

Technology in Focus

Switches

- System unit is the box that contains the central electronic components of the computer
- A computer system can be viewed as an enormous collection of on/off switches

Electrical switches

- Computers work exclusively with numbers, not words
- Everything a computer does, such as processing data or printing a report, is broken down into series of 0s and 1s
 - Binary language
- Electrical switches are inside the computer and can be flipped between these two states: 1 and 0
- On/off button on DVD
 - On is pushed in
 - Off is popped out

Vacuum Tubes

- Earliest generation of electronic computers used devices called vacuum tubes
- Act as computer switches by blocking the flow of electrical current
- Takes up a lot of space
- First high speed digital computer
 - ENIAC
- Produce a lot of heat and burn out frequently
- Two major revolutions for smaller and faster computers were
 - Invention of transistor
 - Fabrication of integrated circuits

Transistors

- Are electrical switches built out of semiconductor either by conducting electricity or act as an insulator
 - Silicon is the semiconductor material used to make transistors
 - Need specific chemicals to turn on and if not then it turns off, acting like a switch
- Early transistors were separate units of metal rods
 - Smaller, produce little heat, quick switching and less expensive

Integrated Circuits

- Are tiny regions of semiconductor material such as silicon
- Most integrated circuits are no more than a quarter inch in size
- Integrated circuits have enabled microprocessors, which are chips that contain a CPU
 - Marked the beginning of the true miniaturization of computers
 - More than 2300 transistors

The Binary Number System

- A number system is an organized plan for representing a number
- Base 10 number system, also known as decimal notation, uses 10 digits (0-9)
- $6954 = 6 \cdot (1000) + 9 \cdot (100) + 5 \cdot (10) + 4 \cdot (1) = 6 \cdot 10^3 + 9 \cdot 10^2 + 5 \cdot 10^1 + 4 \cdot 10^0$
 - Final number 1 is represented as 10^0
- The binary number system is also referred to as the base 2 number system
 - Can still represent all the values that a base 10 number system can
- The binary number system describes a number as the sum of powers of 2
 - Codes for numbers, letters and instructions

Representing Integers

- In the base 10 number system, a whole number is represented as the sum powers of 10
- Binary system works by describing a value as the sum of groups of 1s, 2s, 4s, 8s, etc.
 - Powers of 2: 1,2,4,8,etc
- Number 67
 - Base 10: $6 \times 10^1 + 7 \times 10^0$
 - Binary (base 2): $2^6=64$, you have 3 left over so 32,16,8, and 4 will be 0s because they cannot contribute. You can have 1 group of 2 and 1 group of one
 - 1000011
- Doing this on Windows calculator from the programmer selection is much easier because it converts it from decimal to binary automatically
- Hexadecimal notation is used to make expression of long numbers easier
 - Base 16 number system
 - 0-9 plus letters
 - A=10, B=11, etc

Representing characters: ASCII

- This converts letters and other symbols that we understand to a binary state that the computer can understand
- Older mainframes used EBCDIC while today's personal computers use ASCII
 - ASCII represents each letter or character as an 8 bit binary code
- Remember that a binary digit is a bit and 8 bits is a byte
 - Each single alphabetical or special character is 1 byte (8bits)
 - Total of 8 0s and 1s
- Upper and lowercase letters have different codes

Representing characters: Unicode

- ASCII code can only assign 256 (2^8) different codes
- ASCII codes cannot represent all languages and symbols, because some languages requires more than 256 characters and letters
 - Unicode was created to solve this
 - Uses 16 bits and can code 1,115,000 different codes
 - First 128 are identical to ASCII
 - Anticipated to replace ASCII

Representing decimal numbers

- Institute of electrical and electronics engineering (IEE) established a standard called the floating point standard that describes how numbers with fractional parts should be represented
 - 32-bit system
 - -0.75
 - First tells you neg. or positive
 - Next bit is for magnitude of number (hundreds, tens, etc)
 - Last 23 bits are to store the number value

Interpretation

- Decimal numbers are stored by IEEE standards while alphabet and symbols are stored by Unicode or ASCII
- Certain instructions tell the CPU to expect a negative number next or to interpret the following bit pattern as a character
 - CPU ALWAYS knows which interpretation to use for a series of bits

The CPU machine cycle

- Also called processing cycle
 - Fetch from RAM
 - Decode into CPU language
 - Execute the actual work
 - Store in one of the registers built in CPU

The system clock

- It is the internal clock that is a special crystal that acts like a metronome to keep the steady beat
 - Steady beat or ticks are called clock cycle which set the pace
 - The pace known as clock speed is measured in GHz

Control unit

- Manages the switches of CPU
- Designed to remember the sequence of processing stages and how each switch should be positioned with each beat of the system clock

Stage 1: The fetch stage

- RAM is direct and fast way to access instructions and program information

Cache memory

- Faster than RAM
- Avoids the CPU from needing to fetch instructions from RAM every time
- Before going to RAM the CPU will look in
 - Level 1 cache memory
 - Block of memory that is built onto the CPU chip to store data and commands that have just been used
 - Level 2 cache memory
 - Farther from CPU than level 1
 - Has more storage
 - Level 3 cache memory
 - Can hold an entire program
- Can't upgrade cache
- More cache the better performance speed of your computer

Stage 2: The decode stage

- Collection of commands a specific CPU can execute is called instruction set
 - Each CPU has its own unique instruction set
- Because humans are the ones who write the initial instructions, it is written in an easier language called assembly language
 - ADD for addition, DIV for divide, etc
 - Translated into long strings of binary code called machine language
 - Control unit uses this to set up the hardware in the CPU for the rest of the operations

Stage 3: The execute stage

- Arithmetic logic unit (ALU) does CPU mathematical operations and logical operations such as AND, OR and NOT
- Fed data from the CPU's registers
- The number of bits a computer can work with at a time is referred to as word size
 - 64-bit vs 32-bit

Stage 4: The store stage

- Results from ALU is stored back in the registers and the sequence begins again

Making CPUs even faster