CMPE 310
Systems Design and Programming

L1: Chapter 1 – *Introduction to the Microprocessor and Computer*

UMBC
AN HONORS UNIVERSITY IN MARYLAND

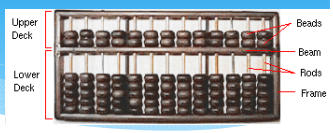
Why Assembly?

- We're going to do assembly language programming, for crying out loud!
- This is obviously some sort of punishment, right?
  - The Good!
    - Able to graduate
    - In order to write high-level language, it is necessary to have some knowledge of assembly they translate into
    - To debug higher-level language, you have to review the resulting assembly language
    - Complier writers must know how to write assembly
      - In order to have the complier do code generation
    - Earn more than programmers who can't write assembly
      - (those applications where assembly is required)
    - Writing assembly language is fun
  - The Bad!
    - Takes too much effort to write in assembly language
  - The Ugly!
    - It is not going to be easy

L1 Objectives

* Trace the evolution of microprocessors
* Understand the difference between General purpose computing systems and embedded systems

What is a computer?

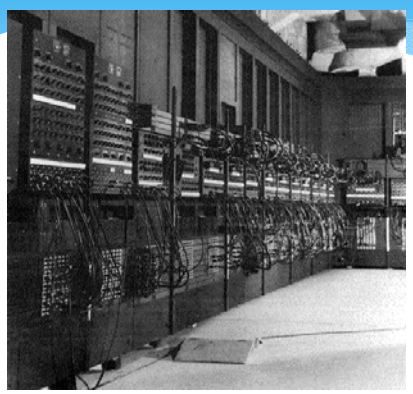


- From *The American Heritage Dictionary*:
  - "One who computes"
    - We could argue that people are computers
  - "A device that computes, especially a programmable electronic machine that performs high-speed mathematical or logical operations or that assembles, stores, correlates, or otherwise processes information."
    - Anything from a simple abacus to the microprocessor-based computers of today
- "Microcomputer": computer system with changeable functionality, based on microprocessor

Computer components

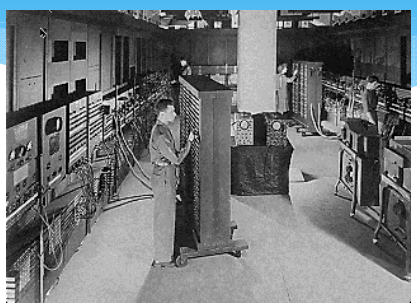
- What are the key components of a computer?
  - **Microprocessor** (MPU/CPU) performs computation
  - **Input** to read data from external devices
    - Examples: Keyboard, mouse, ports (Ethernet, USB, etc.)
  - **Output** to transmit data to external devices
    - Examples: screen, speaker, VGA interface, ports (Ethernet, USB, etc.)
  - **Storage** to hold program code and data
    - RAM, hard disk, possibly other media (CD/DVD, external drive)
- Microcontroller contains smaller-scale versions of these components
  - Computation engine
  - I/O interface
  - Internal storage

The History



The first general-purpose electronic computer – ENIAC, built in UPenn in 1946

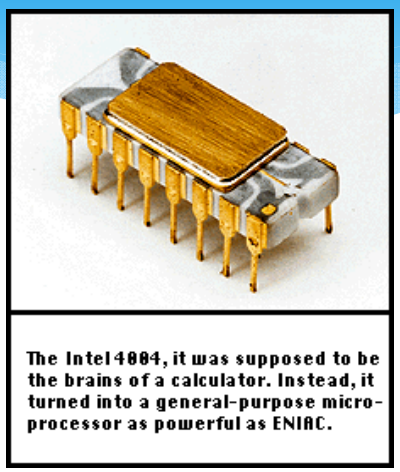
Source: http://ei.cs.vt.edu/~history/ENIAC.Richey.HTML



- Thirty tons (1500 sq. ft)
- 200KW -- Forced air cooling
- **17,000+ vacuum tubes**
- Punch card
- Manual wiring (500 mi)
- Numerical computation (100KIPS)
- **Intel 4004 microprocessor**

80x86 Evolution

- ***4004*** had 2,250 transistors
  - 4-bit microprocessor
  - ***4KB main memory***
  - 45 instructions
  - PMOS technology
  - ***50 ,000 instructions/sec***
- ***8008*** - *1971*
  - ***8-bit*** version of 4004
  - ***16KB main memory***
  - 48 instructions
  - NMOS technology
  - **20 µs clock cycle time**
- ***8080*** - *1973*
  - ***8-bit*** microprocessor
  - **64KB main memory**
  - **2 µs clock cycle time; 500,000 instructions/sec**
  - 10X faster than 8008



The Intel 4004, it was supposed to be the brains of a calculator. Instead, it turned into a general-purpose microprocessor as powerful as ENIAC.

80x86 Evolution

- ***8085*** - *1977*
  - **8-bit** microprocessor - upgraded version of the 8080
  - **64KB main memory**
  - **1.3 µs clock cycle time; 769,230 instructions/sec**
  - 246 instructions
  - Intel sold 200 million copies of this 8-bit microprocessor
- ***8086*** – *1978*; ***8088*** - *1979*
  - **16-bit microprocessor**
  - **1MB main memory**
  - 2.5 MIPS (**400 ns**)
  - 4- or 6-byte instruction cache
  - Other improvements included more registers and additional instructions
- ***80286*** - *1983*
  - 16-bit microprocessor very similar in instruction set to the 8086
  - **16MB main memory.**
  - 4.0 MIPS (**250 ns;** 8MHz)

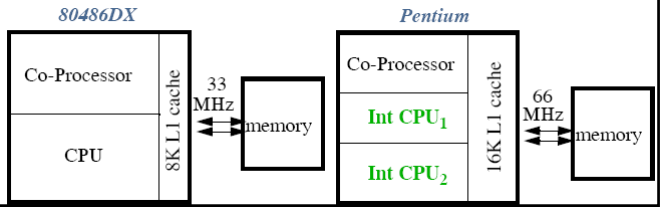
4.77 MHz processing speed
256 K RAM
1 or 2 floppy disk drives

80x86 Evolution

- ***80386*** - *1986*
  - **32-bit microprocessor**
  - **4GB main memory**
  - 12-33MHz
  - Memory management unit added
  - Variations: DX, EX, SL, SLC (cache) and SX.
    80386SX: 16MB through a 16-bit data bus and 24 bit address bus
- ***80486*** - *1989*
  - Incorporated an 80386-like microprocessor, 80387-like floating point **coprocessor** and an **8K byte cache** on one package
  - About half of the instructions executed in 1 clock instead of 2 on the 386
  - **32-bit** microprocessor, 32-bit data bus and 32-bit address bus
  - **4GB** main memory
  - 50 MIPs (25ns,50MHz); Later at 66 and 100MHz (Memory transfers at 33MHz)
  - Variations: SX, DX2, DX4
    DX2: Double clocked version DX4: Triple-clocked version

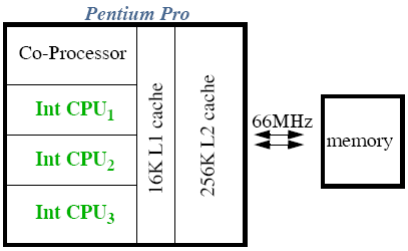
80x86 Evolution

- ***Pentium*** - *1993*
  - 32-bit microprocessor, 64-bit data bus and 32-bit address bus
  - 4GB main memory
  - 60, 66, 90MHz
    1 ½ clocked 100MHz version
    Double clocked 120 and 133MHz versions
    Fastest version is the 233MHz (3 ½ clocked version)
  - **16KB L1 cache (split instruction/data: 8KB each)**
  - Memory transfers at **66MHz (instead of 33MHz)**
  - **Dual integer processors**



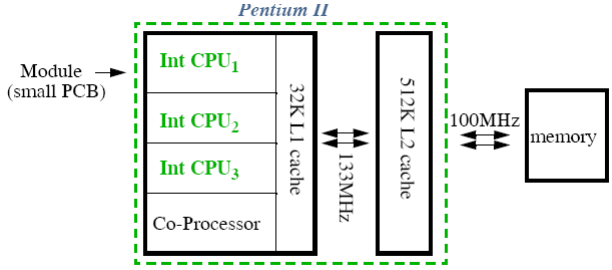
80x86 Evolution

- ***Pentium Pro*** - 1995
  - 32-bit microprocessor, 64-bit data bus and 36-bit address bus
  - **64GB main memory**
  - Initial clock speed: 150 and 166MHz
  - 16KB L1 cache (split instruction/data: 8KB each)
  - **256KB L2 cache**
  - Memory transfers at 66MHz
  - **3 integer processors**



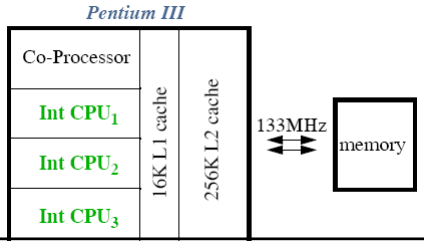
80x86 Evolution

- ***Pentium II*** - **1997**
  - 32-bit microprocessor, 64-bit data bus and 36-bit address bus
  - 64GB main memory
  - Starts at 266MHz
  - **32KB split instruction/data L1 caches (16KB each)**
  - **Module integrated 512KB L2 cache (133MHz)**
  - Memory transfers at 66MHz to **100MHz (1998)**



80x86 Evolution

* ***Pentium III -1999***
  * 32-bit microprocessor, 64-bit data bus and 36-bit address bus
  * 64GB main memory
  * 800MHz and above
  * 32KB split instruction/data L1 caches (16KB each)
  * **On-chip 256KB L2 cache (at clock speed)**
  * Memory transfers 100MHz to **133MHz**
  * **Dual Independent Bus (simultaneous L2 and system memory access)**



80x86 Evolution

* ***Pentium IV***- *2002*
  * 1.4 to 1.9GHz and the latest at 3.20 GHz and 3.46GHz (Hyper-Threading)!
  * 1MB/512KB/256KB L2 cache
  * 800 MHz (about 6.4GB/s)/533 MHz (4.3 GB/s)/ 400MHz (3.2 GB/s) system bus
  * 1066 MHz front side bus
  * Specialized for streaming video, game and DVD applications (144 new SIMD 128-bit instructions)
  * 0.13um, more than 55 million transistors
  * Newer ones are in 90nm transistors, >125 million possible
* ***Pentium D, Core2 Duo, Core Duo, Core2 Extreme Edition*** - *2005-2008*
  * 64-bit core and multiple cores
  * Dual and Quad processing cores
  * Up to 4MB L2 cache and 1066 MHz FSB
  * 65 nm and 45 nm transistors (and lots of them!!!)
* For more details visit ***http://www.intel.com/design/***

Systems Overview

- ***General Purpose Computing Systems***
  - Personal Computers, laptops, workstations, mainframes and servers
- ***Systems for Dedicated Functions***
  - Usually embedded within larger electronic devices (embedded systems)
  - Definitions from several authors:
    - Any computing systems other than a general purpose computer
    - A systems consisting of hardware, main application software and an optional real time operating systems (RTOS)
  - Loosely defined:
    - Any device that includes a programmable computer but is not itself intended to be a general-purpose computer
    - Electronic systems that contain a microprocessor or microcontroller, but we do not think of them as computers - the computer is hidden or embedded in the system
    - It is a system whose principal function is not computational, but which is controlled by a computer embedded within it, ...

A Few Definitions…

- Microprocessor (MPU)
  - A ***single IC*** *that a*ccepts and executes coded instructions
  - Manipulating data and controlling the associated circuitry (memory & I/O)
    - Fetches and processes a set of general-purpose instructions data transfer, ALU operations, stack operations, IO operations and program control, sequencing and supervising operations
- Microcomputer
  - An *integrated* ***system*** of computer components
    - Data storage ICs →RAM and ROM
    - Mass storage elements →External Drives, Hard Drives, CD-ROM
    - Standard I/O devices → monitor, keyboard, mouse, printer, etc.
    - Contains a microprocessor at the heart of the system
- Microcontroller (MCU)
- Similar to a microprocessor except that it also contains MPU, RAM, ROM, and I/O circuitry in that single IC package
  - Allows miniaturization of single application

So… You're a system designer?

* ***System designer***
  * Needs to understand the architecture related to the programming of the processor's memory to carry out the required functionality
  * Unit cost may be low in small quantities compared with designing a dedicated chip
  * Performance varies by application (MIPS, iCOMP) , size and power might be higher due to unnecessary processor hardware

Next time

* 80x86 Hardware Specification