What's in a computer?

- **logical or functional organization: "architecture"**
  - what the pieces are, what they do, how they work
  - how they are connected, how they work together
  - what their properties are

- **physical structure**
  - what they look like, how they are made

- **major pieces**
  - processor ("central processing unit" or CPU)
    does the work, controls the rest
  - memory (RAM = random access memory)
    stores instructions and data while computer is running
  - disks ("secondary storage")
    stores everything even when computer is turned off
  - other devices ("peripherals")

2018 freshman SCI computers

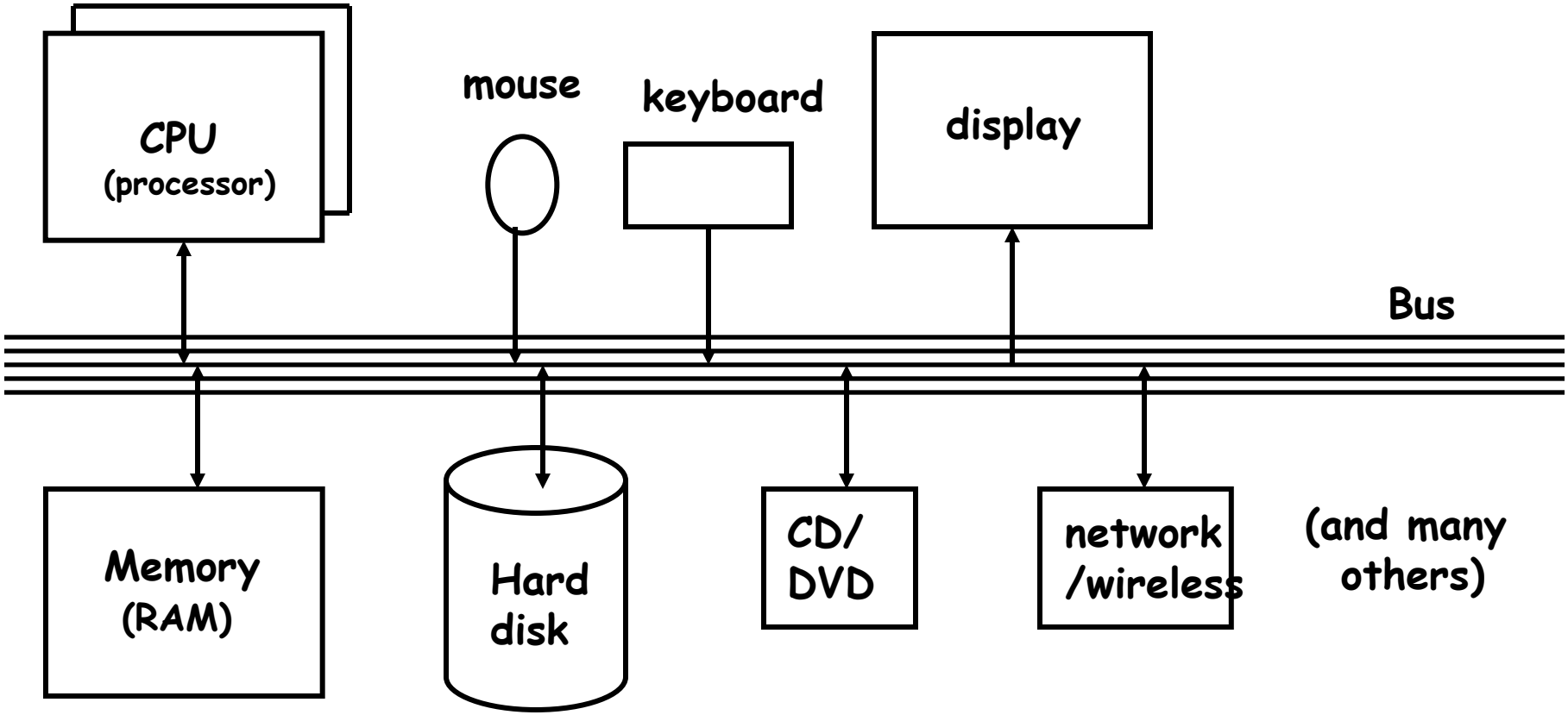
Apple Macbook Pro 13" Retina

- 2.6 GHz Intel Dual Core i5 processor
- 13.3" retina display
- Intel Iris Graphics
- 8 GB memory
- 128 GB PCI-e Flash Storage
- Ethernet and VGA Adapters included
- Mac OS X 10.9 Mavericks

Dell XPS 12

- 4th Generation Intel Core i7 1.8 GHz processor (4M Cache, up to 3.0 GHz)
- 12.5 inch LED Backlit Touch Display FHD resolution (1920 x 1080)
- Intel HD 4400 Graphics
- 8 GB memory
- 256GB Solid State Drive
- Covertible Laptop to Tablet
- Ethernet and VGA adapters incl., 3.35 lbs.
- Windows 8.1 Pro

Block diagram of typical laptop/desktop



CPU

- **can perform a small set of basic operations ("instructions")**
  - arithmetic: add, subtract, multiply, divide, …
  - memory access:
    fetch information from memory, store results back into memory
  - decision making: compare numbers, letters, …
    decide what to do next depending on result of previous computations
  - control the rest of the machine
    tell memory to send data to display; tell disk to read data from network; ...
- **operates by performing sequences of simple operations *very* fast**
- **instructions to be performed are stored in the same memory as the data is**
  - instructions are encoded as numbers: e,g., Add = 1, Subtract = 2, ...
- **CPU is a general-purpose device: putting different instructions into the memory makes it do a different task**
  - this is what happens when you run different programs

How fast is fast?

- **CPU uses an internal "clock" (like a heartbeat) to step through instructions**
- **900 MHz, 2.5 GHz, etc., is the number of clock ticks per second**
  - 1 Hertz = 1 tick per second; abbreviated 1 Hz
  - mega = million
  - giga = billion
  - 1 MHz = 1 megaHertz = 1 million ticks per second
  - 1 GHz = 1 gigaHertz = 1 billion ticks per second = 1000 MHz
- **one instruction (like adding two numbers) might take one, two or several ticks, depending on design of the CPU**
  - might even complete more than one instruction in one tick
- **<u>very</u> rough approximations:**
  - PC/Mac processors execute about 2-3 billion instructions/sec
  - cellphone processors execute about 1-2 billion instructions/sec

Memory (Random Access Memory = "RAM")

- **a place to store information while the computer is running**
  - the programs that are running
  - their data
  - the operating system (Windows, Mac OS X, Unix/Linux, ...)
- **volatile: forgets everything when power is turned off**
- **limited (though large) capacity**
- **logically, a set of numbered boxes ("pigeonholes"? mailboxes?)**
  - each capable of storing one byte = 8 bits of information

    a small number or a single character like **A** or part of a larger value
  - random access

    CPU can access any location as quickly as any other location

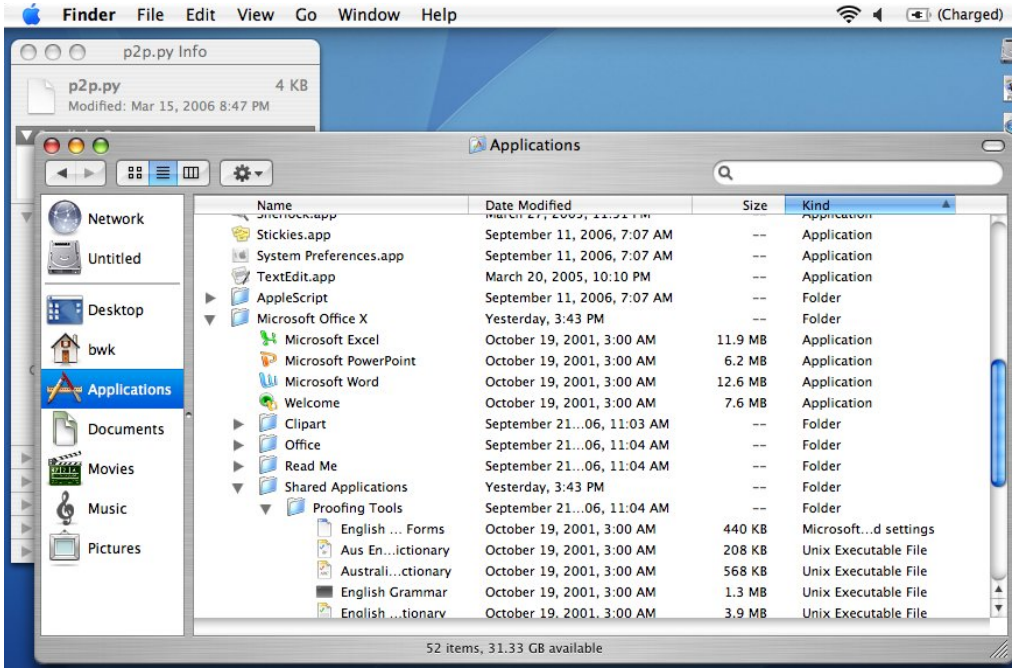
0 1 2 4G

What's a bit? What's a byte?

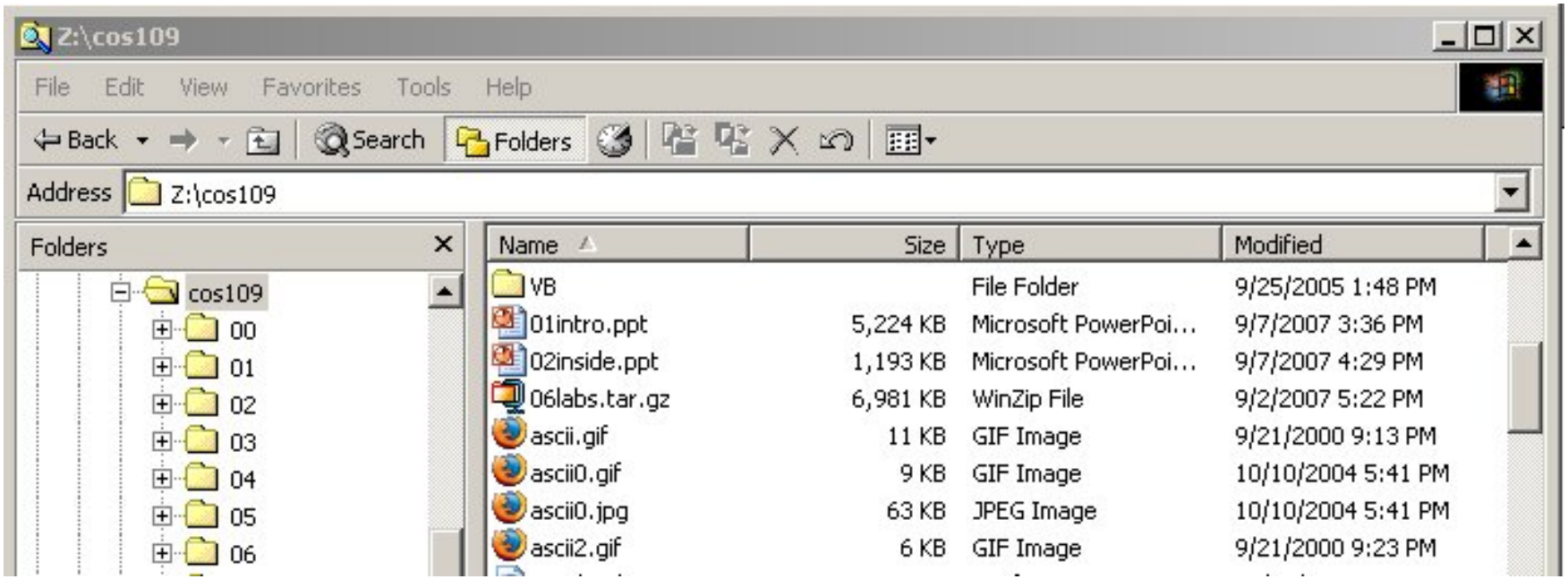
- **a bit is the smallest unit of information**
- **represents one 2-way decision or a choice out of two possibilities**
  - yes / no, true / false, on / off, M / F, ...
- **abstraction of all of these is represented as 0 or 1**
  - enough to tell which of TWO possibilities has been chosen
  - a single digit with one of two values
  - hence "binary digit"
  - hence bit
- **binary is used in computers because it's easy to make fast, reliable, small devices that have only two states**
  - high voltage/low voltage, current flowing/not flowing (chips)
  - electrical charge present/not present (Flash)
  - magnetized this way or that (disks)
  - light bounces off/doesn't bounce off (cd-rom, dvd)
- **all information in a computer is stored and processed as bits**
- **a byte is 8 bits that are treated as a unit**

Disks

- **a place to store information when the power is turned off**
- **often based on magnetic surfaces, rotating machinery**
  - increasingly solid-state Flash memory
- **logical / functional structure: folders (directories) and files**
  - your information: papers, mail, music, web page, …
  - programs and their data: Firefox, Word, iTunes, …
  - operating system(s): Windows, MacOS, Unix, Linux, …
  - bookkeeping info: where things are physically located



Other views of a disk: Window, Unix/Linux




```
bash-3.00$ ls -ltr | tail -8
-rw-r--r--  1 bwk fac     3283 Sep 19 08:10 survey.html
-rw-r--r--  1 bwk fac  6034432 Sep 20 10:43 01intro.ppt
-rw-r--r--  1 bwk fac     6870 Sep 20 10:54 ps1.html
-rw-r--r--  1 bwk fac     2803 Sep 21 08:09 rita.09
-rw-r--r--  1 bwk fac     7101 Sep 21 09:49 ideas.09
-rw-r--r--  1 bwk fac    21766 Sep 21 13:55 index.html
-rw-r--r--  1 bwk fac   143872 Sep 22 15:35 grades09.xls
-rw-r--r--  1 bwk fac     3161 Sep 22 15:44 surveyresults.html
```

Other things

- **CD-ROM, CD-R, CD-RW; DVD**
  - read-only, recordable, rewritable, ~ 650 MB capacity
    same format as audio CD but spins much faster
  - DVD: typically 4.7 or 8.4 GB
- **modem**
  - converts info to/from sound for sending by telephone
  - slow! 56 kilo**bits** per second (56 Kbps): ~ 5000 characters/second
- **network interface**
  - connects computer to network, usually Ethernet
  - Ethernet transfers data at 10-1000 mega**bits** per second
    (10 Mbps ~ 1 MB/sec)
  - wireless is compatible with Ethernet ("wireless Ethernet")
    802.11b (11 Mbps), 802.11g (55 Mbps), 802.11n (600 Mbps) [max]
  - DSL and cable modems are Ethernet-compatible
    slower than Ethernet (typically 0.5 - 4 Mbps); usually at home
  - fiber (e.g., Verizon FiOS) at least 15 Mbps down, 5 Mbps up (higher==$$$)
- **gadgets ("peripherals") on the bus, especially USB**
    USB 2.0 is 480 Mbps (max)

Wrapup on components

- **the logical or functional components of computer hardware**
- **how they fit together, what the numbers measure**
- **some neat Greek/Latin/... prefixes:**
  - (femto, pico,) nano, micro, milli, kilo, mega, giga, (tera, peta, exa)
- **what the basic physical pieces look like**
- **one logical organization can have different physical forms**
- **logical organization hasn't changed much in 60+ years**
- **physical form has changed rapidly for the entire time**
  - many tradeoffs among physical forms (size, weight, power, …)