



Computer Fundamentals

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Lecture 8



Microprocessors

- Microprocessor acts as "brain"
- Key element of all computers
- Provides mathematical and decision making ability
- Current microprocessors contain complex circuits
 - ❑ Pentium
 - ❑ Athlon
 - ❑ SPARC
 - ❑ PowerPC
- Consist of tens of millions of transistors
- Operate at ultra-fast speeds
 - ❑ Over a billion operations per second



Source: <https://www.elprocus.com/microprocessor-history-and-brief-information-about-its-generations>



Microprocessor (cont.)

- Microprocessors are powerful but require other components
- Human brain needs other body parts to be useful
 - ☐ Hands
 - ☐ Feet
 - ☐ Eyes
 - ☐ Ears
 - ☐ Mouth
- Microprocessor system requires
 - ☐ ...



Integrated Circuits

- Commonly known as IC or chip
- Tiny piece of silicon with several electronic parts
- Silicon occupies very little IC volume
 - ❑ Most of the size due to pins and packaging
- Components of IC are very small
 - ❑ Smaller than thickness of a human hair



Source: http://simple.wikipedia.org/wiki/Integrated_circuit



Integrated Circuits (cont.)

- Devices in ICs
 - ☐ Transistors
 - ☐ Diodes
 - ☐ Resistors
 - ☐ Capacitors
 - ☐ Wires

- And are made of the following material
 - ☐ Silicon - semiconductor
 - ☐ Copper - conductor
 - ☐ Silicon Dioxide - insulator

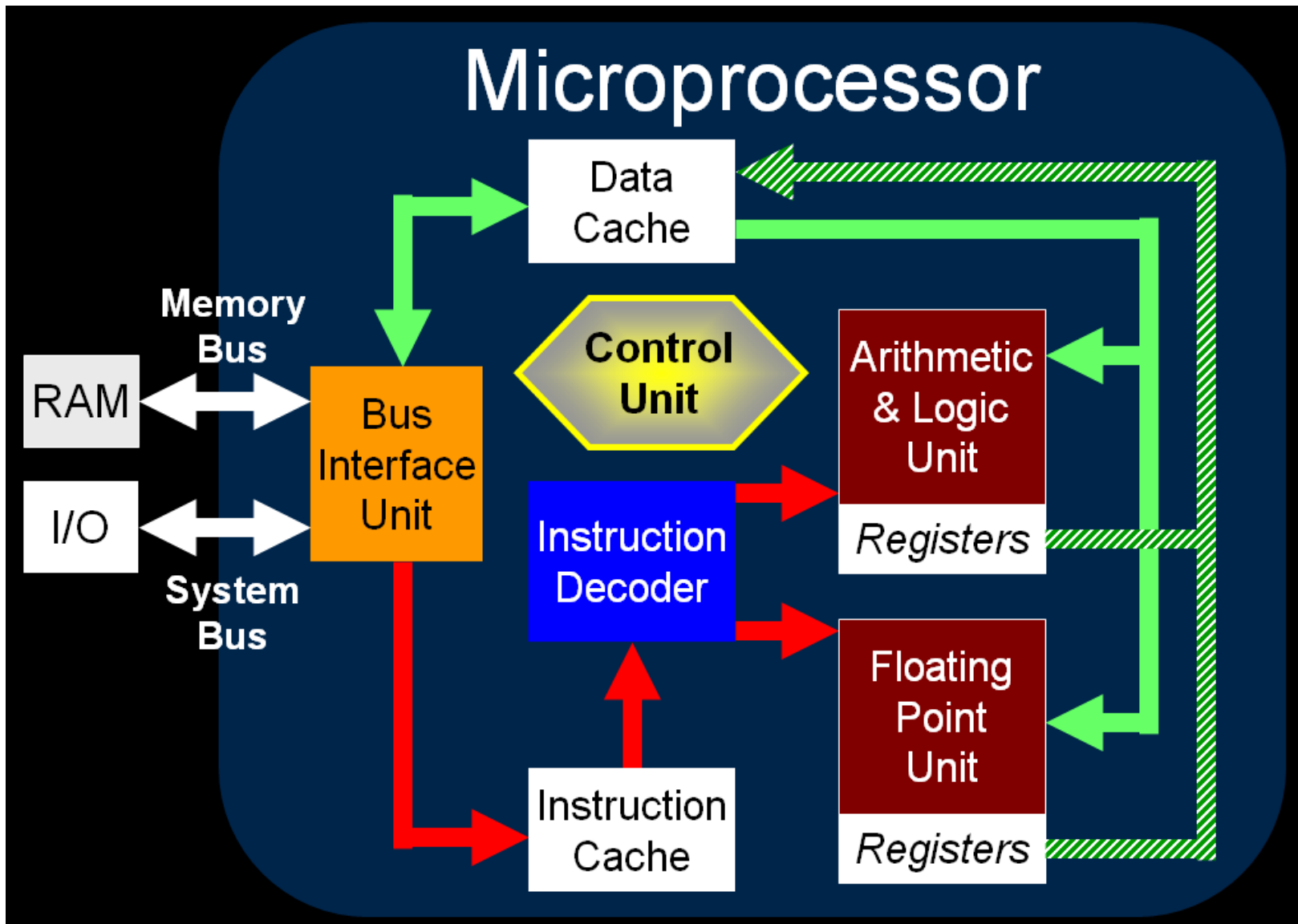


Microprocessors (cont.)

- Also known as CPU
 - ❑ Central Processing Unit
 - ❑ Control Unit
 - Controls resources in computer
 - Instruction set
 - ❑ Arithmetic and Logic Unit
 - Simple math operations
 - Integer unit
 - Have own registers
 - ❑ Floating-Point Unit
 - Also simple math operations
 - Numeric unit
 - Also have own registers



Building Blocks of Microprocessor





Bus Interface Unit

- Receives instructions and data from main memory
 - ❑ Instructions sent to instruction cache
 - ❑ Data sent to data cache
- Also receives processed data and sends to main memory



Instruction Decoder

- Receives programming instructions
 - ❑ Reads the next instruction in from memory
- Decodes instructions for understanding at processing units
 - ❑ Sends component pieces of instruction to destinations
- Passes on decoded instruction to ALU or FPU



Arithmetic and Logic Unit (ALU)

- Also known as "Integer Unit"
- Performs whole-number math
 - ❑ Calculations (subtract, multiply, divide etc.)
 - ❑ Comparisons (is greater than, is smaller than, etc.)
 - ❑ Logical operations (NOT, OR, AND, etc.)
- Latest microprocessors have two identical ALU's
 - ❑ Perform calculations simultaneously
 - ❑ Double the capability



Arithmetic & Logic Unit (ALU) (cont.)

Operations Performed by the Arithmetic Logic Unit

Arithmetic Operations

- + add
- subtract
- × multiply
- ÷ divide
- ^ raise by a power

Logical Operations

- =, ≠ equal to, not equal to
- >, ≥ greater than, not greater than
- <, ≤ less than, not less than
- ≥, ≤ greater than or equal to, not greater than or equal to
- ≤, ≥ less than or equal to, not less than or equal to



Floating-Point Unit (FPU)

- Also known as the "Numeric Unit"
- Performs calculations involving numbers with scientific notation
 - ❑ Floating-point numbers
- Represents extremely small and extremely large numbers
 - ❑ In compact form
- Floating-point calculations are required for working in
 - ❑ Graphics
 - ❑ Engineering
 - ❑ Science and research
- ALU can do these calculations as well
 - ❑ But very slowly



Registers

- ALU and FPU have private memory called registers
- Register also known as accumulator
 - ❑ Small amount but **super-fast**
 - ❑ Placed right next to ALU/FPU
 - For exclusive use
- Storage of intermediate and final results from calculations in registers
- Processed data goes back to data cache from registers
- Data cache sends data to main memory



Control Unit

- Manages the whole microprocessor
- Directs operation of processor
- Tells the memory, ALU and I/O devices how to respond to program's instructions
 - ❑ Hold instruction set
- Tasks include
 - ❑ Fetching instructions and data
 - ❑ Storing data
 - ❑ Managing input/output devices



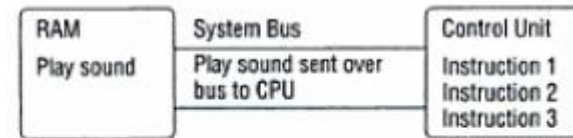
Instruction Set

- Set of machine instructions
 - ❑ Recognizable at microprocessor
 - ❑ Executable at microprocessor
 - ❑ The only language microprocessor knows
- An instruction set includes low-level, a single step-at-a-time instructions
 - ❑ E.g. add, subtract, multiply, divide
- Each microprocessor family has its unique instruction set
- Bigger instruction-sets mean more complex chips
 - ❑ Higher costs
 - ❑ Reduced efficiency
 - ❑ Shorter programs



Machine Cycles

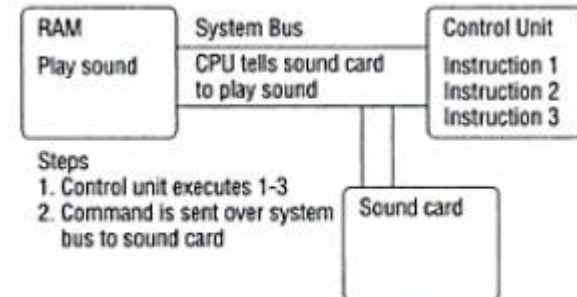
- Steps by CPU to process data
- Instruction cycle
 - ❑ CPU gets the instruction
 - Fetch
 - Decode



Steps

1. Play sound is sent from RAM to CPU
2. Control Unit breaks the command into instruction set the CPU can handle

- Execution cycle
 - ❑ CPU performs the instruction
 - Execute
 - Store



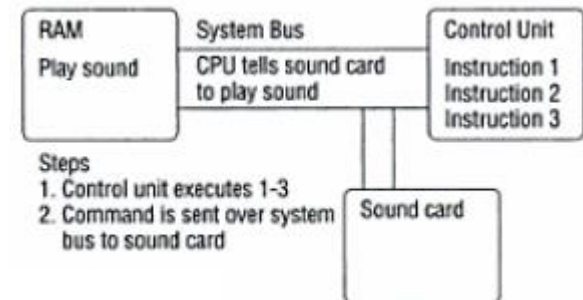
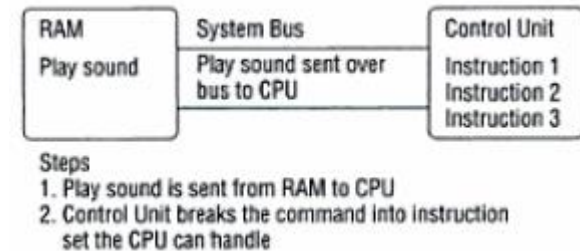
Steps

1. Control unit executes 1-3
2. Command is sent over system bus to sound card



Machine Cycles (cont.)

- Fetching
 - ❑ CU must fetch a command or data from computer's memory.
- Decoding
 - ❑ CU break down the commands into instructions
- Executing
 - ❑ CPU carries out the instructions in order
- Storing
 - ❑ Store results in memory (not always required)





Machine Cycles (cont.)

- Billions of cycles per second
- Pipelining processes more data
 - ❑ Begins fetching new instruction before current cycle completed
 - ❑ 20 instructions simultaneously
 - ❑ Introduced with Intel Pentium IV

Instr. No.	Pipeline Stage						
1	Fetch	Decode	Execute	Store			
2		Fetch	Decode	Execute	Store		
3			Fetch	Decode	Execute	Store	
4				Fetch	Decode	Execute	Store
5					Fetch	Decode	Execute
Clock Cycle	1	2	3	4	5	6	7

Source: https://en.wikipedia.org/wiki/Instruction_pipelining



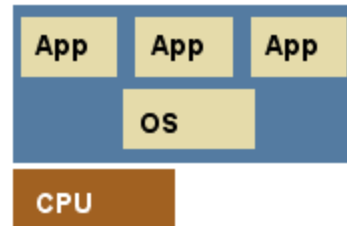
Machine Cycles (cont.)

- Multitasking allows multiple instructions
 - ❑ CPU makes threads of programs (thread = instruction)
 - ❑ Execute one thread from a program at a time
 - ❑ User thinks as if each program is being run simultaneously
- Hyperthreading allows execution of several threads at once
 - ❑ Multiple threads executed at one time
 - ❑ Processor can execute two (rather than one) concurrent streams (or threads) of instructions
 - CPU and simulated CPU
 - ❑ Processor uses stall time (waiting for instruction or data fetch from slow memory) and execute another thread

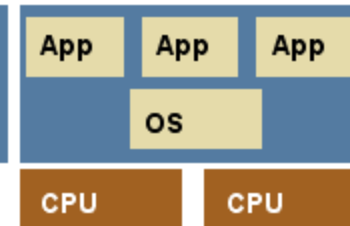


Hyperthreading vs. Standard Modes

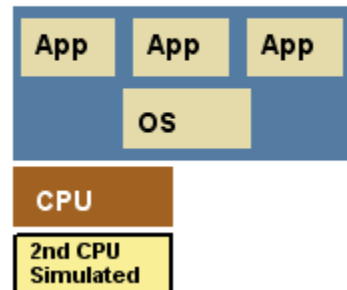
SINGLE CORE



DUAL CORE



**HYPER-THREADING
SINGLE CORE**



**HYPER-THREADING
DUAL CORE**

