Computer Basics

**FIT
100**
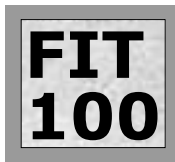
Electronic computers have changed
dramatically over their 50 history, but a few
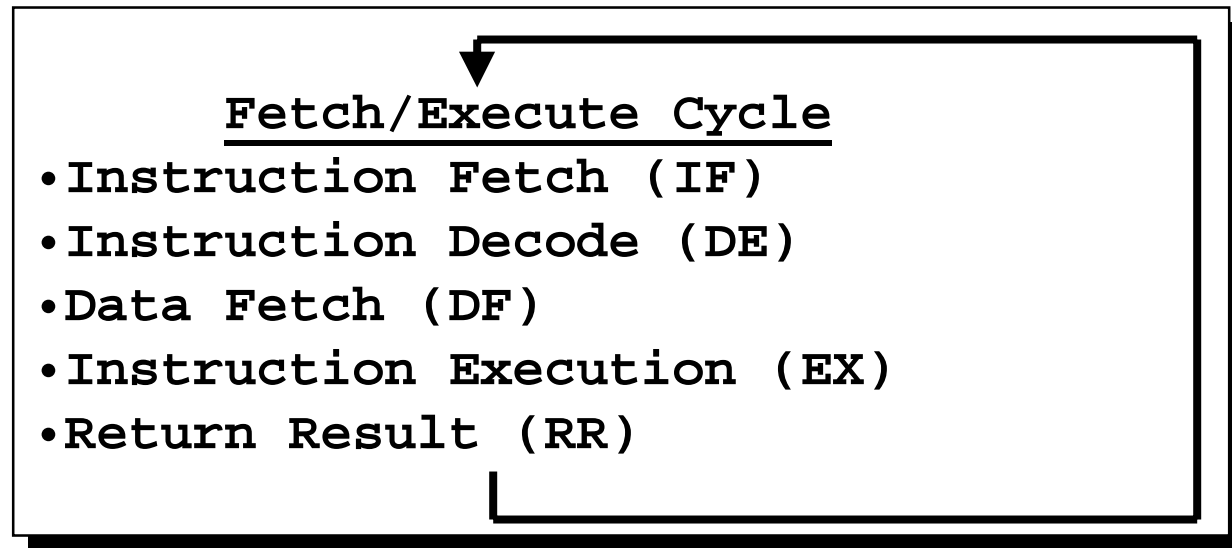basic principles characterize all computers

Abstractly, A Computer Is ...

- ❖ Computers process information by deterministically following (executing) instructions
- ❖ Unlike humans, computers follow instructions *exactly*
  - ❏ Computers have no imagination or creativity
  - ❏ Computers have no intuition
  - ❏ Computers are literal, with no sense of irony, subtlety, proportion, …
  - ❏ Computers don't joke, they're not vindictive or cruel
  - ❏ Computers are not purposeful
- ❖ … computers only execute instructions

> If a computer has any useful characteristics, it's because someone has programmed it -- given it the instructions -- to behave usefully

Interpreting Instructions

❖ To perform instructions, computers use a process known as the *fetch/execute cycle* implemented in their hardware

> ### Fetch/Execute Cycle
>
> - Instruction Fetch (IF)
> - Instruction Decode (DE)
> - Data Fetch (DF)
> - Instruction Execution (EX)
> - Return Result (RR)

❖ The F/E Cycle is an unending process, hence the red arrow

An Analogy ...

❖ At the Nenana Ice Classic, where people pay $2 to guess when the ice will break up on the Tananah River, someone processes the guesses

...

4 May 12:05 PM

4 May 12:04 PM

4 May 12:03 PM

...

Hello, Nenana!
  I'm sure breakup will be on
*** May 4 at 12:04PM ***
  Find $2 enclosed.
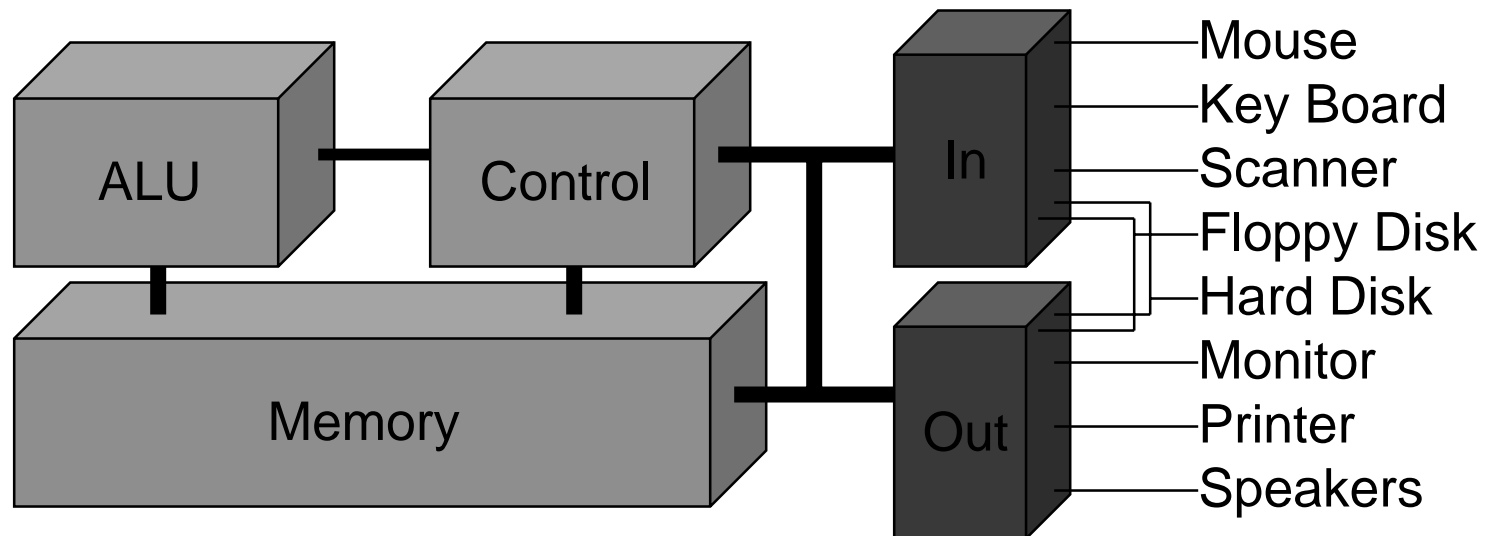   Yours, Frost J. Snowman
      61 River St.
      Circle AK

Get next entry
Find date/time
Get card for d/t
Enter Name
Return Card

Anatomy Of A Computer

❖ A computer is composed five components …

❑ Arithmetic/Logic Unit (ALU) -- the part that "computes", e.g. +

❑ Control -- the part that follows the Fetch/Execute Cycle of the program and tells the ALU what to compute

❑ Memory -- where data, programs are kept while computing

❑ Input -- ports to peripheral devices from which data comes

❑ Output -- ports to peripheral devices to which data goes

ALU	Control	In	— Mouse
			— Key Board
			— Scanner
Memory		Out	— Floppy Disk
			— Hard Disk
			— Monitor
			— Printer
			— Speakers

Memory

❖ The memory is passive, storing programs and data

0	1	2	3	4	5	6	7
R	2	D	2	100	*	R	W

❖ Memory is called RAM for "random access memory" because the control can access any random location in the memory

❖ RAM is volatile, meaning it disappears when the power is turned off … how does the computer remember the date?

❖ For the control to execute (run) a program, it must be stored in the RAM. So, one operating system duty is to move programs & data from the disk to the RAM

Control Rules!

- ❖ The control follows instructions, telling the other parts what to do

- ❖ The instructions come from the program stored in the memory

    Programmers write the instructions (programs) using languages (C, C++, Java, etc.) that are way too complicated for the control to follow … so the programs are translated into a simpler form called machine language that the control can understand. A typical machine instruction is
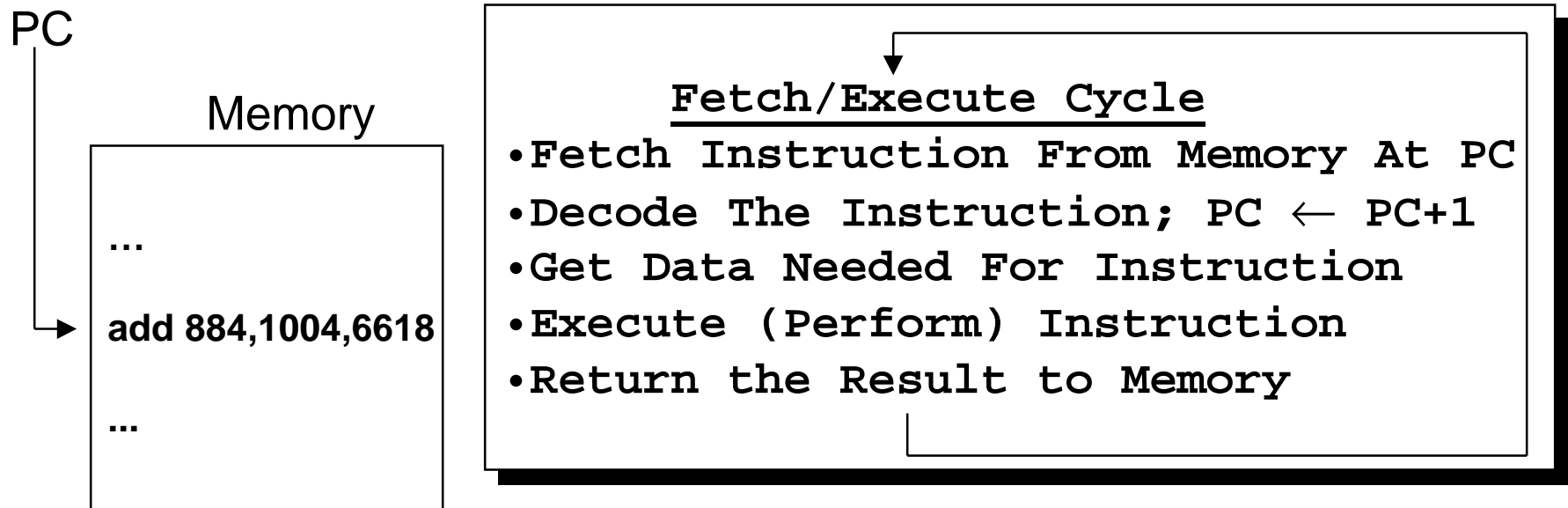
    > add 884, 1004, 6618

    which means "*add the number in memory location 884 to the number in memory location 1004, and put the result in memory location 6618*"

Following Instructions

- ❖ The control keeps track of where it is in the program using a program counter or PC … a better name would be "instruction pointer"

- ❖ The control also fetches data and returns results to the memory

PC

Memory

...

add 884,1004,6618

...

Fetch/Execute Cycle

- Fetch Instruction From Memory At PC
- Decode The Instruction; PC ← PC+1
- Get Data Needed For Instruction
- Execute (Perform) Instruction
- Return the Result to Memory

The PC's PC

❖ After the instruction has been fetched from memory, the PC is incremented to refer to the next instruction in sequence

❖ This scheme should cause the computer to "run" through memory executing all instructions once and "fall off the end of memory"

❖ Computers have machine instructions to branch and jump, i.e. go to some instruction other than the next

❖ Jump and Branch change the PC after increment

❖ Programs generally repeat many instructions

3 PCs: personal computer, program counter and printed circuit board

Emphasis ...

- ❖ The instruction add 884, 1004, 6618

- ❖ Does not add 884 and 1004 together -- we can figure that out with a calculator … it adds whatever numbers are stored in those memory locations

- ❖ Different numbers in those locations produce different results

add 884, 1004, 6618

884		1004		6618
40	+	2	➡	42

884		1004		6618
9	+	-2	➡	7

884		1004		6618
699	+	0	➡	699
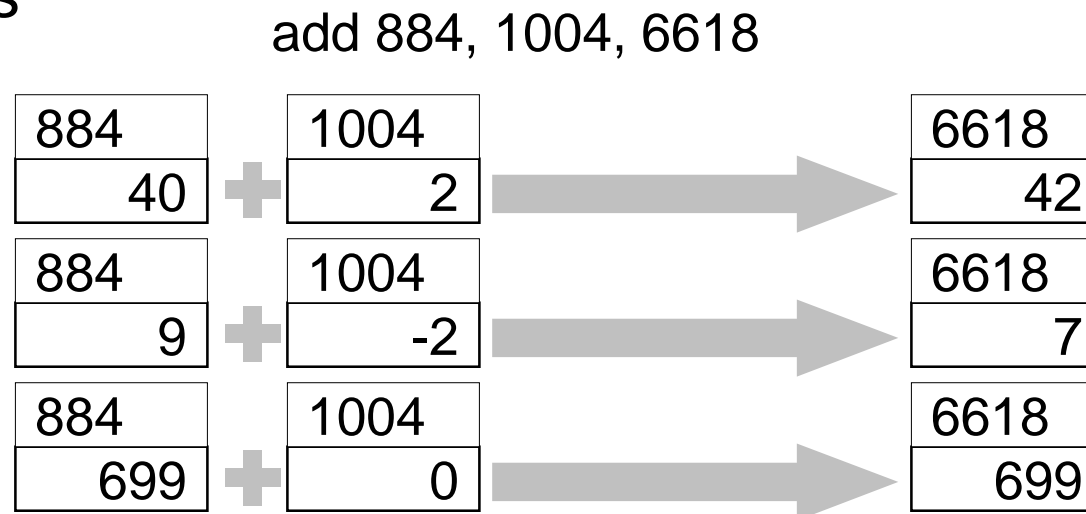
The Numbers, Please

❖ A computer memory location can store a byte of information (8 bits), enough for a keyboard character

❖ A "normal" whole number (integer) uses 4 bytes

❖ A machine instruction uses 4 bytes

❖ Units of memory size are …

- ❑ KB, kilobyte, 1024 bytes … just over a thousand bytes, a "K"
- ❑ MB, megabyte, 1,048,576 bytes … just over a million bytes, a "meg"
- ❑ GB, gigabyte, 1,073,741,824 bytes … just over a billion bytes, a "gig"
- ❑ TB, terabyte, 1,099,511,627,776 bytes … just over a trillion bytes

Strange Numbers

❖ Why do computers use such strange numbers???

  ❏ These numbers are powers of 2

   ✦ $2^{10} = 1,024$　　　　　　　　call it a thousand

   ✦ $2^{20} = 1,048,576$　　　　　call it a million

   ✦ $2^{30} = 1,073,741,824$　　　call it a billion

   ✦ $2^{40} = 1,099,511,627,776$　call it a trillion

❖ When you buy a megabyte of memory you get 48,576 bytes for free!

The Pace Of Computing

- ❖ Think of the clock rate of a computer as the rate it executes instructions, that is, how many Fetch/Execute cycles it can complete in a second (modern computers are *very* complex and can complete more than one instruction per cycle)

- ❖ hertz measures "cycles per second"

- ❖ 100MHz, specifies "100 million cycles per second"

A higher clock rate may not result in a faster running program, because the speed may be limited by other parts of the computer besides instruction execution rate; the speed of getting an instruction's data is often a limitation that worsens with a faster clock

Summary

- ❖ Computers deterministically execute instructions to process information

- ❖ Computers have five parts: ALU, Control, Memory, Input and Output

- ❖ The control implements a process called the Fetch/Execute Cycle

- ❖ The fetch/execute cycle is a fundamental method of deterministically performing operations, and the idea is used many places in computation …

  - ✛ The computer is an electronic fetch/execute cycle, ie, hardware
  - ✛ All other F/E cycles are implemented as programs, ie, software