UMASS AMHERST

ECE 671
Introduction to Computer Networks

Lesson 1
Introduction

Rationale

- Modern computers interact with other devices
  - Data and resources in different location
  - Requires communication between computers
- Data communication is at core of computer networks
  - Protocols for interactions
  - Systems to enable interactions
  - Theoretical foundations for design of networks
- You will learn how computer networks operate, how network systems are designed, and how to experiment with networks in a lab exercises.

Lesson Objectives

- Explain the necessity for computer networks in modern computer engineering
- Describe the structure of the Internet
- Outline components necessary to succeed in a computer networking course

Required Resources

- Kurose, J., & Ross, K. (2017). *Computer networking: A top-down approach* (7th ed.). New York, NY: Pearson Publishing.
    - Chapter 1, “Computer Networks and the Internet” (pp. 1–34)

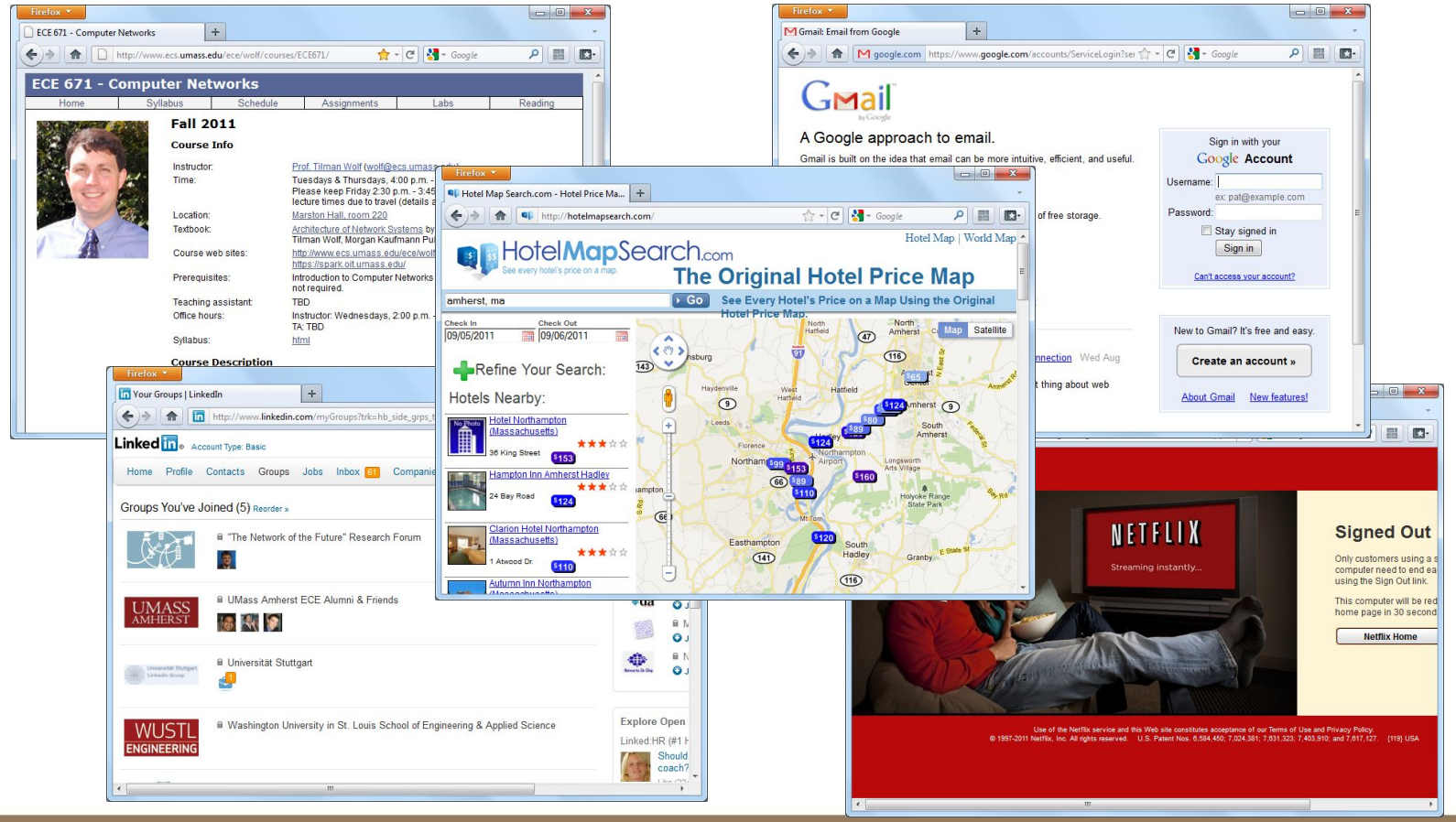
Orchestrated Discussion (Short Answer): Computer Networks

- What devices/systems/concepts can you think of that relate to computer networks?

- What can computer networks be used for?

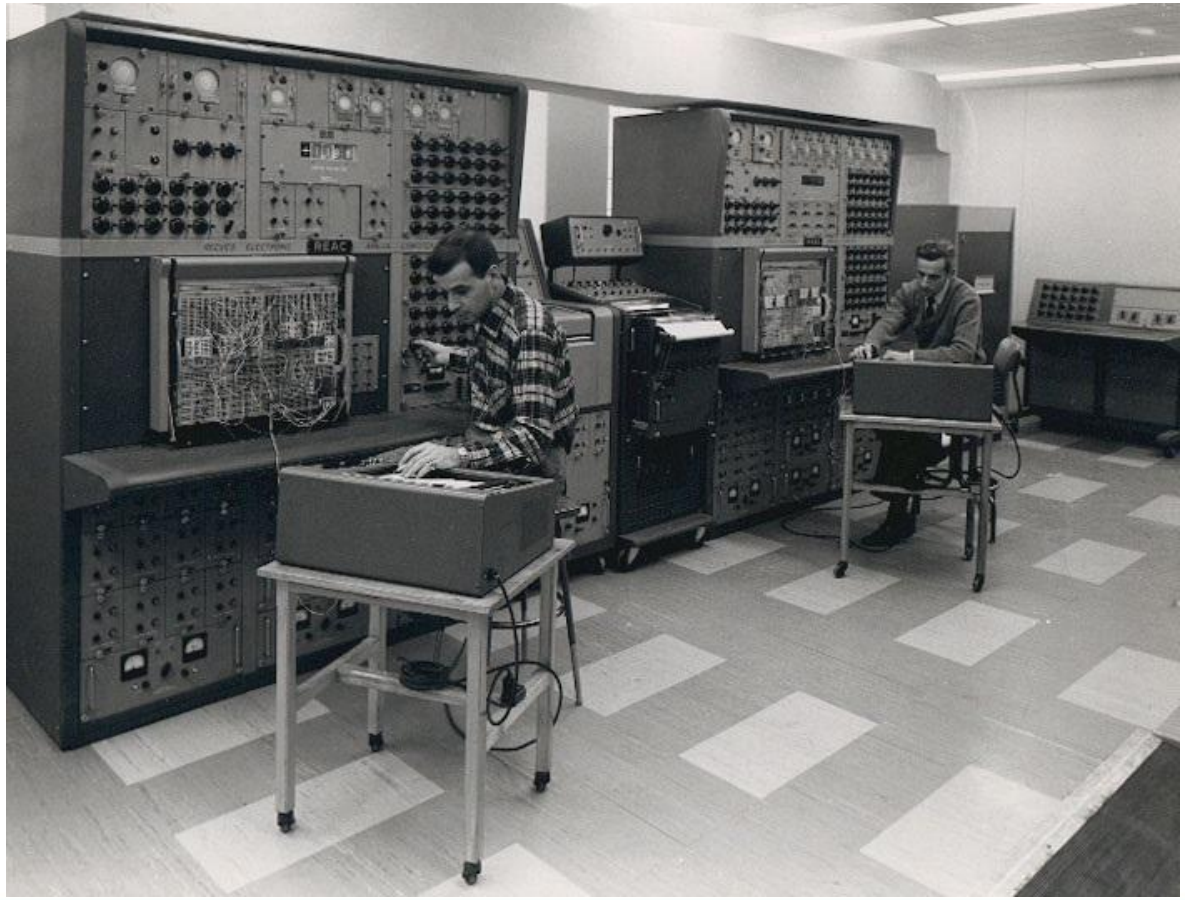
Uses of Internet

- Website access, mash-ups, social networking, etc.



Centralized Computing

- Early days: application(s) on one computer

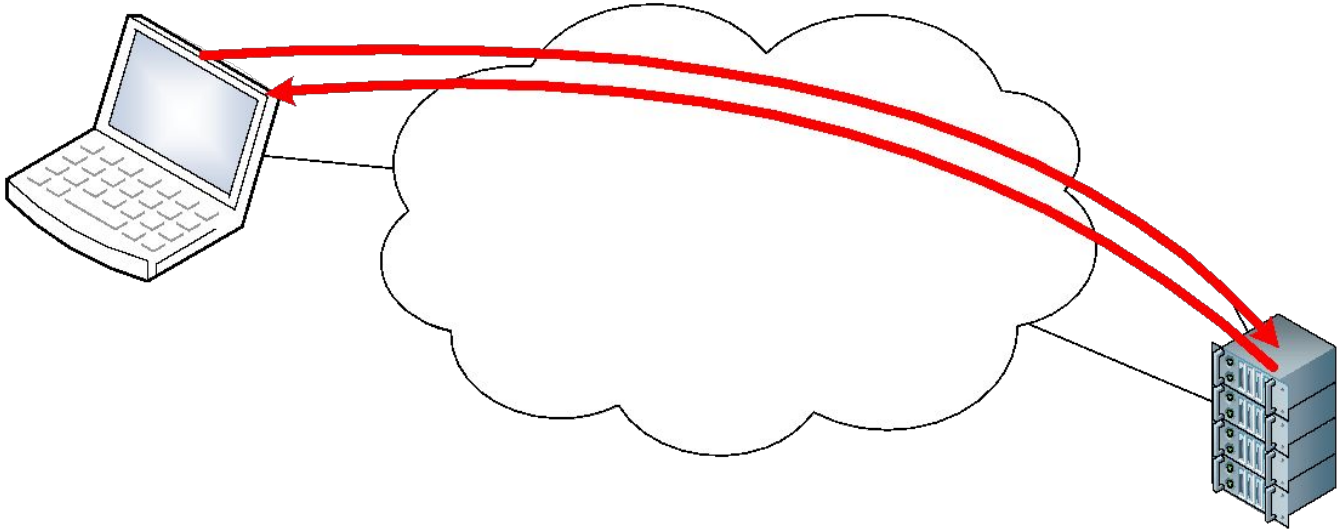


Distributed Computing

- Today: applications interact across many computers

Example: World-Wide Web

- Access to documents
  - Web browser fetches document from web server
- Client (web browser) and server (document source) are distributed
  - Client and server are at different locations



Distributed Applications

- Distributed computing applications use networks
- Distributed application requires data communication
  - Data are stored at different places
  - Data need to be exchanged between computers
- Computer networks enable data communications
  - Network connects geographically distributed nodes
  - Data can be sent between connected nodes
- What applications are inherently distributed?
  - Cannot be implemented on a single computer

Whiteboard: Classify the Applications

Applications	Distributed	NOT Distributed
Social networking		
Text processing		
Email		
Online shopping		
Computer gaming		
Scientific computing		
Web browsing		
Distance education		
TV/video distribution		

Distributed Applications

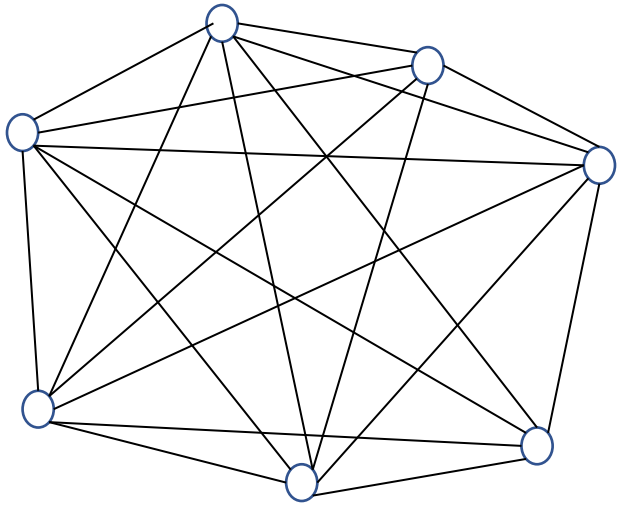
- Classify these example applications (distributed or not distributed)
    - Social networking (distributed)
    - Text processing (not distributed)
    - Email (distributed)
    - Online shopping (distributed)
    - Computer gaming (not distributed, distributed for multiplayer)
    - Scientific computing (not distributed)
    - Web browsing (distributed)
    - Distance education (distributed)
    - TV/video distribution (distributed)

Whiteboard: How to Connect Nodes

- How would you connect two nodes?
  - Three nodes? Four nodes? Five Nodes? …

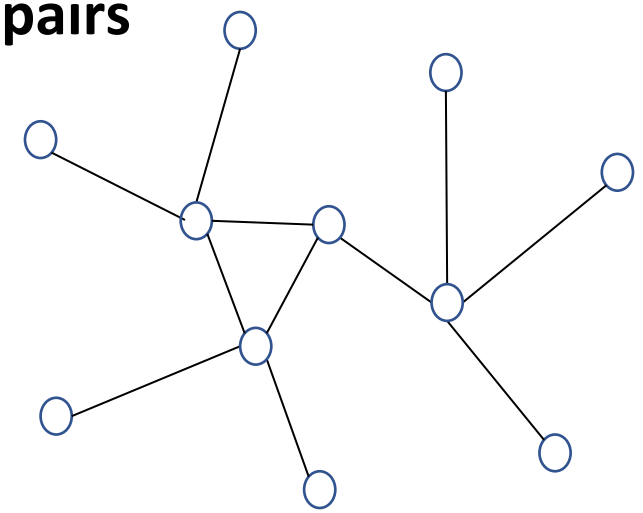
Group Discussion and Report Back (Pen): How to Connect Nodes

- How would you connect two nodes?
  - Three nodes? Four nodes? Five Nodes? …
- Networks can be structured differently
- Simplest approach
  - Connect all computers directly to each other
  - Very expensive for large networks
- What would be a better approach?



How to Connect Nodes

- Better approach to structuring networks
  - Connect computers via multi-hop network
  - Cheaper since links are used my many node pairs
- Network operation is more complex
  - Data relay from node to node
  - Set of protocols specifies rules
- This course looks at structure, operation, and performance of such networks with multiple hops



Poll: Size of Internet

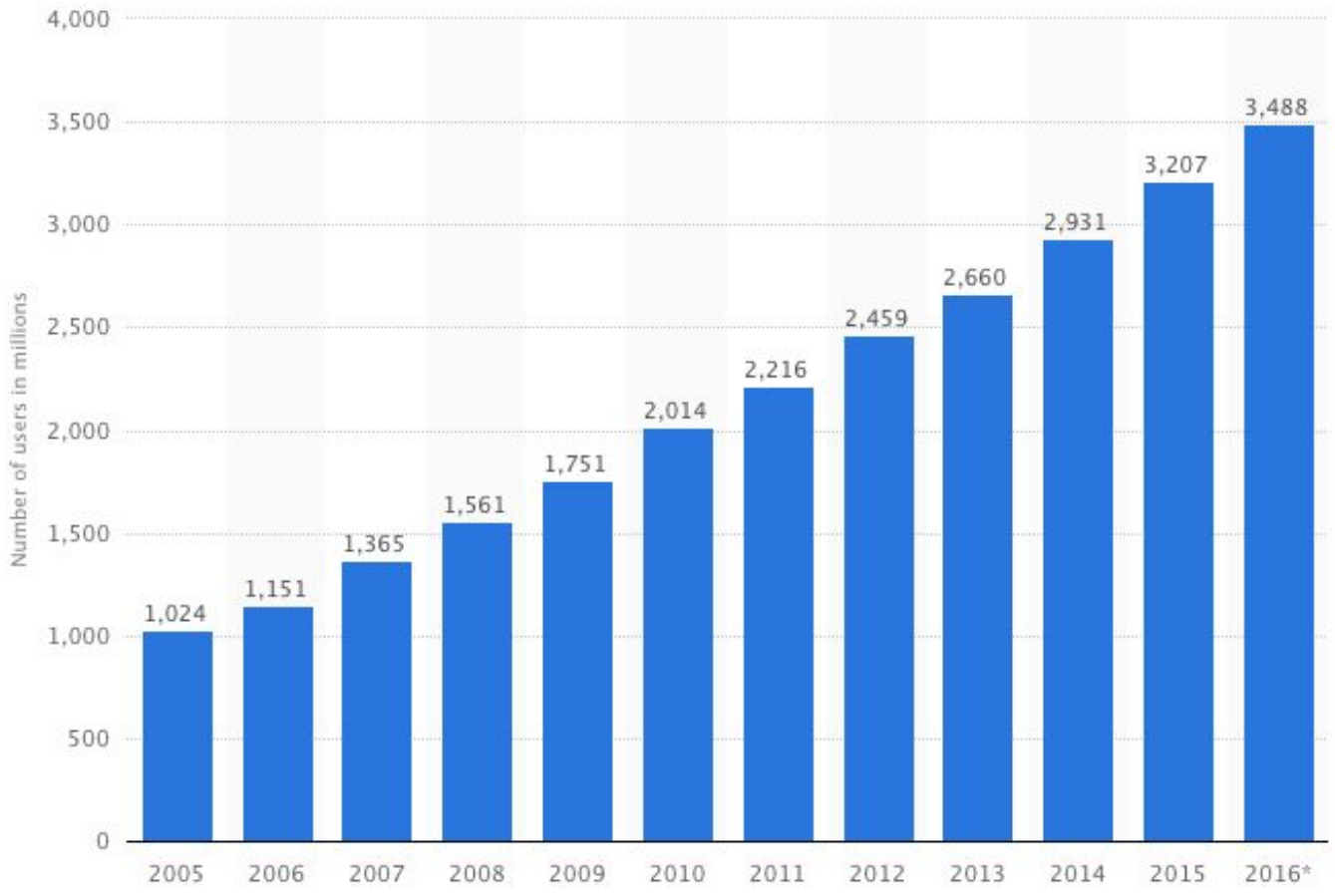
- What is the number of users connected to the Internet?
  - Tens
  - Hundreds
  - Thousands
  - Millions
  - Billions
  - Trillions

Orchestrated Discussion (Short Answer): Size of Internet

- What else should one consider when thinking about the size of the Internet?

Size of Internet

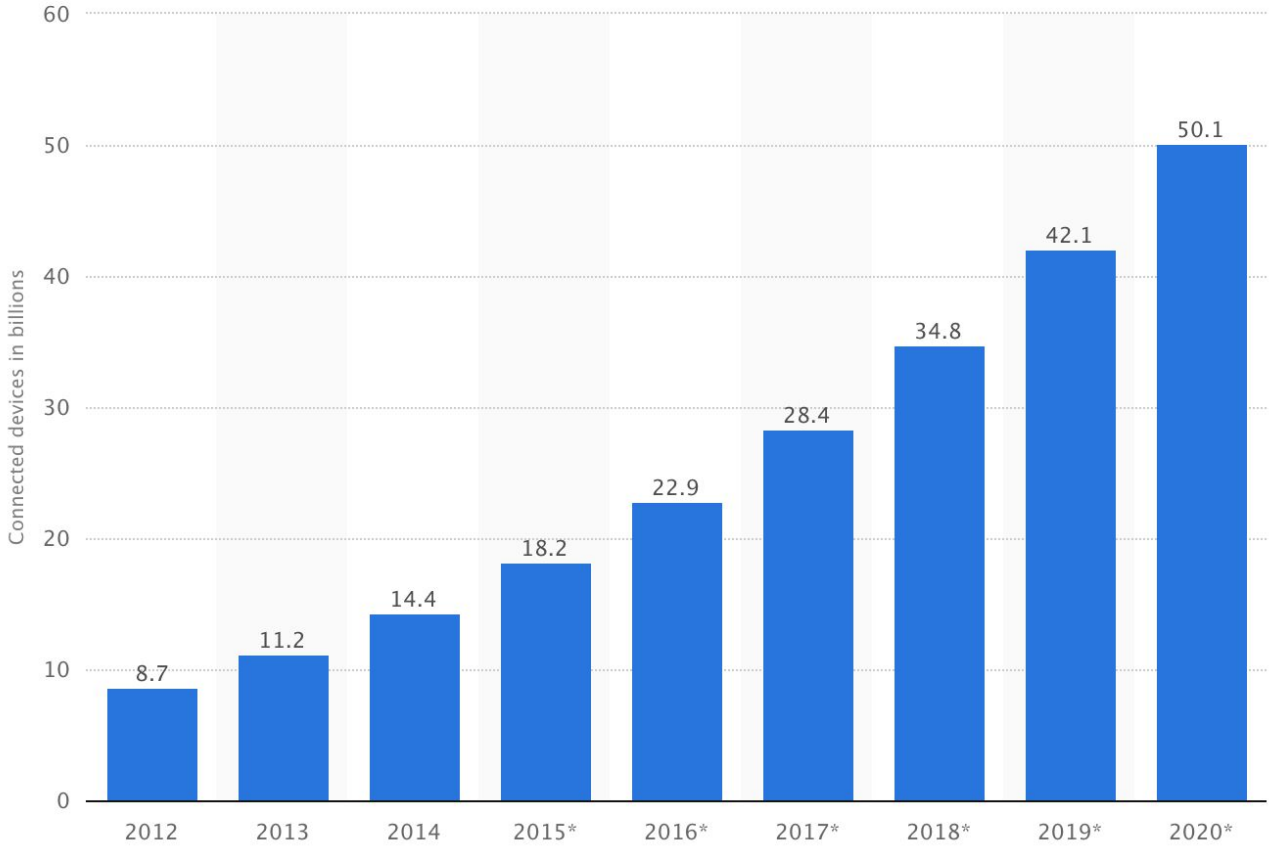
- **Number of Internet users worldwide in millions**



From: statista.com

Orchestrated Discussion (Hand Raise): Size of Internet

- Number of Internet-connected devices in billions



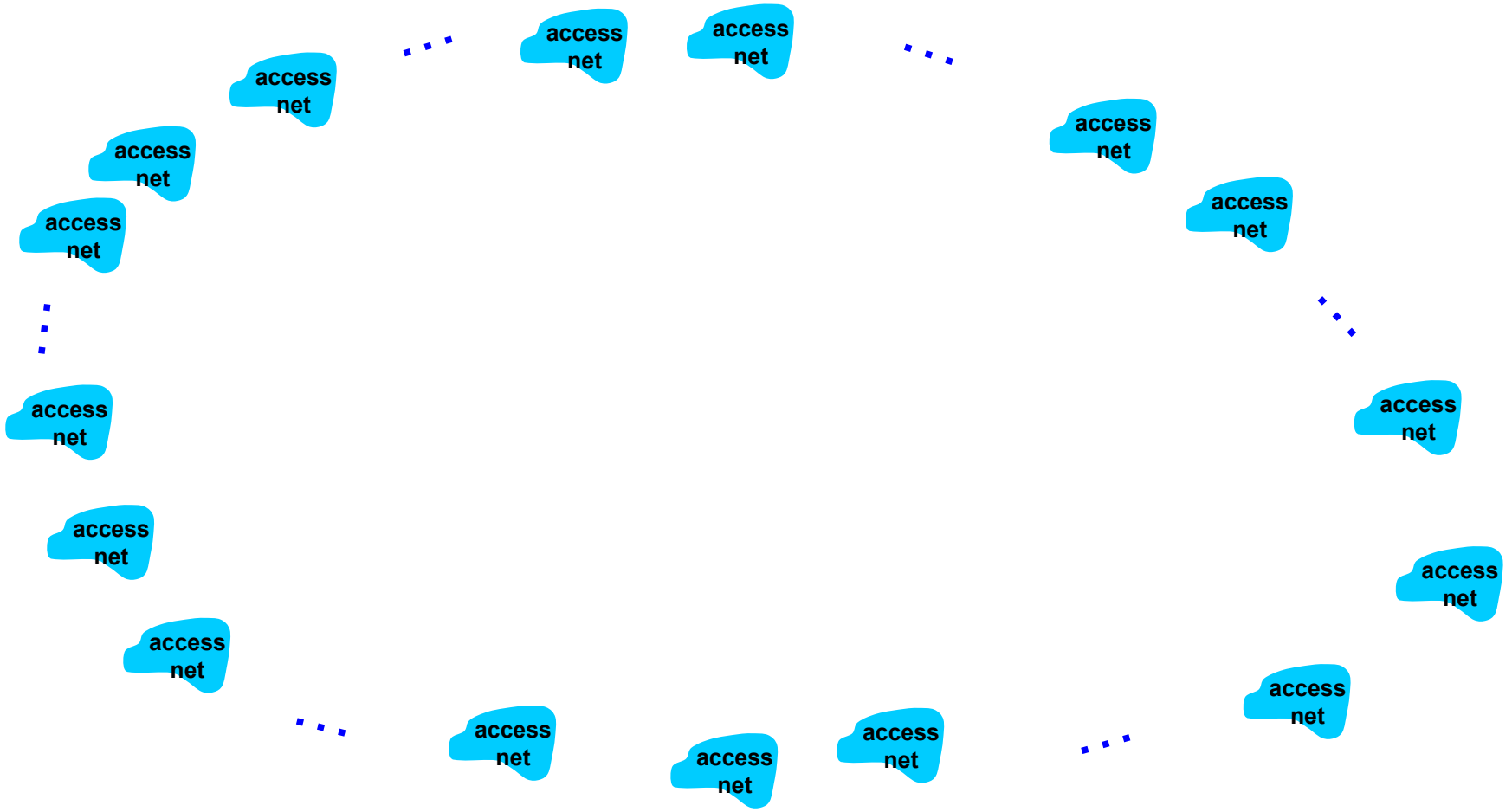
From: statista.com

Internet Structure

- Very large number of nodes need to be connected
  - What is the structure of the Internet?
- Group nodes into networks (e.g., access network)
  - Easier to think of networks than of individual nodes
- Internet is structured as network of networks
  - Each network operates independently
  - Networks collaborate to connect devices across many networks
- Terminology: Internet Service Provider (ISP)
  - Network/entity that connects to Internet

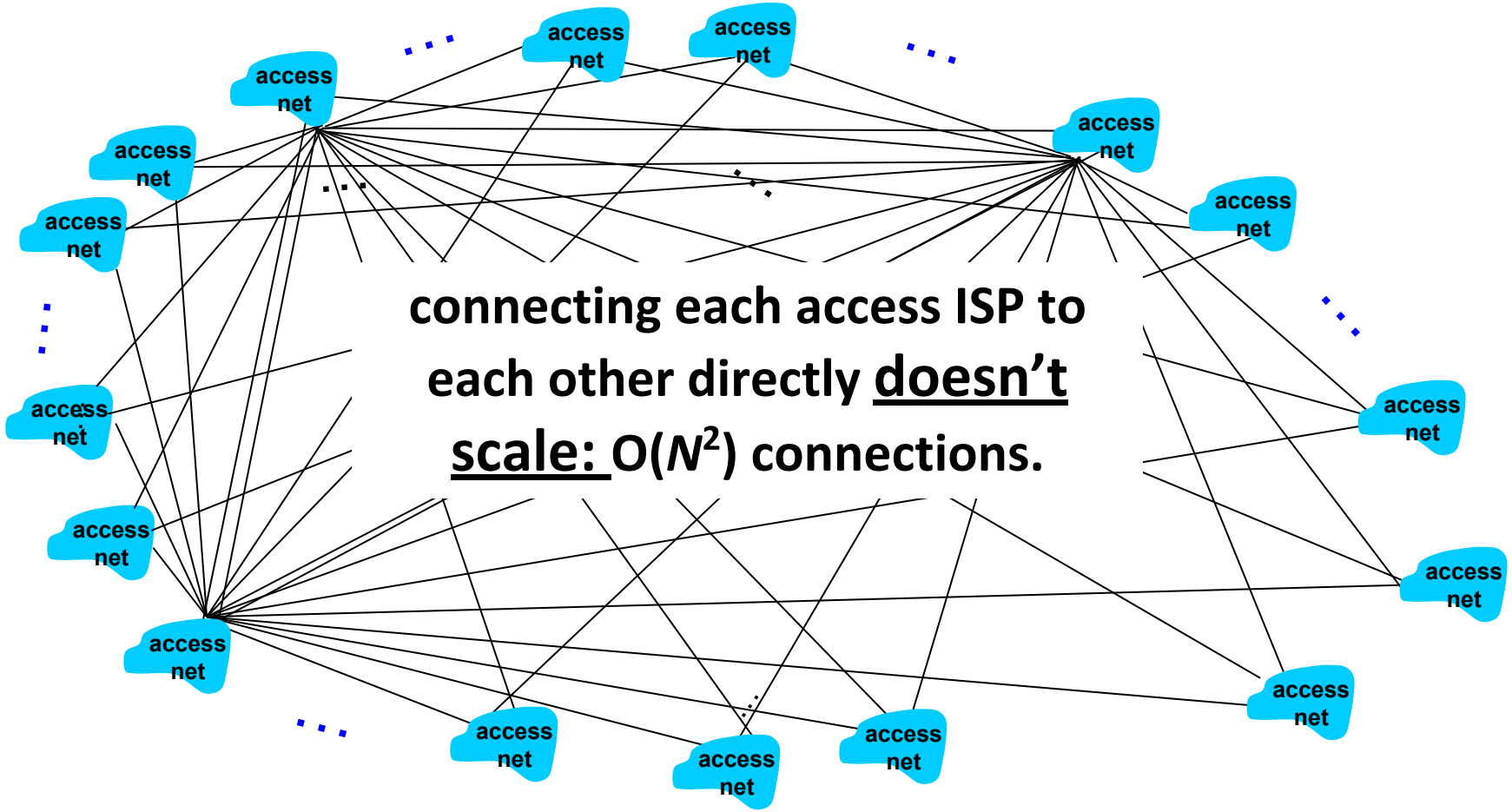
Internet Structure

- Same problem: how to connect millions of access networks?



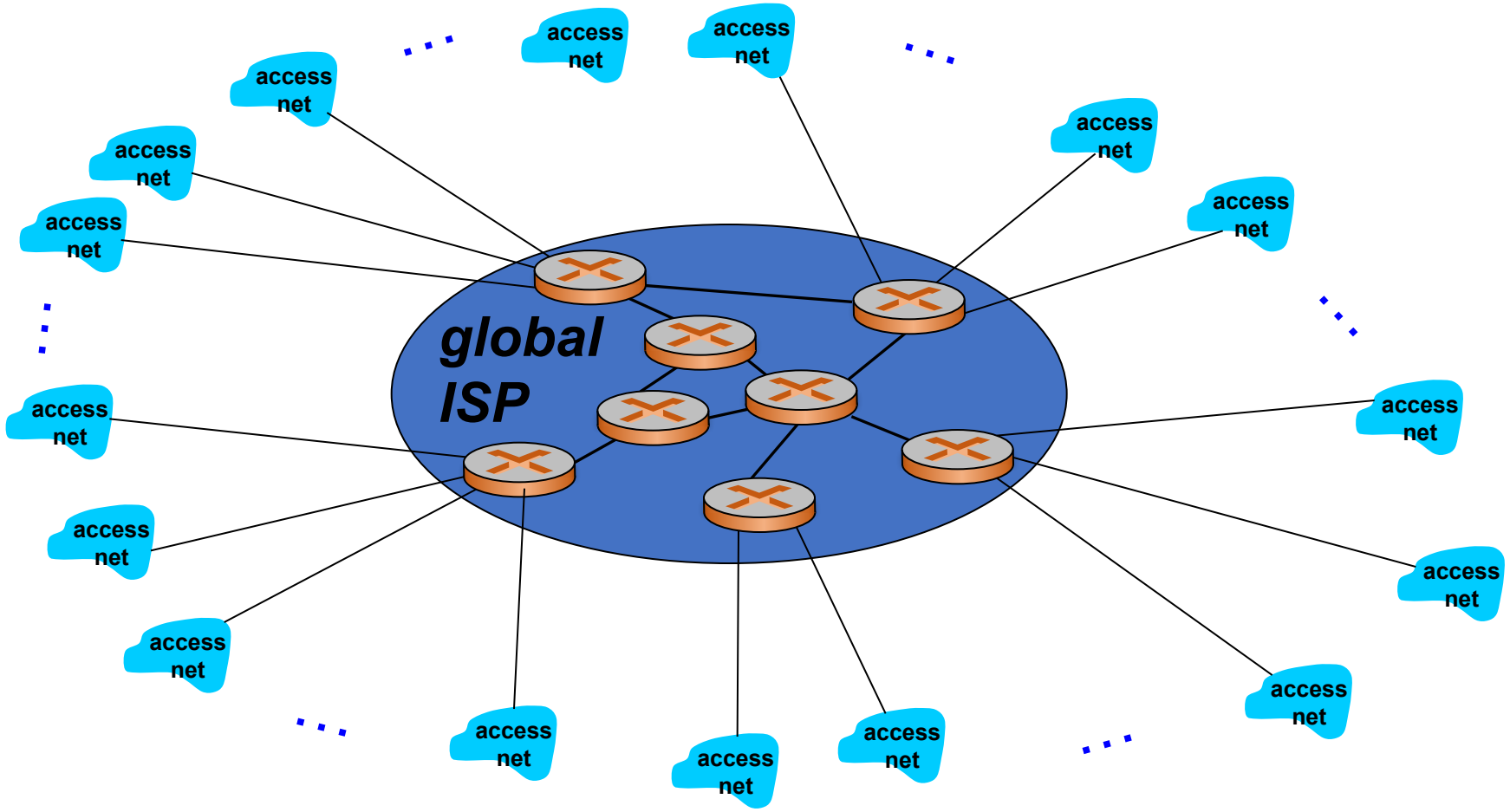
Internet Structure

- Connecting each ISP directly leads to scalability problem



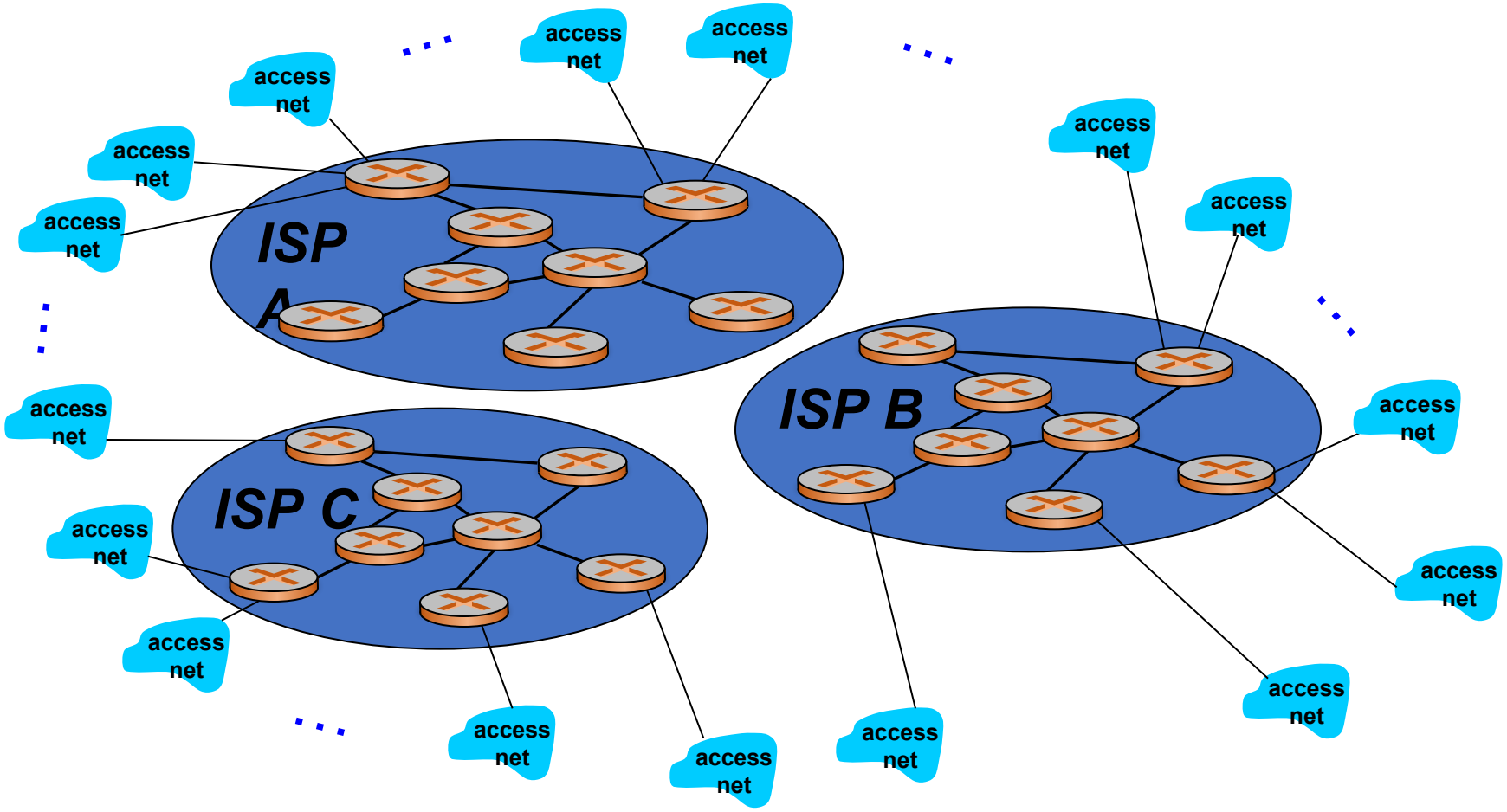
Orchestrated Discussion (Hand Raise): Internet Structure

- One global Intermediate Internet Service Provider



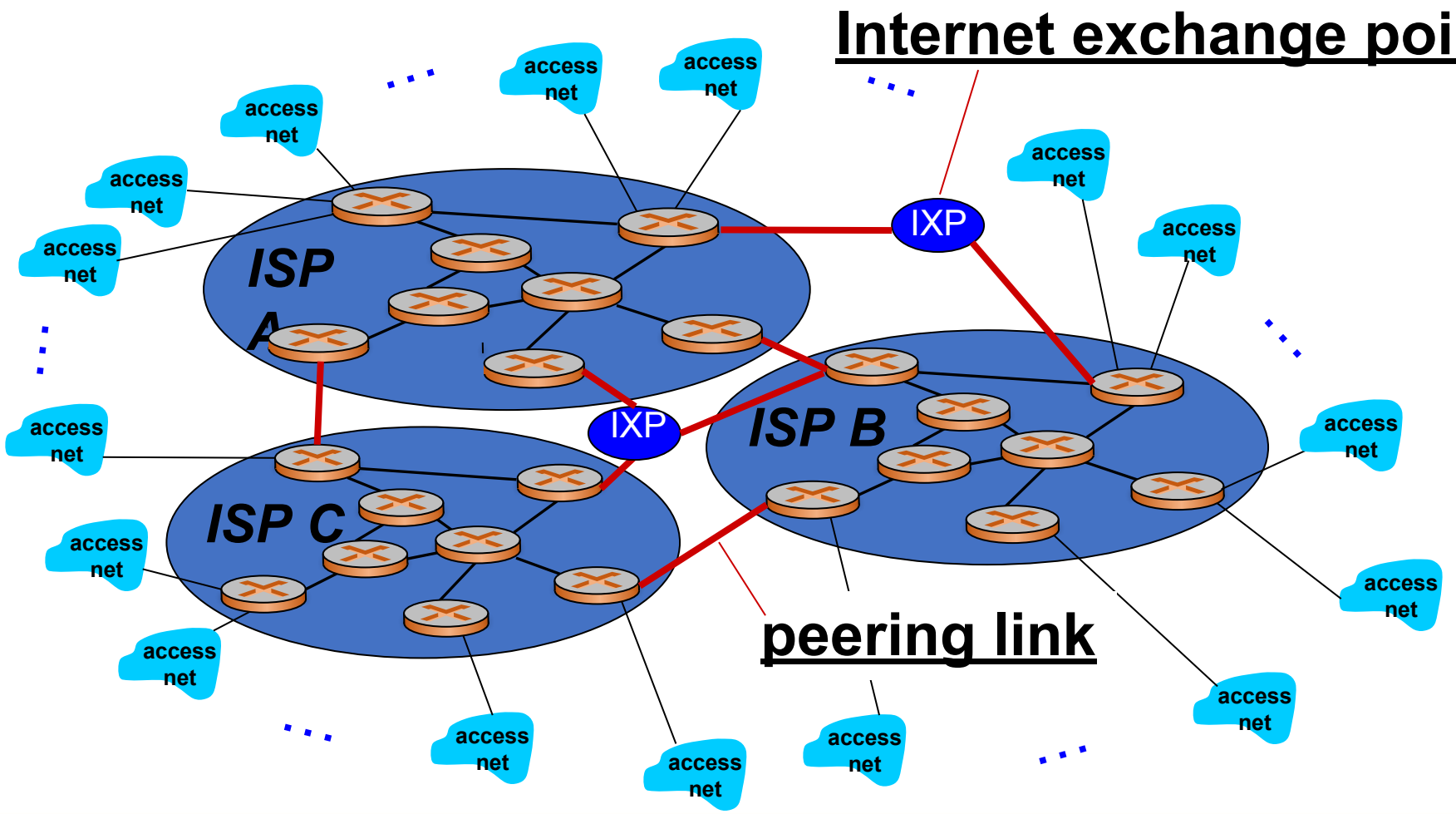
Internet Structure

- If global ISP business is viable, then we get multiple competitors



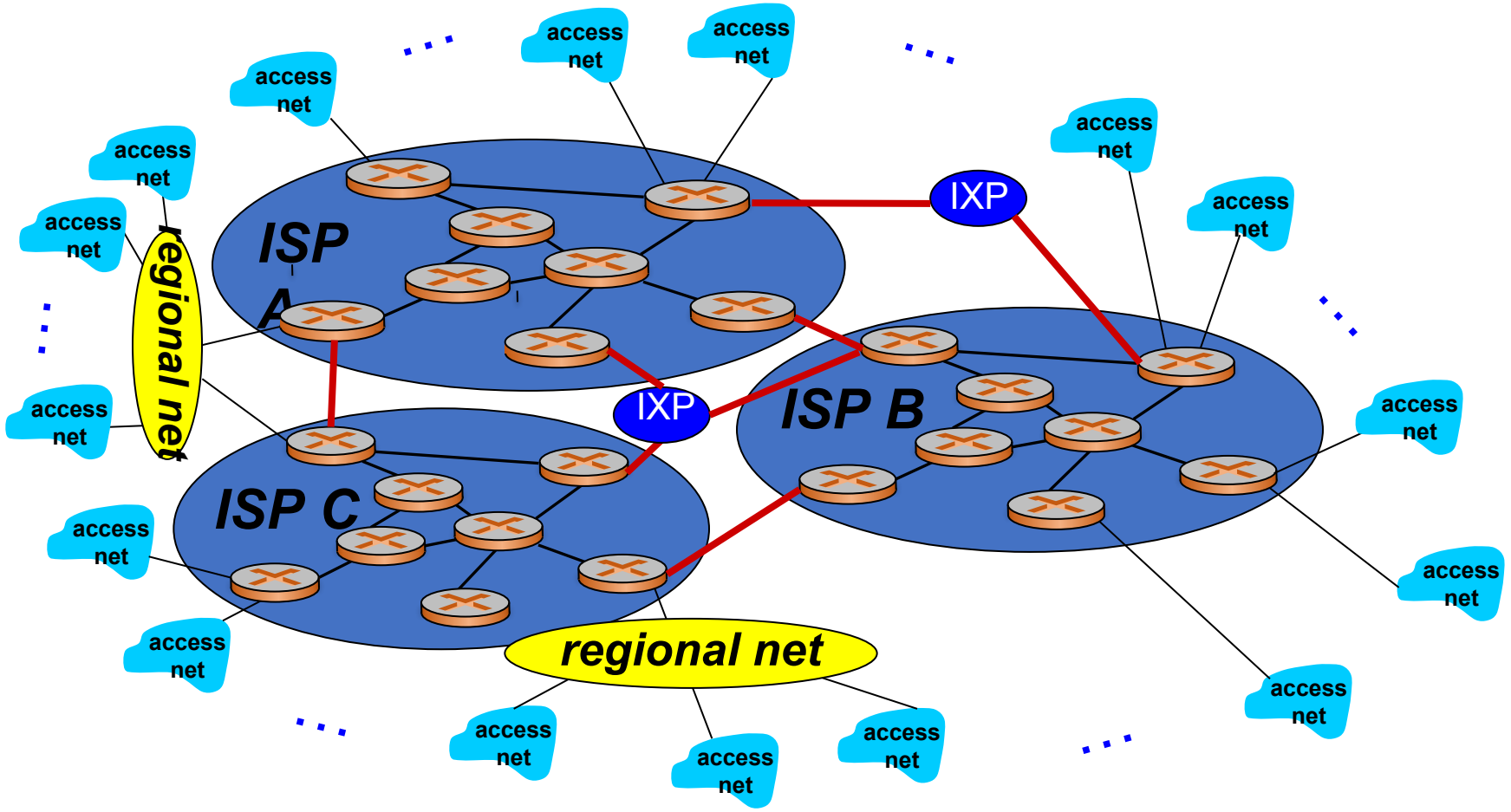
Internet Structure

- Global ISPs connect at Internet Exchange Points (IXP)



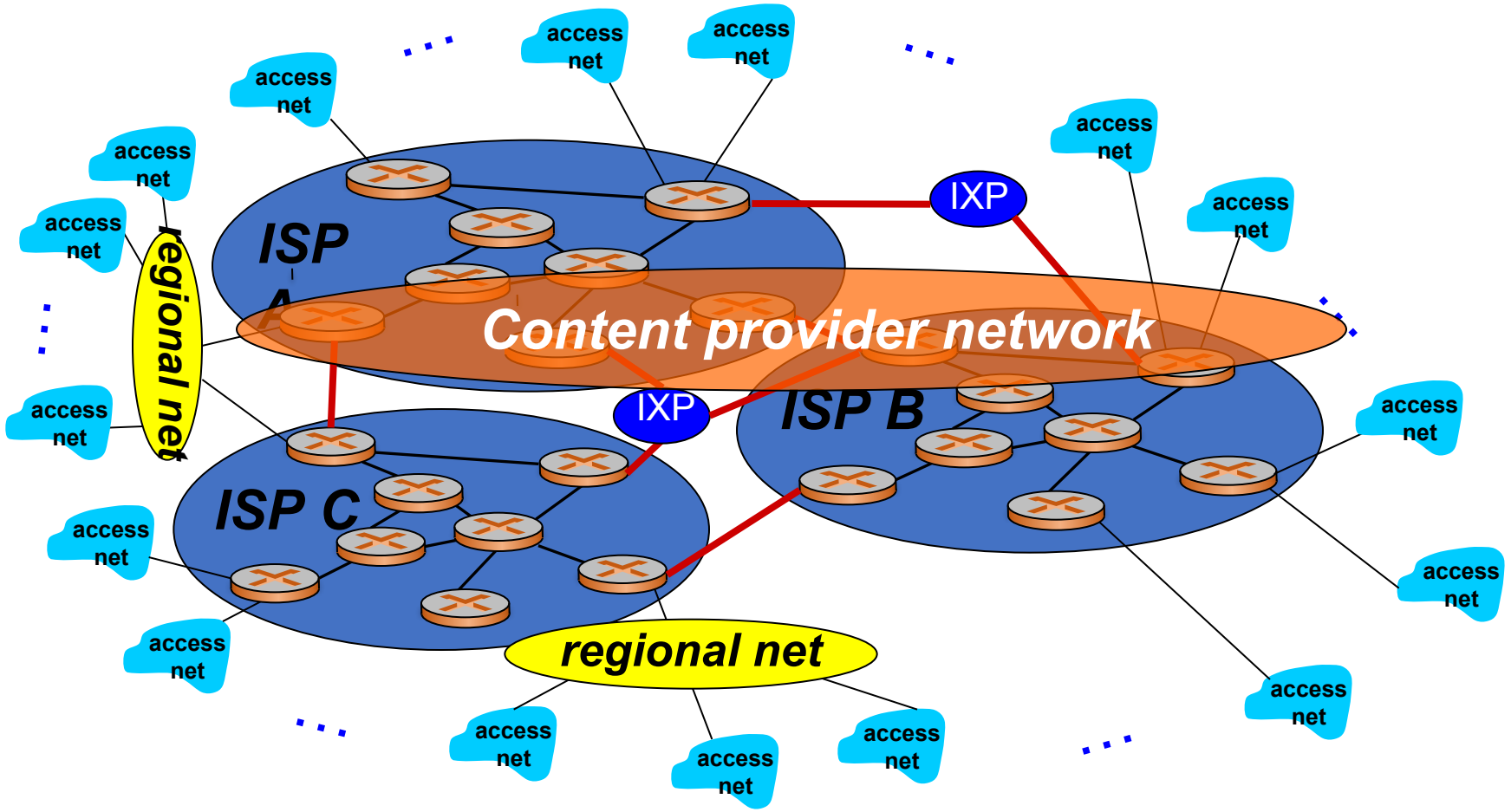
Internet Structure

- Hierarchical expansion may lead to regional networks



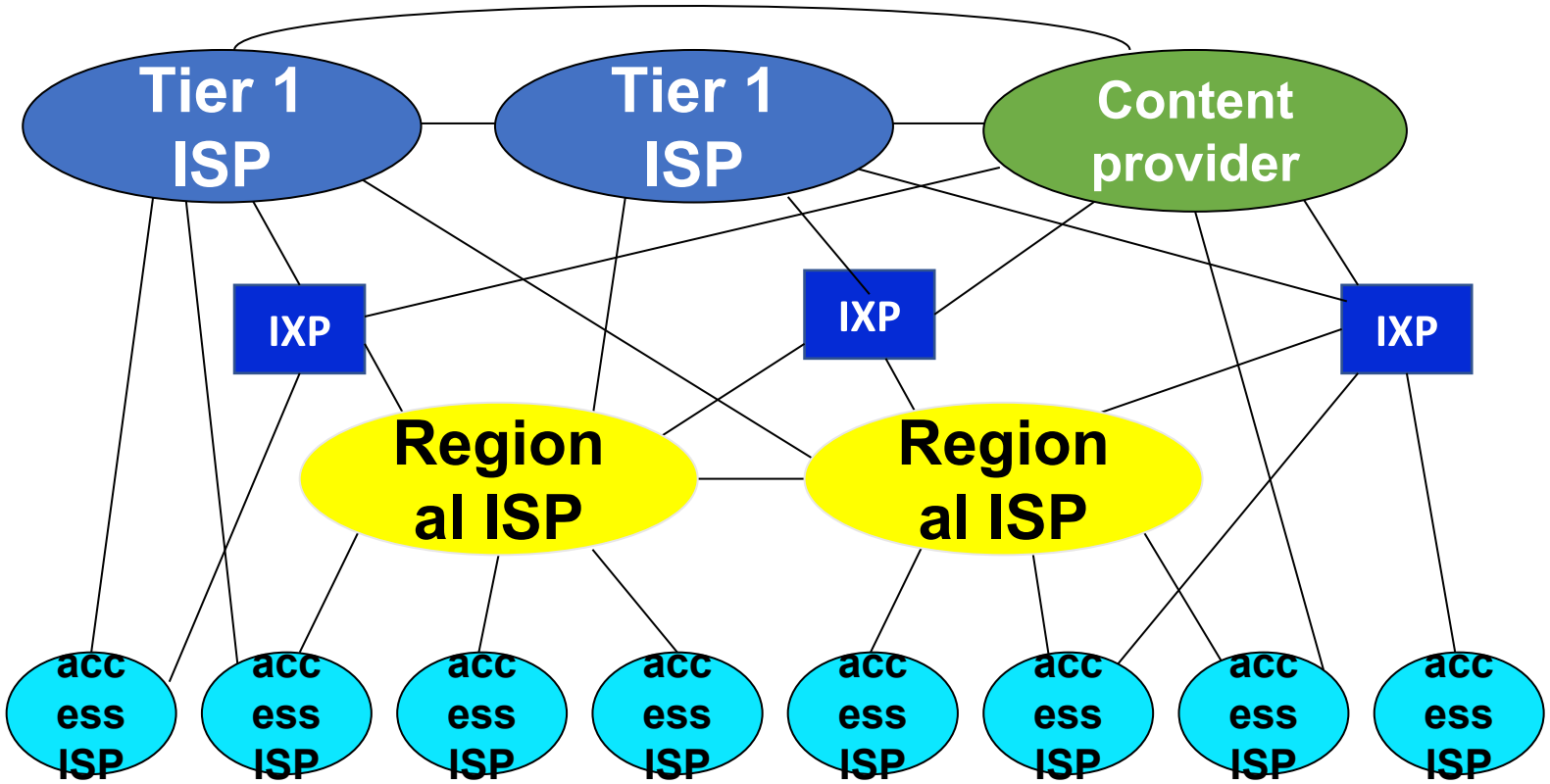
Internet Structure

- Content providers may add their own network



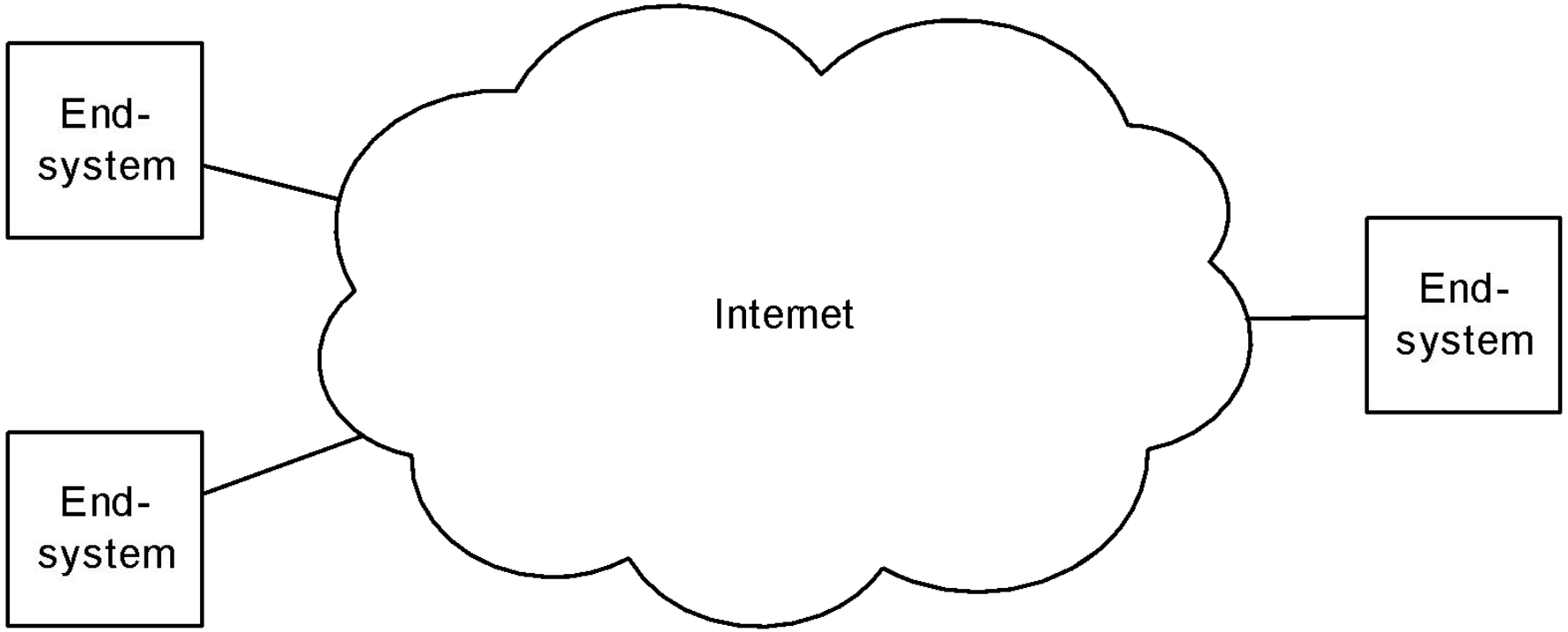
Internet Structure

- Tiered view of Internet structure
  - Tier 1: ISPs with national and international coverage
  - Content providers may bypass Tier 1 ISPs



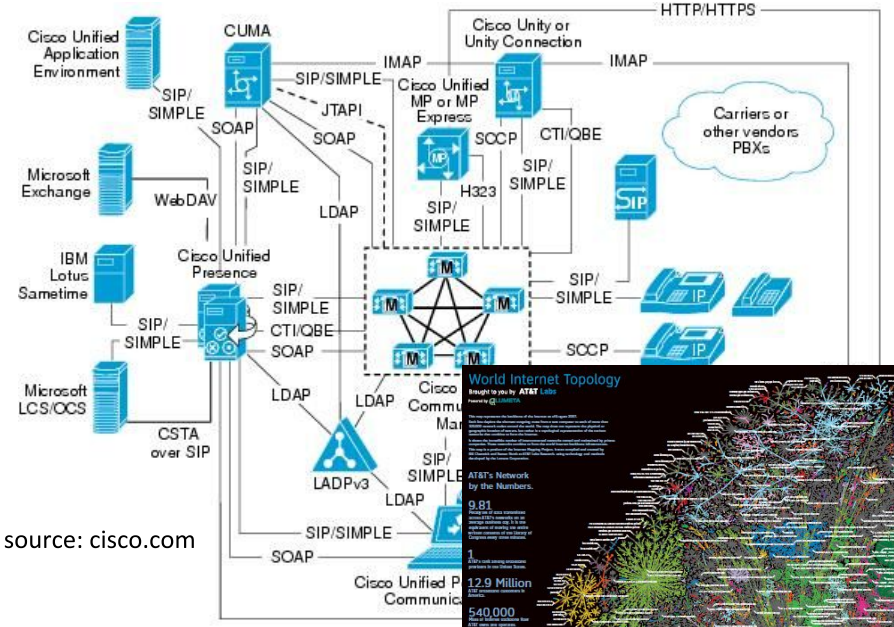
The “Pretty” Picture

- In some cases, Internet internal structure does not matter: view network as “cloud”

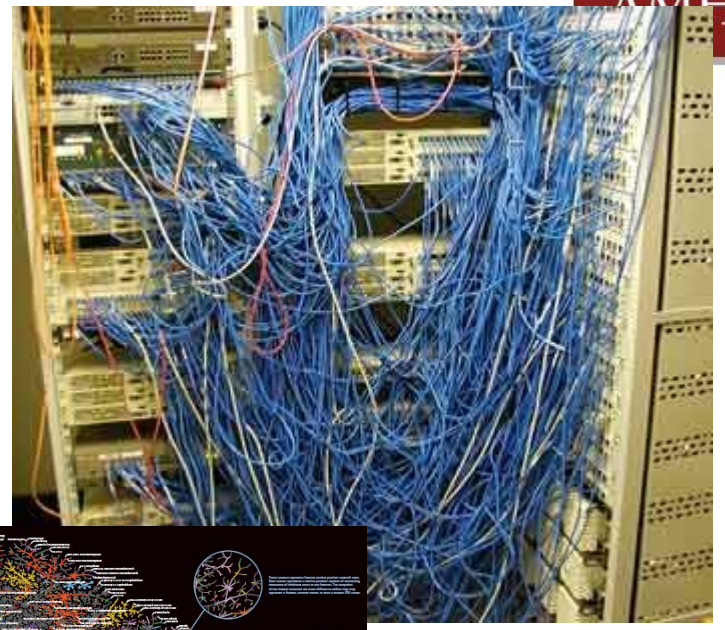


The "Ugly" Picture

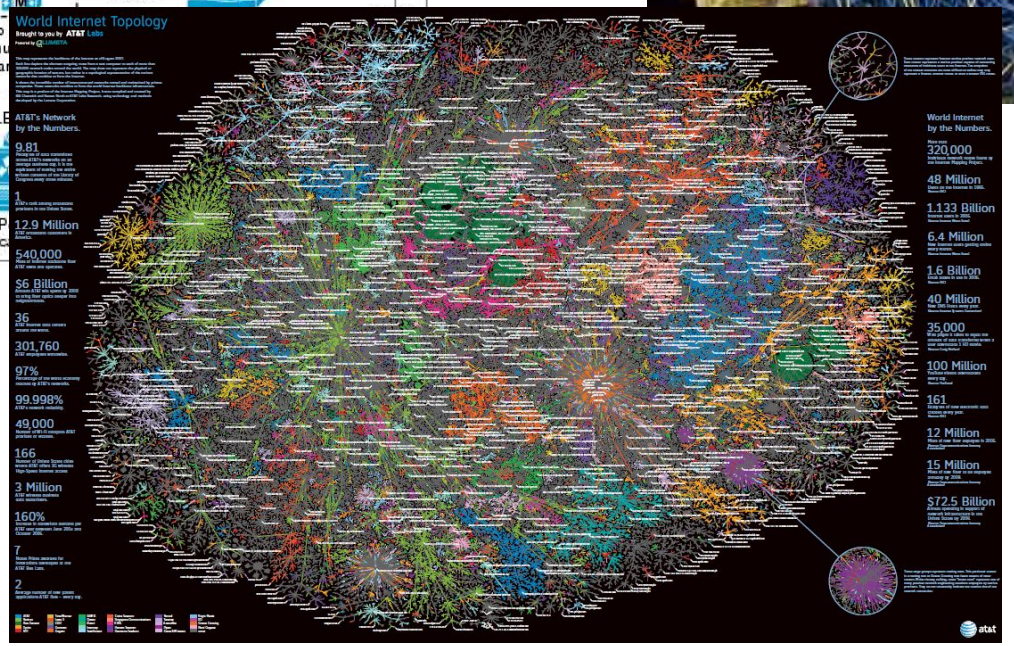
- In some cases, internals do matter…



source: cisco.com



source: aatechnet.com



source: att.com

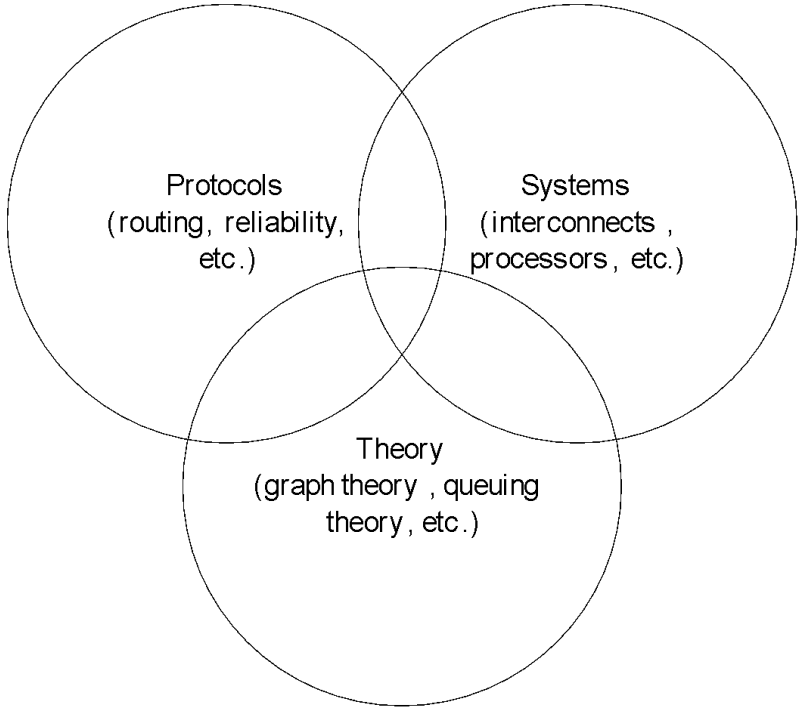
Group Discussion and Report Back (Short Answer): Structure of the Internet

- Discuss what you have learned about the structure of the internet by considering the following questions:
  - In terms of geography, how far can an ISP span? Is there a limit?
  - How do lower- and higher-tier ISPs connect with one another?
  - What is the definition or purpose of a content-provider network?

Facets of Networking

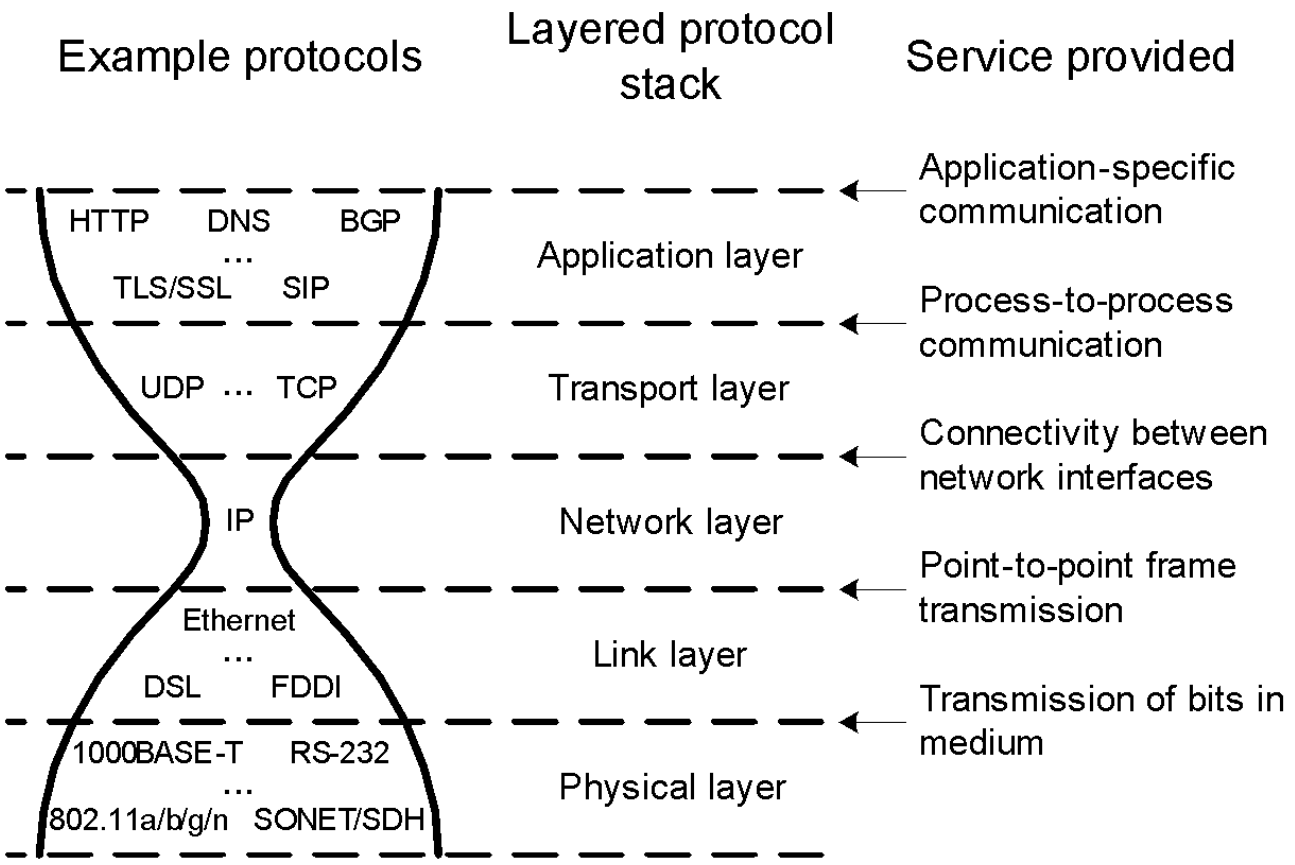
- Our course covers protocols, systems, and theory

- Common goals: functionality, scalability, throughput performance, security, power efficiency, manageability, etc.



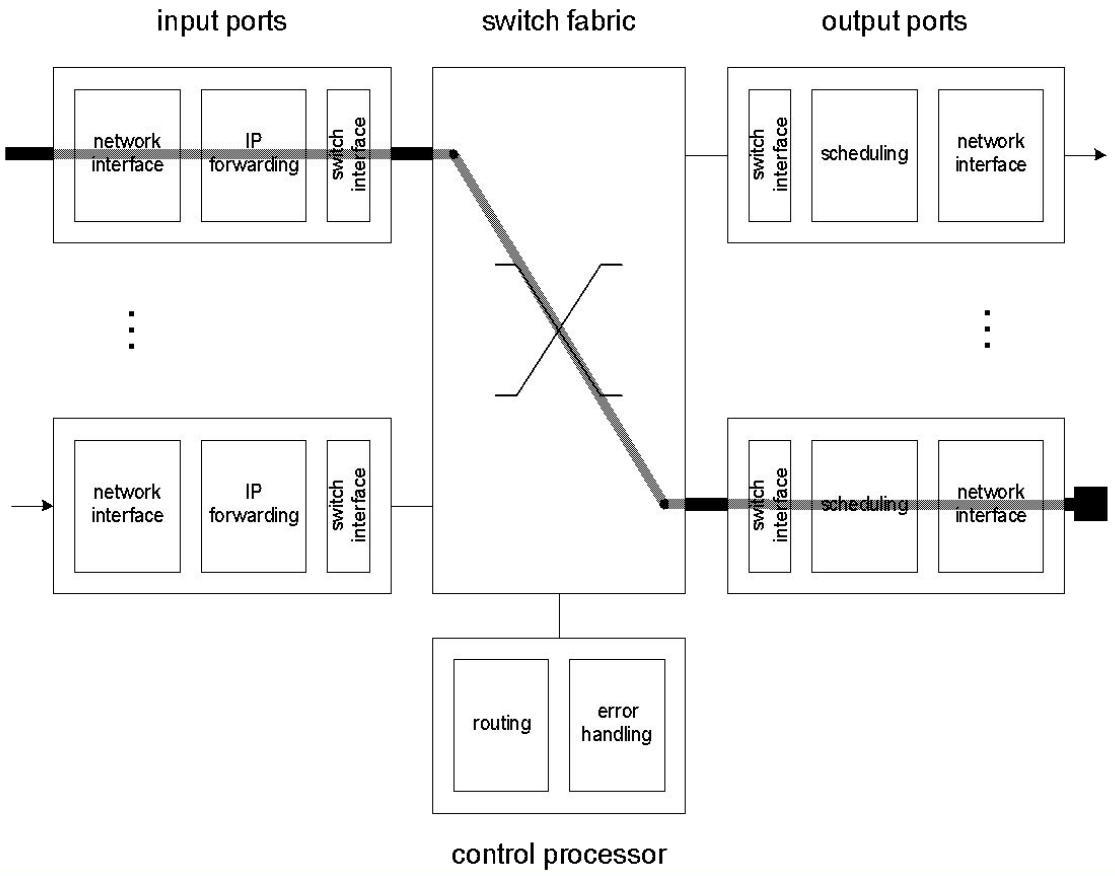
Protocols: Internet Architecture

- **Hourglass architecture of protocol stack**



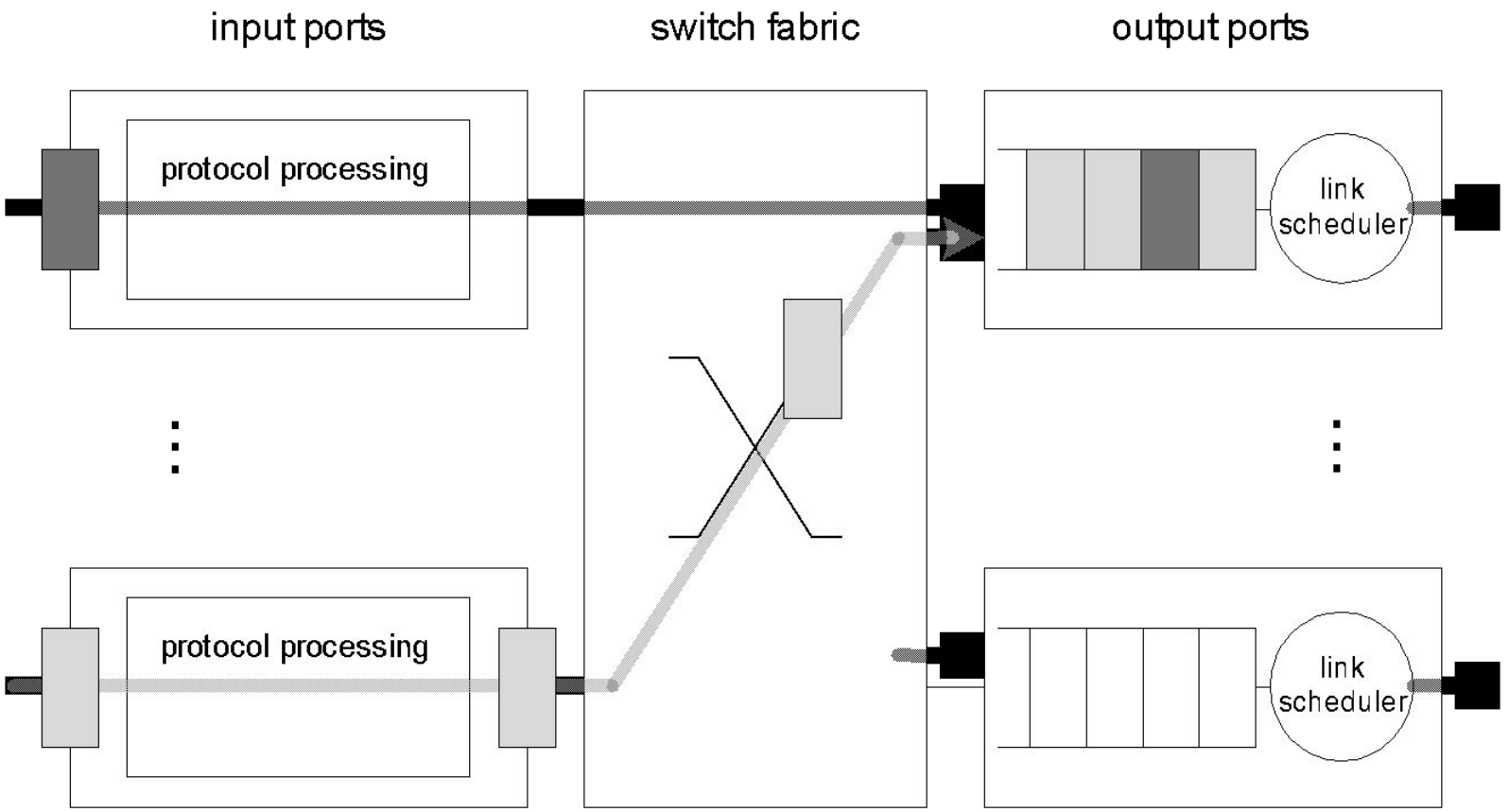
Systems: Generic Router

- Devices and components to achieve performance



Theory: Statistical Multiplexing

- **Operation of network without guarantees**



Course Structure

- Introduction (2 lessons)
  - Networking concepts
- Protocols (6 lessons)
  - Review of Internet protocol stack (top-down)
- Network systems (9 lessons):
  - Performance, interconnects, switches, routers, gateways
- Theory (6 lessons):
  - Queuing theory, quality of service, security
- Assessment (3 exams)

Connected Device: ECE 671 - Administrative Details

- Canvas
  - Course Syllabus
    - Administrative information for the course
  - Directions Page
    - Administrative information for each Lesson
  - Post-work Page
    - Homework for each Lesson
  - Calendar Page

Group Discussion and Report Back (Short Answer): Questions?

- In a small group, discuss questions you may have about the course structure. Try to help each other better understand the layout of the online classroom. Report any remaining questions to the Instructor for class discussion.

Summary of Lesson

- Importance and structure of networks
- Structure and components of the course

Post-work for Lesson 1

Lesson Reflection

- After the Live Lecture, you will reflect on what you learned. Then, you will answer questions and share your observations. Go to the online classroom to view the questions and submit your responses.

To Prepare for the Next Lesson

- Complete and submit the Post-work for Lesson 1.
- Read the Required Readings for Lesson 2.
- Complete the Pre-work for Lesson 2.

Go to the online classroom for details.