Cis1 - Chapter 06

Inside the CPU
The CPU

Executes instructions (the software)

The CPU decision used to be the most important decision you will need to make in purchasing a computer - now it’s just one of many factors.

Operating system software and application software may require a minimum type of CPU

(“any computer” can do word processing and Internet access)
The Operating System
Software and the CPU

• OS manages the CPU
• OS manages what the CPU will work on and when
• The user can only take advantage of the complete abilities of the CPU only if the operating system software and application software also have those abilities (example: AMD’s 3D-Now or Intel’s SSE)
Tighter Circuitry

• closer the circuits are together, the more circuits that can fit on a single chip
• faster performance when there are fewer chips
Moore’s Law

- Gordon Moore, chairman of the board of Intel in the 1960’s said that transistor densities on a single chip would double every 18 months.

2017 - limits of silicon technology?
2030 - computing power of human brain
Measuring performance of the CPU

1. The number of bits processed
2. The size of the CPUs data bus
3. The amount of RAM the CPU can recognize
4. The math coprocessor
5. Multiprocessing capabilities
6. Virtual Memory capabilities
7. The Speed of the CPU
8. Internal Cache capabilities
9. Number of Pipelines
1. The number of bits processed

Number of bits processed - amount of work the CPU can accomplish in one instruction

More bits = More work accomplished per instruction.

(which means faster computer)

(Toll Booth Analogy)
1. The number of bits processed

70’s 4 bit and 8 bit processors (Intel 4004, Motorola 6502)

80’s Intel 8088, 80286: 16 bit processors
(1985/1990) Intel 80386, 80486
1993- Pentium family:
   32 bit processors

Motorola and IBM PowerPC: 32 bit processors

64 bit processors (Compaq Alpha processors, Intel’s IA-64)

More bits in the future!
2. The CPU’s Data Bus

(Toll Booth Analogy Continued)

Data bus - the number or wires between the CPU and “the rest of the computer”

More wires (lanes) the faster the CPU gets the data and software to process

Older CPUs: 8 and 16 bit data bus
Newer CPUs: 32 and 64 bit data bus or more!
3. The Amount of RAM the CPU can Recognize

CPUs are designed to be able to recognize a specific amount of RAM memory.

Today’s microprocessors recognize 4 GB of RAM, but most motherboards support much less (around 512 MB of RAM).

- Intel 8088 -> 1 MB RAM
- Intel 80286 -> 16 MB RAM
- Intel 80386 & later -> 4 GB RAM
4. The Math Co-processor or FPU

For math intensive applications

• games
• graphics
• animation and video
• CAD (Computer Aided Design)

Early microcomputers
• separate Math Co-processor

Later microprocessors
• built-into the CPU
• faster when inside the chip
5. Multiprocessing Abilities

Multiprocessing - ability of the CPU to process more than one task at a time

Example: Sorting some information and calculating a spreadsheet at the same time

“All modern microprocessors” can do multiprocessing

(by rapidly switching between tasks)
6. Virtual Memory

Virtual Memory (VM) - the ability of the CPU and the operating system software to use the hard disk drive as additional RAM when needed (safety net)

Good - no “insufficient memory” error

Bad - performance is very slow when accessing VM

Solution - more RAM
Virtual Memory

data or program instructions most recently transferred from disk to memory

data or program instructions least recently used in memory

page swapped in

page swapped out

DISK

Virtual Memory

MEMORY
7. The Speed of the CPU

Speed measured in megahertz (MHz) - the number of millions of beats per second

Examples:

• “my first computer” 1979 (less than 2 MHz)
• early CPUs 1 - 33 MHz
• typical today: 2.0 GHz – 3.0 GHz (2000 - 3000 MHz)

Faster the CPU, faster the processing (Toll Booth)

Cost $$$ and Manufacturing
8. Internal Cache

Internal Cache - memory inside the CPU chip which stores instructions and data which the CPU is currently working on or may soon need

- “All CPUs” have internal cache
Cache (In General)

- A **disk cache** (either a reserved area of RAM or a special hard disk cache) where a copy of the most recently accessed data and adjacent (most likely to be accessed) data is stored for fast access. *(later)*
- **RAM** itself, which can be viewed as a cache for data that is initially loaded in from the hard disk (or other I/O storage systems).
L1 and L2 Cache
The Cache for RAM

There may be more than one layer of cache between the CPU and RAM (different configurations are possible) (two or three levels is typical today)

for example:

• **L1 cache memory** on the same chip as the microprocessor.

• **L2 cache memory**, which is on a separate chip from the microprocessor but faster to access than regular RAM.
9. Single or Multiple Pipelines

(FYI only)
A CPU executes an instruction in several stages.

Example:
The 5 Stages of the CPU
1. Fetch
2. Decode
3. Operand
4. Execute
5. Write-back
Single or Multiple Pipelines

**Scalar Pipelining** - each stage of the CPU can perform its task while other stages are performing their tasks

Modern microprocessors have this feature.

[In-class demonstration]
Single or Multiple Pipelines

Superscalar Processing - More than one scalar pipeline

Modern processors have many scalar pipelines

Example:
Intel’s Itanium IA-64 has 9 pipelines.
New Technology in Microprocessors

In 1997, Intel included new capabilities for multimedia - MMX (MultiMedia eXtensions)

Intel’s has since released other technologies such as SSE and SSE2 (Streaming SIMD Extensions)

more capabilities for video and audio

• Software must be written to take advantage of these features for them to be a benefit
All CPUs of the past several years have:

“Typical”
1. 32 bit processing
2. 32 or 64 bit data bus
3. can use 4 GB of RAM
4. internal math co-processor
5. Multiprocessing capabilities
6. can do virtual memory
… conclusion
What is happening is with the newer CPUs
7. Number of bits processed - more
8. Speed - Faster and faster!
9. Internal Cache - more and more!
10. Superscalar Pipelines - more and more! (Hyper-pipelined)
11. New Process Technologies

More performance for the price!
Some Suggested Hardware and CPU Web Sites

www.tomshardware.com
www.anandtech.com
www.intel.com
www.apple.com
www.ibm.com
www.motorola.com