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")

Freshman SCI computer for class of 2023

Apple - MacBook Air 13.3" Laptop with Touch ID - Intel Core i5 - 8GB Memory - 256GB Solid State Drive (Latest Model) - Space Gray

Model: MVFJ2LL/A SKU: 6356923

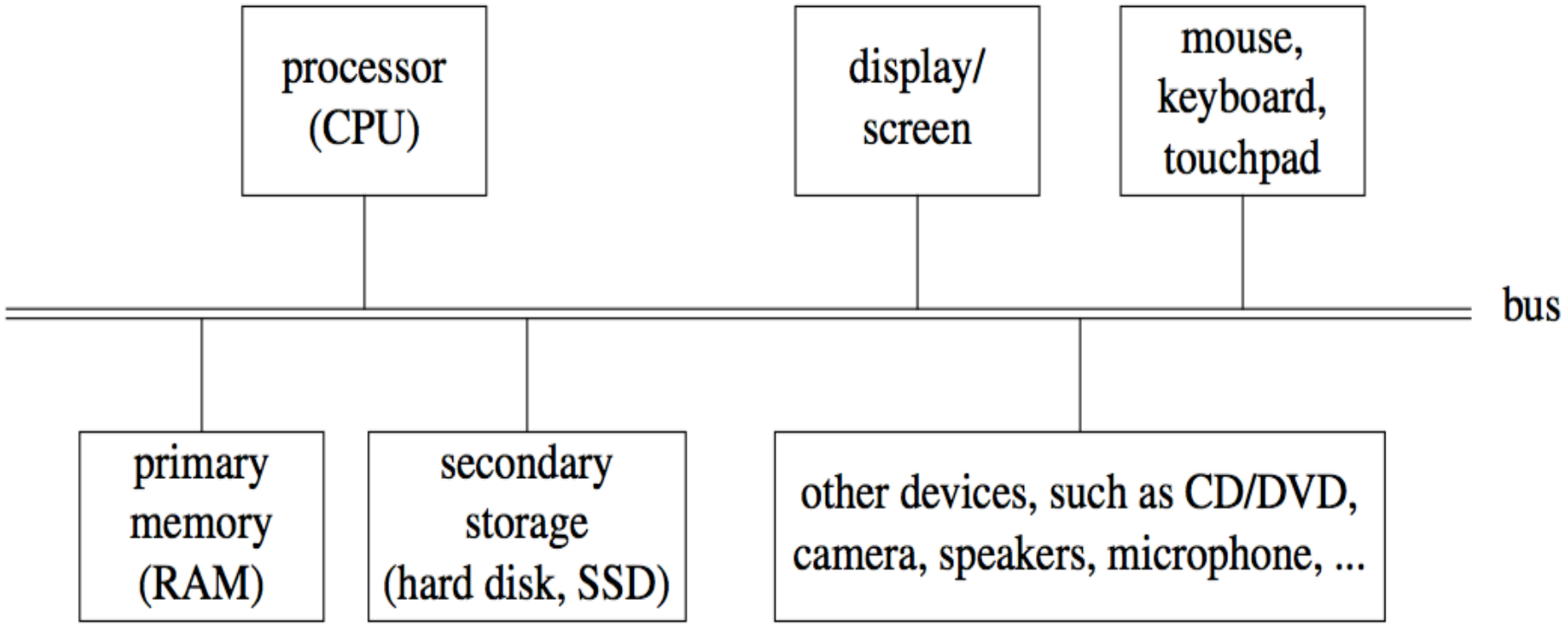
Price Match Guarantee

$1,099.99 c

Save $200

Solid State Drive Capacity	→	256 gigabytes
System Memory (RAM) ⓘ	→	8 gigabytes
Graphics		Intel Iris Plus Graphics 640
Processor Speed (Base) ⓘ	→	2.3 gigahertz
Processor Model ⓘ	→	Intel 7th Generation Core i5
Processor Model Number		Not Available
Operating System ⓘ	→	Mac OS
Battery Life ⓘ		10 hours
Battery Type		Lithium-polymer

Block diagram of a typical laptop computer



CPU: Central Processing Unit

- 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?

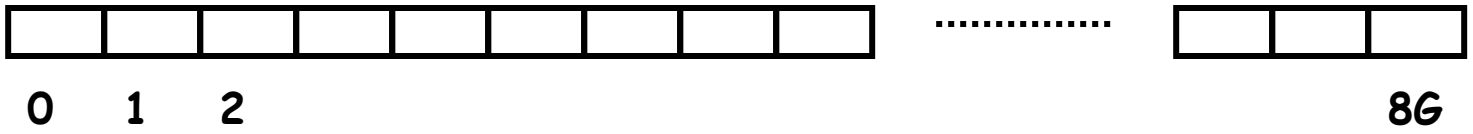
- CPU uses an internal "clock" (like a heartbeat) to step through instructions
- 900 MHz, 2.5 GHz, etc., is the number of clock ticks per second
  - 1 Hertz = 1 tick per second; abbreviated 1 Hz
  - mega = million
  - giga = billion
  - 1 MHz = 1 megaHertz = 1 million ticks per second
  - 1 GHz = 1 gigaHertz = 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
- modern processors execute several 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

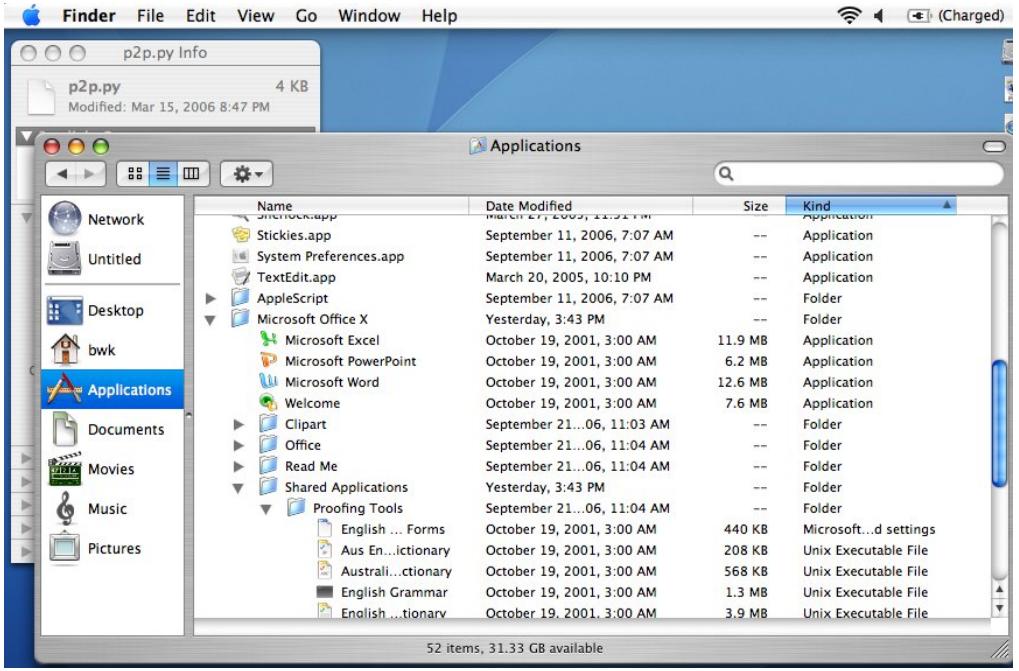


What's a bit? What's a byte?

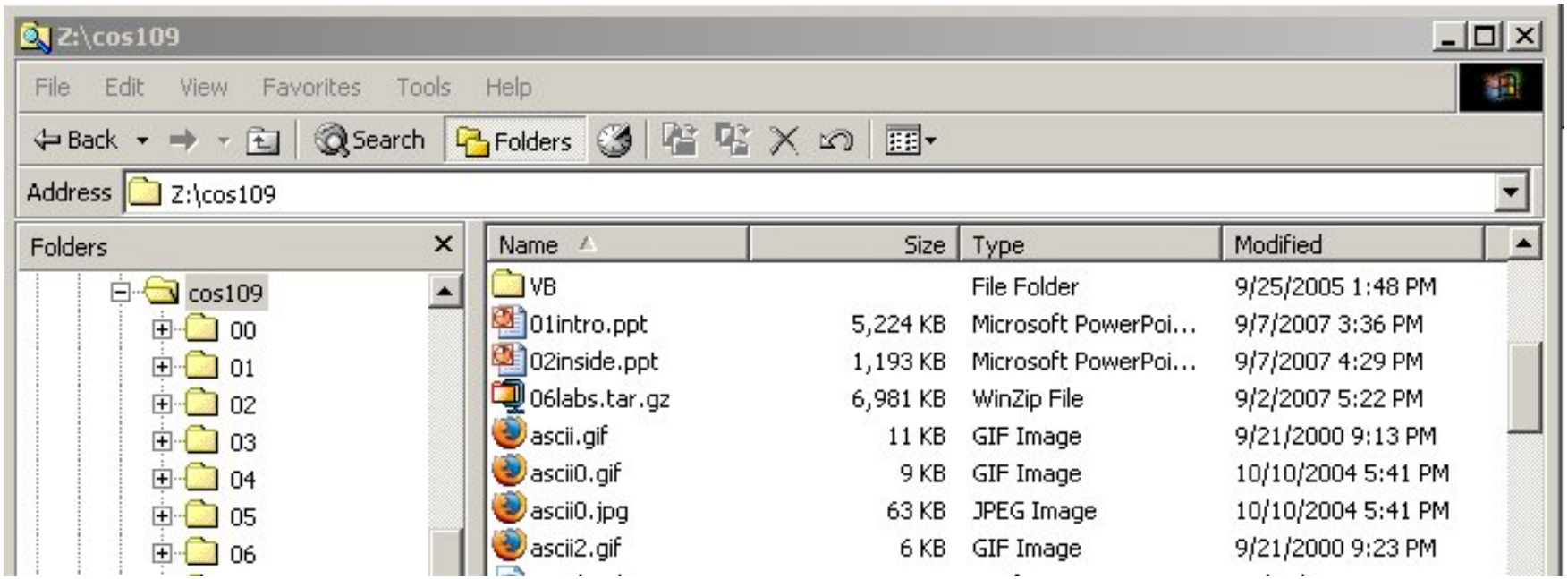
- a bit is the smallest unit of information
- represents one 2-way decision or a choice out of two possibilities
  - yes / no, true / false, on / off, up / down, ...
- abstraction of all of these is represented as 0 or 1
  - enough to tell which of TWO possibilities has been chosen
  - a single digit 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
- was based on magnetic surfaces, rotating machinery
  - today, more often solid-state Flash memory (SSD)
- 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: Windows, Unix/Linux



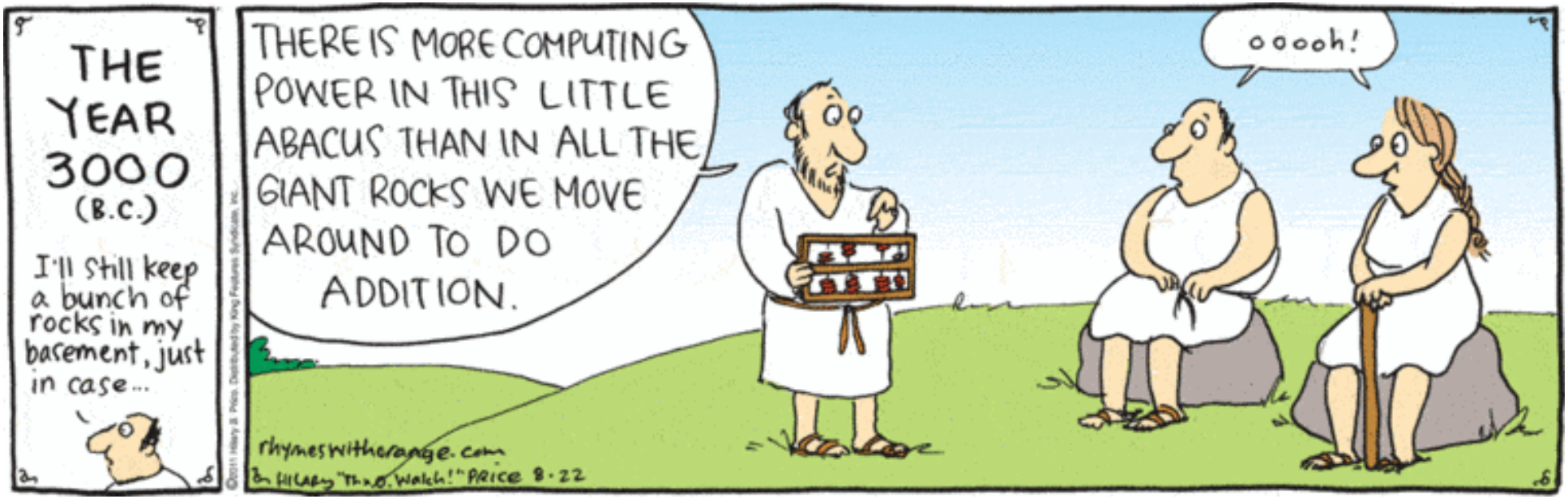

```
bash-3.00$ ls -ltr | tail -8
-rw-r--r--  1 bwk fac     3283 Sep 19 08:10 survey.html
-rw-r--r--  1 bwk fac  6034432 Sep 20 10:43 01intro.ppt
-rw-r--r--  1 bwk fac     6870 Sep 20 10:54 ps1.html
-rw-r--r--  1 bwk fac     2803 Sep 21 08:09 rita.09
-rw-r--r--  1 bwk fac     7101 Sep 21 09:49 ideas.09
-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
```

Wrapup on components

- the logical or functional components of computer hardware
- how they fit together, what the numbers measure
- some Greek/Latin/... prefixes:
  - (...,) nano, micro, milli, kilo, mega, giga, tera, (peta, ...)
- 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, …)

Some numeric prefixes you should know

nano	10^{-9}	billionth
micro	10^{-6}	millionth
milli	10^{-3}	thousandth
-	10^{0}	
kilo	10^{3}	thousand
mega	10^{6}	million
giga	10^{9}	billion
tera	10^{12}	trillion
peta	10^{15}	quadrillion


THE YEAR 3000 (B.C.)
I'll still keep a bunch of rocks in my basement, just in case...
THERE IS MORE COMPUTING POWER IN THIS LITTLE ABACUS THAN IN ALL THE GIANT ROCKS WE MOVE AROUND TO DO ADDITION.
ooooh!
rhymeswithorange.com
HILARY "Th.O. Watch!" PRICE 8-22