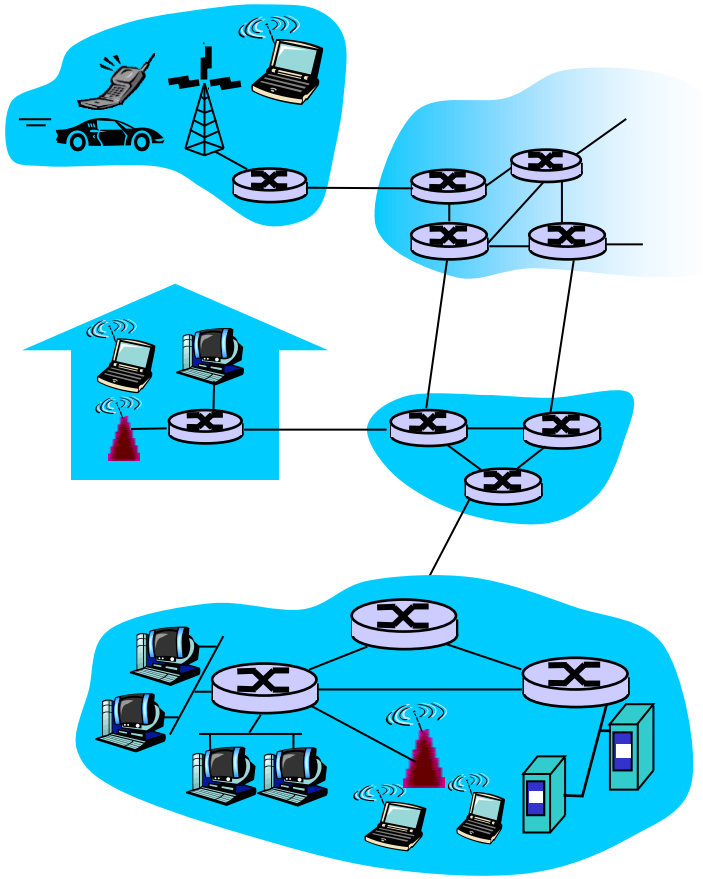
What's the Internet: "nuts and bolts" view (Continued)

- *protocols* control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, Skype, Ethernet
- *Internet: "network of networks"*
  - loosely hierarchical
  - public Internet versus private intranet
- Internet standards
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force



What's the Internet: a service view

- communication *infrastructure* enables distributed applications:
  - Web, VoIP, email, games, e-commerce, file sharing
- communication services provided to apps:
  - reliable data delivery from source to destination
  - "best effort" (unreliable) data delivery

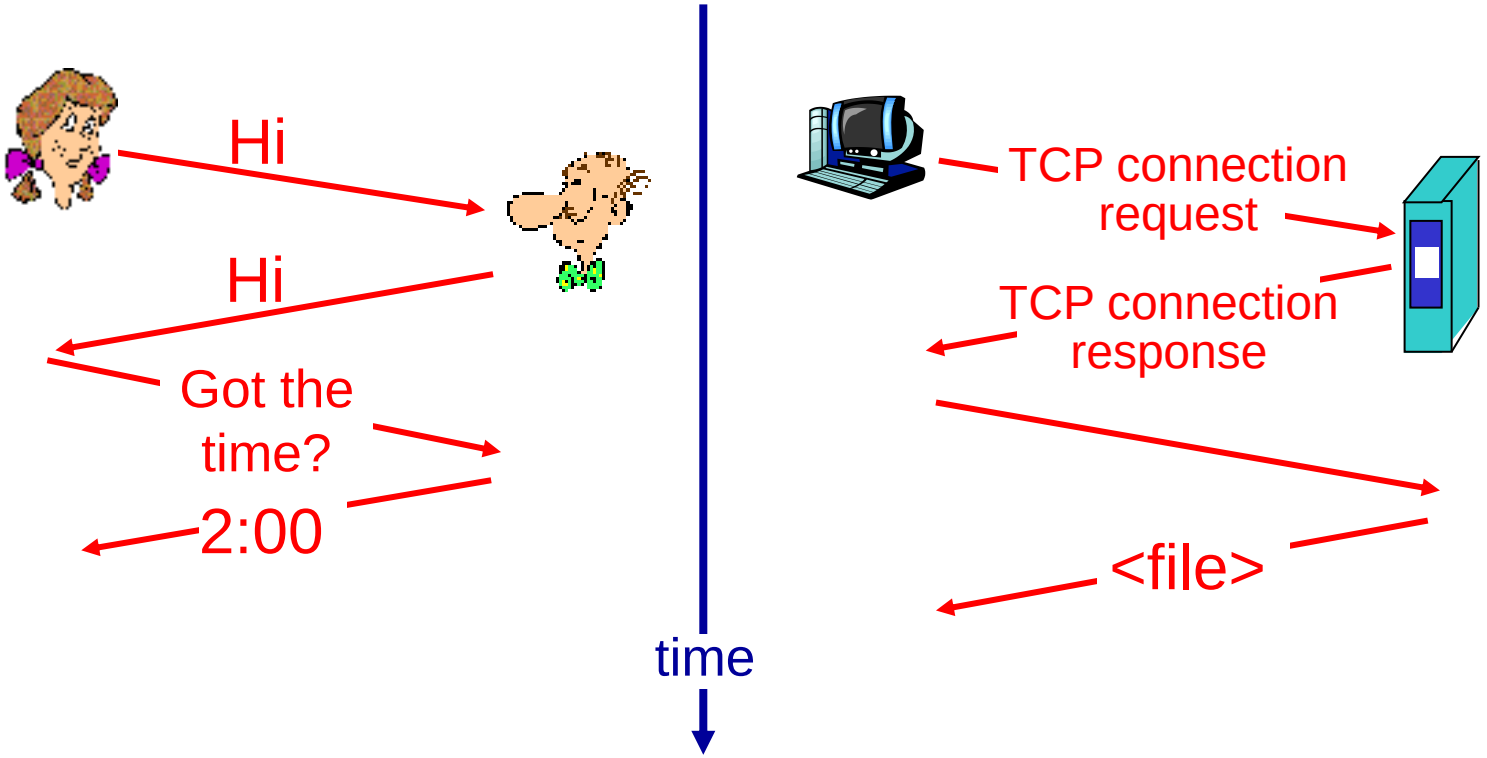


????????

but how these systems and network apps communicate with each other?

What's a protocol?

a human protocol and a computer network protocol:



Q: Other human protocols?

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

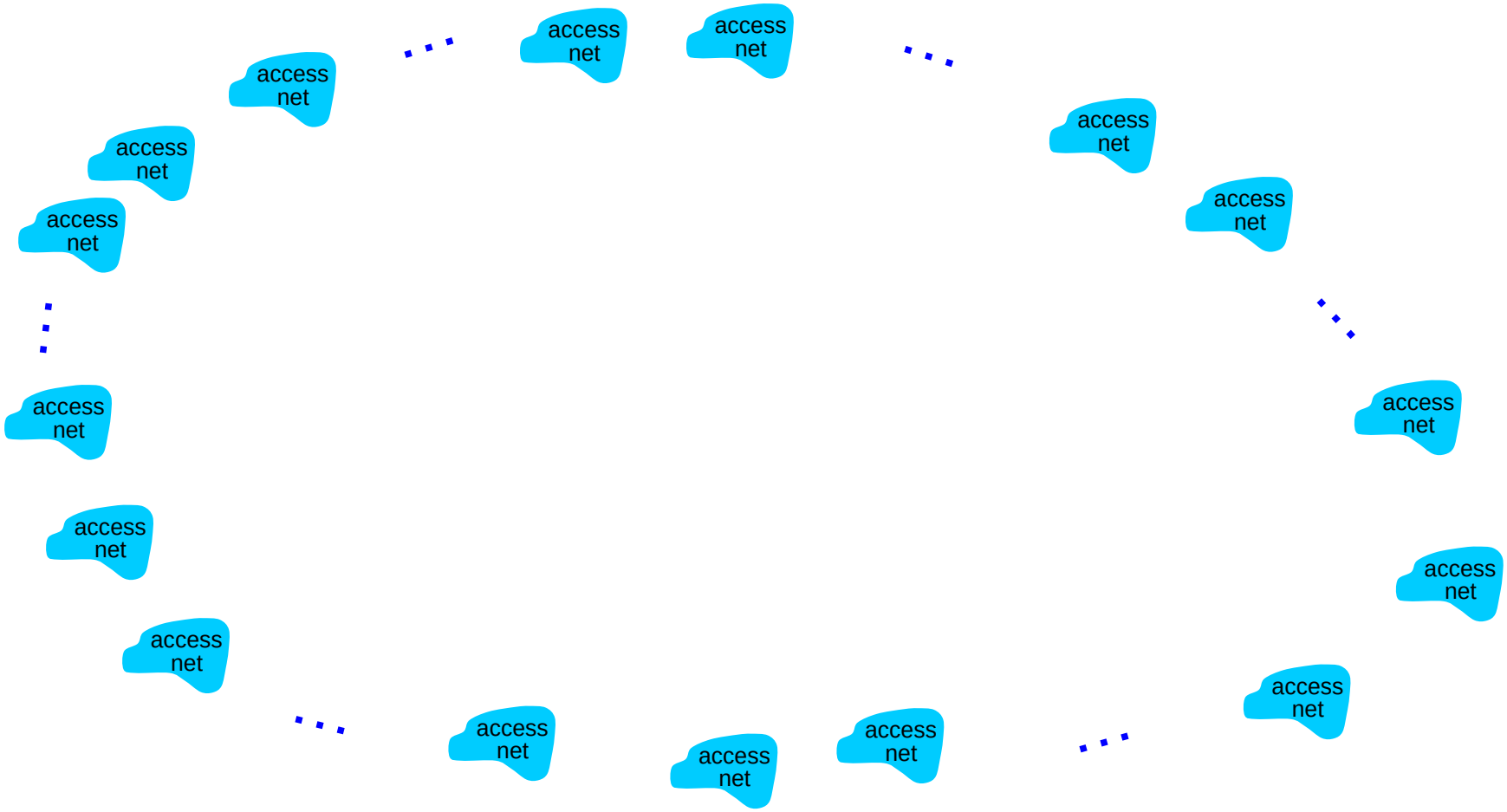
protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt

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 from different networks
- 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

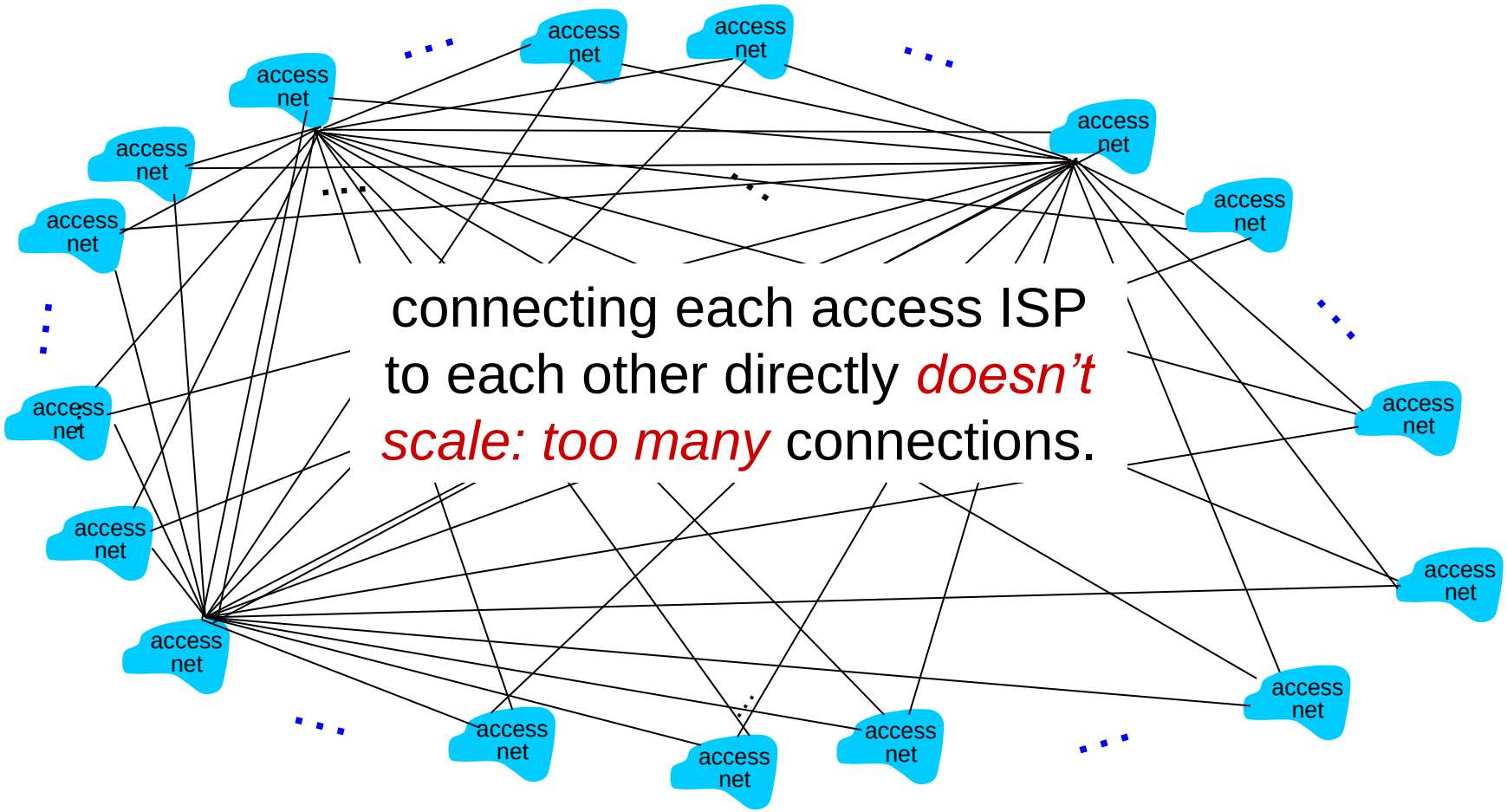
Internet structure: network of networks

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

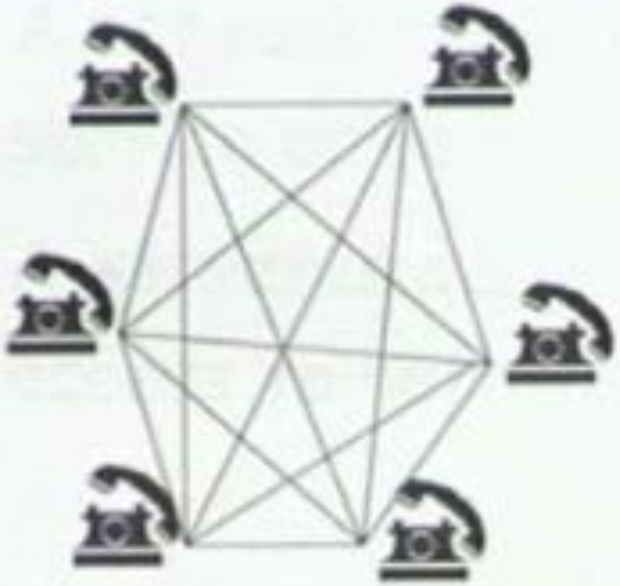


Internet structure: network of networks

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



Remember



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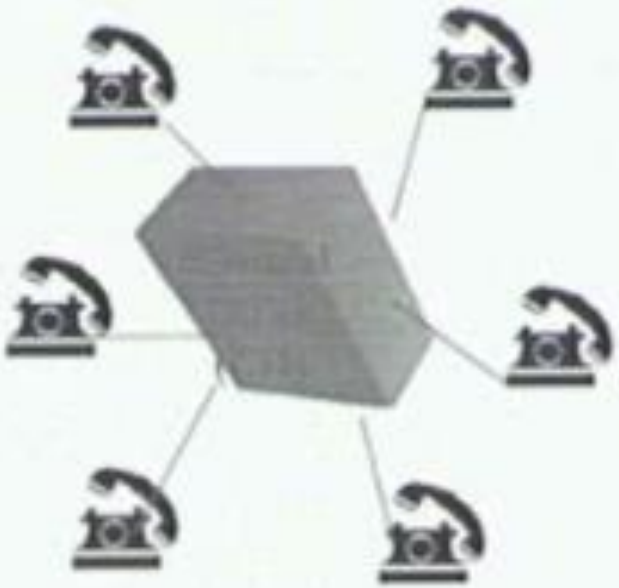

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# of FDX links = N
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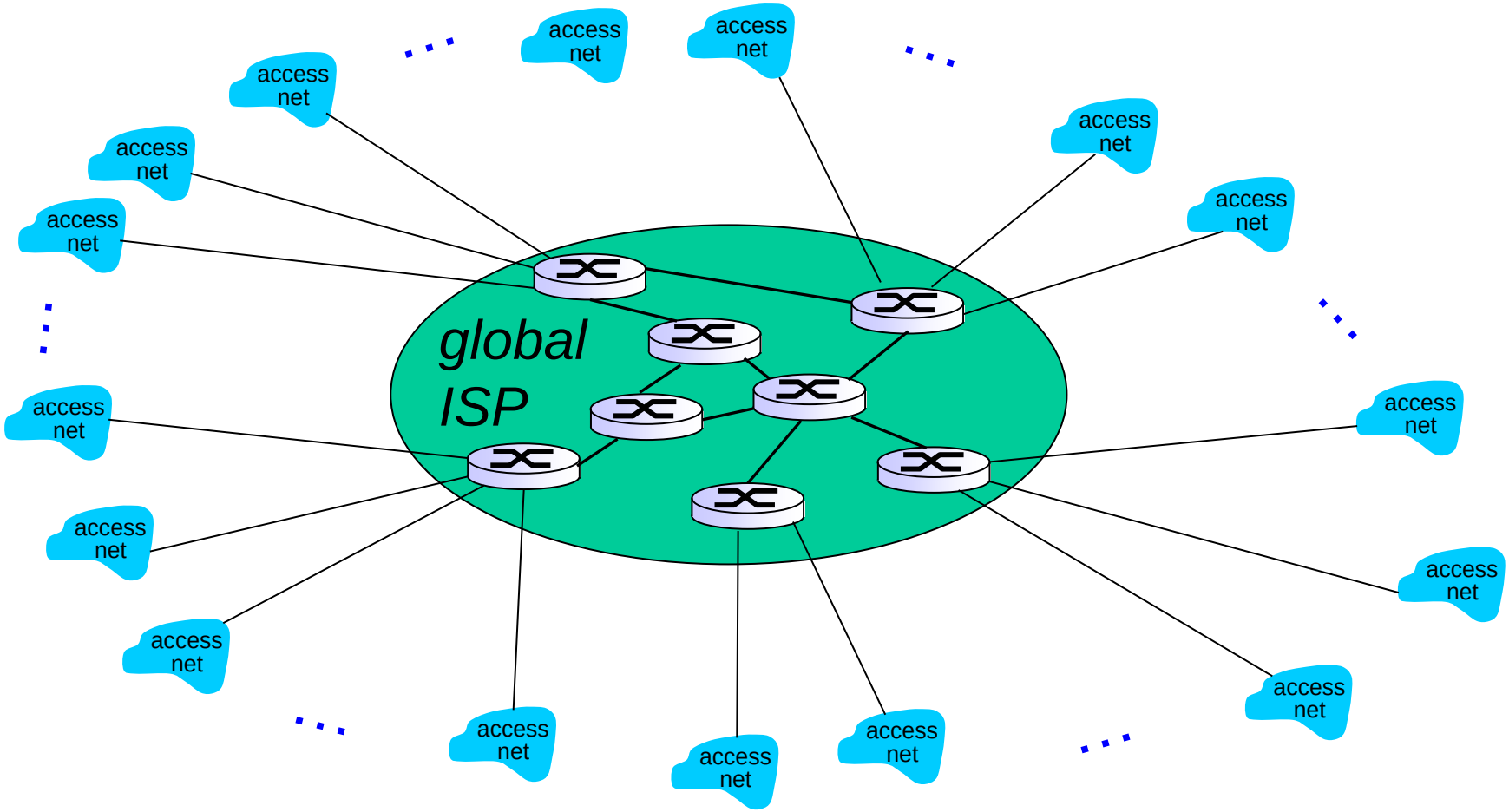
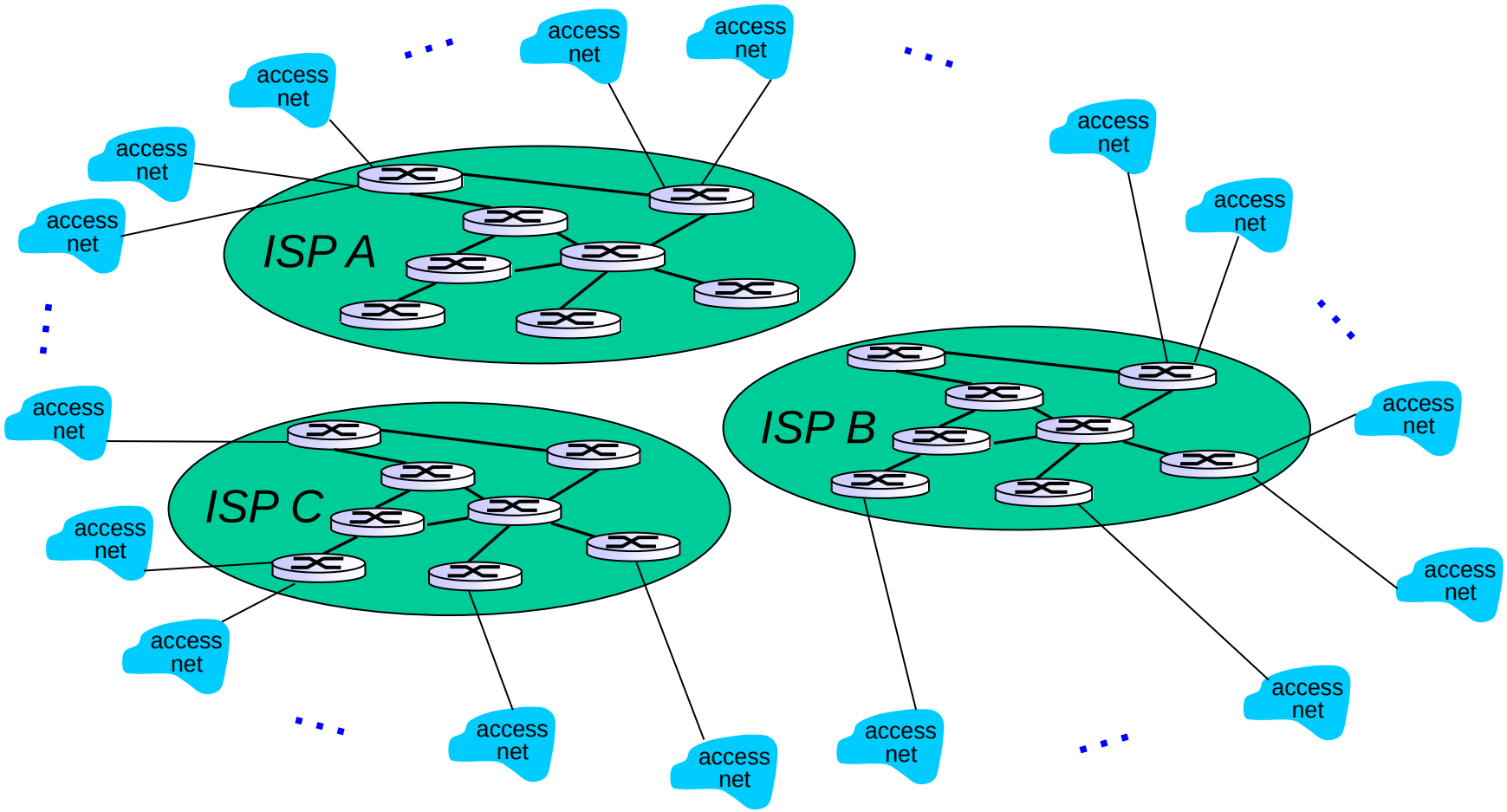
Internet structure: network of networks

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



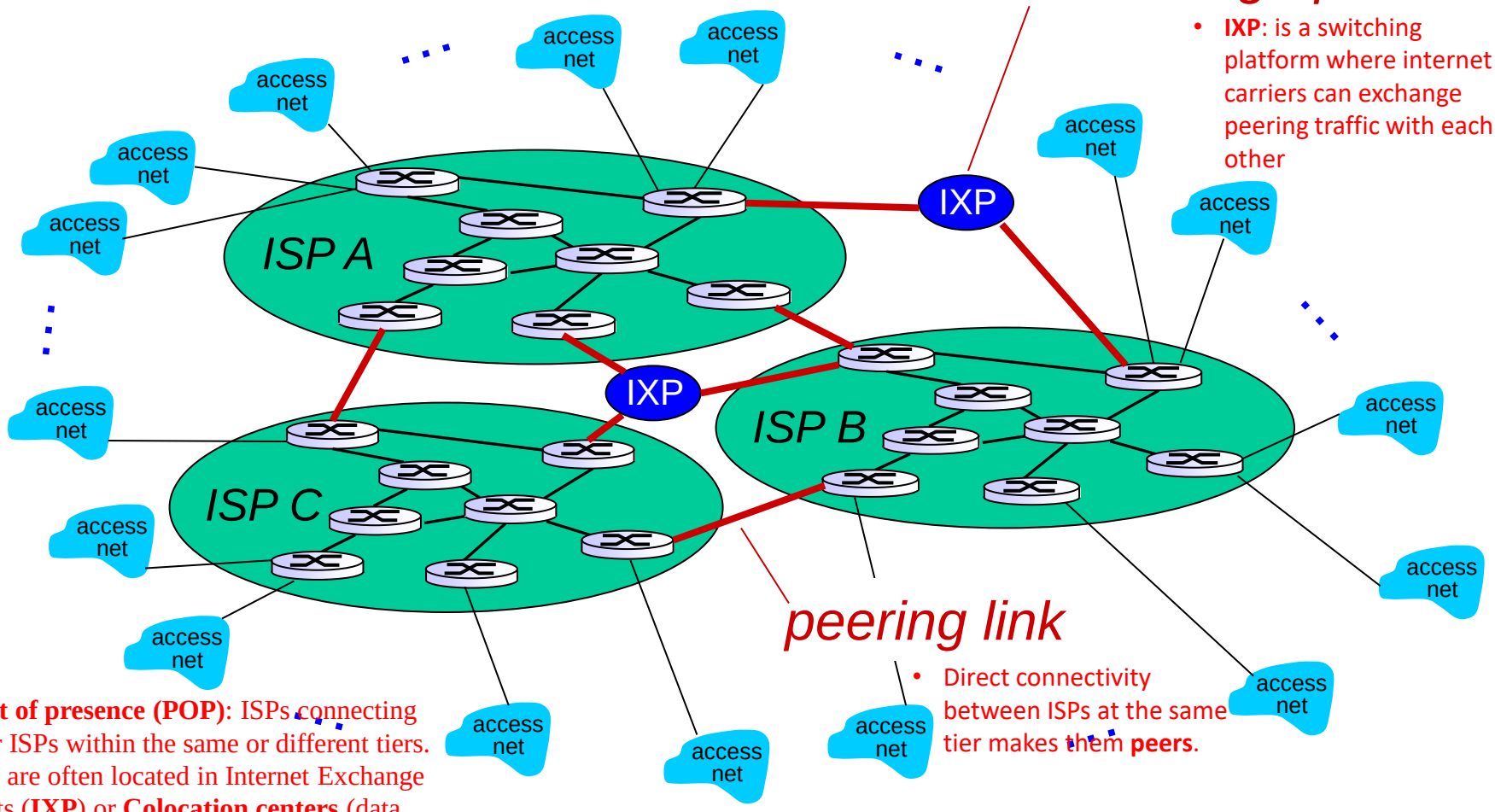
Internet structure: network of networks

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



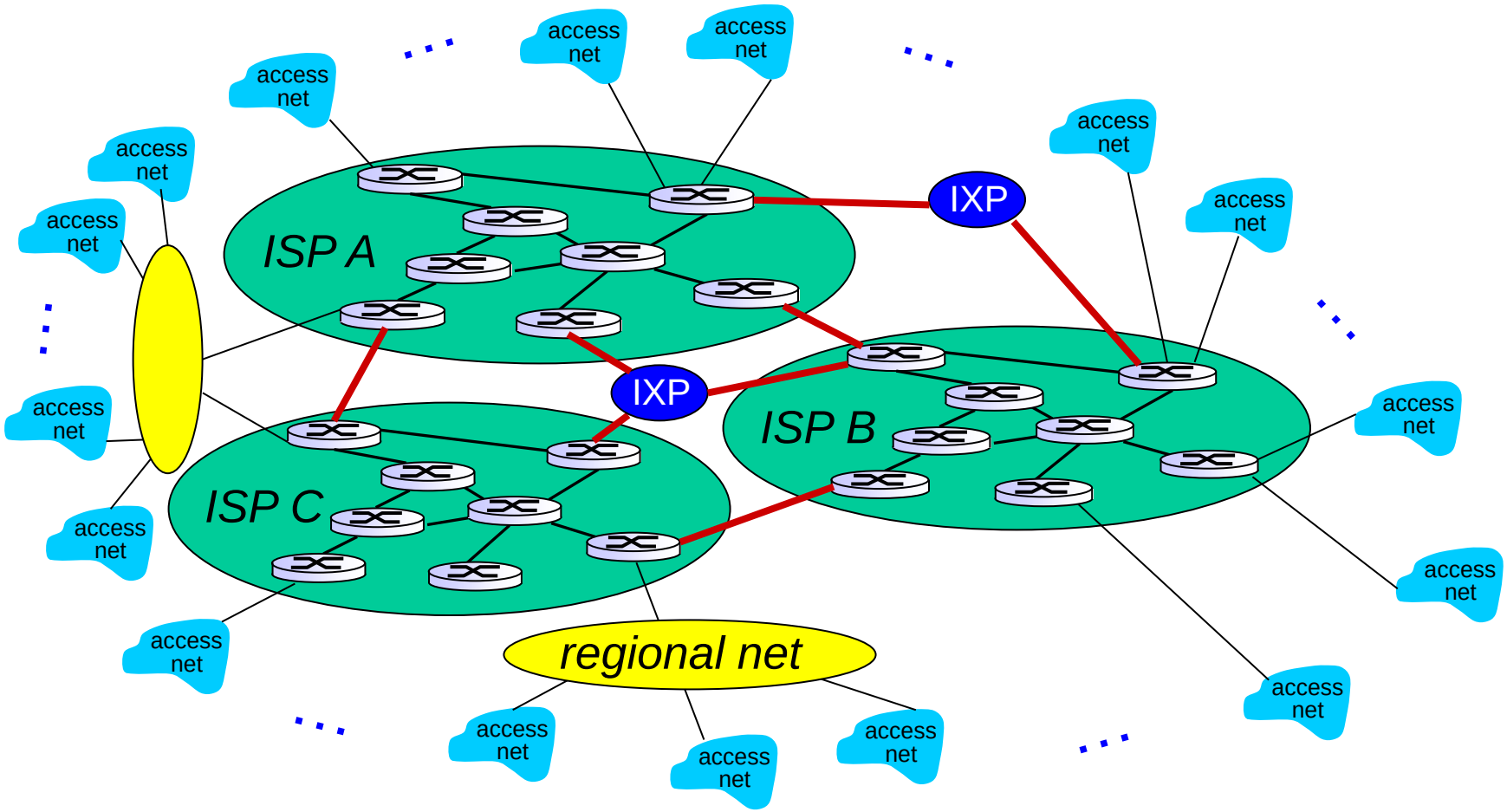
- **IXP**: is a switching platform where internet carriers can exchange peering traffic with each other

- **Point of presence (POP)**: ISPs connecting other ISPs within the same or different tiers.
- PoPs are often located in Internet Exchange Points (**IXP**) or **Colocation centers** (data centers which provide connectivity to retail customers)

- Direct connectivity between ISPs at the same tier makes them **peers**.

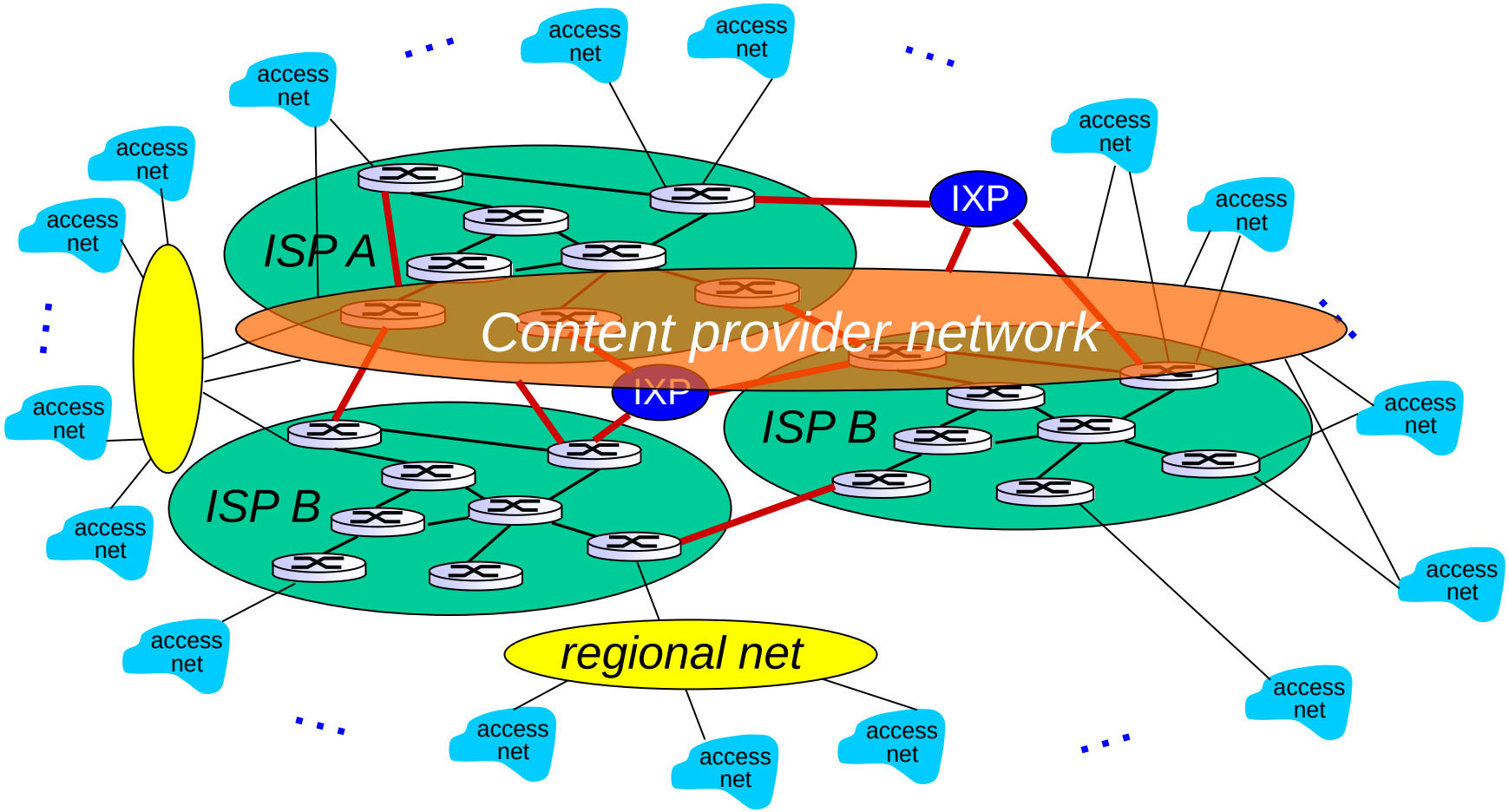
Internet structure: network of networks

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

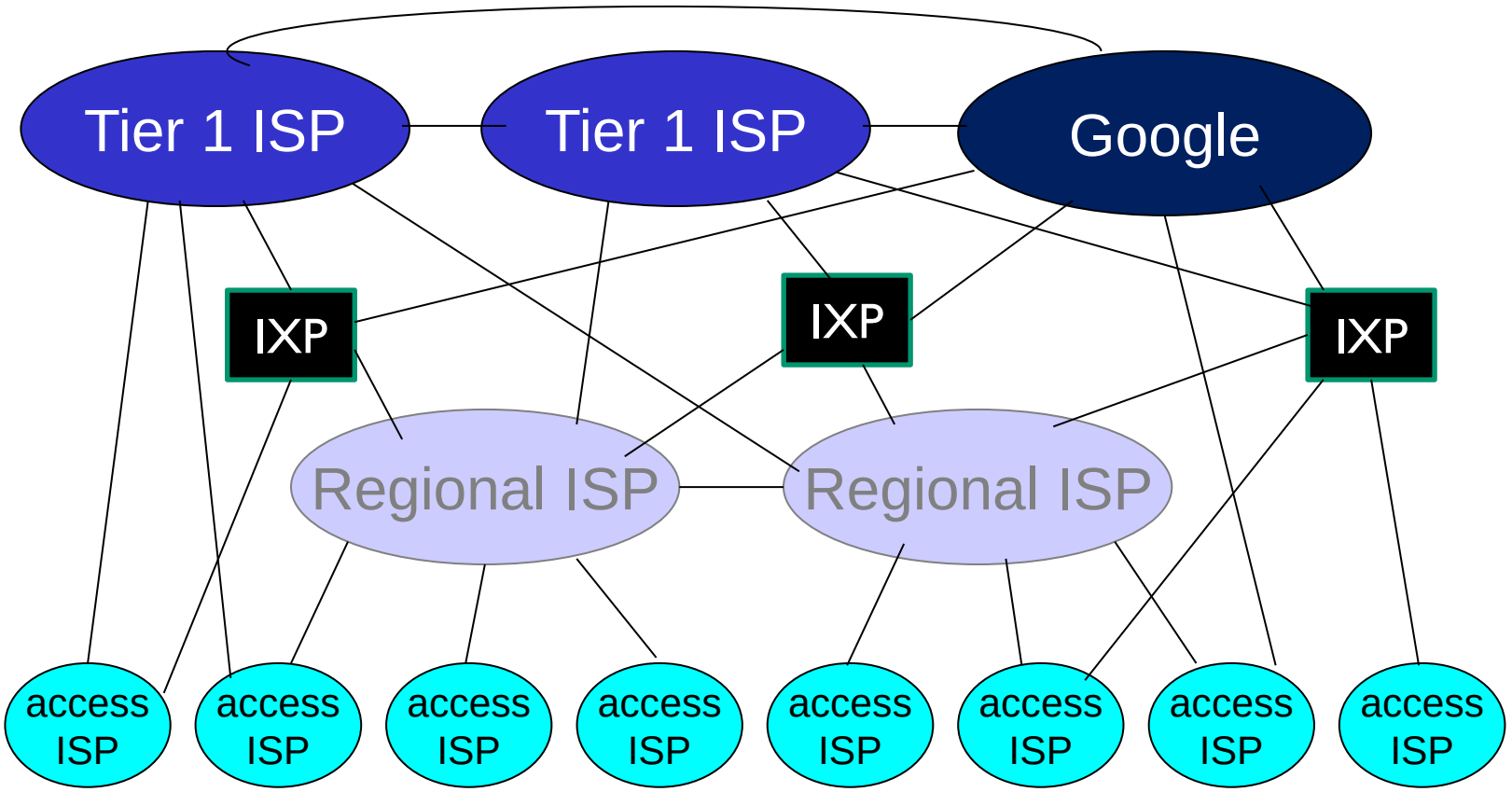


Internet structure: network of networks

… 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

Tier-1 ISP: e.g., Sprint