

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
 - * Compiler writers must know how to write assembly
 - * In order to have the compiler 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

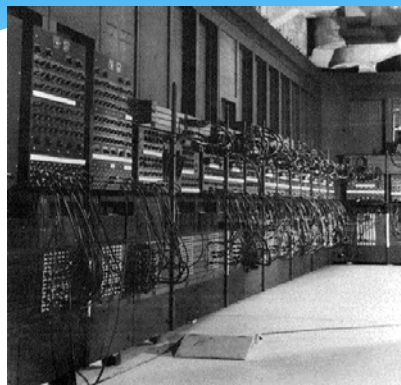


Computer components

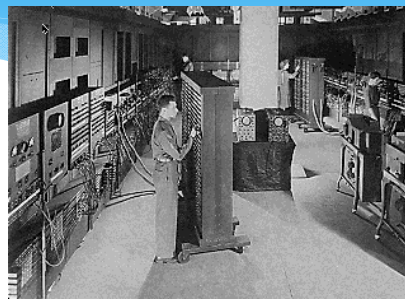
- What are the key components of a computer?
 - ❑ **Microprocessor** (MPU/CPU) performs computation
 - ❑ **Input** to read data from external devices
 - Examples: Keyboard, mouse, ports (Ethernet, USB, etc.)
 - ❑ **Output** to transmit data to external devices
 - Examples: screen, speaker, VGA interface, 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

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The History



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

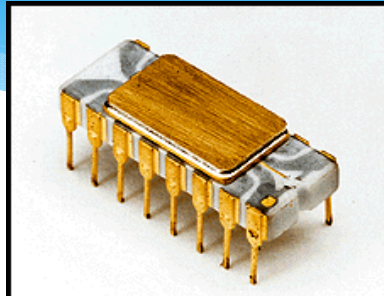


- Thirty tons (1500 sq. ft)
- 200KW -- Forced air cooling
- **17,000+ vacuum tubes**
- Punch card
- Manual wiring (500 mi)
- Numerical computation (100KIPS)
- **Intel 4004 microprocessor**

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

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 μ s clock cycle time**
- * **8080** - 1973
 - * **8-bit** microprocessor
 - * **64KB main memory**
 - * **2 μ s 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 micro-processor as powerful as ENIAC.

80x86 Evolution

- * **8085** - 1977
 - * **8-bit** microprocessor - upgraded version of the 8080
 - * **64KB main memory**
 - * **1.3 μ s 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**)



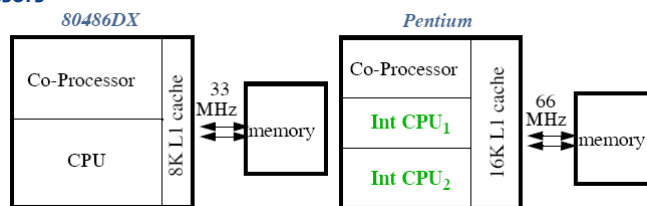
4.77 MHz processing speed
256 K RAM
1 or 2 floppy disk drives

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

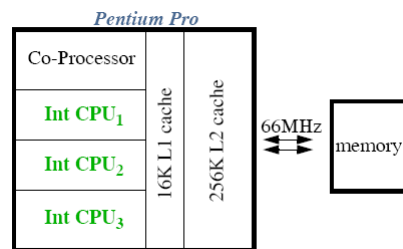
- * **Pentium - 1993**
 - * 32-bit microprocessor, 64-bit data bus and 32-bit address bus
 - * 4GB main memory
 - * 60, 66, 90MHz
 - 1 ½ clocked 100MHz version
 - Double clocked 120 and 133MHz versions
 - Fastest version is the 233MHz (3 ½ clocked version)
 - * **16KB L1 cache (split instruction/data: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



80x86 Evolution

* Pentium Pro - 1995

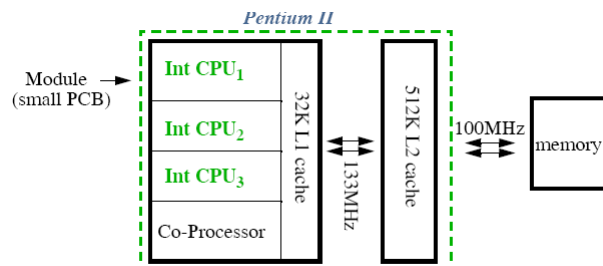
- * 32-bit microprocessor, 64-bit data bus and 36-bit address bus
- * **64GB main memory**
- * Initial clock speed: 150 and 166MHz
- * 16KB L1 cache (split instruction/data: 8KB each)
- * **256KB L2 cache**
- * Memory transfers at 66MHz
- * **3 integer processors**



80x86 Evolution

* Pentium II - 1997

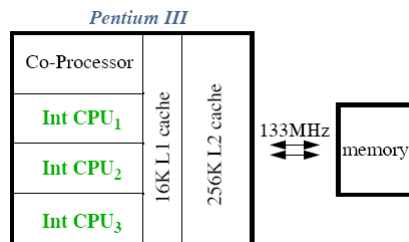
- * 32-bit microprocessor, 64-bit data bus and 36-bit address bus
- * 64GB main memory
- * Starts at 266MHz
- * **32KB split instruction/data L1 caches (16KB each)**
- * **Module integrated 512KB L2 cache (133MHz)**
- * Memory transfers at 66MHz to **100MHz (1998)**



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 accepts 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

