

# The Internet

CSE 120 Spring 2017

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# Administrivia

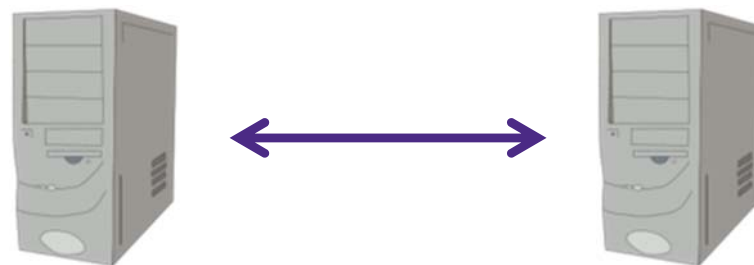
- ❖ Assignments:
  - Binary Practice (4/21)
  - Creativity Assignment (4/24)
  
- ❖ Midterm in class on Wednesday, 4/26
  - 1 sheet of notes (2-sided, letter, handwritten)
  - Fill-in-the-blank(s), short answer questions, maybe simple drawing
    - Questions will cover lectures, assignments, and readings
  - Midterm Review sheet covered in lab next week (4/25)

# Outline

- ❖ **Networks**
- ❖ Growth of the Internet
- ❖ Sending Information

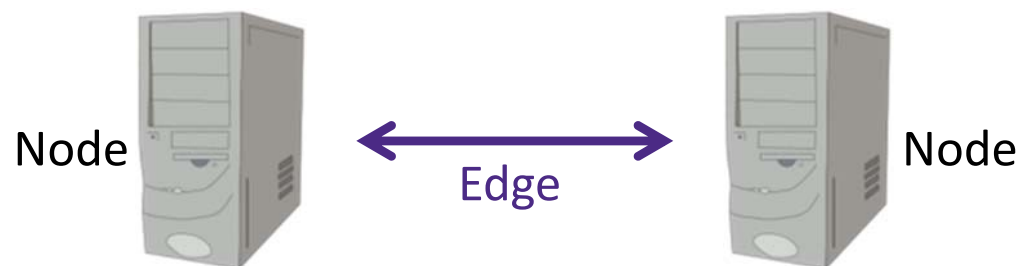
# Communication Channels

- ❖ We often transmit sequences of bits between computers – why?
  - Only capability we need because of binary encoding!
  - Via wire: Ethernet
  - Via wireless: WiFi, 3G/4G, Bluetooth
- ❖ A **network** is a group of computing devices connected together, either by wire or wirelessly



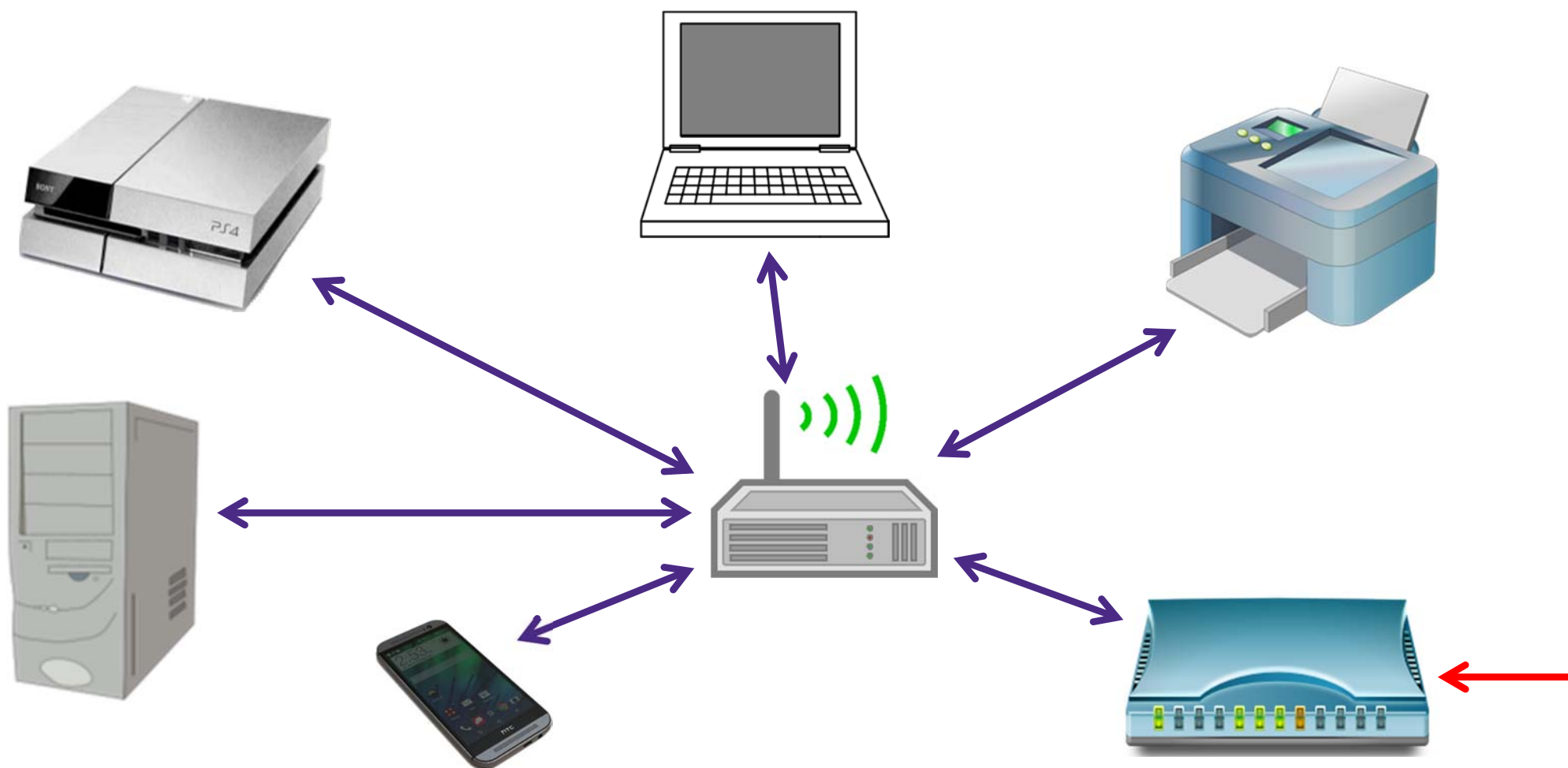
# A Simple Model for Networks

- ❖ One way to represent computer networks is as a **graph**
  - Each **node** represents one machine on the network
  - Each **edge** represents a connection between two machines
  
- ❖ Below is a network of just two computers:
  - 2 nodes and 1 edge

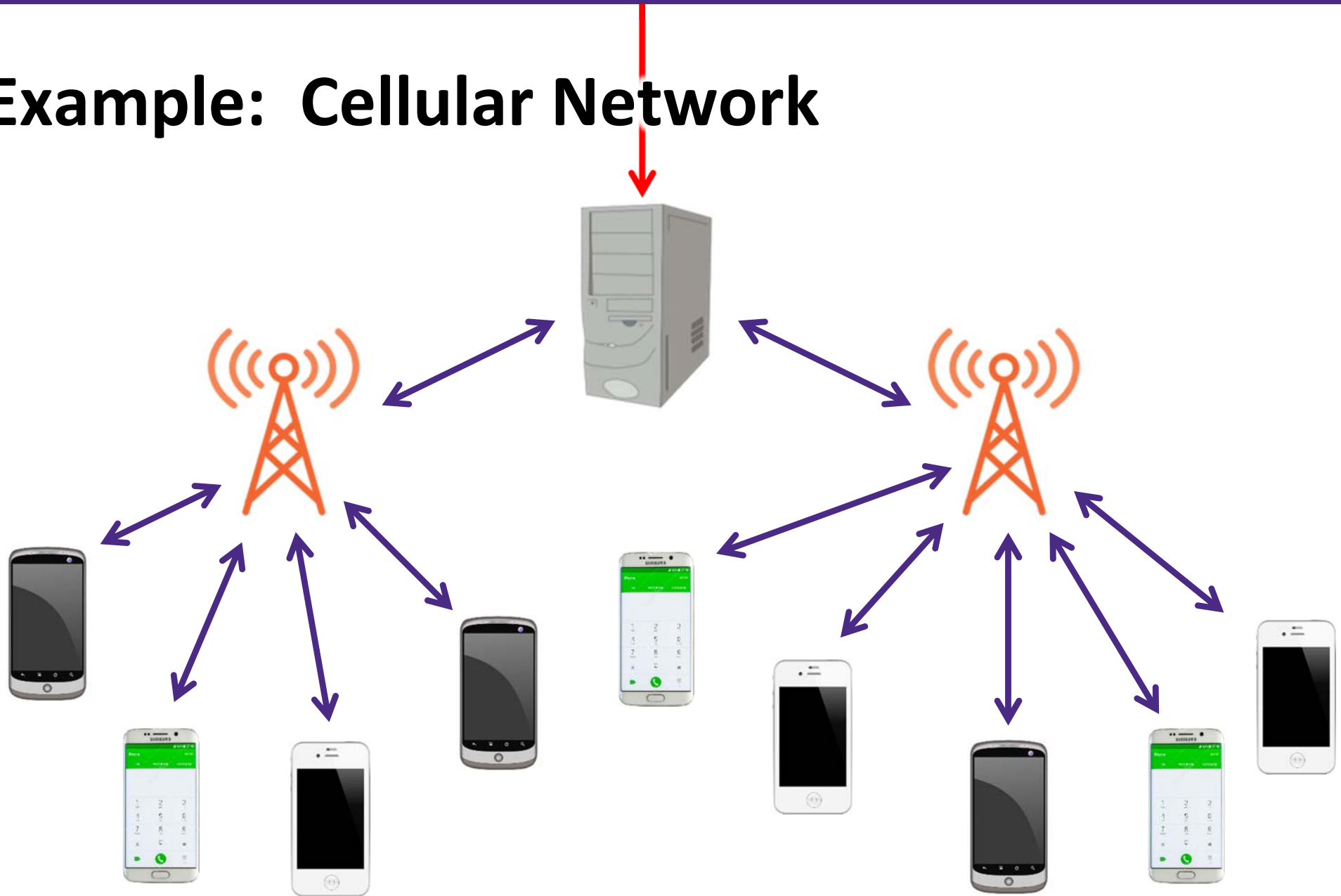


# Example: Home Network

- ❖ The network at my house: 7 nodes, 6 edges
  - Not counting the outside world

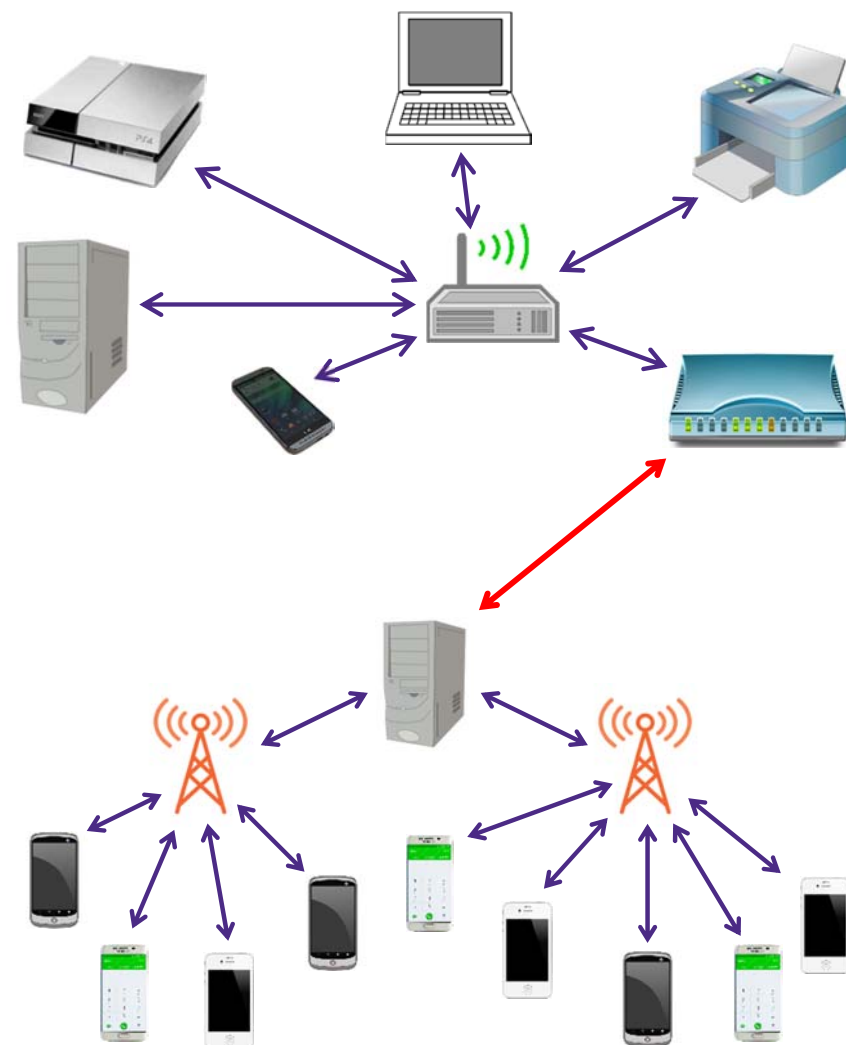


# Example: Cellular Network



# Internetworking

- ❖ If you connect two networks, you still have a network
  - Sometimes called an “internetwork”
- ❖ The largest network of networks on the planet is usually called “The Internet”





# Network Scales

❖ Table from an old UW Networking MOOC:

Scale	Type	Example
Vicinity	PAN (Personal Area Network)	Bluetooth ( <i>e.g.</i> headset)
Building	LAN (Local Area Network)	WiFi, Ethernet
City	MAN (Metropolitan Area Network)	Cable, DSL
Country	WAN (Wide Area Network)	Large ISP
Planet	The Internet (network of all networks)	The Internet

# The Interwebs?

- ❖ The Internet vs. The World Wide Web (WWW)
  - Is there a difference?
- ❖ The **Internet**: All of the *hardware* and *data* associated with the network of all networks (wires, fibers, switches, routers, servers, files, etc.)
- ❖ The **World Wide Web**: The system used to *access* the Internet (data transmission via browsers, web servers, web services, etc.)

# Internet Accessibility

❖ Can now get Internet almost anywhere:

- On a bus
- On a plane
- On a mountain
- In outer space



StarTribune



united.com

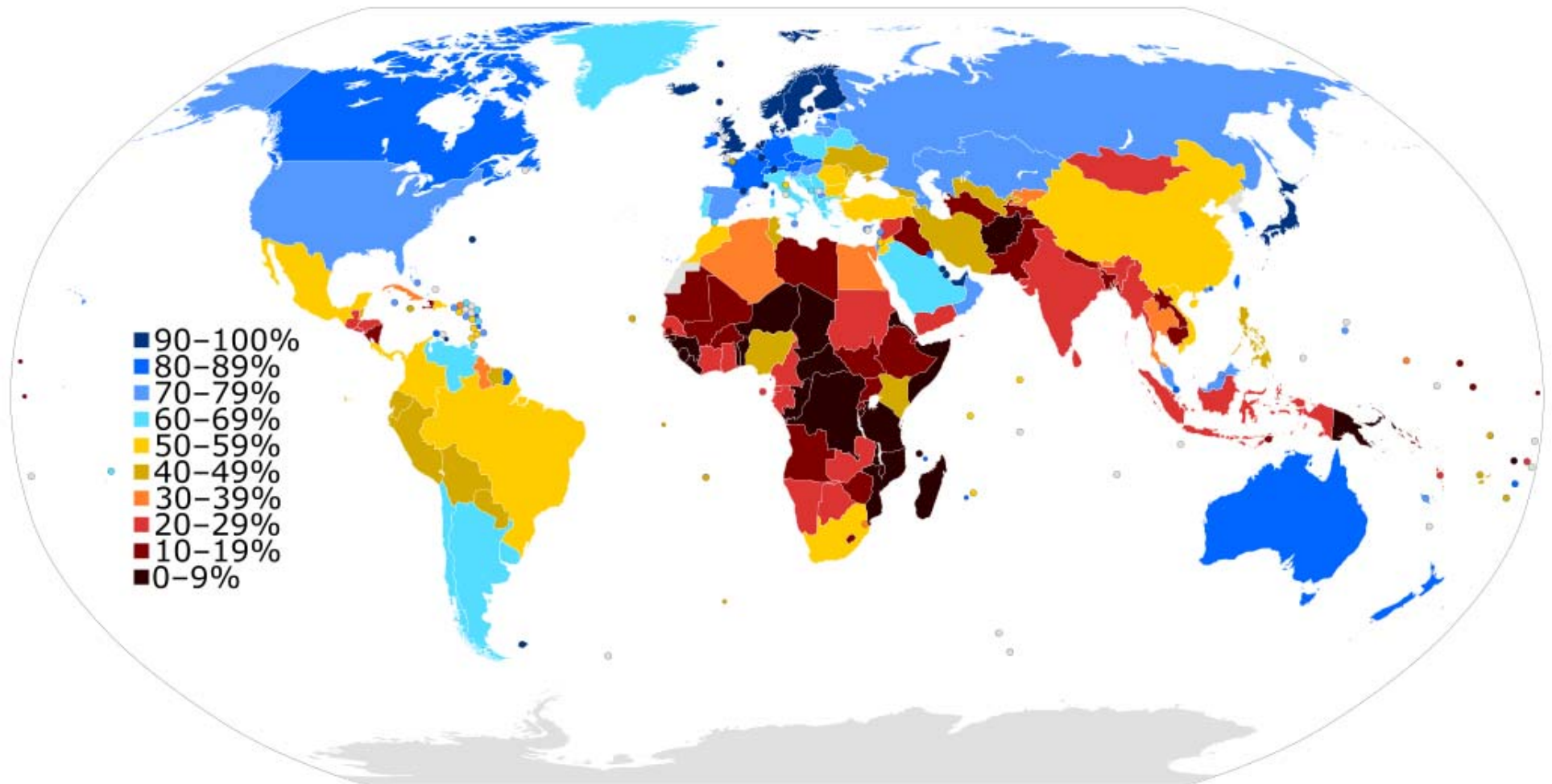


Slash Gear



NASA

# The Internet Today



## Internet Usage as a Percentage of Population (2015)

By Jeff Ogden (W163) - Own work, based on figures from the Wikipedia:List of countries by number of Internet users article in the English Wikipedia, which is in turn based on figures from the International Telecommunications Union (ITU) for 2010 (updated to use figures for 2012 on 28 June 2013).iThe source code of this SVG is valid.This vector image was created with a text editor.This vector image includes elements that have been taken or adapted from this: BlankMap-World6.svg., CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=19202338>

# Question

- ❖ In the last two years, what's the longest stretch of time you've gone without internet?
  - Vote at <http://PollEv.com/justinh>
- A. **Several Hours**
- B. **1-2 days**
- C. **More than 2 days**
- D. **Several weeks**
- E. **More than several weeks**



# Audience Responses

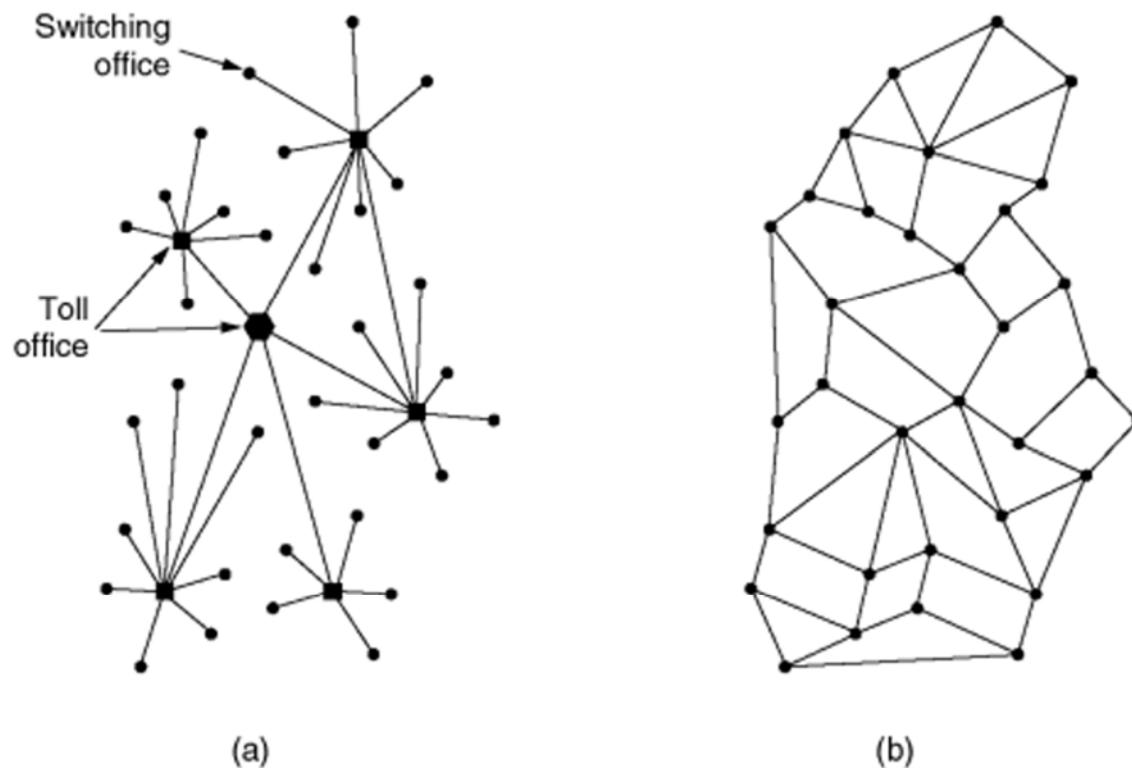
- ❖ Why no Internet?
  - Schoolwork (still used Internet)
  - Vacation in the wild
  - Rural area
  - Assignment to go without Internet (roadtrip)
  - Ran out of data
  - Layover without free airport internet

# Outline

- ❖ Networks
- ❖ **Growth of the Internet**
- ❖ Sending Information

# The DoD and Computer Networks

- ❖ The Department of Defense (DoD) observed that central offices made communication network vulnerable to attack
  - 1950s – The Cold War
  - Can we build a more robust, **decentralized** system?



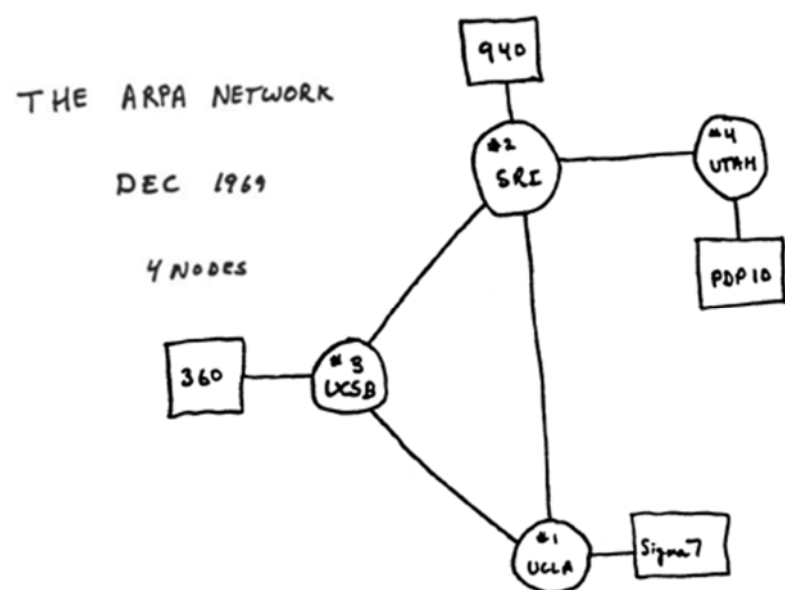
**Figure 1-25.** (a) Structure of the telephone system. (b) Baran's proposed distributed switching system.

Figure from  
[Computer Networks by Tanenbaum and Wetherall](#)



# ARPANET

- ❖ First 4 nodes of ARPANET connected in 1969
  - Stanford, UC Los Angeles, UC Santa Barbara, Utah
- ❖ By Sept. 1971, there were 18 nodes across the US
  - Grew exponentially from there for a long, long time
  - ARPANET superseded by NSFNET in '86, Internet in '91



# Growth of the Internet

- ❖ The major point in building networks is *agreement*
  - The only way to get seamless integration
- ❖ **Open standards/protocols** enabled rapid growth
  - Internet Engineering Task Force (IETF)
    - Request for Comments (RFC)
  - World Wide Web Consortium (W3C)
    - HTML
  - International Standards Organization (ISO)
    - JPEG, MPEG
  - Institute of Electrical and Electronics Engineers (IEEE)
    - WiFi

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# Analogy: Mailing a Letter

- ❖ Want to send a letter to my parents
  - 1) Write their unique address on the envelope
  - 2) Stamp it
  - 3) Drop it in a mailbox
  
- ❖ I rely on the *abstraction* that the US Postal Service will magically deliver the letter to the specified address

# What Information?

- ❖ Remember that all digital information is sent as bits
  - In order to make sense of anything, must follow communication *protocols*
  
- ❖ Example protocols:
  - Ethernet
    - For physical connection in a LAN
  - TCP/IP
    - Transmission control protocol and internet protocol
  - HTTP
    - Hypertext transfer protocol for web pages

# Internet Communication

- 1) Break the information into lots of tiny pieces called **packets**, about 1500 bytes long each
- 2) Packets are sent through the network (passing through many different machines) to their destination
- 3) The packets are reassembled on the other side

❖ Packets must contain:

- Destination address
- Sequence/piece number
- Content/data



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## ❖ Advantages:

- Packets can take separate routes
  - Can even originate from different locations
- If packet is lost, only have to resend small amount of info

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## ❖ Disadvantages:

- Extra transmission data
  - *e.g.* same destination address for many packets
- Every computer along a packet's path sees the content of the packet



# IP Addresses

- ❖ In 1974, Vint Cerf and Bob Kahn completed the specifications for the Internet Protocol (IP)
  - Every device given a unique 32-bit address (**IP address**)
    - Large entities (e.g. companies, universities) can keep an IP address forever and allocate to physical machines as desired
    - For home machines, IP address is typically not permanent
  - Address is used to get information to the right computer on a network

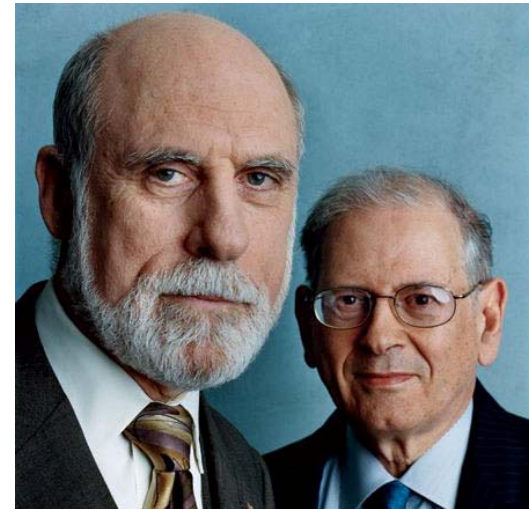
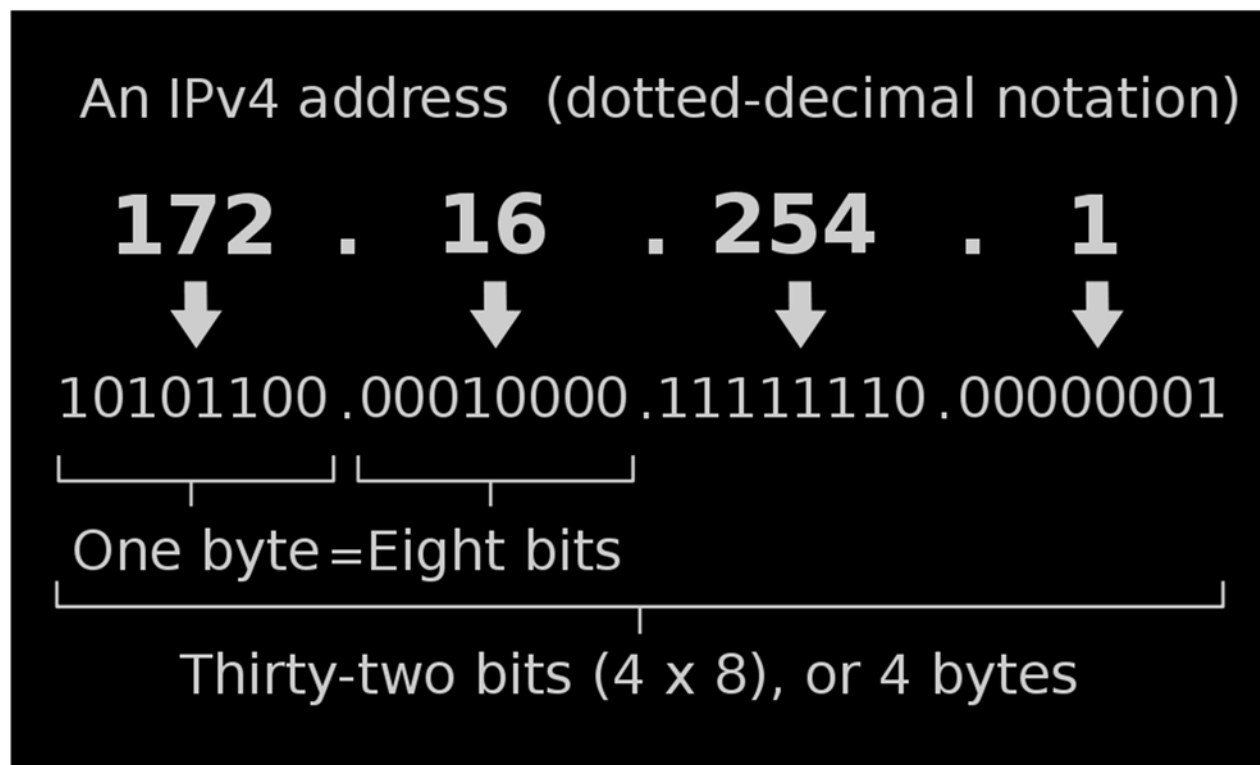


Image:  
[Archeologia](#)  
[Informatica](#)

# IPv4 Addresses

- ❖ Broken into four 8-bit chunks, and specified in “**dotted-decimal notation**”



- Split by **network** and **computer**: **172.16.254.1**
- Unlike a phone number, no “area code”

# Question

❖ How many internet-capable devices do you own?

▪ Vote at <http://PollEv.com/justinh>

A. 0

B. 1

C. 2-5

D. 6-9

E. 10+

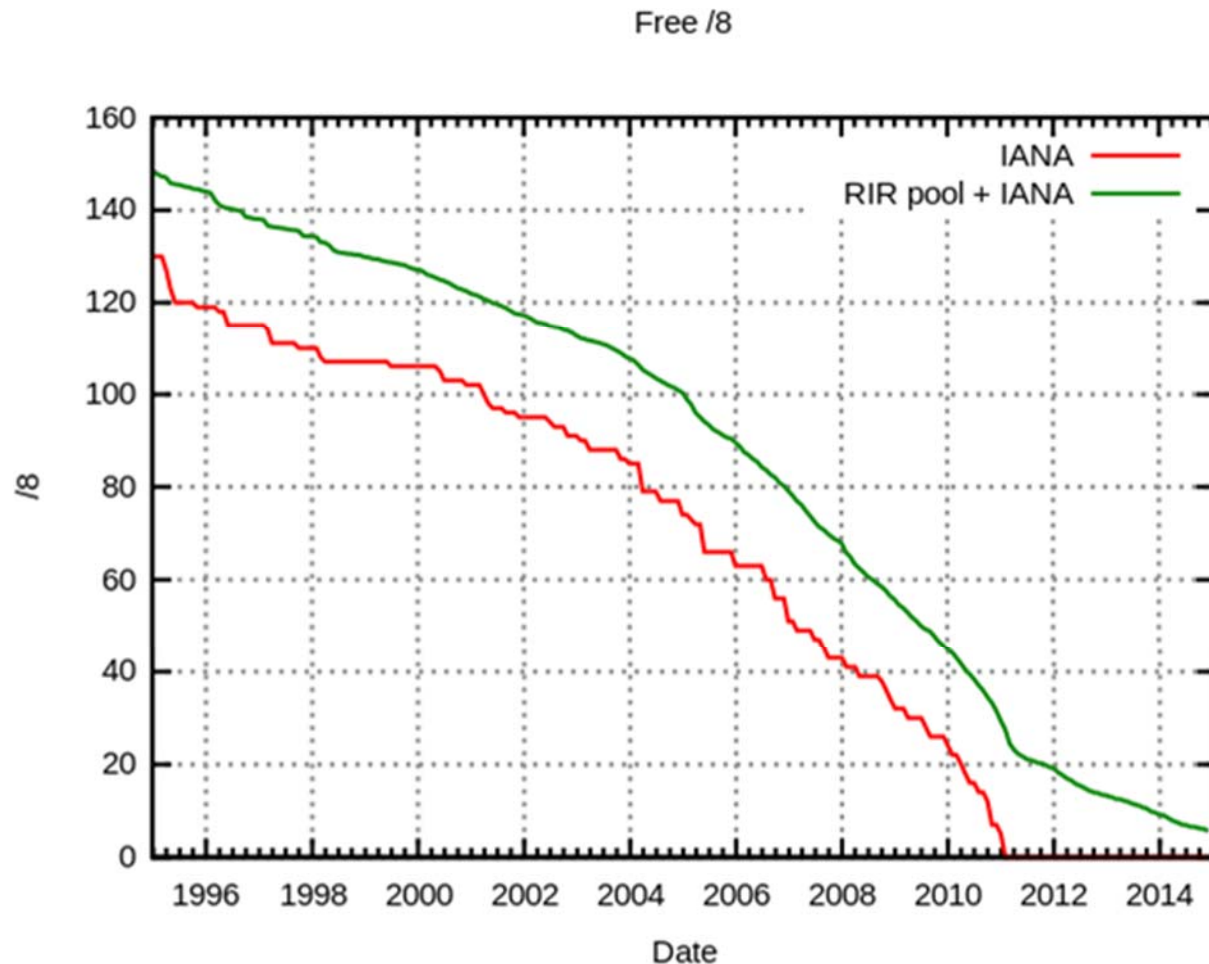


Image: dreamstime.com

❖ How many people are there in the world?

❖ How many IPv4 addresses are there (32 bits)?

# IPv4 Address Exhaustion



Source:  
[Wikimedia Commons](#)

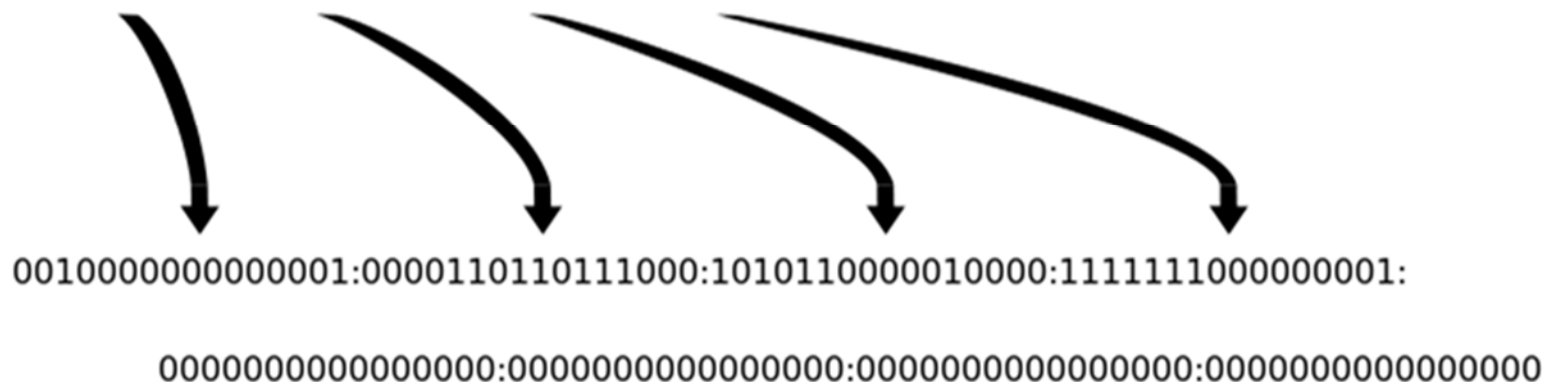
- ❖ Neat video of allocation through the years:
  - [https://www.youtube.com/watch?v=y8WqJum\\_Gfg](https://www.youtube.com/watch?v=y8WqJum_Gfg)

# IPv6

An IPv6 address (in hexadecimal)

**2001:0DB8:AC10:FE01:0000:0000:0000:0000**

↓ ↓ ↓ ↓   
**2001:0DB8:AC10:FE01::** Zeroes can be omitted



Source:  
[Wikimedia Commons](https://commons.wikimedia.org/)

- ❖  $2^{128}$  unique addresses
- ❖ Issue: adoption still in progress
  - Which are you? <https://www.whatismyip.com>

# Domain Name System

- ❖ Remembering IP addresses would be brutal for humans
  - Instead we use domain names, which are human-readable and more flexible
    - *e.g.* `cs.washington.edu` instead of `128.208.3.88`
- ❖ Computers find IP address for a domain name from the **domain name system** (DNS)
  - Another computer that acts as an IP address book
    - Your computer *does* need to know the IP address of the DNS server
  - DNS is an automatic directory search – it's huge!

# Logical vs. Physical

- ❖ Humans see the Internet as a **logical network**: an hierarchy of domains
- ❖ Computers see the Internet as a **physical network**: IP addresses that map to computers
- ❖ The DNS relates the logical network to the physical network by translating domain names to IP addresses
  - Requesting a web page from the same domain name may get “served” to you from a different IP address each time!
  - For improved performance, most web content is stored in multiple locations

# Discussion (If Time)

- ❖ The Internet was supposed to bring the world “closer together”
- ❖ Do you think it has? Why or why not?



# Summary

- ❖ A **network** is a group of computing devices connected together, either by wire or wirelessly
  - From very small to very big
  - The Internet is the largest network of networks
- ❖ The Internet grew rapidly and has become increasingly omnipresent
  - Highly fault-tolerant due to **decentralization**
  - Growth aided by **open standards**
- ❖ Data is passed between computing devices in small pieces called **packets**
  - The **domain name system** translates from domain names to **IP addresses** in order to reach a specific device