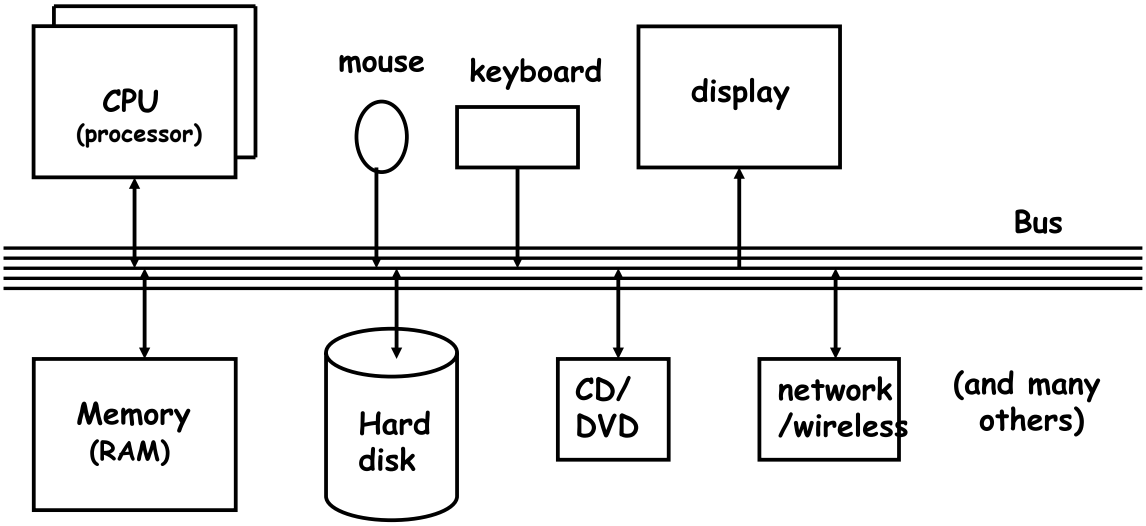
What's in a computer?

- **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")

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?

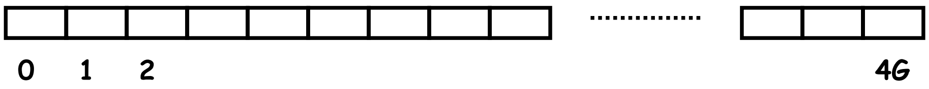
- **CPU uses an internal "clock" (like a heartbeat) to step through instructions**
- **900 MHz, 2.3 GHz, etc., is the number of clock ticks per second**
  - 1 Hertz = 1 tick per second; abbreviated 1 Hz
  - mega = million
  - giga = billion
  - 1 MHz = 1 megaHertz = 1 million ticks per second
  - 1 GHz = 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
- **very rough approximations:**
  - PC/Mac processors execute about 2 billion instructions/sec
  - cellphone processors execute about 1 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

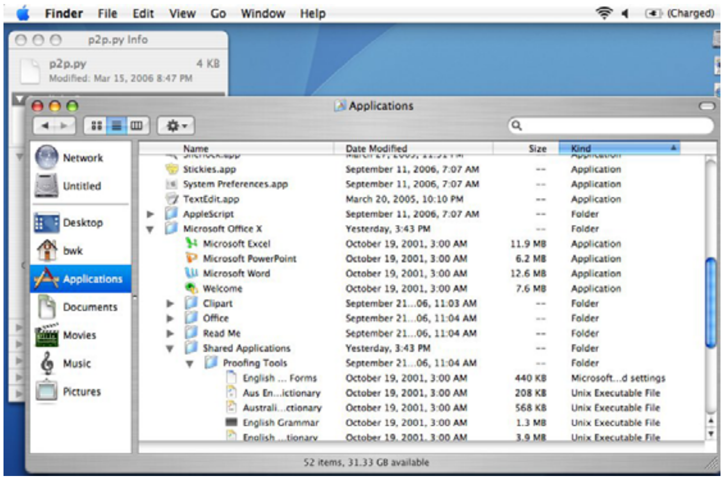


What's a bit? What's a byte?

- **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, 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

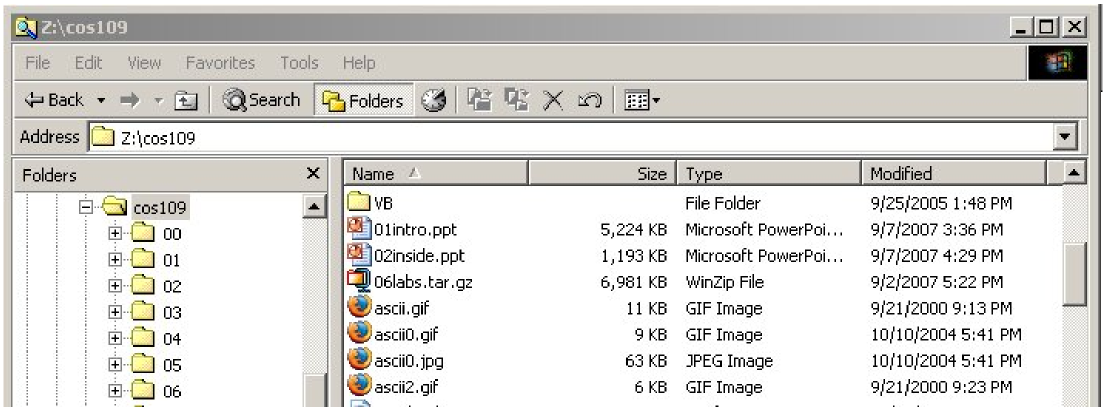
- **a place to store information when the power is turned off**
- **usually based on magnetic surfaces, rotating machinery**
- **logical / functional structure: folders (directories) and files**
  - your information: papers, mail, music, web page, …
  - programs and their data: Firefox, Word, iTunes,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



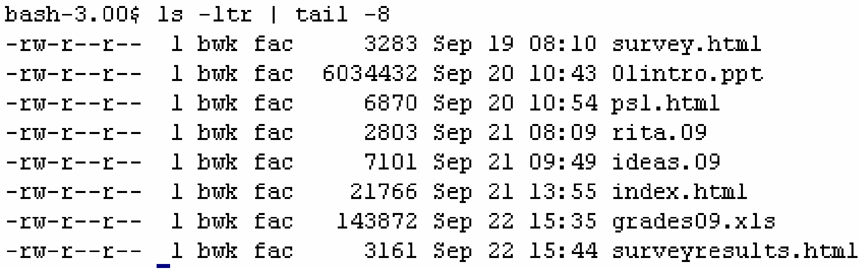
Name	Date Modified	Size	Kind
Stickies.app	September 11, 2006, 7:07 AM	--	Application
System Preferences.app	September 11, 2006, 7:07 AM	--	Application
TextEdit.app	March 20, 2005, 10:10 PM	--	Application
AppleScript	September 11, 2006, 7:07 AM	--	Folder
Microsoft Office X	Yesterday, 3:43 PM	--	Folder
Microsoft Excel	October 19, 2001, 3:00 AM	11.9 MB	Application
Microsoft PowerPoint	October 19, 2001, 3:00 AM	6.2 MB	Application
Microsoft Word	October 19, 2001, 3:00 AM	12.6 MB	Application
Welcome	October 19, 2001, 3:00 AM	7.6 MB	Application
Clipart	September 21...06, 11:03 AM	--	Folder
Office	September 21...06, 11:04 AM	--	Folder
Read Me	September 21...06, 11:04 AM	--	Folder
Shared Applications	Yesterday, 3:43 PM	--	Folder
Proofing Tools	September 21...06, 11:04 AM	--	Folder
English ... Forms	October 19, 2001, 3:00 AM	440 KB	Microsoft...d settings
Aus En...ictionary	October 19, 2001, 3:00 AM	208 KB	Unix Executable File
Australi...ctionary	October 19, 2001, 3:00 AM	568 KB	Unix Executable File
English Grammar	October 19, 2001, 3:00 AM	1.3 MB	Unix Executable File
English ...tionary	October 19, 2001, 3:00 AM	3.9 MB	Unix Executable File

52 items, 31.33 GB available

Other views of a disk: Window, Unix



Name	Size	Type	Modified
VB		File Folder	9/25/2005 1:48 PM
01intro.ppt	5,224 KB	Microsoft PowerPoi...	9/7/2007 3:36 PM
02inside.ppt	1,193 KB	Microsoft PowerPoi...	9/7/2007 4:29 PM
06labs.tar.gz	6,981 KB	WinZip File	9/2/2007 5:22 PM
ascii.gif	11 KB	GIF Image	9/21/2000 9:13 PM
ascii0.gif	9 KB	GIF Image	10/10/2004 5:41 PM
ascii0.jpg	63 KB	JPEG Image	10/10/2004 5:41 PM
ascii2.gif	6 KB	GIF Image	9/21/2000 9:23 PM



```
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 psl.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
  - 56 kilo**<u>bits</u>** per second (56 Kbps): ~ 5000 characters/second
- **network interface**
  - connects computer to network, usually Ethernet (as in Dormnet)
  - Ethernet transfers data at 10-1000 mega**<u>bits</u>** 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) might be 10 Mbps down, 2 Mbps up
- **gadgets ("peripherals") on the bus, especially USB**
  USB 2.0 is 480 Mbps (max)

Functional design is not physical implementation

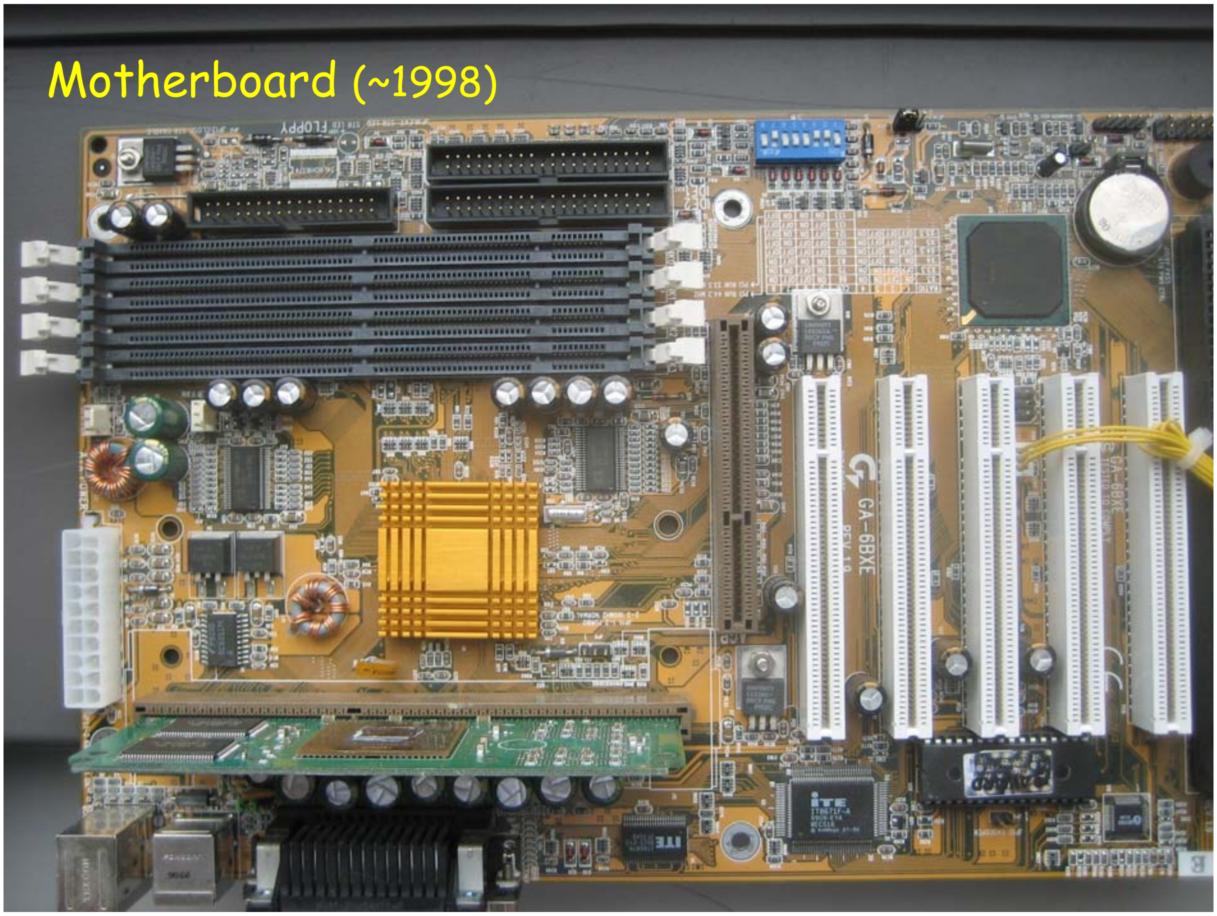
- **block diagram is "architectural" or "functional" or "logical" design**
  - gives components, shows how they are connected, maybe what they do
- **physical construction is how it's built**
  - usually many different ways to build same functional or logical design
  - will all behave more or less the same (same functions)
- **important general rule: the logical / functional organization does not describe a physical implementation**
  - logical abstracts away irrelevant physical details

Levels of abstraction

- **view of a complex item or system at sufficient detail for a particular purpose, but with no unnecessary details**
- **higher level of abstraction means less detail**
- **computer science uses abstraction a lot to manage complexity**
  - user level: files, folders, applications, display, peripherals, ...
  - software level: operating system, memory, ...
  - architectural level
  - hardware level

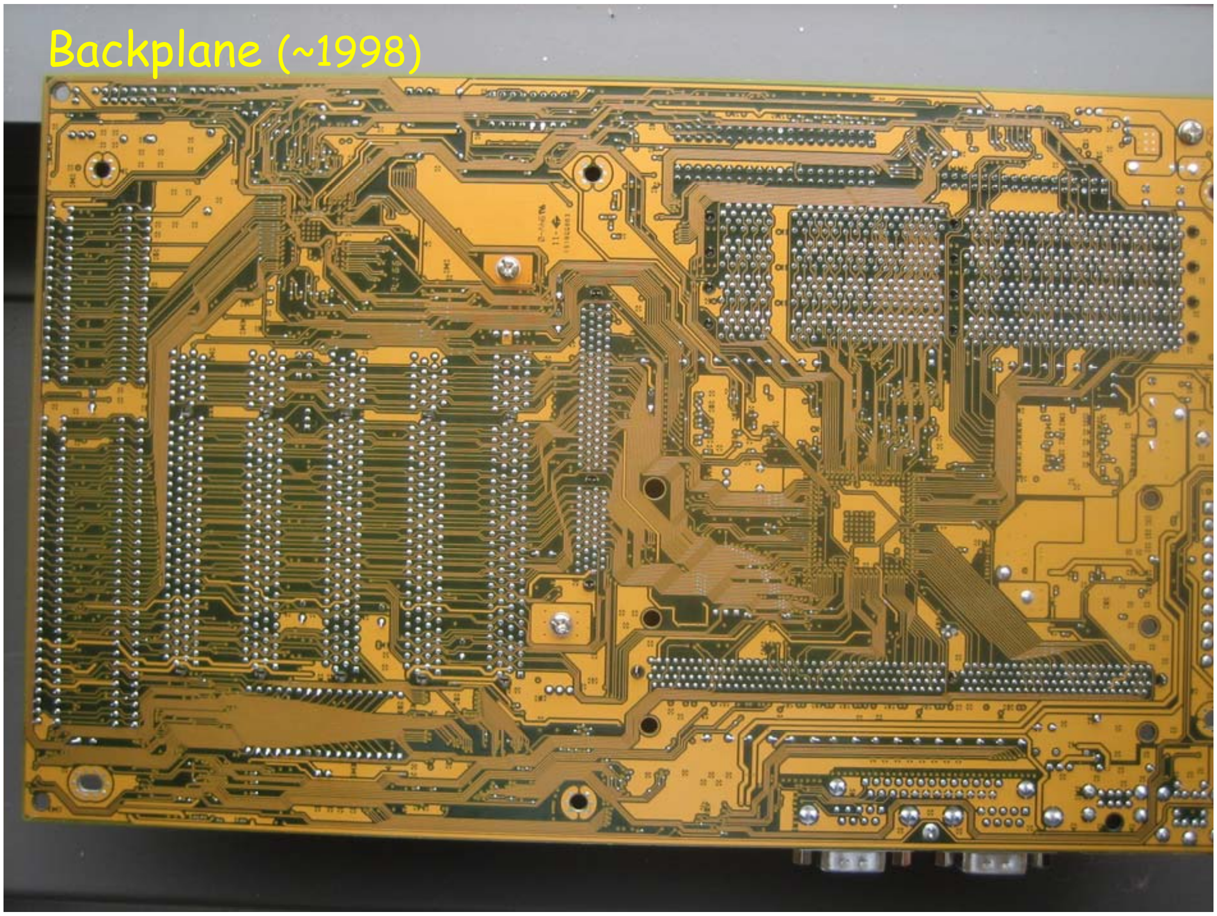
    components, wires, clock, power
  - physical level

    electric circuits, current, voltage, heat, ...

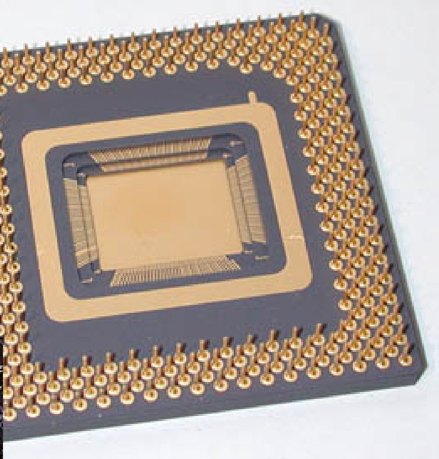


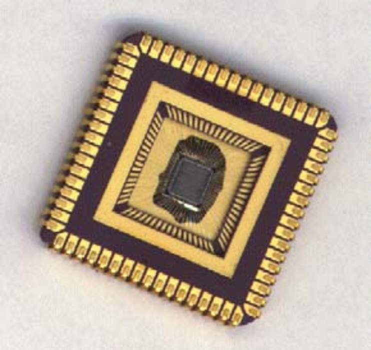
Motherboard (~1998)

Backplane (~1998)

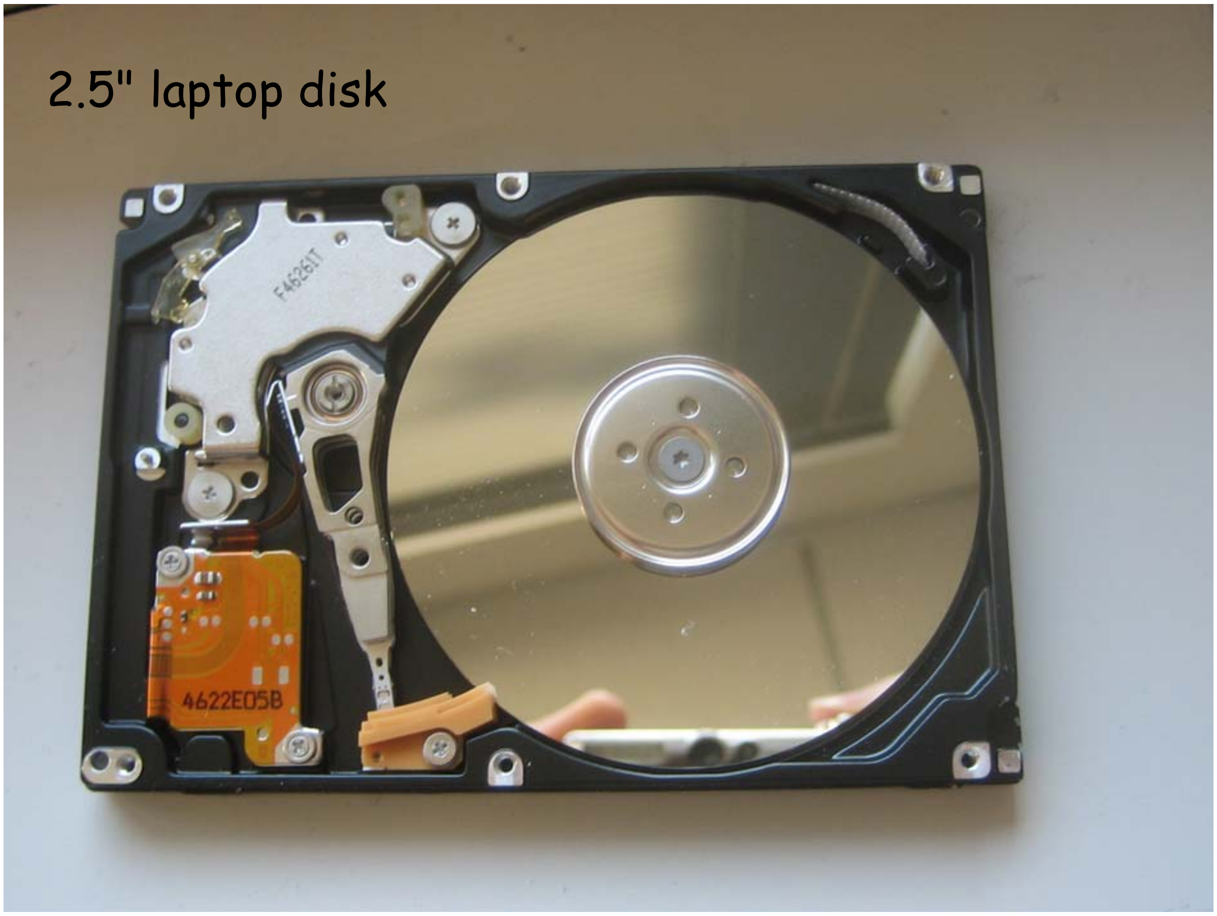


Some CPU chips





2.5" laptop disk



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, …)