CSE4175 Introduction to Computer Networks

Course Intro

Dept. of Computer Engineering,
Sogang University

This material is based on various other sources. Do not post it on the Internet.

Course Intro

Welcome to CSE4175!

- Course Title: Computer Networks (컴퓨터네트워크)
- Time and Location: Tue/Thu 15:00-16:15, R404
- Instructor: 소정민 (AS1013, jso1@sogang.ac.kr)
  - Email me to ask questions or make an appointment
- TA1: 가혜림 (AS1015, sgdhk@naver.com)
- TA2: 김찬민 (R913, bsyzchh@naver.com)
- Lecture slides and other information will appear at http://cyber.sogang.ac.kr.

Prerequisites

- No official prerequisite for this course.
- You will need some basic mathematics, which I assume you already have knowledge on. (If not, you can learn in this course.)
- Programming assignments require you to use C or C++.

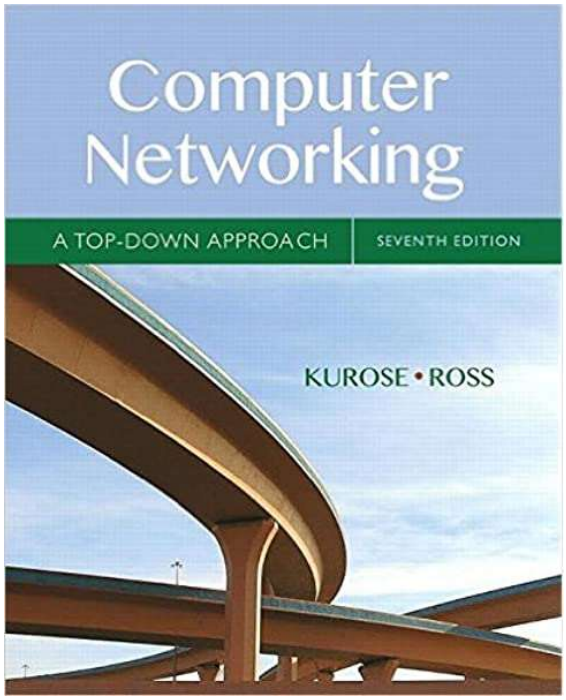
Course Format and Evaluation Criteria

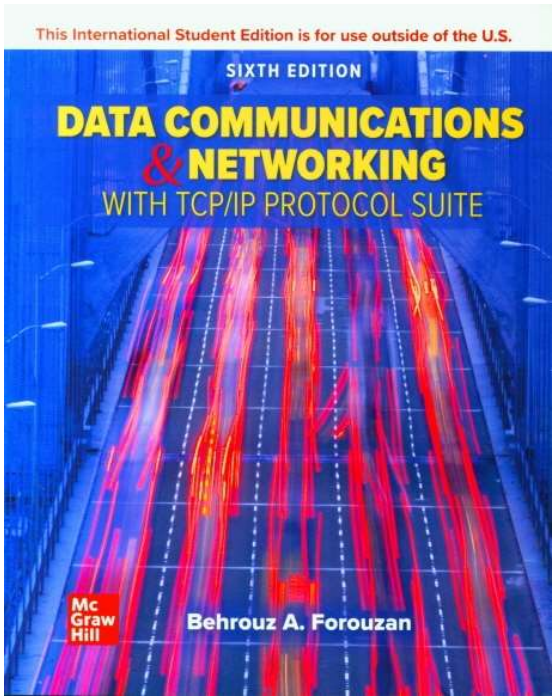
- Course Format
  - Due to COVID-19, all lectures will be done online. (zoom)

- Evaluation
  - Participation (Quiz, HW): 10%
  - Programming Assignments: 30%
  - Mid-term exam: 30%
  - Final exam: 30%

Textbook

- No textbook required. We will use lecture slides as the textbook.
- Contents in the lecture slides are taken from the following books. You can use the books as supplementary material.
  - J. Kurose and K. Ross, Computer Networking: A Top-Down Approach 7th Ed.
  - B. Forouzan, Data Communications and Networking, 6th Ed.



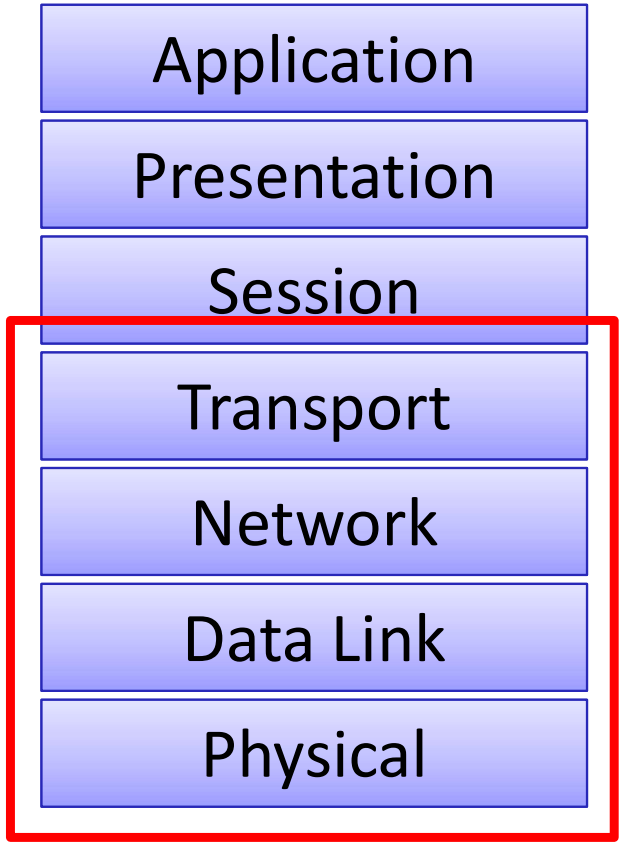


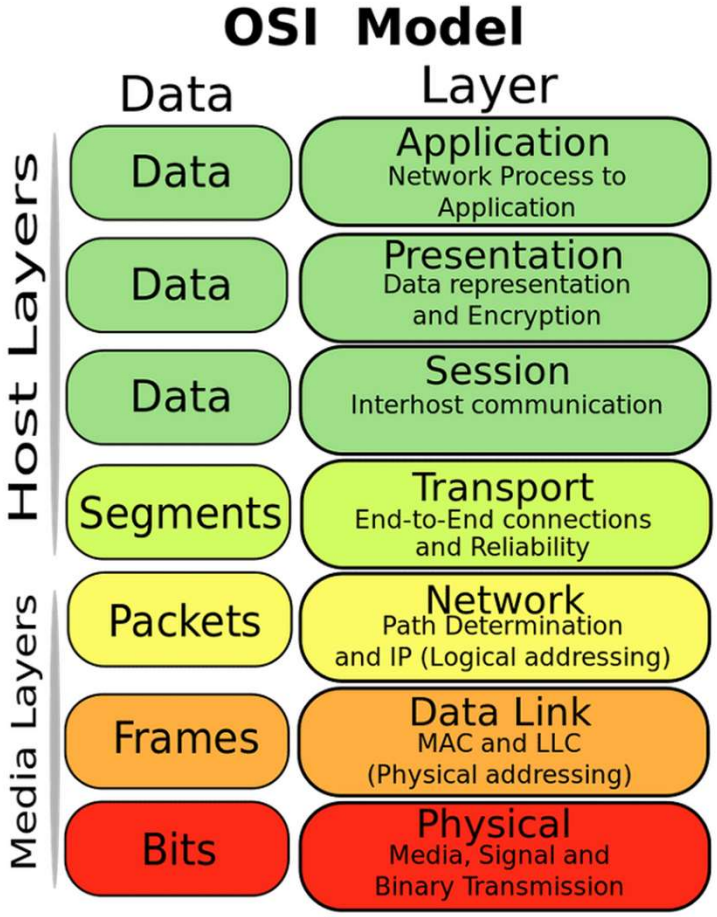
What is course about?

- Learn principles of computer networking
- Learn practice of computer networking
- Internet architectures / protocols as case studies
- Real wireless networks as case studies
- Glimpse into the future of networking

What is course about? (In more technical terms)

- OSI 7 layer architectures and their functions / protocols
  - mostly layers 1-4





At the end of this course, you will learn

- You will understand variety of factoids and concepts
  - Internet layered architecture, HTTP, DNS, P2P, ...
  - modulation, error correction, framing, ...
  - propagation delay, transmit time, queueing delay, ...
  - Wireless networks (Wi-Fi)
  - sockets, ports, ...
  - routing, Dijkstra's algorithm, IP, BGP, OSPF, ...
  - congestion control, flow control, TCP, ...
  - Security, RSA, Digital certificates, MIM attacks, ...

- <u>If you understand 75% of these terms, you shouldn't be here.</u>

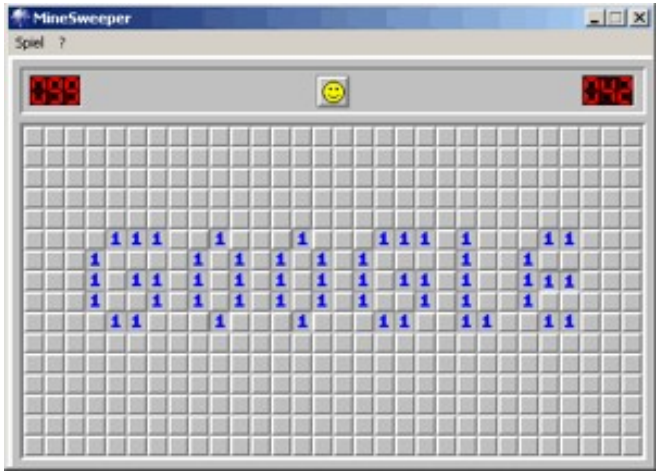
- You will know how to do network programming.

What this course does not cover

- Device drivers (운영체제, 시스템 프로그래밍)
- Cloud computing (분산시스템)
- Graph theory, network theory, proofs (알고리즘)
- Hardware, embedded systems, IoT (임베디드 시스템)
- Modulation schemes, transmitter/receiver design (통신 - 전자공학과)

Computer Networks: Why take this course?

- What can you do if your PC is disconnected from the Internet?



Computer Networks: Why take this course?

- What will you do after you graduate?
- With high probability… become a software engineer
  - application/solution developer
  - web service developer
  - game programmer
  - mobile app programmer
- Almost every IT company runs businesses that are related to computer networks

Computer Networks: Why take this course?

- Most applications require servers

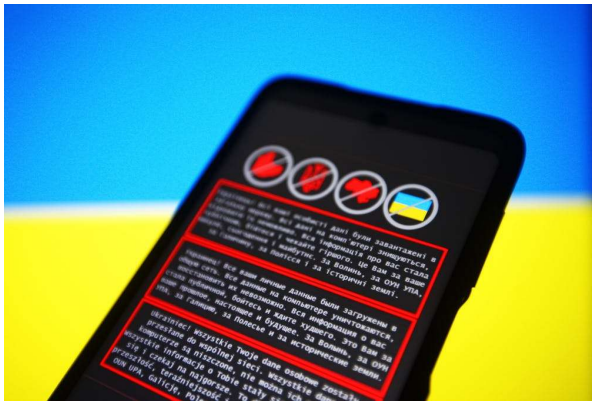
Computer Networks: Why take this course?

- Network performance is directly related to service quality
- The value of network experts increases every day

- e.g.) an online game company
  - the game is a hit!
  - concurrent users: 100,000!
  - traffic explodes!
  - server overloaded!
  - lag! abrupt disconnection!
  - load balancing!
  - sync between servers!
  - sync between client and server!

Computer Networks: Why take this course?

- Network security... most security problems disappear if network does not exist (or is disconnected)



우크라이나 대사 "韓, 사이버 조력 원한다"
전면전 앞두고 우크라 정부·기관에 디도스 공격
'반격' 나선 우크라...세계 해커들도 '지원사격'

러시아가 우크라이나를 침공한 가운데 드미트로 포노마렌코 신임 주한 우크라이나 대사가 26일 서울 마포구 성 니콜라스 정교회 성당에서 열린 재한 우크라이나인 공동 기도회에 참석한 뒤 기자들의 질문을 받고 있다. 2022.02.26./사진제공=뉴시스

Computer Networks: Why take this course?

- Too many bad people out in the world...
  - spam
  - virus, malicious worms
  - hacking
  - distributed denial of service
  - phishing
  - click fraud
  - private information leakage
  - violation of digital rights
  - credit card fraud
  - …

Computer Networks: Why take this course?

- Too many bad people out in the world...
  - spam, virus, malicious worms, hacking, distributed denial of service, phishing, click fraud, private information leakage, violation of digital rights...

- A security expert is basically a networking expert
- Hackers break into a system using a hole in the network protocol implementation
- A security expert
  - detects hacking attempts
  - blocks them
  - and tracks them down

Communications and Networks

Past and Present

History of Communications

signal-fire

post-horse

History of Communications

- 1837: Morse Code - method of transmitting text information using on-off tones

Samuel B. Morse

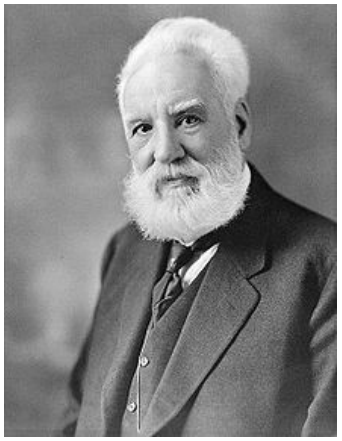
International Morse Code

1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots.
4. The space between two words is equal to seven dots.

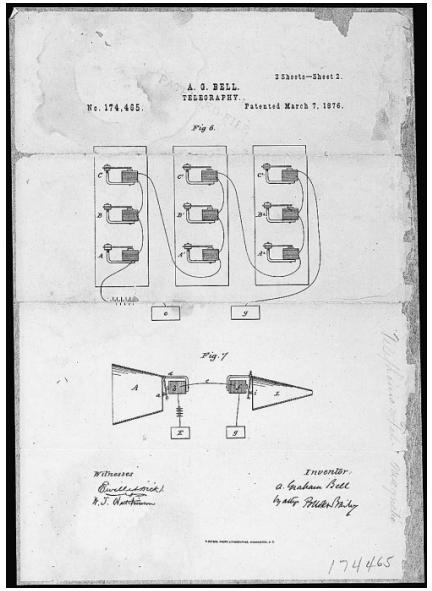
A	• —	U	• • —
B	— • • •	V	• • • —
C	— • — •	W	• — —
D	— • •	X	— • • —
E	•	Y	— • — —
F	• • — •	Z	— — • •
G	— — •		
H	• • • •		
I	• •		
J	• — — —		
K	— • —	1	• — — — —
L	• — • •	2	• • — — —
M	— —	3	• • • — —
N	— •	4	• • • • —
O	— — —	5	• • • • •
P	• — — •	6	— • • • •
Q	— — • —	7	— — • • •
R	• — •	8	— — — • •
S	• • •	9	— — — — •
T	—	0	— — — — —

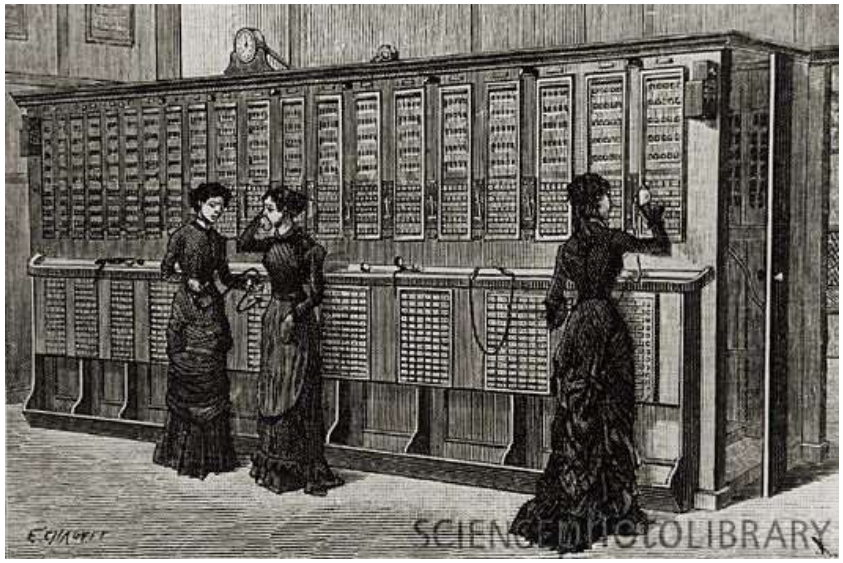
History of Communications

- 1876: Telephone - voice communication



Alexander Graham Bell





History of Communications

- 1895: Wireless communication - communication using radio

Guglielmo Marconi

Marconi Says He Sent
10,000 Across the Atlantic

ACCEPTING BUSINESS IN
BRITISH CAPITAL.

History of Communications

- Advances of communication technology

History of Communications

- Advances of communication technology

History of Communications

- Technology driving force
  - Increase in voice/data traffic
    - smartphones, tablets
    - video calls, video conferences, high-quality audio/video, VR/AR/XR, metaverse
  - New services
    - cloud service
    - mobile applications, location-based services
  - Advances in hardware/software technologies
    - antenna, modems, transceivers
    - algorithms, protocols

History of Computer Networks

- 1957: USSR launches Sputnik I
  - US hit with "Sputnik crisis"

- Advanced Research Projects Agency (ARPA) established
  - Research topics: space, missiles, nuclear weapons, communication
  - Research goal: national defense

History of Computer Networks

- 1961: Leonard Kleinrock published a work on packet switching

- 1962: J. Licklider described a worldwide network of computers called Galactic Network

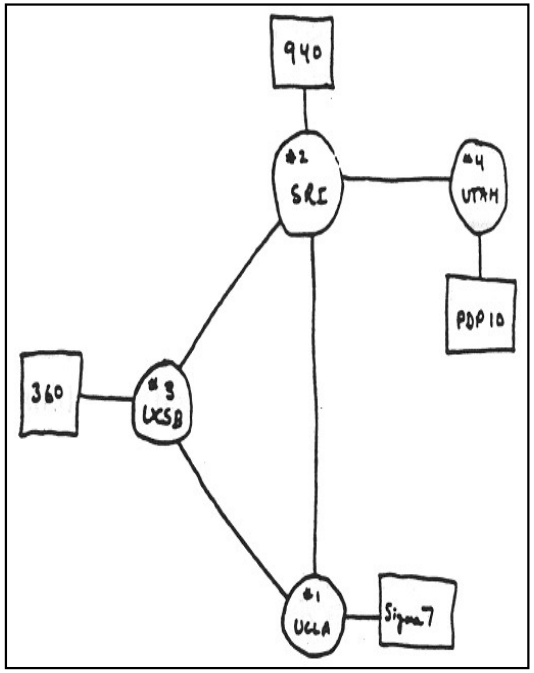
- 1965: Larry Roberts designed the ARPANET that communicated over long distance links

- 1965: Connection established between MIT and UC Berkeley

History of Computer Networks

- 1967: ARPANET (precursor of Internet) proposed

- 1969: 4 remote computers connected
  - UCLA, SRI, UCSB, UTAH

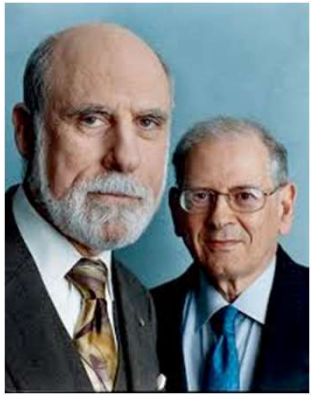


- 1971: 23 computers are connected

History of Computer Networks

- 1971: Ray Tomilson invents email at BBN

- 1972: Bob Kahn and Vint Cerf invented TCP/IP for reliable packet transport



- 1972: ARPANET is open to the public, first email

- 1973: email is actively used
  - 75% of ARPANET traffic is email

- 1973: first international line is established
  - University College of London
  - the Royal Radar Establishment (Norway)

History of Computer Networks

- 1973: David Clark, Bob Metcalfe implemented TCP and designed Ethernet at Xerox PARC

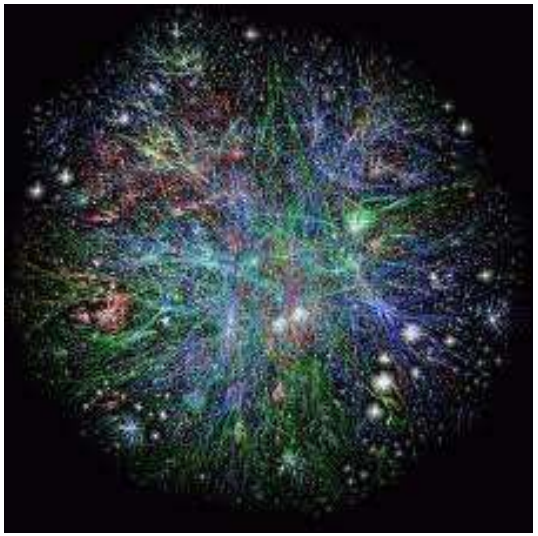
- 1975: Paul Mockapetris developed DNS system for host lookup

- 1980: Radia Perlman invented spanning tree algorithm for bridging separate networks

History of Computer Networks

- 1983: TCP/IP is standardized... The Internet is born

TCP/IP



History of Computer Networks

- 1984: 1000 hosts, DNS developed

- 1988: first Internet worm
  - Robert Morris (Professor of MIT)
  - 100,000 hosts

- 1990: first search engine (Archie)

- 1991
  - WWW (Tim Berners-Lee)
  - Linux (Linus Torvalds)

- 1994: hotmail – first web-based email

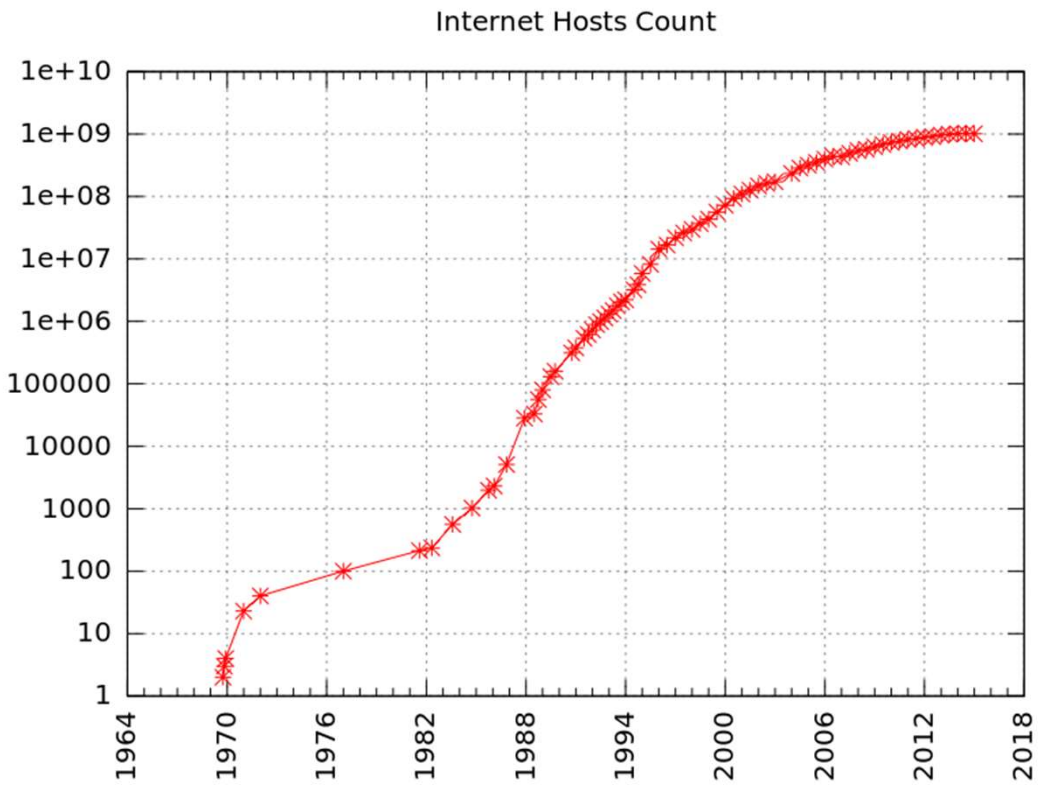
- 1995: JAVA

History of Computer Networks

- 1992: 1 million hosts
- 1994: first pizza delivery using Internet
- 1995: Windows 95
- 1997: Hanmail (Daum)
- 1998: Google
- 1999: first online banking, Cyworld, Naver
- 2000: millenium bug
- 2001: wikipedia
- 2003: facebook
- 2005: Youtube
- 2006: twitter

History of Computer Networks

- Number of hosts
  - 1981: 213
  - 1985: 1,961
  - 1990: 313,000
  - 1995: 4,852,000
  - 2000: 72,398,092
  - 2005: 317,646,084
  - 2012: 903,909,315
  - 2019: 1.01 billions



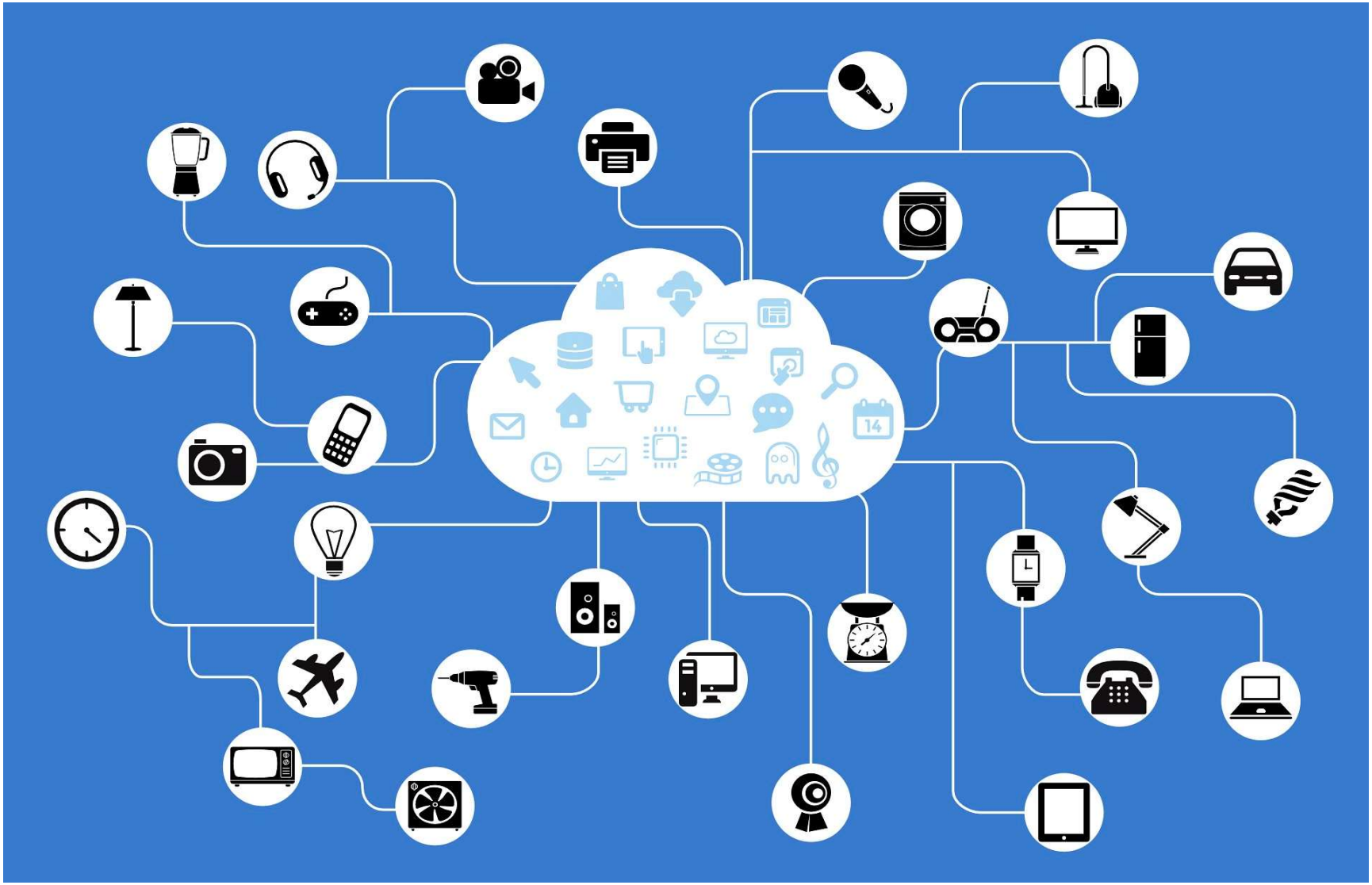
- Number of Internet Users
  - 5,16 billions by January 2023
    - 64.4% of world population

Internet Today

- What we have today is beyond any of the inventors' imagination...

By "YOU" I mean

- "Cool" Internet appliances



By "YOU" I mean

- "Cool" Internet appliances

Web-enabled toaster + weather forecaster

By "YOU" I mean

- "Cool" people

Internet

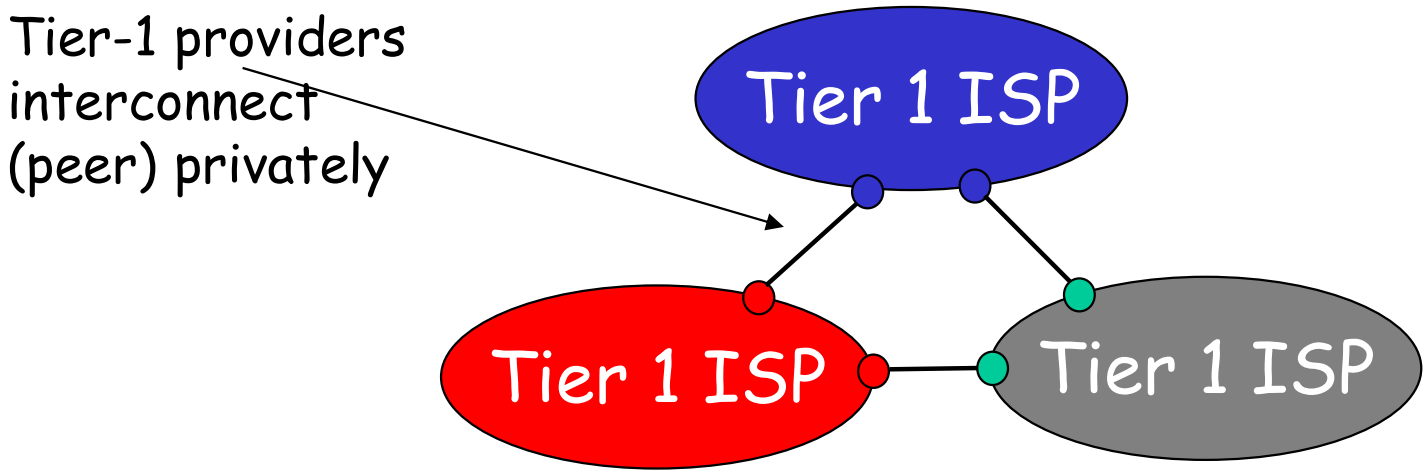
- Millions of end points (you, me, and toasters) are connected over a network
  - Many end points can be addressed by numbers
  - Many others lie behind a virtual end point

- Many networks form a bigger network

- The overall structure called the Internet
  - Defined as network of networks

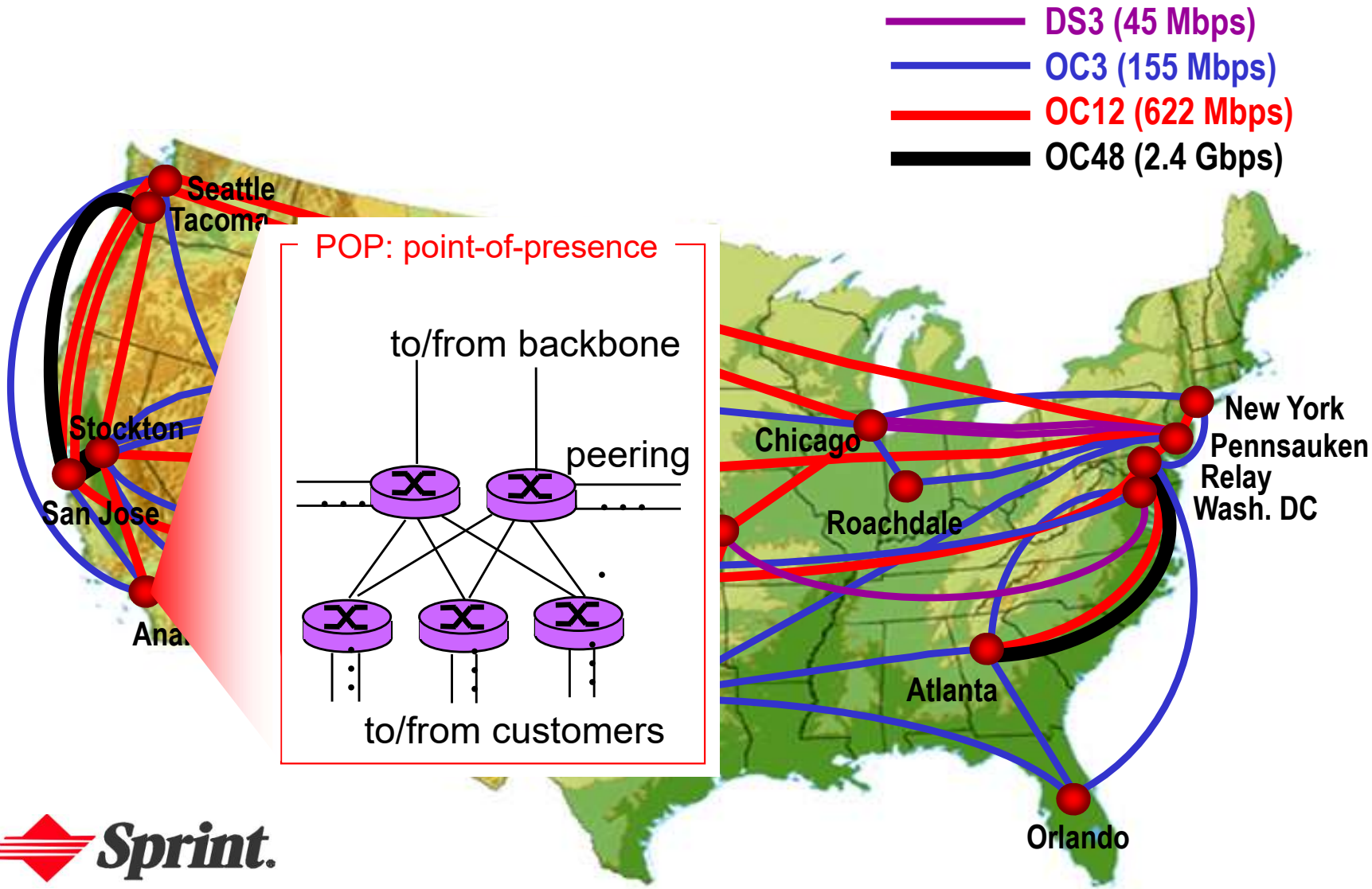
Internet Structure

- Roughly hierarchical
- At center: "tier-1" ISPs (e.g. MCI, Sprint, AT&T)
  - National/international coverage
  - treat each other as equals



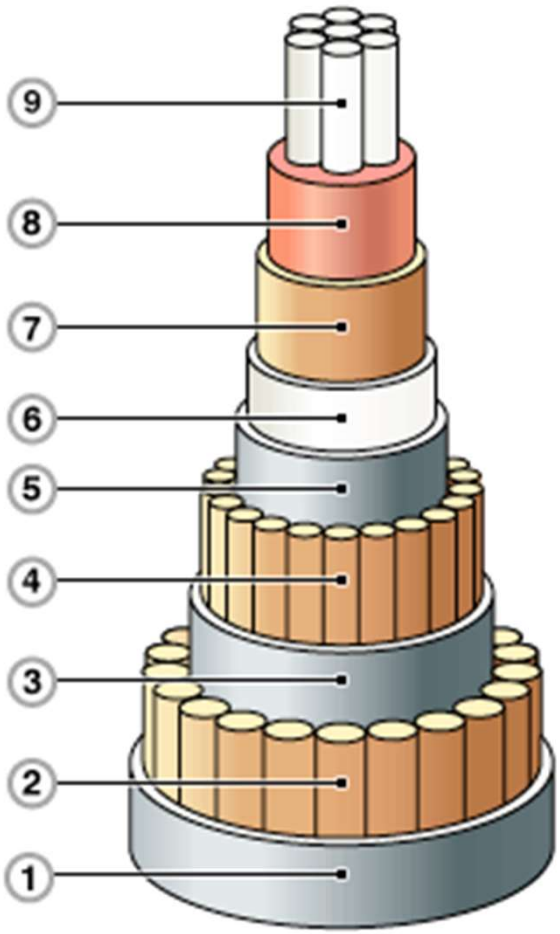
Tier-1 ISP: e.g., Sprint

- Sprint US backbone network



Sprint.

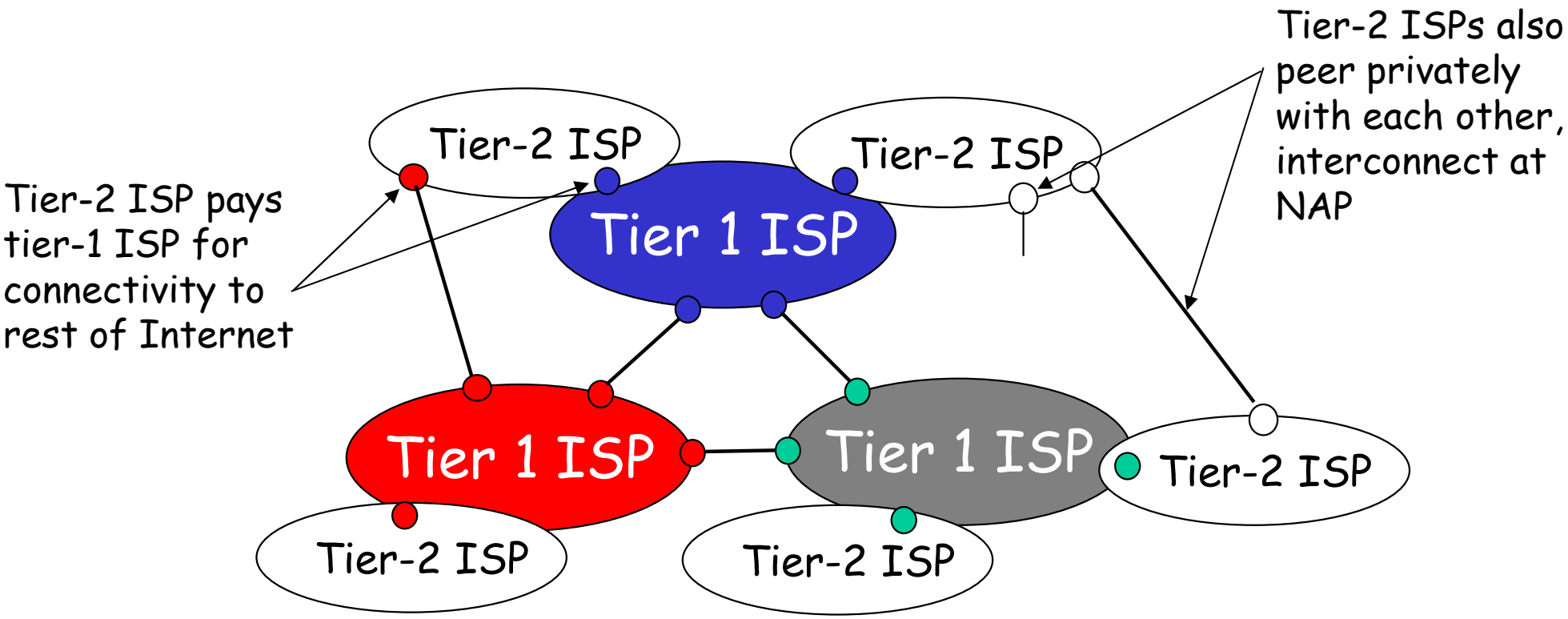
Cables laid out in the oceans



Optical Fiber cross-section

Internet Structure: Network of Networks

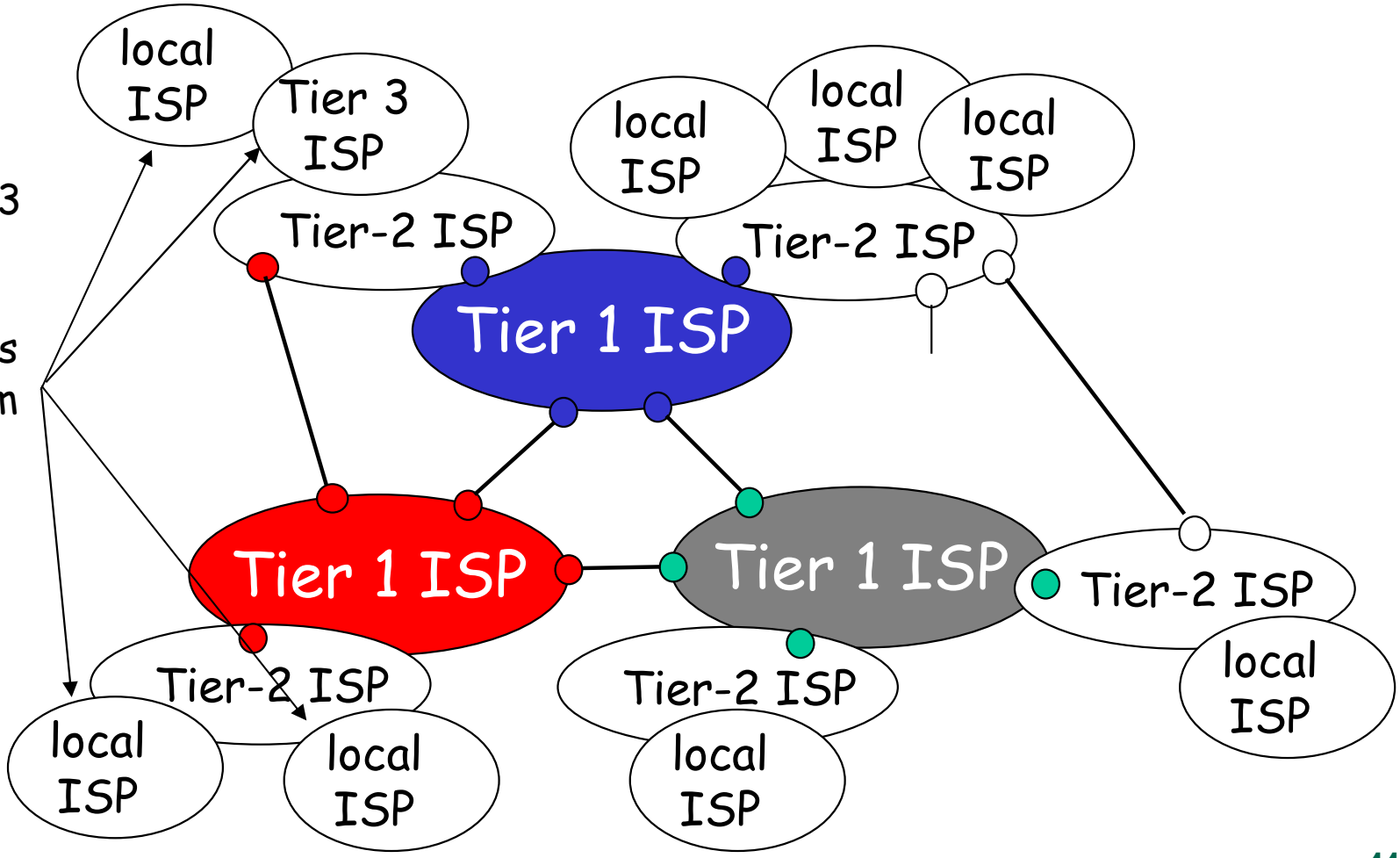
- "Tier-2" ISPs: smaller (often regional) ISPs
  - Korea telecom purchases transit from Cogent, Telia Carrier, Tata Communications, Hurricane Electric, GTT, and Sprint.
  - SK broadband purchases transit from Tata Communications, Verizon, Telia Carrier, NTT America, and China Telecom.



Internet Structure: Network of Networks

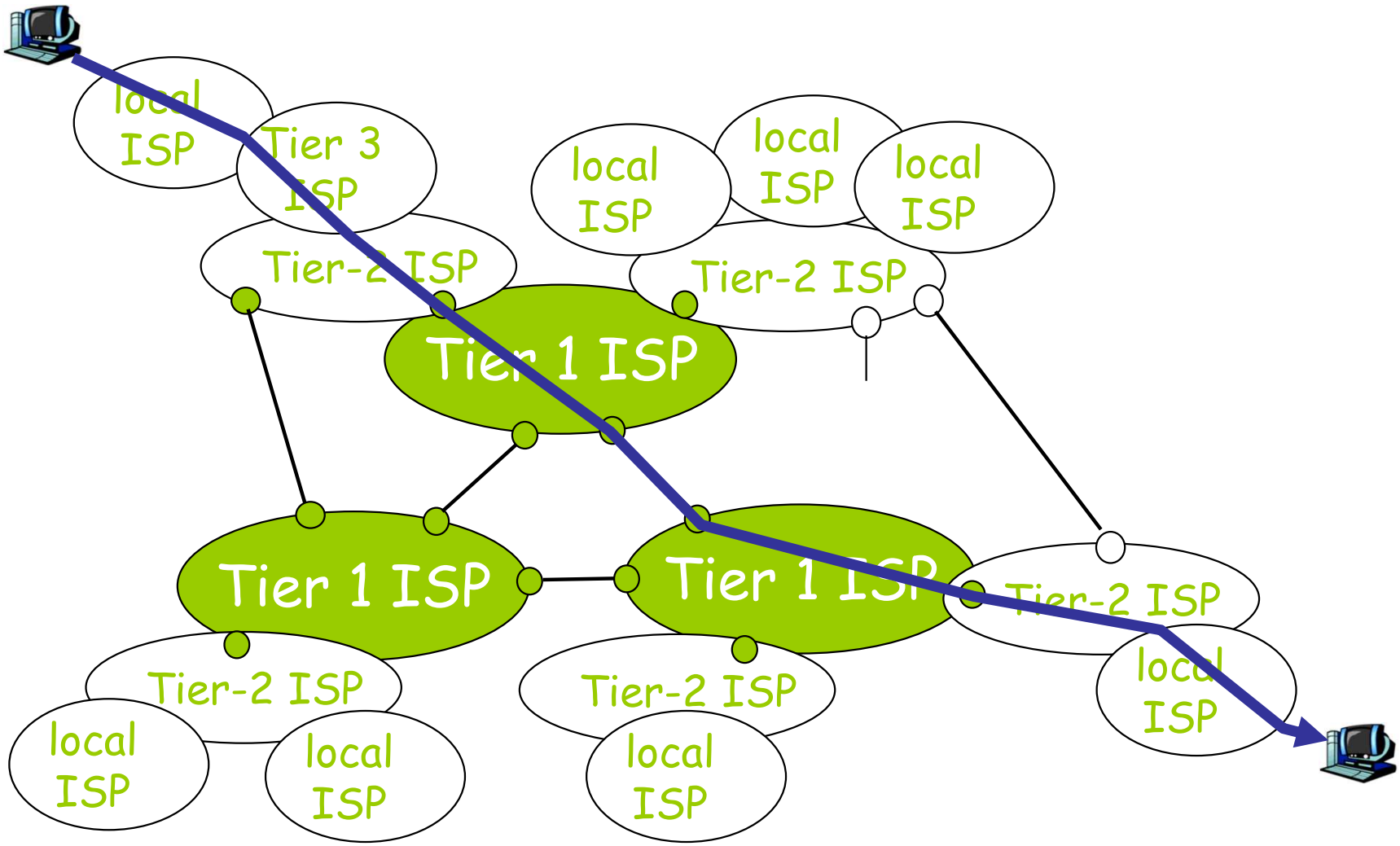
- "Tier-3" ISPs and local ISPs
  - Last hop ("access") network (closest to end systems)

Local and tier- 3 ISPs are *customers* of higher tier ISPs connecting them to rest of Internet



Internet Structure: Network of Networks

- A packet passes through many networks
  - Local ISP (uber) -> T3 (bus to ICN) -> T2 (flight to Tokyo) -> T1 (flight to NYC)



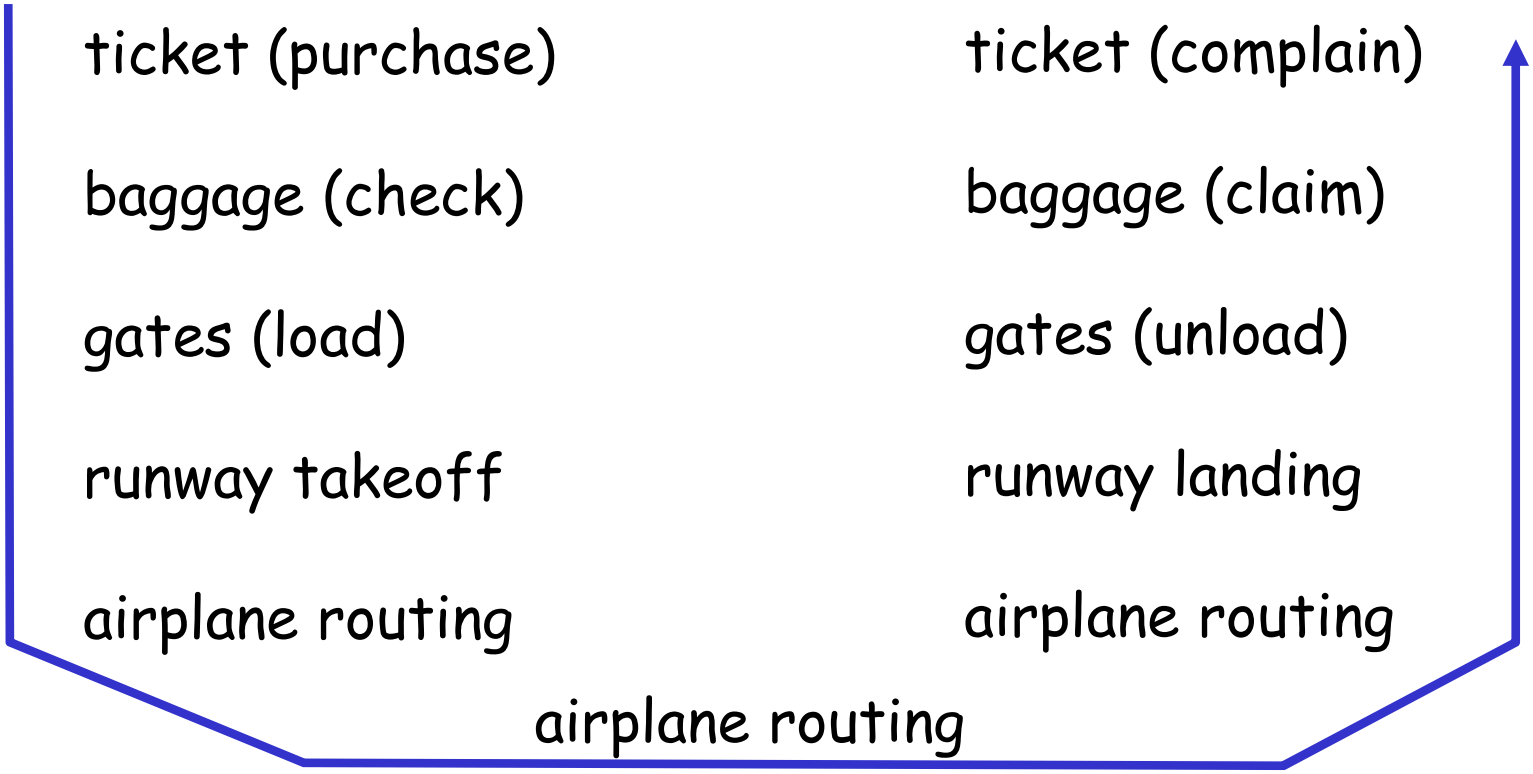
Organizing the giant structure

- Networks are complex
- Many pieces
  - hosts
  - routers
  - links of various media
  - applications
  - protocols
  - hardware, software

- How should we organize structure of the networks?

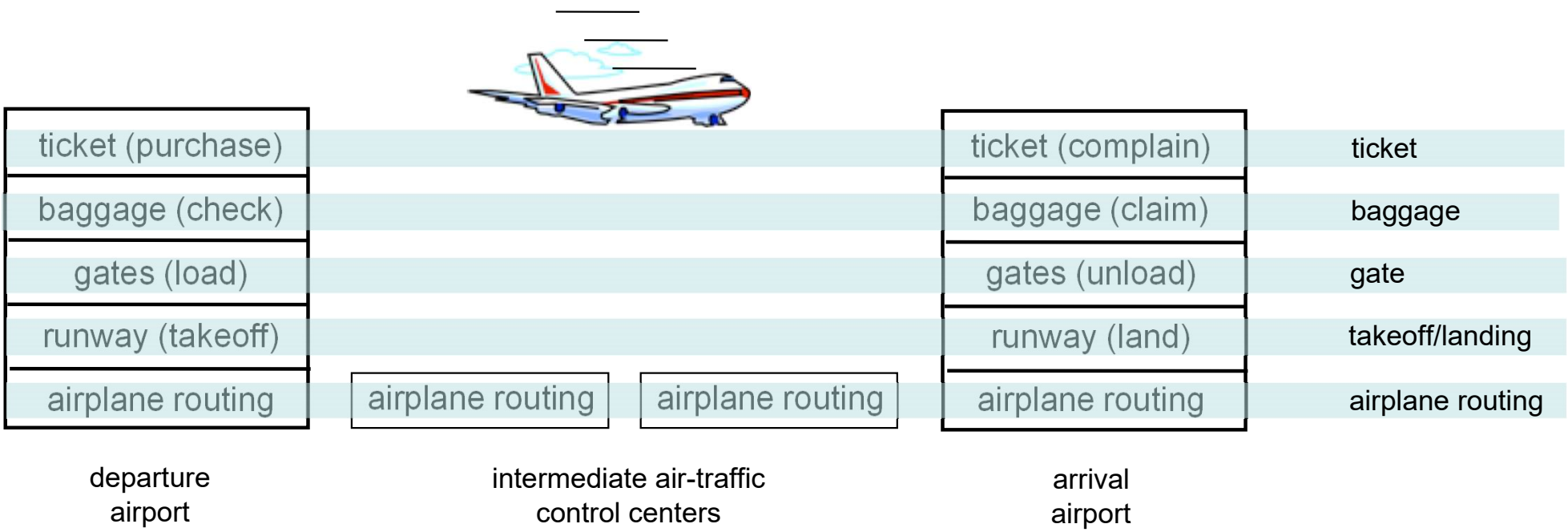
Analogies in air travel

- A series of steps



Layering of airline functionality

- Layers: each layer implements a service
  - Layers communicate with peer layers
  - rely on services provided by the layer below



Why layering?

- Explicit structure allows identification, relationship of complex system's pieces

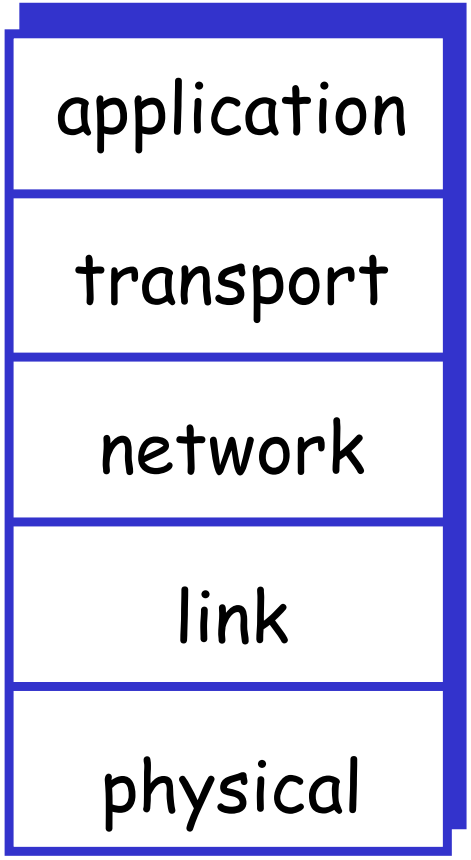
- Modularization eases maintenance, updating of system
  - change of implementation of layer's service transparent to rest of system
  - e.g., runway delay (wheels up time) depends on clearance of destination runway ... doesn't change the baggage tagging systems ... or flight to gate assignment

Protocol "layers"

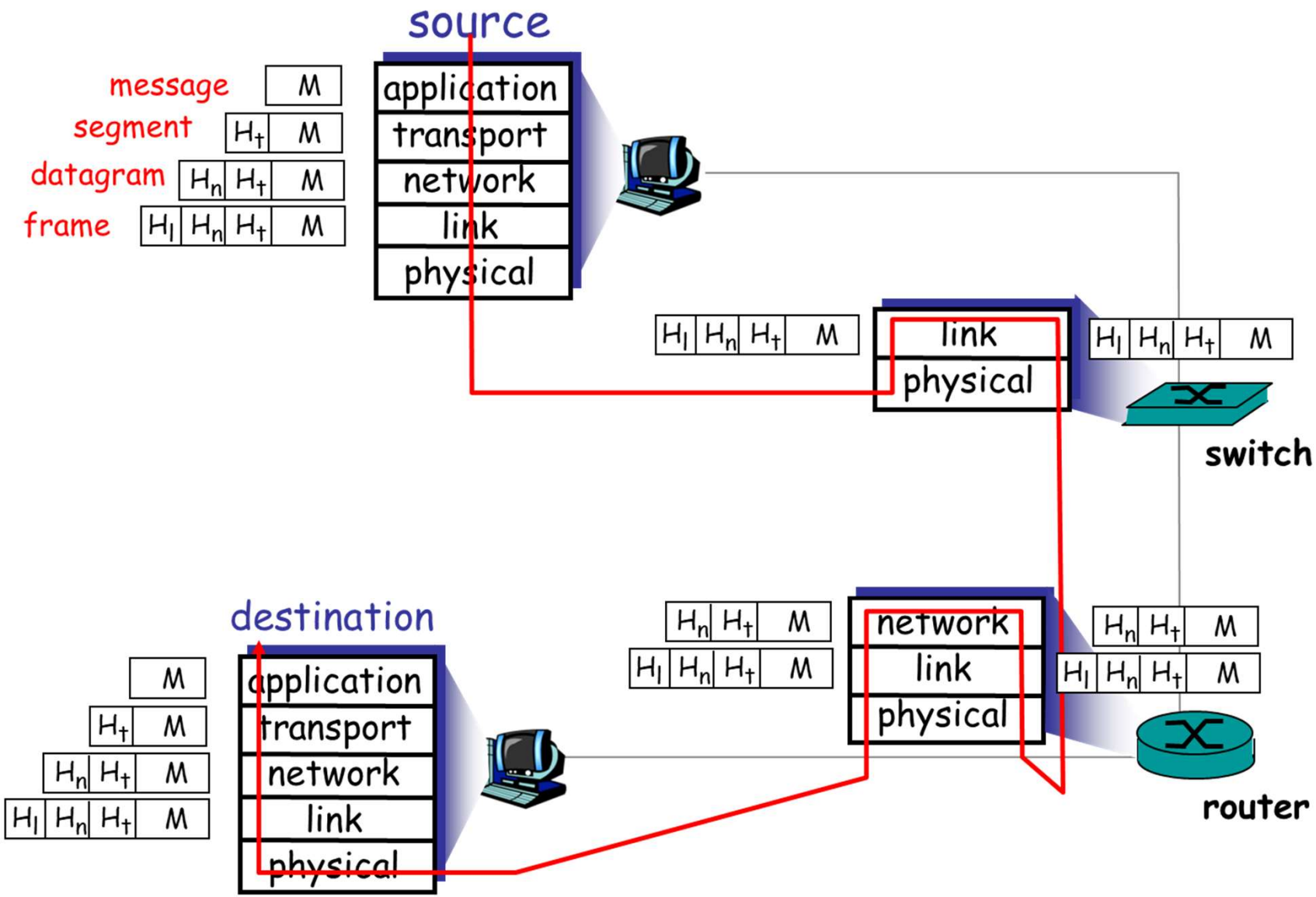
- Service of each layer encapsulated
- Universally agreed services called PROTOCOLS
- A large part of this course will focus on understanding protocols for networking systems

Internet protocol stack

- Application: supporting network applications
  - FTP, SMTP, HTTP, DNS, ...
- Transport: host-host data transfer
  - TCP, UDP, ...
- Network: routing of datagrams from source to destination
  - IP, BGP, routing protocols, ...
- Link: data transfer between neighboring network elements
  - PPP, Ethernet, Wi-Fi, Bluetooth, ...
- Physical: bits "on the wire"
  - OFDM, DSSS, CDMA, coding, ...

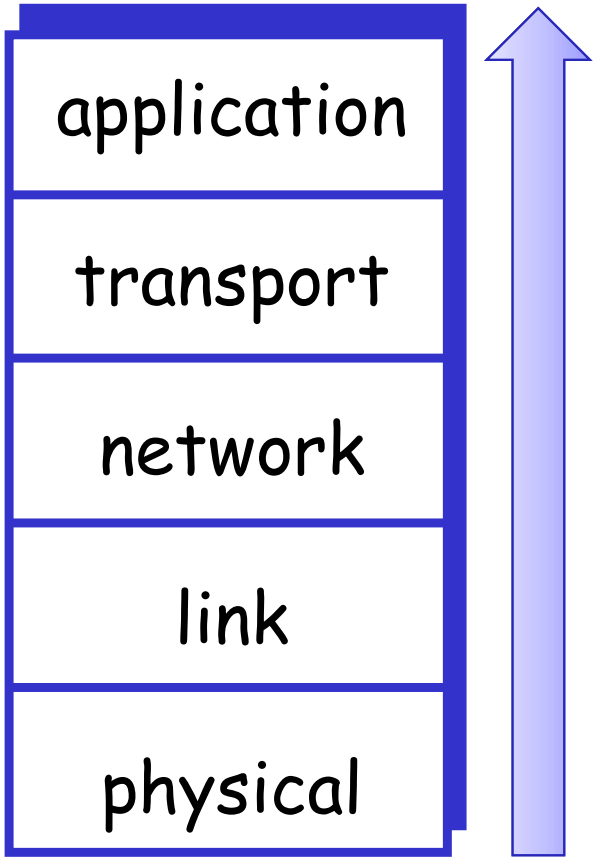


Encapsulation



Our approach: bottom-up

- Physical + Link layer
  - how to send information reliably over various media
- Network layer
  - how to deliver information to hosts around the world
- Transport layer
  - how to control a process-to-process communication
- Application layer
  - communication protocols for various applications



End of Class

Instructor office: AS1013

Email: jso1@sogang.ac.kr