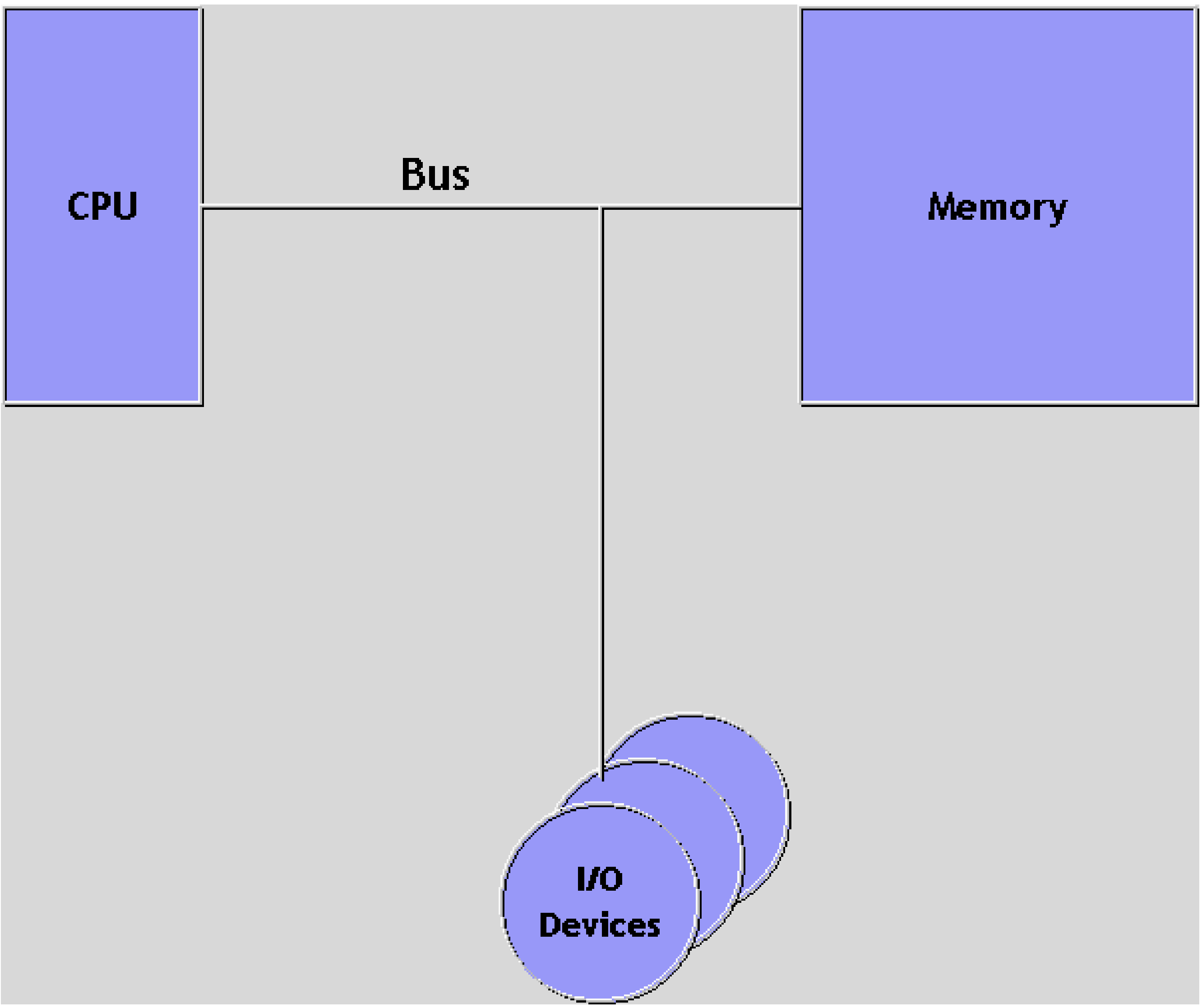
Computer Organization and Instruction Execution

August 22

CSC201 Section 002

Fall, 2000

The Main Parts of a Computer

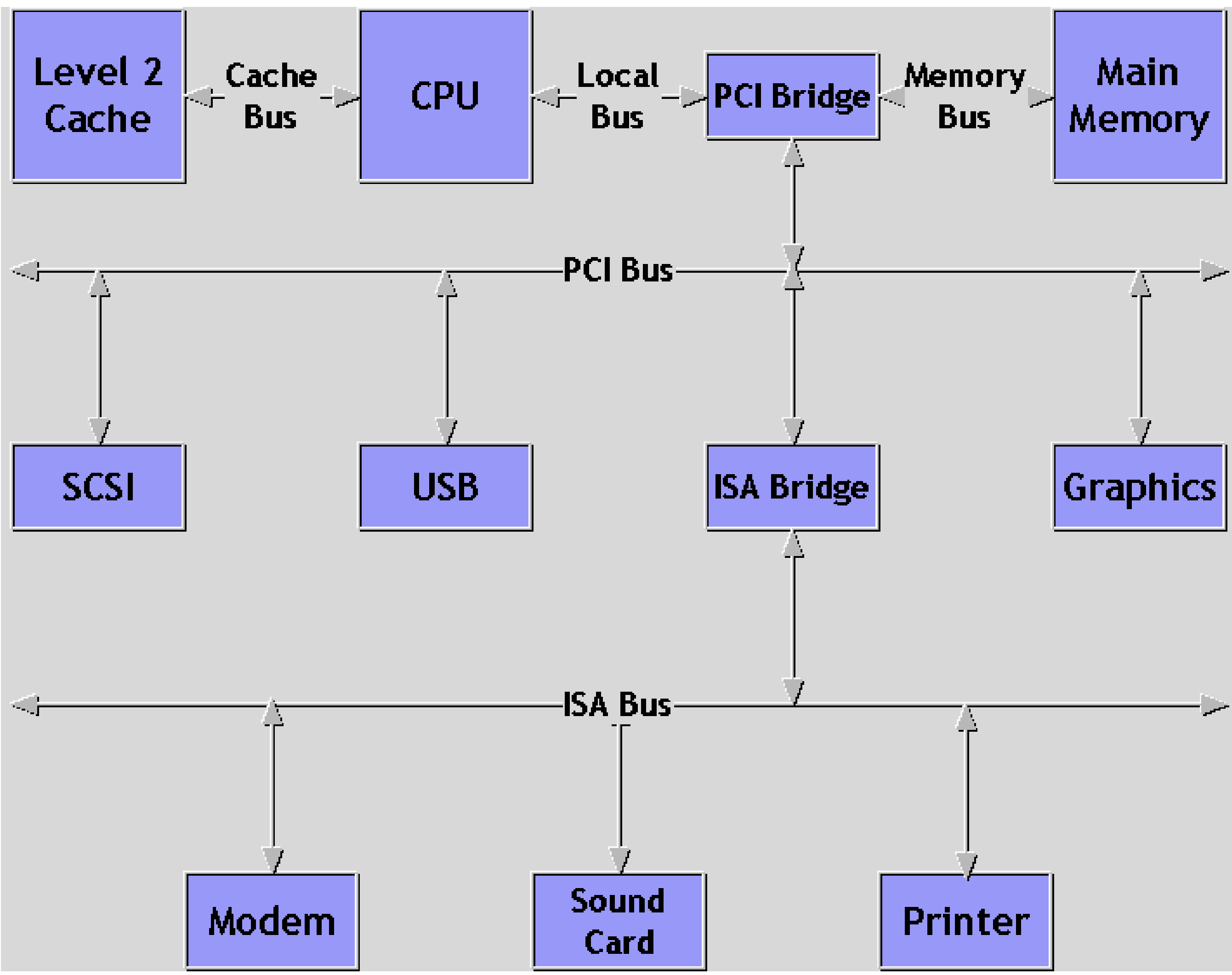


I/O and Storage Devices

- (lots of devices, we'll discuss later)
- I/O devices talk to the CPU via an interface
  - transmits device status, operation to perform, data to be transferred

Buses

- A bus = wires connecting the parts together
- There are lots of buses in a computer system



Properties of Buses

- How many wires are dedicated to transferring data?
  - called the "width" of the data bus
- How fast the bus can transfer data?
- What control and status signals does the bus have?
- How many address lines does the bus have?

An Example: the PCI Bus

- Main high-speed bus standardized in PCs
- Speed up to 66 MHz
- Data width up to 64 bits
- Up to 200 wires total (data + address + control)

Main Memory

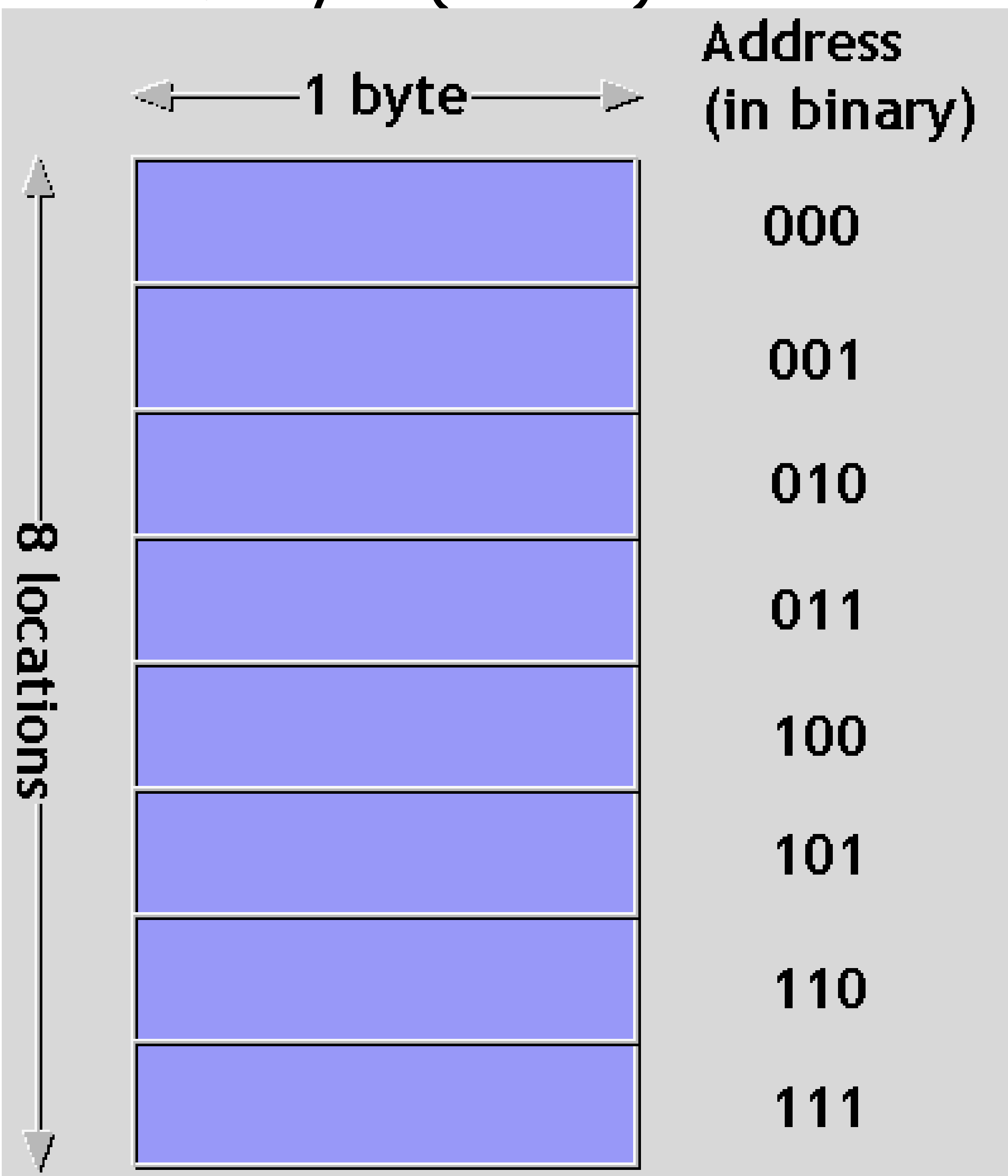
- Purpose is to store programs that are executing, and the data they need
- Speed: 1-5ns (fast memory), 25-100ns (slow memory)
- Compared with speed of a disk: a million times faster!
- But, about a thousand times more expensive
  - plus, data is lost when power is removed

Memory as Post Office Mailboxes

- There are a fixed number of boxes
- Every box has a number, or address
- Every box has the same, fixed size
- Boxes have varying contents

The Unit of Addressability

- In x86 (and most other) architectures, each memory location stores one byte (8 bits)

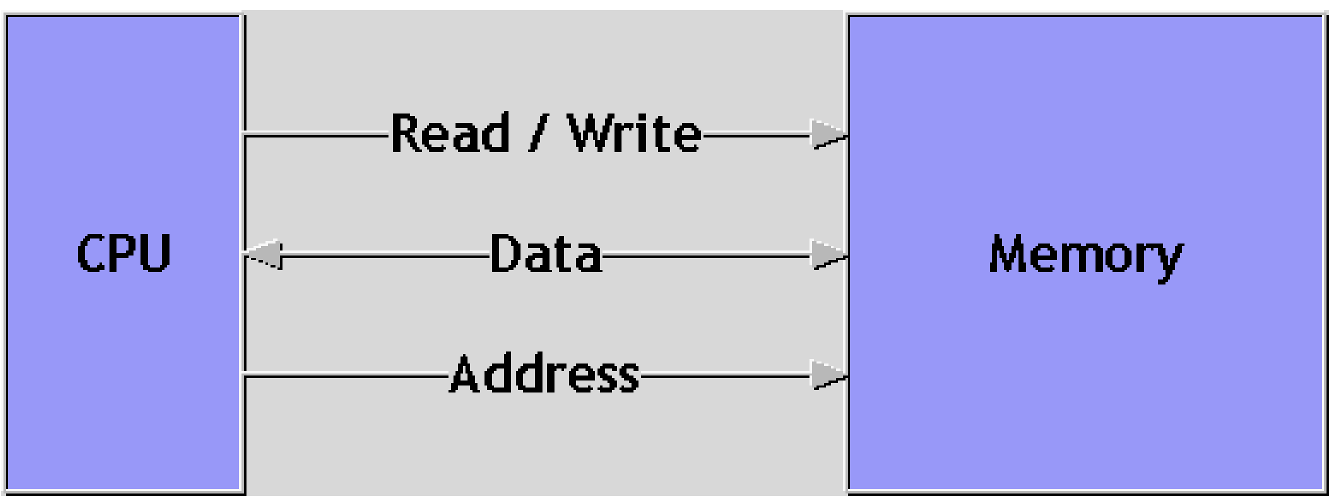


Memory Addresses and Size

- A memory address is specified with n bits
  - this means can be at most 2^n memory locations
  - nowadays, 32-bit addresses are common

N	2^N
16	64K
24	16M
32	4G
48	1.8*10^14
64	2.8*10^19

The Memory Interface



The Memory Read Operation

- The CPU outputs a memory address, then issues the Read command
- The memory looks up the data at the requested location, while the CPU waits
- The memory sends the data to the CPU

The Memory Write Operation

- The CPU outputs a memory address, outputs the data, then issues the Write command
- The memory receives the data, stores it in the specified location

Read Only Memory (ROM)

- Can read the contents, but not change them (easily)
- Useful for storing boot-strap routines, constant-valued parameters

Words

- Most data types are bigger than one byte
- The "word size" of a computer = the size of general-purpose registers
  - a word consists of consecutive bytes in memory
  - "word address" = address of first byte of the word
- Operand sizes in the Pentium

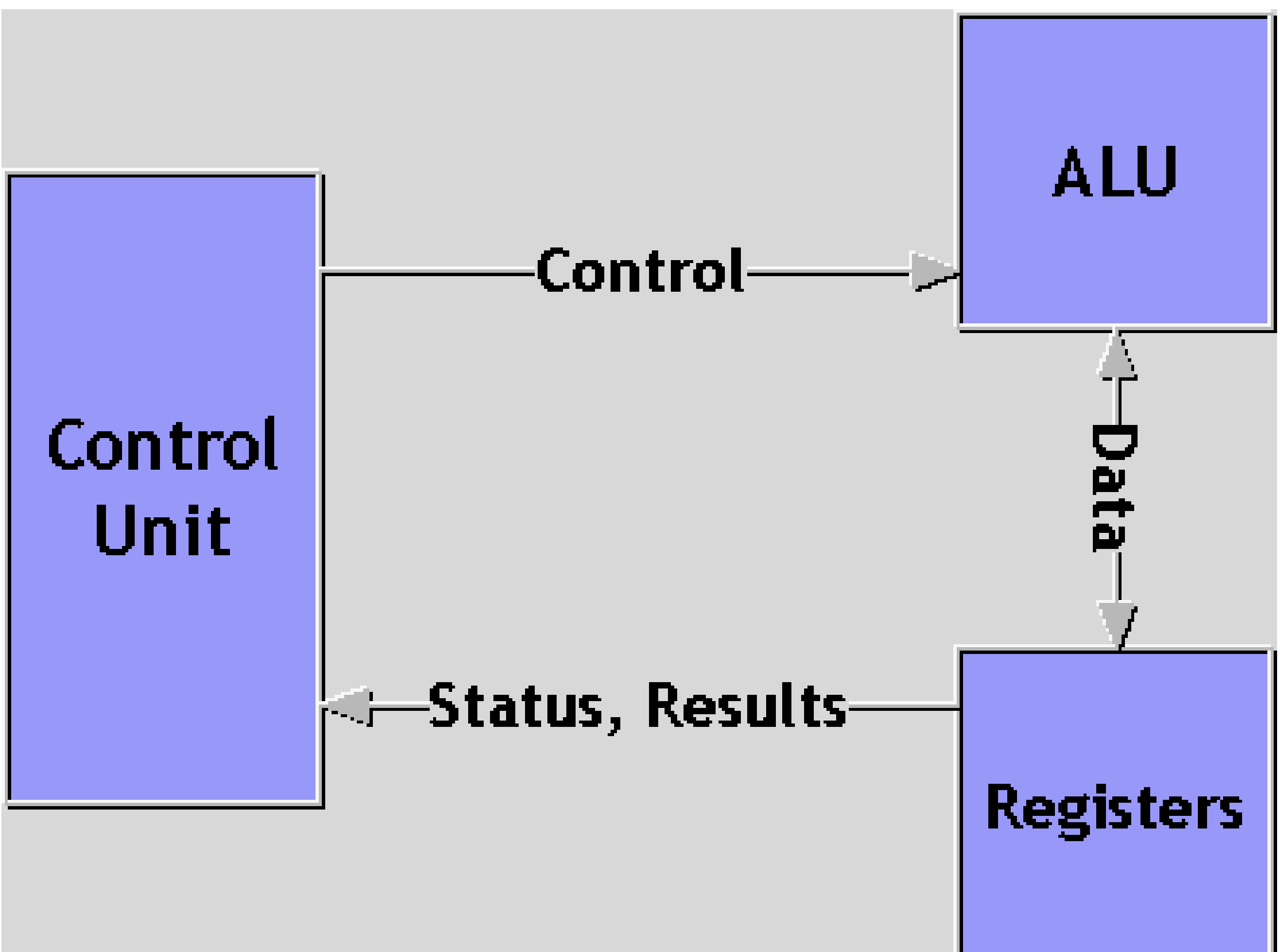
# of bits	Called...
8	Byte
16	Word
32	Doubleword
64	quadword

Interpreting Memory Contents

- You can't look at the value and tell what it means; everything is a bit string!
  - it's up to the program to interpret the contents of memory
- Example:
  - 01101000 01100101 01111001 00100001

The Central Processing Unit, or Processor

- The "brain" of a computer
  - executes program instructions, controls all the parts of the computer
- Consists of registers, the ALU (arithmetic logic unit), and the control unit



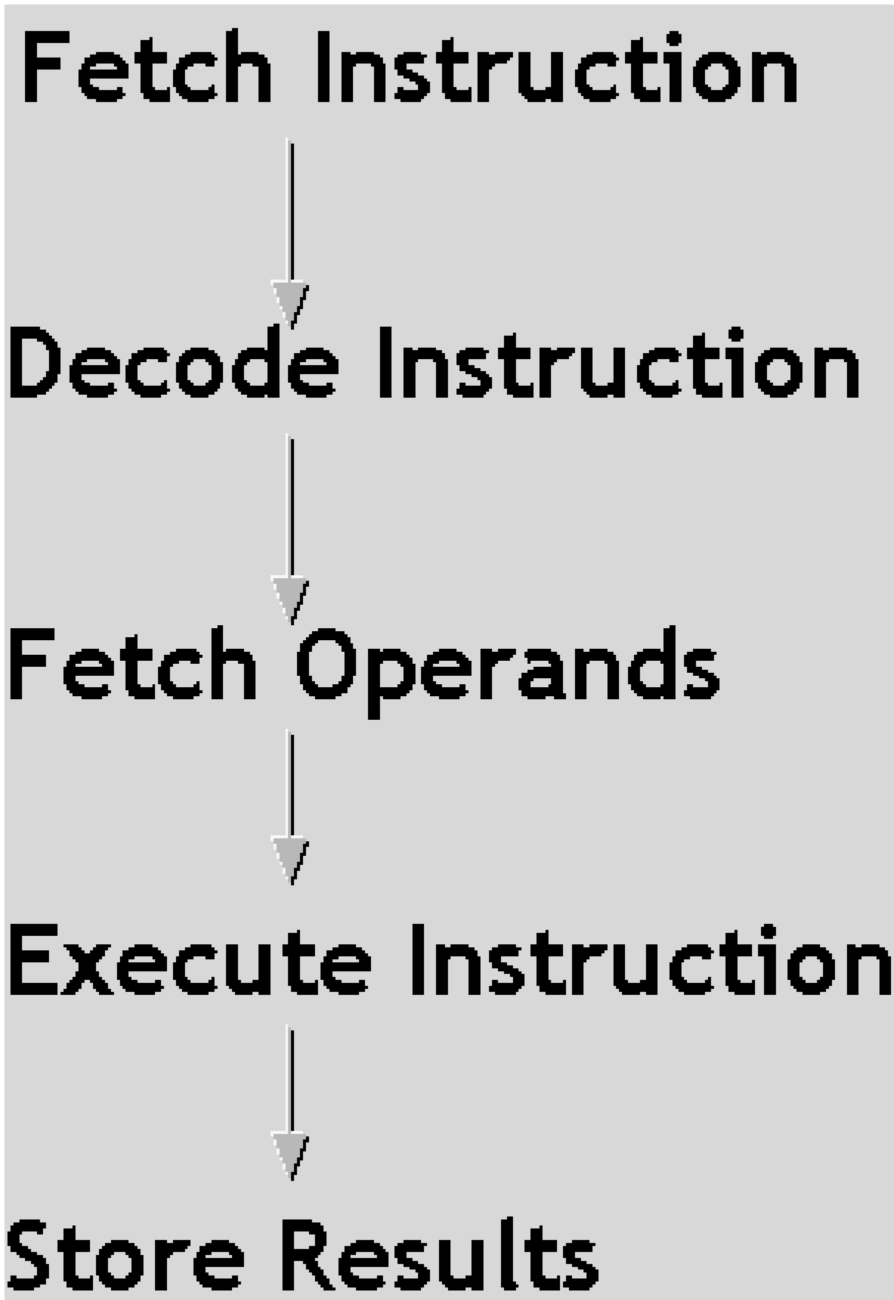
The CPU (cont.)

- Registers are temporary storage locations
  - advantages: speed and efficiency
- The Arithmetic-Logic Unit (ALU) is where data is manipulated (add, AND, compare, multiply, etc.)
- The control unit determines the sequence and timing of everything the CPU does

How Does an Instruction Get Executed?

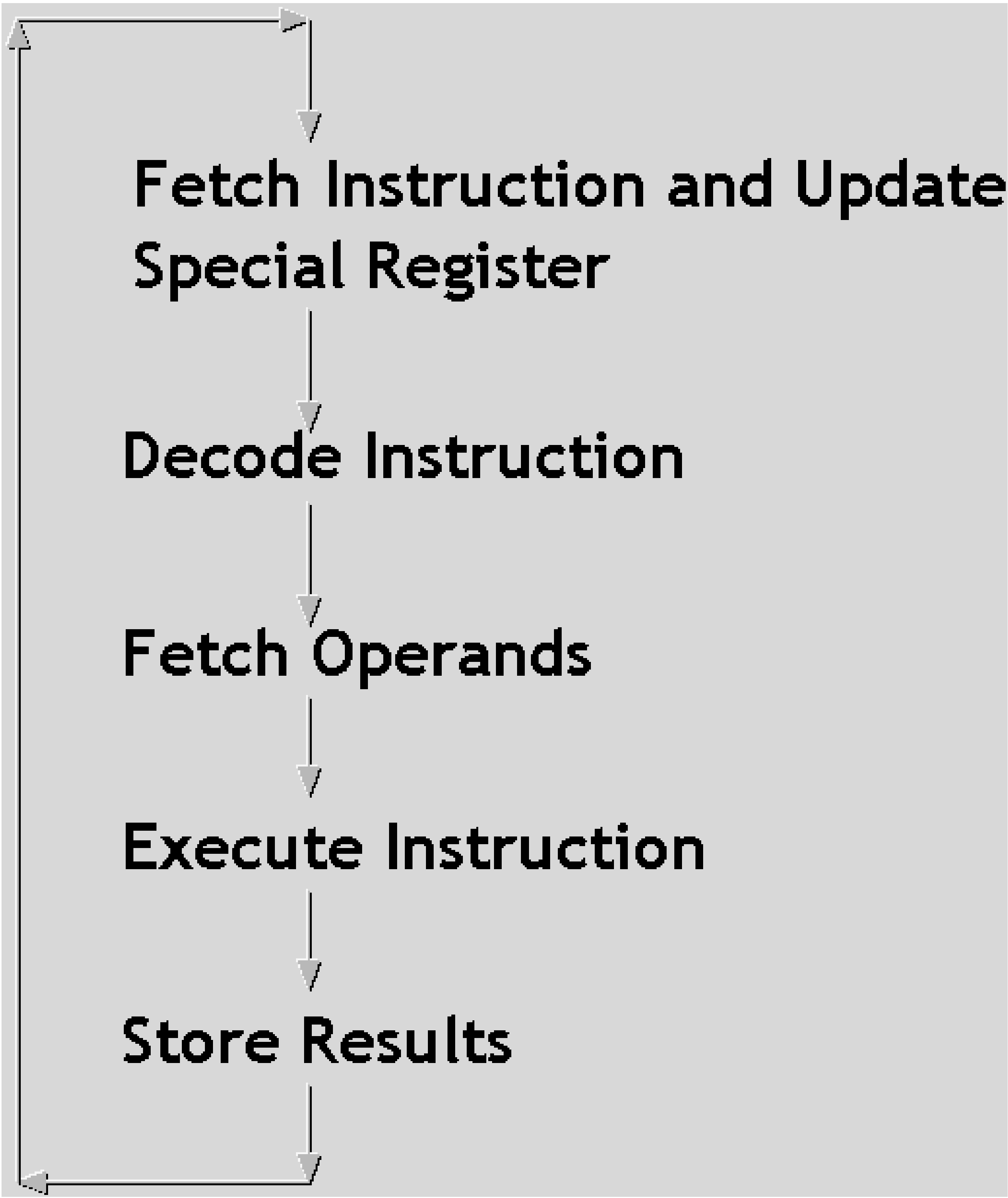
- A special register contains the address of the instruction
- The CPU "fetches" the instruction from memory at that address
- The CPU "decodes" the instruction to figure out what to do
- The CPU "fetches" any data (operands) needed by the instruction, from memory or registers
- The CPU "executes" the operation specified by the instruction on this data
- The CPU "stores" any results into a register or memory

The Instruction Cycle



How Does a Complete Program Get Executed?

- The "special register" is initialized to point to the first instruction of the program
- As part of the instruction fetch cycle, the "special register" is updated to point to the next instruction
- When one instruction is finished, the cycle is begun all over again
  - the CPU never quits; it is always executing something


Fetch Instruction and Update Special Register
Decode Instruction
Fetch Operands
Execute Instruction
Store Results

Clocks and Timing

- The actions of a CPU are synchronized by an external clock
- The speed with which the clock ticks determines how fast the CPU runs
- MHz = one million clock ticks / second
- GHz = one billion clock ticks / second